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Remedial Investigation and Focused Feasibility Study Report

Brookdale Golf Course
1802 Brookdale Road East
Tacoma, Washington

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ABBREVIATIONS AND ACRONYMS

Abbreviation/ Acronym	Definition
amsl	Above mean sea level
ARAR	Applicable or Relevant and Appropriate Regulation
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, And Liability Act
COC	Contaminant of concern
COEC	Chemical of ecological concern
COPC	Contaminant of potential concern
COPEC	Chemicals of potential ecological concern
CSM	Conceptual Site Model
CUL	Cleanup level
Ecology	Washington State Department of Ecology
ECOTOX	EPA's Ecotoxicology Knowledge Database
EISC	Ecological indicator soil concentrations
EPA	Environmental Protection Agency
EPI	Environmental Partners, Inc.
FFS	Focused feasibility study
FSI	Focused subsurface investigation
Ichijo	Ichijo USA Co., LTD.
IHS	Indicator Hazardous Substance
LOEC	Lowest Observed Effect Concentration
mg/kg	Milligrams per kilogram
MTCA	Model Toxics Control Act
PQL	Practical quantitation limit
RI	Remedial Investigation
RI/FFS	Remedial Investigation and Focused Feasibility Study
TEE	Terrestrial Ecological Evaluation
VCP	Voluntary Cleanup Program.
WAC	Washington Administrative Code

1.0 INTRODUCTION

Environmental Partners, Inc. (EPI) is pleased to submit this *Remedial Investigation and Focused Feasibility Study* (RI/FFS) for the Brookdale Golf Course Site located at 1802 Brookdale Road East, Tacoma, Washington (subject property). The general location of the subject property is indicated on Figure 1. The subject property is currently developed and operating as a golf course. The subject property is in the process of redevelopment as a residential subdivision with single-family detached homes. Future residential land uses were considered during the preparation of this RI/FFS. Remedial actions to be performed during redevelopment are addressed under separate cover in a *Cleanup Action Plan* (CAP) for the subject property.

This RI/FFS has been prepared on behalf of the current property owner, Ichijo USA Co., LTD (Ichijo), which recently purchased the subject property from Brookdale PDD, LLC. This RI/FFS has been requested by Ichijo in support of their ongoing efforts to meet the requirements of the Model Toxics Control Act (70.105D RCW) and its implementing regulations (Washington Administrative Code [WAC] 173-340; collectively "MTCA"). For the purpose of this document, and as defined in MTCA, the "Site" shall mean all areas where contaminants from the general maintenance of the Brookdale Golf Course have come to be located. All areas of the Site are located within the subject property boundary.

Environmental investigations of the subject property indicate that soils at the Site are impacted with the organochlorine pesticide dieldrin. In accordance with MTCA 173-340-703 and for the purposes of the RI/FFS, dieldrin is considered the indicator hazardous substance (IHS) and the primary contaminant of concern (COC). Other pesticides were sporadically detected at the Site, but their presence was much less widespread, they had a lower frequency of detection, and their concentrations were in all cases significantly less than dieldrin. The only other compound to exceed an applicable cleanup level was the pesticide aldrin. In no instance did a concentration of aldrin exceed a cleanup level where a concentration of dieldrin did not also exceed a cleanup level.

As detailed herein, soil at the Site is impacted with dieldrin at concentrations exceeding the MTCA Method B Soil Cleanup Level of 0.0625 milligrams/kilogram (mg/kg). The RI has established that these impacts are only to shallow soil and do not exceed depths of 3 feet below grade. These impacts are limited to the greens and tees where pesticides were historically applied because of the focus on the aesthetics of the grass. Pesticides were not applied in the fairways because of lesser aesthetic requirements and due to the large amount of surface area and the associated expense of applying the chemicals over such a large surface area.

It is important to note that dieldrin and other pesticides detected at the Site are exempt from regulatory reporting and that the dieldrin and other compounds noted at the Site do not constitute a "release" under MTCA because (a) the pesticides were applied for their intended purposes and according to label instruction (WAC 183-340-300 (3)(a)) and (b) they were applied in a lawful and non-negligent manner by a natural person (WAC 173-340-300(3)(b)). This RI/FFS has only been prepared due to the pending change in land use from agricultural/recreational (i.e., golf course) to residential. The observed dieldrin concentrations represent a potential threat of exposure to future tenants and landowners and this potential exposure is what Ichijo is seeking to preemptively address.

Additionally, Ichijo is not a potentially liable person (PLP) for any pesticide impacts at the subject property, to the extent they may have occurred, because Ichijo was not an owner or operator at the time of any application of pesticides. Ichijo seeks to maintain its status as a non-PLP by complying with applicable rules and regulations for the proper management, handling, and disposal of impacted soils. As noted above, a CAP is being prepared under separate cover that fully documents the handling, management, disposal, and confirmation monitoring for pesticide-impacted soil remediation at the subject property.

This RI/FFS summarizes the environmental activities conducted at the subject property between 2016 and 2018, evaluates cleanup alternatives for the Site, and selects a cleanup action that meets the requirements of MTCA and is protective of human health and the environment. The selected cleanup action will be implemented under the Voluntary Cleanup Program (VCP).

With the enrollment of the Site into the VCP and the submission of this RI/FFS, Ichijo and EPI request an advisory opinion from Ecology regarding the completeness of the RI/FFS. The CAP will also be submitted to Ecology for review and comment. A final report documenting the successful implementation of the CAP will ultimately be submitted to Ecology after completion of all remedial actions.

1.1 Report Organization

This RI/FFS is organized as follows:

- Section 2.0 presents a description and current and historical uses of the subject property;
- Section 3.0 presents the RI for the Site;
- Section 4.0 presents the FFS for the Site; and
- Section 5.0 presents the limitations of this RI/FFS document.

2.0 DESCRIPTION OF SUBJECT PROPERTY

The subject property is located at 1802 Brookdale Road East in Tacoma, Washington, and comprises four tax parcels (Pierce County tax parcels 0319158700, 0319158701, 0319225700, and 0319225701) totaling approximately 142.3 acres. The subject property is illustrated on Figure 2. Brookdale Golf Course has operated continuously at the subject property since approximately 1931. The subject property is primarily open space with landscaped grass and tree cover. Narrow asphalt cart paths provide access throughout the subject property. The northernmost portion of the subject property is paved with asphalt and serves as the primary parking area. Brookdale Road East forms the northern boundary of the subject property and is the single entry point. Residential neighborhoods are located adjacent to the east, south, and west of the subject property.

The ground elevation at the subject property ranges from approximately 350 feet above mean sea level (amsl) at its southern end to approximately 320 feet amsl in the central and northern portions of the subject property. Soils generally consists of gravelly silts and sands derived from glacial outwash.

Well logs retrieved from the Washington State Department of Ecology (Ecology) Well Log database indicate that depth to shallow groundwater in the area is approximately 8.5 feet below ground surface (bgs). The depth to shallow groundwater is confirmed through observations made during the investigation described in this RI/FFS Report. A deeper aquifer is reportedly present at approximately 57 feet bgs. A copy of the Ecology well logs is provided in Attachment A.

The inferred hydrogeologic gradient is to the east, towards Clover Creek. Clover Creek, the nearest surface water body, runs from east to west through the southern portion of the subject property; North Fork Clover Creek, a tributary of Clover Creek, runs from east to west through the northern portion of the subject property, eventually joining Clover Creek further to the west. Figure 2 presents the orientation of both creeks.

2.1 Historical Uses of Subject Property

EPI's understanding of the historical uses of the subject property is based on information obtained from the Pierce County Assessor's office. The subject property was homesteaded as early as 1850 and was used as a hop farm prior to development as a golf course in 1930. In 1930 the current clubhouse and retail store buildings were constructed. Additional golf course-related outbuildings, including maintenance and utility sheds were constructed between 1960 and 2002. Copies of the historical tax records associated with the subject property are provided in Attachment B.

2.2 Current Site Use

The Brookdale Golf Course, associated buildings and parking areas currently occupy the subject property. The clubhouse, retail store, golf cart storage, and an open-sided building are located on the northern portion of the subject property, proximate to Brookdale Road East. Outbuildings, including maintenance and utility sheds are located proximate to the northwestern corner of the subject property; one shed is located on the southern portion of the subject property, just south of Clover Creek.

3.0 REMEDIAL INVESTIGATION

Between 2016 and 2018, multiple environmental investigations were conducted at the subject property. These investigations have assessed the condition of soil, groundwater, and surface water beneath the subject property and characterized the nature and extent of the hazardous substances that have come to be located at the subject property. The cumulative results of these investigations constitute the RI. The investigations indicate the subject property contains 15 small and distinct areas impacted by the same compounds from the same historical activities, which together constitute a "Site" under MTCA as defined in WAC 173-340-200.

The impacted areas are named Area 1 through Area 15 and are illustrated on Figures 3 and 4. Sample locations and analytical results are displayed by area on Figures 5 through 12. Analytical results are summarized on Tables 1 through 6.

3.1 Constituents of Potential Concern

Based on historical and current subject property uses the constituents of potential concern (COPCs) were:

- Organochlorine pesticides; and
- Organochlorine herbicides.

The potential presence of these compounds was evaluated in soils, groundwater, and surface water at the subject property during the RI. As noted above, at the time these compounds were used at the subject property they were applied in a lawful manner and in accordance with their intended uses and did not constitute a release to the environment under MTCA. It is only due to a change in land use that potential presence of these compounds in soil are considered contaminants.

3.2 Affected Media

Based on geological and hydrogeological conditions and current and future land uses at the subject property, the media of potential concern evaluated during the RI are soil, groundwater, and surface water. Indoor air was not evaluated during the RI because the COPCs are not volatile.

3.3 Environmental Investigations of Subject Property

3.3.1 Limited Pesticide Investigation – Robinson Noble (2016)

An initial limited soil investigation was performed by Robinson Noble in November 2016 to assess the potential presence or absence of organochlorine pesticides and herbicides. Robinson Noble conducted this investigation to evaluate selected areas for possible impacts relating to the historical property operations in areas where the COPCs were most likely to have been used.

A total of three soil samples were collected: sample BGC-1M was collected from beneath the pesticide spray tank located in the maintenance area; sample BGC-2M was collected proximate to the waste oil storage area, also located in the maintenance area; and sample BGC-3G was collected from the practice green located along the northern edge of the golf course. A map of the sample locations was not provided with the Robinson Noble Letter Report.

Each sample was collected using a stainless-steel hand auger, advanced down to an approximate depth of 6 inches bgs and placed into a laboratory-provided container. Samples were analyzed for organochlorine herbicides using U. S. Environmental Protection Agency (EPA) Method 8151 modified for herbicides, and EPA Method 8051 for organochlorine pesticides.

The analytical results for the limited soil investigation indicated the following:

- Dieldrin was the only organochlorine pesticide detected at concentrations greater than the laboratory method detection limit and each detected concentrations exceeded the MTCA Method B CUL of 0.0625.

- Organochlorine herbicides were not detected in any of the samples analyzed. Organochlorine herbicides were eliminated as a COPC as a result.

A copy of the Letter Report prepared by Robinson Noble and the associated laboratory report is provided in Attachment C, results are summarized in Table 1.

3.3.2 Focused Subsurface Investigation – EPI (2017)

Based on the results of Robinson Noble's 2016 Investigation, EPI conducted a broader focused subsurface investigation (FSI) of the subject property. While the initial assessment identified organochlorine pesticides in area where they may have been mixed or formulated, or released in high concentrations, there was no understanding of the potential presence of these compounds in areas where they may have been applied. The objective of the FSI was to assess the presence of organochlorine pesticides in soils within the tees, fairways, and greens of the golf course. Anecdotal information provided by the golf course operated indicated that the pesticides were historically used on the greens and tees because of the focus on the aesthetics of the grass, but was not applied in the fairways due to the large amount of surface area and the associated expense of applying the chemicals over such a large surface area. EPI also assessed the potential presence of organochlorine pesticides in shallow groundwater and surface water at the subject property.

Between January 25 and January 27, 2017, EPI collected soil samples from 9 tees, 9 greens, and 9 fairways distributed across the subject property for a total of 27 sample locations. For each of the tee and green locations, the sample location was centered in either the center of the tee box or the center of the green. For the fairway sample locations, a sample was collected from the approximate center of the fairway midway between the tee and green. At each sample location, soil samples were collected from 6 to 9 inches bgs, 12 to 15 inches bgs, and 18 to 21 inches bgs using a stainless-steel hand auger. Soil collected with the hand auger was homogenized prior to placement into a clean, laboratory-supplied 4-ounce sampling container.

Samples were named according to the number of the course hole from which they were collected and whether they were collected from a tee, green, or fairway. For example, "10:Tee" was collected from the 10^{th} hole within the tee box; "16:Green" was collected from the 16^{th} hole within the green; "15:Fairway" was collected from the 15^{th} hole, within the fairway. Sample locations are illustrated in Figures 3 and 4.

Samples from 6 to 9 inches and 12 to 15 inches from each location were submitted for analysis. Samples collected from 18 to 21 inches were archived and only analyzed if the sample from 12 to 15 inches exhibited a concentration of an organochlorine pesticides greater than the MTCA Method B CUL. A total of 81 soil samples were collected. Of those 81 soil samples, 67 were analyzed for organochlorine pesticides using EPA Method 8081.

EPI collected two grab water samples – one surface water sample from the irrigation pond and one groundwater sample from a spigot at the on-Site well. The on-Site well is completed within the shallow aquifer and it used solely for irrigation purposes. Drinking water at the subject property is supplied by the local municipal supply. Water samples were submitted for analysis of organochlorine pesticides using EPA Method 8081.

3.3.2.1 Soil Analytical Results

Results of the FSI indicated that pesticide impacts were not present in shallow soils within the fairways of the subject property. None of the 18 fairway soil samples contained a detectable concentration of organochlorine pesticides. This finding was consistent with the anecdotal information indicating that pesticides were not used in the fairways.

Dieldrin was detected at concentrations exceeding the MTCA Method B CUL at six of the nine tees tested (Tees 1, 3, 12, 13, 14, and 17) and at all nine of the greens tested (Greens 1, 5, 6, 7, 9, 10, 14, 16, and 18). The pesticide aldrin was also detected at concentrations exceeding the MTCA Method B CUL at Tees 13 and 14 and at Green 5.

A summary of detections in soil, by analyte, is presented in Table 2 below. The analytical results indicate that dieldrin is the primary COPC at the subject property with approximately 60 percent of samples analyzed containing detectable concentrations of dieldrin. Of those samples, 52 percent contained concentrations of dieldrin that exceeded the MTCA Method B CULs. Aldrin was also detected in concentrations that exceed MTCA Method B CULs, but in no instance did the concentration of aldrin exceed the applicable CULs where dieldrin did not. Of the other pesticides detected, none were detected in a sample where dieldrin was not detected. Based on these findings dieldrin is considered the IHS for the subject property and a full characterization of dieldrin will also serve to characterize the maximum extent of the compound detected at lesser frequencies and at lesser concentrations.

Table 2
Organochlorine Pesticides Detected in Soils Exceeding Method Detection Limit
2017 Focused Subsurface Investigation

COPC	Number of Samples Collected	Number of Detections	Frequency of Detections (percent)	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)
4,4-DDE	67	6	9	0.014	0.06
4,4-DDT	67	4	6	0.16	0.7
B-BHC	67	1	15	0.022	0.022
D-BHC	67	20	30	0.011	0.22
Aldrin	67	7	10	0.014	0.29
Endosulfan I	67	2	3	0.028	0.084
Dieldrin	67	40	60	0.023	6.8
Endrin	67	8	12	0.011	0.061
Endrin Aldehyde	67	2	3	0.017	0.018

The soil analytical results are summarized in Table 3. Figures 5 through 12 illustrate dieldrin concentrations. Copies of the laboratory analytical reports are provided in Attachment D.

3.3.2.2 Groundwater and Surface Water Analytical Results

Organochlorine pesticides were not detected in either the surface water sample collected from the irrigation pond or in the groundwater water sample collected form the shallow on-property well.

The groundwater and surface water analytical results are summarized in Table 4. Copies of the laboratory analytical reports are provided in Attachment D.

3.3.3 Continued Subsurface Investigation – EPI (2018)

The 2017 FSI clearly indicated the nature of pesticide impacts at the subject property but did not fully characterize the lateral or vertical extents of those impacts. While 50 percent of the tees and greens had been sampled, there were no data for the other tees or greens. The FSI succeeded in identifying dieldrin as the IHS and in characterizing the vertical extent of pesticides exceeding CULs in some, but not all locations as a result of the FSI. In areas where dieldrin was detected, it was necessary to characterize the lateral extent of those impacts.

The Continued Subsurface Investigation was conducted between April 16 and May 7, 2018. The objectives of the investigation included:

- Assessing the presence or absence of organochlorine pesticides in the remaining tees and greens not yet evaluated (Tees 2, 5, 7, 8, 9, 11, 15, 16, and 18, and Greens 2, 3, 4, 8, 11, 12, 13, 15, and 17).

- Characterize the vertical extent of organochlorine pesticides in those tees and greens where organochlorine pesticides exceed CULs and where the vertical limit has not yet been characterized (Tees 1, 3, 12, 13, 14, and 17, and Greens 1, 5, 6, 7, 9, 10, 14, 16, and 18).

- Characterize the lateral extent of organochlorine pesticides on all tees and greens where they have been identified at concentrations greater than CULs (Tees 1, 3, 12, 13, 14, and 17, and Greens 1, 5, 6, 7, 9, 10, 14, 16, and 18).

A minimum of four sample locations were advanced in each of the tees and greens not previously assessed in the 2017 FSI. Three sample locations were evenly distributed along the outermost edges of these tees and greens to determine the lateral impacts, and one sample location was advanced in the center of each of the tees and greens to assess the vertical impacts. For those course holes with a grouping of tee boxes, one sample location was advanced in the center of each tee. For example, at course hole 17, there were three different tee locations; one sample location was advanced in the center of each of these tee locations and additional sample locations were advanced around the perimeter of the tee area. Sample locations are illustrated on Figures 3 and 4.

Samples were identified according to the number hole and whether they were sampled from a green or a tee. For those holes with more than one tee, the tees were identified alphabetically, with the northernmost tee identified as “A,” remaining tees were named sequentially B, C, D, etc. For example, the sample identified as Tee 4-A was collected from the northernmost tee box on the 4th hole; the sample identified as Tee 11-D was the southernmost tee box located on the 11th hole.

Samples collected from the perimeter of the tees and greens were identified by the number hole and by their cardinal direction. For example, the sample identified as Green 1- E was collected from the eastern edge of the green on the 1st course hole, Tee 4-NW was collected from the northwestern edge of the tee area on the 4th course hole.

EPI collected a total of 693 soil samples from the subject property during the continued subsurface investigation. Soil samples were collected using a stainless-steel hand auger from 6 to 9 inches, 12 to 15 inches, 18 to 21 inches, and 24 to 27 inches bgs. For those tee and green locations previously sampled in the 2017 FSI and where the deepest sample concentrations exceeded CULs, additional deeper soil samples were collected from 24 to 27 inches and 30 to 33 inches bgs. At the completion of sampling, each sample location was backfilled with excess soil generated from the hand-auger borings.

Soil from each sample depth was placed in a stainless-steel bowl and homogenized. Samples were then placed in 4-ounce jars, labeled, and placed in a cooler with ice for transport to the laboratory. Standard chain-of-custody procedures were followed in transporting the soil samples to the laboratory. Soil samples were submitted Friedman and Bruya, Inc. in Seattle, Washington, for chemical analysis of dieldrin using EPA Method 8081.

From each of the new sample locations, samples from the 6 to 9 inches and 12 to 15 inches were submitted for initial analysis of organochlorine pesticides; samples from 18 to 21 inches and 24 to 27 inches were archived and analyzed only if samples from shallower locations exhibited concentrations in excess of the MTCA Method B CUL for soil. A total of 433 of the 693 samples collected were analyzed.

3.3.3.1 Analytical Results

A total of 433 soil samples were submitted for the analysis of dieldrin. As determined in the FSI, dieldrin was the primary COPC. The only other analyte found to exceed a MTCA Method B CUL was aldrin and in no instance did aldrin exceed a CUL in a sample where dieldrin did not. As a result, all samples collected and submitted as part of the Continued Subsurface Investigation were analyzed for dieldrin only. A summary of detections is provided in Table 5, below.

Table 5
Dieldrin Detected in Soils Exceeding Laboratory Method Detection Limit

Location Description	COPC	Number of Samples Collected	Number of Detections	Frequency of Detections (percentage)	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)
Tees	Dieldrin	229	125	55	0.01	9.2
Greens		204	172	84	0.012	23

The analytical results are summarized in Table 6 and depicted in Figures 5 through 12. Copies of the laboratory results are provided in Attachment D.

3.4 Natural Conditions

The subject property is approximately 142.3 acres in area and slopes gently from the north and south towards Clover Creek, a salmon-bearing stream that runs through the middle of the subject property from east to west. The subject property is currently landscaped and operating as the Brookdale Golf Course. The majority of the subject property is covered with manicured lawn and pockets of isolated trees. The subject property has been improved with several buildings that for various operations including a restaurant and clubhouse, retail shop, and multiple maintenance sheds.

3.4.1 Soil

Soils at the Site generally consist of a mixture of well-graded sands with gravel, silts with gravel, and silts with sand down to a maximum explored depth of 3 feet bgs. Gravel and cobbles were prominent in the lower elevations. These conditions are consistent with glacial outwash and alluvial deposits.

3.4.2 Groundwater

Groundwater was not encountered in the shallow soils assessed as part of the RI. Well logs for Resource Protection Wells obtained from Ecology indicate that there are two water-bearing zones at the subject property. Based on the well logs, a shallower water bearing zone is located at approximately 8.5 feet bgs and a deeper water bearing zone is located at approximately 57 feet bgs. The local groundwater migration direction is anticipated to be generally westerly to southwesterly based on topography, surface water flow, and regional surface water bodies.

Copies of the well logs obtained from Ecology are provided in Attachment A.

3.4.3 Surface Water

Clover Creek runs from east to west through the southern portion of the subject property. The North Fork Tributary of Clover Creek runs from east to west through the northern portion of the subject property. Clover Creek ultimately empties into Steilacoom Lake located approximately 5.9 miles west of the subject property.

3.5 Nature and Extent of Contamination

The RI identified contaminated surface soils (from 0 foot bgs to 2 feet bgs) and shallow subsurface soils (down to 2.5 feet bgs) in the tees and greens located throughout the subject property. The contaminated soils contain dieldrin at concentrations exceeding the MTCA Method B CUL for soils. Aldrin was also detected in concentrations that exceed MTCA Method B CUL for soils. The source of the contaminated soils is attributed to the application of pesticides to the subject property as part of regular golf course maintenance; however, the EPA banned the agricultural use of dieldrin and aldrin in 1974 and the golf course reportedly ceased using those pesticides at that time.

The impacted soils are located in 15 distinct areas (Area 1 through Area 15) across the subject property as indicated on Figures 5 through 12. The depth of impacts varies from approximately 0.5 feet to 2.5 feet bgs. The estimated total area of impacted soil within the 15 separate areas is approximately 5 acres and the estimated total volume of impacted soil is approximately 14,000 cubic yards.

Results of the RI indicate that neither groundwater nor surface water have been impacted by either organochlorine herbicides or organochlorine pesticides.

3.6 Terrestrial Ecological Evaluation

In accordance with WAC 173-340-7490, a Terrestrial Ecological Evaluation (TEE) was performed for the Site to determine if it poses a threat to the terrestrial environment. The purpose of the TEE is to identify what plants or animals may be harmed by contaminants located at a Site and to determine CULs that are protective of those plants and animals.

3.6.1 Primary TEE Exclusions

The subject property does not qualify for the primary exclusions from the TEE as documented in WAC 173-340-7491(1). The exclusions do not apply to the subject property due to the surficial nature of the soil impacts, uncapped nature of the property, areas of contiguous undeveloped land adjacent to the subject property, and the presence of contaminants at concentrations greater than background concentrations. In the absence of a TEE exclusion, MTCA requires further evaluation to ensure protection of potential terrestrial and ecological receptors.

3.6.2 Site-Specific TEE

In accordance with WAC 173-340-7491(2)(a)(iii), a Site-specific TEE is required, using the procedures detailed in 173-340-7493, due to the likelihood of wildlife use on the subject property. Though the subject property currently operates as a golf course, wildlife is known to frequent the subject property. Therefore, the procedures detailed in 173-340-7493 for a Site-specific TEE to establish contaminant concentrations that are protective of terrestrial and ecological exposures were used.

It should be noted that because the COCs at the property were used in a lawful manner consistent with their intended uses, those impacts are not considered a release under MTCA and do not require remediation. It is only because of the pending redevelopment of the subject property that remedial actions are contemplated. The redevelopment and remedial actions will occur contemporaneously and there will be no contamination above an applicable cleanup level after redevelopment.

Developing the Site-specific TEE requires the identification of the following:

- Potential Receptors of Concern;
- Chemicals of Potential Ecological Concern (COPECs); and
- Potential Exposure Pathways.

Once those factors have been identified, it is possible to perform toxicological assessments and to identify final chemicals of ecological concern (COECs). The following sections discuss this process in additional detail.

3.6.3 Receptors of Concern

The potential receptors of concern may include vascular plants, soil biota, ground-feeding birds, ground-feeding small mammals, and herbivorous small mammals. These are categorized into the following three basic categories:

- Vascular plants;
- Soil biota; and
- Wildlife.

3.6.4 Initial Chemicals of Ecological Concern

The concentrations of compounds measured at concentrations greater than practical quantitation limits (PQLs) at the subject property were compared against the Ecological Indicator Soil Concentrations for the Protection of Terrestrial Plants and Animals (EISCs; Table 749-3). EISCs are organized in Table 749-3 by receptors of concern as Plants, Soil Biota, and Wildlife.

A compound is considered an initial COEC if any of the following conditions exist:

- If the detected compounds exceeded any EISC in Table 749-3; or
- If an EISC value is not available in Table 749-3 for any particular receptor of concern.

Based on these criteria, the following are considered COECs for the subject property.

- 4,4-DDT;
- B-BHC;
- D-BHC;
- Aldrin;
- Endosulfan I;
- Dieldrin;
- Endrin; and
- Endrin aldehyde.

As stated in Section 1.0, dieldrin is considered the COC for the Site based on the frequency of detection and relative distribution of each compound detected. In conformance with WAC 173-340-703, MTCA allows for selection of IHSs for cleanup actions. There is no instance at the Site where dieldrin has not been detected that other compounds have been detected at elevated concentrations. As discussed above, dieldrin is pervasive at the Site. For this reason, the TEE was also limited to dieldrin.

According to Table 749-3, for hazardous substances where an EISC value is not provided, EISCs will be based on a literature survey conducted in accordance with WAC 173-340-7493(4). For dieldrin, there is only one EISC available, which is for the protection of a potential wildlife receptor. Therefore, a literature study was performed to determine appropriate EISCs for the soil biota and vascular plants receptors of concern for these hazardous substances. All documents obtained through the literature survey are provided in Attachment E.

The results of the literature survey are included in the following sections.

3.6.5 TEE Cleanup Levels

TEE CULs were evaluated for each of the three potential receptors of concern for the subject property. The TEE CULs applicable to dieldrin for each of the receptors of concern are as follows:

- **Wildlife:** According to MTCA Table 749-3, the TEE CUL for dieldrin that is protective of wildlife is 0.07 mg/kg.

- **Vascular Plants:** There is no EISC available for dieldrin that is considered protective of vascular plants in MTCA Table 749-3. EPI researched the EPA's ECOTOXicology knowledgebase (ECOTOX) to identify a CUL for dieldrin protective of vascular plants. The ECOTOX database provided the value of 3.8 mg/kg for the lowest observed effects concentration (LOEC) or the "Minimum Effective Dose". This concentration was identified in an article titled: *Clastogenicity Evaluation of Seven Chemicals Commonly Found at Hazardous Industrial Waste Sites, Shahbeg et al.*, Mutation Research, 224, 1989 (Shahbeg).

  Shahbeg reports an LOEC value of 3.8 mg/kg for clastogenicity in the vascular plant *Tradescantia*. Therefore, the initial screening level vascular plants for dieldrin is 3.8 mg/kg.

- **Soil Biota:** There is no EISC available for dieldrin that is considered protective of soil biota in MTCA Table 749-3. EPI researched the EPA's ECOTOXicology knowledgebase (ECOTOX) to identify CULs for soil biota, specifically earthworms. Multiple values for the LOEC for earthworms were reported and ranged from 25 mg/kg to 150 mg/kg identified in an article entitled: "*Growth and Reproduction of the Earthworm Eisenia fetida Exposed to Sublethal Concentrations of Organic Chemicals,* Neuhauser and Callahan, Soil Biology and Geochemistry, 22, 1990 (Neuhauser & Callahan).

  Neuhauser & Callahan reports an LOEC value for reproductive disruption of 25 mg/kg and an LOEC value for growth disruption of 150 mg/kg in the earthworm *Eisenia fetida*. For the purposes of this TEE, the most conservative value was selected as the preliminary screening level. Therefore, the initial screening level used for dieldrin that is protective of soil biota is 25 mg/kg.

3.6.6 Final TEE Cleanup Level

The final TEE CULs for the Non-Excluded Sites consist of a mix of EISC book values established in Table 749-3 and EISC values developed through the literature survey documented in Section 3.6.5.

A dieldrin TEE CUL was generated for each terrestrial ecological receptor of concern. The final TEE CUL for the COEC is the most conservative (i.e., lowest) value from the TEE CULs generated for each terrestrial ecological receptor of concern. The TEE CULs for dieldrin are as follows (source of TEE CUL in parentheses):

- Vascular Plants – 3.8 mg/kg (Literature Survey)
- Soil Biota – 25 mg/kg (Literature Survey)
- Wildlife – 0.07 mg/kg (Table 749-3)

The most conservative value of these three TEE CULs is 0.07 mg/kg, which is based on protection of wildlife. Therefore, 0.07 mg/kg is the TEE CUL for dieldrin.

For comparison purposes, EPI reviewed the readily available CULs for vascular plants, soil biota, and wildlife for the other compounds detected at the Site, but which were not IHSs. The following concentrations were identified in Table 749-3, WAC 173-340-900.

Table 7
Summary of Non-Dieldrin TEE CULs

Compound	Vascular Plants	Soil Biota	Wildlife
4,4-DDT	NVE	NVE	0.75[a]
B-BHC	NVE	NVE	6
D-BHC	NVE	NVE	6
Aldrin	NVE	NVE	0.1
Endosulfan I	NVE	NVE	NVE
Endrin	NVE	NVE	0.2
Endrin Aldehyde	NVE	NVE	NVE

Notes:
a Sum of DDT, DDD, and DDE.
NVE No value established for this compound.

As summarized above, the non IHS compounds have CULs that are in all cases significantly higher than the selected TEE CUL for dieldrin of 0.07 mg/kg. This further demonstrates that dieldrin is the appropriate IHS for the Site and that remedial actions for dieldrin will be protective of ecological receptors to each of the other compounds sporadically detected at the subject property.

3.7 Conceptual Site Model

A conceptual site model (CSM) was developed for the Site based on the data collected at the subject property. The CSM identifies current and potential future exposure pathways for human and ecological receptors. The CSM is presented as Attachment F and is discussed below.

The environmental media of concern at the Site are surface and shallow subsurface soils. Potential current exposure pathways include dermal and ingestion exposure by commercial/maintenance workers, construction workers, recreational users, and TEE receptors. Potential future exposure pathways to dieldrin impacts include dermal and ingestion exposure by residential receptors and TEE receptors.

- Though currently operating as a golf course, the subject property and surrounding land are currently zoned for residential use by Pierce County and are expected to continue as such in the future.

- Site geology consists of a mixture of well-graded sands with gravel, silts with gravel, and silts with sand.

- Ecology well logs indicate shallow groundwater is present at a depth of approximately 8.5 feet beneath the surface of the Site; deeper groundwater is present at approximately 57 feet beneath the surface of the Site.

- Organochlorine pesticides, including 4,4-DDE, 4,4-DDT, B-BHC, D-BHC, aldrin, endosulfan I, dieldrin, endrin, and endrin aldehyde are COPCs in Site soils.

- There are no COPCs for groundwater and there is no current exposure pathway to groundwater as COPCs were not detected in groundwater.

- There are no vapor intrusion exposure pathways currently at the Site. Organochlorine pesticides are considered non-volatile with exceedingly low vapor pressures. To assess the compounds that may potentially affect air quality, vapor pressures were calculated for the two most frequently detected compounds at the Site: dieldrin and D-BHC (Table 2). The vapor pressure for dieldrin is 1.78×10^{-7} millimeters of mercury (mm Hg) and the vapor pressure for D-BHC of 4.2×10^{-5} mm Hg. These compounds are classified by the National Institutes of Health as "extremely low volatility" and pose no threat of vapor intrusion exposure.

3.8 Cleanup Standards

Cleanup standards consist of CULs and the point of compliance at which those levels must be met. Cleanup standards are used as the basis for developing remedial action objectives for a cleanup action.

3.9 Cleanup Levels

Site CULs for affected media were evaluated in accordance with MTCA and take into consideration exposure pathways and receptors based on current and likely future uses of the Site. Based on current and expected future use of the Site, exposure pathways for human and ecological receptors were considered for the development of applicable CULs. Due to the presence of soil contamination shallower than 6 feet bgs, the potential for TEE exposures exists as well. As documented in Section 3.6.6, the TEE CUL applicable for dieldrin at the Site is 0.07 mg/kg.

The Method B CUL for dieldrin is more stringent than the TEE CULs and is protective of each exposure pathway identified for the Site; the Method B CUL for dieldrin of 0.0625 mg/kg will be used as the final CUL for the Site.

The Method B CUL is used for comparison purposes in Tables 3 and 6 that summarize soil sample analytical results for the subject property.

3.10 Points of Compliance

A point of compliance is that point or location on a property where the CULs must be attained in each medium of concern. The points of compliance for the Site were established in accordance with WAC 173-340-740(6) for soil. The point of compliance for soil shall be all soil throughout the Site or subject property.

3.11 Contaminants of Concern

The COCs for the Site are those COPCs that have been detected in soil, groundwater, or surface water at concentrations exceeding their respective MTCA Method B CULs. Based on the results of the environmental investigations, the only COCs for the Site are dieldrin and aldrin for Site soil. Because there is no instance where aldrin is detected at concentrations greater than the CUL where dieldrin is not, dieldrin is considered the IHS and the primary COC in soils for the Site. There are no COCs for groundwater or surface water.

4.0 FOCUSED FEASIBILITY STUDY

The purpose of an FFS is to develop and evaluate cleanup alternatives for a Site and select a final cleanup action in accordance with WAC 173-340-350(8). The objective of a selected cleanup action is to protect human health and the environment and to meet the requirements of MTCA. This FFS evaluates and selects a cleanup action that can be implemented with construction of the planned residential development of the subject property, and that will serve as a final, permanent remedy for the Site.

4.1 Applicable Regulations

Under WAC 173-240-710, all cleanup actions must comply with applicable federal and state laws and regulations. The work to be performed will be performed under the VCP and will comply with MTCA (70.105D RCW) and its implementing regulations (WAC 173-340). Applicable or Relevant and Appropriate Requirements (ARARs) for the selected remedy will be MTCA, and all potential exposure pathways will be addressed. This RI/FFS contains a fully MTCA-compliant CUL development. Therefore, further consideration of ARARs is not warranted and MTCA has been selected as the regulation with primacy for this project.

4.2 Evaluation Criteria

A selected cleanup action must satisfy the minimum requirements for cleanup actions (WAC 173-340-360(2)). These requirements include both threshold requirements, and other requirements (WAC 173-340-360(2)(a) and (b)). The threshold requirements include:

- Protection of human health and the environment;
- Compliance with cleanup standards;
- Compliance with applicable state and federal laws; and

- Provisions for compliance monitoring.

Other requirements include:

- Use of permanent solutions to the maximum extent practicable;
- Provisions for a reasonable restoration time frame; and
- Consideration of public concerns.

4.3 Selected Cleanup Action

A cleanup action was selected for the Site that is consistent with ARARs, satisfies the evaluation criteria of MTCA, and that can be implemented in conjunction with the construction of the upcoming residential development of the subject property. The cleanup action will serve as the final, permanent remedy for the subject property, and for the Site.

Direct excavation of contaminated soils has been selected as the most effective for addressing soil impacts based on the following:

- Both the depth and lateral extent of impacted soils is limited and well delineated;

- Impacted soils are shallow and are readily accessible to direct excavation; and

- Excavation is practicable, highly effective, permanent, and its effectiveness is quantifiable through performance/confirmation sampling.

The cleanup action will include the following main elements:

- Excavate and remove dieldrin-impacted soils from each of the 15 areas of impact on the subject property. Obtain confirmation soil samples to demonstrate that dieldrin-contaminated soil has been successfully removed from the subject property.

- Load excavated soils into trucks and transport to a permitted Subtitle D landfill or equivalent facility permitted to accept the excavated materials.

- Backfill the remedial excavations with clean, non-impacted soil and restore the surface to approximate development grades.

Because the selected remedial action is a permanent solution, the performance of a disproportionate cost analysis is specifically not required under WAC 173-340-360(3)(d) to support selection of this alternative. A CAP detailing the methodology of the selected cleanup action will be submitted under separate cover.

4.4 Conclusions

The following conclusions are based on the observations and findings from the RI and FFS:

- Groundwater and surface water at the Site are not impacted with organochlorine pesticide or herbicides. Soil is confirmed as the only medium affected at the Site.

- Dieldrin is the primary COC for Site soils. The remediation of dieldrin will address all other organochlorine pesticides at the Site. This will be confirmed through performance and confirmational sampling during remediation to confirm the absence of other organochlorine pesticides in soil at the final limits of excavation.

- Potential current or future exposure pathways to dieldrin in soil include dermal and ingestion exposure by commercial workers during construction activities and through future post-development residential land uses. Potential exposures also include ecological receptors in shallow soil.

- The MTCA Method B Soil CUL is protective of current and future exposure pathways and will be used to guide the excavation and disposal of contaminated soils. The MTCA Method B Soil CUL is the lowest value available and is protective of both the construction worker scenario and ecological receptors.

- The selected remedial alternative is excavation and off-Site disposal of all soils impacted with concentrations of dieldrin at a concentration exceeding the MTCA Method B Soil CUL. This remedial alternative will address all current and potential future exposure pathways for all potential receptors.

A CAP is in preparation as of the date of this report and will be submitted under separate cover. The CAP will present the details for the implementation of the selected remedial alternative.

5.0 LIMITATIONS

To the extent that preparation of this report required the application of best professional judgment and the application of scientific principles, certain results of this work were based on subjective interpretation. EPI makes no warranties, express or implied, including and without limitation warranties as to merchantability or fitness for a particular purpose. The information provided in this report is not to be construed as legal advice.

This RI/FFS Report was prepared solely for Ichijo and the contents herein may not be used or relied upon by any other person without the express written consent and authorization of EPI.

Tables

Table 1
Soil Analytical Results – 2016 Robinson Noble Limited Pesticide Investigation
Remedial Investigation and Focused Feasibility Study Report
Brookdale Golf Course
1802 Brookdale Road East, Tacoma, Washington

Sample Location	Sample ID	Sample Depth (feet)	Sample Date	Dieldrin
Below Spray Tank	BGC-1M	0.5	12/1/2016	**0.094**
Next to Waste Oil Drum	BGC-2M	0.5	12/1/2016	**0.111**
Practice Green	BGC-3G	0.5	12/1/2016	**0.096**
Soil Cleanup Level[a] (MTCA Method B, CLARC Database)				**0.0625**
Preliminary TEE Indicator Concentrations (WAC 173-340-900, Table 749-3)				**0.07**

Notes:

All results presented in milligrams per kilogram (mg/kg); all samples analyzed by U.S. Environmental Protection Agency (EPA) Method 8081.

Data from *Limited Pesticide Investigation Letter Report* by Robinson Noble, dated December 14, 2016.

Bold Bold results indicate that the compound was detected.

(shaded) Shaded cells indicate that the compound was detected at a concentration greater than cleanup level.

a Based on Model Toxics Control Act (MTCA) Method B (Cancer) Soil Cleanup Level; Cleanup Levels and Risk Calculations (CLARC) database.

TEE Terrestrial Ecological Evaluation.

WAC Washington Administrative Code.

Table 3
Soil Analytical Results – 2017 EPI Focused Subsurface Investigation
Remedial Investigation and Focused Feasibility Study Report
Brookdale Golf Course
1802 Brookdale Road East, Tacoma, Washington

Area	Sample Location	Sample Depth (feet)	Sample Date	4,4-DDE	4,4-DDT	B-BHC	D-BHC	Aldrin	Endo-sulfan I	Dieldrin	Endrin	Endrin Aldehyde
Area 1	1:Tee	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	**0.028**	<0.010	<0.010	**0.044**	<0.010	<0.010
		1.5	01/25/2017	**0.014**	**0.016**	<0.010	<0.010	**0.028**	<0.010	**6.8**	**0.022**	<0.010
	9:Green	0.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**1.2**	<0.010	<0.010
		1.0	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.33**	<0.010	<0.010
		1.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.37**	<0.010	<0.010
Area 2	10:Tee	0.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/27/2017	<0.010	<0.010	<0.010	**0.011**	<0.010	<0.010	<0.010	<0.010	<0.010
	18:Green	0.5	01/26/2017	**0.060**	**0.026**	<0.010	**0.069**	<0.010	<0.010	**6.4**	**0.061**	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	**0.052**	<0.010	<0.010	**0.4**	<0.010	**0.017**
		1.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.11**	<0.010	<0.010
Area 3	1:Green	0.5	01/25/2017	<0.010	<0.010	<0.010	**0.085**	<0.010	<0.010	**0.63**	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	**0.05**	<0.010	<0.010	**0.023**	<0.010	<0.010
Area 5	10:Green	0.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.73**	<0.010	<0.010
		1.0	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.22**	<0.010	<0.010
		1.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.14**	<0.010	<0.010
Area 6	3:Tee	0.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.033**	<0.010	<0.010
		1.0	01/27/2017	<0.010	<0.010	<0.010	<0.010	**0.022**	<0.010	**0.14**	<0.010	<0.010
		1.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.056**	<0.010	<0.010
Area 7	7:Green	0.5	01/26/2017	<0.010	**0.70**	<0.010	**0.09**	<0.010	<0.010	**3.4**	0.053	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	**0.054**	<0.010	<0.010	**0.22**	<0.010	<0.010
		1.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.23**	<0.010	<0.010
Area 8	12:Tee	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**2.40**	**0.011**	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.12**	<0.010	<0.010
		1.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.12**	<0.010	<0.010
Area 9	17:Tee	0.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.63**	<0.010	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.13**	<0.010	<0.010
		1.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.065**	<0.010	<0.010
	16:Green	0.5	01/26/2017	**0.018**	<0.010	<0.010	**0.065**	<0.010	<0.010	**3.5**	**0.024**	**0.018**
		1.0	01/26/2017	<0.010	<0.010	<0.010	**0.063**	<0.010	<0.010	**0.48**	<0.010	<0.010
		1.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.038**	<0.010	<0.010
Area 10	4:Tee	0.5	01/26/2017	<0.010	<0.010	<0.010	**0.032**	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	**0.012**	<0.010	<0.010	<0.010	<0.010	<0.010
Area 11	13:Tee	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	**0.13**	<0.010	**1.50**	<0.010	<0.010
		1.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.27**	<0.010	<0.010
Area 12	6:Green	0.5	01/25/2017	<0.010	<0.010	<0.010	**0.13**	<0.010	**0.084**	**1.2**	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	**0.088**	<0.010	**0.028**	**0.49**	<0.010	<0.010
		1.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.17**	<0.010	<0.010
Area 13	15:Fairway	0.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	14:Green	0.5	01/26/2017	<0.010	<0.010	<0.010	**0.12**	<0.010	<0.010	**1.6**	**0.015**	<0.010
		1.0	01/26/2017	**0.015**	<0.010	<0.010	**0.071**	<0.010	<0.010	**0.5**	<0.010	<0.010
		1.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.41**	<0.010	<0.010
Area 14	5:Fairway	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Area 15	6:Tee	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	14:Tee	0.5	01/25/2017	<0.010	<0.010	<0.010	**0.18**	**0.11**	<0.010	**0.70**	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	5:Green	0.5	01/25/2017	**0.029**	**0.016**	<0.010	**0.22**	**0.16**	<0.010	**2.9**	**0.028**	<0.010
		1.0	01/25/2017	**0.014**	<0.010	**0.022**	**0.16**	**0.29**	<0.010	**1.6**	**0.014**	<0.010
		1.5	01/25/2017	<0.010	<0.010	<0.010	**0.052**	**0.014**	<0.010	**0.56**	<0.010	<0.010
Fairways	2:Fairway	0.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	4:Fairway	0.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	7:Fairway	0.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	11:Fairway	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	13:Fairway	0.5	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/25/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	16:Fairway	0.5	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/27/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	18:Fairway	0.5	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
		1.0	01/26/2017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Soil Cleanup Level (MTCA Method B, CLARC Database)				**0.0625[a]**	**2.94[a]**	**0.556[a]**	**NVE**	**0.0588[a]**	**480[b]**	**0.0625[a]**	**24[b]**	**NVE**
Preliminary TEE Indicator Concentrations (WAC 173-340-900, Table 749-3)				**0.75**		**6**	**6**	**0.1**	**NVE**	**0.07**	**0.2**	**NVE**

Notes:

All results presented in milligrams per kilogram (mg/kg); all samples analyzed by EPA Method 8081.

Bold Bold results indicate that the compound was detected.

(shaded) Shaded cells indicate that the compound was detected at a concentration greater than a cleanup level.

a Based on Model Toxics Control Act (MTCA) Method B (Cancer) Soil Cleanup Level; Cleanup Levels and Risk Calculations (CLARC) database.

b Based on MTCA Method B (Non-Cancer) Soil Cleanup Level; CLARC database.

TEE Terrestrial Ecological Evaluation.

WAC Washington Administrative Code.

NVE No value established.

Compounds:

4,4-DDE Dichlorodiphenyldichloroethylene

4,4-DDT Dichlorodiphenyltrichloroethane

B-BHC beta-Hexachlorocyclohexane

D-BHC delta-Hexachlorocyclohexane

Table 4
Groundwater and Surface Water Analytical Results – 2017 EPI Focused Subsurface Investigation
Remedial Investigation and Focused Feasibility Study Report
Brookdale Golf Course
1802 Brookdale Road East, Tacoma, Washington

Sample Location	Sample Date	4,4-DDE	4,4-DDT	B-BHC	D-BHC	Aldrin	Endo-sulfan I	Dieldrin	Endrin	Endrin Aldehyde
Pond	01/27/2017	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Well	01/27/2017	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Notes:
All results presented in micrograms per liter (µg/L); all samples analyzed by U.S. Environmental Protection Agency (EPA) Method 8081.

Compounds:

4,4-DDE	Dichlorodiphenyldichloroethylene
4,4-DDT	Dichlorodiphenyltrichloroethane
B-BHC	beta-Hexachlorocyclohexane
D-BHC	delta-Hexachlorocyclohexane

Table 6
Soil Analytical Results – 2018 EPI Continued Subsurface Investigation
Remedial Investigation and Focused Feasibility Study Report
Brookdale Golf Course
1802 Brookdale Road East, Tacoma, Washington

Area	Tee	Sample Location	Sample Depth (in feet)	Date	Dieldrin
Area 1	Tee 1	Tee 1-A	0.5	4/26/2018	<0.01
Area 1	Tee 1	Tee 1-A	1.0	4/26/2018	<0.01
Area 1	Tee 1	Tee 1-B	0.5	4/26/2018	**0.037**
Area 1	Tee 1	Tee 1-B	1.0	4/26/2018	<0.01
Area 1	Tee 1	Tee 1-C	2.0	4/26/2018	<0.01
Area 1	Tee 1	Tee 1-NE	0.5	4/26/2018	**0.15**
Area 1	Tee 1	Tee 1-NE	1.0	4/26/2018	**0.044**
Area 1	Tee 1	Tee 1-S	0.5	4/26/2018	<0.01
Area 1	Tee 1	Tee 1-S	1.5	4/26/2018	<0.01
Area 1	Tee 1	Tee 1-SW	0.5	4/26/2018	**0.14**
Area 1	Tee 1	Tee 1-SW	1.0	4/26/2018	**0.51**
Area 1	Tee 1	Tee 1-SW	2.0	4/26/2018	**0.15**
Area 1	Putting Green 2	PG 2-NE	0.5	5/7/2018	**3.1**
Area 1	Putting Green 2	PG 2-NE	1.0	5/7/2018	**0.76**
Area 1	Putting Green 2	PG 2-NE	2.0	5/7/2018	<0.01
Area 1	Putting Green 2	PG 2-NW	0.5	5/7/2018	**20**
Area 1	Putting Green 2	PG 2-NW	1.0	5/7/2018	**0.14**
Area 1	Putting Green 2	PG 2-NW	2.0	5/7/2018	**0.4**
Area 1	Putting Green 2	PG 2-S	0.5	5/7/2018	**0.19**
Area 1	Putting Green 2	PG 2-S	1.0	5/7/2018	**0.034**
Area 1	Putting Green 2	PG 2	0.5	5/7/2018	**0.74**
Area 1	Putting Green 2	PG 2	1.0	5/7/2018	**0.081**
Area 1	Putting Green 2	PG 2	2.0	5/7/2018	**0.41**
Area 1	Green 9	Green 9-NE	0.5	5/1/2018	**1.8**
Area 1	Green 9	Green 9-NE	1.0	5/1/2018	**1.3**
Area 1	Green 9	Green 9-NE	2.0	5/1/2018	**0.42**
Area 1	Green 9	Green 9-NW	0.5	5/1/2018	**4.2**
Area 1	Green 9	Green 9-NW	1.0	5/1/2018	**0.13**
Area 1	Green 9	Green 9-NW	2.0	5/1/2018	**0.8**
Area 1	Green 9	Green 9-S	0.5	5/1/2018	**0.11**
Area 1	Green 9	Green 9-S	1.0	5/1/2018	**0.039**
Area 1	Green 9	Green 9	2.0	5/1/2018	**0.29**
Area 2	Putting Green 1	PG 1-E	0.5	5/7/2018	**0.38**
Area 2	Putting Green 1	PG 1-E	1.0	5/7/2018	**0.055**
Area 2	Putting Green 1	PG 1-NW	0.5	5/4/2018	**0.036**
Area 2	Putting Green 1	PG 1-NW	1.0	5/4/2018	<0.01
Area 2	Putting Green 1	PG 1-S	0.5	5/4/2018	**0.61**
Area 2	Putting Green 1	PG 1-S	1.0	5/4/2018	**0.1**
Area 2	Putting Green 1	PG 1-S	1.5	5/4/2018	**0.09**
Area 2	Putting Green 1	PG 1	0.5	5/7/2018	**2**
Area 2	Putting Green 1	PG 1	1.0	5/7/2018	**0.11**
Area 2	Putting Green 1	PG 1	2.0	5/7/2018	**0.08**
Area 2	Green 18	Green 18-NE	0.5	5/4/2018	**0.39**
Area 2	Green 18	Green 18-NE	1.0	5/4/2018	<0.01
Area 2	Green 18	Green 18-NW	0.5	5/4/2018	**1.9**
Area 2	Green 18	Green 18-NW	1.0	5/4/2018	**0.31**
Area 2	Green 18	Green 18-NW	2.0	5/4/2018	**0.23**
Area 2	Green 18	Green 18-S	0.5	5/4/2018	**0.16**
Area 2	Green 18	Green 18-S	1.0	5/4/2018	**0.024**
Area 2	Green 18	Green 18	2.0	5/4/2018	**0.19**
Area 3	Tee 2	Tee 2-A	0.5	4/17/2018	**2.3**
Area 3	Tee 2	Tee 2-A	1.0	4/17/2018	**1.1**
Area 3	Tee 2	Tee 2-A	2.0	4/17/2018	**0.42**
Area 3	Tee 2	Tee 2-NE	0.5	4/17/2018	**0.17**
Area 3	Tee 2	Tee 2-NE	1.0	4/17/2018	<0.01
Area 3	Tee 2	Tee 2-S	0.5	4/17/2018	**0.015**
Area 3	Tee 2	Tee 2-S	1.0	4/17/2018	**0.033**
Area 3	Tee 2	Tee 2-W	0.5	4/17/2018	**0.086**
Area 3	Tee 2	Tee 2-W	1.0	4/17/2018	**0.016**
Area 3	Tee 4	Tee 4-A	0.5	4/18/2018	**0.11**
Area 3	Tee 4	Tee 4-A	1.0	4/18/2018	**0.032**
Area 3	Tee 4	Tee 4-A	2.0	4/18/2018	**0.26**
Area 3	Tee 4	Tee 4-C	0.5	5/7/2018	<0.01
Area 3	Tee 4	Tee 4-C	1.0	5/7/2018	<0.01
Area 3	Tee 4	Tee 4-D	0.5	4/18/2018	**5.1**
Area 3	Tee 4	Tee 4-D	1.0	4/18/2018	**0.52**
Area 3	Tee 4	Tee 4-D	2.0	4/18/2018	<0.01
Area 3	Tee 4	Tee 4-N	0.5	4/18/2018	**0.34**
Area 3	Tee 4	Tee 4-N	1.0	4/18/2018	**0.22**
Area 3	Tee 4	Tee 4-N	2.0	4/18/2018	**0.028**
Area 3	Tee 4	Tee 4-NW	0.5	4/18/2018	**0.058**
Area 3	Tee 4	Tee 4-NW	1.0	4/18/2018	<0.01
Area 3	Tee 4	Tee 4-S	0.5	5/7/2018	**0.023**
Area 3	Tee 4	Tee 4-S	1.0	5/7/2018	**0.013**
Area 3	Green 1	Green 1-E	0.5	4/16/2018	**0.68**
Area 3	Green 1	Green 1-E	1.0	4/16/2018	**0.15**
Area 3	Green 1	Green 1-E	2.0	4/16/2018	**0.06**
Area 3	Green 1	Green 1-NW	0.5	4/16/2018	**0.31**
Area 3	Green 1	Green 1-NW	1.0	4/16/2018	**0.16**
Area 3	Green 1	Green 1-NW	2.0	4/16/2018	**0.047**

Table 6
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Area	Tee	Sample Location	Sample Depth (in feet)	Date	Dieldrin
Area 3	Green 1	Green 1-SW	0.5	4/16/2018	**0.42**
			1.0	4/16/2018	**0.2**
			2.0	4/16/2018	**0.036**
Area 4	Tee 9	Tee 9-A	0.5	4/19/2018	<0.01
			1.0	4/19/2018	<0.01
		Tee 9-B	0.5	4/19/2018	**0.7**
			1.0	4/19/2018	**0.16**
			2.0	4/19/2018	**0.1**
		Tee 9-C	0.5	4/19/2018	**0.17**
			1.0	4/19/2018	**0.88**
			2.0	4/19/2018	**0.087**
		Tee 9-E	0.5	4/19/2018	**0.23**
			1.0	4/19/2018	**0.08**
			1.5	4/19/2018	**0.018**
		Tee 9-N	0.5	4/19/2018	**0.13**
			1.0	4/19/2018	**0.02**
		Tee 9-S	0.5	4/19/2018	**0.022**
			1.0	4/19/2018	<0.01
		Tee 9-W	0.5	4/19/2018	**0.013**
			1.0	4/19/2018	**0.037**
	Tee 11	Tee 11-A	0.5	4/20/2018	**0.37**
			1.0	4/20/2018	**0.065**
			1.5	4/20/2018	**0.043**
		Tee 11-B	0.5	4/20/2018	**2.9**
			1.0	4/20/2018	**0.59**
			2.0	4/20/2018	<0.01
		Tee 11-C	0.5	4/23/2018	**2.3**
			1.0	4/23/2018	**0.71**
			2.0	4/23/2018	<0.01
		Tee 11-D	0.5	4/20/2018	<0.01
			1.0	4/20/2018	<0.01
		Tee 11-N	0.5	4/20/2018	<0.01
			1.0	4/20/2018	<0.01
		Tee 11-NE	0.5	4/20/2018	<0.01
			1.0	4/20/2018	<0.01
		Tee 11-NW	0.5	4/20/2018	<0.01
			1.0	4/20/2018	<0.01
		Tee 11-S	0.5	4/20/2018	**0.036**
			1.0	4/20/2018	<0.01
		Tee 11-SE	0.5	4/20/2018	**0.49**
			1.0	4/20/2018	**0.034**
		Tee 11-SW	0.5	4/20/2018	<0.01
			1.0	4/20/2018	<0.01
	Green 8	Green 8-NE	0.5	5/1/2018	**1.8**
			1.0	5/1/2018	**0.11**
			2.0	5/1/2018	<0.01
		Green 8-NW	0.5	5/1/2018	**2**
			1.0	5/1/2018	**1.5**
			2.0	5/1/2018	**0.031**
		Green 8-S	0.5	5/1/2018	**0.73**
			1.0	5/1/2018	**0.14**
			2.0	5/1/2018	**0.032**
		Green 8	0.5	5/1/2018	**6**
			1.0	5/1/2018	**0.056**
Area 5	Tee 18	Tee 18-A	0.5	4/26/2018	**1.8**
			1.0	4/26/2018	**0.33**
			2.0	4/26/2018	**0.34**
		Tee 18-E	0.5	4/26/2018	**0.46**
			1.0	4/26/2018	**0.054**
		Tee 18-NW	0.5	4/26/2018	<0.01
			1.0	4/26/2018	<0.01
		Tee 18-S	0.5	4/26/2018	**0.47**
			1.0	4/26/2018	**0.31**
			2.0	4/26/2018	<0.01
	Green 10	Green 10-NE	0.5	5/2/2018	**0.72**
			1.0	5/2/2018	**0.31**
			2.0	5/2/2018	**0.054**
		Green 10-SE	0.5	5/1/2018	**0.36**
			1.0	5/1/2018	**0.093**
			1.5	5/1/2018	**0.016**
		Green 10-W	0.5	5/1/2018	**0.18**
			1.0	5/1/2018	**0.1**
			2.0	5/1/2018	<0.01
		Green 10	2.0	5/2/2018	**0.24**
	Green 17	Green 17-E	0.5	5/4/2018	**0.43**
			1.0	5/4/2018	**0.14**
			2.0	5/4/2018	**0.025**
		Green 17-NW	0.5	5/4/2018	**0.15**
			1.0	5/4/2018	**0.057**

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Area	Tee	Sample Location	Sample Depth (in feet)	Date	Dieldrin
Area 5	Green 17	Green 17-SW	0.5	5/4/2018	**0.58**
Area 5	Green 17	Green 17-SW	1.0	5/4/2018	**0.15**
Area 5	Green 17	Green 17-SW	2.0	5/4/2018	<0.01
Area 5	Green 17	Green 17	0.5	5/4/2018	**9**
Area 5	Green 17	Green 17	1.0	5/4/2018	**0.35**
Area 5	Green 17	Green 17	2.0	5/4/2018	**0.24**
Area 6	Tee 3	Tee 3-A	0.5	4/17/2018	<0.01
Area 6	Tee 3	Tee 3-A	1.0	4/17/2018	**0.041**
Area 6	Tee 3	Tee 3-NE	0.5	4/17/2018	<0.01
Area 6	Tee 3	Tee 3-NE	1.0	4/17/2018	<0.01
Area 6	Tee 3	Tee 3-S	0.5	4/17/2018	**0.4**
Area 6	Tee 3	Tee 3-S	1.0	4/17/2018	**0.072**
Area 6	Tee 3	Tee 3-S	1.5	4/17/2018	<0.01
Area 6	Tee 3	Tee 3-SE	0.5	4/17/2018	**0.037**
Area 6	Tee 3	Tee 3-SE	1.0	4/17/2018	**0.29**
Area 6	Tee 3	Tee 3-SE	2.0	4/17/2018	**0.026**
Area 6	Green 2	Green 2-E	0.5	4/16/2018	**0.39**
Area 6	Green 2	Green 2-E	1.0	4/16/2018	**0.17**
Area 6	Green 2	Green 2-E	2.0	4/16/2018	**0.048**
Area 6	Green 2	Green 2-NW	0.5	4/16/2018	**0.064**
Area 6	Green 2	Green 2-NW	1.0	4/16/2018	**0.013**
Area 6	Green 2	Green 2-SW	0.5	4/16/2018	**4.7**
Area 6	Green 2	Green 2-SW	1.0	4/16/2018	**0.57**
Area 6	Green 2	Green 2-SW	2.0	4/16/2018	**0.14**
Area 6	Green 2	Green 2	0.5	4/16/2018	**0.2**
Area 6	Green 2	Green 2	1.0	4/16/2018	**0.044**
Area 7	Tee 8	Tee 8-A	0.5	4/19/2018	<0.01
Area 7	Tee 8	Tee 8-A	1.0	4/19/2018	<0.01
Area 7	Tee 8	Tee 8-B	0.5	4/19/2018	**9.2**
Area 7	Tee 8	Tee 8-B	1.0	4/19/2018	**0.18**
Area 7	Tee 8	Tee 8-B	2.0	4/19/2018	<0.01
Area 7	Tee 8	Tee 8-NE	0.5	4/19/2018	<0.01
Area 7	Tee 8	Tee 8-NE	1.0	4/19/2018	<0.01
Area 7	Tee 8	Tee 8-SE	0.5	4/19/2018	**0.04**
Area 7	Tee 8	Tee 8-SE	1.0	4/19/2018	**0.019**
Area 7	Tee 8	Tee 8-W	0.5	4/19/2018	**1.7**
Area 7	Tee 8	Tee 8-W	1.0	4/19/2018	**0.75**
Area 7	Tee 8	Tee 8-W	2.0	4/19/2018	**0.095**
Area 7	Green 7	Green 7-E	0.5	5/1/2018	**0.55**
Area 7	Green 7	Green 7-E	1.0	5/1/2018	**0.1**
Area 7	Green 7	Green 7-E	2.0	5/1/2018	**0.22**
Area 7	Green 7	Green 7-N	0.5	4/30/2018	**1.1**
Area 7	Green 7	Green 7-N	1.0	4/30/2018	**0.61**
Area 7	Green 7	Green 7-N	2.0	4/30/2018	**0.24**
Area 7	Green 7	Green 7-NW	0.5	5/1/2018	**0.017**
Area 7	Green 7	Green 7-NW	1.0	5/1/2018	<0.01
Area 7	Green 7	Green 7-W	0.5	5/1/2018	**0.38**
Area 7	Green 7	Green 7-W	1.0	5/1/2018	**0.08**
Area 7	Green 7	Green 7-W	1.5	5/1/2018	<0.01
Area 7	Green 7	Green 7	2.0	4/30/2018	**1.4**
Area 7	Green 7	Green 7	2.5	4/30/2018	**0.085**
Area 8	Tee 12	Tee 12-B	0.5	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-B	1.0	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-C	2.0	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-D	0.5	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-D	1.0	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-E	0.5	4/27/2018	**1.9**
Area 8	Tee 12	Tee 12-E	1.0	4/27/2018	**0.41**
Area 8	Tee 12	Tee 12-E	2.0	4/27/2018	**0.047**
Area 8	Tee 12	Tee 12-N	0.5	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-N	1.0	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-NE	0.5	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-NE	1.0	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-SE	0.5	4/27/2018	**0.46**
Area 8	Tee 12	Tee 12-SE	1.0	4/27/2018	**1**
Area 8	Tee 12	Tee 12-SE	2.0	4/27/2018	**0.18**
Area 8	Tee 12	Tee 12-SW	0.5	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-SW	1.0	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-W	0.5	4/27/2018	<0.01
Area 8	Tee 12	Tee 12-W	1.0	4/27/2018	<0.01
Area 8	Green 11	Green 11-E	0.5	5/2/2018	**1.4**
Area 8	Green 11	Green 11-E	1.0	5/2/2018	**0.036**
Area 8	Green 11	Green 11-S	0.5	5/2/2018	**1.8**
Area 8	Green 11	Green 11-S	1.0	5/2/2018	**0.47**
Area 8	Green 11	Green 11-S	2.0	5/2/2018	<0.01
Area 8	Green 11	Green 11-W	0.5	5/2/2018	**0.46**
Area 8	Green 11	Green 11-W	1.0	5/2/2018	**0.13**
Area 8	Green 11	Green 11-W	2.0	5/2/2018	<0.01
Area 8	Green 11	Green 11	0.5	5/2/2018	**5.4**
Area 8	Green 11	Green 11	1.0	5/2/2018	**0.98**
Area 8	Green 11	Green 11	2.0	5/2/2018	**0.22**

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Area	Tee	Sample Location	Sample Depth (in feet)	Date	Dieldrin
Area 9	Tee 17	Tee 17-B	0.5	4/25/2018	<0.01
			1.0	4/25/2018	<0.01
		Tee 17-C	0.5	4/25/2018	<0.01
			2.0	4/25/2018	<0.01
		Tee 17-D	0.5	4/25/2018	**6.7**
			1.0	4/25/2018	**0.1**
			1.5	4/25/2018	**1.1**
			2.0	4/25/2018	**0.17**
		Tee 17-N	0.5	4/25/2018	<0.01
			1.0	4/25/2018	<0.01
		Tee 17-NE	0.5	4/25/2018	<0.01
			1.0	4/25/2018	<0.01
		Tee 17-NW	0.5	4/25/2018	<0.01
			1.0	4/25/2018	<0.01
		Tee 17-S	0.5	4/25/2018	**0.51**
			1.0	4/25/2018	**0.21**
			2.0	4/25/2018	**0.033**
		Tee 17-SE	0.5	4/25/2018	<0.01
			1.0	4/25/2018	<0.01
		Tee 17-SW	0.5	4/25/2018	**4.2**
			1.5	4/25/2018	**0.057**
	Green 16	Green 16-E	0.5	5/3/2018	**1.2**
			1.0	5/3/2018	**1.5**
			2.0	5/3/2018	**0.014**
		Green 16-NW	0.5	5/3/2018	**0.48**
			1.0	5/3/2018	**0.012**
		Green 16-SW	0.5	5/3/2018	**0.27**
			1.0	5/3/2018	**0.24**
			2.0	5/3/2018	**0.031**
Area 10	Green 3	Green 3-NE	0.5	4/16/2018	**0.65**
			1.0	4/16/2018	**0.072**
			1.5	4/16/2018	**0.11**
			2.0	4/16/2018	**0.1**
		Green 3-NW	0.5	4/16/2018	**0.83**
			1.0	4/16/2018	**0.56**
			2.0	4/16/2018	**0.18**
		Green 3-S	0.5	4/16/2018	**0.99**
			1.0	4/16/2018	**0.72**
			2.0	4/16/2018	**0.042**
		Green 3	0.5	4/16/2018	**1.4**
			1.0	4/16/2018	**0.33**
			2.0	4/16/2018	**1.3**
Area 11	Green 12	Green 12-E	0.5	5/2/2018	**0.71**
			1.0	5/2/2018	**0.15**
			2.0	5/2/2018	<0.01
		Green 12-S	0.5	5/2/2018	**0.3**
			1.0	5/2/2018	**0.012**
		Green 12-W	0.5	5/2/2018	**1.3**
			1.0	5/2/2018	**0.073**
			1.5	5/2/2018	<0.01
		Green 12	0.5	5/2/2018	**1.2**
			1.0	5/2/2018	**0.16**
			2.0	5/2/2018	<0.01
	Green 15	Green 15-NE	0.5	5/3/2018	<0.01
			1.0	5/3/2018	<0.01
		Green 15-S	0.5	5/3/2018	**5.9**
			1.0	5/3/2018	**0.085**
			1.5	5/3/2018	<0.01
		Green 15-W	0.5	5/3/2018	<0.01
			1.0	5/3/2018	**0.062**
		Green 15	0.5	5/3/2018	<0.01
			1.0	5/3/2018	<0.01
Area 12	Tee 7	Tee 7-A	0.5	4/18/2018	<0.01
			1.0	4/18/2018	<0.01
		Tee 7-B	0.5	4/18/2018	<0.01
			1.0	4/18/2018	**0.096**
			1.5	4/18/2018	<0.01
		Tee 7-C	0.5	4/18/2018	<0.01
			1.0	4/18/2018	<0.01
		Tee 7-NE	0.5	4/18/2018	<0.01
			1.0	4/18/2018	<0.01
		Tee 7-NW	0.5	4/18/2018	<0.01
			1.0	4/18/2018	**0.039**
		Tee 7-S	0.5	4/18/2018	**0.046**
			1.0	4/18/2018	<0.01
	Green 6	Green 6-NE	0.5	4/30/2018	**0.93**
			1.0	4/30/2018	**0.29**
			2.0	4/30/2018	**0.05**
		Green 6-S	0.5	4/30/2018	**0.39**
			1.0	4/30/2018	**0.085**
			1.5	4/30/2018	<0.01

Table 6
Soil Analytical Results – 2018 EPI Continued Subsurface Investigation
Remedial Investigation and Focused Feasibility Study Report
Brookdale Golf Course
1802 Brookdale Road East, Tacoma, Washington

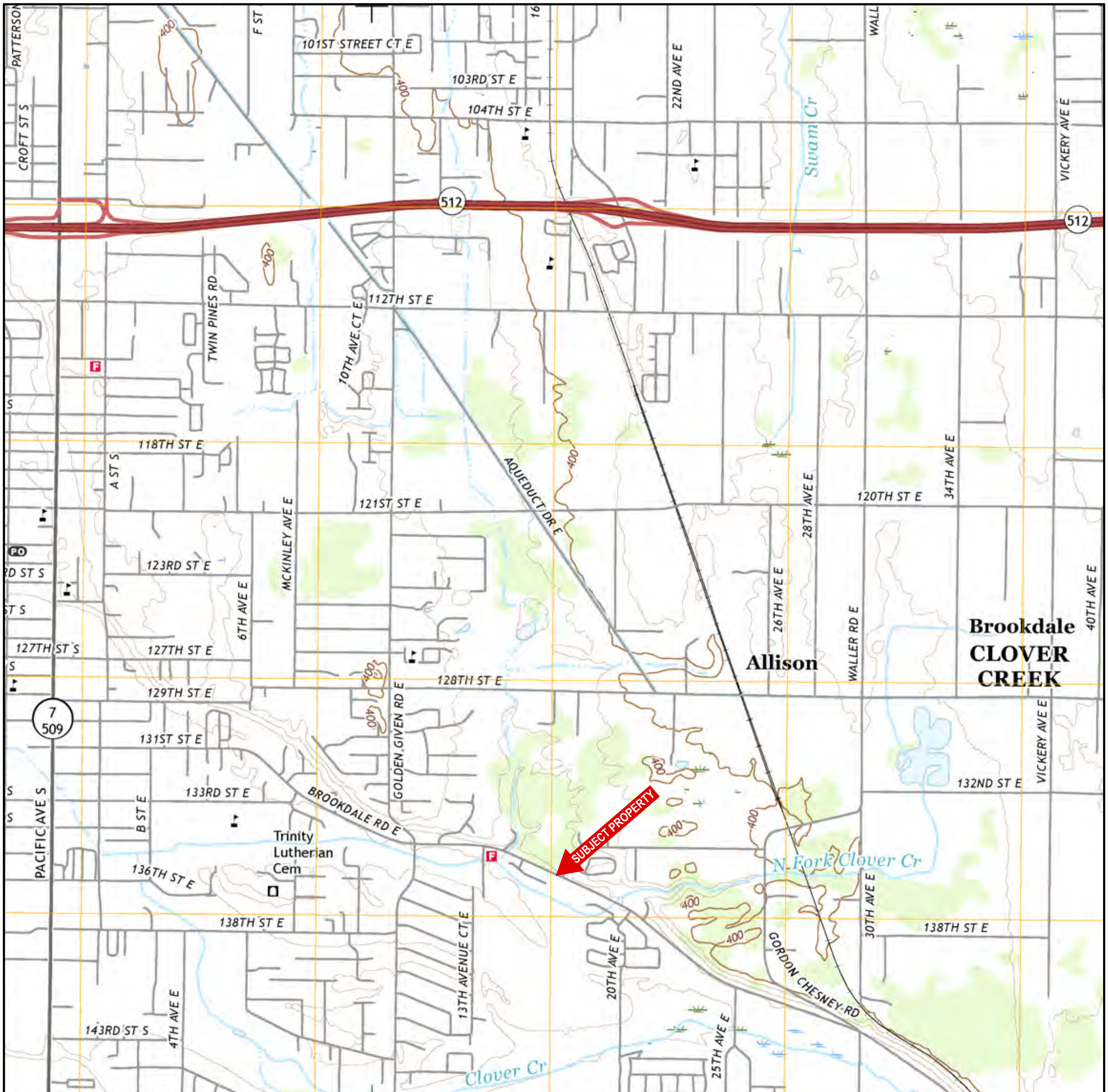
Area	Tee	Sample Location	Sample Depth (in feet)	Date	Dieldrin
Area 12	Green 6	Green 6-W	0.5	4/30/2018	**0.8**
			1.0	4/30/2018	**0.11**
			2.0	4/30/2018	<0.01
		Green 6	2.0	4/30/2018	**0.67**
			2.5	4/30/2018	<0.01
Area 13	Tee 13	Tee 13-B	0.5	4/27/2018	**4.2**
			1.0	4/27/2018	**0.22**
			2.0	4/27/2018	**0.067**
		Tee 13-C	2.0	4/30/2018	**0.081**
			2.5	4/30/2018	**0.17**
		Tee 13-D-NW	0.5	4/30/2018	<0.01
			1.0	4/30/2018	<0.01
		Tee 13-D-SE	0.5	4/30/2018	<0.01
			1.0	4/30/2018	<0.01
		Tee 13-D-SW	0.5	4/30/2018	<0.01
			1.0	4/30/2018	<0.01
		Tee 13-D	0.5	4/30/2018	<0.01
			1.0	4/30/2018	<0.01
		Tee 13-N	0.5	4/30/2018	**0.54**
			1.0	4/30/2018	**0.42**
			2.0	4/30/2018	**0.02**
		Tee 13-NW	0.5	4/30/2018	**1.3**
			1.0	4/30/2018	**1.2**
			2.0	4/30/2018	**0.97**
		Tee 13-SE	0.5	4/27/2018	**0.22**
			1.0	4/27/2018	**0.024**
		Tee 13-SW	0.5	4/30/2018	**0.34**
			1.0	4/30/2018	**0.13**
			2.0	4/30/2018	**0.011**
	Tee 15	Tee 15-A	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 15-E	0.5	4/23/2018	**0.017**
			1.0	4/23/2018	**0.12**
			2.0	4/23/2018	**0.022**
		Tee 15-N	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 15-W	0.5	4/23/2018	**0.083**
			1.0	4/23/2018	**0.016**
	Tee 16	Tee 16-A	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 16-B-E	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 16-B-W	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 16-C	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 16-D-N	0.5	4/23/2018	**0.061**
			1.0	4/23/2018	**0.028**
		Tee 16-D	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 16-NE	0.5	4/25/2018	**0.011**
			1.0	4/25/2018	<0.01
		Tee 16-SE	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
		Tee 16-SW	0.5	4/23/2018	<0.01
			1.0	4/23/2018	<0.01
	Green 14	Green 14-E	0.5	5/3/2018	**1.1**
			1.0	5/3/2018	**0.37**
			2.0	5/3/2018	<0.01
		Green 14-N	0.5	5/3/2018	**6.8**
			1.0	5/3/2018	**2.9**
			2.0	5/3/2018	**0.22**
		Green 14-W	0.5	5/3/2018	**2.1**
			1.0	5/3/2018	**0.18**
			2.0	5/3/2018	<0.01
		Green 14	2.0	5/3/2018	<0.01
Area 14	Tee 5	Tee 5-A	0.5	4/18/2018	<0.01
			1.0	4/18/2018	**0.24**
			2.0	4/18/2018	**0.14**
		Tee 5-NE	0.5	4/18/2018	**0.028**
			1.0	4/18/2018	<0.01
		Tee 5-NW	0.5	4/18/2018	**0.11**
			1.0	4/18/2018	**0.012**
		Tee 5-S	0.5	4/18/2018	**0.11**
			1.0	4/18/2018	**1.4**
			2.0	4/18/2018	**0.01**
	Green 4	Green 4-NE	0.5	4/17/2018	**0.46**
			1.0	4/17/2018	**0.042**
		Green 4-NW	0.5	4/17/2018	**0.049**
			1.0	4/17/2018	**0.077**
			1.5	4/17/2018	**0.027**

Table 6
Soil Analytical Results – 2018 EPI Continued Subsurface Investigation
Remedial Investigation and Focused Feasibility Study Report
Brookdale Golf Course
1802 Brookdale Road East, Tacoma, Washington

Area	Tee	Sample Location	Sample Depth (in feet)	Date	Dieldrin
Area 14	Green 4	Green 4-S	0.5	4/17/2018	**0.16**
			1.0	4/17/2018	**0.049**
		Green 4	0.5	4/17/2018	**5.1**
			1.0	4/17/2018	**0.1**
			1.5	4/17/2018	**0.058**
	Green 5	Green 5-E	0.5	4/30/2018	**23**
			1.0	4/30/2018	**0.076**
			1.5	4/30/2018	**0.051**
		Green 5-NW	0.5	4/26/2018	**7.2**
			1.0	4/26/2018	**0.18**
			2.0	4/26/2018	**0.028**
		Green 5-S	0.5	4/26/2018	**0.16**
			1.0	4/26/2018	**0.18**
			2.0	4/26/2018	**0.092**
		Green 5	2.0	4/26/2018	**0.093**
			2.5	4/26/2018	**0.7**
Area 15	Tee 14	Tee 14-E	0.5	4/19/2018	**0.086**
			1.0	4/19/2018	**0.013**
		Tee 14-N	0.5	4/19/2018	**1.3**
			1.0	4/19/2018	**0.21**
			2.0	4/19/2018	**0.3**
		Tee 14-S	0.5	4/19/2018	**0.024**
			1.0	4/19/2018	**0.019**
	Green 13	Green 13-NE	0.5	5/2/2018	<0.01
			1.0	5/2/2018	<0.01
		Green 13-NW	0.5	5/2/2018	<0.01
			1.0	5/2/2018	<0.01
		Green 13-S	0.5	5/2/2018	<0.01
			1.0	5/2/2018	**0.016**
		Green 13	0.5	5/2/2018	<0.01
			1.0	5/2/2018	<0.01
Soil Cleanup Level[a] (MTCA Method B, CLARC Database)					**0.0625**

Notes:
All results presented in milligrams/kilogram (mg/kg); all samples analyzed by EPA Method 8081.
Bold Bold results indicate that the compound was detected.
[shaded] Shaded cells indicate that the compound was detected at a concentration greater than a cleanup level.
a Based on Model Toxics Control Act (MTCA) Method B (Cancer) Soil Cleanup Level; Cleanup Levels and Risk Calculations (CLARC) database.

Figures



NOTES:

SOURCE: USGS 7.5 MINUTE QUADRANGLE (TOPOGRAPHIC)

TACOMA SOUTH, WA 2017

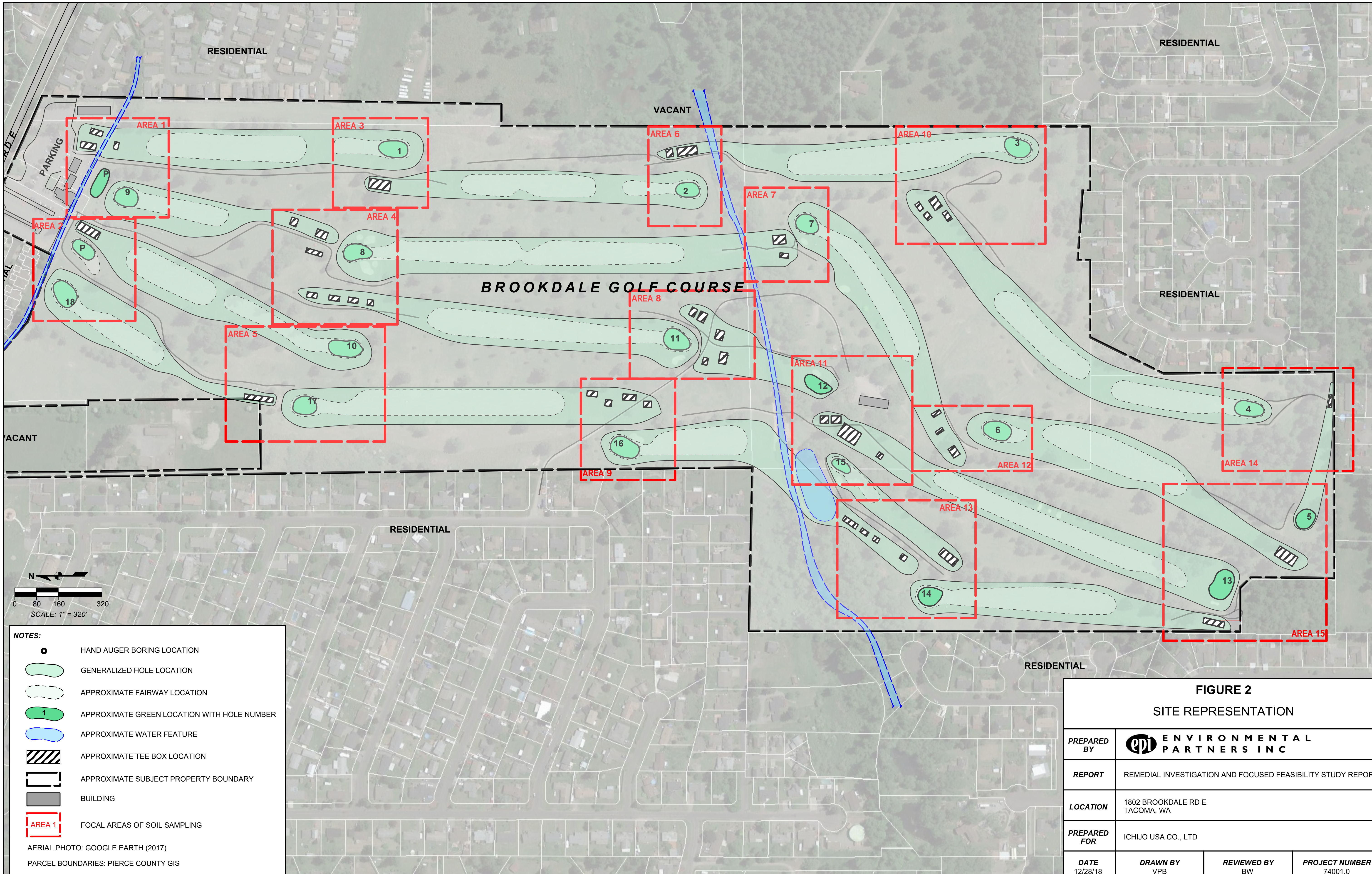
N

SCALE = 1:24,000

FIGURE 1

GENERAL VICINITY MAP

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT		
LOCATION	1802 BROOKDALE RD E TACOMA, WA		
PREPARED FOR	ICHIJO USA CO., LTD		
DATE 12/28/18	***DRAWN BY*** VPB	***REVIEWED BY*** BW	***PROJECT NUMBER*** 74001.0



NOTES:

- HAND AUGER BORING LOCATION
- GENERALIZED HOLE LOCATION
- APPROXIMATE FAIRWAY LOCATION
- APPROXIMATE GREEN LOCATION WITH HOLE NUMBER
- APPROXIMATE WATER FEATURE
- APPROXIMATE TEE BOX LOCATION
- APPROXIMATE SUBJECT PROPERTY BOUNDARY
- BUILDING
- AREA 1 — FOCAL AREAS OF SOIL SAMPLING

AERIAL PHOTO: GOOGLE EARTH (2017)

PARCEL BOUNDARIES: PIERCE COUNTY GIS

FIGURE 2

SITE REPRESENTATION

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

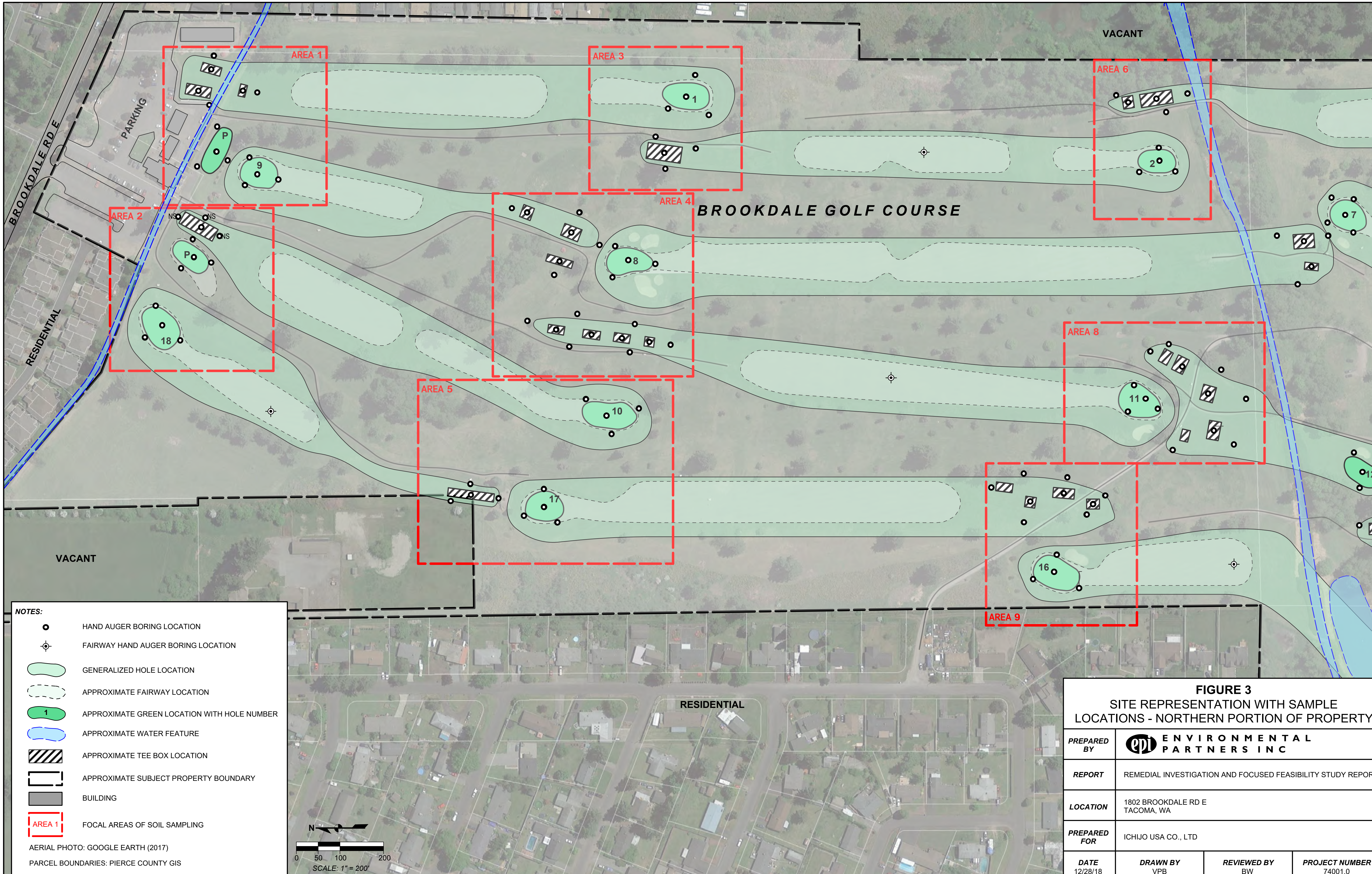


FIGURE 3
SITE REPRESENTATION WITH SAMPLE LOCATIONS - NORTHERN PORTION OF PROPERTY

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

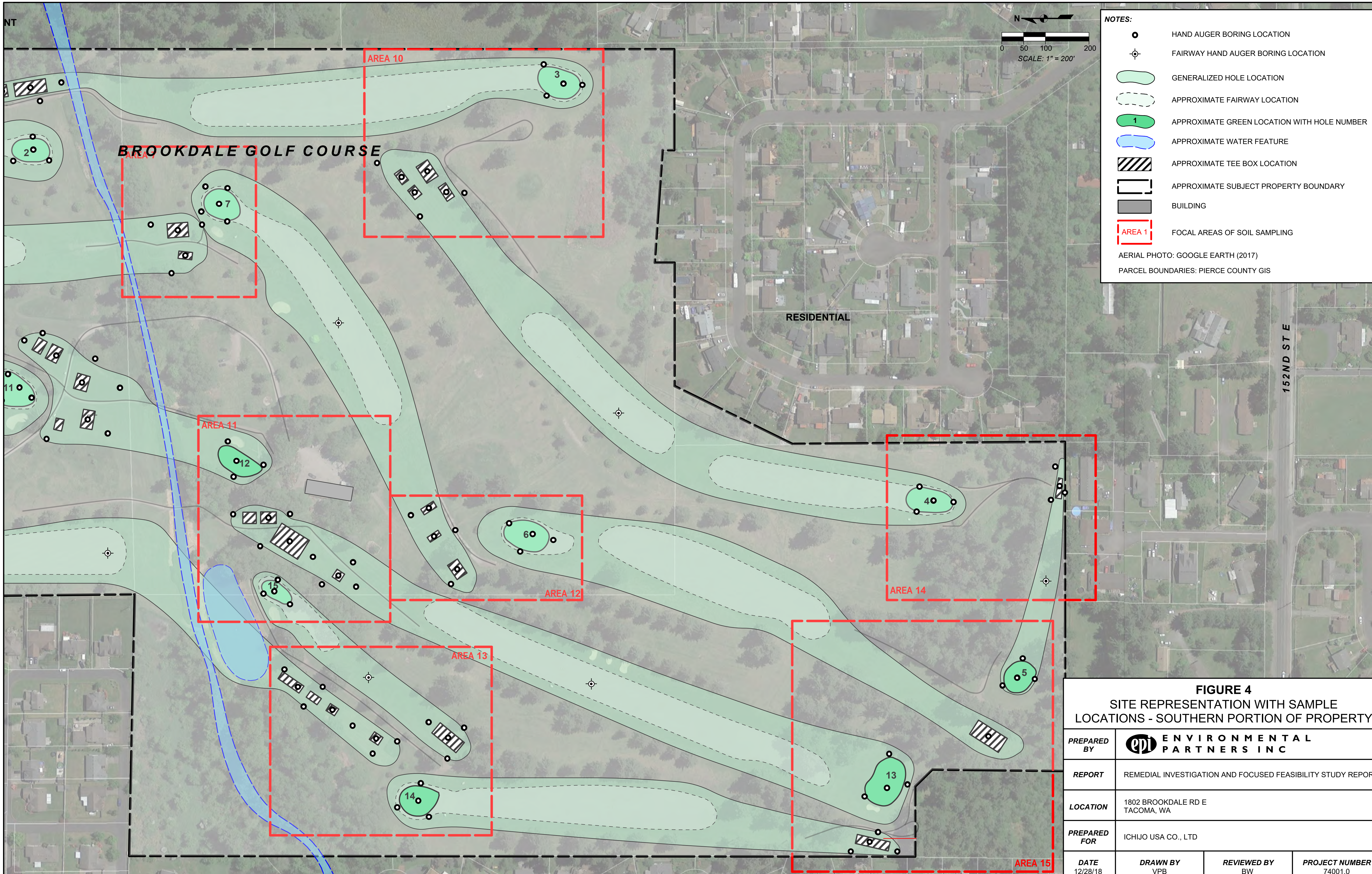
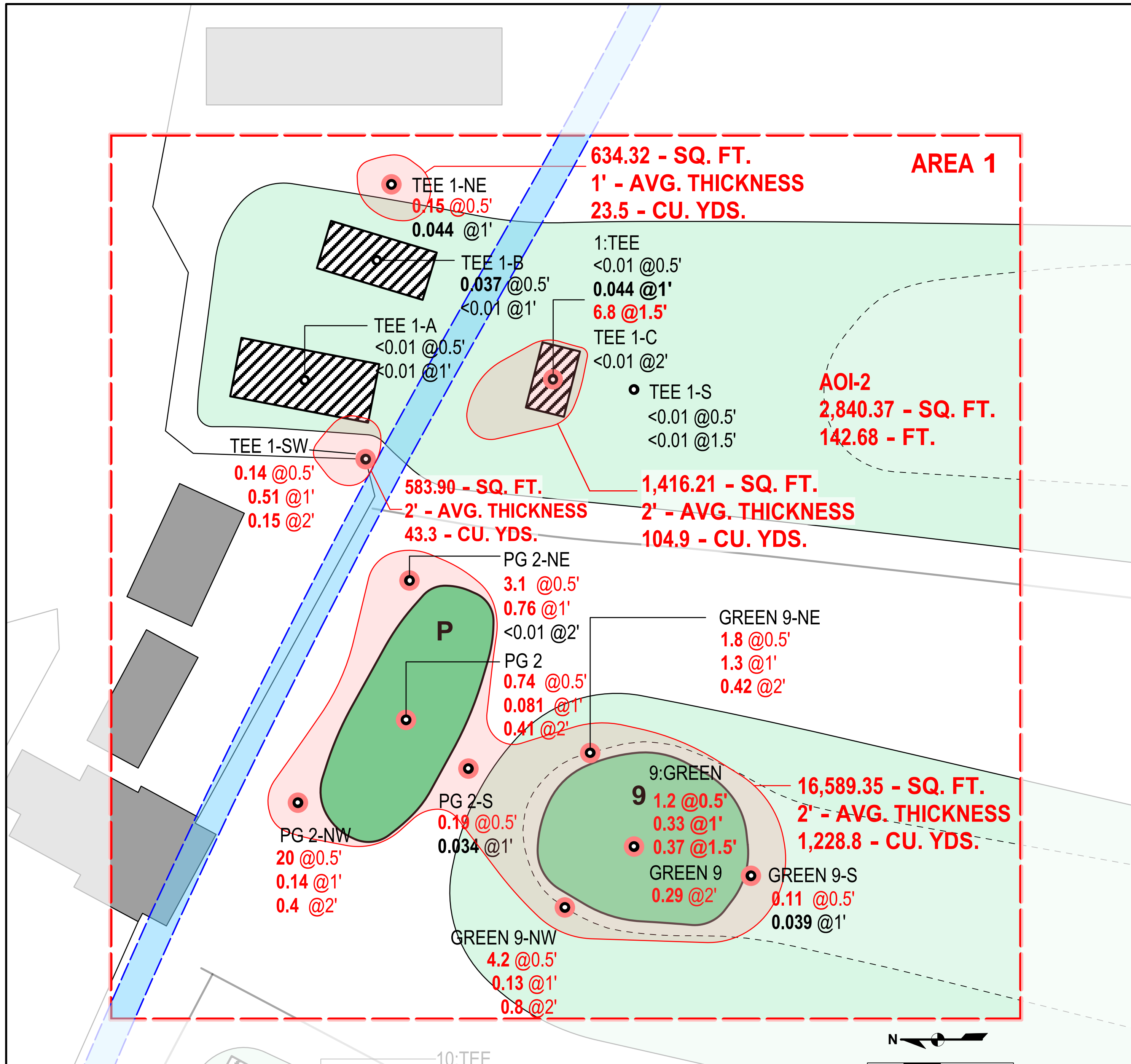
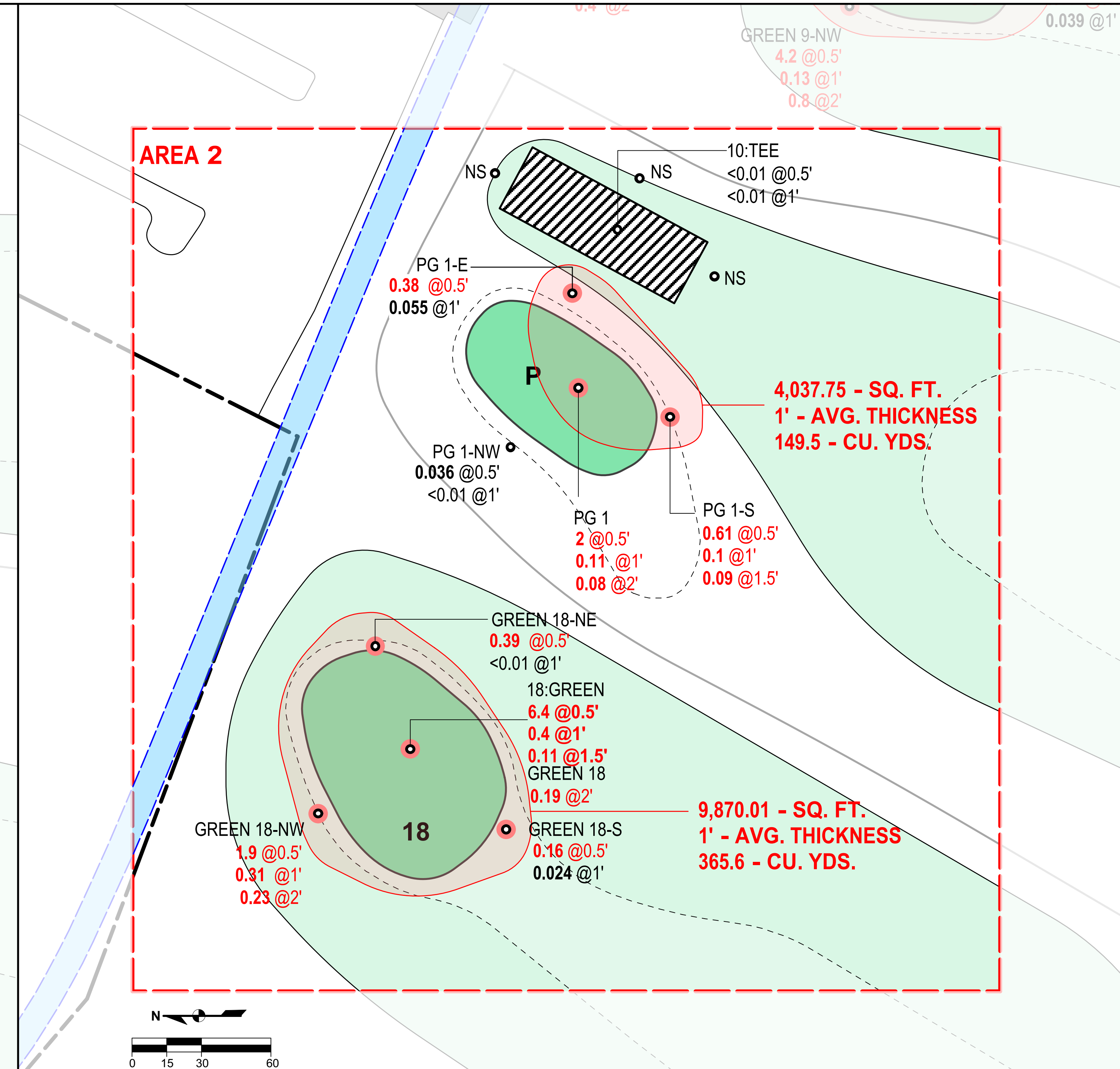


FIGURE 4
SITE REPRESENTATION WITH SAMPLE LOCATIONS - SOUTHERN PORTION OF PROPERTY

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0





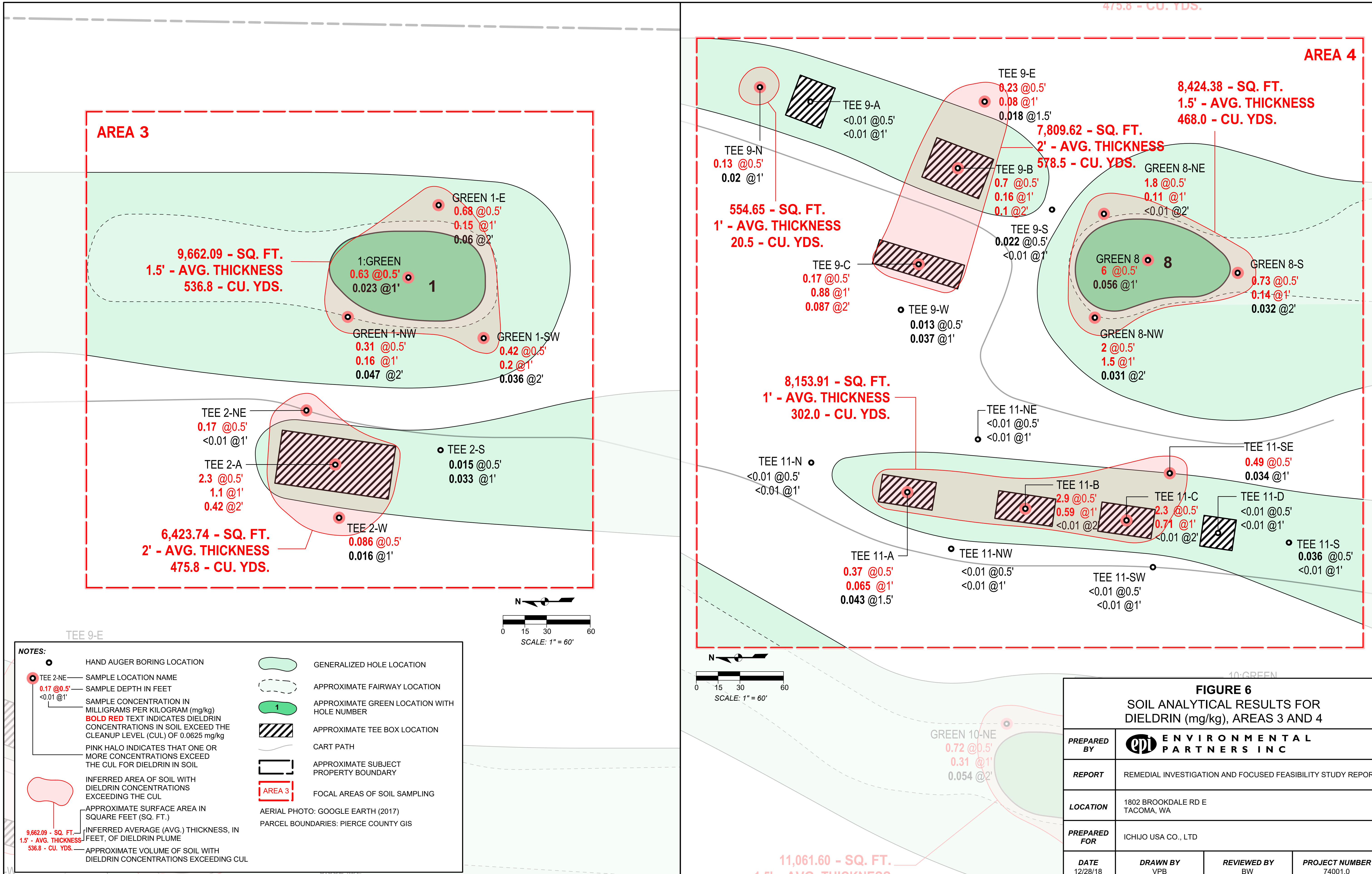
NOTES:

- HAND AUGER BORING LOCATION
- PG 2-S — SAMPLE LOCATION NAME
- 0.19 @0.5' — SAMPLE DEPTH IN FEET IN FEET
- 0.034 @1' — SAMPLE CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) **BOLD RED** TEXT INDICATES DIELDRIN CONCENTRATIONS IN SOIL EXCEED THE CLEANUP LEVEL (CUL) OF 0.0625 mg/kg
- PINK HALO INDICATES THAT ONE OR MORE CONCENTRATIONS EXCEED THE CUL FOR DIELDRIN IN SOIL
- INFERRED AREA OF SOIL WITH DIELDRIN CONCENTRATIONS EXCEEDING THE CUL
- 2,840.37 - SQ. FT. — APPROXIMATE SURFACE AREA IN SQUARE FEET (SQ. FT.)
- 2' - AVG. THICKNESS — INFERRED AVERAGE (AVG.) THICKNESS, IN FEET, OF DIELDRIN PLUME
- 210.4 - CU. YDS. — APPROXIMATE VOLUME OF SOIL WITH DIELDRIN CONCENTRATIONS EXCEEDING CUL
- GENERALIZED HOLE LOCATION
- APPROXIMATE FAIRWAY LOCATION
- 9 — APPROXIMATE GREEN LOCATION WITH HOLE NUMBER (P = PUTTING GREEN)
- APPROXIMATE TEE BOX LOCATION
- CART PATH
- BUILDING
- APPROXIMATE SUBJECT PROPERTY BOUNDARY
- AREA 1 — FOCAL AREAS OF SOIL SAMPLING

AERIAL PHOTO: GOOGLE EARTH (2017)
PARCEL BOUNDARIES: PIERCE COUNTY GIS

FIGURE 5
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 1 AND 2

PREPARED BY	ENVIRONMENTAL PARTNERS INC		
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT		
LOCATION	1802 BROOKDALE RD E TACOMA, WA		
PREPARED FOR	ICHIJO USA CO., LTD		
DATE 12/28/18	DRAWN BY VPB	REVIEWED BY BW	PROJECT NUMBER 74001.0



NOTES:

- HAND AUGER BORING LOCATION
- TEE 2-NE — SAMPLE LOCATION NAME
- 0.17 @0.5' — SAMPLE DEPTH IN FEET
- <0.01 @1' — SAMPLE CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) **BOLD RED** TEXT INDICATES DIELDRIN CONCENTRATIONS IN SOIL EXCEED THE CLEANUP LEVEL (CUL) OF 0.0625 mg/kg
- PINK HALO INDICATES THAT ONE OR MORE CONCENTRATIONS EXCEED THE CUL FOR DIELDRIN IN SOIL
- INFERRED AREA OF SOIL WITH DIELDRIN CONCENTRATIONS EXCEEDING THE CUL
- 9,662.09 - SQ. FT. — APPROXIMATE SURFACE AREA IN SQUARE FEET (SQ. FT.)
- 1.5' - AVG. THICKNESS — INFERRED AVERAGE (AVG.) THICKNESS, IN FEET, OF DIELDRIN PLUME
- 536.8 - CU. YDS. — APPROXIMATE VOLUME OF SOIL WITH DIELDRIN CONCENTRATIONS EXCEEDING CUL
- GENERALIZED HOLE LOCATION
- APPROXIMATE FAIRWAY LOCATION
- APPROXIMATE GREEN LOCATION WITH HOLE NUMBER
- APPROXIMATE TEE BOX LOCATION
- CART PATH
- APPROXIMATE SUBJECT PROPERTY BOUNDARY
- AREA 3 — FOCAL AREAS OF SOIL SAMPLING

AERIAL PHOTO: GOOGLE EARTH (2017)
PARCEL BOUNDARIES: PIERCE COUNTY GIS

FIGURE 6
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 3 AND 4

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

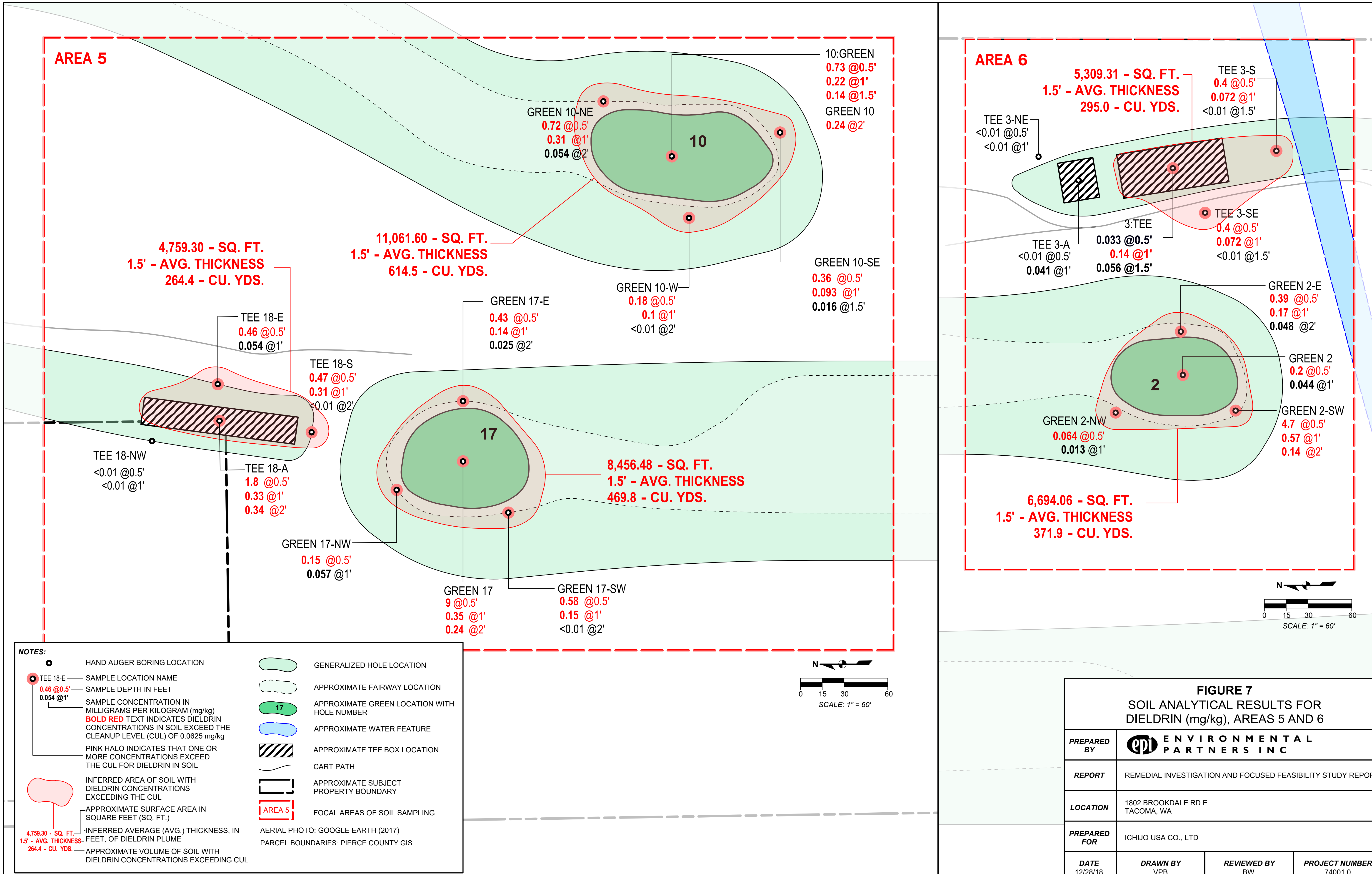


FIGURE 7
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 5 AND 6

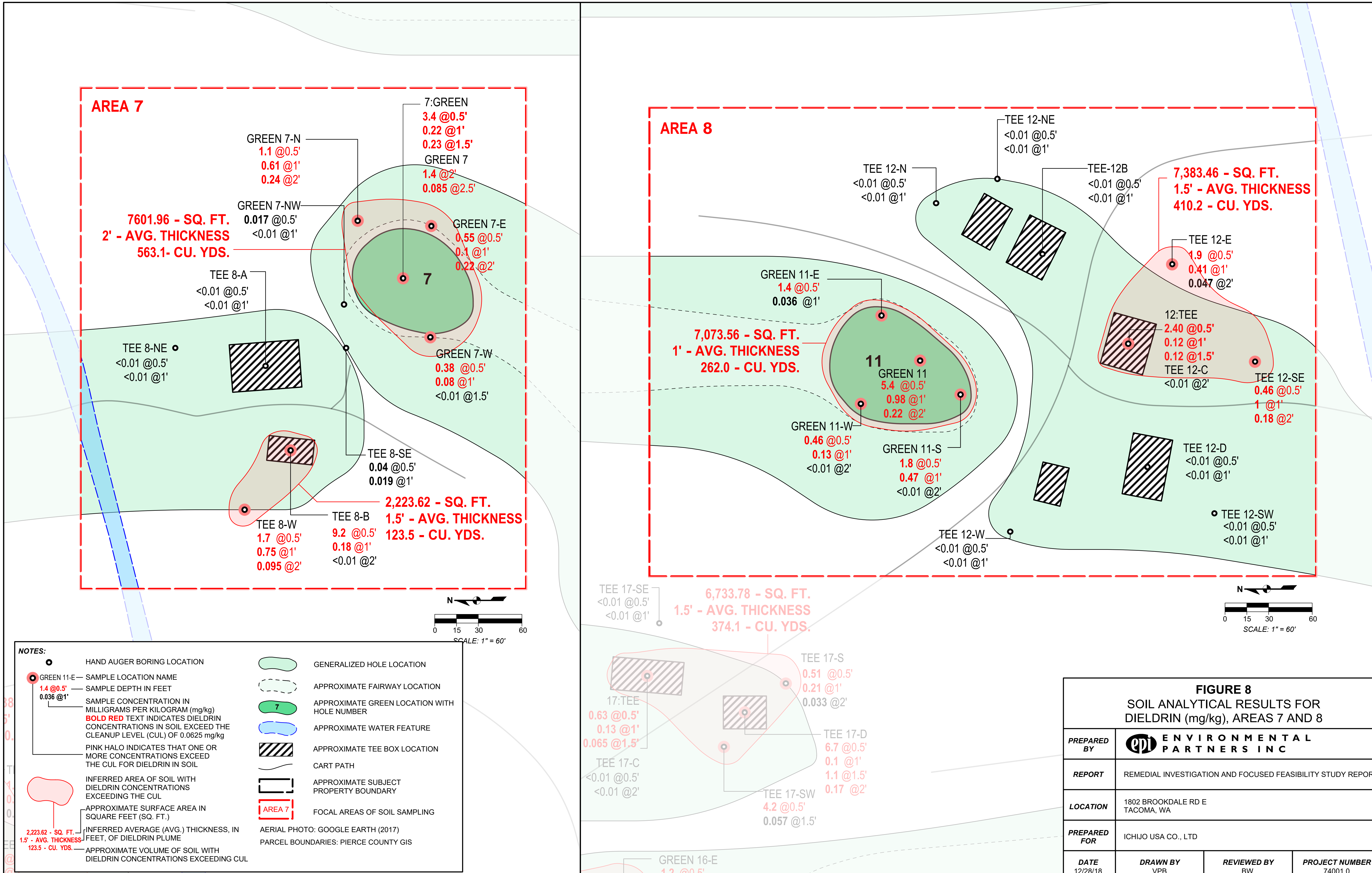


FIGURE 8
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 7 AND 8

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

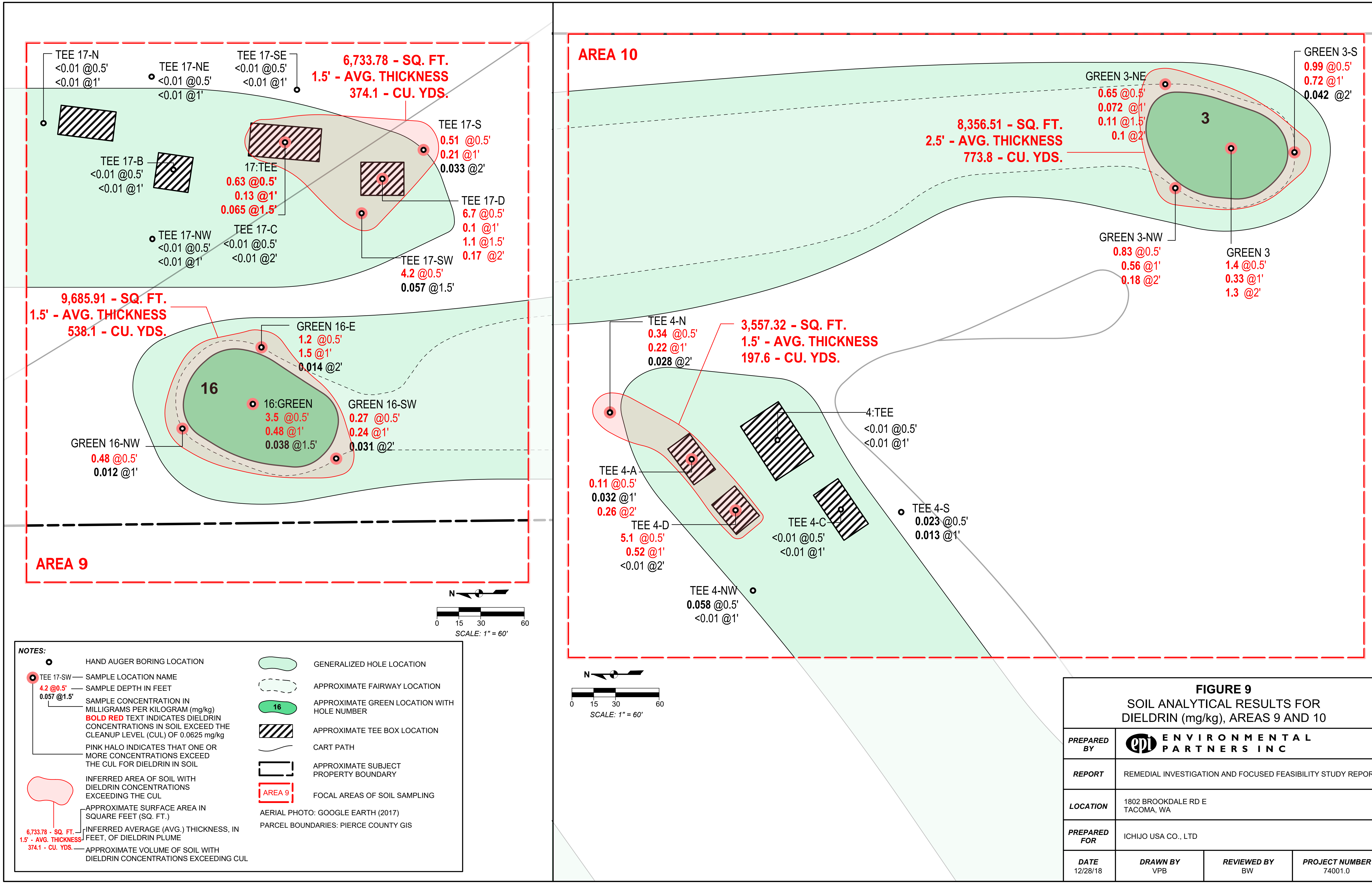


FIGURE 9
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 9 AND 10

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

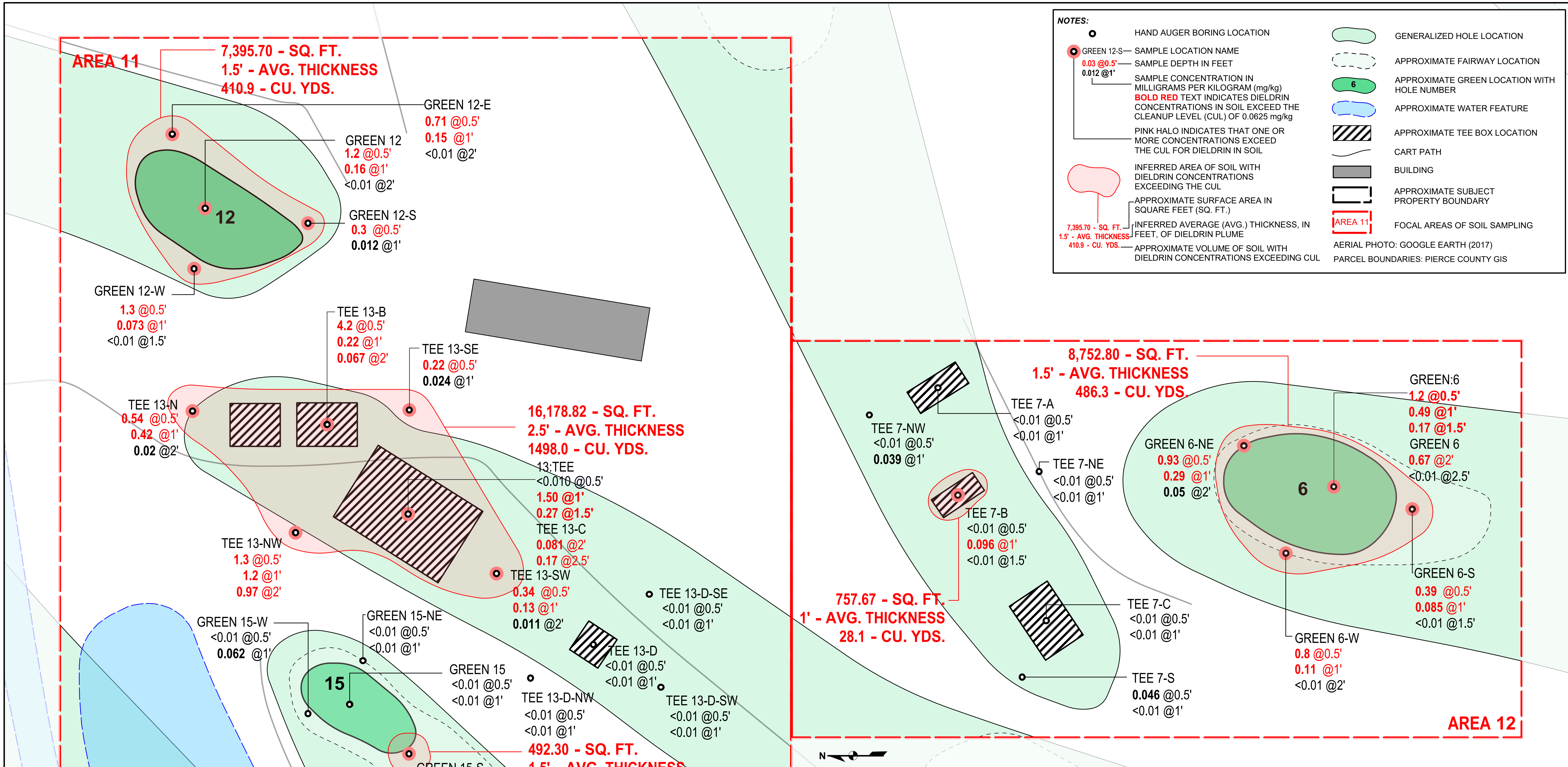
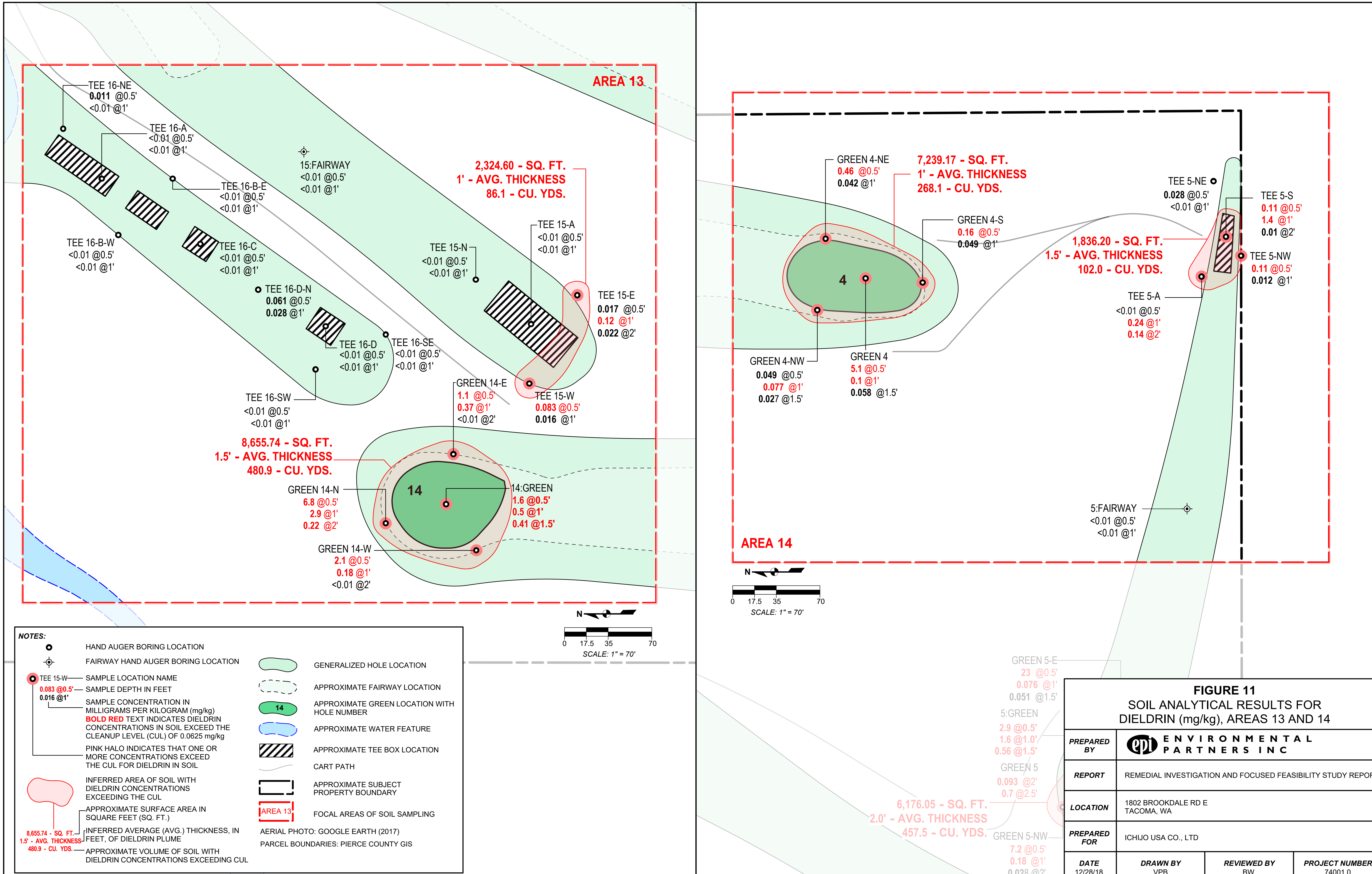


FIGURE 10
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 11 AND 12

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0



NOTES:

- HAND AUGER BORING LOCATION
- FAIRWAY HAND AUGER BORING LOCATION
- TEE 15-W — SAMPLE LOCATION NAME
- 0.083 @0.5' — SAMPLE DEPTH IN FEET
- 0.016 @1' — SAMPLE CONCENTRATION IN MILLIGRAMS PER KILOGRAM (mg/kg) **BOLD RED** TEXT INDICATES DIELDRIN CONCENTRATIONS IN SOIL EXCEED THE CLEANUP LEVEL (CUL) OF 0.0625 mg/kg
- PINK HALO INDICATES THAT ONE OR MORE CONCENTRATIONS EXCEED THE CUL FOR DIELDRIN IN SOIL
- INFERRED AREA OF SOIL WITH DIELDRIN CONCENTRATIONS EXCEEDING THE CUL
- 8,655.74 - SQ. FT. — APPROXIMATE SURFACE AREA IN SQUARE FEET (SQ. FT.)
- 1.5' - AVG. THICKNESS — INFERRED AVERAGE (AVG.) THICKNESS, IN FEET, OF DIELDRIN PLUME
- 480.9 - CU. YDS. — APPROXIMATE VOLUME OF SOIL WITH DIELDRIN CONCENTRATIONS EXCEEDING CUL
- GENERALIZED HOLE LOCATION
- APPROXIMATE FAIRWAY LOCATION
- 14 — APPROXIMATE GREEN LOCATION WITH HOLE NUMBER
- APPROXIMATE WATER FEATURE
- APPROXIMATE TEE BOX LOCATION
- CART PATH
- APPROXIMATE SUBJECT PROPERTY BOUNDARY
- AREA 13 — FOCAL AREAS OF SOIL SAMPLING

AERIAL PHOTO: GOOGLE EARTH (2017)
PARCEL BOUNDARIES: PIERCE COUNTY GIS

FIGURE 11
SOIL ANALYTICAL RESULTS FOR DIELDRIN (mg/kg), AREAS 13 AND 14

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

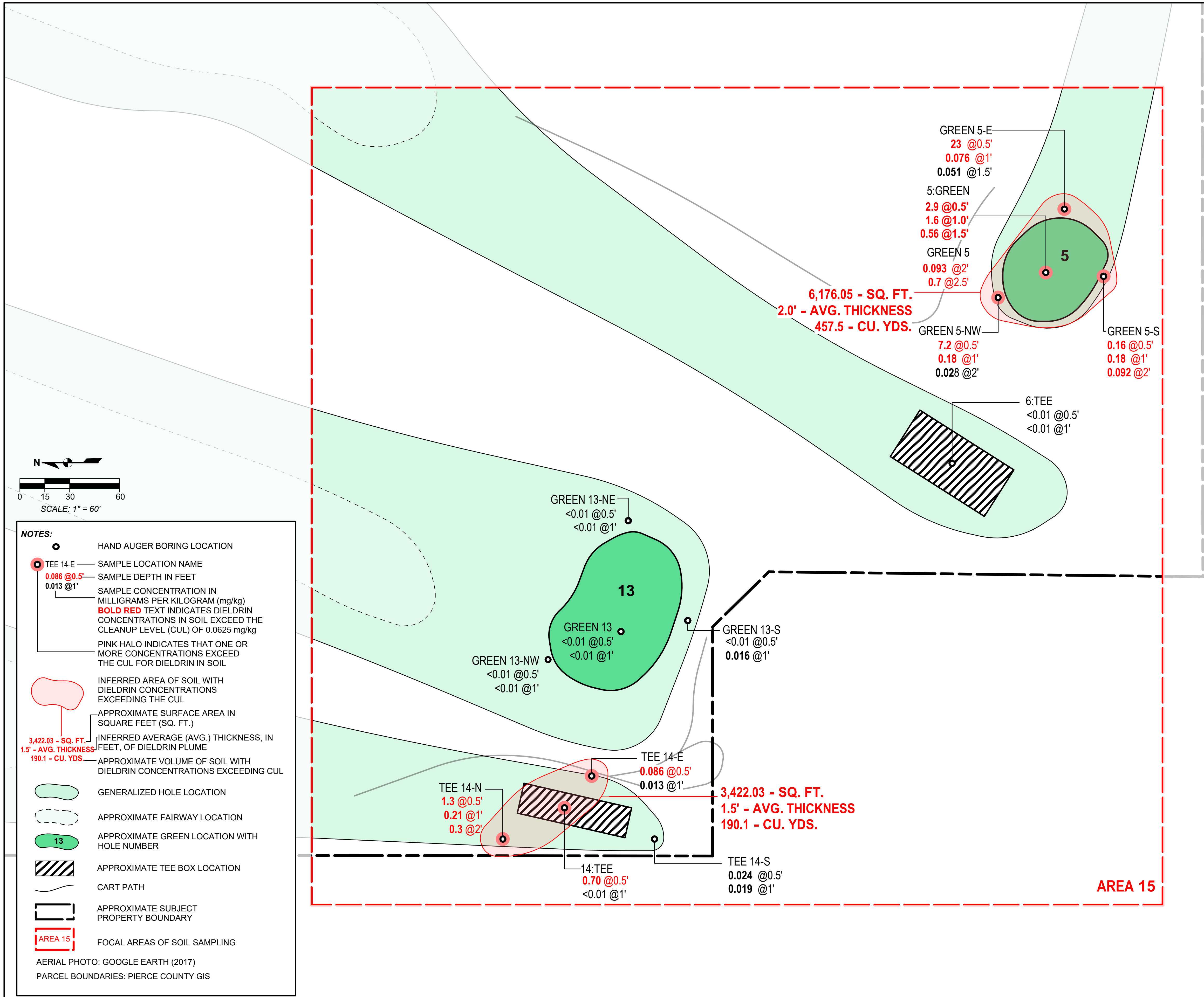


FIGURE 12
SOIL ANALYTICAL RESULTS FOR
DIELDRIN (mg/kg), AREA 15

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	REMEDIAL INVESTIGATION AND FOCUSED FEASIBILITY STUDY REPORT
LOCATION	1802 BROOKDALE RD E TACOMA, WA
PREPARED FOR	ICHIJO USA CO., LTD

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/28/18	VPB	BW	74001.0

Attachment A
Ecology Well Logs

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy (CHARLES BROWN)

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name BROOKDALE GOLF COURSE Address

(2) LOCATION OF WELL: County PIERCE — NW ¼ SE ¼ Sec. 15 T. 19 N., R. 3E W.M.
Bearing and distance from section or subdivision corner NW SE 15 19 3E

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 10 inches.
Drilled 42 ft. Depth of completed well 32 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 10 " Diam. from +2 ft. to 32 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name JOHNSON
Type TELESCOPE Model No.....
Diam. 10" Slot size #120 from 22 ft. to 32 ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 6 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name RED JACKET
Type: SUB H.P. 60

(8) WATER LEVELS: Land-surface elevation above mean sea level..... ft.
Static level 8'5" ft. below top of well Date 12/10/88
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? DRILLER
Yield: 260 gal./min. with 3½ ft. drawdown after 4 hrs.
" 425 " 13 " 11 "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
4PM	21'5"				
4:02PM	8'5"				

Date of test 12/5/88 / 1-10/89
Bailer test..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:
Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
OLD WELL (WATER)	0	12
SAND GRAVEL SM COBBLES	12	25
MED SAND SOME GRAVEL	25	28
" "	28	30
SILTY FINE SAND	30	32
SILTY SANDY GRAVEL — NO-WATER	32	42
SCREEN 10'7" W/PACKER		
PUMP LOWERED 5' INTO SCREEN AFTER WELL DEVELOPMENT FOR SECOND TEST		

RECEIVED JAN 20 1989 DEPARTMENT OF ECOLOGY NORTHWEST REGION

Work started 11-30, 1988. Completed 1-10, 1989

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME MOREK DRILLING (Person, firm, or corporation) (Type or print)
Address P.O. BOX 1650 DUVALL WA 98019

[Signed] [signature] (Well Driller)

License No. 1534 Date 1/15, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. 2-23703

(1) OWNER: Name c/o Charles Brown Brookdale Gof Course Address 1802 Brookdale Rd.E Tacoma, Wa. 98445

(2) LOCATION OF WELL: County Pierce — SE ¼ SW ¼ Sec. 15 T. 19 N., R. 3E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☒

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 10-8 inches.
Drilled 260 ft. Depth of completed well 260 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 10" Diam. from 0 ft. to 240 ft.
Threaded ☐ 8" Diam. from 0 ft. to 242 ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson Well
Type Stainless steel Model No. .....
Diam. 8 Slot size 60 from 242 ft. to 247 ft.
Diam. 8 Slot size 80 from 247 ft. to 257 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name Jacuzzi Bros.
Type: 25s6x6-t4 H.P. 25

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 57 ft. below top of well Date 3-23-79
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test 200 gal./min. with ..... ft. drawdown after 1 hrs.
Artesian flow ..... g.p.m. Date 3-23-79
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface seal	0	20
Gravel some silty clay	0	54
Sand gravel clay binder water 18 GPM	54	91
Hardpan large rock	91	138
Sand & gravel water 80 GPM	138	174
Hard pan & boulders	174	197
Gravel water 150 GPM	197	226
Brown clay	226	240
Blue clay & boulders	240	246
Yellow clay & gravel	246	248
Yellow clay & gravel	248	258
Water, clay & gravel	258	260

RECEIVED
JAN 13 1982
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 6-21, 19 78. Completed 3-23, 19 79

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling Co. (Person, firm, or corporation) (Type or print)

Address P.O. Box 44427 Tacoma, Wa. 98444

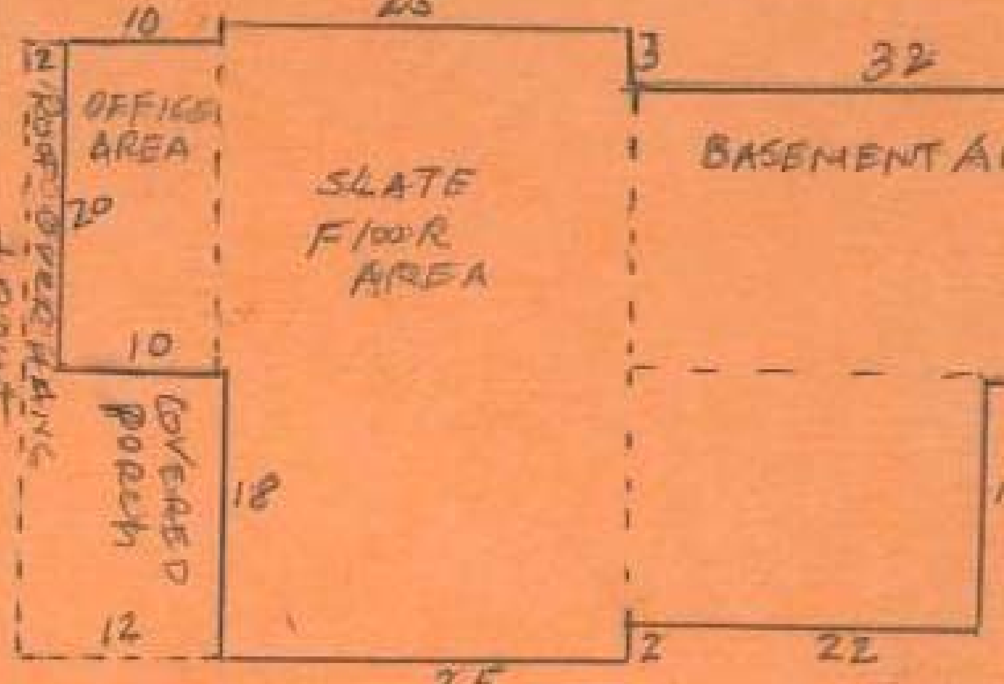
[Signed] (signature) (Well Driller)

License No. 223-02-6500 Date 1-12, 19 82

(USE ADDITIONAL SHEETS IF NECESSARY)

Attachment B
Historical Tax Records

lass A-G			
quare Ft. 2103	Cubic Ft.		
erimeter. 212	Height		
escription	—	+	Total
Rate		6.79	
ement Base Rate			
ut		1.04	
d walls & ceiling		.32	
ed rooms @ .50		1.00	2.36
Rate			
floor		1.50	
...	.48		1.02
6.79 = 13771			
x600x2.20 = 1370			
576 x 2.36 = 1359			
700 x 1.02 = 714			
...g = 750			
...ing x 1.28 = 384			
17754			
... = 270			
17484 x .50 = 8742			
NV = 4371			
AV = 7185			



20x10 =
3x25=
36x25=
16x22=
18x32=

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700 Local #: Parcel #: 0319158700

Tax Year:	2019	Levy:	0.000000	# of Imps:	4	Created On:	
Tax Dist:	PIERCE	Map #:		LEA:	3096	Active On:	10/08/2018
PUC:		Initials:		Acct Type:	Commercial	Inactive On:	
Assign To:	Eric Coldiron					Last Updated:	

Owner's Name and Address

BROOKDALE GOLF LLC
1802 BROOKDALE RD E
TACOMA , WA 98445 - -4810

Property Address

Street: 1802 BROOKDALE RD E
City: PIERCE COUNTY

Business Name

BROOKDALE GOLF COURSE

Sales Summary

Sale Date	Sale Price	Deed Type	Reception #	Book	Page #	Grantor

Legal

Section 15 Township 19 Range 03 Quarter 43 SEG FOR TAX PURPOSES ONLY CANNOT BE SOLD OR SUBD WITHOUT PARCELS 8-002, 8-003, 03-19-22-5-007, 5-700 & 5-701 THAT POR OF L 2 OF S P 91-12-09-0414 LY IN

Section	Township	Range	Qtr	QtrQtr	Government Lot	Government Tract
15	19	03	4	3		

Subdivision Information

Sub Name	Block	Lot	Tract

Land Valuation Summary

Land Type	Abst Cd	Value By	Net SF	Measure	# of Units	Value/Unit	Actual Val	Asmt %	Assessed Val
Commercial	7410L	MRA	3,042,666	Square Feet	3,042,666.000000	$0.19	$582,557	100.00%	$582,557
Class				Sub Class					
Agricultural	9400L	CU	2,959,902	Acres	67.950000	$1,000.00	$67,950	100.00%	$67,950
Class	0			Sub Class	0				
Agricultural	9400L	CU	82,764	Acres	1.900000	$8,340.53	$15,847	100.00%	$15,847
Class	EXCL			Sub Class	0				
Land Subtotal:					69.85		$83,797		$83,797

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700 Local #: Parcel #: 0319158700

Land Attributes

Attribute	Description	Adjustment
C ECONOMIC	INFLUENCE	0.200000
C FUNCTIONAL	FLOOD WAY	1.000000
C FUNCTIONAL	MARGINAL 40 PCT	0.820000
C MA 9 CENTRAL	906 CANYON-PACIFIC-174TH	0.950000
C USE	8 RECREATIONAL LAND	1.000000
C UTILITIES	SEWER/SEPTIC NO	0.900000

Improvement Valuation Summary

Imp #	Property Type	Abst Code	Occupancy	Class	Actual Value	Asmt %	Assessed Val*
1	Commercial	7410	Recreational		$147,672	100.00%	$147,672
2	Commercial	7410	Outbuilding		$3,549	100.00%	$3,549
3	Commercial	7410	Outbuilding		$5,317	100.00%	$5,317
4	Commercial	7410	Recreational		$1,032,598	100.00%	$1,032,598
Improvement Subtotal:					$1,189,136		$1,189,136

Total Property Value

Total Value:	$1,272,897	$1,272,897

*Approximate Assessed Value

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700	Local #:	Parcel #: 0319158700

Imp #:	1			Landscaping $: 0.00
Property Type:	Commercial			
Quality:	Average			
Condition:	Average	Nbhd:	906	
Perimeter:	360	Nbhd Ext:	956	
% Complete:	100.00%	Nbhd Adj:	1.0000	

Occupancy Summary

Occupancy:	Recreational	Occ %:	100%

Built As Summary

Built As:	Clubhouse	Year Built:	1930
Construction Type:	Wood Frame	Year Remodeled:	1990
HVAC:	Forced Air		
Interior Finish:		% Remodeled:	0.6700
Roof Cover:		Adj Year Blt:	1970
Built As SF:	3179	Effective Age:	
# of Baths:	0.00		
# of Bdrms:	0.00		
# of Stories:	2.00		
Story Height:	10		
Sprinkler SF:	0	Diameter:	
Capacity:		Height:	10
Built As:	Retail Store	Year Built:	1930
Construction Type:	Wood Frame	Year Remodeled:	1990
HVAC:	Forced Air		
Interior Finish:		% Remodeled:	0.6700
Roof Cover:		Adj Year Blt:	1970
Built As SF:	1144	Effective Age:	
# of Baths:	0.00		
# of Bdrms:	0.00		
# of Stories:	1.00		
Story Height:	8		
Sprinkler SF:	0	Diameter:	
Capacity:		Height:	8

Improvement Summary

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700 | Local #: | Parcel #: 0319158700

Improvement 1	Units	Units Price	RCN	Actual Value
Add On				
Pre-Fab F/P (LC)	1.0000	$3,038.00	$3,038.00	$608.00
Asphalt (LC)	77900.0000	$2.33	$181,507.00	$36,301.00
Basement				
Unfinished	576.0000	$38.12	$21,954.56	$21,954.56

Improvements Value Summary

IMPNO: 1

RCN Cost/SF:	$170.80	Design Adj:	0.0000	Func Obs %:	0.0000
Total RCN:	$738,358.00	Exterior Adj:	0.0000	Econ Obs %:	0.0000
Phys Depr %	0.8000	Interior Adj:	0.0000	Other Obs %:	0.0000
Phys Depr $:	$590,686.00	Amateur Adj:	0.0000		
RCNLD $:	$147,672.00	RCNLD Cost/$:	$34.16	Market/SF:	$33.95

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700 | Local #: | Parcel #: 0319158700

Imp #:	2			Landscaping $: 0.00
Property Type:	Commercial			
Quality:	Average			
Condition:	Average	Nbhd:	906	
Perimeter:	0	Nbhd Ext:	956	
% Complete:	100.00%	Nbhd Adj:	1.0000	

Occupancy Summary

Occupancy:	Outbuilding	Occ %:	100%

Built As Summary

Built As:	Shed - Utility	Year Built:	1960
Construction Type:	Wood Frame	Year Remodeled:	1975
HVAC:	None		
Interior Finish:		% Remodeled:	0.0000
Roof Cover:		Adj Year Blt:	1960
Built As SF:	1116	Effective Age:	
# of Baths:	0.00		
# of Bdrms:	0.00		
# of Stories:	1.00		
Story Height:	8		
Sprinkler SF:	0	Diameter:	
Capacity:		Height:	8

Improvement Summary

Improvement	Units	Units Price	RCN	Actual Value

Improvements Value Summary

IMPNO: 2

RCN Cost/SF:	$15.90	Design Adj:	0.0000	Func Obs %:	0.0000
Total RCN:	$17,744.00	Exterior Adj:	0.0000	Econ Obs %:	0.0000
Phys Depr %	0.8000	Interior Adj:	0.0000	Other Obs %:	0.0000
Phys Depr $:	$14,195.00	Amateur Adj:	0.0000		
RCNLD $:	$3,549.00	RCNLD Cost/$:	$3.18	Market/SF:	$3.16

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700	Local #:	Parcel #: 0319158700

Imp #:	3			Landscaping $: 0.00
Property Type:	Commercial			
Quality:	Average			
Condition:	Average	Nbhd:	906	
Perimeter:	0	Nbhd Ext:	956	
% Complete:	100.00%	Nbhd Adj:	1.0000	

Occupancy Summary

Occupancy:	Outbuilding	Occ %:	100%

Built As Summary

Built As:	Shed - Equipment	Year Built:	1960
Construction Type:	Wood Frame	Year Remodeled:	1975
HVAC:	None		
Interior Finish:		% Remodeled:	0.8000
Roof Cover:		Adj Year Blt:	1972
Built As SF:	1104	Effective Age:	
# of Baths:	0.00		
# of Bdrms:	0.00		
# of Stories:	1.00		
Story Height:	8		
Sprinkler SF:	0	Diameter:	
Capacity:		Height:	8

Improvement Summary

Improvement	Units	Units Price	RCN	Actual Value

Improvements Value Summary

IMPNO: 3

RCN Cost/SF:	$24.08	Design Adj:	0.0000	Func Obs %:	0.0000
Total RCN:	$26,584.00	Exterior Adj:	0.0000	Econ Obs %:	0.0000
Phys Depr %	0.8000	Interior Adj:	0.0000	Other Obs %:	0.0000
Phys Depr $:	$21,267.00	Amateur Adj:	0.0000		
RCNLD $:	$5,317.00	RCNLD Cost/$:	$4.82	Market/SF:	$4.73

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158700 | Local #: | Parcel #: 0319158700

Imp #:	4			Landscaping $:	0.00
Property Type:	Commercial				
Quality:					
Condition:		Nbhd:	906		
Perimeter:		Nbhd Ext:	956		
% Complete:	100.00%	Nbhd Adj:	1.0000		

Occupancy Summary

Occupancy:	Recreational	Occ %:	100%

Built As Summary

Built As:	Addon Only Comm	Year Built:	2002
Construction Type:		Year Remodeled:	0
HVAC:	None		
Interior Finish:		% Remodeled:	0.0000
Roof Cover:		Adj Year Blt:	0
Built As SF:	1	Effective Age:	
# of Baths:	0.00		
# of Bdrms:	0.00		
# of Stories:	1.00		
Story Height:	8		
Sprinkler SF:	0	Diameter:	0
Capacity:	0	Height:	0

Improvement Summary

Improvement 4	Units	Units Price	RCN	Actual Value
Add On				
Golf Course Hole Value (Class 2 Med range)	9.0000	$149,004.	$1,341,036.00	$1,032,598.00

Improvements Value Summary

IMPNO: 4

RCN Cost/SF:	$1,341,036.00	Design Adj:	0.0000	Func Obs %:	0.0000
Total RCN:	$1,341,036.00	Exterior Adj:	0.0000	Econ Obs %:	0.0000
Phys Depr %	0.0000	Interior Adj:	0.0000	Other Obs %:	0.0000
Phys Depr $:	$308,438.00	Amateur Adj:	0.0000		
RCNLD $:	$1,032,598.00	RCNLD Cost/$:	$1,032,598.00	Market/SF:	$1,059,450.00

Entry Date	Note	Category
07/08/2003	Corrected R/W error, holes were dropped, added back on and finaled on cost approach. 6/03 RJ.	General
08/02/2007	DRO 08-02-07 A Flood Way land attribute is listed on this parcel based on FEMA studies as adopted by the Pierce County Water Programs April 17th, 2007	
08/28/2007	Flood property, left on override. This is a current use property, the current use value is well below market value. It appears that the property owner is in the process of subdividing the golf course into sf res houses.	General
01/07/2010	PSO 1-7-10 For 2010 PI, batch updated Nbhd 906 LEAs to Ext A to pick up new land model and removed Land Overrides.	
03/05/2010	LCP 03/05/2010 The approach to value was left on cost. The group land attributes were updated. The sketch in Stellant is accurate as compared to the observed improvements. The pro shop operator stated the site owner will be out of state for months. He did not think the course conversion to housing is still in the planning.	
08/01/2011	PSO 8/1/11 Removed erroneous land override from 2011 inactive market land line and corrected value which was trended negatively twice in error. Will process 2011 ME correction after Current Use AV is reviewed.	General
08/17/2011	PSO 8/3/11 Removed an erroneous land override from the 2011 inactive market land line and corrected market land value which was trended negatively twice in error. Processed 2011 ME correction.	
01/01/2016	ECO 08/27/2015 Reviewed due to parcels in the group being located in different Tax Code Areas. All Improvements are allocated correctly.	Material Note
01/14/2018	2001213111 - BROOKDALE GOLF CLUB - 160,246 - 32,779 - NF; 1200203517 - GOLFNOW LLC - 981 - 358;	Personal Property

CURRENT USE

PLEASE TYPE OR PRINT

REAL ESTATE EXCISE TAX AFFIDAVIT
CHAPTER 82.45 RCW – CHAPTER 458-61 WAC
FOR USE AT COUNTY TREASURER'S OFFICE

(Use Form No. 84-0001B for Reporting Transfers of Controlling Interest of Entity Ownership to the Department)

THIS AFFIDAVIT WILL NOT BE ACCEPTED UNLESS ALL AREAS 1-7 ARE FULLY COMPLETED

4085804 MC 8

1 SELLER GRANTOR
Name Christine A. Jones and Douglas P. Brown, sole limited partners and general partners of Brookdale Golf Course Limited Partnership, a WA limited partnership
Street P.O. Box 44959
City/State/Zip Tacoma WA 98444

2 BUYER GRANTEE
Name Brookdale Golf LLC, a Washington limited liability company
Street P.O. Box 44959
City/State/Zip Tacoma WA 98444

3 ADDRESS TO SEND ALL PROPERTY TAX RELATED CORRESPONDENCE
Name Brookdale Golf LLC
Street P.O. Box 44959
City/State/Zip Tacoma WA 98444

ALL TAX PARCEL NUMBERS
0319158700, 0319158002, 0319158003, 0319225007, 0319225700, 0319225701, 0319158701

COUNTY TREASURER PLACE ASSESSED VALUE IF TAX EXEMPT
3,460,500.00

4 LEGAL DESCRIPTION OF PROPERTY SITUATED IN ■ UNINCORPORATED Pierce COUNTY ☐ OR IN CITY OF Tacoma

Street Address (if property is improved): 1802 Brookdale Road East, Tacoma, WA 98445

LEGAL DESCRIPTIONS ATTACHED HERETO AS EXHIBIT "A"

5 Is this property currently:

	YES	NO
Classified or designated as forest land? Chapter 84.33 RCW	☐	■
Classified as current use land (open space, farm and agricultural, or timber)? Chapter 84.34 RCW *As to 2172 44 40200 only	■ *	☐
Exempt from property tax as a nonprofit organization? Chapter 84.36 RCW Seller's Exempt Reg. No.	☐	■
Receiving special valuation as historic property? Chapter 84.26 RCW	☐	■

Property Type: ■ land only ☐ land with new building [X] land with previously used building ☐ land with mobile home ☐ timber only ☐ building only

Principal Use: ☐ Apt. (4+ unit) ☐ residential ☐ timber ☐ agricultural ☐ commercial/industrial ■ other golf course

6 Description of personal property included in gross selling price, both tangible (eg; furniture, equipment, etc.) or intangible (eg; goodwill, agreement not to compete, etc.)

9400

If exemption claimed, list WAC number and explanation.

WAC No. (Sec/Sub) 458-61-376(2)(e)

Explanation Transfers where gain is not recognized under the Internal Revenue Code --transfer to limited liability company

Type of Document Quit Claim Deed

Date of Document 5/19/05

Gross Selling Price $	0.00
Personal Property (deduct) $	0.00
Taxable Selling Price $	0.00
Excise Tax: State $	0.00
Local $	0.00
Delinquent Interest: State $	0.00
Local $	0.00
Delinquent Penalty $	0.00
Total Due $	0.00

A MINIMUM OF $2.00 IS DUE AS A PROCESSING FEE AND TAX.

8 (1) NOTICE OF CONTINUANCE (RCW 84.33 OR RCW 84.34)

If the new owner(s) of land that is classified or designated as current use or forest land wish to continue the classification or designation of such land, the new owner(s) must sign below. If the new owner(s) do not desire to continue such classification or designation, all compensating or additional tax calculated pursuant to RCW 84.33.120 and 140 or RCW 84.34.108 shall be due and payable by the seller or transferor at the time of sale. The county assessor must determine if the land transferred qualifies to continue classification or designation and must so indicate below. Signatures do not necessarily mean the land will remain in classification or designation. If it no longer qualifies, it will be removed and the compensating taxes will be applied. All new owners must sign.

This land [X] does ☐ does not qualify for continuance.

Date 6-1-05 Sue Testo
DEPUTY ASSESSOR

(2) NOTICE OF COMPLIANCE (Chapter 84.26 RCW)

If the new owner(s) of property with special valuation as historic property wish to continue this special valuation the new owner(s) must sign below. If the new owner(s) do not desire to continue such special valuation, all additional tax calculated pursuant to Chapter 84.26 RCW, shall be due and payable by the seller or transferor at the time of sale.

(3) OWNER(S) SIGNATURE

[signature] [signature]
Christine A. Jones Douglas P. Brown
sole limited partners & general partners

7 AFFIDAVIT

I Certify Under Penalty of Perjury Under The Laws of The State of Washington That The Foregoing Is True And Correct. (See back of this form).

Signature of Grantor/Agent [signature]
Name (print) Christine A. Jones
Date and Place of Signing: 5/19/05 Tacoma, WA

Signature of Grantee/Agent [signature]
Name (print) Christine A. Jones
Date & Place of Signing: 5/19/05 Tacoma, WA

Perjury: Perjury is a class C felony which is punishable by imprisonment in the state correctional institution for a maximum term of not more than five years, or by a fine in an amount fixed by the court of not more than five thousand dollars ($5,000.00), or by both imprisonment and fine (RCW 9A.20.020 (1C)).

Rej 6/1 exc 4:30

4085804 3 PGS TREASURER'S USE ONLY

06-06-2005 12:45pm RCAROVA
EXCISE COLLECTED:$0.00
PAT MCCARTHY, AUDITOR
PIERCE COUNTY, WASHINGTON

AFF.FEE:$2.00

[]COUNTY TREASURER
[]DEPT. OF REVENUE
[]COUNTY ASSESSOR
[]TAXPAYER

Beginning at a point on the north line of the Christopher Mahon Donation Claim No. 48, in Sections 15 and 22, Township 19 North, Range 3 East of the W.M., 1374.8 feet, more or less, east of the northwest corner of said Donation Claim and 20 feet east of the southeast corner of Lot 3 in said Section 15; thence south parallel with the quarter section line 1416.03 feet; thence east 251.77 feet; thence north parallel with the quarter section line 1352.19 feet to the center of the County Road; thence South 66°12' East along the center of the County Road to the east line of the west half of said Donation Claim; thence south along said line to a point 900 feet north of the south line of said Donation Claim; thence west parallel with the south line of said Donation Claim 900 feet; thence south 900 feet to the south line of said Donation Claim; thence west on the south line of said Donation Claim to a point 817.2 feet east of the southwest corner of said Donation Claim; thence north parallel with the west line of said Donation Claim 2148 feet to the south line of said Section 15; thence east 570.4 feet, more or less to the south quarter section corner of said Section 15; thence north on the quarter section line 3160.1 feet to the north line of the Donation Claim; thence east 20 feet to the point of beginning.

EXCEPT the following described property:

Beginning at a point 817.2 feet east of the southwest corner of the Christopher Mahon Donation Land Claim No. 48 in Sections 15 and 22, Township 19 North, Range 3 East of the W.M., running thence east along the south line of said Donation Land Claim 200 feet; thence north 310.5 feet; thence northwesterly 55 feet, more or less, to a point 162.4 feet east of a point 350 feet north of point of beginning thence west 162.4 feet; thence south 350 feet to the point of beginning; EXCEPT road.

PARCEL B:

The westerly 80 feet of the following:

Commencing at the southwest corner of the west half of the west half of the east half of the C. Mahon Donation Land Claim No. 48 in Sections 15 and 22, Township 19 North, Range 3 East of the W.M.; thence north along the west line of said subdivision 3040 feet to the point of beginning; thence east 630.5 feet to a point 32 feet west of the east line of the west half of the west half of the east half of said Donation Land Claim; thence north 1430 feet, more or less, to the southwesterly line of the Wiederhold-Headly County Road; thence North 66°12' West along the southwesterly line of road to the west line of the west half of the west half of the east half of said Donation Land Claim; thence south along said line 1720 feet, more or less, to point of beginning; EXCEPT County Road.

PARCEL C:

Commencing at the southeast corner of the west half of the Christopher Mahon Donation Land Claim No. 48 in Section 22, Township 19 North, Range 3 East of the W.M.; thence north along the east line of said west half, 900 feet; thence west parallel with the south line of said Mahon Donation Land Claim, 766 feet to the point of beginning; thence west parallel with the south line of said Mahon Donation Land Claim, 134 feet; thence south 258 feet; thence northeasterly 290 feet, more or less, to the point of beginning.

Sp Use 10811608 40

PLEASE TYPE OR PRINT
PLEASE SEE REVERSE

REAL ESTATE EXCISE TAX AFFIDAVIT

CHAPTER 82.45 RCW – CHAPTER 458-61 WAC
FOR USE AT COUNTY TREASURER'S OFFICE

This form is your receipt when stamped by cashier.

(Use Form No. 84-0001B for Reporting Transfers of Controlling Interest of Entity Ownership to the Department of Revenue)

THIS AFFIDAVIT WILL NOT BE ACCEPTED UNLESS ALL AREAS 1-7 ARE FULLY COMPLETED

1 SELLER GRANTOR
Name THE BROWN FAMILY TRUST DATED 05/08/92, CHARLES J. BROWN & RUTH A. BROWN, TRUSTORS AND/OR TRUSTEES
Street P.O. Box 44959
City/State/Zip Tacoma, WA 98444

2 BUYER GRANTEE
Name BROOKDALE GOLF COURSE ~~LIMITED PARTNERSHIP, a Washington limited partnership~~ L.P.
Street P.O. Box 44959
City/State/Zip Tacoma, WA 98444

3 ADDRESS TO SEND ALL PROPERTY TAX RELATED CORRESPONDENCE
Name GRANTEE
Street
City/State/Zip

ALL TAX PARCEL NUMBERS
0319158700* 0319158701*
0319158002
0319158003
0319225007
0319225700*
0319225701*

COUNTY TREASURER PLACE ASSESSED VALUE IF TAX EXEMPT
1,667,190

4 LEGAL DESCRIPTION OF PROPERTY SITUATED IN ☐ UNINCORPORATED Pierce COUNTY ☐ OR IN CITY OF

Street Address (if property is improved): 1802 Brookdale Road East, Tacoma, WA 98445

LEGAL DESCRIPTIONS ATTACHED HERETO.

5 Is this property currently:

	YES	NO
Classified or designated as forest land? Chapter 84.33 RCW	☐	☒
Classified as current use land (open space, farm and agricultural, or timber)? Chapter 84.34 RCW	☒*	☐
Exempt from property tax as a nonprofit organization? Chapter 84.36 RCW Seller's Exempt Reg. No.	☐	☒
Receiving special valuation as historic property? Chapter 84.26 RCW	☐	☒

Property Type: ☒ land only ☐ land with new building ☐ land with previously used building ☐ land with mobile home ☐ timber only ☐ building only

Principal Use: ☐ Apt. (4+ unit) ☐ residential ☐ timber ☐ agricultural ☐ commercial/industrial ☒ other golf course

6 Description of personal property included in gross selling price, both tangible (eg; furniture, equipment, etc.) or intangible (eg; goodwill, agreement not to compete, etc.)

7779600

If exemption claimed, list WAC number and explanation.

WAC No. (Sec/Sub) 458-61-376(2)(e)

Explanation Section 721 - Partners & Partnerships Nonrecognition of gain or loss on contribution

Type of Document QUIT CLAIM DEED

Date of Document 10/5/99

Gross Selling Price $	0.00
Personal Property (deduct) $	0.00
Taxable Selling Price $	0.00
Excise Tax: State $	0.00
Local $	0.00
Delinquent Interest: State $	0.00
Local $	0.00
Delinquent Penalty $	0.00
Total Due $	0.00

A MINIMUM OF $2.00 IS DUE AS A PROCESSING FEE AND TAX.

8 (1) NOTICE OF CONTINUANCE (RCW 84.33 OR RCW 84.34)

If the new owner(s) of land that is classified or designated as current use or forest land wish to continue the classification or designation of such land, the new owner(s) must sign below. If the new owner(s) do not desire to continue such classification or designation, all compensating or additional tax calculated pursuant to RCW 84.33.120 and 140 or RCW 84.34.108 shall be due and payable by the seller or transferor at the time of sale. The county assessor must determine if the land transferred qualifies to continue classification or designation and must so indicate below. Signatures do not necessarily mean the land will remain in classification or designation. If it no longer qualifies, it will be removed and the compensating taxes will be applied. All new owners must sign.

This land ☒ does ☐ does not qualify for continuance.

Date 10-8-99 Sue Testo
DEPUTY ASSESSOR

(2) NOTICE OF COMPLIANCE (Chapter 84.26 RCW)

If the new owner(s) of property with special valuation as historic property wish to continue this special valuation the new owner(s) must sign below. If the new owner(s) do not desire to continue such special valuation, all additional tax calculated pursuant to Chapter 84.26 RCW, shall be due and payable by the seller or transferor at the time of sale.

(3) OWNER(S) SIGNATURE

Charles J. Brown Ruth A. Brown

CHARLES J. BROWN, Partner RUTH A. BROWN, Partner

7 AFFIDAVIT

I Certify Under Penalty of Perjury Under The Laws of The State of Washington That The Foregoing Is True And Correct. (See back of this form).

Signature of Grantor/Agent Charles J. Brown
Name (print) CHARLES J. BROWN
Date and Place of Signing: Yelm, WA 10/5/99

Signature of Grantee/Agent Charles J. Brown
Name (print) CHARLES J. BROWN
Date & Place of Signing: Yelm, WA 10/5/99

Perjury: Perjury is a class C felony which is punishable by imprisonment in the state correctional institution for a maximum term of not more than five years, or by a fine in an amount fixed by the court of not more than five thousand dollars ($5,000.00), or by both imprisonment and fine (RCW 9A.20.020 (1C)).

FOR TREASURER'S USE ONLY

COUNTY TREASURER

REV 84 0001a (3-18-99) (PD 4-01-99)

ETN: 1011608 10-8-1999
Excise Tax Collected: $0.00
Affidavit Processing Fee: $2.00
Cathy Pearsall-Stipek CPO Pierce County Auditor
BY: LISA DRURY

0319158700, 0319158002, 0319158003, 0319225007, 0319225700, 0319225701, 0319158701

PARCEL A:

Beginning at a point on the north line of the Christopher Mahon Donation Claim No. 48, in Sections 15 and 22, Township 19 North, Range 3 East of the W.M., 1374.8 feet, more or less, east of the northwest corner of said Donation Claim and 20 feet east of the southeast corner of Lot 3 in said Section 15; thence south parallel with the quarter section line 1416.03 feet; thence east 251.77 feet; thence north parallel with the quarter section line 1352.19 feet to the center of the County Road; thence South 66°12' East along the center of the County Road to the east line of the west half of said Donation Claim; thence south along said line to a point 900 feet north of the south line of said Donation Claim; thence west parallel with the south line of said Donation Claim 900 feet; thence south 900 feet to the south line of said Donation Claim; thence west on the south line of said Donation Claim to a point 817.2 feet east of the southwest corner of said Donation Claim; thence north parallel with the west line of said Donation Claim 2148 feet to the south line of said Section 15; thence east 570.4 feet, more or less to the south quarter section corner of said Section 15; thence north on the quarter section line 3160.1 feet to the north line of the Donation Claim; thence east 20 feet to the point of beginning;

EXCEPT the following described property:

Beginning at a point 817.2 feet east of the southwest corner of the Christopher Mahon Donation Land Claim No. 48 in Sections 15 and 22, Township 19 North, Range 3 East of the W.M., running thence east along the south line of said Donation Land Claim 200 feet; thence north 310.5 feet; thence northwesterly 55 feet, more or less, to a point 162.4 feet east of a point 350 feet north of point of beginning thence west 162.4 feet; thence south 350 feet to the point of beginning; EXCEPT road.

PARCEL B:

The westerly 80 feet of the following:

Commencing at the southwest corner of the west half of the west half of the east half of the C. Mahon Donation Land Claim No. 48 in Sections 15 and 22, Township 19 North, Range 3 East of the W.M.; thence north along the west line of said subdivision 3040 feet to the point of beginning; thence east 630.5 feet to a point 32 feet west of the east line of the west half of the west half of the east half of said Donation Land Claim; thence north 1430 feet, more or less, to the southwesterly line of the Wiederhold-Headly County Road; thence North 66°12' West along the southwesterly line of road to the west line of the west half of the west half of the east half of said Donation Land Claim; thence south along said line 1720 feet, more or less, to point of beginning; EXCEPT County Road.

PARCEL C:

Commencing at the southeast corner of the west half of the Christopher Mahon Donation Land Claim No. 48 in Section 22, Township 19 North, Range 3 East of the W.M.; thence north along the east line of said west half, 900 feet; thence west parallel with the south line of said Mahon Donation Land Claim, 766 feet to the point of beginning; thence west parallel with the south line of said Mahon Donation Land Claim, 134 feet; thence south 258 feet; thence northeasterly 290 feet, more or less, to the point of beginning.

BROOKDALE GOLF LLC

UBI Number	602172847
Category	LLC
Active/Inactive	Active
State Of Incorporation	WA
WA Filing Date	01/07/2002
Expiration Date	01/31/2018
Inactive Date	
Duration	Perpetual
Registered Agent Information	
Agent Name	LOREN COMBS
Address	225 TACOMA AVE S
City	TACOMA
State	WA
ZIP	984020000
Special Address Information	
Address	
City	
State	
Zip	

Governing Persons (as defined in RCW 23.95.105 (12) (http://app.leg.wa.gov/RCW/supdefault.aspx?cite=23.95.105))

Title	Name	Address
Governor	JONES , CHRISTINE ←	
Governor	BROWN , DOUGLAS ←	

Lt. Blue 73

PIERCE COUNTY

COUNTY-CITY BUILDING

TACOMA, WASHINGTON

Office of Pierce County Assessor
KEN JOHNSTON

September 28, 1972

CASE # OS-004-72

AUD. FEE # 2463739

Board of Commissioners
Room 1046
County City Building

This letter is to acknowledge the receipt of the Open Space taxation agreement for classification of lands under the provisions of Chapter 84.34 R.C.W.

This agreement is between Charles J. Brown & Ruth Brown, the owner, and Pierce County, the granting authority.

Very truly yours,

Carl N. Hansen
Director of Timber and
Open Space Appraisals

NRC:ln

03-19-15-1-020 + 4-000
03-19-22-1-000
03-19-22-1-011 + 2-000

FILED
RICHARD A. GRECO
SEP 6 1972
COUNTY AUDITOR
Clerk of
Board of County Commissioners

Prepare in Triplicate
with one completed copy
to each of the following:
Applicant
Legislative Body
County Assessor

OPEN SPACE TAXATION AGREEMENT

This Agreement between CHARLES J. BROWN and RUTH BROWN (Case No. OS-004-72)

1821 Brookdale Rd. E., Tacoma, Washington 98445 hereinafter called the "owner",

and (insert city or county) Pierce County

2463739

SEP 8 1972

Whereas the owner of the following described real property having made application for classification of that property under the provisions of RCW 84.34,

And whereas, both the owner and legislative authority desire to limit the use of said property, recognizing that such land has substantial public value as open space and that the preservation of such land constitutes an important physical, social, esthetic and economic asset to the public, and both parties agree that the classification of the property during the life of this Agreement shall be for:

OPEN SPACE

(Open Space, Farm and Agricultural, Timber Land)

Now, therefore, the parties, in consideration of the mutual covenants and conditions set forth herein, do agree as follows:

(1) During the term of this Agreement, the land shall only be used in accordance with the preservation of its classified use.

(2) No structures shall be erected upon such land except those directly related to, and compatible with the classified use of the land, or except those residence buildings for such individuals as are engaged in the care, use, operation or management of said land.

(3) This Agreement shall be effective commencing on the date the legislative body receives the signed Agreement from the property owner, and shall remain in effect for a period of at least ten (10) years.

(4) This Agreement shall run with the land described herein and shall be binding upon the heirs, successors and assigns of the parties hereto.

(5) Withdrawal: The land owner may withdraw from this Agreement if after a period of seven years the land owner makes a withdrawal request which request is irrevocable, to the assessor. Three years from the date of that request the assessor shall withdraw the land from the classification, and the applicable taxes and interest shall be imposed as provided in RCW 84.34.070.

(6) Breach: After land has been classified and an Agreement executed, any change of the use of the land, except through compliance with items (5), (7) or (8) of this Agreement, shall be considered a breach of this Agreement, and subject to applicable taxes, penalties and interest as provided in RCW 84.34.080.

(7) A breach of Agreement shall not occur if the change in use results from the sale of land classified under this Act within two years after the death of the owner of at least fifty percent of such land.

(8) Eminent Domain: When any permissible action in eminent domain for the condemnation of the fee title of the land under agreement is filed or when such land is acquired as a result of a sale to a public body, this Agreement shall be null and void as of the date the action is filed and thereafter the Agreement shall not be binding on any party to it.

(9) The County Assessor may require reports from classified land owners. If the owner fails to return a required report within ninety days, the Assessor may declare the Agreement in breach.

Legal Description of classified land:

149.85 acres

See attached legal description.

This Agreement shall be subject to the following conditions:

Subject to continued public access.

The land use classified under RCW 84.34 (Current Use Taxation) may not change on any portion of the subject property. Any partial change in land use will subject the entire property, covered under this agreement, to a rollback and penalty.

It is declared that this Agreement contains the classification and conditions as provided for in RCW ~~84.36~~ 84.34 and the conditions imposed by this Legislative Authority.

Dated SEP 6 1972

Legislative Authority:

PIERCE COUNTY
City or County

By George Sheridan — Chairman
Board of Pierce County Commissioners — Title

As owner(s) of the herein described land I (we) indicate by my (our) signature(s) that I (we) are aware of the potential tax liability and hereby accept the classification and conditions of this Agreement.

Dated Sept 5, 1972

Charles J. Brown
Owner(s)

Ruth Brown

(Must be signed by all Owners)

Subscribed and sworn to before me this

5th day of Sept., 1972

Evelyn L. Ballard
Notary Public

Date signed Agreement received by Legislative Authority SEP 6 1972

Re: OS-004-72 (Charles J. and Ruth Brown)

Parcel No. 03-19-22-1-000:

Beg at a pt on E li of W 1/2 of Mahon DLC 900 ft N of S li of sd DLC in Sec 22-19-3E th W to W li of NE of Sec th N alg sd W li to NW cor of NE th E alg N li of NE of Sec to E li of W 1/2 of Mahon DLC th S alg sd E li to beg.

Parcel No. 03-19-15-1-020 & 4/000:

Beg at a pt on N li of Mahon DLC 1374.8 ft E of NW cor of sd DLC & 20 ft E of SE cor of Lot 3 in Sec 15-19-3E th S par with 1/4 Sec li 1416.03 ft th E 251.77 ft th N 1352.19 ft to C/L of Co. Rd. th S 66 deg 12 min E alg sd C/L to E li of W 1/2 of sd DLC th S alg sd E li to S li of Sec th W alg sd S li to SW cor of SE of Sec th N to N li of sd DLC th E to P.O.B. R/W for Access to Mayfair Co. Park.

Parcel No. 03-19-22-1-011 & 2/000:

Com at a pt on E li of W 1/2 of Mahon DLC 900 ft N of S li of sd DLC in Sec 22-19-3E th W 900 ft to true P.O.B th S 900 ft to S li of sd DLC th W on sd S li to a pt 1017.2 ft E of SW cor of sd DLC th N 310.5 ft th NWly 55 ft m/l to a pt 162.4' ft E of pt 350 ft N and 817.2 ft E of SW cor of sd DLC th W 162.4 ft th N par/w W li of sd DLC 1799 ft m/l to N li of Sec th E 570.4 ft m/l to N 1/4 Sec cor of sd sec th S alg N & S C/L of SEC to a pt W of P.O.B th E to P.O.B.

FOR ASSESSORS USE ONLY

Received by ________________

Date ________________

Amount of Fee ________________

Transmitted to ________________

____

Date of Transmittal ________________

File in Triplicate
No. 1 - Legislative Body
No. 2 - Assessor
No. 3 - Applicant

APPLICATION FOR LAND CLASSIFICATION UNDER RCW 84.34
OPEN SPACE, AGRICULTURAL OR TIMBER LANDS CURRENT USE ASSESSMENT

Name of Applicant CHARLES J. BROWN LE74400

Address 1821 BROOKDALE Rd. E. TACOMA, WA. LE1-1755

Property Location 1802 BROOKDALE Rd. E. TACOMA, WA - 98445

Interest in Property: Fee Owner ________ Contract Purchaser X

Other (Describe Interest) ________________

Legal description of land to be classified: (Include map of property showing location on all improvements)

____

This application may cover more than one parcel, and/or land on which appurtenances necessary to the production, preparation or sale of the agricultural products exist in conjunction with the lands producing such products and/or parcels of one to five acres, which are not contiguous but which otherwise constitute an integral part of the farming operation.

Lands with current use of (1) open space, (2) farm and agricultural, or (3) timber land may be listed on the same application but a legal description must be shown for each classification.

Total acres in classification request 147 ACRES (219.28) 225.28 ac.

Is the land subject to lease or option or other agreement which permits any other use than its present use? Yes ______ No X (Attach copy of lease or option or other agreement

____

Describe completely the current use of each parcel of land in classification request ____

GOLF COURSE

Describe all present improvements (Buildings, etc.) ________________

The PAVING OF PARKING LOT. Added A SMALL PRO-SHOP. Added NEW MEN'S BATHROOM FACILITIES

If application is made for farm and agricultural classification, check which of the following categories apply:

A. _____ Farm and agricultural lands of twenty (20) or more acres.

B. _____ Farm and agricultural lands of five (5) or more acres but less than twenty (20) acres.

Lands which are in category B must have produced a gross income of $100 or more per acre per year for three of the last five calendar years. Attach documentation showing the land has achieved this production level.

C. _____ Farm and agricultural lands of less than five (5) acres.

Lands which are in category C must have produced a gross income of $1,000 or more per year for three of the last five calendar years. Attach documentation showing the land has achieved this production level.

I declare under the penalties for perjury that this application and any attached documents have been examined by me, and to the best of my knowledge constitute a true, correct, and complete statement. I hereby agree to furnish such additional information as may be required by the Legislative Body concerning the current use of the land to be classified.

Owner(s) or Contract Purchaser(s)

Charles J. Brown

Ruth Brown

____

____

Subscribed and sworn to before me this 18th day of Oct 1971

Claire M. Neal

Notary Public in and for the State of Wash

Residing at Tacoma

____

FOR GRANTING AUTHORITY USE ONLY

Date Received _____________ By _____________________

Amount of Application Fee _____________________

Application for Classification:

Approved _______; Approved in Part _______; Denied _______

Owner Notified of Denial on _____________________

Agreement Executed and Mailed to Owner on _____________________

Land Areas Approved for Classification: _____________________

____

Conditions Imposed: _____________________

____

Signed Agreement Received from Property Owner on _____________________

Agreement Transmitted to Assessor on _____________________

____

Signature of Granting Authority

1971 PIERCE COUNTY ASSESSOR'S ROLL

	Legal Description	Land Acres	Land Value	Improvements	Aggregate Valuation	Area Code	Name and Address of Taxpayer	Parcel Number
1538572 7C JT	35.94 AC. 22-19-03E 1/000 MAHON DLC 900 FT N OF S LI OF SD OF NE OF SEC TH N ALG SD W LI TO OF SEC TO E LI OF W 1/2 OF MAHON BEG AT A PT ON E LI OF W 1/2 OF DLC IN SEC 22 19 3E TH W TO W LI NW COR OF NE TH E ALG N LI OF NE DLC TH S ALG SD E LI TO BEG	35.94	10,780	29,700	40,480	755	BROWN CHARLES J 1802 BROOKDALE RD E TACOMA WASHINGTON 98445 BROWN CHARLES J yes	03-19-22-1-00
460,000 2302610 7C BL	18.22 AC. 22-19-03E 1/001 TH N 900 FT TH W 766 FT TO A PT 134 FT W & 266 FT S OF SD PT -A- SEG E 8452 BEG AT SE COR W 1/2 OF C MAHON DLC DESIGNATED -A- TH SWLY TO A PT TH S 634 FT TH E 900 FT TO BEG no	18.22	14,580	1,080	15,660	760	BROWN CHARLES J & RUTH 1821 BROOKDALE RD E TACOMA WASHINGTON 98445 BROWN CHARLES J & RUTH yes	03-19-22-1-00
7C BL	10.00 AC. 22-19-03E 1/005 10 AC OF LOT 4 EXCEPT 152ND ST E SEE NEW DESC. SEE NEW DESC. SEE NEW DESC.	10.00	10,000	7,640	17,640	760	MCCULLOUGH L C 1623 152ND ST E TACOMA WASHINGTON 98445 MCCULLOUGH L C SEE NEW DESC.	G-2504 ~~03-19-22-1-00~~ SEE NEW DESC.
16,000 652172 C BL	17.67 AC. 22-19-03E 1/006 E 1/2 OF MAHON DLC IN NE OF POB TH E 662.5 FT TH N TO N LI OF OF W 1/2 OF W 1/2 OF E 1/2 OF SD COM AT SW COR OF W 1/2 OF W 1/2 OF SEC 22 19 3E TH N 1072.26 FT TO NE OF SEC TH W ALG SD N LI TO W LI DLC TH S ALG SD W LI TO POB	17.67	16,140		16,140	755	IRWIN JOHN D 3830 S 94TH ST TACOMA WASHINGTON 98499 IRWIN JOHN D	03-19-22-1-00
60,000 302610 C BL	.38 AC. 22-19-03E 1/007 N 477 FT M/L TO N LI SD LOT 4 W EXC 152ND ST E BEG SW COR OF MIDDLE 5 AC OF LOT 4 33 FT S 477 FT M/L E 33 FT TO BEG	.38	260		260	760	BROWN CHARLES J & RUTH 1821 BROOKDALE RD E TACOMA WASHINGTON 98445 BROWN CHARLES J & RUTH no	03-19-22-1-007
	22-19-03E 1/010 ASSESSED WITH DIA 4/7 15 19 3E					760	REFERENCE REFERENCE	03-19-22-1-010
936572 WM	36.15 AC. 22-19-03E 1/011 OF MAHON DLC 900 FT N OF S LI OF TO TRUE POB TH S 900 FT TO S LI OF 1017.2 FT E OF SW COR OF SD DLC TH PT 182.4 FT E OF PT 350 FT N & & 2 COM AT A PT ON E LI OF W 1/2 SD DLC IN SEC 22 19 3E TH W 900 FT SD DLC TH W ON SD S LI TO A PT N 310.5 FT TH NWLY 55 FT M/L TO A 817.2 FT E OF SW COR OF SD DLC TH	36.15	10,850		10,850	760	BROWN CHARLES J 1802 BROOKDALE RD E TACOMA WASHINGTON 98445 BROWN CHARLES J yes	03-19-22-1-011

	Acres	Land Value	Improvements	Aggregate Valuation	Area Code	Description	Name and Address of Taxpayer	Parcel Number
1441103 70 BL	5.00	4,200		4,200	720	5.00 AC. 15-19-03E 1/016 E 5 AC LOT 1 SUBJ TO & INCL EASE	INMAN GRACE V 3038 37TH AVE W SEATTLE WASH 98199 INMAN GRACE V	03-19-15-1
40,500 2069541 70 BL	11.12	7,870	18,550	26,420	720	11.12 AC. 15-19-03E 1/018 , 4/8 BEG 1927.8 FT W OF NE COR OF C MAHON DLC TH S 327.54 FT TH W 125 FT TH S 21 DEG 00 MIN 52 SEC W 406.42 FT TO C/L OF WIEDERHULD HEADLY CO RD TH NWLY ALG SD C/L TO INTER C/L OF GIVENS CHESNEY CO RD AS CYD TO P CO 5 10 56 1755245 TH NELY ALG SD C/L TO INTER C/L OF CHESNEY RD EAST TH E ALG SD C/L TO BEG EXC RDS	BROWN C J 1802 E BROOKDALE RD TACOMA WASHINGTON 98445 BROWN C J no	03-19-15-1
0034883 70 BL	8.00	6,000	3,460	9,460	720	8.00 AC. 15-19-03E 1/019 , 4/1 BEG 1374.8 FT E OF NW COR MAHON DLC S PAR & 20 FT E OF N & S C OF SEC 1416.03 FT E 251.77 FT N 1352.19 FT TO CENT OF CO RD N 75 DEG 45 MIN W 259 FT TO BEG SEE NEW DESC. SEE NEW DESC. SEE NEW DESC.	POLLOCK K S 1406 BROOKDALE RD E TACOMA WASHINGTON 98445 KRAUSE J & F SEE NEW DESC.	~~03-19-15-1~~
1938572 70 BL	77.76	27,310		27,310	720	77.76 AC. 15-19-03E 1/020 & 4 BEG AT A PT ON N LI OF MAHON DLC 1374.8 FT E OF NW COR OF SD DLC & 20 FT E OF SE COR OF LOT 3 IN SEC 15 19 3E TH S PAR WITH 1/4 SEC LI 1416.03 FT TH E 251.77 FT TH N 1352.19 FT TO C/L OF CO RD TH S 66 DEG 12 MIN E ALG SD C/L TO E LI OF W 1/2 OF SD DLC TH S ALG SD E LI TO S LI OF SEC TH W ALG SD S LI TO SW COR OF SE OF SEC TH N TO N LI OF SD DLC TH E 20 FT TO POB R/W FOR ACCESS TO MAYFAIR COUNTY PARK	BROWN CHARLES J 1802 BROOKDALE RD E TACOMA WASHINGTON 98445 BROWN CHARLES J yes	03-19-15-1-
5,500 2001347 70 BL	5.00	3,800	11,300	15,100	720	5.00 AC. 15-19-03E 1/022 E 1/2 OF W 1/2 OF NW OF NW OF NE ALSO NW OF SW OF NW OF NE EXC RDS	HARKINS JAMES J %PACIFIC NATL BK OF WASH-BRANCHES HARKINS JAMES J	03-19-15-1-
	2.50	2,500	2,950	5,450	720	2.50 AC. 15-19-03E 1/023 E 1/2 OF E 1/2 OF NW OF NW OF NE SEE NEW DESC SEE NEW DESC SEE NEW DESC	PETERSON RUSSELL 1522 E COLLINS TACOMA WASHINGTON 98445 PETERSON RUSSELL SEE NEW DESC	~~03-19-15-1-~~

E 1/2 OF SD DLC TH N TO BEG SUBJ TO EASE FOR RD ON W 12 FT

16,000 | 6.13 | 6,130 | 12,490 | 18,620 | 720

1652172 70 BL

6.13 AC. 15-19-03E 4/005
E 1/2 OF MAHON DLC IN NE OF SUBD TO INTER S LI OF SE OF LI OF SE OF SEC 15 662.5 FT TH N 1400 FT M/L TO SWLY LI OF
COM AT SW COR OF W 1/2 OF W 1/2 OF SEC 22 19 3E TH N ALG W LI OF SD SEC 15 19 3E & TRUE POB TH E ALG S TO C/L OF CLOVER CREEK TH CONT N WIEDERHOLD CO RD TH NWLY ALG SD RD

IRWIN JOHN D
3830 S 94TH
TACOMA WASHINGTON 98499
IRWIN JOHN D

03-19-15-4

TO A LI PAR TO & 16 FT W OF E LI DLC TH S ALG SD LI TO C/L OF CREEK TO A PT N OF POB TH S TO POB
OF W 1/2 OF W 1/2 OF E 1/2 OF SD CLOVER CREEK TH WLY ALG SD C/L OF

221,500 | 3.15 | 720 | | 720 | 720

1938572 70 BL

3.15 AC. 15-19-03E 4/006
W 1/2 OF W 1/2 OF E 1/2 OF C MAHON 3040 FT TO POB TH E 630.5 FT TO A W 1/2 OF E 1/2 OF SD DLC TH N WIEDERHOLD HEADLY CO RD TH N
WLY 80 FT OF FOLL COM AT SW COR OF DLC TH N ALG W LI OF SD SUBD PT 32 FT W OF E LI OF W 1/2 OF 1430 FT M/L TO SWLY LI OF 66 DEG 12 MIN W ALG SD SWLY LI TO

BROWN C J
1821 BROOKDALE RD E
TACOMA WASHINGTON 98445
BROWN C J

yes . no

03-19-15-4

W LI OF W 1/2 OF W 1/2 OF E 1/2 OF SD DLC TH S ALG SD W LI 1720 FT M/L TO POB

8.01 | 6,410 | | 6,410 | 720

70 BL

8.01 AC. 15-19-03E 4/007
2070 FT N OF SE COR MAHON DLC W CREEK NELY ALG CENT SD CREEK TO PT
22 19 3E 2 D 1/10 BEG 1325 FT W & 660 FT N 478 FT TO CENT OF CLOVER 578 FT N OF BEG S 578 FT TO BEG

SCHWEINLER E B
1256 S AINSWORTH
TACOMA WASHINGTON 98405
SCHWEINLER HAROLD C

03-19-15-4

720

15-19-03E 4/008 ASSESSED WITH D 1/18

03-19-15-4

11,000 | 19.65 | 14,260 | 1,760 | 16,020 | 720

1701387 70 BL

19.65 AC. 15-19-03E 4/009
E 1/2 OF C MAHON DLC TH N ALG W LI 630.5 FT TO A PT 32 FT W OF E LI DLC TH N 1430 FT M/L TO SWLY LI OF 66 DEG 12 MIN W ALG SD SWLY LI TO
COM AT SW COR OF W 1/2 OF W 1/2 OF OF SD SUBD 3040 FT TO POB TH E OF W 1/2 OF W 1/2 OF E 1/2 OF SAID WIEDERHOLD HEADLY CO RD TH N W LI OF W 1/2 OF W 1/2 OF E 1/2 OF

IRWIN JOHN D
3830 S 94TH
TACOMA WASHINGTON 98499
IRWIN JOHN D

03-19-15-4

REFERENCE

1938572 70 WM | 36.15 | 10,850 | 10,850 | 760

36.15 AC. 22-19-03E 1/011 & 2 COM AT A PT ON E LI OF W 1/2
OF MAHON DLC 900 FT N OF S LI OF SD DLC IN SEC 22 19 3E TH W 900 FT
TO TRUE POB TH S 900 FT TO S LI OF SD DLC TH W ON SD S LI TO A PT
1017.2 FT E OF SW COR OF SD DLC TH N 310.5 FT TH NWLY 55 FT M/L TO A
PT 162.4 FT E OF PT 350 FT N & 817.2 FT E OF SW COR OF SD DLC TH

BROWN CHARLES J
1802 BROOKDALE RD E
TACOMA WASHINGTON 98445
BROWN CHARLES J
03-19-22-1

W 162.4 FT TH N PAR WITH W LI OF SD DLC 1799 FT M/L TO N LI OF SEC
TH E 570.4 FT M/L TO N 1/4 SEC COR OF SD SEC TH S ALG N & S C/L OF
SEC TO A PT W OF POB TH E TO POB

22,000 | 2300874 70 CW | 1.14 | 2,420 | 8,020 | 10,440 | 760

1.14 AC. 22-19-03E 1/012 COM AT CENT OF SEC TH S 88 DEG
51 MIN 10 SEC E ALG E & W C/L OF SEC 154.03 FT TO POB TH N 01 DEG
04 MIN 50 SEC E 265 FT TH N 55 DEG 23 MIN 08 SEC E 52.31 FT TH N
01 DEG 04 MIN 50 SEC E 187.44 FT TO S LI OF C MAHON DLC TH S 89 DEG
24 MIN 22 SEC E ALG SD S LI 120 FT TO W LI OF PRI RD CYD TO M MAHON D

SMITH O B & RUTH I
7006 S PUGET SOUND
TACOMA WASHINGTON 98409
SMITH O B & RUTH I
03-19-22-1

REC UNDER AUD FEE # 362800 TH S 01 DEG 04 MIN 50 SEC W ALG SD W LI
OF RD 344.10 FT TH N 88 DEG 51 MIN 10 SEC W PAR WITH SD C/L OF SEC
142.53 FT TH S 01 DEG 04 MIN 50 SEC W 140 FT TO SD C/L OF SEC
TH N 88 DEG 51 MIN 10 SEC W ALG SD C/L 20 FT TO POB EXC S 30 FT FOR
CO RD

2085333 70 CW | .36 | 1,700 | 12,880 | 14,580 | 760

.36 AC. 22-19-03E 1/013 COM AT CENT OF SEC TH S 88 DEG
51 MIN 10 SEC E ALG SD C/L 174.03 FT TO POB TH N 01 DEG
04 MIN 50 SEC E 140 FT TH S 88 DEG 51 MIN 10 SEC E PAR TO SD C/L
142.53 FT TO W LI OF PRI RD REC UNDER FEE # 362800 TH S 01 DEG
04 MIN 50 SEC W ALG SD W LI OF RD 140 FT TO SD C/L OF SEC TH N

AHRENDSEN AHREND C
1423 E 152ND ST
TACOMA WASHINGTON 98445
AHRENDSEN AHREND C
03-19-22-1

88 DEG 51 MIN 10 SEC W ALG SD C/L 142.53 FT TO POB EXC S 30 FT FOR
CO RD

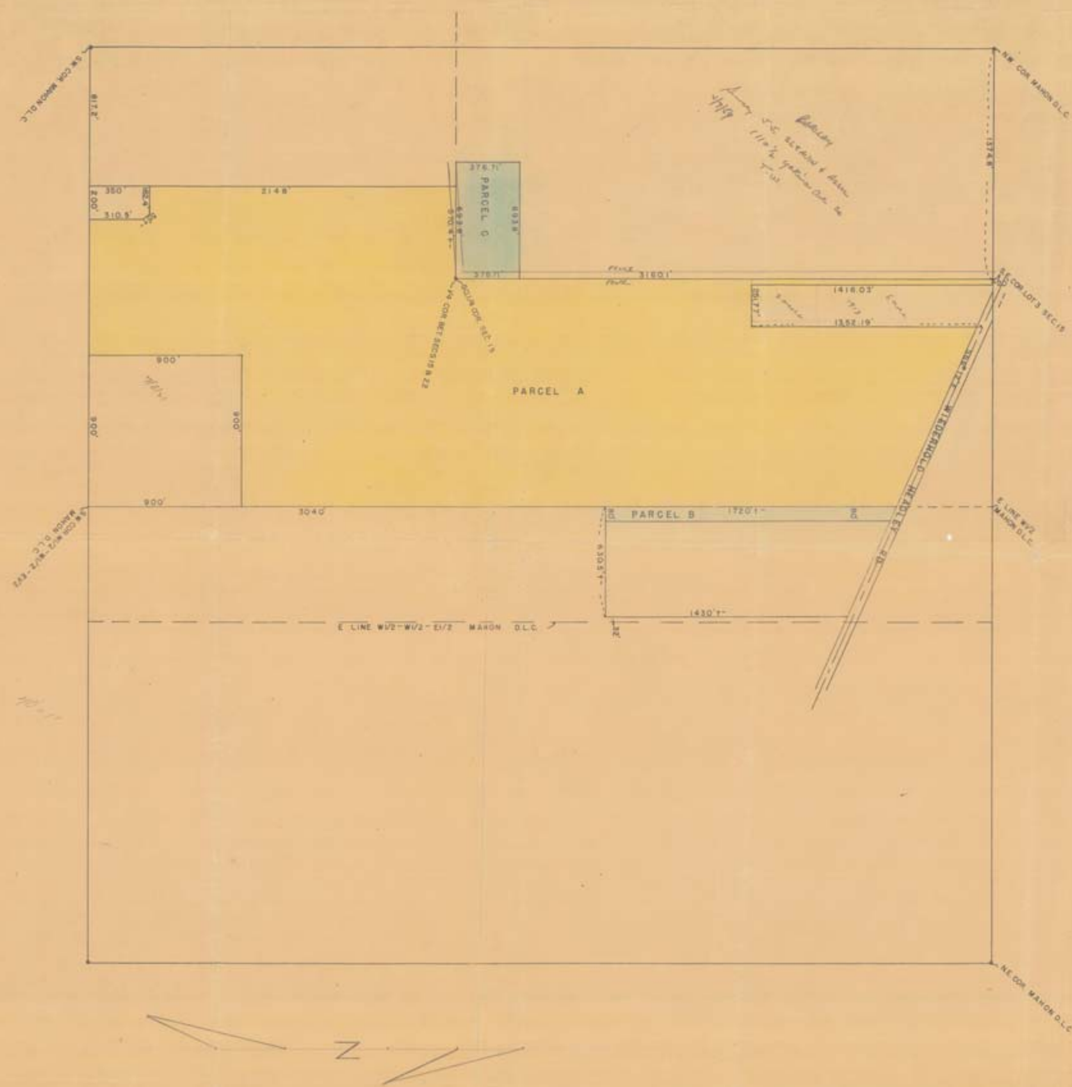
750 | 2146599 | .41 | 300 | 300 | 750

.41 AC. 22-19-03E 1/015 COM AT SE COR OF W 1/2 OF C MAHON
DLC & 4- TH N ALG E LI OF SD W 1/2 900 FT TH W PAR WITH S LI OF SD
MAHON DLC 780 FT TO POB TH W PAR WITH S LI OF SD MAHON DLC 134 FT
TH S ... FT TH NELY 290 FT M/L TO POB SEG E 8452

BROWN CHARLES J & RUTH
1821 BROOKDALE RD E
TACOMA WASHINGTON 98445
BROWN CHARLES J & RUTH
03-19-22-1

no

yes



PARCEL A
PARCEL B
PARCEL C
N.W. COR. MAHON D.L.C.
S.E. COR. LOT 3 SEC. 15
NE COR. MAHON D.L.C.
E LINE W1/2 - W1/2 - E1/2 MAHON D.L.C.
N
214.8'
316.01'
1416.03'
1352.19'
900'
304.0'
350'
310.9'
376.1'
1430'±

2001

OWNER: BROOKDALE GOLF LLC
ADDRESS:

APPLICANT: BROWN, CHARLES
CASE NO: OS 004-72
AUD. FEE. NO.: 2463739

OPEN SPACE CATEGORY	PARCEL NUMBER
OPEN SPACE	03-19-15-8700

DESCRIPTION:

AREA CODE	USE CODE	CARD NO.
515	9400	___ OF ___

1973 ACRES: 69.85

MEMORANDA

MARKET VALUE RECORD

COMMENTS	YEAR	LAND VALUE	BLDG. VALUE	APPRAISER
	2002	918,900	793,800 ← HOLES & STRUCTURES	
	2003	946,500	868,500	
	2004	946,500	845,800	
	2005	1,041,100	970,900	
	2006	1,376,900	942,000	
	20			
	20			
	20			
	20			
	20			
	20			
	20			
	20			
	20			
	20			
	20			
	20			
	20			

CURRENT USE VALUE RECORD

CLASS	ACREAGE		RATE	2002	20	20	20	20	20	20	20	20	20
OPENSPACE	69	85	1000	69,850									
				1st per hole value included as IMP									
LAND IMP.													
TOTALS	69	85		69,850									

Z-2240 rev. 6/00

OWNER: ~~BROWN, CHARLES J.~~ BROOKDALE GOLF LLC
ADDRESS: 1802 BROOKDALE RD. E.
BROOKDALE GOLF COURSE
TACOMA, WA. 98445
APPLICANT:
CASE NO: O.S. 004 - 72
AUD. FEE NO.: 2463739
CURRENT USE RCW 84.34

OPEN SPACE CATEGORY	PARCEL NUMBER 8-700
OPEN SPACE	03-19-15-1-~~020~~ 702

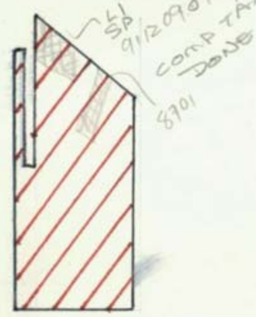
DESCRIPTION: PT. S 3/4 W1/2 E1/2 SEC. 15, T. 19N., R. 3E.
LZ SP 9112090414 SEG E 0417 SEG F 0328

AREA CODE	USE CODE	CARD NO.
515.0	7701	1 OF 1

1973

ACRES: ~~77.76~~ ~~73.63~~ 69.85 ~~10~~

MEMORANDA



OPEN SPACE 77.76 ACS

(9 HOLES)

MARKET VALUE RECORD

COMMENTS: NCI 5600

WILL NEED TO KNOW STRUCTURE VALUES + SUBTRACT THAT FROM THIS TOTAL

found no prop rec card 7-98

YEAR	LAND VALUE	HOLES	BLDG
19 84	~~1,590,054~~ 11,814	(87,746)	
19 85	~~1,422,680~~ 1,552,600	(87,761)	
19 86	~~1,625,900~~ 1,543	(109,316)	
19 87	~~1,463,300~~	(172,440)	
19	1,253,300 2290,826		
19 92	~~2,309,300~~		
19	+ hole val 129,955	(79,345)	
19 94	1,654,000 total less hole val	. 720,700 .	
19	(935,300)		
19 95	1,764 300 total less 720 700 tax hole val.		
19 98	1,060,700	HOLE VALUE: 599000	BLDG VAL: 104,600
19 99	993,700	HOLE VALUES 658,800	BLDG 111,800
~~19~~ 2000	987,900	HOLES 830,100	BLDG 157,800
19 2001	918,900	HOLES 642,600	BLDG 151,200
→ 19 2002	918,900	793,800 ←	HOLES + STRUCTURES
19 2003	946,500	868 500 ←	" "
19 2004	946 500	845,800	
19 2005	1,041,100	970,900	

LAND = 993,700
LAND = 776,400

CURRENT USE VALUE RECORD

CLASS	ACREAGE		RATE	19 84	19 85	19 86	19 87	19 92	19 94	19 98	19 99	~~19~~ 2000	~~19~~ 2001
O. SPACE	~~77~~	76	1,000	~~77,760~~	77,760	77,760	77,760	~~73,630~~					
	~~73~~	~~63~~		73,630	~~73,630~~	~~73,630~~	~~73,630~~						
		~~10~~		73,100	73,100	73,100	73,100	73,100	73,100				
	69.	85								69,850	69850	69,850	69,850
LAND IMP.			HOLES *	167,454	* 167,454	* 199,584	175,590	129,955	720,700	599,000	658,800	830,100	642,600
TOTALS	~~77~~	~~76~~		~~246,214~~ 241,084	~~245,214~~ ~~241,084~~ 240,554	~~277,344~~ ~~273,214~~ 272,684	~~253,350~~ ~~249,220~~ 248,690	~~203,585~~ 203,055	793,800	668,850	728,650	899,950	712,450
	~~73~~	~~63.~~											

Z-2240

CONSTRUCTION SPECIFICATIONS AND BUILDING RECORD

OCCUPANCY

1 VAC. LOT	2 DWELLING	3 OTHER

BASEMENT

1 NONE	2 CRAWL	3 PART	4 HALF	5 FULL

SIZE

HEATING

1 NONE	2 BASIC	3 EXTRA

WARM AIR—F OR G		
ELEC.—RADIANT OR BASEBOARD		
HOT WATER OR STEAM		
HOT WATER OR STEAM RADIANT		
HEAT PUMP		
UNIT HEATERS		

PLUMBING

PLUMBING POINTS [ ]__		
STANDARD		
BATHROOM		
HALF BATH		
OTHER		
NO PLUMBING		

ATTIC

1 NONE	2 UNFIN.	3 PART	4 FULL

WALLS

FRAME/STUCCO	
CONCRETE BLOCK	
BRICK/STONE	
PLATE GLASS FRONT	

ROOF

SHINGLE—ASPH./ASB./WOOD	
SLATE/TILE/METAL	
COMP ON WOOD FRAME	
COMP ON STEEL FRAME	

FLOORS

	B	1	2	3
CONCRETE				
WOOD				
TILE				
WD/STL. FRAME				
REIN. CONCRETE				

INTERIOR FINISH

	B	1	2	3
PLASTER/DRYWALL				
WOOD PANELING				
FIBERBOARD				
UNFINISHED				
CONDITION				

NUMBER OF ROOMS

LIV.		DIN.		KIT.		BA.	
BEDROOMS				FAMILY ROOM			

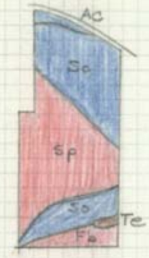
OTHER FEATURES

FINISHED BASEMENT				
FIREPLACE				
AIR CONDITIONING				
DAYLIGHT BSMT.				

COMMERCIAL COMPUTATIONS

WL. HT.			
	BSMT.		
	1ST FLOOR		
	2ND FLOOR		
	3RD FLOOR		
BASE PRICE			
ADJUST %			
FRONT			
HTG/AIRCON			
LIGHTING			
PARTITIONS			
PLUMBING			
ELEVATOR			
SPRINKLER			
S.F. PRICE			
SQUARE FEET			
SUBTOTAL			
ADDITIONS			
TOTAL BASE			
GRADE		%	%
REPL. VALUE			
DEPRECIATION			
TRUE VALUE		%	%

SEC - 15-19-3E 1 20 4—



77.76 ac

SOIL SERIES

Te - CLASS - B - 2% - 1.55 ac

Ac } CLASS - C - 43% - 33.44 ac
So }

Sp } CLASS - D - 55% - 42.77 ac
Fb }

OVEN & RANGE	
EXH. HOOD	
DISHWASHER	
GARBAGE DISP.	
INTER-COM.	
ELEC. GARAGE DOOR	
YARD - SPRINKLER	

H - NH - V

DATE TIME APPRAISER

ECONOMIC DATA

SALES DATA	MO. YR. AMOUNT	1 BUYER / 2 SELLER	3 FEE / 4 AGENT	1 YES / 2 NO
ERECTED/REMODELED	/	/		
AGE/CDU RATING	/	/		

DWELLING COMPUTATIONS

__.__ STORY __		__.__ STORY __	
__ __ __ S.F.		__ __ __ S.F.	
BASEMENT		BASEMENT	
HEATING		HEATING	
PLUMBING		PLUMBING	
ATTIC		ATTIC	
ADDNS. & PCHS. __ __		ADDNS. & PCHS. __ __	
TOTAL		TOTAL	
GRADE __ [ ] __		GRADE __ [ ] __	
TOTAL		TOTAL	
O.F. POINTS [ ] __		O.F. POINTS [ ] __	
TOTAL		TOTAL	
C. & D. FACT.% [ ] __		C. & D. FACT.% [ ] __	
REPL. VALUE		REPL. VALUE	
DEPR. __ %		DEPR __ %	
TRUE VALUE		TRUE VALUE	

SUMMARY OF OTHER BUILDINGS

TYPE	NO.	CONSTRUCTION	SIZE	RATE	GRADE	ERECTED	CDU	REPL VALUE	DEPR	TRUE VALUE
GARAGE										

REVIEWER	DATE	TOTAL TRUE VALUE OTHER BUILDINGS	__ , __ __ , __	__ , __ __ , __
SKETCHED		TOTAL TRUE VALUE ALL BUILDINGS		

GRADE DENOTES QUALITY OF CONSTRUCTION: A—EXCELLENT; B—GOOD; C—AVERAGE; D—CHEAP; E—VERY CHEAP; R—REMODELED
CDU FACTOR REFERS TO CONDITION, DESIRABILITY AND USEFULNESS OF THE BUILDING

91	515 0	3.920	210,000	210,000 Y	3,920	3,920
92	515 0	3.920	210,000	210,000 Y	3,920	3,920
93	515 0	3.920	210,000	210,000 Y	3,920	3,920

03-19-15-1-065

12/19/91 274,000 W800069 9700 92 CHF

FOX DONALD W & CAROL — OX, DONALD W. & CAROL

W800068

11307 26TH AVE E — 11307 26TH AVE E — 03-19-15-1-020

TACOMA WA 98445 — TACOMA, WA 98445 — 00000 03-19-15-1-3

92
91
90
89
88
87
86

15-19-03E&1/065
ONLY COM AT INTER OF N LI OF MAHON
TH S 01 DEG 16 MIN 38 SEC W ALG SD
MIN 22 SEC E 20.44 FT TO A LI PAR/
01 DEG 16 MIN 38 SEC W 21 FT TO
SEC E 238.36 FT ALG SD C/L & C/L
SEC E 150.53 FT TO S LI OF CO RD
FT TH S 64 DEG 26 MIN 06 SEC E
SEC W 277.80 FT TO C/L OF CREEK TH
TH N 48 DEG 13 MIN 16 SEC E 408.35
34.72 FT TH S 75 DEG 12 MIN 52 SEC
TO P CO FOR ADD'L R/W PER ETN
OF S P 91-12-09-0414 ERROR IN

& 4-013 SEG DONE FOR TAX PURPOSES
DLC #48 & N-S 1/2 SEC LI OF SEC 15
1/4 SEC LI 165 FT TH S 76 DEG 48
W & 20 FT E OF SD 1/4 SEC LI TH S
C/L OF CREEK TH S 75 DEG 12 MIN 52
EXT TO POB TH N 01 DEG 16 MIN 38
TH S 70 DEG 26 MIN 03 SEC E 37.95
684.59 FT TH S 29 DEG 06 MIN 36
N 67 DEG 25 MIN 24 SEC W 257.40 FT
FT TH N 01 DEG 16 MIN 38 SEC E
E 20.57 FT TO POB EXC N 10 FT CYD
797928 METES & BOUNDS DESC FOR L 1
SURVEY OUT OF 1-020

CONTINUED

SEG E0414JU 7/24/9280

PERMITS AND LAND SERVICES

AUG 2 0 1990

PIERCE COUNTY

DECLARATION OF BOUNDARY LINE REVISION

WHEREAS, the parties executing this document are the owners of the following described properties in Pierce County, Washington, to wit:

Parcel A - Original

Beginning at a point on the North line of Mahon D.L.C. 1374.8 feet East of the Northwest corner of said D.L.C. and 20 feet east of the Southeast corner of Lot 3 in Section 15, Township 19 North, Range 3 East of the W.M.; thence South parallel with the quarter section line 1416.03 feet; thence East 251.77 feet; thence North 1352.19 feet to the centerline of the county road; thence S 66° 12' E along said centerline to the East line of the West half of said D.L.C.; thence South along the said East line to the South line of Section; thence West along said South line to the Southwest corner of the Southeast section; thence North to the North line of said D.L.C.; thence East 20 feet to the Point of Beginning;

EXCEPT County roads.

Parcel B - Original

The Westerly 80 feet of the following:

Commencing at the Southwest corner of the West half of the West half of the East half of C. Mahon D.L.C.; thence North along the West line of said subdivision 3040 feet to the Point of Beginning; thence East 630.5 feet to a point 32 feet West of the East line of the West half of the West half of the East half of said D.L.C.; thence North 1430 feet, more or less, to the Southwesterly line of Weiderhold-Headly County Road; thence 66° 12' W along said Southwesterly line to the West line of the West half of the West half of the East half of said D.L.C.; thence South along said West line 1720 feet, more or less, to the Point of Beginning.

WHEREAS, the foregoing described properties have common boundaries as shown on attached Legal Description Map and

WHEREAS, the Pierce County Subdivision Code, Chapter 67.02.010(6) has provisions to allow for adjusting boundary lines between contiguous properties.

NOW, THEREFORE, in consideration of the mutual benefits to the foregoing described properties, the parties do for themselves, their heirs and assigns, revise the boundary line of each parcel, with the boundaries to be shown on attached Legal Description Exhibit Map and described as follows:

Parcel A - Revised

Beginning at a point on the North line of Mahon D.L.C. 1374.8 feet East of the Northwest corner of said D.L.C. and 20 feet East of the Southeast corner of Lot 3 in Section 15, Township 19 North, Range 3 East; thence South parallel with the quarter section line 1416.03 feet; thence East 251.77 feet; thence North 1352.19 feet to the centerline of county road; thence S 66° 12' E along said centerline to the East line of the West half of said D.L.C.; thence South along said East line to the South line of section; thence West along said South line to the Southwest corner of the Southeast section; thence North to the North line of said D.L.C.; thence East 20 feet to the Point of Beginning;

EXCEPT County roads.

OCT 8 1990

TAX EXEMPT DATE
Pierce County

By RC Auth. Sig.

9010080184

ALSO EXCEPT Beginning at the Northeast corner of the Mahon D.L.C.; thence N 89° 58' 58" W along the North line of said D.L.C. 2648.75 feet to the Northeast corner of the West half of said D.L.C.; thence S 00° 04' 56" E along the East line of said West half of said D.L.C. 531.59 feet to a point on the South right-of-way line of Weidenhold-Headly County Road; thence N 66° 26' 38" W along said South right-of-way line 119.43 feet to the True Point of Beginning; thence continuing N 66° 26' 38" W along said South right-of-way line 75.25 feet; thence S 28° 11' 53" W 318.88 feet; thence S 61° 48' 07" E 75.00 feet; thence N 28° 11' 53" E 324.97 feet to the True Point of Beginning.

AND the Westerly 80 feet of the following:

Commencing at the Southwest corner of the West half of the West half of the East half of C. Mahon D.L.C.; thence North along the West line of said subdivision 3040 feet to the Point of Beginning; thence East 630.5 feet to a point 32 feet West of the East line of the West half of the West half of the East half of said D.L.C.; thence North 1430 feet, more or less, to the Southwesterly line of Weiderhold-Headly County Road; thence 66° 12' W along said Southwesterly line to the West line of the West half of the West half of the East half of said D.L.C.; thence South along said West line 1720 feet, more or less, to the Point of Beginning.

Parcel B - Revised

Beginning at the Northeast corner of the Mahon D.L.C.; thence N 89° 58' 58" W along the North line of said D.L.C. 2648.75 feet to the Northeast corner of the West half of said D.L.C.; thence S 00° 04' 56" E along the East line of said West half of said D.L.C. 531.59 feet to a point on the South right-of-way line of Weidenhold-Headly County Road; thence N 66° 26' 38" W along said South right-of-way line 119.43 feet to the True Point of Beginning; thence continuing N 66° 26' 38" W along said South right-of-way line 75.25 feet; thence S 28° 11' 53" W 318.88 feet; thence S 61° 48' 07" E 75.00 feet; thence N 28° 11' 53" E 324.97 feet to the True Point of Beginning.

9010080184

Recorded under Auditor's Fee #________________________
Records of Pierce County, Washington.

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 28 day of August, 1990.

Charles J. Brown Ruth Brown

STATE OF WASHINGTON)
) ss.
COUNTY OF Pierce)

On this day personally appeared before me Charles and Ruth Brown, Husband & wife to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed for the purpose therein mentioned.

GIVEN UNDER MY hand and official seal this 28 day of August, 1990.

Notary Public in and for the State of Washington, residing at Spanaway.

CHARLES W. HAVILAND NOTARY PUBLIC STATE OF WASHINGTON

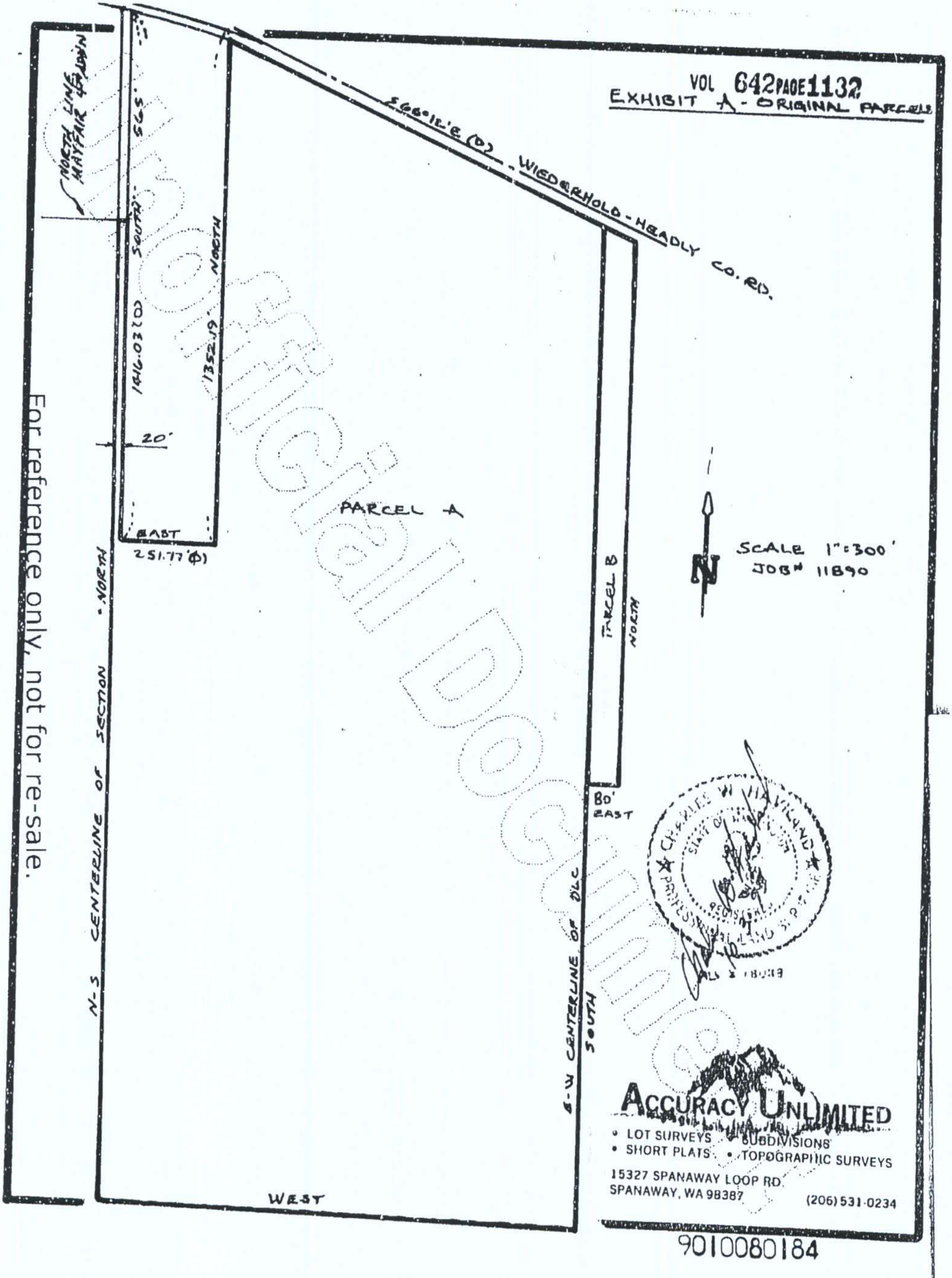
90 OCT -8 AM 9:29

AUDITOR PIERCE CO. WASH

9010080184

VOL 642 PAGE 1132

EXHIBIT A - ORIGINAL PARCELS

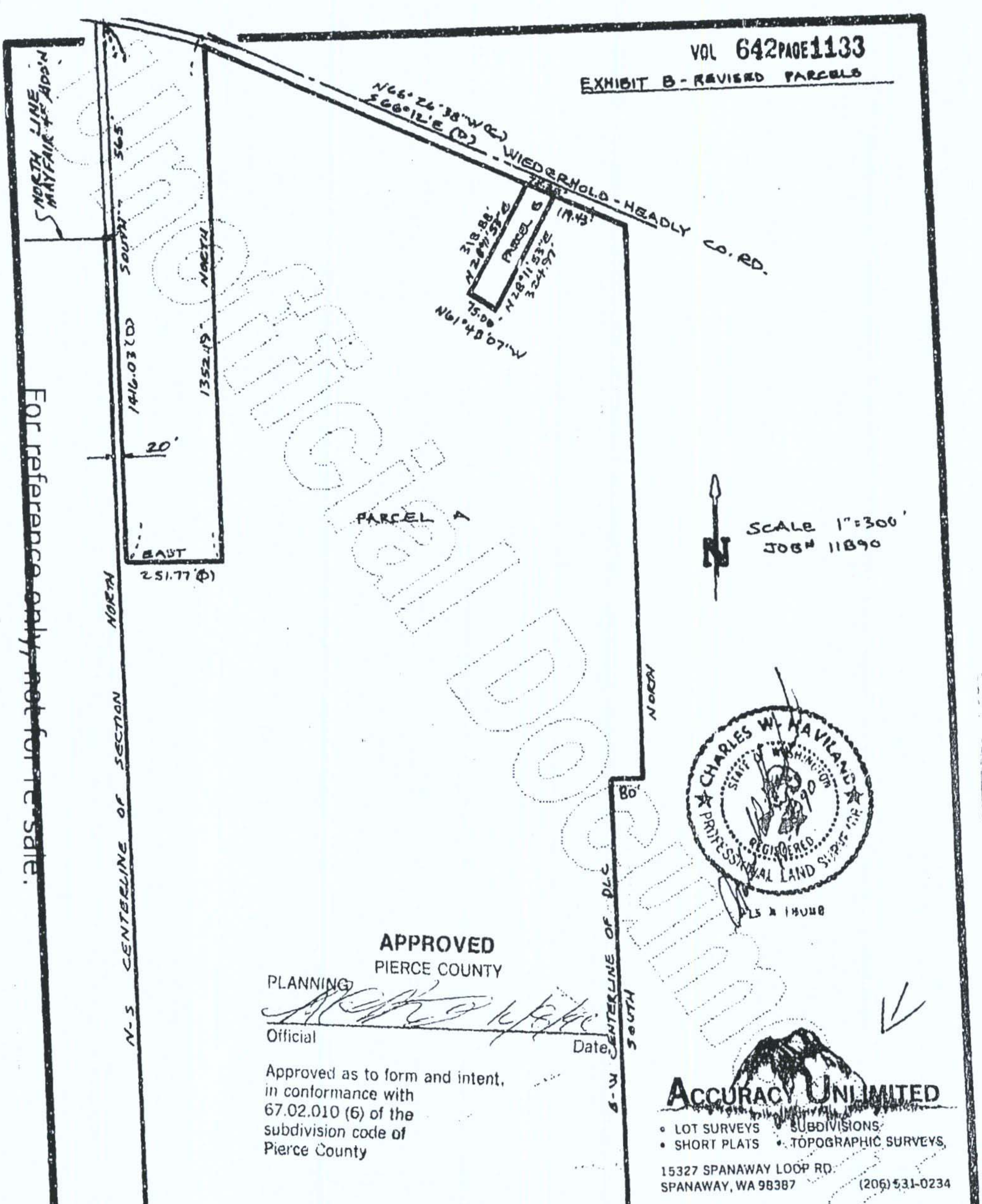


ACCURACY UNLIMITED

- LOT SURVEYS
- SUBDIVISIONS
- SHORT PLATS
- TOPOGRAPHIC SURVEYS

15327 SPANAWAY LOOP RD.
SPANAWAY, WA 98387
(206) 531-0234

9010080184


VOL 642PAGE1133
EXHIBIT B - REVISED PARCELS
NORTH LINE MAYFAIR 1st ADD'N
365'
SOUTH
NORTH
1416.03 (D)
1352.49'
20'
EAST
251.77 (D)
N66°26'38"W (C)
S66°12'E (D)
WIEDERHOLD - HEADLY CO. RD.
119.43'
318.88'
N28°11'53"E
PARCEL B
N28°11'53"E
324.97'
75.00'
N61°48'07"W
PARCEL A
SCALE 1"=300'
JOB# 11B90
N
NORTH
80'
N-S CENTERLINE OF SECTION
NORTH
S-W CENTERLINE OF DLC
SOUTH
WEST
CHARLES W. HAVILAND
STATE OF WASHINGTON
REGISTERED
PROFESSIONAL LAND SURVEYOR
APPROVED
PIERCE COUNTY
PLANNING
Official
Date
Approved as to form and intent, in conformance with 67.02.010 (6) of the subdivision code of Pierce County
ACCURACY UNLIMITED
• LOT SURVEYS • SUBDIVISIONS
• SHORT PLATS • TOPOGRAPHIC SURVEYS
15327 SPANAWAY LOOP RD.
SPANAWAY, WA 98387 (206) 531-0234

9010080184

9005180393

VOL. 0612 PAGE 4038
VOL. 0612 PAGE 0547

DECLARATION OF BOUNDARY LINE REVISION

WHEREAS, the parties executing this document are the owners of the following described properties in Pierce County, Washington, to wit:

PARCEL "A": (03-19-15-1-059)

COMMENCING AT THE STONE MONUMENT AT THE INTERSECTION OF THE NORTH LINE OF THE CHRISTOPHER MAHON DONATION LAND CLAIM NO. 48 AND THE NORTH-SOUTH QUARTER SECTION LINE OF SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST OF THE WILLAMETTE MERIDIAN; THENCE S0°38'30"E, ALONG SAID QUARTER SECTION LINE, 165.00 FEET; THENCE S78°43'30"E, 20.39 FEET TO A LINE PARALLEL WITH AND 20.00 FEET EAST OF SAID QUARTER SECTION LINE; THENCE S0°38'30"E, 21.00 FEET TO THE CENTERLINE OF A CREEK AND THE POINT OF BEGINNING, SAID POINT OF BEGINNING BEING THE SOUTHWEST CORNER OF THAT CERTAIN PARCEL CONVEYED TO PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6 BY WARRANTY DEED RECORDED NOVEMBER 11, 1978 UNDER AUDITOR'S NO. 2869180; THENCE S77°08'00"E, 257.74 FEET, MORE OR LESS, ALONG THE CENTERLINE OF SAID CREEK AND THE CENTERLINE EXTENDED TO THE EAST LINE OF THAT TRACT OF LAND CONVEYED TO JOHN F. KRAUSE AND ROBERT C. POLLOCK BY DEED RECORDED UNDER AUDITOR'S NO. 993343; THENCE SOUTH ALONG SAID EAST LINE OF KRAUSE/POLLOCK TRACT 537.56 FEET; THENCE S89°21'30"W, 251.16 FEET, MORE OR LESS, TO THE WEST LINE OF KRAUSE/POLLOCK TRACT; THENCE N0°38'30"W, 593.09 FEET TO THE TRUE POINT OF BEGINNING., IN PIERCE COUNTY, WASHINGTON.

PARCEL "B": (03-19-15-1-020)

BEGINNING AT A POINT ON THE NORTH LINE OF MAHON D.L.C., 1374.8 FEET EAST OF THE NORTHWEST CORNER OF DAID D.L.C. AND 20 FEET EAST OF THE SOUTHEAST CORNER OF LOT 3 IN SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE SOUTH PARALLEL WITH THE QUARTER SECTION LINE, 1416.03 FEET; THENCE EAST 251.77 FEET; THENCE NORTH 1352.19 FEET TO THE CENTERLINE OF COUNTY ROAD; THENCE S66°12'E, ALONG SAID CENTERLINE TO THE EAST LINE OF THE WEST HALF OF SAID D.L.C.; THENCE SOUTH ALONG SAID EAST LINE TO THE SOUTH LINE OF SECTION; THENCE WEST ALONG SAID SOUTH LINE TO THE SOUTHWEST CORNER OF THE SOUTHEAST QUARTER OF SECTION; THENCE NORTH TO NORTH LINE OF SAID D.L.C.; THENCE EAST 20 FEET TO THE POINT OF BEGINNING.

90 MAY 18 PM 3:53

AUDITOR PIERCE CO. WASH

PERMITS AND LAND SERVICES
MAR 1 ? 1990
PIERCE COUNTY

MAY 18 1990

EXCISE TAX EXEMPT DATE ______
Pierce County

By ______ Auth. Sig.

and

WHEREAS, the foregoing described properties have common boundaries as shown on attached Exhibit "A" and

WHEREAS, the Pierce County Subdivision Code, Chapter 67.02.010(6) has provisions to allow for adjusting boundary lines between contiguous properties.

9005180393

14

DECLARATION OF BOUNDARY LINE REVISION

NOW, THEREFORE, in consideration of the mutual benefits to the foregoing described properties, the parties do for themselves, their heirs and assigns, revise the boundary line of each parcel, with the boundaries to be as shown on attached Exhibit "B" and described as follows:

PARCEL "A":

COMMENCING AT THE STONE MONUMENT AT THE INTERSECTION OF THE NORTH LINE OF CHARLES MAHON D.L.C. NO. 48 WITH THE NORTH-SOUTH QUARTER SECTION LINE OF SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE ALONG SAID QUARTER SECTION LINE S0°38'30"E, 165.00 FEET; THENCE S78°43'30"E, 20.39 FEET TO A LINE 20 FEET EAST OF AND PARALLEL WITH SAID QUARTER SECTION LINE; THENCE S0°38'30"E, 21.00 FEET TO THE CENTERLINE OF CREEK AND THE TRUE POINT OF BEGINNING' THENCE S77°08'00"E, 237.74 FEET ALONG SAID CREEK AND CREEK EXTENDED; THENCE S0°38'30"E, 537.56 FEET; THENCE S89°21'30"W, 231.16 FEET; THENCE N0°38'30"W, 593.09 FEET TO THE TRUE POINT OF BEGINNING.

PARCEL "B":

BEGINNING AT A POINT ON THE NORTH LINE OF MAHON D.L.C., 1374.8 FEET EAST OF THE NORTHWEST CORNER OF SAID D.L.C. AND 20 FEET EAST OF THE SOUTHEAST CORNER OF LOT 3 IN SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE SOUTH, PARALLEL WITH THE QUARTER SECTION LINE, 1416.03 FEET; THENCE EAST 251.77 FEET; THENCE NORTH 1352.19 FEET TO THE CENTERLINE OF COUNTY ROAD; THENCE S66°12'E, ALONG SAID CENTERLINE TO THE EAST LINE OF THE WEST HALF OF SAID D.L.C.; THENCE SOUTH ALONG SAID EAST LINE TO THE SOUTH LINE OF SECTION; THENCE WEST ALONG SAID SOUTH LINE TO THE SOUTHWEST CORNER OF THE SOUTHEAST QUARTER OF SECTION; THENCE NORTH TO NORTH LINE OF SAID D.L.C.; THENCE EAST 20 FEET TO THE POINT OF BEGINNING;

TOGETHER WITH THE EAST 20 FEET OF THE FOLLOWING DESCRIBED TRACT:

COMMENCING AT THE STONE MONUMENT AT THE INTERSECTION OF THE NORTH LINE OF THE C. MAHON D.L.C., NO. 48 AND THE NORTH/SOUTH QUARTER SECTION LINE OF SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE S0°38'30"E, ALONG SAID QUARTER SECTION LINE, 165.00 FEET; THENCE S78°43'30"E, 20.39 FEET TO A LINE PARALLEL WITH AND 20.00 FEET EAST OF SAID QUARTER SECTION LINE; THENCE S0°38'30"E, 21.00 FEET TO THE CENTERLINE OF A CREEK AND THE POINT OF BEGINNING, SAID POINT OF BEGINNING BEING THE SOUTHWEST CORNER OF THAT CERTAIN PARCEL CONVEYED TO PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6 BY WARRANTY DEED RECORDED NOVEMBER 11, 1978 UNDER AUDITOR'S NO. 2869180; THENCE S77°08'00"E, 257.74 FEET, MORE OR LESS, ALONG THE CENTERLINE OF SIAD CREEK AND THE CENTERLINE EXTENDED TO THE EAST LINE OF THAT TRACT OF LAND CONVEYED TO JOHN F. KRAUSE AND ROBERT C. POLLOCK BY DEED RECORDED UNDER AUDITOR'S NO. 993343; THENCE SOUTH ALONG SAID EAST LINE OF KRAUSE/POLLOCK TRACT, 537.56 FEET; THENCE S89°21'30"W, 251.16 FEET, MORE OR LESS, TO THE WEST LINE OF KRAUSE/POLLOCK TRACT; THENCE N0°38'30"W, 593.09 FEET TO THE TRUE POINT OF BEGINNING, IN PIERCE COUNTY WASHINGTON.

9005180393

FREE CONSENT STATEMENT

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 14 day of November, 1989.

O.H. Ellingson
Stephen J Baskett

ACKNOWLEDGMENT
(Corporation)

STATE OF WASHINGTON,
County of PIERCE } ss.

On this 14 day of November, 1989, before me personally appeared O.H. ELLINGSON + STEVE BASKETT, to me known to be the FIRE COMMISSIONERS of the corporation that executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that he w___ authorized to execute said instrument and that the seal affixed thereto (if any) is the corporate seal of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Official Seal the day and year first above written.

[signature]
Notary Public in and for the State of Washington,
residing at TACOMA

9005180393

FREE CONSENT STATEMENT

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 14 day of November, 1989.

O.H. Ellingson

Stephen T Baskett

ACKNOWLEDGEMENT

STATE OF WASHINGTON,]
] ss
COUNTY OF PIERCE]

I, Yvonne Grissom Notary Public in and for the state of Washington, residing at TACOMA do hereby certify that of this 14 day of November, 1989, personally appeared before me O.H. ELLINGSON & STEVE BASKETT to me known to be the individuals described in and who executed the within instrument and acknowledged that they signed and sealed the same as ______ free and voluntary act and deed for the uses and purposes herein mentioned.

GIVEN UNDER MY HAND AND OFFICIAL SEAL this 14 day of November, 1989.

Yvonne Grissom
Notary Public in and for the State of Washington, residing at TACOMA.

9005180393

FREE CONSENT STATEMENT

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 8 day of February, 1990.

Charles Brown 12/21/90

X Ruth Brown

ACKNOWLEDGEMENT

STATE OF WASHINGTON,]
] ss
COUNTY OF PIERCE]

I, YVONNE GRISSOM Notary Public in and for the state of Washington, residing at TACOMA do hereby certify that of this 8 day of February, 1990, personally appeared before me Charles BROWN to me known to be the individual__ described in and who executed the within instrument and acknowledged that he signed and sealed the same as his free and voluntary act and deed for the uses and purposes herein mentioned.

GIVEN UNDER MY HAND AND OFFICIAL SEAL this 8 day of February, 1990.

Yvonne Grissom
Notary Public in and for the State of Washington, residing at TACOMA.

YVONNE GRISSOM NOTARY PUBLIC STATE OF WASHINGTON

STATE OF ~~WASHINGTON~~ California,
County of Riverside } ss.

On this day personally appeared before me Ruth Brown

to me known to be the individual__ described in and who executed the within and foregoing instrument and acknowledged that she signed the same as her free and voluntary act and deed for

OFFICIAL SEAL
AUDREY JEAN FLEISCHMAN
NOTARY PUBLIC—CALIFORNIA
PRINCIPAL OFFICE IN RIVERSIDE COUNTY
My Commission Expires SEPT. 20, 1991

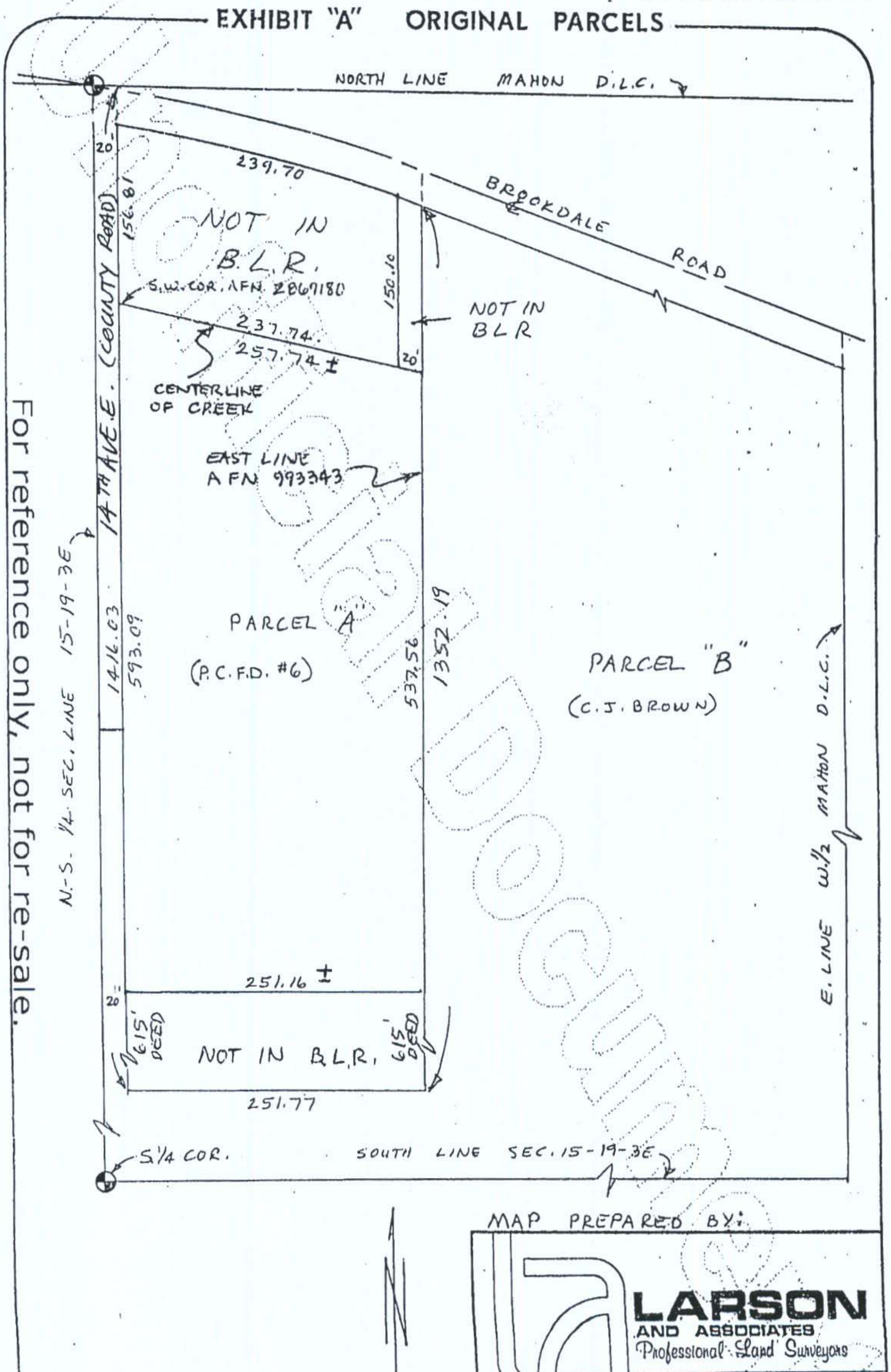
Given under my hand and official seal this 21 day of Feb, 1990

Audrey Jean Fleischman

Notary Public in and for the State of ~~Washington~~ Calif, residing at Palm Desert

9005180393

151c



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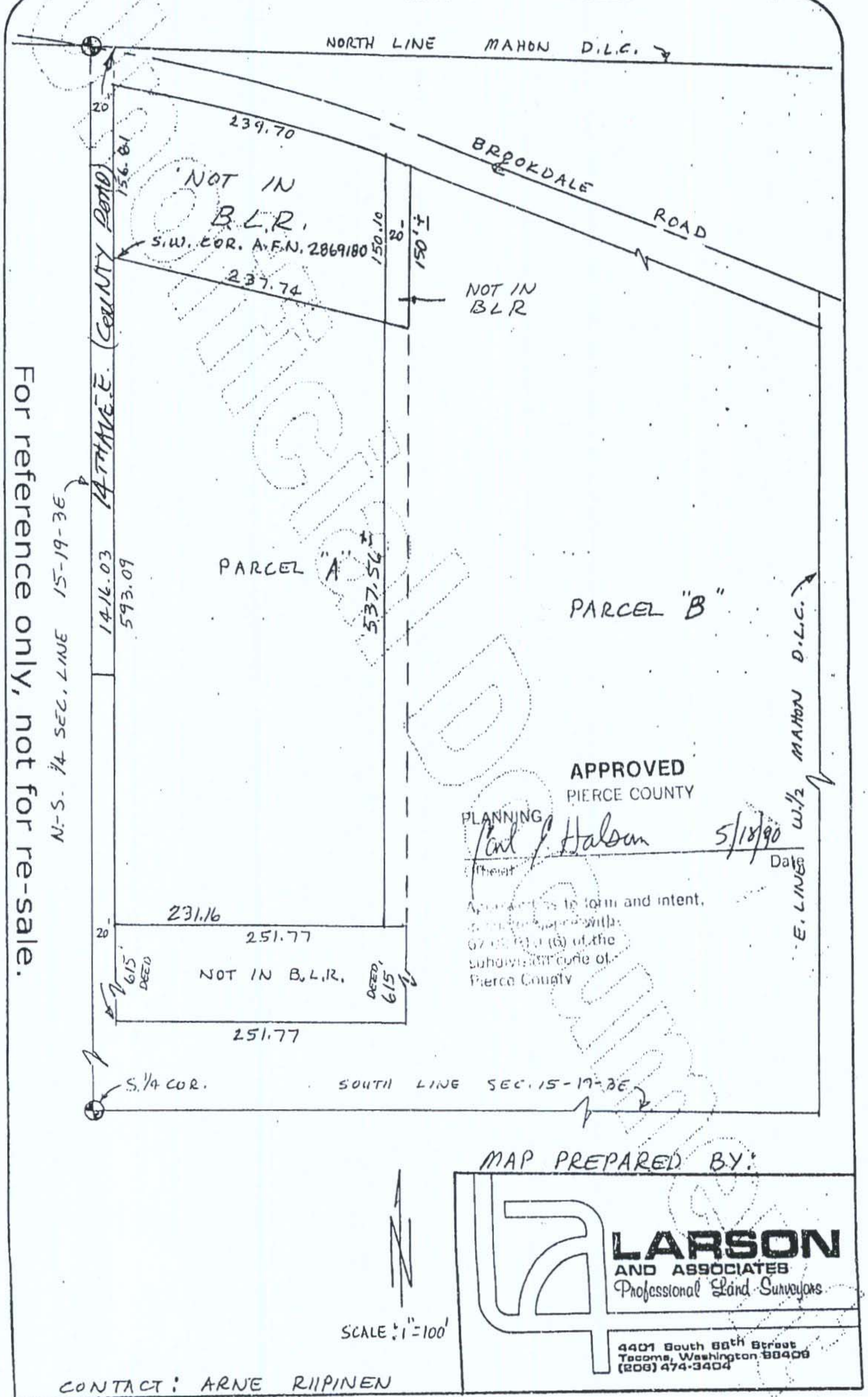
9005180393

EXHIBIT "B" REVISED PARCELS



9005180393

SAFECO

SAFECO TITLE INSURANCE COMPANY

VOL. 0612 PAGE 0554

THIS SPACE RESERVED FOR RECORDER'S USE

VOL. 0612 PAGE 4045

Filed for Record at Request of

NAME PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6 - Attn: Chief Les Flue

ADDRESS 10050 - 114th Street

CITY AND STATE Tacoma, WA 98444

QUIT CLAIM DEED

THE GRANTOR, PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6,

for and in consideration of ONE DOLLAR ($1.00) and other good and valuable consideration,

conveys and quit claims to CHARLES J. BROWN and RUTH BROWN, husband and wife,

the following described real estate, situated in the County of Pierce, State of Washington, including any after acquired title:

The east 20 feet of the following described Tract:
Commencing at the stone monument at the intersection of the North line of Charles Mahon D.L.C. No. 48 with the North-South Quarter section line of Section 15, Township 19 North, Range 3 East, W.M.; thence along said Quarter section line S 0°38'30" E, 165.00 feet; thence S 78°43'30" E, 20.39 feet to a line 20 feet East of and parallel with said Quarter section line; thence S 0°38'30" E, 21.00 feet to the centerline of creek and the TRUE POINT OF BEGINNING; thence S 77°08'00" E, 237.74 feet along said creek and creek extended; thence S 0°38'30" E, 537.56 feet; thence S 89°21'30" W, 231.16 feet; thence N 0°38'30" W, 593.09 feet to the TRUE POINT OF BEGINNING.

Situate in Pierce County, State of Washington.

Auditor's Note: This document was not cleared for excise tax as required for all conveyances.

Dated ______________, 19 89.

______________ (Individual)

______________ (Individual)

PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6

By [signature] (President)

By [signature] (Secretary)

STATE OF WASHINGTON
COUNTY OF ______ } ss.

On this day personally appeared before me ______________

to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that ______ signed the same as ______ free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this ______ day of ______________, 19 ____

____
Notary Public in and for the State of Washington, residing at ______________.

STATE OF WASHINGTON
COUNTY OF Pierce } ss.

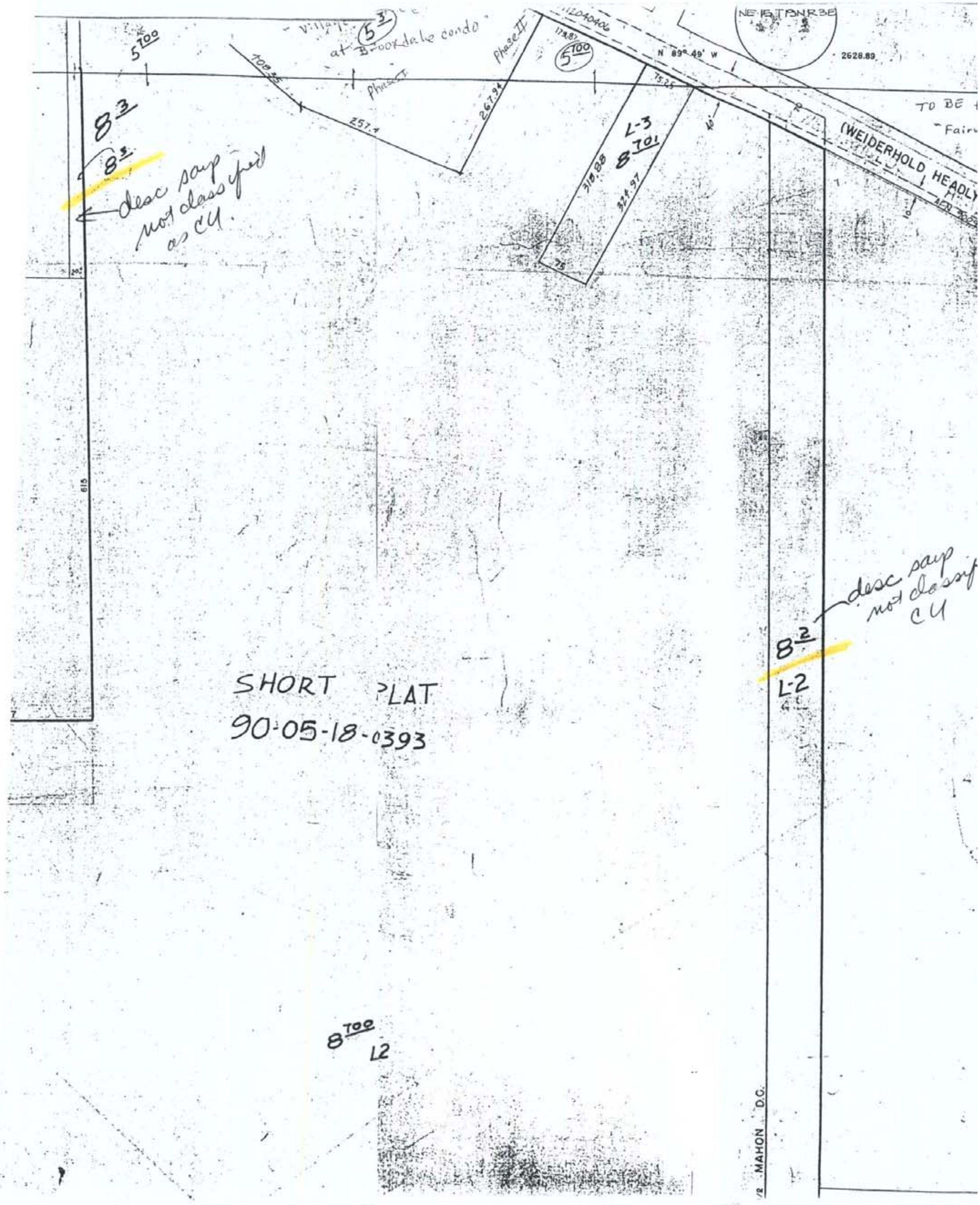
On this 14 day of November, 19 89, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared O.H. ELLINGSON and R.L. FLUE ; FIRE CHIEF to me known to be the Chairman ~~XXXXXXX~~ and Commissioners ~~XXXXXXX~~, respectively, of FIRE PROTECTION DISTRICT NO. 6 the corporation that executed the foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that they are authorized to execute the said instrument and that the seal affixed is the corporate seal of said corporation.

Witness my hand and official seal hereto affixed the day and year first above written.

[signature]
Notary Public in and for the State of Washington, residing at TACOMA

9005180393

TL-5 R3 2/76



NE 18 T13N R3E
2628.89
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TO BE
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(WEIDERHOLD HEADLY
at Brookdale condo
Phase II
Phase I
5 3
5 700
8 3
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257.4
267.94
L-3
8 701
318.88
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75.25
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40'
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8 2
desc saup not classif CU
L-2
SHORT PLAT
90-05-18-0393
8 700
L2
MAHON D.C.

JU	08/10/92					1	E-0417
91	515 0	3.920	210,000	210,000 Y	3,920		3,920
92	515 0	3.920	210,000	210,000 Y	3,920		3,920
93	515 0	3.920	210,000	210,000 Y	3,920		3,920

12/19/91 274,000 W800069 9700 92 CHF 03-19-15-1-065

FOX DONALD W & CAROL — OX, DONALD W. & CAROL

W800068

11307 26TH AVE E — 11307 26TH AVE E — 03-19-15-1-020

TACOMA WA 98445 — TACOMA, WA 98445 — 00000 03-19-15-1-3

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91
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86

15-19-03E&1/065 & 4-013 SEG DONE FOR TAX PURPOSES ONLY COM AT INTER OF N LI OF MAHON DLC #48 & N-S 1/2 SEC LI OF SEC 15 TH S 01 DEG 16 MIN 38 SEC W ALG SD 1/4 SEC LI 165 FT TH S 76 DEG 48 MIN 22 SEC E 20.44 FT TO A LI PAR/ W & 20 FT E OF SD 1/4 SEC LI TH S 01 DEG 16 MIN 38 SEC W 21 FT TO C/L OF CREEK TH S 75 DEG 12 MIN 52 SEC E 238.36 FT ALG SD C/L & C/L EXT TO POB TH N 01 DEG 16 MIN 38 SEC E 150.53 FT TO S LI OF CO RD TH S 70 DEG 26 MIN 03 SEC E 37.95 FT TH S 64 DEG 26 MIN 06 SEC E 684.59 FT TH S 29 DEG 06 MIN 36 SEC W 277.80 FT TO C/L OF CREEK TH N 67 DEG 25 MIN 24 SEC W 257.40 FT TH N 48 DEG 13 MIN 16 SEC E 408.35 FT TH N 01 DEG 16 MIN 38 SEC E 34.72 FT TH S 75 DEG 12 MIN 52 SEC E 20.57 FT TO POB EXC N 10 FT CYD TO P CO FOR ADD'L R/W PER ETN 797928 METES & BOUNDS DESC FOR L 1 OF S P 91-12-09-0414 ERROR IN SURVEY OUT OF 1-020

CONTINUED

SEG E0414JU 7/24/92BO

**** COMPLETED SEGREGATIONS ****

JU 08/10/92 2 E-0417

91	515 0	73.630	1,253,300	1,253,300	Y	249,430	172,440	421,870
92	515 0	73.630	1,253,300	1,253,300	Y	249,430	172,440	421,870
93	515 0	73.630	1,253,300	1,253,300	Y	249,430	172,440	421,870

03-19-15-1-702

7777 92 CH

BROWN CHARLES J & RUTH — BROWN, CHARLES J. & RUTH

PO BOX Q — P.O. BOX Q — 03-19-15-1-020

YELM WA 98597 — YELM, WA 98597 — 00000 03-19-15-1-3

92 15-19-03E&1/702 & 4-700 SEG DONE FOR TAX PURPOSES
ONLY BEG AT A PT ON N LI OF MAHON DLC 1374.8 FT E OF NW COR OF SD
91 DLC & 20 FT E OF SE COR LOT 3 IN SEC 15 TH S PAR/W 1/4 SEC LI
1416.03 FT TH E 251.77 FT TH N 1352.19 FT TO C/L OF CO RD TH S 66
90 DEG 12 MIN E ALG SD C/L TO E LI OF W 1/2 OF SD DLC TH S ALG SD E LI
TO S LI OF SEC TH W ALG SD S LI TO SW COR OF SE OF SEC TH N TO N LI
89 OF SD DLC TH E 20 FT TO POB EXC WIEDERHOLD-HEADLEY CO RD
(BROOKDALE RD E) & EXC 14TH AVE E ALSO EXC FOLL DESC PROP COM AT
88 INTER OF N LI OF MAHON DLC #48 & N-S 1/4 SEC LI OF SEC 15 S 01 DEG
16 MIN 38 SEC W ALG SD 1/4 SEC LI 165 FT TH S 76 DEG 48 MIN 22 SEC E
87 20.44 FT TO A LI PAR/W & 20 FT E OF SD 1/4 SEC LI TH S 01 DEG 16
MIN 38 SEC W 21 FT TO C/L OF CREEK TH S 75 DEG 12 MIN 52 SEC E 238.36
86 FT ALG SD C/L & C/L EXT TO POB TH N 01 DEG 16 MIN 38 SEC E 150.53 FT

CONTINUED

TO S LI OF CO RD TH S 70 DEG 26 MIN 03 SEC 37.95 FT TH S 64 DEG 26
MIN 06 SEC E 684.59 FT TH S 29 DEG 06 MIN 36 SEC W 277.80 FT TO C
/L OF CREEK TH N 67 DEG 25 MIN 24 SEC W 257.60 FT TH N 48 DEG 13 MIN
16 SEC E 408.35 FT TH N 01 DEG 16 MIN 38 SEC E 34.72 FT TH S 75 DEG
12 MIN 52 SEC E 20.57 FT TO POB CURRENT USE RCW 84.34 1973 OPEN
SPACE AUD FEE #2463739 73.63 AC OUT OF 1-020
SEG E0417CH/JU 7/24/92BO

SEG-CONT

91 R 515 0
92 R 515 0
93 R 515 0

92 CH 03-19-15-4-013

REFERENCE REFERENCE

03-19-15-4-000
00000 03-19-15-4-2

92 15-19-03E&4/013 ASSESSED/W 1-065
SEG E0417JU 7/24/92BO
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91 R 515 0
92 R 515 0
93 R 515 0

92 CH 03-19-15-4-700

REFERENCE REFERENCE

03-19-15-4-000
00000 03-19-15-4-2

92 15-19-03E&4/700 ASSESSED/W 1-702
SEG E0417JU 7/24/92BO
91
90
89
88
87
86

77.550	1,463,300	253,350	172,440
77.550	1,463,300	253,350	172,440
77.550	1,463,300	253,350	172,440

DECLARATION OF BOUNDARY LINE REVISION

WHEREAS, the parties executing this document are the owners of the following described properties in Pierce County, Washington, to wit:

Parcel A - Original
Beginning at a point on the North line of Mahon D.L.C. 1374.8 feet East of the Northwest corner of said D.L.C. and 20 feet east of the Southeast corner of Lot 3 in Section 15, Township 19 North, Range 3 East of the W.M.; thence South parallel with the quarter section line 1416.03 feet; thence East 251.77 feet; thence North 1352.19 feet to the centerline of the county road; thence S 66° 12' E along said centerline to the East line of the West half of said D.L.C.; thence South along the said East line to the South line of Section; thence West along said South line to the Southwest corner of the Southeast section; thence North to the North line of said D.L.C.; thence East 20 feet to the Point of Beginning;

EXCEPT County roads.

Parcel B - Original
The Westerly 80 feet of the following:
Commencing at the Southwest corner of the West half of the West half of the East half of C. Mahon D.L.C.; thence North along the West line of said subdivision 3040 feet to the Point of Beginning; thence East 630.5 feet to a point 32 feet West of the East line of the West half of the West half of the East half of said D.L.C.; thence North 1430 feet, more or less, to the Southwesterly line of Weiderhold-Headly County Road; thence 66° 12' W along said Southwesterly line to the West line of the West half of the West half of the East half of said D.L.C.; thence South along said West line 1720 feet, more or less, to the Point of Beginning.

WHEREAS, the foregoing described properties have common boundaries as shown on attached Legal Description Map and
WHEREAS, the Pierce County Subdivision Code, Chapter 67.02.010(6) has provisions to allow for adjusting boundary lines between contiguous properties.
NOW, THEREFORE, in consideration of the mutual benefits to the foregoing described properties, the parties do for themselves, their heirs and assigns, revise the boundary line of each parcel, with the boundaries to be shown on attached Legal Description Exhibit Map and described as follows:

Parcel A - Revised
Beginning at a point on the North line of Mahon D.L.C. 1374.8 feet East of the Northwest corner of said D.L.C. and 20 feet East of the Southeast corner of Lot 3 in Section 15, Township 19 North, Range 3 East; thence South parallel with the quarter section line 1416.03 feet; thence East 251.77 feet; thence North 1352.19 feet to the centerline of county road; thence S 66° 12' E along said centerline to the East line of the West half of said D.L.C.; thence South along said East line to the South line of section; thence West along said South line to the Southwest corner of the Southeast section; thence North to the North line of said D.L.C.; thence East 20 feet to the Point of Beginning;

EXCEPT County roads.

11

ALSO EXCEPT Beginning at the Northeast corner of the Mahon D.L.C.; thence N 89° 58' 58" W along the North line of said D.L.C. 2648.75 feet to the Northeast corner of the West half of said D.L.C.; thence S 00° 04' 56" E along the East line of said West half of said D.L.C. 531.59 feet to a point on the South right-of-way line of Weidenhold-Headly County Road; thence N 66° 26' 38" W along said South right-of-way line 119.43 feet to the True Point of Beginning; thence continuing N 66° 26' 38" W along said South right-of-way line 75.25 feet; thence S 28° 11' 53" W 318.88 feet; thence S 61° 48' 07" E 75.00 feet; thence N 28° 11' 53" E 324.97 feet to the True Point of Beginning.

AND the Westerly 80 feet of the following:

Commencing at the Southwest corner of the West half of the West half of the East half of C. Mahon D.L.C.; thence North along the West line of said subdivision 3040 feet to the Point of Beginning; thence East 630.5 feet to a point 32 feet West of the East line of the West half of the West half of the East half of said D.L.C.; thence North 1430 feet, more or less, to the Southwesterly line of Weiderhold-Headly County Road; thence 66° 12' W along said Southwesterly line to the West line of the West half of the West half of the East half of said D.L.C.; thence South along said West line 1720 feet, more or less, to the Point of Beginning.

Parcel B - Revised

Beginning at the Northeast corner of the Mahon D.L.C.; thence N 89° 58' 58" W along the North line of said D.L.C. 2648.75 feet to the Northeast corner of the West half of said D.L.C.; thence S 00° 04' 56" E along the East line of said West half of said D.L.C. 531.59 feet to a point on the South right-of-way line of Weidenhold-Headly County Road; thence N 66° 26' 38" W along said South right-of-way line 119.43 feet to the True Point of Beginning; thence continuing N 66° 26' 38" W along said South right-of-way line 75.25 feet; thence S 28° 11' 53" W 318.88 feet; thence S 61° 48' 07" E 75.00 feet; thence N 28° 11' 53" E 324.97 feet to the True Point of Beginning.

9010080184

Recorded under Auditor's Fee #______________________
Records of Pierce County, Washington.

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 28 day of August, 1990.

Charles J. Brown   Ruth Brown

____________________   ____________________

STATE OF WASHINGTON)
) ss.
COUNTY OF Pierce)

On this day personally appeared before me Charles and Ruth Brown, Husband & wife to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed for the purpose therein mentioned.

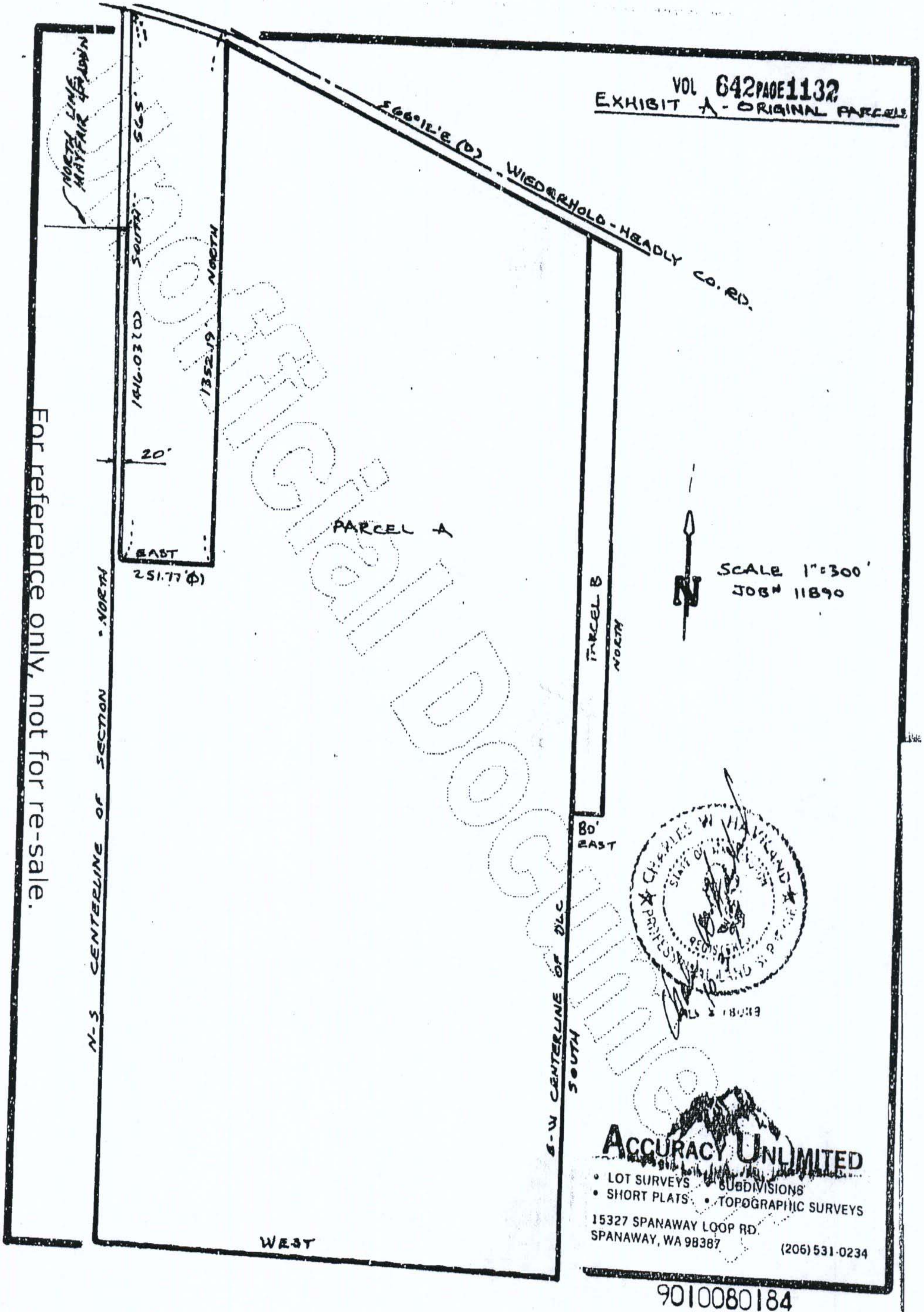
GIVEN UNDER MY hand and official seal this 28 day of August, 1990.

____
Notary Public in and for the State of Washington, residing at Spanaway.

CHARLES W. HAVILAND NOTARY PUBLIC STATE OF WASHINGTON

90 OCT -8 AM 9:29

9010080184

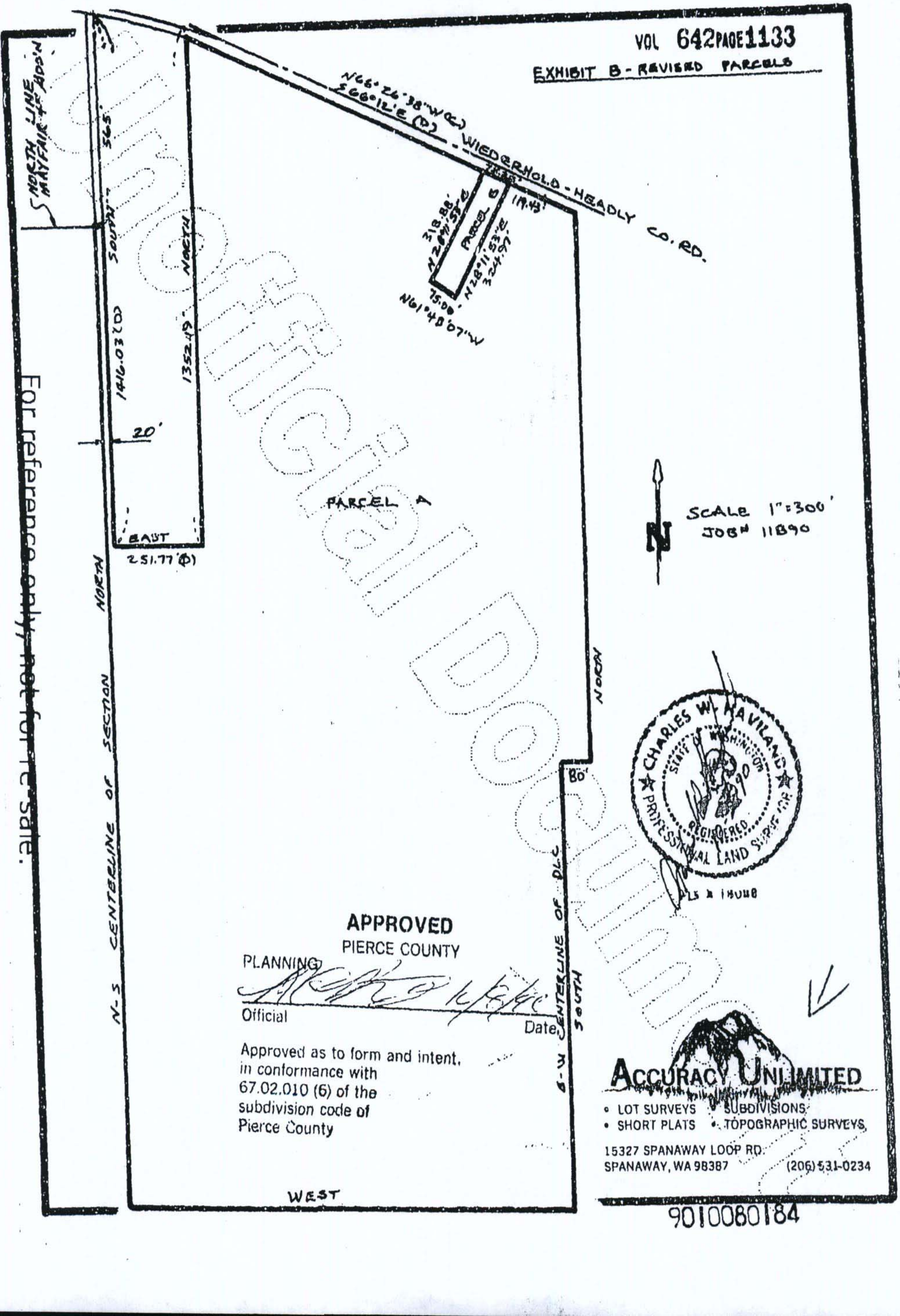


VOL 642 PAGE 1132
EXHIBIT A - ORIGINAL PARCELS
S66°12'E (D) WIEDERHOLD-HEADLY CO. RD.
NORTH LINE MAYFAIR GARDEN
565'
SOUTH 1416.03'(D)
NORTH 1352.19'
20'
EAST 251.77'(D)
PARCEL A
PARCEL B
NORTH
SCALE 1"=300'
JOB# 11890
N-S CENTERLINE OF SECTION NORTH
E-W CENTERLINE OF DLC SOUTH
80' EAST
WEST
ACCURACY UNLIMITED
• LOT SURVEYS • SUBDIVISIONS
• SHORT PLATS • TOPOGRAPHIC SURVEYS
15327 SPANAWAY LOOP RD.
SPANAWAY, WA 98387
(206) 531-0234

9010080184

VOL 642 PAGE 1133

EXHIBIT B - REVISED PARCELS



APPROVED
PIERCE COUNTY
PLANNING

Official Date

Approved as to form and intent, in conformance with 67.02.010 (6) of the subdivision code of Pierce County

ACCURACY UNLIMITED

- LOT SURVEYS
- SUBDIVISIONS
- SHORT PLATS
- TOPOGRAPHIC SURVEYS

15327 SPANAWAY LOOP RD.
SPANAWAY, WA 98387 (206) 531-0234

9010080184

DECLARATION OF BOUNDARY LINE REVISION

WHEREAS, the parties executing this document are the owners of the following described properties in Pierce County, Washington, to wit:

PARCEL "A": (03-19-15-1-059)

COMMENCING AT THE STONE MONUMENT AT THE INTERSECTION OF THE NORTH LINE OF THE CHRISTOPHER MAHON DONATION LAND CLAIM NO. 48 AND THE NORTH-SOUTH QUARTER SECTION LINE OF SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST OF THE WILLAMETTE MERIDIAN; THENCE S0°38'30"E, ALONG SAID QUARTER SECTION LINE, 165.00 FEET; THENCE S78°43'30"E, 20.39 FEET TO A LINE PARALLEL WITH AND 20.00 FEET EAST OF SAID QUARTER SECTION LINE; THENCE S0°38'30"E, 21.00 FEET TO THE CENTERLINE OF A CREEK AND THE POINT OF BEGINNING, SAID POINT OF BEGINNING BEING THE SOUTHWEST CORNER OF THAT CERTAIN PARCEL CONVEYED TO PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6 BY WARRANTY DEED RECORDED NOVEMBER 11, 1978 UNDER AUDITOR'S NO. 2869180; THENCE S77°08'00"E, 257.74 FEET, MORE OR LESS, ALONG THE CENTERLINE OF SAID CREEK AND THE CENTERLINE EXTENDED TO THE EAST LINE OF THAT TRACT OF LAND CONVEYED TO JOHN F. KRAUSE AND ROBERT C. POLLOCK BY DEED RECORDED UNDER AUDITOR'S NO. 993343; THENCE SOUTH ALONG SAID EAST LINE OF KRAUSE/POLLOCK TRACT 537.56 FEET; THENCE S89°21'30"W, 251.16 FEET, MORE OR LESS, TO THE WEST LINE OF KRAUSE/POLLOCK TRACT; THENCE N0°38'30"W, 593.09 FEET TO THE TRUE POINT OF BEGINNING., IN PIERCE COUNTY, WASHINGTON.

PARCEL "B": (03-19-15-1-020)

BEGINNING AT A POINT ON THE NORTH LINE OF MAHON D.L.C., 1374.8 FEET EAST OF THE NORTHWEST CORNER OF DAID D.L.C. AND 20 FEET EAST OF THE SOUTHEAST CORNER OF LOT 3 IN SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE SOUTH PARALLEL WITH THE QUARTER SECTION LINE, 1416.03 FEET; THENCE EAST 251.77 FEET; THENCE NORTH 1352.19 FEET TO THE CENTERLINE OF COUNTY ROAD; THENCE S66°12'E, ALONG SAID CENTERLINE TO THE EAST LINE OF THE WEST HALF OF SAID D.L.C.; THENCE SOUTH ALONG SAID EAST LINE TO THE SOUTH LINE OF SECTION; THENCE WEST ALONG SAID SOUTH LINE TO THE SOUTHWEST CORNER OF THE SOUTHEAST QUARTER OF SECTION; THENCE NORTH TO NORTH LINE OF SAID D.L.C.; THENCE EAST 20 FEET TO THE POINT OF BEGINNING.

90 MAY 18 PM 3:53
AUDITOR PIERCE CO. WASH

PERMITS AND LAND SERVICES
MAR 1 1990
PIERCE COUNTY

EXCISE TAX EXEMPT DATE MAY 18 1990
Pierce County
By BC Auth. Sig.

and

WHEREAS, the foregoing described properties have common boundaries as shown on attached Exhibit "A" and

WHEREAS, the Pierce County Subdivision Code, Chapter 67.02.010(6) has provisions to allow for adjusting boundary lines between contiguous properties.

DECLARATION OF BOUNDARY LINE REVISION

NOW, THEREFORE, in consideration of the mutual benefits to the foregoing described properties, the parties do for themselves, their heirs and assigns, revise the boundary line of each parcel, with the boundaries to be as shown on attached Exhibit "B" and described as follows:

PARCEL "A":

COMMENCING AT THE STONE MONUMENT AT THE INTERSECTION OF THE NORTH LINE OF CHARLES MAHON D.L.C. NO. 48 WITH THE NORTH-SOUTH QUARTER SECTION LINE OF SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE ALONG SAID QUARTER SECTION LINE S0°38'30"E, 165.00 FEET; THENCE S78°43'30"E, 20.39 FEET TO A LINE 20 FEET EAST OF AND PARALLEL WITH SAID QUARTER SECTION LINE; THENCE S0°38'30"E, 21.00 FEET TO THE CENTERLINE OF CREEK AND THE TRUE POINT OF BEGINNING' THENCE S77°08'00"E, 237.74 FEET ALONG SAID CREEK AND CREEK EXTENDED; THENCE S0°38'30"E, 537.56 FEET; THENCE S89°21'30"W, 231.16 FEET; THENCE N0°38'30"W, 593.09 FEET TO THE TRUE POINT OF BEGINNING.

PARCEL "B":

BEGINNING AT A POINT ON THE NORTH LINE OF MAHON D.L.C., 1374.8 FEET EAST OF THE NORTHWEST CORNER OF SAID D.L.C. AND 20 FEET EAST OF THE SOUTHEAST CORNER OF LOT 3 IN SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE SOUTH, PARALLEL WITH THE QUARTER SECTION LINE, 1416.03 FEET; THENCE EAST 251.77 FEET; THENCE NORTH 1352.19 FEET TO THE CENTERLINE OF COUNTY ROAD; THENCE S66°12'E, ALONG SAID CENTERLINE TO THE EAST LINE OF THE WEST HALF OF SAID D.L.C.; THENCE SOUTH ALONG SAID EAST LINE TO THE SOUTH LINE OF SECTION; THENCE WEST ALONG SAID SOUTH LINE TO THE SOUTHWEST CORNER OF THE SOUTHEAST QUARTER OF SECTION; THENCE NORTH TO NORTH LINE OF SAID D.L.C.; THENCE EAST 20 FEET TO THE POINT OF BEGINNING;

TOGETHER WITH THE EAST 20 FEET OF THE FOLLOWING DESCRIBED TRACT:

COMMENCING AT THE STONE MONUMENT AT THE INTERSECTION OF THE NORTH LINE OF THE C. MAHON D.L.C., NO. 48 AND THE NORTH/SOUTH QUARTER SECTION LINE OF SECTION 15, TOWNSHIP 19 NORTH, RANGE 3 EAST, W.M.; THENCE S0°38'30"E, ALONG SAID QUARTER SECTION LINE, 165.00 FEET; THENCE S78°43'30"E, 20.39 FEET TO A LINE PARALLEL WITH AND 20.00 FEET EAST OF SAID QUARTER SECTION LINE; THENCE S0°38'30"E,21.00 FEET TO THE CENTERLINE OF A CREEK AND THE POINT OF BEGINNING, SAID POINT OF BEGINNING BEING THE SOUTHWEST CORNER OF THAT CERTAIN PARCEL CONVEYED TO PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6 BY WARRANTY DEED RECORDED NOVEMBER 11, 1978 UNDER AUDITOR'S NO. 2869180; THENCE S77°08'00"E, 257.74 FEET, MORE OR LESS, ALONG THE CENTERLINE OF SIAD CREEK AND THE CENTERLINE EXTENDED TO THE EAST LINE OF THAT TRACT OF LAND CONVEYED TO JOHN F. KRAUSE AND ROBERT C. POLLOCK BY DEED RECORDED UNDER AUDITOR'S NO. 993343; THENCE SOUTH ALONG SAID EAST LINE OF KRAUSE/POLLOCK TRACT, 537.56 FEET; THENCE S89°21'30"W, 251.16 FEET, MORE OR LESS, TO THE WEST LINE OF KRAUSE/POLLOCK TRACT; THENCE N0°38'30"W, 593.09 FEET TO THE TRUE POINT OF BEGINNING, IN PIERCE COUNTY WASHINGTON.

9005180393

FREE CONSENT STATEMENT

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 14 day of November, 1989.

O. H. Ellingson
Stephen T Baskett

ACKNOWLEDGMENT
(Corporation)

STATE OF WASHINGTON,
County of Pierce } ss.

On this 14 day of November, 1989, before me personally appeared O.H. ELLINGSON + STEVE BASKETT, to me known to be the FIRE COMMISSIONERS

of the corporation that executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that he w__ authorized to execute said instrument and that the seal affixed thereto (if any) is the corporate seal of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Official Seal the day and year first above written.

[signature]
Notary Public in and for the State of Washington, residing at TACOMA

(3)a

9005180393

FREE CONSENT STATEMENT

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 14 day of November, 1989.

O.H. Ellingson

Stephen T Baskett

ACKNOWLEDGEMENT

STATE OF WASHINGTON,]
] ss
COUNTY OF Pierce]

I, Yvonne Grissom Notary Public in and for the state of Washington, residing at Tacoma do hereby certify that of this 14 day of November, 1989, personally appeared before me O.H. Ellingson & Steve Baskett to me known to be the individuals described in and who executed the within instrument and acknowledged that they signed and sealed the same as ____ free and voluntary act and deed for the uses and purposes herein mentioned.

GIVEN UNDER MY HAND AND OFFICIAL SEAL this 14 day of November, 1989.

Yvonne Grissom
Notary Public in and for the State of Washington, residing at Tacoma.

9005180393

FREE CONSENT STATEMENT

IN WITNESS WHEREOF, said parties hereto have caused this instrument to be executed this 8 day of February, 1990.

Charles Brown 12/21/90

X Ruth Brown

ACKNOWLEDGEMENT

STATE OF WASHINGTON,]
] ss
COUNTY OF PIERCE]

I, YVONNE GRISSOM Notary Public in and for the state of Washington, residing at TACOMA do hereby certify that of this 8 day of February, 1990, personally appeared before me Charles BROWN to me known to be the individual described in and who executed the within instrument and acknowledged that he signed and sealed the same as his free and voluntary act and deed for the uses and purposes herein mentioned.

GIVEN UNDER MY HAND AND OFFICIAL SEAL this 8 day of February, 1990.

Yvonne Grissom
Notary Public in and for the State of Washington, residing at TACOMA.

YVONNE GRISSOM NOTARY PUBLIC STATE OF WASHINGTON

STATE OF ~~WASHINGTON~~ California,
County of Riverside } ss.

On this day personally appeared before me Ruth Brown

to me known to be the individual described in and who executed the within and foregoing instrument and acknowledged to me that she signed the same as her free and voluntary act and deed for

OFFICIAL SEAL
AUDREY JEAN FLEISCHMAN
NOTARY PUBLIC—CALIFORNIA
PRINCIPAL OFFICE IN RIVERSIDE COUNTY
My Commission Expires SEPT. 20, 1991

Given under my hand and official seal this 21 day of Feb., 1990

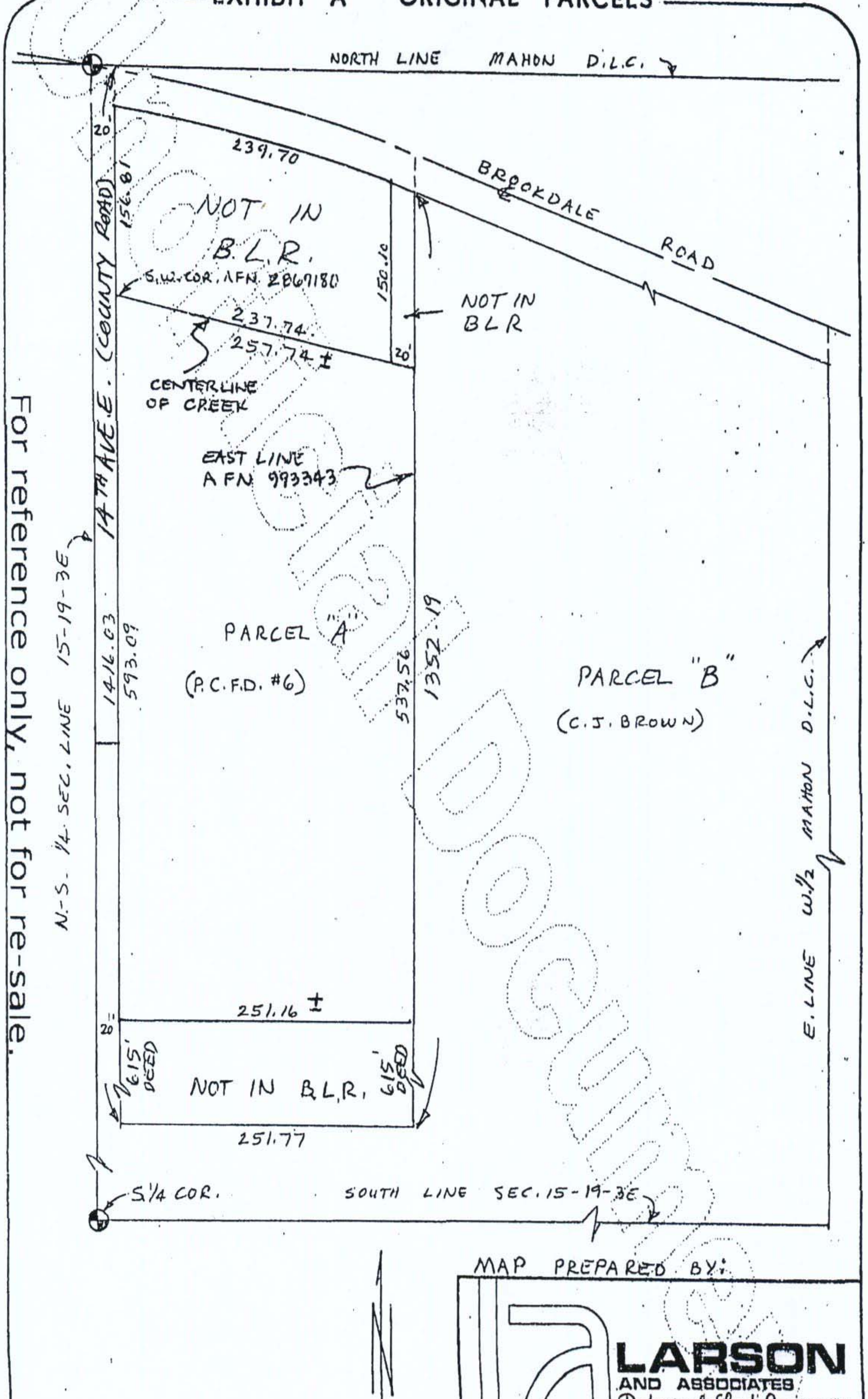
Audrey Jean Fleischman

Notary Public in and for the State of ~~Washington~~ Calif., residing at Palm Desert

9005180393

VOL. 0612 PAGE 0552
VOL. 0612 PAGE 4043

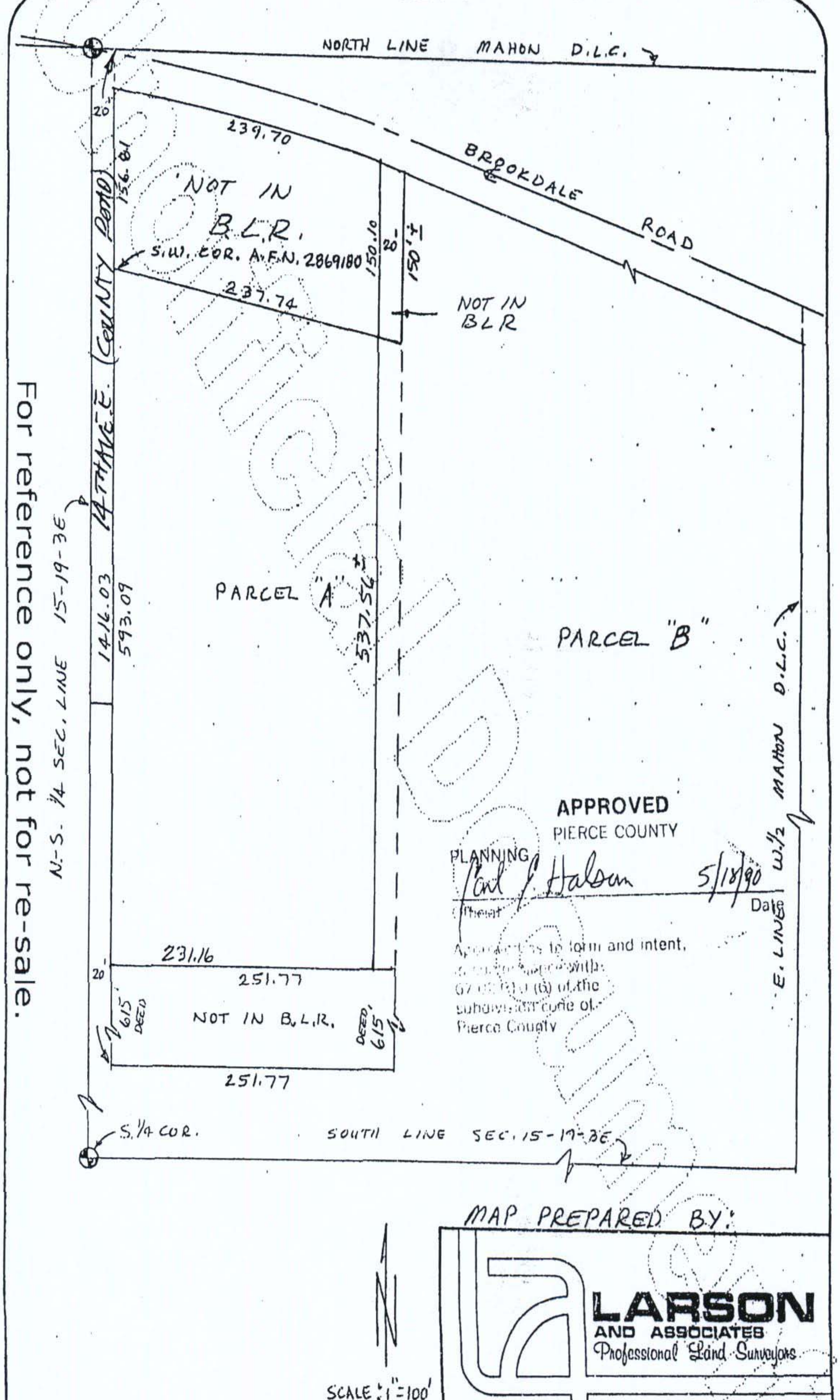
EXHIBIT "A" ORIGINAL PARCELS



(4)

9005180393

EXHIBIT "B" REVISED PARCELS



9005180393

SAFECO

SAFECO TITLE INSURANCE COMPANY

VOL. 0612 PAGE 0554

THIS SPACE RESERVED FOR RECORDER'S USE

VOL. 0612 PAGE 4045

Filed for Record at Request of

NAME PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6 - Attn: Chief Les Flue

ADDRESS 10050 - 114th Street

CITY AND STATE Tacoma, WA 98444

QUIT CLAIM DEED

THE GRANTOR, PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6,

for and in consideration of ONE DOLLAR ($1.00) and other good and valuable consideration,

conveys and quit claims to CHARLES J. BROWN and RUTH BROWN, husband and wife,

the following described real estate, situated in the County of Pierce,
State of Washington, including any after acquired title:

The east 20 feet of the following described Tract:
Commencing at the stone monument at the intersection of the North line of Charles Mahon D.L.C. No. 48 with the North-South Quarter section line of Section 15, Township 19 North, Range 3 East, W.M.; thence along said Quarter section line S 0°38'30" E, 165.00 feet; thence S 78°43'30" E, 20.39 feet to a line 20 feet East of and parallel with said Quarter section line; thence S 0°38'30" E, 21.00 feet to the centerline of creek and the TRUE POINT OF BEGINNING; thence S 77°08'00" E, 237.74 feet along said creek and creek extended; thence S 0°38'30" E, 537.56 feet; thence S 89°21'30" W, 231.16 feet; thence N 0°38'30" W, 593.09 feet to the TRUE POINT OF BEGINNING.

Situate in Pierce County, State of Washington.

Auditor's Note
This document was not cleared for excise tax as required for all conveyances.

Dated ______________, 19 89.

______________ (Individual)

______________ (Individual)

PIERCE COUNTY FIRE PROTECTION DISTRICT NO. 6

By [signature] (President)

By [signature] (Secretary)

STATE OF WASHINGTON
COUNTY OF } ss.

On this day personally appeared before me ______________

to me known to be the individual described in and who executed the within and foregoing instrument, and acknowledged that ______________ signed the same as ______________ free and voluntary act and deed, for the uses and purposes therein mentioned.

GIVEN under my hand and official seal this ______ day of ______________, 19 ____

Notary Public in and for the State of Washington, residing at ______________.

STATE OF WASHINGTON
COUNTY OF Pierce } ss.

On this 14 day of November, 19 89, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Dick Ellingson

and R.L. Flue ; Fire Chief

to me known to be the Chairman ~~President~~ and Commissioners ~~Secretary~~, respectively, of FIRE PROTECTION DISTRICT No. 6, the corporation that executed the foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that they are authorized to execute the said instrument and that the seal affixed is the corporate seal of said corporation.

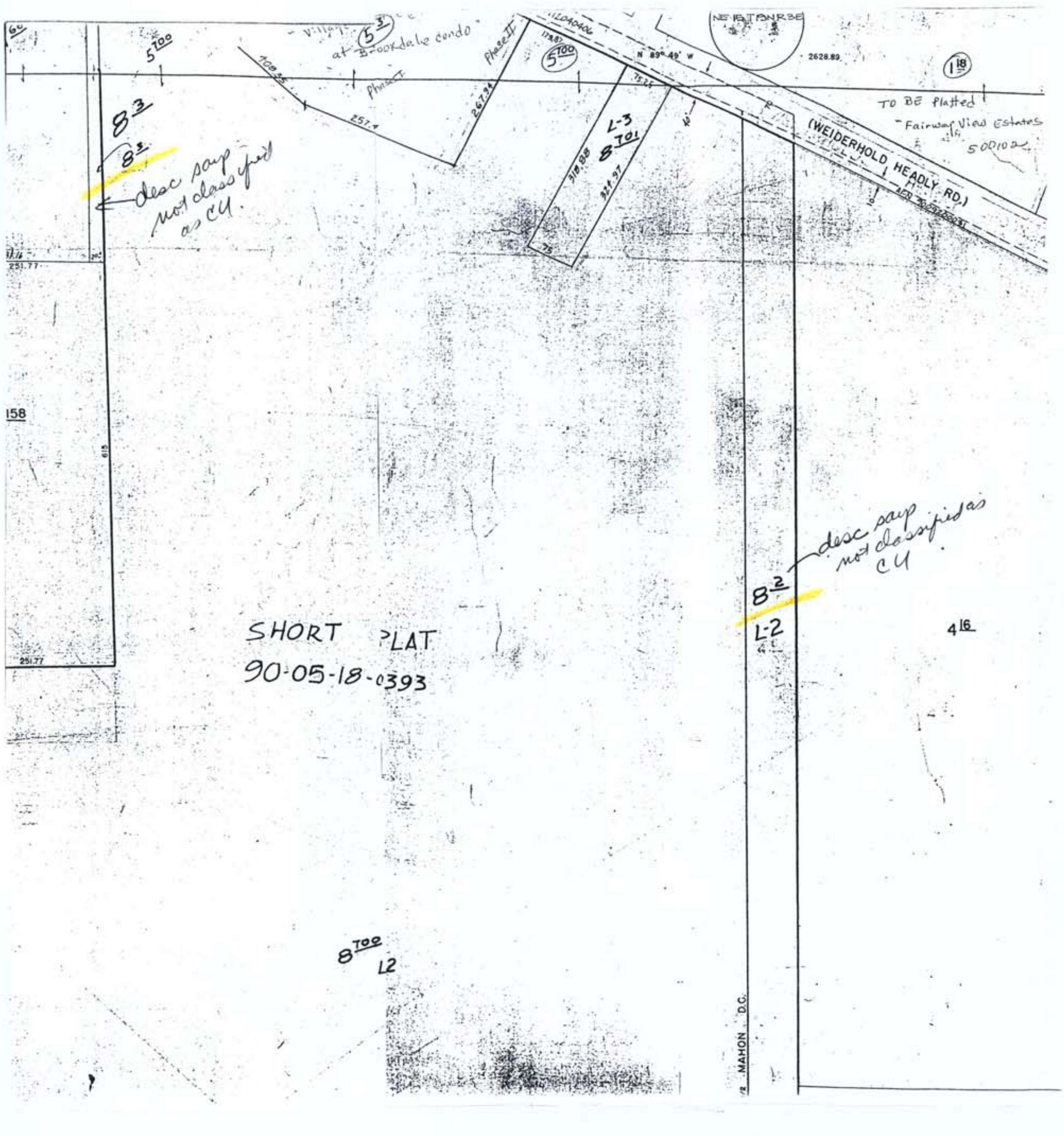
Witness my hand and official seal hereto affixed the day and year first above written.

Yvonne Grisson

Notary Public in and for the State of Washington, residing at Tacoma

9005180393

TL-5 R3 2/76



at Brookdale condo
Phase II
Phase I
5 3
5 700
5 700
N 89° 49' W
2628.89
1 18
TO BE Platted
Fairway View Estates
500102
(WEIDERHOLD HEADLY RD.)
8 3
8 3
desc sdup not classified as CU
L-3
8 701
267.94
257.4
318.88
321.97
75
251.77
251.77
158
desc sdup not classified as CU
8 2
L-2
4 16
SHORT PLAT
90-05-18-0393
8 700
L2
MAHON D.C.

92 515 0 3.010 27,300 27,300 27,300
93 515 0 3.010 27,300 27,300 27,300
94 515 0 3.010 27,300 27,300 27,300

03-19-15-1-066

06/11/90 20,000 C758697 9600 93 VZZ

BOUCHER PAUL A & MARLEEN J BOUCHER PAUL A & MARLEEN J

W619244

13715 14TH AVE E 13715 14TH AVE E 03-19-15-1-059

TACOMA WA 98445 TACOMA WA 98445 00000 03-19-15-1-3

93 15-19-03E&1/066 PARCEL "A" OF DBLR 90-05-18-0393
DESC AS COM AT INTER OF N LI OF C MAHON DLC #48 WITH N-S 1/4 LI
92 OF SEC 15 TH S 00 DEG 38 MIN 30 SEC E 165 FT TH S 78 DEG 43 MIN 30
SEC E 20.39 FT TO A LI 20 FT E & PAR/W SD 1/4 SEC LI TH S 00 DEG 38
91 MIN 30 SEC E 21 FT TO C/L OF CREEK & POB TH S 77 DEG 08 MIN E 237.74
FT TH S 00 DEG 38 MIN 30 SEC E 537.56 FT TH S 89 DEG 21 MIN 30
90 SEC W 231.16 FT TH N 00 DEG 38 MIN 30 SEC W 593.09 FT TO POB OUT OF
1-059 SEG F-0328JU 10-21-93CL
89
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87

92 515 0 3.920 273,700 273,700 273,700
93 515 0 3.920 273,700 273,700 273,700
94 515 0 3.920 273,700 273,700 273,700

03-19-15-5-003

12/19/91 274,000 W800069 9700 93 COM

FOX DONALD W & CAROL FOX DONALD W & CAROL

W800068

11307 26TH AVE E 11307 26TH AVE E 03-19-15-1-065

TACOMA WA 98445 TACOMA WA 98445 00000 03-19-15-1-3

93 15-19-03E&5/003 L 1 OF S P 91-12-09-0414 EXC NLY
10 FT THEREOF CYD TO P CO PER ETN 797928 TOG/W EASE & RESTRICTIONS
92 OF REC OUT OF 1-065 SEG F-0328JU 10-21-93CL
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88
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92	515 0	3.130	13,200	13,200	13,200
93	515 0	3.130	13,200	13,200	13,200
94	515 0	3.130	13,200	13,200	13,200

03-19-15-8-002 ✓

7411 93 COM

BROWN CHARLES J & RUTH — BROWN CHARLES J & RUTH

PO BOX Q — P O BOX Q — 03-19-15-4-006

YELM WA 98597 — YELM WA 98597 — 00000 03-19-15-4-1

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15-19-03E&8/002
BE SOLD OR SUBD WITHOUT PARCELS
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CLASSIFIED CURRENT USE & DESC AS
DEG 50 MIN 29 SEC W 1692.22 FT TH
N 01 DEG 50 MIN 29 SEC E SWLY LI
RD TO POB EXC THAT POR CYD TO P CO
RESTRICTIONS OF REC OUT OF 4-006

SEG FOR TAX PURPOSES ONLY CANNOT
8-003, 03-19-22-5-007 5-700, &
91-12-09-0414 LY IN SEC 15 & NOT
FOLL BEG AT NE COR SD L 2 TH S 01
N 88 DEG 09 MIN 31 SEC W 80 FT TH
OF BROOKDALE RD E TH SELY ALG SD
PER ETN 797928 TOG/W EASE &
SEG F-0328JU 10-21-93CL

92	515 0	.230	2,300	2,300	2,300
93	515 0	.230	2,300	2,300	2,300
94	515 0	.230	2,300	2,300	2,300

03-19-15-8-003 ✓

7411 93 COM

BROWN CHARLES J & RUTH — BROWN CHARLES J & RUTH

PO BOX Q — P O BOX Q — 03-19-15-1-059

YELM WA 98597 — YELM WA 98597 — 00000 03-19-15-4-2

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15-19-03E&8/003
BE SOLD OR SUBD WITHOUT PARCELS
& 5-701 THAT POR OF L 2 OF S P
CLASSIFIED CURRENT USE & DESC AS
AT INTER OF N LI OF C MAHON DLC
DEG 38 MIN 30 SEC E 165 FT TH S 78
LI PAR/W & 20 FT E OF SD 1/4 SEC
FT TO C/L OF CREEK & POB S 77 DEG
MIN 30 SEC E 537.56 FT TH S 89 DEG
DEG 38 MIN 30 SEC W 593.09 FT TO
OF SD S P 91-12-09-0414 TOG/W
1-059 SEG F-0328JU 10-21-93CL

SEG FOR TAX PURPOSES ONLY CANNOT
8-002, 8-700 03-19-22-5-007, 5-700
91-12-09-0414 LY IN SEC 15 & NOT
FOLL E 20 FT OF FOLL DESC TR COM
#48 & N-S SEC LI OF SEC 15 TH S 0
DEG 43 MIN 30 SEC E 20.39 FT TO A
LI TH S 00 DEG 38 MIN 30 SEC E 21
08 MIN E 257.74 FT TH S 00 DEG 38
21 MIN 30 SEC W 251.16 FT TH N 0
POB EXC ANY POR THEREOF LY IN L 1
EASE & RESTRICTIONS OF REC OUT OF

SEG-CONT

92	515 0	73.100	2,290,826	209,300	2,500,126 Y	203,055	79,345	282,400
93	515 0	73.100	2,290,826	209,300	2,500,126 Y	203,055	79,345	282,400
94	515 0	73.100	2,290,826	209,300	2,500,126 Y	203,055	79,345	282,400

03-19-15-8-700

7777 93 COM

BROWN CHARLES J & RUTH — BROWN CHARLES J & RUTH

PO BOX Q — P O BOX Q — 03-19-15-1-702

YELM WA 98597 — YELM WA 98597 — 00000 03-19-15-4-0

15-19-03E&8/700 SEG FOR TAX PURPOSES ONLY CANNOT
BE SOLD OR SUBD WITHOUT PARCELS 8-002, 8-003, 03-19-22-5-007,
5-700 & 5-701 THAT POR OF L 2 OF S P 91-12-09-0414 LY IN SEC 15 &
CLASSIFIED CURRENT USE EXC THAT POR CYD TO P CO PER ETN 797928
TOG/W EASE & RESTRICTIONS OF REC CURRENT USE RCW 84.34 1973 OPEN
SPACE AFN 2463739 69.85 ACS OUT OF 1-702 SEG F-0328JU/CH
10-21-93CL

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92	515 0	.550	18,474	18,474 Y	530	530
93	515 0	.550	18,474	18,474 Y	530	530
94	515 0	.550	18,474	18,474 Y	530	530

03-19-15-8-701

7777 93 COM

BROWN CHARLES J & RUTH — BROWN CHARLES J & RUTH

PO BOX Q — P O BOX Q — 03-19-15-1-702

YELM WA 98597 — YELM WA 98597 — 00000 03-19-15-4-2

15-19-03E&8/701 L 3 OF S P 91-12-09-0414 EXC NLY
10 FT THEREOF CYD TO P CO PER ETN 797928 TOG/W EASE & RESTRICTIONS
OF REC CURRENT USE RCW 84.34 1973 OPEN SPACE AFN 2463739 OUT OF
1-702 SEG F-0328CH/JU 10-22-93CL

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92 590 0 .410 7,700 7,700 7,700
93 590 0 .410 7,700 7,700 7,700
94 590 0 .410 7,700 7,700 7,700

03-19-22-5-007

7411 93 COM

BROWN CHARLES J & RUTH BROWN CHARLES J & RUTH

2146599

PO BOX Q P O BOX Q 03-19-22-1-015

YELM WA 98597 YELM WA 98597 00000 03-19-22-1-3

93 22-19-03E&5/007 SEG FOR TAX PURPOSES ONLY CANNOT
92 BE SOLD OR SUBD WITHOUT PARCELS 5-700, 5-701, 03-19-15-8-700,
91 8-002 & 8-003 THAT POR OF L 2 OF S P 91-12-09-0414 NOT CLASSIFIED
90 CURRENT USE LY IN SEC 22 & DESC AS FOLL COM AT SE COR OF W 1/2 OF
89 C MAHON DLC #48 TH N ALG E LI SD W 1/2 900 FT TH W PAR/W S LI SD DLC
88 766 FT TO POB TH W PAR/W S LI SD DLC 134 FT TH S 266 FT TH NELY 290
87 FT M/L TO POB OUT OF 1-015 SEG F-0328JU 10-22-93CL

92 585 0 35.940 676,300 676,300 Y 105,940 22,200 128,140
93 585 0 35.940 676,300 676,300 Y 105,940 22,200 128,140
94 585 0 35.940 676,300 676,300 Y 105,940 22,200 128,140

03-19-22-5-700

7777 93 COM

BROWN CHARLES J & RUTH BROWN CHARLES J & RUTH

1938272

PO BOX Q P O BOX Q 03-19-22-1-000

YELM WA 98597 YELM WA 98597 00000 03-19-22-1-2

93 22-19-03E&5/700 SEG FOR TAX PURPOSES ONLY CANNOT
92 BE SOLD OR SUBD WITHOUT PARCELS 5-007, 5-701, 03-19-15-8-700,
91 8-002 & 8-003 THAT POR OF L 2 OF S P 91-12-09-0414 LY IN S D #403 &
90 FPD #6 TOG/W EASE & RESTRICTIONS OF REC CURRENT USE RCW 84.34 1973
89 OPEN SPACE AFN 2463739 35.94 ACS OUT OF 1-000 SEG F-0328CH/JU
88 10-22-93
87

SEG-CONT

JU 11/05/93 5 F-0328

92	590 0	36.150	680,300	680,300 Y	92,150	92,150
93	590 0	36.150	680,300	680,300 Y	92,150	92,150
94	590 0	36.150	680,300	680,300 Y	92,150	92,150

03-19-22-5-701 ✓

7777 93 COM

BROWN CHARLES J & RUTH BROWN CHARLES J & RUTH

1938572

PO BOX Q P O BOX Q 03-19-22-1-011

YELM WA 98597 YELM WA 98597 00000 03-19-22-1-3

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22-19-03E&5/701
BE SOLD OR SUBD WITHOUT PARCELS
8-002 & 8-003 THAT POR OF L 2 OF
& FPD #7 EXC THAT POR NO IN
5-007 TOG/W EASE & RESTRICTIONS OF
OPEN SPACE AFN 2463739 36.15 ACS

SEG FOR TAX PURPOSES ONLY CANNOT
5-007, 5-700, 03-19-15-8-700,
S P 91-12-09-0414 LY IN S D #403
CURRENT USE ASSESSED AS PARCEL
REC CURRENT USE RCW 84.34 1973
OUT OF 1-011 SEG F-0328CH/JU

156.440	3,990,100	209,300	401,675	101,545
156.440	3,990,100	209,300	401,675	101,545
156.440	3,990,100	209,300	401,675	101,545

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158701 Local #: Parcel #: 0319158701

Tax Year:	2019	Levy:	0.000000	# of Imps:		Created On:	
Tax Dist:	PIERCE	Map #:		LEA:	3096	Active On:	10/08/2018
PUC:		Initials:		Acct Type:	Commercial	Inactive On:	
Assign To:	Eric Coldiron					Last Updated:	

Owner's Name and Address

BROOKDALE GOLF LLC
1802 BROOKDALE RD E
TACOMA , WA 98445 - -4810

Property Address

Street: 1802 BROOKDALE RD E
City: PIERCE COUNTY

Business Name

BROOKDALE GOLF COURSE

Sales Summary

Sale Date	Sale Price	Deed Type	Reception #	Book	Page #	Grantor

Legal

Section 15 Township 19 Range 03 Quarter 42 L 3 SP 91-12-09-0414 EXC NLY 10 FT THEREOF CYD TO P CO PER ETN 797928 TOG/W EASE & RESTRICTIONS OF REC CURRENT USE RCW 84.34 1973 OPEN SPACE AFN 246373

Section	Township	Range	Qtr	QtrQtr	Government Lot	Government Tract
15	19	03	4	2		

Subdivision Information

Sub Name	Block	Lot	Tract

Land Valuation Summary

Land Type	Abst Cd	Value By	Net SF	Measure	# of Units	Value/Unit	Actual Val	Asmt %	Assessed Val
Commercial	7410L	MRA	23,958	Square Feet	23,958.000000	$0.19	$4,587	100.00%	$4,587
Class				Sub Class					
Agricultural	9400L	CU	3,485	Acres	0.080000	$1,000.00	$80	100.00%	$80
Class	0			Sub Class	0				
Agricultural	9400L	CU	20,473	Acres	0.470000	$8,361.70	$3,930	100.00%	$3,930
Class	EXCL			Sub Class	0				
Land Subtotal:					0.55		$4,010		$4,010

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319158701 Local #: Parcel #: 0319158701

Land Attributes

Attribute	Description	Adjustment
C ECONOMIC	INFLUENCE	0.200000
C FUNCTIONAL	FLOOD WAY	1.000000
C FUNCTIONAL	MARGINAL 40 PCT	0.820000
C MA 9 CENTRAL	906 CANYON-PACIFIC-174TH	0.950000
C USE	8 RECREATIONAL LAND	1.000000
C UTILITIES	SEWER/SEPTIC NO	0.900000

Improvement Valuation Summary

Imp #	Property Type	Abst Code	Occupancy	Class	Actual Value	Asmt %	Assessed Val*
Improvement Subtotal:					$0		$0

Total Property Value

Total Value:	$4,010	$4,010

*Approximate Assessed Value

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE - ACCOUNT NOTES - ACCOUNT NOTES

Entry Date	Note	Category
08/02/2007	DRO 08-02-07 A Flood Way land attribute is listed on this parcel based on FEMA studies as adopted by the Pierce County Water Programs April 17th, 2007.	
08/29/2007	FBO 8/29/2007 Took land off of OR due to addition of floodwayattribute.	General
01/07/2010	PSO 1-7-10 For 2010 PI, batch updated Nbhd 906 LEAs to Ext A to pick up new land model and removed Land Overrides.	
03/05/2010	LCP 03/05/2010 The approach to value was left on cost. The group land attributes were updated.	
08/01/2011	PSO 8/1/11 Removed Land Override from 2012 inactive land line.	General
01/01/2016	ECO 08/27/2015 Reviewed due to parcels in the group being located in different Tax Code Areas. All Improvements are allocated correctly.	Material Note

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225007 | Local #: | Parcel #: 0319225007

Tax Year:	2019	Levy:	0.000000	# of Imps:		Created On:	
Tax Dist:	PIERCE	Map #:		LEA:	3096	Active On:	10/08/2018
PUC:		Initials:		Acct Type:	Commercial	Inactive On:	
Assign To:	Eric Coldiron					Last Updated:	

Owner's Name and Address

BROOKDALE GOLF LLC
1802 BROOKDALE RD E
TACOMA , WA 98445 - -4810

Property Address

Street: 1802 BROOKDALE RD E
City: PIERCE COUNTY

Business Name

BROOKDALE GOLF COURSE

Sales Summary

Sale Date	Sale Price	Deed Type	Reception #	Book	Page #	Grantor

Legal

Section 22 Township 19 Range 03 Quarter 13 : SEG FOR TAX PURPOSES ONLY CANNOT BE SOLD OR SUBD WITHOUT PARCELS 5-700, 5-701, 03-19-15-8-700, 8-002 & 8-003 THAT POR OF L 2 OF S P 91-12-09-0414 NOT CLAS

Section	Township	Range	Qtr	QtrQtr	Government Lot	Government Tract
22	19	03	1	3		

Subdivision Information

Sub Name	Block	Lot	Tract

Land Valuation Summary

Land Type	Abst Cd	Value By	Net SF	Measure	# of Units	Value/Unit	Actual Val	Asmt %	Assessed Val
Commercial	7410L	MRA	17,860	Square Feet	17,860.000000	$0.19	$3,420	100.00%	$3,420
Class				Sub Class					
Land Subtotal:					0.41		$3,420		$3,420

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225007 Local #: Parcel #: 0319225007

Land Attributes

Attribute	Description	Adjustment
C ECONOMIC	INFLUENCE	0.200000
C FUNCTIONAL	MARGINAL 40 PCT	0.820000
C MA 9 CENTRAL	906 CANYON-PACIFIC-174TH	0.950000
C USE	8 RECREATIONAL LAND	1.000000
C UTILITIES	SEWER/SEPTIC NO	0.900000

Improvement Valuation Summary

Imp #	Property Type	Abst Code	Occupancy	Class	Actual Value	Asmt %	Assessed Val*
Improvement Subtotal:					$0		$0

Total Property Value

Total Value:	$3,400	$3,400

*Approximate Assessed Value

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE - ACCOUNT NOTES - ACCOUNT NOTES

Entry Date	Note	Category
01/07/2010	PSO 1-7-10 For 2010 PI, batch updated Nbhd 906 LEAs to Ext A to pick up new land model and removed Land Overrides.	
01/29/2010	JLO/BFO 1/29/10 For 2010 PI, added Golf Course Frontage 1.0 adjustment.	
03/05/2010	LCP 03/05/2010 The approach to value was left on cost. The group land attributes were updated.	
01/01/2016	ECO 08/27/2015 Reviewed due to parcels in the group being located in different Tax Code Areas. All Improvements are allocated correctly.	General

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225700 | Local #: | Parcel #: 0319225700

Tax Year:	2019	Levy:	0.000000	# of Imps:	1	Created On:	
Tax Dist:	PIERCE	Map #:		LEA:	3096	Active On:	10/08/2018
PUC:		Initials:		Acct Type:	Commercial	Inactive On:	
Assign To:	Eric Coldiron					Last Updated:	

Owner's Name and Address

BROOKDALE GOLF LLC
1802 BROOKDALE RD E
TACOMA, WA 98445 - 4810

Property Address

Street: 1802 BROOKDALE RD E
City: PIERCE COUNTY

Business Name

BROOKDALE GOLF COURSE

Sales Summary

Sale Date	Sale Price	Deed Type	Reception #	Book	Page #	Grantor

Legal

Section 22 Township 19 Range 03 Quarter 12 SEG FOR TAX PURPOSES ONLY CANNOT BE SOLD OR SUBD WITHOUT PARCELS 5-007, 5-701, 03-19-15-8-700, 8-002 & 8-003 THAT POR OF L 2 OF S P 91-12-09-0414 LY IN

Section	Township	Range	Qtr	QtrQtr	Government Lot	Government Tract
22	19	03	1	2		

Subdivision Information

Sub Name	Block	Lot	Tract

Land Valuation Summary

Land Type	Abst Cd	Value By	Net SF	Measure	# of Units	Value/Unit	Actual Val	Asmt %	Assessed Val
Commercial	7410L	MRA	1,556,834	Square Feet	1,556,834.400000	$0.19	$298,076	100.00%	$298,076
Class				Sub Class					
Agricultural	9400L	CU	1,556,834	Acres	35.740000	$1,000.00	$35,740	100.00%	$35,740
Class	0			Sub Class	0				
Land Subtotal:					35.74		$35,740		$35,740

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225700 Local #: Parcel #: 0319225700

Land Attributes

Attribute	Description	Adjustment
C ECONOMIC	INFLUENCE	0.200000
C FUNCTIONAL	FLOOD WAY	1.000000
C FUNCTIONAL	MARGINAL 40 PCT	0.820000
C MA 9 CENTRAL	906 CANYON-PACIFIC-174TH	0.950000
C USE	8 RECREATIONAL LAND	1.000000
C UTILITIES	SEWER/SEPTIC NO	0.900000

Improvement Valuation Summary

Imp #	Property Type	Abst Code	Occupancy	Class	Actual Value	Asmt %	Assessed Val*
1	Commercial	7410	Recreational		$1,033,598	100. 00%	$1,033,598
Improvement Subtotal:					$1,033,598		$1,033,598

Total Property Value

Total Value:	$1,069,340	$1,069,340

*Approximate Assessed Value

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225700	Local #:	Parcel #: 0319225700

Imp #:	1			Landscaping $: 0.00
Property Type:	Commercial			
Quality:				
Condition:		Nbhd:	906	
Perimeter:		Nbhd Ext:	956	
% Complete:	100.00%	Nbhd Adj:	1.0000	

Occupancy Summary

Occupancy:	Recreational	Occ %:	100%

Built As Summary

Built As:	Addon Only Comm	Year Built:	2002
Construction Type:		Year Remodeled:	0
HVAC:	None		
Interior Finish:		% Remodeled:	0.0000
Roof Cover:		Adj Year Blt:	0
Built As SF:	1	Effective Age:	
# of Baths:	0.00		
# of Bdrms:	0.00		
# of Stories:	1.00		
Story Height:	8		
Sprinkler SF:	0	Diameter:	0
Capacity:	0	Height:	0

Improvement Summary

Improvement 1	Units	Units Price	RCN	Actual Value
Add On				
Misc Improvements	1.0000	$0.00	$0.00	$1,000.00
Golf Course Hole Value (Class 2 Med range)	9.0000	$149,004.	$1,341,036.00	$1,032,598.00

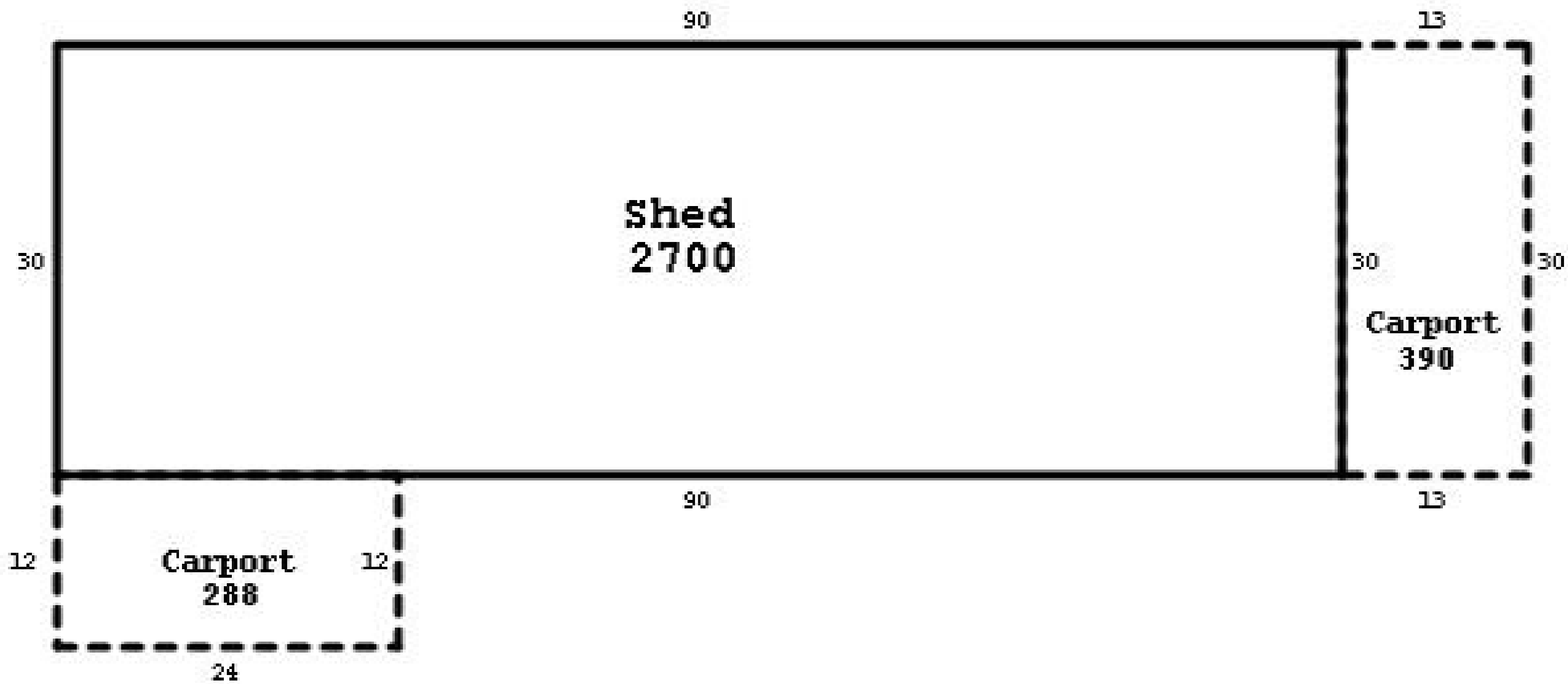
Improvements Value Summary

IMPNO: 1

RCN Cost/SF:	$1,342,036.00	Design Adj:	0.0000	Func Obs %:	0.0000
Total RCN:	$1,342,036.00	Exterior Adj:	0.0000	Econ Obs %:	0.0000
Phys Depr %	0.0000	Interior Adj:	0.0000	Other Obs %:	0.0000
Phys Depr $:	$308,438.00	Amateur Adj:	0.0000		
RCNLD $:	$1,033,598.00	RCNLD Cost/$:	$1,033,598.00	Market/SF:	$1,060,418.00

Entry Date	Note	Category
07/08/2003	Corrected R/W error, holes were dropped, added back on and finaled on cost approach. 6/03 RJ.	General
08/02/2007	DRO 08-02-07 A Flood Way land attribute is listed on this parcel based on FEMA studies as adopted by the Pierce County Water Programs April 17th, 2007.	
08/29/2007	FBO 8/29/2007 Took land off of OR due to addition of floodwayattribute.	General
08/27/2008	08/26/08 FBM Looked at due to error list.	General
01/07/2010	PSO 1-7-10 For 2010 PI, batch updated Nbhd 906 LEAs to Ext A to pick up new land model and removed Land Overrides.	
03/05/2010	LCP 03/05/2010 The approach to value was left on cost. The group land attributes were updated. The sketch in Stellant is accurate as compared to the observed improvements.	
05/23/2011	FBG 05/23/2011 Per DC request. SF changed from 35.94 to 35.74	
08/01/2011	PSO 8/1/11 Removed Land Override from 2012 inactive land line.	General
01/01/2016	ECO 08/27/2015 Reviewed due to parcels in the group being located in different Tax Code Areas. All Improvements are allocated correctly. There appears to be some type of equiptment shed on this parcel that is not on the record. Next PI cycle verify these improvements.	Material Note
07/06/2017	ECN 07/05/2017 Verified equiptment shed on parcel. Originally built in 1931, this functions as a maintenance/storage shed. Very poor condition. Placed as an add-on with an override value of $1000. Minimal contribution to overall value.	General

0319225700



ECN 07/05/2017

tch by Apex Medina™

C/U

OWNER: BROOKDALE GOLF LLC
ADDRESS:

APPLICANT:
CASE NO:
AUD. FEE. NO.: 2463739

OPEN SPACE CATEGORY	PARCEL NUMBER		
OP SPACE	03-19-22-5700		
DESCRIPTION:	AREA CODE	USE CODE	CARD NO.
	590	9400	___ OF ___

1973

ACRES: 35.94

MEMORANDA	MARKET VALUE RECORD				
	COMMENTS	YEAR	LAND VALUE	BLDG. VALUE	APPRAISER
		2003	487,000	647,800	
		2004	487,000	626,300	
		2005	535,700	742,000	
		2006	708,400	715,500	
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			
		20			

CURRENT USE VALUE RECORD

CLASS	ACREAGE	RATE	2003	20	20	20	20	20	20	20	20	20
O SPACE	35.94	1000	35,940									
LAND IMP.												
TOTALS	35.94		35,940									

Z-2240 rev. 6/00

OWNER: BROWN, CHARLES J.
ADDRESS: BROOKDALE GOLF COURSE
1802 BROOKDALE RD. E.
TACOMA, WA. 98445
APPLICANT:
CASE NO: O.S. 004-72
AUD. FEE NO.: 2463739
CURRENT USE RCW 84.34

OPEN SPACE CATEGORY: OPEN SPACE

DESCRIPTION: NW NE SEC. 22, T.19N., R.3E.

PARCEL NUMBER	AREA CODE	USE CODE	CARD NO.
03-19-22-~~1-000~~ 5-700	585.0	~~7701~~ 7777	1 OF 1

ACRES: 35.94

1973

MEMORANDA

OPEN SPACE 35.94 ACS

(9 HOLES)

9

MARKET VALUE RECORD

COMMENTS	YEAR	LAND VALUE (TOTAL)	HOLES	BLDG
	19 84	656,630	(26,136)	
	19 85	563,600	(26,136)	
	19 86	751,500	(26,136)	
	19 87	676,300	(24,461)	
	1992	1,127,200 - 70,000 holes (imp change)	of 22,200	22,200
	19 94	851,000	—	
	19 95	879,400 -70,000 hole		
	19 98	879,400	(599,000 hole value - NO IMP)	
	19 99	907,800	(658,800 hole value - NO IMP)	
	19 2000	907,800	(830,100 hole value - NO IMP)	
	19 2001+2	472,800	642,600	—
	19			
	19			
	19			
	19			
	19			
	19			

CURRENT USE VALUE RECORD

CLASS	ACREAGE		RATE	19 84	19 85	19 86	19 87	19 92	19 98	19 99	2000	2001	2002
O. SPACE	35	94	1,000	35,940	35,940	35,940	35,940	35,940	35,940	35,940	35,940	35940	35,940
													1st year hole value not valued with C.U. IMP
LAND IMP.			*	93,030	93,030	110,880	81,155	70,000	hole value 599,000	hole value 658,800	830,100	642,600	
TOTALS	35	94		128,970	128,970	146,820	117,095	105,940	634,940	694,740	866,040	678,540	35,940

Z-2240

OWNERSHIP

BROWN, CHARLES J.
BROOKDALE GOLF COURSE
1802 BROOKDALE RDE.
TAC WN 98445

AUD FEE # 2463739

O.S. 004-72

ADDRESS OF PROPERTY

DESCRIPTION

SEC-22-19-3E 1000
BEG AT A PT ON E LI OF W 1/2
OF MAHON DLC 900 FT N ETC

CURRENT USE RCW 84.34 1973 35.94 ac

PARCEL NUMBER		
03-19-22-1-000		
AREA CODE	USE CODE	CARD NO.
585 (755)	7701	1 OF 1

RECORD OF OWNERSHIP	DATE	PRICE
		@50%
		@100%
	* SEE ATT'D	SHEET
M.V. 35.94 ACS. @ 15,682/Ac; IMP- "0"		

MARKET VALUE

ASSESSED VALUE RECORD

YEAR	LAND	% COMP.	BUILDINGS	TOTAL	APPRAISER	POSTED
1973	10,780					
1974	21,560					
1976	167,620	IMPS 63,900	0		BG	
1977	107820		HOUSE 13,975 w/o			
1980	563,617	"	20,301 w/o		GB	

MEMORANDA

1931

CORR

= 87500
33875
55610

PERMIT RECORD

DATE	LAND	BLDG	COMPLETE	APPR.
1980	563,597	? 19,397 w/o		GB
1982	628,277	26,532		Com

PROPERTY FACTORS

NO. ACRES	TOPOGRAPHY		IMPROVEMENTS		STREET OR ROAD		DISTRICT	
	LEVEL		ALL UTILITIES		PAVED		STATIC	
	HIGH		WATER		SEMI-IMPROVED		IMPROVING	
	LOW		SEWER		DIRT		DECLINING	
	ROLLING		GAS		PROPOSED		BLIGHTED AREA	
	SWAMP				SIDEWALK			
	VIEW							

1 LOT 2 GROSS 3 NONE

LAND DATA COMPUTATIONS 1980 (1982)

FRONTAGE	DEPTH	UNIT VALUE	DEPTH FACTOR	ACTUAL VALUE	CLASSIFICATION	NO. OF ACRES	RATE	TRUE VALUE	ASSESSED VALUE	TRUE VALUE	ASSESSED VALUE
---	---	---			O.S.	D/L 35.94	130	4670		REC. BASE-1,000/A 35,940	35,940
					VIEW ACREAGE	Devel.		53,610		84,000	64,680
LOT DEPRECIATION				___%	TOTAL	35.94					
CORNER INFLUENCE											
TOTAL VALUE LAND (GROSS)								58,280	29,140	119,940	100,620
TOTAL VALUE BUILDINGS											
TOTAL VALUE LAND & BUILDINGS											

RESIDENTIAL
11—1 family
12—2-4 family
13—5-19 family
14—20+ family
15—group quarters
16—residential hotel
17—mobile home park
18—transient lodging
19—other residential

MANUFACTURING
21—food & kindred
22—textile mill
23—apparel & similar
24—lumber & wood
25—furniture & fixtures
26—paper & allied
27—printing & allied
28—chemical & allied
29—petrol. refin. & rel.
31—rubber & plastic
32—stone, clay & glass
33—primary metal
34—fabricated metal
35—prof. & scien. instr.
39—misc. mfg.

TRANSP., COMM. & UTIL.
41—rail transit
42—motor vehicles
43—aircraft
44—marine craft
45—street R.O.W.
46—auto parking
47—communication
48—utilities
49—other T.,C.&U.

TRADE
51—wholesale
52—retail-bldg. mtls., hdwr. & farm equip.
53—retail-gen. mdse.
54—retail-food
55—retail-auto, boat & air
56—retail-apparel & acc.
57—retail-home furn.
58—retail-eat & drink
59—other retail

SERVICES
61—finan., ins. & R.E.
62—personal
63—business
64—repair
65—professional
66—contract constr.
67—governmental
68—educational
69—misc. services

RECREATIONAL
71—culture or nat. exhib.
72—public assembly
73—amusements
74—rec. activities
75—resorts & camps
76—parks
79—other C.,E.&R.

RESOURCE
81—agriculture
82—agr. related
83—forestry & related
84—fishing & related
85—mining & related
89—other resource

UNDEVELOPED L & W
91—unused land
92—non com'l forest
93—water areas
94—vacant floor area
95—under constr.
99—other undev. L & W

PIERCE COUNTY, WASHINGTON

PARECL # 03-19-22-1-000 ONLY = 35.94 AC

NOTE: GOLF COURSE ENCOMPASSES OTHER PARCELS LISTED AS FOLLOWS
SEC 22-19-03E DIA 1-011, 1-001, 1-015 & 2-000
SEC 15-19-03E DIA 1-020 & 4-000(REF) = 132.54 AC OVERALL 168.48 AC

BROOKDALE GOLF COURSE

HIGHEST & BEST USE:

(168.48 AC @ 3000 = 505,440)

APPORTIONED VALUE TO DIAGRAM 1-000 35.94 AC @ 3000 = $107,820

IMPROVEMENT VALUE DEPRECIATED TO -0- -0-

TOTAL VALUE: $107,820

APPRAISAL MADE 9/15/75 BG

PARCEL # 03-19-22-1-000 ONLY

CURRENT USE:

RECREATIONAL LAND VALUATION
(168.48 AC @ 800 = 134780)

APPORTIONED VALUE TO DIAGRAM 1-000 35.94 AC @ 800 = $ 28,750

IMPROVEMENT VALUE BREAKDOWN

CLASS I GOLF COURSE (MARSHALL-SWIFT MANUAL) 18 HOLES @ 23000 @ 65% GOOD 23000 X .65 = 14950 X 18 =	$269100
STRUCTURES (NO CHANGE)	$ 63500
CARETAKERS HOUSE (NO CHANGE)	$ 9960
	$371310

APPRAISAL MADE 9/15/75 BG

NOTE: IF THE ENTIRE GOLF COURSE WERE TO BE APPRAISED ENCOMPASSING THE ABOVE LISTED PARCELS THE VALUE ESTIMATE ARRIVED AT USING THE HIGHEST & BEST USE CONCEPT WOULD BE $505,440 AND THE VALUE ESTIMATE USING THE CURRENT USE CONCEPT WOULD BE: $477,340.

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225701 **Local #:** **Parcel #:** 0319225701

Tax Year:	2019	**Levy:**	0.000000	**# of Imps:**		**Created On:**	
Tax Dist:	PIERCE	**Map #:**		**LEA:**	3096	**Active On:**	10/08/2018
PUC:		**Initials:**		**Acct Type:**	Commercial	**Inactive On:**	
Assign To:	Eric Coldiron					**Last Updated:**	

Owner's Name and Address

BROOKDALE GOLF LLC
1802 BROOKDALE RD E
TACOMA, WA 98445 - 4810

Property Address

Street: 1802 BROOKDALE RD E
City: PIERCE COUNTY

Business Name

BROOKDALE GOLF COURSE

Sales Summary

Sale Date	Sale Price	Deed Type	Reception #	Book	Page #	Grantor

Legal

Section 22 Township 19 Range 03 Quarter 21 SEG FOR TAX PURPOSES ONLY CANNOT BE SOLD OR SUBD WITHOUT PARCELS 5-007, 5-700, 03-19-15-8-700, 8-002 & 8-003 THAT POR OF L 2 OF S P 91-12-09-0414 LY IN

Section	Township	Range	Qtr	QtrQtr	Government Lot	Government Tract
22	19	03	2	1		

Subdivision Information

Sub Name	Block	Lot	Tract

Land Valuation Summary

Land Type	Abst Cd	Value By	Net SF	Measure	# of Units	Value/Unit	Actual Val	Asmt %	Assessed Val
Commercial	7410L	MRA	1,574,694	Square Feet	1,574,694.000000	$0.19	$301,495	100.00%	$301,495
Class				**Sub Class**					
Agricultural	9400L	CU	1,574,694	Acres	36.150000	$1,000.00	$36,150	100.00%	$36,150
Class	0			**Sub Class**	0				
Land Subtotal:					**36.15**		**$36,150**		**$36,150**

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE

Account #: 0319225701 **Local #:** **Parcel #:** 0319225701

Land Attributes

Attribute	Description	Adjustment
C ECONOMIC	INFLUENCE	0.200000
C FUNCTIONAL	FLOOD WAY	1.000000
C FUNCTIONAL	MARGINAL 40 PCT	0.820000
C MA 9 CENTRAL	906 CANYON-PACIFIC-174TH	0.950000
C USE	8 RECREATIONAL LAND	1.000000
C UTILITIES	SEWER/SEPTIC NO	0.900000

Improvement Valuation Summary

Imp #	Property Type	Abst Code	Occupancy	Class	Actual Value	Asmt %	Assessed Val*
Improvement Subtotal:					**$0**		**$0**

Total Property Value

Total Value:	**$36,150**	**$36,150**

*Approximate Assessed Value

PIERCE COUNTY ASSESSOR
PROPERTY PROFILE - ACCOUNT NOTES - ACCOUNT NOTES

Entry Date	Note	Category
08/02/2007	DRO 08-02-07 A Flood Way land attribute is listed on this parcel based on FEMA studies as adopted by the Pierce County Water Programs April 17th, 2007.	
08/29/2007	FBO 8/29/2007 Took land off of OR due to addition of floodwayattribute.	General
01/07/2010	PSO 1-7-10 For 2010 PI, batch updated Nbhd 906 LEAs to Ext A to pick up new land model and removed Land Overrides.	
03/05/2010	LCP 03/05/2010 The approach to value was left on cost. The group land attributes were updated. The sketch in Stellant is accurate as compared to the observed improvements.	
08/01/2011	PSO 8/1/11 Removed erroneous land override from 2011 inactive market land line and corrected value which was trended negatively twice in error. Will process 2011 ME correction after Current Use AV is reviewed.	General
08/17/2011	PSO 8/3/11 Removed an erroneous land override from the 2011 inactive market land line and corrected market land value which was trended negatively twice in error. Processed 2011 ME correction.	
01/01/2016	ECO 08/27/2015 Reviewed due to parcels in the group being located in different Tax Code Areas. All Improvements are allocated correctly.	Material Note

Attachment C
2016 Robinson Noble Limited Pesticide Investigation Letter Report and Laboratory Analytical Results

ROBINSON
NOBLE

December 14, 2016

Paul Green
Azure Green Consultants
409 East Pioneer
Puyallup WA 98372

Subject: Limited Pesticide Investigation – Brookdale Golf Course, 1802 Brookdale Road East, Tacoma, Washington

Dear Paul,

Robinson Noble is pleased to present this letter documenting the limited soil investigation to evaluate the presence or absence of organochlorine pesticides and herbicides. This limited evaluation is intended to assess selected areas for impacts related to its use as a golf course.

This study was limited to the collection of three soil samples, including two from the maintenance/ area (underneath the pesticide spray system and by the waste oil storage area) and one from the practice green close to the clubhouse. The soil samples were collected from approximately six below the surface using a stainless-steel hand auger. The collected soil samples were placed into laboratory-provided pre-cleaned containers, preserved as appropriate, and transported to the project laboratory under chain-of-custody.

Laboratory analysis were completed using EPA Method 8151 modified for herbicides and EPA Method 8081 for organochlorine pesticides. Libby Environmental, Inc., performed these analyses under subcontract to us.

As we discussed on the phone today, laboratory analysis for herbicides did not identify any compounds above laboratory detection limits. However, testing for organochlorine pesticides identified one compound, dieldrin, above laboratory detection limits.

We compared the laboratory reported concentrations to Washington Model Toxics Control Act (MTCA) for unrestricted (residential) land use. There are two cleanup limit values for dieldrin in soils. The first value is for non-carcinogenic exposures and the second one is for carcinogenic exposures. For residential exposures, especially in initial screening investigations such as this the carcinogenic exposure value is usually the most appropriate for comparison.

Table 1 below summarizes the dieldrin concentrations and the cleanup limits. You will note that each of the three samples is fairly close to the carcinogenic cleanup limit and well below the non-carcinogenic cleanup limit. This limited data does not suggest a severe issue with pesticides but the exceedance of the MTCA cleanup limit for carcinogenic exposures may present issues with future use of the subject for residential uses

Table 1

Sample Identification	Location	Dieldrin Concentration (mg/Kg)
BGC-1M	Below spray tank	**0.0939**
BGC-2M	Next to waste oil drum	**0.111**
BGC-3G	Practice green	**0.0956**
MTCA Method A Carcinogenic		0.0625
MTCA Method A Non-Carcinogenic		4.00

Bold denotes MTCA Method A Carcinogenic Exposure Cleanup Limit exceeded.

Considering your planned future use of the site additional investigation appropriate to more clearly define the nature of pesticide residuals. Once that is done, it will be possible evaluate the actions needed to address any pesticide concentrations above cleanup limits and proceed with redevelopment. It is just as likely that significant cleanup will not be needed compared to the chance that substantial efforts would be required for redevelopment.

We are currently working on preparing a cost estimate to complete this characterization. Our estimate will include collecting samples from 0-12 inches in depth and 18-24 inches in depth from each green and a sample from 0-12 inches from each fairway. The investigation will also evaluate near surface groundwater quality in five locations. Based on the data discussed in this letter our analyses will focus on organochlorine pesticides only.

I will forward the cost estimate tomorrow as soon as it is complete. If you have questions or need additional information, please contact us. Thank you for the opportunity to be of service.

Sincerely,
Robinson Noble, Inc.

John F. Hildenbrand
Principal Environmental Scientist

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Libby Environmental
Sherry Chilcutt
4139 Libby Rd. NE
Olympia, WA 98506

RE: Azure-Green-Brookdale
Work Order Number: 1612045

December 14, 2016

Attention Sherry Chilcutt:

Fremont Analytical, Inc. received 3 sample(s) on 12/5/2016 for the analyses presented in the following report.

Herbicides by EPA Method 8151A
Organochlorine Pesticides by EPA Method 8081
Sample Moisture (Percent Moisture)

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Chelsea Ward
Project Manager

DoD/ELAP Certification #L2371, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

Fremont Analytical

Date: *12/14/2016*

CLIENT: Libby Environmental
Project: Azure-Green-Brookdale
Work Order: 1612045

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
1612045-001	BGC-1M	12/01/2016 2:05 PM	12/05/2016 2:00 PM
1612045-002	BGC-2M	12/01/2016 2:09 PM	12/05/2016 2:00 PM
1612045-003	BGC-3G	12/01/2016 2:20 PM	12/05/2016 2:00 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **1612045**

Date: **12/14/2016**

CLIENT: Libby Environmental

Project: Azure-Green-Brookdale

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Fremont Analytical

Analytical Report

Work Order: **1612045**
Date Reported: **12/14/2016**

Client: Libby Environmental
Project: Azure-Green-Brookdale
Lab ID: 1612045-001
Client Sample ID: BGC-1M

Collection Date: 12/1/2016 2:05:00 PM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Organochlorine Pesticides by EPA Method 8081				Batch ID: 15639		Analyst: EM
Toxaphene	ND	0.117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Alpha BHC	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Beta BHC	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Gamma BHC (Lindane)	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Delta BHC	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Heptachlor	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Aldrin	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Heptachlor epoxide	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
gamma-Chlordane	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Endosulfan I	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
alpha-Chlordane	ND	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Dieldrin	0.0939	0.0117		mg/Kg-dry	1	12/14/2016 8:48:00 AM
4,4´-DDE	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Endrin	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Endosulfan II	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
4,4´-DDD	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Endrin aldehyde	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Endosulfan sulfate	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
4,4´-DDT	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Endrin ketone	ND	0.0233		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Methoxychlor	ND	0.0583		mg/Kg-dry	1	12/14/2016 8:48:00 AM
Surr: Decachlorobiphenyl	106	17.8-157		%Rec	1	12/14/2016 8:48:00 AM
Surr: Tetrachloro-m-xylene	95.2	11-150		%Rec	1	12/14/2016 8:48:00 AM
Herbicides by EPA Method 8151A				Batch ID: 15643		Analyst: SG
Dicamba	ND	37.5		µg/Kg-dry	1	12/13/2016 10:59:43 PM
2,4-D	ND	32.1		µg/Kg-dry	1	12/13/2016 10:59:43 PM
2,4-DP	ND	26.8		µg/Kg-dry	1	12/13/2016 10:59:43 PM
2,4,5-TP (Silvex)	ND	21.4		µg/Kg-dry	1	12/13/2016 10:59:43 PM
2,4,5-T	ND	53.5		µg/Kg-dry	1	12/13/2016 10:59:43 PM
Dinoseb	ND	32.1	Q	µg/Kg-dry	1	12/13/2016 10:59:43 PM
Dalapon	ND	214		µg/Kg-dry	1	12/13/2016 10:59:43 PM
2,4-DB	ND	26.8		µg/Kg-dry	1	12/13/2016 10:59:43 PM
MCPP	ND	4,710		µg/Kg-dry	1	12/13/2016 10:59:43 PM
MCPA	ND	3,000		µg/Kg-dry	1	12/13/2016 10:59:43 PM
Picloram	ND	53.5		µg/Kg-dry	1	12/13/2016 10:59:43 PM
Bentazon	ND	37.5		µg/Kg-dry	1	12/13/2016 10:59:43 PM
Chloramben	ND	21.4		µg/Kg-dry	1	12/13/2016 10:59:43 PM

Analytical Report

Work Order: **1612045**

Date Reported: **12/14/2016**

Client: Libby Environmental

Collection Date: 12/1/2016 2:05:00 PM

Project: Azure-Green-Brookdale

Lab ID: 1612045-001

Matrix: Soil

Client Sample ID: BGC-1M

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Herbicides by EPA Method 8151A				Batch ID: 15643		Analyst: SG
Acifluorfen	ND	85.7	Q	µg/Kg-dry	1	12/13/2016 10:59:43 PM
3,5-Dichlorobenzoic acid	ND	42.8		µg/Kg-dry	1	12/13/2016 10:59:43 PM
4-Nitrophenol	ND	32.1		µg/Kg-dry	1	12/13/2016 10:59:43 PM
Dacthal (DCPA)	ND	32.1		µg/Kg-dry	1	12/13/2016 10:59:43 PM
Surr: 2,4-Dichlorophenylacetic acid	2.64	20.1-168	S	%Rec	1	12/13/2016 10:59:43 PM

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

S - Outlying surrogate recovery(ies) observed.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Sample Moisture (Percent Moisture)				Batch ID: R33229		Analyst: BB
Percent Moisture	16.6	0.500		wt%	1	12/6/2016 8:15:05 AM

Fremont Analytical

Analytical Report

Work Order: **1612045**
Date Reported: **12/14/2016**

Client: Libby Environmental
Project: Azure-Green-Brookdale
Lab ID: 1612045-002
Client Sample ID: **BGC-2M**

Collection Date: 12/1/2016 2:09:00 PM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Organochlorine Pesticides by EPA Method 8081				Batch ID: 15639		Analyst: EM
Toxaphene	ND	0.120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Alpha BHC	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Beta BHC	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Gamma BHC (Lindane)	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Delta BHC	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Heptachlor	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Aldrin	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Heptachlor epoxide	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
gamma-Chlordane	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Endosulfan I	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
alpha-Chlordane	ND	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Dieldrin	0.111	0.0120		mg/Kg-dry	1	12/14/2016 9:44:00 AM
4,4´-DDE	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Endrin	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Endosulfan II	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
4,4´-DDD	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Endrin aldehyde	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Endosulfan sulfate	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
4,4´-DDT	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Endrin ketone	ND	0.0241		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Methoxychlor	ND	0.0602		mg/Kg-dry	1	12/14/2016 9:44:00 AM
Surr: Decachlorobiphenyl	102	17.8-157		%Rec	1	12/14/2016 9:44:00 AM
Surr: Tetrachloro-m-xylene	92.3	11-150		%Rec	1	12/14/2016 9:44:00 AM
Herbicides by EPA Method 8151A				Batch ID: 15643		Analyst: SG
Dicamba	ND	42.5		µg/Kg-dry	1	12/13/2016 9:23:53 PM
2,4-D	ND	36.5		µg/Kg-dry	1	12/13/2016 9:23:53 PM
2,4-DP	ND	30.4		µg/Kg-dry	1	12/13/2016 9:23:53 PM
2,4,5-TP (Silvex)	ND	24.3		µg/Kg-dry	1	12/13/2016 9:23:53 PM
2,4,5-T	ND	60.8		µg/Kg-dry	1	12/13/2016 9:23:53 PM
Dinoseb	ND	36.5	Q	µg/Kg-dry	1	12/13/2016 9:23:53 PM
Dalapon	ND	243		µg/Kg-dry	1	12/13/2016 9:23:53 PM
2,4-DB	ND	30.4		µg/Kg-dry	1	12/13/2016 9:23:53 PM
MCPP	ND	5,350		µg/Kg-dry	1	12/13/2016 9:23:53 PM
MCPA	ND	3,400		µg/Kg-dry	1	12/13/2016 9:23:53 PM
Picloram	ND	60.8		µg/Kg-dry	1	12/13/2016 9:23:53 PM
Bentazon	ND	42.5		µg/Kg-dry	1	12/13/2016 9:23:53 PM
Chloramben	ND	24.3		µg/Kg-dry	1	12/13/2016 9:23:53 PM

Analytical Report

Work Order: **1612045**
Date Reported: **12/14/2016**

Client: Libby Environmental
Project: Azure-Green-Brookdale
Lab ID: 1612045-002
Client Sample ID: **BGC-2M**

Collection Date: 12/1/2016 2:09:00 PM
Matrix: Soil

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Herbicides by EPA Method 8151A				Batch ID: 15643		Analyst: SG
Acifluorfen	ND	97.2	Q	µg/Kg-dry	1	12/13/2016 9:23:53 PM
3,5-Dichlorobenzoic acid	ND	48.6		µg/Kg-dry	1	12/13/2016 9:23:53 PM
4-Nitrophenol	ND	36.5		µg/Kg-dry	1	12/13/2016 9:23:53 PM
Dacthal (DCPA)	ND	36.5		µg/Kg-dry	1	12/13/2016 9:23:53 PM
Surr: 2,4-Dichlorophenylacetic acid	2.25	20.1-168	S	%Rec	1	12/13/2016 9:23:53 PM

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

S - Outlying surrogate recovery(ies) observed.

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Sample Moisture (Percent Moisture)				Batch ID: R33229		Analyst: BB
Percent Moisture	20.0	0.500		wt%	1	12/6/2016 8:15:05 AM

Fremont Analytical

Analytical Report

Work Order: **1612045**
Date Reported: **12/14/2016**

Client: Libby Environmental
Collection Date: 12/1/2016 2:20:00 PM
Project: Azure-Green-Brookdale
Lab ID: 1612045-003
Matrix: Soil
Client Sample ID: BGC-3G

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Organochlorine Pesticides by EPA Method 8081				Batch ID: 15639		Analyst: EM
Toxaphene	ND	0.117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Alpha BHC	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Beta BHC	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Gamma BHC (Lindane)	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Delta BHC	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Heptachlor	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Aldrin	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Heptachlor epoxide	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
gamma-Chlordane	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Endosulfan I	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
alpha-Chlordane	ND	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Dieldrin	0.0956	0.0117		mg/Kg-dry	1	12/14/2016 9:55:00 AM
4,4´-DDE	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Endrin	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Endosulfan II	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
4,4´-DDD	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Endrin aldehyde	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Endosulfan sulfate	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
4,4´-DDT	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Endrin ketone	ND	0.0235		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Methoxychlor	ND	0.0587		mg/Kg-dry	1	12/14/2016 9:55:00 AM
Surr: Decachlorobiphenyl	117	17.8-157		%Rec	1	12/14/2016 9:55:00 AM
Surr: Tetrachloro-m-xylene	94.4	11-150		%Rec	1	12/14/2016 9:55:00 AM
Herbicides by EPA Method 8151A				Batch ID: 15643		Analyst: SG
Dicamba	ND	41.4		µg/Kg-dry	1	12/13/2016 10:40:33 PM
2,4-D	ND	35.5		µg/Kg-dry	1	12/13/2016 10:40:33 PM
2,4-DP	ND	29.6		µg/Kg-dry	1	12/13/2016 10:40:33 PM
2,4,5-TP (Silvex)	ND	23.7		µg/Kg-dry	1	12/13/2016 10:40:33 PM
2,4,5-T	ND	59.2		µg/Kg-dry	1	12/13/2016 10:40:33 PM
Dinoseb	ND	35.5	Q	µg/Kg-dry	1	12/13/2016 10:40:33 PM
Dalapon	ND	237		µg/Kg-dry	1	12/13/2016 10:40:33 PM
2,4-DB	ND	29.6		µg/Kg-dry	1	12/13/2016 10:40:33 PM
MCPP	ND	5,210		µg/Kg-dry	1	12/13/2016 10:40:33 PM
MCPA	ND	3,310		µg/Kg-dry	1	12/13/2016 10:40:33 PM
Picloram	ND	59.2		µg/Kg-dry	1	12/13/2016 10:40:33 PM
Bentazon	ND	41.4		µg/Kg-dry	1	12/13/2016 10:40:33 PM
Chloramben	ND	23.7		µg/Kg-dry	1	12/13/2016 10:40:33 PM

Analytical Report

Work Order: **1612045**

Date Reported: **12/14/2016**

Client: Libby Environmental

Collection Date: 12/1/2016 2:20:00 PM

Project: Azure-Green-Brookdale

Lab ID: 1612045-003

Matrix: Soil

Client Sample ID: BGC-3G

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Herbicides by EPA Method 8151A				Batch ID: 15643		Analyst: SG
Acifluorfen	ND	94.6	Q	µg/Kg-dry	1	12/13/2016 10:40:33 PM
3,5-Dichlorobenzoic acid	ND	47.3		µg/Kg-dry	1	12/13/2016 10:40:33 PM
4-Nitrophenol	ND	35.5		µg/Kg-dry	1	12/13/2016 10:40:33 PM
Dacthal (DCPA)	ND	35.5		µg/Kg-dry	1	12/13/2016 10:40:33 PM
Surr: 2,4-Dichlorophenylacetic acid	84.5	20.1-168		%Rec	1	12/13/2016 10:40:33 PM

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Sample Moisture (Percent Moisture)				Batch ID: R33229		Analyst: BB
Percent Moisture	20.9	0.500		wt%	1	12/6/2016 8:15:05 AM

Date: *12/14/2016*

Work Order:	1612045
CLIENT:	Libby Environmental
Project:	Azure-Green-Brookdale

QC SUMMARY REPORT

Herbicides by EPA Method 8151A

Sample ID **MB-15643** SampType: **MBLK** Units: **µg/Kg** Prep Date: **12/8/2016** RunNo: **33383**
Client ID: **MBLKS** Batch ID: **15643** Analysis Date: **12/13/2016** SeqNo: **633421**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dicamba	ND	35.0									
2,4-D	ND	30.0									
2,4-DP	ND	25.0									
2,4,5-TP (Silvex)	ND	20.0									
2,4,5-T	ND	50.0									
Dinoseb	ND	30.0									Q
Dalapon	ND	200									
2,4-DB	ND	25.0									
MCPP	ND	4,400									
MCPA	ND	2,800									
Picloram	ND	50.0									
Bentazon	ND	35.0									
Chloramben	ND	20.0									
Acifluorfen	ND	80.0									Q
3,5-Dichlorobenzoic acid	ND	40.0									
4-Nitrophenol	ND	30.0									
Dacthal (DCPA)	ND	30.0									
Surr: 2,4-Dichlorophenylacetic acid	1,470		1,000		147	20.1	168				

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Sample ID **LCS-15643** SampType: **LCS** Units: **µg/Kg** Prep Date: **12/8/2016** RunNo: **33383**
Client ID: **LCSS** Batch ID: **15643** Analysis Date: **12/13/2016** SeqNo: **633413**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dicamba	237	35.0	200.0	0	119	24.7	141				
2,4-D	249	30.0	200.0	0	125	22.4	130				
2,4-DP	249	25.0	200.0	0	124	26.4	130				
2,4,5-TP (Silvex)	233	20.0	200.0	0	117	21.2	138				
2,4,5-T	238	50.0	200.0	0	119	22.8	144				
Dinoseb	112	30.0	200.0	0	56.2	5	165				

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Herbicides by EPA Method 8151A

Sample ID **LCS-15643**	SampType: **LCS**	Units: **µg/Kg**	Prep Date: **12/8/2016**	RunNo: **33383**
Client ID: **LCSS**	Batch ID: **15643**		Analysis Date: **12/13/2016**	SeqNo: **633413**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dalapon	1,490	200	1,000	0	149	18.4	162				
2,4-DB	246	25.0	200.0	0	123	5	164				
MCPP	972	4,400	1,000	0	97.2	22.2	157				
MCPA	1031	2,800	1,000	0	103	47.4	128				
Picloram	231	50.0	200.0	0	116	5	175				
Bentazon	242	35.0	200.0	0	121	7.59	162				
Chloramben	116	20.0	200.0	0	57.8	5	147				
Acifluorfen	155	80.0	200.0	0	77.3	5	163				
3,5-Dichlorobenzoic acid	222	40.0	200.0	0	111	18.7	139				
4-Nitrophenol	206	30.0	200.0	0	103	5	163				
Dacthal (DCPA)	266	30.0	200.0	0	133	5	164				
Surr: 2,4-Dichlorophenylacetic acid	1,300		1,000		130	20.1	168				

Sample ID **1612045-002ADUP**	SampType: **DUP**	Units: **µg/Kg-dry**	Prep Date: **12/8/2016**	RunNo: **33383**
Client ID: **BGC-2M**	Batch ID: **15643**		Analysis Date: **12/13/2016**	SeqNo: **633415**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dicamba	ND	43.2						0		30	
2,4-D	ND	37.0						0		30	
2,4-DP	ND	30.9						0		30	
2,4,5-TP (Silvex)	ND	24.7						0		30	
2,4,5-T	ND	61.7						0		30	
Dinoseb	ND	37.0						0		30	Q
Dalapon	ND	247						0		30	
2,4-DB	ND	30.9						0		30	
MCPP	ND	5,430						0		30	
MCPA	ND	3,460						0		30	
Picloram	ND	61.7						0		30	
Bentazon	ND	43.2						0		30	
Chloramben	ND	24.7						0		30	

Fremont Analytical

Date: *12/14/2016*

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Herbicides by EPA Method 8151A

Sample ID **1612045-002ADUP** SampType: **DUP** Units: **µg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33383**
Client ID: **BGC-2M** Batch ID: **15643** Analysis Date: **12/13/2016** SeqNo: **633415**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Acifluorfen	ND	98.7						0		30	Q
3,5-Dichlorobenzoic acid	ND	49.4						0		30	
4-Nitrophenol	ND	37.0						0		30	
Dacthal (DCPA)	ND	37.0						0		30	
Surr: 2,4-Dichlorophenylacetic acid	60.1		1,234		4.87	20.1	168		0		S

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).
S - Outlying surrogate recovery(ies) observed.

Sample ID **1612045-002AMS** SampType: **MS** Units: **µg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33383**
Client ID: **BGC-2M** Batch ID: **15643** Analysis Date: **12/13/2016** SeqNo: **633416**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dicamba	212	42.0	240.0	0	88.4	31.9	118				
2,4-D	239	36.0	240.0	0	99.7	12.4	134				
2,4-DP	228	30.0	240.0	0	94.9	27.2	129				
2,4,5-TP (Silvex)	218	24.0	240.0	0	90.8	28.6	134				
2,4,5-T	238	60.0	240.0	0	99.2	13.1	147				
Dinoseb	61.8	36.0	240.0	0	25.8	10	179				
Dalapon	1,500	240	1,200	0	125	24.9	139				
2,4-DB	270	30.0	240.0	0	113	50.2	152				
MCPP	937	5,280	1,200	0	78.1	37.8	140				
MCPA	969	3,360	1,200	0	80.7	13.7	147				
Picloram	220	60.0	240.0	0	91.7	5	153				
Bentazon	213	42.0	240.0	0	88.9	15	140				
Chloramben	90.2	24.0	240.0	0	37.6	5	162				
Acifluorfen	47.1	96.0	240.0	0	19.6	15	140				
3,5-Dichlorobenzoic acid	193	48.0	240.0	0	80.6	10	164				
4-Nitrophenol	173	36.0	240.0	0	71.9	44.8	125				
Dacthal (DCPA)	222	36.0	240.0	0	92.4	5	132				
Surr: 2,4-Dichlorophenylacetic acid	1,130		1,200		94.0	20.1	168				

Date: *12/14/2016*

Fremont Analytical

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Herbicides by EPA Method 8151A

Sample ID **1612045-002AMS**	SampType: **MS**			Units: **µg/Kg-dry**		Prep Date:	**12/8/2016**		RunNo: **33383**		
Client ID: **BGC-2M**	Batch ID: **15643**					Analysis Date:	**12/13/2016**		SeqNo: **633416**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID **1612045-002AMSD**	SampType: **MSD**			Units: **µg/Kg-dry**		Prep Date:	**12/8/2016**		RunNo: **33383**		
Client ID: **BGC-2M**	Batch ID: **15643**					Analysis Date:	**12/13/2016**		SeqNo: **633417**		
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dicamba	250	42.3	241.6	0	104	31.9	118	212.1	16.6	30	
2,4-D	273	36.2	241.6	0	113	12.4	134	239.2	13.3	30	
2,4-DP	269	30.2	241.6	0	111	27.2	129	227.7	16.5	30	
2,4,5-TP (Silvex)	260	24.2	241.6	0	108	28.6	134	217.9	17.5	30	
2,4,5-T	278	60.4	241.6	0	115	13.1	147	238.1	15.6	30	
Dinoseb	56.5	36.2	241.6	0	23.4	10	179	61.85	8.95	30	
Dalapon	1,490	242	1,208	0	124	24.9	139	1,501	0.489	30	
2,4-DB	302	30.2	241.6	0	125	50.2	152	270.2	11.2	30	
MCPP	1164	5,320	1,208	0	96.4	37.8	140	0		30	
MCPA	1226	3,380	1,208	0	101	13.7	147	0		30	
Picloram	237	60.4	241.6	0	97.9	5	153	220.1	7.23		
Bentazon	248	42.3	241.6	0	103	15	140	213.4	14.9	30	
Chloramben	98.8	24.2	241.6	0	40.9	5	162	90.20	9.05	30	
Acifluorfen	44.1	96.6	241.6	0	18.3	15	140	0		30	
3,5-Dichlorobenzoic acid	229	48.3	241.6	0	94.8	10	164	193.4	16.8	30	
4-Nitrophenol	196	36.2	241.6	0	81.2	44.8	125	172.6	12.8	30	
Dacthal (DCPA)	264	36.2	241.6	0	109	5	132	221.8	17.5	30	
Surr: 2,4-Dichlorophenylacetic acid	1,300		1,208		108	20.1	168		0		

Work Order:	1612045
CLIENT:	Libby Environmental
Project:	Azure-Green-Brookdale

QC SUMMARY REPORT

Organochlorine Pesticides by EPA Method 8081

Sample ID **TOX-CCV-A-15639** SampType: **CCV** Units: **mg/L** Prep Date: **12/14/2016** RunNo: **33385**
Client ID: **CCV** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633435**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Toxaphene	922	0.100	1,000	0	92.2	80	120				

Sample ID **MB-15639** SampType: **MBLK** Units: **mg/Kg** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **MBLKS** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633433**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Toxaphene	ND	0.100									
Alpha BHC	ND	0.0100									
Beta BHC	ND	0.0100									
Gamma BHC (Lindane)	ND	0.0100									
Delta BHC	ND	0.0100									
Heptachlor	ND	0.0100									
Aldrin	ND	0.0100									
Heptachlor epoxide	ND	0.0100									
gamma-Chlordane	ND	0.0100									
Endosulfan I	ND	0.0100									
alpha-Chlordane	ND	0.0100									
Dieldrin	ND	0.0100									
4,4´-DDE	ND	0.0200									
Endrin	ND	0.0200									
Endosulfan II	ND	0.0200									
4,4´-DDD	ND	0.0200									
Endrin aldehyde	ND	0.0200									
Endosulfan sulfate	ND	0.0200									
4,4´-DDT	ND	0.0200									
Endrin ketone	ND	0.0200									
Methoxychlor	ND	0.0500									
Surr: Decachlorobiphenyl	0.0619		0.05000		124	17.8	157				
Surr: Tetrachloro-m-xylene	0.0507		0.05000		101	11	150				

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Organochlorine Pesticides by EPA Method 8081

Sample ID **LCS-15639** SampType: **LCS** Units: **mg/Kg** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **LCSS** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633432**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alpha BHC	0.245	0.0100	0.2000	0	123	54.2	139				
Beta BHC	0.245	0.0100	0.2000	0	122	56.5	142				
Gamma BHC (Lindane)	0.242	0.0100	0.2000	0	121	55.5	142				
Delta BHC	0.238	0.0100	0.2000	0	119	47.4	157				
Heptachlor	0.284	0.0100	0.2000	0	142	50.9	153				
Aldrin	0.241	0.0100	0.2000	0	120	43.7	147				
Heptachlor epoxide	0.247	0.0100	0.2000	0	123	56.2	137				
gamma-Chlordane	0.244	0.0100	0.2000	0	122	58.5	136				
Endosulfan I	0.241	0.0100	0.2000	0	120	60	132				
alpha-Chlordane	0.246	0.0100	0.2000	0	123	46.1	140				
Dieldrin	0.242	0.0100	0.2000	0	121	61.2	133				
4,4´-DDE	0.254	0.0200	0.2000	0	127	55.4	142				
Endrin	0.257	0.0200	0.2000	0	128	56.5	143				
Endosulfan II	0.240	0.0200	0.2000	0	120	62	143				
4,4´-DDD	0.304	0.0200	0.2000	0	152	53.3	145				S
Endrin aldehyde	0.203	0.0200	0.2000	0	102	39.5	153				
Endosulfan sulfate	0.251	0.0200	0.2000	0	126	53.8	148				
4,4´-DDT	0.399	0.0200	0.2000	0	200	48.2	152				S
Endrin ketone	0.261	0.0200	0.2000	0	131	28.5	162				
Methoxychlor	0.475	0.0500	0.2000	0	237	34.6	159				S
Surr: Decachlorobiphenyl	0.0636		0.05000		127	17.8	157				
Surr: Tetrachloro-m-xylene	0.0513		0.05000		103	11	150				

NOTES:
S - Outlying spike recovery observed (high bias). Samples are non-detect for this analyte; no further action required.

Sample ID **1612045-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **BGC-1M** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633429**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Toxaphene	ND	0.118						0		30	
Alpha BHC	ND	0.0118						0		30	

Fremont Analytical

Date: *12/14/2016*

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Organochlorine Pesticides by EPA Method 8081

Sample ID **1612045-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **BGC-1M** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633429**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Beta BHC	ND	0.0118						0		30	
Gamma BHC (Lindane)	ND	0.0118						0		30	
Delta BHC	ND	0.0118						0		30	
Heptachlor	ND	0.0118						0		30	
Aldrin	ND	0.0118						0		30	
Heptachlor epoxide	ND	0.0118						0		30	
gamma-Chlordane	ND	0.0118						0		30	
Endosulfan I	ND	0.0118						0		30	
alpha-Chlordane	ND	0.0118						0		30	
Dieldrin	0.117	0.0118						0.09387	21.8	30	
4,4´-DDE	ND	0.0236						0		30	
Endrin	ND	0.0236						0		30	
Endosulfan II	ND	0.0236						0		30	
4,4´-DDD	ND	0.0236						0		30	
Endrin aldehyde	ND	0.0236						0		30	
Endosulfan sulfate	ND	0.0236						0		30	
4,4´-DDT	ND	0.0236						0		30	
Endrin ketone	ND	0.0236						0		30	
Methoxychlor	ND	0.0590						0		30	
Surr: Decachlorobiphenyl	0.0700		0.05902		119	17.8	157		0		
Surr: Tetrachloro-m-xylene	0.0544		0.05902		92.2	11	150		0		

Sample ID **1612045-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **BGC-1M** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633430**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alpha BHC	0.297	0.0118	0.2365	0	125	49.1	158				
Beta BHC	0.955	0.0118	0.2365	0	404	50.9	160				S
Gamma BHC (Lindane)	0.281	0.0118	0.2365	0	119	55.3	157				
Delta BHC	0.947	0.0118	0.2365	0	400	55.8	160				S

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Organochlorine Pesticides by EPA Method 8081

Sample ID **1612045-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **BGC-1M** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633430**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Heptachlor	0.343	0.0118	0.2365	0	145	53.6	167				
Aldrin	0.284	0.0118	0.2365	0	120	46.4	145				
Heptachlor epoxide	0.300	0.0118	0.2365	0	127	48.5	151				
gamma-Chlordane	0.297	0.0118	0.2365	0	125	49	162				
Endosulfan I	0.306	0.0118	0.2365	0	129	44.7	162				
alpha-Chlordane	0.297	0.0118	0.2365	0	125	46.3	153				
Dieldrin	0.406	0.0118	0.2365	0.09387	132	48	162				
4,4´-DDE	0.306	0.0237	0.2365	0	129	39.9	162				
Endrin	0.308	0.0237	0.2365	0	130	50.5	166				
Endosulfan II	0.286	0.0237	0.2365	0	121	51	152				
4,4´-DDD	0.367	0.0237	0.2365	0	155	45.8	160				
Endrin aldehyde	0.240	0.0237	0.2365	0	102	38.3	156				
Endosulfan sulfate	0.290	0.0237	0.2365	0	123	53.2	154				
4,4´-DDT	0.505	0.0237	0.2365	0	213	45.7	168				S
Endrin ketone	0.311	0.0237	0.2365	0	131	68.3	144				
Methoxychlor	0.676	0.0591	0.2365	0	286	43.4	178				S
Surr: Decachlorobiphenyl	0.0641		0.05914		108	17.8	157				
Surr: Tetrachloro-m-xylene	0.0490		0.05914		82.9	11	150				

NOTES:
S - Outlying spike recovery(ies) observed.

Sample ID **1612045-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **BGC-1M** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633467**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alpha BHC	0.297	0.0115	0.2300	0	129	49.1	158	0.2965	0.282	30	
Beta BHC	0.933	0.0115	0.2300	0	406	50.9	160	0.9548	2.35	30	S
Gamma BHC (Lindane)	0.285	0.0115	0.2300	0	124	55.3	157	0.2814	1.23	30	
Delta BHC	0.875	0.0115	0.2300	0	381	55.8	160	0.9466	7.81	30	S
Heptachlor	0.349	0.0115	0.2300	0	152	53.6	167	0.3432	1.70	30	
Aldrin	0.289	0.0115	0.2300	0	126	46.4	145	0.2837	1.94	30	

Fremont Analytical

Date: *12/14/2016*

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Organochlorine Pesticides by EPA Method 8081

Sample ID **1612045-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **12/8/2016** RunNo: **33385**
Client ID: **BGC-1M** Batch ID: **15639** Analysis Date: **12/14/2016** SeqNo: **633467**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Heptachlor epoxide	0.303	0.0115	0.2300	0	132	48.5	151	0.2997	1.08	30	
gamma-Chlordane	0.302	0.0115	0.2300	0	131	49	162	0.2968	1.57	30	
Endosulfan I	0.309	0.0115	0.2300	0	134	44.7	162	0.3057	1.01	30	
alpha-Chlordane	0.303	0.0115	0.2300	0	132	46.3	153	0.2968	2.03	30	
Dieldrin	0.406	0.0115	0.2300	0.09387	136	48	162	0.4062	0.0515	30	
4,4´-DDE	0.312	0.0230	0.2300	0	136	39.9	162	0.3059	1.87	30	
Endrin	0.315	0.0230	0.2300	0	137	50.5	166	0.3082	2.11	30	
Endosulfan II	0.291	0.0230	0.2300	0	127	51	152	0.2861	1.70	30	
4,4´-DDD	0.371	0.0230	0.2300	0	161	45.8	160	0.3670	1.13	30	S
Endrin aldehyde	0.238	0.0230	0.2300	0	104	38.3	156	0.2404	0.802	30	
Endosulfan sulfate	0.294	0.0230	0.2300	0	128	53.2	154	0.2901	1.40	30	
4,4´-DDT	0.506	0.0230	0.2300	0	220	45.7	168	0.5046	0.360	30	S
Endrin ketone	0.311	0.0230	0.2300	0	135	68.3	144	0.3107	0.181	30	
Methoxychlor	0.661	0.0575	0.2300	0	287	43.4	178	0.6762	2.27	30	S
Surr: Decachlorobiphenyl	0.0545		0.05749		94.7	17.8	157		0		
Surr: Tetrachloro-m-xylene	0.0470		0.05749		81.8	11	150		0		

NOTES:
S - Outlying spike recovery(ies) observed.

Work Order: 1612045
CLIENT: Libby Environmental
Project: Azure-Green-Brookdale

QC SUMMARY REPORT

Sample Moisture (Percent Moisture)

Sample ID **1612048-004ADUP** SampType: **DUP** Units: **wt%** Prep Date: **12/6/2016** RunNo: **33229**
Client ID: **BATCH** Batch ID: **R33229** Analysis Date: **12/6/2016** SeqNo: **630165**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Percent Moisture	12.0	0.500						12.08	0.294	20	

Sample Log-In Check List

Client Name:	**LIBBY**	Work Order Number:	**1612045**
Logged by:	**Erica Silva**	Date Received:	**12/5/2016 2:00:00 PM**

Chain of Custody

#	Question	Yes	No	NA / Other
1.	Is Chain of Custody complete?	Yes ☑	No ☐	Not Present ☐
2.	How was the sample delivered?	Client		

Log In

#	Question	Yes	No	NA / Other
3.	Coolers are present?	Yes ☑	No ☐	NA ☐
4.	Shipping container/cooler in good condition?	Yes ☑	No ☐	
5.	Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact)	Yes ☐	No ☐	Not Required ☑
6.	Was an attempt made to cool the samples?	Yes ☑	No ☐	NA ☐
7.	Were all items received at a temperature of >0°C to 10.0°C*	Yes ☑	No ☐	NA ☐
8.	Sample(s) in proper container(s)?	Yes ☑	No ☐	
9.	Sufficient sample volume for indicated test(s)?	Yes ☑	No ☐	
10.	Are samples properly preserved?	Yes ☑	No ☐	
11.	Was preservative added to bottles?	Yes ☐	No ☑	NA ☐
12.	Is there headspace in the VOA vials?	Yes ☐	No ☐	NA ☑
13.	Did all samples containers arrive in good condition(unbroken)?	Yes ☑	No ☐	
14.	Does paperwork match bottle labels?	Yes ☑	No ☐	
15.	Are matrices correctly identified on Chain of Custody?	Yes ☑	No ☐	
16.	Is it clear what analyses were requested?	Yes ☑	No ☐	
17.	Were all holding times able to be met?	Yes ☑	No ☐	

Special Handling (if applicable)

#	Question	Yes	No	NA
18.	Was client notified of all discrepancies with this order?	Yes ☐	No ☐	NA ☑

Person Notified: ______ Date ______

By Whom: ______ Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding: ______

Client Instructions: ______

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler	8.6
Sample	4.1

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Libby Environmental, Inc.
4139 Libby Road NE Ph: 360-352-2110
Olympia, WA 98506 Fax: 360-352-4154
www.LibbyEnvironmental.com

Chain of Custody Record

1612045

Date: 12/5/16 Page: 1 of 1

Client: Libby Environmental
Address: See above
City: State: Zip:
Phone: Fax:
Client Project # L161202-1

Project Manager: Sherry Chilcutt
Project Name: Azure-Green-Brookdale
Location: City, State: Tacoma, Wa
Collector: JFH Date of Collection: 12-1-16
Email: libbyenv@aol.com

	Sample Number	Depth	Time	Sample Type	Container Type	VOC 8260	NWTPH-Gx	BTEX 8021	NWTPH-HCID	NWTPH-Dx	NWTPH-Dx/Dx	c PAH 8270	PAH 8270	Semi Vol 8270	PCB 8082	MTCA 5 Metals	RCRA 8 Metals	Chlorinated Pesticides	Herbicides		Field Notes
1	BGC-1M	6"	2:05	Soil	4oz													X	X		
2	BGC-2M	6"	2:09	↓	↓													X	X		
3	BGC-3G	6"	2:20	↓	↓													X	X		
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					
13																					
14																					
15																					
16																					
17																					

Relinquished by:	Date / Time	Received by:	Date / Time
[signature]	12-5-16 1400	[signature]	12/5/16 1400

Sample Receipt
Good Condition? Y N
Temp. °C
Seals Intact? Y N N/A
Total Number of Containers

Remarks:

TAT: 24HR 48HR 5-DAY (circled: 5-DAY)

LEGAL ACTION CLAUSE: *In the event of default of payment and/or failure to pay, Client agrees to pay the costs of collection including court costs and reasonable attorney fees to be determined by a cout of law.*

Distribution: White - Lab, Yellow - File, Pink - Originator

Attachment D
2017 and 2018 Environmental Partners Inc.
Laboratory Analytical Results

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 11, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 804290

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 17, 2018 from the Brookdale 74001, F&BI 804290 project. There are 43 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0511R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 17, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 804290 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804290 -01	Green1-NW:0.5
804290 -02	Green1-NW:1.0
804290 -03	Green1-NW:1.5
804290 -04	Green1-NW:2.0
804290 -05	Green1-SW:0.5
804290 -06	Green1-SW:1.0
804290 -07	Green 1-SW:1.5
804290 -08	Green 1-SW:2.0
804290 -09	Green 1-E:0.5
804290 -10	Green 1-E:1.0
804290 -11	Green 1-E:1.5
804290 -12	Green 1-E:2.0
804290 -13	Green 2:0.5
804290 -14	Green 2:1.0
804290 -15	Green 2:1.5
804290 -16	Green 2:2.0
804290 -17	Green 2-E:0.5
804290 -18	Green 2-E:1.0
804290 -19	Green 2-E:1.5
804290 -20	Green 2-E:2.0
804290 -21	Green 2-SW:0.5
804290 -22	Green 2-SW:1.0
804290 -23	Green 2-SW:1.5
804290 -24	Green 2-SW:2.0
804290 -25	Green 2-NW:0.5
804290 -26	Green 2-NW:1.0
804290 -27	Green 2-NW:1.5
804290 -28	Green 2-NW:2.0
804290 -29	Green 3-NW:0.5
804290 -30	Green 3-NW:1.0
804290 -31	Green 3-NW:1.5
804290 -32	Green 3-NW:2.0
804290 -33	Green 3-S:0.5
804290 -34	Green 3-S:1.0
804290 -35	Green 3-S:1.5

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
804290 -36	Green 3-S:2.0
804290 -37	Green 3-NE:0.5
804290 -38	Green 3-NE:1.0
804290 -39	Green 3-NE:1.5
804290 -40	Green 3-NE:2.0
804290 -41	Green 3:0.5
804290 -42	Green 3:1.0
804290 -43	Green 3:1.5
804290 -44	Green 3:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green1-NW:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-01 1/6
Date Analyzed:	04/18/18	Data File:	041809.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.31

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green1-NW:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-02 1/6
Date Analyzed:	04/18/18	Data File:	041810.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	68	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.16

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green1-NW:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-04 1/6
Date Analyzed:	04/30/18	Data File:	043027.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.047

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green1-SW:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-05 1/6
Date Analyzed:	04/18/18	Data File:	041811.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.42

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green1-SW:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-06 1/6
Date Analyzed:	04/18/18	Data File:	041812.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.20

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 1-SW:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-08 1/6
Date Analyzed:	04/30/18	Data File:	043028.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.036

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 1-E:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-09 1/6
Date Analyzed:	04/18/18	Data File:	041813.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.68

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 1-E:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-10 1/6
Date Analyzed:	04/18/18	Data File:	041814.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.15

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 1-E:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-12 1/6
Date Analyzed:	04/30/18	Data File:	043029.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.060

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-13 1/6
Date Analyzed:	04/18/18	Data File:	041815.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.20

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-14 1/6
Date Analyzed:	04/18/18	Data File:	041816.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	65	50	150
DBC	74	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.044

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-E:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-17 1/6
Date Analyzed:	04/18/18	Data File:	041817.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.39

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-E:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-18 1/6
Date Analyzed:	04/18/18	Data File:	041818.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.17

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-E:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-20 1/6
Date Analyzed:	04/30/18	Data File:	043030.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.048

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-SW:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-21 1/60
Date Analyzed:	04/20/18	Data File:	042051.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77 d	50	150
DBC	120 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	4.7

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-SW:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-22 1/6
Date Analyzed:	04/18/18	Data File:	041824.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.57

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-SW:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-24 1/6
Date Analyzed:	04/30/18	Data File:	043031.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.14

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-NW:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-25 1/6
Date Analyzed:	04/18/18	Data File:	041825.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.064

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 2-NW:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-26 1/6
Date Analyzed:	04/18/18	Data File:	041826.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.013

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NW:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-29 1/6
Date Analyzed:	04/18/18	Data File:	041827.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.83

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NW:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-30 1/6
Date Analyzed:	04/18/18	Data File:	041828.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.56

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NW:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-32 1/6
Date Analyzed:	04/30/18	Data File:	043032.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-S:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-33 1/6
Date Analyzed:	04/18/18	Data File:	041829.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.99

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-S:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-34 1/6
Date Analyzed:	04/18/18	Data File:	041837.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.72

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-S:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-36 1/6
Date Analyzed:	04/30/18	Data File:	043033.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	78	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.042

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NE:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-37 1/6
Date Analyzed:	04/18/18	Data File:	041838.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.65

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NE:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-38 1/6
Date Analyzed:	04/18/18	Data File:	041839.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	78	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.072

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NE:1.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-39 1/6
Date Analyzed:	04/30/18	Data File:	043037.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3-NE:2.0 ht	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	05/03/18	Lab ID:	804290-40 1/6
Date Analyzed:	05/06/18	Data File:	050642.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	68	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3:0.5	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-41 1/60
Date Analyzed:	04/20/18	Data File:	042052.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84 d	50	150
DBC	92 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.4

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3:1.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	804290-42 1/6
Date Analyzed:	04/18/18	Data File:	041841.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.33

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 3:2.0	Client:	Environmental Partners
Date Received:	04/17/18	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	804290-44 1/6
Date Analyzed:	04/30/18	Data File:	043038.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.3

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	08-827 mb 1/6
Date Analyzed:	04/18/18	Data File:	041823.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/17/18	Lab ID:	08-764 mb2 1/6
Date Analyzed:	04/18/18	Data File:	041808.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	04/26/18	Lab ID:	08-918 mb 1/6
Date Analyzed:	04/30/18	Data File:	043019.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	95	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804290
Date Extracted:	05/03/18	Lab ID:	08-971 mb2 1/6
Date Analyzed:	05/06/18	Data File:	050610.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/11/18
Date Received: 04/17/18
Project: Brookdale 74001, F&BI 804290

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804290-21 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	3.9 ve	0 b	0 b	50-150	nm

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	97	70-130

Date of Report: 05/11/18
Date Received: 04/17/18
Project: Brookdale 74001, F&BI 804290

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804168-01 1/6 (Duplicate)

Analyte	Reporting Units	Sample Result	Duplicate Result	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	<0.01	<0.01	nm

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	84	70-130

Date of Report: 05/11/18
Date Received: 04/17/18
Project: Brookdale 74001, F&BI 804290

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF SOIL SAMPLES FOR ORGANOCHLORINE PESTICIDES BY EPA METHOD 8081B

Laboratory Code: 804303-07 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.027	79 b	70 b	50-150	12 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	91	70-130

Date of Report: 05/11/18
Date Received: 04/17/18
Project: Brookdale 74001, F&BI 804290

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805024-42 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.13	126 b	128 b	50-150	2 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	102	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804290

SAMPLE CHAIN OF CUSTODY

ME 4/17/18

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425)395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): [signature]

PROJECT NAME: Brookdale

PO #: 74001 ~~74401~~ per other pages + coc ms 5/11/18

REMARKS: * Dieldrin only per BJ ME 4/17/18

INVOICE TO: EPI

Page # 1 of 5 BOS

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Green 1-NW-0.5	01	4/16/18	0855	Soil	1								X				* Archive all samples not marked for immediate analysis.
Green 1-NW-1.0	02	↓	0856	↓	1								X				
Green 1-NW-1.5	03		0910		1												
Green 1-NW-2.0	04		0925		1								◆				◆ - per BJ 4/25/18 ME
Green 1-SW-0.5	05		0934		1								X				
Green 1-SW-1.0	06		0936		1								X				
Green 1-SW-1.5	07		0942		1												
Green 1-SW-2.0	08		0955		1								◆				
Green 1-E-0.5	09		1003		1								X				
Green 1-E-1.0	10	↓	1005	↓	1								X				

Samples received at 4 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-17-18	11:42
Received by: [signature]	Cristian Baldelom	FedEx	4-17-18	1142
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/17/18	1230

804290

SAMPLE CHAIN OF CUSTODY ME 4/17/18

Page # 2 of 5 B05

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing	
PROJECT NAME Brookdale	PO # 74001
REMARKS	INVOICE TO EPI

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:
SAMPLE DISPOSAL
☐ Dispose after 30 days
☒ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Green 1-E:1.5	11	4/16/18	1020	soil	1												*Archive all samples not marked for immediate analysis.
Green 1-E:2.0	12	↓	1025	↓	1								◆				
Green 2:0.5	13		1046		1								X				
Green 2:1.0	14		1051		1								X				
Green 2:1.5	15		1056		1												
Green 2:2.0	16		1110		1												
Green2-E:0.5	17		1120		1								X				
Green2-E:1.0	18		1123		1								X				
Green2-E:1.5	19		1130		1												
Green2-E:2.0	20	↓	1137	↓	1								◆				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-17-18	1142
Received by: [signature]	Cristian Balderrama	FEDEX	4-17-18	1142
Relinquished by:				
Received by: [signature]	Nhan Pham	FEBI	4/17/18	1230

804240

SAMPLE CHAIN OF CUSTODY

ME 4/17/18

Page # 3 of 5 BO5

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wong	
PROJECT NAME Brookdale	PO # 74001
REMARKS	INVOICE TO EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Green 2 - SW : 0.5	21	4/16/18	1145	soil	1								X				* Archive all samples not marked for immediate analysis
Green 2 - SW : 1.0	22	↓	1147	↓	1								X				
Green 2 - SW : 1.5	23	↓	1150	↓	1												
Green 2 - SW : 2.0	24	↓	1156	↓	1								♦				

BJ 4-17-18

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-17-18	1142
Received by: [signature]	CRISTIAN BALDELOMAR	FEDEX	4-17-18	1142
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4-17-18	1230

804290

SAMPLE CHAIN OF CUSTODY

ME 4/17/18 BOS

Page # 4 of 5

Report To: Beau Johnson
Company: EPI
Address: 1180 NW Maple St, Suite 310
City, State, ZIP: Issaquah, WA 98027
Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): [signature]
PROJECT NAME: Brookdale
PO #: 74001
REMARKS:
INVOICE TO: EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 2-NW:0.5	25	4/16/18	12:04	soil	1								X				* Archive all samples not marked for immediate analysis.
GREEN 2-NW:1.0	26	↓	12:08	↓	1								X				
GREEN 2-NW:1.5	27		12:14		1												
GREEN 2-NW:2.0	28		12:18		1												
GREEN 3-NW:0.5	29		13:26		1								X				
GREEN 3-NW:1.0	30		13:33		1								X				
GREEN 3-NW:1.5	31		13:38		1												
GREEN 3-NW:2.0	32		13:45		1								◆				
GREEN 3-S:0.5	33		13:55		1								X				
GREEN 3-S:1.0	34	↓	13:57	↓	1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-17-18	1142
Received by:	[signature]	Cristian Baldetorn	FedEx	4/17/18	1142
Relinquished by:					
Received by:	[signature]	Nhan Phan	F&BI	4/17/18	1250

804290

SAMPLE CHAIN OF CUSTODY

ME 4/17/18

Page # 5 of 5 B05

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 3-S:1.5	35	4/16/18	13:59	soil	1												* Archive all samples not marked for immediate analysis.
GREEN 3-S:2.0	36	↓	14:00	↓	1								◆				
GREEN 3-NE:0.5	37		14:15		1								X				
GREEN 3-NE:1.0	38		14:22		1								X				
GREEN 3-NE:1.5	39		14:30		1								◆				
GREEN 3-NE:2.0	40 ~~30~~ EWB		14:33		1								⌖				⌖ - per BJ 5/2/18
GREEN 3:0.5	41 ~~31~~ EWB		14:40		1								X				ME
GREEN 3:1.0	42 ~~32~~ EWB		14:43		1								X				
GREEN 3:1.5	43 ~~33~~ EWB		14:52		1												
GREEN 3:2.0	44 ~~34~~ EWB	↓	14:55	↓	1								◆				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau John	EPI	4-17-18	1142
Received by:	[signature]	Cristian Baldelomar	FEDEX	4/17/18	1142
Relinquished by:					
Received by:	[signature]	Nhan Phan	FBI	4/17/18	12:30

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 11, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 804303

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 18, 2018 from the Brookdale 74001, F&BI 804303 project. There are 40 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0511R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 18, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 804303 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804303 -01	Green4-S:0.5
804303 -02	Green4-S:1.0
804303 -03	Green4-S:1.5
804303 -04	Green4-S:2.0
804303 -05	Green4-NW:0.5
804303 -06	Green4-NW:1.0
804303 -07	Green4-NW:1.5
804303 -08	Green4-NW:2.0
804303 -09	Green4:0.5
804303 -10	Green4:1.0
804303 -11	Green4:1.5
804303 -12	Green4:2.0
804303 -13	Green4-NE:0.5
804303 -14	Green4-NE:1.0
804303 -15	Green4-NE:1.5
804303 -16	Green4-NE:2.0
804303 -17	Tee3-A:0.5
804303 -18	Tee3-A:1.0
804303 -19	Tee3-A:1.5
804303 -20	Tee3-A:2.0
804303 -21	Tee3-NE:0.5
804303 -22	Tee3-NE:1.0
804303 -23	Tee3-NE:1.5
804303 -24	Tee3-NE:2.0
804303 -25	Tee3-SE:0.5
804303 -26	Tee3-SE:1.0
804303 -27	Tee3-SE:1.5
804303 -28	Tee3-SE:2.0
804303 -29	Tee3-S:0.5
804303 -30	Tee3-S:1.0
804303 -31	Tee3-S:1.5
804303 -32	Tee3-S:2.0
804303 -33	Tee2-A:0.5
804303 -34	Tee2-A:1.0
804303 -35	Tee2-A:1.5

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
804303 -36	Tee2-A:2.0
804303 -37	Tee2-W:0.5
804303 -38	Tee2-W:1.0
804303 -39	Tee2-W:1.5
804303 -40	Tee2-W:2.0
804303 -41	Tee2-S:0.5
804303 -42	Tee2-S:1.0
804303 -43	Tee2-S:2.0
804303 -44	Tee2-NE:0.5
804303 -45	Tee2-NE:1.0
804303 -46	Tee2-NE:1.5
804303 -47	Tee2-S:1.5

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-S:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-01 1/6
Date Analyzed:	04/19/18	Data File:	041923.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.16

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-S:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-02 1/6
Date Analyzed:	04/19/18	Data File:	041924.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.049

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-NW:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-05 1/6
Date Analyzed:	04/19/18	Data File:	041925.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.049

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-NW:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-06 1/6
Date Analyzed:	04/19/18	Data File:	041926.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.077

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-NW:1.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/26/18	Lab ID:	804303-07 1/6
Date Analyzed:	04/30/18	Data File:	043020.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.027

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-09 1/60
Date Analyzed:	04/20/18	Data File:	042053.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83 d	50	150
DBC	89 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	5.1

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-10 1/6
Date Analyzed:	04/19/18	Data File:	041928.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4:1.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/26/18	Lab ID:	804303-11 1/6
Date Analyzed:	04/30/18	Data File:	043023.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.058

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-NE:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/25/18	Lab ID:	804303-13 1/6
Date Analyzed:	04/27/18	Data File:	042732.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	96	20	121
DBC	119	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.46

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green4-NE:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/25/18	Lab ID:	804303-14 1/6
Date Analyzed:	04/27/18	Data File:	042733.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	97	20	121
DBC	111	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.042

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-A:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/25/18	Lab ID:	804303-17 1/6
Date Analyzed:	04/27/18	Data File:	042734.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	94	20	121
DBC	104	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-A:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/25/18	Lab ID:	804303-18 1/6
Date Analyzed:	04/27/18	Data File:	042735.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	97	20	121
DBC	108	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.041

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-NE:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-21 1/6
Date Analyzed:	04/19/18	Data File:	041929.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-NE:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-22 1/6
Date Analyzed:	04/19/18	Data File:	041915.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-SE:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-25 1/6
Date Analyzed:	04/19/18	Data File:	041908.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	77	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.037

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-SE:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-26 1/6
Date Analyzed:	04/19/18	Data File:	041909.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.29

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-SE:2.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/26/18	Lab ID:	804303-28 1/6
Date Analyzed:	04/30/18	Data File:	043024.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.026

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-S:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-29 1/6
Date Analyzed:	04/19/18	Data File:	041910.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	68	50	150
DBC	72	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.40

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-S:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-30 1/6
Date Analyzed:	04/19/18	Data File:	041911.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.072

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee3-S:1.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/26/18	Lab ID:	804303-31 1/6
Date Analyzed:	04/30/18	Data File:	043025.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	73	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-A:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-33 1/60
Date Analyzed:	04/20/18	Data File:	042054.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83 d	50	150
DBC	89 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.3

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-A:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-34 1/6
Date Analyzed:	04/19/18	Data File:	041913.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	67	50	150
DBC	74	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.1

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-A:2.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/26/18	Lab ID:	804303-36 1/6
Date Analyzed:	04/30/18	Data File:	043026.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.42

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-W:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-37 1/6
Date Analyzed:	04/19/18	Data File:	041930.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.086

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-W:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-38 1/6
Date Analyzed:	04/19/18	Data File:	041931.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	77	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.016

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-S:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-41 1/6
Date Analyzed:	04/19/18	Data File:	041936.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.015

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-S:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-42 1/6
Date Analyzed:	04/19/18	Data File:	041937.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.033

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-NE:0.5	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-44 1/6
Date Analyzed:	04/19/18	Data File:	041938.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.17

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee2-NE:1.0	Client:	Environmental Partners
Date Received:	04/18/18	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	804303-45 1/6
Date Analyzed:	04/19/18	Data File:	041939.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	08-827 mb2 1/6
Date Analyzed:	04/19/18	Data File:	041922.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/18/18	Lab ID:	08-831 mb 1/6
Date Analyzed:	04/19/18	Data File:	041907.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/24/18	Lab ID:	08-887 mb 1/6
Date Analyzed:	04/25/18	Data File:	042525.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804303
Date Extracted:	04/26/18	Lab ID:	08-918 mb 1/6
Date Analyzed:	04/30/18	Data File:	043019.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	95	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Date of Report: 05/11/18
Date Received: 04/18/18
Project: Brookdale 74001, F&BI 804303

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804303-22 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	87	82	50-150	6

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	91	70-130

Date of Report: 05/11/18
Date Received: 04/18/18
Project: Brookdale 74001, F&BI 804303

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804290-21 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	3.9 ve	0 b	0 b	50-150	nm

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	97	70-130

Date of Report: 05/11/18
Date Received: 04/18/18
Project: Brookdale 74001, F&BI 804303

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Percent Recovery LCSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	91	93	70-130	2

Date of Report: 05/11/18
Date Received: 04/18/18
Project: Brookdale 74001, F&BI 804303

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804303-07 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.027	79 b	70 b	50-150	12 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	91	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804303

SAMPLE CHAIN OF CUSTODY

ME 04-18-18 [redacted] Page # 1 of 6 B05

[redacted] Beau Johnson

Company EPI

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SAMPLERS (signature) [signature]

PROJECT NAME: Brookdale

PO #: 74001

REMARKS: *Dieldrin only per BJ, ML 4/18/18

INVOICE TO: EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 4-S:0.5	01	4/17/18	8:09	Soil	1								X				Archive all samples not marked for immediate analysis.
GREEN 4-S:1.0	02	↓	8:12	↓	1								X				
GREEN 4-S:1.5	03		8:16		1												
GREEN 4-S:2.0	04		8:20		1												
GREEN 4-NW:0.5	05		8:24		1								X				
GREEN 4-NW:1.0	06		8:27		1								X				
GREEN 4-NW:1.5	07		8:33		1								◇				
GREEN 4-NW:2.0	08		8:37		1												
GREEN 4:0.5	09		8:42		1								X				
GREEN 4:1.0	10	↓	8:44	↓	1								X				

Samples received at 4 °C

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-18-18	0730
Received by: [signature]	James Bruya	F&B	4/18	0730
Relinquished by:				
Received by:				

SAMPLE CHAIN OF CUSTODY

804303

ME 04-18-18

Repo[redacted] Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [signature]

PROJECT NAME Brookdale

PO # 74001

REMARKS

INVOICE TO EPI

[redacted]age # 2 of 6 805

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 4:1.5	11	4/17/18	8:49	Soil	1								◇				* Archive all samples not
GREEN 4:2.0	12		8:57		1												marked for
GREEN 4-NE:0.5	13		9:06		1								◆				immediate analy
GREEN 4-NE:1.0	14		9:10		1								◆				◆ -per BJ
GREEN 4-NE:1.5	15		9:21		1												4/25/18 ME
GREEN 4-NE:2.0	16		9:25		1												◇ -per BJ
TEE 3-A:0.5	17		9:47		1								◆				4/25/18 ME
TEE 3-A:1.0	18		9:50		1								◆				
TEE 3-A:1.5	19		9:59		1												
TEE 3-A:2.0	20		10:02		1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-18-18	0730
Received by:	[signature]	James Bruya	F&B	4/18	0730
Relinquished by:					
Received by:					

804303

SAMPLE CHAIN OF CUSTODY

ME 04-18-18 [redacted]

Page # 3 of 6 805

Re[redacted] To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [signature]

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [X] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [X] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	ANALYSES REQUESTED: TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
~~TEE 3-B: 0.5~~			~~10:10~~														Dispose of these samples 4/18 Disposed EWB
~~TEE 3-B: 1.0~~			~~10:13~~														
~~TEE 3-B: 1.5~~			~~10:22~~														
~~TEE 3-B: 2.0~~			~~10:26~~														
TEE 3-NE: 0.5	21	4/17/18	10:38	Soil	1								X				* Archive all samples not marked for immediate analysis.
TEE 3-NE: 1.0	22	↓	10:45	↓	1								X				
TEE 3-NE: 1.5	23	↓	10:54	↓	1												
TEE 3-NE: 2.0	24	↓	10:58	↓	1												
TEE 3-SE: 0.5	25	↓	11:04	↓	1								X				
TEE 3-SE: 1.0	26	↓	11:10	↓	1								X				

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Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-18-18	0730
Received by: [signature]	James Bruya	F&B	4-18	0730
Relinquished by:				
Received by:				

804303
[redacted]

SAMPLE CHAIN OF CUSTODY

ME 04-18-18
[redacted]

Page # 4 of 6 B05

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0014 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wong	
PROJECT NAME	PO # 74001
REMARKS	INVOICE TO EPI

TURNAROUND TIME
- [X] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [X] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
TEE3-SE:1.5	27	04/17/18	11:44	Soil	1												* Archive all samples not marked for immediately.
TEE3-SE:2.0	28	↓	11:50	↓	1								◇				
TEE3-S:0.5	29		12:05		1								X				
TEE3-S:1.0	30		12:06		1								X				
TEE3-S:1.5	31		12:08		1								◇				
TEE3-S:2.0	32	↓	12:10	↓	1												

BJ 4-18-18

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-18-18	0730
Received by:	[signature]	James Bruya	F&B	4/18	0730
Relinquished by:					
Received by:					

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Seattle, WA 98119-2029
Ph. (206) 285-8282

804303
[redacted]

SAMPLE CHAIN OF CUSTODY

ME 04-18-18 [redacted] # 5 of 6 B05

Report To: Beau Johnson
Company: EPI
Address: 1180 NW Maple St, Suite 310
City, State, ZIP: Issaquah, WA 98027
Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wong

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☒ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
						ANALYSES REQUESTED											
Tee 2-A: 0.5	33	4/17/18	1314	Soil	1								X				* Archive all samples not marked for immediate analysis.
Tee 2-A: 1.0	34	↓	1321	↓	1								X				
Tee 2-A: 1.5	35		1344		1												
Tee 2-A: 2.0	36		1346		1								◇				
Tee 2-W: 0.5	37		1359		1								X				
Tee 2-W: 1.0	38		1403		1								X				
Tee 2-W: 1.5	39		1408		1												
Tee 2-W: 2.0	40		1410		1												
Tee 2-S: 0.5	41		1420		1								X				
Tee 2-S: 1.0	42	↓	1427	↓	1								X				

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3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-18-18	0730
Received by:	[signature]	James Bruya	F&B	4/18	0730
Relinquished by:					
Received by:					

804303 [redacted]

SAMPLE CHAIN OF CUSTODY

ME 04-18-18 [redacted] Page # 6 of 6 B05

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epiwa.com

SAMPLERS (signature): [signature]

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee2-S: 2.0	43	4/17/18	1441	soil	1												*Archive all samples not marked for immediate analysis.
Tee2-NE: 0.5	44	↓	1449	↓	1								X				
Tee2-NE: 1.0	45	↓	1518	↓	1								X				
Tee2-NE: 1.5	46	↓	1539	↓	1												
Tee2-S: 1.5	47	4/17	1427	soil	1												

BS 4-18-18

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Ben Shaw	EPI	4-18-18	0730
Received by:	[signature]	James Bruya	F&B	4/18	730
Relinquished by:					
Received by:					

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 14, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: 74001, F&BI 804344

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 19, 2018 from the 74001, F&BI 804344 project. There are 43 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0514R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 19, 2018 by Friedman & Bruya, Inc. from the Environmental Partners 74001, F&BI 804344 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804344-01	Tee 4-N:0.5
804344-02	Tee 4-N:1.0
804344-03	Tee 4-N:1.5
804344-04	Tee 4-N:2.0
804344-05	Tee 4-NW:0.5
804344-06	Tee 4-NW:1.0
804344-07	Tee 4-NW:1.5
804344-08	Tee 4-NW:2.0
804344-09	Tee 4-D:0.5
804344-10	Tee 4-D:1.0
804344-11	Tee 4-D:1.5
804344-12	Tee 4-D:2.0
804344-13	Tee 4-A:0.5
804344-14	Tee 4-A:1.0
804344-15	Tee 4-A:1.5
804344-16	Tee 4-A:2.0
804344-17	Tee 5-NE:0.5
804344-18	Tee 5-NE:1.0
804344-19	Tee 5-NE:1.5
804344-20	Tee 5-NE:2.0
804344-21	Tee 5-A:0.5
804344-22	Tee 5-A:1.0
804344-23	Tee 5-A:1.5
804344-24	Tee 5-A:2.0
804344-25	Tee 5-S:0.5
804344-26	Tee 5-S:1.0
804344-27	Tee 5-S:1.5
804344-28	Tee 5-S:2.0
804344-29	Tee 5-NW:0.5
804344-30	Tee 5-NW:1.0
804344-31	Tee 7-C:0.5
804344-32	Tee 7-C:1.0
804344-33	Tee 7-C:1.5
804344-34	Tee 7-C:2.0

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
804344-35	Tee 7-NW:0.5
804344-36	Tee 7-NW:1.0
804344-37	Tee 7-NW:1.5
804344-38	Tee 7-NW:2.0
804344-39	Tee 5-NW:1.5
804344-40	Tee 5-NW:2.0
804344-41	Tee 7-A:0.5
804344-42	Tee 7-A:1.0
804344-43	Tee 7-A:1.5
804344-44	Tee 7-A:2.0
804344-45	Tee 7-B:0.5
804344-46	Tee 7-B:1.0
804344-47	Tee 7-B:1.5
804344-48	Tee 7-B:2.0
804344-49	Tee 7-S:0.5
804344-50	Tee 7-S:1.0
804344-51	Tee 7-S:1.5
804344-52	Tee 7-S:2.0
804344-53	Tee 7-NE:0.5
804344-54	Tee 7-NE:1.0
804344-55	Tee 7-NE:1.5
804344-56	Tee 7-NE:2.0

The 8081B analysis for samples Tee 4-N:2.0 and Tee 4-D:2.0 was requested outside of the holding time. The data were flagged accordingly.

All other quality control requirements were acceptable.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-N:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-01 1/6
Date Analyzed:	05/01/18	Data File:	050128.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.34

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-N:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-02 1/6
Date Analyzed:	05/01/18	Data File:	050129.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.22

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-N:2.0 ht	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	05/08/18	Lab ID:	804344-04 1/6
Date Analyzed:	05/09/18	Data File:	050909.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.028

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-NW:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-05 1/6
Date Analyzed:	05/01/18	Data File:	050130.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.058

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-NW:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-06 1/6
Date Analyzed:	05/01/18	Data File:	050131.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-D:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-09 1/60
Date Analyzed:	05/03/18	Data File:	050310.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89 d	50	150
DBC	176 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	5.1

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-D:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-10 1/6
Date Analyzed:	05/01/18	Data File:	050133.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.52

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-D:2.0 ht	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	05/08/18	Lab ID:	804344-12 1/6
Date Analyzed:	05/09/18	Data File:	050910.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	108	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-A:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-13 1/6
Date Analyzed:	05/01/18	Data File:	050134.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-A:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-14 1/6
Date Analyzed:	05/01/18	Data File:	050135.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.032

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 4-A:2.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-16 1/6
Date Analyzed:	05/01/18	Data File:	050136.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.26

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-NE:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-17 1/6
Date Analyzed:	04/20/18	Data File:	042021.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.028

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-NE:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-18 1/6
Date Analyzed:	04/20/18	Data File:	042024.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	75	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-A:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-21 1/6
Date Analyzed:	04/20/18	Data File:	042025.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-A:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-22 1/6
Date Analyzed:	04/20/18	Data File:	042026.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.24

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-A:2.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-24 1/6
Date Analyzed:	05/01/18	Data File:	050137.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	62	50	150
DBC	72	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.14

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-S:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-25 1/6
Date Analyzed:	04/20/18	Data File:	042027.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	78	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-S:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-26 1/60
Date Analyzed:	04/23/18	Data File:	042337.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81 d	50	150
DBC	81 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.4

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-S:2.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-28 1/6
Date Analyzed:	05/01/18	Data File:	050138.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.010

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-NW:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-29 1/6
Date Analyzed:	04/20/18	Data File:	042029.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 5-NW:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-30 1/6
Date Analyzed:	04/20/18	Data File:	042030.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.012

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-C:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-31 1/6
Date Analyzed:	04/20/18	Data File:	042034.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-C:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-32 1/6
Date Analyzed:	04/20/18	Data File:	042035.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-NW:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-35 1/6
Date Analyzed:	04/20/18	Data File:	042036.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	78	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-NW:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-36 1/6
Date Analyzed:	04/20/18	Data File:	042037.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.039

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-A:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-41 1/6
Date Analyzed:	04/20/18	Data File:	042038.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-A:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-42 1/6
Date Analyzed:	04/20/18	Data File:	042039.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-B:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-45 1/6
Date Analyzed:	04/20/18	Data File:	042040.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	75	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-B:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-46 1/6
Date Analyzed:	04/20/18	Data File:	042041.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.096

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-B:1.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	804344-47 1/6
Date Analyzed:	05/01/18	Data File:	050139.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	68	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-S:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-49 1/6
Date Analyzed:	04/20/18	Data File:	042042.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.046

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-S:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-50 1/6
Date Analyzed:	04/20/18	Data File:	042043.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-NE:0.5	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-53 1/6
Date Analyzed:	04/20/18	Data File:	042044.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 7-NE:1.0	Client:	Environmental Partners
Date Received:	04/19/18	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	804344-54 1/6
Date Analyzed:	04/20/18	Data File:	042045.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804344
Date Extracted:	04/30/18	Lab ID:	08-950 mb 1/6
Date Analyzed:	05/01/18	Data File:	050106.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804344
Date Extracted:	04/19/18	Lab ID:	08-857 mb 1/6
Date Analyzed:	04/20/18	Data File:	042020.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804344
Date Extracted:	05/08/18	Lab ID:	08-988 mb 1/6
Date Analyzed:	05/09/18	Data File:	050906.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	98	50	150
DBC	114	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/14/18
Date Received: 04/19/18
Project: 74001, F&BI 804344

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF SOIL SAMPLES FOR ORGANOCHLORINE PESTICIDES BY EPA METHOD 8081B

Laboratory Code: 804344-17 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.028	71 b	69 b	50-150	3 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	93	70-130

Date of Report: 05/14/18
Date Received: 04/19/18
Project: 74001, F&BI 804344

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804371-08 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	93	89	50-150	4

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	96	70-130

Date of Report: 05/14/18
Date Received: 04/19/18
Project: 74001, F&BI 804344

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 805107-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	3.7	181 b	102 b	50-150	56 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	98	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804344

SAMPLE CHAIN OF CUSTODY

ME 04-19-18

Page # 1 of 6 (804)

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME: Brookdale

PO #: 74001

REMARKS: * Dieldrin only per BJ ME 4/19/18

INVOICE TO: EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 4-N: 0.5	01	4/18/18	0818	soil	1								◆				* Archive all samples not
Tee 4-N: 1.0	02	↓	0826	↓	1								◆				marked for immediate
Tee 4-N: 1.5	03		0841		1												analysis.
Tee 4-N: 2.0	04		0845		1								⌀				◆ - per BJ 4/27/18
Tee 4-NW: 0.5	05		0853		1								◆				ME
Tee 4-NW: 1.0	06		0901		1								◆				⌀ per BJ
Tee 4-NW: 1.5	07		0913		1												5/7/18 ME
Tee 4-NW: 2.0	08		0920		1												
Tee 4-D: 0.5	09		0929		1								◆				
Tee 4-D: 1.0	10	↓	0930	↓	1								◆				

Samples received at 4 °C

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-19-18	11:40am
Received by:	[signature]	Brad Reitz	FedEx SDC	4/19/18	11:40a
Relinquished by:					
Received by:	[signature]	Nhan Phan	FeBI	4/19/18	1235

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

804344

SAMPLE CHAIN OF CUSTODY

ME 04-19-18 804 [redacted]age # 2 of 6

Repo[redacted] Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425)395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Ding

PROJECT NAME	PO #
Brookdale	74001
REMARKS	**INVOICE TO**
	EPI

[redacted] TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 4-D: 1.5	11	4/18/18	0933	soil	1												* Archive all samples not marked for immediate analysis.
Tee 4-D: 2.0	12	↓	0935	↓	1								Φ				
Tee 4-A: 0.5	13	↓	0942	↓	1								◆				
Tee 4-A: 1.0	14	↓	1013	↓	1								◆				
Tee 4-A: 1.5	15	↓	1023	↓	1												
Tee 4-A: 2.0	16	↓	1030	↓	1								◆				
Tee ~~#~~ 5-NE: 0.5	17	↓	1154	↓	1								X				
Tee 5-NE: 1.0	18	↓	1158	↓	1								X				
Tee 5-NE: 1.5	19	↓	1201	↓	1												
Tee 5-NE: 2.0	20	↓	1206	↓	1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-19-18	11:40
Received by: [signature]	Brad Kratz	FedEx SDC	4/19/18	11:40
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/19/18	1235

804344

SAMPLE CHAIN OF CUSTODY

ME 04-19-18 [redacted]

Page # 3 [804] of 4

Report [redacted] Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
						ANALYSES REQUESTED											
TeeS-A:0.5	21	4/18/18	1211	soil	1								X				* Archive all samples not marked for immediate analysis.
TeeS-A:1.0	22	↓	1213	↓	1								X				
TeeS-A:1.5	23	↓	1217	↓	1												
TeeS-A:2.0	24	↓	1222	↓	1								◆				
TeeS-S:0.5	25	↓	1233	↓	1								X				
TeeS-S:1.0	26	↓	1235	↓	1								X				
TeeS-S:1.5	27	↓	1240	↓	1												
TeeS-S:2.0	28	↓	1242	↓	1								◆				
TeeS-NW:0.5	29	↓	1253	↓	1								X				
TeeS-NW:1.0	30	↓	1307	↓	1								X				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-19-18	1140am
Received by: [signature]	Brad Raitz	FedEx SDC	4/19/18	1140am
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/19/18	1235

804344

SAMPLE CHAIN OF CUSTODY

ME 04-19-18 804

[redacted] Page # 4 of 6

Report [redacted] Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wong

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
						ANALYSES REQUESTED											
Tee 7-C: 0.5	31	4/18/18	1411	Soil	1								X				*Archive all samples not marked for immediate analysis.
Tee 7-C: 1.0	32	↓	1414	↓	1								X				
Tee 7-C: 1.5	33		1417		1												
Tee 7-C: 2.0	34		1419		1												
Tee 7-NW: 0.5	35		1348		1								X				
Tee 7-NW: 1.0	36		1352		1								X				
Tee 7-NW: 1.5	37		1354		1												
Tee 7-NW: 2.0	38	↓	1358	↓	1												
					BJ	4-19-18											

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-19-18	11:40am
Received by: [signature]	Brad Reitz	FedEx SDC	4/19/18	11:40am
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/19/18	1235

804344

SAMPLE CHAIN OF CUSTODY

ME 04-19-18 B04

Page # 4 of 6

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee5-NW: 1.5	39	4/18/18	1322	soil	1												* Archive all samples not marked for immediate analysis.
Tee5-NW: 2.0	40	↓	1324	↓	1												
~~Tee5~~ Tee7-A: 0.5	41		1448		1								X				
Tee7-A: 1.0	42		1451		1								X				
Tee7-A: 1.5	43		1527		1												
Tee7-A: 2.0	44		1535		1												
Tee 7-B: 0.5	45		1428		1								X				
Tee7-B: 1.0	46		1434		1								X				
Tee7-B: 1.5	47		1439		1								◆				
Tee7-B: 2.0	48	↓	1444	↓	1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-19-18	11:40am
Received by: [signature]	Brad Reitz	FedEx SDC	4/19/18	11:40am
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/19/18	12:35

SAMPLE CHAIN OF CUSTODY

~~803~~ EWB 804344 · ME 04-19-18

Page # 6 804 of 6

Report To BEAN JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA. 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)	
[redacted]	
PROJECT NAME	PO #
BROOKDALE	
REMARKS	INVOICE TO

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
TEE 7-S:0.5	49	04/18/18	15:45	SOIL	1								X				
TEE 7-S:1.0	50	↓	15:50	↓	↓								X				
TEE 7-S:1.5	51	↓	15:55	↓	↓								~~X~~ hold				
TEE 7-S:2.0	52	↓	16:00	↓	↓								~~X~~ hold BJ				
TEE 7-NE:0.5	53	↓	16:06	↓	↓								X				
TEE 7-NE:1.0	54	↓	16:09	↓	↓								X				
TEE 7-NE:1.5	55	↓	16:11	↓	↓								~~X~~ hold				
TEE 7-NE:2.0	56	↓	16:20	↓	↓								~~X~~ hold BJ				
						BJ 4-19-18											

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Bean Johnson	EPI	4-19-18	11:40am
Received by: [signature]	Brad Reitz	FedEx SDC	4/19/18	11:40am
Relinquished by:				
Received by: [signature]	Nhan Phan	FEBI	4/19/18	1235

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 11, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 804371

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 20, 2018 from the Brookdale 74001, F&BI 804371 project. There are 45 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0511R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 20, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 804371 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804371-01	Tee8-A:0.5
804371-02	Tee8-A:1.0
804371-03	Tee8-A:1.5
804371-04	Tee8-A:2.0
804371-05	Tee8-B:0.5
804371-06	Tee8-B:1.0
804371-07	Tee8-B:1.5
804371-08	Tee8-B:2.0
804371-09	Tee8-NE:0.5
804371-10	Tee8-NE:1.0
804371-11	Tee8-NE:1.5
804371-12	Tee8-NE:2.0
804371-13	Tee8-W:0.5
804371-14	Tee8-W:1.0
804371-15	Tee8-W:1.5
804371-16	Tee8-W:2.0
804371-17	Tee8-SE:0.5
804371-18	Tee8-SE:1.0
804371-19	Tee8-SE:1.5
804371-20	Tee8-SE:2.0
804371-21	Tee9-W:0.5
804371-22	Tee9-W:1.0
804371-23	Tee9-W:1.5
804371-24	Tee9-W:2.0
804371-25	Tee9-S:0.5
804371-26	Tee9-S:1.0
804371-27	Tee9-S:1.5
804371-28	Tee9-S:2.0
804371-29	Tee9-N:0.5
804371-30	Tee9-N:1.0
804371-31	Tee9-N:1.5
804371-32	Tee9-N:2.0
804371-33	Tee9-E:0.5
804371-34	Tee9-E:1.0
804371-35	Tee9-E:1.5

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
804371-36	Tee9-E:2.0
804371-37	Tee9-B:0.5
804371-38	Tee9-B:1.0
804371-39	Tee9-B:1.5
804371-40	Tee9-B:2.0
804371-41	Tee9-C:0.5
804371-42	Tee9-C:1.0
804371-43	Tee9-C:1.5
804371-44	Tee9-C:2.0
804371-45	Tee9-A:0.5
804371-46	Tee9-A:1.0
804371-47	Tee9-A:1.5
804371-48	Tee9-A:2.0
804371-49	Tee14-S:0.5
804371-50	Tee14-S:1.0
804371-51	Tee14-S:1.5
804371-52	Tee14-S:2.0
804371-53	Tee14-E:0.5
804371-54	Tee14-E:1.0
804371-55	Tee14-E:1.5
804371-56	Tee14-E:2.0
804371-57	Tee14-N:0.5
804371-58	Tee14-N:1.0
804371-59	Tee14-N:1.5
804371-60	Tee14-N:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-A:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-01 1/6
Date Analyzed:	04/23/18	Data File:	042311.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-A:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-02 1/6
Date Analyzed:	04/23/18	Data File:	042314.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	75	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-B:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-05 1/120
Date Analyzed:	04/24/18	Data File:	042418.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82 d	50	150
DBC	79 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	9.2

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-B:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-06 1/6
Date Analyzed:	04/23/18	Data File:	042316.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	75	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-B:2.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	804371-08 1/6
Date Analyzed:	05/01/18	Data File:	050119.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-NE:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-09 1/6
Date Analyzed:	04/23/18	Data File:	042317.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-NE:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-10 1/6
Date Analyzed:	04/23/18	Data File:	042318.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-W:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-13 1/60
Date Analyzed:	04/24/18	Data File:	042419.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91 d	50	150
DBC	93 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.7

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-W:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-14 1/6
Date Analyzed:	04/23/18	Data File:	042320.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.75

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-W:2.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	804371-16 1/6
Date Analyzed:	05/01/18	Data File:	050117.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.095

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-SE:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-17 1/6
Date Analyzed:	04/23/18	Data File:	042324.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.040

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee8-SE:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-18 1/6
Date Analyzed:	04/23/18	Data File:	042325.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.019

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-W:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-21 1/6
Date Analyzed:	04/23/18	Data File:	042326.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.013

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-W:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-22 1/6
Date Analyzed:	04/23/18	Data File:	042327.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.037

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-S:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-25 1/6
Date Analyzed:	04/23/18	Data File:	042328.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.022

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-S:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-26 1/6
Date Analyzed:	04/23/18	Data File:	042329.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-N:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-29 1/6
Date Analyzed:	04/23/18	Data File:	042330.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.13

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-N:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-30 1/6
Date Analyzed:	04/23/18	Data File:	042331.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.020

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-E:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-33 1/6
Date Analyzed:	04/23/18	Data File:	042332.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.23

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-E:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-34 1/6
Date Analyzed:	04/23/18	Data File:	042333.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.080

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-E:1.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	804371-35 1/6
Date Analyzed:	05/01/18	Data File:	050118.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	62	50	150
DBC	72	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.018

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-B:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-37 1/6
Date Analyzed:	04/23/18	Data File:	042334.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.70

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-B:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-38 1/6
Date Analyzed:	04/23/18	Data File:	042335.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.16

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-B:2.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	804371-40 1/6
Date Analyzed:	05/01/18	Data File:	050125.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-C:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-41 1/6
Date Analyzed:	04/24/18	Data File:	042429.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.17

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-C:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-42 1/6
Date Analyzed:	04/24/18	Data File:	042420.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.88

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-C:2.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	804371-44 1/6
Date Analyzed:	05/01/18	Data File:	050126.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.087

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-A:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-45 1/6
Date Analyzed:	04/24/18	Data File:	042421.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	76	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee9-A:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-46 1/6
Date Analyzed:	04/24/18	Data File:	042422.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-S:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-49 1/6
Date Analyzed:	04/24/18	Data File:	042423.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	75	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.024

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-S:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-50 1/6
Date Analyzed:	04/24/18	Data File:	042424.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	78	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.019

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-E:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-53 1/6
Date Analyzed:	04/24/18	Data File:	042425.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	76	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.086

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-E:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-54 1/6
Date Analyzed:	04/24/18	Data File:	042426.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.013

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-N:0.5	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-57 1/60
Date Analyzed:	04/25/18	Data File:	042535.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82 d	50	150
DBC	81 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.3

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-N:1.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	804371-58 1/6
Date Analyzed:	04/24/18	Data File:	042434.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	20	121
DBC	85	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.21

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee14-N:2.0	Client:	Environmental Partners
Date Received:	04/20/18	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	804371-60 1/6
Date Analyzed:	05/01/18	Data File:	050127.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.30

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/30/18	Lab ID:	08-950 mb 1/6
Date Analyzed:	05/01/18	Data File:	050106.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	08-875 mb 1/6
Date Analyzed:	04/23/18	Data File:	042310.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804371
Date Extracted:	04/23/18	Lab ID:	08-876 mb 1/6
Date Analyzed:	04/24/18	Data File:	042417.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/11/18
Date Received: 04/20/18
Project: Brookdale 74001, F&BI 804371

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804371-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	84	73	50-150	14

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	88	70-130

Date of Report: 05/11/18
Date Received: 04/20/18
Project: Brookdale 74001, F&BI 804371

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804371-41 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.17	102 b	113 b	50-150	10 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	89	70-130

Date of Report: 05/11/18
Date Received: 04/20/18
Project: Brookdale 74001, F&BI 804371

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804371-08 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	93	89	50-150	4

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	96	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804371

SAMPLE CHAIN OF COUSTODY

ME 04-20-18 BOS

Page # 1 of 7

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001

REMARKS	INVOICE TO
*Dieldrin only per BJ ML 4/20/18	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes (◆ - per BJ 4/27/18 ME)
Tee8-A:0.5	01	4/19/18	0807	Soil	1								X				* Archive all samples not marked for immediate analysis
Tee8-A:1.0	02	↓	0812	↓	1								X				
Tee8-A:1.5	03		0818		1												
Tee8-A:2.0	04		0826		1												
Tee8-B:0.5	05		0832		1								X				
Tee8-B:1.0	06		0836		1								X				
Tee8-B:1.5	07		0838		1												
Tee8-B:2.0	08		0841		1								◆				
Tee8-NE:0.5	09		0905		1								X				Samples received at 5 °C
Tee8-NE:1.0	10		0908		1								X				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-20-18	12:52
Received by:	[signature]	Wes Herring	Fed Ex	4.20.18	12 52P
Relinquished by:					
Received by:	[signature]	Elizabeth Webber-Bruya	F&BI	4/20/18	13:45

804371

SAMPLE CHAIN OF COUSTODY

ME 04-20-18 805

Page # 2 of 7

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)	
PROJECT NAME: Brookdale	PO #: 74001
REMARKS	INVOICE TO: EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee8-NE:1.5	11	4/19/2018	0917	soil	1												*Archive all samples not
Tee8-NE:2.0	12	↓	0921	↓	1												marked for immediate
Tee8-W:0.5	13		0849		1								X				analysis
Tee8-W:1.0	14		0850		1								X				
Tee8-W:1.5	15		0854		1												
Tee8-W:2.0	16		0857		1								◆				
Tee8-SE:0.5	17		0928		1								X				
Tee8-SE:1.0	18		0930		1								X				
Tee8-SE:1.5	19		0936		1												
Tee8-SE:2.0	20	↓	0940	↓	1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	Beau Johnson	EPI	4-20-18	12:52
Received by:	Wes Herring	FedEx	4-20-18	12:52pm
Relinquished by:	Elizabeth Webber-Bruya	F&BI	4/20/18	13:45
Received by:				

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SAMPLE CHAIN OF CUSTODY

ME 04-20-18 B05

Page # 3 of 7

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)	
Betsy Wing	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH ______
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☒ Archive Samples
☐ Other ______

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee9-W:0.5	21	4/19/18	1050	soil	1								X				*All samples not marked for immediate analysis to be archived.
Tee9-W:1.0	22		1102		1								X				
Tee9-W:1.5	23		1132		1												
Tee9-W:2.0	24		1144		1												
~~Tee9-B:0.5~~					1								X				
~~Tee9-B:1.0~~					1								X				
~~Tee9-B:1.5~~					1												
~~Tee9-B:2.0~~					1												
~~Tee9-A:0.5~~					1								X				
~~Tee9-A:1.0~~					1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-20-18	12:52
Received by: [signature]	WES Herring	FedEx	4-20-18	1252pm
Relinquished by:				
Received by: [signature]	Elizabeth Webber-Bruya	F&BI	4/20/18	1345

804371

SAMPLE CHAIN OF CUSTODY

ME 04-20-18 4 B05

Page # 4 of 7

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epiwa.com

SAMPLERS (signature) Betsy Oig

PROJECT NAME Brookdale

PO # 74001

REMARKS

INVOICE TO EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee9-S:0.5	25	4/19/18	0957	soil	1								X				* Archive all
Tee9-S:1.0	26	↓	1004	↓	1								X				samples not
Tee9-S:1.5	27	↓	1013	↓	1												marked for immediate
Tee9-S:2.0	28	↓	1018	↓	1												analysis.
Tee9-N:0.5	29	↓	1029	↓	1								X				
Tee9-N:1.0	30	↓	1032	↓	1								X				
Tee9-N:1.5	31	↓	1034	↓	1												
Tee9-N:2.0	32	↓	1036	↓	1												
Tee9-E:0.5	33	↓	1247	↓	1								X				
Tee9-E:1.0	34	↓	1249	↓	1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-20-18	12:52
Received by: [signature]	Wes Herring	FedEx	4-20-18	1252pm
Relinquished by: [signature]	Elizabeth Webber-Bruya	F?BI	4/20/18	1345
Received by:				

804371

SAMPLE CHAIN OF CUSTODY

ME 04-20-18

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing		Page # 5 of 7 (805)
PROJECT NAME Brookdale	PO # 74001	TURNAROUND TIME ☒ Standard Turnaround ☐ RUSH ___ Rush charges authorized by:
REMARKS	INVOICE TO EPI	SAMPLE DISPOSAL ☐ Dispose after 30 days ☒ Archive Samples ☐ Other ___

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee9-E:1.5	35	4/19/18	1252	Soil	1								◆				*Archive all samples not marked for immediate analysis.
Tee9-E:2.0	36		1254		1												
Tee9-B:0.5	37		1305		1								X				
Tee9-B:1.0	38		1307		1								X				
Tee9-B:1.5	39		1314		1												
Tee9-B:2.0	40		1328		1								◆				
Tee9-C:0.5	41		1335		1								X				
Tee9-C:1.0	42		1338		1								X				
Tee9-C:1.5	43		1341		1												
Tee9-C:2.0	44	↓	1345	↓	1								◆				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-20-18	12:52
Received by:	[signature]	Wes Herring	FedEx	4-20-18	1252 pm
Relinquished by:	[signature]	Elizabeth Webber-Bruya	F&BI	4/20/18	1345
Received by:					

SAMPLE CHAIN OF CUSTODY

804371

ME 04-20-18

Page # 6 of 7

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME: Brookdale

PO #: 74001

REMARKS:

INVOICE TO: EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	8081 Pesticides				Notes
Tee 9-A: 0.5	45	4/19/18	1403	Soil	1								X				Archive all samples not marked for immediate analysis.
Tee 9-A: 1.0	46	4/19/18	1406	Soil	1								X				
Tee 9-A: 1.5	47	4/19/18	1408	Soil	1												
Tee 9-A: 2.0	48	4/19/18	1410	Soil	1												
Tee 14-S: 0.5	49	4/19/18	1430	Soil	1								X				
Tee 14-S: 1.0	50	4/19/18	1433	Soil	1								X				
Tee 14-S: 1.5	51	4/19/18	1441	Soil	1												
Tee 14-S: 2.0	52	4/19/18	1450	Soil	1												
Tee 14-E: 0.5	53	4/19/18	1456	Soil	1								X				
Tee 14-E: 1.0	54	4/19/18	1459	Soil	1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: (signature)	Beau Johnson	EPI	4-20-18	12:52
Received by: (signature)	WES HERRING	FedEx	4-20-18	12:52pm
Relinquished by: (signature)	Elizabeth Webber-Bruya	F&BI	4/20/18	1345
Received by:				

SAMPLE CHAIN OF CUSTODY

804371

ME 04-20-18

Page # 7 of 7 (805)

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 14-E:1.5	55	4/19/18	1504	soil	1												Archive all samples not marked for immediate analysis.
Tee 14-E:2.0	56	4/19/18	1506	soil	1												
Tee 14-N:0.5	57	↓	1516	↓	1								X				
Tee 14-N:1.0	58		1520		1								X				
Tee 14-N:1.5	59		1523		1												
Tee 14-N:2.0	60	↓	1527	↓	1								◆				
~~Tee 9-W:0.5~~		↓	1050 ~~1516~~	↓	1								X				
~~Tee 9-W:1.0~~			1102 ~~1520~~		1								X				
~~Tee 9-W:1.5~~			1132		1												
~~Tee 9-W:2.0~~		↓	1144	↓	1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	4-20-18	12:52
Received by: [signature]	Wes Herring	FedEx	4-20-18	1252 pm
Relinquished by: [signature]	Elizabeth Webber-Bruya	F&BI	4/20/18	1345
Received by:				

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 11, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 804386

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 23, 2018 from the Brookdale 74001, F&BI 804386 project. There are 28 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0511R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on April 23, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 804386 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804386-01	Tee11-N:0.5
804386-02	Tee11-N:1.0
804386-03	Tee11-N:1.5
804386-04	Tee11-N:2.0
804386-05	Tee11-A:0.5
804386-06	Tee11-A:1.0
804386-07	Tee11-A:1.5
804386-08	Tee11-A:2.0
804386-09	Tee11-NE:0.5
804386-10	Tee11-NE:1.0
804386-11	Tee11-NE:1.5
804386-12	Tee11-NE:2.0
804386-13	Tee11-B:0.5
804386-14	Tee11-B:1.0
804386-15	Tee11-B:1.5
804386-16	Tee11-B:2.0
804386-17	Tee11-SE:0.5
804386-18	Tee11-SE:1.0
804386-19	Tee11-SE:1.5
804386-20	Tee11-SE:2.0
804386-21	Tee11-SW:0.5
804386-22	Tee11-SW:1.0
804386-23	Tee11-SW:1.5
804386-24	Tee11-SW:2.0
804386-25	Tee11-NW:0.5
804386-26	Tee11-NW:1.0
804386-27	Tee11-NW:1.5
804386-28	Tee11-NW:2.0
804386-29	Tee11-S:0.5
804386-30	Tee11-S:1.0
804386-31	Tee11-D:0.5
804386-32	Tee11-D:1.0

All quality control requirements were acceptable.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-N:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-01 1/6
Date Analyzed:	04/24/18	Data File:	042435.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	20	121
DBC	88	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-N:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-02 1/6
Date Analyzed:	04/24/18	Data File:	042436.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	20	121
DBC	90	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-A:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-05 1/6
Date Analyzed:	04/24/18	Data File:	042437.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	20	121
DBC	92	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.37

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-A:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-06 1/6
Date Analyzed:	04/24/18	Data File:	042438.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	20	121
DBC	86	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.065

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-A:1.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/30/18	Lab ID:	804386-07 1/6
Date Analyzed:	05/01/18	Data File:	050140.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.043

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-NE:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-09 1/6
Date Analyzed:	04/24/18	Data File:	042439.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	20	121
DBC	91	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-NE:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-10 1/6
Date Analyzed:	04/24/18	Data File:	042440.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	20	121
DBC	93	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-B:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-13 1/60
Date Analyzed:	04/25/18	Data File:	042536.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83 d	50	150
DBC	84 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.9

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-B:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-14 1/6
Date Analyzed:	04/24/18	Data File:	042442.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	20	121
DBC	87	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.59

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-B:2.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/30/18	Lab ID:	804386-16 1/6
Date Analyzed:	05/01/18	Data File:	050141.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-SE:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-17 1/6
Date Analyzed:	04/24/18	Data File:	042443.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	20	121
DBC	91	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.49

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-SE:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-18 1/6
Date Analyzed:	04/24/18	Data File:	042444.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	20	121
DBC	86	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.034

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-SW:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-21 1/6
Date Analyzed:	04/24/18	Data File:	042450.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-SW:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-22 1/6
Date Analyzed:	04/24/18	Data File:	042453.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-NW:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-25 1/6
Date Analyzed:	04/24/18	Data File:	042454.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-NW:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-26 1/6
Date Analyzed:	04/24/18	Data File:	042455.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-S:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-29 1/6
Date Analyzed:	04/25/18	Data File:	042537.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.036

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-S:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-30 1/6
Date Analyzed:	04/25/18	Data File:	042538.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-D:0.5	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-31 1/6
Date Analyzed:	04/25/18	Data File:	042539.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee11-D:1.0	Client:	Environmental Partners
Date Received:	04/23/18	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	804386-32 1/6
Date Analyzed:	04/26/18	Data File:	042540.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/30/18	Lab ID:	08-950 mb 1/6
Date Analyzed:	05/01/18	Data File:	050106.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	08-876 mb 1/6
Date Analyzed:	04/24/18	Data File:	042417.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804386
Date Extracted:	04/23/18	Lab ID:	08-882 mb 1/6
Date Analyzed:	04/24/18	Data File:	042449.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/11/18
Date Received: 04/23/18
Project: Brookdale 74001, F&BI 804386

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804371-41 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.17	102 b	113 b	50-150	10 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	89	70-130

Date of Report: 05/11/18
Date Received: 04/23/18
Project: Brookdale 74001, F&BI 804386

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804386-21 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	85	86	50-150	1

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	103	70-130

Date of Report: 05/11/18
Date Received: 04/23/18
Project: Brookdale 74001, F&BI 804386

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804371-08 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	93	89	50-150	4

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	96	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804386

SAMPLE CHAIN OF CUSTODY

ME 04/23/18

B04

Page # 1 of 4

Report To: Beau Johnson

Company: EPI

Address: Issaquah, WA 98027

City, State, ZIP: 1180 NW Maple St, Ste 310

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME: Brookdale

PO #: 74001

REMARKS: * Dieldrin Only per BJ 4/23/18 ME

INVOICE TO: EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee11-N:0.5	01	4/20/18	0803	soil	1								X				* Archive all
Tee11-N:1.0	02	↓	0808	↓	1								X				samples not
Tee11-N:1.5	03		0822		1												marked for immediate analysis.
Tee11-N:2.0	04		~~0859~~ 0827		1												◆ - per BJ
~~[illegible]~~ Tee11-A:0.5	05		0831		1								X				4/27/18 ME
Tee11-A:1.0	06		0844		1								X				
Tee11-A:1.5	07		0859		1								◆				
Tee11-A:2.0	08		0907		1												
Tee11-NE:0.5	09		0915		1								X				
Tee11-NE:1.0	10	↓	0918	↓	1								X				

Samples received at 4 °C

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4/23/18	11:10
Received by:	Roke	Roke	Fedex (SDC)	23APR18	1110
Relinquished by: Rec.	[signature]	~~Elizabeth~~ Elizabeth Webber-~~Bruya~~	F&BI	4/23/18	1220
Received by:					

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

804386

SAMPLE CHAIN OF CUSTODY

ME 04/23/18

B04

Page # 2 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St. Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74601
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 11-NE: 1.5	11	4/20/18	0921	soil	1												* Archive all samples not marked for immediate analysis.
Tee 11-NE: 2.0	12	↓	0926	↓	1												
Tee 11-B: 0.5	13		0933		1								X				
Tee 11-B: 1.0	14		0935		1								X				
Tee 11-B: 1.5	15		1001		1												
Tee 11-B: 2.0	16		1011		1								◆				
Tee 11-SE: 0.5	17		1017		1								X				
Tee 11-SE: 1.0	18		1021		1								X				
Tee 11-SE: 1.5	19		1030		1												
Tee 11-SE: 2.0	20	↓	1035	↓	1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4/23/18	11:10
Received by:	Roke	Roke	Fedex (SDC)	23APR18	1110
~~Relinquished by:~~ Rec.	[signature]	Elizabeth Webber-Bruya	F?BI	4/23/18	1220
Received by:					

804386

SAMPLE CHAIN OF CUSTODY ME 04/23/18

B04

Page # 3 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee11-SW:0.5	21	4/20/18	1152	soil	1								X				*Archive all samples not marked for immediate analysis.
Tee11-SW:1.0	22	↓	1158	↓	1								X				
Tee11-SW:1.5	23		1212		1												
Tee11-SW:2.0	24		1221		1												
Tee11-NW:0.5	25		1044		1								X				
Tee11-NW:1.0	26		1054		1								X				
Tee11-~~NW~~ NW:1.5	27		1111		1												
Tee11-NW:2.0	28		1129		1												
Tee11-S:0.5	29		1320		1								X				
Tee11-S:1.0	30	↓	1341	↓	1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4/23/18	11:10
Received by:	Roke	Roke	Fedex (SDC)	4/23/18	11:10
~~Relinquished by:~~ Rec:	[signature]	Elizabeth Webber-Bruya	F?BI	4/23/18	12:20
Received by:					

804386

SAMPLE CHAIN OF CUSTODY

ME 04/23/18 B04 4

Page # 4 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0610 Email beauj@epi-wa.com

SAMPLERS (signature)	
Betsy Wong	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee11-D: 0.5	31	4/20/18	1416	Soil	1								X				Archive all samples not marked for immediate analysis.
Tee11-D: 1.0	32	4/20/18	1425	Soil	1								X				

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau Johnson	EPI	4-23-18	1110
Received by:	[signature]	Roke	Fedex (SDC)	23APR18	1110
Relinquished by: Received:	[signature]	Elizabeth Webber-Bruya	F&BI	4/23/18	1220
Received by:					

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 11, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: 74001, F&BI 804406

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 24, 2018 from the 74001, F&BI 804406 project. There are 37 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0511R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on April 24, 2018 by Friedman & Bruya, Inc. from the Environmental Partners 74001, F&BI 804406 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804406-01	TEE11-C:0.5
804406-02	TEE11-C:1.0
804406-03	TEE11-C:1.5
804406-04	TEE11-C:2.0
804406-05	TEE15-A:0.5
804406-06	TEE15-A:1.0
804406-07	TEE15-A:1.5
804406-08	TEE15-A:2.0
804406-09	TEE15-W:0.5
804406-10	TEE15-W:1.0
804406-11	TEE15-W:1.5
804406-12	TEE15-W:2.0
804406-13	TEE15-E:0.5
804406-14	TEE15-E:1.0
804406-15	TEE15-E:1.5
804406-16	TEE15-E:2.0
804406-17	TEE15-N:0.5
804406-18	TEE15-N:1.0
804406-19	TEE15-N:1.5
804406-20	TEE15-N:2.0
804406-21	TEE16-SE:0.5
804406-22	TEE16-SE:1.0
804406-23	TEE16-SE:1.5
804406-24	TEE16-SE:2.0
804406-25	TEE16-D:0.5
804406-26	TEE16-D:1.0
804406-27	TEE16-D:1.5
804406-28	TEE16-D:2.0
804406-29	TEE16-SW:0.5
804406-30	TEE16-SW:1.0
804406-31	TEE16-SW:1.5
804406-32	TEE16-SW:2.0
804406-33	TEE16-D-N:0.5
804406-34	TEE16-D-N:1.0
804406-35	TEE16-D-N:1.5

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
804406-36	TEE16-D-N:2.0
804406-37	TEE16-C:0.5
804406-38	TEE16-C:1.0
804406-39	TEE16-C:1.5
804406-40	TEE16-C:2.0
804406-41	TEE16-B-W:0.5
804406-42	TEE16-B-W:1.0
804406-43	TEE16-B-W:1.5
804406-44	TEE16-B-W:2.0
804406-45	TEE16-B-E:0.5
804406-46	TEE16-B-E:1.0
804406-47	TEE16-B-E:1.5
804406-48	TEE16-B-E:2.0
804406-49	TEE16-A:0.5
804406-50	TEE16-A:1.0
804406-51	TEE16-A:1.5
804406-52	TEE16-A:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE11-C:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-01 1/60
Date Analyzed:	05/01/18	Data File:	050107A.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	96 d	50	150
DBC	98 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.3

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE11-C:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-02 1/6
Date Analyzed:	04/27/18	Data File:	042725.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	20	121
DBC	102	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.71

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE11-C:2.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	05/02/18	Lab ID:	804406-04 1/6
Date Analyzed:	05/07/18	Data File:	050714.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	65	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-A:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-05 1/6
Date Analyzed:	04/27/18	Data File:	042726.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	93	20	121
DBC	107	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-A:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-06 1/6
Date Analyzed:	04/27/18	Data File:	042727.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	20	121
DBC	111	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-W:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-09 1/6
Date Analyzed:	04/27/18	Data File:	042728.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91	20	121
DBC	105	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.083

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-W:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-10 1/6
Date Analyzed:	04/27/18	Data File:	042729.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	20	121
DBC	97	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.016

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-E:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-13 1/6
Date Analyzed:	04/27/18	Data File:	042730.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	20	121
DBC	98	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.017

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-E:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-14 1/6
Date Analyzed:	04/27/18	Data File:	042731.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	93	20	121
DBC	110	18	174

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.12

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-E:2.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	05/02/18	Lab ID:	804406-16 1/6
Date Analyzed:	05/07/18	Data File:	050715.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.022

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-N:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-17 1/6
Date Analyzed:	04/26/18	Data File:	042639.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE15-N:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-18 1/6
Date Analyzed:	04/26/18	Data File:	042640.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-SE:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-21 1/6
Date Analyzed:	04/26/18	Data File:	042641.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-SE:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-22 1/6
Date Analyzed:	04/26/18	Data File:	042541.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-D:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-25 1/6
Date Analyzed:	04/26/18	Data File:	042542.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-D:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-26 1/6
Date Analyzed:	04/26/18	Data File:	042543.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-SW:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-29 1/6
Date Analyzed:	04/26/18	Data File:	042544.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-SW:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-30 1/6
Date Analyzed:	04/26/18	Data File:	042642.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	76	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-D-N:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-33 1/6
Date Analyzed:	04/26/18	Data File:	042643.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.061

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-D-N:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-34 1/6
Date Analyzed:	04/26/18	Data File:	042644.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.028

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-C:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-37 1/6
Date Analyzed:	04/26/18	Data File:	042645.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-C:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-38 1/6
Date Analyzed:	04/26/18	Data File:	042646.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	77	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-B-W:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-41 1/6
Date Analyzed:	04/26/18	Data File:	042647.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-B-W:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-42 1/6
Date Analyzed:	04/26/18	Data File:	042648.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-B-E:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-45 1/6
Date Analyzed:	04/26/18	Data File:	042649.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-B-E:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-46 1/6
Date Analyzed:	04/26/18	Data File:	042652.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-A:0.5	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-49 1/6
Date Analyzed:	04/26/18	Data File:	042653.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	68	50	150
DBC	75	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE16-A:1.0	Client:	Environmental Partners
Date Received:	04/24/18	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	804406-50 1/6
Date Analyzed:	04/26/18	Data File:	042654.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	77	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804406
Date Extracted:	04/25/18	Lab ID:	08-890 mb 1/6
Date Analyzed:	04/25/18	Data File:	042534.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804406
Date Extracted:	04/24/18	Lab ID:	08-882 mb2 1/6
Date Analyzed:	04/26/18	Data File:	042638.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804406
Date Extracted:	05/02/18	Lab ID:	08-960 mb2 1/6
Date Analyzed:	05/06/18	Data File:	050620.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/11/18
Date Received: 04/24/18
Project: 74001, F&BI 804406

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804386-21 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	85	86	50-150	1

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	103	70-130

Date of Report: 05/11/18
Date Received: 04/24/18
Project: 74001, F&BI 804406

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804406-22 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	<0.01	80	50-150

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	96	70-130

Date of Report: 05/11/18
Date Received: 04/24/18
Project: 74001, F&BI 804406

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804509-36 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	82	82	50-150	0

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	101	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804406

SAMPLE CHAIN OF CUSTODY

ME 04-24-18

Page # 1 of 1 B03 B

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)	Betsy Wing
PROJECT NAME	Brookdale
PO #	74001
REMARKS	*Dieldrin only per BJ ML 4/24/18
INVOICE TO	EPI

TURNAROUND TIME

- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL

- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

						ANALYSES REQUESTED											
Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee11-C:0.5	01	4/23/18	0814	Soil	1								X				* Archive all
Tee11-C:1.0	02	↓	0820	↓	1								X				samples not marked for
Tee11-C:1.5	03		0823		1												immediate analysis.
Tee11-C:2.0	04		0826		1								♦				
Tee15-A:0.5	05		0847		1								X				♦ - per BJ
Tee15-A:1.0	06		0848		1								X				5/2/18
Tee15-A:1.5	07		0850		1												MG
Tee15-A:2.0	08		0856		1												
Tee15-W:0.5	09		0904		1								X				
Tee15-W:1.0	10	↓	0909	↓	1								X				

Samples received at 4 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/24/18	1032AM
Received by: [signature]	Jorel Underdown	Fedex	4/24	1032AM
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/24/18	1200

804406

SAMPLE CHAIN OF CUSTODY

ME 04-24-18

Page # 2 303 of 6

~~Report To~~ Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	**INVOICE TO**
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee15-W:1.5	-11	4/23/16	0931	soil	1												*Archive all
Tee15-W:2.0	12	↓	0936	↓	1												samples not
Tee15-E:0.5	13		0945		1								X				marked for immediate
Tee15-E:1.0	14		0947		1								X				analysis.
Tee15-E:1.5	15		0950		1												
Tee15-E:2.0	16		0955		1								◆				
Tee15-N:0.5	17		0959		1								X				
Tee15-N:1.0	18		1003		1								X				
Tee15-N:1.5	19		1007		1												
Tee15-N:2.0	20	↓	1015	↓	1												

Samples received at 4 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/24/18	10:32AM
Received by: [signature]	Janel Ulderdam	Fedex	4/24	10:32AM
Relinquished by:				
Received by: [signature]	Nhan Phan	F&BI	4/24/18	1200

804408

SAMPLE CHAIN OF CUSTODY

ME 04-24-18

Page # 3 of 6 (803)

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (*signature*) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH

Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee16-SE:0.5	21	4/23/18	1035	Soil	1								X				*Archive all samples not marked for immediate analysis.
Tee16-SE:1.0	22	↓	1038	↓	1								X				
Tee16-SE:1.5	23		1047		1												
Tee16-SE:2.0	24		1051		1												
Tee16-D:0.5	25		1058		1								X				
Tee16-D:1.0	26		1106		1								X				
Tee16-D:1.5	27		1136		1												
Tee16-D:2.0	28		1145		1												
Tee16-SW:0.5	29		1247		1								X				
Tee16-SW:1.0	30	↓	1251	↓	1								X				

Samples received at ____ °C

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/24/18	10:32AM
Received by: [signature]	Jorel Underdown	Fedex	4/24	10:32A
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/24/18	1200

804406

SAMPLE CHAIN OF CUSTODY

ME 04-24-18 — Page # 4 of 6 (B03)

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature)	
Betsy Wing	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☒ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee16-SW:1.5	31	4/23/18	~~1325~~ 1257	Soil	1												*Archive all samples not marked for immediate analysis.
Tee16-SW:2.0	32	↓	~~1406~~ 1309	↓	1												
Tee16-D-N:0.5	33		1316		1								X				
Tee16-D-N:1.0	34		1325		1								X				
Tee16-D-N:1.5	35		1338		1												
Tee16-D-N:2.0	36		1346		1												
Tee16-C:0.5	37		1351		1								X				
Tee16-C:1.0	38		1357		1								X				
Tee16-C:1.5	39		1406		1												
Tee16-C:2.0	40	↓	1409	↓	1												Samples received at ___

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/24/18	10:32 AM
Received by: [signature]	Jokel Underdal	Fedex	4/24	10:32 AM
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/24/18	1200

804406

SAMPLE CHAIN OF CUSTODY

ME 04-24-18

Page # 5 of 6

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epiwa.com

SAMPLERS (signature)	
Betsy Wing	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee16-B-W:0.5	41	4/23/18	1417	Soil									X				Archive all samples not marked for immediate analysis.
Tee16-B-W:1.0	42		1418										X				
Tee16-B-W:1.5	43		1430														
Tee16-B-W:2.0	44		1432														
Tee16-B-E:0.5	45		1436										X				
Tee16-B-E:1.0	46		1438										X				
Tee16-B-E:1.5	47		1500														
Tee16-B-E:2.0	48		1505														
Tee16-A:0.5	49		1512										X				
Tee16-A:1.0	50	↓	1524	↓									X				Samples received at ___

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/24/18	10:32AM
Received by: [signature]	Joel Middleton	Fedex	4/24	10:32Am
Relinquished by:				
Received by: [signature]	Nhan Phan	FeBI	4/24/18	1200

804406

SAMPLE CHAIN OF CUSTODY

ME 04-24-18

Page # 6 [803] of 6

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425)395-0010 Email: beauj@epiwa.com

SAMPLERS (signature)	
Betsy Wing	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee16-A:1.5	51	4/23/18	1538	soil	1												* Archive all samples not marked for immediate analysis.
Tee16-A:2.0	52	4/23/18	1545	soil	1												

Samples received at ____ °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/24/18	10:32am
Received by:	Sorel Underdown	Fedex	4/24	10:32AM
Relinquished by:				
Received by:	Nhan Phan	FeBI	4/24/18	1200

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 21, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: 74001, F&BI 804450

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 26, 2018 from the 74001, F&BI 804450 project. There are 31 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0521R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 26, 2018 by Friedman & Bruya, Inc. from the Environmental Partners 74001, F&BI 804450 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804450-01	Tee16-NE:0.5
804450-02	Tee16-NE:1.0
804450-03	Tee16-NE:1.5
804450-04	Tee16-NE:2.0
804450-05	Tee17-N:0.5
804450-06	Tee17-N:1.0
804450-07	Tee17-N:1.5
804450-08	Tee17-N:2.0
804450-09	Tee17-NW:0.5
804450-10	Tee17-NW:1.0
804450-11	Tee17-NW:1.5
804450-12	Tee17-NW:2.0
804450-13	Tee17-B:0.5
804450-14	Tee17-B:1.0
804450-15	Tee17-NE:0.5
804450-16	Tee17-NE:1.0
804450-17	Tee17-NE:1.5
804450-18	Tee17-NE:2.0
804450-19	Tee17-D:1.5
804450-20	Tee17-D2.0
804450-21	Tee17-SW:0.5
804450-22	Tee17-SW:1.5
804450-23	Tee17-C:0.5
804450-24	Tee17-C:2.0
804450-25	Tee17-C:2.5
804450-26	Tee17-SE:0.5
804450-27	Tee17-SE:1.0
804450-28	Tee17-SE:1.5
804450-29	Tee17-SE:2.0
804450-30	Tee17-S:0.5
804450-31	Tee17-S:1.0
804450-32	Tee17-S:1.5
804450-33	Tee17-S:2.0
804450-34	Tee17-D:0.5
804450-35	Tee17-D:1.0
804450-36	Tee17-SW:1.5
804450-37	Tee17-SW:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee16-NE:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-01 1/6
Date Analyzed:	04/30/18	Data File:	043042.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.011

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee16-NE:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-02 1/6
Date Analyzed:	05/01/18	Data File:	043045.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-N:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-05 1/6
Date Analyzed:	05/01/18	Data File:	043046.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-N:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-06 1/6
Date Analyzed:	05/01/18	Data File:	043047.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-NW:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-09 1/6
Date Analyzed:	05/01/18	Data File:	043048.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-NW:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-10 1/6
Date Analyzed:	05/01/18	Data File:	043049.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-B:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-13 1/6
Date Analyzed:	05/01/18	Data File:	043050.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	83	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-B:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-14 1/6
Date Analyzed:	05/01/18	Data File:	043051.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-NE:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-15 1/6
Date Analyzed:	05/01/18	Data File:	043052.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-NE:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-16 1/6
Date Analyzed:	05/01/18	Data File:	043053.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-D:1.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	05/08/18	Lab ID:	804450-19 1/6
Date Analyzed:	05/09/18	Data File:	050907.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.1

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-D2.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	05/14/18	Lab ID:	804450-20 1/6
Date Analyzed:	05/15/18	Data File:	051540.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.17

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-SW:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-21 1/60
Date Analyzed:	05/03/18	Data File:	050308.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	91 d	50	150
DBC	182 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	4.2

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-SW:1.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-22 1/6
Date Analyzed:	05/01/18	Data File:	050108.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.057

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-C:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-23 1/6
Date Analyzed:	05/01/18	Data File:	050109.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-C:2.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-24 1/6
Date Analyzed:	05/01/18	Data File:	050110.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-SE:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-26 1/6
Date Analyzed:	05/01/18	Data File:	050111.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-SE:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-27 1/6
Date Analyzed:	05/01/18	Data File:	050112.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-S:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-30 1/6
Date Analyzed:	05/01/18	Data File:	050113.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.51

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-S:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-31 1/6
Date Analyzed:	05/01/18	Data File:	050114.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.21

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-S:2.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	05/08/18	Lab ID:	804450-33 1/6
Date Analyzed:	05/09/18	Data File:	050908.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.033

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-D:0.5	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-34 1/60
Date Analyzed:	05/03/18	Data File:	050309.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	95 d	50	150
DBC	178 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	6.7

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee17-D:1.0	Client:	Environmental Partners
Date Received:	04/26/18	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	804450-35 1/6
Date Analyzed:	05/01/18	Data File:	050116.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804450
Date Extracted:	04/26/18	Lab ID:	08-919 mb 1/6
Date Analyzed:	04/30/18	Data File:	043041.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	90	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804450
Date Extracted:	05/08/18	Lab ID:	08-988 mb 1/6
Date Analyzed:	05/09/18	Data File:	050906.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	98	50	150
DBC	114	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 804450
Date Extracted:	05/14/18	Lab ID:	08-1046 mb 1/6
Date Analyzed:	05/15/18	Data File:	051517.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/21/18
Date Received: 04/26/18
Project: 74001, F&BI 804450

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805107-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	3.7	181 b	102 b	50-150	56 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	98	70-130

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Date of Report: 05/21/18
Date Received: 04/26/18
Project: 74001, F&BI 804450

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804450-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.011	78	87	50-150	11

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	102	70-130

Date of Report: 05/21/18
Date Received: 04/26/18
Project: 74001, F&BI 804450

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804450-20 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.13	89 b	108 b	50-150	19 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	100	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804450

SAMPLE CHAIN OF CUSTODY

ME 04/26/18

Page # 1 of ~~8~~ 4 ~~6~~ BOS

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Ste 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)	
Betsy Wing	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 16-NE: 0.5	01	4/25/18	0805	soil	1								X				*Archive all samples not marked for immediate analysis.
Tee 16-NE: 1.0	02	↓	0812	↓	1								X				
Tee 16-NE: 1.5	03	↓	0819	↓	1												
Tee 16-NE: 2.0	04	↓	0841	↓	1												
Tee 17-N: 0.5	05	↓	0856	↓	1								X				
Tee 17-N: 1.0	06	↓	0904	↓	1								X				
Tee 17-N: 1.5	07	↓	0921	↓	1												
Tee 17-N: 2.0	08	↓	0936	↓	1												
Tee 17-NW: 0.5	09	↓	0941	↓	1								X				
Tee 17-NW: 1.0	10	↓	0944	↓	1								X				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/26/18	0630
Received by: [signature]	Michael Erdahl	F&Bry	↓	↓
Relinquished by:				
Received by:		Samples received at 4 °C		

804450

SAMPLE CHAIN OF CUSTODY

ME 04/26/18

Page # 2 805 of 84 ews

Report To: Bean Johnson

Company: EPI

Address: 1180 NW Maple St, Ste 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME: Brookdale

PO #: 74001

REMARKS:

INVOICE TO: EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes (⊗ - per BW 4/25/18 ME)
Tee17-NW:1.5	11	4/25/18	0958	Soil	1												Archive all samples not scheduled for immediate analysis.
Tee17-NW:2.0	12	↓	1005	↓	1												
Tee17-B:0.5	13		1014		1								⊗				
Tee17-B:1.0	14		1100		1								⊗				
~~Tee17-B:1.5~~					1												
~~Tee17-B:2.0~~					1												
Tee17-NE:0.5	15		1112		1								⊗				
Tee17-NE:1.0	16		1130		1								⊗				
Tee17-NE:1.5	17		1142		1												
Tee17-NE:2.0	18	↓	1146	↓	1												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/26/18	0630
Received by: [signature]	Michael Erdahl	F&BI	4/26/18	↓
Relinquished by:				
Received by:		Samples received at 4 °C		

804450

SAMPLE CHAIN OF CUSTODY

ME 04/26/18

Page # 3 of 3 4 EWB

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Ste 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME: Brookdale

PO #: 74001

REMARKS:

INVOICE TO: EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee17-D:1.5	19	4/25/18	1347	soil	1								◆				* Archive all samples not marked for immediate analysis.
Tee17-D:2.0	20	↓	1352	↓	1								⊕				
Tee17-SW:0.5	21		1400		1								⊗				
Tee17-SW:1.0	22		1404		1								⊗				⊕ per BJ
Tee17-C:0.5	23		1418		1								⊗				5/10/18 ME
Tee17-C:2.0	24		1520		1								⊗				
Tee17-C:2.5	25		1545		1												
Tee17-SE:0.5	26		1240		1								⊗				* Added at
Tee17-SE:1.0	27		1243		1								⊗				Lab EWB
Tee17-SE:1.5	28	↓	1250	↓	1												

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI	4/26/18	0636
Received by: [signature]	Michael Erdahl	F&Bn	4/26/18	6
Relinquished by:				
Received by:		Samples received at 4 °C		

804450

SAMPLE CHAIN OF CUSTODY

ME 04-26-18

Page # 4 of 4

Report To: Beau Johnson

Company: EPI

Address: 118 NW Maple St

City, State, ZIP: Issaquah

Phone: ______ Email: ______

SAMPLERS (signature):

PROJECT NAME	PO #

REMARKS	INVOICE TO
* COC Generated in Lab	

TURNAROUND TIME
- ☐ Standard Turnaround
- ☐ RUSH ______

Rush charges authorized by: ______

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other ______

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	ANALYSES REQUESTED: TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 17-SE:2.0	29	04/25/18	1253	Soil	1												⊗ Per BW 4/25/18 EWB
Tee 17-S:0.5	30	|	1302	|	1								⊗				
Tee 17-S:1.0	31	|	1310	|	1								⊗				
Tee 17-S:1.5	32	|	1321	|	1												
Tee 17-S:2.0	33	|	1326	|	1								◆				◆ per BJ 5/3/18 ME
Tee 17-D:0.5	34	|	1336	|	1								⊗				
Tee 17-D:1.0	35	|	1339	|	1								⊗				
Tee 17-SW:1.5	36	|	1406	|	1												
Tee 17-SW:2.0	37	//	1410	|	1												

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:					
Received by:	[signature]	Elizabeth Webber-Bruya	F&BI	4/26/18	810
Relinquished by:					
Received by:					

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 16, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 804509

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 27, 2018 from the Brookdale 74001, F&BI 804509 project. There are 39 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0516R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 27, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 804509 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804509-01	Tee18-S:0.5
804509-02	Tee18-S:1.0
804509-03	Tee18-S:1.5
804509-04	Tee18-S:2.0
804509-05	Tee18-A:0.5
804509-06	Tee18-A:1.0
804509-07	Tee18-A:1.5
804509-08	Tee18-A:2.0
804509-09	Tee18-E:0.5
804509-10	Tee18-E:1.0
804509-11	Tee18-E:1.5
804509-12	Tee18-E:2.0
804509-13	Tee18-NW:0.5
804509-14	Tee18-NW:1.0
804509-15	Tee18-NW:1.5
804509-16	Tee18-NW:2.0
804509-17	Tee1-C:2.0
804509-18	Tee1-C:2.5
804509-19	Tee1-NE:0.5
804509-20	Tee1-NE:1.0
804509-21	Tee1-NE:1.5
804509-22	Tee1-NE:2.0
804509-23	Tee1-B:0.5
804509-24	Tee1-B:1.0
804509-25	Tee1-B:1.5
804509-26	Tee1-B:2.0
804509-27	Tee1-A:0.5
804509-28	Tee1-A:1.0
804509-29	Tee1-A:1.5
804509-30	Tee1-A:2.0
804509-31	Tee1-SW:0.5
804509-32	Tee1-SW:1.0
804509-33	Tee1-SW:1.5
804509-34	Tee1-SW:2.0
804509-35	Tee1-S:0.5

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
804509-36	Tee1-S:1.0
804509-37	Tee1-S:1.5
804509-38	Green5:2.0
804509-39	Green5:2.5
804509-40	Tee1-S:2.0
804509-41	Green5-S:0.5
804509-42	Green5-S:1.0
804509-43	Green5-S:1.5
804509-44	Green5-S:2.0
804509-45	Green5-NW:0.5
804509-46	Green5-NW:1.0
804509-47	Green5-NW:1.5
804509-48	Green5-NW:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-S:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-01 1/6
Date Analyzed:	05/02/18	Data File:	050228.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.47

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-S:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-02 1/6
Date Analyzed:	05/02/18	Data File:	050229.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.31

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-S:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	804509-04 1/6
Date Analyzed:	05/09/18	Data File:	050955.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-A:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-05 1/60
Date Analyzed:	05/03/18	Data File:	050314.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86 d	50	150
DBC	178 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.8

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-A:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-06 1/6
Date Analyzed:	05/02/18	Data File:	050231.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.33

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-A:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	804509-08 1/6
Date Analyzed:	05/10/18	Data File:	050958.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.34

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-E:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-09 1/6
Date Analyzed:	05/02/18	Data File:	050232.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.46

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-E:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-10 1/6
Date Analyzed:	05/02/18	Data File:	050233.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.054

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-NW:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-13 1/6
Date Analyzed:	05/02/18	Data File:	050234.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee18-NW:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-14 1/6
Date Analyzed:	05/02/18	Data File:	050235.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-C:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-17 1/6
Date Analyzed:	05/02/18	Data File:	050236.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-NE:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-19 1/6
Date Analyzed:	05/02/18	Data File:	050237.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.15

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-NE:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-20 1/6
Date Analyzed:	05/02/18	Data File:	050238.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.044

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-B:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-23 1/6
Date Analyzed:	05/02/18	Data File:	050239.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.037

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-B:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-24 1/6
Date Analyzed:	05/02/18	Data File:	050240.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-A:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-27 1/6
Date Analyzed:	05/02/18	Data File:	050241.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-A:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-28 1/6
Date Analyzed:	05/02/18	Data File:	050242.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-SW:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-31 1/6
Date Analyzed:	05/03/18	Data File:	050311.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	65	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.14

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-SW:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-32 1/6
Date Analyzed:	05/03/18	Data File:	050312.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.51

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-SW:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	804509-34 1/6
Date Analyzed:	05/10/18	Data File:	050959.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.15

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-S:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-35 1/6
Date Analyzed:	05/03/18	Data File:	050313.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	62	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee1-S:1.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-36 1/6
Date Analyzed:	05/02/18	Data File:	050213.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-38 1/6
Date Analyzed:	05/02/18	Data File:	050215.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.093

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5:2.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	804509-39 1/6
Date Analyzed:	05/10/18	Data File:	050960.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	121	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.70

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5-S:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-41 1/6
Date Analyzed:	05/02/18	Data File:	050216.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.16

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5-S:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-42 1/6
Date Analyzed:	05/02/18	Data File:	050217.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5-S:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	804509-44 1/6
Date Analyzed:	05/10/18	Data File:	050961.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.092

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5-NW:0.5	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-45 1/60
Date Analyzed:	05/03/18	Data File:	050315.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84 d	50	150
DBC	181 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	7.2

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5-NW:1.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	804509-46 1/6
Date Analyzed:	05/02/18	Data File:	050227.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green5-NW:2.0	Client:	Environmental Partners
Date Received:	04/27/18	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	804509-48 1/6
Date Analyzed:	05/10/18	Data File:	050962.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.028

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	04/30/18	Lab ID:	08-952 mb2 1/6
Date Analyzed:	05/02/18	Data File:	050226.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/09/18	Lab ID:	08-1028 mb 1/6
Date Analyzed:	05/09/18	Data File:	050954.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804509
Date Extracted:	05/01/18	Lab ID:	08-960 mb 1/6
Date Analyzed:	05/02/18	Data File:	050225.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/16/18
Date Received: 04/27/18
Project: Brookdale 74001, F&BI 804509

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804509-36 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	82	82	50-150	0

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	101	70-130

Date of Report: 05/16/18
Date Received: 04/27/18
Project: Brookdale 74001, F&BI 804509

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804525-39 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.22	144 b	107 b	50-150	29 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	100	70-130

Date of Report: 05/16/18
Date Received: 04/27/18
Project: Brookdale 74001, F&BI 804509

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804509-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	85	89	50-150	5

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	90	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804509

SAMPLE CHAIN OF CUSTODY

ME 04-27-18

Page # 1 of 5 COS

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
*Dieldrin Only per BJ EWB	EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes ◆-per BJ 5/7/18 ME
Tee 18-S: 0.5	01	4/26/18	0814	Soil	1								X				*Archive all samples not marked for immediate analysis.
Tee 18-S: 1.0	02	↓	0821	↓	1								X				
Tee 18-S: 1.5	03		0835		1												
Tee 18-S: 2.0	04		0838		1								◆				
Tee 18-A: 0.5	05		0844		1								X				
Tee 18-A: 1.0	06		0847		1								X				
Tee 18-A: 1.5	07		0849		1												
Tee 18-A: 2.0	08		0857		1								◆				
Tee 18-E: 0.5	09		0905		1								X				
Tee 18-E: 1.0	10	↓	0908	↓	1								X				Samples received at 4 °C

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI		
Received by: [signature]	Will Perkins	FedEx	04/27	1414
Relinquished by: [signature]	Misty Sgualbaldi	EPI	4/27	14:14
Received by: E.D. W-Bry	Elizabeth Webber-Bruya	F?BI	4/27/18	1600

804509

SAMPLE CHAIN OF CUSTODY

ME 04-27-18 [redacted] C05

Page # 2 of 5

Report [redacted] Beau Johnson

Company EPI

Address 1180 NW Maple St

City, State, ZIP Issaquah, WA 98027

Phone ______ Email ______

SAMPLERS (signature)	
PROJECT NAME: Brookdale	PO #: 74001
REMARKS: * COC page generated in Lab. EWB	INVOICE TO

TURNAROUND TIME
- ☐ Standard Turnaround
- ☐ RUSH ______
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other ______

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee 18-E:1.5	11	4/26/18	0911	Soil	1												
Tee 18-E:2.0	12		0914		1												
Tee 18-NW:0.5	13		0921		1								X				
Tee 18-NW:1.0	14		0924		1								X				
Tee 18-NW:1.5	15		0930		1												
Tee 18-NW:2.0	16		0932		1												
Tee 1~~8~~-C:2.0 (EWB)	17		1002		1								X				
Tee 1-C:2.5	18		1015		1												
Tee 1-NE:0.5	19		1026		1								X				
Tee 1-NE:1.0	20		1029		1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:					
Received by:	[signature]	Elizabeth Webber-Bruys	F?BI	4/27/18	1600
Relinquished by:					
Received by:					

804509

SAMPLE CHAIN OF CUSTODY

ME 04-27-18 [redacted] Page # 3 of 5 COS

Re[redacted] To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)		
Betsy Wing		
PROJECT NAME	PO #	
Brookdale	74001	
REMARKS	INVOICE TO	
	EPI	

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee1-NE:1.5	21	4/26/18	1033	Soil	1												*Archive all samples not marked for immediate analysis.
Tee1-NE:2.0	22	↓	1040	↓	1												
Tee1-B:0.5	23		1043		1								X				
Tee1-B:1.0	24		1049		1								X				
Tee1-B:1.5	25		1059		1												
Tee1-B:2.0	26		1104		1												
Tee1-A:0.5	27		1120		1								X				
Tee1-A:1.0	28		1124		1								X				
Tee1-A:1.5	29		1135		1												
Tee1-A:2.0	30	↓	1137	↓	1												

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI		
Received by: Will Perkins	Will Perkins	FedEx SDC	04/27	1414
Relinquished by: MS	Misty Sgualdini	EPI	4/27	14:14
Received by: E. Webber-Bruya	Elizabeth Webber-Bruya	F?BI	4/27	1600

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

804509

SAMPLE CHAIN OF CUSTODY

ME 04-27-18 COS

Page # 4 of 5

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St, Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425)395-0010 Email: beauj@epiwa.com

SAMPLERS (signature): Betsy Wing

PROJECT NAME: Brookdale

PO #: 74001

REMARKS:

INVOICE TO: EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Tee1-SW:0.5	31	4/26/18	1224	Soil	1								X				*Archive all samples not marked for immediate analysis
Tee1-SW:1.0	32	↓	1227	↓	1								X				
Tee1-SW:1.5	33		1229		1												
Tee1-SW:2.0	34		1232		1								◆				
Tee1-S:0.5	35		1244		1								X				
Tee1-S:1.0	36		1252		1								X				
Tee1-S:1.5	37		1258		1												
Green5:2.0	38		1333		1								X				
Green5:2.5	39		1415		1								◆				
~~Green 5~~ Tee1-S:2.0	40	↓	1300	↓	1												

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	Betsy Wing	Betsy Wing	EPI		
Received by:	[signature]	Will Perkins	FedEx	04/27	1414
Relinquished by:	[signature]	Misty Squillacci	EPI	4/27	14:14
Received by:	[signature]	Elizabeth Webber-Bruya	F&BI	4/27	1600

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

804509

SAMPLE CHAIN OF COUSTODY

ME 04-27-18 [redacted] 5 COS of 5

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Ste 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-1010 Email beau@epiwa.com

SAMPLERS (signature) Betsy Wing	
PROJECT NAME Brookdale	PO # 74001
REMARKS	INVOICE TO EPI

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☒ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Green 5-S:0.5	41	4/26/18	1424										X				* Archive all samples not marked for immediate analysis.
Green 5-S:1.0	42		1430										X				
Green 5-S:1.5	43		1445														
Green 5-S:2.0	44		1452										◆				
Green 5-NW:0.5	45		1458										X				
Green 5-NW:1.0	46		1502										X				
Green 5-NW:1.5	47		1507														
Green 5-NW:2.0	48		1510										◆				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: Betsy Wing	Betsy Wing	EPI		
Received by: Will P.	Will Perkins	FedEx SDC	04/27	1414
Relinquished by:	Misty Sguilbeit	EPI	4/27	14:14
Received by: E.D. W-B	Elizabeth Webber-Bruya	F&BI	4/27/18	1600

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 16, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 804525

Dear Mr Johnson:

Included are the results from the testing of material submitted on April 30, 2018 from the Brookdale 74001, F&BI 804525 project. There are 32 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0516R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on April 30, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 804525 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
804525-01	Tee12-SW:0.5
804525-02	Tee12-SW:1.0
804525-03	Tee12-SW:1.5
804525-04	Tee12-SW:2.0
804525-05	Tee12-SE:0.5
804525-06	Tee12-SE:1.0
804525-07	Tee12-SE:1.5
804525-08	Tee12-SE:2.0
804525-09	Tee12-E:0.5
804525-10	Tee12-E:1.0
804525-11	Tee12-E:1.5
804525-12	Tee12-E:2.0
804525-13	Tee12-D:0.5
804525-14	Tee12-D:1.0
804525-15	Tee12-D:1.5
804525-16	Tee12-D:2.0
804525-17	Tee12-NE:0.5
804525-18	Tee12-NE:1.0
804525-19	Tee12-NE:1.5
804525-20	Tee12-NE:2.0
804525-21	Tee12-W-0.5
804525-22	Tee12-W-1.0
804525-23	Tee12-W-1.5
804525-24	Tee12-W-2.0
804525-25	Tee12-N-0.5
804525-26	Tee12-N-1.0
804525-27	Tee12-N-1.5
804525-28	Tee12-N-2.0
804525-29	Tee12-B-0.5
804525-30	Tee12-B-1.0
804525-31	Tee12-B-1.5
804525-32	Tee12-B-2.0
804525-33	Tee12-C:2.0
804525-34	Tee-13-SE:0.5
804525-35	Tee-13-SE:1.0
804525-36	Tee-13-SE:1.5
804525-37	Tee-13-SE:2.0
804525-38	Tee-13-B:0.5
804525-39	Tee-13-B:1.0
804525-40	Tee-13-B:1.5
804525-41	Tee-13-B:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-SW:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-01 1/6
Date Analyzed:	05/03/18	Data File:	050355.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-SW:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-02 1/6
Date Analyzed:	05/04/18	Data File:	050356.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-SE:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-05 1/6
Date Analyzed:	05/04/18	Data File:	050357.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.46

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-SE:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-06 1/6
Date Analyzed:	05/04/18	Data File:	050358.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.0

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ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-SE:2.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	05/08/18	Lab ID:	804525-08 1/6
Date Analyzed:	05/11/18	Data File:	051115.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-E:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-09 1/60
Date Analyzed:	05/07/18	Data File:	050710.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84 d	50	150
DBC	91 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.9

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-E:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-10 1/6
Date Analyzed:	05/04/18	Data File:	050360.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.41

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-E:2.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	05/08/18	Lab ID:	804525-12 1/6
Date Analyzed:	05/11/18	Data File:	051116.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.047

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-D:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-13 1/6
Date Analyzed:	05/04/18	Data File:	050361.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-D:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-14 1/6
Date Analyzed:	05/04/18	Data File:	050362.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-NE:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-17 1/6
Date Analyzed:	05/04/18	Data File:	050363.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-NE:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-18 1/6
Date Analyzed:	05/04/18	Data File:	050364.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-W-0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-21 1/6
Date Analyzed:	05/06/18	Data File:	050621.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	67	50	150
DBC	84	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-W-1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-22 1/6
Date Analyzed:	05/06/18	Data File:	050622.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-N-0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-25 1/6
Date Analyzed:	05/06/18	Data File:	050623.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-N-1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-26 1/6
Date Analyzed:	05/06/18	Data File:	050624.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-B-0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-29 1/6
Date Analyzed:	05/06/18	Data File:	050625.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-B-1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-30 1/6
Date Analyzed:	05/06/18	Data File:	050626.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	105	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee12-C:2.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-33 1/6
Date Analyzed:	05/06/18	Data File:	050627.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee-13-SE:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-34 1/6
Date Analyzed:	05/06/18	Data File:	050628.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	66	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.22

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee-13-SE:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-35 1/6
Date Analyzed:	05/06/18	Data File:	050629.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.024

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee-13-B:0.5	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-38 1/60
Date Analyzed:	05/07/18	Data File:	050723.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76 d	50	150
DBC	95 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	4.2

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee-13-B:1.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	804525-39 1/6
Date Analyzed:	05/02/18	Data File:	050214.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.22

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee-13-B:2.0	Client:	Environmental Partners
Date Received:	04/30/18	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	05/08/18	Lab ID:	804525-41 1/6
Date Analyzed:	05/11/18	Data File:	051117.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.067

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	08-952 mb 1/6
Date Analyzed:	05/02/18	Data File:	050212.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	04/30/18	Lab ID:	08-951 mb 1/6
Date Analyzed:	05/03/18	Data File:	050332.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 804525
Date Extracted:	05/08/18	Lab ID:	08-1025 mb 1/6
Date Analyzed:	05/11/18	Data File:	051125.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/16/18
Date Received: 04/30/18
Project: Brookdale 74001, F&BI 804525

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804525-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	93	90	50-150	3

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	101	70-130

Date of Report: 05/16/18
Date Received: 04/30/18
Project: Brookdale 74001, F&BI 804525

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804525-39 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.22	144 b	107 b	50-150	29 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	100	70-130

Date of Report: 05/16/18
Date Received: 04/30/18
Project: Brookdale 74001, F&BI 804525

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 705114-11 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	4.9	0 b	0 b	50-150	nm

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	88	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

804525

SAMPLE CHAIN OF CUSTODY ME 04/30/18

COS

Page # 1 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Ste 310

City, State, ZIP Issaquah, WA 98027

Phone (425)395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [X] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [X] Archive Samples
- [ ] Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
TEE12-SW:0.5	soil 01	4/27/18	8:21	soil	1								X				*Archive all samples not marked for immediate analysis
TEE12-SW:1.0	02	↓	8:24	↓	1								X				
TEE12-SW:1.5	03		8:30		1								X (scribbled out)				
TEE12-SW:2.0	04		8:33		1								X (scribbled out)				
TEE12-SE:0.5	05		8:44		1								X				[redacted] -per BS 5/7/18 ME
TEE12-SE:1.0	06		8:49		1								X				
TEE12-SE:1.5	07		8:55		1								X (scribbled out)				
TEE12-SE:2.0	08		9:05		1								[redacted]				
TEE12-E:0.5	09		9:15		1								X				
TEE12-E:1.0	10 ↓	↓	9:18	↓	1								X				Samples received at 4 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. Winspergen	EPI	4/30/18	0623
Received by: [signature]	Michael Erdahl	FcBm	↓	↓
Relinquished by:				
Received by:		Samples received at ____ °C		

804525

SAMPLE CHAIN OF CUSTODY ME 04/30/18

Page # 2 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Ste 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME	PO #
Brookdale	74001

REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [x] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [x] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
TEE12-E:1.5	soil 11	4/27/18	0922	soil	1								[illegible]				* Archive all samples not marked for immediate analysis.
TEE12-E:2.0	12	↓	0925	soil	~~2~~ 1								[redacted]				
TEE12-D:0.5	13		0936	↓	1								X				
TEE12-D:1.0	14		0938		1								X				
TEE12-D:1.5	15		0942		1												
TEE12-D:2.0	16		0944		1												
TEE12-E:0.5	17		1001		1								X				
TEE12-E:1.0	18		1004		1								X				
TEE12-E:1.5	19		1010		1												
TEE12-E:2.0	20 ↓	↓	1015	↓													

NE

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. Hinsperger	EPI	4/30/18	0623
Received by: [signature]	Michael Erdahl	FEB Inc	↓	↓
Relinquished by:				
Received by:		Samples received at 4 °C		

804525

SAMPLE CHAIN OF CUSTODY

ME 04/30/18

COS

Page # 3 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Ste 310

City, State, ZIP Issaquah, WA 98027

Phone (425)395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME Brookdale

PO # 74001

REMARKS

INVOICE TO EPI

TURNAROUND TIME
X Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
X Archive Samples
☐ Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
TEE12-W:0.5	804525-21	4/27/18	1027	soil	1								X				* Archive all samples not marked for immediate analysis.
TEE12-W:1.0	22	↓	1030	↓	1								X				
TEE12-W:1.5	23	↓	1035	↓	1												
TEE12-W:2.0	24	↓	1046	↓	1												
TEE12-N:0.5	25	↓	1106	↓	1								X				
TEE12-N:1.0	26	↓	1110	↓	1								X				
TEE12-N:1.5	27	↓	1116	↓	1												
TEE12-N:2.0	28	↓	1125	↓	1												
TEE12-B:0.5	29	↓	1235	↓	1								X				
TEE12-B:1.0	30	↓	1239	↓	1								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. HINSPERGER	EPI	4/30/18	0623
Received by: [signature]	Michael Erdahl	F&B Inc	↓	↓
Relinquished by:				
Received by:		Samples received at 4 °C		

804320

SAMPLE CHAIN OF CUSTODY

ME 04/30/18 C05

Page # 34 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Ste 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)	
PROJECT NAME: Brookdale	PO #: 74001
REMARKS	INVOICE TO: EPI

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☑ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
TEE12-B:1.5	501131	4/27/18	1242	Soil	1												*Archive all
TEE12-B:2.0	32	↓	1244	↓	1												samples not marked for
TEE13-C:2.0	33		1255		1								X				immediate
TEE13-SE:0.5	34		1322		1								X				analysis
TEE13-SE:1.0	35		1328		1								X				
TEE13-SE:1.5	36		1352		1												
TEE13-SE:2.0	37		1354		1												
TEE13-B:0.5	38		1404		1								X				
TEE13-B:1.0	39		1413		1								X				
TEE13-B:1.5	40		1433		1												
TEE13-B:2.0	41		1436														

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	[redacted]PANY	DATE	TIME
Relinquished by:	N. Winsperger	EPI	4/30/18	0623
Received by:	Michael Erdahl	F&BInc.	↓	↓
Relinquished by:				
Received by:				
		Samples received at 4 °C		

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 18, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 805024

Dear Mr Johnson:

Included are the results from the testing of material submitted on May 2, 2018 from the Brookdale 74001, F&BI 805024 project. There are 43 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0518R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on May 2, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 805024 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
805024 -01	Green 7-E:0.5
805024 -02	Green 7-E:1.0
805024 -03	Green 7-E:1.5
805024 -04	Green 7-E:2.0
805024 -05	Green 7-W:0.5
805024 -06	Green 7-W:1.0
805024 -07	Green 7-W:1.5
805024 -08	Green 7-W:2.0
805024 -09	Green 7-NW:0.5
805024 -10	Green 7-NW:1.0
805024 -11	Green 7-NW:1.5
805024 -12	Green 7-NW:2.0
805024 -13	Green 8:0.5
805024 -14	Green 8:1.0
805024 -15	Green 8:1.5
805024 -16	Green 8:2.0
805024 -17	Green 8-S:0.5
805024 -18	Green 8-S:1.0
805024 -19	Green 8-S:1.5
805024 -20	Green 8-S:2.0
805024 -21	Green 8-NE:0.5
805024 -22	Green 8-NE:1.0
805024 -23	Green 8-NE:1.5
805024 -24	Green 8-NE:2.0
805024 -25	Green 8-NW:0.5
805024 -26	Green 8-NW:1.0
805024 -27	Green 8-NW:1.5
805024 -28	Green 8-NW:2.0
805024 -29	Green 9:0.5
805024 -30	Green 9:1.0
805024 -31	Green 9:1.5
805024 -32	Green 9:2.0
805024 -33	Green 9-S:0.5
805024 -34	Green 9-S:1.0
805024 -35	Green 9-S:1.5

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
805024 -36	Green 9-S:2.0
805024 -37	Green 9-NE:0.5
805024 -38	Green 9-NE:1.0
805024 -39	Green 9-NE:1.5
805024 -40	Green 9-NE:2.0
805024 -41	Green 9-NW:0.5
805024 -42	Green 9-NW:1.0
805024 -43	Green 9-NW:1.5
805024 -44	Green 9-NW:2.0
805024 -45	Green 10-SE:0.5
805024 -46	Green 10-SE:1.0
805024 -47	Green 10-SE:1.5
805024 -48	Green 10-SE:2.0
805024 -49	Green 10-W:0.5
805024 -50	Green 10-W:1.0
805024 -51	Green 10-W:1.5
805024 -52	Green 10-W:2.0

All quality control requirements were acceptable.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-E:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-01 1/6
Date Analyzed:	05/07/18	Data File:	050724.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.55

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-E:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-02 1/6
Date Analyzed:	05/07/18	Data File:	050716.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	65	50	150
DBC	80	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-E:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-04 1/6
Date Analyzed:	05/15/18	Data File:	051521.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	110	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.22

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-W:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-05 1/6
Date Analyzed:	05/07/18	Data File:	050717.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.38

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-W:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-06 1/6
Date Analyzed:	05/07/18	Data File:	050718.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.080

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-W:1.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-07 1/6
Date Analyzed:	05/15/18	Data File:	051522.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-NW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-09 1/6
Date Analyzed:	05/07/18	Data File:	050719.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.017

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-NW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-10 1/6
Date Analyzed:	05/07/18	Data File:	050720.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-13 1/600
Date Analyzed:	05/09/18	Data File:	050915.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71 d	50	150
DBC	65 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	6.0

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-14 1/6
Date Analyzed:	05/07/18	Data File:	050722.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	67	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.056

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-S:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-17 1/6
Date Analyzed:	05/07/18	Data File:	050743.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.73

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-S:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-18 1/6
Date Analyzed:	05/07/18	Data File:	050744.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.14

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-S:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-20 1/6
Date Analyzed:	05/15/18	Data File:	051523.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.032

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-NE:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-21 1/60
Date Analyzed:	05/09/18	Data File:	050916.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85 d	50	150
DBC	110 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.8

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-NE:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-22 1/6
Date Analyzed:	05/07/18	Data File:	050730.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	67	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-NE:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-24 1/6
Date Analyzed:	05/15/18	Data File:	051524.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-NW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-25 1/60
Date Analyzed:	05/09/18	Data File:	050917.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75 d	50	150
DBC	113 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.0

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-NW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-26 1/60
Date Analyzed:	05/09/18	Data File:	050918.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75 d	50	150
DBC	120 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.5

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 8-NW:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-28 1/6
Date Analyzed:	05/15/18	Data File:	051525.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.031

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-32 1/6
Date Analyzed:	05/07/18	Data File:	050733.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	64	50	150
DBC	87	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.29

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-S:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-33 1/6
Date Analyzed:	05/07/18	Data File:	050734.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	67	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-S:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-34 1/6
Date Analyzed:	05/07/18	Data File:	050735.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	57	50	150
DBC	79	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.039

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-NE:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-37 1/60
Date Analyzed:	05/09/18	Data File:	050919.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71 d	50	150
DBC	98 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.8

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-NE:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-38 1/6
Date Analyzed:	05/07/18	Data File:	050737.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	64	50	150
DBC	82	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.3

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-NE:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-40 1/6
Date Analyzed:	05/15/18	Data File:	051526.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	115	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.42

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ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-NW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-41 1/600
Date Analyzed:	05/09/18	Data File:	050920.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	57 d	50	150
DBC	107 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	4.2

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-NW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-42 1/6
Date Analyzed:	05/06/18	Data File:	050614.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.13

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 9-NW:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-44 1/6
Date Analyzed:	05/15/18	Data File:	051527.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.80

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-SE:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-45 1/6
Date Analyzed:	05/07/18	Data File:	050739.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.36

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-SE:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-46 1/6
Date Analyzed:	05/07/18	Data File:	050740.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.093

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-SE:1.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-47 1/6
Date Analyzed:	05/15/18	Data File:	051528.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.016

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-W:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-49 1/6
Date Analyzed:	05/07/18	Data File:	050741.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-W:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	805024-50 1/6
Date Analyzed:	05/07/18	Data File:	050742.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-W:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	805024-52 1/6
Date Analyzed:	05/15/18	Data File:	051532.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	08-971 mb 1/6
Date Analyzed:	05/06/18	Data File:	050609.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/02/18	Lab ID:	08-970 mb 1/6
Date Analyzed:	05/07/18	Data File:	050709.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 805024
Date Extracted:	05/14/18	Lab ID:	08-1046 mb 1/6
Date Analyzed:	05/15/18	Data File:	051517.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/18/18
Date Received: 05/02/18
Project: Brookdale, F&BI 805024

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805024-42 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.13	126 b	128 b	50-150	2 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	102	70-130

Date of Report: 05/18/18
Date Received: 05/02/18
Project: Brookdale, F&BI 805024

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805024-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.55	73 b	65 b	50-150	12 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	95	70-130

Date of Report: 05/18/18
Date Received: 05/02/18
Project: Brookdale, F&BI 805024

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804450-20 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.13	89 b	108 b	50-150	19 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	100	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

805024

SAMPLE CHAIN OF CUSTODY ME 05/02/18

C04

Page # 1 of 6

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)	
[signature]	
PROJECT NAME	PO #
BROOKDALE	
REMARKS	INVOICE TO

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 7-E:0.5	01	5/1/18	0816	soil	1								X				ARCHIVE
Green 7-E:1.0	02	↓	0818	↓	↓								X				SAMPLES NOT
Green 7-E:1.5	03	↓	0837	↓	↓												MARKED FOR ANALYSES
Green 7-E:2.0	04	↓	0846	↓	↓								◆				◆ per BJ
GREEN 7-W:0.5	05	↓	851	↓	↓								X				5/9/18 ME
GREEN 7-W:1.0	06	↓	853	↓	↓								X				
GREEN 7-W:1.5	07	↓	855	↓	↓								◆				
GREEN 7-W:2.0	08	↓	858	↓	↓												
GREEN 7-NW:0.5	09	↓	908	↓	↓								X				
GREEN 7-NW:1.0	10	↓	910	↓	↓								X				Samples received at 2 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. LINSPERGER	EPI	05/02/18	650
Received by: [signature]	James Bruya	F&B	5/2	650
Relinquished by:				
Received by:				

805024

SAMPLE CHAIN OF CUSTODY

ME 05/02/18

Page # 2 of 6 COY

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA. 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)	
PROJECT NAME BROOKDALE	PO #
REMARKS	INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 7-NW:1.5	11	5/1/18	912	soil	1												
GREEN 7-NW:2.0	12		916														
GREEN 8:0.5	13		940										X				
GREEN 8:1.0	14		941										X				
GREEN 8:1.5	15		952														
GREEN 8:2.0	16		955														
GREEN 8-S:0.5	17		1003										X				
GREEN 8-S:1.0	18		1005										X				
GREEN 8-S:1.5	19		1059														
GREEN 8-S:2.0	20		1101										◆				

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SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. WINSPERGER	EPI	05/02/18	650
Received by:	James Bruya	F&B	5/2/18	650
Relinquished by:				
Received by:				

805024

SAMPLE CHAIN OF CUSTODY ME 05/02/18

C04

Page # 3 of 6

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)

PROJECT NAME	PO #
74001	
REMARKS	INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 8-NE:0.5	21	05/01/18	1110	SOIL	1								X				
GREEN 8-NE:1.0	22		1111										X				
GREEN 8-NE:1.5	23		1114														
GREEN 8-NE:2.0	24		1116														
GREEN 8-NW:0.5	25		1124										X				
GREEN 8-NW:1.0	26		1126										X				
GREEN 8-NW:15	27		1129														
GREEN 8-NW:2.0	28		1135														
GREEN 9:0.5	29		1225														
GREEN 9:1.0	30		1227														

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3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. HINSPERGER	EPI	05/02/18	650
Received by:	James Bruya	F&B	5/2	650
Relinquished by:				
Received by:				

805024

SAMPLE CHAIN OF CUSTODY

ME 05/02/18 C04

Page # 4 of 6

Report To Beau Johnson

Company EPI

Address 1180 NW Maple 87.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [signature]

PROJECT NAME 74001

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 9:1.5	31	5/1/18	1229	Soil	1												
GREEN 9:2.0	32	↓	1240	↓	↓								X				
GREEN 9-S:0.5	33	↓	1252	↓	↓								X				
GREEN 9-S:1.0	34	↓	1259	↓	↓								X				
GREEN 9-S:1.5	35	↓	1324	↓	↓												
GREEN 9-S:2.0	36	↓	1330	↓	↓												
GREEN 9-NE:0.5	37	↓	1344	↓	↓								X				
GREEN 9-NE:1.0	38	↓	1346	↓	↓								X				
Green 9 NE:1.5	39	↓	1359	↓	↓												
Green 9-NE:2.0	40	↓	1407	↓	↓								■				

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3012 16th Avenue West
Seattle, WA 98119-2029
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SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. HINSPERGER	EPI	05/02/18	650
Received by: [signature]	James Bruya	F&B	5/2/18	650
Relinquished by:				
Received by:				

805024

SAMPLE CHAIN OF CUSTODY

ME 05/02/18

C04

Page # 5 of 6

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA. 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)	
PROJECT NAME BROOKDALE	PO #
REMARKS	INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 9-NW:0.5	41	05/01/18	1420	SOIL	1								X				
GREEN 9-NW:1.0	42	↓	1422	↓	↓								X				
GREEN 9-NW:1.5	43		1424														
GREEN 9-NW:2.0	44		1427										◆				
GREEN 10-SE:0.5	45		1440										X				
GREEN 10-SE:1.0	46		1441										X				
GREEN 10-SE:1.5	47		1454										◆				
GREEN 10-SE:2.0	48		1501														
GREEN 10-W:0.5	49		1510										X				
GREEN 10-W:1.0	50	↓	1514	↓	↓								X				

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3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. LINSPERGER	EPI	05/02/18	650
Received by: [signature]	James Bruya	F&B	5/2	650
Relinquished by:				
Received by:				

805024 [redacted]

SAMPLE CHAIN OF CUSTODY

ME 05/02/18 [redacted] CW4

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Report To BEAL JOHNSON

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Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA - 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)

PROJECT NAME BROOKDALE

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 10-W:1.5	51	05/01/18	1525	SOIL	1												
GREEN 10-W:2.0	52	↓	1533	↓	↓								■				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. HINSPENGER	EPI	05/02/18	650
Received by:	James Bruya	F&B	5/2	650
Relinquished by:				
Received by:				

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 18, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: 74001, F&BI 805025

Dear Mr Johnson:

Included are the results from the testing of material submitted on May 2, 2018 from the 74001, F&BI 805025 project. There are 47 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0518R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on May 2, 2018 by Friedman & Bruya, Inc. from the Environmental Partners 74001, F&BI 805025 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
805025 -01	Green 5-E:0.5
805025 -02	Green 5-E:1.0
805025 -03	Green 5-E:1.5
805025 -04	Green 5-E:2.0
805025 -05	Tee 13-N:0.5
805025 -06	Tee 13-N:1.0
805025 -07	Tee 13-N:1.5
805025 -08	Tee 13-N:2.0
805025 -09	Tee 13-NW:0.5
805025 -10	Tee 13-NW:1.0
805025 -11	Tee 13-NW:1.5
805025 -12	Tee 13-NW:2.0
805025 -13	Tee 13-C:2.0
805025 -14	Tee 13-C:2.5
805025 -15	Tee 13-SW:0.5
805025 -16	Tee 13-SW:1.0
805025 -17	Tee 13-SW:1.5
805025 -18	Tee 13-SW:2.0
805025 -19	Tee 13-D:0.5
805025 -20	Tee 13-D:1.0
805025 -21	Tee 13-D:1.5
805025 -22	Tee 13-D:2.0
805025 -23	Tee 13-D-SE:0.5
805025 -24	Tee 13-D-SE:1.0
805025 -25	Tee 13-D-SE:1.5
805025 -26	Tee 13-D-SE:2.0
805025 -27	Tee 13-D-SW:0.5
805025 -28	Tee 13-D-SW:1.0
805025 -29	Tee 13-D-SW:1.5
805025 -30	Tee 13-D-SW:2.0
805025 -31	Tee 13-D-NW:0.5
805025 -32	Tee 13-D-NW:1.0
805025 -33	Tee 13-D-NW:1.5
805025 -34	Tee 13-D-NW:2.0
805025 -35	Green 6:2.0

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
805025 -36	Green 6:2.5
805025 -37	Green 6-NE:0.5
805025 -38	Green 6-NE:1.0
805025 -39	Green 6-NE:1.5
805025 -40	Green 6-NE:2.0
805025 -41	Green 6-S:0.5
805025 -42	Green 6-S:1.0
805025 -43	Green 6-S:1.5
805025 -44	Green 6-S:2.0
805025 -45	Green 6-W:0.5
805025 -46	Green 6-W:1.0
805025 -47	Green 6-W:1.5
805025 -48	Green 6-W:2.0
805025 -49	Green 7:2.0
805025 -50	Green 7:2.5
805025 -51	Green 7-N:0.5
805025 -52	Green 7-N:1.0
805025 -53	Green 7-N:1.5
805025 -54	Green 7-N:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 5-E:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-01 1/600
Date Analyzed:	05/09/18	Data File:	050914.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78 d	50	150
DBC	80 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	23

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 5-E:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-02 1/6
Date Analyzed:	05/03/18	Data File:	050334.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	91	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.076

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 5-E:1.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-03 1/6
Date Analyzed:	05/14/18	Data File:	051408.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	114	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.051

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-N:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-05 1/6
Date Analyzed:	05/03/18	Data File:	050335.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.54

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-N:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-06 1/6
Date Analyzed:	05/03/18	Data File:	050336.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.42

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-N:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-08 1/6
Date Analyzed:	05/14/18	Data File:	051407.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.020

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-NW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-09 1/60
Date Analyzed:	05/07/18	Data File:	050712.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85 d	50	150
DBC	91 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.3

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-NW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-10 1/60
Date Analyzed:	05/07/18	Data File:	050713.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75 d	50	150
DBC	80 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.2

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-NW:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-12 1/6
Date Analyzed:	05/14/18	Data File:	051406.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	112	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.97

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-C:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-13 1/6
Date Analyzed:	05/03/18	Data File:	050339.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.081

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-C:2.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-14 1/6
Date Analyzed:	05/03/18	Data File:	050340.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.17

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-SW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-15 1/6
Date Analyzed:	05/03/18	Data File:	050341.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	70	50	150
DBC	78	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.34

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-SW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-16 1/6
Date Analyzed:	05/03/18	Data File:	050342.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.13

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-SW:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-18 1/6
Date Analyzed:	05/11/18	Data File:	051118.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.011

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-19 1/6
Date Analyzed:	05/03/18	Data File:	050343.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	60	50	150
DBC	68	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-20 1/6
Date Analyzed:	05/03/18	Data File:	050344.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D-SE:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-23 1/6
Date Analyzed:	05/03/18	Data File:	050345.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D-SE:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-24 1/6
Date Analyzed:	05/03/18	Data File:	050346.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D-SW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-27 1/6
Date Analyzed:	05/03/18	Data File:	050347.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D-SW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-28 1/6
Date Analyzed:	05/03/18	Data File:	050348.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D-NW:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-31 1/6
Date Analyzed:	05/03/18	Data File:	050351.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Tee 13-D-NW:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-32 1/6
Date Analyzed:	05/03/18	Data File:	050352.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-35 1/6
Date Analyzed:	05/03/18	Data File:	050353.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.67

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6:2.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-36 1/6
Date Analyzed:	05/03/18	Data File:	050354.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-NE:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-37 1/6
Date Analyzed:	05/06/18	Data File:	050631.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.93

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-NE:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-38 1/6
Date Analyzed:	05/06/18	Data File:	050632.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	73	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.29

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-NE:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-40 1/6
Date Analyzed:	05/11/18	Data File:	051119.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.050

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-S:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-41 1/6
Date Analyzed:	05/06/18	Data File:	050633.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.39

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-S:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-42 1/6
Date Analyzed:	05/06/18	Data File:	050634.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.085

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-S:1.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-43 1/6
Date Analyzed:	05/11/18	Data File:	051120.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-W:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-45 1/6
Date Analyzed:	05/06/18	Data File:	050635.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	161	50	150
DBC	208	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.80

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-W:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-46 1/6
Date Analyzed:	05/06/18	Data File:	050636.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 6-W:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-48 1/6
Date Analyzed:	05/11/18	Data File:	051121.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-49 1/6
Date Analyzed:	05/06/18	Data File:	050637.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.4

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7:2.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-50 1/6
Date Analyzed:	05/06/18	Data File:	050639.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	66	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.085

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-N:0.5	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-51 1/60
Date Analyzed:	05/07/18	Data File:	050728.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72 d	50	150
DBC	96 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.1

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-N:1.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	805025-52 1/6
Date Analyzed:	05/06/18	Data File:	050641.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	109	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.61

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 7-N:2.0	Client:	Environmental Partners
Date Received:	05/02/18	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	805025-54 1/6
Date Analyzed:	05/11/18	Data File:	051122.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	115	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.24

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	08-960 mb2 1/6
Date Analyzed:	05/06/18	Data File:	050620.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 805025
Date Extracted:	05/02/18	Lab ID:	08-966 mb 1/6
Date Analyzed:	05/03/18	Data File:	050350.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001, F&BI 805025
Date Extracted:	05/09/18	Lab ID:	08-1028 mb 1/6
Date Analyzed:	05/09/18	Data File:	050954.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/18/18
Date Received: 05/02/18
Project: 74001, F&BI 805025

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804509-36 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	82	82	50-150	0

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	101	70-130

Date of Report: 05/18/18
Date Received: 05/02/18
Project: 74001, F&BI 805025

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805025-01 1/6 (Matrix Spike)

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	5.7 ve	117 b	0 b	50-150	nm

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	105	70-130

Date of Report: 05/18/18
Date Received: 05/02/18
Project: 74001, F&BI 805025

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804509-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	85	89	50-150	5

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	90	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

805025

SAMPLE CHAIN OF CUSTODY

ME 05/02/18 C05

Page # 1 of 6

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)

PROJECT NAME 74001

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 5-E:0.5	01	4/30/18	812	soil	1								X				[redacted] -per BS
GREEN 5-E:1.0	02		814										X				5/9/18 ME
GREEN 5-E:1.5	03		816										[redacted]				
GREEN 5-E:2.0	04		823														
TEE 13-N:0.5	05		841										X				
TEE 13-N:1.0	06		843										X				
TEE 13-N:1.5	07		847														
TEE 13-N:2.0	08		850										[redacted]				~~Hold~~
TEE 13-NW:0.5	09		858										X				
TEE 13-NW:1.0	10		901										X				Samples received at 2 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. HINSPERGER	EPI	05/02/18	650
Received by:	JAMES BRUYA	F&B	5/2	650
Relinquished by:				
Received by:				

805025

SAMPLE CHAIN OF CUSTODY

ME 05/02/18

C05

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP Issaquah, WA

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [redacted]

PROJECT NAME 74001

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
TEE 13-NW:1.5	11	4/30/18	903	Soil	1												
TEE 13-NW:2.0	12		906										[redacted]				~~Hold~~
TEE 13-C:2.0	13		920										X				
TEE 13-C:2.5	14		941										X				
TEE 13-SW:0.5	15		959										X				
TEE 13-SW:1.0	16		1006										X				
TEE 13-SW:1.5	17		1012														
TEE 13-SW:2.0	18		1016										[redacted]				
TEE 13-D:0.5	19		1030										X				
TEE 13-D:1.0	20	↓	1032	↓	↓								X				

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3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. HINSPERGER	EPI	05/02/18	650
Received by: [signature]	James Bruya	F&B	5/2	650
Relinquished by:				
Received by:				

805025
[redacted]

SAMPLE CHAIN OF CUSTODY ME 05/02/18

C05

Page # 3 of 6

Report To: Beau Johnson
Company: EPI
Address: 1180 NW Maple St.
City, State, ZIP: Issaquah, WA
Phone: 425-395-0060 Email: beauj@epi-wa.com

SAMPLERS (signature): [signature] [redacted]

PROJECT NAME	PO #
74001	
REMARKS	**INVOICE TO**

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH ______
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other ______

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides by 8081				Notes
TEE 13-D:1.5	21	4/30/18	1034	Soil	1												
TEE 13-D:2.0	22		1036														
TEE 13-D-SE:0.5	23		1045										X				
TEE 13-D-SE:1.0	24		1046										X				
TEE 13-D-SE:1.5	25		1047														
TEE 13-D-SE:2.0	26		1048														
TEE 13-D-SW:0.5	27		1113										X				
TEE 13-D-SW:1.0	28		1114										X				
TEE 13-D-SW:1.5	29		1116														
TEE 13-D-SW:2.0	30	↓	1118	↓	↓												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. HINSPERGER	EPI	05/02/18	650
Received by: [signature]	Michael Erdahl	F&Bnx	5/2/18	650
Relinquished by:				
Received by:				

805025

SAMPLE CHAIN OF CUSTODY

ME 05/02/18

C05

Page # 4 of 6

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)	
PROJECT NAME 74001	PO #
REMARKS	INVOICE TO

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides by 8021				Notes
TEE 13-D-NW:0.5	31	4/30/18	1125	Soil	1								X				
TEE 13-D-NW:1.0	32		1127										X				
TEE 13-D-NW:1.5	33		1128														
TEE 13-D-NW:2.0	34		1130														
GREEN 6:2.0	35		1301										X				
GREEN 6:2.5	36		1316										X				
GREEN 6-NE:0.5	37		1325										X				
GREEN 6-NE:1.0	38		1327										X				
GREEN 6-NE:1.5	39		1330														
GREEN 6-NE:2.0	40	↓	1354	↓	↓												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. Hunsperger	EPI	05/02/18	0852
Received by:	Michael Erdahl	F&B	↓	↓
Relinquished by:				
Received by:				

805025

SAMPLE CHAIN OF CUSTODY ME 05/02/18

Page # 5 of 6 COS

Report To Bean Johnson

Company EPI

Address 180 NW Maple St.

City, State, ZIP Issaquah WA

Phone 425-395-0010 Email beanj@epi-wa.com

SAMPLERS (signature)

PROJECT NAME 74001

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides by 8021				Notes
GREEN 6-S:0.5	41	4/30/18	1402	soil	1								X				
GREEN 6-S:1.0	42	↓	1404	↓	↓								X				
GREEN 6-S:1.5	43		1417										◆				
GREEN 6-S:2.0	44		1419														
GREEN 6-W:0.5	45		1424										X				
GREEN 6-W:1.0	46		1427										X				
GREEN 6-W:1.5	47		1430														
GREEN 6-W:2.0	48		1433										◆				
GREEN 7:2.0	49		1502										X				
GREEN 7:2.5	50	↓	1506	↓	↓								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. HINSPERGER	EPI	05/02/18	650
Received by:	Michael Erdahl	F&B	↓	↓
Relinquished by:				
Received by:				

805025

SAMPLE CHAIN OF CUSTODY

ME 05/02/18

Page # 6 of 6

Report To Beau Johnson

Company EPI

Address 180 NW Maple St.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)

PROJECT NAME	PO #
24001	
REMARKS	INVOICE TO

TURNAROUND TIME
☑ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides by 8081				Notes
GREEN 7-N:0.5	51	4/30/18	1516	soil	1								X				
GREEN 7-N:1.0	52	↓	1518	↓	↓								X				
GREEN 7-N:1.5	53	↓	1530	↓	↓												
GREEN 7-N:2.0	54	↓	1535	↓	↓												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	N. LINSPERGEN	EPI	05/02/18	650
Received by:	Michael Erdahl	F&B	↓	↓
Relinquished by:				
Received by:				

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 21, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale, F&BI 805048

Dear Mr Johnson:

Included are the results from the testing of material submitted on May 3, 2018 from the Brookdale, F&BI 805048 project. There are 44 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0521R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on May 3, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale, F&BI 805048 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
805048 -01	Green 10:0.5
805048 -02	Green 10:1.0
805048 -03	Green 10:1.5
805048 -04	Green 10:2.0
805048 -05	Green 10-NE:0.5
805048 -06	Green 10-NE:1.0
805048 -07	Green 10-NE:1.5
805048 -08	Green 10-NE:2.0
805048 -09	Green 11-W:0.5
805048 -10	Green 11-W:1.0
805048 -11	Green 11-W:1.5
805048 -12	Green 11-W:2.0
805048 -13	Green 11:0.5
805048 -14	Green 11:1.0
805048 -15	Green 11:1.5
805048 -16	Green 11:2.0
805048 -17	Green 11-E:0.5
805048 -18	Green 11-E:1.0
805048 -19	Green 11-E:1.5
805048 -20	Green 11-E:2.0
805048 -21	Green 11-S:0.5
805048 -22	Green 11-S:1.0
805048 -23	Green 11-S:1.5
805048 -24	Green 11-S:2.0
805048 -25	Green 12:0.5
805048 -26	Green 12:1.0
805048 -27	Green 12:1.5
805048 -28	Green 12:2.0
805048 -29	Green 12-E:0.5
805048 -30	Green 12-E:1.0
805048 -31	Green 12-E:1.5
805048 -32	Green 12-E:2.0
805048 -33	Green 12-W:0.5
805048 -34	Green 12-W:1.0
805048 -35	Green 12-W:1.5
805048 -36	Green 12-W:2.0
805048 -37	Green 12-S:0.5
805048 -38	Green 12-S:1.0

CASE NARRATIVE (Continued)

Laboratory ID	Environmental Partners
805048 -39	Green 12-S:1.5
805048 -40	Green 12-S:2.0
805048 -41	Green 13-NE:0.5
805048 -42	Green 13-NE:1.0
805048 -43	Green 13-NE:1.5
805048 -44	Green 13-NE:2.0
805048 -45	Green 13-S:0.5
805048 -46	Green 13-S:1.0
805048 -47	Green 13-S:1.5
805048 -48	Green 13-S:2.0
805048 -49	Green 13:0.5
805048 -50	Green 13:1.0
805048 -51	Green 13:1.5
805048 -52	Green 13:2.0
805048 -53	Green 13-NW:0.5
805048 -54	Green 13-NW:1.0
805048 -55	Green 13-NW:1.5
805048 -56	Green 13-NW:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-04 1/6
Date Analyzed:	05/08/18	Data File:	050829.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.24

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-NE:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-05 1/6
Date Analyzed:	05/08/18	Data File:	050806.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	127	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.72

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-NE:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-06 1/6
Date Analyzed:	05/08/18	Data File:	050807.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	115	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.31

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 10-NE:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-08 1/6
Date Analyzed:	05/15/18	Data File:	051533.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.054

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-W:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-09 1/6
Date Analyzed:	05/08/18	Data File:	050808.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	119	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.46

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-W:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-10 1/6
Date Analyzed:	05/08/18	Data File:	050809.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	117	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.13

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-W:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-12 1/6
Date Analyzed:	05/15/18	Data File:	051534.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-13 1/600
Date Analyzed:	05/11/18	Data File:	051105.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84 d	50	150
DBC	100 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	5.4

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-14 1/6
Date Analyzed:	05/08/18	Data File:	050811.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	124	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.98

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-16 1/6
Date Analyzed:	05/15/18	Data File:	051535.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	110	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.22

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-E:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-17 1/6
Date Analyzed:	05/08/18	Data File:	050812.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	130	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.4

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-E:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-18 1/6
Date Analyzed:	05/08/18	Data File:	050830.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	71	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.036

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-S:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-21 1/60
Date Analyzed:	05/11/18	Data File:	051106.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83 d	50	150
DBC	98 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.8

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-S:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-22 1/6
Date Analyzed:	05/08/18	Data File:	050832.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.47

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 11-S:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-24 1/6
Date Analyzed:	05/15/18	Data File:	051536.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-25 1/6
Date Analyzed:	05/08/18	Data File:	050833.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.2

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-26 1/6
Date Analyzed:	05/08/18	Data File:	050834.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88	50	150
DBC	105	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.16

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-28 1/6
Date Analyzed:	05/15/18	Data File:	051537.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-E:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-29 1/6
Date Analyzed:	05/08/18	Data File:	050835.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.71

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-E:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-30 1/6
Date Analyzed:	05/08/18	Data File:	050836.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.15

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-E:2.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-32 1/6
Date Analyzed:	05/15/18	Data File:	051538.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-W:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-33 1/60
Date Analyzed:	05/11/18	Data File:	051107.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92 d	50	150
DBC	105 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.3

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-W:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-34 1/6
Date Analyzed:	05/08/18	Data File:	050838.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	108	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.073

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-W:1.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	805048-35 1/6
Date Analyzed:	05/15/18	Data File:	051539.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-S:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-37 1/6
Date Analyzed:	05/08/18	Data File:	050839.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	115	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.30

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 12-S:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-38 1/6
Date Analyzed:	05/08/18	Data File:	050840.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.012

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ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13-NE:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-41 1/6
Date Analyzed:	05/08/18	Data File:	050841.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13-NE:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-42 1/6
Date Analyzed:	05/08/18	Data File:	050842.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13-S:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-45 1/6
Date Analyzed:	05/08/18	Data File:	050843.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13-S:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-46 1/6
Date Analyzed:	05/08/18	Data File:	050847.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	116	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.016

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-49 1/6
Date Analyzed:	05/08/18	Data File:	050848.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	105	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-50 1/6
Date Analyzed:	05/08/18	Data File:	050849.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13-NW:0.5	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-53 1/6
Date Analyzed:	05/07/18	Data File:	050745.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	97	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 13-NW:1.0	Client:	Environmental Partners
Date Received:	05/03/18	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	805048-54 1/6
Date Analyzed:	05/07/18	Data File:	050746.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	08-974 mb 1/6
Date Analyzed:	05/08/18	Data File:	050805.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92	50	150
DBC	109	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale, F&BI 805048
Date Extracted:	05/03/18	Lab ID:	08-971 mb2 1/6
Date Analyzed:	05/06/18	Data File:	050610.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	87	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale, F&BI 805048
Date Extracted:	05/14/18	Lab ID:	08-1046 mb 1/6
Date Analyzed:	05/15/18	Data File:	051517.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/21/18
Date Received: 05/03/18
Project: Brookdale, F&BI 805048

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805024-42 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.13	126 b	128 b	50-150	2 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	102	70-130

Date of Report: 05/21/18
Date Received: 05/03/18
Project: Brookdale, F&BI 805048

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805048-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.21	112 b	117 b	50-150	4 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	112	70-130

Date of Report: 05/21/18
Date Received: 05/03/18
Project: Brookdale, F&BI 805048

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804509-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	85	89	50-150	5

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	90	70-130

Date of Report: 05/21/18
Date Received: 05/03/18
Project: Brookdale, F&BI 805048

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 804450-20 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.13	89 b	108 b	50-150	19 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	100	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

805 048

SAMPLE CHAIN OF CUSTODY

ME 05-03-18

Page # 1 of ~~5~~ 6

Report To: BEAU JOHNSON

Company: EPI

Address: 1180 NW MAPLE ST. SUITE 310

City, State, ZIP: ISSAQUAH, WA. 98027

Phone: (425) 395-0010 Email

SAMPLERS (signature): [signature]

PROJECT NAME: Brookdale

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 10:0.5	01	05/02/18	902	SOIL	1												ARCHIVE SAMPLES NOT MARKED FOR ANALYSIS
GREEN 10:1.0	02	↓	904	↓	↓												
GREEN 10:1.5	03		905														◆ - per BJ
GREEN 10:2.0	04		925										X				5/10/16 ME
GREEN 10-NE:0.5	05		942										X				
GREEN 10-NE:1.0	06		945										X				
GREEN 10-NE:1.5	07		949														
GREEN 10-NE:2.0	08		1012										◆				
GREEN 11-W:0.5	09		1023										X				
GREEN 11-W:1.0	10	↓	1025	↓	↓								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Joe Sherwood	EPI	5/3/18	0832
Received by: [signature]	James Bruya	F&B	5/3	0832
Relinquished by:				
Received by:		Samples received at 2 °C		

805048

SAMPLE CHAIN OF CUSTODY

~~ME 05-02-18~~

Page # 2 of 6

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA. 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)

PROJECT NAME: BROOKDALE

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 11- W: 1.5	11	05/02/18	1028	SOIL	1												
GREEN 11- W: 2.0	12		1031										◆				
GREEN 11: 0.5	13		1042										X				
GREEN 11: 1.0	14		1044										X				
GREEN 11: 1.5	15		1045														
GREEN 11: 2.0	16		1048										◆				
GREEN 11- E: 0.5	17		1055										X				
GREEN 11- E: 1.0	18		1058										X				
GREEN 11- E: 1.5	19		1102														
GREEN 11- E: 2.0	20		1107														

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	Joe Sherrod	EPI	5/3/18	0832
Received by:	James Bruya	F&B	5/3	0832
Relinquished by:				
Received by:				

805048

SAMPLE CHAIN OF CUSTODY

ME 05-03-18

Page # 3 of 6

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)

PROJECT NAME: BROOKDALE

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 11-S:0.5	21	05/02/18	1116	SOIL	1								X				
GREEN 11-S:1.0	22	↓	1118	↓	↓								X				
GREEN 11-S:1.5	23		1121														
GREEN 11-S:2.0	24		1122										◆				
GREEN 12:0.5	25		1222										X				
GREEN 12:1.0	26		1224										X				
GREEN 12:1.5	27		1226														
GREEN 12:2.0	28		1228										◆				
GREEN 12-E:0.5	29		1236										X				
GREEN 12-E:1.0	30	↓	1238	↓	↓								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Joe Sherrod	EPI	5/3/18	0832
Received by:	[signature]	James Bruya	F&B	5/3	0830
Relinquished by:					
Received by:					

805048

SAMPLE CHAIN OF CUSTODY

ME 05-03-18 [redacted] Page # 4 of 6

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St.

City, State, ZIP: Issaquah, WA 98027

Phone: 425-395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature):

PROJECT NAME: 74001

PO #:

REMARKS:

INVOICE TO:

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES				Notes
GREEN 12-E:1.5	31	05/02/18	1239	SOIL	1												
GREEN 12-E:2.0	32		1247										◆				
Green 12-W:0.5	33		1253										X				
Green 12-W:1.0	34		1255										X				
Green 12-W:1.5	35		1258										◆				
Green 12-W:2.0	36		1303														
GREEN 12-S:0.5	37		1308										X				
GREEN 12-S:1.0	38		1310										X				
GREEN 12-S:1.5	39		1312														
GREEN 12-S:2.0	40		1313														

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	Joe Shemod	EPI	5/3/18	0832
Received by:	James Bruya	F&B	5/3	0830
Relinquished by:				
Received by:				

805048

SAMPLE CHAIN OF CUSTODY

ME 05-03-18

Page # 5 of 6

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [signature]

PROJECT NAME 74001

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
☑ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
Green 13-NE:0.5	41	5/2/18	1327	Soil	1								X				
Green 13-NE:1.0	42	↓	1329	↓	↓								X				
Green 13-NE:1.5	43		1330														
Green 13-NE:2.0	44		1332														
GREEN 13-S:0.5	45		1337										X				
GREEN 13-S:1.0	46		1345										X				
Green 13-S:1.5	47		1408														
Green 13-S:2.0	48		1416														
GREEN 13:0.5	~~45~~ 49	ME 5/2/18	1433										X				
GREEN 13:1.0	50	↓	1435	↓	↓								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Joe Skems	EPI	5/3/18	0832
Received by: [signature]	James Bruya	FBI	5/3	0832
Relinquished by:				
Received by:				

805048

SAMPLE CHAIN OF CUSTODY

ME 05-03-18

Page # 6 of 6 (COS)

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St.

City, State, ZIP: Issaquah, WA 98027

Phone: 425-395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature): [signature]

PROJECT NAME: 74001

PO #:

REMARKS:

INVOICE TO:

TURNAROUND TIME
- ☑ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 13:1.5	51	05/02/18	1506	SOIL	1												
GREEN 13:2.0	52	↓	1508	↓	↓												
GREEN 13-NW:0.5	53	↓	1513	↓	↓								X				
GREEN 13-NW:1.0	54	↓	1515	↓	↓								X				
GREEN 13-NW:1.5	55	↓	1518	↓	↓												
GREEN 13-NW:2.0	56	↓	1521	↓	↓												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Joe Shems	EPI	5/3/18	0832
Received by:	[signature]	James Bruya	F&B	5/3	0832
Relinquished by:					
Received by:					

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 23, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale 74001, F&BI 805107

Dear Mr Johnson:

Included are the results from the testing of material submitted on May 7, 2018 from the Brookdale 74001, F&BI 805107 project. There are 35 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0523R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on May 7, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale 74001, F&BI 805107 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
805107 -01	Green 14-N:0.5
805107 -02	Green 14-N:1.0
805107 -03	Green 14-N:1.5
805107 -04	Green 14-N:2.0
805107 -05	Green 14:0.5
805107 -06	Green 14:1.0
805107 -07	Green 14:1.5
805107 -08	Green 14:2.0
805107 -09	Green 14-E:0.5
805107 -10	Green 14-E:1.0
805107 -11	Green 14-E:1.5
805107 -12	Green 14-E:2.0
805107 -13	Green 14-W:0.5
805107 -14	Green 14-W:1.0
805107 -15	Green 14-W:1.5
805107 -16	Green 14-W:2.0
805107 -17	Green 15-S:0.5
805107 -18	Green 15-S:1.0
805107 -19	Green 15-S:1.5
805107 -20	Green 15-S:2.0
805107 -21	Green 15:0.5
805107 -22	Green 15:1.0
805107 -23	Green 15:1.5
805107 -24	Green 15:2.0
805107 -25	Green 15-NE:0.5
805107 -26	Green 15-NE:1.0
805107 -27	Green 15-NE:1.5
805107 -28	Green 15-NE:2.0
805107 -29	Green 15-W:0.5
805107 -30	Green 15-W:1.0
805107 -31	Green 15-W:1.5
805107 -32	Green 15-W:2.0
805107 -33	Green 16-NW:0.5
805107 -34	Green 16-NW:1.0
805107 -35	Green 16-NW:1.5
805107 -36	Green 16-NW:2.0
805107 -37	Green 16-SW:0.5
805107 -38	Green 16-SW:1.0
805107 -39	Green 16-SW:1.5
805107 -40	Green 16-SW:2.0
805107 -41	Green 16-E:0.5
805107 -42	Green 16-E:1.0
805107 -43	Green 16-E:1.5
805107 -44	Green 16-E:2.0

All quality control requirements were acceptable.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-N:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-01 1/600
Date Analyzed:	05/11/18	Data File:	051110.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85 d	50	150
DBC	98 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	6.8

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-N:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-02 1/60
Date Analyzed:	05/11/18	Data File:	051111.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92 d	50	150
DBC	107 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.9

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-N:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	805107-04 1/6
Date Analyzed:	05/16/18	Data File:	051634.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	90	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.22

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-08 1/6
Date Analyzed:	05/09/18	Data File:	050932.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-E:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-09 1/6
Date Analyzed:	05/09/18	Data File:	050933.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.1

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-E:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-10 1/6
Date Analyzed:	05/09/18	Data File:	050934.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	106	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.37

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-E:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	805107-12 1/6
Date Analyzed:	05/16/18	Data File:	051635.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-W:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-13 1/60
Date Analyzed:	05/11/18	Data File:	051112.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	88 d	50	150
DBC	100 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.1

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-W:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-14 1/6
Date Analyzed:	05/09/18	Data File:	050936.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.18

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 14-W:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	805107-16 1/6
Date Analyzed:	05/16/18	Data File:	051636.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-S:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-17 1/600
Date Analyzed:	05/11/18	Data File:	051113.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86 d	50	150
DBC	95 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	5.9

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-S:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-18 1/6
Date Analyzed:	05/09/18	Data File:	050938.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	120	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.085

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-S:1.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	805107-19 1/6
Date Analyzed:	05/16/18	Data File:	051637.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-21 1/6
Date Analyzed:	05/10/18	Data File:	050963.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	69	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-22 1/6
Date Analyzed:	05/10/18	Data File:	050964.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-NE:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-25 1/6
Date Analyzed:	05/10/18	Data File:	050965.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-NE:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-26 1/6
Date Analyzed:	05/10/18	Data File:	050966.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-W:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-29 1/6
Date Analyzed:	05/10/18	Data File:	050967.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 15-W:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-30 1/6
Date Analyzed:	05/10/18	Data File:	050968.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	85	50	150
DBC	117	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.062

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-NW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-33 1/6
Date Analyzed:	05/09/18	Data File:	050939.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	84	50	150
DBC	110	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.48

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-NW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-34 1/6
Date Analyzed:	05/09/18	Data File:	050940.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.012

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-SW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-37 1/6
Date Analyzed:	05/09/18	Data File:	050941.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.27

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-SW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-38 1/6
Date Analyzed:	05/09/18	Data File:	050942.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	132	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.24

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-SW:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	805107-40 1/6
Date Analyzed:	05/16/18	Data File:	051638.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.031

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-E:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-41 1/6
Date Analyzed:	05/09/18	Data File:	050943.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	108	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.2

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-E:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	805107-42 1/60
Date Analyzed:	05/11/18	Data File:	051114.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	90 d	50	150
DBC	105 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.5

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 16-E:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	805107-44 1/6
Date Analyzed:	05/16/18	Data File:	051639.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.014

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/09/18	Lab ID:	08-1028 mb 1/6
Date Analyzed:	05/09/18	Data File:	050954.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	92	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/08/18	Lab ID:	08-988 mb 1/6
Date Analyzed:	05/09/18	Data File:	050906.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	98	50	150
DBC	114	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale 74001, F&BI 805107
Date Extracted:	05/15/18	Lab ID:	08-1070 mb 1/6
Date Analyzed:	05/16/18	Data File:	051633.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	90	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/23/18
Date Received: 05/07/18
Project: Brookdale 74001, F&BI 805107

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805108-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	89	90	50-150	1

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	94	70-130

Date of Report: 05/23/18
Date Received: 05/07/18
Project: Brookdale 74001, F&BI 805107

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 804509-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	85	89	50-150	5

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	90	70-130

Date of Report: 05/23/18
Date Received: 05/07/18
Project: Brookdale 74001, F&BI 805107

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 805107-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	3.7	181 b	102 b	50-150	56 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	98	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

805107

SAMPLE CHAIN OF CUSTODY

ME 05-07-18

Page # 1 of 5 COS

Report To Beau Johnson

Company EPI

Address 1180 NW maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [signature]

PROJECT NAME Brookdale

PO # 74001

REMARKS

INVOICE TO EPI

TURNAROUND TIME
☑ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☑ Archive Samples
☐ Other

ANALYSES REQUESTED

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes (◆ - per BJ 5/15/18 ME)
Green14-N:0.5	-01	5/3/18	0855	Soil	1								X				*Archive all samples not marked for immediate analysis.
Green 14-N: 1.0	-02	↓	0856	↓	1								X				
Green 14-N:1.5	-03		0858		1												
Green14-N:2.0	-04		0905		1								◆				
Green14-0.5	-05		0911		1								[crossed out]				Archive only
Green14-1.0	-06		0913		1								[crossed out]				Archive only
Green14-1.5	-07		0915		1												
Green14-2.0	-08		0931		1								X				
Green 14-E:0.5	-09		0942		1								X				
Green 14-E:1.0	-10	↓	0944	↓	1								X				

Samples received at 2 °C

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	5-7-18	0750
Received by: [signature]	Michael Erdahl	FEB	↓	↓
Relinquished by:				
Received by:				

805107

SAMPLE CHAIN OF CUSTODY

ME 05-07-18

Page # 2 of 5 COS

Report To: Beau Johnson

Company: EPI

Address: 1180 NW Maple St Suite 310

City, State, ZIP: Issaquah, WA 98027

Phone: (425) 395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature)	
[signature]	
PROJECT NAME	**PO #**
Brookdale	74001
REMARKS	**INVOICE TO**
	EPI

TURNAROUND TIME
- X Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- X Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Green 14-E: 1.5	-11	5/3/18	0947	Soil	1												*Archive all samples not marked for immediate analysis.
Green 14-E: 2.0	-12	↓	0948	↓	1								◆ (circled)				
Green 14-W: 0.5	-13		0954		1								X				
Green 14-W: 1.0	-14		1001		1								X				
Green 14-W: 1.5	-15		1005		1												
Green 14-W: 2.0	-16		1011		1								◆ (circled)				
Green 15-S: 0.5	-17		1023		1								X				
Green 15-S: 1.0	-18		1025		1								X				
Green 15-S: 1.5	-19		1027		1								◆ (circled)				
Green 15-S: 2.0	-20	↓	1028	↓	1												

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau John	EPI	5-7-18	c 750
Received by:	[signature]	Michael Erdahl	F&B	↓	↓
Relinquished by:					
Received by:					

805104

SAMPLE CHAIN OF CUSTODY

ME 05-07-18

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425) 395-0016 Email beauj@epi-wa.com

SAMPLERS (signature)	
Betsy Wing	
PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME

- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL

- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	8081 Pesticides				Notes
Green 15 : 0.5	-21		1033										◆				*Archive all samples not
Green 15 : 1.0	-22		1035										◆				marked for immediate
Green 15 : 1.5	-23		1044														analysis.
Green 15 : 2.0	-24		1052														◆ per BT 5/7/18
Green 15 NE : 0.5	-25		1056										◆				ME
Green 15 - NE : 1.0	-26		1100										◆				
Green 15 - NE : 1.5	-27		1125														
Green 15 - NE : 2.0	-28		1136														
Green 15 - W : 0.5	-29		1246										◆				
Green 15 - W : 1.0	-30		1254										◆				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	5-7-18	0750
Received by: [signature]	Michael Erdahl	F&BI	↓	↓
Relinquished by:				
Received by:				

805107

SAMPLE CHAIN OF CUSTODY

ME 05-07-18

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suit 310

City, State, ZIP Issaquah, WA 98027

Phone (425)395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) Betsy Wing

PROJECT NAME Brookdale

PO # 74001

REMARKS

INVOICE TO EPI

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☒ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
Green 15-W:1.5	-31	5/3/18	1256	Soil	1												* Archive all samples not marked for immediate analysis.
Green 15-W:2.0	-32	↓	1300	↓	1												
Green 16-NW:0.5	-33		1313		1								X				
Green 16-NW:1.0	-34		1317		1								X				
Green 16-NW:1.5	-35		1322		1												
Green 16-NW:2.0	-36		1326		1												
Green 16-SW:0.5	-37		1334		1								X				
Green 16-SW:1.0	-38		1345		1								X				
Green 16-SW:1.5	-39		1414		1												
Green 16-SW:2.0	-40	↓	1430	↓	1								◉				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Beau John	EPI	5-7-18	0750
Received by:	[signature]	Michael Erdahl	F&Bi	↓	↓
Relinquished by:					
Received by:					

805107

SAMPLE CHAIN OF CUSTODY

ME 05-07-18 Page # 5 of 5 C05

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone (425)395-0010 Email beauj@epi-wa.com

SAMPLERS (signature) [signature]

PROJECT NAME	PO #
Brookdale	74001
REMARKS	INVOICE TO
	EPI

TURNAROUND TIME
- [X] Standard Turnaround
- [ ] RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- [ ] Dispose after 30 days
- [X] Archive Samples
- [ ] Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 16-E:0.5	-41	05/03/18	1436	SOIL	1								X				* Archive all samples not marked for immediate anal.
GREEN 16-E:1.0	-42	↓	1446	↓									X				
GREEN 16-E:1.5	-43		1448														
GREEN 16-E:2.0	-44		1449										◆				

BJ 5-7-18

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	5-7-18	0750
Received by: [signature]	Michael Erdahl	FεBn	↓	↓
Relinquished by:				
Received by:				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 23, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: Brookdale, F&BI 805108

Dear Mr Johnson:

Included are the results from the testing of material submitted on May 7, 2018 from the Brookdale, F&BI 805108 project. There are 30 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0523R.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

CASE NARRATIVE

This case narrative encompasses samples received on May 7, 2018 by Friedman & Bruya, Inc. from the Environmental Partners Brookdale, F&BI 805108 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
805108 -01	Green 17-SW:0.5
805108 -02	Green 17-SW:1.0
805108 -03	Green 17-SW:1.5
805108 -04	Green 17-SW:2.0
805108 -05	Green 17:0.5
805108 -06	Green 17:1.0
805108 -07	Green 17:1.5
805108 -08	Green 17:2.0
805108 -09	Green 17-E:0.5
805108 -10	Green 17-E:1.0
805108 -11	Green 17-E:1.5
805108 -12	Green 17-E:2.0
805108 -13	Green 17-NW:0.5
805108 -14	Green 17-NW:1.0
805108 -15	Green 17-NW:1.5
805108 -16	Green 17-NW:2.0
805108 -17	Green 18:0.5
805108 -18	Green 18:1.0
805108 -19	Green 18:2.0
805108 -20	Green 18-S:0.5
805108 -21	Green 18-S:1.0
805108 -22	Green 18-S:1.5
805108 -23	Green 18-S:2.0
805108 -24	Green 18-NW:0.5
805108 -25	Green 18-NW:1.0
805108 -26	Green 18-NW:1.5
805108 -27	Green 18-NW:2.0
805108 -28	Green 18-NE:0.5
805108 -29	Green 18-NE:1.0
805108 -30	Green 18-NE:1.5
805108 -31	Green 18-NE:2.0
805108 -32	PG 1-S:0.5
805108 -33	PG 1-S:1.0
805108 -34	PG 1-S:1.5
805108 -35	PG 1-NW:0.5
805108 -36	PG 1-NW:1.0
805108 -37	PG 1-NW:1.5
805108 -38	PG 1-NW:2.0

All quality control requirements were acceptable.

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-SW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-01 1/6
Date Analyzed:	05/09/18	Data File:	050861.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.58

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-SW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-02 1/6
Date Analyzed:	05/08/18	Data File:	050850.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.15

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-SW:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/15/18	Lab ID:	805108-04 1/6
Date Analyzed:	05/16/18	Data File:	051648.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	88	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-05 1/600
Date Analyzed:	05/11/18	Data File:	051108.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83 d	50	150
DBC	94 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	9.0

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-06 1/6
Date Analyzed:	05/08/18	Data File:	050852.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	74	50	150
DBC	108	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.35

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/15/18	Lab ID:	805108-08 1/6
Date Analyzed:	05/16/18	Data File:	051640.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.24

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-E:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-09 1/6
Date Analyzed:	05/08/18	Data File:	050853.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	111	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.43

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-E:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-10 1/6
Date Analyzed:	05/08/18	Data File:	050854.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	106	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.14

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-E:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/15/18	Lab ID:	805108-12 1/6
Date Analyzed:	05/16/18	Data File:	051641.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	86	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.025

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-NW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-13 1/6
Date Analyzed:	05/08/18	Data File:	050855.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	105	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.15

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 17-NW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-14 1/6
Date Analyzed:	05/08/18	Data File:	050856.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	105	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.057

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-19 1/6
Date Analyzed:	05/08/18	Data File:	050857.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.19

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-S:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-20 1/6
Date Analyzed:	05/09/18	Data File:	050858.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	108	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.16

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-S:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-21 1/6
Date Analyzed:	05/09/18	Data File:	050859.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	76	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.024

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-NW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-24 1/60
Date Analyzed:	05/11/18	Data File:	051109.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86 d	50	150
DBC	99 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	1.9

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-NW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-25 1/6
Date Analyzed:	05/09/18	Data File:	050947.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	116	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.31

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-NW:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/15/18	Lab ID:	805108-27 1/6
Date Analyzed:	05/16/18	Data File:	051642.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	81	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.23

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-NE:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-28 1/6
Date Analyzed:	05/09/18	Data File:	050945.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	107	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.39

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Green 18-NE:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-29 1/6
Date Analyzed:	05/09/18	Data File:	050946.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-S:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-32 1/6
Date Analyzed:	05/09/18	Data File:	050949.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.61

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-S:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-33 1/6
Date Analyzed:	05/09/18	Data File:	050950.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.10

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-S:1.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/15/18	Lab ID:	805108-34 1/6
Date Analyzed:	05/16/18	Data File:	051643.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	85	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.090

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-NW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-35 1/6
Date Analyzed:	05/09/18	Data File:	050951.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.036

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-NW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	805108-36 1/6
Date Analyzed:	05/09/18	Data File:	050952.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	72	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale, F&BI 805108
Date Extracted:	05/07/18	Lab ID:	08-986 mb 1/6
Date Analyzed:	05/08/18	Data File:	050846.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86	50	150
DBC	104	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	Brookdale, F&BI 805108
Date Extracted:	05/15/18	Lab ID:	08-1070 mb 1/6
Date Analyzed:	05/16/18	Data File:	051633.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	90	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/23/18
Date Received: 05/07/18
Project: Brookdale, F&BI 805108

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 805108-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	89	90	50-150	1

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	94	70-130

Date of Report: 05/23/18
Date Received: 05/07/18
Project: Brookdale, F&BI 805108

QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B

Laboratory Code: 805108-01 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	0.44	104 b	61 b	50-150	52 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	94	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

805108

SAMPLE CHAIN OF CUSTODY ME 05/07/18

C05

Page # 1 of 4

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA. 98027

Phone (425) 395-0010 Email

SAMPLERS (signature) [signature]

PROJECT NAME: BROOKDALE

PO #:

REMARKS:

INVOICE TO:

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 17-SW:0.5	01	05/04/18	815	SOIL	1								X				ARCHIVE SAMPLES
GREEN 17-SW:1.0	02	↓	817	↓	↓								X				NOT MARKED FOR ANALYSIS
GREEN 17-SW:1.5	03		821														
GREEN 17-SW:2.0	04		823										◆				◆ per BJ
GREEN 17 [illegible]: 0.5	05		832										X				5/15/18 ME
GREEN 17 [illegible]: 1.0	06		835										X				
GREEN 17 [illegible]: 1.5	07		838														
GREEN 17 [illegible]: 2.0	08		850										◆				
GREEN 17-E:0.5	09		900										X				Samples received at 2 °C
GREEN 17-E:1.0	10	↓	905	↓	↓								X				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	5-7-18	0756
Received by: [signature]	Michael Erdahl	F&B	↓	↓
Relinquished by:				
Received by:				

805108

SAMPLE CHAIN OF CUSTODY ME 05/07/18

C05

Page # 2 of 4

Report To BEAU JOHNSON

Company EPI

Address 1180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)	
PROJECT NAME BROOKDALE	PO #
REMARKS	INVOICE TO

TURNAROUND TIME
☐ Standard Turnaround
☐ RUSH
Rush charges authorized by:
SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN 17-E:1.5	11	05/04/18	915	SOIL	1												
GREEN 17-E:2.0	12	↓	925	↓	↓								◆				
GREEN 17-NW:0.5	13		939										X				
GREEN 17-NW:1.0	14		945										X				
GREEN 17-NW:1.5	15		1006														
GREEN 17-NW:2.0	16		1013														
GREEN 18:0.5	17		1033										[illegible]				
GREEN 18:1.0	18		1037														
GREEN 18:2.0	19		1053										X				
GREEN 18-S:0.5	20	↓	1108	↓	↓								X				

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	Beau Johnson	EPI	5-7-18	0730
Received by:	Michael Erdahl	F&BInc	↓	↓
Relinquished by:				
Received by:		Samples received at 2 °C		

805109

SAMPLE CHAIN OF CUSTODY

ME 05/07/18

COS

Page # 3 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St, Suite 310

City, State, ZIP Issaquah, WA 98027

Phone ______ Email ______

SAMPLERS (signature) [signature]

PROJECT NAME: BROOKDALE

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
- ☒ Standard Turnaround
- ☐ RUSH ______
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Archive Samples
- ☐ Other ______

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	Pesticides 8081				Notes
GREEN 18-S:1.0	21	05/04/18	1111	SOIL	1								X				
GREEN 18-S:1.5	22		1118														
GREEN 18-S:2.0	23		1145														
GREEN 18-NW:0.5	24		1239										X				
GREEN 18-NW:1.0	25		1242										X				
GREEN 18-NW:1.5	26		1243														
GREEN 18-NW:2.0	27		1246										●				
GREEN 18-NE:0.5	28		1300										X				
GREEN 18-NE:1.0	29		1301										X				
GREEN 18-NE:1.5	30	↓	1306	↓	↓												

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Beau Johnson	EPI	5-7-18	0750
Received by: [signature]	Michael Erdahl	F&Binc	↓	↓
Relinquished by:				
Received by:		Samples received at 2 °C		

805108

SAMPLE CHAIN OF CUSTODY

ME 05/07/18 C05

Page # 4 of 4

Report To Bean Johnson

Company EPI

Address 1180 NW Maple St. Suite 310

City, State, ZIP Issaquah, WA. 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)

PROJECT NAME Brookdale

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Change "PG" samples to "PG 1"

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
GREEN18-NE:2.0	31	05/04/18	1311	SOIL	1												
PG-S:0.5	32	↓	1323	↓	↓								X				
PG-S:1.0	33	↓	1329	↓	↓								X				
PG-S:1.5	34	↓	1334	↓	↓								◆				
PG-NW:0.5	35	↓	1421	↓	↓								X				
PG-NW:1.0	36	↓	1422	↓	↓								X				
PG-NW:1.5	37	↓	1428	↓	↓												
PG-NW:2.0	38	↓	1440	↓	↓												

Friedman & Bruya, Inc.

3012 16th Avenue West

Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Bean Johnson	EPI	5-7-18	0750
Received by: [signature]	Michael Erdahl	F&Bi	↓	↓
Relinquished by:				
Received by:		Samples received at	2 °C	

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Arina Podnozova, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

May 23, 2018

Beau Johnson, Project Manager
Environmental Partners, Inc.
1180 NW Maple St, Suite 310
Issaquah, WA 98027

RE: 74001 Brookdale, F&BI 805114

Dear Mr Johnson:

Included are the results from the testing of material submitted on May 7, 2018 from the 74001 Brookdale, F&BI 805114 project. There are 26 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
c: Cynthia Moon
EPI0523R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on May 7, 2018 by Friedman & Bruya, Inc. from the Environmental Partners 74001 Brookdale, F&BI 805114 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Environmental Partners
805114 -01	PG 1-E:0.5
805114 -02	PG 1-E:1.0
805114 -03	PG 1-E:1.5
805114 -04	PG 1-E:2.0
805114 -05	PG 1:0.5
805114 -06	PG 1:1.0
805114 -07	PG 1:1.5
805114 -08	PG 1:2.0
805114 -09	PG 2:0.5
805114 -10	PG 2:1.0
805114 -11	PG 2-NW:0.5
805114 -12	PG 2-NW:1.0
805114 -13	PG 2-NW:1.5
805114 -14	PG 2-NW:2.0
805114 -15	TEE 4-C:0.5
805114 -16	TEE 4-C:1.0
805114 -17	TEE 4-C:1.5
805114 -18	TEE 4-C:2.0
805114 -19	TEE 4-S:0.5
805114 -20	TEE 4-S:1.0
805114 -21	PG 2:1.5
805114 -22	PG 2:2.0
805114 -23	PG 2-S:0.5
805114 -24	PG 2-S:1.0
805114 -25	PG 2-S:1.5
805114 -26	PG 2-S:2.0
805114 -27	PG 2-NE:0.5
805114 -28	PG 2-NE:1.0
805114 -29	PG 2-NE:1.5
805114 -30	PG 2-NE:2.0
805114 -31	TEE 4-S:1.5
805114 -32	TEE 4-S:2.0

All quality control requirements were acceptable.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-E:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-01 1/6
Date Analyzed:	05/11/18	Data File:	051126.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	96	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.38

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1-E:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-02 1/6
Date Analyzed:	05/11/18	Data File:	051127.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.055

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-05 1/60
Date Analyzed:	05/15/18	Data File:	051518.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	97 d	50	150
DBC	115 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	2.0

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-06 1/6
Date Analyzed:	05/11/18	Data File:	051129.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	101	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.11

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 1:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/15/18	Lab ID:	805114-08 1/6
Date Analyzed:	05/16/18	Data File:	051644.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	75	50	150
DBC	57	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.080

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-09 1/6
Date Analyzed:	05/11/18	Data File:	051130.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.74

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-10 1/6
Date Analyzed:	05/11/18	Data File:	051131.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	103	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.081

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-NW:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-11 1/600
Date Analyzed:	05/15/18	Data File:	051519.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	86 d	50	150
DBC	99 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	20

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-NW:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-12 1/6
Date Analyzed:	05/11/18	Data File:	051133.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	79	50	150
DBC	100	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.14

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-NW:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/15/18	Lab ID:	805114-14 1/6
Date Analyzed:	05/16/18	Data File:	051645.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	89	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.40

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE 4-C:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-15 1/6
Date Analyzed:	05/11/18	Data File:	051134.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE 4-C:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-16 1/6
Date Analyzed:	05/11/18	Data File:	051135.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE 4-S:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-19 1/6
Date Analyzed:	05/11/18	Data File:	051136.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	81	50	150
DBC	102	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.023

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	TEE 4-S:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-20 1/6
Date Analyzed:	05/11/18	Data File:	051137.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	78	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.013

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/15/18	Lab ID:	805114-22 1/6
Date Analyzed:	05/16/18	Data File:	051646.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	80	50	150
DBC	92	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.41

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-S:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-23 1/6
Date Analyzed:	05/11/18	Data File:	051138.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	82	50	150
DBC	109	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.19

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-S:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-24 1/6
Date Analyzed:	05/11/18	Data File:	051139.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	95	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.034

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-NE:0.5	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-27 1/60
Date Analyzed:	05/15/18	Data File:	051520.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	108 d	50	150
DBC	122 d	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	3.1

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-NE:1.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	805114-28 1/6
Date Analyzed:	05/11/18	Data File:	051141.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	77	50	150
DBC	94	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	0.76

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	PG 2-NE:2.0	Client:	Environmental Partners
Date Received:	05/07/18	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/15/18	Lab ID:	805114-30 1/6
Date Analyzed:	05/16/18	Data File:	051647.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	83	50	150
DBC	93	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/08/18	Lab ID:	08-1025 mb 1/6
Date Analyzed:	05/11/18	Data File:	051125.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	89	50	150
DBC	99	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Analysis For Organochlorine Pesticides By EPA Method 8081B

Client Sample ID:	Method Blank	Client:	Environmental Partners
Date Received:	Not Applicable	Project:	74001 Brookdale, F&BI 805114
Date Extracted:	05/15/18	Lab ID:	08-1070 mb 1/6
Date Analyzed:	05/16/18	Data File:	051633.D
Matrix:	Soil	Instrument:	GC7
Units:	mg/kg (ppm) Dry Weight	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
TCMX	90	50	150
DBC	98	50	150

Compounds:	Concentration mg/kg (ppm)
Dieldrin	<0.01

Date of Report: 05/23/18
Date Received: 05/07/18
Project: 74001 Brookdale, F&BI 805114

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF SOIL SAMPLES FOR ORGANOCHLORINE PESTICIDES BY EPA METHOD 8081B

Laboratory Code: 805108-04 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	<0.01	89	90	50-150	1

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	94	70-130

Date of Report: 05/23/18
Date Received: 05/07/18
Project: 74001 Brookdale, F&BI 805114

**QUALITY ASSURANCE RESULTS
FOR THE ANALYSIS OF SOIL SAMPLES FOR
ORGANOCHLORINE PESTICIDES
BY EPA METHOD 8081B**

Laboratory Code: 705114-11 1/6 (Matrix Spike) 1/6

Analyte	Reporting Units	Spike Level	Sample Result	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Dieldrin	mg/kg (ppm)	0.1	4.9	0 b	0 b	50-150	0 b

Laboratory Code: Laboratory Control Sample 1/6

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Dieldrin	mg/kg (ppm)	0.1	88	70-130

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for the analyte were outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte may be due to carryover from previous sample injections.

cf - The sample was centrifuged prior to analysis.

d - The sample was diluted. Detection limits were raised and surrogate recoveries may not be meaningful.

dv - Insufficient sample volume was available to achieve normal reporting limits.

f - The sample was laboratory filtered prior to analysis.

fb - The analyte was detected in the method blank.

fc - The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. Variability is attributed to sample inhomogeneity.

hs - Headspace was present in the container used for analysis.

ht – The analysis was performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j - The analyte concentration is reported below the lowest calibration standard. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The laboratory control sample(s) percent recovery and/or RPD were out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the analyte is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc - The sample was received with incorrect preservation or in a container not approved by the method. The value reported should be considered an estimate.

ve - The analyte response exceeded the valid instrument calibration range. The value reported is an estimate.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

805714

SAMPLE CHAIN OF CUSTODY

ME 05-07-18 — Page # 1 of 4 (COS)

Report To: Beau Johnson
Company: EPI
Address: 1180 NW Maple St.
City, State, ZIP: Issaquah, WA 98027
Phone: 425-395-0010 Email: beauj@epi-wa.com

SAMPLERS (signature)	
PROJECT NAME: 74001	PO #
REMARKS	INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
PG1-E:0.5	01	05/07/18	820	SOIL	1								X				ARCHIVE SAMPLES
PG1-E:1.0	02	↓	822	↓	↓								X				NOT CHECKED FOR ANALYSIS
PG1-E:1.5	03		826														◆ - per BJ
PG1-E:2.0	04		835										◆	No MA	5/15/18		5/15/18 ME
PG1:0.5	05		844										X				
PG1:1.0	06		848										X				
PG1:1.5	07		856														
PG1:2.0	08		904										◆				
PG2:0.5	09		919										X				
PG2:1.0	10	↓	921	↓	↓								X				

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. Hinsperger	EPI	05/07/18	1405
Received by: [signature]	Elizabeth Webber-Bruya	F&BI	05/07/18	1405
Relinquished by:				
Received by:		Samples received at 5 °C		

805114

SAMPLE CHAIN OF CUSTODY

ME 05-07-18 COS

Page # 2 of 4

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP 1180 NW Maple St.

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)

PROJECT NAME: 2400(

PO #:

REMARKS:

INVOICE TO:

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
PG2-NW:0.5	11	05/07/18	1011	SOIL	1								X				
PG2-NW:1.0	12	↓	1013	↓	↓								X				
PG2-NW:1.5	13	↓	1016	↓	↓												
PG2-NW:2.0	14	↓	1020	↓	↓								◆				
TEE4-C:0.5	15	↓	1152	↓	↓								X				
TEE4-C:1.0	16	↓	1155	↓	↓								X				
TEE4-C:1.5	17	↓	1202	↓	↓												
TEE4-C:2.0	18	↓	1210	↓	↓												
TEE4-S:0.5	19	↓	1215	↓	↓								X				
TEE4-S:1.0	20	↓	1223	↓	↓								X				

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SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. Winsperger	EPI	05/07/18	1405
Received by: [signature]	Elizabeth Webber-Bye	F?BI	5/7/18	1405
Relinquished by:				
Received by:				

805114

SAMPLE CHAIN OF CUSTODY

ME 05-07-18

Page # 3 of 4 (COS)

Report To Beau Johnson

Company EPI

Address 1180 NW Maple St.

City, State, ZIP Issaquah, WA 98027

Phone 425-395-0010 Email beauj@epi-wa.com

SAMPLERS (signature)

PROJECT NAME 74001

PO #

REMARKS

INVOICE TO

TURNAROUND TIME
☑ Standard Turnaround
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
PG 2 : 1.5	21	05/07/18	923	SOIL	1												
PG 2 : 2.0	22	↓	926	↓	↓								◆				
PG 2-S : 0.5	23		932										X				
PG 2-S : 1.0	24		938										X				
PG 2-S : 1.5	25		944														
PG 2-S : 2.0	26		950														
PG 2-NE : 0.5	27		958										X				
PG 2-NE : 1.0	28		1001										X				
PG 2-NE : 1.5	29		1003														
PG 2-NE : 2.0	30	↓	1005	↓	↓								◆				

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Seattle, WA 98119-2029
Ph. (206) 285-8282

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	N. HINSPERGER	EPI	05/07/18	1405
Received by:	[signature]	Elizabeth Webber-Bruya	F&BI	5/7/18	1405
Relinquished by:					
Received by:					

805114

SAMPLE CHAIN OF COUSTODY

ME 05-07-18

Page # 4 of 4

Report To BEAL JOHNSON

Company EPI

Address 180 NW MAPLE ST. SUITE 310

City, State, ZIP ISSAQUAH, WA 98027

Phone (425) 395-0010 Email

SAMPLERS (signature)	
[signature]	
PROJECT NAME	PO #
BROOKDALE	
REMARKS	INVOICE TO

TURNAROUND TIME
☒ Standard Turnaround
☐ RUSH
Rush charges authorized by:
SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Archive Samples
☐ Other

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of Jars	TPH-HCID	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260C	SVOCs by 8270D	PAHs 8270D SIM	PESTICIDES 8081				Notes
TEE 4-5: 1.5	31	05/07/18	1231	SOIL	1												
TEE 4-5: 2.0	32	↓	1233	↓	↓												

Friedman & Bruya, Inc.

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Seattle, WA 98119-2029

Ph. (206) 285-8282

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	N. HINSPERGER	EPI	05/07/18	1405
Received by: [signature]	Elizabeth Webber-Bruya	F&BI	5/7/18	1405
Relinquished by:				
Received by:				

Attachment E
Terrestrial Ecological Evaluation Literature Survey

Mutation Research, 224 (1989) 437–445
Elsevier

MUTGEN 01485

Clastogenicity evaluation of seven chemicals commonly found at hazardous industrial waste sites

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Keywords: Clastogenicity; Industrial waste; Tradescantia; Micronucleus

Summary

7 chemicals commonly found at the industrial waste sites were tested with the Tradescantia–Micronucleus (Trad–MCN) assay to evaluate their clastogenic potential. Chemicals selected from the US EPA Superfund Priority 1 list were: aldrin, arsenic trioxide, 1,2-benz[*a*,*h*]anthracene, dieldrin, heptachlor, lead tetraacetate and tetrachloroethylene. Results of repeated tests for clastogenicity yielded the minimum effective dose (MED) for clastogenicity of 0.44 ppm for lead tetraacetate, 1.88 ppm for heptaclor, 3.81 ppm for dieldrin and arsenic trioxide and 1,2-benz[*a*,*h*]anthracene yielded positive responses at the MED of 3.96 ppm and 12.50 ppm respectively. Aldrin and tetrachloroethylene were considered to be immiscible with water, and the tests yielded negative responses. Tetrachloroethylene in gaseous state was also used to treat the flower buds. Results of tetrachloroethylene vapor phase treatment yielded a positive response at the MED of 30 ppm/min after a 2-h exposure. 5 chemicals determined to be clastogens by this test were ranked according to their MED in the descending order of potency as follows: lead tetraacetate, heptachlor, dieldrin, arsenic trioxide and 1,2-benz[*a*,*h*]anthracene. Results of this study indicate that the Trad–MCN bioassay could be effectively utilized for assessing the potential clastogenicity of the chemicals commonly found at the industrial hazardous waste sites.

The chemicals abandoned at the industrial waste sites are the major environmental pollutants in the soil and water of the nearby area. The long-range effects of these hazardous wastes carried in the water table and accumulated in the aquafers are the worries for generations to come. Among more than a thousand known contaminants in the ground water near these waste sites, 7 chemicals were selected from the US EPA's Priority 1 chemical list (Waters et al., 1987) for laboratory tests using the Tradescantia–Micronucleus (Trad–MCN) bioassay. The main purpose of this investigation is to determine the "Minimum Effective Dose" (MED) of each of these chemicals under this test system. The extended aim is to validate the Trad–MCN bioassay for its capability to de-

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0165-1218/89/$03.50

tect these individual chemicals at their relative low concentrations before testing the mixture forms (Yang and Rauchman, 1987) or conducting on site monitoring (Ma et al., 1984). Although Trad–MCN has been applied to ground water testing (Ma et al., 1987), surface water testing (Ma et al., 1985) and mutagenicity analysis of soil samples (Ho et al., 1983) as well as on site monitoring of air pollutants (Ma et al., 1982; Fang, 1981), a clastogenicity test of water and soil samples from the hazardous waste sites has so far not been conducted. The results of this study could determine the efficacy of the Trad–MCN bioassay for clastogenicity studies of the agents found at the hazardous waste sites.

Materials and methods

Plants of Tradescantia clone No. 4430 used in this investigation were raised in a greenhouse and were pre-conditioned in a growth chamber at a temperature range of 16–25 °C and a 16/8 h (light/dark) photoperiod for 2 weeks or more before the cuttings were selected for conducting tests. The 7 chemicals used in this study were randomly selected from US EPA's Superfund Priority 1 list. Arsenic trioxide (CAS No. 7440-38-2 + 3), 1,2-benz[*a*,*h*]anthracene (CAS No. 53-70-3), dieldrin (CAS No. 60-57-1), lead tetraacetate (CAS No. 7439-92-1), and tetrachloroethylene (CAS No. 127-18-4) were obtained from Aldrich Chemical Company, 940 W. St. Paul, Milwaukee, WI 53233. Aldrin (CAS No. 309-00-2) was obtained from Crescent Chemical Inc., 1312 Motor Parkway, Hauauppauge, NY 11788 and heptachlor (CAS No. 76-44-8) from Chem Service Inc., P.O. Box 3108, West Chester, PA 19381. The purity level for these compounds was greater than 99%.

A series of preliminary experiments was conducted to determine the solubility in water, dimethyl sulfoxide (DMSO), ethanol (EtOH) and NaOH alkaline solution, as well as the optimal dose range for each of these chemicals under the pH range of 6–9. Since most of these chemicals were insoluble in water, aldrin, dieldrin, heptachlor, lead tetraacetate and tetrachloroethylene were first dissolved in DMSO and then diluted with water to the proper concentrations to treat the plant cuttings. Both aldrin and tetrachloroethylene were precipitated out after mixing with water. Arsenic trioxide was first dissolved in NaOH solution, and 1,2-benz[*a*,*h*]anthracene was dissolved in EtOH for treatments.

The plant cutting selection, treatment procedure, sample size, fixation, data collection, and analysis followed the conventional protocol as described in an earlier publication (Ma, 1983). As a rule, around 1500 tetrads per experimental group were scored to derive the MCN/100 tetrads frequencies. Analysis of variance and the Dunnett's t statistic were used to determine the significance of the difference among a series of treated against one control group. Since the chemicals used in the treatment solutions were in relatively low concentration, a modified procedure of 30 h continuous treatment period without recovery time was used (Ma et al., 1984, 1987). Most of the diluted water solutions for treatments were more-or-less in an emulsion state. Absorption of the very diluted emulsion through the vascular system of the plant cuttings was efficient enough to induce the chromosome damage judging by the cause/effect relationship (Ma et al., 1983a, 1984). Although Trad–MCN bioassay is primarily a genotoxicity test using the MCN frequency as the indicator of chromosome damage, the physiological injuries of the leaves and stem as well as the flower buds are also the reliable endpoints of toxicity and, at the same time, the signs of overdose. The overdose effects can also be expressed by the presence of dead cells in the tetrads (Ma et al., 1983a) and the decline of MCN frequencies. During the treatment period, the liquid mixtures were aerated by bubbling air through a fine tubing (2 mm in diameter). For inorganic chemicals, a $NaHSO_3$ solution was used as the positive control, and for the organic chemicals, benzo[*a*]pyrene was used as the positive control. Appropriate solvent controls were used to rule out the excessive clastogenicity of the solvents. A dynamic flow gas fumigation system (Ma et al., 1984) was used for gaseous treatment.

Results and discussion

Arsenic trioxide is used in manufacturing glass and enamel in addition to its extensive usage as a herbicide and an insecticide. The genotoxic effects of arsenic trioxide has been extensively evaluated in a variety of in vitro and in vivo animal test systems. This compound yielded negative responses for gene mutation in prokaryotic systems (Rossman et al., 1980; Tiedmann and Einbrodt, 1982; Marzin and Phi, 1985; Hemmerly and Demerec, 1955), in Chinese hamster lung cells (Rossman et al., 1980), Syrian hamster embryo cells (Lee et al., 1985) and in the *Drosophila melanogaster* sex-linked recessive lethal assay (Dugatova, 1980). However, in most of the studies, this compound has produced positive results for chromosome aberrations in human lymphocytes (Nakamuro and Sayato, 1981; Oppenheim and Fishheim, 1965; Sweins, 1983; Wan et al., 1982; Larramendy et al., 1981; Nordensen et al., 1981; Zanzoni and Jung, 1980); in Syrian hamster embryo cells (Lee et al., 1985); in Drosophila for aneuploidy (Dugatora et al., 1980); in the mouse micronucleus test (Deknudt et al., 1986) and for chromosome aberrations in mouse bone-marrow cells (Sram, 1976). In the current study, arsenic trioxide was dissolved in NaOH solution at pH 7 in the lower concentrations and at pH close to 9 in the higher concentration. The results of treated samples at 4 concentrations, along with negative, positive and solvent control groups are given in Table 1.

Treatment with the dosage ranging from 0.2 ppm through 19.8 ppm gave a dose-related increase of MCN frequencies. Clastogenic responses given in this bioassay agree with the earlier findings on chromosome breaks in human lymphocytes, and SCE in cultured cells of human and Syrian hamsters (Larramendy et al., 1981; Nordenson et al., 1981; Nakamuro and Sayato, 1981).

The hazardous chemical, 1,2-benz[*a*,*h*]anthracene is a coal tar byproduct. It has been reported to covalently bound to DNA (Alfred and Dipaolo, 1968; Kuroki and Heidelberger, 1971; Duncan and Brooks, 1972; Bowden et al., 1974), and induced cell transformation (Sivak et al., 1980; Reznikoff et al., 1973; Hubermann et al., 1972; Pienta et al., 1977; Casto, 1973). The only clastogenicity evaluation of this compound was reported by Pal (1981) who claimed that the derivatives of this compound induced a high rate of SCE in cultured Chinese hamster ovary cells.

Ethanol was a better solvent for 1,2-benz[*a*,*h*]-anthracene than DMSO. The diluted EtOH solution of this chemical was utilized to treat the plant cuttings. Results of a series of treatments with increasing dosages, together with the negative and the solvent controls are given in Table 2.

Positive responses were demonstrated if the treated groups were compared with the negative control (water), but only T-2 and T-3 groups showed positive responses if they were compared with the solvent control (1.5% ethanol).

The biological effects of lead compounds in general have been studied through epidemiological approaches in occupationally-exposed populations (Al-Hakkak et al., 1986; Ding, 1987; Ichiba et al., 1987; Parkinson et al., 1987; Schmid and Bauchinger, 1972). Cytogenetic damage, physiological disturbance, blood pressure, and possibly

TABLE 1

CLASTOGENICITY OF ARSENIC TRIOXIDE DETECTED BY THE Trad–MCN BIOASSAY

Expt. group	Solvent	Concentration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	NaOH	0.20 ppm	1.27	0.30	–	pH = 7
T-2	NaOH	1.98 ppm	6.70	4.64	+/–	pH = 7
T-3	NaOH	3.96 ppm	8.18	2.74	+	pH = 8
T-4	NaOH	19.80 ppm	36.99	10.41	+	pH = 9
C-W	water		1.20	0.26		negative control
C-S	NaOH	9.25 ppm [a]	2.03	0.71		solvent control
C-P	$NaHSO_3$ [b]	5.20 ppm	12.30	0.60	+	positive control

[a] Solvent only.
[b] Known clastogen.

TABLE 2

CLASTOGENICITY OF 1,2-BENZ[*a*,*h*]ANTHRACENE DETECTED BY THE Trad–MCN BIOASSAY

Expt. group	Solvent	Concentration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	EtOH	2.5 ppm	5.69	1.40	–	
T-2	EtOH	12.5 ppm	6.24	1.51	+	
T-3	EtOH	25.0 ppm	8.92	1.13	+	
T-4	EtOH	50.0 ppm	5.87	0.85	–	overdose [a]
C-W	water		3.65	0.43		negative control
C-S	EtOH	1.5% [b]	4.30	0.85		solvent control
C-P	BaP	12.6 ppm	15.50	1.52	+	positive control

[a] Dead cells and physiological injuries of leaves and flower buds.
[b] Solvent only.

the cancer rate were affected by lead exposures in vivo. Lead acetate was reported to be a strong clastogen which breaks chromosomes in Chinese hamster ovary cells (Bauchinger and Schmid, 1972), in bone-marrow erythrocytes of rats (Kharchenko and Andreera, 1987; Tachi et al., 1985) and in cultured lymphocyte of humans. Chromatid aberrations were incuded by lead compounds of different valences at different rates (Gasiorek and Bauchinger, 1981). Kharchenko and Andreera (1987) claimed that spermatogenesis in rats was inhibited by lead acetate. Results of current tests on lead tetraacetate at 6 increasing dosages are given in Table 3. Positive responses were observed in lower dosages while the concentrations equal to or higher than 23.5 ppm were toxic and exhibited the overdose effects. The MED of this chemical was as low as 0.44 ppm for Trad–MCN test. Perhaps it was due to the high toxicity of this chemical that no positive linear dose-response could be obtained. Its range of clastogenicity was rather narrow. Although a great deal of attention has been paid to the hazardous nature of this group of simple organic lead molecules, more studies should be performed because of its high toxicity and clastogenicity.

Dieldrin, an insecticide, has shown no detectable mutagenic response in several prokaryotic and eukaryotic bioassays. In a few cytogenetic studies, i.e. mouse bone-marrow cells (Dean et al.,

TABLE 3

CLASTOGENICITY OF LEAD TETRAACETATE DETECTED BY THE Trad–MCN BIOASSAY

Expt. group	Solv.	Concentration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	DMSO	0.44 ppm	17.79	8.56	+	high variance
T-2	DMSO	2.35 ppm	18.93	2.90	+	
T-3	DMSO	11.75 ppm	13.07	5.50	+	
T-4	DMSO	23.50 ppm	3.34	0.43	–	overdose [a]
T-5	DMSO	44.00 ppm	2.81	0.31	–	overdose [a]
T-6	DMSO	88.00 ppm	2.20	0.67	–	overdose [a]
C-S	DMSO	0.25 ppm [b]	2.90	2.0		solvent control
C-W	Water		1.81	0.54		negative control
C-P	BaP	12.60 ppm	15.50	1.52	+	positive control

[a] Dead cells and physiological injuries of leaves and flower buds.
[b] Solvent only.

TABLE 4

CLASTOGENICITY OF DIELDRIN DETECTED BY THE Trad–MCN ASSAY

Expt. group	Solvent	Concentration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	DMSO	0.38 ppm	1.35	0.4	–	
T-2	DMSO	3.81 ppm	9.80	1.8	+	
T-3	DMSO	19.05 ppm	3.40	0.6	–	overdose [a]
C-S	DMSO	0.25% [b]	2.90	2.0		solvent control
C-W	water		1.81	0.5		negative control
C-P	BaP	12.60 ppm	15.50	1.52	+	positive control

[a] Dead cells and physiological injuries of leaves and flower buds.
[b] Solvent only.

1975), the mouse dominant lethal assay (Dean et al., 1975, Epstein et al., 1972) and human lymphocytes in vivo (Dean et al., 1975), this compound yielded negative results. However, positive responses were obtained in studies on inhibition of intercellular communication of rodent cells in vitro (Kurata et al., 1982; Wade et al., 1980; Lin et al., 1986).

Positive response was obtained in the current study with the dieldrin treatment at around 3.81 ppm. The results are given in Table 4.

The chemical used in this test was in a 0.25% DMSO solution, and the solvent control group of this DMSO concentration gave a slightly elevated MCN frequency. A 5-fold increase of the MED gave an overdose response. Dead cells and dissynchrony of the meiotic stages of the pollen mother cells were observed in the overdosed group.

The insecticide heptachlor (heptachloro-tetrahydro-methanoindene) is known to be toxic and inhibitory to fetal development in rats (Yamaguchi et al., 1987). However, for gene mutation (Marshall et al., 1976) and DNA damage (Probst et al., 1981), heptachlor produced negative results except the waxy mutation in maize (Gentile et al., 1982). It also yielded negative response in the mouse dominant lethal assay (Epstein et al., 1972). However, this compound was positive for the inhibition of intercellular communication in rodent cells treated in vitro (Telang et al., 1982; Kurata et al., 1982). At the dosage ranging from 5 to 20 mg/kg to rat, reduced body weight and higher mortality rates were observed (Yamaguchi et al., 1987).

Current data which are given in Table 5 indicate high toxicity at around 18.8 ppm, and a short range of dose-related responses beginning at 1.88 ppm.

Both aldrin and tetrachloroethylene were immiscible with water although they were soluble in

TABLE 5

CLASTOGENICITY OF HEPTACHLOR DETECTED BY THE Trad–MCN BIOASSAY

Expt. group	Solvent	Concentration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	DMSO	1.88	5.90	1.30	+	
T-2	DMSO	9.40	8.20	2.34	+	
T-3	DMSO	18.80	4.80	0.67	+/–	overdose [a]
C-S	DMSO	0.25% [b]	2.90	0.20		solvent control
C-W	water		1.88	0.35		negative control
C-P	BaP	12.60 ppm	12.60	1.52	+	positive control

[a] Dead cells.
[b] Solvent only.

TABLE 6

CLASTOGENICITY EVALUATION OF ALDRIN IN THE Trad–MCN ASSAY

Expt. group	Solvent	Concen- tration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	DMSO	1.83 ppm	3.59	0.97	–	immiscible
T-2	DMSO	9.15 ppm	3.10	0.49	–	with water
T-3	DMSO	36.59 ppm	3.89	0.63	–	
C-S	DMSO	0.5% [a]	5.30	0.22		solvent control
C-W	water		4.26	0.52		negative control
C-P	BaP	12.60 ppm	15.50	1.52	+	positive control

[a] Solvent only.

DMSO but precipitated out after mixing with water. Thus, little absorption of these chemicals through the stem could take place. Negative responses were obtained in the dosages given in these tests as shown in Tables 6 and 7. A positive control group using benzo[*a*]pyrene was included in Tables 2–7, and serves as the reference for organic compounds in this study. Tetrachloroethylene was also tested under its gaseous state. Preliminary results are given in Table 7.

Clastogenicity studies of aldrin (an insecticide) conducted in human lymphocyte cultures (Georgian, 1975) and the MCN induction in vivo in mice and rats (Rani et al., 1980) showed positive results for chromosome aberrations but yielded no detectable response for micronuclei induction and for dominant lethal test in mice (Georgian, 1975).

Tetrachloroethylene (a volatile compound used in dry cleaning and for decreasing metals) is a well known neurotoxin. An epidemiological survey has been made in dry cleaning workers who were chronically exposed for a long duration (Bazylewicz-Walczak and Marszal-Wisniewska, 1986; Dudek and Nowachi, 1987). These indicated that this chemical affected the function of the psychomotor and central nervous system, and caused neurological disturbances. Ikeda et al. (1980) reported chromosome damage in cultured lymphocytes in humans.

Based upon the data obtained from Trad–MCN tests, 5 out of 7 chemicals were positive, and these clastogens can be ranked according to their MED in the following descending order of potency: lead tetraacetate (0.44 ppm), heptachlor (1.88 ppm), dieldrin (3.81 ppm), arsenic trioxide (3.96 ppm), 1,2-benz[*a*,*h*]anthracene (12.50 ppm). Based upon the study of Yang and Rauchman (1987), the average concentration of arsenic trioxide in the

TABLE 7

CLASTOGENICITY EVALUATION OF TETRACHLOROETHYLENE (IN LIQUID AND GASEOUS FORMS) IN THE Trad–MCN ASSAY

Expt. group	Solvent	Concen- tration	MCN/100 tetrads	S.E.	Signif. 0.05	Remarks
T-1	DMSO	150 ppm	1.22	0.26	–	immiscible
T-2	DMSO	300 ppm	4.99	0.62	–	with water
T-3	DMSO	600 ppm	3.23	0.92	–	
T-G		30 ppm/min/2 h	4.56	0.71	+	gaseous
C-G			1.90	0.25		gas control
C-S	DMSO	2% [a]	6.93	2.91	+/–	solvent control
C-P	BaP [b]	12.6 ppm	15.50	1.52	+	positive control

[a] Solvent only.

[b] Known clastogen.

ground water samples collected near the hazardous waste sites was about 7 times (30.60 ppm/3.96 ppm) higher than the MED obtained by the Trad-MCN bioassay, and the average lead concentration was about 80 times (37.0 ppm/0.44 ppm) higher than the MED. Results of the current study indicate that the Trad-MCN bioassay was capable to detect very low concentrations of clastogens in liquid forms if absorbed through the vascular system of the plant cuttings. It is a potential bioassay to assess the clastogenicity of chemicals commonly found at the industrial hazardous waste sites.

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GROWTH AND REPRODUCTION OF THE EARTHWORM *EISENIA FETIDA* EXPOSED TO SUBLETHAL CONCENTRATIONS OF ORGANIC CHEMICALS

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Summary—The determination of a short-term LC_{50} toxicity value for a chemical is a useful indicator of the potential biological effect of the chemical if released into the environment. However, it is possible that adverse effects of the chemical may occur at sublethal concentrations far below LC_{50} values. Using the earthworm *Eisenia fetida* (Savigny) as an indicator organism for soil ecosystems, concentrations of 10 organic chemicals were evaluated for sublethal effects on earthworm growth and reproduction.

Following short-term exposure to sublethal concentrations of carbaryl and dieldrin, *E. fetida* was allowed to resume growth and reproduction to determine whether such effects were permanent.

The effect on earthworm populations as a representative soil organism could be a sentinel for the effects of more destructive soil processes.

INTRODUCTION

Man's activities have resulted in increasing concentrations of potentially-toxic materials being deliberately or unintentionally distributed in soil ecosystems. Soil can no longer be considered a waste depository without consideration of effects on soil ecosystems. Earthworms, one of the largest and most easily quantified components of soil biota, play a major role in maintaining soil fertility and structure (Edwards and Lofty, 1977). The effect on earthworms as a representative soil organism could be a sentinel for the indication of more destructive soil processes.

A number of laboratories have developed earthworm toxicity tests (Davis, 1971; Stenersen, 1979; Lofs-Holmin, 1980, 1982; Goats and Edwards, 1982; Karnak and Hamelink, 1982). Most of these tests have involved measuring the LC_{50} of various chemicals, mostly pesticides. Lofs-Holmin evaluated the sublethal effects of pesticides on earthworm growth (Lofs-Holmin, 1980) and reproduction (Lofs-Holmin, 1982).

The LC_{50} of a given chemical is often not a useful indicator of the potential ecological consequences of the chemical, because reproduction may be inhibited or halted at chemical concentrations far below a given LC_{50} (Neuhauser *et al.*, 1984). Other sublethal effects on earthworms include decreased nervous system functioning (Drewes *et al.*, 1987; Callahan *et al.*, 1985). To gain an insight into the sublethal effects of organic chemicals, the effects of priority pollutants (US EPA, 1979) on earthworm growth and reproduction were examined. To further evaluate the persistence of sublethal effects of two chemicals, carbaryl and dieldrin, earthworms exposed to each chemical were subsequently allowed to grow and reproduce without further exposure to the chemicals.

METHODS AND MATERIALS

Growth and reproduction

The test components included basic organic media (horse manure), sand, the test chemical and deionized water. Glass Petri dishes, 100 by 20 mm were used as experimental containers. Industrial quartz sand (dominant fine sand with >50% of particles sized 0.05–0.2 mm) were used to provide drainage. Dry sand (30 g) was placed in the bottom of the dish. The sand was brought to 20 ± 2% moisture by adding the proper amount of water to the dish. A mixture of the horse manure and the test substrate (20 g wet wt) was placed on top of the sand. The controls contained only horse manure, sand and deionized water. The manure contained a moisture content of 75 ± 5% after the test chemical was added. If the test chemical added to the manure was not water-soluble, an organic solvent, such as acetone, was added in the same quantity to the control manure. Sequential weighings were made to insure that all of the organic solvent was evaporated before the worms were added to the manure. None of the chosen test chemicals were volatile. When the moisture content was <75% after the test chemical was added, deionized water was added to the manure to bring the moisture content up to the prescribed level. Care was exercised to insure that the test chemical was evenly distributed and mixed into the manure.

Two young worms, <10 mg and <1 week old, were added to each of five Petri dishes for each chemical concentration tested. The Petri dishes were kept at a temperature of 25°C for the duration of the test. This temperature was found to give maximum growth and reproduction for *Eisenia fetida* (Savigny) (Kaplan *et al.*, 1980). Under these circumstances

Table 1. The mean final weights of *E. fetida* (g worm^{-1}) and total cocoon production worm^{-1} 8 weeks^{-1} for the concentration (mg kg^{-1}) of organic chemicals indicated (N = 10)

	Chemical concentration (mg kg^{-1})								F value
Carbaryl	0	25	50	100	150	200	250	500	
Weight	0.47^{a1}	0.35^{b}	0.31^{b}	0.17^{cd}	0.10^{d}	0.20^{c}	0.14^{cd}	Death	$F^{6}_{21} = 16.72^{*2}$
Cocoons	7.7^{a}	3.1^{b}	1.2^{b}	0^{b}	0^{b}	0^{b}	0^{b}		$F^{6}_{21} = 28.09^{*}$
Chloroacetamide	0	250	300	350	400	450	500	1000	
Weight	0.41^{a}	0.44^{a}	0.42^{a}	0.37^{a}	0.47^{a}	0.46^{a}	0.44^{a}	Death	$F^{6}_{27} = 1.08$
Cocoons	7.4^{a}	5.7^{a}	5.5^{a}	5.8^{a}	8.8^{a}	8.8^{a}	7.4^{a}		$F^{6}_{27} = 2.45$
1,2 *Dichloropropane*	0	34,800	46,300	57,800	69,300	80,800	92,300		
Weight	0.51^{a}	0.50^{a}	0.52^{a}	0.47^{a}	0.57^{a}	0.53^{a}	Death		$F^{5}_{17} = 2.02$
Cocoons	7.1^{a}	6.4^{a}	8.3^{a}	5.3^{a}	7.0^{a}	6.3^{a}			$F^{5}_{17} = 2.75$
Dieldrin	0	25	50	100	150	200	250	500	
Weight	0.45^{a}	0.48^{a}	0.41^{a}	0.42^{a}	0.32^{b}	0.24^{b}	0.14^{b}	Death	$F^{6}_{24} = 14.15^{*}$
Cocoons	8.4^{a}	4.6^{b}	3.5^{b}	0^{c}	0^{c}	0^{c}	0^{c}		$F^{6}_{24} = 14.85^{*}$
Dimethylphthalate	0	5900	11,800	23,600	47,200	70,800	94,400		
Weight	0.41^{a}	0.39^{a}	0.39^{a}	0.38^{a}	0.36^{a}	0.35^{a}	Death		$F^{5}_{24} = 0.49$
Cocoons	7.7^{a}	9.3^{a}	8.2^{a}	7.2^{a}	7.3^{a}	2.9^{b}			$F^{5}_{24} = 7.34^{*}$
N-Nitrosodiphenylamine	0	1400	1600	1800	2000	2200	2400		
Weight	0.52^{a}	0.57^{a}	$0..39^{a}$	0.46^{a}	0.44^{a}	0.39^{a}	Death		$F^{5}_{18} = 2.58$
Cocoons	8.7^{a}	5.0^{b}	1.2^{b}	2.4^{b}	3.7^{b}	1.2^{b}			$F^{5}_{18} = 4.43^{*}$
Fluorene	0	250	500	750	1000	1500			
Weight	0.57^{a}	0.49^{a}	0.51^{a}	0.47^{a}	0.43^{a}	Death			$F^{4}_{19} = 2.14$
Cocoons	7.1^{a}	6.2^{a}	6.3^{a}	3.6^{b}	4.3^{a}				$F^{4}_{19} = 4.56^{*}$
4-*Nitrophenol*	0	600	900	1200	1500	1800	2000		
Weight	0.49^{a}	0.47^{a}	0.50^{a}	0.43^{a}	0.46^{a}	0.42^{a}	Death		$F^{5}_{16} = 1.01$
Cocoons	7.4^{a}	4.5^{ab}	3.4^{bc}	1.9^{c}	2.8^{c}	0.3^{d}			$F^{5}_{16} = 3.13^{*}$
Phenol	0	2400	2900	3400	3900	4900	5900	6900	
Weight	0.50^{a}	0.47^{a}	0.48^{a}	0.53^{a}	0.53^{a}	0.54^{a}	0.56^{a}	Death	$F^{6}_{24} = 1.01$
Cocoons	8.4^{a}	10.3^{a}	9.6^{a}	8.7^{a}	6.9^{a}	6.2^{a}	9.5^{a}		$F^{6}_{24} = 1.41$
2,4,6 *Trichlorophenol*	0	100	200	300	400				
Weight	0.43^{a}	0.50^{a}	0.46^{a}	0.42^{a}	Death				$F^{3}_{13} = 2.84$
Cocoons	6.9^{a}	5.0^{ab}	3.4^{b}	4.0^{b}					$F^{3}_{13} = 3.93^{*}$

[1]Means with a common letter in the same row are not significantly different, $P < 0.05$. N = 10 for all points.
[2]*Indicates significant F value at degrees of freedom indicated, $P < 0.05$.

Table 2. The lowest concentration of test chemicals that showed a significant difference in growth or reproduction from the control *E. fetida*

Chemical	Lowest concentration of chemical ($mg\ kg^{-1}$) to show significant difference from control for: Growth	Reproduction
Carbaryl	25	25
Dieldrin	150	25
2,4,6 Trichlorophenol	Death at 400	200
Chloroacetamide	Death at 1000	NE[1]
Fluorene	Death at 1500	750
4-Nitrophenol	Death at 2000	900
N-Nitrosodiphenylamine	Death at 2400	1400
Phenol	Death at 6900	NE
1,2 Dichloropropane	Death at 92,300	NE
Dimethylphthalate	Death at 94,400	70,800

NE[1]—no effect observed at the highest non-lethal concentration.

growth and reproduction were not limited by the amount of manure (Neuhauser *et al.*, 1980). The complete exposure was for 8 weeks although worms were also evaluated for growth and reproduction at 4 and 6 weeks. At these times, cocoons were removed and the worms were re-fed new manure, to which the appropriate concentration of test substance was added. The range of concentrations tested for each chemical included one concentration that had no sublethal effect, at least four concentrations that had a sublethal effect and one concentration that had a lethal effect. Selection of these concentrations helped to optimize the possibility of separating threshold concentrations for impairment of growth and reproduction.

The final earthworm weight and mean cocoon production per worm per 8 weeks for each chemical concentration were tested for significant differences using one-way analysis of variance. When a significant F value was obtained, Duncan's new multiple range test (Steel and Torrie, 1960) was used to determine differences.

Recovery

To evaluate the possible residual effects of persistent chemicals, the worms exposed to carbaryl and dieldrin were tested for an additional 8 weeks in manure without added chemicals. The worms were evaluated for growth and reproduction at every 2 weeks. The old manure and cocoons were removed and the worms were re-fed fresh untreated manure at each observation opportunity. The final earthworm weights and mean cocoon production per worm for weeks 8–16 were tested for significant differences using one-way analysis of variance. When a significant F value was obtained, Duncan's new multiple range test (Steel and Torrie, 1960) was used to determine differences.

RESULTS AND DISCUSSION

Growth and reproduction

The final weights and total cocoon production achieved by *E. fetida* exposed to the various concentrations of test chemicals show that only carbaryl and dieldrin caused statistically-significant reductions in both growth and cocoon production at sublethal chemical concentrations, whereas five other chemicals had a significant effect on cocoon production alone (Table 1).

The highest sublethal concentrations of the other chemicals tested showed no significant weight reductions when compared to controls, although all tests were designed to evaluate both sublethal as well as lethal effects during the exposure period. Dimethylphthalate, *N*-nitrosodiphenylamine, fluorene, 4-nitrophenol and 2,4,6 trichlorophenol significantly reduced reproduction at concentrations that did not kill the worms. Chloroacetamide, 1,2 dichloropropane, and phenol caused no reduction in cocoon production or growth even at the highest concentrations tested.

Carbaryl and dieldrin have been established as neurotoxins to earthworms (Drews and Vining, 1984). These two chemicals affected earthworm growth and reproduction at the lowest concentrations of the ten chemicals tested (Table 2). Venter and Reinecke (1988) demonstrated that exposing *E. fetida* to dieldrin concentrations of 30 $mg\ kg^{-1}$ decreased cocoon production when compared to controls and dieldrin concentrations of 50 $mg\ kg^{-1}$ decreased the rate of clitellate formation.

Recovery

To evaluate the possibility of recovery from sublethal effects after exposure to carbaryl and dieldrin, the horse-manure test-chemical substrate was replaced with horse manure only and earthworm weight and cocoon production were monitored for an additional 8 weeks. Earthworm growth in the presence and absence of carbaryl (Fig. 1) and dieldrin (Fig. 2) show that the worms exposed to sublethal concentrations of each chemical were able to resume normal growth rates when the chemical was removed from their environment.

Growth rates for both carbaryl- and dieldrin-exposed worms generally decreased with increasing concentrations of each chemical (Table 3). Upon removal of the chemical from the worms' environment, those exposed to the highest concentrations of chemical showed the greatest recovery growth rates. At the end of the 16 weeks, the data from Figs 1 and 2 were analyzed and there was no significant difference in the final weight of the worms for any of the concentrations of both chemicals tested, including controls.

Cocoon production was severely hindered by the presence of carbaryl or dieldrin (Table 3). Removal of either chemical permitted cocoon production to begin after 8 weeks for the higher concentrations. At 25 mg carbaryl kg^{-1} and at 25, 50 and 100 mg dieldrin kg^{-1}, a similar number of cocoons were produced as in the controls. It is apparent that the worms were able to start reproduction after the inhibiting chemical was removed.

These results strongly suggest that even though the population density may not be immediately affected (i.e. increased mortality) exposure to sublethal concentrations results in reproductive changes that reduce the succeeding population density. Carbaryl or dieldrin at 50 $mg\ kg^{-1}$ reduced the cocoon production by >50% which means that the populations would be significantly reduced in 2–3 generations (Table 1).

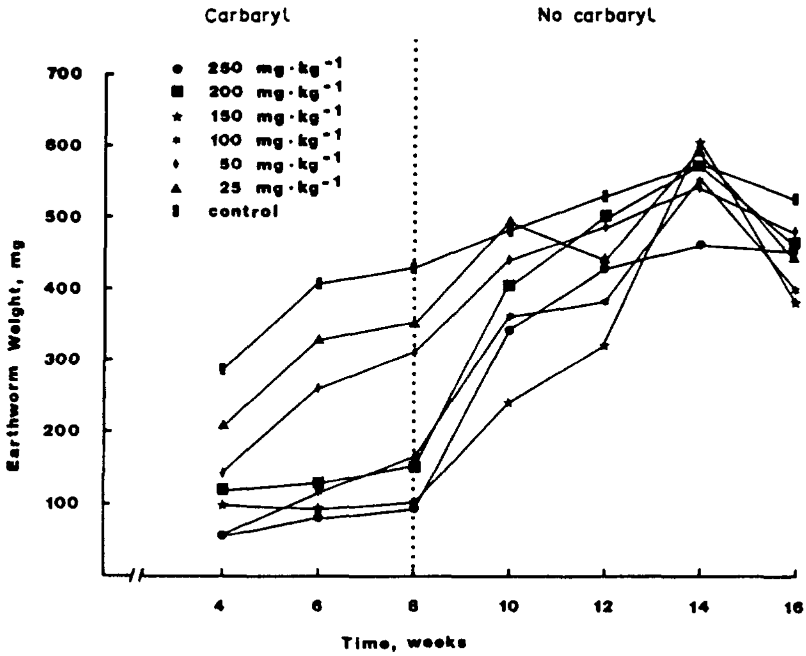

Fig. 1. The growth of *E. fetida* in the presence and absence of various concentrations of carbaryl. $N = 10$.

The sublethal effects of pesticides on earthworms can be very disruptive of important life history events such as growth and reproduction (this research) and nervous system functioning (Drewes and Vining, 1984) which could result in effects on important soil processes. Although recovery of reproduction and nervous system functioning were observed after dieldrin exposure (Drewes and Vining, 1984), more permanent damage has resulted from exposure to benomyl (Drewes *et al.*, 1987), suggesting that recovery may not occur in some cases.

Our research suggests that more consideration should be given to evaluating sublethal effects under field conditions to determine ecological implications of toxic materials. It is obvious that LC_{50} estimates should be considered a first approximation of toxic effect and that more refined tests (e.g. growth and reproduction) should be used to fully evaluate toxic substances.

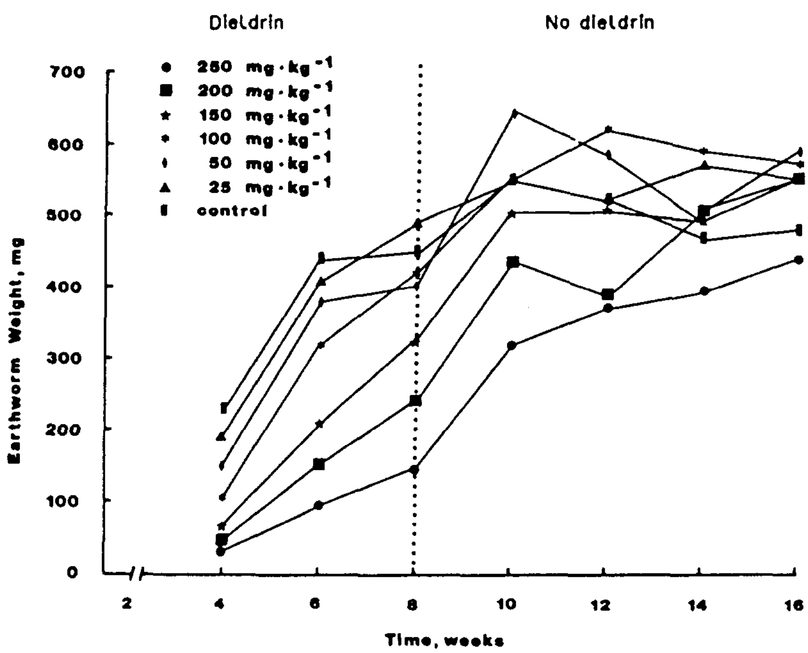

Fig. 2. The growth of *E. fetida* in the presence and absence of various concentrations of dieldrin. $N = 10$.

Table 3. Growth rates and cocoon production for *E. fetida* grown in the presence and absence of carbaryl or dieldrin ($N = 10$)

Concentration (mg kg^{-1})	Carbaryl					Dieldrin				
	Growth (mg day^{-1})		Cocoon production (cocoon's worm^{-1})			Growth (mg day^{-1})		Cocoon production (cocoon's worm^{-1})		
	0–8 weeks carbaryl	8–16 weeks no carbaryl	0–8 weeks carbaryl	0–16 weeks no carbaryl	Total	0–8 weeks dieldrin	8–16 weeks no dieldrin	0–8 weeks dieldrin	8–16 weeks no dieldrin	Total
Control	7.5^{a}[1]	1.8^{a}	7.7^{a}	18.1^{ab}	25.8^{a}	7.9^{a}	0.5^{a}	8.4^{a}	19.4^{ab}	27.8^{a}
25	6.1^{b}	2.0^{a}	3.1^{b}	22.4^{a}	25.5^{a}	8.8^{a}	1.4^{b}	4.6^{b}	24.1^{a}	28.7^{a}
50	5.4^{b}	3.0^{ab}	1.2^{b}	12.7^{c}	13.9^{b}	7.1^{a}	3.2^{b}	2.1^{b}	20.1^{b}	22.2^{a}
100	2.7^{cd}	4.1^{b}	0	10.0^{c}	10.0^{b}	7.3^{a}	2.7^{b}	0	23.8^{a}	23.8^{a}
150	1.6^{d}	5.2^{bc}	0	13.5^{b}	13.5^{b}	5.5^{b}	4.3^{bc}	0	14.9^{bc}	14.9^{b}
200	2.5^{c}	5.5^{c}	0	13.7^{b}	13.7^{b}	4.1^{b}	5.7^{c}	0	15.2^{bc}	15.2^{b}
250	1.4^{d}	6.4^{c}	0	9.6^{c}	9.6^{b}	2.3^{c}	5.4^{c}	0	11.6^{c}	11.6^{b}

[1]Means with a common letter in the same column are not significantly different, $P < 0.05$. $N = 10$ for all points.

Acknowledgement—This work was supported by a Co-operative Agreement from the U.S. Environmental Protection Agency to Cornell University.

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TOXICOLOGICAL PROFILE FOR ALDRIN/DIELDRIN

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

September 2002

DISCLAIMER

UPDATE STATEMENT

A toxicological profile for aldrin/dieldrin was released in 1993. An updated draft for public comment version was released on October 17, 2000. This edition supersedes any previously released draft or final profile.

Toxicological profiles are revised and republished as necessary, but no less than once every three years. For information regarding the update status of previously released profiles, contact ATSDR at:

Agency for Toxic Substances and Disease Registry
Division of Toxicology/Toxicology Information Branch
1600 Clifton Road NE, E-29
Atlanta, Georgia 30333

FOREWORD

This toxicological profile is prepared in accordance with guidelines* developed by the Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Protection Agency (EPA). The original guidelines were published in the *Federal Register* on April 17, 1987. Each profile will be revised and republished as necessary.

The ATSDR toxicological profile succinctly characterizes the toxicologic and adverse health effects information for the hazardous substance described therein. Each peer-reviewed profile identifies and reviews the key literature that describes a hazardous substance's toxicologic properties. Other pertinent literature is also presented, but is described in less detail than the key studies. The profile is not intended to be an exhaustive document; however, more comprehensive sources of specialty information are referenced.

The focus of the profiles is on health and toxicologic information; therefore, each toxicological profile begins with a public health statement that describes, in nontechnical language, a substance's relevant toxicological properties. Following the public health statement is information concerning levels of significant human exposure and, where known, significant health effects. The adequacy of information to determine a substance's health effects is described in a health effects summary. Data needs that are of significance to protection of public health are identified by ATSDR and EPA.

Each profile includes the following:

(A) The examination, summary, and interpretation of available toxicologic information and epidemiologic evaluations on a hazardous substance to ascertain the levels of significant human exposure for the substance and the associated acute, subacute, and chronic health effects;

(B) A determination of whether adequate information on the health effects of each substance is available or in the process of development to determine levels of exposure that present a significant risk to human health of acute, subacute, and chronic health effects; and

(C) Where appropriate, identification of toxicologic testing needed to identify the types or levels of exposure that may present significant risk of adverse health effects in humans.

The principal audiences for the toxicological profiles are health professionals at the federal, state, and local levels; interested private sector organizations and groups; and members of the public.

This profile reflects ATSDR's assessment of all relevant toxicologic testing and information that has been peer-reviewed. Staff of the Centers for Disease Control and Prevention and other federal scientists have also reviewed the profile. In addition, this profile has been peer-reviewed by a nongovernmental panel and was made available for public review. Final responsibility for the contents and views expressed in this toxicological profile resides with ATSDR.

Julie Louise Gerberding, M.D., M.P.H.
Administrator
Agency for Toxic Substances and
Disease Registry

*Legislative Background

The toxicological profiles are developed in response to the Superfund Amendments and Reauthorization Act (SARA) of 1986 (Public law 99–499) which amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund). This public law directed ATSDR to prepared toxicological profiles for hazardous substances most commonly found at facilities on the CERCLA National Priorities List and that pose the most significant potential threat to human health, as determined by ATSDR and the EPA. The availability of the revised priority list of 275 hazardous substances was announced in the *Federal Register* on November 17, 1997 (62 FR 61332). For prior versions of the list of substances, see *Federal Register* notices dated April 29, 1996 (61 FR 18744); April 17, 1987 (52 FR 12866); October 20, 1988 (53 FR 41280); October 26, 1989 (54 FR 43619); October 17, 1990 (55 FR 42067); October 17, 1991 (56 FR 52166); October 28, 1992 (57 FR 48801); and February 28, 1994 (59 FR 9486). Section 104(I)(3) of CERCLA, as amended, directs the Administrator of ATSDR to prepare a toxicological profile for each substance on the list.

QUICK REFERENCE FOR HEALTH CARE PROVIDERS

Toxicological Profiles are a unique compilation of toxicological information on a given hazardous substance. Each profile reflects a comprehensive and extensive evaluation, summary, and interpretation of available toxicologic and epidemiologic information on a substance. Health care providers treating patients potentially exposed to hazardous substances will find the following information helpful for fast answers to often-asked questions.

Primary Chapters/Sections of Interest

Chapter 1: Public Health Statement: The Public Health Statement can be a useful tool for educating patients about possible exposure to a hazardous substance. It explains a substance's relevant toxicologic properties in a nontechnical, question-and-answer format, and it includes a review of the general health effects observed following exposure.

Chapter 2: Relevance to Public Health: The Relevance to Public Health Section evaluates, interprets, and assesses the significance of toxicity data to human health.

Chapter 3: Health Effects: Specific health effects of a given hazardous compound are reported by *route of exposure*, by *type of health effect* (death, systemic, immunologic, reproductive), and by *length of exposure* (acute, intermediate, and chronic). In addition, both human and animal studies are reported in this section.

> ***NOTE:*** Not all health effects reported in this section are necessarily observed in the clinical setting. Please refer to the Public Health Statement to identify general health effects observed following exposure.

Pediatrics: Four new sections have been added to each Toxicological Profile to address child health issues:

Section 1.6 How Can (Aldrin/Dieldrin) Affect Children?
Section 1.7 How Can Families Reduce the Risk of Exposure to (Aldrin/Dieldrin)?
Section 3.7 Children's Susceptibility
Section 6.6 Exposures of Children

Other Sections of Interest:

Section 3.8 Biomarkers of Exposure and Effect
Section 3.11 Methods for Reducing Toxic Effects

ATSDR Information Center

Phone: 1-888-42-ATSDR or (404) 498-0110 ***Fax:*** (404) 498-0057
E-mail: atsdric@cdc.gov ***Internet:*** http://www.atsdr.cdc.gov

The following additional material can be ordered through the ATSDR Information Center:

Case Studies in Environmental Medicine: Taking an Exposure History—The importance of taking an exposure history and how to conduct one are described, and an example of a thorough exposure history is provided. Other case studies of interest include *Reproductive and Developmental Hazards; Skin Lesions and Environmental Exposures; Cholinesterase-Inhibiting Pesticide Toxicity;* and numerous chemical-specific case studies.

Managing Hazardous Materials Incidents is a three-volume set of recommendations for on-scene (prehospital) and hospital medical management of patients exposed during a hazardous materials incident. Volumes I and II are planning guides to assist first responders and hospital emergency department personnel in planning for incidents that involve hazardous materials. Volume III—*Medical Management Guidelines for Acute Chemical Exposures*—is a guide for health care professionals treating patients exposed to hazardous materials.

Fact Sheets (ToxFAQs) provide answers to frequently asked questions about toxic substances.

Other Agencies and Organizations

The National Center for Environmental Health (NCEH) focuses on preventing or controlling disease, injury, and disability related to the interactions between people and their environment outside the workplace. *Contact:* NCEH, Mailstop F-29, 4770 Buford Highway, NE, Atlanta, GA 30341-3724 • Phone: 770-488-7000 • FAX: 770-488-7015.

The National Institute for Occupational Safety and Health (NIOSH) conducts research on occupational diseases and injuries, responds to requests for assistance by investigating problems of health and safety in the workplace, recommends standards to the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA), and trains professionals in occupational safety and health. *Contact:* NIOSH, 200 Independence Avenue, SW, Washington, DC 20201 • Phone: 800-356-4674 or NIOSH Technical Information Branch, Robert A. Taft Laboratory, Mailstop C-19, 4676 Columbia Parkway, Cincinnati, OH 45226-1998 • Phone: 800-35-NIOSH.

*The National Institute of Environmental Health Sciences (*NIEHS) is the principal federal agency for biomedical research on the effects of chemical, physical, and biologic environmental agents on human health and well-being. *Contact:* NIEHS, PO Box 12233, 104 T.W. Alexander Drive, Research Triangle Park, NC 27709 • Phone: 919-541-3212.

Referrals

The Association of Occupational and Environmental Clinics (AOEC) has developed a network of clinics in the United States to provide expertise in occupational and environmental issues. *Contact:* AOEC, 1010 Vermont Avenue, NW, #513, Washington, DC 20005 • Phone: 202-347-4976 • FAX: 202-347-4950 • e-mail: aoec@dgs.dgsys.com • AOEC Clinic Director: http://occ-env-med.mc.duke.edu/oem/aoec.htm.

The American College of Occupational and Environmental Medicine (ACOEM) is an association of physicians and other health care providers specializing in the field of occupational and environmental medicine. *Contact:* ACOEM, 55 West Seegers Road, Arlington Heights, IL 60005 • Phone: 847-818-1800 • FAX: 847-818-9266

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THE PROFILE HAS UNDERGONE THE FOLLOWING ATSDR INTERNAL REVIEWS:

1. Health Effects Review. The Health Effects Review Committee examines the health effects chapter of each profile for consistency and accuracy in interpreting health effects and classifying end points.

2. Minimal Risk Level Review. The Minimal Risk Level Workgroup considers issues relevant to substance-specific minimal risk levels (MRLs), reviews the health effects database of each profile, and makes recommendations for derivation of MRLs.

PEER REVIEW

A peer review panel was assembled for aldrin/dieldrin. The panel consisted of the following members:

1. Dr. William B. Buck, Private Consultant, Consul-Tox, Inc., Tolono, Illinois.

2. Dr. Samuel Epstein, Professor of Environmental and Occupational Medicine, School of Public Health, University of Illinois Medical Center, Chicago, Illinois.

3. Dr. Syed Ghiasuddin, Toxicologist, Office of Water Management, Indiana Department of Environmental Management, Indianapolis, Indiana.

4. Dr. Alan Hall, Private Consultant, Evergreen, Colorado.

5. Dr. James Klaunig, Professor and Director of Toxicology, Indiana University School of Medicine, Indianapolis, Indiana.

6. Dr. Peter Lacouture, Associate Director, Clinical Research, The Purdue Frederick Company, Norwalk, Connecticut.

7. Dr. Fumio Matsumura, Assistant Director, Toxic Substances Program, LEHR Facility, University of California, Davis, California.

8. Dr. Edward Morgan, Assistant Professor, Department of Pharmacology, Emory University, Atlanta, Georgia.

9. Dr. Raghubir Prasad Sharma, Fred C. Davison Distinguished Chair in Toxicology, College of Veterinary Medicine, The University of Georgia, Athens, Georgia.

These experts collectively have knowledge of aldrin/dieldrin's physical and chemical properties, toxicokinetics, key health end points, mechanisms of action, human and animal exposure, and quantification of risk to humans. All reviewers were selected in conformity with the conditions for peer review specified in Section 104(I)(13) of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended.

Scientists from the Agency for Toxic Substances and Disease Registry (ATSDR) have reviewed the peer reviewers' comments and determined which comments will be included in the profile. A listing of the peer reviewers' comments not incorporated in the profile, with a brief explanation of the rationale for their exclusion, exists as part of the administrative record for this compound. A list of databases reviewed and a list of unpublished documents cited are also included in the administrative record.

The citation of the peer review panel should not be understood to imply its approval of the profile's final content. The responsibility for the content of this profile lies with the ATSDR.

CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1. PUBLIC HEALTH STATEMENT

This public health statement tells you about aldrin and dieldrin and the effects of exposure to these chemicals.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Aldrin has been found in at least 207 of the 1,613 current or former NPL sites, and dieldrin has been found in at least 287 of the 1,613 current or former NPL sites. However, the total number of NPL sites evaluated for these substances is not known. As more sites are evaluated, the sites at which aldrin and dieldrin are found may increase. This information is important because exposure to these substances may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to aldrin or dieldrin, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with them. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT ARE ALDRIN AND DIELDRIN?

Aldrin and dieldrin are the common names of two structurally similar compounds that were once used as insecticides. They are chemicals that are made in the laboratory and do not occur naturally in the environment. The scientific name for aldrin is 1,2,3,4,10,10-hexachloro-1,4,4α,5,8,8α-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene. The abbreviation for the scientific name of aldrin is HHDN. Technical-grade aldrin contains not less than 85.5% aldrin.

The trade names used for aldrin include Aldrec, Aldrex, Drinox, Octalene, Seedrin, and Compound 118. The scientific name for dieldrin is 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4α,5,6,7,8,8α-octahydro-1,4-endo,exo-5,8-dimethanonaphthalene. The abbreviation for the scientific name for dieldrin is HEOD. Technical-grade dieldrin contains not less than 85% dieldrin. The trade names used for dieldrin include Alvit, Dieldrix, Octalox, Quintox, and Red Shield.

Pure aldrin and dieldrin are white powders, while technical-grade aldrin and dieldrin are tan powders. Aldrin and dieldrin slowly evaporate in the air. Aldrin evaporates more readily than dieldrin. Both aldrin and dieldrin have mild chemical odors. You might find aldrin and dieldrin in the soil, in water, or in homes where these compounds were used to kill termites. You might also find aldrin and dieldrin in plants and animals near hazardous waste sites.

Aldrin and dieldrin are no longer produced or used. From the 1950s until 1970, aldrin and dieldrin were used extensively as insecticides on crops such as corn and cotton. The U.S. Department of Agriculture canceled all uses of aldrin and dieldrin in 1970. In 1972, however, EPA approved aldrin and dieldrin for killing termites. Use of aldrin and dieldrin to control termites continued until 1987. In 1987, the manufacturer voluntarily canceled the registration for use in controlling termites.

In this profile, the two chemicals are discussed together because aldrin readily changes into dieldrin once it enters either the environment or your body. More information on the chemical and physical properties of aldrin and dieldrin is found in Chapter 4. More information on the production and use of aldrin and dieldrin is found in Chapter 5.

1.2 WHAT HAPPENS TO ALDRIN AND DIELDRIN WHEN THEY ENTER THE ENVIRONMENT?

Aldrin and dieldrin can enter the environment from accidental spills or leaks from storage containers at waste sites. In the past, aldrin and dieldrin entered the environment when farmers used these compounds to kill pests on crops and when exterminators used them to kill termites. Aldrin and dieldrin are still present in the environment from these past uses. Sunlight and bacteria in the environment can change aldrin to dieldrin. Therefore, you can find dieldrin in places where aldrin was originally released. Dieldrin in soil or water breaks down (degrades) very slowly. Dieldrin sticks to soil and may stay there unchanged for many years. Water does not easily wash dieldrin off soil. Dieldrin does not dissolve in water very well and is therefore not found in water at high concentrations. Most dieldrin in the environment attaches to soil and to sediments at the bottoms of lakes, ponds, and streams. Dieldrin can travel large distances by attaching to dust particles, which can then be transported great distances by the wind. Dieldrin can evaporate slowly from surface water or soil. In the air, dieldrin changes to photodieldrin within a few days. Plants can take up dieldrin from the soil and store it in their leaves and roots. Fish or animals that eat dieldrin-contaminated materials store a large amount of the dieldrin in their fat. Animals or fish that eat other animals have levels of dieldrin in their fat many times higher than animals or fish that eat plants. For more information, see Chapters 5 and 6.

1.3 HOW MIGHT I BE EXPOSED TO ALDRIN AND DIELDRIN?

For most people, exposure to aldrin and dieldrin occurs when they eat foods contaminated with either chemical. Contaminated foods might include fish or shellfish from contaminated lakes or streams, root crops, dairy products, and meats. Exposure to aldrin and dieldrin also occurs when you drink water, breathe air, or come into contact with contaminated soil at hazardous waste sites. Skin contact and breathing of aldrin and dieldrin by workers who used these chemicals to kill insects were at one time common. However, aldrin and dieldrin are no longer produced and no longer used. People with the greatest potential for exposure include those who live in homes that were once treated for termites using aldrin or dieldrin. Studies indicate that people can be exposed to aldrin and dieldrin years after they were applied in a home.

Exposure to aldrin is generally limited because aldrin is changed quickly to dieldrin in the environment. Dieldrin remains in the environment for a long time and is usually detected in soil, sediment, and animal fat. Levels of both aldrin and dieldrin have decreased over the years since they are no longer produced or used. The levels of aldrin and dieldrin in air and water are typically very low. For more information on human exposure to aldrin and dieldrin, see Chapter 6.

1.4 HOW CAN ALDRIN/DIELDRIN ENTER AND LEAVE MY BODY?

Aldrin can enter your bloodstream through your lungs when you breathe air, through your stomach after eating food or drinking water containing it, or through your skin. Exposure to aldrin or dieldrin around hazardous waste sites can mainly occur by breathing contaminated air or touching contaminated soil. Exposure near hazardous waste sites can also occur by eating contaminated food or drinking contaminated water. Exposure of the general population most likely occurs through eating food contaminated with aldrin or dieldrin. Exposure of some infants occurs by drinking mother's milk containing aldrin or dieldrin. Studies in animals show that both aldrin and dieldrin enter the body quickly after exposure. Once aldrin is inside your body, it quickly changes to dieldrin. Dieldrin then stays in your fat for a long time. Dieldrin can change to other products. Most dieldrin and its breakdown products leave your body in the feces. Some breakdown products can also leave in the urine. It can take many weeks or years for all of the compound to leave your body. Chapter 3 contains more information on how aldrin and dieldrin enter and leave the body.

1.5 HOW CAN ALDRIN/DIELDRIN AFFECT MY HEALTH?

Aldrin and dieldrin affect your health in similar ways. Symptoms of aldrin and dieldrin poisoning have been seen in people who were exposed to very large amounts of these pesticides during their manufacture. Symptoms of poisoning have also been seen in people who intentionally or accidentally ate or drank large amounts of aldrin or dieldrin. Most of these people experienced convulsions or other nervous system effects, and some had kidney damage. Some people who intentionally ate or drank large amounts of aldrin or dieldrin died. Health effects in people exposed to smaller amounts of aldrin or dieldrin occur because levels of the chemicals build up in the body over time. Exposure to moderate levels of aldrin or dieldrin for a long time causes headaches, dizziness, irritability, vomiting, or uncontrollable muscle movements. Some sensitive people seem to develop a condition in which aldrin or dieldrin causes the body to destroy its own blood cells. We do not know whether aldrin or dieldrin affects the ability of people to fight diseases. We also do not know whether aldrin or dieldrin affects the ability of men to father children, or causes birth defects or cancer in people. The International Agency for Research on Cancer has determined that aldrin and dieldrin are not classifiable as to their carcinogenicity to humans. Based on studies in animals, the EPA has determined that aldrin and dieldrin are probable human carcinogens.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests. One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Results from animal studies show that high levels of aldrin and dieldrin cause effects on the nervous system and on the kidneys similar to those seen in people. Results from animal studies also show additional effects of aldrin and dieldrin after exposure to lower levels for longer periods. We do not know whether these effects also occur in people. These other health effects of aldrin and dieldrin in animals include changes in the liver and reduced ability to fight infections. In addition, animals born to mothers who have eaten large amounts of aldrin or dieldrin do not live very long. This results, in part, from the newly born animals being poisoned by aldrin or dieldrin in the mother's milk. Studies in animals give conflicting information about whether aldrin and dieldrin cause birth defects. Studies in animals also give conflicting information about whether aldrin and dieldrin make it more difficult for male animals to reproduce. Some studies show that aldrin and dieldrin may damage sperm. Aldrin and dieldrin have been shown to cause liver cancer in mice, but not in other species of animals.

Additional information regarding the health effects of aldrin and dieldrin can be found in Chapter 3.

1.6 HOW CAN ALDRIN/DIELDRIN AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans. Potential effects on children resulting from exposures of the parents are also considered.

Children can be exposed to aldrin or dieldrin in the same ways as adults, mainly by eating food contaminated with aldrin or dieldrin, or by exposure in homes treated for termites using aldrin or dieldrin. Children can also be exposed by coming into contact with aldrin- or dieldrin-contaminated water, air, or soil near hazardous waste sites. There are no known unique exposure pathways for children. We do not know if children’s intake of aldrin or dieldrin per kilogram of body weight is different than that of adults.

Adults and children who swallowed (either by accident or on purpose) amounts of aldrin or dieldrin that were much greater than those found in the environment suffered convulsions, and some died. We do not know whether children differ from adults in their susceptibility to health effects from aldrin or dieldrin exposure.

We do not know whether aldrin or dieldrin affect the ability of people to have children or whether they cause birth defects in children. Some studies in animals show that females given aldrin or dieldrin by mouth have smaller numbers of babies. Some other studies show that large amounts of aldrin damage the testes, but it is unknown whether such large amounts affect the ability of animals to reproduce. Pregnant animals given aldrin or dieldrin by mouth had some babies with low birth weights and some with skeletal variations. Because these effects occurred in animals, they might also occur in humans. Aldrin and dieldrin can cross the placenta. Dieldrin has been found in human breast milk. More information on this topic can be found in Sections 3.7 and 6.6.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO ALDRIN OR DIELDRIN?

If your doctor finds that you have been exposed to significant amounts of aldrin or dieldrin, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Since aldrin and dieldrin are no longer produced or used, exposure to these compounds will occur from past usage. Families with the greatest risk of exposure to aldrin and dieldrin are those living in homes that were once treated with either chemical for termite protection. Aldrin and dieldrin were usually applied to the basement level of homes to protect the foundation from termites. Studies indicate that detectable levels of both chemicals can exist in a home for up to 10 years after the first application. Before buying a home, families should investigate what, if any, pesticides have been used within the home.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO ALDRIN/DIELDRIN?

Aldrin is quickly changed to dieldrin in the body, and dieldrin can be measured in your blood, urine, and body tissues if you have been exposed to a large amount. Tests to measure aldrin or dieldrin in such bodily tissues or fluids are not usually available at a doctor's office because special equipment is needed. However, a sample taken in the doctor's office can be properly packed and shipped to a special laboratory, if necessary. Because aldrin changes to dieldrin fairly quickly in the body, these methods are useful for finding aldrin only within a few days after you are exposed to aldrin. Since dieldrin can stay in the body for months, measurements of dieldrin can be made for much longer after you are exposed to either aldrin or dieldrin. The test results cannot be used to predict if you will have any adverse health effects. Exposure to other chemicals at the same time as exposure to aldrin and/or dieldrin could cause some confusion in understanding test results for aldrin and/or dieldrin. More information about tests to find dieldrin in the body is presented in Chapters 3 and 7.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA).

Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for aldrin and dieldrin include the following:

The federal government has developed regulatory standards and guidelines to protect people from the harmful health effects of aldrin and dieldrin. In 1974, EPA banned all uses of aldrin or dieldrin except as a termite killer. In 1981, EPA required labeling changes to warn against applying these chemicals near water supplies, heating ducts, or crawl spaces. They also warned against applying them too frequently.

EPA advises lifetime drinking water exposure concentration limits (DWELs, see Table 8-1) for aldrin and dieldrin of 0.001 and 0.002 mg/L, respectively, for protection against adverse non-cancer health effects, that assume all of the exposure to the contaminant is from drinking water. Regarding cancer risk, EPA advises a lower drinking water exposure concentration limit of 0.0002 mg/L for aldrin and dieldrin that would, in theory, limit the lifetime risk for developing cancer from exposure to each compound to 1 in 10,000.

The FDA regulates the residues of aldrin and dieldrin in raw foods. The allowable range for residues is from 0 to 0.1 ppm depending on the type of food product. This limits the intake of aldrin and dieldrin in food to levels considered to be safe.

EPA has named aldrin and dieldrin as hazardous solid waste materials. If quantities greater than 1 pound enter the environment, the National Response Center of the federal government must be told immediately.

OSHA recommended a maximum average amount of aldrin and dieldrin in the air in the workplace to protect workers. This amount is 250 micrograms in a cubic meter of air ($\mu g/m^3$) for an 8-hour workday over a 40-hour workweek. NIOSH recommended the same limit (250 $\mu g/m^3$) for both compounds for up to a 10-hour workday over a 40-hour workweek. For more information, see Chapter 8.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Web site: http://www.atsdr.cdc.gov

* Information line and technical assistance

Phone: 1-888-42-ATSDR (1-888-422-8737)
Fax: 1-404-498-0057

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

* To order toxicological profiles, contact

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000

2. RELEVANCE TO PUBLIC HEALTH

2.1 BACKGROUND AND ENVIRONMENTAL EXPOSURES TO ALDRIN AND DIELDRIN IN THE UNITED STATES

Aldrin ($C_{12}H_8Cl_6$) and dieldrin ($C_{12}H_8Cl_6O$) are two organochlorine insecticides that were used for agricultural and public health purposes from the early 1950s until 1989, when their manufacture in the United States was discontinued. Aldrin and dieldrin were popular pesticides for corn and cotton crops, and were used as a prophylactic and for treatment of timber against termite infestation. Consistent with their intended use on insects in soil, aldrin and dieldrin are not very water soluble, but readily bind to sediment and are rarely leached into deeper soil layers and groundwater. As they take decades to break down in the environment, past agricultural uses of aldrin and dieldrin have resulted in persisting soil residues and uptake in a wide range of crops. In biological systems of soils, plants, and animals, aldrin converts rapidly to dieldrin by a microsomal oxidation reaction (epoxidation). The half-life of dieldrin in temperate soils is about 5 years, while it disappears more quickly (up to 90% in 1 month) from tropical soils. Organochlorine pesticides, including dieldrin, continue to enter streams in the United States from atmospheric deposition and erosion of soils contaminated from past use. Aldrin and dieldrin may be volatilized from sediment and redistributed by air currents, contaminating areas far from their sources. Nationally, levels of aldrin and dieldrin have declined since their agricultural uses were discontinued. Aldrin bioconcentrates in mollusks and fish, and high levels of dieldrin have been found concentrated in fish, snails, and lake trout. Detectable dieldrin concentrations in fish have shown a strong association with corn production acreage.

Exposure to aldrin or dieldrin at hazardous waste sites is possible via inhalation, oral, or dermal routes. The Henry's law constants of aldrin and dieldrin indicate that volatilization from moist soil surfaces will occur. Both compounds also bind strongly to soil particles and are often associated with dust particles in the atmosphere. Exposure to these pesticides can therefore occur through inhalation and dermal contact with vapor and particulate phase aldrin and dieldrin. Populations residing near hazardous waste disposal sites may be subject to higher levels of aldrin and dieldrin in environmental media (i.e., air, soil) than those experienced by the general population. Aldrin has been identified in at least 207 of the 1,613 hazardous waste sites while dieldrin has been identified in at least 287 of the 1,613 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL). However, the number of NPL sites evaluated for aldrin and dieldrin is not known. As more sites are evaluated, the number of sites where aldrin and/or dieldrin has been detected may increase.

Exposure of the general population to aldrin and dieldrin may occur through ingestion of contaminated food (including fish and shellfish) or water, through inhalation of contaminated air, especially in homes that have been treated with either pesticide, and through dermal contact with contaminated soil or water. The dietary contribution is likely the most significant route of human exposure. Oral exposure may occur through consumption of foods that are contaminated with aldrin or dieldrin. These foods would include those obtained from plants grown on contaminated lands or from animals living in contaminated areas, as well as commercial food products high in animal fat, such as dairy, fish, and meat products. This is the result of previous widespread use, biomagnification, and persistence in the environment. Because of aldrin's rapid conversion to dieldrin, most of the dietary intake is in the form of dieldrin. During the period of 1965–1970, U.S. dietary intake was reported to be #40 ng aldrin/kg/day and #80 ng dieldrin/kg/day. Since 1970, the use of aldrin and dieldrin on food has been cancelled, and dietary intake has decreased. In 1988, on the basis of total diet analyses, daily intake of dieldrin in adults in the United States was estimated at #5 ng/kg/day; a slightly higher daily intake of #11 ng/kg/day was estimated for infants. High levels of dietary exposures to dieldrin in adults were estimated to be primarily due to frequent consumption of summer and winter squash grown on contaminated lands. Dieldrin was found in Food and Drug Administration (FDA) Total Diet study foods during the period of 1991–1999, with maximum levels in squash. Aldrin currently appears to be below the FDA limit of detection in food. Oral exposure to aldrin or dieldrin could also occur through ingestion of contaminated water. Studies indicate, however, that levels of aldrin and dieldrin in drinking water are extremely low.

Regarding exposure of the general population through inhalation of contaminated air, air samples from several states collected in 1970–1972 revealed mean ambient concentrations of 0.4 ng/m^3 for aldrin and 1.6 ng/m^3 for dieldrin. In 1972, the estimated U.S. average daily intake of aldrin plus dieldrin from the atmosphere was about 0.6 ng/kg body weight. Another source of exposure not related to living near a hazardous waste site is residue from the past use of aldrin or dieldrin for termite extermination. Although use for this application was voluntarily canceled by the manufacturer in 1987, aldrin and dieldrin levels in treated homes have been shown to decline slowly, with detectable levels present as many as 10 years after treatment. Dieldrin has been detected in human placenta, amniotic fluid, fetal blood, and breast milk, and breast milk levels appear to be correlated to dwelling dieldrin treatment for termite control. Dieldrin tends to be stored in high-fat tissues within the body, but can be mobilized during lactation or starvation.

See Chapter 6 for more detailed information regarding concentrations of aldrin and dieldrin in environmental media.

2.2 SUMMARY OF HEALTH EFFECTS

Data regarding the health effects of aldrin or dieldrin in humans come from either epidemiological reports of occupational exposure or case reports of accidental or intentional poisonings. As precise levels of exposure are not known, these studies are inadequate for quantitative assessment of the health effects of aldrin or dieldrin. The main and best documented effect of acute high-level exposure to aldrin or dieldrin in humans is central nervous system excitation culminating in convulsions. Central nervous system stimulation is the cause of death in acute poisoning. Longer-term exposure of humans in occupational settings has also been associated with central nervous system intoxication, but other toxic effects in workers routinely exposed to these pesticides have not been conclusively established. A few case reports have attributed liver and kidney toxicity and hemolytic anemia to oral exposure to aldrin or dieldrin, but these effects were not observed in larger occupational studies, suggesting that they are likely to be quite rare.

Studies in animals have mainly involved oral exposure. Oral data in animals are consistent with the findings in humans that the central nervous system is an important target of toxicity, but further show that other effects may also be associated with exposure to aldrin or dieldrin, including liver and kidney toxicity, immunosuppression, fetal toxicity and increased postnatal mortality, neurodevelopmental effects, and decreased reproductive function. No studies were located regarding developmental effects in humans and conflicting results exist in animals. Fetuses may be affected through transplacental exposure. The liver is the critical target of chronic toxicity in several species based on available long-term oral studies, although data on other end points known to be sensitive from shorter-duration studies (e.g., immunosuppression, subtle neurological effects) are insufficient. The mechanism for aldrin and dieldrin toxicity is not equally well understood for all target organs.

Aldrin and dieldrin are carcinogenic in animals, but this effect appears to be specific to the mouse liver. The International Agency for Research on Cancer has categorized aldrin and dieldrin as Group 3 (unclassifiable as to human carcinogenic potential) chemicals. Based on the finding of liver tumors in mice, EPA classified both aldrin and dieldrin as B2, probable human carcinogens; however, current mechanistic data suggest that the mouse carcinogenicity data may not be highly relevant to humans. The preponderance of evidence appears to indicate that aldrin and dieldrin induce a carcinogenic response through nongenotoxic mechanisms (i.e., not acting directly on the DNA).

Limited reports of adverse effects in aldrin- or dieldrin-exposed children (indicate similar signs and symptoms to those in adults. Limited animal data indicate that dose-response may change with age. The principal health effects are discussed in the following sections.

Hepatic Effects. While adverse hepatic effects have not generally been observed in workers employed in the manufacture or application of aldrin or dieldrin, the liver was the most sensitive target of aldrin and dieldrin toxicity in chronic-duration animal studies. Serum liver enzyme activities (alkaline phosphatase, alanine and aspartate aminotransferases) were normal in volunteers who ingested low doses of dieldrin (0.14–3 g/kg/day) for 18 months; however, slight increases in alanine and aspartate aminotransferase activities have been correlated with increased serum levels of dieldrin in pesticide-exposed workers. Liver injury was observed in a child who drank an unknown quantity of a 5% dieldrin solution. However, the dieldrin solution most likely contained a substantial amount of solvent, and it is unclear whether the hepatic toxicity was directly due to the dieldrin or the solvent. The injury appeared to be reversible to some extent; however, the child was not followed for a sufficient period to determine whether the injury was completely reversible. Exposure of animals to $0.025 mg/kg/day of aldrin or dieldrin over intermediate-to-chronic periods has also been reported to cause adverse effects such as elevated serum enzyme levels, decreased serum proteins, hyperplasia, bile duct proliferation, focal degeneration, and areas of necrosis in the liver.

These degenerative effects are distinct from the adaptive changes observed in livers of a number of animal species in response to exposure to aldrin, dieldrin, or other chlorinated hydrocarbon pesticides. Such adaptive changes occur as a result of the induction of microsomal enzymes by aldrin or dieldrin and include increases in liver weight and/or size, liver cell enlargement, cytoplasmic eosinophilia, an increase in the smooth endoplasmic reticulum, an increase in microsomal protein, an increase in cytochrome P-450 content, and/or an increase in microsomal enzyme activity. Studies of workers employed in the manufacture or application of aldrin or dieldrin have not shown evidence of microsomal enzyme induction. Studies have shown, however, that species differences exist with respect to the magnitude of these changes. The most prolific changes have been observed in rats, with dogs, mice, and monkeys experiencing progressively lesser changes. It might be expected, based on the close evolutionary relationship between Rhesus monkeys and humans, that limited enzyme induction might also occur in humans.

Neurological Effects. Central nervous system excitation is the primary adverse effect observed in humans in cases of aldrin or dieldrin intoxication. In cases of acute intoxication, in which a large amount of these pesticides is ingested over a short period of time, convulsions occur within several minutes after ingestion. In cases of longer-term exposures, where a slow rate of elimination from the body results in a gradual buildup of these agents in the blood to toxic levels, convulsions may also be produced . During such longer-term exposures, however, other less-serious symptoms of central nervous system toxicity may also be observed including headaches, dizziness, hyperirritability, general malaise, nausea, vomiting, muscle twitching, or myoclonic jerking.

Both acute- and longer-duration studies in animals support these findings. For example, acute-duration oral exposure to aldrin caused subtle neurological changes as indicated by altered electroconvulsive shock threshold in the offspring of mice exposed during gestation. Operant behavior was disrupted in rats following single doses of dieldrin ranging from 0.5 to 16.7 mg/kg, whereas convulsions resulted at higher doses ranging from 40 to 50 mg/kg. When aldrin or dieldrin was administered to rats for 3 days, convulsions were observed at a dose of 10 mg/kg/day.

In intermediate-duration animal studies, impaired learning was found at 0.1 dieldrin/kg/day, physical signs of neurotoxicity (tremors) occurred at aldrin or dieldrin doses at as low as 0.5 mg/kg/day, and histopathological degenerative changes in the brain were found at doses as low as 0.7 mg/kg/day.

In chronic studies, serious neurological effects including convulsions and/or tremors developed in rats and dogs administered dieldrin at doses as low as 0.5 mg/kg/day and in rats administered 2.1 mg aldrin/kg/day. Central nervous system histopathological changes were noted at lower doses. Slight neuronal degeneration in dogs was reported following 1 year of exposure to aldrin or dieldrin at 0.2 mg/kg/day, and cerebral edema and small foci of degeneration were reported in rats exposed to dieldrin at 0.016 mg/kg/day for 2 years; however, these effects were reported in studies limited by the small number of animals examined.

It is highly unlikely that high enough levels of aldrin or dieldrin could be absorbed acutely by persons living near hazardous waste sites to cause convulsions, although exposure to sufficiently high levels may cause some of the less adverse central nervous system effects.

It is generally believed that the central nervous system excitation observed in animals results from a generalized activation of synaptic activity throughout the central nervous system; however, it has not been established whether aldrin and dieldrin act at the nerve terminal to facilitate neurotransmitter release or whether these agents cause excitation by depressing activity of inhibitory neurotransmitters within the central nervous system. Experimental evidence appears to indicate a blocking action on the $GABA_A$ receptor-chloride channel complex. Additional information on mechanisms of neurotoxicity of aldrin and dieldrin is included in Section 3.5.

Reproductive Effects. Studies in humans have not addressed whether adverse reproductive effects occur as a result of exposure to aldrin or dieldrin. However, decreased fertility was observed in several (but not all) studies at doses as low as 0.63 mg aldrin/kg/day or 0.125 mg dieldrin/kg/day administered to maternal or paternal animals by the oral route. In additional animal studies of reproductive toxicity following intraperitoneal injection of aldrin, investigators have observed several adverse effects of this agent on the male reproductive system. These findings include decreased sperm count, degeneration of germ cells, decreased weights of seminal vesicles and prostate and coagulating glands, decreased seminiferous tubule diameter, decreased plasma and testicular testosterone, decreased prostatic fructose content and acid phosphatase activity, and decreased plasma luteinizing hormone and follicular stimulating hormone. Also, *in vitro* studies conducted using rat prostate tissue have shown that dieldrin blocks binding of the androgen, 5α-dihydrotestosterone, to a protein fraction of the prostate. These findings may provide clues regarding the mechanism of the decreased fertility in males. Based on the findings reported in these studies, an adverse effect of exposure to sufficiently high levels of aldrin or dieldrin on male fertility cannot be excluded.

Developmental Effects. Studies in humans have not addressed whether adverse developmental effects occur as a result of exposure to aldrin or dieldrin. External malformations have been observed in a study in mice and hamsters at doses of 15 and 30 mg dieldrin/kg/day, respectively, but at doses 10 times lower, conflicting results regarding these types of effects were reported. Decreased postnatal survival following *in utero* exposure to dieldrin has been observed in a number of studies in laboratory animals. This decrease in survival does not appear to be dependent on exposure to this agent postnatally via the mothers' milk or to effects of dieldrin on maternal behavior, although these factors appear to contribute to the postnatal mortality. However, the mechanism for the neonate lethality at present is not known. In addition, subtle changes in neurological function, such as changes in the electroconvulsive shock threshold, have been observed in offspring of mice treated with aldrin during pregnancy.

See Chapter 3 for more detailed information regarding the health effects of aldrin and dieldrin.

2.3 MINIMAL RISK LEVELS (MRLs)

Inhalation MRLs

Information regarding inhalation toxicity of aldrin and dieldrin in humans is mainly available from studies of workers involved in the manufacture or use of the chemicals (de Jong 1991; Hunter et al. 1972; Jager 1970; Kazantzis et al. 1964; Morgan and Lin 1978; Morgan and Roan 1974; Morgan et al. 1980; Patel and Rao 1958; Sandifer et al. 1981; van Raalte 1977; van Sittert and de Jong 1987; Versteeg and Jager 1973; Warnick and Carter 1972). Limitations associated with these reports include lack of quantitative exposure data, lack of data on duration of exposure, the possibility of multiple routes of exposure (i.e., dermal as well as inhalation), and concurrent exposure to other chemicals. The human occupational data therefore essentially provide only qualitative data on health effects associated with inhalation exposures to aldrin and dieldrin and are unsuitable for MRL derivation. Extremely limited animal inhalation toxicity data are available for aldrin and dieldrin in several species (Treon et al. 1957b), but limitations of these studies, particularly lack of exposure levels and sublimation of the chemicals that may have generated thermal decomposition products and/or other volatile contaminants, also preclude derivation of inhalation MRLs.

Oral MRLs

Acute-duration Oral MRLs

Aldrin

- An MRL of 0.002 mg/kg/day has been derived for acute-duration oral exposure (14 days or less) to aldrin.

The acute-duration oral MRL for aldrin was derived based on observations of 18% decreased body weight and a significantly increased electroconvulsive shock brain seizure threshold in the offspring of mice gavaged with 2 or 4 mg/kg/day for 5–7 days during the third trimester of pregnancy (Al-Hachim 1971). There was no effect on the acquisition of a conditioned avoidance response in the offspring. Another acute-duration oral developmental toxicity study of aldrin showed developmental toxicity at higher doses of aldrin in both mice and hamsters (Ottolenghi et al. 1974). Administration of aldrin by gavage caused an increase in the incidence of webbed feet in mice following 25 mg/kg on gestation day (Gd) 9 and increased fetal mortality in hamsters following 50 mg/kg/day on Gd 7, 8, or 9. These results support the developmental toxicity of aldrin. Additionally, the neurodevelopmental effect is consistent with evidence showing that the central nervous system is a well-documented target of aldrin and dieldrin toxicity in adult animals. Because the end points measured in the current study may be more sensitive indicators of fetal toxicity than overt neonatal neurological effects and fetal death or malformations, the lowest tested dose is considered to be a lowest-observed-adverse-effect level (LOAEL) for developmental toxicity. The acute-duration MRL of 0.002 mg/kg/day was derived by dividing the 2 mg/kg/day LOAEL by an uncertainty factor of 1,000 (10 for extrapolating from a LOAEL to a NOAEL, 10 for extrapolating from animals to humans, and 10 for human variability).

Dieldrin

An acute-duration oral MRL was not derived for dieldrin. Severe signs of neurotoxicity were reported in humans accidently or intentionally ingesting relatively large doses of dieldrin (Black 1974; Garrettson and Curley 1969). Convulsions were observed in rats given dieldrin in single oral doses ranging from 10 to 50 mg/kg (Mehrotra et al. 1989; Wagner and Greene 1978; Woolley et al. 1985). Other studies in rats reported disruption of operant behavior (Burt 1975) and impaired responses in an inescapable foot shock stress paradigm (Carlson and Rosellini 1987) following acute oral administration of dieldrin at doses of 2.5 and 0.5 mg/kg, respectively. Monkeys orally administered 0.1 mg dieldrin/kg/day for 55 days showed signs of impaired learning <15 days after the initiation of treatment (Smith et al. 1976). This study identified a no-observed-adverse-effect level (NOAEL) of 0.01 mg/kg/day for impaired learning in monkeys treated for up to 55 days; the NOAEL was used as the basis for derivation of an intermediate-duration oral MRL for dieldrin. Adverse effects were also observed in the immune system of mice following acute oral exposure to dieldrin levels as low as 0.065 mg/kg (Loose et al. 1981), indicating that the immune system may be the most sensitive target of dieldrin-induced toxicity in animals. However, due to the lack of data to suggest that the immune system may be a target of toxicity in humans following ingestion of dieldrin, an acute-duration oral MRL for dieldrin based on immunotoxicity was not derived.

Intermediate-duration Oral MRLs

Aldrin

An intermediate-duration oral MRL was not derived for aldrin due to lack of appropriate effect levels. In intermediate-duration oral studies, the lowest NOAEL of 0.63 mg/kg/day was identified for decreased body weight in rats consuming aldrin for 27 weeks (Treon et al. 1953b). The associated LOAEL of 1.25 mg/kg/day, which was also a NOAEL for other systemic effects (liver and kidney weight), was within the range of 0.89–1.78 mg/kg/day reported in dogs exposed for 9 months for frank signs of neurotoxicity that included tremors, convulsions, labored respiration, and vomiting (Treon et al. 1951b). NOAELs for these neurotoxic effects were not identified. The neurotoxic effects are considered by ATSDR to be serious effects, and MRLs are not derived using LOAELs for serious end points. An intermediate-duration MRL was not derived based on the NOAEL of 0.63 mg/kg/day for decreased body weight because of its proximity (within a factor of 10) to the LOAELs for serious end points.

Dieldrin

- An MRL of 0.0001 mg/kg/day has been derived for intermediate-duration oral exposure (15–364 days) to dieldrin.

The intermediate-duration oral MRL for dieldrin was derived based on observations of impaired learning of a successive discrimination reversal task in squirrel monkeys fed 0.1 mg dieldrin/kg/day for 55 days, whereas the 0.01 mg/kg/day dose level had no apparent effect on learning (Smith et al. 1976). The study by Burt (1975) provides supporting evidence of neurotoxicity in rats fed dieldrin in the diet for 60–120 days. A concentration of 5 ppm (a calculated dose level of 0.25 mg/kg/day, using reference values from EPA (1986m) resulted in significantly impaired maze training; no adverse effects were seen in rats exposed for 60 days to a concentration resulting in a dose level of 0.025 mg/kg/day. The intermediate-duration oral MRL of 0.0001 mg/kg/day was calculated by dividing the 0.01 mg/kg/day NOAEL by an uncertainty factor of 100 (10 for extrapolating from animals to humans and 10 for human variability).

Chronic-duration Oral MRLs

Aldrin

- An MRL of 0.00003 mg/kg/day has been derived for chronic-duration oral exposure (365 days or more) to aldrin.

The liver was the most sensitive target of aldrin toxicity in chronic-duration studies. Rats exposed to aldrin at doses as low as 0.025 mg/kg/day for 2 years had increases in relative liver weight and hepatic histopathological changes similar to those induced by other chlorinated insecticides (Fitzhugh et al. 1964). The hepatic lesions that were seen at 0.025 mg/kg/day were characterized by hypertrophy of centrilobular hepatocytes, cytoplasmic eosinophilia, and peripheral migration of basophilic granules along with less prominent alterations of cytoplasmic vacuolation and bile duct proliferations. Liver changes were marked at 2.5 mg/kg/day and included an increase in the severity of hepatic cell vacuolation; this is consistent with evidence for dose-related progression of hepatotoxicity in other studies (Deichmann et al. 1967; Harr et al. 1970; Thorpe and Walker 1973; Treon et al. 1955b).

Several of the liver cell changes that were observed at 0.025 mg/kg/day were considered to be consistent with marked adaptation. Modifications occurring in the mixed function oxidase system consequent to the adaptive response may result in it's functional enhancement or neutralization. This in turn has the consequence of potentiating or inhibiting toxic responses to other exogenous substances. Even though the mechanism of aldrin-mediated hepatotoxicity has not been elucidated, the potential significance of the marked adaptive response in cell injury cannot be dismissed. The extreme magnitiude of cellular adaption that results from aldrin toxicity creates a liver that potentially has a tremendously heightened state of metabolic activity which correspondingly may have a similiarly heightened capacity to toxify or detoxify upon continued exposure to aldrin (or other substance that may be present at NPL sites).

Particularly in considering that the liver is a major target organ for aldrin toxicity, and the marked adaptive response and other histopathologic lesions (cytoplasmic vacuolation and bile duct proliferation) observed in the Fitzhugh et al. study, a chronic-duration oral MRL for aldrin of 0.00003 mg/kg/day was derived by dividing the LOAEL of 0.025 mg/kg/day by 1,000 (10 for extrapolating from a LOAEL to a NOAEL, 10 for extrapolating from animals to humans, and 10 for human variability).

Dieldrin

C An MRL of 0.00005 mg/kg/day has been derived for chronic-duration oral exposure (365 days or more) to dieldrin.

The liver was the most sensitive target of dieldrin toxicity in chronic-duration studies. Rats that were exposed to 0.005, 0.05, or 0.5 mg/kg/day dieldrin in the diet for 2 years had increased relative liver weight at $0.05 mg/kg/day and liver parenchymal cell changes characteristic of organochlorine exposure, as well as indications of focal hyperplasia, at 0.5 mg/kg/day (Walker et al. 1969). There were no indications of dieldrin-related changes in serum alkaline phosphatase or SGPT, histology of non-liver tissues, or body weight in any of the exposed groups, although signs of dieldrin neurotoxicity (irritability, tremors, and occasional convulsions) occurred at 0.5 mg/kg/day. These behavioral changes usually occurred during handling, did not progress after 3 months of exposure, and did not affect well-being. Based on the 0.005 mg/kg/day NOAEL for liver effects and considering the evidence for dose-related progression of hepatotoxicity, the chronic oral MRL of 0.00005 mg/kg/day was calculated for dieldrin using an uncertainty factor of 100 (10 for extrapolating from animals to humans and 10 for human variability).

The main source of general population oral exposure to aldrin and dieldrin is through the diet (see Section 6.5). In an FDA Total Diet study conducted in 1982–1984, mean dietary intake of dieldrin in the United States was 0.5 µg/day (0.007 µg/kg/day assuming a 70-kg body weight) (Gunderson 1988; Lombardo 1986), which is approximately 7 times lower than the dieldrin chronic oral MRL. In the same study, aldrin intake was <0.001 µg/kg/day, which is approximately 30 times lower than the aldrin chronic oral MRL.

3. HEALTH EFFECTS

3.1 INTRODUCTION

The primary purpose of this chapter is to provide public health officials, physicians, toxicologists, and other interested individuals and groups with an overall perspective on the toxicology of aldrin/dieldrin. It contains descriptions and evaluations of toxicological studies and epidemiological investigations and provides conclusions, where possible, on the relevance of toxicity and toxicokinetic data to public health.

A glossary and list of acronyms, abbreviations, and symbols can be found at the end of this profile.

Aldrin and dieldrin are structurally similar pesticides. The only difference between the structures of aldrin and dieldrin is the presence, in dieldrin, of an epoxied ring at the site of one of the carbon-carbon double bonds in aldrin (see Chapter 4). Because aldrin is rapidly metabolized to dieldrin in the body and converted to dieldrin in the environment, these two compounds are discussed together throughout Chapter 3 and the rest this document.

3.2 DISCUSSION OF HEALTH EFFECTS BY ROUTE OF EXPOSURE

To help public health professionals and others address the needs of persons living or working near hazardous waste sites, the information in this section is organized first by route of exposure (inhalation, oral, and dermal) and then by health effect (death, systemic, immunological, neurological, reproductive, developmental, genotoxic, and carcinogenic effects). These data are discussed in terms of three exposure periods: acute (14 days or less), intermediate (15–364 days), and chronic (365 days or more).

Levels of significant exposure for each route and duration are presented in tables and illustrated in figures. The points in the figures showing no-observed-adverse-effect levels (NOAELs) or lowest-observed-adverse-effect levels (LOAELs) reflect the actual doses (levels of exposure) used in the studies. LOAELS have been classified into "less serious" or "serious" effects. "Serious" effects are those that evoke failure in a biological system and can lead to morbidity or mortality (e.g., acute respiratory distress or death). "Less serious" effects are those that are not expected to cause significant dysfunction or death, or those whose significance to the organism is not entirely clear. ATSDR acknowledges that a considerable amount of judgment may be required in establishing whether an end point should be classified as a NOAEL, "less serious" LOAEL, or "serious" LOAEL, and that in some cases, there will be insufficient data to decide whether the effect is indicative of significant dysfunction. However, the Agency has established guidelines and policies that are used to classify these end points. ATSDR believes that there is sufficient merit in this approach to warrant an attempt at distinguishing between "less serious" and "serious" effects. The distinction between "less serious" effects and "serious" effects is considered to be important because it helps the users of the profiles to identify levels of exposure at which major health effects start to appear. LOAELs or NOAELs should also help in determining whether or not the effects vary with dose and/or duration, and place into perspective the possible significance of these effects to human health.

The significance of the exposure levels shown in the Levels of Significant Exposure (LSE) tables and figures may differ depending on the user's perspective. Public health officials and others concerned with appropriate actions to take at hazardous waste sites may want information on levels of exposure associated with more subtle effects in humans or animals (LOAEL) or exposure levels below which no adverse effects (NOAELs) have been observed. Estimates of levels posing minimal risk to humans (Minimal Risk Levels or MRLs) may be of interest to health professionals and citizens alike.

Levels of exposure associated with carcinogenic effects (Cancer Effect Levels, CELs) of aldrin and dieldrin are indicated in Tables 3-1 and 3-2, respectively, and Figures 3-1 and 3-2, respectively. Because cancer effects could occur at lower exposure levels, Figures 3-1 and 3-2 also show a range for the upper bound of estimated excess risks, ranging from a risk of 1 in 10,000 to 1 in 10,000,000 (10^{-4} to 10^{-7}), as developed by EPA.

Estimates of exposure levels posing minimal risk to humans (Minimal Risk Levels or MRLs) have been made for aldrin and dieldrin. An MRL is defined as an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (noncarcinogenic) over a specified duration of exposure. MRLs are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration within a given route of exposure. MRLs are based on noncancerous health effects only and do not consider carcinogenic effects. MRLs can be derived for acute, intermediate, and chronic duration exposures for inhalation and oral routes. Appropriate methodology does not exist to develop MRLs for dermal exposure.

Although methods have been established to derive these levels (Barnes and Dourson 1988; EPA 1990d), uncertainties are associated with these techniques. Furthermore, ATSDR acknowledges additional uncertainties inherent in the application of the procedures to derive less than lifetime MRLs. As an example, acute inhalation MRLs may not be protective for health effects that are delayed in development or are acquired following repeated acute insults, such as hypersensitivity reactions, asthma, or chronic bronchitis. As these kinds of health effects data become available and methods to assess levels of significant human exposure improve, these MRLs will be revised.

A User's Guide has been provided at the end of this profile (see Appendix B). This guide should aid in the interpretation of the tables and figures for Levels of Significant Exposure and the MRLs.

3.2.1 Inhalation Exposure

Virtually all of the studies presented in this section on inhalation exposure are either epidemiological reports of occupational exposure or case reports of either accidental or intentional poisonings. Extremely limited information was located regarding the effects of inhalation exposures of animals to aldrin or dieldrin. In many of the human and animal studies, inhalation exposure may occur simultaneously with dermal exposure. Thus, many of the effects reported in this section may be due, in part, to dermal exposure to aldrin or dieldrin. Furthermore, in occupational studies and case reports of poisonings, precise levels of exposure are not known. Thus, the results in this section are not presented in an LSE table and figure.

No studies were located regarding cardiovascular, musculoskeletal, hepatic, renal, or dermal/ocular effects in humans or animals after inhalation exposure to aldrin/dieldrin.

3.2.1.1 Death

No increase in mortality from any cause was reported in workers who had been employed in the manufacture of aldrin, dieldrin, endrin, and/or telodrin at a facility in the Netherlands for >4 years (cohort=233 workers) (van Raalte 1977; Versteeg and Jager 1973). Furthermore, in a 20-year follow-up of this population and expansion of the cohort to include workers exposed for at least 1 year between 1954 and 1970 (cohort=570 workers), a lower than expected overall incidence of mortality was observed (de Jong 1991). Although the workers described by de Jong represented a unique population because they had been under observation for an average of 25.86 years, all of the studies described above are limited because of the small number of subjects used (#570 workers), uncertainty regarding exposure levels, and the potential exposure of the subjects to more than one of these pesticides and/or to other chemicals at the chemical manufacturing complex. Several of these studies have attempted to estimate exposures using blood levels. However, blood levels were not obtained for approximately 10 years (during what is expected to have been the period of heaviest exposures) and extrapolations were based on data obtained in a study using constant daily low-level oral dosing (Hunter and Robinson 1967). It is unclear whether such extrapolations accurately reflect exposure levels in the occupational situation. Only two case studies were located regarding deaths that may have been attributable to occupational exposure to aldrin or dieldrin (Muirhead et al. 1959; Pick et al. 1965). One of these studies concerned a farmer with multiple exposures to insecticides that contained dieldrin. The farmer died in hemolytic crisis after developing immunohemolytic anemia (Muirhead et al. 1959). Immunologic testing revealed a strong antigenic response to red blood cells coated with dieldrin. The other study concerned a worker from an orange grove who developed aplastic anemia and died following repeated exposures to aldrin during spraying (Pick et al. 1965). In the latter study, the relationship between aldrin exposure and the aplastic anemia is considerably more tenuous, being linked only in that the onset of symptoms corresponded with spraying and the condition deteriorated upon subsequent exposure.

Only very limited data were located regarding death in animals following inhalation exposure to aldrin or dieldrin. Cats, guinea pigs, rats, rabbits, and mice were exposed to aldrin vapors and particles generated by sublimating aldrin at 200 EC (Treon et al. 1957b). Aldrin levels of 108 mg/m^3 for 1 hour resulted in death in 9 out of 10 rats, 3 out of 4 rabbits, and 2 out of 10 mice. Cats and guinea pigs were less sensitive. One out of 1 cat and no guinea pigs died following exposure to 215 mg/m^3 for 4 hours. Interpretation of the results of this study are limited in that sublimation may have resulted in the generation of atmospheres containing a higher proportion of volatile contaminants and thermal decomposition products than would be expected in atmospheres typical of most occupational exposures.

3.2.1.2 Systemic Effects

Respiratory Effects. Extremely limited information is available regarding the respiratory effects of aldrin and dieldrin in humans after inhalation exposure. A study of workers with at least 4 years of employment in the manufacture of aldrin, dieldrin, endrin, or telodrin found no new pulmonary disease or deterioration of existing pulmonary disease (Jager 1970). Similarly, no increase in mortality from respiratory diseases was noted in workers employed for at least 1 year at the same plant during 1954–1970 when these workers were followed for at least 20 years (de Jong 1991). In contrast, in another study that examined workers involved in the manufacture of aldrin, dieldrin, and/or endrin for at least a year, a significantly increased incidence of pneumonia and other pulmonary diseases was found when compared to the incidence in U.S. white males (Ditraglia et al. 1981). However, all of these studies are limited by small sample size and the possible exposure of the workers to other chemicals and/or pesticides.

Extremely limited data were located regarding respiratory effects in animals after inhalation exposure to aldrin or dieldrin. Cats, guinea pigs, rats, rabbits, and mice exposed to aldrin vapors and particles generated by sublimating aldrin at 200 EC were reported to have exhibited symptoms indicative of mucous membrane irritation (Treon et al. 1957b). However, the exposure levels associated with these effects were not reported, and the contribution of thermal decomposition products or other volatile contaminants other than aldrin cannot be eliminated.

Cardiovascular Effects. Very limited information is available regarding the cardiovascular effects of aldrin and dieldrin in humans after inhalation exposure. Suggestive evidence of an association between dieldrin and hypertension was obtained in a study examining disease incidence in patients with elevated fat levels of dieldrin (Radomski et al. 1968). However, the number of patients with hypertension in this study was low (eight cases), and elevated fat levels of other pesticide residues also correlated with hypertension. Furthermore, other studies did not support the correlation of hypertension with dieldrin exposure. For example, a study examining disease incidence in 2,620 pesticide-exposed workers reported no increase in the incidence of hypertension in workers with elevated serum dieldrin (Morgan et al. 1980). Also, workers involved in the manufacture of aldrin, dieldrin, endrin, or telodrin for at least 4 years had normal blood pressure (Jager 1970). Similarly, no increased mortality from circulatory system diseases was observed in the mortality study by de Jong (1991). All of these studies are limited because the subjects were exposed to a variety of other chemicals.

A slight, but significant, increase in serum cholesterol was observed in pesticide-exposed workers with elevated serum dieldrin (Morgan and Lin 1978). However, this study was limited in that the workers were occupationally exposed to a number of different pesticides and other chemicals including hydrocarbon solvents.

No studies were located regarding cardiovascular effects in animals after inhalation exposure to aldrin or dieldrin.

Gastrointestinal Effects. No increased mortality from digestive system causes was observed in a mortality study of workers employed in the manufacture of aldrin and dieldrin for at least 1 year between 1954 and 1970 (de Jong 1991).

No studies were located regarding gastrointestinal effects in animals after inhalation exposure to aldrin or dieldrin.

Hematological Effects. No abnormal values for hemoglobin, white blood cells, or erythrocyte sedimentation rate were found in workers who had been employed in the manufacture of aldrin, dieldrin, endrin, or telodrin for at least 4 years (Jager 1970). Similarly, no increase in blood diseases was observed in a morbidity study of workers employed at the plant described by Jager (1970) over the period of 1979–1990 (de Jong 1991). Also, workers who had been involved in either the manufacture or application of pesticides and who had elevated blood levels of dieldrin, had no hematological effects of clinical significance (Morgan and Lin 1978; Warnick and Carter 1972). These studies are limited by either potential exposure to other chemicals (de Jong 1991; Jager 1970; Morgan and Lin 1978) or by known exposure to other pesticides as demonstrated by elevated blood levels of "β-benzine [sic] hexachloride" (β-benzene hexachloride), heptachlor epoxied, 1,1,1-trichloro-2,2-bis(*p*-chloro-phenyl)ethane (*p,p*'-DDT), 1,1,1-trichloro-2-(*o*-chlorophenyl)2-(*p*-chlorophenyl)ethane (*o,p*'-DDT), and 1,1-dichloro-2,2-bis(*p*-chloro-phenyl) ethene (*p,p*'-DDE) (Warnick and Carter 1972).

A case of immunohemolytic anemia attributable to multiple dieldrin exposures was reported (Muirhead et al. 1959). Also, a worker from a grove where aldrin was sprayed developed aplastic anemia (Pick et al. 1965) and one person employed in the manufacture of aldrin and dieldrin between 1954 and 1970 died from aplastic anemia (de Jong 1991). However, it is unclear whether these cases of aplastic anemia were directly due to aldrin or dieldrin exposures because exposure to a variety of other chemicals was possible. Also, three cases of pancytopenia and one case of thrombocytopenia associated with exposure to dieldrin were reported during 1961 (AMA 1962). However, no assessment of whether dieldrin was the causative agent was provided in the report.

No studies were located regarding hematologic effects in animals after inhalation exposure to aldrin or dieldrin.

Musculoskeletal Effects. No studies were located regarding musculoskeletal effects in humans or animals after inhalation exposure to aldrin or dieldrin.

Hepatic Effects. Although a slight increase in serum hepatic enzymes (serum alanine aminotransferase [ALT] and serum aspartate aminotransferase [AST]) has been observed to correlate with serum dieldrin levels in one study of pesticide-exposed workers (Morgan and Lin 1978), no evidence of any hepatic effects of aldrin or dieldrin exposure have been observed in other studies of workers involved in either the manufacture (de Jong 1991; Hoogendam et al. 1965; Hunter et al. 1972; Jager 1970; van Sittert and de Jong 1987) or the manufacture or application (Morgan and Roan 1974; Warnick and Carter 1972) of these pesticides. Parameters that have been examined in the negative studies include serum hepatic enzyme activity (Hoogendam et al. 1965; Jager 1970; Morgan and Roan 1974; van Sittert and de Jong 1987; Warnick and Carter 1972), hepatic enlargement (Jager 1970), and tests intended to detect microsomal enzyme induction (Hunter et al. 1972; Jager 1970; Morgan and Roan 1974; van Sittert and de Jong 1987). All of the studies are limited by the potential exposure of the workers to other chemicals and/or organochlorine pesticides.

No studies were located regarding hepatic effects in animals after inhalation exposure to aldrin or dieldrin.

Renal Effects. No evidence of renal damage was seen in workers employed for four or more years in the manufacture of aldrin or dieldrin (Jager 1970). This study is limited by the potential exposure of the workers to other chemicals.

Endocrine Effects. No studies were located regarding endocrine effects in humans or animals after inhalation exposure to aldrin or dieldrin.

Dermal Effects. No evidence of dermatitis was seen in workers employed for four or more years in the manufacture of aldrin, dieldrin, endrin, or telodrin (Jager 1970). This study is limited by the possible exposure of the workers to other chemicals.

Extremely limited data were located regarding dermal/ocular effects in animals after inhalation exposure to aldrin or dieldrin. Cats, guinea pigs, rats, rabbits, and mice exposed to aldrin vapors and particles generated by sublimating aldrin at 200 EC were reported to have exhibited symptoms indicative of mucous membrane irritation (Treon et al. 1957b). However, the exposure levels associated with these effects were not reported and the contribution of thermal decomposition products or other volatile contaminants other than aldrin cannot be eliminated.

Ocular Effects. No studies were located regarding ocular effects in humans or animals after inhalation exposure to aldrin or dieldrin.

3.2.1.3 Immunological and Lymphoreticular Effects

Limited information is available regarding the immunological effects of aldrin or dieldrin in humans after inhalation exposure. A case report was located concerning a pesticide sprayer who developed immunohemolytic anemia after multiple exposures to dieldrin, heptachlor, and toxaphene (Muirhead et al. 1959). Antibodies for dieldrin-coated or heptachlor-coated red blood cells were found in the subject's serum. However, this study is limited because of the exposure of the subject to other pesticides.

No studies were located regarding immunological effects in animals after inhalation exposure to aldrin or dieldrin.

3.2.1.4 Neurological Effects

Central nervous system excitation culminating in convulsions was the principal adverse effect noted in occupational studies of workers employed in either the application or manufacture of aldrin or dieldrin. In many cases, convulsions appeared suddenly and without prodromal signs (Hoogendam et al. 1965; Kazantzis et al. 1964; Patel and Rao 1958). Electroencephalograms (EEGs) taken shortly after the convulsions revealed bilateral irregular alpha rhythms interrupted by spike and wave patterns (Avar and Czegledi-Janko 1970; Kazantzis et al. 1964). In one case study of dieldrin sprayers who developed convulsions, the convulsive episodes did not follow known accidental overexposures (Patel and Rao 1958). Rather, the convulsions developed anywhere from 14 to 154 days after the first exposure to dieldrin. The time to onset was more rapid for those sprayers using the more concentrated spray. An accumulative type of intoxication was also reported in workers involved in the manufacture of aldrin, dieldrin, telodrin, or endrin (Jager 1970). In this report, convulsions were believed to have been caused by either accumulating levels of dieldrin in the blood or modest overexposures in the presence of subconvulsive accumulations of dieldrin.

Other central nervous system symptoms reported by workers involved in the manufacture or application of aldrin and/or dieldrin included headaches (Jager 1970; Patel and Rao 1958), dizziness (Jager 1970), hyperirritability (Jager 1970; Kazantzis et al. 1964), general malaise (Jager 1970), nausea and vomiting (Jager 1970; Kazantzis et al. 1964), anorexia (Jager 1970), muscle twitching (Jager 1970; Patel and Rao 1958), and myoclonic jerking (Jager 1970; Kazantzis et al. 1964). The more severe symptoms were accompanied by EEG patterns with bilateral spike and wave complexes and multiple spike and wave discharges in the alpha region (Jager 1970; Kazantzis et al. 1964). Less severe symptoms were accompanied by bilateral theta (Jager 1970; Kazantzis et al. 1964) and/or delta (Kazantzis et al. 1964) wave discharges.

In all cases in which follow-up of the subjects was reported, removal from the source of exposure caused a rapid physical recovery and a slower recovery of the EEG activity (within a year) to normal levels (Avar and Czegledi-Janko 1970; Hoogendam et al. 1962, 1965; Jager 1970; Kazantzis et al. 1964).

A morbidity study of workers employed in the manufacture of aldrin and dieldrin between 1979 and 1990 noted no degenerative disorders of the nervous system (de Jong 1991). However, this study reported significant increases in mental diseases among those <30 years old and in those 46–50 years old. The diseases were classified as stress reactions, short-term depression, or sleep disorders. It is unclear whether these effects were the result of aldrin/dieldrin exposure.

Results from a comprehensive neurological workup of 27 workers involved in either the manufacture or application of dieldrin were compared to those of a group of unexposed workers (Sandifer et al. 1981). Scores on five psychological tests were significantly different from those of the unexposed controls; however, the importance of the results was questioned by the authors because of differences in the degree of literacy between the two groups. Also, three exposed workers had abnormal electromyograms (EMGs) suggesting a peripheral neuropathy. However, EMGs were not obtained in the control group; thus, the significance of these results is unknown.

No studies were located regarding neurological effects in animals after inhalation exposure to aldrin or dieldrin.

3.2.1.5 Reproductive Effects

No studies were located regarding reproductive effects in humans or animals after inhalation exposure to aldrin or dieldrin.

3.2.1.6 Developmental Effects

No studies were located regarding developmental effects in humans or animals after inhalation exposure to aldrin or dieldrin.

3.2.1.7 Cancer

Selected Mortality Studies. Aldrin and dieldrin were manufactured at two sites worldwide in plants at the Rocky Mountain Arsenal in Denver, Colorado, and at Pernis in the Netherlands. Workers from these plants have been included in two series of retrospective cohort mortality studies which have been updated several times. Exposure to dibromochloropropane (DBCP) and several organophosphates may also have occurred in the Denver plant. Cancer mortality findings of the studies at the Denver plant (Amoateng-Adjepong et al. 1995; Brown 1992; Ditraglia et al. 1981; Ribbens 1985) and the Pernis plant (de Jong 1991; de Jong et al. 1997; Jager 1970; Ribbens 1985; van Raalte 1977) are inconclusive, as summarized below.

The first study of the Denver plant found no significant increase in cancer mortality, but concluded that additional follow-up was necessary due to a small number of deaths (173) and the relatively short period of observation (Ditraglia et al. 1981). In the follow-up by Brown (1992), 1,158 workers who were employed for at least 6 months prior to 1965 and were followed through 1987 were investigated. Cause-specific mortality analysis of 337 deaths showed an increase in liver and biliary tract cancer (five cases observed) that was statistically significant when compared to state and local rates (Standardized mortality ratios [SMRs] of 5.10 and 4.86, respectively), but not the national rate (SMR=3.93). All of these five deaths (three from biliary tract/bile duct cancer, one from gall bladder cancer, and one from hepatoma) occurred after 15 years of latency (SMR=4.85). The cohort in the most recent study of the Denver plant (Amoateng-Adjepong et al. 1995) was expanded to 2,384 subjects and followed through 1990 (median 29 years). The median age at hiring was 26 years and the median tenure was 2 years. The increase in hepatobiliary cancer was of a lower magnitude than in the previous study and was no longer statistically significant, although no additional cases had occurred (5 cases observed/2.0 expected based on state rates, SMR=249). Based on this information and findings that the cancers were not limited to any particular production unit, did not display duration-response trends, and essentially occurred in the biliary tract or gall bladder (rather than liver), the investigators concluded that the hepatobiliary cancer excess was not due to occupational exposures at the plant.

No indications of a carcinogenic effect were found in the early mortality studies of the Dutch (Pernis) workers (Jager 1970; Ribbens 1985; van Raalte 1977). Similarly, in the follow-up study by de Jong (1991), there were no increases in cause-specific mortality among 76 deaths in 570 workers who were employed for at least 1 year between 1954 and 1970 and followed-up until 1987. Follow-up of this cohort until 1993 (118 deaths) showed a significant increase in mortality from rectal cancer (6 deaths observed versus 1.5 expected compared to Netherlands national rates, SMR=390.4) and an insignificant increase in liver cancer deaths (2 observed versus 0.9 expected, SMR=225.0) (de Jong et al. 1997). Stratification by dose level (low, moderate, or high exposure based on blood levels of dieldrin) did not disclose any indications of a dose-response relation for either of these causes of death.

Equivocal evidence exists for an association between dieldrin and breast cancer risk from three human epidemiologic studies (Dorgan et al. 1999; Høyer et al. 1998, 2000). In these studies, while dieldrin exposure was verified through blood sampling, and exposure by inhalation, as well as by ingestion and dermal contact, was possible, no specific route of exposure was identified or estimated with any certainty.

The potential of dieldrin to affect breast cancer risk was evaluated in a prospective nested case control study of women in Denmark (Høyer et al. 1998). Serum samples were obtained from 7,712 women from 1976 to 1978. In 1996–1997, serum samples from 240 women who had developed invasive breast cancer and 477 matched breast cancer-free controls were analyzed for levels of dieldrin and 17 other organochlorine pesticides or metabolites and 28 PCB congeners. Controls and cases were matched for age, date of examination, and vital status at the examination. Irrespective of breast cancer status, dieldrin was detected in 78% of the women enrolled in the study, with median levels at 24.4 ng/g lipid. Dieldrin was the only organochlorine compound of those tested associated with a significant increase in breast cancer risk. Women in the highest quartile of the serum dieldrin range had double the risk of breast cancer compared to women in the lowest quartile (odds ratio [OR] 2.25, 95% confidence interval [CI] 1.32–3.84, p trend=0.003). Relative risk (RR) did not change significantly when adjusted for potential confounders of weight and number of full-term pregnancies (OR 2.05, 95% CI 1.17–3.57, p trend=0.01).

A subsequent study using the same cohort of Danish women investigated whether breast cancer survival was affected by past exposure to dieldrin (Høyer et al. 2000). Dieldrin, at blood concentrations >57.6 ng/g, representative of the highest quartile, was found to have a significant adverse effect on overall survival and breast cancer specific survival compared to the lowest quartile levels of <12 ng/g lipid (RR 2.78, 95% CI 1.38–5.59, p trend<0.01; RR 2.61, 95% CI 0.97–7.01, p trend<0.01) in this case-control study of Danish women between 20 and 80 years of age. A total of 195 breast cancer cases, who each provided two blood samples that were taken in 1976–1978 and 1981–1983, respectively, were included in the survival analysis. The median duration of follow-up with regard to death was 86 months after the first examination (1976–1978) and 79 months after the second examination (1981–1983). Relative risk was adjusted for number of positive lymph nodes and tumor size and grade. When the analysis was performed using an average of the blood concentrations from the two collections, the association was even stronger, with a 5-fold higher risk of death in women from the highest quartile compared to the lowest quartile (RR 5.76, 95% CI 1.86–17.92, p trend<0.01) and a clear dose-response relationship. Potential confounders as body mass index, age at menopause, and hormone replacement therapy did not influence the results. This study was limited by small size, 6–39 women per quartile.

A cohort study of women from Missouri failed to find an association between serum dieldrin levels and breast cancer risk (Dorgan et al. 1999). Blood samples were collected from 7,224 women from 1977 to 1987. During the 9.5-year follow-up period, 105 women developed breast cancer; each was matched to two controls based on age and date of blood collection. Dieldrin was detected in serum in 56.2% of the cases and 61.8% of the controls. The relative risk of cancer in the highest dieldrin serum concentration range quartile was moderately lower compared to the lowest quartile (RR 0.7, 95% CI 0.3–1.3, p=0.44).

Animal Cancer Studies. No studies were located regarding cancer in animals after inhalation exposure to aldrin or dieldrin. As summarized in Section 3.2.2.7, EPA derived carcinogenic potency estimates for oral exposure to aldrin and dieldrin using liver tumor responses in mice. Based on the oral data, unit risk estimates for inhalation exposures (the excess cancer risk associated with lifetime exposure to 1 $\mu g/m^3$) of 4.9×10^{-3} and 4.6×10^{-3} were calculated for aldrin and dieldrin, respectively (EPA 1986; IRIS 2002a, 2002b). Based on these unit risk values, aldrin and dieldrin cancer risk levels of 10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7} correspond to 70 years of continuous exposure to 0.02, 0.002, 0.0002, and 2.0×10^{-5} $\mu g/m^3$, respectively (1.3, 1.3×10^{-1}, 1.3×10^{-2}, and 1.3×10^{-3} ppt). The predicted cancer risks are considered conservative upper estimates. The actual risk of cancer is unlikely to be higher and may be substantially lower.

3.2.2 Oral Exposure

3.2.2.1 Death

A 2-year-old child died a short time after consuming an unknown quantity of a 5% solution of dieldrin (Garrettson and Curley 1969). It is unclear from this report whether the child died during the severe convulsions produced by the dieldrin or during the postictal period (the period immediately following a seizure that is characterized by central nervous system depression). This child's 4-year-old brother, who also consumed an unknown quantity of the 5% dieldrin solution, experienced severe convulsions but recovered completely.

Of several persons who consumed wheat that had been mixed with aldrin and lindane for a period of 6–12 months, an infant female child died within a few hours after experiencing a severe generalized convulsion (Gupta 1975).

The doses at which aldrin is acutely lethal in experimental animals are quite similar to lethal dieldrin doses. Oral LD_{50} values for single doses of aldrin in rats ranged from 39 to 64 mg/kg (Gaines 1960; Treon et al. 1952). Oral LD_{50} values for single doses of dieldrin in adult rats ranged from 37 to 46 mg/kg/day (Gaines 1960; Lu et al. 1965; Treon et al. 1952). Aldrin was lethal in females at a slightly lower dose when it was administered in solution in oil (LD_{50}=48 mg/kg) than when it was administered in a kerosene vehicle (LD_{50}=64 mg/kg) (Treon et al. 1952).

The age of the animals appeared to influence the acute toxicity of a single administration of dieldrin. Newborn rats had a relatively high LD_{50} (168 mg/kg) (Lu et al. 1965); whereas 2-week-old rats had an LD_{50} of 25 mg/kg, which is somewhat lower that the adult LD_{50} value (Lu et al. 1965). When aldrin was widely used as an insecticide, several incidents were reported in which livestock died as the result of accidental mixing of unspecified amounts of aldrin with livestock feed (Buck and Van Note 1968). In an incident in which both calves and adult cattle were exposed, mortality occurred exclusively among the calves.

Decreased survival in animals consuming aldrin and/or dieldrin over longer periods was seen at lower doses. All rats consuming 15 mg/kg/day aldrin or dieldrin in the diet died by the end of the second week of exposure (Treon et al. 1951a). Rats exposed to aldrin or dieldrin for 6 weeks exhibited increased mortality at estimated doses of 8 and 16 mg/kg/day, respectively (NCI 1978a). When exposed for 2 years or more, rats exhibited decreased survival at doses of 0.5–2.5 mg/kg/day aldrin or dieldrin (Deichmann et al. 1970; Fitzhugh et al. 1964; Harr et al. 1970; NCI 1978a).

In intermediate- and chronic-duration studies, dogs and mice appeared to have a sensitivity to the lethal effects of aldrin and/or dieldrin that is similar to that of rats. All dogs given aldrin at doses of 0.89–1.78 mg/kg/day or dieldrin at doses of 1.95–4.24 mg/kg/day died or were killed in a moribund condition in a 9-month dietary study (Treon et al. 1951b). Dogs appeared to survive for longer periods if the dog was larger or older at the start of the study. Decreased survival in dogs exposed for 25 months was also observed at 1 mg/kg/day aldrin or 0.5 mg/kg/day of dieldrin (Fitzhugh et al. 1964). In mice, decreased survival was seen at 1.3 mg/kg/day dieldrin (Thorpe and Walker 1973; Walker et al. 1972). In contrast, hamsters appeared to be less sensitive to dieldrin. Exposure to 14.9 mg/kg/day dieldrin for 120 weeks had no effect on hamster survival (Cabral et al. 1979).

The highest NOAEL values, all LD_{50} values, and all reliable LOAEL values for death in each species and duration category are recorded for aldrin in Table 3-1 and for dieldrin in Table 3-2 and plotted for aldrin in Figure 3-1 and for dieldrin in Figure 3-2.

3.2.2.2 Systemic Effects

No studies were located regarding dermal/ocular effects in humans or animals after oral exposure to aldrin or dieldrin.

The highest NOAEL values and all reliable LOAEL values for each study for each end point for dieldrin are recorded in Table 3-2 and plotted in Figure 3-2.

Table 3-1. Levels of Significant Exposure to Aldrin - Oral

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
ACUTE EXPOSURE							
Death							
1	Rat	1 x (GO)				39[d] (LD_{50}, male) 60 (LD_{50}, female)	Gaines 1960
2	Rat	2 wk ad lib (F)				15 (10/10 died)	Treon et al. 1951a
3	Rat	1 d (G)				63.6 (LD_{50})	Treon et al. 1952
4	Rat	1 d (GO)				48.3 (LD_{50})	Treon et al. 1952
Neurological							
5	Rat	3 d 1x/d (GO)		5		10 (convulsions)	Mehrotra et al. 1989
Reproductive							
6	Mouse	5 d 1x/d (G)		1.0			Epstein et al. 1972
Developmental							
7	Mouse	5-7 d (GO)			2[b] (decreased body weight and increased seizure threshold in offspring)		Al-Hachim 1971

Table 3-1. Levels of Significant Exposure to Aldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
8	Mouse	1 x Gd 9 (GO)				25 (webbed feet)	Ottolenghi et al. 1974
9	Hamster	1 x Gd 7, 8, or 9 (GO)				50 (increased fetal mortality)	Ottolenghi et al. 1974

Table 3-1. Levels of Significant Exposure to Aldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
INTERMEDIATE EXPOSURE							
Death							
10	Rat	6 wk ad lib (F)				8 (2/10 died)	NCI 1978a
11	Mouse	6 wk ad lib (F)				2.6 (2/10 died)	NCI 1978a
12	Dog	9 mo ad lib (F)				0.89-1.78 (2/2 died)	Treon et al. 1951b
13	Dog	5 wk 5d/wk (C)				1.5 (3/3 pre-weanlings died)	Treon et al. 1955b
Systemic							
14	Rat	27 wk ad lib (F)	Hepatic	1.25			Treon et al. 1953b
			Renal	1.25			
			Bd Wt	0.63	1.25 (decreased body weight gain)		
15	Dog	9 mo ad lib (F)	Gastro		0.89-1.78 (vomiting)		Treon et al. 1951b
			Hepatic		0.89-1.78 (moderate hepatocellular degeneration)		

Table 3-1. Levels of Significant Exposure to Aldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
Neurological							
16	Dog	9 mo ad lib (F)				0.89-1.78 (hypersensitivity; tremors; convulsions; neuronal degeneration)	Treon et al. 1951b

Table 3-1. Levels of Significant Exposure to Aldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
CHRONIC EXPOSURE							
Death							
17	Rat	31 mo 7d/wk (F)				2.5 (33% reduced survival in females)	Deichmann et al. 1970
18	Rat	2 yr ad lib (F)				2.5 (58% reduced survival)	Fitzhugh et al. 1964
19	Mouse	80 wk ad lib (F)				0.78 (34% reduced survival)	NCI 1978a
Systemic							
20	Rat	25 mo ad lib (F)	Hemato	0.25			Deichmann et al. 1967
			Hepatic		0.25 (slight liver degeneration)		
			Renal		0.25 (hyaline casts)		
21	Rat	2 yr ad lib (F)	Hepatic		0.025^c (hepatocellular enlargement and vacuolation, bile duct proliferation)		Fitzhugh et al. 1964; Reuber 1980
			Renal	0.1	0.5 (nephritis)	2.5 (bladder distension and hemorrhages)	
22	Dog	15.7 mo 7 d/wk 1-3x/d (F)	Hepatic	0.04-0.09	0.12-0.25 (hyaline droplet degeneration)		Treon et al. 1955b
			Renal		0.04-0.09 (vacuolation of renal tubules)		

Table 3-1. Levels of Significant Exposure to Aldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
Neurological							
23	Rat	74-80 wk ad lib (F)				1.5 (convulsions)	NCI 1978a
24	Mouse	80 wk ad lib (F)			0.39 (hyperexcitability)		NCI 1978a
Reproductive							
25	Rat	3 gen ad lib (F)				0.63 (decreased number of litters)	Treon et al. 1954a
Developmental							
26	Rat	3 gen ad lib (F)				0.125 (increased mortality of offspring)	Treon et al. 1954a
Cancer							
27	Rat	74-80 wk ad lib (F)				1.5 (CEL - thyroid)	NCI 1978a
28	Mouse	2 yr 7d/wk (F)				1.3 (CEL - liver)	Davis and Fitzhugh 1962

Table 3-1. Levels of Significant Exposure to Aldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
29	Mouse	80 wk ad lib (F)				0.52 (CEL - liver)	NCI 1978a

[a]The number corresponds to entries in Figure 3-1.

[b]Used to derive an acute oral Minimal Risk Level (MRL) of 0.002 mg/kg/day; LOAEL (2 mg/kg/day) divided by an uncertainty factor of 1,000 (10 for use of a LOAEL, 10 for extrapolation from animals to humans, and 10 for human variability).

[c]Used to derive a chronic oral Minimal Risk Level (MRL) of 0.00003 mg/kg/day; LOAEL (0.025 mg/kg/day) divided by an uncertainty factor of 1,000 (10 for used of a LOAEL, 10 for extrapolation from animals to humans, and 10 for human variability).

[d]Differences in levels of health effects and cancer effects between males and females are not indicated in Figure 3-1. Where such differences exist, only the levels of effect for the most sensitive gender are presented.

ad lib = ad libitum; (C) = capsule; CEL = cancer effect level; d = day(s); (F) = feed; (G) = gavage (not specified); Gastro = gastrointestinal; Gd = gestation day(s); gen = generation(s); (GO) = gavage (oil); LD_{50} = lethal dose, 50% kill; LOAEL = lowest-observed-adverse-effect level; mo = month(s); NOAEL = no-observed-adverse-effect level; wk = week(s); x = time(s); yr = year(s)

Figure 3-1. Levels of Significant Exposure to Aldrin - Oral

Acute (≤14 days)

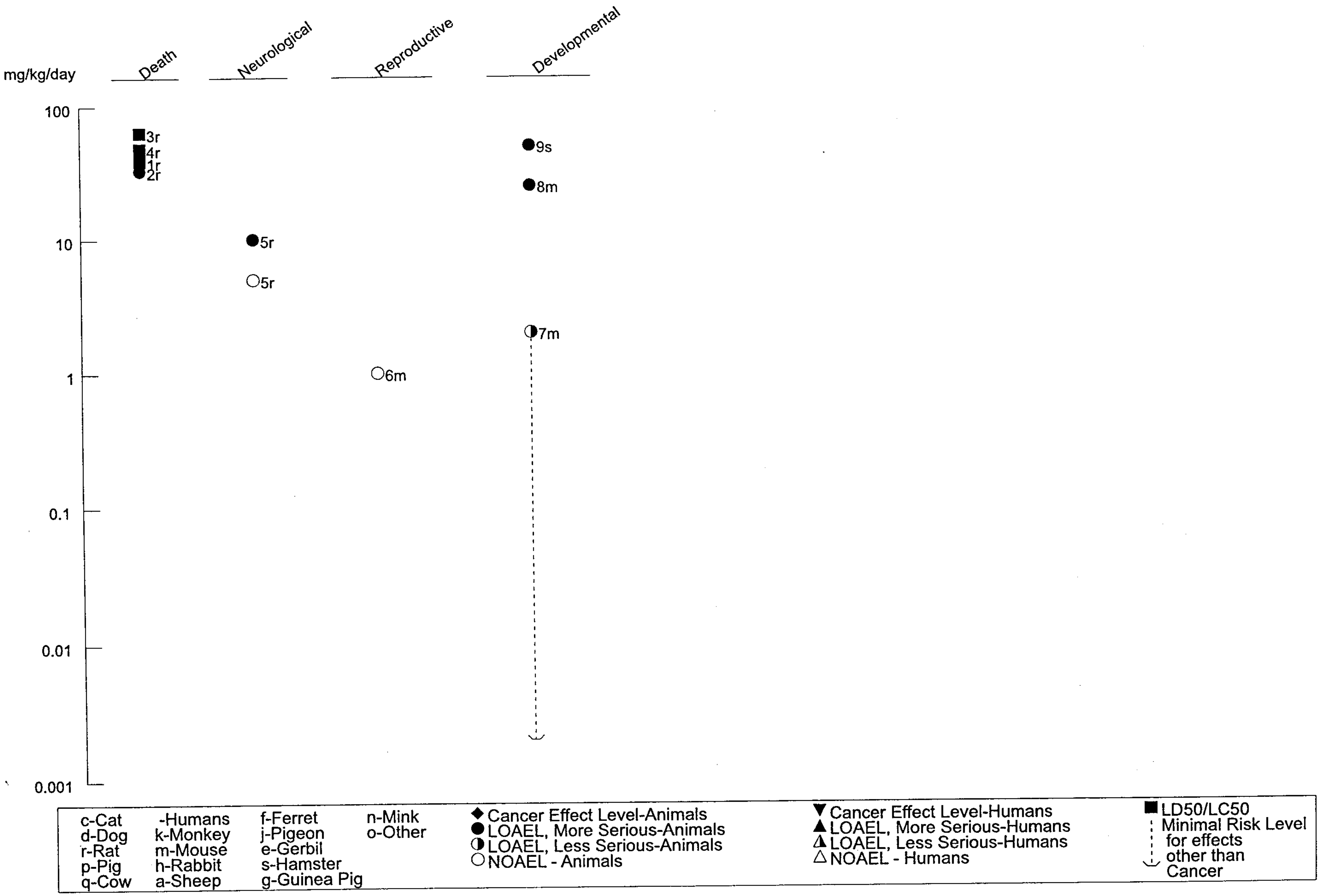
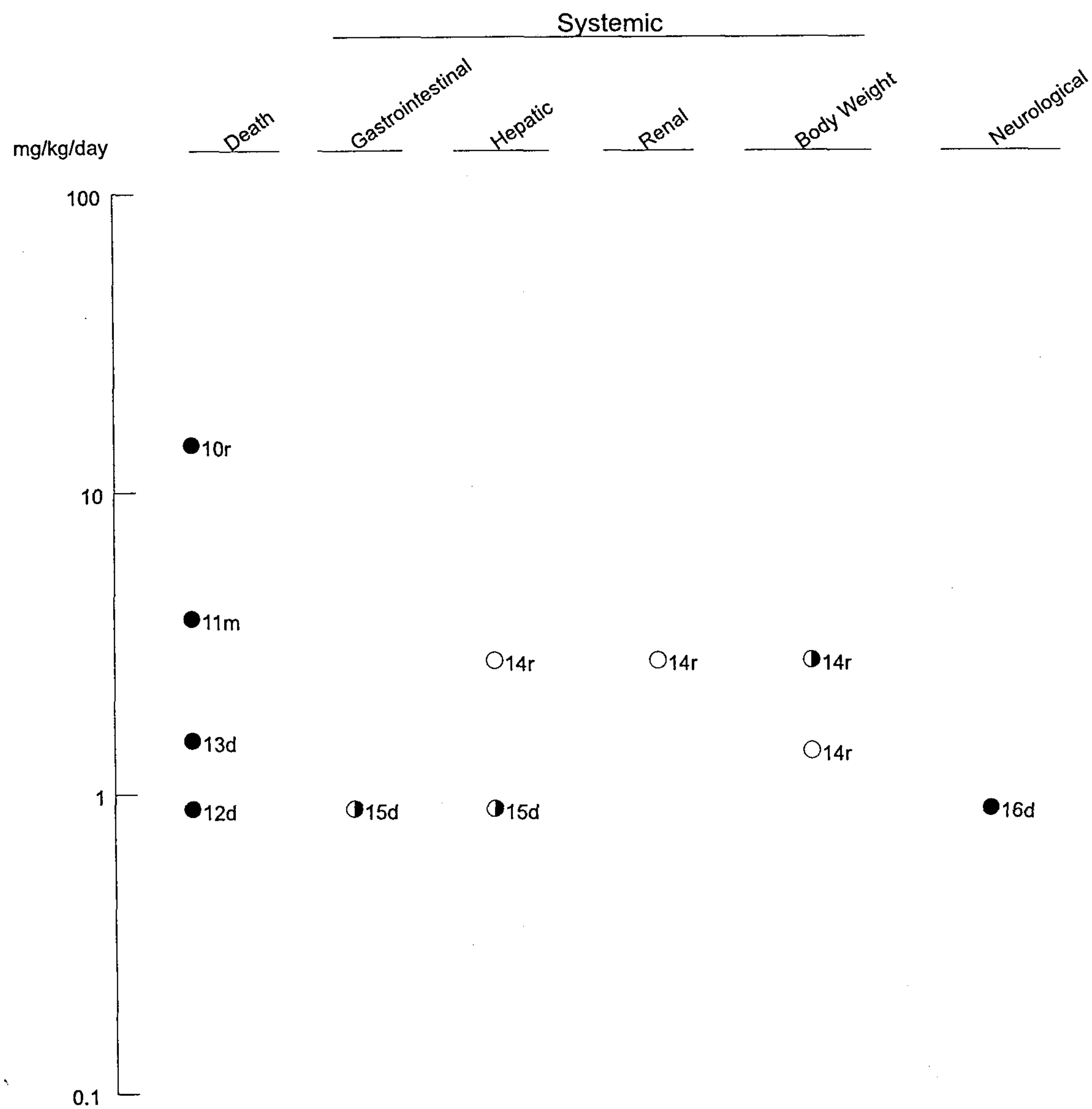


Figure 3-1. Levels of Significant Exposure to Aldrin - Oral (*Continued*)

Intermediate (15-364 days)



c-Cat -Humans f-Ferret n-Mink
d-Dog k-Monkey j-Pigeon o-Other
r-Rat m-Mouse e-Gerbil
p-Pig h-Rabbit s-Hamster
q-Cow a-Sheep g-Guinea Pig

◆ Cancer Effect Level-Animals
● LOAEL, More Serious-Animals
◑ LOAEL, Less Serious-Animals
○ NOAEL - Animals

▼ Cancer Effect Level-Humans
▲ LOAEL, More Serious-Humans
◭ LOAEL, Less Serious-Humans
△ NOAEL - Humans

■ LD50/LC50
Minimal Risk Level for effects other than Cancer

Figure 3-1. Levels of Significant Exposure to Aldrin - Oral (*Continued*)

Chronic (≥365 days)

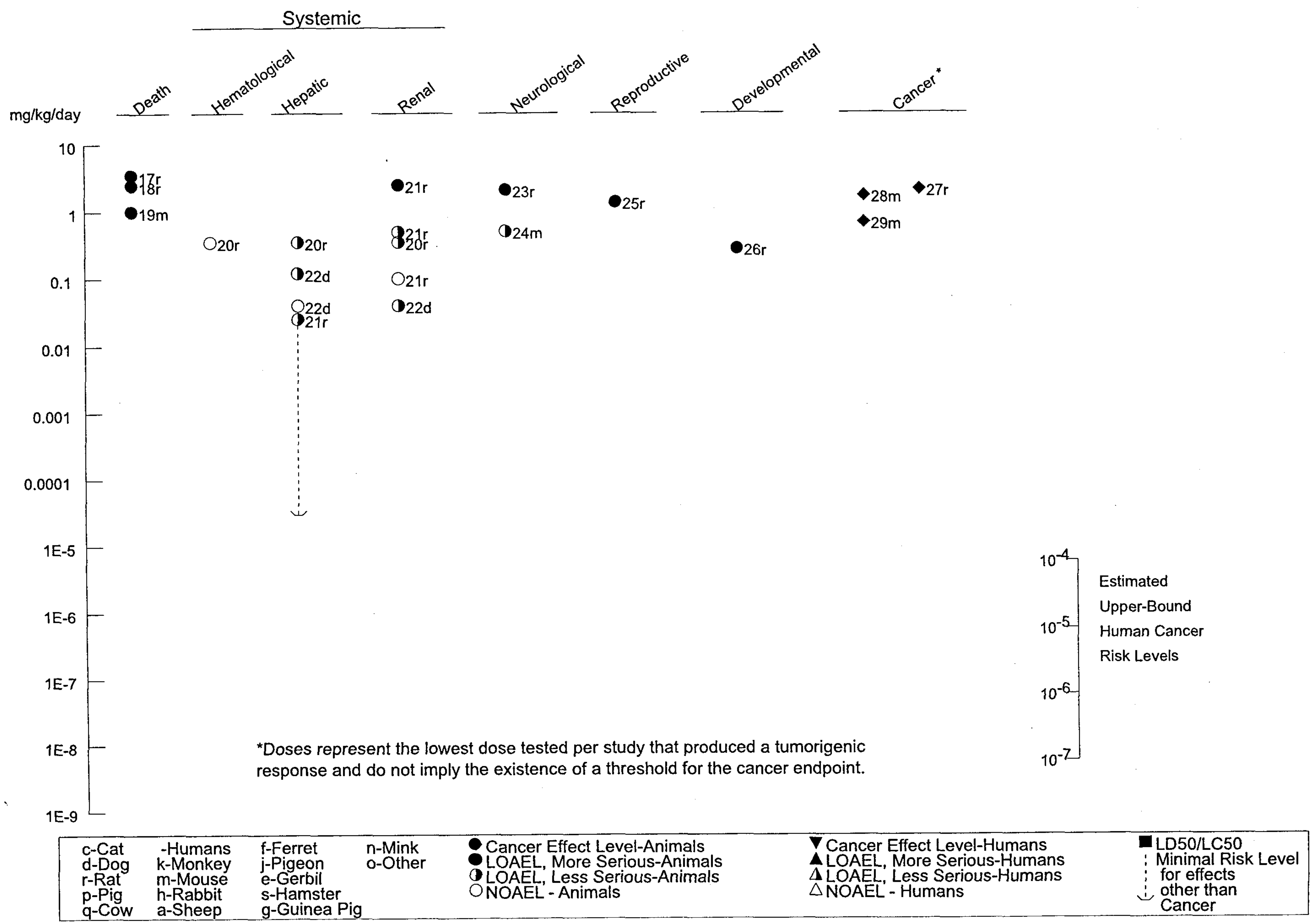


Table 3-2. Levels of Significant Exposure to Dieldrin - Oral

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
	ACUTE EXPOSURE						
	Death						
1	Rat	10 d 1x/d Gd7-16 (GO)		3		6 (13/32 dams died)	Chernoff et al. 1975
2	Rat	1 x (GO)				46 (LD_{50})	Gaines 1960
3	Rat	1 x (GO)				168 (LD_{50}, newborn)	Lu et al. 1965
4	Rat	1 x (GO)				37 (LD_{50}, young adult)	Lu et al. 1965
5	Rat	4 d 1 x (GO)				9 (LD_{50}, 14-16 day old)	Lu et al. 1965
6	Rat	1 x (GO)				25 (LD_{50}, 14-16 day old)	Lu et al. 1965
7	Rat	4 d 1x/d (GO)				54.8 (LD_{50}, young adult)	Lu et al. 1965
8	Rat Carworth	2 wk ad lib (F)				15 (10/10 died)	Treon et al. 1951a
9	Rat	1 d (GO)				38.8 (LD_{50})	Treon et al. 1952

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
Systemic							
10	Rat	1 x (GO)	Hepatic		26 (increased lipid peroxidation)		Goel et al. 1988
11	Rat	1 x (GO)	Hepatic		30 (decreased lipid peroxidation)		Kohli et al. 1977
12	Rat	3 d 1x/d (GO)	Cardio	10			Mehrotra et al. 1989
13	Mouse	1-2 wk ad lib (F)	Hepatic	1.6			Wright et al. 1972
Immunological/Lymphoreticular							
14	Mouse	2 x (GO)			16.6 (impaired T-cell activity)		Fournier et al. 1988
15	Mouse	1 x (GO)		12		18 (increased lethality following viral infection)	Krzystniak et al. 1985
16	Mouse	2 wk ad lib (F)			0.065 (impaired antigen processing by macrophages)		Loose et al. 1981
Neurological							
17	Rat	1 x (GO)		8.4		16.7 (disrupted operant behavior)	Burt 1975
18	Rat	1 x (GO)				2.5 (disrupted operant behavior)	Burt 1975

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
19	Rat	1 x (GO)				0.5 (impaired behavior)	Carlson and Rosellini 1987
20	Rat	1 x (GO)			40 (hypothermia)	50 (convulsions)	Wagner and Greene 1978
21	Rat	1 x (GO)				25 (increased evoked potentials)	Woolley et al. 1985
22	Sheep	4 d (C)				20 (impaired operant behavior; EEG changes)	Sandler et al. 1969
	Developmental						
23	Rat	10 d 1x/d Gd7-16 (GO)		6			Chernoff et al. 1975
24	Mouse	10 d 1x/d Gd7-16 (GO)		1.5		3 (supernumerary ribs)	Chernoff et al. 1975
25	Mouse	13 d Gd6-18 (GO)			2 (low blood glucose level in neonates)		Costella and Virgo 1980
26	Mouse	1 x (GO)				15 (webbed foot; cleft palate)	Ottolenghi et al. 1974
27	Hamster	1 x Gd 7, 8, or 9 (GO)				30 (open eye; webbed foot; cleft palate; increased resorptions; increased fetal mortality)	Ottolenghi et al. 1974

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
INTERMEDIATE EXPOSURE							
Death							
28	Rat	6 wk ad lib (F)				16 (7/10 died)	NCI 1978a
29	Mouse	6 wk ad lib (F)				2.6 (7/10 died)	NCI 1978a
30	Mouse	74 d ad lib (F)				2.6 (17% increased mortality)	Virgo and Bellward 1975
31	Mouse	40 wk (F)				7.5 (4/4 died)	Wright et al. 1972
32	Dog	9 mo ad lib (F)				1.95-4.24 (3/3 died)	Treon et al. 1951b
Systemic							
33	Rat	6 mo ad lib (F)	Hepatic		10 (hepatocellular necrosis)		Ahmed et al. 1986a
			Renal		10 (epithelial cell degeneration)		
34	Rat	15 d (GO)	Hepatic		5 (diffuse necrosis)		Bandyopadhyay et al. 1982b
			Renal		5 (glomerulonephritis; renal tubular nephrosis)		
35	Rat (Fischer- 344)	90d (F)	Hepatic	0.5			Kolaja et al. 1996a

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
36	Rat	1-6 mo (F)	Hepatic		2 (decreased hepatic protein; areas of necrosis)		Shakoori et al. 1982
37	Rat	27 wk ad lib (F)	Hepatic	1.25			Treon et al. 1953b
			Renal	1.25			
38	Mouse (B6C3F1)	90d (F)	Hepatic	1.3			Kolaja et al. 1996a
39	Mouse (B6C3F1)	28d (F)	Hepatic	1.3			Stevenson et al. 1995a
40	Mouse	40 wk (F)	Hepatic	1.6			Wright et al. 1972
41	Dog	9 mo ad lib (F)	Gastro	0.73-1.85	1.95-4.24 (vomiting)		Treon et al. 1951b
			Hepatic		0.73-1.85 (moderate hepatocellular degeneration)		
	Immunological/Lymphoreticular						
42	Mouse	10 wk ad lib (F)				0.13 (increased lethality following protozoan infection)	Loose 1982
43	Mouse	3, 6, 18 wk, 7d/wk, 1x/d (F)				0.13 (increased lethality following tumor implant)	Loose et al. 1981

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
Neurological							
44	Monkey	55-109 d 1x/d (F)		0.01[b]		0.1 (learning deficit)	Smith et al. 1976
45	Rat	6-120 d (F)		0.025		0.25 (disrupted operant behavior)	Burt 1975
46	Rat	60 d ad lib (GO)				0.5 (tremors)	Mehrotra et al. 1989
47	Dog	9 mo ad lib (F)				0.73-1.85 (neuronal degeneration convulsions)	Treon et al. 1951b
Reproductive							
48	Mouse	120 d 1x/d (F)				0.65 (decreased litter size)	Good and Ware 1969
49	Mouse	74 d ad lib (F)		0.65		1.3 (decreased fertility)	Virgo and Bellward 1975
50	Mouse	74 d ad lib (F)		0.65	1.3 (long latency to nursing)		Virgo and Bellward 1975
Developmental							
51	Mouse	74 d ad lib (F)		0.325		0.65 (increased pup mortality)	Virgo and Bellward 1975

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)		LOAEL Serious (mg/kg/day)		Reference
CHRONIC EXPOSURE									
Death									
52	Rat	31 mo (F)					1.5	(11% reduced survival in females)	Deichmann et al. 1970
53	Rat	2 yr ad lib (F)					2.5	(58% reduced survival)	Fitzhugh et al. 1964
54	Mouse	80 wk ad lib (F)					0.65	(10% increased mortality)	NCI 1978a
55	Mouse	132 wk 1x/d (F)					1.3	(50% mortality reached at 15 months versus 20-24 months in controls)	Walker et al. 1972
Systemic									
56	Human	18 mo (C)	Hemato	0.003					Hunter and Robinson 1967
			Hepatic	0.003					
57	Monkey	69 mo 1x/d (F)	Hepatic	0.1					Wright et al. 1978
58	Rat	2 yr ad lib (F)	Hepatic		0.025	(hepatocellular enlargement and vacuolation, bile duct proliferation)			Fitzhugh et al. 1964; Reuber 1980
			Renal	0.5	2.5	(nephritis)	5	(bladder distension and hemorrhages)	

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
59	Rat	2 yr ad lib (F)	Resp	0.5			Walker et al. 1969
			Cardio	0.5			
			Gastro	0.5			
			Hemato	0.5			
			Musc/skel	0.5			
			Hepatic	0.005[c] F	0.05 F (increased liver weight with parenchymal cell changes including focal hyperplasia at a higher dose)		
			Renal	0.5			
			Endocr	0.5			
			Dermal	0.5			
			Bd Wt	0.5			
60	Mouse	92 wk 7d/wk ad lib (F)	Hepatic	1.3			Tennekes et al. 1981
61	Mouse	2 yr (F)	Hepatic		1.3 (liver hyperplasia)		Thorpe and Walker 1973
62	Dog	15.7 mo 7 d/wk 1-3x/d (F)	Hepatic	0.14-0.26			Treon et al. 1955b
			Renal		0.14-0.26 (vacuolation of renal tubules)		

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
63	Dog	2 yr 1x/d (C)	Resp	0.05			Walker et al. 1969
			Cardio	0.05			
			Gastro	0.05			
			Hemato	0.05			
			Musc/skel	0.05			
			Hepatic	0.05			
			Renal	0.05			
			Endocr	0.05			
			Dermal	0.05			
			Ocular	0.05			
			Bd Wt	0.05			
Neurological							
64	Human	18 mo (C)		0.003			Hunter and Robinson 1967
65	Rat	59-80 wk ad lib (F)			1.45 (hyperexcitability)		NCI 1978a
66	Rat	104-105 wk ad lib (F)		0.5		2.5 (convulsions)	NCI 1978b
67	Rat	2 yr ad lib (F)		0.05		0.5 (tremors and occasional convulsions)	Walker et al. 1969
68	Mouse	80 wk ad lib (F)				0.33 (tremors)	NCI 1978a

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
69	Dog	2 yr 1x/d (C)		0.05			Walker et al. 1969
Reproductive							
70	Rat	3 gen ad lib (F)				0.125 (decreased number of litters)	Treon et al. 1954a
Developmental							
71	Rat	3 gen ad lib (F)				0.125 (increased mortality of offspring)	Treon et al. 1954a
Cancer							
72	Mouse	2 yr 7d/wk (F)				1.3 (CEL - liver)	Davis and Fitzhugh 1962
73	Mouse	75 wk ad lib (F)				1.3 (CEL - liver)	Lipsky et al. 1989
74	Mouse	85 wk ad lib (F)				1.3 (CEL - liver)	Meierhenry et al. 1983
75	Mouse	80 wk ad lib (F)				0.65 (CEL - liver)	NCI 1978a

Table 3-2. Levels of Significant Exposure to Dieldrin - Oral (continued)

Key to figure[a]	Species (Strain)	Exposure/ duration/ frequency (Specific route)	System	NOAEL (mg/kg/day)	LOAEL Less serious (mg/kg/day)	LOAEL Serious (mg/kg/day)	Reference
76	Mouse	92 wk 7d/wk ad lib (F)				1.3 (CEL - liver)	Tennekes et al. 1981
77	Mouse	132 wk 1x/d (F)				1.3 (CEL- liver)	Walker et al. 1972
78	Mouse	128 wk 1x/d (F)				0.33 (CEL - liver)	Walker et al. 1972

[a]The number corresponds to entries in Figure 3-2.

[b]Used to derive an intermediate oral Minimal Risk Level (MRL) of 0.0001 mg/kg/d; NOAEL (0.01 mg/kg/day) divided by an uncertainty factor of 100 (10 for extrapolation from animals to humans and 10 for human variability).

[c]Used to derive a chronic oral Minimal Risk Level (MRL) of 0.00005 mg/kg/d; NOAEL (0.005 mg/kg/day) divided by an uncertainty factor of 100 (10 for extrapolation from animals to humans and 10 for human variability).

ad lib = ad libitum; (C) = capsule; Cardio = cardiovascular; CEL = cancer effect level; d = day(s); EEG = electroencephalogram; (F) = feed; Gastro = gastrointestinal; Gd = gestation day(s); gen = generation(s); (GO) = gavage oil; Hemato = hematological; LD_{50} = lethal dose, 50% kill; LOAEL = lowest-observed-adverse-effect level; mo = month(s); NOAEL = no-observed-adverse-effect level; wk = week(s); x = time(s); yr = year(s)

Figure 3-2. Levels of Significant Exposure to Dieldrin - Oral

Acute (≤14 days)

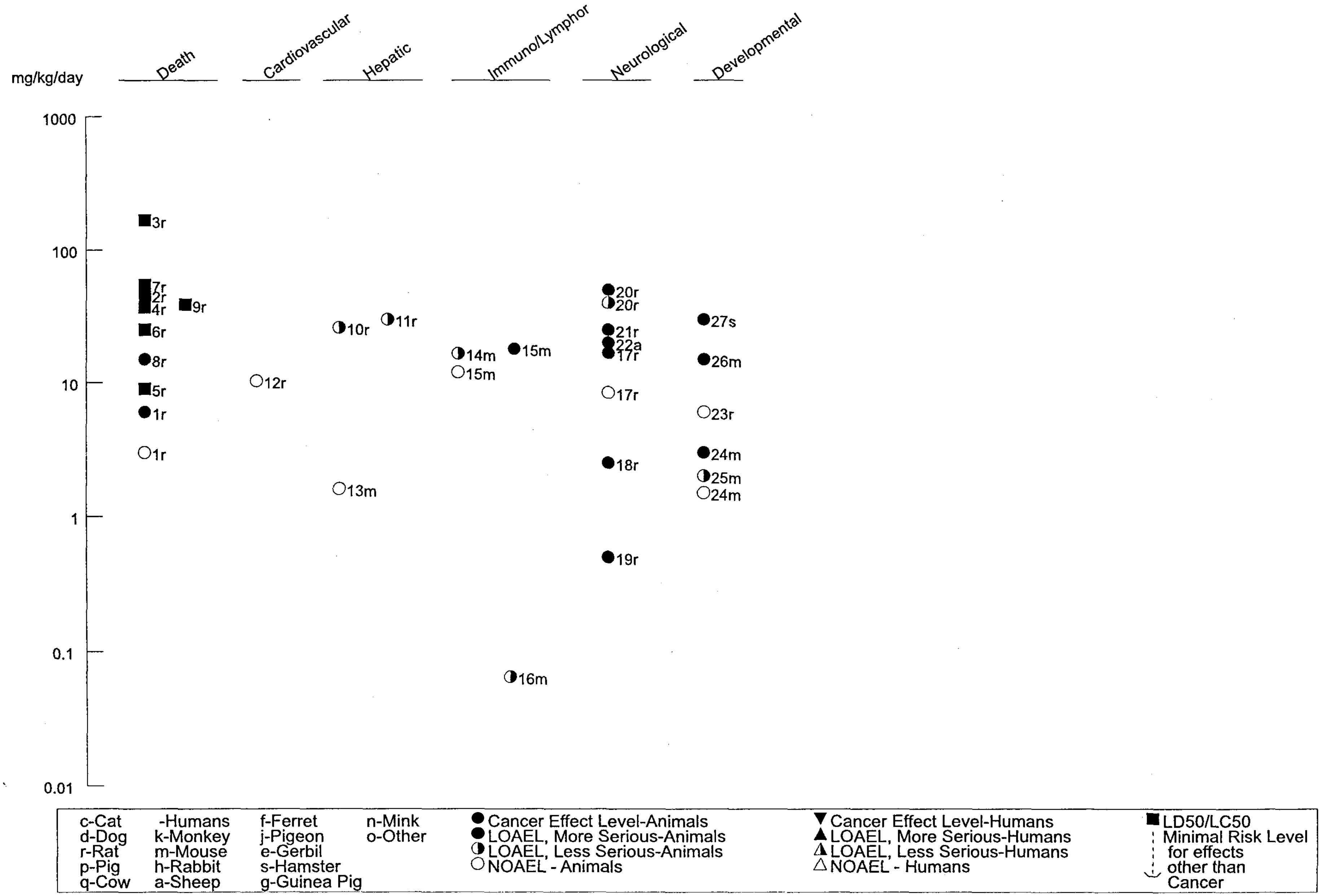


Figure 3-2. Levels of Significant Exposure to Dieldrin - Oral (*Continued*)

Intermediate (15-364 days)

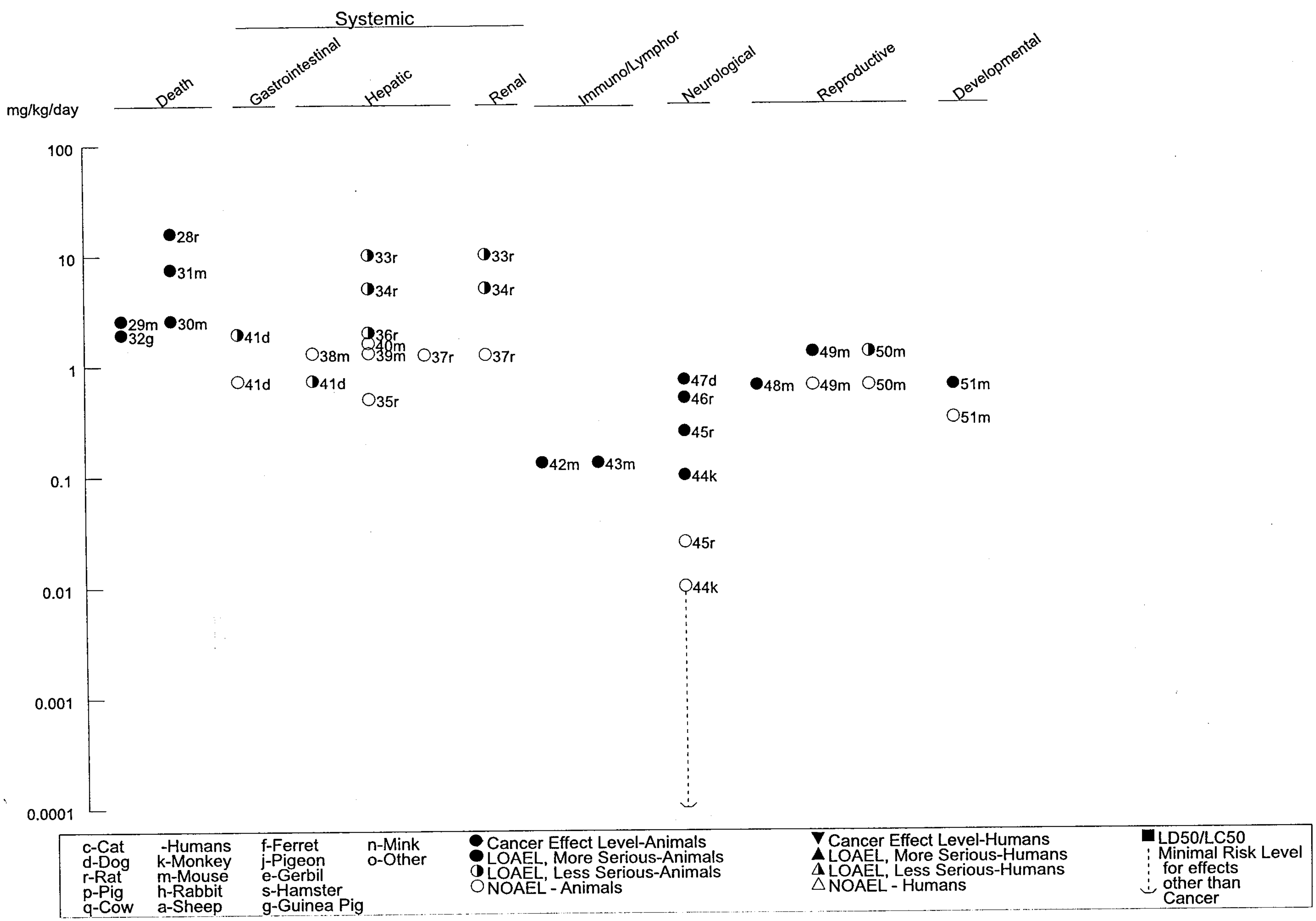


Figure 3-2. Levels of Significant Exposure to Dieldrin - Oral (*Continued*)

Chronic (≥365 days)

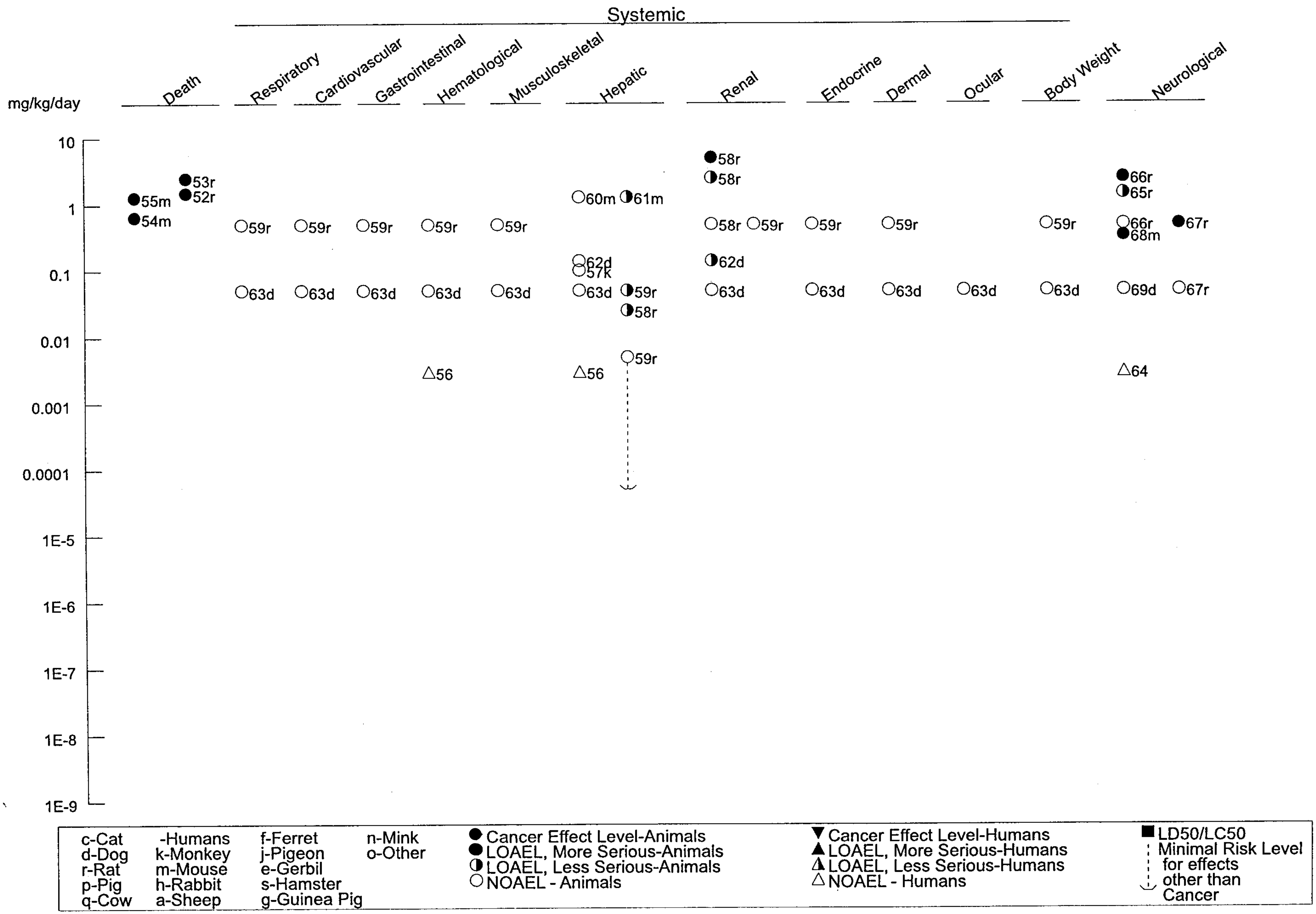
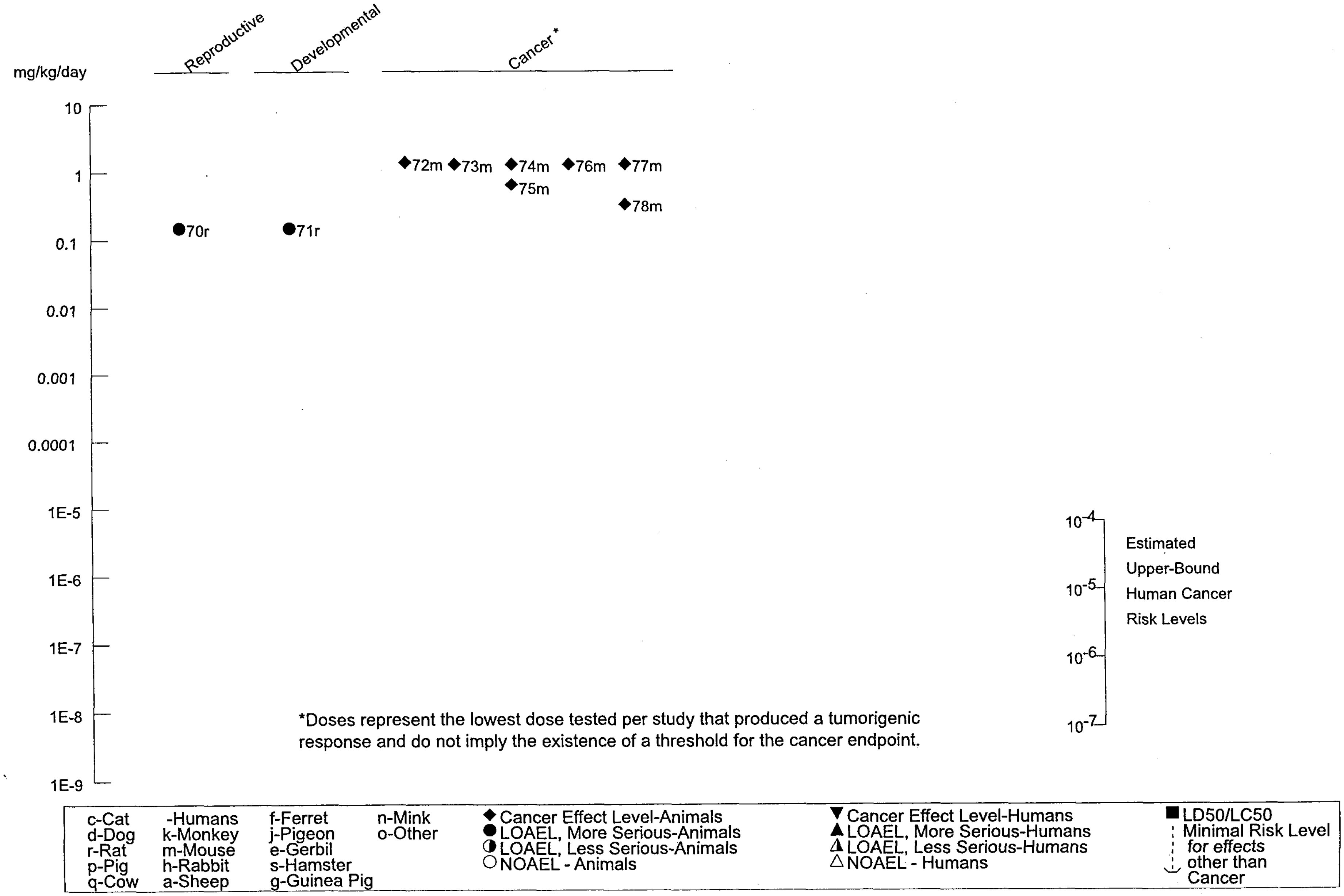


Figure 3-2. Levels of Significant Exposure to Dieldrin - Oral (*Continued*)

Chronic (≥365 days)



Respiratory Effects. No studies were located regarding respiratory effects in humans after oral exposure to aldrin or dieldrin.

Routine gross and microscopic examinations showed no adverse effects in the lungs of rats exposed to #3.75 mg/kg/day of aldrin or dieldrin for 6 months (Treon et al. 1951a), #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a, 1978b), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969); mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a); or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969).

Cardiovascular Effects. A young man who attempted suicide by consuming approximately 25.6 mg/kg of aldrin had extremely labile blood pressure upon admission to the hospital (Spiotta 1951). His electrocardiogram was normal. Another man who ingested 120 mg/kg of dieldrin had tachycardia and elevated blood pressure at the time of his admission to the hospital (Black 1974). Both men were suffering from convulsions at the time that these effects were observed; thus, it is possible that these cardiovascular effects may have been the result of altered activity in the central nervous system. In the case of the man who ingested 120 mg/kg of dieldrin, the cardiovascular effects were controlled with β-adrenergic blocking drugs, suggesting that the effects were due to increased sympathetic output (Black 1974).

A correlation between adipose tissue levels of dieldrin and the incidence of hypertension was reported in a study of terminal hospital patients (Radomski et al. 1968). However, interpretation of these results is limited by the small number of cases of hypertension (eight cases) and the observation that the levels of a number of other pesticides in adipose tissues also correlated with the incidence of hypertension.

Acute oral administration of aldrin and dieldrin inhibited Ca^{2+}-pump activity in the heart (and brain) of rats (Mehrortra et al. 1989). Treatment by gavage for 3 days caused significantly decreased cardiac calmodulin levels at doses as low as 1 mg/kg/day dieldrin and 5 mg/kg/day aldrin, and significant inhibition of Ca^{2+}ATPase activity in heart sarcoplasmic reticulum at 10 mg/kg/day aldrin or dieldrin. The authors suggested that such changes could adversely affect cardiac contractility by altering calmodulin-regulated Ca^{2+}-pump activity in neurons, but no measurement of cardiac function were performed to support this hypothesis.

Routine gross and microscopic examinations showed no adverse effects in the heart of rats exposed to #3.75 mg/kg/day of aldrin or dieldrin for 6 months (Treon et al. 1951a), #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969); mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a); or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969). Examination of the vascular system does not appear to have been performed in these studies.

Chronic exposure of rats to dieldrin at dietary doses as low as 0.016 mg/kg/day was reported to cause fibrinoid degeneration, inflammation, endothelial proliferation, and perivascular edema in small-to-medium-size arteries (Harr et al. 1970). However, this condition is known to occur spontaneously, no dose-response information was provided, and statistical analyses of these data were not presented. Also, the study by Harr et al. (1970) utilized a semisynthetic diet rather than standard rodent chow, and it is unclear whether such a diet may have affected the outcome of this study. Thus, the significance of this finding is unknown.

Gastrointestinal Effects. No studies were located regarding gastrointestinal effects in humans following oral exposure to aldrin or dieldrin.

Dogs that ingested lethal doses of aldrin (as low as 0.89–1.78 mg/kg/day over a period of 5–6 months) or dieldrin (as low as 1.95–4.24 mg/kg/day over a period of 11 days–1.3 months) during a 9-month study vomited and became emaciated several days prior to death (Treon et al. 1951b). It is unclear whether the vomiting was directly due to gastrointestinal irritation. Routine gross and microscopic examinations showed no adverse effects in the stomach or intestines of rats exposed to #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969); mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a); or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969).

Hematological Effects. Limited information is available on hematological effects in orally-exposed humans. Groups of 3–4 volunteers who consumed dieldrin in capsules at doses as high as 0.003 mg/kg/day over a period of 18 months experienced no adverse effects on cellular components of the blood (hemoglobin, packed cell volume, total and differential white blood cell count) or plasma proteins (Hunter and Robinson 1967). Blood coagulation tests were normal in the case of a man who ingested 120 mg/kg of dieldrin followed by repeated stomach lavage in an effort to limit absorption (Black 1974).

One case of immunohemolytic anemia attributable to ingestion of dieldrin was reported (Hamilton et al. 1978). Three cases of pancytopenia and one case of thrombocytopenia have also been associated with exposure to dieldrin, but no assessment regarding whether dieldrin was the causative agent was provided in the report (AMA 1962).

Routinely-examined hematological indices were normal in dietary studies of rats exposed to 0.25 mg/kg/day aldrin for up to 25 months (Deichmann et al. 1967), rats exposed to #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969), and dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969). Some histological changes in blood-forming tissues of exposed animals have been reported. The rats that were exposed to 0.25 mg/kg/day aldrin for 25 months had moderate to marked congestion of the red pulp with slight hemolysis in the spleen (Deichmann et al. 1967), but the significance of these findings is unclear due to a lack of incidence data and the normal hematology indices. Dogs given doses as low as 1 mg/kg/day of either aldrin or dieldrin for 25 months had a reduced number of mature granulocytes and erythroid cells in the bone marrow (Fitzhugh et al. 1964), but these data are limited by small numbers of animals (1–2 males and 1–2 females per dose).

Musculoskeletal Effects. No studies were located regarding musculoskeletal effects in humans after oral exposure to aldrin or dieldrin.

Muscular lesions, including focal edema, coagulative necrosis, and chronic myositis (inflammation), were observed in rats that were fed aldrin in doses of 0.016 mg/kg/day for 750 days or 0.032 mg/kg/day for 546 days (Harr et al. 1970). Although these effects were not observed in controls, interpretation of the findings is complicated by study limitations, which include small numbers of animals (two per sex per dose), lack of incidence data, and use of a semisynthetic diet rather than standard rodent chow. Additionally, no gross or histopathological changes in muscle were reported in other studies at higher oral doses, including rats exposed to #3.75 mg/kg/day of aldrin or dieldrin for 6 months (Treon et al. 1951a), #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969), mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969).

Treatment of rats with 1.25 mg/kg/day of dieldrin for 60 days was reported to impair the performance of rats who had been trained to pull a weight up an inclined plane in order to receive food (Khairy 1960). Although the author attributed the impaired performance to a decrease in muscular efficiency, no attempt was made to determine whether the effect was neurological or muscular in origin. Thus, this effect cannot be established as a musculoskeletal effect.

Hepatic Effects. Healthy male subjects who consumed up to 0.003 mg/kg/day of dieldrin in capsules for 18 months showed no clinical signs and had no adverse hepatic effects as indicated by normal serum levels of liver enzymes (alanine and aspartate aminotrasferases, and alkaline phosphatase); however, no liver function tests or biopsies were performed (Hunter and Robinson 1967). However, a child who drank an unknown quantity of a 5% dieldrin solution and who experienced severe convulsions had evidence of liver dysfunction (Garrettson and Curley 1969). The half-life of phenobarbital in the child was greatly increased shortly after the initial intoxication, indicating a decreased ability of the liver to metabolize phenobarbital. Six months later, the phenobarbital half-life had returned to normal levels. However, serum alkaline phosphatase and thymol turbidity test results were elevated above normal levels. Evidence of liver damage (elevated serum aminotransferases) was also observed in a man 5 days after ingesting 120 mg/kg of dieldrin despite vigorous intervention to limit absorption (Black 1974). In the study by Black (1974), the dieldrin was a 15% solution in toluene. It is likely that the solution ingested by the child described by Garrettson and Curley (1969) also contained solvents and possibly emulsifiers. It is possible that the other ingredients in the dieldrin solutions contributed to the hepatic toxicity that was observed.

A number of adaptive changes characteristically produced by halogenated hydrocarbon pesticides were observed in livers of dogs, mice, and rats exposed to aldrin and/or dieldrin. These changes include an increase in liver weight and/or size (Bandyopadhyay et al. 1982b; Deichmann et al. 1967, 1970; Fitzhugh et al. 1964; Kohli et al. 1977; Olson et al. 1980; Tennekes et al. 1981; Treon et al. 1951a, 1953b, 1955b; Walker et al. 1969; Walton et al. 1971; Wright et al. 1972), liver cell enlargement (Olson et al. 1980; Treon et al. 1951a, 1954b; Walker et al. 1972), cytoplasmic eosinophilia with migration of basophilic granules (Fitzhugh et al. 1964; Treon et al. 1951a, 1954b; Walker et al. 1969, 1972), an increase in the smooth endoplasmic reticulum (Wright et al. 1972), an increase in microsomal protein (Wright et al. 1972), an increase in cytochrome P-450 content (Walton et al. 1971; Wright et al. 1972, 1978), and/or an increase in microsomal enzyme activity (Den Tonkelaar and van Esch 1974; Kohli et al. 1977; Tennekes et al. 1981; Walton et al. 1971; Wright et al. 1972, 1978).

Within 1 week, alterations of liver cell ultrastructure (an increase in cytoplasmic vacuoles and smooth endoplasmic reticulum) and increased microsomal protein and mixed-function oxidase activity were observed in rats exposed to 8 mg/kg/day or mice exposed to 1.6 mg/kg/day of dieldrin (Wright et al.

1972). After 4 weeks of exposure to 2 mg/kg/day of dieldrin, similar effects were observed in dogs. In addition, liver cell enlargement and increased levels of cytochrome P-450 were apparent in rats and mice 4 weeks after exposure to 8 and 1.6 mg/kg/day, respectively (Wright et al. 1972). Cessation of dosing with dieldrin allowed the reversal of these changes in these animals (Wright et al. 1972). The lowest dose at which an increase in liver-to-body-weight ratio was observed in rats was 0.00035 mg/kg/day of dieldrin for 85 days (Olson et al. 1980). However, this study was limited in that only one dose of dieldrin was tested and animals received limited rations during the last 15 days of the study to maintain their body weights below normal. Monkeys exposed to dieldrin for between 5 and 6 years had a more limited response than dogs, mice, or rats. Exposure to concentrations as high as 0.1 mg/kg/day of dieldrin produced increased mixed-function oxidase activity and cytochrome P-450 content in livers but no histologic changes in the liver that were observable by light or electron microscopy (Wright et al. 1972, 1978). In virtually all of these studies no other evidence of hepatic toxicity was reported; thus, these adaptive changes were not considered to be adverse.

Mixed results regarding changes in hepatic lipid peroxidation have been observed. A single oral dose of 30 mg/kg was reported to decrease hepatic lipid peroxidation in male rats (Kohli et al. 1977). In contrast, a single oral dose of 26 mg/kg was reported to increase hepatic lipid peroxidation in female rats (Goel et al. 1988). It is unclear whether the contrasting results of these two studies are attributable to sex-related differences in metabolism.

Limited evidence for adverse hepatic effects has been observed in rats in intermediate-duration studies following 1–6 months of exposure to 2 mg/kg/day of dieldrin (Shakoori et al. 1982) or 6 months of exposure to 10 mg/kg/day of dieldrin (Ahmed et al. 1986a). At 2 mg/kg/day dieldrin, adverse effects were limited to decreased hepatic protein and some instances of necrosis (Shakoori et al. 1982). At 10 mg/kg/day, there was an increase in serum hepatic enzyme activity (alkaline phosphatase and/or alanine aminotransferase) with decreases in hepatic protein and areas of necrosis (Ahmed et al. 1986a). The statistical significance of the incidence of necrotic areas was not presented. Both of these studies are limited because only one dose of dieldrin was used. No histopathological changes were observed in the livers of rats exposed to #3.75 mg/kg/day aldrin or dieldrin for 6 months, although small numbers of animals were examined (Treon et al. 1951a). Dogs that ingested doses as low as 0.89–1.78 mg/kg/day of aldrin or 0.73–1.85 mg/kg/day of dieldrin for 9 months had moderate parenchymatous degeneration (Treon et al. 1955b). Although the degeneration appeared to increase in severity with dose, this study is limited by a small number of animals.

Evidence for adverse hepatic effects has also been observed in chronic studies. Hyaline droplet degeneration was observed in the livers of dogs that ingested 0.12–0.25 mg/kg/day of aldrin for 15.7 months (Treon et al. 1955b). Similar effects were not observed in dogs that ingested 0.14–0.26 mg/kg/day of dieldrin over the same period. In dogs exposed to 1 mg/kg/day of aldrin or dieldrin for 25 months, slight-to-moderate fatty degeneration was observed (Fitzhugh et al. 1964). Also, in dogs given doses as low as 0.2 mg/kg/day of dieldrin for up to 1 year, degeneration was observed (Kitselman 1953). The degree of necrosis increased with dose. However, these studies are limited in that too few animals were tested (Fitzhugh et al. 1964; Kitselman 1953; Treon et al. 1955b). Both male and female dogs exposed to 0.05 mg/kg/day of dieldrin for 2 years had elevated serum alkaline phosphatase levels, and males at this dose had decreased serum proteins (Walker et al. 1969). The origin of the increased serum alkaline phosphatase activity was unknown, but not believed to be due to bone disorders or biliary obstruction (i.e., the usual clinical interpretation of elevated serum alkaline phosphatase in dogs [Cornelius 1970; Walker et al. 1969]). The decrease in total serum proteins was slight and considered to have no clinical or toxicological significance since the electrophoretic pattern of the proteins was unchanged. The possibility that increased serum alkaline phosphatase may not necessarily represent hepatic damage in dogs was also raised by El-Aharaf et al. (1972), who showed that dogs exposed to 0.05–0.20 mg/kg/day of dieldrin for 1 year had increased serum alkaline phosphatase of hepatic origin but no increase in serum levels of 5'-nucleotidase (a hepatic membrane enzyme that should be elevated in the serum as a result of hepatic damage). Because hepatic levels of alkaline phosphatase increased in parallel with serum levels of alkaline phosphatase, these authors suggested that alkaline phosphatase may be transferred directly from the hepatocyte to the sinusoidal blood.

Rats exposed to doses of dieldrin ranging from 0.016 to 0.063 mg/kg/day throughout their lifetime were reported to have developed hepatic lesions consisting of centrilobular degeneration and peripheral hyperplasia (Harr et al. 1970). Pyknosis of hepatocellular nuclei was also reported; however, no statistics, dose-response data, or incidence data were presented to support this conclusion. Also, the rats in this study received dieldrin in a semisynthetic diet, and it is unclear whether such a diet may have affected the study outcome.

Rats exposed via their diets to aldrin or dieldrin for 2 years at doses as low as 0.025 mg/kg/day had increases in liver-to-body-weight ratio and hepatic histopathological changes consistent with exposure to chlorinated hydrocarbons (Fitzhugh et al. 1964). At 2.5 mg/kg/day, gross enlargement of the liver was observed, and the histopathological changes were considered to be marked and included an increase in the severity of hepatic cell vacuolation. The hepatic lesions that were seen at the aldrin dose of

0.025 mg/kg/day were characterized by hypertrophy of centrilobular hepatocytes, cytoplasmic eosinophilia, and peripheral migration of basophilic granules along with less prominent alterations of cytoplasmic vacuolation and bile duct proliferation, changes consistent with a marked hepatic adaptive response associated with induction of the hepatic mixed function oxidase system and proliferation of smooth endoplasmic reticulum. No NOAEL for liver effects of chronic aldrin exposure was identified. Based on the LOAEL of 0.025 mg/kg/day (Fitzhugh et al. 1964) and considering the evidence for dose-related progression of hepatotoxicity in this and other studies, a chronic oral MRL of 3.0x10^{-5} mg/kg/day was calculated for aldrin as described in the footnote in Table 3-1.

Rats that were exposed to 0.005, 0.05, or 0.5 mg/kg/day dieldrin in the diet for 2 years similarly had increased absolute and relative liver weights at $0.05 mg/kg/day, and at the highest dose of 0.5 mg/kg/day, liver parenchymal cell changes characteristic of organochlorine exposure, as well as indications of focal hyperplasia (Walker et al. 1969). Based on the 0.005 mg/kg/day NOAEL for liver effects (Walker et al. 1969) and considering the evidence for dose-related progression of hepatotoxicity, a chronic oral MRL of 5.0x10^{-5} mg/kg/day was calculated for dieldrin as described in the footnote in Table 3-2.

Mice exposed to 1.3 mg/kg/day dieldrin for 2 years had livers with occasional necrotic areas (Thorpe and Walker 1973); however, this study is limited because it is unclear whether the necrotic areas were secondary to tumor development, the incidence of these areas was not reported, and only one dose of dieldrin was tested. Routine histological examinations in other chronic studies showed no nonneoplastic liver changes in mice exposed to #1.04 mg/kg/day aldrin for 80 weeks (NCI 1978a), #0.65 mg/kg/day dieldrin for 80 weeks (NCI 1978a), or 1.3 mg/kg/day dieldrin for 92 weeks (Tennekes et al. 1981), although the emphasis in these studies was on detection of carcinogenicity.

Renal Effects. A man who attempted suicide by consuming approximately 25.6 mg/kg of aldrin had elevated blood urea nitrogen, gross hematuria, and albuminuria upon admission to the hospital (Spiotta 1951). By 17 days after admission, levels of nitrogen, blood, and protein in the urine had returned to normal. Six weeks after the suicide attempt, the ability to concentrate the urine was determined to be poor. In contrast, a man who ingested 120 mg/kg of dieldrin had no evidence of renal damage (Black 1974). In both of these case reports, the actual dose available for absorption was unknown because efforts were made to limit absorption of the chemicals from the gastrointestinal tract.

Adverse effects on the kidneys have been observed following exposure of rats and dogs to aldrin and/or dieldrin. Exposure of rats to 5 mg/kg/day of dieldrin for 15 days resulted in membranous glomerulonephritis, nephrosis in the proximal convoluted tubules, vacuolated cytoplasm, necrotic cells in the tubular lumen, and large intertubular spaces (Bandyopadhyay et al. 1982b). Similarly, exposure of rats to 10 mg/kg/day of dieldrin for 6 months in a single–dose level study resulted in degenerative changes in the epithelial cells of the kidney and lymphocyte and macrophage infiltration (Ahmed et al. 1986a). Rats exposed to 0.25 mg/kg/day of dieldrin for 25 months in a single-dose level study showed slight lymphocyte infiltration, vascular congestion in the renal cortex, and hyaline casts in the renal tubules (Deichmann et al. 1967). Increases in the incidence and severity of nephritis were also observed in male rats exposed to doses as low as 0.5 mg/kg/day of aldrin or 0.125 mg/kg/day of dieldrin for 2 years (Fitzhugh et al. 1964; Harr et al. 1970; Reuber 1980). However, these studies are limited because no statistical analyses were presented to support these conclusions. Dogs exposed to doses of aldrin or dieldrin as low as 0.2 mg/kg/day also had degeneration of the renal tubules (Fitzhugh et al. 1964; Kitselman 1953), but these studies are limited by the absence of sufficient experimental detail, the lack of histopathological data on many of the animals, and the small number of animals tested. In the study by Fitzhugh et al. (1964), only one or two males and females were used per dose; in the study by Kitselman (1953), three dogs were used per dose. Slight vacuolation of the renal tubules was also reported in dogs exposed to doses as low as 0.14–0.26 mg/kg/day of dieldrin or 0.04–0.09 mg/kg/day of aldrin for 15.7 months, but this study was also limited by the small number of dogs used (Treon et al. 1955b). Routine gross and microscopic examinations showed no adverse effects in the kidneys of rats exposed to #3.75 mg/kg/day of aldrin or dieldrin for 6 months (Treon et al. 1951a), #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a, 1978b), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969); mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a); or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969).

Endocrine Effects. No information was located regarding effects of aldrin or dieldrin on the endocrine system in humans following oral exposure.

Histological examination of nonreproductive endocrine tissues in intermediate- and chronic-duration studies showed no aldrin- or dieldrin-related non-neoplastic changes in animals. Tissues that were examined in these studies included adrenal, thyroid, parathyroid, pancreas, and/or pituitary in rats exposed to #3.75 mg/kg/day of aldrin or dieldrin for 6 months (Treon et al. 1951a), rats exposed to #3.75 mg/kg/day aldrin for up to 80 weeks (NCI 1978a), mice exposed to #1.04 mg/kg/day aldrin for up to 80 weeks (NCI 1978a), rats exposed to #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969), rats exposed #3.25 mg/kg/day dieldrin for 80–104 weeks (NCI 1978a), mice exposed to #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), and dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969). Animal fertility studies indicate that the testis is a target of aldrin and dieldrin in males (see Section 3.2.2.5, Reproductive Effects).

The ability of chlorinated hydrocarbons to disrupt estrogen homeostatis, by up-regulating selected gene transcription, has been hypothesized to be responsible for their oncogenic effects. While dieldrin alone did not show any evidence of estrogenicity when administered to rats by intragastric intubation at a dose of 7.5 µmol/kg/day, 5 days/week, for 9 months, when administered with toxaphene (30 µmol toxaphene/kg/day and 7.5 µmol/kg/day), bone mass density was significantly increased (Syversen et al. 2000). A single dose of dieldrin (37 mg/kg) administered to female rats by gavage significantly increased expression of cytochrome P450 CYP1A1, CYP1A2, and CYP1B1, which are involved in estrogen metabolism, in the liver, kidney, and mammary tissues (Badawi et al. 2000).

Dermal Effects. Routine histological examinations showed no adverse effects in the skin of rats exposed to #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969); mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a); or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969).

Ocular Effects. Routine histological examinations showed no adverse effects in the eyes of rats exposed to #3 mg/kg/day aldrin or #3.25 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a), or #0.5 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969); mice exposed to #1.04 mg/kg/day aldrin or #0.65 mg/kg/day dieldrin for up to 80 weeks (NCI 1978a); or dogs exposed to #0.05 mg/kg/day dieldrin for up to 2 years (Walker et al. 1969).

3.2.2.3 Immunological and Lymphoreticular Effects

Limited information was located regarding immunological effects in humans after oral exposure to aldrin or dieldrin. A case report was located concerning a man who developed immunohemolytic anemia after eating fish that contained high levels of dieldrin (Hamilton et al. 1978). Testing of the patient's serum revealed a positive antibody test for dieldrin-coated red blood cells.

An epidemiological study of 98 breast-fed and 73 bottle-fed Inuit infants from Nunavik (Arctic Quebec, Canada) indicated that the RR of experiencing otitis media (three or more episodes) over the first year of life increased with prenatal exposure to dieldrin (Dewailly et al. 2000). The RR for 4–7-month-old infants in the highest exposure group (>43 µg/kg dieldrin in maternal breast milk) as compared to infants in the lowest exposure group (<21 µg/kg) was 1.75 (95% CI 1.05–2.91). The RR of infants experiencing three or more episodes of otitis media over the first year of life was 3.5 (95% CI 0.95–12.97). No clinically relevant differences were noted between breast-fed and bottle-fed infants with regard to immunologic parameters, nor were any of the immunologic parameters associated with prenatal dieldrin exposure.

Immunosuppression by dieldrin has been reported in a number of studies in mice. An increase in lethality of mouse hepatitis virus three and a decrease in the antigenic response to the virus were observed in mice given a single oral dose of dieldrin ($18 mg/kg) (Krzystyniak et al. 1985). Similarly, an increase in lethality of infections with the malaria parasite, *Plasmodium berghei*, or *Leishmania tropica* in mice was produced by treatment of the mice with dieldrin in the diet at doses as low as 0.13 mg/kg/day for 10 weeks (Loose 1982). Also, a decrease in tumor cell killing in mice was observed after dieldrin treatment with doses as low as 0.13 mg/kg/day for 3, 6, or 18 weeks (Loose et al. 1981).

Since resistance to intracellular organisms and tumor cell killing require induction of cell-mediated immunity through thymus-derived lymphocyte (T-lymphocyte) interactions with macrophages, the effects of dieldrin consumption on the activity of these components of the response were tested. A decrease in antigen processing by alveolar macrophages was observed in mice following consumption of dieldrin for 2 weeks (Loose et al. 1981). Macrophages that ingested sheep red blood cell antigen manifested a significantly impaired ability to transfer an adequate immunogen to naive control mice. Splenic and alveolar macrophages were the most sensitive cell types as the decrease occurred following exposure to dieldrin doses as low as 0.065 mg/kg/day (lowest tested dose). Peritoneal macrophage antigen processing was significantly depressed at 0.65 mg/kg/day, and Kupffer cell antigen processing was depressed at

6.5 mg/kg/day. This effect was observed in the absence of effects on macrophage respiration, phagocytic activity or capacity, or microbicidal activity. In addition, macrophages from dieldrin-treated (0.65 mg/kg/day for 10 weeks) mice were found to produce a soluble factor that induced T-lymphocyte suppressor cells (Loose 1982). Inhibition of lymphocyte proliferation was also seen in a mixed lymphocyte reaction test in which splenic cells from mice treated twice with 16.6 mg/kg dieldrin were combined with stimulator cells from control animals (Fournier et al. 1988). However, this study is limited because only one dose level of dieldrin was tested.

All reliable LOAEL values for immunologic effects of dieldrin in mice in acute- and intermediate-duration studies are recorded in Table 3-2 and plotted in Figure 3-2.

3.2.2.4 Neurological Effects

Case reports regarding accidental poisonings or suicide attempts provide the majority of the information on the neurological effects of aldrin and dieldrin by the oral route. Two children who consumed an unknown amount of a 5% dieldrin solution began to salivate heavily and developed convulsions within 15 minutes (Garrettson and Curley 1969). In the surviving child, the seizure episode lasted for 7.5 hours before being controlled by phenobarbital. EEG recordings taken from this child showed bursts of synchronous high-voltage slow waves. Both the child's condition and the EEG recordings returned to normal with time. Convulsions also developed rapidly in a man who attempted suicide by consuming an estimated 25.6 mg/kg of aldrin (Spiotta 1951) and in a man who ingested 120 mg/kg of dieldrin (Black 1974). Anticonvulsants were given to control the seizures, but one man exhibited motor hyperexcitability and restlessness for several days (Spiotta 1951), and the other required muscle paralysis to sufficiently control the convulsions to allow artificial respiration (Black 1974). EEGs taken a few days after admission showed epileptiform activity, but the EEGs returned toward normal with time.

A small group of persons who consumed wheat that had been mixed with aldrin and lindane over a period of 6–12 months developed a variety of central nervous system symptoms (Gupta 1975). These included bilateral myoclonic jerks, generalized seizures, auditory and visual auras, hyperexcitability, and irritability. In some cases, the onset of symptoms was abrupt. EEGs showed spike and wave activity and abnormal bursts of slow delta-wave discharges. After exposure was discontinued, the symptoms slowly improved. However, 1 year after exposure, infrequent myoclonic jerks were observed in several of the subjects. One subject also complained of memory loss and irritability, and a 7-year-old child was believed to have developed mild mental retardation as a result of the exposure. Although both aldrin and lindane had been mixed with the wheat, the author concluded that the effects observed were due to the aldrin exposure because in previous years wheat had been routinely mixed with lindane and consumed with no apparent adverse effects. Persistent headaches, irritability, and short-term memory loss were also reported following recovery from convulsions in a man who ingested 120 mg/kg of dieldrin (Black 1974).

Dieldrin administered to volunteers daily for 18 months at doses as high as 0.003 mg/kg/day had no effect on central nervous system activity (as measured by EEG), peripheral nerve activity, or muscle activity (Hunter and Robinson 1967).

Ingestion of aldrin and dieldrin most likely was not a significant route of exposure and therefore probably did not contribute significantly to the neurological effects observed in many of the occupational studies presented in Section 3.2.1.4. However, in the study by Patel and Rao (1958), the authors could not eliminate oral exposure by dieldrin since workers reportedly mixed the dieldrin solutions with their bare hands and some time later consumed food using their hands.

Convulsions were also observed in rats given single doses of dieldrin ranging from 40 to 50 mg/kg (Wagner and Greene 1978; Woolley et al. 1985). When aldrin or dieldrin was administered to rats for 3 days, convulsions were observed at a dose of 10 mg/kg/day (Mehrotra et al. 1989). Transient hypothermia and anorexia were also observed following a single dose of 40 mg/kg (Woolley et al. 1985). Long-term potentiation of limbic evoked potentials was observed following a single dose of 25 mg/kg, and subthreshold limbic stimulation caused convulsions following a single dose of 40 mg/kg (Woolley et al. 1985). Neurotoxic signs observed in cattle poisoned with unspecified dietary concentrations of aldrin included tremors, running, hyperirritability, and seizures (Buck and Van Note 1968).

Operant behavior was disrupted in rats following single doses of dieldrin ranging from 0.5 to 16.7 mg/kg. The simpler paradigms of fixed interval responding and maze training were both impaired at doses as low as 16.7 mg/kg, whereas differential responding to low rates of reinforcement was impaired at 2.5 mg/kg (Burt 1975). Responses in an inescapable foot shock stress paradigm were impaired at doses as low as 0.5 mg/kg (Carlson and Rosellini 1987). In sheep, operant responding was decreased 38–76% during a 4-day treatment with 20 mg/kg/day dieldrin (Sandler et al. 1969). EEGs obtained during exposure showed high-voltage, slow wave activity.

In studies of intermediate duration, operant behavior was disrupted at somewhat lower doses of dieldrin. Following 60–120 days of exposure of rats to 0.25 mg/kg/day, dieldrin significantly impaired maze training (Burt 1975). In a study which was used as the basis for an intermediate-duration oral MRL (Smith et al. 1976), monkeys orally administered 0.1 mg dieldrin/kg/day for 55 days demonstrated impaired learning (difficulty learning a successive discrimination reversal task); this effect was not seen in monkeys administered 0.01 mg/kg/day, a dose considered to be a NOAEL for impaired learning. No effect on operant behavior in rats was observed following 0.025 mg/kg/day for 60–120 days. Sheep appeared to be somewhat less sensitive to the effects of dieldrin on behavior, although a small number of animals was used in these studies (Van Gelder 1975). The lowest dose at which sheep had impaired operant behavior was 2.5 mg/kg/day for 12 weeks. This was determined using an auditory signal detection test. Visual discrimination was not impaired until doses of 10 mg/kg/day were administered, and maze training and extinction of a conditioned avoidance response were not impaired at 15 mg/kg/day (Van Gelder 1975).

Physical signs of neurotoxicity were observed in two single-dose level, intermediate-duration studies in rats. Tremors were observed in rats at a dose of 0.5 mg/kg/day for 60 days (Mehrotra et al. 1988) and hyperexcitability was observed at 2.5 mg/kg/day in an 8-week study (Wagner and Greene 1978). Exposure to 1.25 mg/kg/day aldrin or dieldrin for 6 months caused degenerative histological changes in brain cells of rats (Treon et al. 1951a). Dogs given aldrin at 0.89–1.78 mg/kg/day or dieldrin at 0.73–1.85 mg/kg/day for up to 9 months experienced neuronal degeneration in the cerebral cortex and convulsions (Treon et al. 1951b). At this dose, aldrin-treated dogs also exhibited hypersensitivity to stimulation, twitching, and tremors. At higher doses, the basal ganglia and cerebellum also exhibited degenerative changes.

Irritability, tremors, and/or convulsions were observed in rats exposed to aldrin or dieldrin in doses ranging from 0.65 to 3.25 mg/kg/day, but not #0.05 mg/kg/day, for 1.5–2 years (NCI 1978a, 1978b; Walker et al. 1969). Mice experienced hyperexcitability, fighting and/or tremors at 0.39 mg/kg/day aldrin or 0.33 mg/kg/day dieldrin in 80-week bioassays (NCI 1978a).

EEGs taken from dogs exposed to 0.05 mg/kg/day for 2 years were normal (Walker et al. 1969). However, dogs were reported to develop convulsions when given 0.5 mg/kg/day for 25 months (Fitzhugh et al. 1964), and slight neuronal degeneration was reported following 1 year of exposure to aldrin or dieldrin at 0.2 mg/kg/day (Kitselman 1953). However, both of these studies are limited by the small number of animals tested. The only other study that noted histopathological evidence of central nervous system damage was a 2-year study of the effects of dieldrin in rats (Harr et al. 1970). Cerebral edema and small foci of degeneration were reported in rats exposed to dieldrin at 0.016 mg/kg/day, but no statistical analysis of these results was presented. Also, the study by Harr et al. (1970) used a semisynthetic diet, and it is unclear whether the use of such a diet may have affected the study outcome.

The highest NOAEL values and all reliable LOAEL values for neurological effects in each species and duration category are recorded for aldrin in Table 3-1 and for dieldrin in Table 3-2 and plotted for aldrin in Figure 3-1 and for dieldrin in Figure 3-2.

3.2.2.5 Reproductive Effects

Aldrin levels in blood and placental tissues of women who had premature labor or spontaneous abortions were significantly higher than in women with normal deliveries (Saxena et al. 1980). However, interpretation of this study is limited because levels of six other organochlorine pesticides were also significantly elevated and because other potential distinctions between the two groups that might have contributed to premature labor or abortion, such as smoking or alcohol consumption, were not addressed. Nevertheless, this observation suggests that aldrin can pass through the human placenta and accumulate in the developing fetus. Similarly, accumulation of dieldrin in the amniotic fluid and in the developing fetus has been reported by Polishuk et al. (1977b).

Acute exposure of male mice to aldrin or dieldrin produced no adverse effects on reproduction. Male mice treated with doses of aldrin up to 1 mg/kg/day for a period of 5 days showed no significant effects in a dominant lethal study (Epstein et al. 1972). Similarly, single oral doses of dieldrin ranging from 12.5 to 50 mg/kg had no significant effect on the number of pregnancies produced by male mice in a dominant lethal assay (Dean et al. 1975).

A significant but slight decrease in fertility was observed in female mice exposed to 1.3 or 1.95 mg/kg/day of dieldrin from 4 weeks prior to mating through weaning (Virgo and Bellward 1975). In this study, males were exposed to test material only during the 2-week mating period. Similarly, male and female rats receiving diet containing aldrin or dieldrin at doses of aldrin as low as 0.63 mg/kg/day and dieldrin as low as 0.125 mg/kg/day from the time they were 28 days old had decreased fertility (decreased number of litters) during the first mating of the parental generation in a three-generation reproduction study (Treon et al. 1954a). A subsequent mating of the parental rats receiving aldrin showed no reproductive effects, and those receiving dieldrin failed to show a consistent dose-related effect on fertility. At matings of the offspring, no effect on fertility (number of litters) was observed at 0.125 mg/kg/day; however, effects on fertility due to higher doses were difficult to assess because few offspring survived to be mated. In contrast, no consistent effect of doses of dieldrin as high as 2 mg/kg/day was found on the conception rate of male and female rats exposed from the time they were 28 days old through the period of mating (initiated when the rats were 146 days old) (Harr et al. 1970). These results are limited in that no statistical analysis of the data was presented. In addition, male and female mice exposed to 0.65 mg/kg/day of dieldrin for 30 days prior to mating and then for 90 days thereafter experienced no adverse effects on fertility, fecundity, or the length of gestation (Good and Ware 1969). The only adverse reproductive effect observed in this study was a slight decrease in litter size. However, this study is limited in that only one dose level of dieldrin was tested.

A number of adverse reproductive effects were observed in dogs following exposure of males and females to 0.15 or 0.30 mg/kg/day for 14 months prior to mating (Deichmann et al. 1971). These included delayed estrus, reduced libido, lack of mammary function and development, and an increased number of stillbirths. However, this study is limited by the small number of animals tested.

Maternal behavior was adversely affected by dieldrin when mice were treated from 4 weeks prior to delivery until weaning. At 1.3 mg/kg/day, Virgo and Bellward (1975) observed a delay in the time before mice nursed their pups. Also, at doses of 1.95 mg/kg/day and above, some dieldrin-treated maternal animals violently shook the pups, ultimately killing them, and others neglected their litters (Virgo and Bellward 1975). At doses of dieldrin above 1.95 mg/kg/day, high maternal mortality was also observed in this study.

The highest NOAEL for dieldrin and all reliable LOAEL values for reproductive effects in animals after oral exposure to aldrin or dieldrin are recorded for aldrin in Table 3-1 and for dieldrin in Table 3-2 and plotted for aldrin in Figure 3-1 and for dieldrin in Figure 3-2.

3.2.2.6 Developmental Effects

No studies were located regarding developmental effects in humans after oral exposure to aldrin or dieldrin. However, a study of dieldrin levels in women and their fetuses during labor revealed detectable levels of dieldrin in the placenta, amniotic fluid, and fetal blood (Polishuk et al. 1977b). These results suggest that dieldrin can pass through the human placenta and accumulate in the developing fetus.

Conflicting results have been obtained in animal studies examining the ability of aldrin and dieldrin to cause external malformations or skeletal anomalies. Such effects have been observed in mice and hamsters following a single very large dose of aldrin or dieldrin in mid-gestation (Ottolenghi et al. 1974). Significant increases in cleft palate and webbed foot were observed in mice following a dose of 15 mg/kg of dieldrin or 25 mg/kg of aldrin on gestation day 9. Significant increases in cleft palate, open eye, and webbed foot were seen following a dose of 30 mg/kg of dieldrin or 50 mg/kg of aldrin on gestation days 7, 8, and/or 9 in hamsters. Fetal mortality was also significantly increased, and fetal weight was significantly decreased in hamsters. No information was provided regarding the health of maternal animals in this study. Also, this study is limited in that only a single dose of aldrin and dieldrin was tested. A significant increase in supernumerary ribs was observed in mice from dams exposed to 3 or 6 mg/kg/day dieldrin on gestation days 7–16 (Chernoff et al. 1975). In this study, these doses of dieldrin also caused an increase in the maternal liver-to-body-weight ratio. However, other studies examining developmental effects of aldrin and/or dieldrin have failed to observe similar malformations or anomalies. No developmental defects were observed in rats exposed to concentrations of dieldrin as high as 6 mg/kg/day from gestation day 7 to 16 (Chernoff et al. 1975). Also, no significant developmental effects were observed in mice exposed to doses of dieldrin as high as 4 mg/kg/day from gestation day 6 to 14 (Dix et al. 1977), although the number of litters tested in this study was somewhat low.

Offspring of mice treated for 5–7 days during the third trimester of pregnancy with 2 or 4 mg/kg/day of aldrin had 18% decreased body weight and a significantly increased electroconvulsive shock brain seizure threshold, although there was no disruption of the acquisition of a conditioned avoidance response (Al-Hachim 1971). Based on the 2 mg/kg/day LOAEL for developmental effects, an acute oral MRL of 0.002 mg/kg/day was calculated for aldrin as described in the footnote in Table 3-1. Rat pups that were exposed to 0.00035 mg/kg/day dieldrin from gestation day 5 until the pups were 70 days old showed a significant improvement in swimming and maze running performance (Olson et al. 1980). This dose of dieldrin is several orders of magnitude below any other dose at which developmental effects have been observed. Interpretation of these results is difficult because the significance of improved performance in behavioral paradigms is unknown, and the study is limited because only one dose of dieldrin was tested.

Increased postnatal mortality has been one of the most consistent developmental findings reported for aldrin and dieldrin. Mice exposed to dieldrin in the diet at doses as low as 1 mg/kg/day from 4 weeks prior to mating through weaning had significantly decreased pup survival (Virgo and Bellward 1975). Maternal mortality was unaffected in this study at doses below 2.6 mg/kg/day. A similar decrease in postnatal survival has been observed in rats and dogs exposed to aldrin and/or dieldrin by the oral route. Increased mortality of offspring during the first 5 days of life was observed at 0.125 mg/kg/day of either aldrin and dieldrin in the first mating of a three-generation reproduction study in rats (Treon et al. 1954a). Maternal mortality was unaffected at doses as high as 1.25 mg/kg/day of either aldrin or dieldrin. Similarly, rats exposed to dieldrin from the time that they were 28 days old to when they were mated at 146 days old had decreased postnatal pup survival at doses as low as 0.125 mg/kg/day (Harr et al. 1970). Maternal mortality in this study was unaffected at doses below 0.5 mg/kg/day. This study is limited, however, in that no statistical analysis of the data was presented to confirm this assertion. Also, the rats in this study received a semisynthetic diet, and it is unclear whether such a diet may have affected the study outcome. Dogs exposed to doses of aldrin as low as 0.2 mg/kg/day or dieldrin at doses as low as 0.6 mg/kg/day for up to 1 year had poor litter survival (Kitselman 1953). In some instances, apparently normal puppies were born but died after a few days of nursing. Although maternal toxicity was not specifically addressed in this study, dogs receiving similar doses of aldrin and dieldrin had histopathological evidence of hepatic and renal toxicity. This study is also limited because too few dogs were tested, pregnancies were incidental to the study protocol, and thus adequate controls were not used. Dogs mated 2 weeks to 9 months after a 14-month exposure to doses of aldrin as low as 0.15 mg/kg/day also had high mortality among the offspring (Deichmann et al. 1971). However, this study was also limited by the small number of animals tested.

A number of studies have been undertaken to assess the cause of the decreased pup survival. To test whether the decrease in pup survival was dependent on maternal postnatal care, a cross-fostering experiment was performed (Virgo and Bellward 1977). Mice born to dieldrin-exposed dams were nursed by untreated dams. Significantly decreased pup survival was also observed in this study at 1 mg/kg/day irrespective of whether pups were nursed by birth or foster maternal animals. In a single-dose level study of mice that were exposed to 2 mg/kg/day dieldrin between 6 and 18 days of gestation, pups that were examined at varying times after birth had a rapid decrease in blood glucose and depletion of tissue glycogen stores that were significant when compared to controls (Costella and Virgo 1980). These decreases occurred despite apparently normal gluconeogenesis. Cardiac failure, secondary to cardiac glycogen depletion, has been proposed as the cause of death (Costella and Virgo 1980).

Histopathological examination of pups born to treated maternal animals was performed in two studies. Rat pups born to dams treated with dieldrin at doses as low as 0.004–0.008 mg/kg/day had neural lesions consisting of cerebral edema, internal and external hydrocephalus, and focal neuronal degeneration. Hepatic degeneration was seen in the pups of dams fed doses of dieldrin as low as 0.016 mg/kg/day (Harr et al. 1970). However, no information regarding the dose-dependency of these effects or the relative numbers of animals affected was reported. Also, the rats in this study received a semisynthetic diet, and it is unclear whether such a diet may have affected the study outcome. Offspring from dogs that had been treated with doses of aldrin as low as 0.2 mg/kg/day or dieldrin as low as 0.6 mg/kg/day had degeneration of hepatic and renal tissues (Kitselman 1953). Both of these studies are limited by the lack of supporting clinical chemistry data and the absence of statistical analyses of the histopathological data. Furthermore, in the study by Kitselman (1953), not all offspring were examined histopathologically.

The highest NOAEL values and all reliable LOAEL values for developmental effects in animals after acute- or intermediate-duration exposure to dieldrin are recorded in Table 3-2 and plotted in Figure 3-2.

3.2.2.7 Cancer

A few epidemiological studies have examined cancer mortality in workers employed in the manufacture of aldrin and dieldrin. The results of these studies may be found in Sections 3.2.1.7 and 3.2.3.7. However, although possible, ingestion of aldrin or dieldrin is not thought to have been a significant source of exposure in these studies because manufacturing practices limit such exposures (Jager 1970).

Equivocal evidence exists for an association between dieldrin and breast cancer risk from three human epidemiologic studies (Dorgan et al. 1999; Høyer et al. 1998, 2000). In these studies, while dieldrin exposure was verified through blood sampling, and exposure by ingestion, as well as by inhalation and dermal contact, was possible, no specific route of exposure was identified or estimated with any certainty.

The potential of dieldrin to affect breast cancer risk was evaluated in a prospective nested case control study of women in Denmark (Høyer et al. 1998). Serum samples were obtained from 7,712 women from 1976 to 1978. In 1996–1997, serum samples from 240 women who had developed invasive breast cancer and 477 matched breast cancer-free controls were analyzed for levels of dieldrin and 17 other organochlorine pesticides or metabolites and 28 PCB congeners. Controls and cases were matched for age, date of examination, and vital status at the examination. Irrespective of breast cancer status, dieldrin was detected in 78% of the women enrolled in the study, with median levels at 24.4 ng/g lipid. Dieldrin was the only organochlorine compound of those tested associated with a significant increase in breast cancer risk. Women in the highest quartile of the serum dieldrin range had double the risk of breast cancer compared to women in the lowest quartile (OR 2.25, 95% CI 1.32–3.84, p trend=0.003). Relative risk did not change significantly when adjusted for potential confounders of weight and number of full-term pregnancies (OR 2.05, 95% CI 1.17–3.57, p trend=0.01).

A subsequent study using the same cohort of Danish women investigated whether breast cancer survival was affected by past exposure to dieldrin (Høyer et al. 2000). Dieldrin at blood concentrations >57.6 ng/g, representative of the highest quartile, was found to have a significant adverse effect on overall survival and breast cancer specific survival compared to the lowest quartile levels of <12 ng/g lipid (RR 2.78, 95% CI 1.38–5.59, p trend<0.01; RR 2.61, 95% CI 0.97–7.01, p trend<0.01) in this case-control study of Danish women between 20 and 80 years of age. A total of 195 breast cancer cases, who each provided two blood samples that were taken in 1976–1978 and 1981–1983, respectively, were included in the survival analysis. The median duration of follow-up with regard to death was 86 months after the first examination (1976–1978) and 79 months after the second examination (1981–1983). Relative risk was adjusted for number of positive lymph nodes and tumor size and grade. When the analysis was performed using an average of the blood concentrations from the two collections, the association was even stronger, with a 5-fold higher risk of death in women from the highest quartile compared to the lowest quartile (RR 5.76, 95% CI 1.86–17.92, p trend<0.01) and a clear dose-response relationship. Potential confounders as body mass index, age at menopause, and hormone replacement therapy did not influence the results. This study was limited by small size, 6–39 women per quartile.

A cohort study of women from Missouri failed to find an association between serum dieldrin levels and breast cancer risk (Dorgan et al. 1999). Blood samples were collected from 7,224 women from 1977 to 1987. During the 9.5-year follow-up period, 105 women developed breast cancer; each was matched to two controls based on age and date of blood collection. Dieldrin was detected in serum in 56.2% of the cases and 61.8% of the controls. The relative risk of cancer in the highest dieldrin serum concentration range quartile was moderately lower compared to the lowest quartile (RR 0.7, 95% CI 0.3–1.3, p=0.44).

Several bioassays indicate that the response in mice to prolonged ingestion of aldrin or dieldrin differs from that in other species in that a generalized hepatomegaly observed in several species (rat [Cleveland 1966; Fitzhugh et al. 1964; Hodge et al. 1967; Treon and Cleveland 1955; Walker et al. 1969], dog [Fitzhugh et al. 1964; Hodge et al. 1967; Walker et al. 1969], and mouse [Davis and Fitzhugh 1962; Walker et al. 1972]) appears to be uniquely followed in mice, after about 1 year with threshold levels of aldrin or dieldrin in the diet, by an increase in liver tumors. With respect to aldrin, studies in two strains of mice (C3HeB/Fe and $B6C3F_1$) show an increase in hepatic tumors with chronic exposure (Davis and Fitzhugh 1962; NCI 1978a). A significant increase in the incidence of hepatocellular carcinoma was reported in males receiving 0.52 mg/kg/day of aldrin for 80 weeks (NCI 1978a). An increase in the incidence of hepatic cell adenomas at 1.3 mg/kg/day was also reported in a 2-year study by Davis and Fitzhugh (1962). Reevaluation of the histopathology data by Reuber (1980) and other pathologists indicated that most tumors classified by Davis and Fitzhugh (1962) as hepatic cell adenomas were hepatocellular carcinomas (Epstein 1975).

With respect to dieldrin, bioassays in Balb/c, CF_1, $B6C3F_1$, C3HeB/Fe, C3H/He, and C57BL/6J mice have also shown an increase in the incidence of hepatocellular adenoma and/or carcinomas with chronic exposure. A study in $B6C3F_1$ mice by NCI (1978a) showed a significant increase in the incidence of hepatocellular carcinoma with exposure of males to 0.65 mg/kg/day for 80 weeks. Increased incidences of hepatocellular carcinomas were also reported in male C3H/He, $B6C3F_1$, and C57BL/6J mice exposed to 1.3 mg dieldrin/kg/day for 85 weeks (Meierhenry et al. 1983) and in male CF_1 mice exposed to 1.3 mg dieldrin/kg/day for 92 weeks (Tennekes et al. 1981). An increase in both hepatocellular adenomas (Type A tumors) and hepatocellular carcinomas (Type B tumors) in CF_1 mice that ingested 1.3 mg/kg/day for 2 years was identified by Thorpe and Walker (1973). Similarly, a significant increase was observed in the incidence of hepatocellular carcinomas and combined incidence of both hepatocellular adenomas and carcinomas in a 132-week study at 1.3 mg/kg/day and of combined incidence of both hepatocellular adenomas and carcinomas in a 128-week study at 0.33 mg/kg/day in CF_1 mice (Walker et al. 1972). In a 75-week study in Balb/c mice (Lipsky et al. 1989) and a 2-year study in C3HeB/Fe mice, (Davis and Fitzhugh 1962) increases in the incidence of hepatic cell adenoma were observed at 1.3 mg/kg/day. However, reexamination of the histopathology data by Reuber (1980) and other pathologists showed an increase in the incidence of hepatocellular carcinomas (Epstein 1975). Although reanalysis of the data presented in the Walker et al. (1972) study by Reuber also indicated a significant increase in pulmonary adenomas and carcinomas in female mice at 0.013 and 0.13 mg/kg/day and a significant increase in lymphoid and other tumors in female mice at 0.13 mg/kg/day (Epstein 1975), these conclusions were based on errors in the reporting of the number of females examined at 0.013 and 0.13 mg/kg/day (Hunt et al. 1975).

In addition to producing an increase in the incidence of hepatocellular carcinomas in mice, dieldrin was also shown to significantly decrease the time to tumor development in mice at doses as low as 0.013 mg/kg/day in females and 0.13 mg/kg/day in males (Tennekes et al. 1982).

Carcinogenicity studies of aldrin and/or dieldrin in rats and hamsters have produced mostly negative results (Cabral et al. 1979; Deichmann et al. 1967, 1970; Fitzhugh et al. 1964; NCI 1978b; Walker et al. 1969). However, several of these studies have been determined to be flawed based on limited microscopic examination of animals (Fitzhugh et al. 1964; Walker et al. 1969), too few animals being used (Fitzhugh et al. 1964; NCI 1978b), and/or high levels of early mortality with insufficient numbers of animals surviving until termination of the study (Deichmann et al. 1970; Fitzhugh et al. 1964). Furthermore, reanalysis of the data from the study by Fitzhugh et al. (1964) revealed a significant increase in multiple- site tumors when doses of aldrin and dieldrin at or below 0.5 mg/kg/day were combined and an increased incidence of liver carcinomas at 5 mg/kg/day when data from both sexes were combined (Epstein 1975).

A carcinogenic response was also observed in rats exposed to 1.5 mg/kg/day of aldrin for 80 weeks (NCI 1978a). These animals had a significantly increased incidence of follicular cell adenoma and carcinoma of the thyroid. Also, a significant increase in adrenal cortical adenomas was seen in female rats at this dose. However, these effects were not dose-dependent. Similarly, a significant increase in the combined incidence of adrenal cortical adenomas and carcinomas was observed in females given 1.5 mg/kg/day for 59 weeks but not at 3 mg/kg/day (NCI 1978a). This result was, however, discounted by the study authors because of the historical variability of this result in control animals.

There is evidence that dieldrin can act as a liver tumor promoter in mice, but not in rats (Kolaja et al. 1996c). Preneoplastic focal hepatic lesions were initiated by intraperitoneal treatments with diethylnitrosamine (two injections separated by two weeks in male F344 rats, two injections per week for 8 weeks in male B6C3F1 mice). After the preneoplastic lesions developed, dieldrin was administered in the diet for 7, 30, or 60 days at estimated doses of 0.05, 0.15 or 0.5 mg/kg/day in the rats and 0.013, 0.13, or 1.3 mg/kg/day in the mice. Dieldrin induced significant increases in the number, volume, and deoxyribonucleic acid (DNA) labeling index of the DEN-induced preneoplastic foci in mice at the highest dose after 30 and 60 days. The lower doses (#0.13 mg/kg/day) did not produce these promotional effects at any time point. The results of this study are consistent with findings of other studies of generally similar design by the same investigators (Kolaja et al. 1995a, 1995b, 1998).

The lowest dose that produced a tumorigenic response (Cancer Effect Levels, CELs) for each species and duration category of exposure to aldrin and dieldrin are recorded for aldrin in Table 3-1 and for dieldrin in Table 3-2 and plotted for aldrin in Figure 3-1 and for dieldrin in Figure 3-2.

The EPA reviewed the carcinogenicity data on aldrin and dieldrin and calculated human potency estimates using liver tumor responses in mice (EPA 1986l; IRIS 2002a, 2002b). The potency estimates (q_1^*) represent a 95% upper confidence limit of the extra lifetime human risks. Using potency estimates calculated from three data sets in two mouse strains and both sexes (Davis 1965; Epstein 1975; NCI 1978a), a geometric mean of 17 $(mg/kg/day)^{-1}$ was chosen for the oral cancer risk estimate for aldrin (IRIS 2002a). The unit risk estimate for drinking water exposures (the excess cancer risk associated with lifetime exposure to 1 μg/L) is 4.9×10^{-4}. Using potency estimates calculated from 13 data sets in five mouse strains and both sexes (Davis 1965; Epstein 1975; Meierhenry et al. 1983; NCI 1978a, 1978b; Tennekes et al. 1981; Thorpe and Walker 1973; Walker et al. 1972), a geometric mean of 16 $(mg/kg/day)^{-1}$ was chosen for the oral cancer risk estimate for dieldrin (IRIS 2002b). The unit risk estimate for drinking water exposures to dieldrin is 4.6×10^{-4}. Based on the unit risk values for aldrin and dieldrin, cancer risk levels of 10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7} correspond to 70 years of continuous drinking water exposure to 0.2, 0.02, 0.002, and 0.0002 μg/L, respectively (0.006, 0.0006, 6.0×10^{-5}, and 6.0×10^{-6} μg/kg/day). The predicted cancer risks are considered conservative upper estimates. The actual risk of cancer is unlikely to be higher and may be substantially lower. These values are recorded in Figures 3-1 and 3-2.

3.2.3 Dermal Exposure

As indicated in the section on inhalation exposure, it is often difficult to clearly separate dermal from inhalation exposures in many occupational studies. Thus, many of the findings described in the section on inhalation exposure are repeated here.

3.2.3.1 Death

No increase in mortality from any cause was found in studies of workers who had been employed in the manufacture of aldrin, dieldrin, endrin, and/or telodrin at a facility in the Netherlands for >4 years (cohort=233 workers) (van Raalte 1977; Versteeg and Jager 1973). Furthermore, in a 20-year follow-up of this population and expansion of the cohort to include workers employed for at least 1 year during 1954–1970 (cohort=570 workers), a lower than expected overall mortality was observed (de Jong 1991). Although the group of workers described by de Jong (1991) represents a unique population because they have been under medical supervision for an average of 25.86 years, all of the studies described above are limited because of the small number of subjects used (#570 workers) and the potential exposure of the subjects to more than one of these pesticides and/or to other chemicals at the chemical manufacturing complex. Several of these studies have attempted to estimate exposure levels using blood levels. However, blood levels were not obtained for approximately 10 years (during what is expected to have been the period of heaviest exposure) and extrapolations were based on data obtained in a study using constant daily low-level oral dosing (Hunter and Robinson 1967). It is unclear whether such extrapolations accurately reflect exposure levels in the occupational situation. Only two case studies were located regarding deaths that may have been attributable to occupational exposure to aldrin or dieldrin (Muirhead et al. 1959; Pick et al. 1965). One concerned a farmer with multiple exposures to insecticide containing dieldrin. The farmer died in hemolytic crisis after developing immunohemolytic anemia (Muirhead et al. 1959). Immunologic testing revealed a strong antigenic response of blood cells coated with dieldrin. The other concerned a worker from an orange grove who developed aplastic anemia and died following repeated exposures to aldrin during spraying (Pick et al. 1965). In the latter study, the relationship between aldrin exposure and the aplastic anemia is considerably more tenuous, being linked only in that the onset of symptoms corresponded with spraying and the condition deteriorated upon subsequent exposure.

In rats, a single dermal application of aldrin in xylene was reported to produce death in 50% of the animals tested at 98 mg/kg/day (Gaines 1960). Dieldrin in xylene produced an LD_{50} value of 60 mg/kg/day in female rats and 90 mg/kg/day in male rats (Gaines 1960). However, this study is limited because the rats were not restrained, oral intake could not be eliminated, and the xylene vehicle has intrinsic dermal toxicity. A single 24-hour dermal exposure of rabbits to dry crystallized aldrin or dieldrin resulted in LD_{50} values between 600 and 1,250 mg/kg for both chemicals (Treon et al. 1953a). Similar results were obtained when these chemicals were prepared as oil solutions and maintained in contact with the skin for 24 hours. Also, sheep dipped in a solution of 200 mg/L of dieldrin (twice the recommended dose) experienced an 11% mortality rate within the 1st month following exposure (Glastonbury et al. 1987). This study is limited because the preparation of dieldrin used was unsuitable for use in emulsions and may have been stripped from the bath during the dipping of the first sheep resulting in much higher doses for some animals than others. In addition, wool biting was observed among these sheep; this type of oral exposure may have contributed to the lethal effects.

Dermal exposure of rabbits to aldrin or dieldrin (2 hours/day, 5 days/week, for 10 weeks) resulted in slightly greater lethality when these chemicals were prepared as solutions in oil and much greater lethality when the chemicals were administered as suspensions in kerosene than when crystallized material was placed directly in contact with the skin (Treon et al. 1953a). In the case of aldrin, three out of three rabbits survived exposure to average doses of 34–39 mg/kg/day during the 10-week period; one out of three died after exposure to 19–26 mg/kg/day in oil; and three out of three died after exposure to 19–27 mg/kg/day in kerosene. Crystallized dieldrin exposures of 39–41 mg/kg/day were survived by three out of three rabbits; but all rabbits died at 43–57 mg/kg/day in oil and 24–26 mg/kg/day in kerosene. The greater lethality of the kerosene suspensions may have been associated with greater absorption as a result of skin damage caused by the kerosene.

The highest NOAEL values and all reliable LOAEL values for death in each species and duration category are recorded for aldrin in Table 3-3 and for dieldrin in Table 3-4.

3.2.3.2 Systemic Effects

The highest NOAEL values for each study for dermal/ocular effects are recorded for aldrin in Table 3-3 and for dieldrin in Table 3-4.

Respiratory Effects. Conflicting reports were located regarding the respiratory effects of aldrin and dieldrin in humans after dermal exposure. In a study of workers with at least 4 years of employment in the manufacture of aldrin, dieldrin, endrin, or telodrin, no new pulmonary disease or deterioration of existing pulmonary disease were observed (Jager 1970). Similarly, no increase in mortality from respiratory diseases was noted in workers employed for at least 1 year at the same facility during 1954–1970 when these workers were followed for at least 20 years (de Jong 1991). In contrast, however, in another study that examined workers involved in the manufacture of aldrin, dieldrin, and/or endrin for

Table 3-3. Levels of Significant Exposure to Aldrin - Dermal

Species (Strain)	Exposure/ Duration/ Frequency	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
ACUTE EXPOSURE						
Death						
Rabbit	1 d 24hr/d				1250 (4/4 died)	Treon et al. 1953a
INTERMEDIATE EXPOSURE						
Death						
Rabbit	10 wk 5d/wk 2hr/d				120-125 (2/3 died-dry) 19-26 (1/3 died-oil solution) 4-5 (2/4 died-kerosene suspension)	Treon et al. 1953a
Systemic						
Rabbit	10 wk 5d/wk 2hr/d	Dermal	221-320			Treon et al. 1953a

d = day(s); hr = hour(s); LOAEL = lowest-observed-adverse-effect level; NOAEL = no-observed-adverse-effect level; wk = week(s)

Table 3-4. Levels of Significant Exposure to Dieldrin - Dermal

Species (Strain)	Exposure/ Duration/ Frequency	System	NOAEL (mg/kg/day)	LOAEL: Less serious (mg/kg/day)	LOAEL: Serious (mg/kg/day)	Reference
ACUTE EXPOSURE						
Death						
Rabbit	1 d 24hr/d				360 (1/4 died - dry) 600 (1/4 died - oil solution)	Treon et al. 1953a
Systemic						
Human	4 d 24hr/d	Dermal	0.5%			Suskind 1959
Immunological/Lymphoreticular						
Human	4 d 24hr/d		0.5%			Suskind 1959
INTERMEDIATE EXPOSURE						
Death						
Rabbit	10 wk 5d/wk 2hr/d				97-174 (3/3 died-dry) 43-57 (3/3 died-oil solution) 4-5 (2/3 died-kerosene suspension)	Treon et al. 1953a
Systemic						
Rabbit	10 wk 5d/wk 2hr/d	Dermal	97-174			Treon et al. 1953a
Neurological						
Human	180 d 5.5d/wk 6hr/d		1.8			Fletcher et al. 1959

d = day(s); hr = hour(s); LOAEL = lowest-observed-adverse-effect level; NOAEL = no-observed-adverse-effect level; wk = week(s) at least a year, a significantly increased incidence of pneumonia and other pulmonary diseases was observed when the incidence in the exposed workers was compared to the incidence in U.S. white males (Ditraglia et al. 1981). Both studies are limited by the small sample size and the possible exposure of the workers to other chemicals and/or pesticides. In addition, inhalation exposure may have contributed to the production of these effects since exposures by both inhalation and dermal absorption are likely in these populations of workers.

No effects on lung weight or pathology were found in a study in which rabbits were wrapped with material containing up to 0.04% dieldrin for up to 52 weeks (Witherup et al. 1961). However, this study is limited in that some animals from the study were treated with a variety of drugs to control "extraneous" diseases.

Cardiovascular Effects. Limited information was available regarding the cardiovascular effects of aldrin or dieldrin in humans after dermal exposure. Suggestive evidence of an association between dieldrin and hypertension was obtained in a study examining the incidence of certain diseases in patients with elevated fat levels of dieldrin (Radomski et al. 1968). However, elevated fat levels of other pesticide residues also correlated with hypertension in this study. Furthermore, a study examining disease incidence in 2,620 workers exposed to a number of pesticides reported no increase in the incidence of hypertension in workers with elevated serum dieldrin (Morgan et al. 1980). The lack of a correlation between hypertension and aldrin or dieldrin exposure is also supported by the observation that workers involved in the manufacture of aldrin, dieldrin, endrin, or telodrin for at least 4 years had normal blood pressure (Jager 1970). Similarly, no increase in mortality from circulatory system diseases was observed in a mortality study by de Jong (1991). All of these studies are limited because the subjects were exposed to a variety of other chemicals.

A slight, but significant, increase in serum cholesterol was observed in pesticide-exposed workers with elevated serum dieldrin (Morgan and Lin 1978). However, this study was limited in that the workers were occupationally exposed to a number of different pesticides and other chemicals including hydrocarbon solvents.

No effects on heart weight or pathology were found in a study in which rabbits were wrapped with material containing up to 0.04% dieldrin for up to 52 weeks (Witherup et al. 1961). However, this study is limited in that some animals from the study were treated with a variety of drugs to control "extraneous" diseases.

Gastrointestinal Effects. No increased mortality from digestive system causes was observed in a mortality study of workers employed in the manufacture of aldrin and dieldrin for at least 1 year between 1954 and 1970 (de Jong 1991).

No studies were located regarding gastrointestinal effects in animals after dermal exposure to aldrin or dieldrin.

Hematological Effects. No abnormal values for hemoglobin, white blood cells, or erythrocyte sedimentation rate were found in workers who had been employed in the manufacture of aldrin, dieldrin, endrin, or telodrin for at least 4 years (Jager 1970). Similarly, no increase in blood diseases was observed in a morbidity study of workers employed at the same facility for at least 1 year (de Jong 1991). Also, workers who had been involved in either the manufacture or application of pesticides and who had significantly elevated blood levels of dieldrin compared to controls not employed in pesticide-related jobs had no hematological effects of clinical significance (Warnick and Carter 1972). These studies are limited by either potential exposure to other chemicals (Jager 1970) or by known exposure to other pesticides as demonstrated by elevated blood levels of β-benzine [sic] hexachloride (β-benzene hexachloride), heptachlor epoxied, *p,p*'-DDT, *o,p*'-DDT, and *p,p*'-DDE (Warnick and Carter 1972).

A case of immunohemolytic anemia attributable to dieldrin exposure was reported (Muirhead et al. 1959). Also, a worker from a grove where aldrin was sprayed developed aplastic anemia (Pick et al. 1965), and one person employed in the manufacture of aldrin and dieldrin between 1954 and 1970 died from aplastic anemia (de Jong 1991). However, it is unclear whether these cases of aplastic anemia were directly due to aldrin or dieldrin exposures because exposure to a variety of other chemicals was possible. Three cases of pancytopenia and one case of thrombocytopenia associated with exposure to dieldrin were reported during 1961 (AMA 1962). However, no assessment regarding whether dieldrin was the causative agent was provided in the report.

No studies were located regarding hematologic effects in animals after dermal exposure to aldrin or dieldrin.

Musculoskeletal Effects. No studies were located regarding musculoskeletal effects in humans or animals after dermal exposure to aldrin or dieldrin.

Hepatic Effects. Although a slight increase in serum hepatic enzymes (alanine and aspartate aminotransferases) has been observed to correlate with serum dieldrin levels in pesticide-exposed workers (Morgan and Lin 1978), no evidence of any hepatic effects of aldrin or dieldrin exposure have been observed in other studies of workers involved in either the manufacture (de Jong 1991; Hoogendam et al. 1965; Hunter et al. 1972; Jager 1970; van Sittert and de Jong 1987) or the manufacture or application (Morgan and Roan 1974; Warnick and Carter 1972) of these pesticides. Parameters that have been examined in the negative studies include serum hepatic enzyme activity (Hoogendam et al. 1965; Jager 1970; Morgan and Roan 1974; van Sittert and de Jong 1987; Warnick and Carter 1972), hepatic enlargement (Jager 1970), and tests intended to detect microsomal enzyme induction (Hunter et al. 1972; Jager 1970; Morgan and Roan 1974; van Sittert and de Jong 1987). All of the studies are limited by the potential exposure of the workers to other chemicals and/or organochlorine pesticides.

No effects on liver weight, serum proteins, thymol turbidity, serum alkaline phosphatase, or pathology were found in a study in which rabbits were wrapped with material containing up to 0.04% dieldrin for up to 52 weeks (Witherup et al. 1961). However, this study is limited in that some animals from the study were treated with a variety of drugs to control "extraneous" diseases.

Renal Effects. No evidence of renal damage was seen in workers employed for four or more years in the manufacture of aldrin, dieldrin, endrin, or telodrin (Jager 1970). However, this study is limited by the potential exposure of these workers to other chemicals.

No studies were located regarding renal effects in animals after dermal exposure to aldrin or dieldrin.

Endocrine Effects. No studies were located regarding endocrine effects in humans or animals after dermal exposure to aldrin or dieldrin.

Dermal Effects. Contact dermatitis was observed in police recruits wearing socks that had been moth-proofed with a solution containing dieldrin (Ross 1964). Several recruits had a positive patch test when tested against the moth-proofing agent. The outbreak of the dermatitis appeared to have been exacerbated by the presence of the particular dye used in the socks and by the fact that the recruits' feet had sweated heavily. In contrast, no evidence of dermatitis was seen in volunteers who wore patches of cotton broadcloth or wool flannel impregnated with up to 0.5% dieldrin by weight for 4 days (Suskind 1959) or in workers employed for four or more years in the manufacture of aldrin, dieldrin, endrin, or telodrin

(Jager 1970). The study by Jager (1970) is limited by the potential exposure of these workers to other chemicals.

Application of up to 6,000 mg/kg of aldrin or 3,600 mg/kg of dieldrin as either the crystalline material or as a solution in oil to the skin of rabbits for 24 hours was reported to result in occasional very slight erythema, but the lowest doses associated with this effect were not reported (Treon et al. 1953a). In contrast, no irritation was observed following application of 221–320 mg/kg/day aldrin or 97–174 mg/kg/day of dieldrin to the skin of rabbits for 2 hours/day, 5 days/week, for up to 10 weeks (Treon et al. 1953a). Also, no treatment-related effects were observed after microscopic examination of the skin of rabbits wrapped with wool fabric containing up to 0.04% dieldrin by weight for 52 weeks (Witherup et al. 1961).

Ocular Effects. No studies were located regarding ocular effects in humans or animals after dermal exposure to aldrin or dieldrin.

3.2.3.3 Immunological and Lymphoreticular Effects

Limited information is available regarding the immunological effects of aldrin and dieldrin in humans after dermal exposure. No sensitization was observed in volunteers who were reexposed to fabric containing up to 0.5% dieldrin 2 weeks following a 4-day exposure (Suskind 1959). However, a case report was located concerning a man who developed immunohemolytic anemia after multiple exposures to dieldrin, heptachlor, and toxaphene while spraying cotton fields (Muirhead et al. 1959). Antibodies for dieldrin-coated or heptachlor-coated red blood cells were found in the subject's serum. However, this study is limited because of the exposure of the subject to other pesticides.

No studies were located regarding immunological effects in animals after dermal exposure to aldrin or dieldrin.

All reliable LOAEL values for immunologic effects of dieldrin in humans in acute-duration dermal studies are recorded in Table 3-4.

3.2.3.4 Neurological Effects

Central nervous system excitation culminating in convulsions was the principal toxic effect noted in occupational studies of workers employed in either the manufacture or application of aldrin or dieldrin. In many cases, convulsions appeared suddenly and without prodromal signs (Hoogendam et al. 1965; Kazantzis et al. 1964; Patel and Rao 1958). EEGs taken shortly after the convulsions revealed bilateral irregular alpha rhythms interrupted by spike and wave patterns (Avar and Czegledi-Janko 1970; Kazantzis et al. 1964). In the case of dieldrin sprayers who developed convulsions, the convulsive episodes did not follow known accidental overexposures (Patel and Rao 1958). Rather, the convulsions developed anywhere from 14 to 154 days after the first exposure to dieldrin. The time to onset was more rapid for sprayers using the more concentrated spray. An accumulative type of poisoning was also reported in workers involved in the manufacture of aldrin, dieldrin, telodrin, or endrin (Jager 1970). In this report, convulsions were believed to have been caused by either accumulating levels of dieldrin in the blood or modest overexposures in the presence of subconvulsive accumulations of dieldrin. Other central nervous system symptoms reported by workers involved in the manufacturer or application of aldrin and/or dieldrin included headaches (Jager 1970; Patel and Rao 1958), dizziness (Jager 1970), hyperirritability (Jager 1970; Kazantzis et al. 1964), general malaise (Jager 1970), nausea and vomiting (Jager 1970; Kazantzis et al. 1964), anorexia (Jager 1970), muscle twitching (Jager 1970; Patel and Rao 1958), and myoclonic jerking (Jager 1970; Jenkins and Toole 1964; Kazantzis et al. 1964). The more severe symptoms were accompanied by EEG patterns with bilateral spike and wave complexes and multiple spike and wave discharges in the alpha region (Jager 1970; Kazantzis et al. 1964). Less severe symptoms were accompanied by bilateral theta (Jager 1970; Kazantzis et al. 1964) and/or delta (Kazantzis et al. 1964) wave discharges.

In all cases in which follow-up of the subjects was reported, removal from the source of exposure caused a rapid physical recovery and a slower recovery (within a year) of the EEG activity to normal levels (Avar and Czegledi-Janko 1970; Hoogendam et al. 1962, 1965; Jager 1970; Jenkins and Toole 1964; Kazantzis et al. 1964).

No symptoms of poisoning were observed in workers who were exposed to an estimated 1.8 mg/kg/day for 6 months at 6 hours/day for 5.5 days/week based on accumulation of dieldrin on absorbent pads that were attached to various surfaces on the workers (Fletcher et al. 1959).

A morbidity study of workers employed in the manufacture of aldrin and dieldrin between 1979 and 1990 noted no degenerative disorders of the nervous system (de Jong 1991). However, this study reported significant increases in mental disorders among those <30 years old and in those 46–50 years old. The diseases were classified as stress reactions, short-term depression, or sleep disorders. It is unclear whether these effects were directly the result of aldrin or dieldrin exposure or may have had some other cause.

Results of a comprehensive neurological work-up of 27 workers involved in either the manufacture or application of dieldrin were compared to those of unexposed workers (Sandifer et al. 1981). Scores on five psychological tests were significantly different from those of the unexposed controls; however, the importance of the results was questioned by the authors because of a lack of equality in the level of literacy of the two groups. Also, three exposed workers had abnormal EMGs suggesting a peripheral neuropathy. However, EMGs were not obtained in the control group; thus, the significance of these results is unknown.

Tremors and convulsions were reported in a study examining the effects of acute dermal exposure to aldrin or dieldrin in rabbits (Treon et al. 1953a). However, the doses associated with these effects were not reported. Neurological symptoms including salivation, grinding of the teeth, and spasms were observed in rabbits that were dipped into an emulsion of dieldrin, xylene, Triton X-155®, and water, at doses as low as 70 mg/kg once a week until death or termination of the experiment (Bundren et al. 1952). This study is limited in that no vehicle control was used and some dose levels were tested on a single animal.

The highest NOAEL for neurological effects in humans in an intermediate-duration study is recorded in Table 3-4.

3.2.3.5 Reproductive Effects

No studies were located regarding reproduction effects in humans or animals after dermal exposure to aldrin or dieldrin.

3.2.3.6 Developmental Effects

No studies were located regarding developmental effects in humans after dermal exposure to aldrin or dieldrin.

The only study located that referred to developmental effects following dermal exposure was a case report of a number of lambs that died either prior to or during parturition (Glastonbury et al. 1987). Ewes had been dipped in an aqueous emulsion of 210 mg/L of dieldrin on one occasion up to 4 months prior to giving birth. External appearance of the lambs was normal, but the lambs were small. Also, the brains of these lambs had an abnormal cerebellar structure. It is unclear whether these effects can be attributed entirely to dieldrin exposure since vitamin A deficiency was also observed in these sheep and vitamin A deficiency is known to cause fetal mortality.

3.2.3.7 Cancer

Aldrin and dieldrin were manufactured at two sites worldwide in plants at the Rocky Mountain Arsenal in Denver, Colorado, and at Pernis in the Netherlands. Workers from these plants have been included in two series of retrospective cohort mortality studies which have been updated several times. Exposure to DBCP and several organophosphates may also have occurred in the Denver plant. Cancer mortality findings of the studies at the Denver plant (Amoateng-Adjepong et al. 1995; Brown 1992; Ditraglia et al. 1981; Ribbens 1985) and the Pernis plant (de Jong 1991; de Jong et al. 1997; Jager 1970; Ribbens 1985; van Raalte 1977) are inconclusive, as summarized below.

The first study of the Denver plant found no significant increase in cancer mortality, but concluded that additional follow-up was necessary due to a small number of deaths (173) and relatively short period of observation (Ditraglia et al. 1981). In the follow-up by Brown (1992), 1,158 workers who were employed for at least 6 months prior to 1965 and were followed through 1987 were investigated. Cause-specific mortality analysis of 337 deaths showed an increase in liver and biliary tract cancer (five cases observed) that was statistically significant when compared to state and local rates (SMRs of 5.10 and 4.86, respectively), but not the national rate (SMR 3.93). All of these five deaths (three from biliary tract/ bile duct cancer, one from gall bladder cancer, and one from hepatoma) occurred after 15 years of latency (SMR=4.85). The cohort in the most recent study of the Denver plant (Amoateng-Adjepong et al. 1995) was expanded to 2,384 subjects and followed through 1990 (median 29 years). The median age at hiring was 26 years and the median tenure was 2 years. The increase in hepatobiliary cancer was of a lower magnitude than in the previous study and was no longer statistically significant, although no additional cases had occurred (five cases observed/2.0 expected based on state rates, SMR=249). Based on this information and findings that the cancers were not limited to any particular production unit, did not display duration-response trends, and essentially occurred in the biliary tract or gall bladder (rather than liver), the investigators concluded that the hepatobiliary cancer excess was not due to occupational exposures at the plant.

No indications of a carcinogenic effect were found in the early mortality studies of the Dutch (Pernis) workers (Jager 1970; Ribbens 1985; van Raalte 1977). Similarly, in the follow-up study by de Jong (1991), there were no increases in cause-specific mortality among 76 deaths in 570 workers who were employed for at least 1 year between 1954 and 1970 and followed-up until 1987. Follow-up of this cohort until 1993 (118 deaths) showed a significant increase in mortality from rectal cancer (6 deaths observed versus 1.5 expected compared to Netherlands national rates, SMR=390.4) and an insignificant increase in liver cancer deaths (two observed versus 0.9 expected, SMR=225.0) (de Jong et al. 1997). Stratification by dose level (low, moderate, or high exposure based on blood levels of dieldrin) did not disclose any indications for a dose-response relation for either of these causes of death.

Equivocal evidence exists for an association between dieldrin and breast cancer risk from three human epidemiologic studies (Dorgan et al. 1999; Høyer et al. 1998, 2000). In these studies, while dieldrin exposure was verified through blood sampling, and exposure by dermal contact, as well as by inhalation and ingestion, was possible, no specific route of exposure was identified or estimated with any certainty.

The potential of dieldrin to affect breast cancer risk was evaluated in a prospective nested case control study of women in Denmark (Høyer et al. 1998). Serum samples were obtained from 7,712 women from 1976 to 1978. In 1996–1997, serum samples from 240 women who had developed invasive breast cancer and 477 matched breast cancer-free controls were analyzed for levels of dieldrin and 17 other organochlorine pesticides or metabolites and 28 PCB congeners. Controls and cases were matched for age, date of examination, and vital status at the examination. Irrespective of breast cancer status, dieldrin was detected in 78% of the women enrolled in the study, with median levels at 24.4 ng/g lipid. Dieldrin was the only organochlorine compound of those tested associated with a significant increase in breast cancer risk. Women in the highest quartile of the serum dieldrin range had double the risk of breast cancer compared to women in the lowest quartile (OR 2.25, 95% CI 1.32–3.84, p trend=0.003). Relative risk did not change significantly when adjusted for potential confounders of weight and number of full-term pregnancies (OR 2.05, 95% CI 1.17–3.57, p trend=0.01).

A subsequent study using the same cohort of Danish women investigated whether breast cancer survival was affected by past exposure to dieldrin (Høyer et al. 2000). Dieldrin at blood concentrations >57.6 ng/g, representative of the highest quartile, was found to have a significant adverse effect on overall survival and breast cancer specific survival compared to the lowest quartile levels of <12 ng/g lipid (RR 2.78, 95% CI 1.38–5.59, p trend<0.01; RR 2.61, 95% CI 0.97–7.01, p trend<0.01) in this case-control study of Danish women between 20 and 80 years of age. A total of 195 breast cancer cases, who each provided two blood samples that were taken in 1976–1978 and 1981–1983, respectively, were included in the survival analysis. The median duration of follow-up with regard to death was 86 months after the first examination (1976–1978) and 79 months after the second examination (1981–1983). Relative risk was adjusted for number of positive lymph nodes and tumor size and grade. When the analysis was performed using an average of the blood concentrations from the two collections, the association was even stronger, with a 5-fold higher risk of death in women from the highest quartile compared to the lowest quartile (RR 5.76, 95% CI 1.86–17.92, p trend<0.01) and a clear dose-response relationship. Potential confounders as body mass index, age at menopause, and hormone replacement therapy did not influence the results. This study was limited by small size, 6–39 women per quartile.

A cohort study of women from Missouri failed to find an association between serum dieldrin levels and breast cancer risk (Dorgan et al. 1999). Blood samples were collected from 7,224 women from 1977 to 1987. During the 9.5-year follow-up period, 105 women developed breast cancer; each was matched to two controls based on age and date of blood collection. Dieldrin was detected in serum in 56.2% of the cases and 61.8% of the controls. The relative risk of cancer in the highest dieldrin serum concentration range quartile was moderately lower compared to the lowest quartile (RR 0.7, 95% CI 0.3–1.3, p=0.44).

No studies were located regarding cancer in animals after dermal exposure to aldrin or dieldrin.

3.2.4 Other Routes of Exposure

Dieldrin, 10 mg/kg/day, injected intraperitoneally for 5 days, did not appear to have any estrogenic action in mature male rats as the serum and urinary levels of $\alpha_{2\mu}$-globulin were not significantly altered (Nagahori et al. 2001).

3.3 GENOTOXICITY

Sister chromatid exchanges and chromosomal aberrations were studied in a population of floriculturists occupationally exposed to several pesticides, including aldrin (Dulout et al. 1985). A statistically significant increase in sister chromatid exchanges, but not exchange type chromosome aberrations, was seen in workers with clinical symptoms of pesticide exposure as compared to those without symptoms. There was an increase in exchange-type chromosome aberrations in this population when compared to nonfloriculturists. Interpretations based on this study are limited because the route and dose of exposure could not be determined, since the workers could have been exposed via inhalation or dermal contact following the spraying of the greenhouses with the pesticide aerosols. In addition, there was concomitant exposure to other organophosphorus, carbamate, and organochlorine insecticides.

Lymphocytes from workers in a dieldrin manufacturing facility were examined for chromosome aberrations (Dean et al. 1975). No statistically significant differences in either chromatid-type or chromosome-type aberrations were seen in current workers when compared to former workers or to unexposed controls. While there was no occupational exposure to other pesticides in this study, the exposure could have occurred via inhalation and/or dermal contact.

No studies were located regarding genotoxic effects in animals after inhalation exposure to aldrin or dieldrin.

No studies were located regarding genotoxic effects in humans after oral exposure to aldrin or dieldrin.

Studies in a variety of mammalian species have demonstrated a unique sensitivity of the mouse liver to dieldrin-induced hepatocarcinogenicity, and mechanistic studies suggest a nongenotoxic mode of action (Stevenson et al. 1999; WHO 1989). Aldrin and dieldrin were found to induce DNA synthesis in the mouse liver (Busser and Lutz 1987; Kamendulis et al. 2001). The effects of dieldrin on changes in hepatocyte DNA synthesis, mitosis, apoptosis, and ploidy were studied in rats and mice treated with a 0, 1, 3, or 10 mg dieldrin/kg diet (Kamendulis et al. 2001). Livers from mice fed only the highest dose (10 mg dieldrin/kg) exhibited significantly increased DNA synthesis and mitosis at 14, 28, or 90 days on the diet and a significant increase in octaploid (8N) hepatocytes. No changes were observed in rat livers. The apoptotic index in the liver of mice in any treatment group did not change over a 90-day treatment and study period. In another study in which single doses of aldrin were administered orally to male rats and male and female mice (0.016, 0.011, and 0.008 mmol/kg [5.84, 4.01, and 2.92 mg/kg], respectively), DNA synthesis in the liver was stimulated only in male mice (Busser and Lutz 1987).

Single doses of aldrin administered orally to three groups of male Swiss mice (13.0, 19.5, and 39.0 mg/kg) resulted in a statistically significant increase in the number of abnormal metaphases in dividing spermatocytes. There was also a significant increase at all doses of univalents, indicating a decreased pairing of meiotic chromosomes (Rani and Reddy 1986).

A dominant lethal assay was conducted using 40 male CF_1 mice orally dosed with 12.5 or 25 mg/kg of dieldrin (Dean et al. 1975). The results of this assay indicated that the overall mean percentage of implantations was significantly reduced in the females mated with males receiving 12.5 mg/kg dieldrin. However, a second series of experiments showed that the overall mean of successful implantations was significantly higher in the 25 mg/kg group than in the controls. Several doses of both aldrin and dieldrin were tested in a dominant lethal study conducted in mice (Epstein et al. 1972). Dieldrin did not meet any criteria for mutagenic effects. Females mated to males exposed to aldrin did show some reduction in implantations, but these were judged to be nonsignificant upon statistical analysis.

Present *in vivo* data have not established whether or not aldrin or dieldrin react directly with DNA to produce mutations in either the germ cells or in the somatic cells. The reduced meiotic pairing reported by Rani and Reddy (1986) does suggest that aldrin can cross the blood/testis barrier, but the results of Dean et al. (1975) offer no clear evidence that there are significant reactions with DNA.

No studies were located regarding genotoxic effects in animals after dermal exposure to aldrin or dieldrin.

In vitro studies assaying for genotoxicity of aldrin or dieldrin have been conducted in several species. Significant increases in chromosome aberrations have been reported in cultured human lung cells. Similar results have been observed in bone marrow cells of mice treated intraperitoneally with dieldrin (Majumdar et al. 1976). Sister chromatid exchanges were significantly increased in Chinese hamster ovary cells at doses of dieldrin that caused marked cell cycle delay when tested both with and without S9 (Galloway et al. 1987). However, no chromosome aberrations were seen in this study. In addition, only 3 of 4,800 cells from 48 Chinese hamsters exposed via intraperitoneal injection of 60 mg/kg of dieldrin showed aberrant chromosomes (Dean et al. 1975).
Mitotic gene conversion in *Saccharomyces cerevisiae* was negative in a host-mediated assay in which adult male CF_1 mice were orally dosed for 5 consecutive days with 5 or 10 mg/kg of dieldrin (Dean et al.

1975). Micronuclei formation was increased in *Tradescantia* by 3.81 ppm dieldrin, but aldrin yielded negative results (Sandhu et al. 1989). The authors speculated that the immiscibility of aldrin in water contributed to the negative findings of that chemical.

Dieldrin-induced gene mutation has been reported to be positive in Chinese hamster V79 cells (Ahmed et al. 1977b) and in *Salmonella* (Ennever and Rosenkranz 1986; Majumdar et al. 1977) but negative in *Aspergillus nidulans* (Crebelli et al. 1986). Dieldrin-induced gene mutation in several strains of *Salmonella* has also been reported to be negative, with and without activation (De Flora et al. 1984; Glatt et al. 1983; Haworth et al. 1983; Marshall et al. 1976; Moriya et al. 1983; Shirasu 1975), but weakly positive results were reported in *Salmonella* following photoactivation with ultraviolet light (De Flora et al. 1989). Dieldrin produced positive results for focus formation in the BPV-1 DNA carrying C3H/10T(½) mouse embryo fibroblast cell line (T1) (Kowalski et al. 2000). Aldrin and dieldrin were not mutagenic in a *Bacillus subtilis* rec-assay (Shirasu 1975), or in *E. coli* (Ashwood-Smith et al. 1972; Fahrig 1974; Shirasu 1975) or *Saccharomyces cerevisiae* (Fahrig 1974). Aldrin was not mutagenic in *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537, and TA1538 (Moriya et al. 1983).

The preponderance of evidence appears to indicate that aldrin and dieldrin induce a carcinogenic response through nongenotoxic mechanisms (i.e., not acting directly on the DNA). There is some evidence that the activity of several specific transfer ribonucleic acids (tRNAs) is depressed by exposure to dieldrin, but it is uncertain whether this is due to decreased synthesis or to direct inactivation (Chung and Williams 1986). Other possible mechanisms for the cellular effects of aldrin and dieldrin include increasing unscheduled DNA synthesis (UDS), since increased DNA synthesis in hepatocytes was observed in B6C3F1 mice fed $1 mg dieldrin/kg for $7 days (Klaunig et al. 1995; Stevenson et al. 1995a), and a positive effect has been reported for dieldrin in SV-40 transformed human fibroblast cells in culture with and without metabolic activation (Ahmed et al. 1977a). However, UDS assays have been negative in both Fischer 344 rat (Probst et al. 1981) and Balb/c mouse (Klaunig et al. 1984) primary hepatocyte cultures.

Another possible mechanism for the nongenotoxic action of aldrin and dieldrin involves the inhibition of metabolic cooperation and gap junctional intercellular communication. These effects have been reported in Chinese hamster cells (Jone et al. 1985; Kurata et al. 1982; Trosko et al. 1987), rat and mouse hepatocytes (Klaunig and Ruch 1987; Klaunig et al. 1990), and human teratocarcinoma cells (Wade et al. 1986; Zhong-Xiang et al. 1986). While these effects are epigenetic, rather than genotoxic, these processes may offer insight into cellular changes in metabolism and proliferation that could explain cell cycle changes and the disparate results of genotoxicity assays. Key *in vivo* genotoxicity studies are presented in Table 3-5, and *in vitro* genotoxicity studies are presented in Table 3-6.

3.4 TOXICOKINETICS

3.4.1 Absorption

3.4.1.1 Inhalation Exposure

Studies directly measuring absorption of aldrin or dieldrin in humans following inhalation exposure of known amounts of these pesticides were not located. However, results of a survey of women in pesticide-treated homes showed a correlation between the treatment and dieldrin levels in human breast milk (Stacey and Tatum 1985). Inhalation was suggested as the most probable route of exposure because absorption by skin contact with pesticide-treated surfaces was not believed to contribute significantly to the exposures. Measurable levels of aldrin and dieldrin in indoor air have been detected several years after pesticide treatment of homes (Dobbs and Williams 1983).

In vivo studies on absorption following inhalation exposure of animals to aldrin/dieldrin were not located. In an *in vitro* study using isolated perfused rabbit lungs, aldrin (0.25, 0.50, 1.0, 1.5, 2.0, 2.5, and 3.0 μmol) was taken up by simple diffusion and then metabolized at a slower rate to dieldrin in the lung. Dieldrin was detected 3 minutes after initiation of the experiment. The rate of uptake of aldrin by the lung was biphasic consisting of a rapid phase followed by a slower phase, which could be related to the metabolic turnover of aldrin to dieldrin (Mehendale and El-Bassiouni 1975).

3.4.1.2 Oral Exposure

Volunteers were fed dieldrin at concentrations of 0.0001, 0.0007, and 0.003 mg/kg/day for 18–24 months. A dose-related increase in blood and adipose tissue levels of dieldrin was found (Hunter and Robinson 1967; Hunter et al. 1969). However, no quantitative data specifically describing absorption of aldrin/dieldrin following oral exposure were found in the literature.

Table 3-5. Genotoxicity of Aldrin/Dieldrin *In Vivo*

Species (test system)	End point	Results: Without activation	Results: With activation	Reference
Human (occupational cohort)	Sister chromatid exchange	NA	+ (several pesticides including aldrin)	Dulout et al. 1985
Human (occupational cohort)	Chromosome aberrations	NA	– (dieldrin)	Dean et al. 1975
Swiss mice (oral exposure)	Increased abnormal metaphases	NA	+	Rani and Reddy 1986
	Increased number of univalents (decreased pairing of meiotic chromosomes)	NA	+	
Chinese hamsters (intraperitoneal	Chromosome aberrations	NA	– (dieldrin)	Dean et al. 1975
Mice (intraperitoneal	Chromosome aberrations	NA	+ (dieldrin)	Majumdar et al. 1976
Mice (oral exposure)	Increased hepatocyte DNA synthesis	NA	+ (dieldrin)	Kamendulis et al. 2001
	Mitosis	NA	+ (dieldrin)	
	Apoptosis	NA	– (dieldrin)	
	Ploidy	NA	+ (dieldrin)	
Rat (oral exposure)	Increased hepatocyte DNA synthesis	NA	– (dieldrin)	Kamendulis et al. 2001
	Mitosis	NA	– (dieldrin)	
	Apoptosis	NA	– (dieldrin)	
	Ploidy	NA	– (dieldrin)	

– = negative result; + = positive result; DNA = deoxyribonucleic acid; NA = not applicable

Table 3-6. Genotoxicity of Aldrin/Dieldrin *In Vitro*

Species (test system)	End point	Results: With activation	Results: Without activation	Reference
Chinese hamster ovary cells	Sister chromatid exchange	+ (dieldrin)	+ (dieldrin)	Galloway et al. 1987
	Chromosome aberrations	– (dieldrin)	– (dieldrin)	
Chinese hamster V79 cells	Gene mutation	NA	+	Ahmed et al. 1977b
Cultured human lung cells	Chromosome aberrations	NA	+	Majumdar et al. 1976
Saccharomyces cerevisiae	Mitotic gene conversation	NA	–	Dean et al. 1975; Fahrig 1974
Tradescantia	Micronuclei formation	NA	+ (dieldrin)	Sandhu et al. 1989
		NA	– (aldrin)	
Salmonella typhimurium	Gene mutation	+	+	Ennevar and Rosenkranz 1986; Majumdar et al. 1977
		–	–	De Flora et al. 1984; Glatt et al. 1983; Haworth et al. 1983; Marshall et al. 1976; Moriva et al. 1983; Shirasu 1975
			(+) (photoactivation)	De Flora et al. 1989
E. coli	Gene mutation	NA	–	Ashwood-Smith et al. 1972; Fahrig 1974; Shirasu 1975
Bacillus subtillis	Gene mutation	NA	–	Shirasu 1975
Aspergillus nidulans	Gene mutation	NA	–	Crebelli et al. 1986
SV-40 transformed Human fibroblast	Unscheduled DNA synthesis	NA	+	Ahmed et al. 1977a

Table 3-6. Genotoxicity of Aldrin/Dieldrin *In Vitro* (*continued)*

Species (test system)	End point	Results: With activation	Results: Without activation	Reference
Rat hepatocyte	Unscheduled DNA synthesis	NA	–	Probst et al. 1981
Mouse hepatocyte	Unscheduled DNA synthesis	NA	–	Klaunig et al. 1984
Mouse embyro fibroblast	Focus formation	NA	+	Kowalski et al. 2000

– = negative result; + = positive result; (+) = weakly positive result; DNA = deoxyribonucleic acid; NA = not applicable

Several metabolic studies indicate that dieldrin is absorbed from the gastrointestinal tract and is transported via the hepatic portal vein (Heath and Vandekar 1964). Following dosing with radiolabeled aldrin and dieldrin, high levels of radioactivity were detected in the liver, blood, and stomach and/or duodenum of dosed rats within 1–5 hours (Heath and Vandekar 1964; Iatropoulos et al. 1975). Twenty-four hours following a single oral administration to rats of 10 mg/kg, 50% of the dose was found in fat (Hayes 1974a).

3.4.1.3 Dermal Exposure

Although data are limited regarding absorption of aldrin and dieldrin following dermal exposure in humans, it appears to occur rapidly. Aldrin and dieldrin were first detected in urine 4 hours after dermal application of a single dose (0.004 mg/cm^2) of aldrin and dieldrin, radiolabeled with carbon 14 (^{14}C), to the forearm of six volunteers. Based on urinary ^{14}C excretion, it was estimated that 7.8% of aldrin and 7.7% of dieldrin was absorbed over a 5-day period (Feldmann and Maibach 1974). The accuracy of these values is questionable since the dose used was small, the ^{14}C recovery in the urine was low, the major route of excretion was in the feces (not the urine), and a large individual variation in data was reported.

Aldrin was rapidly absorbed into the skin of female rats following dermal application at doses of 0.006, 0.06, and 0.6 mg/cm^2 (Graham et al. 1987). Aldrin and dieldrin were detected in the skin 1 hour after aldrin application for all three dose levels. The amount absorbed was proportional to the dose applied. *In vitro* studies of rat skin strips incubated with aldrin showed absorption of aldrin was complete by 80 minutes (Graham et al. 1987). Absorption from fabric that had been impregnated with up to 0.04% dieldrin was also demonstrated in rabbits (Witherup et al. 1961).

3.4.2 Distribution

3.4.2.1 Inhalation Exposure

No studies were located regarding distribution following inhalation exposure to aldrin or dieldrin in humans or animals.

3.4.2.2 Oral Exposure

Aldrin is rapidly converted to dieldrin. Distribution of dieldrin is initially general, but within a few hours it is redistributed primarily to fat. A study was conducted on volunteers who ingested dieldrin in doses of 0, 0.0001, 0.0007, or 0.003 mg/kg/day for 24 months (Hunter and Robinson 1967; Hunter et al. 1969). Dieldrin concentrations in blood and adipose tissue increased in a dose-related manner with a finite upper limit for the storage of dieldrin corresponding to a balance between the amount ingested and the amount eliminated daily. This was observed at about 15 months with the eventual body burden characteristic of a person and his particular daily intake (Hunter et al. 1969). The study also found that the concentrations of dieldrin in both adipose tissue and blood are proportional to the given daily dose (Hunter and Robinson 1967). The blood dieldrin concentrations increased by 4 and 10 times in the 0.0001- and 0.003-mg/kg/day dose groups, respectively, when compared to controls. Relationships were derived for the concentration of dieldrin in both adipose tissue and blood in terms of the given daily dosage. Using these relationships it was estimated that the exposure of the general population was equivalent to 0.025 mg/day (0.00033 mg/kg/day). For higher doses of dieldrin, a significant correlation existed between the concentration of dieldrin in blood and the concentration in adipose tissue. The average ratio of the concentration in the adipose tissue to that in the blood was 156:1 (Hunter and Robinson 1967). The existence of a functional relationship between the concentration of dieldrin in the adipose tissue and that in the blood gives strong support to the concept of a dynamic equilibrium in the distribution of dieldrin between these tissues. Animal experiments indicate that this type of equilibrium also exists between the concentrations in the blood and brain, and between those in the blood and liver. When dieldrin administration was terminated, its concentration in blood decreased exponentially following first order kinetics with an estimated half-life of approximately 369 days (range, 141–592 days) (Hunter et al. 1969).

A study of the body burden of dieldrin showed that the bioconcentration and rate of elimination of dieldrin were related to the lipid mass of the individual (Hunter and Robinson 1967, 1968). The highest concentrations of dieldrin in adipose tissue were found in the leanest subjects, and these subjects also exhibited the smallest total body burden. On the other hand, the proportion of the total exposure dose retained in the adipose tissue was highest in those subjects with the greatest total body fat (Hunter and Robinson 1968). The study also showed no increase in the concentration of dieldrin in whole blood during surgical stress or in periods of complete fasting, and it was concluded that the body burden of this compound in the general population constitutes no danger of intoxication as a result of tissue catabolism in times of illness or weight loss (Hunter and Robinson 1968).

Samples of brain, liver, and adipose tissue were collected from 29 randomly selected autopsies of people in Holland (DeVlieger et al. 1968). These people, with three exceptions, lived in an area where a plant manufacturing aldrin, dieldrin, and endrin is situated, but were not employed at that plant. The mean concentration of dieldrin in the white matter of the brain was significantly greater (0.0061 mg/kg) than that in the gray matter (0.0047 mg/kg). In comparison, the mean concentrations of dieldrin in the liver and adipose tissue were 0.03 and 0.17 mg/kg, respectively. Levels of dieldrin were detected in samples of adipose tissue taken from autopsy patients (Adeshina and Todd 1990; Ahmad et al. 1988; Holt et al. 1986). Dieldrin was detected at concentrations ranging from 0.36 to 0.13 mg/kg. No aldrin was detected.

Placental transfer of dieldrin occurs (Polishuk et al. 1977b). A study of women and their offspring during labor showed higher concentrations of dieldrin in fetal blood than in the mother's blood (1.22 mg/kg and 0.53 mg/kg, respectively). Dieldrin levels were also higher in the placenta (0.8 mg/kg) than in the uterus (0.54 mg/kg) (Polishuk et al. 1977b).

Tissue distribution of ^{14}C following single-dose oral administration of ^{14}C-dieldrin (0.43 mg/kg) to rats indicated that the initial rapid uptake of ^{14}C by the liver during the first 3 hours after dosing is followed by a biphasic decrease and redistribution of the compound among body tissues including adipose tissue, kidney, and lymph nodes, with the majority being distributed to the adipose tissue. During the redistribution process, the lymphatic system seems to be the major transport pathway; the parallel increase of lymph node and adipose tissue values indicated an equilibrium between lymph and depot fat (Iatropoulos et al. 1975). Between 24 and 48 hours after a single oral dose of dieldrin was administered to rats, the amount of dieldrin in fat increased to about 50% of the dose. Dieldrin's affinity for fat is illustrated by the ratio of its concentration in fat to that in blood (>130:1) (Hayes 1974a). In female rats fed 2.5 mg/kg/day for 6 months, the ratio of the concentrations of dieldrin in the blood, liver, and fat was 1:30:500, respectively (Deichmann et al. 1968). Most of the dieldrin absorbed through the skin of guinea pigs, dogs, and monkeys is accumulated in the subcutaneous fat (Sundaram et al. 1978a, 1978b).

Species differences in tissue distribution of dieldrin in rodents have been reported (Hutson 1976). When male rats and mice were subjected to a single dose of ^{14}C-dieldrin (3 mg/kg), liver and fat residues were higher in the mice than in the rats 8 days after ingestion. The liver concentration in mice (0.94 mg/kg) was about nine times higher than in rats (0.11 mg/kg). Fat samples in mice contained dieldrin levels (11.6 mg/kg) that were twice as high as the levels in rats (5.6 mg/kg) (Hutson 1976). Sex differences in tissue distribution of dieldrin in rodents have also been reported (Davison 1973; Walker et al. 1969). Female rats fed dieldrin (0.002, 0.01, and 0.1 mg/kg/day) in their diet for 39 weeks had a higher proportion of the total dose in their carcasses than did male rats that were treated similarly (Davison 1973). Also, female rats fed dieldrin (0, 0.005, and 0.5 mg/kg/day) in their diet for 2 years had tissue concentrations of dieldrin between two and ten times that of male rats fed the same dietary concentration (Walker et al. 1969).

Following repeated dosing (2–104 weeks), an equilibrium or steady state is reached between the intake, storage, and excretion of dieldrin in various strains of rats and beagle dogs. Steady-state kinetics were determined by measuring both the level of radioactivity retained in fat, blood, liver, and brain and the percentage of the administered dose excreted at sublethal doses. The steady-state tissue concentration of dieldrin was dose- and time-dependent. In dogs receiving daily oral doses of 0.005 or 0.05 mg/kg/day dieldrin for 2 years, the steady-state blood residue levels were reached in 12–18 weeks or 18–30 weeks, respectively (Walker et al. 1969). In rats receiving 0.0002–2.5 mg/kg/day dieldrin in the diet, steady state was reached in 4–39 weeks; equilibrium was reached earlier in rats receiving higher doses of dieldrin (Baron and Walton 1971; Davison 1973; Ludwig et al. 1964; Walker et al. 1969). In rats receiving daily oral doses of 0.012 mg/kg/day ^{14}C-aldrin for 3 months, steady state was reached in 53 days (Ludwig et al. 1964).

In another study, the steady-state concentration in adipose tissues of rats receiving dietary concentrations of 1.25 mg/kg/day dieldrin for 8 weeks was reported to be 50 mg/kg dieldrin (Baron and Walton 1971). The elimination of dieldrin residues from the adipose tissue of rats subsequently placed on untreated diets was reasonably rapid with estimated half-lives reported to be 4.5 days (Baron and Walton 1971). The estimated half-lives for the adipose tissue and brain were 10.3 and 3 days, respectively, for rats on a basic diet for 12 weeks, following consumption of a diet containing 0.5 mg/kg/day dieldrin for 8 weeks (Robinson et al. 1969). The half-lives of dieldrin in the liver were estimated to be 1.3 and 10.2 days for the rapid and slower elimination, respectively, and similar values were estimated for the blood. The concentrations of dieldrin in adipose tissue were considerably greater than those in other tissues, with storage in the four tissues as follows: adipose tissue >> liver > brain > blood (Robinson et al. 1969).

3.4.2.3 Dermal Exposure

No studies were located regarding distribution following dermal exposure to aldrin or dieldrin in humans.

Guinea pigs exposed dermally to dieldrin at concentrations varying from 0.0001 to 0.1% for 6 months showed the highest tissue distribution in adipose tissue, with lower concentrations in the liver and brain (Sundaram et al. 1978b). Rabbits exposed to fabric containing up to 0.04% dieldrin for 52 weeks also showed slight accumulation in the omental and renal fat (Witherup et al. 1961).

3.4.2.4 Other Routes of Exposure

The administration of dieldrin by the intraperitoneal route ensures more or less complete absorption. The ^{14}C-residues in tissues of rats dosed by intraperitoneal injection with a total dose of 0.01, 0.1, or 1.0 mg/kg were distributed among the brain, blood, liver, and subcutaneous fat with the highest levels in the fat. Radioactivity excreted by groups given dieldrin by intraperitoneal injection was not significantly different from that of orally treated groups (Lay et al. 1982).

In another study (Cooke et al. 2001) in male Sprague-Dawley rats injected intraperitoneally with 75 mg/kg ^{14}C-aldrin or 62 mg/kg ^{14}C-dieldrin once a week for 3 weeks, the highest levels of dieldrin ^{14}C-residues were also observed in the fat, whereas the distribution of aldrin ^{14}C-residues to the spleen was comparable to fat. In the reproductive organs, the testicular ^{14}C-residue content of both chemicals was always considerably lower than that of the epididymis, and the seminal vesicle fluid contained lower quantities of label than the seminal vesicles.

3.4.3 Metabolism

3.4.3.1 Inhalation Exposure

No studies were located regarding metabolism following inhalation exposure to aldrin or dieldrin in humans.

An *in vitro* study using rabbit lung perfusates showed that aldrin was metabolized to dieldrin within the endoplasmic reticulum. Aldrin metabolism was dose dependent. Up to 70% of aldrin was metabolized in 1 hour at low doses (#3 μmol) (Mehendale and El-Bassiouni 1975).

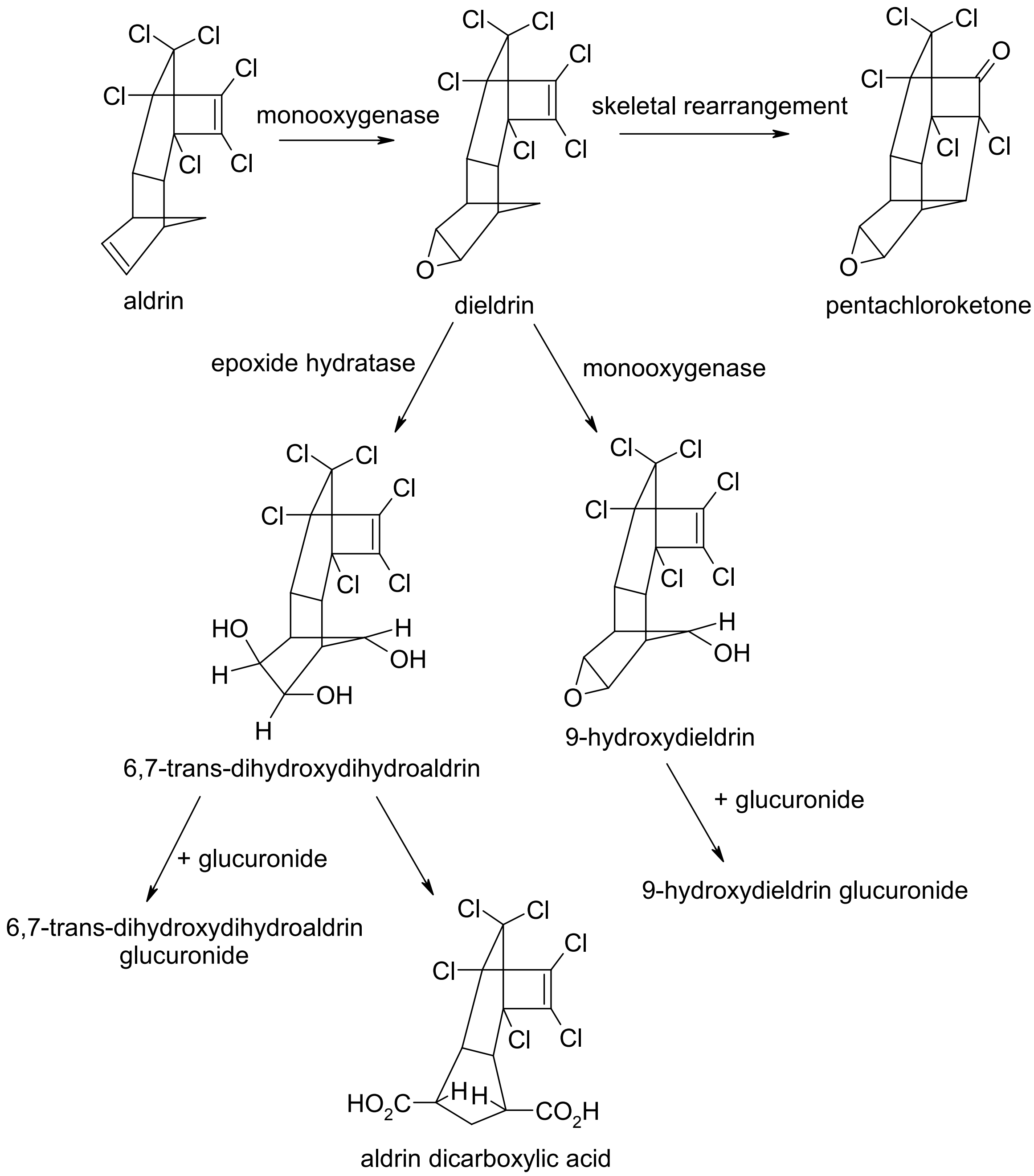
3.4.3.2 Oral Exposure

No studies were located specifically regarding metabolism following oral exposure to aldrin or dieldrin in humans.

The initial and major step in the biotransformation of aldrin in experimental animals is the formation of the corresponding epoxied dieldrin (Wong and Terriere 1965). Aldrin is readily converted to dieldrin primarily in the liver by mixed-function oxidases (Wong and Terriere 1965) and to a lesser extent in the lung (Lang et al. 1986) and skin (Graham et al. 1987; Lang et al. 1986). The known metabolic pathways of aldrin and dieldrin in laboratory animals are presented in Figure 3-3.

The formation of dieldrin by epoxidation of aldrin is a reaction catalyzed by monooxygenases in liver and lung microsomes. Aldrin epoxidation was studied in rat liver microsomes (Wolff et al. 1979). Microsomes from phenobarbital-treated rats showed a three-fold increase in dieldrin formation, whereas 3-methylcholanthrene treatment markedly depressed enzyme activity. Thus, cytochrome P-450, not cytochrome P-448, seems to be involved in epoxidation. *In vitro* studies compared the oxidation of aldrin to dieldrin in extrahepatic and hepatic tissues of rats (Lang et al. 1986). The authors tried to identify the pathway by which aldrin is metabolized in liver, lung, seminal vesicle, and subcutaneous granulation tissue. Many organs and tissues possess low cytochrome P-450 content. In these cases, an alternative oxidative pathway mediated by prostaglandin endoperoxide synthase (PES) might be more important. PES consists of a cyclooxygenase which catalyzes the bisdioxygenation of arachidonic acid to prostaglandin G_2 (PGG_2). In a second step, a reduction by hydroperoxidase to prostaglandin H_2

Figure 3-3. Proposed Metabolic Pathway for Aldrin and Dieldrin*



*Adapted from EPA 1987a

(PGH_2) occurs. The aldrin epoxidation was completely nicotine adenine dinucleotide phosphate (NADPH)-dependent in liver microsomes and hepatocytes. In lung microsomes, two pathways were involved. The NADPH-dependent activity was 1.5% and the arachidonic acid-dependent aldrin epoxidation was 0.3% of the activity found in the liver. In seminal vesicle microsomes and granulation tissue microsomes, aldrin epoxidation was stimulated by arachidonic acid and inhibited by indomethacin (a specific inhibitor of cyclooxygenase). These results suggest that aldrin was epoxidized by a prostaglandin synthase–mediated pathway in extrahepatic tissues as an alternative enzyme in the cytochrome P-450-dependent monooxygenases (Lang et al. 1986).

In mammals, two major metabolism routes of dieldrin seem to be predominant: (1) direct oxidation by cytochrome oxidases, resulting in 9-hydroxydieldrin (the Chemical Abstract Service [CAS] numbering system equivalent of 12-hydroxydieldrin), and (2) the opening of the epoxied ring by epoxied hydrases, resulting in 6,7-*trans*-dihydroxydihydroaldrin (the CAS numbering system equivalent of 4,5-*trans*-dihydroxy–dihydroaldrin) (Müller et al. 1975). Dieldrin is hydroxylated to 9-hydroxydieldrin by liver microsomal monooxygenases in rats, and the reaction is inhibited by the addition of the monooxygenase inhibitor, sesamex (Matthews and Matsumura 1969). Metabolism of dieldrin is 3–4 times more rapid in male than in female rats (Matthews et al. 1971). The difference is attributed to the greater ability of males to metabolize dieldrin to its more polar metabolites, primarily 9-hydroxydieldrin. Species differences in rates of metabolism have been observed in rats and mice. The hydroxylation reaction occurs more rapidly in rats than it does in mice as indicated by a higher ratio in rats of 9-hydroxy-^{14}C-dieldrin to ^{14}C-dieldrin (Hutson 1976).

The 9-hydroxydieldrin glucuronide is formed both *in vivo* and *in vitro*. It has been identified in the bile of rats (Chipman and Walker 1979); however, it is generally excreted in the feces in free form (Hutson 1976). The 9-hydroxydieldrin glucuronide is formed rapidly *in vitro* from dieldrin (which is hydroxylated first to 9-hydroxydieldrin) upon incubation with rat liver microsomes and uridine diphosphoglucuronic acid (Hutson 1976; Matthews et al. 1971).

Dieldrin is also metabolized by epoxide hydratase to form 6,7-*trans*-dihydroxydihydroaldrin, which was originally isolated and identified in rabbits and mice (Korte and Arent 1965) and later found also to form in other animals including Rhesus monkeys and chimpanzees (Müller et al. 1975). The 6,7-*trans*-dihydroxydihydroaldrin glucuronide is formed *in vitro* in hepatic microsomal preparations from rabbits or rats in the presence of uridine diphosphoglucuronic acid and NADPH (Matthews and Matsumura 1969).

6,7-*trans*-Dihydroxydihydroaldrin can be further oxidized to aldrin dicarboxylic acid or conjugated to glucuronic acid (Baldwin et al. 1972; Hutson 1976).

Pentachloroketone, also known as Klein's metabolite, is a major urinary metabolite in male rats, but it is only found in trace amounts in the urine of female rats and male mice (Baldwin et al. 1972; Hutson 1976; Matthews et al. 1971). Pentachloroketone is formed by molecular rearrangement. It has been suggested that pentachloroketone is the product of rearrangement of the same intermediate that leads to 9-hydroxydieldrin (Bedford and Hutson 1976).

3.4.3.3 Dermal Exposure

No studies were located regarding metabolism following dermal exposure to aldrin or dieldrin in humans.

Data show that the skin is capable of metabolizing aldrin to the stable epoxied dieldrin (Graham et al. 1987). Dieldrin was detected in the skin of rats 1 hour after aldrin application at three dose levels (0.1, 1.0, and 10 mg/kg). The amount of conversion was greatest at the lowest dose levels suggesting enzyme saturation at higher doses. The authors concluded that, following topical application, up to 10% conversion of aldrin to dieldrin by skin enzymes can occur during percutaneous absorption (Graham et al. 1987). *In vitro* studies using mouse skin microsomal preparations and rat whole skin strips also showed that metabolism of aldrin to dieldrin took place in the skin (Graham et al. 1987).

3.4.4 Elimination and Excretion

3.4.4.1 Inhalation Exposure

No studies were located regarding excretion following inhalation exposure to aldrin or dieldrin in humans or animals.

3.4.4.2 Oral Exposure

Excretion in humans is primarily in the feces via the bile. 9-Hydroxydieldrin was found in the feces of seven workers occupationally exposed to aldrin and dieldrin (Richardson and Robinson 1971). An estimated half-life for dieldrin elimination is reported to be 369 days (Hunter et al. 1969). Dieldrin is also excreted via lactation in nursing mothers. Dieldrin concentrations of 19–26 ppb were found in breast milk (Schecter et al. 1989b).

In rats dosed with ^{14}C-aldrin at 0.012 mg/kg/day for 3 months, both aldrin and dieldrin were found in the feces, with lower concentrations of both compounds also found in the urine (Ludwig et al. 1964). Pentachloroketone was also detected in the urine of rats fed diets containing 1.25 mg/kg/day of aldrin (Klein et al. 1968).

Following administration of single oral doses of ^{14}C-dieldrin to rats, mice, monkeys, and chimpanzees, radioactivity accounting for 95, 95, 79, and 79% of the dose, respectively, was excreted in the feces, which is the main route of excretion (Hutson 1976; Müller et al. 1975). The ratio of radioactivity excreted in the feces and in the urine is 19 in rats and mice and 3.8 in monkeys and chimpanzees (Müller et al. 1975). Unchanged dieldrin and 9-hydroxydieldrin and its glucuronide are the major components in the feces of rats, monkeys, and chimpanzees, with lesser amounts of 6,7-dihydroxydihydroaldrin and aldrin dicarboxylic acid (Baldwin et al. 1972; Hutson 1976; Matthews et al. 1971; Müller et al. 1975). 9-Hydroxydieldrin has also been found in the urine of monkeys given a single dose of 0.5 mg/kg of dieldrin (Müller et al. 1975) and in mouse urine (Hutson 1976). Elimination of aldrin dicarboxylic acid occurs mainly in the urine of mice and rats (Baldwin et al. 1972; Hutson 1976) and in the feces of rats (Hutson 1976). Unchanged dieldrin was found in the feces of mice, rats, rabbits, and monkeys at concentrations ranging from 0.3 to 9.0% of the single dose administered (0.5 mg/kg) (Müller et al. 1975).

Excretion of dieldrin is 3–4 times more rapid in male than in female rats (Matthews et al. 1971). The difference was attributed to the greater ability of males to metabolize dieldrin to its more polar metabolites. An *in vitro* study using rat liver perfusates showed a sexual difference in the hepatic excretion of dieldrin. The appearance of radioactivity in the bile of livers of males was approximately three times as rapid as the appearance of radioactivity in the bile of livers of females (Klevay 1970). Species differences have been reported for the excretion of dieldrin and/or its metabolites between male CFE rats and male CF_1 or LACG mice (Baldwin et al. 1972; Hutson 1976). Excretion was more rapid in the rat than in the mouse. The ratio of 9-hydroxy-^{14}C-dieldrin to ^{14}C-dieldrin was higher in rats than in mice, indicating a slightly more rapid excretion by the rat (Hutson 1976).

In rabbits, 6,7-*trans*-dihydroxydihydroaldrin is the major metabolite excreted in the urine. Following administration of single oral doses of ^{14}C-dieldrin to rabbits, elimination was greater in urine, accounting for 81–83% of the dose (Müller et al. 1975). 6,7-*trans*-Dihydroxydihydroaldrin has also been identified in the urine of mice (Müller et al. 1975). 6,7-*trans*-Dihydroxydihydroaldrin glucuronide has been identified in urine of rabbits and monkeys (Müller et al. 1975).

Pentachloroketone is the major component in rat urine (Baldwin et al. 1972; Hutson 1976; Matthews et al. 1971). The mouse, unlike the rat, does not appear to excrete pentachloroketone as a urinary metabolite. Pretreatment of CFE rats with dieldrin caused an enhancement of the urinary excretion of pentachloroketone, but no effect on the pattern of excretion of urinary metabolites could be detected when CF_1 mice were given similar treatments (Baldwin et al. 1972). Aldrin dicarboxylic acid, unchanged dieldrin, and 9-hydroxydieldrin glucuronide have also been found in lower concentrations in the urine of rats (Hutson 1976; Müller et al. 1975).

3.4.4.3 Dermal Exposure

No studies were located regarding excretion following dermal exposure to aldrin or dieldrin in humans or animals.

3.4.4.4 Other Routes of Exposure

Elimination of ^{14}C following intraperitoneal or intravenous injection of ^{14}C-dieldrin to male rats was either approximately equal to or slightly less than that observed following oral dosing (between 70 and 80% of the total dose was excreted by 2 weeks postdosing) (Cole et al. 1970; Lay et al. 1982). Excretion occurred primarily in the feces (about 90%). Biliary elimination was measured experimentally following intraperitoneal administration. The rate of ^{14}C elimination in the bile increased following pretreatment of rats with phenobarbital (Chipman and Walker 1979).

3.4.5 Physiologically Based Pharmacokinetic (PBPK)/Pharmacodynamic (PD) Models

Physiologically based pharmacokinetic (PBPK) models use mathematical descriptions of the uptake and disposition of chemical substances to quantitatively describe the relationships among critical biological processes (Krishnan et al. 1994). PBPK models are also called biologically based tissue dosimetry models. PBPK models are increasingly used in risk assessments, primarily to predict the concentration of potentially toxic moieties of a chemical that will be delivered to any given target tissue following various combinations of route, dose level, and test species (Clewell and Andersen 1985). Physiologically based pharmacodynamic (PBPD) models use mathematical descriptions of the dose-response function to quantitatively describe the relationship between target tissue dose and toxic end points.

PBPK/PD models refine our understanding of complex quantitative dose behaviors by helping to delineate and characterize the relationships between: (1) the external/exposure concentration and target tissue dose of the toxic moiety, and (2) the target tissue dose and observed responses (Andersen et al. 1987; Andersen and Krishnan 1994). These models are biologically and mechanistically based and can be used to extrapolate the pharmacokinetic behavior of chemical substances from high to low dose, from route to route, between species, and between subpopulations within a species. The biological basis of PBPK models results in more meaningful extrapolations than those generated with the more conventional use of uncertainty factors.

The PBPK model for a chemical substance is developed in four interconnected steps: (1) model representation, (2) model parametrization, (3) model simulation, and (4) model validation (Krishnan and Andersen 1994). In the early 1990s, validated PBPK models were developed for a number of toxicologically important chemical substances, both volatile and nonvolatile (Krishnan and Andersen 1994; Leung 1993). PBPK models for a particular substance require estimates of the chemical substance-specific physicochemical parameters, and species-specific physiological and biological parameters. The numerical estimates of these model parameters are incorporated within a set of differential and algebraic equations that describe the pharmacokinetic processes. Solving these differential and algebraic equations provides the predictions of tissue dose. Computers then provide process simulations based on these solutions.

The structure and mathematical expressions used in PBPK models significantly simplify the true complexities of biological systems. If the uptake and disposition of the chemical substance(s) is adequately described, however, this simplification is desirable because data are often unavailable for many biological processes. A simplified scheme reduces the magnitude of cumulative uncertainty. The adequacy of the model is, therefore, of great importance, and model validation is essential to the use of PBPK models in risk assessment.

PBPK models improve the pharmacokinetic extrapolations used in risk assessments that identify the maximal (i.e., the safe) levels for human exposure to chemical substances (Andersen and Krishnan 1994). PBPK models provide a scientifically sound means to predict the target tissue dose of chemicals in humans who are exposed to environmental levels (for example, levels that might occur at hazardous waste sites) based on the results of studies where doses were higher or were administered in different species. Figure 3-4 shows a conceptualized representation of a PBPK model.

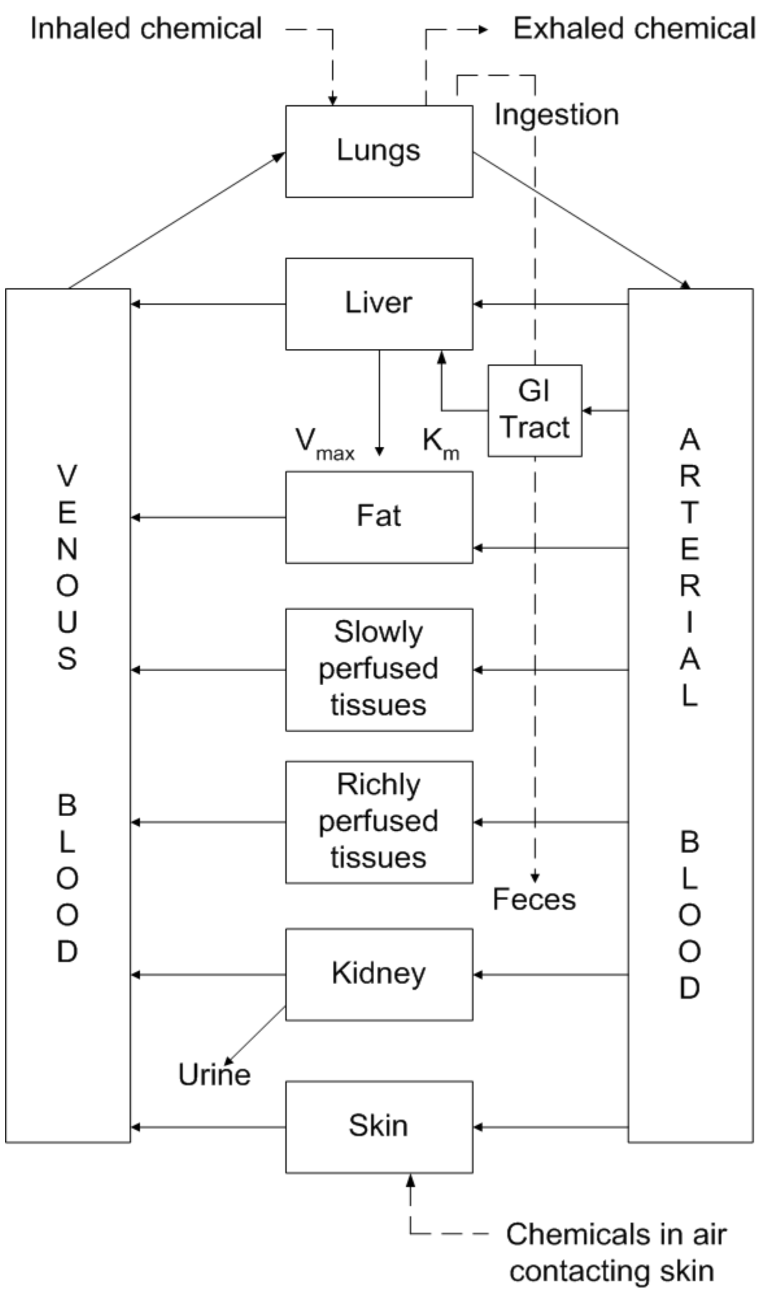
No PBPK models for aldrin or dieldrin were located.

3.5 MECHANISMS OF ACTION

3.5.1 Pharmacokinetic Mechanisms

Mechanisms of aldrin or dieldrin absorption following inhalation, oral, or dermal exposure in humans or animals were not identified. However, since both aldrin and dieldrin are lipophilic substances, absorption via passive diffusion is likely. No information was located regarding transport mechanisms in the blood. Given the high degree of solubility of aldrin and dieldrin in lipids, one might expect these chemicals to be associated with the lipid fraction of blood. In biological systems, aldrin is rapidly converted to dieldrin. Following exposure to aldrin or dieldrin, animal data indicate that dieldrin is widely distributed initially (with rapid uptake by the liver), then redistributed primarily to fat (Deichmann et al. 1968; Hayes 1974a; Hutson 1976; Iatropoulos et al. 1975). The lymphatic system appears to be the major transport pathway during redistribution (Iatropoulos et al. 1975). Animal data also indicate that epoxidation of aldrin to dieldrin is catalyzed by monooxygenases, primarily in the liver (Wong and Terriere 1965), but also in lungs (Lang et al. 1986) and skin (Graham et al. 1987; Lang et al. 1986). The study of Lang et al. (1986) provides evidence that aldrin may also be epoxidized by a prostaglandin synthetase-mediated pathway in extrahepatic tissues. Results from a dermal study indicate that the metabolism of aldrin and dieldrin may be a saturable process (Graham et al. 1987). Further metabolism, such as the hydroxylation of dieldrin to 9-hydroxydieldrin, has also been shown to occur in the liver (Matthews and Matsumura 1969). In animals administered aldrin or dieldrin, fecal excretion (via the bile) of parent compound and metabolites is the main route of elimination, with lesser amounts found in the urine (Ludwig et al. 1964). Dieldrin is also excreted in the breast milk of nursing mothers (Schecter et al. 1989b).

Figure 3-4. Conceptual Representation of a Physiologically Based Pharmacokinetic (PBPK) Model for a Hypothetical Chemical Substance



Source: adapted from Krishnan et al. 1994

Note: This is a conceptual representation of a physiologically based pharmacokinetic (PBPK) model for a hypothetical chemical substance. The chemical substance is shown to be absorbed via the skin, by inhalation, or by ingestion, metabolized in the liver, and excreted in the urine or by exhalation.

3.5.2 Mechanisms of Toxicity

A number of studies have investigated the mechanism of aldrin and dieldrin neurotoxicity. As discussed in Section 3.2.2.4, aldrin and dieldrin characteristically stimulate the central nervous system causing hyperexcitation and generalized seizures (convulsions). It is generally believed that the hyperexcitatory effects of these chemicals result from a generalized activation of synaptic activity throughout the central nervous system, although it is unclear whether aldrin and dieldrin act at the nerve terminal to facilitate neurotransmitter release, or if they cause excitation by depressing activity of inhibitory neurotransmitters within the central nervous system (Joy 1982; Shankland 1982).

Facilitation of neurotransmitter release by dieldrin has been proposed to occur as the result of the ability of aldrin or dieldrin to inhibit brain calcium ATPases (Mehrotra et al. 1988, 1989). These enzymes are involved in pumping calcium out of the nerve terminal. By inhibiting their activity, aldrin and dieldrin would cause a build-up of intracellular levels of calcium and an enhancement of neurotransmitter release.

Most recently, however, the role of aldrin and dieldrin in blocking inhibitory activity within the brain has received a great deal of attention as the probable mechanism underlying the central nervous system excitation. Based on the observed interaction of other cyclodiene insecticides with the inhibitory neurotransmitter, gamma aminobutyric acid (GABA) (Matsumura and Ghiasuddin 1983), numerous studies were undertaken to assess the effects of aldrin and dieldrin on GABA receptor function. Both *in vitro* experiments using rat brain membranes and intravenous or intraperitoneal administration of aldrin and dieldrin to rats have shown that these agents are capable of blocking the activity of GABA by blocking the influx of chloride through the $GABA_A$ receptor-ionophore complex (Abalis et al. 1986; Bloomquist 1992, 1993; Bloomquist and Soderlund 1985; Bloomquist et al. 1986; Cole and Casida 1986; Gant et al. 1987; Ikeda et al. 1998; Lawrence and Casida 1984; Liu et al. 1997a, 1997b; Nagata and Narahashi 1994, 1995; Narahashi et al. 1992, 1995, 1998; Obata et al. 1988; Pomes et al. 1994). Overall, based on good correlations of effects from the molecular level to whole animal toxicity, the preponderance of evidence indicates that the convulsant and other neurotoxic effects of aldrin and dieldrin are consequent to a blocking action on the $GABA_A$ receptor-chloride channel complex.

Pesticides have been implicated in the etiology of the Lewy body diseases, which involve intracellular deposits consisting of fibrils of α-synuclein. Dieldrin has been shown to stimulate α-synuclein fibril formation *in vitro* (Uversky et al. 2001). While α-synuclein is a natively unfolded protein, dieldrin induces a conformational change in α-synuclein, a time-dependent increase in secondary structure, which preceded the increase in fibril formation. The natively unfolded state of α-synuclein arises from the large net negative charge at neutral pH and the low intrinsic hydrophobicity. Uversky et al. (2001) proposed that nonpolar dieldrin binds to α-synuclein and shifts the equilibrium from the unfolded state to a folded intermediate conformation. The intermediate then associates, leading to fibril formation.

In a study of organochlorine compounds in human brain, there was a substantially higher concentration of dieldrin in Parkinson's disease tissue compared with Alzheimer's disease and nondemented nonparkinsonian controls tissue (Corrigan et al. 2000).

A preponderance of evidence from studies in a variety of mammalian species indicates a unique sensitivity of the mouse liver to aldrin- and dieldrin-induced hepatocarcinogenicity and mechanistic studies suggest a nongenotoxic mode of action (Stevenson et al. 1999; WHO 1989) via promotion of spontaneously initiated (background) liver cells (see Sections 3.2.2.7 and 3.3). The cellular and molecular mechanisms involved in the promotion of the liver tumors have not been fully elucidated, but appear to mainly involve species-specific susceptibility of the mouse to dieldrin-induced oxidative stress and inhibition of gap junctional communication (Jone et al. 1985; Klaunig and Ruch 1987; Klaunig et al. 1990, 1995, 1998; Kurata et al. 1982; Ruch and Klaunig 1986; Stevenson et al. 1999; Trosko et al. 1987; van Ravenzwaay and Kunz 1988; Wade et al. 1986; Zhong-Xiang et al. 1986). As discussed by Stevenson et al. (1999), the production of reactive oxygen species, depletion of hepatocyte antioxidant defenses such as vitamin E, and peroxidation of liver lipid have been shown to accompany oxidative metabolism of dieldrin in mice, apparently resulting in modulation of gene expression that favors the clonal expansion of spontaneously initiated cells.

The effects of dieldrin on changes in hepatocyte DNA synthesis, mitosis, apoptosis, and ploidy were studied in rats and mice treated with 0, 1, 3, or 10 mg dieldrin/kg diet (Kamendulis et al. 2001). No changes were observed in rat liver. Liver from mice fed only the highest dose (10 mg dieldrin/kg) exhibited significantly increased DNA synthesis and mitosis at 14, 28, or 90 days on the diet and a significant increase in octaploid (8N) hepatocytes. The apoptotic index in the liver of mice in any treatment group did not change over a 90-day treatment and study period.

The ability of chlorinated hydrocarbons to disrupt estrogen homeostatis, by up-regulating selected gene transcription, has also been hypothesized to be responsible for their oncogenic effects. Neither aldrin nor dieldrin showed evidence of estrogenicity as evidenced by lack of induction of transcriptional activation of an estrogen-responsive reported gene in transfected HeLa cells (Tully et al. 2000). There is evidence of a synergistic estrogenic effect of dieldrin and toxaphene on the bone mass density in rats. While dieldrin alone did not show any evidence of estrogenicity when administered to rats by intragastric intubation at a dose of 7.5 µmol/kg/day, 5 days/week, for 9 months, when administered with toxaphene (30 µmol toxaphene/kg/day and 7.5 µmol/kg/day), bone mass density was significantly increased (Syversen et al. 2000). In contrast, the results of several estrogen-responsive assays in the mouse uterus, MCF-7 human breast cancer cells, and yeast-based reporter gene assays, indicate that the activities of both dieldrin and toxaphene, as well as a binary mixture of the two were minimally estrogenic (Ramamoorthy et al. 1997a).

A single dose of dieldrin (37 mg/kg), administered to female rats by gavage significantly increased expression of cytochrome P450 CYP1A1, CYP1A2, and CYP1B1, which are involved in estrogen metabolism, in the liver, kidney, and mammary tissues (Badawi et al. 2000).

3.5.3 Animal-to-Humans

Most of the available human data come from cases of acute oral exposure to relatively high levels of aldrin or dieldrin (Black 1974; Garrettson and Curley 1969; Gupta 1975; Spiotta 1951) or from chronically exposed workers (de Jong 1991; Ditraglia et al. 1981; Hoogendam et al. 1965; Jager 1970; Morgan and Lin 1978; Morgan et al. 1980; Sandifer et al. 1981; Van Raalte 1977; Van Sittert and de Jong 1987; Versteeg and Jager 1973; Warnick and Carter 1972). In both humans and animals, high doses of aldrin or dieldrin result primarily in neurotoxicity. Epidemiologic studies involving chronic exposure to aldrin and/or dieldrin similarly indicate that the central nervous system is a major organ of toxicity. Chronic animal studies additionally demonstrate adverse effects in the kidney and liver; the liver being the most sensitive target. Liver effects are indicated in limited reports of humans exposed to levels of aldrin or dieldrin that result in neurotoxic symptoms (Black 1974; Garrettson and Curley 1969). Although the human data are extremely limited, at present, there is no evidence to suggest that noncancer effects seen in animal studies would be different from those in humans. Available information is suggestive of general similarity in the metabolic pathways and disposition of aldrin and dieldrin in humans and experimental animals (Deichmann et al. 1968; DeVlieger et al. 1968; Hayes 1974a; Hunter and Robinson 1967; Hunter et al. 1969; Iatropoulus et al. 1975). However, elimination rates vary among animal species and between males and females, thus contributing to uncertainty in extrapolation of toxicokinetic data from animals to humans.

Oral bioassays in animals have demonstrated that aldrin and/or dieldrin are liver carcinogens in mice, but not rats (Davis and Fitzhugh 1962; Deichmann et al. 1967, 1970; Fitzhugh et al. 1964; Meierhenry et al. 1983; NCI 1978a, 1978b; Tennekes et al. 1981; Thorpe and Walker 1973; Walker et al. 1969, 1972). Based on the results of retrospective cancer mortality studies in aldrin and dieldrin production workers, there is inconclusive evidence of carcinogenicity in occupationally-exposed humans (Amoateng-Adjepong et al. 1995; Brown 1992; de Jong 1991; de Jong et al. 1997; Ditraglia et al. 1981; Jager 1970; Ribbens 1985; van Raalte 1977). As summarized in Section 3.5.2 (Mechanisms of Toxicity), accumulating evidence indicates that the species-specificity of dieldrin-induced hepatocarcinogenicity involves susceptibility of the mouse to dieldrin-induced oxidative stress, resulting in the promotion of spontaneously initiated (background) liver tumors. Because other species, including humans, appear to be resistant to dieldrin-induced oxidative stress (Jager 1970; Stevenson et al. 1999), it does not appear that the mouse carcinogenicity data can be extrapolated to humans with a high degree of certainty.

3.6 TOXICITIES MEDIATED THROUGH THE NEUROENDOCRINE AXIS

Recently, attention has focused on the potential hazardous effects of certain chemicals on the endocrine system because of the ability of these chemicals to mimic or block endogenous hormones. Chemicals with this type of activity are most commonly referred to as *endocrine disruptors*. However, appropriate terminology to describe such effects remains controversial. The terminology *endocrine disruptors*, initially used by Colborn and Clement (1992), was also used in 1996 when Congress mandated the Environmental Protection Agency (EPA) to develop a screening program for "...certain substances [which] may have an effect produced by a naturally occurring estrogen, or other such endocrine effect[s]...". To meet this mandate, EPA convened a panel called the Endocrine Disruptors Screening and Testing Advisory Committee (EDSTAC), which in 1998 completed its deliberations and made recommendations to EPA concerning *endocrine disruptors.* In 1999, the National Academy of Sciences released a report that referred to these same types of chemicals as *hormonally active agents*. The terminology *endocrine modulators* has also been used to convey the fact that effects caused by such chemicals may not necessarily be adverse. Many scientists agree that chemicals with the ability to disrupt or modulate the endocrine system are a potential threat to the health of humans, aquatic animals, and wildlife. However, others think that endocrine-active chemicals do not pose a significant health risk, particularly in view of the fact that hormone mimics exist in the natural environment. Examples of natural hormone mimics are the isoflavinoid phytoestrogens (Adlercreutz 1995; Livingston 1978; Mayr et al. 1992). These chemicals are derived from plants and are similar in structure and action to endogenous estrogen. Although the public health significance and descriptive terminology of substances capable of affecting the endocrine system remains controversial, scientists agree that these chemicals may affect the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body responsible for maintaining homeostasis, reproduction, development, and/or behavior (EPA 1997). Stated differently, such compounds may cause toxicities that are mediated through the neuroendocrine axis. As a result, these chemicals may play a role in altering, for example, metabolic, sexual, immune, and neurobehavioral function. Such chemicals are also thought to be involved in inducing breast, testicular, and prostate cancers, as well as endometriosis (Berger 1994; Giwercman et al. 1993; Hoel et al. 1992).

No studies were located regarding endocrine disruption in humans after exposure to aldrin or dieldrin.

In vivo studies in animals suggest that aldrin and dieldrin may disrupt normal reproductive hormone levels in male animals and be an endocrine disruptor in females. Decreased androgen production and degenerative changes in the germ cells were seen in male rats after intermediate-duration intraperitoneal exposures to aldrin. Aldrin also induced estrus changes and/or endometrial proliferation in treated dogs and ovariectomized rats. *In vitro* studies suggest that dieldrin may inhibit binding of 5α-dihydro-testosterone and 17β-estradiol to the androgen and estrogen receptors, respectively, as well as cause effects such as estrogenic induction of breast cell proliferation. Overall, *in vitro* evidence for dieldrin estrogenicity indicates weak potency compared to 17β-estradiol. Apparently contradictory results were reported in different studies for several of the assays, indicating that caution should be used in interpreting the collective *in vitro* results.

Gonadotrophic effects were observed in male rats that were treated with 0.15 mg/kg/day aldrin by intraperitoneal injection for 26 days (Chatterjee et al. 1988a, 1988b, 1988c). These effects include decreased sperm count, degeneration of germ cells, decreased weights of seminal vesicles and prostate and coagulating glands, decreased seminiferous tubule diameter, decreased plasma and testicular testosterone, decreased prostatic fructose content and acid phosphatase activity, and decreased plasma luteinizing hormone and follicular stimulating hormone. Dieldrin caused changes in testosterone production and ultrastructure in rat interstitial (Leydig) testicular cells *in vitro*; significant increases in testosterone production were observed, and the Leydig cells had increased numbers of cytoplasmic vesicles which resembled lipid droplets (Ronco et al. 1998). Dieldrin also reduced the stimulatory effect of human chorionic gonadotropin (HCG) on Leydig cell testosterone production, although dieldrin-induced ultrastructural changes in HCG-stimulated Leydig cells were similar to those found in the unstimulated cells (Ronco et al. 1998). Other *in vitro* studies showed that dieldrin significantly inhibited binding of 5α-dihydrotestosterone to the androgen receptor in rat prostate cytosol and to androgen-binding protein in rat epididymal cytosol, although binding to human sex hormone-binding globulin was not reduced (Danzo 1997; Wakeling et al. 1973).

Estrogenic effects have been observed in some studies of aldrin and dieldrin. Changes in dogs orally exposed to 0.15 or 0.30 mg/kg/day aldrin for 14 months prior to mating included delayed estrus, reduced libido, and lack of mammary function and development (Deichmann et al. 1971), although this study is limited by small numbers of animals. Uterine weight glycogen content were increased in immature female rats and ovariectomized mature rats that were subcutaneously treated with 1 mg/kg/day aldrin for 3 days (Chatterjee et al. 1992). The increased uterine weight was due to proliferation of the endometrium and endometrial glands in both the immature and ovariectomized mature rats. A persistent vaginal estrus was additionally induced in the treated ovariectomized rats (Chatterjee et al. 1992). Immature female rats that were intraperitoneally administered 3 mg/kg/day dieldrin for 3 days showed no changes in uterine and pituitary weights, uterine peroxidase activity, circulating thyroxine levels, or levels of follicular stimulating hormone, luteinizing hormone, thyroid stimulating hormone, prolactin, and growth hormone in the pituitary gland (Wade et al. 1997). Dieldrin slightly decreased binding of 17β-estradiol to the estrogen receptor in extracts of uterine tissue from these rats (Wade et al. 1997). There were no significant dose-related changes in uterine weight, peroxidase activity, or estrogen or progesterone receptor binding in immature (21-day-old) mice that were intraperitoneally administered approximately 1–100 mg/kg/day dieldrin for 3 days (Ramamoorthy et al. 1997a).

In *in vitro* studies, dieldrin weakly induced proliferation of MCF-7 human breast cancer cells (an estrogenic effect) at a concentration that was an order of magnitude lower than cytotoxic levels; the potency of dieldrin relative to estradiol was 0.0001 (Soto et al. 1994, 1995). Results of other MCF-7 assays similarly showed that dieldrin was a weak inducer of cell growth or did not induce proliferation (Ramamoorthy et al. 1997a; Wade et al. 1997). Levels of estrogen and progesterone receptors in MCF-7 cells were slightly increased by dieldrin (Soto et al. 1995). Dieldrin did not significantly induce chloramphenicol acetyl transferase (CAT) activity in MCF-7 cells transiently transfected with plasmids containing estrogen-responsive 5'-promoter regions from the rat creatine kinase B and human cathepsin D genes (Ramamoorthy et al. 1997a). Binding of 17β-estradiol to the estrogen receptor in human MCF-7 cells, young rabbit uterine cells, or alligator oviduct cells was not competitively decreased by dieldrin (Danzo 1997; Ramamoorthy et al. 1997a; Vonier et al. 1996). Dieldrin had minimal estrogen receptor-mediated β-galactosidase (β-gal) activity in an estrogen-responsive reporter system in yeast (Ramamoorthy et al. 1997a).

The overall *in vivo* and *in vitro* evidence indicates that aldrin and dieldrin may be disruptive of reproductive hormone levels in male animals and weakly estrogenic in females. Limited animal data further suggest that dieldrin is not disruptive of thyroid or pituitary hormone levels in females.

3.7 CHILDREN'S SUSCEPTIBILITY

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans, when all biological systems will have fully developed. Potential effects on offspring resulting from exposures of parental germ cells are considered, as well as any indirect effects on the fetus and neonate resulting from maternal exposure during gestation and lactation. Relevant animal and *in vitro* models are also discussed.

Children are not small adults. They differ from adults in their exposures and may differ in their susceptibility to hazardous chemicals. Children's unique physiology and behavior can influence the extent of their exposure. Exposures of children are discussed in Section 6.6 Exposures of Children.

Children sometimes differ from adults in their susceptibility to hazardous chemicals, but whether there is a difference depends on the chemical (Guzelian et al. 1992; NRC 1993). Children may be more or less susceptible than adults to health effects, and the relationship may change with developmental age (Guzelian et al. 1992; NRC 1993). Vulnerability often depends on developmental stage. There are critical periods of structural and functional development during both prenatal and postnatal life and a particular structure or function will be most sensitive to disruption during its critical period(s). Damage may not be evident until a later stage of development. There are often differences in pharmacokinetics and metabolism between children and adults. For example, absorption may be different in neonates because of the immaturity of their gastrointestinal tract and their larger skin surface area in proportion to body weight (Morselli et al. 1980; NRC 1993); the gastrointestinal absorption of lead is greatest in infants and young children (Ziegler et al. 1978). Distribution of xenobiotics may be different; for example, infants have a larger proportion of their bodies as extracellular water and their brains and livers are proportionately larger (Altman and Dittmer 1974; Fomon 1966; Fomon et al. 1982; Owen and Brozek 1966; Widdowson and Dickerson 1964). The infant also has an immature blood-brain barrier (Adinolfi 1985; Johanson 1980) and probably an immature blood-testis barrier (Setchell and Waites 1975). Many xenobiotic metabolizing enzymes have distinctive developmental patterns. At various stages of growth and development, levels of particular enzymes may be higher or lower than those of adults, and sometimes unique enzymes may exist at particular developmental stages (Komori et al. 1990; Leeder and

Kearns 1997; NRC 1993; Vieira et al. 1996). Whether differences in xenobiotic metabolism make the child more or less susceptible also depends on whether the relevant enzymes are involved in activation of the parent compound to its toxic form or in detoxification. There may also be differences in excretion, particularly in newborns who all have a low glomerular filtration rate and have not developed efficient tubular secretion and resorption capacities (Altman and Dittmer 1974; NRC 1993; West et al. 1948). Children and adults may differ in their capacity to repair damage from chemical insults. Children also have a longer remaining lifetime in which to express damage from chemicals; this potential is particularly relevant to cancer.

Certain characteristics of the developing human may increase exposure or susceptibility, whereas others may decrease susceptibility to the same chemical. For example, although infants breathe more air per kilogram of body weight than adults breathe, this difference might be somewhat counterbalanced by their alveoli being less developed, which results in a disproportionately smaller surface area for alveolar absorption (NRC 1993).

Neurological symptoms (for example, convulsions, abnormal EEGs, hyperexcitability, restlessness) have been reported in adults and children following ingestion (accidental or intentional) of aldrin or dieldrin (Black 1974; Garrettson and Curley 1969; Gupta 1975; Spiotta 1951). Two young children (2 and 4 years of age) experienced severe convulsions within 15 minutes after consuming an unknown quantity of a 5% solution of dieldrin; the younger child died whereas the older brother recovered completely after exhibiting evidence of liver dysfunction (Garrettson and Curley 1969). The observed effects could not be attributed solely to dieldrin because the ingested solution likely also contained solvents and emulsifiers. Among 11 people experiencing evidence of neurotoxicity associated with the consumption of wheat mixed with aldrin and lindane for a period of 6–12 months, a female infant was reported to suffer a severe convulsion, followed by death a few hours later (Gupta 1975). Since no symptoms had been observed among individuals previously consuming wheat mixed only with lindane, it was assumed that the neurotoxic effects were the result of aldrin poisoning. A 7-year-old child in this same group was thought to have developed mild mental retardation as a result of the poisoning. However, these limited oral human data do not conclusively indicate age-related differences in susceptibility to aldrin or dieldrin poisoning. Signs of neurotoxicity have also been reported in occupational studies of workers employed in the application or manufacture of aldrin or dieldrin where exposures may have been predominantly by inhalation (Hoogendam et al. 1965; Jager 1970; Kazantzis et al. 1964; Patel and Rao 1958). No data were located regarding adverse effects in humans dermally exposed to aldrin or dieldrin, although both aldrin and dieldrin have been shown to pass through the skin and enter the blood of adults (Feldman and

Maibach 1974). It is expected that children and adults would be similarly affected by dermal exposure to aldrin or dieldrin, although no data were available to substantiate this assumption.

Limited oral LD_{50} studies indicate that newborn rats may be less sensitive than adult rats to high acute doses of dieldrin, while 2-week-old rats may be somewhat more sensitive than adults (Lu et al. 1965). In a study of adult cattle and calves given feed which was accidently mixed with aldrin, mortality occurred exclusively among calves (Buck and Van Note 1968); however, information regarding the amount of aldrin in the feed, and relative consumption rates of calves and adult cattle were not available. No other information was available to suggest that children may be more susceptible than adults to aldrin or dieldrin.

It is generally believed that the neurotoxicity of both aldrin and dieldrin is based on alterations in synaptic activity within the central nervous system (Joy 1982; Shankland 1982). As discussed in Section 3.5.2, Mechanisms of Toxicity, recent *in vitro* and *in vivo* animal studies have shown that aldrin and dieldrin are capable of blocking the activity of the inhibitory neurotransmitter GABA, an indication that both chemicals may exert their neurotoxic effects via blockage of inhibitory activity within the brain. If neurological effects seen in response to aldrin and dieldrin exposure are dependent on maturation of the central nervous system, then immature nervous systems might be less sensitive to the effects elicited by aldrin and dieldrin.

There is conflicting information regarding the developmental toxicity of aldrin and dieldrin. In some cases, increased incidences of external malformations or skeletal anomalies were observed following oral exposure of pregnant laboratory animals to aldrin or dieldrin in mid-gestation (Chernoff et al. 1975; Ottolenghi et al. 1974); no significant malformations or anomalies were seen in other studies (Chernoff et al. 1975; Dix et al. 1977). These studies were limited in design and study details. A more consistently reported developmental effect was that of decreased postnatal survival in laboratory animals following *in utero* exposure to dieldrin (Harr et al. 1970; Kitselman 1953; Treon et al. 1954a; Virgo and Bellward 1975, 1977). Dieldrin has been detected in human placenta, amniotic fluid, and fetal blood, and may be found in higher concentration in fetal blood than in the mother's blood (Polishuk et al. 1977b). Furthermore, dieldrin is excreted in the breast milk of nursing mothers (Schecter et al. 1989b). In an animal study designed to test whether decreased pup survival might be related to maternal postnatal care, mice born to dieldrin-exposed dams and then nursed by untreated dams exhibited similar survival rates to those nursed by their exposed dams, suggesting that decreased pup survival was correlated with *in utero*, rather than postnatal, exposure (Virgo and Bellward 1977). Intraperitoneal injection of aldrin in male rats resulted in plasma decreases in luteinizing hormone, follicular hormone, and testosterone, as well as decreases in testicular testosterone (Chatterjee et al. 1988a, 1988b, 1988c). In an *in vitro* study using rat interstitial testicular cells, dieldrin caused a significant increase in testosterone production (Ronco et al. 1998). There is some evidence that aldrin and dieldrin may be estrogenic. Oral administration of aldrin resulted in delayed estrous in dogs (Deichmann et al. 1971). Subcutaneous injection of aldrin resulted in a persistent vaginal estrous in ovarectomized rats (Chatterjee et al. 1992). Dieldrin slightly decreased binding of 17β-estradiol to the estrogen receptor in extracts of uterine tissue from immature female rats intraperitoneally administered dieldrin (Wade et al. 1997). Dieldrin weakly induced both cellular proliferation and slight increases in the levels of estrogen and progesterone receptors within MCF-7 human breast cancer cells (Soto et al. 1994, 1995). The overall evidence indicates that aldrin and dieldrin may be disruptive of reproductive hormone levels in male animals and weakly estrogenic in females; the developmental significance of these findings is not clear at present.

The pharmacokinetics of aldrin and dieldrin are expected to be similar in children and adults. No studies were located to indicate any age-dependent differences in absorption rates. As discussed in detail in Section 3.4, Toxicokinetics, aldrin is rapidly converted to dieldrin. Dieldrin (either absorbed or converted from aldrin) is found mainly in the liver during the first 3 hours following absorption, but is quickly distributed to fat and eliminated primarily in the feces (via the bile) with a calculated half time of elimination of 369 days. The slow elimination may play a role in the delayed onset of neurotoxicity symptoms seen in some cases of repeated exposure to relatively low doses of aldrin or dieldrin. Although there are no data to indicate age-related differences in the pharmacokinetics of aldrin or dieldrin, any age-related increases in average body fat could conceivably result in increased susceptibility. Aldrin is readily converted to dieldrin, primarily in the liver, through epoxidation catalyzed by monooxygenases (Wong and Terriere 1965). Available information indicates that cytochrome P-450 is involved (Wolff et al. 1979); however, specific enzymes have not been identified. In the rat, it has been shown that dieldrin is largely hydroxylated to 9-hydroxydieldrin by liver microsomal monooxygenases, which is then conjugated with glucuronide, to some extent, before excretion (Matthews and Matsumura 1969). Enzyme systems responsible for these metabolic pathways may operate in the very young at levels below those in adults (Calabrese 1978). This could result in increased toxic effects due to decreased rates of excretion in the young, although no supportive data are presently available.

There is some indication that aldrin and dieldrin may impair cellular immunity (Krzystyniak et al. 1985; Loose 1982; Loose et al. 1981). Aldrin- or dieldrin-induced impairment of the immature immune system of infants and children (Calabrese 1978) might result in a lower level of resistance to infections than adults.

There are no biomarkers of exposure or effect for aldrin or dieldrin that are unique to children or that have been validated in children or adults exposed as children. No studies were located regarding interactions of aldrin or dieldrin with other chemicals in children. Limited data concerning interactions with other chemicals in adults (see Section 3.9, Interactions With Other Chemicals) did not suggest that such interactions would be different in children. No information was located regarding pediatric-specific methods for reducing peak absorption following exposure to aldrin or dieldrin, reducing body burden, or interfering with the mechanism of action for toxic effects.

There is no information regarding possible transgenerational effects of aldrin or dieldrin exposure in humans, and limited animal data are inconclusive. Reduced meiotic pairing in dividing spermatocytes of mice orally administered single doses of aldrin indicates that aldrin can cross the blood/testis barrier (Rani and Reddy 1986). However, the mostly negative results of dominant lethal assays (Dean et al. 1975; Epstein et al. 1972) indicate little potential for significant reactions with DNA.

3.8 BIOMARKERS OF EXPOSURE AND EFFECT

Biomarkers are broadly defined as indicators signaling events in biologic systems or samples. They have been classified as markers of exposure, markers of effect, and markers of susceptibility (NAS/NRC 1989).

Due to a nascent understanding of the use and interpretation of biomarkers, implementation of biomarkers as tools of exposure in the general population is very limited. A biomarker of exposure is a xenobiotic substance or its metabolite(s) or the product of an interaction between a xenobiotic agent and some target molecule(s) or cell(s) that is measured within a compartment of an organism (NAS/NRC 1989). The preferred biomarkers of exposure are generally the substance itself or substance-specific metabolites in readily obtainable body fluid(s), or excreta. However, several factors can confound the use and interpretation of biomarkers of exposure. The body burden of a substance may be the result of exposures from more than one source. The substance being measured may be a metabolite of another xenobiotic substance (e.g., high urinary levels of phenol can result from exposure to several different aromatic compounds). Depending on the properties of the substance (e.g., biologic half-life) and environmental conditions (e.g., duration and route of exposure), the substance and all of its metabolites may have left the body by the time samples can be taken. It may be difficult to identify individuals exposed to hazardous substances that are commonly found in body tissues and fluids (e.g., essential mineral nutrients such as copper, zinc, and selenium). Biomarkers of exposure to aldrin/dieldrin are discussed in Section 3.8.1.

Biomarkers of effect are defined as any measurable biochemical, physiologic, or other alteration within an organism that, depending on magnitude, can be recognized as an established or potential health impairment or disease (NAS/NRC 1989). This definition encompasses biochemical or cellular signals of tissue dysfunction (e.g., increased liver enzyme activity or pathologic changes in female genital epithelial cells), as well as physiologic signs of dysfunction such as increased blood pressure or decreased lung capacity. Note that these markers are not often substance specific. They also may not be directly adverse, but can indicate potential health impairment (e.g., DNA adducts). Biomarkers of effects caused by aldrin are discussed in Section 3.8.2.

A biomarker of susceptibility is an indicator of an inherent or acquired limitation of an organism's ability to respond to the challenge of exposure to a specific xenobiotic substance. It can be an intrinsic genetic or other characteristic or a preexisting disease that results in an increase in absorbed dose, a decrease in the biologically effective dose, or a target tissue response. If biomarkers of susceptibility exist, they are discussed in Section 3.10 “Populations That Are Unusually Susceptible”.

3.8.1 Biomarkers Used to Identify or Quantify Exposure to Aldrin

Exposure to aldrin and dieldrin is measured almost exclusively by determining the level of dieldrin in the blood. Because aldrin is rapidly converted to dieldrin in the body, the detection of aldrin in body tissues is rare. Blood levels of dieldrin are specific for aldrin and dieldrin. Dieldrin levels measured in blood samples of members of the general population in the United States between 1976 and 1980 in the National Health and Nutrition Examination Survey (NHANES II) were found to be approximately 1.4 ppb (Murphy and Harvey 1985; Stehr-Green 1989). It is likely that current baseline blood levels in the general population would be lower.

Detection of dieldrin in the blood may indicate either recent or past exposure to aldrin or dieldrin. Dieldrin would be detected in the blood either immediately after inhalation, oral, or dermal absorption or as stores of dieldrin are slowly released from adipose tissue. In humans, dieldrin has a relatively long half-life in the body (Hunter and Robinson 1967; Hunter et al. 1969; Jager 1970). Hunter et al. (1969) calculated a mean half-life of 369 days, and Jager (1970) estimated a mean half life of 266 days. Thus, exposures of sufficient magnitude occurring several years earlier may still be detected in the blood. A GABA radioreceptor assay has been developed that could serve as a sensitive biomarker for exposure to dieldrin (Saleh et al. 1993). GABA (gamma aminobutyric acid) is the major inhibitory neurotransmitter in the central nervous system (see Section 3.5.2). Although potentially useful for reproducibly detecting nanogram levels of dieldrin in minute blood samples (0.1 mL), this method is not specific for aldrin and dieldrin because it would also detect other nervous system toxicants with high specific binding affinity to the chloride channel of $GABA_A$ receptor-ionophore sites (e.g., endosulfan and other cyclodiene insecticides, hexachlorocyclohexanes, pyrethroids, bicyclophosphates, and bicycloorthocarboxylate insecticides).

Because dieldrin rapidly redistributes to adipose tissue, the highest levels of dieldrin are found in fat (except immediately after exposure). Thus, fat levels of dieldrin are also a good source for identifying exposure to aldrin or dieldrin. However, obtaining fat samples requires at least minor surgery; therefore, this method is not commonly used. The 1982 Human Adipose Tissue Survey found dieldrin present in adipose tissue at a mean concentration of 458 ppb. It is likely that current levels would be lower.

Because of its high fat content, breast-milk levels of dieldrin may give some information about prior exposures and accumulation of dieldrin in fatty tissues. Breast-milk levels of dieldrin may be lowered by frequent nursing (Ackerman 1980).

Following relatively long-term exposure to constant levels of aldrin or dieldrin, a steady state of body levels of dieldrin is achieved (Hunter and Robinson 1967; Hunter et al. 1969). Thus, when repeated and regular exposure is known to have occurred, the exposure level may be calculated from blood or fat levels using the equations described by Hunter et al. (1969) (exposure level equals the blood level divided by 0.086 or the fat level divided by 0.0185).

The metabolite of dieldrin, 9-hydroxydieldrin, has been detected in human feces (Richardson and Robinson 1971). However, this metabolite has not been routinely used to identify or quantify exposure to aldrin or dieldrin.

Prior to the use of blood levels to monitor exposure to aldrin and dieldrin, EEGs were used to monitor workers for possible overexposure to these substances (Hoogendam et al. 1962, 1965; Jager 1970). However, this technique is most reliable when a baseline EEG recording from each subject has been obtained prior to exposure. Also, any centrally acting neuroexcitatory substance could produce EEG changes similar to those produced by aldrin or dieldrin, limiting the specificity of this technique.

3.8.2 Biomarkers Used to Characterize Effects Caused by Aldrin

Although none of the following effects are specific for aldrin or dieldrin, measurement of a number of parameters may provide useful information when exposure to aldrin or dieldrin is suspected. In animals, microsomal enzyme induction is one of the earliest and most sensitive effects caused by organochlorine pesticides such as aldrin and dieldrin (Wright et al. 1972). Indicators that have been used to try to assess microsomal enzyme induction in humans following exposure to aldrin or dieldrin include urinary levels of D-glucaric acid and the ratio of urinary 6-β-hydroxycortisol to 17-hydroxy-corticosteroids (Jager 1970; Morgan and Roan 1974). Other substances such as barbiturates, phenytoin, chlorbutanol, aminopyrine, phenylbutazone, progesterone, and contraceptive steroids as well as other organochlorine pesticides also cause microsomal enzyme induction and cause changes in these parameters (Morgan and Roan 1974).

Central nervous system excitation culminating in convulsions is, in some cases, the only symptom of aldrin or dieldrin intoxication. EEG changes in occupationally exposed workers have been monitored in the past in an attempt to detect central nervous system changes prior to the onset of convulsions (Jager 1970). Characteristic changes include bilateral synchronous spikes, spike and wave complexes, and slow theta waves (Avar and Czegledi-Janko 1970; Garrettson and Curley 1969; Hoogendam et al. 1962, 1965; Jager 1970; Kazantzis et al. 1964; Spiotta 1951); however, these changes are not specific for aldrin or dieldrin overexposure and may be produced by several neuroexcitatory substances. A good correlation between blood levels of dieldrin and central nervous system toxicity has been established (Brown et al. 1964; Jager 1970). Thus, blood levels in excess of 0.2 mg/L are frequently associated with adverse central nervous system effects.

Studies of immune activity have not routinely been done in humans to assess immunosuppression caused by aldrin and dieldrin, but studies indicate that measurements of cytotoxic T-lymphocyte activity or of macrophage-antigen processing may be good indicators of the adverse effects of aldrin and dieldrin on the immune system (Loose 1982; Loose et al. 1981). However, such tests would not be specific for aldrin- or dieldrin-mediated immunosuppression.

Another potential adverse effect of aldrin and dieldrin on the immune system that has been reported only twice is the induction of immunohemolytic anemia. A Coomb's test can be used to measure the ability of the subject's serum to cause a positive immune reaction with dieldrin-coated red blood cells (Hamilton et al. 1978).

3.9 INTERACTIONS WITH OTHER CHEMICALS

Limited information is available regarding the influence of other chemicals on the toxicity of aldrin and dieldrin. Administration of the pesticides Aramite, DDT, and methoxychlor with aldrin to rats did not cause an increase over the incidence of cancer observed in the presence of aldrin alone (Deichmann et al. 1967). However, no increase in cancer incidence was observed with any of these substances administered singly. Thus, it is unclear whether the conditions of this assay were adequate to detect an additive or synergistic effect if it existed.

Induction of microsomal enzymes by ochratoxin, a mycotoxin, was observed to enhance conversion of aldrin to dieldrin (Farb et al. 1973). Also, induction of microsomal enzymes by the pesticides hexachlorobenzene and DDT caused a decrease in storage in adipose tissue and/or an increased rate of excretion of the metabolites of aldrin and dieldrin in the feces and urine (Clark et al. 1981; Street and Chadwick 1967). However, these studies did not present information regarding the effects of these interactions on the toxicity of aldrin or dieldrin. Thus, it is unknown whether the changes in the pharmacokinetics of aldrin and dieldrin affected their toxicity.

The ability of chlorinated hydrocarbons to disrupt estrogen homeostatis, by up-regulating selected gene transcription, has been hypothesized to be responsible for their oncogenic effects. Neither aldrin nor dieldrin showed evidence of estrogenicity as evidenced by lack of induction of transcriptional activation of an estrogen-responsive reported gene in transfected HeLa cells (Tully et al. 2000). There is evidence of a synergistic estrogenic effect of dieldrin and toxaphene on the bone mass density in rats. While dieldrin alone did not show any evidence of estrogenicity when administered to rats by intragastric intubation at a dose of 7.5 µmol/kg/day, 5 days/week, for 9 months, when administered with toxaphene (30 µmol toxaphene/kg/day and 7.5 µmol/kg/day), bone mass density was significantly increased (Syversen et al. 2000). In contrast, the results of several estrogen-responsive assays in the mouse uterus, MCF-7 human breast cancer cells, and yeast-based reporter gene assays, indicate that the activities of both dieldrin and toxaphene, as well as a binary mixture of the two were minimally estrogenic (Ramamoorthy et al. 1997a).

3.10 POPULATIONS THAT ARE UNUSUALLY SUSCEPTIBLE

A susceptible population will exhibit a different or enhanced response to aldrin than will most persons exposed to the same level of aldrin in the environment. Reasons may include genetic makeup, age, health and nutritional status, and exposure to other toxic substances (e.g., cigarette smoke). These parameters result in reduced detoxification or excretion of aldrin, or compromised function of organs affected by aldrin/dieldrin. Populations who are at greater risk due to their unusually high exposure to aldrin are discussed in Section 6.7, Populations With Potentially High Exposures.

A susceptible population will exhibit a different or enhanced response to aldrin or dieldrin than will most persons exposed to the same level of aldrin or dieldrin in the environment. Reasons include genetic make-up, developmental stage, health and nutritional status, and chemical exposure history. These parameters result in decreased function of the detoxification and excretory processes (mainly hepatic and renal) or the pre-existing compromised function of target organs. For these reasons we expect the elderly with declining organ function and the youngest of the population with immature and developing organs will generally be more vulnerable to toxic substances than healthy adults. Populations who are at greater risk due to their unusually high exposure are discussed in Section 6.7, "Populations With Potentially High Exposure."

Review of the literature regarding toxic effects of aldrin and dieldrin did not reveal any populations that are known to be unusually sensitive to aldrin or dieldrin. However, some populations that may potentially demonstrate unusual sensitivity include the very young with immature hepatic detoxification systems, persons with impaired liver function, and persons with impaired immune function.

Aldrin and dieldrin are metabolized in the liver primarily by microsomal mixed-function oxidases. To some extent, the oxidized metabolites 9-hydroxydieldrin and 6,7-*trans*-dihydroxydihydroaldrin are conjugated with glucuronide prior to excretion (Matthews and Matsumura 1969). In the very young, the microsomal enzyme system and the enzyme systems responsible for glucuronide conjugation operate at levels below those in adults (Calabrese 1978). Thus, the very young may experience increased toxic effects due to the decreased rates of excretion. Similarly, persons with impaired liver function may also experience increased toxicity because of their limited ability to fully metabolize aldrin or dieldrin. The suggestive evidence of bioconcentration of dieldrin in the fetus (Polishuk et al. 1977b) and the possibility of consumption of contaminated breast milk by infants indicate that these groups have an increased risk, because they may have higher body burdens of these pesticides than adults.

Persons suffering from compromised immune function may demonstrate an increased susceptibility to infections because of the ability of aldrin and dieldrin to impair cellular immunity (Krzystyniak et al. 1985; Loose 1982; Loose et al. 1981). Infants and children may also be susceptible because the human immune system does not reach maturity until 10–12 years of age (Calabrese 1978).

Although aldrin and dieldrin cause central nervous system excitation leading, in some cases, to convulsions, no evidence of an enhanced susceptibility to the excitatory effects of aldrin or dieldrin in persons with preexisting anomalous EEGs was observed (Jager 1970).

3.11 METHODS FOR REDUCING TOXIC EFFECTS

This section will describe clinical practice and research concerning methods for reducing toxic effects of exposure to aldrin/dieldrin. However, because some of the treatments discussed may be experimental and unproven, this section should not be used as a guide for treatment of exposures to aldrin/dieldrin. When specific exposures have occurred, poison control centers and medical toxicologists should be consulted for medical advice. No texts were located that provide specific information about treatment following exposures to aldrin/dieldrin.

3.11.1 Reducing Peak Absorption Following Exposure

General recommendations reported for reducing absorption following acute high-dose exposure to aldrin and dieldrin include removing the individual from the source of exposure and decontaminating exposed skin using alcohol or soap and water (HSDB 2001a, 2001b). Dermal absorption is fairly efficient, so decontamination attempts should be accomplished quickly. An initial soap and water wash, followed by an alcohol wash, followed by a second soap and water wash have been suggested for decontaminating skin and hair after aldrin or dieldrin exposure (Hall and Rumack 1992), but it is unclear whether this represents any true improvement over thorough washing with soap and water. A number of strategies have been suggested to minimize absorption from the gastrointestinal tract. Ipecac-induced emesis has been suggested for gastric emptying, although there is a risk of pulmonary aspiration of gastric contents and resultant pneumonitis from hydrocarbon solvents due to potential early onset of unconsciousness or convulsions (HSDB 2001a, 2001b). When emesis is contraindicated, gastric lavage has been suggested as an alternative method for emptying the stomach if ingestion was recent (within 60–90 minutes) (Klaassen 1990). A cuffed endotracheal tube is recommended if hydrocarbon solvents were also ingested. Since activated charcoal can adsorb aldrin and dieldrin, it has also been commonly used as a method for reducing intestinal uptake following ingestion (HSDB 2001a, 2001b). Another method for reducing absorption is the use of a cathartic; activated charcoal is frequently given mixed as a slurry with one of the saline cathartics or sorbitol (Hall and Rumack 1992; HSDB 2001a, 2001b). The mechanism by which aldrin and dieldrin are absorbed from the gastrointestinal tract is unknown; however, their highly lipophilic nature suggests dissolution in the cell membrane.

3.11.2 Reducing Body Burden

There are no proven or accepted strategies for reducing the body burden of dieldrin. A majority of dieldrin's final metabolites are conjugated with glucuronic acid in the liver; most excretion is in the bile, with smaller amounts in the urine (Richardson and Robinson 1971). Fecal metabolites have been measured but not quantitatively compared with metabolites secreted through the bile duct; thus, it is unclear whether enterohepatic recirculation occurs. However, some biliary metabolites, such as 9-hydroxydieldrin glucuronide, seem to be deconjugated by gut microfloral glucuronidases since they are excreted in the feces in aglycone form (Chipman and Walker 1979; Hutson 1976). Deconjugation frequently favors enterohepatic recirculation (Sipes and Gandolfi 1991). If significant enterohepatic recirculation could be demonstrated, methods to interfere with the reabsorption from the gut into the systemic circulation might be effective in accelerating the excretion of aldrin and dieldrin metabolites. There are several possible strategies for reducing intestinal resorption of bile excretions; the simplest is repeated doses of activated charcoal (without cathartics) (Levy 1982). Another strategy, which has been effective in experiments with another lipophilic xenobiotic, chlordecone, is the oral administration of the anion exchange resin, cholestryamine (Boylan et al. 1978). However, it effectiveness with aldrin or dieldrin poisoning is unknown.

The pharmacokinetics of aldrin and dieldrin are not completely understood. Once absorbed by the gastrointestinal tract, these pesticides are transported to the liver via the portal vein (Heath and Vandekar 1964). They are found mainly in the liver for the first 3 hours but have also been found in the blood, lymph, kidneys, fetus, and adipose tissue (Heath and Vandekar 1964; Iatropoulos et al. 1975). The interval immediately after absorption may be a window of opportunity for removing the xenobiotic from the circulation before it partitions into adipose tissue. Potential strategies include hemodialysis and hemoperfusion (Klaassen 1990). However, the large molecular weights and lipophilic nature of these compounds argues against effective removal by hemodialysis. Another potential strategy for removal would be to attempt to increase dieldrin excretion by enhancing its metabolism. Dieldrin's metabolism to 9-hydroxydieldrin and excretion are substantially greater in male than in female rats (Matthews et al. 1971), indicating that a specific form of cytochrome P-450 may be more prevalent in male rats. If the specific form(s) of cytochrome P-450 responsible for the more rapid metabolism and excretion could be identified, specific inducers could be used to speed dieldrin's excretion in humans (Sipes and Gandolfi 1991). Long-term storage is in adipose tissue, primarily in the form of dieldrin (Hutson 1976), but initially some residues are also found in the liver and brain. It is unclear whether detrimental effects would be expected from this storage, although there is equilibrium between dieldrin in fat and blood.

Release of dieldrin from fat has not resulted in a significant health hazard in people with low body burdens of dieldrin (Hunter and Robinson 1968).

3.11.3 Interfering with the Mechanism of Action for Toxic Effects

The mechanism for aldrin and dieldrin toxicity is not equally well understood for all target organs. The central nervous system is the most sensitive target for acute toxicity; aldrin and dieldrin are stimulants that can cause excitation, convulsions, and seizures (Wagner and Greene 1978; Woolley et al. 1985). There are multiple theories about the mechanism of action; it is unclear whether dieldrin facilitates excitatory neurotransmitter release or interferes with inhibitory neurotransmitter action.

One hypothesis is that the majority of dieldrin's neurotoxicity is due to its interactions with a receptor for the inhibitory neurotransmitter GABA (see Section 3.5.2). Dieldrin is thought to be a competitive inhibitor of binding to the $GABA_A$ receptor t-butylbicyclophosphorothionate (TBPS) binding site (Lawrence and Casida 1984), and *in vitro* experiments have shown that it blocks the chloride channel in $GABA_A$- receptor complex (Abalis et al. 1986; Bloomquist and Soderlund 1985; Bloomquist et al. 1986; Cole and Casida 1986; Gant et al. 1987; Lawrence and Casida 1984; Obata et al. 1988). Administration of benzodiazepines, which act at the GABA receptor to potentiate GABA binding (Bloom 1990), has been suggested as a method for treating aldrin- or dieldrin-induced seizures (HSDB 2001a, 2001b). This standard method of reducing central nervous system excitation might be acting at the same molecular site as dieldrin and, thus, specifically interfering with its mechanism of action. If $GABA_A$- receptor interactions are the major mechanism of central nervous system toxicity, potential research approaches for interfering with the mechanism of action would include the use of agonists such as muscimol or GABA to compete for binding at the receptor, inhibitors of GABA re-uptake such as guvacine or nipecotic acid, and blocking GABA catabolism with aminooxyacetic acid (Bloom 1990). Although benzodiazepines are safer, barbiturates also act at the GABA receptor to potentiate GABA binding and might reduce the central nervous system toxicity of dieldrin (Bloom 1990). Phenytoin has been used for seizures refractory to treatment with diazepam or barbiturate (Hall and Rumack 1992).

Adrenergic β-blockers were used effectively to control blood pressure in a dieldrin-poisoned individual (Black 1974), suggesting that such treatment may be effective in other dieldrin-poisonings where elevated blood pressure occurs.

A potential investigative strategy to reduce aldrin toxicity might be to channel aldrin metabolism to the liver where it is more likely to immediately continue to be metabolized to less toxic metabolites. While most conversion of aldrin to dieldrin occurs in the liver, some aldrin is converted to dieldrin outside of the liver. Since further metabolism and conjugation of dieldrin for excretion take place mainly in the liver, any dieldrin created outside the liver has a greater chance of causing toxic effects. Aldrin is converted to dieldrin outside the liver by the more ubiquitous prostaglandin endoperoxidase synthetase. A possible method for reducing the extrahepatic transformation of aldrin to dieldrin would be to inhibit the activity of prostaglandin endoperoxidase synthetase with the cyclooxygenase inhibitors aspirin and indomethacin. Also, ascorbic acid supplementation during dieldrin treatment has been observed to partially reduce the hepatic and renal toxicity of dieldrin treatment in experimental animals (Bandyopadhyay et al. 1982b). However, the reproducibility, effectiveness in humans, and potential mechanism for the reduction in toxicity are unknown.

Mitigation strategies that may be developed in the future for other lipophilic pesticides should be considered for their applicability to aldrin and dieldrin.

3.12 ADEQUACY OF THE DATABASE

Section 104(I)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of aldrin/dieldrin is available. Where adequate information is not available, ATSDR, in conjunction with the National Toxicology Program (NTP), is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of aldrin/dieldrin.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

3.12.1 Existing Information on Health Effects of Aldrin

The existing data on health effects of inhalation, oral, and dermal exposure of humans and animals to aldrin/dieldrin are summarized in Figure 3-5. The purpose of this figure is to illustrate the existing information concerning the health effects of aldrin. Each dot in the figure indicates that one or more studies provide information associated with that particular effect. The dot does not necessarily imply anything about the quality of the study or studies, nor should missing information in this figure be interpreted as a "data need". A data need, as defined in ATSDR's *Decision Guide for Identifying Substance-Specific Data Needs Related to Toxicological Profiles* (Agency for Toxic Substances and Disease Registry 1989), is substance-specific information necessary to conduct comprehensive public health assessments. Generally, ATSDR defines a data gap more broadly as any substance-specific information missing from the scientific literature.

3.12.2 Identification of Data Needs

Acute-Duration Exposure. Populations in areas that contain hazardous waste sites may be exposed to aldrin or dieldrin for brief periods. Exposure would most likely occur by the inhalation or oral routes, but dermal exposure is also possible. There are acute-duration oral exposure data in humans from cases of accidental or intentional poisonings that indicate that the central nervous system is a major target organ of aldrin and dieldrin toxicity by the oral route. Convulsions have been observed following ingestion of very high concentrations of aldrin and dieldrin (Black 1974; Garrettson and Curley 1969; Spiotta 1951). Also, acute oral exposure in humans has been reported to cause renal toxicity (Spiotta 1951). Renal toxicity has not been reported in studies in animals after acute-duration ingestion of high concentrations of aldrin or dieldrin; however, the number of studies examining systemic effects associated with acute-duration exposures is quite limited. Studies in laboratory animals examining the effects of ingestion of aldrin or dieldrin have supported the conclusion that the nervous system is a major target organ of aldrin and dieldrin toxicity (Burt 1975; Carlson and Rosellini 1987; Mehrotra et al. 1989; Treon et al. 1953a; Wagner and Greene 1978; Woolley et al. 1985). In such studies, convulsions as well as impaired responding in operant behavioral paradigms were reported. In addition, immune suppression (Krzystyniak et al. 1985; Loose et al. 1981), developmental toxicity (Al-Hachim 1971; Ottolenghi et al. 1974), and adaptive changes in the liver (Wright et al. 1972) have been observed in acutely exposed animals. Results of these studies indicate that the immune system may be the most sensitive target organ for the effects of brief oral exposures to aldrin or dieldrin. An acute-duration oral MRL was not derived

Figure 3-5. Existing Information on Health Effects of Aldrin/Dieldrin

	Death	Systemic: Acute	Systemic: Intermediate	Systemic: Chronic	Immunologic/Lymphoretic	Neurologic	Reproductive	Developmental	Genotoxic	Cancer
Inhalation	•		•	•	•	•			•	•
Oral	•	•	•	•	•	•				•
Dermal	•	•	•	•	•	•			•	•

Human

	Death	Systemic: Acute	Systemic: Intermediate	Systemic: Chronic	Immunologic/Lymphoretic	Neurologic	Reproductive	Developmental	Genotoxic	Cancer
Inhalation	•	•								
Oral	•	•	•	•	•	•	•	•	•	•
Dermal	•	•	•	•		•	•			

Animal

• Existing Studies

for dieldrin because the database indicates that the most sensitive target of toxicity is the immune system in rats administered acute doses of dieldrin (Loose et al. 1981) and there are no data to suggest that the immune system may be a target of toxicity in humans following ingestion of dieldrin. An acute-duration oral MRL was derived for aldrin based on a neurological effect (altered electroconvulsive shock threshold) and decreased body weight in offspring of treated mice (Al-Hachim 1971).

No information is available regarding acute-duration inhalation exposure to aldrin or dieldrin in humans, and extremely limited information is available from studies in animals (Treon et al. 1957b). Although the volatility of aldrin and dieldrin is quite low and levels in the atmosphere are expected to be quite low, absorption of these compounds by the lungs occurs to a significant extent (Mehendale and El-Bassiouni 1975). Toxicokinetic data do not indicate that dissimilar target organs would be affected as a result of inhalation exposure to aldrin or dieldrin. Thus, additional studies examining the effects of acute inhalation exposure to saturating concentrations of aldrin or dieldrin would be helpful in determining whether toxic effects would occur as a result of brief inhalation exposure.

Information regarding the acute effects of dermal exposure of aldrin or dieldrin is limited to lethality studies in animals (Gaines 1960; Treon et al. 1953a). Dermal exposure to aldrin and dieldrin is possible in contaminated soil, and toxicokinetic studies indicate that dermally applied aldrin and dieldrin are absorbed (Feldmann and Maibach 1974; Graham et al. 1987; Witherup et al. 1961). Toxicokinetic data do not suggest that dissimilar target organs would be affected as a result of dermal exposure. Thus, studies examining the effects of acute dermal exposure to aldrin or dieldrin would be useful.

Intermediate-Duration Exposure. Few reports were located regarding effects in humans after intermediate-duration exposure to aldrin or dieldrin by any route. In one study, exposure was by the oral route (Gupta 1975). In two other studies, exposure most likely occurred as the result of combined inhalation and dermal (and possibly oral) exposures (Fletcher et al. 1959; Patel and Rao 1958). These studies showed that the nervous system is a major target organ in humans after intermediate-duration exposures. Studies in laboratory animals confirm this observation (Burt 1975; Mehrotra et al. 1988; Smith et al. 1976; Treon et al. 1951b; Wagner and Greene 1978). Other targets identified in intermediate-duration oral studies in animals include the immune system (Loose 1982), the developing neonate (Al-Hachim 1971; Deichmann et al. 1971; Harr et al. 1970; Treon et al. 1954a; Virgo and Bellward 1975), the reproductive system (Treon et al. 1954a; Virgo and Bellward 1975, 1977), the kidney (Ahmed et al. 1986a; Bandyopadhyay et al. 1982b), and the liver (Ahmed et al. 1986a; Shakoori et al. 1982; Treon et al. 1951a, 1951b). An intermediate-duration oral MRL for aldrin was not derived due to lack of suitable effect levels. Intermediate-duration studies of aldrin are essentially limited to studies that found frank neurotoxic effects (e.g., tremors, convulsions) at the lowest tested doses; LOAELs for serious end points are inappropriate for deriving MRLs. An intermediate-duration oral MRL was developed for dieldrin based on a NOAEL for impaired learning in monkeys (Smith et al. 1976).

No data were located regarding intermediate-duration inhalation exposures in animals, and human exposure levels were not quantified. Therefore, no intermediate-duration inhalation MRL was derived for either aldrin or dieldrin. Also, only limited information was located regarding lethality, neurological effects, and dermal effects after intermediate-duration dermal exposures (Bundren et al. 1952; Treon et al. 1953a). As noted above, absorption occurs by both the inhalation and dermal routes, and toxicokinetic data indicate that similar target organs would be affected following exposure to either route; thus, additional studies examining the effects of aldrin and dieldrin by the inhalation and dermal routes would be helpful.

Chronic-Duration Exposure and Cancer. A number of epidemiological studies have been conducted on workers exposed chronically to aldrin and dieldrin (de Jong 1991; Ditraglia et al. 1981; Hoogendam et al. 1965; Jager 1970; Morgan and Lin 1978; Morgan et al. 1980; Sandifer et al. 1981; van Raalte 1977; van Sittert and de Jong 1987; Versteeg and Jager 1973; Warnick and Carter 1972). In these studies, doses are usually not well quantified, and concomitant inhalation, dermal, and possibly oral exposures have occurred. Follow-up and expansion of previously identified worker cohorts could provide additional useful information on chronic effects. It is difficult to recommend new populations for future epidemiological studies of effects caused by chronic-duration inhalation, oral, or dermal exposure because (1) these agents have not been manufactured in the United States since 1974, and (2) workers who have been involved in the use of the remaining stocks of these agents are likely to have been also exposed to a variety of other pesticides. Data from the existing epidemiological studies indicate that the nervous system is a major target organ for chronic inhalation, dermal, and possibly oral exposures in humans (Hoogendam et al. 1962, 1965; Jager 1970; Sandifer et al. 1981). Chronic oral studies in animals also indicate that the nervous system is a major target organ (Fitzhugh et al. 1964; Harr et al. 1970; Kitselman 1953; NCI 1978a, 1978b; Walker et al. 1969), but additionally demonstrate adverse effects of aldrin and dieldrin on the kidney (Deichmann et al. 1967; Fitzhugh et al. 1964; Harr et al. 1970; Treon et al. 1955b) and liver (Fitzhugh et al. 1964; Kitselman 1953; NCI 1978a; Thorpe and Walker 1973; Treon et al. 1955b; Walker et al. 1969). The liver was the most sensitive target of toxicity in chronic-duration studies and hepatic effect levels in rats (Fitzhugh et al. 1964; Walker et al. 1969) were used as the basis of chronic oral MRLs for both aldrin and dieldrin. No chronic animal studies were located for the inhalation route; only one animal study was located examining the effects of chronic dermal exposure (Witherup et al. 1961). Studies examining the effects caused by low-level chronic exposures by both the inhalation and oral routes would be valuable for determining whether such exposures could cause toxicity in populations exposed to aldrin and dieldrin near hazardous waste sites for extended periods.

Epidemiological studies examining cancer mortality in two series of workers exposed to aldrin and dieldrin provide no conclusive evidence of carcinogenicity in humans (Amoateng-Adjepong et al. 1995; Brown 1992; de Jong 1991; de Jong et al. 1997; Ditraglia et al. 1981; Jager 1970; Ribbens 1985; van Raalte 1977). Possible increases in liver, biliary, and rectal cancer were suggested in some of the later studies, but additional follow-up of these populations is needed to establish the effects. Several studies in mice have shown that oral exposure to aldrin or dieldrin caused an increase in the incidence of malignant liver tumors (Davis and Fitzhugh 1962; Meierhenry et al. 1983; NCI 1978a; Tennekes et al. 1981; Thorpe and Walker 1973; Walker et al. 1972). However, studies in rats (Cabral et al. 1979; Deichmann et al. 1967, 1970; Fitzhugh et al. 1964; NCI 1978b; Walker et al. 1969) have been either equivocal or flawed. Although aldrin and dieldrin are generally regarded as mouse-specific carcinogens, additional studies by the oral route in a species other than the mouse would help to clarify the carcinogenic potential. If species differences in the carcinogenic potential of these chemicals are verified, additional studies related to the mechanism of species specificity would be informative for predicting human susceptibility. Also, studies by routes other than oral would clarify whether inhalation or dermal exposures could also cause cancer. Toxicokinetic data do not indicate that any different response would be expected following exposures by these routes. Accumulating evidence indicates that aldrin and dieldrin are nongenotoxic tumor promoters acting through species-specific susceptibility of the mouse to induction of oxidative stress and inhibition of gap junctional communication (Jone et al. 1985; Klaunig and Ruch 1987; Klaunig et al. 1990, 1995, 1998; Kurata et al. 1982; Ruch and Klaunig 1986; Trosko et al. 1987; van Ravenzwaay and Kunz 1988; Wade et al. 1986; Zhong-Xiang et al. 1986). Additional mechanistic studies would be useful for better understanding the apparent species-specific carcinogenicity of aldrin and dieldrin in animals and relating these findings to humans.

Genotoxicity. There were only two studies on *in vivo* exposure of humans to aldrin or dieldrin. Both were limited due to concomitant exposure to other pesticides and inconclusive route and dose of exposure (Dean et al. 1975; Dulout et al. 1985). Additional genotoxicity assays using tissues from humans exposed *in vivo* would be useful if these were accompanied by adequate quantitative exposure measurements.

Numerous studies investigating the *in vitro* genotoxic effects of aldrin or dieldrin were available in the current literature (Ahmed et al. 1977a, 1977b; Crebelli et al. 1986; Dean et al. 1975; De Flora et al. 1984, 1989; Ennever and Rosenkranz 1986; Galloway et al. 1987; Glatt et al. 1983; Haworth et al. 1983; Klaunig et al. 1984; Majumdar et al. 1976, 1977; Marshall et al. 1976; Probst et al. 1981; Sandhu et al. 1989). They provide no conclusive evidence for genotoxic effects, particularly for direct action on the DNA molecule. The positive studies are primarily from the same research group, and while differences in results could be due to different concentrations used, different strains of test species, or other laboratory protocol differences, it would be useful to have independent confirmation or refutation of these studies using adequate techniques (especially in mammalian systems). Results of such studies would provide useful information on potential genotoxic effects in humans.

Reproductive Toxicity. One study in humans attempted to correlate blood levels of dieldrin with premature labor or spontaneous abortions in pregnant women (Saxena et al. 1980); however, this study failed to establish causality. No other human data regarding reproductive effects of aldrin or dieldrin were located. Studies in laboratory animals exposed orally to aldrin or dieldrin present conflicting data on the ability of these agents to cause decreased fertility (Dean et al. 1975; Epstein et al. 1972; Good and Ware 1969; Harr et al. 1970; Treon et al. 1954a; Virgo and Bellward 1975). Some of these studies are limited. Additional studies examining the effects of oral exposure to aldrin or dieldrin would be helpful for clarifying this issue. No studies in animals were found regarding reproductive effects of exposure by the inhalation or dermal routes. Thus, studies examining effects on reproduction by inhalation or dermal exposure would also be useful. Animal studies performed using intraperitoneal injection of aldrin demonstrate adverse effects on male reproductive capacity (Chatterjee et al. 1988a, 1988b, 1988c). Additional studies examining fertility in animals exposed by the oral, dermal, or inhalation routes would be helpful in determining whether the effects are specific to intraperitoneal injection.

Developmental Toxicity. No human studies are available on developmental effects for any exposure route. Similarly, no studies are available for animals exposed via the inhalation route, and negligible information is available for animals exposed via the dermal route (Glastonbury et al. 1987). Several studies report a decrease in postnatal survival for offspring of dogs, rats, and mice exposed to aldrin or dieldrin by the oral route (Deichmann et al. 1971; Harr et al. 1970; Kitselman 1953; Treon et al. 1954a; Virgo and Bellward 1975), although many of these studies are flawed. Additional studies assessing postnatal survival after maternal exposure by all three routes would be helpful. Also, additional studies attempting to clarify the mechanism of the postnatal mortality would be informative. Adverse developmental effects have been observed following maternal oral exposure to aldrin (Al-Hachim 1971), and an acute-duration oral MRL for aldrin was derived based on the decrease in pup body weight and increased electroconvulsive shock threshold of pups observed in this study. Teratogenic effects have been observed in only a limited number of the studies performed to assess developmental toxicity (Ottolenghi et al. 1974); additional well-conducted studies examining this parameter may help clarify this issue.

Immunotoxicity. Isolated cases of dieldrin-induced immunohemolytic anemia have been reported in humans exposed by the inhalation, oral, and dermal routes (Hamilton et al. 1978; Muirhead et al. 1959). However, in epidemiological studies of workers exposed to these substances, similar effects have not been reported (de Jong 1991; Jager 1970). Thus, this effect may be idiosyncratic in nature. As large populations exposed to aldrin or dieldrin may be difficult to find, this response may be better studied in one of the strains of mice known to have a propensity for developing autoimmune diseases. Studies in animals via the oral (Krzystyniak et al. 1985; Loose 1982; Loose et al. 1981) and intraperitoneal routes (Bernier et al. 1987, 1988; Fournier et al. 1986, 1988; Hugo et al. 1988a, 1988b; Jolicoeur et al. 1988; Krzystyniak et al. 1986, 1987, 1989) indicate that aldrin and dieldrin may be immunosuppressive agents, at least during acute- and short intermediate-duration exposures. These studies have also examined the mechanism for the immune suppression. However, additional studies examining potential longer-term effects on the immune system by all three routes as well as short-term effects by the inhalation and dermal routes would be important for estimating human susceptibility for populations exposed for varying amounts of time at hazardous waste sites.

Neurotoxicity. Numerous human studies across all three routes indicate that the central nervous system is a major target of aldrin and dieldrin toxicity (Black 1974; Garrettson and Curley 1969; Hoogendam et al. 1965; Jager 1970; Kazantzis et al. 1964; Patel and Rao 1958; Spiotta 1951). Studies in animals tend to support these findings, although studies in animals have been primarily by the oral route (Burt 1975; Mehrotra et al. 1989; NCI 1978a, 1978b; Smith et al. 1976; Treon et al. 1951b, 1953a; Wagner and Greene 1978; Walker et al. 1969; Woolley et al. 1985). An intermediate-duration oral MRL was developed for dieldrin based on impaired learning in monkeys (Smith et al. 1976). Both *in vitro* and *in vivo* studies in animals have provided a well-defined mechanism of action for neuroexcitation (Abalis et al. 1986; Bloomquist and Soderlund 1985; Bloomquist et al. 1986; Cole and Casida 1986; Gant et al. 1987; Lawrence and Casida 1984; Matsumura and Ghiasuddin 1983; Obata et al. 1988; Shankland 1982). Reports of human intoxication have provided information regarding blood levels that may be associated with the production of severe neurotoxic symptoms (convulsions, muscle jerks) (Brown et al. 1964; Jager 1970). However, information regarding the mechanism of action suggests that more subtle adverse effects of neurologic origin may be produced by aldrin and dieldrin. Thus, studies focusing on less severe forms of neurotoxicity (i.e., affective changes) may be informative. Studies in animals using behavioral paradigms designed to detect such changes or studies in persons exposed to aldrin or dieldrin would be useful for further defining these effects and the exposure levels associated with them.

Epidemiological and Human Dosimetry Studies. Human studies on aldrin and dieldrin consist of either case reports of accidental or intentional poisonings (Black 1974; Garrettson and Curley 1969; Hoogendam et al. 1965; Kazantzis et al. 1964; Patel and Rao 1958; Spiotta 1951) or epidemiological studies of workers employed in the manufacture or application of these agents (de Jong 1991; Ditraglia et al. 1981; Hoogendam et al. 1965; Jager 1970; Morgan and Lin 1978; Morgan et al. 1980; Sandifer et al. 1981; van Raalte 1977; van Sittert and de Jong 1987; Versteeg and Jager 1973; Warnick and Carter 1972). Exposures in the case reports are virtually all oral, whereas exposures in the epidemiological studies are mainly inhalation and dermal, with very slight potential for accidental oral intake. Additional follow-up of cohorts from previously conducted epidemiological studies would be the best approach for obtaining additional human data. Locating new populations for future epidemiological studies is likely to be difficult because aldrin and dieldrin have not been manufactured in the United States since 1974 and the use of these agents has been restricted to termite extermination. Also, because aldrin and dieldrin have not been imported into the United States since 1985, use has been limited to the use of remaining pre-1985 stocks. Thus, at the present time, very few persons are likely to be exposed to aldrin or dieldrin. The only subgroups of the population with possible exposure are termite exterminators and persons who have recently had their homes exterminated. If such groups are located, information regarding immunologic, reproductive, and developmental effects and correlation of these effects with blood levels of dieldrin associated with exposure would be useful.

Biomarkers of Exposure and Effect.

Exposure. Exposure to aldrin and dieldrin is currently measured almost exclusively by determining the level of dieldrin in the blood (Jager 1970). This measure is specific for both aldrin and dieldrin. However, because aldrin is rapidly converted to dieldrin in the body (Wong and Terriere 1965), it is impossible to determine which of the two substances caused the blood levels of dieldrin to rise. Because dieldrin has a long half-life of elimination in humans (Hunter and Robinson 1967; Hunter et al. 1969; Jager 1970), measurement of dieldrin levels in the blood does not give any information about whether an acute-, intermediate-, or chronic-term exposure has occurred, whether such exposures have occurred recently, or whether a substantial period of time has elapsed since exposure occurred. The sensitivity of this biomarker of exposure appears to be sufficient to measure even background levels in the population; thus, no new biomarkers of exposure appear to be needed at this time.

Effect. The central nervous system excitation resulting from aldrin or dieldrin exposure can be monitored, to a great extent, by monitoring EEG changes (Hoogendam et al. 1962, 1965; Jager 1970). Characteristic changes include bilateral synchronous spikes, spike and wave complexes, and slow theta and delta waves (Avar and Czegledi-Janko 1970; Garrettson and Curley 1969; Hoogendam et al. 1962, 1965; Jager 1970; Kazantzis et al. 1964; Spiotta 1951). However, similar changes may be recorded in cases of central nervous system excitation caused by other agents. Thus, this measure is not specific for aldrin- or dieldrin-induced neurotoxicity. Blood levels of dieldrin have been correlated with adverse neurological effects caused by aldrin and dieldrin (Brown et al. 1964; Jager 1970). Such a measurement may also be used to monitor for adverse neurotoxic effects caused by these agents. Also, as understanding of the fundamental mechanism by which aldrin and dieldrin cause central nervous system excitation develops, tests may be developed to specifically monitor for the underlying neurological changes caused by aldrin and dieldrin.

No tests specific for aldrin- or dieldrin-induced toxic effects on the liver or kidney exist; however, standard liver and kidney function tests should be able to identify the hepatic or renal toxicity that is produced. Microsomal enzyme induction may be measured by determining parameters such as urinary levels of D-glucaric acid and the ratio of urinary 6-β-hydroxycortisol to 17-hydroxycorticosteroids. However, these tests are not specific for aldrin or dieldrin. Immune suppression of the type produced by aldrin or dieldrin may be detected by challenge with a T-lymphocyte-dependent antigen; however, this test also is not specific for aldrin or dieldrin.

Absorption, Distribution, Metabolism, and Excretion. Human and animal data are available that show that aldrin and dieldrin are absorbed after exposure via all three routes (Feldmann and Maibach 1974; Graham et al. 1987; Hayes 1974a; Heath and Vandekar 1964; Hunter and Robinson 1967; Hunter et al. 1969; Mehendale and El-Bassiouni 1975; Stacey and Tatum 1985). Quantitative data on the absorption of aldrin and dieldrin in humans and animals following exposure via all routes are limited. Animal studies indicate that aldrin and dieldrin are absorbed rather quickly and that the amount absorbed is proportional to the dose applied for the oral and dermal routes (Graham et al. 1987; Heath and Vandekar 1964; Iatropoulos et al. 1975). However, data concerning absorption rates are needed for all three routes. Because of the limited number of absorption studies for all three routes in general, it would be helpful to have additional quantitative data in animals that might serve as a basis for estimates of absorption in humans.

No studies were located regarding distribution following inhalation exposure to aldrin or dieldrin in humans or animals. Data on distribution via the dermal route for humans were not located. However, numerous data exist that describe distribution after oral administration of aldrin or dieldrin (Adeshina and Todd 1990; Ahmad et al. 1988; Deichmann et al. 1968; DeVlieger et al. 1968; Hayes 1974a; Holt et al. 1986; Hunter and Robinson 1967, 1968; Hunter et al. 1969; Iatropoulos et al. 1975). These studies indicate that dieldrin is distributed in the blood to adipose tissue, brain, and liver tissues, and is then redistributed primarily to fat. Concentrations of dieldrin have been shown to increase in a dose-related manner in blood and adipose tissues of humans and eventually reach a steady state (Hunter and Robinson 1967; Hunter et al. 1969). Kinetic studies in rats and dogs support these findings and provide further information on steady state kinetics following repeated dosing (Baron and Walton 1971; Davison 1973; Ludwig et al. 1964; Walker et al. 1969). Because data are sufficient regarding distribution following oral exposure to aldrin or dieldrin, no more studies via this route are needed. However, inhalation and dermal studies investigating distribution would be valuable because the potential exists for exposure to occur in humans via these routes.

No studies were located regarding metabolism of aldrin or dieldrin in humans and animals via the inhalation route. Also, human data on metabolism via the oral and dermal routes were not located. Metabolism has been characterized in animals following oral exposure (Baldwin et al. 1972; Bedford and Hutson 1976; Chipman and Walker 1979; Hutson 1976; Korte and Arent 1965; Matthews and Matsumura 1969; Matthews et al. 1971; Müller et al. 1975; Wolff et al. 1979; Wong and Terriere 1965). Sex-related and species differences have been observed in metabolism in animals (Baldwin et al. 1972; Hutson 1976; Korte and Arent 1965; Matthews and Matsumura 1969; Matthews et al. 1971). Because differences in metabolism may occur with differences in the route of exposure, it would be useful to have more data on inhalation and dermal metabolic studies as a comparison with the available oral studies.

No human or animal data were located regarding excretion following inhalation or dermal exposure to aldrin or dieldrin. There are, however, a number of studies in animals (Baldwin et al. 1972; Hutson 1976; Klein et al. 1968; Klevay 1970; Ludwig et al. 1964; Matthews et al. 1971; Müller et al. 1975) and a limited number of studies in humans (Hunter et al. 1969; Richardson and Robinson 1971; Schecter et al. 1989b) that describe excretion following oral exposure to aldrin or dieldrin. These studies are sufficient to characterize excretion following oral exposure to aldrin or dieldrin. These studies show quantitatively that the metabolites are excreted primarily in the feces in both humans and animals. Species and sex-related differences in excretion of metabolites have been observed following oral exposure in animals (Baldwin et al. 1972; Hutson 1976; Klein et al. 1968; Klevay 1970; Ludwig et al. 1964; Matthews et al. 1971; Müller et al. 1975). Also, sex-related and species differences have been observed in the rates of excretion. Studies on excretion following inhalation and dermal exposure to aldrin or dieldrin would be useful to determine if excretion patterns vary with different routes.

Comparative Toxicokinetics. Numerous studies using a variety of animal species indicate that the kinetics of aldrin and dieldrin differ across species (Baldwin et al. 1972; Hutson 1976; Klein et al. 1968; Klevay 1970; Ludwig et al. 1964; Matthews et al. 1971; Müller et al. 1975). The differences are primarily quantitative. Although the kinetic data alone do not allow for the identification of target organs common to humans and animals, the distribution data coupled with toxicity data appear to suggest that target organs are similar. Interspecies differences and sex-related differences in rats and mice have been observed for the metabolism and excretion of aldrin and dieldrin. These interspecies differences coupled with a lack of data across different routes indicate that it may be difficult to compare the kinetics of aldrin or dieldrin in animals with that in humans. Further studies across several species and via all three exposure routes would be useful in determining similarities and differences between humans and animals.

Methods for Reducing Toxic Effects. The mechanism by which aldrin and dieldrin are absorbed from the gastrointestinal tract is unknown but is presumed to involve dissolution in the cell membrane. Current methods for reducing absorption from the gastrointestinal tract involve removing these chemicals from the site of absorption (HSDB 2001a, 2001b; Klaassen 1990). Additional studies examining the method of absorption would provide valuable information for developing methods that interfere with gastrointestinal absorption. Numerous studies have examined the distribution of aldrin and dieldrin after gastrointestinal absorption (Adeshina and Todd 1990; Ahmad et al. 1988; Deichmann et al. 1968; DeVlieger et al. 1968; Hayes 1974a; Holt et al. 1986; Hunter and Robinson 1967, 1968; Hunter et al. 1969; Iatropoulos et al. 1975). Additional studies on distribution are not necessary at this time. No established method exists for reducing the body burden of aldrin and dieldrin. However, available information indicates that reducing enterohepatic recirculation or removal from the blood before these chemicals partition to tissue may be effective (Chipman and Walker 1979; Heath and Vandekar 1964; Iatropolous et al. 1975; Richardson and Robinson 1971; Sipes and Gandolfi 1991). Studies examining the effectiveness of repeated doses of activated charcoal, cholestyramine, hemodialysis, and hemoperfusion in reducing body burden would be useful. The neurotoxicity of aldrin and dieldrin is believed to result, at least in part, from interference with GABA function (Abalis et al. 1986; Bloomquist and Soderlund 1985; Bloomquist et al. 1986; Cole and Casida 1986; Gant et al. 1987; Lawrence and Casida 1984; Obata et al. 1988), and benzodiazepines and barbiturates have been effective in mitigating some of the neurological symptoms of aldrin and dieldrin overexposures (Black 1974; Garrettson and Curley 1969; Spiotta 1951). However, additional studies examining the effectiveness of potentiating the GABAergic function in mitigating aldrin and dieldrin's neurologic effects would be helpful. A decrease in the hepatic and renal effects of dieldrin has been observed when animals received ascorbic acid supplements during dieldrin treatment (Bandyopadhyay et al. 1982b). Further study clarifying this effect and identifying a potential mechanism for the mitigating effects of ascorbic acid would be valuable.

Children's Susceptibility. The information on health effects of aldrin and dieldrin in humans is derived mainly from cases of accidental or intentional exposure of adults to high amounts of the pesticide, and the main adverse effect is neurotoxicity. Limited reports of adverse effects in aldrin- or dieldrin-exposed children (Garrettson and Curley 1969; Gupta 1975) indicate similar signs and symptoms to those in adults. Limited animal data indicate that young animals may respond to aldrin or dieldrin differently than adult animals (Buck and Van Note 1968; Lu et al. 1965), but there is no conclusive evidence to suggest that young animals are more susceptible than older ones. Further studies that evaluate a number of different end points in young as well as older organisms would provide valuable information.

No information was located concerning whether the developmental process is altered in humans exposed to aldrin or dieldrin either prenatally or postnatally. Studies in animals have provided conflicting evidence regarding developmental malformations and anomalies (Chernoff et al. 1975; Dix et al. 1977; Ottolenghi et al. 1974), and further well-conducted research would be helpful to clarify this issue. Although animal studies suggest that aldrin and dieldrin may be disruptive of reproductive hormone levels in males and weakly estrogenic in females, additional well-designed studies are needed to clarify the developmental significance of these findings.

No data were located concerning whether pharmacokinetics of aldrin or dieldrin in children are different from adults. Although dieldrin has been detected in human placenta, amniotic fluid, fetal blood, and breast milk (Polishuk et al. 1977b; Schecter et al. 1989b), additional quantitative studies in animals would provide valuable information. There are no PBPK models for aldrin or dieldrin in either adults or children. There is no information to evaluate whether absorption, distribution, metabolism, or excretion of aldrin or dieldrin in children might be different than in adults.

There are no biomarkers of exposure or effect that have been validated in children. There are no data on interactions of aldrin or dieldrin with other chemicals in children, and extremely limited data in adults which are inadequate to determine whether the same effects will be observed in children. There are no pediatric-specific methods to reduce peak absorption of aldrin or dieldrin following exposure, or to reduce body burden, or to interfere with mechanisms of action for aldrin or dieldrin.

Child health data needs relating to exposure are discussed in Section 6.8.1, Identification of Data Needs: Exposures of Children.

3.12.3 Ongoing Studies

On-going studies regarding the health effects of aldrin and/or dieldrin were reported in the Federal Research in Progress File (FEDRIP 2001) database. Table 3-7 presents a summary of ongoing studies that address the health effects of aldrin or dieldrin.

Table 3-7. Ongoing Studies on Aldrin and Dieldrin[a]

Investigator	Affiliation	Research description	Sponsor
Ahmed SA	Virginia Polytechnic Institute, College of Veterinarian Medicine, Blacksburg, VA	The effect of environmental estrogens on the lymphocytes: immunologic cell culture	USDA
Bloomquist JR	Virginia Polytechnic Institute, Blacksburg, VA	Insecticide neurotoxicity and Parkinson's diseases	USDA
Dillon G	University of North Texas, Fort Worth, TX	Neurotoxin interactions with ligand-gated ion channels	NIEHS
Freedman J	Duke University, Durham, NC	Mechanism of stress induced developmental abnormalities	NIEHS
Gross T	University of Florida, Gainesville, FL	Organochlorine pesticides and developmental mortality	NIEHS
Lauder J	University of NC at Chapel Hill, Chapel Hill, NC	Organochlorine pesticides and serotonergic development	NIEHS
Narahashi T	Northwestern University, Chicago, IL	Mode of action of insecticides–electrophysiologic	NINDS
Schwartz S	Fred Hutchinson Cancer Research Center, Seattle, WA	Phytoestrogens, organochlorines and fibroid risk	NIEHS

[a] Derived from FEDRIP 2001

NIEHS = National Institute of Environmental Science; NINDS = National Institute of Neurological Disorders and Stroke; USDA = U.S. Department of Agriculture

4. CHEMICAL AND PHYSICAL INFORMATION

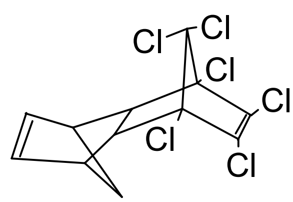
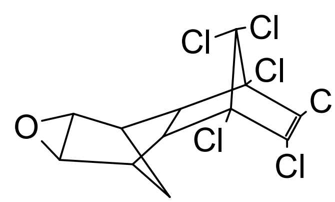
4.1 CHEMICAL IDENTITY

Information regarding the chemical identity of aldrin/dieldrin is located in Table 4-1.

4.2 PHYSICAL AND CHEMICAL PROPERTIES

Information regarding the physical and chemical properties of aldrin/dieldrin is located in Table 4-2.

Table 4-1. Chemical Identity of Aldrin and Dieldrin[a]

Characteristic	Aldrin	Dieldrin
Synonym(s)	1,2,3,4,10,10-Hexachloro-1,4,4α 5,8,8α-hexahydro-exo-1,4-endo-5,8-dimethano- naphthalene; HHDN[b]	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4α,5,6,7,8,8α-octa-hydro-1,4-endo,exo-5,8-dimethanonaphthalene; HEOD[b]
Registered trade name(s)	Aldrec; Aldrex; Drinox; Octalene; Seedrin; Compound 118	Alvit; Dieldrix; Octalox; Quintox; Red Shield[c]
Chemical formula	$C_{12}H_8Cl_6$	$C_{12}H_8Cl_6O$
Chemical structure[d]		
Identification numbers:		
CAS registry	309-00-2	60-57-1
NIOSH RTECS	IO2000000	IO1750000
EPA hazardous waste	P004	PO37
OHM/TADS	7215090[c]	7216516[c]
DOT/UN/NA/IMCO shipping	IM06.1 NA2762	UN2761
HSDB	199	322
NCI	C00044	C00124

[a]All information obtained from HSDB 2001a or 2001b unless otherwise noted.
[b]Tomlin 1997
[c]OHM/TADS 1990b
[d]Verschueren 2001

CAS = Chemical Abstracts Services; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous/Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

Table 4-2. Physical and Chemical Properties of Aldrin and Dieldrin[a]

Property	Aldrin	Dieldrin
Molecular weight	364.91	380.91
Color	White (pure); tan to brown (technical grade)	White (pure); light brown (technical grade)
Physical state	Crystalline solid[b]	Crystalline solid[b]
Melting point	104–105.5 EC[c]; 49–60 EC (technical grade)[c]	176–177 EC[c]; 95 EC (technical grade)[d]
Boiling point	Decomposes[e]	Decomposes[e]
Density	1.6 g/L at 20 EC[f]	1.75 g/L at 25 EC[f]
Odor	Mild chemical odor[e]	Mild chemical odor[e]
Odor threshold:		
Water	No data	No data
Air	0.017 mg/kg[c]	0.041 mg/kg[c]
Solubility:		
Water at 20 EC	0.011 mg/L[g]	0.110 mg/L[g]
Organic solvents	Very soluble in most organic solvents[b]	Moderately soluble in common organic solvents except aliphatic petroleum solvents and methyl alcohol[b]
Partition coefficients:		
Log K_{ow}	6.50[h]	6.2[c]
Log K_{oc}	7.67[i]	6.67[i]
Vapor pressure:		
at 20 EC	$7.5x10^{-5}$ mmHg[b]	$3.1x10^{-6}$ mmHg[b]
at 25 EC	$1.2x10^{-4}$ mmHg	$5.89x10^{-6}$ mmHg[j]
Henry's law constant:		
at 25 EC	$4.9x10^{-5}$ atm-m^3/mol[k]	$5.2x10^{-6}$ atm-m^3/mol[k]
Autoignition temperature	No data	No data
Flashpoint	No data	No data
Flammability limits	Nonflammable[f]	Nonflammable[f]
Conversion factors	1 ppm=14.96 mg/m^3 at 25 EC, 1 atm	1 ppm=15.61 mg/m^3 at 25 EC, 1 atm[l]
Explosive limits	Stable[f]	Stable[f]

[a]All information obtained from HSDB 2001a or 2001b unless otherwise noted.
[b]Budavari et al. 2001
[c]Verschueren 2001
[d]Hayes 1982
[e]NIOSH 1997
[f]Weiss 1986
[g]Bus and Leber 2001
[h]Hansch et al. 1995
[i]Briggs 1981
[j]Grayson and Fosbraey 1982
[k]Guerin and Kennedy 1992
[l]EPA 1987a

5. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.1 PRODUCTION

Aldrin was first synthesized in the United States as a pesticide in 1948 (EPA 1986d). Aldrin and dieldrin have not been produced in the United States since 1974 (Sittig 1985). It is not known how much aldrin and dieldrin are presently stored in the United States.

Aldrin and dieldrin are included on the most recent Toxics Release Inventory (TRI99) as reportable chemicals when released or transferred from TRI99 facilities (TRI99 2001). EPA received one TRI99 form from Safety Keen (Deer Park) Inc. located in Deer Park, Texas. This facility performed the waste treatment of aldrin and reported no other uses. There was no other information available from the TRI99 database concerning aldrin or dieldrin.

Aldrin was manufactured by the Diels-Alder condensation of hexachlorocyclopentadiene with bicyclo[2.2.1]-2,5-heptadiene. The final condensation reaction was usually performed at approximately 120 EC and at atmospheric pressure. Excess bicycloheptadiene was removed by distillation. The final product was usually further purified by recrystallization (Sittig 1980). In 1967, the composition of technical-grade aldrin was reported to be as follows: 90.5% hexachlorohexahydrodimethanonaphthalene (HHDN); 3.5% other polychlorohexahydrodimethanonaphthalene compounds (isodrin); 0.6% hexachlorobutadiene; 0.5% octachlorotetrahydromethanoindene (chlordane); 0.5% octachlorocyclopentene; 0.3% toluene; 0.2% hexachlorocyclopentadiene; 0.1% HHDN di-adduct; <0.1% hexachloroethane; <0.1% bicycloheptadiene; and 3.6% other compounds (IARC 1974a).

Dieldrin was manufactured by the epoxidation of aldrin. The epoxidation of aldrin was obtained by reacting it either with a peracid (producing dieldrin and an acid byproduct) or with hydrogen peroxide and a tungstic oxide catalyst (producing dieldrin and water) (Sittig 1980). Peracetic acid and perbenzoic acid were generally used as the peracid acid (HSDB 2001b). When using a peracid, the epoxidation reaction was performed noncatalytically or with an acid catalyst such as sulfuric acid or phosphoric acid. When using hydrogen peroxide, tungsten trioxide was generally used as the catalyst (Sittig 1980). Dieldrin contained not <85% by weight HEOD and not >15% by weight of insecticidally related compounds (Clayton and Clayton 1994).

5.2 IMPORT/EXPORT

Before the 1974 near-total ban by EPA on aldrin and dieldrin use, aldrin and dieldrin were not imported into the United States. Aldrin was imported from Shell International (Holland) for formulation and limited use in the United States from 1974 to 1985, except when imports were temporarily ceased in 1979 and 1980. Between 1981 and 1985, an estimated 1–1.5 million pounds of aldrin were imported annually. EPA reports that aldrin has not been imported since 1985 (EPA 1986d). No information could be found that explicitly provided information about dieldrin importation.

No information could be found regarding the exportation of aldrin or dieldrin.

5.3 USE

Aldrin and dieldrin are active against insects by contact or ingestion (Hayes 1982). Thus, their primary use was for the control of termites around buildings, corn pests by application to soil and in the citrus industry (EPA 1980a). Other past uses included general crop protection from insects; timber preservation; and termite-proofing of plastic and rubber coverings of electrical and telecommunication cables, and of plywood and building boards (Worthing and Walker 1983). In 1966, aldrin use in the United States peaked at 19 million pounds, but by 1970, use had decreased to 10.5 million pounds. During this same period (1966–1970), annual dieldrin use dropped from 1 million to 670,000 pounds. These decreases were attributed primarily to increased insect resistance to the two chemicals, and to the development and availability of more effective and environmentally safer pesticides (EPA 1980a).

In 1970, the U.S. Department of Agriculture canceled all uses of aldrin and dieldrin based on the concern that these chemicals could cause severe aquatic environmental change and are potentially carcinogenic (EPA 1980a). Early in 1971, EPA initiated cancellation proceedings for aldrin and dieldrin, but did not order the suspension of aldrin and dieldrin use. In 1972, under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act as amended by the Federal Pesticide Control Act of 1972, an EPA order lifted the cancellation of aldrin and dieldrin use in three cases: subsurface ground insertion for termite control; dipping of nonfood plant roots and tops; and moth-proofing in manufacturing processes using completely closed systems (EPA 1980a, 1986d). In 1974, these last two registered uses were voluntarily abandoned by the registrant, Shell Chemical Company (EPA 1986d). The final registered use of aldrin and dieldrin as termiticides was voluntarily canceled by the Scallop Corporation (part of the Shell Chemical Company) on May 15, 1987 (EPA 1989a). Chapman Chemical Company, however, still used aldrin as the active ingredient in their termiticide formulation ALDREC. Chapman's failure to disclose the exact formulation of ALDREC to the EPA forced the EPA to cancel all use of the compound on February 21, 1989. Since this time, all uses of aldrin and dieldrin have been canceled (EPA 1990b).

5.4 DISPOSAL

Aldrin and dieldrin are classified as hazardous wastes (EPA 1988a, 1990c). Subtitle C of the Resource Conservation and Recovery Act of 1976 (RCRA) creates a comprehensive program for the safe management of hazardous waste. Section 3004 of RCRA requires owners and operators of facilities that treat, store, or dispose of hazardous waste to comply with standards established by EPA that are "necessary to protect human health and the environment" (EPA 1987h).

The Chemical Manufacturers Association recommends disposing of aldrin and dieldrin by incineration (HSDB 2001b). Incineration by rotary kiln (at 820–1,600 EC), liquid injection (at 877–1,038 EC), and fluidized bed (at 450–980 EC), with residence times of seconds for gases and liquids and hours for solids, is recommended (HSDB 2001a). Aldrin and dieldrin are often mixed with vermiculite, sodium bicarbonate, or a sand-soda ash mixture prior to incineration (OHM/TADS 1990a). The incineration of these chemicals emits highly toxic fumes of hydrogen chloride and chlorinated breakdown products (HSDB 2001a). Thus, incinerators used for disposal of aldrin and dieldrin must have an acid scrubber and an after-burner (OHM/TADS 1990a). Also, prior to incineration, local air and fire authorities must be contacted (OHM/TADS 1990a, 1990b).

Another recommended disposal method for aldrin and dieldrin is burying the chemicals in landfills. Contaminated material should be buried 8–12 feet underground in an isolated area away from water supplies, with a layer of clay, a layer of lye, and a second layer of clay beneath the wastes (OHM/TADS 1990a). Gravity filtration of solids, followed by dual-media filtration of the liquids, followed by activated carbon adsorption (100–300 pounds of carbon per pound of soluble material) is also an approved disposal method (OHM/TADS 1990b). Finally, disposal of small amounts of aldrin and dieldrin can be accomplished through degradation by active metals (sodium or lithium) in liquid ammonia (HSDB 2001b; Sittig 1985).

6. POTENTIAL FOR HUMAN EXPOSURE

6.1 OVERVIEW

Aldrin was first synthesized in the United States as a pesticide in 1948 (EPA 1986d) while dieldrin was first used by cotton growers in the 1950s (Clayton and Clayton 1994). By 1970, the U.S. Department of Agriculture canceled all uses of aldrin and dieldrin (EPA 1980a). Restrictions on their use as termiticides, for dipping of non-food plant roots and tops, and for moth-proofing were lifted by EPA in 1972. In 1974, however, the latter two uses were voluntarily canceled by the manufacturer, Shell Chemical Company (EPA 1986d). The final registered use of aldrin and dieldrin as termiticides was voluntarily canceled by the Scallop Corporation (part of the Shell Chemical Company) on May 15, 1987 (EPA 1989a). The Chapman Chemical Company, however, continued to use aldrin in their termiticide formulation until it was ultimately canceled by the EPA on February 21, 1989.

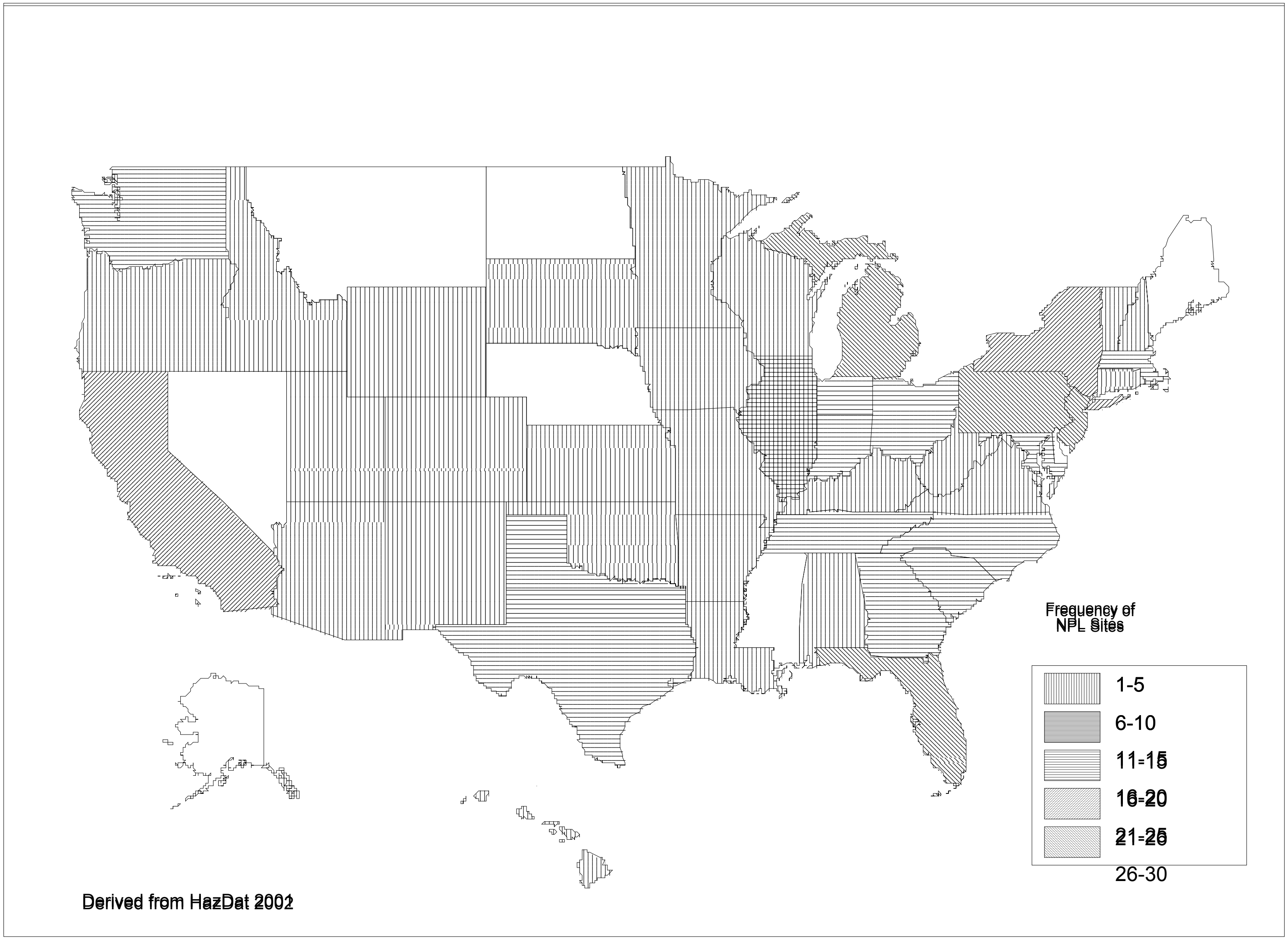
Aldrin is readily converted to dieldrin, which is ubiquitous in the environment. Dieldrin persists because it is more resistant to biotransformation and abiotic degradation than aldrin. As a result, it is found in all environmental media, even at a distance from the site of concentration. Dieldrin bioconcentrates and biomagnifies through the terrestrial and aquatic food chains. Transport of aldrin and dieldrin in soils is minimal because these compounds tend to bind tightly to soil. Based on their physical properties, volatilization from moist soil surfaces is expected. Most dieldrin and aldrin found in surface water are the result of runoff from contaminated soil. Aldrin undergoes photolysis to dieldrin, which in turn may be degraded by ultraviolet radiation or microbial action into the more persistent compound, photo dieldrin.

Past agricultural uses of aldrin and dieldrin have resulted in persisting soil residues and uptake in a wide range of crops. Exposure of the general population to aldrin and dieldrin may occur through ingestion of contaminated water or food products and through inhalation of contaminated air, especially in homes that have been treated with either pesticide.

Aldrin has been identified in at least 207 of the 1,613 hazardous waste sites while dieldrin has been identified in at least 287 of the 1,613 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (HazDat 2002). However, the number of sites evaluated for aldrin and dieldrin is not known. The frequency of these sites can be seen in Figures 6-1 and 6-2. Of these

Figure 6-1. Frequency of NPL Sites with Aldrin Contamination

Figure 6-2. Frequency of NPL Sites with Dieldrin Contamination



sites, 205 of the 207 aldrin sites are located within the United States, 1 is located in the Virgin Islands (not shown), and 1 is located in Puerto Rico (not shown). For dieldrin, 285 of the 287 sites are located within the United States and 2 are located in the country of Guam.

6.2 RELEASES TO THE ENVIRONMENT

Aldrin and dieldrin production and use in the United States has been canceled by the EPA (EPA 1990b). Because of the persistent nature of these compounds, however, these compounds are still present in the environment. Aldrin and dieldrin have been identified in a variety of environmental media (air, surface water, groundwater, soil, and sediment) collected at 207 and 287 of the 1,613 NPL hazardous waste sites, respectively (HazDat 2002).

Aldrin and dieldrin are included on the most recent Toxic Chemical Release Inventory (TRI99) as reportable chemicals when released or transferred from TRI99 facilities (TRI99 2001). EPA received one TRI99 form from Safety Keen (Deer Park) Inc. located in Deer Park, Texas. This facility performed the waste treatment of aldrin and reported no releases to the environment. EPA received no other release data for aldrin or dieldrin, indicating that no reportable releases to the environment occurred in 1999.

The TRI data should be used with caution because only certain types of facilities are required to report. This is not an exhaustive list.

6.2.1 Air

Aldrin has been identified in air samples collected at 6 of the 207 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2002). Dieldrin has been identified in air samples collected at 14 of the 287 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2002).

Past application of aldrin and dieldrin for termite control is a continuing source of contamination of indoor air. In addition, these compounds may be released to the atmosphere from previously treated soil and contaminated surface waters. Release of aldrin and dieldrin into the air may also occur as a result of atmospheric dispersal of contaminated soils at NPL sites and farmlands where these compounds had been used.

6.2.2 Water

Aldrin has been identified in 20 surface water and 93 groundwater samples collected at 207 of the 1,613 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2002). Dieldrin has been identified in 40 surface water and 107 groundwater samples collected at 287 of the 1,613 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2002).

Aldrin and dieldrin may be released to surface waters as a result of runoff from contaminated croplands and NPL sites. Although aldrin and dieldrin are no longer permitted for general use, dieldrin, in particular, has been detected in many waterways and cropping soils. Due to the persistence of these compounds, especially dieldrin, they have been detected in a wide variety of aquatic systems. Aldrin and dieldrin have been detected in seawater samples (Sauer et al. 1989), industrial effluents and fresh water samples (Staples et al. 1985). The high organic carbon partition coefficient (K_{oc}) values for aldrin and dieldrin suggest movement through soil and contamination of groundwater will be minimal. The only reports of aldrin or dieldrin contamination of groundwater occurred at sites with high concentrations of these compounds.

6.2.3 Soil

Aldrin has been identified in 145 soil and 45 sediment samples collected at 207 of the 1,613 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2002). Dieldrin has been identified in 243 soil and 89 sediment samples collected at 287 of the 1,613 NPL hazardous waste sites where it was detected in some environmental media (HazDat 2002).

Possible releases of aldrin and dieldrin to soil may come from the improper disposal of old stocks. Wet and dry deposition of particulate phase aldrin and dieldrin from the atmosphere is another potential source of soil contamination.

6.3 ENVIRONMENTAL FATE

6.3.1 Transport and Partitioning

Experimental log K_{oc} values for aldrin range from 5.38 to 7.67 (Briggs 1981; Ding and Wu 1995). Based on a classification scheme, these log K_{oc} values indicate that aldrin is expected to be immobile in soil (Swann et al. 1983). The mobility of aldrin and dieldrin in the soil environment, however, can be enhanced at hazardous waste sites where organic solvents may be present. These organic solvents have the ability to increase the water solubility of nonpolar compounds which in turn increases their mobility in soil (Sawhney 1989). The organic solvents in a sense act as a transport medium for chemicals that would normally bind strongly to soil. At waste disposal sites, where bioremediation techniques are proposed to reduce the mass of carbon-containing contaminants, there is the potential for augmenting the leaching properties of organochlorine compounds such as aldrin and dieldrin. The lipid materials in bacterial cell membranes may lead to a repartitioning of aldrin and dieldrin sorbed to soil colloids. This can lead to a phenomenon called facilitated transport where the mobility of hydrophobic pollutants adsorbed to soils may be enhanced by biosorption on bacteria and move into aquifers along with the bioremedial bacterial cultures (Lindqvist and Enfield 1992). Except at NPL sites, however, this potential source of groundwater pollution would seem to be remote. This appears to be true in light of the small number of reports of aldrin and dieldrin groundwater contamination at locations other than NPL sites. Volatilization of aldrin from soil is more rapid when it is applied to the soil surface rather than incorporated into the soil. A loss of 50% from a surface application was estimated to occur within 1–2 weeks after application compared to 10–15 weeks for soil-incorporated aldrin (Caro and Taylor 1971; Elgar 1975). The relatively rapid loss of both aldrin and dieldrin from soil during the first few months after application has been attributed to loss by volatilization. The volatilization potential of field-applied dieldrin (10 ppm) was studied for 5 months using three different soil moisture regimes (Willis et al. 1972). The three soil moisture regimes included: (1) flooded to a depth of 10 cm; (2) moist; and (3) nonflooded with no water added except for natural rainfall. The results showed that the soil moisture had an effect on the volatilization rate. About 18% of the applied dieldrin volatilized from a moist plot in 5 months, but only 2 and 7% volatilized from the flooded and nonflooded plots, respectively. Flooding retarded the volatilization potential of surface-applied dieldrin. Volatilization of dieldrin from the non-flooded plot tended to increase with increasing precipitation (Willis et al. 1972).

Volatilization of aldrin from water surfaces is expected (Thomas 1990) based upon a Henry's law constant of 4.9×10^{-5} atm/m^3/mole (Guerin and Kennedy 1992). Volatilization from water surfaces, however, may be attenuated by adsorption to suspended solids and sediment in the water column. The volatile loss of aldrin from sterile, deionized water kept at 30 EC was studied over a 30 day period (Guerin and Kennedy 1992); the volatilization half-life of aldrin from the open flask was 5.8 days. In one study, the desorption of aldrin from sediment into water was investigated (Ding and Wu 1993). Researchers simulated a river bed by spiking a sediment sample with 287.6 ng aldrin/g sediment and passing 7,780 mL water/day over the sediment. The concentration of aldrin detected in the effluent water after one day was 0.135 ng/mL while by day 40, the concentration decreased to 0.06 ng/mL. The concentration of dieldrin was not measured in this study.

According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere (Bidleman 1988), aldrin, which has a vapor pressure of $1.2x10^{-4}$ mmHg at 25 EC (HSDB 2001a), will exist in both the vapor and particulate phases in the ambient atmosphere. Particulate-phase aldrin may be transported through the atmosphere by wind and later removed from air by wet and dry deposition (Millet et al. 1997).

The logarithm of the *n*-octanol/water partition coefficient (log K_{ow}) is a useful preliminary indicator of potential bioaccumulation of a compound. The log K_{ow} for aldrin ranges from 5.68 (McLean et al. 1988) to 7.4 (Briggs 1981), indicating a high potential for bioaccumulation. In modeling ecosystem tests, bioconcentration factors (BCFs) for aldrin were 3,140 in fish and 44,600 in snails (Metcalf et al. 1973). The BCF of aldrin in orange-red killifish was studied over an 8 week period in a semi-static system at 25 EC (CITI 1992.). At a concentration of 1 mg/L, aldrin had BCFs ranging from 3,490 to 20,000, while at 0.1 mg/L, aldrin had BCFs ranging from 1,550 to 9,450.

Experimental evidence indicates that aldrin is rapidly metabolized to dieldrin by some organisms, which then bioconcentrates and biomagnifies (EPA 1980a; Metcalf et al. 1973). Radiolabeled aldrin added to a model ecosystem was rapidly converted to dieldrin. Of the radiolabel stored in organisms, 95.9% of the total stored in the fish *Gambusia affinis*, 91.6% stored in the snails of the genus *Physa*, and 85.7% stored in the algae *Oedogonium cardiacum* were in the form of dieldrin.

Aldrin also bioconcentrates in terrestrial ecosystems. In a model ecosystem study, 2.09 ppm radiolabeled aldrin was applied to a vermicullite soil (Cole et al. 1976). After 20 days, researchers detected only 0.463 ppm aldrin and 0.159 ppm dieldrin. Corn, that had been grown on the vermicullite soil for 14 days, contained 2.83 ppm radiolabeled carbon with 0.762 ppm being aldrin and 1.538 ppm dieldrin. Approximately 78% of the plant residue was in the roots and 22% in the shoots. On day 15, a prairie vole (*Microtus ochrogaster*) was introduced to the model ecosystem. After 5 days of exposure, the concentrations of aldrin and dieldrin in the vole were 0.08 and 3.56 ppm, respectively. To study the uptake of pesticides in plants, radiolabeled aldrin and dieldrin were monitored over one week in a controlled laboratory setting (Kloskowski et al. 1981). After 1 week of exposure of barley plants to 2 ppm of both pesticides, the concentrations of aldrin and dieldrin in plant tissue were 9.7 and 4.0 ppm, respectively. One research study, however, observed no plant uptake of either aldrin or dieldrin in maize and pearl millet over a 3-year period grown in a clay loam soil (Gupta et al. 1979). Aldrin was applied at a rate of 3, 9, and 15 kg active ingredient (ai) per hectare (ha) once per year before the sowing of crops and mixed up to a depth of 10 cm. No residues of either aldrin or dieldrin could be detected in plant tissues from any of the years of experimentation, even at the highest dosage of 15 kg ai/ha.

Biotransfer factors (BTFs) for beef and cow's milk have been determined for aldrin. The concept of biotransfer is useful since it takes into account exposure through both food and water pathways. Biotransfer factors for beef and milk are defined as the concentration of a compound in beef or milk (mg/kg) divided by the daily intake of the compound by the animal (mg/day). The biotransfer values for beef and milk were estimated to be 0.085 and 0.023, respectively (Travis and Arms 1988). Biotransfer factors for aldrin in beef and milk are directly proportional to the K_{ow}. In addition, a BCF for aldrin in vegetables was also determined. The bioconcentration factor was defined as the ratio of the concentration in aboveground parts (mg of compound/kg of dry plant) to the concentration in soil (mg of compound/kg of dry soil); the BCF was estimated to be 0.021 (Travis and Arms 1988). The vegetation bioconcentration factor is inversely proportional to the square root of K_{ow}. The regression equations for beef, milk, and vegetation provide a technique for predicting a chemical's BTF in beef and milk and BCF in vegetation. Consequently, regression analyses will be of value in more precisely quantifying human exposure to organics through the terrestrial food chains (Travis and Arms 1988).

Dieldrin is nonpolar and, therefore, has a strong affinity for organic matter and sorbs tightly to soil particulates based on its log K_{oc} of 6.7 (Briggs 1981). Volatilization is the principal loss process of dieldrin from soil; however, the process is relatively slow due to its low vapor pressure and strong sorption to soil. It may also be impeded by low soil moisture or incorporation of the compound into the soil (Cliath and Spencer 1971). Volatilization of dieldrin from dry soil is slower than aldrin (<10 g/hectare/day) based on its vapor pressure of 5.89×10^{-6} mmHg at 25 EC (Grayson and Fosbraey 1982). The volatilization rate decreases with time (Nash 1983) and increases with increasing temperature to a maximum at 25 EC (Nash and Gish 1989). In one experiment, 150 grams of dieldrin was applied to a sandy loam soil and monitored for volatile loss (Nash 1983). After 11 days, 53.1±14.2 mg had volatilized, while 110±18.6 mg had remained on the soil surface. Based on the Henry's law constant and the K_{oc}, the volatilization half-life of dieldrin from soil has been estimated to be 868 days (Jury et al. 1987b). Movement of dieldrin through the soil solution is extremely slow, indicating little potential for groundwater contamination. Using a low pollution potential scenario (soil with a high organic content and a high average water content), it is estimated that it will take 2,594 years for dieldrin to travel to a depth of 3 meters. Even with a high pollution potential scenario (soil with a low organic content and a low water content), it would still take an estimated 270 years for dieldrin to reach a depth of 3 meters (Jury et al. 1987b). Analysis of environmental groundwater samples, however, have shown that on some occasions, dieldrin has contaminated groundwater systems (EPA 1986i; Hallberg 1989; HazDat 2001). Dieldrin has been estimated to have a sorption coefficient on mixed-liquor solids (typical of municipal waste water treatment plants) of 38.9 mg/g at an equilibrium concentration of 1.0 mg/L (Dobbs et al. 1989). Movement of dieldrin in waterborne sediment is a major loss pathway from treated soil (Caro and Taylor 1971; Eye 1968; Hardee et al. 1964).

Volatilization of dieldrin from water surfaces is expected (Thomas 1990) based upon a Henry's law constant of 5.2×10^{-6} atm/m^3/mole (Guerin and Kennedy 1992). Volatilization from water surfaces, however, may be attenuated by adsorption to suspended solids and sediment in the water column. The volatile loss of dieldrin from sterile, deionized water kept at 30 EC was studied over a 30-day period (Guerin and Kennedy 1992). The study found that the half-life for the volatilization of dieldrin from the open flask was 17 days.

According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere (Bidleman 1988), dieldrin, which has a vapor pressure of 5.89×10^{-6} mmHg at 25 EC (Grayson and Fosbraey 1982), will exist in both the vapor and particulate phases in the ambient atmosphere. Dieldrin may be transported great distances in the atmosphere and be removed by wet or dry deposition (Baldwin et al. 1977; Millet et al. 1997). Snowpack samples were collected at 12 sites in the Northwest Territories, Canada, in the winter of 1985–1986; dieldrin was found in all 21 samples at a mean concentration of 0.75 ng/L (Gregor and Gummer 1989). There were no known local sources of dieldrin in the Canadian Arctic snow. Dieldrin was detected with a mean concentration close to 1 pg/m^3 in arctic air measured at Alert, Canada; Tagish, Canada; and Dunai Island, Canada-Russia in the 1990s (Bidleman 1999).

Like aldrin, dieldrin has a high potential for bioaccumulation as indicated by a log K_{ow} value that ranges from 4.32 (Geyer et al. 1987) to 6.2 (Briggs 1981). Measured bioconcentration factors for dieldrin are 2,700 in fish and 61,657 in snails (Metcalf et al. 1973). A second study using the same model ecosystem found bioconcentration factors for dieldrin to be 6,145 in fish, 7,480 in algae, 247 in crabs (*Uca minax*), 1,015 in clams (*Corbicula manilensis*), 1,280 in the water plant *Elodea*, and 114,935 in snails (Sanborn and Yu 1973). A BCF of 2,095 has been determined for the ciliate *Tetrahymena pyriformis* exposed to 1 μg/mL dieldrin for 12 hours (Bhatnagar et al. 1988). A biomagnification factor of 1.0 has been determined for dieldrin for rainbow trout on a lipid weight basis; the average wet weight bioconcentration factor is 2.3 (Connell 1989). Channel catfish, exposed to varying concentrations of dieldrin, were used to determine when equilibrium was reached between uptake of dieldrin and elimination from muscle tissue. At 13 ppt, equilibrium was reached after 56 days, whereas, at 49 ppt, equilibrium was not reached even after 70 days of exposure (Shannon 1977). The bioaccumulation factor of dieldrin in orange-red killifish was studied over an 8-week period in a semi static system at 25 EC (CITI 1992). At a concentration of 1 mg/L, dieldrin had BCFs ranging from 4,860 to 14,500 while at 0.1 mg/L, dieldrin had a BCF ranging from 5,390 to 12,500.

Biotransfer factors for beef and cow milk and a bioconcentration factor for vegetables have been determined for dieldrin. The biotransfer values for dieldrin in beef and milk were estimated to be 0.008 and 0.011, respectively, while the BCF for vegetables was estimated to be 0.098 (Travis and Arms 1988).

In a biomagnification study, the concentrations of organochlorine compounds in sediments, amphipods, isopods, and sculpins from the Bothnian Bay and the Bothnian Sea were measured (Strandberg et al. 2000). Dieldrin was detected in sediments (three samples), amphipods (three samples), isopods (five samples), and sculpins (three samples) in the Bothnian Bay with mean concentrations of 0.39, 87, 92, and 42 ng/g lipid, respectively. Dieldrin was detected in sediments (three samples), amphipods (four samples), isopods (five samples), and sculpins (three samples) with mean concentrations of 0.51, 110, 55, and 80 ng/g lipid, respectively. Possible explanations given for the low biomagnification factor potential of the sculpin were that it could have less capacity to accumulate hydrophobic organic environmental contaminants or a greater ability to metabolize or excrete the compounds.

Uptake of dieldrin by redworms (*Eisenia foetida*) was determined for Chester and silt loam samples that had been aged with dieldrin for periods of 49 and 30 years, respectively (Morrison et al. 2000). The worms assimilated 10.8% of the dieldrin in unaged Chester loam resulting in a tissue concentration of 53.5 mg/kg. The worms assimilated 4.48% of the dieldrin in the Chester loam aged 49 years resulting in a tissue concentration of 15.1 mg/kg. In unaged silt loam, the worms assimilated 12.8% of the dieldrin resulting in a tissue concentration of 40.0 mg/kg, while the worms in the silt loam aged 30 years assimilated 19.9% of the dieldrin resulting in a tissue concentration of 6.13 mg/kg. It was suggested that the aging dieldrin in field soils reduced acute toxicity and therefore bioavailability to earthworms.

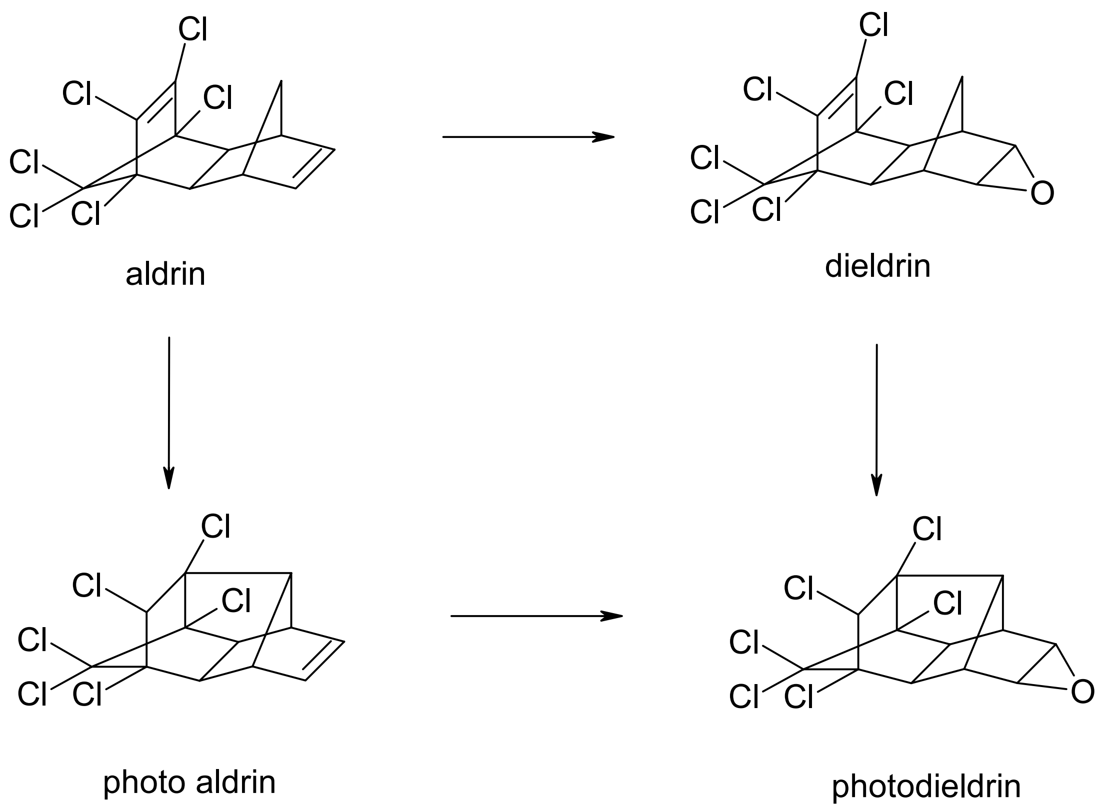
Data indicate that dieldrin is taken up by various crops (Beall and Nash 1969, 1971). To determine whether foliar contamination of soybean plants occurred via root sorption or vapor sorption, 20 ppm ^{14}C-dieldrin was applied to surface or subsurface soil, and residue levels in soybean plants were determined (Beall and Nash 1971). The results indicated that foliar contamination by dieldrin occurred by both root sorption (10.8 ppm) and vapor sorption (8.5 ppm) (Beall and Nash 1971). In a greenhouse experiment, various crop seedlings took up dieldrin from soils treated with 0.5 or 5.0 ppm dieldrin (Beall and Nash 1969). Mean concentrations of dieldrin found in soybeans, wheat, corn, alfalfa, brome grass, and cucumber treated with 0.5 ppm dieldrin were 0.017, 0.147, 0.017, 0.031, 0.075, and 0.070 ppm (dry weight). Mean concentrations of dieldrin found in soybeans, wheat, corn, alfalfa, brome grass, and cucumber treated with 5.0 ppm dieldrin were 0.194, 1.385, 0.171, 0.350, 0.808, and 0.185 ppm (dry weight) (Beall and Nash 1969).

6.3.2 Transformation and Degradation

6.3.2.1 Air

While the evidence supports the view that a considerable proportion of the aldrin and dieldrin used in agriculture reaches the atmosphere, it seems probable that atmospheric degradation and wet and dry deposition prevents accumulation of aldrin. In laboratory studies, vapor-phase aldrin is photochemically isomerized and epoxidated by sunlight to photoaldrin, dieldrin, or photodieldrin (see Figure 6-3) (Glotfelty 1978). In order to determine the potential for photodegradation to occur in the ambient atmosphere, the degradation of aldrin and dieldrin was studied on thin film plates and exposed to environmental ultraviolet (UV) radiation (>290 nm) (Chen et al. 1984). Aldrin and dieldrin had photodegradative half-lives of 113 and 153 hours, respectively. Researchers also reported that aldrin and dieldrin have UV absorbance maximums of 227 and 229 nm, respectively. Irradiation of aldrin (5 mg) vapor with ultraviolet light for 45 hours resulted in the formation of photoaldrin (20–30 ug) and dieldrin (50–60 ug). Irradiation of either photoaldrin (2 mg) or dieldrin (0.5 mg) vapor for 65 hours and 91 minutes, respectively, resulted in a single photoproduct, photodieldrin (20–30 ug), which was resistant to further photolyses (Crosby and Moilanen 1974). Since photodieldrin no longer contains a chromophore, it is believed to be a stable photoproduct of aldrin (dieldrin) (Glotfelty 1978). Results of a

Figure 6-3. Aldrin Degradation



laboratory study, however, revealed that photolysis of photoaldrin and photodieldrin in the presence of triethylamine gave photometabolites arising from the loss of chlorine atoms (Dureja et al. 1986). Information regarding the persistence of photodieldrin in the atmosphere was not located; however, air samples taken in 1973 in Ireland contained dieldrin, but neither aldrin nor the photoproducts of aldrin or dieldrin were detected (Baldwin et al. 1977).

Vapor-phase aldrin and dieldrin are expected to degrade in the atmosphere by reaction with photochemically-produced hydroxyl radicals. The half-lives for this reaction in air are estimated to range from 1 to 10 hours for aldrin and 3 to 30 days for dieldrin based on an estimated rate constant (Kwok and Atkinson 1995). Vapor-phase aldrin may also be degraded in the atmosphere by reaction with ozone. Although there are no experimental data, reaction with ozone is expected to be an important atmospheric degradation reaction for aldrin in the vapor phase. An estimated half-life for this reaction ranges from 19 minutes to 2 hours (Atkinson and Carter 1984). Studies indicate that aldrin will also react with nitrogen dioxide in the ambient atmosphere to produce dieldrin (Nojima et al. 1982). After 3 hours of exposure to nitrogen dioxide and UV radiation >290 nm, 32% of vapor-phase aldrin was converted to dieldrin. Aldrin and dieldrin may be more stable than implied by these lifetimes if they are associated with particulate matter in the atmosphere. Particulate-phase aldrin and dieldrin, however, will not participate in hydroxyl radical reactions in the atmosphere.

6.3.2.2 Water

The resistance of aldrin and dieldrin to soil leaching generally precludes their appearance in groundwater. The general absence of aldrin and dieldrin from groundwater samples supports this conclusion (Richard et al. 1975; Spalding et al. 1980). The potential for surface runoff of aldrin and dieldrin in soils is supported by reports of detectable quantities of these compounds in surface waters (Hindin et al. 1964; Richard et al. 1975).

Aldrin, irradiated with ultraviolet light in an oxygenated aqueous solution, underwent little change except in the presence of amino acids and humic acids present in natural waters (Ross and Crosby 1975, 1985). In filtered natural field water, aldrin was photooxidized by 75% to dieldrin after 48 hours of irradiation at 238 nm (Ross and Crosby 1985). More than 80% of the initial dieldrin added to natural water (from a drainage canal in an agricultural area) was present after 15 weeks of incubation in the dark (Sharom et al. 1980). Dieldrin exposed to sunlight is converted to photodieldrin, a stereoisomer of dieldrin. It is unlikely, however, that photodieldrin occurs widely in the environment. Microorganisms isolated from lake water and lake-bottom sediments may convert dieldrin to photodieldrin under anaerobic conditions (Fries 1972). The stability of dieldrin and aldrin was determined in distilled (pH 6.8) and roof water (pH 7.4) (McDougall et al. 1994). The samples were kept in the dark, at 23 EC over a 36-week period. The study found that after 36 weeks, dieldrin remained stable while aldrin degraded in both roof water and distilled water. The half-lives of aldrin in distilled water and roof water were 4.9 and 5.1 weeks, respectively. The study did not find dieldrin as a breakdown product of aldrin degradation. An extrapolated hydrolysis rate constant of 3.8×10^{-5} $hour^{-1}$ at pH 7 and 25 EC has been determined for aldrin based on a measured value at 75 EC (EPA 1989d). The half-life for this reaction is 760 days.

Aldrin was degraded under anaerobic conditions in biologically active waste water sludge (pH 7–8, 35 EC) with a half-life of <1 week (Hill and McCarty 1967). Under aerobic conditions, however, only 1.5% of aldrin degraded when exposed to an activated sewage sludge (Freitag et al. 1985). Aldrin has a reported biodegradation half-life of 24 days in surface waters based on a non-acclimated river die-away test (Eichelberger and Lichtenberg 1971). Dieldrin does not undergo any significant degradation in biologically active waste water sludge or by sewage sludge microorganisms under anaerobic conditions (Battersby and Wilson 1988; Hill and McCarty 1967). After 48 hours of continuous anaerobic digestion with primary sludge, dieldrin was degraded by only 11% (Buisson et al. 1990). Likewise, when incubated for 32 days with anaerobic sludge, only 24% of the dieldrin was removed (Kirk and Lester 1988). In contrast, aerobic incubation with activated sludge removed 55% of the dieldrin in 9 days (Kirk and Lester 1988). A mixed, anaerobic microbial enrichment culture was able to degrade 10 µg/mL dieldrin by 50% in 30 days. Syn-monodechlorodieldrin and anti-monodechlorodieldrin, both of which are resistant to microbial degradation, were identified as the initial degradation products (Maule et al. 1987). In another study, dieldrin was degraded by 30–60% using activated sludge treatment, with the most effective removal by activated sludge aged 4 days as opposed to sludge aged 6 and 9 days (Buisson et al. 1988). Both aldrin and dieldrin, present at 100 mg/L, reached 0% of their theoretical biological oxygen demand (BOD) in 2.5 weeks using an activated sludge inoculum at 30 mg/L and the Japanese Ministry of International Trade and Industry (MITI) test (CITI 1992).

Dieldrin undergoes minor degradation to photodieldrin in marine environments. The marine algae of the genus *Dunaliella* had the maximum degradation activity, degrading 23% of aldrin to dieldrin and 8.5% of dieldrin to photodieldrin (Patil et al. 1972).

6.3.2.3 Sediment and Soil

In the soil, aldrin is converted to dieldrin by epoxidation (Gannon and Bigger 1958). Aldrin epoxidation occurs in all aerobic and biologically active soils, with 50–75% of end-season residues detected as dieldrin. The transformation of aldrin to aldrin acid also occurs in soils. The half-life of aldrin in soil is estimated to be 53 days. Mathematical modeling estimates that aldrin, applied to soil up to 15 cm in depth, will degrade to dieldrin by 69% after 81 days. At a typical soil application rate of 1.1–3.4 kg/hectare, the half-life of aldrin was estimated to be 0.3 years with 95% disappearance in 3 years (Freedman 1989). Loam soils treated with aldrin at 25 pounds per 5-inch acre over a 5-year period from 1958 to 1962 contained in the fall of 1968, 4–5% of the applied dosages mainly in the form of dieldrin. Aldrin treated soils also contained photodieldrin, which amounted to 1.5% of the recovered dieldrin (Lichtenstein et al. 1970). The degradation of aldrin and dieldrin was studied under upland and flooded soil conditions (Castro and Yoshida 1971). For the upland soil condition, water was added to give 80% of the maximum water-holding capacity of the soil. For the flooded soil condition, the water level was maintained 5 cm above the soil surface resulting in an anaerobic environment. Results showed that aldrin was more persistent in flooded than in upland soil. After 2 months of incubation under upland conditions, 33–58% of added aldrin remained in the soil. Under flooded conditions, 64–81% remained in the soil (Castro and Yoshida 1971).

The change in aldrin concentration and its conversion to dieldrin was also studied over a 3-year period in a clay loam soil in India (Gupta et al. 1979). Aldrin was applied at a rate of 3, 9, and 15 kg active ai/ha once per year before the sowing of crops and mixed up to a depth of 10 cm. After the first year of application at 3, 9, and 15 kg ai/ha, the concentrations of aldrin in soil were 1.801, 3.665, and 8.797 ppm, respectively. By the end of the third year, the concentrations of aldrin was 1.824, 3.453, and 9.736 ppm for the three application rates of 3, 9, and 15 kg ai/ha, respectively. Dieldrin was detected as a breakdown product of aldrin by the third year at a concentration of 0.055, 0.245, and 0.695 ppm for the three application rates, respectively. Maize and pearl millet grown on the treated soil were also analyzed for aldrin and dieldrin concentrations. No residues of either aldrin or dieldrin could be detected in plant samples from any of the years of experimentation, even at the highest application rate of 15 kg ai/ha.

Dieldrin is much more resistant to biodegradation than aldrin (Castro and Yoshida 1971; Gannon and Bigger 1958; Jagnow and Haider 1972; Willis et al. 1972). Of 20 soil microbes that were able to degrade dieldrin, only 13 of them could also degrade aldrin to dieldrin (Patil et al. 1970). The bacteria *Aerobacter aerogenes* aerobically degraded approximately 12% of dieldrin to aldrin diol within 5 days, but no further degradation was detected with increased incubation periods (Wedemeyer 1968). At a soil application rate of 1.1–3.4 kg/hectare, dieldrin was estimated to have a half-life of 2.5 years and a 95% disappearance from soil in 8 years (Freedman 1989), although other studies indicate that dieldrin loses between 75 and 100% of its biological activity in 3 years (Jury et al. 1987b). After 6 months, dieldrin persisted in moist, flooded, and nonflooded soils, indicating that these three soil moisture conditions had no effect on the degradation of soil-incorporated dieldrin (Willis et al. 1972). The roots of grass grown on the plots contained 11.6 ppm dieldrin while the aerial grass parts contained only 0.05 ppm (Voerman and Besemer 1975). Twenty-one years after the application of dieldrin to the foundation of a house at an application rate commonly used for termite control, 10% of the original dieldrin remained, primarily in the upper 6 inches of soil (Bennett et al. 1974). Aldrin and dieldrin applied to soil may also undergo degradation by ultraviolet light to form photodieldrin; this reaction may occur as a result of microbial action as well (Matsumura et al. 1970; Suzuki et al. 1974). After ultraviolet irradiation for 168 hours, dieldrin applied to various environmental media was found to be photodecomposed by 9.6% on loam soil, 1.2% on clay soil, and 44% on activated charcoal; the degradation products were photodieldrin and an unknown compound (Elbeit et al. 1983). Residues in soil samples found after application of dieldrin to soil (0.83 kg/hectare in soil that already contained 0.521 ppm dieldrin) consisted largely of unchanged dieldrin (2.581 ppm) and photodieldrin (0.029 ppm).

6.3.2.4 Other Media

No studies were located regarding the degradation or transformation of aldrin or dieldrin in other media.

6.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

Aldrin is readily converted to dieldrin in the environment. Dieldrin is subject to atmospheric transport, and, as a result, is ubiquitous in the environment. Dieldrin persists because it is relatively resistant to biotransformation and abiotic degradation. Thus, it is found in low levels in all media (air, water, and soil).

6.4.1 Air

Aldrin and dieldrin enter the atmosphere through various mechanisms such as spray drift during application of the compounds as insecticides, water evaporation, and suspension of particulates to which the compounds are absorbed. The analysis of 2,479 air samples from 16 states from 1970 to 1972 revealed the following ambient concentrations: aldrin, mean 0.4 ng/m^3 (3x10^{-5} ppb), 13.5% of samples positive; dieldrin, mean 1.6 ng/m^3 (1x10^{-4} ppb), 94% of samples positive (Kutz et al. 1976).

The annual atmospheric deposition of dieldrin to the five Great Lakes was estimated based on measurements taken in the late 1970s (Eisenreich et al. 1981). The results indicated that 0.54, 0.38, 0.55, 0.17, and 0.13 metric tons/year were deposited into Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario, respectively. The annual mean gas-phase, particulate-phase, and precipitation concentrations of dieldrin were studied over the U.S. Great Lakes from 1990 to 1992 (Hoff et al. 1996). The annual mean gas-phase concentrations of dieldrin over Lakes Superior, Michigan, Erie, and Ontario were 14, 34, 30, and 23 pg/m^3, respectively. The particulate-phase concentrations of dieldrin over Lakes Superior, Michigan, Erie, and Ontario were 1.5, 1.9, 3.2, and 1.6 pg/m^3, respectively. Finally, the concentrations of dieldrin in precipitation falling over Lakes Superior, Michigan, Erie, and Ontario were 0.4, 0.99, 0.8, and 0.6 ng/L, respectively. The total wet deposition of dieldrin in 1992 for Lakes Superior, Michigan, Erie, and Ontario was 21, 58, 28, and 11 kg, respectively. More recent data on the atmospheric concentrations of aldrin and dieldrin were gathered in 1986, approximately 10 years after the use of aldrin and dieldrin was restricted in the Great Lakes Basin (Chan and Perkins 1989). It was found that aldrin was present in 5 of 75 wet precipitation samples at three of four sampling sites located around the basin. Two of the three sites had a mean concentration of 0.01 ng/L (1.0x10^{-5} ppb), while the third site had a mean concentration of 0.24 ng/L (2.4x10^{-4} ppb). Dieldrin was detected at all four sites and in >60% of the samples at mean concentrations ranging from 0.41 to 1.81 ng/L (4.1x10^{-4}–1.8x10^{-3} ppb). The highest concentrations of both aldrin and dieldrin were found in samples collected at Pelee Island at the western end of Lake Erie (maximum concentrations of 3.4 ng/l [3.4x10^{-3} ppb] and 5.9 ng/L [5.9x10^{-3} ppb], respectively). In 1979–1980, dieldrin was detected in the ambient air and rainfall over College Station, Texas, at average concentrations of 0.08 ng/m^3 (5.1x10^{-6} ppb) and 0.80 ng/L (8x10^{-4} ppb), respectively (Atlas and Giam 1988). The washout ratio (concentration in rain/concentration in air) for dieldrin was calculated to be 8.9. Dieldrin was present in rainfall measured at three points in Canada during 1984, at mean concentrations of 0.78 ng/L (7.8x10^{-4} ppb) over Lake Superior, 0.27 ng/L in New Brunswick, and 0.38 ng/L (3.8x10^{-4} ppb) over northern Saskatchewan (Strachan 1988).

Between 1991 and 1993, 18 fogwater samples, 31 rainwater samples, and 17 atmosphere (gas and particles) samples were analyzed for aldrin and dieldrin from a rural area in Colmar, east of France (Millet et al. 1997). The mean concentrations of aldrin and dieldrin in fogwater collected from 1991 to 1993 were 3.5 and 5 ng/mL, respectively. The mean concentrations of particle bound aldrin and dieldrin in fogwater collected from 1991 to 1993 were 15 and 17 ng/mL, respectively. The mean concentrations of aldrin and dieldrin in rainwater collected in 1992 were 0.05 and 0.5 ng/ml, respectively. The mean concentration for both aldrin and dieldrin in the vapor-phase collected in 1992 was the same at 0.7 ng/cm^3. Finally, the mean concentrations of aldrin and dieldrin in the particulate phase collected in 1992 were 0.6 and 0.7 ng/mL, respectively.

The atmospheric concentration of both aldrin and dieldrin were studied in the National Park of Ordesa, Spain from April to August 1995 (Nerin et al. 1996). The study found that on April 10 and August 23, the concentration of aldrin was below detection limit (1 pg/m^3) while on June 23, the concentration of aldrin was 12 pg/m^3. The concentration of dieldrin on April 10 was also below the detection limit (1 pg/m^3), but was detected at a concentrations of 6 and 3 pg/m^3 on June 23 and August 23, respectively.

6.4.2 Water

A comprehensive study of U.S. drinking water samples (1975) revealed that <17% of the samples contained dieldrin, with 78% of the positive samples containing concentrations between 4 and 10 ng of dieldrin per L of water (0.004–0.01 ppb) (EPA 1980a). In a recent study, the concentration of various pesticides were measured six times from September 1995 to September 1996 in drinking water samples from 80 randomly selected residences of Maryland (MacIntosh et al. 1999). Dieldrin was not detected in any of the samples taken during this test (limit of detection=25 μg/L). Between November 1, 1983 and July 1, 1992, the California EPA tested various wells for pesticide residues throughout the state of California (California EPA 1995). Aldrin and dieldrin were not detected in any of the 1,304 wells (covering 33 counties) sampled during this study. In another study, dieldrin residues were analyzed for in 208 well water samples collected from nine urban areas from across the United States (Kolpin et al. 1997). Dieldrin was detected in 2.4% of wells samples (detection limit=0.005 μg/L) at a maximum concentration of 0.045 μg/L. Along the north coast of Australia, 659 water samples were surveyed for pesticide residues (McDougall et al. 1994); 20% of storage tanks of domestic water supplies were contaminated with dieldrin at or above 0.05 μg/L.

In earlier studies, dieldrin was found more often than any other pesticide in water samples collected from all major river basins (mean concentration, 7.5 ng/L [0.0075 ppb]) in the United States (Weaver et al. 1965). In 1976, dieldrin was reported in many fresh surface waters of the United States with mean concentrations ranging from 5 to 395 ng/L (0.005–0.395 ppb) (EPA 1980a). Data maintained in the STORET database for 1980–1982 included aldrin and dieldrin concentrations in industrial effluent, ambient water, sediments, and biota. Median values from all STORET stations were as follows (Staples et al. 1985):

	Aldrin			Dieldrin		
Media	Median (ppb)	Number of samples	Percentage detectable	Median (ppb)	Number of samples	Percentage detectable
Effluent	<0.01	677	3.1	<0.01	676	3.7
Water	0.001	7,891	40.0	0.001	7,609	40.0
Sediment	0.1	2,048	33.0	0.8	1,812	33.0
Biota	<0.1	211	0	0.03	530	41

Influent and effluent samples from New York City's 14 water pollution control plants were collected and analyzed six times during the course of 5 years (1989–1993) to determine the concentration of chemical contaminants (Stubin et al. 1996). Of the 168 samples collected, aldrin was detected in 12 influent water samples in 1990, once in 1992 and 9 times in 1993. The concentration of aldrin in influent samples ranged from 0.024 to 1.1 μg/L. Aldrin was also detected in effluent samples 11 times in 1990, twice in 1992, and six times in 1993. The concentration of aldrin in effluent samples ranged from 0.008 to 0.44 μg/L. Dieldrin, however, was not detected in any influent samples, and was only detected in two effluent samples taken in 1993. The concentration of dieldrin in the effluent samples ranged from 0.012 to 0.028 μg/L.

In 1980, aldrin and dieldrin were detected in water samples taken from the Inner Harbor Navigation Canal of Lake Pontchartrain (New Orleans, Louisiana) on the ebb and flood tides at a depth of 1.5 meters; respective concentrations were 0.3 ng/L (0.0003 ppb) and 5.6 ng/L (0.0056 ppb) for aldrin and 0.6 ng/L (0.0006 ppb) and 5.9 ng/L (0.0059 ppb) for dieldrin (McFall et al. 1985). In 1987, dieldrin was detected in seawater samples taken from the Gulf of Mexico at concentrations ranging from 0.009 to 0.02 ng/L ($9x10^{-6}$–$2x10^{-5}$ ppm) and from seawater off the southeastern United States at 0.007–0.01 ng/L ($7x10^{-6}$–$1x10^{-5}$ ppm); aldrin was also detected in the southeastern U.S. coastal waters at concentrations of 0.31–1.5 ng/L (0.0003–0.001 ppb) (Sauer et al. 1989). Aldrin and dieldrin were detected in water and sediment samples taken between 1975 and 1980 at 160–180 stations on major rivers of the United States as part of the National Pesticide Monitoring Program. Aldrin and dieldrin were both detected in 0.2% of the 2,946 water samples and in 0.6 and 12% of the approximately 1,016 sediment samples, respectively (USGS 1985). In 1988, dieldrin was detected in 9% of 422 groundwater samples taken from a sandy, alluvial aquifer in Illinois at a median concentration of 0.01 μg/L ($1.0x10^{-5}$ ppb), and in 4% of groundwater well samples taken in the vicinity of an agrichemical dealer facility, at a mean concentration of 0.03 μg/L ($3.0x10^{-5}$ ppb) (Hallberg 1989). Out of 2,459 sites from the largest river basins and aquifers in the United States tested between 1992 and 1996, dieldrin had a frequency of detection of 1.63% and a maximum concentration of 0.068 μg/L (Koplin et al. 2000).

Analysis of urban storm water runoff collected between 1979 and 1983 in the Canadian Great Lakes Basin found dieldrin to be present in approximately 32 of 124 water samples at a mean concentration of $5.1x10^{-4}$ μg/L ($5.1x10^{-4}$ ppb) and in approximately 17 of 110 runoff sediment samples at a mean concentration of $4.4x10^{-3}$ mg/kg (4.4 ppb). Aldrin was found in approximately 13 of 129 runoff sediment samples at a mean concentration of $1.2x10^{-3}$ mg/kg (1.2 ppb) but was not detected in any water samples (Marsalek and Schroeter 1988). These concentrations resulted in mean annual loadings to the Canadian Great Lakes Basin of 0.2 kg/year for aldrin and 0.6 kg/year for dieldrin. In 1982, water samples taken from 19 U.S. cities for the National Urban Runoff Program, found aldrin to be present only in samples taken from Washington, D.C., at a concentration of 0.1 μg/L (0.1 ppb) (6% of samples), and dieldrin was detected only in water from Bellevue, Washington, at 0.008–0.1 μg/L (0.008–0.1 ppb) (2% of samples) (Cole et al. 1984). Water sampling conducted during the 1986 spring isothermal period in the Great Lakes did not detect aldrin in any samples. Dieldrin, however, was present in all samples at mean concentrations ranging from 0.300 ng/L (0.0003 ppb) for Lake Superior to 0.402 ng/L ($4.2x10^{-4}$ ppb) in Lake Erie (Stevens and Neilson 1989).

Aldrin was identified in leachate from the Love Canal industrial landfill in Niagara Falls, New York, at a concentration of 0.023 mg/L (23 ppb) (data were gathered prior to 1982) (Brown and Donnelly 1988). In 1986, a waste site was identified in Clark County, Washington, that contained buried drums believed to have originally held chemicals used at a plywood manufacturing plant. Analysis of the soil and water contamination found aldrin to be present in groundwater samples taken from shallow wells on site at a maximum concentration of 2.12 μg/L (2.12 ppb) and in groundwater samples from nearby private wells at 0.79 μg/L (0.79 ppb) (EPA 1986i). At a hazardous waste site in Gallaway, Tennessee, drums and bottles containing chemicals from a pesticide blending operation had been emptied or discarded into a number of small ponds on the site. Dieldrin was present in on-site surface waters at 0.40–1.4 ppb, but was not detected in any off-site water samples (EPA 1987i).

6.4.3 Sediment and Soil

As a result of the rapid conversion of aldrin to dieldrin, soil residues of dieldrin are found in higher concentration and with greater frequency than residues of aldrin, even though aldrin was applied more frequently to the soil. The amount of dieldrin and aldrin residues in soils was monitored from 12 separate farm lands located in the Fraser Valley of British Columbia, Canada in 1989 (Szeto and Price 1991). Each farm had a known history of at least 25 years of vegetable growing and use of various pesticides. Aldrin was detected on one farmland with muck soil at a mean concentration of 78 ppb dry weight, while dieldrin was detected on two farmlands containing muck soils at a mean concentration of 692 ppb dry weight (range from 104 to 1,280). In a separate study, the concentration ranges of dieldrin in agricultural soil samples taken in 1995 and 1996 from Alabama, Ohio, Indiana, and Illinois were not detected (nd)–23, nd–4250, nd–69, and nd–13 ng/g dry weight, respectively (Bidleman 1999).

An analysis of sediment samples taken from Lake Ontario in 1981 showed that dieldrin levels had increased from approximately 26 ng/g (26 ppb) in 1970 to 48 ng/g (48 ppb) in 1980, although the use of dieldrin was banned in much of the Great Lakes Basin in the early 1970s (Eisenreich et al. 1989). The National Soils Monitoring Program (Kutz et al. 1976) detected dieldrin in soils at varying concentrations and areas throughout 24 states; the mean concentration ranged from 1 to 49 ppb. At a hazardous waste site in Gallaway, Tennessee, drums and bottles containing chemicals from a pesticide blending operation had been emptied or discarded into a number of small ponds on the site. Dieldrin was present in sediment samples from on-site ponds at 1,400 ppb and in one off-site sediment sample (concentration not specified) (EPA 1987i). Sediment samples taken from two lakes near the U.S. Army Rocky Mountain Arsenal, Colorado in 1983, indicated that aldrin and dieldrin persisted in the sediments long after deposition ceased. Concentrations up to 2,050 ppb for aldrin and 100 ppb for dieldrin at a core depth of approximately 21 cm were found in one lake. A second lake also had elevated levels of aldrin and dieldrin contamination, but at lower concentrations (approximately 250 ppb for aldrin and 40 ppb for dieldrin) and at a lower core depth, indicating that most of the deposition had occurred at an earlier date (Bergersen 1987). The concentration of dieldrin and aldrin was also studied in sediment samples from three coastal lagoons in the southeast of the Gulf of Mexico (Botello et al. 1994). The average concentrations of aldrin in sediment samples taken from the Carmen, Machona, and Alvarado lagoons were 0.70, 1.15, and 2.11 ng/g dry weight, respectively. The average concentrations of dieldrin in sediment samples taken from the Carmen, Machona, and Alvarado lagoons were 6.84, 0.59, and 2.05 ng/g dry weight, respectively. A monitoring survey of 17 wetland areas in the north central United States, found dieldrin to be present in only one Iowa sediment sample at 170 ng/g (170 ppb) dry weight (Martin and Hartman 1985).

6.4.4 Other Environmental Media

The persistence of dieldrin in the environment is demonstrated by a monitoring survey conducted in and around cotton fields in four counties in Alabama between 1972 and 1974. Although cotton farmers had not used aldrin or dieldrin "for several years," dieldrin was found to be present at 7–40 ppb in 50% of the soil samples; at <100 ppb in 50% of forage samples with levels declining over time; at an average concentration of 1,490 ppb in 11 of 19 rat tissue samples with number of positive samples increasing between 1973 and 1974; at low levels in some quail tissue samples (maximum level=790 ppb); at levels declining from 302 to 70 ppb between 1972 and 1974 for mockingbird tissue samples; and at <30 ppb in most of the 25% positive fish tissue samples taken from farm ponds (Elliott 1975). Aldrin was estimated to have a half-life of 1.7 days on crops with the half-life of dieldrin ranging from 2.7 to 6.8 days depending on the crop and formulation (Willis and McDowell 1987). These half-life values were based on the disappearance of aldrin and dieldrin due to volatilization, adsorption to plant surfaces, relative humidity, rain, wind, temperature, and sunlight.

Dieldrin was detected in the liver and fat of arctic ground squirrels trapped near three lakes located at the foothills of the Brooks Range, Alaska between 1991 and 1993 (Allen-Gil et al. 1997). The mean concentrations of dieldrin in squirrel liver from Elusive Lake (seven samples), Feniak Lake (seven samples), and Schrader Lake (seven samples) were 10.91, 1.53, and 14.42 µg/g wet weight, respectively. The mean concentrations of dieldrin in squirrel fat from Elusive Lake (no samples), Feniak Lake (seven samples), and Schrader Lake (five samples) were below the minimum detectable limit, 0.0, and 0.5 µg/g wet weight, respectively.

Blood samples were collected and analyzed for dieldrin concentrations from nestling bald eagles at active nests in the Canadian portion of the Great Lakes Basin from 1990 to 1994 (Donaldson et al. 1999). Mean dieldrin concentrations in eagle blood samples taken from Lake Erie, Huron, Nipigon, Superior, and Woods were 0.003 (30 samples), 0.007 (1 sample), 0.0031 (7 samples), 0.0051 (11 samples), and 0.0031 mg/kg wet weight (2 samples), respectively. Residue levels of dieldrin in unhatched bald eagle eggs collected along Lake Erie from 1974 to 1980 (six samples) and from 1989 to 1994 (six samples) were 1.28 and 0.49 mg/kg wet weight, respectively. Seven bald eagle eggs from the Tanana River, Alaska collected in 1990 and 1991 contained dieldrin with a mean concentration of 0.028 ppm (Ritchie and Ambrose 1996). Peregrin falcon eggs from Rankin Inlet collected from 1991 to 1994 (20 samples) and from 1982 and 1986 (36 samples) contained dieldrin at mean concentrations of 0.361 (range of 0.13–1.66) and 0.41 (range of 0.045–1.80) µg/g wet weight, respectively (Braune et al. 1999). Osprey eggs collected at five locations on the Fraser River from 1991 to 1997 contained dieldrin; the highest concentrations were reported at the Fraser River site below Quesnel with a mean value of 5.2 µg/kg wet weight (Elliott et al. 2000). Lower concentrations were reported for eggs collected at the other locations with mean values generally <2 µg/kg wet weight. dieldrin was detected with a mean concentration of 0.25 µg/g in 75 out of 312 double-crested cormorant eggs and embryos collected from Cat Island, Green Bay, Wisconsin in 1994 and 1995 (Custer et al. 1999). The mean concentration of deldrin in tree swallow eggs and tree swallow nestlings collected in 1998 at Pigeon Creek, Iowa (three samples); Duck Creek, Iowa (three samples); and Lindsey Harbor, Iowa (seven samples) along the Upper Mississippi River was 0.03 µg/g wet weight (Custer et al. 2000).

Waterfowl from Northern Canada were collected from 1988 to 1995 and divided into browsers, grazers, omnivores, molluscivores, and piscivores (Braune et al. 1999). The highest concentrations of dieldrin were found in tissues of waterfowl feeding at the upper trophic levels. Concentrations of dieldrin ranged from nd to 5.0 ng/g wet weight, nd to 3.2 ng/g wet weight, nd to 15.9 ng/g wet weight, nd to 120 ng/g wet weight, and nd to 54.7 ng/g wet weight, respectively.

Mean concentrations of dieldrin in snapping turtle eggs collected at four sites along the St. Lawrence River in the Mohawk territory of Akwesasne during June, 1998 ranged from 4 to 280 ng/g wet weight with an overall mean concentration of 38.13 ng/g wet weight (de Solla et al. 2001). Aldrin and dieldrin were detected in the plasma of juvenile alligators from three lakes in central Florida (Guillette et al. 1999). The mean concentrations of dieldrin in males from Lake Woodruff, Lake Apopka, and Orange Lake were 0.24, 1.68, and 0.75 ng/mL plasma, respectively. The mean concentrations of dieldrin in females from these lakes were 0.31, 2.87, and 0.39 ng/mL plasma, respectively. The mean concentration of aldrin for juvenile alligators in all three lakes was 0.34 ng/mL plasma.

In 1985, fish samples taken from the lower Savannah River in Georgia and South Carolina were found to occasionally contain dieldrin but at concentrations of <0.01 µg/g (10 ppb) (Winger et al. 1990); common carp and white bass samples from a lake in Kansas located in an agricultural area had mean concentrations of 0.069 and 0.058 ppb, respectively (Arruda et al. 1988). Fish samples taken from tributary rivers around the Great Lakes in 1980–1981 had dieldrin levels up to 0.15 mg/kg (150 ppb) (average concentration=0.03 mg/kg [30 ppb]) (DeVault 1985). Fish taken from Lake Huron between 1970 and 1980 had mean dieldrin concentrations ranging from 0.01 to 0.50 mg/kg (10–500 ppb) (EPA 1985e); however, by 1984, mean concentrations of dieldrin in Lake Michigan coho salmon had dropped to 0.01 μg/g (10 ppb) from 0.06 μg/g (60 ppb) in 1980 (DeVault et al. 1988). An analysis of 315 composite samples of whole fish collected from 107 sites nationwide in 1980–1981 as part of the National Pesticide Monitoring Program found that the mean concentrations of dieldrin were essentially unchanged since 1978–1979. In 1978, dieldrin was detected in 81% of the samples, and in 1980, in 75% of the samples at mean concentrations of 0.05 μg/g (50 ppb) wet weight and 0.04 μg/g (40 ppb), respectively (Schmitt et al. 1985). Three of eight samples of bluegill (*Lepomis macrochrius*) collected from the San Joaquin Valley in July 1981 contained dieldrin at concentrations ranging from 0.005 to 0.008 mg/kg (5–8 ppb) wet weight; four of the eight common carp (*Cyprinus carpio*) obtained from the same sites contained dieldrin at concentrations ranging from 0.015 to 0.067 mg/kg (15–67 ppb) wet weight (Saiki and Schmitt 1986). Dieldrin was also detected in a variety of fish taken from a section of Lake Oconee in Georgia that received storm runoff from insecticide-treated areas between 1981 and 1982. Dieldrin concentrations ranged from <10 to 200 μg/kg (10–200 ppb). Dieldrin was not detected in fish taken from the lake after 1982 (Bush et al. 1986). A survey of 17 wetland areas in the north central United States found dieldrin in two fish samples taken from Kansas and Iowa at concentrations of 6 ng/g (6 ppb) and 9 ng/g (9 ppb), respectively (Martin and Hartman 1985). Dieldrin was found in 5 of 20 raw bluefish fillets collected in Massachusetts waters in 1986, at concentrations of 0.02–0.04 ppm (20–40 ppb); after cooking, dieldrin was still detected in the fillets, indicating that heating does not degrade the pesticide in foods (Trotter et al. 1989). Aldrin and dieldrin were detected in shrimp (*Penaeus setiferus* and *Penaeus aztecus*) collected from the Calcasieu River Basin in an industrial area of Louisiana in 1985–1986. Aldrin was present in shrimp taken from 7 of 30 stations at concentrations ranging from 0.01 to 0.12 μg/g (10–120 ppb), and dieldrin was present in 21 of 30 samples at concentrations of 0.05–9.47 μg/g (50–9,470 ppb) (average concentration 1.57 μg/g [1,570 ppb]) (Murray and Beck 1990). Between October 1981 and September 1986, over 12,044 imported and 6,391 domestic commodities were sampled for pesticide residues. Dieldrin was detected in 420 imported and 44 domestic products; however, the tolerance (the maximum amount of a residue expected in a food when a pesticide is used according to label directions, provided that the level does not present an unacceptable health risk) for dieldrin was exceeded in only eight imported products and one domestic product, indicating that most agricultural products do not contain harmful levels of dieldrin (Hundley et al. 1988).

The concentrations of dieldrin and aldrin were studied in bivalve mollusks obtained from three coastal lagoons in the southeast of the Gulf of Mexico (Botello et al. 1994). The average concentration of aldrin in bivalve mollusks collected from the Carmen, Machona, and Alvarado lagoons were 2.56, 1.61, and 6.61 ng/g dry weight, respectively. Dieldrin was not detected in any bivalve mollusks collected from the Carmen, Machona, and Alvarado lagoons. Dieldrin concentrations were analyzed for in nine marine mammal species samples collected in 1987 (Becker et al. 1997). The means and standard deviations of dieldrin in northern fur seal, ringed seal, pilot whale, harbor porpoise, beluga whale from the Arctic, and beluga whale from Cook Inlet were 13.6, 43.2±53.8, 262±240, 963±294, 290±106, and 105±66.2 ng/g wet weight, respectively.

One study examined persistent organochlorines concentrations in blubber samples from 16 dead beluga whales collected during 1993–1994 in the St. Lawrence River estuary (Muir et al. 1996). The mean concentrations of dieldrin in seven female and nine male beluga whales were 1,360 ng/g lipid weight (lw) (range=326–2,360 ng/g lw) and 2,020 ng/g lw (range=1,440–2,620 ng/g lw), respectively. The study found a temporal upward trend in dieldrin concentration in female beluga whales and slightly augmented levels of dieldrin in males. The average dieldrin concentration in female beluga whales in 1987 was 450 ng/g lw while in males, the average concentration of dieldrin measured from 1986 to 1988 was 1,650 ng/g lw. In a separate study, biopsies were collected from Right whales in the Bay of Fundy in 1994 (30 samples), 1995 (17 samples), and 1996 (15 samples) and at sites in Georgia and Cape Cod Bay in 1997 (Weisbrod et al. 2000). For each collection period mean concentrations were 513 and 93 ng/g sample lipid content and nd, respectively, for aldrin and 1,141, 1,349, and 4,244 ng/g sample lipid content, respectively, for dieldrin. Zooplankton samples collected in 1995 and 1996 from Georges Bank, Bay of Fundy, and Cape Cod Bay contained aldrin at concentrations that were undetectable to 8.9 ng/g sample lipid content and dieldrin at concentrations that were undetectable to 23 ng/g sample lipid content.

Dieldrin concentrations were determined in archived samples of whole lake trout collected yearly from eastern Lake Ontario between 1977 and 1993 (Huestis et al. 1996). The mean concentrations of dieldrin in trout collected in 1977, 1980, 1983, 1986, 1989, 1990, 1992, and 1993 were 313, 218, 135, 103, 97.3, 99.0, 73.1, and 78.4 ng/g, respectively. An investigation of the temporal trends of pesticide residues in fish from Lake Michigan indicated a decrease in dieldrin concentrations from 1982 to 1990 (Miller et al. 1992). Total dieldrin concentrations in lake trout decreased 68% from 410±50 μg/kg in 1982 to 130±30 μg/kg in 1990. In Lake Superior, dieldrin concentrations in fish did not appear to as much over a 3-year period. The total dieldrin concentration in lake trout in 1982 was 50±10 μg/kg while in 1985, the concentration was 40±10 μg/kg. In a separate study (Zabik et al. 1996), concentrations of dieldrin in skin-off lake trout collected from both Lake Huron and Lake Michigan, and siscowets from Lake Superior were reported as 0.029, 0.076, and 0.027 ppm, respectively.

During the fiscal years 1989 to 1994, the U.S. Food and Drug Administration (FDA) collected and analyzed 545 domestic surveillance samples of mixed feed rations for pesticide residues (Lovell et al. 1996). The mixed feed rations represented feed fed to cattle, poultry, swine, pets, fish, and other miscellaneous animals. The results indicated that dieldrin was detected in five samples (three trace, two quantifiable) at 10 μg/kg.

Lichens collected in the Arctic between 1993 and 1994 contained detectable residues of dieldrin; concentrations of below detection to 0.72 ng/g dry weight were reported with the highest concentrations found in samples collected from Makinson Inlet and King Edward Point in the Northwest Territories (Braune et al. 1999). Saxifrage samples from Ellesmere Island and Axel Heiberg Island, collected in 1990, contained dieldrin at mean concentrations of 0.46 and 0.44 ng/g dry weight, respectively.

6.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

Use of aldrin and dieldrin for pest control on crops such as cotton, corn, and citrus products was canceled by the EPA in 1974 (EPA 1974a), while use for extermination of termites was voluntarily canceled by the manufacturer in 1987 (EPA 1990b). However, during the period of widespread use and production of aldrin and dieldrin, intake by workers who manufactured these compounds was estimated to range from 0.72 to 1.10 mg/person/day with a good correlation between levels in tissue (fat, serum, and urine) and total length of exposure or intensity of exposure (Hayes and Curley 1968). The National Occupational Exposure Survey, conducted by NIOSH between 1980 and 1983, estimated that 647 employees were exposed to aldrin and 760 employees were exposed to dieldrin in the workplace (NOES 1990). One pest control operator was found to have 0.5 and 0.3 ug dieldrin on his left and right hands, respectively, >2 years after his last exposure to aldrin; serum blood levels taken at the same time showed 10 ppb dieldrin. A further analysis of individuals exposed to dieldrin found no correlation between the pesticide levels on their hands and in their sera (Kazen et al. 1974). A 1981 survey of Florida citrus field workers found dieldrin to be present in >3% of the 567 serum samples, at a mean concentration of 1.8 ppm (1,800 ppb) (Griffith and Duncan 1985). Workers cleaning up hazardous waste sites may also be exposed, but no information on monitored levels of exposure was found.

In one pilot study, food, beverage, and biological specimens (blood and urine) were collected and analyzed for pesticides from six farm families living in Iowa and North Carolina (Brock et al. 1998). Although dieldrin concentrations were below detection limits(0.23 ng/mL) in five of the families studied, one family in particular had elevated levels. One farmer from Iowa had a mean dieldrin concentration of 20.55±2.61 ng/ml while that person's spouse had a mean concentration of 7.52±0.68 ng/mL. Solid food samples from this farm also contained elevated levels of dieldrin ranging from 15.0 to 28.0 ng/g. On the other five farms, dieldrin concentrations in solid food samples were below the detection limit (0.75 ng/g). Finally, dieldrin levels in beverages were below the detection limit in five of the farm families studied except for the one family from Iowa with elevated dieldrin levels, which had an average concentration of 11.0 ng/g.

The National Health and Nutrition Examination Survey (NHANES II) conducted between 1976 and 1980, found that an estimated 10.6% of the population aged 12–74-years-old, were exposed to dieldrin based on an analysis of blood serum and urine specimens (Stehr-Green 1989). When specimens from populations in the northeast, midwest and south regions of the United States were examined almost 20% of the adults aged 45–74 years had quantifiable levels of dieldrin (mean concentration 1.4 ppb), while only 1.5% of the adults aged 12–24-years-old had quantifiable levels (mean concentration 1.4 ppb) (Murphy and Harvey 1985; Stehr-Green 1989). Dieldrin was found in 14 of 46 adipose tissue samples taken from cadavers and surgical patients during the 1982 Human Adipose Tissue Survey conducted by EPA on a nationwide basis. Concentrations of dieldrin in wet tissue were in trace amounts ranging from 0.053 to 3.84 μg/g (53–3,840 ppb) (mean concentration, 0.458 μg/g or 458 ppb). Aldrin was not present in any of the samples; the detection level was 0.010 μg/g (10 ppb) for a 20-g tissue sample (EPA 1986a). In 1976 and 1984, human adipose tissue samples were taken from cadavers of Canadians from the Great Lakes region and examined for the presence of a variety of compounds. Dieldrin was found in 100% of the tissue samples taken each year at a mean concentration of 0.049 μg/g (49 ppb) wet weight in 1976 (Mes et al. 1982) and 0.047 μg/g (47 ppb) wet weight in 1984 (Williams et al. 1988). Adipose tissue collected from 46 infertile women in Belgium between 1996 and 1998 contained dieldrin at a mean concentration of 13.1±6.6 ng/g. Dieldrin was not detected in the serum of the women (Pauwels et al. 2000). Based on a study with 12 male volunteers who ingested up to 225 ug dieldrin per day for up to 2 years, a wet weight BCF of 30 was calculated, although the BCF for the lipid fraction of body weight was 45. Other studies have found wet weight BCFs ranging from 38 to 77 (mean, 48.7) and lipid basis BCFs ranging from 55 to 115 (mean, 70.9) (Geyer et al. 1986, 1987). Blood samples taken from residents of El Paso, Texas, during 1982–1983, showed aldrin to be present in 39 of 112 samples (34%) at a mean concentration of 4.6 ppb (Mossing et al. 1985).

Individuals living in homes contaminated by past termiticide treatment constitute a significant group exposed to aldrin and dieldrin in indoor air. Measurements of air concentrations in homes 1–10 years after termiticide treatment showed dieldrin levels ranging from 0.0006 to 0.03 ppb in living rooms and bedrooms and all interior areas (Dobbs and Williams 1983). Air samples were taken and analyzed for aldrin over the course of 6 months from 29 dwellings treated with aldrin for prevention of termite infestation (Gun et al. 1992). Blood samples were also analyzed for dieldrin levels of one occupant from each dwelling. The concentration of atmospheric aldrin was recorded for the first six months of the study. Prior to treatment, the median concentration of aldrin was 0.044 μg/m^3; 1 week post-treatment 2.6 μg/m^3; 6 weeks post-treatment, 0.72 μg/m^3; and 6 months post-treatment, 0.57 μg/m^3. Prior to treatment, the median concentration of dieldrin in blood was 0.75 ng/mL while 3 months post-treatment the median concentration was 1.2 ng/mL.

The levels of aldrin and dieldrin were monitored in human blood samples taken from the general population from the rural town of Ahmedabad, India (Bhatnagar et al. 1992). Blood samples from 31 male subjects, ages 18–57 (mean 28.4 years), were collected from 1989 to 1990. The concentration of aldrin and dieldrin ranged from 0 to 0.813 μg/L (mean 0.200 μg/L) and from 0 to 3.730 μg/L (mean 2.152 μg/L), respectively.

A pilot study of non-occupational general population exposure to pesticides in ambient air inside and outside the home was conducted in nine homes in Florida in August 1985. Air was monitored for 24 hours outside the house and inside the house, and personal air monitors were worn by one occupant of each house. Aldrin and dieldrin were detected in indoor air at 6 and 5 of the 9 households, respectively; outdoors at 4 of the 9 households each; and by personal monitors for 3 and 5 of the 9 individuals, respectively. In one designated high-pesticide-use household, aldrin and dieldrin were detected in the indoor air at average concentrations of 0.058 μg/m^3 (0.004 ppb) and 0.038 μg/m^3 (0.002 ppb), respectively. Neither compound was detected in the outdoor air immediately adjacent to the home, and concentrations detected with personal air monitors were half (aldrin) to one-third (dieldrin) the concentrations for ambient indoor air (Lewis et al. 1988). A composite sample of the dust from four Seattle homes collected in 1988–1989 showed dieldrin to be present at 1.1 ppm, although none of the homeowners could remember using the pesticide. It was suggested that the source of the dieldrin was soil surrounding the homes; however, since the use of dieldrin is restricted to termite control, and Seattle has few termites, the source of the contaminated soil is unknown (Roberts and Camann 1989).

Atmospheric sampling of aldrin and dieldrin conducted from 1970 to 1972 indicated that aldrin and dieldrin were present at mean concentrations of 0.4 ng/m^3 (2.7x10^{-5} ppb) and 1.6 ng/m^3 (1.02x10^{-4} ppb), respectively (Kutz et al. 1976). Combining these figures and assuming that 20 m^3 of air are inspired each day, average daily intake of aldrin plus dieldrin from the atmosphere would be 0.57 ng/kg body weight in 1972. However, the cancellation of the use of these compounds suggests that current inhalation intake will be much less. Guicherit and Schulting (1985) used data on air samples collected in the western part of the Netherlands in 1979–1981 and calculated the average daily intake by inhalation to be 0.02 ng dieldrin/kg body weight and 0.01 ng aldrin/kg body weight.

A significant source of general population exposure to dieldrin is through diet. In the absence of occupational or domestic use as a pesticide, food is probably the primary source of dieldrin residues in human adipose tissues (Ackerman 1980). Because of the rapid epoxidation of aldrin in the environment, it is not considered to be an important human dietary contaminant, with an average intake of <0.001 µg/kg/day. Dieldrin, however, may be ingested as a result of eating contaminated fish, milk, and other foods with a high fat content including meat. EPA established tolerances for aldrin and dieldrin in or on raw agricultural commodities at maximums of 0.0–0.1 ppm, depending on the crop (Sittig 1980). Table 6-1 shows a summary of dieldrin residues in adult dietary components analyzed in 1981–1982 (Gartrell et al. 1986a). A 1985 Canadian survey of foods found that although aldrin was not detected in any of the food samples analyzed, dieldrin was detected in all food composites at 0.00011 µg/g in fruit; 0.0019 µg/g in milk; 0.0031 µg/g in leafy vegetables, eggs, and meat; and 0.023 µg/g in root vegetables (Davies 1988). Dieldrin residues may persist in foods such as milk butterfat and subcutaneous fat in cattle with an estimated half-life in butterfat of 9 weeks (Dingle et al. 1989). Samples of ultra-pasteurized heavy cream and cow's milk purchased in Binghamton, New York, in 1986 had dieldrin levels of 0.006 and 0.003 ppm, respectively (Schecter et al. 1989a).

Table 6-1. Dieldrin Residues in Adult Dietary Components (1980–1982)[a]

Food group	Residue range (ppm)	Average concentration (µg/day)
Dairy	Trace to 0.003	0.0006
Fish, poultry, meat	Trace to 0.004	0.0012
Potatoes	Trace to 0.002	0.0004
Root vegetables	Trace to 0.005	0.0004
Leaf vegetables	Trace to 0.002	0.0002
Legumes	ND	ND
Garden fruits	Trace to 0.011	0.0021
Fruits	0.001	0.0001
Cereals and grain	0.004	0.0001
Oils and fats	Trace to 0.002	0.0003
Sugar	ND	ND
Beverages	ND	ND

[a]Derived from Gartrell et al. 1986a

ND = not detected

During the period of 1965–1970, total U.S. dietary intake was reported to be 0.05–0.08 ug dieldrin/kg/day and 0.0001–0.04 ug aldrin/kg/day (IARC 1974b). Since 1970, the use of aldrin and dieldrin on food has been cancelled, and dietary intake has decreased. An FDA Total Diet Study, conducted between 1982 and 1984, found that aldrin intake was <0.001 μg/kg/day for all age and sex groups (Gunderson 1988; Lombardo 1986). Adults had a dieldrin intake of 0.007 μg/kg/day (25–30-year-old males). Dieldrin was found in 15% of the food samples analyzed. These values represent a decrease from the 1980 Total Diet Study. Between 1980 and 1982–1984, daily intakes of dieldrin decreased from 22 ng/kg/day to 8 ng/kg/day for adults (Gunderson 1988). Recently, a Total Diet Study conducted by FDA, found dieldrin in only 6% of the food items analyzed from 1990 (FDA 1991). A daily intake of 0.0016 μg/kg body weight was estimated for 60–65-year-old females, respectively (FDA 1991). The average daily dietary intake of chemical contaminants in food were estimated for 116,957 U.S. adults in 1990 based on annual diet as part of the annual U.S. FDA Total Diet Study (MacIntosh et al. 1996). The estimated mean dietary exposure of dieldrin for 78,882 adult females and 38,075 adult males studied ranged from 0.08 to 0.43 μg/day (mean=0.5 μg/day) and from 0.02 to 4.0 μg/day (mean=0.5 μg/day), respectively. High levels of dietary exposures to dieldrin were estimated to be primarily due to frequent consumption of summer and winter squash, while those with low exposure were dominated by foods that contained residue levels below the limits of detection. During the Total Diet Study conducted by the FDA from November 1993 to June 1994, dieldrin was detected 58 times (concentrations and estimated daily intakes not specified) out of a total of 783 foods sampled (FDA 1995). Assuming that 2 L of water are ingested each day, the average drinking water contribution of dieldrin may range from 0.1 to 0.29 ng/kg/day for a 70 kg adult. These levels are well below the Acceptable Daily Intake (ADI) of 0.1 μg/kg/day recommended by the World Health Organization (WHO) for dieldrin (Geyer et al. 1986). Organohalogen residue levels were monitored from May 1990 to July 1991 in 806 composite milk samples collected from 63 cities within the United States (Trotter and Dickerson 1993). Dieldrin was detected in 172 milk samples ranging from trace amounts to 2 μg/L (detection limit=0.5 μg/L).

6.6 EXPOSURES OF CHILDREN

This section focuses on exposures from conception to maturity at 18 years in humans. Differences from adults in susceptibility to hazardous substances are discussed in 3.7 Children's Susceptibility.
Children are not small adults. A child's exposure may differ from an adult's exposure in many ways. Children drink more fluids, eat more food, breathe more air per kilogram of body weight, and have a larger skin surface in proportion to their body volume. A child's diet often differs from that of adults. The developing human's source of nutrition changes with age: from placental nourishment to breast milk

or formula to the diet of older children who eat more of certain types of foods than adults. A child's behavior and lifestyle also influence exposure. Children crawl on the floor, put things in their mouths, sometimes eat inappropriate things (such as dirt or paint chips), and spend more time outdoors. Children also are closer to the ground, and they do not use the judgment of adults to avoid hazards (NRC 1993).

The widespread use of agricultural pesticides in California has raised concerns about exposures in nearby residential communities, particularly to children (Bradman et al. 1997). To determine the potential exposure to dieldrin, house dust and handwipe samples from children were collected and analyzed from 11 homes, 5 of which had at least 1 farmworker resident. Dieldrin was detected in house dust from one home of a farmworker at a concentration of 0.10 μg/g. Dust loading (the fraction dislodgeable by vacuum) of dieldrin was 0.45 $\mu g/m^2$. These data indicates that the highest chronic daily intake for children would be $1.0x10^{-3}$ μg/kg/day. Nine middle-income households located in the Raleigh-Durham-Chapel Hill area of North Carolina were evaluated for children's pesticide exposure (Lewis et al. 1994). Each house had at least one child in the 6-month to 5-year range. Aldrin was detected in five of the houses, while dieldrin was detected in all nine houses in various matrices (soil samples, dust samples, air samples, etc.). Since dieldrin was detected so often and at higher concentrations, it was studied more intently. The researchers found that the mean concentration of dieldrin was 0.12 μg/g in house dust samples, <0.01 μg/g in child hand rinse samples, 0.01 $\mu g/m^3$ in air samples taken from the living room, and 0.03 μg/g in play area soil. The estimated exposures of children by respiration and ingestion of house dust ranged from not detectable to 0.13 μg/day and from not detectable to 0.04 μg/day, respectively. Judging by these results, it appears that inhalation of indoor air from houses contaminated with aldrin and dieldrin is a major route of child exposure. Due to the greater persistence of dieldrin in the environment, children are expected to have greater exposure to dieldrin than aldrin.

Inhalation of aldrin and dieldrin in outdoor ambient air, however, is not expected to be a significant source of exposure for children. During a study of atmospheric concentrations of chemical contaminants from 1970 to 1972, researchers found that the mean concentrations for aldrin and dieldrin were 0.4 and 1.6 ng/m^3, respectively (Kutz et al. 1976). Since all but one of their uses were canceled by the EPA in 1974, ambient air concentrations of aldrin and dieldrin are expected to be much lower today. Children living near NPL sites containing high concentrations of aldrin and dieldrin, however, may be exposed to higher than normal atmospheric concentrations. Studies of this nature, however, have not been located. Inhalation exposure may be important during a spill of aldrin or dieldrin before environmental equilibrium is attained. Under these conditions, high concentrations of both compounds would be found in the atmosphere, especially closer to the ground since both compounds are heavier than air. This situation, however, is not expected to occur since aldrin and dieldrin are no longer produced or used commercially.

In Streaky Bay, a rural community located on the west coast of South Australia, the contamination of a school by aldrin was studied (Calder et al. 1993). Between August and November 1986, a 0.5% aqueous aldrin emulsion was used within the school as a termiticide. The geometric mean air concentrations of aldrin sampled within the school were 0.09 μg/m^3 in March 1987, 0.11 μg/m^3 in May 1988, 0.05 μg/m^3 in August 1988, and 0.06 μg/m^3 in September 1988. Aldrin contamination was highest in carpet samples with concentrations ranging from 31,600 to 77,000 μg/100 cm^2. Aldrin is rapidly metabolized to dieldrin and was therefore monitored for in school attendants (Calder et al. 1993). The arithmetic mean concentration of dieldrin in serum samples collected from 138 people was 1.41 ng/mL with a maximum concentration of 9.3 ng/mL in 1987. One year later in 1988, the arithmetic mean concentration of dieldrin decreased to 0.74 ng/mL with a maximum of 2.2 ng/mL.

The FDA Total Diet studies are based on levels found in representative commercially available food products. However, many infants receive human breast milk as a major dietary component rather than milk purchased in grocery stores. Therefore, the daily intake of aldrin and dieldrin by infants may be more closely related to concentrations of dieldrin found in mother's milk. Infants are particularly sensitive to aldrin and dieldrin due to their higher intestinal permeability and immature detoxification system. Dieldrin was found in the breast milk of 80.8% of 1,436 nursing women sampled in 1980, with the greatest percentage (88.9%) in samples collected in the southeastern United States and the lowest percentage from samples collected in the northeast (63.9%) (Savage et al. 1981). The mean fat-adjusted residue level of these samples was 164 ppb. Assuming that milk fat accounts for approximately 3% of whole milk, this would correspond to approximately 5 ppb in whole milk. Of 54 nursing mothers studied in Hawaii (1979–1980), 94% had dieldrin in their milk (Takei et al. 1983). The mean concentration in milk fat was 42 ppb, which would correspond to a concentration of 1.3 ppb in whole milk. Of 57 nursing women sampled in 1973–1974 in Arkansas and Mississippi, 28% had a dieldrin residue level of 4 ppb in their milk (Strassman and Kutz 1977). A level of 0.5 ppb was found in a national survey of the general Canadian population (Davies and Mes 1987).

Several factors may influence the levels of dieldrin found in breast milk. For example, a highly significant ($p<0.001$) association was reported in women with low levels of dieldrin in breast milk and a history of breast-feeding several children (Ackerman 1980). In addition, women who consume foods lower on the food chain, i.e., vegetarians, had dieldrin levels in their breast milk that were only 1–2% as high as the average levels in the United States (Hergenrather et al. 1981). Also, a mother's total body weight may influence the concentration of dieldrin found in breast milk. In a study of Israeli women conducted in 1975, those weighing over 72 kg had significantly lower levels of dieldrin in their breast milk (6 ppb) than those weighing under 63 kg (8.7 ppb) (Polishuk et al. 1977a). This difference was observed despite similar plasma levels of dieldrin in the two groups. A Swedish study found that dieldrin levels in mother's milk decreased from 0.076 μg/g (44 ppb) to 0.010 μg/g (10 ppb) between 1967 and 1984–1985; the use of dieldrin in Sweden was prohibited in 1970 (Norén and Meironyte 2000). A survey of 14 human milk donors whose homes in western Australia had been treated yearly with various pesticides for termite control found dieldrin residues in the milk ranging from 2 to 35 ng/g (2–35 ppb) (mean of 13 ng/g [13 ppb]) (Stacey and Tatum 1985). Milk levels of dieldrin peaked at 7–8 months after house treatment. Three of the 14 houses had recently been treated with aldrin, and the houses of the 11 other donors had been treated with aldrin previously. Dietary intake may have contributed partially to the milk levels since there was not a good correlation between dieldrin and the most recent use of aldrin.

A total of 412 breast milk samples from women in all provinces of Canada were analyzed for organochlorine residues in 1986 (Mes et al. 1993). Dieldrin was detected in 94% of all samples (detection limit=0.009 ng/g) at a mean concentration of 0.46 ng/g (maximum=4.42 ng/g). The study also examined dieldrin concentrations from earlier years. In both 1967 and 1970, the mean concentration of dieldrin in Canadian breast milk samples was 5 ng/g, in 1975, it was 2 ng/g, while in 1982, the concentration dropped to 1 ng/g. Breast milk samples were collected from 23 primiparous mothers and analyzed for their total amount of organochlorine residues from January to November 1992 (Quinsey et al. 1996). The results indicated that the mean daily intake of dieldrin from breast milk would be 0.32 μg/kg body weight/day with a range of 0.06 to 2.24 μg/kg body weight/day. The difference in organochlorine pesticide concentrations in human milk and infant formulas was examined in 1993 (Pico et al. 1995). Human milk samples were obtained from 15 women aged 29–40 living along the Spanish Mediterranean coastal area. The infant formulas analyzed included 11 starting formulas, 11 follow-up formulas, 4 adapted infant formulas, and 17 specialized formulas. Aldrin and dieldrin were not detected in either human milk nor formula samples (detection limit for aldrin=5.1 μg/L, detection limit for dieldrin=6.0 μg/L).

Studies show that transplacental transfer of aldrin and dieldrin occurs. A study of organochlorine compounds in mothers and fetuses during labor found that dieldrin concentrations in extracted lipids of fetal blood (1.22 ppm) and placenta (0.80 ppm) greatly exceeded those in maternal blood (0.53 ppm) and uterine muscle (0.54 ppm) (Polishuk et al. 1977b). In a study measuring contaminant levels in the cord blood of newborn aboriganals and non-aboriginals of the Northwest Territories and Southern Quebec, Canada, mean concentrations of aldrin were found to be 0.01 μg/L in all populations (Van Oostdam et al. 1999). A study of four Iraqi women with no known exposure to organochlorine pesticides found dieldrin levels in the placenta to range from 0.006 to 0.020 mg/kg total tissue weight and average dieldrin levels in their milk to range from 0.007 to 0.023 mg/kg whole milk. However, there was no correlation between the level of dieldrin in the placenta and the level in milk for each individual (Al-Omar et al. 1986).

An FDA Total Diet Study, conducted between 1982 and 1984, found that aldrin intake was <0.001 μg/kg/day for all age and sex groups and that toddlers (2-years-old) had the highest intake levels for dieldrin at 0.016 μg/kg/day, followed by infants at 0.010 μg/kg/day (Gunderson 1988; Lombardo 1986). In 1980 and from 1982 to 1984, daily intakes of dieldrin decreased from 33 to 10 μg/kg/day for infants and from 46 to 16 ng/kg/day for toddlers (Gunderson 1988). The average daily dietary intake for adolescent males (14–16-year-olds) was 0.08 μg/kg/day in 1984. Recently, a Total Diet Study conducted by the FDA found dieldrin residues in only 6% of the food items analyzed from 1990 (FDA 1991). Daily intakes of 0.0014 and 0.0016 μg/kg body weight were estimated for infants 6–11 months old and for 14–16-year-old adolescents in 1990 (FDA 1991). During the Total Diet Study conducted by the FDA from November 1993 to June 1994, dieldrin was detected 58 times (concentrations and estimated daily intakes not specified) out of a total of 783 foods sampled (FDA 1995). The Total Diet Study food list includes many foods eaten by infants and children.

6.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Infants and toddlers are possibly exposed to higher levels of aldrin or dieldrin in the diet than are adults. Table 6-2 is a listing of calculated daily dietary intakes of dieldrin for adults, toddlers, and infants. Infant and toddler dietary intakes decreased significantly from 1978 to 1982. They remained elevated, however, when compared with adult dietary intake.

Higher exposure rates can be expected for large segments of the population residing in homes treated with aldrin or dieldrin for termite control. Measurements of air concentrations in homes 1–10 years after

Table 6-2. Calculated Dietary Intakes (μg/kg of Body Weight/Day) of Dieldrin for Three Population Groups[a]

Group	1981–1982	1980	1979	1978
Adults	0.016	0.022	0.016	0.017
Infants	0.020	0.033	0.048	0.045
Toddlers	0.023	0.046	0.036	0.039

[a]Derived from Gartrell et al. 1986a, 1986b

pesticide treatment showed dieldrin concentrations ranging from 0.002 to 0.17 ppb in roof voids and from 0.0006 to 0.03 ppb in living rooms and bedrooms and all interior areas (Dobbs and Williams 1983). The indoor air concentrations of aldrin and dieldrin were monitored in the basement, main level, and upstairs area of a treated home from September 1987 to April 1995 (Wallace et al. 1996). In this particular home, aldrin had been poured directly into the foundation blocks during construction. Initially, the aldrin concentrations in air samples taken from the living area and the basement in September 1987 were 300 and 5,000 ng/m^3, respectively, while dieldrin concentrations were 7 and 28 ng/m^3, respectively. By June 1989, levels of aldrin in the living area and basement were 20 and 300 ng/m^3, respectively, while dieldrin concentrations were 5 and 20 ng/m^3, respectively. At the end of the study in April 1995, levels of aldrin in the living area and basement were 2 and 12 ng/m^3, respectively, while dieldrin concentrations were 3 and 20 ng/m^3, respectively. The concentrations of aldrin and dieldrin in air collected outside the home in April 1995 were <0.05 and 0.3 ng/m^3, respectively. Eight years after the initial treatment, aldrin and dieldrin were still detected in the living space of the home.

An assessment of the environmental contamination of a residential community built on a thick layer of harbor sludge in the Netherlands, found that the maximal combined daily intake of aldrin, dieldrin, isodrin, and telodrin by soil ingestion, inhalation of contaminated indoor air, and diet exceeded the ADI by a factor of three (Van Wijnen and Stijkel 1988). The concentrations of these compounds were highest in soil samples taken from the top 40 cm. The total indoor air concentrations of the compounds in the living rooms of homes built on contaminated soil were 10 times higher than outdoor air levels (9.9 ng/m^3 versus 0.8 ng/m^3); levels in the crawl spaces of these homes were 100 times higher (88.7 ng/m^3) than outdoor levels although no explanation was given for these elevated levels. Dieldrin concentrations were also elevated in vegetables grown in the soil (up to 40 mg/kg fresh weight) and resulted in a recommendation against the consumption of home-grown vegetables. Dieldrin concentrations were not elevated in drinking water samples in any of the homes tested.

Persons with chronic skin disease may be at increased risk from occupational exposure to pesticides. A formulator with scleroderma had higher blood and tissue levels of dieldrin than did his associates with similar exposures (Hayes 1982). Residents who live near hazardous waste sites that contain aldrin or dieldrin may also have greater exposure to these compounds as a result of contact with contaminated environmental media. Although aldrin is unlikely to persist, dieldrin may enter surface water as a result of surface runoff of contaminated soil. Only limited information in available regarding the extent of contamination at hazardous waste sites and the levels to which individuals may be exposed.

6.8 ADEQUACY OF THE DATABASE

Section 104(I)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of aldrin and dieldrin is available. Where adequate information is not available, ATSDR, in conjunction with the National Toxicology Program (NTP), is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of aldrin and dieldrin.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

6.8.1 Identification of Data Needs

Physical and Chemical Properties. The physical and chemical properties of aldrin and dieldrin are sufficiently well defined to allow assessments of the environmental fate of the compounds to be made (Budavari 1996; Clayton and Clayton 1994; Guerin and Kennedy 1992; Hayes 1982; HSDB 2001a, 2001b; NIOSH 1997; Verschueren 1996). No additional information is needed.

Production, Import/Export, Use, Release, and Disposal. The risk for exposure of the general population to substantial levels of aldrin or dieldrin is quite low. Aldrin and dieldrin have not been produced in the United States since 1974, nor is there any indication that U.S. production of either of these two chemicals will resume (EPA 1990b). Aldrin has not been imported into the United States since 1985 (EPA 1986d). No information was available regarding exports of aldrin or dieldrin, nor was information available regarding the amount of these insecticides currently stockpiled in the United States Information regarding stockpile levels of aldrin and dieldrin would prove useful.

Currently, all uses of aldrin and dieldrin have been canceled (EPA 1990b). However, due to the persistence of dieldrin in the environment, the likelihood of its bioconcentration, and the former widespread use of both aldrin and dieldrin, these agents are still found at low levels in foods such as root crops and meat and dairy products. Concentrations of dieldrin are significantly higher than aldrin residues due to the high rate of conversion of aldrin to dieldrin in the environment and dieldrin's relative stability in environmental matrices.

The soil around dwellings that have been treated with termiticides containing aldrin and dieldrin is the environmental media most likely to be contaminated with significant quantities of aldrin and dieldrin. The air within treated homes may also contain elevated levels of these agents.

According to the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. Section 11023, industries are required to submit chemical release and off-site transfer information to the EPA. The Toxic Chemical Release Inventory (TRI), which contains this information for 1997, became available in May of 1990. This database will be updated yearly and should provide a list of industrial production facilities and emissions. However, for aldrin and dieldrin, there are no TRI data, indicating that no industrial releases of either of these chemicals were reported for 1997.

Incineration and activated-carbon adsorption have >99% efficiencies as methods for disposing of aldrin or dieldrin (HSDB 2001a, 2001b). However, no information is available regarding the amounts of aldrin or dieldrin disposed of by each method. Additional information on current disposal patterns would prove useful.

Environmental Fate. Aldrin released to surface and shallow subsurface soils partitions to the atmosphere where it is transported (Caro and Taylor 1971; Elgar 1975; McLean et al. 1988). In deeper subsurface soils, aldrin generally is sorbed to soil particulates (McLean et al. 1988); under most environmental conditions, aldrin should not leach to groundwater (McLean et al. 1988). Aldrin is biotransformed to dieldrin in aerobic soils (Gannon and Bigger 1958; Gupta et al. 1979). Additional information is needed on the transformations of aldrin in anaerobic soils and sediments.

Dieldrin sorbs to soils and sediments (Briggs 1981; Cliath and Spencer 1971). The compound also partitions to biota and slowly volatilizes from soils to the atmosphere (Nash 1983). Dieldrin is transported in the particulate phase in surface water runoff (Caro and Taylor 1971; Eye 1968; Hardee et al. 1964) and in the atmosphere (Baldwin et al. 1977). In deep subsurface soils, dieldrin is sorbed to particulates and does not leach to groundwater (Dobbs et al. 1989). The compound is persistent in environmental media, being resistant to biodegradation and abiotic transformation (Gannon and Bigger 1958; Jagnow and Haider 1972). Based on dieldrin's vapor pressure, it will exist in both the vapor and particulate phase in the atmosphere (Grayson and Fosbraey 1982). Vapor-phase dieldrin is expected to react with hydroxyl radical; while particulate phase dieldrin will be removed from the atmosphere by wet and dry deposition. Information concerning the relative percentage of dieldrin that will exist in the particulate and vapor-phase in the environment would prove useful in predicting its atmospheric fate.

Bioavailability from Environmental Media. Limited available pharmacokinetic data indicate that the compounds are absorbed by humans following inhalation of contaminated air (Stacey and Tatum 1985). Absorption also occurs following oral and dermal exposures (Feldmann and Maibach 1974; Heath and Vandekar 1964; Hunter and Robinson 1967; Hunter et al. 1969; Iatropoulos et al. 1975). Additional information is needed on the absorption of the compounds following ingestion of contaminated drinking water and soils. This information would be useful in evaluating the importance of various routes of exposure to populations living in the vicinity of hazardous waste sites.

Food Chain Bioaccumulation. Aldrin and dieldrin are bioconcentrated by plants, animals, and aquatic organisms and biomagnified in aquatic and terrestrial food chains (Bhatnagar et al. 1988; Cole et al. 1976; Connell 1989; Donaldson et al. 1999; Metcalf et al. 1973; Sanborn and Yu 1973; Shannon 1977; Travis and Arms 1988). Food chain bioaccumulation appears to be a more important fate process for dieldrin, which is very persistent in nature, than for aldrin, which is rapidly converted to dieldrin (EPA 1980a; Metcalf et al. 1973). No additional information is necessary.

Exposure Levels in Environmental Media. Aldrin and dieldrin have historically been detected in ambient air (Hoff et al. 1996), surface water (EPA 1980a; Stubin et al. 1996), drinking water (EPA 1980a), soils (Eisenreich et al. 1989; Kutz et al. 1976), sediments (Bergersen 1987; Staples et al. 1985), and foods (EPA 1985e; Hundley et al. 1988). Many current monitoring studies indicate that the concentrations of both aldrin and dieldrin in environmental matrices are decreasing (California EPA 1995; MacIntosh et al. 1999; Miller et al. 1992). Aldrin has been identified in at least 207 of the 1,613 hazardous waste sites and dieldrin has been identified in at least 287 of the 1,613 hazardous waste sites that have been proposed for inclusion on the EPA NPL (HazDat 2002). Recent estimates of dietary intake, which is believed to be the most important source of exposure for most members of the general population, are also available (FDA 1991, 1995). More recent monitoring data would be useful in more accurately predicting human exposure.

Exposure Levels in Humans. The presence of dieldrin in human blood and adipose tissue has been used as an indicator of exposure to aldrin and dieldrin (Brock et al. 1998). The compounds have also been widely detected in human breast milk (Davies and Mes 1987; Quinsey et al. 1996; Savage et al. 1981; Takei et al. 1983). Additional information on the concentration of these compounds in the biological tissue and fluids of populations living in the vicinity of NPL sites would be helpful in assessing the extent to which these populations have been exposed to these compounds.

Exposures of Children. With the detection of dieldrin in drinking water (Kolpin et al. 1997), studies that detail the exposure of infants fed formula prepared from tap water would prove helpful. More data are needed to properly assess aldrin and dieldrin exposure to children who live, play, or attend school near NPL sites and farmlands that have been treated with these pesticides. Information regarding the number of houses in the United States that have been treated with aldrin and dieldrin formulations in the past would be useful in determining the number of children that would be potentially exposed today. The stability of these compounds, especially dieldrin, suggests the possibility that they may be brought home by farm workers who work on farmlands previously treated with these compounds. More exposure studies that monitor aldrin and dieldrin exposure to children of farm workers would be extremely valuable.

Child health data needs relating to susceptibility are discussed in Section 3.12.2, Identification of Data Needs: Children's Susceptibility.

Exposure Registries. No exposure registries for aldrin and dieldrin were located. These substances are not currently any of the compounds for which subregistries have been established in the National Exposure Registry. These substances will be considered in the future when chemical selection is made for subregistries to be established. The information that is amassed in the National Exposure Registry facilitates the epidemiological research needed to assess adverse health outcomes that may be related to exposure to these substances.

Information is particularly needed on the size of the populations potentially exposed to aldrin and dieldrin through contact with contaminated media in the vicinity of hazardous waste sites. The development of an exposure registry would provide a useful reference tool in assessing exposure levels and frequencies. It would also facilitate the conduct of epidemiological or health studies to assess any adverse health effects resulting from exposure to aldrin and/or dieldrin. In addition, a registry developed on the basis of exposure sources would allow an assessment of the variations in exposure levels from one source to another and the effect of geographical, seasonal, and regulatory action on the level of exposure within a certain source. These assessments, in turn, would provide a better understanding of the needs for research or data acquisition on the current exposure levels.

6.8.2 Ongoing Studies

A pilot project is under way in South Dakota to identify types and levels of pesticide residues in breast milk of South Dakota residents and to evaluate the effect of diet and maternal weight change on proximate composition and pesticide excretion levels in milk. The project will also estimate pesticide loading in breast-fed and non-breast-fed infants. To date, trace amounts of dieldrin (>0.001 ppm) have been detected in human milk samples. Levels of dieldrin appear to decrease from week 1 to week 7 postpartum.

Remedial investigations and feasibility studies conducted at the NPL sites contaminated with aldrin and dieldrin will add to the available database on exposure levels in environmental media and in humans and will contribute information for exposure registries. Investigations at the sites will also increase the current knowledge regarding the transport and transformation of aldrin and dieldrin at hazardous sites. No other long-term research studies regarding the environment fate and transport of aldrin and dieldrin or the occupational and general population exposure to these compounds were identified.

The Federal Research in Progress (FEDRIP 2001) database and the Current Research and Information System database funded by the U.S. Department of Agriculture (CRIS/USDA 2001) provide additional information obtainable from a few ongoing studies that may fill in some of the data needs identified in Section 6.8.1. These studies are summarized in Table 6-3.

Table 6-3. Ongoing Studies on the Potential for Human Exposure to Aldrin and Dieldrin

Investigator	Affiliation	Research description	Sponsor	Source
Childress C	Department of Interior, U.S. Geological Survey, Water Resources Division, North-Central North Carolina	There is no long-term regional water-quality monitoring data for many of the streams and tributaries to the drinking water supplies of the Research Triangle area of North Carolina. Many of these streams continue to receive a complex combination of treated industrial and municipal waste, in addition to nonpoint urban and agricultural runoff. This study is aimed at documenting the spatial differences in regional surface-water quality. The study will test for dieldrin concentrations.	U.S. Geological Survey	FEDRIP 2001
Morlock S	Department of Interior, U.S. Geological Survey, Water Resources Division, Northwest Indiana	To build an extensive database of major contaminates in the most contaminated tributaries of Lake Michigan and to assess the mobility of these contaminants. This information can be used to estimate the loads of these contaminants to Lake Michigan. The contaminants to be studied are 100 polychlorinated biphenyl (PCB) congeners, dieldrin, and chlordane.	U.S. Geological Survey	FEDRIP 2001

7. ANALYTICAL METHODS

The purpose of this chapter is to describe the analytical methods that are available for detecting, measuring, and/or monitoring aldrin and dieldrin, their metabolites, and other biomarkers of exposure and effect to aldrin and dieldrin. The intent is not to provide an exhaustive list of analytical methods. Rather, the intention is to identify well-established methods that are used as the standard methods of analysis. Many of the analytical methods used for environmental samples are the methods approved by federal agencies and organizations such as EPA and the National Institute for Occupational Safety and Health (NIOSH). Other methods presented in this chapter are those that are approved by groups such as the Association of Official Analytical Chemists (AOAC) and the American Public Health Association (APHA). Additionally, analytical methods are included that modify previously used methods to obtain lower detection limits and/or to improve accuracy and precision.

7.1 BIOLOGICAL MATERIALS

Analytical methods exist for measuring aldrin, dieldrin, and their metabolites in blood, body tissues, breast milk, urine, food, fish, and feces. The primary method used is gas chromatography (GC) coupled with electron capture detection (ECD). Since aldrin is metabolized rapidly to dieldrin, exposure to aldrin or dieldrin is measured exclusively by determining levels of dieldrin in blood. Exposure is also measured by determining the levels of dieldrin in fat since it is rapidly distributed to adipose tissue. Metabolites of aldrin and dieldrin have been measured in feces and urine; however, they are not routinely used to quantify exposure to aldrin or dieldrin (Klein et al. 1968; Walker et al. 1969). A summary of the methods for various biological media is presented in Table 7-1.

Dieldrin is determined in blood and fat using GC/ECD. Two commonly used preparation methods for determining levels of dieldrin in blood are the acetone extraction procedure and the hexane extraction procedure (EMMI 1997; Robinson et al. 1967). The difference between the two is in the initial step where dieldrin is extracted from blood with either acetone or hexane. Both preparation methods are followed by concentration and extraction with hexane. A comparison of the two methods showed that the concentration of dieldrin in the blood with the hexane extraction method is only 65–70% of the concentration of dieldrin in blood using the acetone extraction method. The authors suggest that the relationship may indicate a partitioning of dieldrin between hexane and whole blood (Robinson et al. 1967). The reproducibility of the acetone technique is better than that of hexane. One preparation

Table 7-1. Analytical Methods for Determining Aldrin/Dieldrin in Biological Materials

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Blood (dieldrin)	Hexane extraction.	GC/ECD	1 ng/mL	100%	MacCuaig 1976
Blood or serum	Samples are extracted using hexane. Concentrate down to 0.5 mL in hexane. Dilution may be necessary.	GC/ECD HERL Method 004	NR	NR	EMMI 1997
Serum (dieldrin)	Denature with methanol, mixed solvent extraction with hexane/ethylether, elute from activated silica gel.	GC/ECD	NR	70–75%	Burse et al. 1983
Adipose tissue	Samples are extracted using petroleum ether and acetonitrile. Filter through sodium chloride. Concentrate to 5 mL in petroleum ether.	GC/ECD HERL Method 001	NR	NR	EMMI 1997
Tissue and human milk	Samples are extracted using acetonitrile and concentrated down using hexane.	GC/ECD HERL Method 003	NR	NR	EMMI 1997
Milk (aldrin and dieldrin)	Milk sample homogenized, fat extraction. Florisil clean-up, elution with hexane and acetonitrile.	GC/ECD	NR	NR	Stacey and Tatum 1985
Milk	Homogenize milk. Multiresidue extraction through microcartridge. Elution with hexane and methanol.	GC/ECD	NR	aldrin 99% dieldrin 70%	Barcarolo et al. 1988

Table 7-1. Analytical Methods for Determining Aldrin/Dieldrin in Biological Materials (*continued*)

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Food	Samples are extracted using methyl cyanide. Residues are concentrated in petroleum ether and purified using Florisil.	GC/ECD AOAC Method 970.52	NR	$80%	Helrich 1990
Fatty foods	Samples are extracted using petroleum ether and acetonitrile. Clean-up using Florisil.	GC/ECD FDA Method 211.1	NR	NR	EMMI 1997
Non-fatty foods	Samples are extracted with acetonitrile or water-acetonitrile. Residues are transferred into petroleum ether.	GC/ECD FDA Method 212.1	NR	NR	EMMI 1997
Fish	Blended fish samples are extracted using petroleum ether and acetonitrile. Concentration and cleanup of extrant is done using an alumina or silica column.	GC/ECD USGS Method O9104	NR	NR	EMMI 1997
Feces (9-hydroxy-dieldrin)	Feces homogenized and extracted with acetone, then hexane. Florisil clean-up. Elute with acetone and hexane.	GC/ECD GC/MS	NR	NR	Richardson and Robinson 1971

Table 7-1. Analytical Methods for Determining Aldrin/Dieldrin in Biological Materials (*continued*)

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Urine (urinary metabolites of aldrin and dieldrin)	Urine mixed with ethyl ether and petroleum ether. Dried over anhydrous sulfate, concentrated. Florisil clean-up. Elution with ethyl ether/ petroleum ether to remove aldrin and ethyl ether/acetone to remove dieldrin.	GC/ECD	NR	NR	Klein et al. 1968
Fat, liver, brain (dieldrin)	Tissues extracted with hexane/acetone solution. Fats partitioned between hexane and dimethyl formamide. Florisil clean-up. Elution with 10% ether in hexane.	GC/ECD	0.5 ng	95%	Walker et al. 1969

AOAC = Association of Official Analytical Chemists; FDA = Food and Drug Administration; GC/ECD = gas chromatography/electron capture detector; GC/MS = gas chromatography/mass spectrometry; ng = nanogram; NR = not reported; USGS = U.S. Geological Survey method used for measuring levels of dieldrin in fat includes extraction with hexane/acetone solution, partitioning between hexane and dimethylformamide (DMF), clean-up, and elution in hexane. Recovery and sensitivity of this technique are good. Precision was not reported (Walker et al. 1969).

Aldrin and dieldrin have also been measured in samples of milk using GC/ECD (Barcarolo et al. 1988; EMMI 1997; Stacey and Tatum 1985; Takei et al. 1983). Sample preparation steps for milk involve homogenization, lipid extraction with hexane and acetone, residue extraction with acetonitrile, and partitioning into hexane. Recovery was adequate for dieldrin and good for aldrin. Precision was good. Sensitivity was not reported (Barcarolo et al. 1988).

A method describing the extraction of aldrin and dieldrin from fish samples employs similar procedures (EMMI 1997). This method is only applicable for fish tissue containing at least 0.1 μg/kg of analyte. A specific detection limit, however, was not mentioned for aldrin or dieldrin. Homogenized fish samples are extracted using petroleum ether and concentrated in acetonitrile. Cleanup is performed using an alumina or silica column. A GC/ECD is used to determine the total concentration of aldrin or dieldrin in the sample. Percent recovery was not reported.

7.2 ENVIRONMENTAL SAMPLES

Methods exist for determining aldrin and dieldrin in air, water, municipal effluents, sludge, and soil (Clesceri et al. 1998a; EPA 1986j; NIOSH 1984; OSW 1986a). The most common methods involve separation by GC coupled with ECD, electrolytic conductivity detector, or mass spectrometry (MS). GC has also been used with Fourier transform infrared spectroscopy (FTIR). Table 7-2 summarizes the methods that have been used to analyze for aldrin and dieldrin in environmental samples. The primary methods used for analyzing aldrin and dieldrin in air are GC/ECD and GC/electrolytic conductivity detector. The preparation method recommended by NIOSH for analysis of aldrin in air samples involves trapping the air on a glass fiber filter and extraction in an isooctane gas bubbler (NIOSH 1984). An alternative procedure to this method is the replacement of the gas bubbler with a stainless steel trapping tube packed with Tenax®GC (Wallace and Sherren 1986). Tenax®GC is an efficient absorbent for aldrin. The solvent trapping efficiency for the isooctane procedure ranges from 83 to 94% while the trapping

Table 7-2. Analytical Methods for Determining Aldrin/Dieldrin in Environmental Samples

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Air (aldrin)	Adsorption on Tenax®-GC, elution with acetone/ petroleum spirit.	GC/ECD	0.003 ppb	76–110%	Wallace and Sherren 1986
Air (aldrin)	Collection on glass fiber filter; extract in isooctane glass bubbler.	GC/ECD NIOSH Method 5502	2.2 ppm	103%	NIOSH 1984
Water	Samples extracted with methylene chloride. Solvent exchange to hexane prior to GC analysis.	GC/ECD Method OSW 8080A	aldrin 0.004 ppb dieldrin 0.002 ppb	aldrin 81% dieldrin 90%	EPA 1986j
Water	Samples extracted with methylene chloride, dried and concentrated. Solvent exchange to hexane.	GC/MS	1 ppb for aldrin and dieldrin)	aldrin 83–96% in reagent water; 94% river water dieldrin 97–106% in reagent water, 90% in river water	Alford-Stephens et al. 1986
Municipal and industrial effluent	Samples extracted with methylene chloride. Heat solution to 80 EC and add hexane. Concentrate.	GC/ECD APHA Method 6630C	aldrin 0.004 ppb dieldrin 0.002 ppb	aldrin 100% dieldrin 100%	Clesceri et al. 1998a
Municipal and industrial effluent	Sample is extracted with methylene chloride at pH>11 and then at pH<2. Extract is dried, concentrated, and analyzed.	GC/MS APHA Method 6410B	aldrin 1.9 ppb dieldrin 2.5 ppb	aldrin 1–166% dieldrin 29–136%	Clesceri et al. 1998b

Table 7-2. Analytical Methods for Determining Aldrin/Dieldrin in Environmental Samples (*continued*)

Sample matrix	Preparation method	Analytical method	Sample detection limit	Percent recovery	Reference
Soil	Samples extracted with acetone. Solvent exchange to hexane, dried over sodium sulfate; acetone added.	GC/MS	5 ng (aldrin and dieldrin)	aldrin 76–102% dieldrin 84–101%	Kobayashi et al. 1983
Soil	Soil mixed with acetone, filtered dried, extracted with hexane.	GC/MS	5 ng	aldrin 90% dieldrin 94%	Kobayashi et al. 1983
Solid waste, soils, and groundwater	Sample extraction varies depending on the matrix being tested.	GC/MS OSW Method 8250A	aldrin 1.9 ppb (water) dieldrin 2.5 ppb (water)	aldrin 0.1–166% dieldrin 29–136%	OSW 1986b
Soil/sludge	Samples are extracted with hexane-acetone (1:1) or methylene chloride-acetone (1:1). If necessary, an appropriate clean-up procedure is performed prior to analysis.	Narrow Bore Capillary Column with ECD OSW Method 8081B	aldrin 0.8 ppb (sludge) dieldrin 0.49 ppb (sludge)	aldrin 92% in sludge, 92% in clay dieldrin 89% in sludge, 113% in clay	OSW 1986a

APHA = American Public Health Assoication; EPA = Environmental Protection Agency; GC/ECD = gas chromatography/electron capture detector; GC/MS = gas chromatography/mass spectrometry; ng = nanogram; NIOSH = National Institute for Occupational Safety and Health; OSW = Office of Solid Waste efficiency for Tenax®GC is >99%. Also, use of Tenax®GC does not require frequent replenishment of the volatile solvent needed for the isooctane bubbler, and the Tenax®GC trapping tube can be transported easily from sampling sites to the laboratory (Wallace and Sherren 1986). The sensitivity of these methods is in the low- to sub-ppb range. Precision is good. Recoveries for these methods are generally good but can range from 76 to 110%, depending on the series of solvents used in the preparation method. The methods most frequently used to analyze water samples containing aldrin and dieldrin are GC/ECD and GC/MS. Interferences by phthalate esters can pose a problem in pesticide determinations when using the ECD. Interferences from phthalates can best be minimized by avoiding contact with any plastic materials. The contamination from phthalate esters can be completely eliminated with an electrolytic conductivity detector (EPA 1986j).

Aldrin and dieldrin are isolated from aqueous media by extraction in methylene chloride followed by drying with sodium sulfate, concentration, and solvent exchange to hexane (Alford-Stevens et al. 1986; EPA 1986j; Marsden et al. 1986). The limit of detection for both aldrin and dieldrin is in the low- to sub-ppb range for GC/ECD and GC/MS, respectively. Accuracy is generally good with the percent recoveries for dieldrin (90–106%) being higher that those for aldrin (81–96%). The precision obtained using GC/MS was better than that obtained using GC/ECD. The majority of analytical laboratories continue to rely on ECD for determination of aldrin and dieldrin. The main reason is that ECD provides a greater degree of sensitivity than MS. The difference in sensitivity has been reported to be as much as 2–3 orders of magnitude. The sensitivity of this method, however, depends on the level of interferences. Samples may require cleanup with a Florisil® column. The ECDs, however, do not provide the molecular structure information that is obtained with an MS detector. The structural information increases the level of confidence that the compound being measured has been correctly identified (Alford-Stevens et al. 1986). GC/FTIR has also been used to measure aldrin and dieldrin in water. However, this is not the recommended method because chlorinated pesticides are weak infrared absorbers (Gomez-Taylor et al. 1978).

Aldrin and dieldrin in solid samples such as soil and sediment are quantified mainly by GC/ECD and GC/MS (EPA 1986j; Kobayashi et al. 1983; Marsden et al. 1986). The soil or sediment samples are prepared for analysis by extraction with a mixture of methylene chloride and acetone, followed by drying with sodium sulfate, and solvent exchange to hexane. Recoveries are generally good, and detection limits are in the low- to sub-ppb range for GC/MS and GC/ECD, respectively. While GC/ECD is highly sensitive, this method requires a complicated clean-up procedure to remove interferences in the sample that produce peaks having the same retention times. The MS detector is a simple, rapid, and selective method for the determination of aldrin and dieldrin in soil and is free from sample-related interferences (Kobayashi et al. 1983). Aldrin and dieldrin have been measured in fruits and vegetables using GC/ECD. Sample preparation involves boiling in water with a cyclic steam distillation unit with 2,2,4-trimethylpentane in the solvent trap. Variations in recoveries were reported. Sensitivity and precision were not reported (Santa Maria et al. 1986).

7.3 ADEQUACY OF THE DATABASE

Section 104(I)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of aldrin and dieldrin are available. Where adequate information is not available, ATSDR, in conjunction with the National Toxicology Program (NTP), is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of aldrin and dieldrin.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

7.3.1 Identification of Data Needs

Methods for Determining Biomarkers of Exposure and Effect.

Exposure. Methods exist for determining aldrin and dieldrin in blood (Burse et al. 1983; MacCuaig 1976; Robinson et al. 1967), milk (Barcarolo et al. 1988; Stacey and Tatum 1985; Takei et al. 1983), body tissues (Walker et al. 1969), feces (Richardson and Robinson 1971), and urine (Klein et al. 1968). These methods are sensitive for measuring levels at which health effects might occur, as well as background levels in the population. Methods for determining dieldrin in blood are relatively precise; however, improvements in recovery of dieldrin are needed. These improvements would allow for better evaluation of exposure to aldrin or dieldrin. Sensitive techniques exist for measuring dieldrin in tissues;

however, precision data are lacking. Data on the determination of dieldrin or its metabolites in milk, urine, and feces are limited. More information on the sensitivity and recovery obtained for these methods is needed to evaluate the value of using levels of dieldrin or its metabolites as an indicator of exposure.

Effect. The methods for determining biomarkers of effect are the same as those for exposure, and are subject to the same limitations. Improved methods could allow a better assessment of the relationship between levels of dieldrin in blood, body tissues, and fluids and the known health effects associated with these chemicals.

Methods for Determining Parent Compounds and Degradation Products in Environmental Media. Methods for determining levels of aldrin and dieldrin in air (NIOSH 1984; Wallace and Sherren 1986), water (Alford-Stevens et al. 1986; EPA 1986j), and soil (EPA 1986j; Kobayashi et al. 1983; Marsden et al. 1986) are sensitive enough to measure background levels in the environment, as well as levels at which health effects might occur. Analytical procedures for the analysis of aldrin and dieldrin in foods were also located (EMMI 1997). Research investigating the relationship between levels measured in air, water, soil, and foods and observed health effects could increase our confidence in existing methods and/or indicate where improvements are needed.

7.3.2 Ongoing Studies

No ongoing studies regarding new analytical methods for determining aldrin and dieldrin in environmental media or food products were reported in either the CRIS/USDA database or the Federal Research in Progress database (CRIS/USDA 2001; FEDRIP 2001).

8. REGULATIONS AND ADVISORIES

The international, national, and state regulations and guidelines regarding aldrin and dieldrin in air, water, and other media are summarized in Table 8-1.

ATSDR has developed two MRL values for aldrin. An acute-duration oral MRL of $2x10^{-3}$ mg/kg/day was derived for aldrin based on its ability to cause decreased body weight and neurological changes (increased electroconvulsive shock threshold) in offspring of mice exposed during gestation (Al-Hachim 1971). A chronic-duration oral MRL of $3x10^{-5}$ mg/kg/day was derived for aldrin based on liver effects in rats (hepatocellular enlargement, cytoplasmic eosinophilia, and peripheral migration of basophilic granules along with less prominent alterations of cytoplasmic vacuolation and bile duct proliferation) (Fitzhugh et al. 1964). ATSDR has also derived two MRL values for dieldrin. An intermediate-duration oral MRL of $1x10^{-4}$ mg/kg/day was derived for dieldrin based on impaired learning of a successive discrimination reversal task in monkeys (Smith et al. 1976). A chronic-duration oral MRL of $5x10^{-5}$ mg/kg/day was derived for dieldrin based on liver parenchymal cell changes in rats (Walker et al. 1969).

EPA (IRIS 2002a, 2002b) has derived oral reference doses (RfDs) for aldrin and dieldrin of $3x10^{-5}$ and $5x10^{-5}$ mg/kg/day, respectively, based on liver toxicity in rats (Fitzhugh et al. 1964; Walker et al. 1969). No inhalation MRLs or reference concentrations (RfCs) have been derived for aldrin or dieldrin.

Aldrin and dieldrin are on the list of chemicals appearing in "Toxic Chemicals Subject to Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986" (EPA 1999c).

All uses of aldrin and dieldrin were canceled in 1974, except for subsurface ground insertion for termite control, dipping of nonfood roots and tops, and moth-proofing by manufacturing processes in a closed system (EPA 1974a). In 1987, these final three uses were voluntarily canceled by the sole manufacturer (EPA 1989a).

Table 8-1. Regulations and Guidelines Applicable to Aldrin/Dieldrin

Agency	Description	Information		Reference
INTERNATIONAL Guidelines:				
IARC	Carcinogenicity classification Aldrin and dieldrin	Group 3[a]		IARC 2001
NATIONAL Regulations and Guidelines:				
a. Air				
ACGIH	TWA Aldrin and dieldrin[b]	 0.25 mg/m^3		ACGIH 2001
NIOSH	TWA-REL Aldrin and dieldrin IDLH Aldrin Dieldrin	 0.25 mg/m^3 0.25 mg/m^3 0.50 mg/m^3		NIOSH 2001
OSHA	8-hour TWA Aldrin and dieldrin[b]	 0.25 mg/m^3		OSHA 2001b 29CFR1910.1000
	8-hour TWA for construction industry Aldrin and dieldrin[b]	 0.25 mg/m^3		OSHA 2001c 29CFR1926.55
	8-hour TWA for shipyard industry Aldrin and dieldrin[b]	 0.25 mg/m^3		OSHA 2001a 29CFR1915.1000
b. Water				
EPA	Drinking water standards and health advisories Aldrin 10-kg child 1-day and 10-day DWEL[c]	 $3x10^{-4}$ mg/L $1x10^{-3}$ mg/L		EPA 2000
	Dieldrin 10-kg child 1-day and 10-day DWEL[c]	 $5x10^{-4}$ mg/L $2x10^{-3}$ mg/L		
	Groundwater monitoring Aldrin and dieldrin	Method 8080 8270	PQL (µg/L) 0.05 10	EPA 2001d 40CFR264 Appendix IX

Table 8-1. Regulations and Guidelines Applicable to Aldrin/Dieldrin *(continued)*

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
EPA	Land disposal restrictions—universal treatment standards		EPA 2001g 40CFR268.48
	Aldrin		
	Wastewater standard	0.021 mg/L[2]	
	Non-wastewater standard	0.066 mg/kg[2]	
	Dieldrin		
	Wastewater standard	0.017 mg/L[2]	
	Non-wastewater standard	0.130 mg/kg[2]	
	National recommended water quality criteria		EPA 1999h
	Aldrin		
	Freshwater	3.0 μg/L	
	Saltwater	1.3 μg/L	
	Human health consumption		
	Water and organism	1.3×10^{-4} μg/L	
	Organism only	1.4×10^{-4} μg/L	
	Dieldrin		
	Freshwater	0.24 μg/L	
	Saltwater	0.71 μg/L	
	Human health consumption		
	Water and organism	1.4×10^{-4} μg/L	
	Organism only	1.4×10^{-4} μg/L	
	Reportable quantity of hazardous substance designated pursuant to Section 311 of the Clean Water Act—aldrin and dieldrin	1 pound	EPA 2001b 40CFR117.3
	Requirement to monitor unregulated contaminant—aldrin and dieldrin		EPA 1999i 64 FR 1495
	Toxic pollutant effluent standards—ambient water criterion for aldrin/dieldrin in navigable waters	0.003 μg/L	EPA 2001l 40CFR129.100
	Water programs—designation of hazardous substance in accordance with Section 311(b)(2)(A) of the Act		EPA 2001m 40CFR116.4

Table 8-1. Regulations and Guidelines Applicable to Aldrin/Dieldrin *(continued)*

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
c. Food			
USDA	Labeling of seed treated with aldrin (technical) and dieldrin	"This seed has been treated with poison"	USDA 2001 7CFR201.31a
d. Other			
ACGIH	Carcinogenicity classification		ACGIH 2001
	Aldrin	A3[d]	
	Dieldrin	A4[e]	
EPA	Aldrin		IRIS 2001a
	Carcinogenicity classification	B2[f]	
	Oral slope factor	$1.7x10^{1}$ $(mg/kg/day)^{-1}$	
	Drinking water unit risk	$4.9x10^{-4}$ $(\mu g/L)^{-1}$	
	Inhalation unit risk	$4.9x10^{-3}$ $(\mu g/m^3)^{-1}$	
	RfC	Not available	
	RfD	$3x10^{-5}$ mg/kg/day	
	Dieldrin		IRIS 2001b
	Carcinogenicity classification	B2[f]	
	Oral slope factor	$1.6x10^{1}$ $(mg/kg/day)^{-1}$	
	Drinking water unit risk	$4.6x10^{-4}$ $(\mu g/L)^{-1}$	
	Inhalation unit risk	$4.6x10^{-3}$ $(\mu g/m^3)^{-1}$	
	RfC	Not available	
	RfD	$5x10^{-5}$ mg/kg/day	
	Effluent guidelines and standards; toxic pollutant designated pursuant to Section 307(a)(1) of the Act—aldrin and dieldrin		EPA 2001c 40CFR401.15
	Health-based limits for exclusion of waste-derived residues—residue concentration limits		EPA 2001e 40CFR266 Appendix VII
	Aldrin and dieldrin	$2x10^{-5}$ mg/kg	
	Identification and listing as a hazardous waste and identified as an acute hazardous waste		EPA 2001f 40CFR261.33(e)
	Aldrin	P004	
	Dieldrin	P037	
	Pesticide classification for aldrin and dieldrin	Chlorinated organic pesticide	EPA 2001j 40CFR180.3(e)(4)

Table 8-1. Regulations and Guidelines Applicable to Aldrin/Dieldrin *(continued)*

Agency	Description	Information	Reference
NATIONAL *(cont.)*			
EPA	Reportable quantity designated as a CERCLA hazardous substance under Section 311(b)(4) and 307(a) of the Clean Water Act and RCRA Section 3001—aldrin and dieldrin	1 pound	EPA 2001a 40CFR302.4
	Risk specific doses		EPA 2001h 40CFR266 Appendix V
	Aldrin	$2.0x10^{-3}$ ug/m^3	
	Dieldrin	$2.2x10^{-3}$ ug/m^3	
	Superfund, extremely hazardous substance and threshold planning quantity—aldrin	500/10,000 pounds	EPA 2001i 40CFR355 Appendix A
	Toxic chemical release reporting; Community right-to-know—effective date		EPA 2001k 40CFR372.65
	Aldrin	01/01/87	
STATE Regulations and Guidelines:			
a. Air			
Washington	Toxic air pollutant and acceptable source impact levels (annual average at 10^{-6} risk)		BNA 2001
	Aldrin	$2.0x10^{-4}$ µg/m^3	
	Dieldrin	$2.2x10^{-4}$ µg/m^3	
Wisconsin	Hazardous air contaminants acceptable ambient concentrations		WI Department of Natural Resources 1997
	Adrin and dieldrin		
	<25 feet emission point	0.020880 pounds/hour	
	š25 feet emission point	0.086400 pounds/hour	
b. Water			
Arizona	Drinking water guideline		HSDB 2001a,b
	Aldrin	0.002 µg/L	
	Dieldrin	0.001 µg/L	
California	Drinking water guideline		HSDB 2001a,b
	Aldrin and dieldrin	0.05 µg/L	

Table 8-1. Regulations and Guidelines Applicable to Aldrin/Dieldrin *(continued)*

Agency	Description	Information	Reference
STATE *(cont.)*			
Florida	Drinking water guideline		HSDB 2001a,b
	Aldrin	0.05 μg/L	
	Dieldrin	0.1 μg/L	
Hawaii	Unregulated contaminant	Monitoring is required	HI Department of Health 1999a
Hawaii	Water quality standards		BNA 2001
	Aldrin		
	Freshwater		
	Acute	3.0 μg/L	
	Chronic	No standard	
	Saltwater		
	Acute	1.3 μg/L	
	Chronic	No standard	
	Fish Consumption	2.6×10^{-5} μg/L	
	Dieldrin		
	Freshwater		
	Acute	2.5 μg/L	
	Chronic	1.9×10^{-3} μg/L	
	Saltwater		
	Acute	0.71 μg/L	
	Chronic	1.9×10^{-3} μg/L	
	Fish Consumption	2.5×10^{-5} μg/L	
Illinois	Primary drinking water standard		BNA 2001
	Aldrin and dieldrin	1 μg/L	
Kansas	Water quality standards		BNA 2001
	Aldrin		
	Aquatic life		
	Acute	3 μg/L	
	Chronic	1×10^{-3} μg/L	
	Agriculture		
	Livestock	1 μg/L	
	Public health		
	Food procurement	7.9×10^{-5} μg/L	
	Dieldrin		
	Aquatic life		
	Acute	1.0 μg/L	
	Chronic	1.9×10^{-3} μg/L	
	Agriculture		
	Livestock	1.0 μg/L	
	Public health		
	Food procurement	7.6×10^{-5} μg/L	

Table 8-1. Regulations and Guidelines Applicable to Aldrin/Dieldrin *(continued)*

Agency	Description	Information	Reference
STATE *(cont.)*			
Maine	Drinking water guideline		HSDB 2001b
	Dieldrin	0.02 μg/L	
New Hampshire	Drinking water guideline		HSDB 2001a,b
	Aldrin and dieldrin	0.002 μg/L	
New Jersey	Ground water quality criteria		BNA 2001
	Aldrin and dieldrin	0.002 μg/L	
South Dakota	Unregulated chemicals—aldrin and dieldrin	Required monitoring by all community and non-transient non-community water systems	BNA 2001

[a]Group 3: not classifiable as to its carcinogenicity to humans
[b]Skin notation: danger of cutaneous absorption
[c]DWEL: A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a contaminant is from a drinking water source.
[d]A3: confirmed animal carcinogen with unknown relevance to humans
[e]A4: not classifiable as a human carcinogen
[f]B2: Probable human carcinogen

ACGIH = American Conference of Governmental Industrial Hygienists; BNA = Bureau of National Affairs; CERCLA = Comprehensive Environmental Response Compensation and Liability Act; CFR = Code of Federal Regulations; DWEL = drinking water equivalent level; EPA = Environmental Protection Agency; FR = Federal Register; HSDB = Hazardous Substances Data Bank; IARC = International Agency for Research on Cancer; IDLH = immediately dangerous to life or health; IRIS = Integrated Risk Information System; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration; PQL = practical quantitation limits; RCRA = Resource Conservation Recovery Act; REL = recommended exposure limit; RfC = inhalation reference concentration; RfD = oral reference dose; TWA = time-weighted average; USDA = U.S. Department of Agriculture

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10. GLOSSARY

Absorption—The taking up of liquids by solids, or of gases by solids or liquids.

Acute Exposure—Exposure to a chemical for a duration of 14 days or less, as specified in the Toxicological Profiles.

Adsorption—The adhesion in an extremely thin layer of molecules (as of gases, solutes, or liquids) to the surfaces of solid bodies or liquids with which they are in contact.

Adsorption Coefficient (K_{oc})—The ratio of the amount of a chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of the chemical in solution at equilibrium.

Adsorption Ratio (Kd)—The amount of a chemical adsorbed by a sediment or soil (i.e., the solid phase) divided by the amount of chemical in the solution phase, which is in equilibrium with the solid phase, at a fixed solid/solution ratio. It is generally expressed in micrograms of chemical sorbed per gram of soil or sediment.

Benchmark Dose (BMD)—Usually defined as the lower confidence limit on the dose that produces a specified magnitude of changes in a specified adverse response. For example, a BMD_{10} would be the dose at the 95% lower confidence limit on a 10% response, and the benchmark response (BMR) would be 10%. The BMD is determined by modeling the dose response curve in the region of the dose response relationship where biologically observable data are feasible.

Benchmark Dose Model—A statistical dose-response model applied to either experimental toxicological or epidemiological data to calculate a BMD.

Bioconcentration Factor (BCF)—The quotient of the concentration of a chemical in aquatic organisms at a specific time or during a discrete time period of exposure divided by the concentration in the surrounding water at the same time or during the same period.

Biomarkers—Broadly defined as indicators signaling events in biologic systems or samples. They have been classified as markers of exposure, markers of effect, and markers of susceptibility.

Cancer Effect Level (CEL)—The lowest dose of chemical in a study, or group of studies, that produces significant increases in the incidence of cancer (or tumors) between the exposed population and its appropriate control.

Carcinogen—A chemical capable of inducing cancer.

Case-Control Study—A type of epidemiological study which examines the relationship between a particular outcome (disease or condition) and a variety of potential causative agents (such as toxic chemicals). In a case-controlled study, a group of people with a specified and well-defined outcome is identified and compared to a similar group of people without outcome.

Case Report—Describes a single individual with a particular disease or exposure. These may suggest some potential topics for scientific research but are not actual research studies.

Case Series—Describes the experience of a small number of individuals with the same disease or exposure. These may suggest potential topics for scientific research but are not actual research studies.

Ceiling Value—A concentration of a substance that should not be exceeded, even instantaneously.

Chronic Exposure—Exposure to a chemical for 365 days or more, as specified in the Toxicological Profiles.

Cohort Study—A type of epidemiological study of a specific group or groups of people who have had a common insult (e.g., exposure to an agent suspected of causing disease or a common disease) and are followed forward from exposure to outcome. At least one exposed group is compared to one unexposed group.

Cross-sectional Study—A type of epidemiological study of a group or groups which examines the relationship between exposure and outcome to a chemical or to chemicals at one point in time.

Data Needs—Substance-specific informational needs that if met would reduce the uncertainties of human health assessment.

Developmental Toxicity—The occurrence of adverse effects on the developing organism that may result from exposure to a chemical prior to conception (either parent), during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the life span of the organism.

Dose-Response Relationship—The quantitative relationship between the amount of exposure to a toxicant and the incidence of the adverse effects.

Embryotoxicity and Fetotoxicity—Any toxic effect on the conceptus as a result of prenatal exposure to a chemical; the distinguishing feature between the two terms is the stage of development during which the insult occurs. The terms, as used here, include malformations and variations, altered growth, and *in utero* death.

Environmental Protection Agency (EPA) Health Advisory—An estimate of acceptable drinking water levels for a chemical substance based on health effects information. A health advisory is not a legally enforceable federal standard, but serves as technical guidance to assist federal, state, and local officials.

Epidemiology—Refers to the investigation of factors that determine the frequency and distribution of disease or other health-related conditions within a defined human population during a specified period.

Genotoxicity—A specific adverse effect on the genome of living cells that, upon the duplication of affected cells, can be expressed as a mutagenic, clastogenic or carcinogenic event because of specific alteration of the molecular structure of the genome.

Half-life—A measure of rate for the time required to eliminate one half of a quantity of a chemical from the body or environmental media.

Immediately Dangerous to Life or Health (IDLH)—The maximum environmental concentration of a contaminant from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects.

Incidence—The ratio of individuals in a population who develop a specified condition to the total number of individuals in that population who could have developed that condition in a specified time period.

Intermediate Exposure—Exposure to a chemical for a duration of 15–364 days, as specified in the Toxicological Profiles.

Immunologic Toxicity—The occurrence of adverse effects on the immune system that may result from exposure to environmental agents such as chemicals.

Immunological Effects—Functional changes in the immune response.

***In Vitro*—**Isolated from the living organism and artificially maintained, as in a test tube.

***In Vivo*—**Occurring within the living organism.

Lethal Concentration$_{(LO)}$ (LC_{LO})—The lowest concentration of a chemical in air which has been reported to have caused death in humans or animals.

Lethal Concentration$_{(50)}$ (LC_{50})—A calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.

Lethal Dose$_{(LO)}$ (LD_{LO})—The lowest dose of a chemical introduced by a route other than inhalation that has been reported to have caused death in humans or animals.

Lethal Dose$_{(50)}$ (LD_{50})—The dose of a chemical which has been calculated to cause death in 50% of a defined experimental animal population.

Lethal Time$_{(50)}$ (LT_{50})—A calculated period of time within which a specific concentration of a chemical is expected to cause death in 50% of a defined experimental animal population.

Lowest-Observed-Adverse-Effect Level (LOAEL)—The lowest exposure level of chemical in a study, or group of studies, that produces statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control.

Lymphoreticular Effects—Represent morphological effects involving lymphatic tissues such as the lymph nodes, spleen, and thymus.

Malformations—Permanent structural changes that may adversely affect survival, development, or function.

Minimal Risk Level (MRL)—An estimate of daily human exposure to a hazardous substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified route and duration of exposure.

Modifying Factor (MF)—A value (greater than zero) that is applied to the derivation of a minimal risk level (MRL) to reflect additional concerns about the database that are not covered by the uncertainty factors. The default value for a MF is 1.

Morbidity—State of being diseased; morbidity rate is the incidence or prevalence of disease in a specific population.

Mortality—Death; mortality rate is a measure of the number of deaths in a population during a specified interval of time.

Mutagen—A substance that causes mutations. A mutation is a change in the DNA sequence of a cell's DNA. Mutations can lead to birth defects, miscarriages, or cancer.

Necropsy—The gross examination of the organs and tissues of a dead body to determine the cause of death or pathological conditions.

Neurotoxicity—The occurrence of adverse effects on the nervous system following exposure to a chemical.

No-Observed-Adverse-Effect Level (NOAEL)—The dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse.

Octanol-Water Partition Coefficient (K_{ow})—The equilibrium ratio of the concentrations of a chemical in *n*-octanol and water, in dilute solution.

Odds Ratio (OR)—A means of measuring the association between an exposure (such as toxic substances and a disease or condition) which represents the best estimate of relative risk (risk as a ratio of the incidence among subjects exposed to a particular risk factor divided by the incidence among subjects who were not exposed to the risk factor). An odds ratio of greater than 1 is considered to indicate greater risk of disease in the exposed group compared to the unexposed.

Organophosphate or Organophosphorus Compound—A phosphorus containing organic compound and especially a pesticide that acts by inhibiting cholinesterase.

Permissible Exposure Limit (PEL)—An Occupational Safety and Health Administration (OSHA) allowable exposure level in workplace air averaged over an 8-hour shift of a 40-hour workweek.

Pesticide—General classification of chemicals specifically developed and produced for use in the control of agricultural and public health pests.

Pharmacokinetics—The science of quantitatively predicting the fate (disposition) of an exogenous substance in an organism. Utilizing computational techniques, it provides the means of studying the absorption, distribution, metabolism and excretion of chemicals by the body.

Pharmacokinetic Model—A set of equations that can be used to describe the time course of a parent chemical or metabolite in an animal system. There are two types of pharmacokinetic models: data-based and physiologically-based. A data-based model divides the animal system into a series of compartments which, in general, do not represent real, identifiable anatomic regions of the body whereby the physiologically-based model compartments represent real anatomic regions of the body.

Physiologically Based Pharmacodynamic (PBPD) Model—A type of physiologically-based dose-response model which quantitatively describes the relationship between target tissue dose and toxic end points. These models advance the importance of physiologically based models in that they clearly describe the biological effect (response) produced by the system following exposure to an exogenous substance.

Physiologically Based Pharmacokinetic (PBPK) Model—Comprised of a series of compartments representing organs or tissue groups with realistic weights and blood flows. These models require a variety of physiological information: tissue volumes, blood flow rates to tissues, cardiac output, alveolar ventilation rates and, possibly membrane permeabilities. The models also utilize biochemical information such as air/blood partition coefficients, and metabolic parameters. PBPK models are also called biologically based tissue dosimetry models.

Prevalence—The number of cases of a disease or condition in a population at one point in time.

Prospective Study—A type of cohort study in which the pertinent observations are made on events occurring after the start of the study. A group is followed over time.

q_1*—The upper-bound estimate of the low-dose slope of the dose-response curve as determined by the multistage procedure. The q_1* can be used to calculate an estimate of carcinogenic potency, the incremental excess cancer risk per unit of exposure (usually µg/L for water, mg/kg/day for food, and $\mu g/m^3$ for air).

Recommended Exposure Limit (REL)—A National Institute for Occupational Safety and Health (NIOSH) time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek.

Reference Concentration (RfC)—An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer health effects during a lifetime. The inhalation reference concentration is for continuous inhalation exposures and is appropriately expressed in units of mg/m^3 or ppm.

Reference Dose (RfD)—An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure of the human population to a potential hazard that is likely to be without risk of deleterious effects during a lifetime. The RfD is operationally derived from the no-observed-adverse-effect level (NOAEL-from animal and human studies) by a consistent application of uncertainty factors that reflect various types of data used to estimate RfDs and an additional modifying factor, which is based on a professional judgment of the entire database on the chemical. The RfDs are not applicable to nonthreshold effects such as cancer.

Reportable Quantity (RQ)—The quantity of a hazardous substance that is considered reportable under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Reportable quantities are (1) 1 pound or greater or (2) for selected substances, an amount established by regulation either under CERCLA or under Section 311 of the Clean Water Act. Quantities are measured over a 24-hour period.

Reproductive Toxicity—The occurrence of adverse effects on the reproductive system that may result from exposure to a chemical. The toxicity may be directed to the reproductive organs and/or the related endocrine system. The manifestation of such toxicity may be noted as alterations in sexual behavior, fertility, pregnancy outcomes, or modifications in other functions that are dependent on the integrity of this system.

Retrospective Study—A type of cohort study based on a group of persons known to have been exposed at some time in the past. Data are collected from routinely recorded events, up to the time the study is undertaken. Retrospective studies are limited to causal factors that can be ascertained from existing records and/or examining survivors of the cohort.

Risk—The possibility or chance that some adverse effect will result from a given exposure to a chemical.

Risk Factor—An aspect of personal behavior or lifestyle, an environmental exposure, or an inborn or inherited characteristic, that is associated with an increased occurrence of disease or other health-related event or condition.

Risk Ratio—The ratio of the risk among persons with specific risk factors compared to the risk among persons without risk factors. A risk ratio greater than 1 indicates greater risk of disease in the exposed group compared to the unexposed.

Short-Term Exposure Limit (STEL)—The American Conference of Governmental Industrial Hygienists (ACGIH) maximum concentration to which workers can be exposed for up to 15 min continually. No more than four excursions are allowed per day, and there must be at least 60 min between exposure periods. The daily Threshold Limit Value - Time Weighted Average (TLV-TWA) may not be exceeded.

Standardized Mortality Ratio (SMR)—A ratio of the observed number of deaths and the expected number of deaths in a specific standard population.

Target Organ Toxicity—This term covers a broad range of adverse effects on target organs or physiological systems (e.g., renal, cardiovascular) extending from those arising through a single limited exposure to those assumed over a lifetime of exposure to a chemical.

Teratogen—A chemical that causes structural defects that affect the development of an organism.

Threshold Limit Value (TLV)—An American Conference of Governmental Industrial Hygienists (ACGIH) concentration of a substance to which most workers can be exposed without adverse effect. The TLV may be expressed as a Time Weighted Average (TWA), as a Short-Term Exposure Limit (STEL), or as a ceiling limit (CL).

Time-Weighted Average (TWA)—An allowable exposure concentration averaged over a normal 8-hour workday or 40-hour workweek.

Toxic Dose$_{(50)}$ (TD$_{50}$)—A calculated dose of a chemical, introduced by a route other than inhalation, which is expected to cause a specific toxic effect in 50% of a defined experimental animal population.

Toxicokinetic—The study of the absorption, distribution and elimination of toxic compounds in the living organism.

Uncertainty Factor (UF)—A factor used in operationally deriving the Minimal Risk Level (MRL) or Reference Dose (RfD) or Reference Concentration (RfC) from experimental data. UFs are intended to account for (1) the variation in sensitivity among the members of the human population, (2) the uncertainty in extrapolating animal data to the case of human, (3) the uncertainty in extrapolating from data obtained in a study that is of less than lifetime exposure, and (4) the uncertainty in using lowest-observed-adverse-effect level (LOAEL) data rather than no-observed-adverse-effect level (NOAEL) data. A default for each individual UF is 10; if complete certainty in data exists, a value of one can be used;

however a reduced UF of three may be used on a case-by-case basis, three being the approximate logarithmic average of 10 and 1.

Xenobiotic—Any chemical that is foreign to the biological system.

APPENDIX A

ATSDR MINIMAL RISK LEVEL AND WORKSHEETS

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 U.S.C. 9601 et seq.], as amended by the Superfund Amendments and Reauthorization Act (SARA) [Pub. L. 99–499], requires that the Agency for Toxic Substances and Disease Registry (ATSDR) develop jointly with the U.S. Environmental Protection Agency (EPA), in order of priority, a list of hazardous substances most commonly found at facilities on the CERCLA National Priorities List (NPL); prepare toxicological profiles for each substance included on the priority list of hazardous substances; and assure the initiation of a research program to fill identified data needs associated with the substances.

The toxicological profiles include an examination, summary, and interpretation of available toxicological information and epidemiologic evaluations of a hazardous substance. During the development of toxicological profiles, Minimal Risk Levels (MRLs) are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration for a given route of exposure. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. MRLs are based on noncancer health effects only and are not based on a consideration of cancer effects. These substance-specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors to identify contaminants and potential health effects that may be of concern at hazardous waste sites. It is important to note that MRLs are not intended to define clean-up or action levels.

MRLs are derived for hazardous substances using the no-observed-adverse-effect level/uncertainty factor approach. They are below levels that might cause adverse health effects in the people most sensitive to such chemical-induced effects. MRLs are derived for acute (1–14 days), intermediate (15–364 days), and chronic (365 days and longer) durations and for the oral and inhalation routes of exposure. Currently, MRLs for the dermal route of exposure are not derived because ATSDR has not yet identified a method suitable for this route of exposure. MRLs are generally based on the most sensitive chemical-induced end point considered to be of relevance to humans. Serious health effects (such as irreparable damage to the liver or kidneys, or birth defects) are not used as a basis for establishing MRLs. Exposure to a level above the MRL does not mean that adverse health effects will occur.

MRLs are intended only to serve as a screening tool to help public health professionals decide where to look more closely. They may also be viewed as a mechanism to identify those hazardous waste sites that are not expected to cause adverse health effects. Most MRLs contain a degree of uncertainty because of the lack of precise toxicological information on the people who might be most sensitive (e.g., infants, elderly, nutritionally or immunologically compromised) to the effects of hazardous substances. ATSDR uses a conservative (i.e., protective) approach to address this uncertainty consistent with the public health principle of prevention. Although human data are preferred, MRLs often must be based on animal studies because relevant human studies are lacking. In the absence of evidence to the contrary, ATSDR assumes that humans are more sensitive to the effects of hazardous substance than animals and that certain persons may be particularly sensitive. Thus, the resulting MRL may be as much as a hundredfold below levels that have been shown to be nontoxic in laboratory animals.

Proposed MRLs undergo a rigorous review process: Health Effects/MRL Workgroup reviews within the Division of Toxicology, expert panel peer reviews, and agencywide MRL Workgroup reviews, with participation from other federal agencies and comments from the public. They are subject to change as new information becomes available concomitant with updating the toxicological profiles. Thus, MRLs in the most recent toxicological profiles supersede previously published levels. For additional information regarding MRLs, please contact the Division of Toxicology, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road, Mailstop E-29, Atlanta, Georgia 30333.

MRL WORKSHEET

Chemical Name: Aldrin
CAS Number: 309-00-2
Date: April, 2002
Profile Status: Third Draft, Post Public
Route: [ ] Inhalation [X] Oral
Duration: [X] Acute [ ] Intermediate [ ] Chronic
Key to Figure: 7m
Species: mouse

Minimal Risk Level: 0.002 [X] mg/kg/day [ ] ppm

Reference: Al-Hachim GM. 1971. Effect of aldrin on the condition avoidance response and electroshock seizure threshold of offspring from aldrin-treated mother. Psychopharmacologia 21:370-373.

Experimental design: Pregnant albino mice (7/group) were given aldrin at 0, 2, or 4 mg/kg by gavage during the third trimester of pregnancy for 5–7 days. The 0 mg/kg/day dose group received only corn oil. Litters were weaned at 30 days of age. Three groups of 10 offspring were randomly selected from each group of maternal animals and were subsequently tested for effects of prenatal exposure to aldrin. From the time of weaning until they were 37 days old, the offspring were tested for the acquisition of conditioned avoidance response. On post partum day 38, the offspring were tested for electroshock seizure threshold.

Effects noted in study and corresponding doses: At both 2 and 4 mg/kg/day, offspring showed decreased body weight and increased electroconvulsive shock thresholds. Values at both levels were statistically significant, but the effects seen at 4 mg/kg/day were not of greater magnitude than those seen at 2 mg/kg/day. Conditioned avoidance responding was not affected.

Dose and end point used for MRL derivation: 2 mg/kg/day; decreased body weight and electroconvulsive shock threshold in offspring of treated mice.

[ ] NOAEL [X] LOAEL

Uncertainty Factors used in MRL derivation:

[X] 10 for use of a LOAEL
[X] 10 for extrapolation from animals to humans
[X] 10 for human variability

Was a conversion factor used from ppm in food or water to a mg/body weight dose?
No.

If an inhalation study in animals, list conversion factors used in determining human equivalent dose:
Not applicable.

Was a conversion used from intermittent to continuous exposure?
No.

Other additional studies or pertinent information that lend support to this MRL: Another study showed developmental toxicity at higher doses of aldrin in mice and hamsters (Ottolenghi 1974). Hamsters showed increased fetal mortality at 50 mg/kg when aldrin was administered on gestation days 7, 8, or 9, and mice showed an increase in the incidence of webbed feet at 25 mg/kg when aldrin was administered on gestation day 9. These results support the developmental toxicity of aldrin. The end points measured in the MRL study may be more sensitive indicators of fetal toxicity than fetal death or malformations.

Agency Contact (Chemical Manager): G. Douglas Hanley

MRL WORKSHEET

Chemical Name: Aldrin
CAS Number: 309-00-2
Date: June, 2002
Profile Status: Third Draft, Post Public
Route: [ ] Inhalation [X] Oral
Duration: [ ] Acute [ ] Intermediate [X] Chronic
Key to Figure: 21r
Species: rat

Minimal Risk Level: 0.00003 [X] mg/kg/day [ ] ppm

Reference: Fitzhugh OG, Nelson AA, Quaife ML. 1964. Chronic oral toxicity of aldrin and dieldrin in rats and dogs. Food Cosmet Toxicol 2:551-562.

Experimental design: Weanling Osborne-Mendel strain rats (24/dose, evenly divided by sex) were administered aldrin (recrystallized, #99% purity) in the diet at concentrations of 0, 0.5, 2, 10, 50, 100, or 150 ppm for 2 years. Aldrin was dissolved in corn oil prior to mixing in the diet. Feed and water were available *ad libitum*. During the exposure period, the rats were evaluated for body weight (weekly), clinical observations, and mortality; it is unclear how often observations for clinical signs and mortality were made. At the end of the exposure period, surviving rats were sacrificed and autopsied. Animals that died before the end of the first year of exposure were autopsied, but organ weights were not recorded. Only 68% (115/168) of the rats in the study were examined microscopically; most of these only had the liver, kidneys, testes, and gross lesions or tumors examined. The other animals had a more extensive histopathological examination that included lung, heart, liver, spleen, pancreas, stomach, small intestine, colon, kidney, adrenal gland, thyroid, tumors, and gross lesions; additionally, the urinary bladder and prostate were frequently examined.

Effects noted in study and corresponding doses: Significant increases in liver to body-weight ratio and hepatic histopathological changes consistent with exposure to chlorinated hydrocarbons were observed at doses as low as 0.5 ppm. The hepatic lesions at 0.5 and 2 ppm were slight (e.g., enlarged centrilobular hepatocytes with cytoplasmic eosinophilia somewhat increased, and peripheral migration of the basophilic granules along with less prominent alterations of cytoplasmic vacuolation and bile duct proliferation), but progressed in severity with increasing dose. At 10 ppm, an increase in vacuolation of hepatic cells was observed. Survival was reduced at 50 ppm and above, and distended and hemorrhagic bladders were seen in males dying before termination of the study. In animals exposed to 100 and 150 ppm, an increase in the severity of nephritis was observed. This occurred predominantly in males. Reassessment of the renal histopathology data by Reuber (1980) found that male rats ingesting 10 ppm and above had an increased incidence and greater severity of nephritis than did control animals. Some of the animals that consumed high doses and died early had diffuse necrosis of the renal tubules.

A number of the changes at 0.5 ppm are consistent with a marked hepatic adaptive response associated with induction of the hepatic mixed function oxidase system and proliferation of smooth endoplasmic reticulum. The observation of hepatocellular hypertrophy is consistent with adaption. Increased cytoplasmic eosinophilia in this case is likely associated with the adaptive response of marked proliferation of the smooth endoplasmic reticulum (SER). The peripheralization of cytoplasmic basophilic granules is most likely the result of outward compression of detached ribosomes by massively expanding SER. Ribosomal detachment has been observed in chlorinated hydrocarbon toxicity. Cytoplasmic vacuolation is a common manifestation of cellular degeneration. Bile duct proliferation is known to occur in response to chronic toxic injury. Modifications occurring in the mixed function oxidase system consequent to the adaptive response may result in its functional enhancement or neutralization. This in turn has the consequence of potentiating or inhibiting toxic responses to other exogenous substances. While the mechanism of aldrin-mediated hepatotoxicity has not been elucidated, the adaptive response is considered to be an adverse effect of aldrin. The cellular adaption that results from aldrin toxicity creates a liver that potentially has a tremendously heightened state of metabolic activity, which correspondingly may have a similarly heightened capacity to toxify or detoxify upon continued exposure to aldrin.

Dose and end point used for MRL derivation: 0.5 ppm (0.025 mg/kg/day); enlarged hepatocyte, increase in cytoplasmic eosinophilia with peripheral migration of basophilic granules, and possible increases in vacuolation and bile duct proliferation.

[ ] NOAEL [X] LOAEL

Uncertainty Factors used in MRL derivation:

- [X] 10 for use of a LOAEL
- [X] 10 for extrapolation from animals to humans
- [X] 10 for human variability

Was a conversion factor used from ppm in food or water to a mg/body weight dose? ppm doses (mg/kg diet) were multiplied by a food factor of 0.05 kg diet/kg body weight/day (EPA 1986m). The resulting doses were 0, 0.025, 0.1, 0.5, 2.5, 5, and 7.5 mg/kg/day.

If an inhalation study in animals, list conversion factors used in determining human equivalent dose: Not applicable.

Was a conversion used from intermittent to continuous exposure?
No.

Other additional studies or pertinent information that lend support to this MRL: Other adverse hepatic effects observed in chronic-duration studies with aldrin include hyaline droplet degeneration in dogs that ingested 0.12–0.25 mg/kg/day of aldrin for 15.7 months (Treon et al. 1955b) and slight-to-moderate fatty degeneration in dogs exposed to 1 mg/kg/day of aldrin for 25 months (Fitzhugh et al. 1964). These studies are, however, limited in that the number of dogs tested was quite small. Several chronic duration studies with dieldrin also showed adverse hepatic effects. Rats exposed to 0.16–0.063 mg/kg/day dieldrin throughout their lifetime were reported to have hepatic lesions consisting of centrilobular degeneration and peripheral hyperplasia (Harr et al. 1970), but incidence data and statistical analyses were not provided to support this conclusion and the use of a semisynthetic diet may have compromised the rats. Also mice exposed to 1.3 mg/kg/day dieldrin for 2 years had livers with occasional necrotic areas (Thorpe and Walker 1973), but incidence was not reported and it is unclear whether the necrotic areas were secondary to tumor development. In the 2-year study used to derive the MRL for dieldrin, absolute and relative liver weights were increased in female rats at $0.05 mg/kg/day, and liver parenchymal cell changes, "considered to be characteristic of exposure to organochlorine insecticide" but not otherwise specified, were increased at 0.5 at mg/kg/day.

The chronic oral MRL is the same as the EPA RfD for aldrin (IRIS 2002a), as the value (3x10^{-5} mg/kg/day) is based on the same study (Fitzhugh et al. 1964), species (rat), end point (liver effects), and effect level (0.025 mg/kg/day LOAEL). The chronic oral MRL remains the same as that reported previously by ATSDR (1993).

Agency Contact (Chemical Manager): G. Douglas Hanley

MRL WORKSHEET

Chemical Name: Dieldrin
CAS Number: 60-57-1
Date: June, 2002
Profile Status: Third Draft, Post Public
Route: [ ] Inhalation [X] Oral
Duration: [ ] Acute [X] Intermediate [ ] Chronic
Key to Figure: 44K
Species: monkey

Minimal Risk Level: 0.0001 [X] mg/kg/day [ ] ppm

Reference: Smith RM, Cunningham WL, Van Gelder GA. 1976. Dieldrin toxicity and successive discrimination reversal in squirrel monkeys (*Saimiri sciureus*). J Toxicol Environ Health 1:737-747.

Experimental design: Technical dieldrin was dissolved in absolute ethanol and injected into marshmallows in 10 µL amounts, which resulted in doses of 0.01 or 0.1 mg dieldrin/kg/day when fed to squirrel monkeys. The low- and high-dose groups consisted of three and four monkeys, respectively; another group of two monkeys served as controls. All monkeys were tested for their ability to learn a visual nonspatial successive discrimination reversal task during a 55-day period of daily dosing with dieldrin.

Effects noted in study and corresponding doses: Signs of impaired learning were apparent within 15 days of treatment initiation in the 0.1 mg/kg/day dose group, and persisted throughout the 55 days of treatment. The monkeys consuming 0.01 mg dieldrin/kg/day did not appear to be adversely affected with respect to learning ability when compared to controls.

Dose and end point used for MRL derivation: 0.01 mg/kg/day; impaired learning of a successive discrimination reversal task.

[X] NOAEL [ ] LOAEL

Uncertainty Factors used in MRL derivation:

[X] 10 for extrapolation from animals to humans
[X] 10 for human variability

Was a conversion factor used from ppm in food or water to a mg/body weight dose?
No.

If an inhalation study in animals, list conversion factors used in determining human equivalent dose:
Not applicable.

Was a conversion used from intermittent to continuous exposure?
No.

Other additional studies or pertinent information that lend support to this MRL: The choice of this end point is supported by the study of Burt (1975) in which impaired maze training was noted in rats treated for 60–120 days with a diet containing 5 ppm of dieldrin (converted to a dose of 0.25 mg/kg/day using reference values from EPA 1986m).

Agency Contact (Chemical Manager): G. Douglas Hanley

MRL WORKSHEET

Chemical Name:	Dieldrin
CAS Number:	60-57-1
Date:	June, 2002
Profile Status:	Third Draft, Post Public
Route:	[ ] Inhalation [X] Oral
Duration:	[ ] Acute [ ] Intermediate [X] Chronic
Key to Figure:	59r
Species:	rat

Minimal Risk Level: 0.00005 [X] mg/kg/day [ ] ppm

Reference: Walker AIT, Stevenson DE, Robinson J, et al. 1969. The toxicology and pharmacodynamics of dieldrin (HEOD): Two-year oral exposures of rats and dogs. Toxicol Appl Pharmacol 15:345-373.

Experimental design: Rats (25/sex/dose; 45/sex/controls) were fed diet containing 0, 0.1, 1.0, or 10.0 ppm dieldrin for 2 years. Based on intake assumptions reported by investigators (1 ppm=0.0475 mg/kg/day in males and 0.0582 mg/kg/day in females), doses were . 0.005, 0.05, and 0.5 mg/kg/day. Study end points included clinical observations, food intake, body weight, clinical chemistry, hematology, urine indices, organ weights, gross pathology, and histology (including liver, heart, lungs, spleen, lymph nodes, stomach, intestines, kidneys, bladder, thyroid, parathyroid, adrenals, pancreas, reproductive tissues, brain, muscle, skin, and eyes). Liver-related clinical chemistry indices included plasma alkaline phosphatase, SGOT, and bile pigments in the urine.

Effects noted in study and corresponding doses: Effects in the rats included increased absolute and relative liver weights in females at $0.05 mg/kg/day. Liver parenchymal cell changes, "considered to be characteristic of exposure to organochlorine insecticide" but not otherwise specified, were increased in high-dose females; total incidences during 2 years of exposure were 0/23, 0/23, 0/23, and 6/23 females at 0, 0.005, 0.05, and 0.5 mg/kg/day, respectively. In males, these liver parenchymal changes were only observed in one high-dose animal (i.e., 1/23 at 0.5 mg/kg/day). Two of the 0.5 mg/kg/day females and one control female also showed focal hyperplasia of the hepatic parenchymal cells, forming microscopic nodules. Other kinds of hepatic lesions (focal parenchymal necrosis, proliferated ductules, focal fibrosis, and/or cystic hyperplasia of intrahepatic bile ducts) were seen in a few rats of both sexes, but were not treatment-related as they were dispersed among the test and control groups (5/23, 0/23, 2/23, and 5/23 in females and 4/43, 0/23, 1/23, and 2/23 in males at 0, 0.005, 0.05, and 0.5 mg/kg/day, respectively). There were no indications of dieldrin-related changes in serum alkaline phosphatase or SGPT, histology of non-liver tissues, or body weight in any of the exposed groups, although irritability, tremors, and occasional convulsions (characteristic signs of dieldrin neurotoxicity) occurred at 0.5 mg/kg/day. These behavioral changes usually occurred during handling, did not progress after 3 months of exposure, and did not affect well-being.

Dose and end point used for MRL derivation: 0.005 mg/kg/day. Liver weight was increased at the LOAEL (0.05 mg/kg/day), with progression to parenchymal cell changes including focal hyperplasia at 0.5 mg/kg/day.

[X] NOAEL [ ] LOAEL

Uncertainty Factors used in MRL derivation:

[ ] 10 for use of a LOAEL
[X] 10 for extrapolation from animals to humans
[X] 10 for human variability

Was a conversion factor used from ppm in food or water to a mg/body weight dose?
No. Dietary ppm concentration was converted to mg/kg/day dose using reported intake assumptions as indicated in the experimental design summarized above.

If an inhalation study in animals, list conversion factors used in determining human equivalent dose:
Not applicable.

Was a conversion used from intermittent to continuous exposure?
No.

Other additional studies or pertinent information that lend support to this MRL: Other studies in rats and dogs support the choice of liver toxicity as the end point for the chronic oral MRL (Fitzhugh et al. 1964; Harr et al. 1970). Exposure for 2 years caused slight hepatic histopathological changes in rats at 0.025 and 0.1 mg/kg/day that were considered to be adverse effects of dieldrin (Fitzhugh et al. 1964). At 2.5 mg/kg/day and above, the changes were considered to be marked and included an increase in the severity of hepatic cell vacuolation. In the Harr et al. (1970) study, centrilobular degeneration and pyknosis of hepatic cell nuclei were reported in rats fed “critical levels of dieldrin” (0.016–0.063 mg/kg/day) throughout their lifetimes. However, the specific doses at which these effects were observed were not noted. Chronic studies in dogs also indicated that dieldrin produced degenerative effects in the liver (Fitzhugh et al. 1964; Kitselman 1953). In the Fitzhugh et al. (1964) study, a slight fatty change in the liver and a slight hepatic cell atrophy was reported at 0.5 mg/kg/day. This study was limited, however, in that no controls were used and only 1–2 males and females per dose were tested. In Kitselman (1953), slight degeneration of the liver was reported in one of three dogs fed 0.2 mg/kg/day and in all three dogs fed 0.6 mg/kg/day for a year. This study is also limited in that too few animals were tested (a total of three dogs per dose), replacement dogs were used, and details of the study protocol were incomplete.

The chronic oral MRL is the same as the EPA RfD for dieldrin (IRIS 2002b), as the value ($5x10^{-5}$ mg/kg/day) is based on the same study (Walker et al. 1969), species (rat), end point (liver effects), and effect level (0.005 mg/kg/day NOAEL). The basis of the MRL (species and end point) differs from that used in the previous version of the ATSDR profile (ATSDR 1993), although the actual value (5 x 10^{5} mg/kg/day) is unchanged. The basis of the MRL has been changed to address misinterpretations of the critical study in the previous ATSDR profile (ATSDR 1993).

The MRL was previously based on a NOAEL of 0.005 mg/kg/day for liver effects in dogs from the Walker et al. (1969) study. In the dog study, groups of five males and five females were given capsules containing 0, 0.005, or 0.05 mg/kg/day dieldrin for 2 years. The study end points were essentially the same as in the Walker et al. (1969) rat study, but additionally included assessments of SGPT, BSP clearance (control and high-dose groups), and neurology (EEG recordings in control and high-dose groups). Effects in the dogs occurred at 0.05 mg/kg/day and included increased absolute and relative liver weights in females, increased serum alkaline phosphatase in males and females beginning after 30 weeks of exposure, and decreased total serum proteins in males. There were no changes in histology of the liver or other tissues, histochemical distribution of fat or alkaline phosphatase activity in the liver, or liver function as assessed by BSP clearance. The origin of the increased serum alkaline phosphatase activity was unknown, but was not believed to be due to bone disorders or biliary obstruction (i.e., the usual clinical interpretation of elevated serum alkaline phosphatase in dogs [Cornelius 1970; Walker et al. 1969]). The decrease in total serum proteins was slight and considered to have no clinical or toxicological significance since the electrophoretic pattern of the proteins was unchanged. There were no exposure-related behavioral changes as found in the rats. ATSDR (1993) previously interpreted the high dose in dogs (0.05 mg/kg/day) as a LOAEL for liver effects based on the increases in liver weight and serum alkaline phosphatase, and used the NOAEL (0.005 mg/kg/day) to derive the MRL. Considering the lack of histological changes in the liver, evidence that the increased serum alkaline phosphatase is not liver-related, and lack of effect on liver function as assessed by BSP clearance, as well as the investigators' conclusions that there were no histopathologic liver lesions attributable to dieldrin in the dogs, the evidence indicates that 0.05 mg/kg/day should be classified as a NOAEL rather than a LOAEL. The 0.05 mg/kg/day NOAEL in dogs is not used to derive the MRL, however, because re-evaluation of the rat data shows that this dose is a LOAEL in rats, as discussed below.

ATSDR (1993) previously classified all of the doses in the Walker et al. (1969) rat study as NOAELs. This classification was based on an interpretation that hepatotoxic effects (focal hyperplasia of hepatic parenchymal cells, focal parenchymal necrosis, proliferated ductules, focal fibrosis, and cystic hyperplasia of intrahepatic bile ducts) were observed in both treated and control animals with no indication of an increase in incidence or severity in treated animals. Re-evaluation of the report shows that there are actually two categories of tabulated liver data (i.e., one labeled "Liver[a]" and one labeled "Organochlorine insecticide changes"). The lesions tabulated as "Organochlorine insecticide changes" are in fact liver parenchymal effects that are characteristic of dieldrin and other organochlorine insecticides (and are treatment-related in the dog study), whereas other kinds of liver lesions (i.e., those simply tabulated as "Liver[a]") are the effects that were dispersed throughout the control and treated groups and not attributable to exposure. In other words, ATSDR previously correctly interpreted the "Liver" data as negative, but did not recognize that the other category of liver effects (i.e., the organochlorine insecticide changes) provides positive evidence. This interpretation is supported by the footnote to the "Liver[a]" heading, which states that these liver lesions "...are considered not to be associated with exposure to organochlorine insecticide", the investigators' conclusion that "Histopathologic liver lesions attributable to dieldrin were observed in the rats (10 ppm) but not in dogs", and the fact that the dieldrin-attributable liver effects are discussed in the report text using the incidences from the "Organochlorine insecticide changes" column in the table. Therefore, there is a progression of liver effects as shown by increased liver weight at 0.05 mg/kg/day and histological changes at 0.5 mg/kg/day. Consequently, 0.005 and 0.05 mg/kg/day are reclassified as a NOAEL and LOAEL, respectively, and the NOAEL is used as the basis of the MRL.

<u>Agency Contact (Chemical Manager):</u> G. Douglas Hanley

APPENDIX B

USER'S GUIDE

Chapter 1

Public Health Statement

This chapter of the profile is a health effects summary written in non-technical language. Its intended audience is the general public especially people living in the vicinity of a hazardous waste site or chemical release. If the Public Health Statement were removed from the rest of the document, it would still communicate to the lay public essential information about the chemical.

The major headings in the Public Health Statement are useful to find specific topics of concern. The topics are written in a question and answer format. The answer to each question includes a sentence that will direct the reader to chapters in the profile that will provide more information on the given topic.

Chapter 2

Relevance to Public Health

This chapter provides a health effects summary based on evaluations of existing toxicologic, epidemiologic, and toxicokinetic information. This summary is designed to present interpretive, weight-of-evidence discussions for human health end points by addressing the following questions.

1. What effects are known to occur in humans?

2. What effects observed in animals are likely to be of concern to humans?

3. What exposure conditions are likely to be of concern to humans, especially around hazardous waste sites?

The chapter covers end points in the same order they appear within the Discussion of Health Effects by Route of Exposure section, by route (inhalation, oral, dermal) and within route by effect. Human data are presented first, then animal data. Both are organized by duration (acute, intermediate, chronic). *In vitro* data and data from parenteral routes (intramuscular, intravenous, subcutaneous, etc.) are also considered in this chapter. If data are located in the scientific literature, a table of genotoxicity information is included.

The carcinogenic potential of the profiled substance is qualitatively evaluated, when appropriate, using existing toxicokinetic, genotoxic, and carcinogenic data. ATSDR does not currently assess cancer potency or perform cancer risk assessments. Minimal risk levels (MRLs) for noncancer end points (if derived) and the end points from which they were derived are indicated and discussed.

Limitations to existing scientific literature that prevent a satisfactory evaluation of the relevance to public health are identified in the Chapter 3 Data Needs section.

Interpretation of Minimal Risk Levels

Where sufficient toxicologic information is available, we have derived minimal risk levels (MRLs) for inhalation and oral routes of entry at each duration of exposure (acute, intermediate, and chronic). These MRLs are not meant to support regulatory action; but to acquaint health professionals with exposure levels at which adverse health effects are not expected to occur in humans. They should help physicians and public health officials determine the safety of a community living near a chemical emission, given the concentration of a contaminant in air or the estimated daily dose in water. MRLs are based largely on toxicological studies in animals and on reports of human occupational exposure.

MRL users should be familiar with the toxicologic information on which the number is based. Chapter 2, "Relevance to Public Health," contains basic information known about the substance. Other sections such as Chapter 3 Section 3.9, "Interactions with Other Substances," and Section 3.10, "Populations that are Unusually Susceptible" provide important supplemental information.

MRL users should also understand the MRL derivation methodology. MRLs are derived using a modified version of the risk assessment methodology the Environmental Protection Agency (EPA) provides (Barnes and Dourson 1988) to determine reference doses for lifetime exposure (RfDs).

To derive an MRL, ATSDR generally selects the most sensitive end point which, in its best judgement, represents the most sensitive human health effect for a given exposure route and duration. ATSDR cannot make this judgement or derive an MRL unless information (quantitative or qualitative) is available for all potential systemic, neurological, and developmental effects. If this information and reliable quantitative data on the chosen end point are available, ATSDR derives an MRL using the most sensitive species (when information from multiple species is available) with the highest NOAEL that does not exceed any adverse effect levels. When a NOAEL is not available, a lowest-observed-adverse-effect level (LOAEL) can be used to derive an MRL, and an uncertainty factor (UF) of 10 must be employed. Additional uncertainty factors of 10 must be used both for human variability to protect sensitive subpopulations (people who are most susceptible to the health effects caused by the substance) and for interspecies variability (extrapolation from animals to humans). In deriving an MRL, these individual uncertainty factors are multiplied together. The product is then divided into the inhalation concentration or oral dosage selected from the study. Uncertainty factors used in developing a substance-specific MRL are provided in the footnotes of the LSE Tables.

Chapter 3

Health Effects

Tables and Figures for Levels of Significant Exposure (LSE)

Tables (3-1, 3-2, and 3-3) and figures (3-1 and 3-2) are used to summarize health effects and illustrate graphically levels of exposure associated with those effects. These levels cover health effects observed at increasing dose concentrations and durations, differences in response by species, minimal risk levels (MRLs) to humans for noncancer end points, and EPA's estimated range associated with an upper- bound individual lifetime cancer risk of 1 in 10,000 to 1 in 10,000,000. Use the LSE tables and figures for a quick review of the health effects and to locate data for a specific exposure scenario. The LSE tables and figures should always be used in conjunction with the text. All entries in these tables and figures represent studies that provide reliable, quantitative estimates of No-Observed-Adverse-Effect Levels (NOAELs), Lowest-Observed-Adverse-Effect Levels (LOAELs), or Cancer Effect Levels (CELs).

The legends presented below demonstrate the application of these tables and figures. Representative examples of LSE Table 3-1 and Figure 3-1 are shown. The numbers in the left column of the legends correspond to the numbers in the example table and figure.

LEGEND

See LSE Table 3-1

(1) Route of Exposure One of the first considerations when reviewing the toxicity of a substance using these tables and figures should be the relevant and appropriate route of exposure. When sufficient data exists, three LSE tables and two LSE figures are presented in the document. The three LSE tables present data on the three principal routes of exposure, i.e., inhalation, oral, and dermal (LSE Table 3-1, 3-2, and 3-3, respectively). LSE figures are limited to the inhalation (LSE Figure 3-1) and oral (LSE Figure 3-2) routes. Not all substances will have data on each route of exposure and will not therefore have all five of the tables and figures.

(2) Exposure Period Three exposure periods - acute (less than 15 days), intermediate (15–364 days), and chronic (365 days or more) are presented within each relevant route of exposure. In this example, an inhalation study of intermediate exposure duration is reported. For quick reference to health effects occurring from a known length of exposure, locate the applicable exposure period within the LSE table and figure.

(3) Health Effect The major categories of health effects included in LSE tables and figures are death, systemic, immunological, neurological, developmental, reproductive, and cancer. NOAELs and LOAELs can be reported in the tables and figures for all effects but cancer. Systemic effects are further defined in the "System" column of the LSE table (see key number 18).

(4) Key to Figure Each key number in the LSE table links study information to one or more data points using the same key number in the corresponding LSE figure. In this example, the study represented by key number 18 has been used to derive a NOAEL and a Less Serious LOAEL (also see the 2 "18r" data points in Figure 3-1).

(5) Species The test species, whether animal or human, are identified in this column. Chapter 2, "Relevance to Public Health," covers the relevance of animal data to human toxicity and Section 3.4, "Toxicokinetics," contains any available information on comparative toxicokinetics. Although NOAELs and LOAELs are species specific, the levels are extrapolated to equivalent human doses to derive an MRL.

(6) Exposure Frequency/Duration The duration of the study and the weekly and daily exposure regimen are provided in this column. This permits comparison of NOAELs and LOAELs from different studies. In this case (key number 18), rats were exposed to 1,1,2,2-tetrachloroethane via inhalation for 6 hours per day, 5 days per week, for 3 weeks. For a more complete review of the dosing regimen refer to the appropriate sections of the text or the original reference paper, i.e., Nitschke et al. 1981.

(7) System This column further defines the systemic effects. These systems include: respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, renal, and dermal/ocular. "Other" refers to any systemic effect (e.g., a decrease in body weight) not covered in these systems. In the example of key number 18, 1 systemic effect (respiratory) was investigated.

(8) NOAEL A No-Observed-Adverse-Effect Level (NOAEL) is the highest exposure level at which no harmful effects were seen in the organ system studied. Key number 18 reports a NOAEL of 3 ppm for the respiratory system which was used to derive an intermediate exposure, inhalation MRL of 0.005 ppm (see footnote "b").

(9) LOAEL A Lowest-Observed-Adverse-Effect Level (LOAEL) is the lowest dose used in the study that caused a harmful health effect. LOAELs have been classified into "Less Serious" and "Serious" effects. These distinctions help readers identify the levels of exposure at which adverse health effects first appear and the gradation of effects with increasing dose. A brief description of the specific end point used to quantify the adverse effect accompanies the LOAEL. The respiratory effect reported in key number 18 (hyperplasia) is a Less serious LOAEL of 10 ppm. MRLs are not derived from Serious LOAELs.

(10) Reference The complete reference citation is given in Chapter 9 of the profile.

(11) CEL A Cancer Effect Level (CEL) is the lowest exposure level associated with the onset of carcinogenesis in experimental or epidemiologic studies. CELs are always considered serious effects. The LSE tables and figures do not contain NOAELs for cancer, but the text may report doses not causing measurable cancer increases.

(12) Footnotes Explanations of abbreviations or reference notes for data in the LSE tables are found in the footnotes. Footnote "b" indicates the NOAEL of 3 ppm in key number 18 was used to derive an MRL of 0.005 ppm.

LEGEND

See Figure 3-1

LSE figures graphically illustrate the data presented in the corresponding LSE tables. Figures help the reader quickly compare health effects according to exposure concentrations for particular exposure periods.

(13) Exposure Period The same exposure periods appear as in the LSE table. In this example, health effects observed within the intermediate and chronic exposure periods are illustrated.

(14) Health Effect These are the categories of health effects for which reliable quantitative data exists. The same health effects appear in the LSE table.

(15) Levels of Exposure concentrations or doses for each health effect in the LSE tables are graphically displayed in the LSE figures. Exposure concentration or dose is measured on the log scale "y" axis. Inhalation exposure is reported in mg/m^3 or ppm and oral exposure is reported in mg/kg/day.

(16) NOAEL In this example, the open circle designated 18r identifies a NOAEL critical end point in the rat upon which an intermediate inhalation exposure MRL is based. The key number 18 corresponds to the entry in the LSE table. The dashed descending arrow indicates the extrapolation from the exposure level of 3 ppm (see entry 18 in the Table) to the MRL of 0.005 ppm (see footnote "b" in the LSE table).

(17) CEL Key number 38r is 1 of 3 studies for which Cancer Effect Levels were derived. The diamond symbol refers to a Cancer Effect Level for the test species-mouse. The number 38 corresponds to the entry in the LSE table.

(18) Estimated Upper-Bound Human Cancer Risk Levels This is the range associated with the upper-bound for lifetime cancer risk of 1 in 10,000 to 1 in 10,000,000. These risk levels are derived from the EPA's Human Health Assessment Group's upper-bound estimates of the slope of the cancer dose response curve at low dose levels (q_1*).

(19) Key to LSE Figure The Key explains the abbreviations and symbols used in the figure.

SAMPLE

1 6

Table 3-1. Levels of Significant Exposure to [Chemical x] – Inhalation

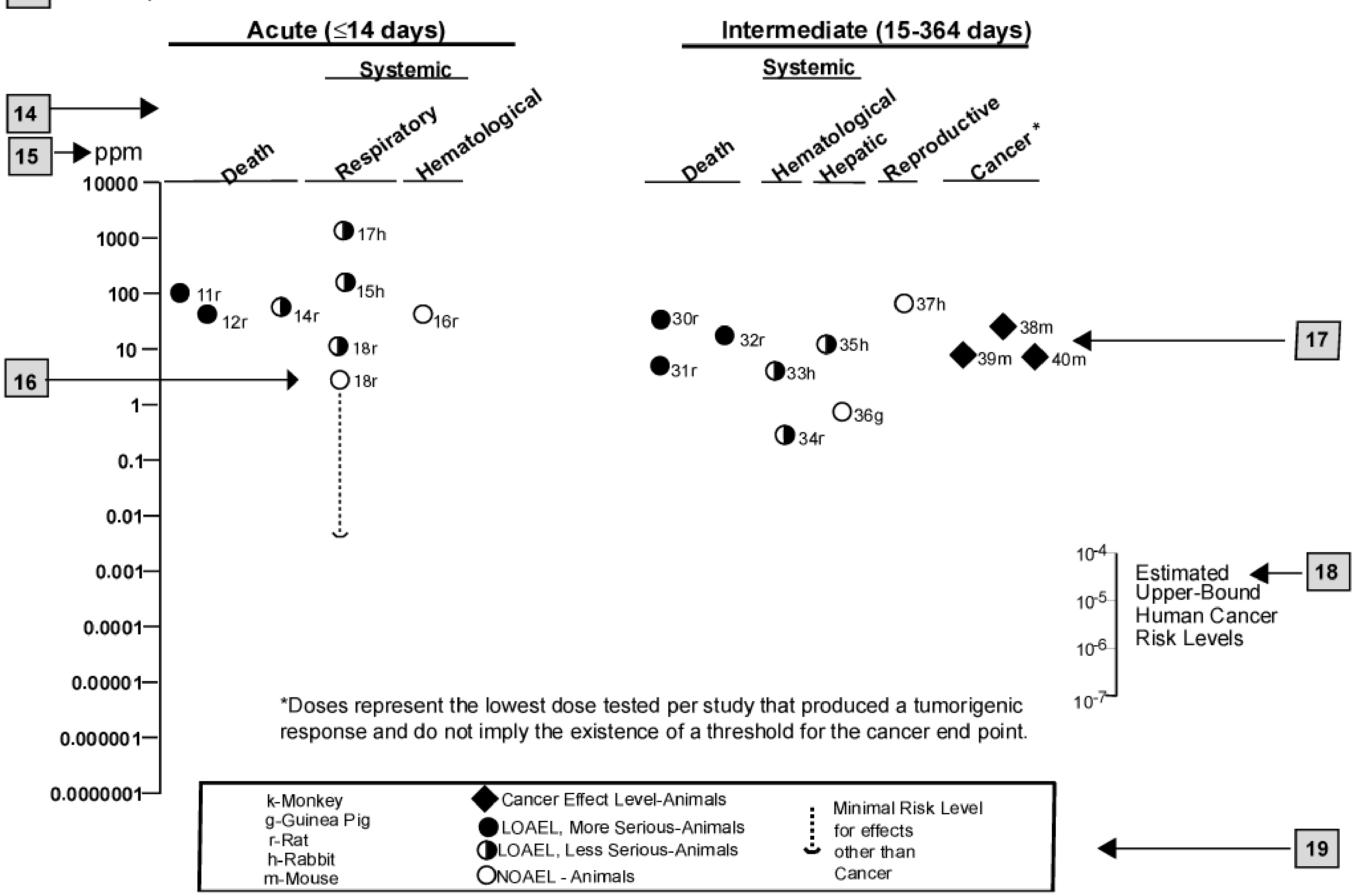
	Key to figure[a]	Species	Exposure frequency/ duration	System	NOAEL (ppm)	LOAEL (effect) Less serious (ppm)	LOAEL (effect) Serious (ppm)	Reference
2 6	INTERMEDIATE EXPOSURE							
		5	6	7	8	9		10
3 6	Systemic	9	9	9	9	9		9
4 6	18	Rat	13 wk 5 d/wk 6 hr/d	Resp	3[b]	10 (hyperplasia)		Nitschke et al. 1981
	CHRONIC EXPOSURE							
							11	
	Cancer						9	
	38	Rat	18 mo 5 d/wk 7 hr/d				20 (CEL, multiple organs)	Wong et al. 1982
	39	Rat	89–104 wk 5 d/wk 6 hr/d				10 (CEL, lung tumors, nasal tumors)	NTP 1982
	40	Mouse	79–103 wk 5 d/wk 6 hr/d				10 (CEL, lung tumors, hemangiosarcomas)	NTP 1982

[a] The number corresponds to entries in Figure 3-1.

12 6 [b] Used to derive an intermediate inhalation Minimal Risk Level (MRL) of $5x10^{-3}$ ppm; dose adjusted for intermittent exposure and divided by an uncertainty factor of 100 (10 for extrapolation from animal to humans, 10 for human variability).

SAMPLE

Figure 3-1. Levels of Significant Exposure to [Chemical X] - Inhalation



APPENDIX C

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ACOEM	American College of Occupational and Environmental Medicine
ACGIH	American Conference of Governmental Industrial Hygienists
ADI	acceptable daily intake
ADME	absorption, distribution, metabolism, and excretion
AED	atomic emission detection
AOEC	Association of Occupational and Environmental Clinics
AFID	alkali flame ionization detector
AFOSH	Air Force Office of Safety and Health
ALT	alanine aminotransferase
AML	acute myeloid leukemia
AOAC	Association of Official Analytical Chemists
AP	alkaline phosphatase
APHA	American Public Health Association
AST	aspartate aminotranferase
atm	atmosphere
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BAT	best available technology
BCF	bioconcentration factor
BEI	Biological Exposure Index
BSC	Board of Scientific Counselors
C	centigrade
CAA	Clean Air Act
CAG	Cancer Assessment Group of the U.S. Environmental Protection Agency
CAS	Chemical Abstract Services
CDC	Centers for Disease Control and Prevention
CEL	cancer effect level
CELDS	Computer-Environmental Legislative Data System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curie
CI	confidence interval
CL	ceiling limit value
CLP	Contract Laboratory Program
cm	centimeter
CML	chronic myeloid leukemia
CPSC	Consumer Products Safety Commission
CWA	Clean Water Act
DHEW	Department of Health, Education, and Welfare
DHHS	Department of Health and Human Services
DNA	deoxyribonucleic acid
DOD	Department of Defense
DOE	Department of Energy
DOL	Department of Labor
DOT	Department of Transportation

DOT/UN/ NA/IMCO	Department of Transportation/United Nations/ North America/International Maritime Dangerous Goods Code
DWEL	drinking water exposure level
ECD	electron capture detection
ECG/EKG	electrocardiogram
EEG	electroencephalogram
EEGL	Emergency Exposure Guidance Level
EPA	Environmental Protection Agency
F	Fahrenheit
F_1	first-filial generation
FAO	Food and Agricultural Organization of the United Nations
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FPD	flame photometric detection
fpm	feet per minute
FR	*Federal Register*
FSH	follicle stimulating hormone
g	gram
GC	gas chromatography
gd	gestational day
GLC	gas liquid chromatography
GPC	gel permeation chromatography
HPLC	high-performance liquid chromatography
HRGC	high resolution gas chromatography
HSDB	Hazardous Substance Data Bank
IARC	International Agency for Research on Cancer
IDLH	immediately dangerous to life and health
ILO	International Labor Organization
IRIS	Integrated Risk Information System
Kd	adsorption ratio
kg	kilogram
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
L	liter
LC	liquid chromatography
LC_{Lo}	lethal concentration, low
LC_{50}	lethal concentration, 50% kill
LD_{Lo}	lethal dose, low
LD_{50}	lethal dose, 50% kill
LDH	lactic dehydrogenase
LH	luteinizing hormone
LT_{50}	lethal time, 50% kill
LOAEL	lowest-observed-adverse-effect level
LSE	Levels of Significant Exposure
m	meter
MA	*trans,trans*-muconic acid
MAL	maximum allowable level
mCi	millicurie
MCL	maximum contaminant level
MCLG	maximum contaminant level goal

MFO	mixed function oxidase
mg	milligram
mL	milliliter
mm	millimeter
mmHg	millimeters of mercury
mmol	millimole
mppcf	millions of particles per cubic foot
MRL	Minimal Risk Level
MS	mass spectrometry
NAAQS	National Ambient Air Quality Standard
NAS	National Academy of Science
NATICH	National Air Toxics Information Clearinghouse
NATO	North Atlantic Treaty Organization
NCE	normochromatic erythrocytes
NCEH	National Center for Environmental Health
NCI	National Cancer Institute
ND	not detected
NFPA	National Fire Protection Association
ng	nanogram
NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute for Occupational Safety and Health
NIOSHTIC	NIOSH's Computerized Information Retrieval System
NLM	National Library of Medicine
nm	nanometer
NHANES	National Health and Nutrition Examination Survey
nmol	nanomole
NOAEL	no-observed-adverse-effect level
NOES	National Occupational Exposure Survey
NOHS	National Occupational Hazard Survey
NPD	nitrogen phosphorus detection
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NR	not reported
NRC	National Research Council
NS	not specified
NSPS	New Source Performance Standards
NTIS	National Technical Information Service
NTP	National Toxicology Program
ODW	Office of Drinking Water, EPA
OERR	Office of Emergency and Remedial Response, EPA
OHM/TADS	Oil and Hazardous Materials/Technical Assistance Data System
OPP	Office of Pesticide Programs, EPA
OPPTS	Office of Prevention, Pesticides and Toxic Substances, EPA
OPPT	Office of Pollution Prevention and Toxics, EPA
OR	odds ratio
OSHA	Occupational Safety and Health Administration
OSW	Office of Solid Waste, EPA
OW	Office of Water
OWRS	Office of Water Regulations and Standards, EPA
PAH	polycyclic aromatic hydrocarbon
PBPD	physiologically based pharmacodynamic

PBPK	physiologically based pharmacokinetic
PCE	polychromatic erythrocytes
PEL	permissible exposure limit
PID	photo ionization detector
pg	picogram
pmol	picomole
PHS	Public Health Service
PMR	proportionate mortality ratio
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PSNS	pretreatment standards for new sources
RBC	red blood cell
REL	recommended exposure level/limit
RfC	reference concentration
RfD	reference dose
RNA	ribonucleic acid
RTECS	Registry of Toxic Effects of Chemical Substances
RQ	reportable quantity
SARA	Superfund Amendments and Reauthorization Act
SCE	sister chromatid exchange
SGOT	serum glutamic oxaloacetic transaminase
SGPT	serum glutamic pyruvic transaminase
SIC	standard industrial classification
SIM	selected ion monitoring
SMCL	secondary maximum contaminant level
SMR	standardized mortality ratio
SNARL	suggested no adverse response level
SPEGL	Short-Term Public Emergency Guidance Level
STEL	short term exposure limit
STORET	Storage and Retrieval
TD_{50}	toxic dose, 50% specific toxic effect
TLV	threshold limit value
TOC	total organic carbon
TPQ	threshold planning quantity
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TWA	time-weighted average
UF	uncertainty factor
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VOC	volatile organic compound
WBC	white blood cell
WHO	World Health Organization
>	greater than
$	greater than or equal to
=	equal to
<	less than
#	less than or equal to
%	percent

α	alpha
β	beta
γ	gamma
δ	delta
μm	micrometer
μg	microgram
q_1^*	cancer slope factor
–	negative
+	positive
(+)	weakly positive result
(–)	weakly negative result

APPENDIX D

INDEX

ES/ER/TM-126/R2

Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision

ES/ER/TM-126/R2

Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision

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PREFACE

This report presents a standard method for deriving benchmarks for the purpose of "contaminant screening," performed by comparing measured ambient concentrations of chemicals. The work was performed under Work Breakdown Structure 1.4.12.2.3.04.07.02 (Activity Data Sheet 8304). In addition, this report presents sets of data concerning the effects of chemicals in soil on invertebrates and soil microbial processes, benchmarks for chemicals potentially associated with United States Department of Energy sites, and literature describing the experiments from which data were drawn for benchmark derivation.

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CONTENTS

TABLES

ABBREVIATIONS

CCME	Canadian Council of Ministers of the Environment
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	United States Department of Energy
EIV	Ecotoxicological Intervention Value
EPA	United States Environmental Protection Agency
ER-L	Effects Range Low
HCl	Hydrochloric Acid
LCT	Lowest Concentration Tested
LOEC	Lowest Observed Effect Concentration
NOEC	No Observed Effect Concentration
OECD	Organization for Economic Cooperation and Development
ORR	Oak Ridge Reservation
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
RC	Remediation Criteria
RIVM	National Institute of Public Health and Environmental Protection
USGS	United States Geological Survey

EXECUTIVE SUMMARY

One of the initial stages in ecological risk assessments for hazardous waste sites is the screening of contaminants to determine which of them are worthy of further consideration as "contaminants of potential concern." This process is termed "contaminant screening." It is performed by comparing measured ambient concentrations of chemicals to benchmark concentrations. Currently, no standard benchmark concentrations exist for assessing contaminants in soil with respect to their toxicity to soil- and litter-dwelling invertebrates, including earthworms, other micro- and macroinvertebrates, or heterotrophic bacteria and fungi. This report presents a standard method for deriving benchmarks for this purpose, sets of data concerning effects of chemicals in soil on invertebrates and soil microbial processes, and benchmarks for chemicals potentially associated with United States Department of Energy sites. In addition, literature describing the experiments from which data were drawn for benchmark derivation. Chemicals that are found in soil at concentrations exceeding both the benchmarks and the background concentration for the soil type should be considered contaminants of potential concern.

1. SCREENING BENCHMARKS IN ECOLOGICAL RISK ASSESSMENT

An important step in ecological risk assessments is screening the chemicals occurring on a site for contaminants of potential concern. Screening may be accomplished by comparing reported ambient concentrations to a set of toxicological benchmarks. Multiple endpoints for assessing risks posed by soil-borne contaminants to organisms directly impacted by them have been established. Benchmarks for toxic effects of contaminants on terrestrial plants are presented in a companion manuscript (Efroymson et al. 1997). This report presents benchmarks for soil invertebrates and microbial processes and addresses only chemicals found at United States Department of Energy (DOE) sites. The benchmarks for microbial processes have not been updated since 1995. No benchmarks for pesticides are presented.

If a chemical's concentration or reported detection limit exceeds the screening benchmark, additional analysis may be needed to determine the hazards posed by that chemical (i.e., it is a contaminant of potential concern). However, if the chemical's concentration or detection limit falls below the proposed benchmark, the chemical may be ignored during further study unless public concern or ancillary evidence suggest that it should be retained.

Soil benchmarks are based on data provided by toxicity studies in the field or, more commonly, in laboratory settings. Most of the soil concentrations of metals reported from waste sites are from extractions with hydrochloric acid (HCl) or other mineral acids which are intended to provide estimates of total concentrations. Similarly, concentrations of organic contaminants in waste site soils are total concentrations derived from rigorous extractions by solvents. In some cases, toxicity tests report contaminant concentrations extracted from soils, but various extractants are used that may not yield total concentrations. More commonly, the concentrations reported are nominal concentrations of a soluble form (i.e., a highly bioavailable form) of the chemical added to soil. We have chosen to use nominal concentrations from the literature to compare to the "total" extracted quantities of a chemical reported for waste sites.

These benchmarks are appropriate for contaminant screening purposes only. An assessor must realize that soil and invertebrate characteristics play a large part in toxicity and incorporate these site-specific considerations in the evaluation of the potential hazards of a chemical. If chemical concentrations reported in soils supporting many earthworms exceed one or more of the benchmarks presented in this report, or if a benchmark is exceeded by background soil concentrations, it is generally safe to assume that the benchmark is a poor measure of risk to earthworms at that site.

After discussing methods, this report presents the results of the literature reviews and benchmark derivation for toxicity to earthworms (Sect. 3), heterotrophic microbes and their processes (Sect. 4), and other invertebrates (Sect. 5). The final sections compare the benchmarks to other criteria and background concentrations of chemicals and draw conclusions concerning the utility of the benchmarks.

2. METHODS

2.1 DATA

References on the toxicity of selected chemicals to soil and litter dwelling invertebrates, microbes, and microbial processes were obtained from searches of bibliographic data bases (BIOSIS, POL TOX I, current contents), review articles, and conventional literature searching. Reports of toxicity tests of individual chemicals in laboratory, greenhouse, or field settings were obtained. Data presented in this report were derived mainly from primary sources. More specific information on the types of effects data available for each group of organisms is given in the appropriate section of this report. The general criteria for inclusion of a study in the data set used to derive toxicity benchmarks follow.

1. Methodology was clearly stated (especially concentrations of applied chemicals) and followed in the experiment.

2. Results were quantified as measures of survivorship, growth, respiration, reproduction, substrate transformation, or enzyme activity.

3. Results were presented in numeric form, or graphical presentations of data were clearly interpretable.

4. An unambiguous reduction existed in the measured parameter within the range of applied concentrations of the chemical of interest.

The data selected for soil benchmarks using these criteria appear in Appendix A through Appendix C. Data were collected in the following categories for analysis:

1. Chemical—The effects of individual chemicals of interest were analyzed. In the case of metals, the metal is listed in the "Chemical" field. For organics, the compound is listed in the "Chemical" field.

2. Chemical Form—The form in which the chemical was added to the experimental medium (e.g., soluble salt, organic).

3. Growth Medium—Substrate in which organisms were kept during the experiment. The media included natural and artificial soil, manure, soil/litter microcosms, and other experimental substrates.

4. Cation exchange capacity is the sum of the exchangeable cations that a soil can adsorb, expressed as milliequivalents per 100 g of soil. Soil organic and inorganic constituents contain negatively charged sites that are the location of important interactions with positively charged ions in soil solution. These interactions affect the toxicity of many contaminants.

5. Organic matter—Soil organic matter is important in reactions of many contaminants in the soil. Percentage organic matter, if given, was converted to percentage organic carbon by the equation (Nelson and Sommers, 1982):

$$\%\text{organic matter} / 2 = \%\text{organic carbon}$$

6. Soil pH—The pH of the soil exerts control over chemical reactions that affect speciation and bioavailability of chemicals

7. Species—The species of earthworm, other invertebrate, or microorganism is necessary when provided. However, most microbiological experiments were conducted with an undefined, mixed native microflora.

8. Exposure duration—How long the organisms were exposed to the test chemical.

9. NOEC Applied—The no observed effect concentration (NOEC) is defined as the highest applied concentration of the chemical of interest causing a reduction of 20% or less in a measured response.

10. LOEC Applied—The lowest observed effect concentration (LOEC) is defined as the lowest applied concentration of the chemical of interest causing a greater than 20% reduction in a measured response. In some cases, the LOEC for the test was the lowest concentration tested (LCT) or the only concentration reported, as when the EC_{50} (or ED_{50}) was reported.

11. Growth parameter—Response varied with the type of organism and experiment.

12. Percent decrease—Percent decrease in measured parameter compared to control organism.

2.2 SELECTION OF LEVELS OF EFFECTS

Twenty percent reduction in growth, reproduction, or activity was used as the threshold for significant effects to be consistent with other screening benchmarks for ecological risk assessment and with current regulatory practice (Suter et al. 1995). In brief, most regulatory criteria are based on concentrations in toxicity tests that cause effects which are statistically significantly different from controls. On average, these concentrations correspond to greater than a 20% difference in effects. In addition, regulatory actions may be based on comparisons of biological parameters measured on contaminated sites to those from reference sites. Differences between parameters at sites generally must be greater than 20% to be reliably detected in such studies. Therefore, the 20% effects level is treated as a conservative approximation of the threshold for regulatory concern.

2.3 DERIVATION OF BENCHMARKS

Because of the diversity of soils, species, chemical forms, and test procedures, it is impossible to estimate concentrations that would constitute thresholds for toxic effects on the invertebrate communities at particular sites from published toxicity data. This situation is analogous to the problem of deriving benchmarks for sediments. In this report, the method used for deriving soil benchmarks is based on the National Oceanographic and Atmospheric Administration's method for deriving the Effects Range Low (ER-L) (Long and Morgan, 1990), which has been recommended as a sediment screening benchmark by the U.S. Environmental Protection Agency (EPA) Region IV. The ER-L is the tenth percentile of the distribution of various toxic effects thresholds for various organisms in sediments.

This approach can be justified by assuming that the toxicity of a chemical in soil is a random variate, the toxicity of contaminated soil at a particular site is drawn from the same distribution, and the assessor should be 90% certain of protecting organisms growing in the site soil. Any bias in the data set would mitigate against that assumption. In this implementation of the approach, the bias most likely to be significant is the use of soluble salts of metals in the toxicity tests. These salts are likely to be more toxic than the mixture of forms encountered in field soils. That bias would result in conservative benchmark values. Other possible sources of bias include the exclusion of synergistic and antagonistic effects resulting from interactions between chemicals, use of a limited number of test species that may not be representative of those in the field, use of artificial soils that may not be representative of soils in general, and other laboratory test conditions that may not be representative of field conditions. The direction and magnitude of these potential biases is unknown.

The toxicity benchmarks were derived by rank-ordering the LOEC values and then picking a number that approximated the 10th percentile. As with the ER-Ls, statistical fitting was not used because there were seldom sufficient data and because these benchmarks are to be used as screening values and do not require the consistency and precision of regulatory criteria. If there were 10 or fewer values for a chemical, the lowest LOEC was used. If there were more than 10 values, the 10th percentile LOEC value was used. If the 10th percentile fell between LOEC values, a value was chosen by interpolation. Since these benchmarks are intended to be thresholds for significant effects on growth and production, test endpoints that indicate a high frequency of lethality are not appropriate. Therefore, when a benchmark is based on an LC_{50} or on some other endpoint that includes a 50% or greater reduction in survivorship, the value is divided by a factor of 5; this factor is based on the authors' expert judgment. Although no data exist for comparison of lethal and sublethal effects concentrations in tests conducted with the same species and soils, it is assumed that a factor of 5 can be used to approximate the ratio LC_{50}/EC_{20}.

In all cases, benchmark values were rounded down to one significant figure. This rounding was done for two reasons. First, it is not appropriate to ascribe greater precision to a number than it actually possesses; these benchmarks are very imprecise. Second, the rounding serves to emphasize the fact that the benchmarks are conceptually distinct from the test endpoint values from which they were derived. That is, an LOEC may be a precise estimate of the lowest toxic concentration for a particular plant variety in a particular test system, but when an LOEC is used as a benchmark for all plants in field soils, it is a qualitatively different and much more poorly defined value.

Benchmarks were derived in the previously described manner for earthworms and microbial heterotrophs. Insufficient information was available for establishing benchmarks for other invertebrates, as discussed in the appropriate section of this report. Proposed screening benchmarks for toxic effects of contaminants in soils are presented in Table 1 (earthworms) and Table 2 (microbial populations).

Table 1. Screening benchmark concentrations for the toxicity of chemicals to earthworms

Chemical	Soil (mg/kg)
Arsenic	60
Cadmium	20
Chromium	0.4
Copper	50
Lead	500
Mercury	0.1
Nickel	200
Selenium	70
Zinc	200
Chloroacetamide	2
3-chloroaniline	30
2,4-dichloroaniline	100
3,4-dichloroaniline	20
2,4,5-trichloroaniline	20
2,3,5,6-tetrachloroaniline	20
Pentachloroaniline	100
1,2-dichloropropane	700
Dimethylphthalate	200
Fluorene	30
N-nitrosodiphenylamine	20
Phenol	30
4-nitrophenol	7
3-chlorophenol	10
3,4-dichlorophenol	20
2,4,5-trichlorophenol	9
2,4,6-trichlorophenol	10
2,3,4,5-tetrachlorophenol	20
Pentachlorophenol	6
Chlorobenzene	40
1,4-dichlorobenzene	20
1,2,3-trichlorobenzene	20
1,2,4-trichlorobenzene	20
1,2,3,4-tetrachlorobenzene	10
Pentachlorobenzene	20
Nitrobenzene	40

Table 2. Screening benchmark concentrations for the toxicity of chemicals to soil microorganisms and microbial processes

Chemical	Soil (mg/kg)
Aluminum	600
Arsenic	100
Barium	3000
Boron	20
Cadmium	20
Chromium	10
Cobalt	1000
Copper	100
Fluorine	30
Iron	200
Lanthanum	50
Lead	900
Lithium	10
Manganese	100
Mercury	30
Molybdenum	200
Nickel	90
Selenium	100
Silver	50
Tin	2000
Titanium	1000
Tungsten	400
Vanadium	20
Zinc	100
Acrylonitrile	1000
Carbon tetrachloride	1000
Cis-1,4-dichloro-2-butene	1000
Hexachlorobenzene	1000
Nitrobenzene	1000
Phenol	100
Pentachlorophenol	400
Trans-1,4-dichloro-2-butene	1000

This method of deriving screening benchmarks for soil organisms may appear as insufficiently conservative. This impression might result from the fact that the derivation of the benchmark (like the derivation of the ER-L values) implies a significant effect on approximately 10% of the species. However, the method probably is sufficiently conservative for the following reasons. First, the benchmarks were derived for a community-level assessment endpoint. Given the water, nutrient, or physical limitations of most soil- and litter-dwelling communities, a reduction in survival, growth, or reproduction of 10% of earthworm species or reduction of the rates of 10% of microbial processes is likely to be acceptable. Second, the benchmarks derived by these methods have proved to be conservative in practice. In some cases, the benchmarks are lower than background concentrations (Sect. 7). The benchmarks are based on toxicity tests that dose growth substrates with soluble salts of metals which are more available than most naturally occurring metals and even metals at many, if not most, waste sites.

The authors have attempted to assign levels of confidence to the benchmarks; these are presented with the appropriate chemicals in Sect. 3. The criteria best reflecting that confidence are as follows:

1. Low Confidence—Benchmarks based on fewer than 10 literature values.

2. Moderate Confidence—Benchmarks based on 10 to 20 literature values.

3. High Confidence—Benchmarks based on more than 20 literature values.

High confidence in a benchmark based on more than 20 reported toxic concentrations may be reduced to moderate if the range of plant, earthworm, or microbial species tested is narrow (i.e., only one species of earthworms was tested). Moderate or high confidence benchmarks were in some instances demoted one level if the value approximating the 10th percentile was the lowest concentration tested and caused a greater than 30% reduction in the measured growth parameter. These criteria may seem arbitrary, but the result is a confidence classification that fairly reflects the authors' professional judgment.

Any scheme for deriving a set of standard ecotoxicological benchmarks is based on assumptions that may be questioned by readers. The procedure used herein is consistent with current regulatory practice and contains a minimum of assumptions or factors. Readers who care to make other assumptions or add safety factors may make use of the data presented herein to calculate their own benchmarks.

3. EARTHWORMS

3.1 INTRODUCTION

Earthworms are probably the most important soil invertebrate in promoting soil fertility (Edwards, 1992). Their feeding and burrowing activities break down organic matter and release nutrients and improve aeration, drainage, and aggregation of soil. Earthworms are also important components of the diets of many higher animals.

Earthworms are known to take up many inorganic and organic soil contaminants. Availability of contaminants for uptake from the soil is controlled by soil characteristics. van Gestel (1992) concludes that, with the exception of extremes in pH, it is not possible to predict metal availability on the basis of soil variables. Availability of contaminants from plant litter in varying degrees of decomposition is also complex and poorly understood. The feeding and burrowing habits of earthworms determine their exposure to chemicals in soil and litter. Geophagus organisms (those taking in large amounts of soil during feeding on well-decomposed organic material) and those living on or near the soil surface may have greater exposure to organic chemicals than worms feeding on litter pulled down into burrows in the subsoil (Curl et al., 1987). Organic contaminants may undergo oxidation by the cytochrome P-450 and other enzyme systems within the earthworm. Earthworms also may bind xenobiotics and their metabolites in unextractable forms (Stenersen, 1992). Physiological response mechanisms to metals are species specific (Tomlin, 1992). Much of the ingested lead, cadmium, and zinc (the three most studied inorganic contaminants) is accumulated in chloragogenous tissue (intestinal wall) of the posterior alimentary canal (Morgan et al., 1993). Little is known about mechanisms of toxicity of chemicals in earthworms.

3.2 EARTHWORM DATA SELECTION

Information suitable for calculating screening benchmarks was available for a limited number of metals and a larger number of organic compounds. Toxic effects information on polychlorinated biphenyls (PCBs) is not available and information is limited for polycyclic aromatic hydrocarbons (PAHs). The toxicity of many agricultural pesticides has been tested, but as stated previously, it is not presented herein. Data on which the benchmarks are based are given in Appendix A; benchmarks are given in Table 1.

Only experiments in which earthworms were exposed to soil (natural or artificial mixture of natural components), soil/litter microcosms, or manure were considered for determining benchmark levels of contaminants in soils. The main alternative method is the contact filter paper test in which the organisms are placed on filter paper containing the chemical to be tested for toxicity. Results are presented as mg chemical per cm^2 filter paper and are therefore not comparable to results given as concentrations (mg per kg substrate). The test gives information about skin contact toxicity but not oral ingestion toxicity (Reinecke, 1992). Although uptake through the cuticle is considered an important uptake route for some organic chemicals (Stenersen, 1992), oral ingestion is an important uptake route for metals and organic compounds found in soil and litter. Heimbach (1988) reports that there is little correlation between contact paper test and OECD artificial soil test results. Good correlation between the OECD artificial soil test and field tests are reported for several pesticides (Heimbach, 1992).

Acute and chronic toxicity are tested in experiments evaluating the effects of chemicals on earthworms. Mortality is the main endpoint in acute toxicity tests with results reported as the concentration causing death in 50% of the test population (LC_{50}). In the case of organic compounds, most of the literature reports LC_{50} values.

Change of individual body weight, which may indicate sublethal effects, can also be measured during acute toxicity tests. Endpoints that indicate effects important to population dynamics include cocoon production, cocoon hatching rates, and juvenile survival (Kokta, 1992). It should be noted that several researchers have found a negative correlation between adult body weight and reproduction (Kokta, 1992), and the conclusion is that these characteristics should be investigated together.

3.3 EARTHWORM TEST SPECIES

Experiments on the toxicity of chemicals to earthworms have been performed with representatives of three families (*Megascolecidae*, *Eudrilidae*, and *Lumbricidae*) and 12 species representing earthworms from Europe and North America, Africa, India, and Asia.

The most commonly used earthworm, *Eisenia fetida*, is a nonburrowing organism found in compost piles and other organic-rich environments (Lee, 1985). It belongs to the epigeic ecological category of Bouche (1992). *Eisenia fetida* may be the most prolific of worms with a shorter lifespan than others of the *Lumbricidae* family. Its natural habitat may be under the bark of fallen trees, and protozoa may be an essential part of its diet (Lee, 1985). *Eisenia andrei* is considered a sibling species of *E. fetida* by most researchers (Bouche, 1992); however, it has been treated as a subspecies of *E. fetida* by others in the past (van Gestel and Ma, 1988). These earthworms are considered ideal for toxicity testing because of the ease with which populations are maintained in the laboratory. The short generation time of *E. fetida* allows investigation of effects of chemicals on reproduction and second generation survival.

Lumbricus rubellus is a shallow-burrowing lumbricid active in the surface and litter horizons of pastures and grasslands (Lee, 1985). It may forage for food, such as dead roots, in the subsurface horizon and dig deep burrows in which to rest during periods of environmental stress. In the litter layer, *L. rubellus* feeds on slightly decomposed plant remains, dung, and bacteria.

The genus *Allolobophora* is represented in the toxicity literature by three species. *Allolobophora chlorotica* is a shallow-burrowing lumbricid worm found in permanent pasture and other grasslands (Lee, 1985). It spends most of its life in the topsoil feeding on well-decomposed plant remains (humus). It is considered to be geophagus because it ingests a large quantity of soil during feeding. *Allolobophora caliginosa* and *Apporectodea caliginosa* are classified by Dindal (1990) as the same organism. It is similar to *A. chlorotica* in its burrowing and feeding habits and is common in alkaline soils of Egypt (Lee, 1985). No life history information was available on the species *A. tuberculata*.

Octolasium cyaneum is a burrowing lumbricid species that lives in the soil and feeds on dead roots (Lee, 1985). It is common in pasture lands where it creates deep horizontal burrows.

Dendrobaena rubida is an ubiquitous forest litter inhabiting lumbricid (Lee, 1985). It feeds on slightly decomposed leaf litter and does not burrow into the soil.

The *Eudrilidae* family is represented by *Eudrilus eugeniae*. This tropical species from west Africa is now widespread throughout tropical and temperate regions (Neuhauser et al., 1979). It is a common inhabitant of topsoils and prefers habitats with high concentrations of organic matter.

The *Megascolecidae* family is represented by three organisms for which little information is available. *Perionyx excavatus* is the Indian subcontinent equivalent of *Eisenia fetida*, preferring compost heaps and other accumulations of organic material (Lee, 1985). It is known to feed on animal dung. *Pheretima posthuma* is originally from east and southeast Asia. No life history information was found on *Octochaetus pattoni*; however, other members of the genus occur in New Zealand (Lee, 1985).

3.4 EARTHWORM DATA AND BENCHMARK DERIVATION

3.4.1 Inorganic Compounds

Arsenic. Fischer and Koszorus (1992) tested the effects of 68 ppm of arsenic (as potassium arsenate) on growth and reproduction of *Eisenia fetida* (average initial age of 5 weeks) when added to a combination of peaty marshland soil and horse manure (1:1). The number of survivors and their live mass and the number of cocoons produced were measured. The number of cocoons produced per worm showed the highest sensitivity to arsenic with a 56% reduction at the test concentration.

The benchmark of 60 ppm arsenic is based on this study only. Because of the lack of data, confidence in this benchmark is low.

Cadmium. van Gestel and his colleagues in the Netherlands have established a fairly standard procedure for testing the toxicity of chemicals to earthworms in an artificial soil mixture made up of (by dry weight) 10% sphagnum peat, 20% kaolin clay, and 69% fine sand and $CaCO_3$ to adjust the pH to approximately 6 (OECD soil) (van Gestel et al., 1992). The work in this citation evaluated the effects of Cd, added to the soil as $CdCl_2$, on growth and reproduction (cocoons/worm/week, percent fertility of cocoons, juveniles/fertile cocoon, juveniles/worm/week) of *Eisenia andrei* after 21 days. The Cd was added in aqueous form and the resultant substrate added to 1 L glass jars. Approximately 5 g finely ground cow dung was added to a shallow hole in the middle of the substrate to serve as a food source for the 10 worms. A concentration of 18 ppm Cd was required to reduce the number of cocoons produced/week and the number of juveniles/worm (23 and 22%). Growth and reproduction were not affected at 10 ppm Cd. In other experiments by van Gestel et al. (1991a) using the same system but comparing the results from putting the food source in a hole with those from mixing it in with substrate, growth was reduced 44% by 100 ppm (32 ppm had no effect) in the former case and 40% by 32 ppm (10 ppm had no effect), in the latter. The EC_{50} for clitella development (indicating sexual maturity) was 108 ppm Cd for dung placed in a center hole in the substrate, and 27 ppm for dung mixed in with substrate.

Khalil et al. (1996) measured the mortality and cocoon production of *Aporrectodea caliginosa* when exposed to various concentrations of cadmium, copper and zinc sulfate in an Egyptian soil. After eight weeks of exposure to 10 mg/kg of cadmium, the lowest concentration tested, cocoon production was reduced 25%. Toxicity tests with mixtures of the contaminants were also conducted, and it was concluded that the three metals act antagonistically at the concentrations tested.

Spurgeon and Hopkin (1995) investigated the effect of cadmium (as nitrate) on survival, growth, cocoon production, and cocoon viability of *Eisenia fetida* in an OECD artificial soil. The lowest EC50, 215 ppm, was for growth. The investigators also studied the toxicity of metal-contaminated field soils and an artificial soil contaminated with multiple metals.

Spurgeon et al. (1994) kept adult *E. fetida* in contaminated OECD artificial soil (pH 6.3) for 8 weeks to test the effects of Cd [as $Cd(NO_3)_2$] on survival and growth of the earthworms. Results were reported as LC_{50}s for mortality and EC_{50}s for effects on cocoon production. After 56 days, the calculated LC_{50} was greater than 300 ppm Cd. The EC_{50} for cocoon production was 46.3 ppm.

The effects of Cd added to horse manure (as Cd acetate) on *E. fetida* (initially less than 2 weeks old) was investigated by Malecki et al. (1982). Two growth periods were used, 8 and 20 weeks, and survival, weight gain, and cocoon production were measured. The most sensitive parameter was cocoon production. In the 8-week test, the lowest concentration tested, 25 ppm Cd, caused a 52% decrease in cocoon production. In the 20-week test, the lowest concentration tested, 50 ppm Cd, caused a 24% decrease in cocoon production.

The previously described system (horse manure) was used by Neuhauser et al. (1984) to look at the effects of Cd added as various soluble salts on growth and reproduction of *E. fetida*. The authors report their results with pooled data from all forms of a metal. After 6 weeks, both growth (weight) and cocoon production were decreased (25 and 100%) by 100 ppm Cd, the lowest concentration tested.

Bengtsson et al. (1986) report the effects of Cd on reproduction in the earthworm *Dendrobaena rubida* when grown in substrate at varying acidity. The metal was added to a 1:2 (volume) combination of sandy soil and well-decomposed cattle dung with a resulting organic carbon of about 6%. After 4 months at pH 4.5, the number of cocoons produced per worm was reduced 62% by 100 ppm Cd, while 10 ppm had no effect. The percent hatched cocoons, hatchlings/cocoon, and total number of hatchlings were not affected. At pH 5.5, the number of cocoons produced per worm, hatchlings/cocoon, and total number of hatchlings were reduced 78, 71, and 74%, respectively, by 100 ppm Cd, while 10 ppm had no effect. The percent hatched cocoons was not affected. At pH 6.5, the percent hatched cocoons, hatchlings/cocoon, and total number of hatchlings were reduced 47, 38, and 30%, respectively, by 100 ppm Cd, while 10 ppm had no effect. The number of cocoons/worm was not affected.

van Gestel and van Dis (1988) conducted a series of experiments in a sandy soil (1.7% organic matter, CEC 5.5 meq/100 g soil) to investigate the effects of acidity on acute toxicity of Cd ($CdCl_2$) to adult *E. andrei*. The LC_{50} was between 320 and 560 ppm Cd after 14 days at pH 4.1 and >1000 (no effect) at pH 7. The LC50 concentration in OECD soil, with 10% organic matter at pH 7, was also >1000 (no effect).

Neuhauser et al. (1985) used OECD artificial soil (pH 6) to determine LC_{50} of Cd (added as Cd nitrate) for adult *E. fetida*. After 14 days, the LC_{50} was calculated to be 1843 ppm Cd.

In a study examining the effects of soil factors on Cd toxicity and uptake, Ma (1982) used a sandy loam soil (pH 7.3, 8% organic matter) spiked with $CdCl_2$ to determine the effects of Cd on survival of adult *Lumbricus rubellus*. After 12 weeks, 1000 ppm Cd caused an 82% decrease in survival while 150 ppm had no effect.

A benchmark of 20 ppm has been computed for Cd on the basis of the 18 available concentrations causing toxicity. Confidence in this benchmark is moderate.

Chromium. Abbasi and Soni (1983) worked with a system in which the earthworm *Octochaetus pattoni* was kept in concrete tanks containing a mixture of soil and animal dung for 60 days to assess the effect of Cr(VI), added as $K_2Cr_2O_7$, on survival and reproduction. Survival was the most sensitive measure with a 75% decrease resulting from 2 ppm Cr, the lowest concentration tested. The number of cocoons produced was not diminished until the concentration reached 20 ppm Cr (highest concentration tested); the number of juveniles produced was not affected.

These same researchers (Soni and Abbasi, 1981) found no survival of *Pheretima posthuma* after 61 days in a paddy soil to which 10 ppm Cr(VI) (lowest concentration tested) was added.

van Gestel et al. (1992), in the system described previously for Cd, also found growth of *E. andrei* to be more sensitive to Cr than reproduction. In this case, Cr(III) was added as chromic nitrate to OECD soil. A concentration of 32 ppm Cr reduced growth by 30% while cocoons/worm/week, percent fertile cocoons, and juveniles/worm/week were reduced 28, 22, and 51%, respectively, by 100 ppm Cr.

Molnar et al. (1989) examined the effects of Cr(III) and Cr(VI) on growth and reproduction of *Eisenia fetida* in an undefined substrate. Chromium (VI) was added as $K_2Cr_2O_7$ and Cr(III) as $KCr(SO_4)_2$. Reproduction after 8 weeks was the measure most sensitive to Cr(III) with a 55% decrease in the number of cocoons and hatchlings at 625 ppm Cr(III). The authors indicate that reproduction was also sensitive to Cr(VI) but no data were given. After 2 weeks, mass gain of juveniles was decreased 34% by 2,500 ppm Cr(III) (625 ppm had no effect) and 43% by 625 ppm Cr(VI) (lowest concentration tested). After 4 weeks, mass gain of juveniles was decreased 39% by 2,500 ppm Cr(III) (625 ppm had no effect), and Cr(VI) had no effect. Chromium(VI) at 1,250 ppm was ineffective when worms were introduced after the soil had equilibrated for 2 weeks, regardless of the length of exposure.

It is difficult to set a benchmark concentration for toxicity of Cr to earthworms. Survival may be more sensitive than reproduction to the metal when it is added to the earthworm substrate as a soluble salt. The relative toxicity of Cr(III) and Cr(VI) is not clear from these studies. Cr(VI) ions can pass through cell membranes with much greater ease than Cr(III) ions. However, it is thought that Cr(VI) is reduced to Cr(III) inside the cell (Molnar et al., 1989); this latter may be the final active form. Without a better understanding of Cr transformations in the soil, transport across earthworm cell membranes, and reactions within the cell, it is difficult to separate the effects of the two different forms.

The 0.4 ppm benchmark for Cr is based on the work of Abbasi and Soni (1983). A safety factor of 5 was applied to the 2 ppm LOEC because it caused a 75% reduction in earthworm survival.

Confidence in this benchmark is low because it is based on only five reported concentrations causing toxicity to earthworms.

Copper. Neuhauser et al. (1984) evaluated the effects of soluble forms of copper on growth and reproduction *E. fetida* as described for Cd. The authors report their results with pooled data from all forms of a metal. After 6 weeks, both growth (weight) and cocoon production were decreased (75 and 85%) by 2000 ppm Cu, while 1000 ppm had no effect.

Khalil et al. (1996) measured the mortality and cocoon production of *Aporrectodea caliginosa* when exposed to various concentrations of cadmium, copper and zinc sulfate in an Egyptian soil. Eight weeks of exposure to 100 ppm of copper led to a 36% decrease in cocoon production (NOEC = 50 ppm). Toxicity tests with mixtures of the contaminants were also conducted, and it was concluded that the three metals act antagonistically at the concentrations tested.

Spurgeon and Hopkin (1995) investigated the effect of copper (as nitrate) on survival, growth, cocoon production, and cocoon viability of *Eisenia fetida* in an OECD artificial soil. The lowest EC50, 601 ppm, was for growth. The investigators also studied the toxicity of metal-contaminated field soils and an artificial soil contaminated with multiple metals.

Neuhauser et al. (1985) used the OECD artificial soil (pH 6) to estimate LC_{50} of Cu (added as Cu nitrate) for adult *E. fetida*. After 14 days, the LC_{50} was 643 ppm Cu.

Spurgeon et al. (1994) kept adult *E. fetida* in contaminated OECD artificial soil (pH 6.3) for 8 weeks to test the effects of Cu (as $Cu(NO_3)_2$) on survival and growth of the earthworms, as described for Cd. After 56 days, the calculated LC_{50} was 555 ppm, and the EC_{50} for cocoon production was 53.3 ppm.

The effects of Cu added to horse manure (as copper acetate) on *E. fetida* (initially less than 2 weeks old) was investigated by Malecki et al. (1982). Two growth periods were used, 8 and 20 weeks, and survival, weight gain, and cocoon production were measured. The most sensitive parameter was cocoon production. In the 8-week test, 500 ppm Cu caused a 24% decrease in cocoon production, while 300 ppm had no effect. In the 20-week test, 1000 ppm Cu caused a 24% decrease in cocoon production, while 500 ppm had no effect.

Bengtsson et al. (1986) looked at the effects of copper on *Dendrobaena rubida* at different acidities in the same type of experiments described for Cd. After 4 months at pH 4.5, the number of cocoons produced per worm, hatchlings/cocoon, and total number of hatchlings were reduced 70, 64, and 74%, respectively, by 100 ppm Cu, the lowest concentration tested. The percent hatched cocoons was not affected. At pH 5.5, the number of cocoons produced per worm, hatchlings/cocoon, and percent hatched cocoons were reduced 96, 100, and 100%, respectively, by 500 ppm Cu, while 100 ppm had no effect. The total number of hatchlings was not affected. At pH 6.5, the number of cocoons produced per worm, hatchlings/cocoon, and percent hatched cocoons were reduced 90, 100, and 100%, respectively, by 500 ppm Cu, while 100 ppm had no effect. The total number of hatchlings was not affected.

In experiments by van Gestel et al. (1991b) using the same system described previously but with Cu ($CuCl_2$) mixed homogeneously with the OECD substrate, growth of *E. fetida* was reduced 32% by 100 ppm (32 ppm had no effect). The EC_{50} for clitella development (sexual development) was >100 ppm Cu.

In a study examining the effects of soil factors on Cu toxicity and uptake, Ma (1982) used a sandy loam soil (pH 7.3, 8% organic matter) spiked with $CuCl_2$ to determine the effects of Cu on survival of adult *Lumbricus rubellus*. After 12 weeks, 1000 ppm Cu caused an 82% decrease in survival while 150 ppm had no effect.

The effect of soil organic carbon on toxicity of Cu ($CuSO_4$) to the earthworm *Octolasium cyaneum* was evaluated by Streit and Jaggy (1983). They determined the 14-day LC_{50} in a Brown soil, a Rendzina soil, and a peat soil containing 3.2, 14, and 43% organic carbon, respectively. LC_{50} concentrations were 180, 850, and 2500 ppm, respectively.

van Rhee (1975) tested the effects of a single concentration of Cu added to a polder soil on body weight, number of cocoons produced per week, mortality and sexual development of *Allolobophora caliginosa*. After 60 days, number of cocoons produced was the only measure affected; it decreased by 27% in the presence of 110 ppm Cu.

Using the OECD artificial soil (pH 6) and 21-day test procedure, van Gestel et al. (1989) looked at the effects of Cu (as $CuCl_2$) on reproductive parameters of adult *E. andrei*. After 21 days, cocoon production was decreased 36% by the addition of 180 ppm Cu to the substrate, while 120 ppm had no effect. Cocoon hatchability and number of juveniles per cocoon were not affected.

The sublethal effects of Cu on *L. rubellus* were investigated with respect to mortality, growth, cocoon production, and litter breakdown activity (Ma, 1984). Loamy sand field soil (5.7% organic matter, pH 4.8), with Cu added as $CuCl_2$, was placed in bags with leaf litter added to the top. In an experiment lasting 6 weeks, the number of cocoons produced was decreased 42% by 131 ppm (HNO_3:H_2SO_4 extractable), while 54 ppm had no effect. In another study using this soil with the pH adjusted to between 4.8 and 7.1, Ma investigated at the effect of acidity on toxicity of Cu ($CuSO_4$) to *L. rubellus* growth and reproduction. At pH 4.8, 148 ppm Cu resulted in a 26% decrease in production (83 ppm had no effect). At pH 6, a 33% reduction in cocoon production resulted from 278 ppm Cu, while 148 ppm had no effect. In a 6-week experiment using a calcareous sandy loam soil (pH 7.3, organic matter 3.4%), the number of cocoons produced was diminished 41% in cultures to which 63 ppm Cu were added as $CuCl_2$ (13 ppm had no effect).

The relative sensitivity of several lumbricid earthworms to Cu ($CuCl_2$) added to a sandy soil (pH 5, organic matter 5%) was investigated by Ma (1988). EC_{50}s for cocoon production of *L. rubellus*, *Aporrectodea caliginosa*, and *Allolobophora chlorotica* were 122, 68, and 51 ppm Cu.

The work of Streit and Jaggy (1983) and others shows that the organic carbon content of the soil is a strong determinant of the bioavailability and toxicity of copper. From the studies cited, it appears that low pH has a compounding effect, with an increase in Cu availability resulting from more acid conditions. Overall, reproduction is more sensitive than mortality, and there is no consistent evidence that one genus of earthworms is any less tolerant to Cu under a given set of conditions than another genus.

The benchmark for Cu was established at 60 ppm. Confidence in this benchmark is moderate.

Lead. Bengtsson et al. (1986) examined the effects of lead on *Dendrobaena rubida* at different acidities in the same type of experiments as those described for Cd. After 4 months at pH 4.5, the number of cocoons produced per worm, hatchlings/cocoon, and percent hatched cocoons were reduced 75, 100, and 100%, respectively, by 500 ppm Pb, while 100 ppm had no effect. At pH 5.5 and 6.5, Pb had no effect at any level on any of the measures.

Spurgeon and Hopkin (1995) investigated the effect of lead (as nitrate) on survival, growth, cocoon production, and cocoon viability of *Eisenia fetida* in an OECD artificial soil. The lowest EC50, 1629 ppm, was that for cocoon production. The investigators also studied the toxicity of metal-contaminated field soils and an artificial soil contaminated with multiple metals.

Spurgeon et al. (1994) kept adult *E. fetida* in contaminated OECD artificial soil (pH 6.3) for 8 weeks to examine the effects of Pb (as $Pb(NO_3)_2$) on survival and growth of the earthworms as described for Cd. After 56 days, the calculated LC_{50} was 3760 ppm, and the EC_{50} for cocoon production was 1940 ppm.

The effects of Pb added to horse manure (as lead acetate) on *E. fetida* was investigated by Malecki et al. (1982), as described above for Cd. The most sensitive parameter was cocoon production. In the 8-week test, 4000 ppm Pb caused a 50% decrease in cocoon production, while 2000 ppm had no effect. In the 20-week test, 5000 ppm Pb caused a 28% decrease in cocoon production, while 1000 ppm had no effect.

Neuhauser et al. (1985) used the OECD artificial soil (pH 6) to determine LC_{50} of Pb [added as Pb (NO_3)] for adult *E. fetida*. After 14 days, the LC_{50} was calculated to be 5941 ppm Pb.

Neuhauser et al. (1984) evaluated the effects of soluble forms of lead on growth and reproduction of *E. fetida* as described for Cd. The authors report their results with pooled data from all forms of a metal. After 6 weeks, cocoon production was decreased 80% by 5000 ppm Pb, the lowest concentration tested. Growth was not affected until 40,000 ppm was added to the substrate.

A benchmark of 500 ppm has been established for Pb based on the work of Bengtsson et al. (1986) which showed inhibition of reproduction at this concentration. Confidence in this benchmark is low because of the limited amount of data.

Mercury. Abbasi and Soni (1983) worked with *Octochaetus pattoni* in a system described previously for Cd. They assessed the effect of Hg(II), added as $HgCl_2$, on survival and reproduction. Survival and cocoon production were reduced 65 and 40% at 0.5 ppm Hg, the lowest concentration tested. The number of juveniles produced was not affected.

The effect of methyl mercury on survival and segment regeneration of *E. fetida* was investigated by Beyer et al. (1985). Methyl mercury chloride was added to an undefined potting soil in which the earthworms were cultured for 84 days. A concentration of 12.5 ppm Hg reduced survival by 21%, and the ability to regenerate excised segments was reduced by 69%. Methyl mercury at 2.5 ppm had no effect.

It is not possible to evaluate the relative toxicity of forms of Hg based on these two studies which used different systems and evaluated two different families of earthworms.

A benchmark of 0.1 ppm was established for Hg based on the work of Abbasi and Soni (1983). A safety factor of 5 was applied to the 0.5 ppm LOEC because it caused a 65% reduction in earthworm survival. Confidence in this benchmark is low because of the limited amount of data.

Nickel. The effects of Ni (added to horse manure as Ni acetate) on *E. fetida* were investigated by Malecki et al. (1982), as described for Cd. The most sensitive parameter was cocoon production. In the 8-week test, 300 ppm Ni caused a 41% decrease in cocoon production, while 200 ppm had no effect. In the 20-week test, 200 ppm Ni caused a 23% decrease in cocoon production, while 100 ppm had no effect.

Neuhauser et al. (1985) used the OECD artificial soil (pH 6) to determine LC_{50} of Ni (added as Ni nitrate) for adult *E. fetida*. After 14 days, the LC_{50} was calculated to be 757 ppm Ni.

Neuhauser et al. (1984) evaluated the effects of soluble forms of nickel on growth and reproduction *E. fetida* as described for Cd. The authors report their results with pooled data from all forms of a metal. After 6 weeks, cocoon production was decreased 33% by 250 ppm Ni, the lowest concentration tested. Growth was not affected until 500 ppm was added to the substrate.

In a study examining the effects of soil factors on Ni toxicity and uptake, Ma (1982) used a sandy loam soil (pH 7.3, 8% organic matter) spiked with $NiCl_2$ to determine the effects of Ni on survival of adult *Lumbricus rubellus*. After 12 weeks, 1000 ppm Cd caused a 31% decrease in survival while 150 ppm had no effect.

A benchmark of 200 ppm has been established for Ni based on the work of Malecki et al. (1982) which showed inhibition of reproduction at this concentration. Confidence in this benchmark is low because of the limited amount of data.

Selenium. Fischer and Koszorus (1992) tested the effects of 77 ppm of selenium (as sodium arsenite) on growth and reproduction of *Eisenia fetida* when added to a combination of peaty marshland soil and horse manure (1:1). Number of survivors and their live mass and number of cocoons produced were measured. The number of cocoons produced per worm showed the highest sensitivity to selenium with a 69% reduction at the test concentration.

The benchmark of 70 ppm is based on this study. Confidence in this benchmark is low.

Zinc. van Gestel et al. (1993) evaluated the effect of zinc added as $ZnCl_2$ to OECD artificial soil (pH 6.2), on the growth and reproduction of *E. andrei*. The numbers of cocoons and juveniles produced were reduced 31 and 42% by 560 ppm, while 320 ppm had no effect. The percent fertile cocoons and number of juveniles per fertile cocoon were not affected until Zn was added to a concentration of 1000 ppm Zn, and percent growth of individuals increased with increasing Zn concentration.

Khalil et al. (1996) measured the mortality and cocoon production of *Aporrectodea caliginosa* when exposed to various concentrations of cadmium, copper and zinc sulfate in an Egyptian soil. Exposure to 300 ppm of zinc, the lowest concentration tested, led to a 20% reduction in cocoon production. Toxicity tests with mixtures of the contaminants were also conducted, and it was concluded that the three metals act antagonistically at the concentrations tested.

Spurgeon and Hopkin (1995) investigated the effect of zinc (as nitrate) on survival, growth, cocoon production, and cocoon viability of *Eisenia fetida* in an OECD artificial soil. The lowest EC50, 1078 ppm, was for mortality. For the derivation of the benchmark, the LC50 was divided by 5 to give a concentration of 216 ppm. The EC50 for a growth effect was greater than 400 ppm. The investigators also studied the toxicity of metal-contaminated field soils and an artificial soil contaminated with multiple metals.

Spurgeon and Hopkin (1996a) conducted toxicity tests with zinc (as nitrate) and three earthworm species to determine whether the earthworm population distribution near a smelter could be related to species sensitivity to metals. Tests were conducted in OECD artificial soil. The growth rates of *Eisenia fetida* and *Aporrectodea rosea* were reduced by 69% and 48%, respectively, following exposure to 190 ppm for 21 days, the lowest concentration tested. The same concentration led to a 32% decrease in the rate of cocoon production by *Lumbricus rubellus*. Effects on other endpoints tested, such as survival, percentage of fertile cocoons, and rate of production of juveniles, occurred at higher concentrations.

Spurgeon and Hopkin (1996b) used a range of artificial soils with differing organic matter content and soil pH for tests of the toxicity of zinc to *Eisenia fetida*. The EC50 concentrations for cocoon production in soils with of pH 6.0 and 5%, 10% and 15% organic matter were 136, 462, and 592 ppm, respectively. The EC50 concentrations for cocoon production in soils of pH 6.0 and 5%, 10% and 15% organic matter were 199, 343, and 548 ppm, respectively. The EC50 concentrations for cocoon production in soils of pH 6.0 and 5%, 10% and 15% organic matter were 142, 189, and 230 ppm, respectively. Mortality was observed at higher concentrations. In the range of pH and organic matter in the soils tested, a decrease in pH and/or organic matter content of soils led to a lower toxic concentration of zinc.

Spurgeon et al. (1994) kept adult *E. fetida* in contaminated OECD artificial soil (pH 6.3) for 8 weeks to test the effects of Zn (as $Zn(NO_3)_2$) on survival and growth of the earthworms as described for Cd. After 56 days, the calculated LC_{50} was 745 ppm, and the EC_{50} for cocoon production was 276 ppm.

Neuhauser et al. (1985) used the OECD artificial soil (pH 6) to determine LC_{50} of Zn [added as Zn (NO_3)] for adult *E. fetida*. After 14 days, the LC_{50} was calculated to be 662 ppm Zn. To derive the benchmark, a concentration of 132 ppm (662/5) was used.

van Rhee (1975) tested the effects of one concentration of Zn (1100 ppm) added to a polder soil on body weight, number of cocoons produced per week, mortality and sexual development of *Allolobophora caliginosa*. After 60 days, there was a 53% loss of body weight and a 22% increase in mortality; clitellum development and cocoon production were completely inhibited.

Neuhauser et al. (1984) evaluated the effects of soluble forms of zinc on growth and reproduction *E. fetida* as described for Cd. The authors report their results with data pooled from all forms of a metal. After 6 weeks, cocoon production was decreased 50% by 2500 ppm Zn, while 1000 ppm had no effect. Growth was not affected until 5000 ppm was added to the substrate.

The effects of Zn added to horse manure (as zinc acetate) on *E. fetida was* investigated by Malecki et al. (1982), as described for Cd. The most sensitive parameter was cocoon production. In the 8-week test, 2000 ppm Zn caused a 36% decrease in cocoon production, while 1000 ppm had no effect. In the 20-week test, 5000 ppm Zn caused a 53% decrease in cocoon production, while 2500 ppm had no effect.

A benchmark of 100 ppm is established for zinc. The benchmark is somewhat lower than concentrations at which effects have been observed. The low concentrations include: measures of cocoon production of *Eisenia fetida* in two artificial soils (136 ppm, 142 ppm) (Spurgeon and Hopkin 1996b) and 132 ppm, which is the LC50 for *Eisenia fetida* divided by 5 (Neuhauser et al. 1985). The authors have moderate confidence in this benchmark.

3.4.2 Organic Compounds

A small number of research groups have been conducting experiments on the toxicity of organic compounds and pesticides to earthworms. As a result, there are a limited number of experimental designs in use, and data are mainly in the form of LC_{50}s. The following review describes the experimental designs of the various groups; the reader is directed to Appendix A for complete data.

Chloroacetamide. van Gestel and van Dis (1988) evaluated the effects of soil pH and organic matter content on toxicity of chloroacetamide to survival of adult *E. andrei*. The LC_{50} (14 d) in a sandy soil (1.7% organic matter) at pH 4.1 and 7 was determined. Clearly, pH had an effect in this soil with higher LC_{50} values at pH 7. In the OECD artificial soil (7.7% organic matter) at pH 7, the LC_{50} was similar to that in the sandy soil at the same pH. It appears that differences in the organic matter content in this range were not determining the toxicity of this compound.

Heimbach (1984) also used the OECD artificial soil (pH 7) to evaluate the effects of this compound on the survival of *E. fetida* after 28 days. He found an LC_{50} of 24 ppm.

The effect of chloroacetamide on growth and reproduction of *E. fetida* after 56 days of growth in horse manure was assessed by Neuhauser and Callahan (1990). A concentration of 500 ppm had no effect on the earthworms, but 1000 ppm caused 100% mortality.

The LC_{50} value between 10 and 18 (van Gestel and van Dis, 1988) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to the lower bound on the LC_{50} to obtain the benchmark of 2 ppm chloroacetamide. Confidence in this benchmark is low because of the limited amount of data.

3-Chloroaniline. van Gestel and Ma (1993) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms, *E. andrei* and *L. rubellus*. In a sandy soil with pH 4.8 and 3.7% organic matter, LC_{50} values were lower for both earthworm species than it was in the OECD artificial soil with pH 5.9 and 8.1% organic matter. The authors conclude that, with this narrow a range of pH values, it is likely that the difference in organic matter is responsible for the results.

The LC_{50} value of 195 (van Gestel and Ma, 1993) was the lowest toxic concentration of the four reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 30 ppm 3-chloroaniline. Confidence in this benchmark is low.

2,4-Dichloroaniline. van Gestel et al. (1989) used the OECD artificial soil (pH 6) to determine the effects of this compound on growth and reproduction of *E. andrei*. After 21 days, cocoon production was reduced 23% by 100 ppm, while 56 ppm had no effect. Cocoon fertility and number of juveniles per cocoon were not affected by concentrations up to 180 ppm, the highest concentration tested.

van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms, *E. andrei* and *L. rubellus*. Two sandy soils had similar pH values (5.3 and 5.6) but different organic matter levels (3.7 and 6.1%). The OECD artificial soil had a pH of 5.9 and 8.1% organic matter. A peaty soil also used had a pH of 4 and organic matter content of 15.6%. The LC_{50} values for 2-4-dichloroaniline ranged from 145 to 824 ppm, with organic matter being the more important determinant of bioavailability of this compound within the narrow pH range of soils used.

The 100 ppm benchmark is based on the work of van Gestel et al. (1989) which showed inhibition of reproduction at this concentration. This test endpoint is chosen as more appropriate than lethality (LC_{50}). Confidence in the benchmark is low because of the few data available.

3,4-Dichloroaniline. van Gestel and van Dis (1988) investigated the effects of soil pH and organic matter content on the toxicity of this compound to *E. fetida*. A sandy soil (1.7% organic matter) was tested at pH 4.1 and 7. The OECD artificial soil had a pH of 7 and 7.7% organic matter. The LC_{50} values ranged from 140 to 250 ppm increased with increasing organic matter content. No difference related to pH was seen in the sandy soil.

The LC_{50} value of 140 (van Gestel and van Dis, 1988) was the lowest toxic concentration of the three reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 3,4-dichloroaniline. Confidence in this benchmark is low.

2,4,5-Trichloroaniline. van Gestel and Ma (1993) evaluated the effects of this compound on the earthworms *E. andrei* and *L. rubellus* as described for 3-chloroaniline. As was the case for that compound, it is likely that the difference in organic matter is responsible for the results.

The lowest LC_{50} value of 134 derives from this work. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 2,4,5-trichloroaniline. Confidence in this benchmark is low.

2,3,5,6-Tetrachloroaniline. van Gestel and Ma (1993) evaluated the effects of this compound on the earthworms *E. andrei* and *L. rubellus* as described for 3-chloroaniline. There is not much difference in the results under different pH and organic matter conditions, and it is not clear that organic matter affecting the bioavailability as in the case of 3-chloroaniline and 2,4,5-trichloroaniline.

The lowest LC_{50} value of 116 ppm derives from this work. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 2,3,5,6-tetrachloroaniline. Confidence in this benchmark is low.

Pentachloroaniline. van Gestel and Ma (1993) evaluated the effects of this compound on the earthworms *E. andrei* and *L. rubellus* as described previously. There is considerable difference in the LC_{50}s but no discernible pattern was evident based on soil characteristics or species of earthworm tested.

The lowest LC_{50} value of 825 derives from this work. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 100 ppm pentachloroaniline. Confidence in this benchmark is low.

1,2-Dichloropropane. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four earthworms, *Perionyx excavatus*, *Eudrilus eugeniae, Eisenia fetida,* and *Allolobophora tuberculata*. They determined the LC_{50} after 14 days and found less than two-fold difference in sensitivity among the worms; sensitivity decreased in the order *P. excavatus*>*E. fetida*>*A. tuberculata*>*E. eugeniae*.

Neuhauser and Callahan (1990) investigated the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 80,800 ppm had no effect on the earthworms, but 92,300 ppm caused 100% mortality.

The LC_{50} value of 3880 (Neuhauser et al., 1986) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 700 ppm 1,2-dichloropropane. Confidence in this benchmark is low.

Dimethylphthalate. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four species of earthworms, as described previously. The LC_{50}s after 14 days showed a three-fold difference in sensitivity among the worms; sensitivity decreased in the order *P. excavatus*>*E. eugeniae*>*E. fetida*>*A. tuberculata*.

Neuhauser and Callahan (1990) evaluated the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 47,200 ppm had no effect on the earthworms, but 70,800 ppm caused a 62% reduction in cocoon production.

The LC_{50} value of 1064 (Neuhauser et al., 1986) was the lowest toxic concentration of the three reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 200 ppm dimethylphthalate. Confidence in this benchmark is low.

Fluorene. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four earthworms, as described previously. The LC_{50}s after 14 days showed little difference in sensitivity among the worms; sensitivity decreased in the order *P. excavatus*>*E. fetida*>*E. eugeniae*>*A. tuberculata*.

Neuhauser and Callahan (1990) investigated the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 500 ppm had no effect on the earthworms, but 750 ppm caused a 49% reduction in cocoon production.

The LC_{50} value of 170 (Neuhauser et al., 1986) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 30 ppm fluorene. Confidence in this benchmark is low.

N-nitrosodiphenylamine. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four earthworms, as described previously. The LC_{50}s after 14 days showed little difference in sensitivity among the worms; sensitivity decreased in the order *E. eugeniae*>*P. excavatus*>*E. fetida*>*A. tuberculata*.

Neuhauser and Callahan (1990) looked at the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 1400 ppm (lowest concentration tested) caused a 37% reduction in cocoon production.

The LC_{50} value of 109 (Neuhauser et al., 1986) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm N-nitrosodiphenylamine. Confidence in this benchmark is low.

Phenol. Neuhauser et al. (1986) used OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four species of earthworms, as described previously. The LC_{50}s after 14 days showed a less than three-fold difference in sensitivity among the worms; sensitivity decreased in the order *E. eugeniae*>*P. excavatus*>*E. fetida*>*A. tuberculata*.

Neuhauser and Callahan (1990) assessed the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 3900 ppm had no effect on the earthworms, but 4900 ppm caused a 26% reduction in cocoon production.

The LC_{50} value of 188 (Neuhauser et al., 1986) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 30 ppm phenol. Confidence in this benchmark is low.

4-Nitrophenol. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four species of earthworms, as described previously. The LC_{50}s after 14 days showed little difference in sensitivity among the worms; sensitivity decreased in the order *E. fetida*>*E. eugeniae*>*P. excavatus*>*A. tuberculata*.

Neuhauser and Callahan (1990) looked at the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 600 ppm (the lowest concentration tested) caused a 39% reduction in cocoon production.

The LC_{50} value of 38 (Neuhauser et al., 1986) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 7 ppm 4-nitrophenol. Confidence in this benchmark is low.

3-Chlorophenol. van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms, *E. andrei* and *L. rubellus*. Two sandy soils had similar pH values (5.3 and 5.6) but different organic matter levels (3.7 and 6.1%). The OECD artificial soil had a pH of 5.9 and 8.1% organic matter. A peaty soil also used had a pH of 4 and organic matter content of 15.6%. The LC_{50} values ranged from 75 to 633 ppm, with organic matter being the more important determinant of bioavailability of this compound within the narrow pH range of soils used.

van Gestel and Ma (1988) looked at the effects of this compound on survival of *L. rubellus* and *E. andrei* in two humic sand soils of differing organic matter content (3.7 and 6.1%) but similar pH (5 and

5.6). These investigators found a three-fold difference between the highest and lowest values with no strong trend in relation to earthworm species or soil factors.

The benchmark for this compound has been established at 10 ppm. The LC_{50} of 75 from the work of van Gestel and Ma (1990) approximates the 10th percentile. A safety factor of 5 was applied to this value to obtain the benchmark. Confidence in this benchmark is low because all 12 values of the data set are LC_{50}s.

3,4-Dichlorophenol. van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms, *E. andrei* and *L. rubellus*, as described previously. The LC_{50} values ranged from 134 to 680 ppm, with a trend of organic matter being more important than pH as a determinant of bioavailability for this compound.

van Gestel and Ma (1988) assessed at the effects of this compound on survival of *L. rubellus* and *E. andrei* in two humic sand soils of differing organic matter content but similar with respect to pH, as described previously. There was about a three-fold difference between the highest and lowest values with no strong trend in relation to earthworm species or soil factors.

The benchmark for this compound was established at 20 ppm. The LC_{50} of 134 from the work of van Gestel and Ma (1990) approximates the 10th percentile. A safety factor of 5 was applied to this value to obtain the benchmark. Confidence in this benchmark is low because all 12 values of the data set are LC_{50}s.

2,4,5-Trichlorophenol. van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworm species, *E. andrei* and *L. rubellus*, as described previously. The LC_{50} values ranged from 46 to 875 ppm, with a trend of organic matter being more important than pH as a determinant of bioavailability within earthworm type. *E. andrei* appears to be more sensitive than *L. rubellus* to this compound.

van Gestel and Ma (1988) assessed the effects of this compound on survival of *L. rubellus* and *E. andrei* in two humic sand soils of differing organic matter content but similar pH, as described previously. The LC_{50} values ranged from 52 to 290 ppm, with a trend of organic matter being the more important determinant of bioavailability within earthworm type. *E. andrei* again appears to be more sensitive to this compound than *L. rubellus*.

The benchmark for this compound was established at 9 ppm. The LC_{50} of 46 from the work of van Gestel and Ma (1990) approximates the 10th percentile. A safety factor of 5 was applied to this value to obtain the benchmark. Confidence in this benchmark is low because all 12 values of the data set are LC_{50}s.

2,4,6-Trichlorophenol. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four earthworms, as described previously. The LC_{50}s after 14 days showed little difference in sensitivity among the worms; sensitivity decreased in the order *E. fetida*>*P. excavatus*>*E. eugeniae*>*A. tuberculata*.

Neuhauser and Callahan (1990) assessed the effect of this compound on growth and reproduction of *E. fetida* after 56 days of growth in horse manure. A concentration of 100 ppm (lowest concentration tested) caused a 28% reduction in cocoon production.

The LC_{50} value of 58 (Neuhauser et al., 1986) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 10 ppm for 2,4,6-trichlorophenol. Confidence in this benchmark is low.

2,3,4,5-Tetrachlorophenol. van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms, *E. andrei* and *L. rubellus*, as described previously. The LC_{50} values ranged from 117 to 875 ppm, with a trend of organic matter being more important that pH as a determinant of bioavailability within earthworm species. *E. andrei* appears to be more sensitive than *L. rubellus* to this compound.

van Gestel and Ma (1988) looked at the effects of this compound on survival of *L. rubellus* and *E. andrei* in two humic sand soils of differing organic matter content but similar pH, as described previously. The LC_{50} values ranged from 116 to 828 ppm, with a trend of organic matter being the more important determinant of bioavailability within earthworm type. *E. andrei* again appears to be more sensitive to this compound than *L. rubellus*.

The LC_{50} value of 116 (van Gestel and Ma, 1990) was the lowest toxic concentration of the eight reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 2,3,4,5-tetrachlorophenol. Confidence in this benchmark is low.

Pentachlorophenol. van Gestel and van Dis (1988) investigated the effects of soil pH and organic matter content on the toxicity of this compound to *E. fetida*. A sandy soil (1.7% organic matter) was tested at pH 4.1 and 7. The OECD artificial soil had a pH of 7 and 7.7% organic matter. There was no strong trend related to organic matter, but the highest LC_{50} occurred in the more acid soil.

Fitzgerald et al. (1996) investigated the role of species, temperature, and soil type on toxicity of pentachlorophenol to earthworms. The researchers estimated incipient lethal levels (ILLs), which they defined as a time-independent LC50, i. e., an LC50 that does not change if the test is run for a longer period of time. The ILLs for *Eisenia fetida* grown for 14 days in an artificial soil at 24°C or 15°C were 37 ppm and 27 ppm, respectively. The ILL for *Eisenia fetida* grown for 14 days in a clay soil at 24°C was 72 ppm. The ILL for *Eisenia eugeniae* at 24°C was 168 ppm. *Lumbricus terrestris* grown at 15°C had an ILL of 191 ppm.

van Gestel et al. (1989) used the OECD artificial soil (pH 6) to determine the effects of this compound on the growth and reproduction of *E. andrei*. After 21 days, percent cocoon hatching success was reduced 50% by 32 ppm, while 10 ppm had no effect. Cocoon production and number of juveniles per cocoon were not affected until 100 ppm was added.

Heimbach (1984) used the OECD artificial soil (pH 7) to evaluate the effects of this compound on survival of *E. fetida* after 28 days. He found an LC_{50} of 87 ppm.

van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms, *E. andrei* and *L. rubellus*, as described previously. The LC_{50} values ranged from 83 to 2298 ppm, with the highest value occurring in soil with the highest organic matter content for each earthworm species. *E. andrei* appears to be more sensitive than *L. rubellus* to this compound.

van Gestel and Ma (1988) investigated the effects of this compound on survival of *L. rubellus* and *E. andrei* in two humic sand soils of differing organic matter content but similar pH, as described previously. The LC_{50} values ranged from 94 to 1094 ppm, with no strong trend related to organic matter. *E. andrei* again appears to be more sensitive to this compound than *L. rubellus*.

The 10th percentile of the data is about 30 ppm. A safety factor of 5 is applied to the value to obtain the benchmark of 6 ppm pentachlorophenol. Confidence in this benchmark is low because all but one of the 22 values in the data set are LC_{50}s.

Chlorobenzene. van Gestel et al. (1991b) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms species, *E. andrei* and *L. rubellus*. In a sandy soil with pH 4.8 and 3.7% organic matter and OECD artificial soil (pH 5.9 and 8.1% organic matter), LC_{50} values were lower for *E. fetida* than for *L. rubellus*. Values ranged from 240 to 1107 ppm.

The LC_{50} value of 240 (van Gestel et al., 1991b) was the lowest toxic concentration of the four reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 40 ppm chlorobenzene. Confidence in this benchmark is low.

1,4-Dichlorobenzene. van Gestel et al. (1991b) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms species, *E. andrei* and *L. rubellus*. In a sandy soil with pH 4.8 and 3.7% organic matter and the OECD artificial soil (pH 5.9 and 8.1% organic matter), LC_{50} values were lower in the soil with a lower percentage of organic matter. LC_{50} values ranged from 128 to 615 ppm.

The LC_{50} value of 128 (van Gestel et al., 1991b) was the lowest toxic concentration of the four reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 1,4-dichlorobenzene. Confidence in this benchmark is low.

1,2,3-Trichlorobenzene. van Gestel and Ma (1990) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms species, *E. andrei* and *L. rubellus*, as described previously. The LC_{50} values ranged from 115 to 563 ppm, with the highest LC_{50} occurring in soil with the highest organic matter content. No trend in sensitivity of earthworm species was evident.

The LC_{50} value of 115 (van Gestel and Ma, 1990) was the lowest toxic concentration of the eight reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 1,2,3-trichlorobenzene. Confidence in this benchmark is low because of the limited amount of data.

1,2,4-Trichlorobenzene. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four earthworms species, as described previously. The LC_{50}s after 14 days showed little difference in sensitivity among the worms; sensitivity decreased in the order *E. eugeniae*>*P. excavatus*>*E. fetida*>*A. tuberculata*.

The LC_{50} value of 127 ppm (Neuhauser et al., 1986) was the lowest toxic concentration of the four reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm 1,2,4-trichlorobenzene. Confidence in this benchmark is low.

1,2,3,4-Tetrachlorobenzene. van Gestel et al. (1991b) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms species, *E. andrei* and *L. rubellus*. In a sandy soil with pH 4.8 and 3.7% organic matter and the OECD artificial soil (pH 5.9 and 8.1% organic matter), LC_{50} values were lower in the soil with less organic matter. The LC_{50} values ranged from 75 to 223 ppm.

The LC_{50} value of 75 (van Gestel et al., 1991b) was the lowest toxic concentration of the five reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 10 ppm 1,2,3,4-tetrachlorobenzene. Confidence in this benchmark is low.

Pentachlorobenzene. van Gestel et al. (1991a) investigated the effects of soil pH and organic matter content on the toxicity of this compound to two earthworms species, *E. andrei* and *L. rubellus*, as described previously. In a sandy soil and the OECD artificial soil, LC_{50} values were lower in the soil with a lower percentage of organic matter. LC_{50} values ranged from 72 to 223 ppm.

The LC_{50} value of 115 (van Gestel et al., 1991b) was the lowest toxic concentration of the four reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 20 ppm pentachlorobenzene. Confidence in this benchmark is low.

Nitrobenzene. Neuhauser et al. (1986) used the OECD artificial soil (pH 6) to assess the effects of this compound on survival of adults of four earthworms species, as described previously. The LC_{50}s after 14 days showed little difference in sensitivity among the worms; sensitivity decreased in the order *E. eugeniae*>*E. fetida*>*P. excavatus*>*A. tuberculata*.

The LC_{50} value of 226 (Neuhauser et al., 1986) was the lowest toxic concentration of the four reported. A safety factor of 5 was applied to this LC_{50} to obtain the benchmark of 40 ppm nitrobenzene. Confidence in this benchmark is low.

4. MICROBIAL HETEROTROPHS AND PROCESSES

4.1 INTRODUCTION

Soil microorganisms play a critical role in nutrient cycling. As primary consumers of soil organic matter, soil microbes convert nutrients to plant-available forms and serve as a food source for higher trophic levels. The soil microbiota is a heterogeneous collection of highly adaptable organisms exploiting the many micro-niches in the soil. The effect of contaminants may be to change the microbial community structure without overall changes in the functional ability of the community. The authors' assessment endpoint, however, is microflora community functioning. This is measured as effects on C mineralization, N transformation, and enzyme activities.

Little information is available on the mechanisms of toxicity of contaminants to soil microorganisms. Some metal ions may inhibit enzyme reactions by complexing with enzyme substrates, combining with the protein active group of the enzyme, or reacting with the enzyme-substrate complex (Juma and Tabatabai, 1977).

As with the others benchmarks, much of the variance is due to the variance in soil characteristics that influence toxicity. These characteristics control bioavailability to all soil-dwelling organisms, with pH and organic matter content being among those that are very important.

4.2 MICROBE DATA SELECTION

Toxic response data were collected for inorganic elements and organic compounds. Measures of effects of soil-borne chemicals on microorganisms include growth, respiration, nitrogen transformation reactions (denitrification, mineralization, and nitrification), C mineralization, P mineralization, cellulolytic activity, oxidation of hydrogen gas, alpha-glucosidase synthesis, and other enzyme activities.

Many enzymes that are produced by plants and microbes can exist and function extracellularly in the soil for varying periods of time, depending on soil micro-environmental factors (Tabatabai, 1982). For this reason, it may not be appropriate to interpret measured effects of chemicals on soil enzyme activities as representing effects on soil microbial populations. Soil enzymes do, however, give valuable information about the functioning of the soil in organic matter degradation. These enzymes include urease which catalyzes the hydrolysis of urea to CO_2 and NH_3; phosphatases which catalyze the hydrolysis of phospho esters and anhydrides; arylsulfatase which catalyzes the hydrolysis of the arylsulfate ion; amidase, which catalyzes the hydrolysis of acid amides with the release of NH_3; amylases, enzymes which catalyze the hydrolysis of starch and glycogen; and dehydrogenases, a group of enzymes which catalyze the dehydrogenation of many organic compounds. Dehydrogenase activity is considered by some to provide an overall estimate of microbial activity. None of these activities is accepted as adequate for characterizing the response of the soil microbial community to toxic stress because of the many soil and microbial factors affecting them at the micro-environment level. However, it is often the case that benchmarks are based on the effects of a chemical on a single activity (e.g., reduction of phosphatase activity) because of lack of other data.

Most of the research used to establish benchmarks was conducted in the laboratory with native soil microflora in small samples of soil or soil/litter microcosms. Exposure durations ranged from one and one-half hours to one and one-half years. The chemicals tested were mixed into the soil in the form of salts. Bacteria, actinomycetes, and fungi are included and evaluated together. Tests conducted in culture media are not included because they are not directly relevant to the soil environment.

4.3 MICROBE DATA AND BENCHMARK DERIVATION

A short review of the available literature is discussed in the following text. Data are summarized in Appendix B, and benchmarks are given in Table 2.

4.3.1 Inorganic Chemicals

Aluminum. The effects of soil characteristics on effects of Al (as $AlCl_3$) on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979). Soils were chosen with a range in pH, organic matter, and clay contents (6.2 to 7.6; 5.4 to 10.6%; 26 to 34%). Air-dried, sieved soil samples were placed in flasks with the test chemical added in solution. The samples were incubated for 90 minutes before microbial activity was stopped and arylsulfatase activity measured. In all soils, a concentration of 675 ppm Al reduced the enzyme activity between 24 and 43%. The least inhibition occurred in the soil with the highest contents of organic matter and clay.

Juma and Tabatabai (1977) used essentially the same system and three of the same soils to evaluate the effects of several metals on soil acid and alkaline phosphatase activities. Three soils were used to test effects and acid phosphatase activity with pH, organic matter, and clay ranging from 5.8 to 7.8, 5.2 to 11%, and 23 to 30%. Alkaline phosphatase activity was not tested in the most acid soil. For Al in a loam soil (pH 5.8; percent organic matter 5.2) acid phosphatase activity was reduced, and alkaline phosphatase activity was reduced in another loam soil (pH 7.4, percent organic matter 11) by a concentration of 675 ppm Al. Aluminum had no effect on the activity of either enzyme in an alkaline soil (pH 7.8, percent organic matter 7.4).

The benchmark of 600 ppm of Al was derived from the previously described studies. Confidence in the benchmark is low because of the limited amount and type of data available.

Arsenic. Juma and Tabatabai (1977) used the system described for Al to evaluate the effects of two forms of As on soil acid and alkaline phosphatase activities. Arsenic (III) had no effect on acid phosphatase activity in any of the three soils. At a concentration of 1875 ppm As (lowest concentration tested), acid phosphatase activity was reduced in a loam soil (pH 7.8; percent organic matter 7.4). Arsenic (V) was more toxic than As(III) to both enzyme complexes. Alkaline and acid phosphatase activities were reduced by as little as 187.5 ppm As(V) (lowest concentration tested) in soils of pH 5.8 to 7.4 and percent organic matter 5.2 to 11.

Frankenberger and Tabatabai (1981) investigated the effect of As(III) on amidase activity in three soils in shaker flask assays as described previously. After 2 1/2 hrs, amidase activity was reduced in all three soils. Activity was almost totally inhibited in the soil with the soils tested with a lowest concentration of 1873 ppm.

The effective concentration of 187 ppm (Frankenberger and Tabatabai, 1981) is the lowest of the eight reported. Confidence in the benchmark of 100 ppm is low because of the limited amount and type of data available.

Barium. The influence of soil characteristics on effects of Ba on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) using methods described for Al. A reduction in activity was measured in only one of the four soils, having the lowest pH and organic matter content. A 22% reduction in activity was caused by 3433 ppm Ba (only concentration tested).

The benchmark of 3000 ppm is based on this study. Confidence in the benchmark is low because of the limited amount of data available.

Boron. The influence of soil characteristics on effects of B on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) using methods described for Al. Approximately the same degree of reduction in activity was measured in all soils at 270 ppm, and at 27 ppm in a loam (pH 6.5, percent organic matter 5.8) There was no clear relationship between magnitude of reduction in activity and soil pH and organic matter.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effects of B on soil acid and alkaline phosphatase activities. Acid phosphatase activity was not affected in the soil with the highest pH. It was reduced in the other two soils at a concentration of 270 ppm. Alkaline phosphatase activity was not affected by B in the soils tested.

The effective concentration of 27 ppm (Al-Khafaji and Tabatabai, 1979) is the lowest of the six reported. Confidence in the benchmark of 20 ppm is low because of the limited amount and type of data available.

Cadmium. The influence of soil characteristics on effects of Cd on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) using methods described for Al. A reduction in activity was measured in all four soils (23 to 55%) at 2810 ppm Cd, with the greatest reduction in the soil with the lowest clay content.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effects of Cd on soil acid and alkaline phosphatase activities. Acid phosphatase activity was reduced in all three of the soils (44 to 51%) at 2810 ppm. Alkaline phosphatase activity was reduced 27% in the loam soil at a concentration of 281 ppm and 78% at 2810 ppm in a clay loam soil in which this was the only concentration tested.

Haanstra and Doelman (1991) investigated short- and long-term effects of metals on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils (sand, sandy loam, silt loam, clay, and sandy peat) of varying characteristics. Soil pH ranged from 7.7 to 4, organic matter content from 1.6 to 12.8%, and clay from 2 to 60%. Metals were added as salts to the sieved soils in flasks, and enzyme activity was measured after a 6-week or 18-month study. Results were reported as EC_{50}. In the 6-week incubation study on the effects of Cd, data from the sandy loam soil were not available. Data for the effects on phosphatase activity were also not available for sandy peat. For all three enzyme systems, the highest EC_{50}s were found in the soil with the highest clay content (9520, 9779, and 4460 ppm for arylsulfatase, phosphatase, and urease activities, respectively). The lowest EC_{50}s were 1888 ppm for arylsulfatase, and 840 and 340 ppm in the sand for phosphatase and urease activities. In the 18-month study, data from the sandy peat soil were not available for arylsulfatase and phosphatase. The highest EC_{50}s were 230 ppm in the soil with the highest pH for phosphatase, 30 ppm Cd in the sandy loam soil for urease, and 121 ppm in the sand (lowest pH, organic matter, and clay) for arylsulfatase.

The effects of several elements on dehydrogenase activity of the native soil microflora in a composite soil sample from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985). Soil was amended with glucose and alfalfa, with the metal salts added in solution. After 6 days, a concentration of 30 ppm Cd (lowest concentration tested), added as cadmium nitrate, reduced dehydrogenase activity by 47%.

Lighthart and Bond (1976) investigated the effects of Cd (as $CdCl_2$) added to a small (600 ml) soil and litter microcosm. Soil was homogenized and sieved and the overlying plant litter layer was sieved. The Cd (0.006 or 6.1 ppm Cd) was introduced into the microcosm by injecting an aqueous solution into the soil and litter with a syringe. After 24 days, the native soil and litter microflora exhibited a 43% reduction in respiration (O_2 uptake) in microcosms inoculated with 6.1 ppm Cd.

Threshold levels of Cd (as cadmium acetate) for soil respiration of native microflora in three soils were determined by Reber (1989). The soils ranged in pH from 5.6 to 7, percent organic matter 1.7 to 2.6, and percent clay 3.2 to 21.3. There was no clear relationship between these soil characteristics and the magnitude of reduction in soil respiration at the concentrations tested. The highest LOEC concentration (56.3 ppm) for Cd was associated with the soil containing the lowest percentage of organic matter and the lowest pH.

Liang and Tabatabai (1977) investigated the effects of various metals on N mineralization by native soil microflora in four soils varying in pH from 6 to 7.8, clay from 23 to 34%, and organic matter content from 6 to 11%. Only one concentration of each metal was tested and was added to the soil as a salt solution. Cadmium reduced N mineralization in two soils at 562 ppm but no relationship between soil characteristics and effects of Cd could be discerned.

Bollag and Barabasz (1979) evaluated the effects of several metals on denitrification in autoclaved soil by three species of soil-dwelling *Pseudomonas* species of bacteria andon denitrification in soil by native soil microflora. The silt loam soil was autoclaved to kill the majority of its microflora, inoculated with individual metals and bacterial populations, and incubated 4 days under anaerobic conditions. The same soil was used to determine the effects of metals on denitrification by the native soil microflora after 21-day incubation under anaerobic conditions. In the autoclaved soil, two of the three *Pseudomonas* species had reductions in activity at 50 ppm Cd, while the third was more sensitive to the toxic effects of this metal (and Cu and Zn) on denitrification. The native soil population in unautoclaved soil was more tolerant of the Cd, with reductions in activity at 100 ppm Cd. It is not clear whether this difference is due to changes in the chemical and physical nature of the soil during autoclaving or to other organisms in the natural soil being more tolerant to Cd.

Khan and Frankland (1984) used a dyed cellophane film technique to evaluate the effects of Cd on cellulolytic activity of native soil microflora in a Brown earth soil (pH 4.6). The film was encased in nylon mesh, buried in the potted soils containing Cd added as $CdCl_2$, and allowed to equilibrate for 15 days. After a further 30 days past the equilibrium period, the film was retrieved and analyzed for dye release. A 35% reduction in percent cellulose decomposition was measured in pots containing 100 ppm Cd, while 50 ppm had no effect.

Lighthart et al. (1977) evaluated the effects of a number of metals at single concentrations on respiration of native soil microflora in small coniferous forest soil/litter microcosms. Metals in solution form were mixed into the soil and litter which were then layered in the microcosm. Cadmium at 920 ppm reduced respiration 61%.

In a study on the effects of Cd on N mineralization and nitrification by native soil microflora in a moderately acid soil, Bewley and Stotzky (1983) found N mineralization to be unaffected by Cd levels up to 1000 ppm, the highest concentration tested. Nitrification was reduced 62% by 1000 ppm.

The effects of Cd as $CdCl_2$ on carbon and nitrogen mineralization and nitrogen transformations in alfalfa-amended sieved soil were determined by Suter and Sharples (1984). The silt loam soil had a pH of 4.7. At 3 days, respiration was reduced by 20% at 500 ppm, but at later dates no significant reduction occurred. Ammonia levels were increased (by as much as a factor of 12) on days 22 to 53 at 50 ppm Cd and higher. Nitrate levels were reduced by >21% on days 25, 32, and 39 at 50 ppm Cd and higher, but on days 46 and 53 significant effects occurred at only 100 ppm and higher. These results suggest that nitrification is highly sensitive to Cd relative to C mineralization and may be chronically reduced at 50 ppm.

A benchmark of 20 ppm Cd was established as the 10th percentile of the 47 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Chromium. Liang and Tabatabai (1977) investigated the effects of various metals on N mineralization by native soil microflora in four soils, as described for Cd. Chromium(III) at 260 ppm reduced N mineralization in the soil containing the highest organic matter content. This same soil showed an effect of added Cu.

The effects of Cr(III) on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985) as described previously for Cd. After 6 days, a concentration of 30 ppm Cr (the lowest concentration tested) reduced dehydrogenase activity by 54%.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Cr on soil acid and alkaline phosphatase activities. Acid and alkaline phosphatase activities were affected at 1635 ppm in all three soils to about the same degree, but greater inhibition of alkaline phosphatase activity occurred in the soil with the greatest content of organic matter and clay.

Ross et al. (1981) evaluated the relative toxicities of forms of Cr to respiration of native soil microflora in a loam and a sandy loam soil. After 22 days, Cr (III), tested at only 100 ppm, caused reductions in both soils of 41 and 48%. A concentration of 10 ppm (the lowest concentration tested) Cr (VI) caused reductions in both soils (27 and 33%). In this experiment, Cr(VI) was more toxic than Cr(III) to soil respiration.

Premi and Cornfield (1969, 1969/1970) investigated the effects of Cr added to a sandy loam soil on nitrogen transformations by native soil microflora. In a 21-day experiment (1969), nitrification was severely inhibited at 1000 ppm Cr (added as sulfate salt), but was unaffected at 100 ppm. In an 8-week experiment (1969/1970) with sucrose and ammonium nitrate added to the soil, nitrification was not affected by 10,000 ppm Cr, the highest concentration tested. Possible reasons for the differences in results for the two sets of experiments are differences in exposure duration and effects of amendments.

Bhuiya and Cornfield (1976) investigated the effects of several metals on N mineralization and nitrification by native soil microflora in a sandy soil at different pH levels. Metals were added to the soil as oxides to achieve a concentration of 1000 ppm, and the pH was adjusted to 7 (or left at the natural pH 6) before a 2-month equilibration period. After an additional 6 or 12 weeks past the equilibrium period, N transformation measures were made. After 6 weeks, both mineralization and nitrification were reduced by 1000 ppm Cr at pH 7, but not at pH 6. After 12 weeks, neither mineralization nor nitrification was affected by Cr at either pH.

The effects of soil characteristics on toxicity of Cr to arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) using methods described for Al. Activity was reduced in all soils at 1300 ppm Cr. Magnitude of reduction was inversely related to soil organic C content.

Haanstra and Doelman (1991) investigated short- and long-term effects of Cr on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils, as described for Cd. In the 6-week incubation study on the effects of Cr, data from the silt loam soil were not available for arylsulfatase activity and not available from the sandy loam soil for urease. The highest EC_{50}s were 3203, 5512, and 4470 ppm, respectively, for arylsulfatase, phosphatase, and urease activities found in different soils. The lowest was 17 ppm in the sand for arylsulfatase and 1170 and 490 ppm in the clay for phosphatase and urease. In an 18-month study, the highest EC_{50}s were 1798, 20020, and 1110 ppm Cr, respectively, for arylsulfatase, phosphatase, and urease activities found in different soils. The lowest were 12 and <1 ppm in the clay for arylsulfatase and urease activities and 2692 ppm in the sandy loam for phosphatase activity.

The benchmark for Cr was established at 10 ppm because the 10th percentile lies between the EC_{50} values of 12 and 15 ppm from the work of Haanstra and Doelman (1991). Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Cobalt. Lighthart et al. (1977) evaluated the effects of Co at a single concentration on respiration of native soil microflora in soil/litter microcosms, as described for Cd. Co at 1362 ppm reduced respiration 23%.

The benchmark of 1000 ppm comes from this study. Confidence in the benchmark is low because of the limited amount of data available.

Copper. Liang and Tabatabai (1977) investigated the effects of various metals on N mineralization by native soil microflora in four soils, as described for Cd. Copper at 320 ppm severely reduced N mineralization in one soil. This same soil showed an effect of added Cr(III).

The effects of Cu on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985) using methods described for Cd. A concentration of 30 ppm Cu (the lowest concentration tested) Cu reduced dehydrogenase activity by 28%.

Bollag and Barabasz (1979) evaluated the effects of Cu on denitrification by three species of soil-dwelling *Pseudomonas* species of bacteria in autoclaved soil and by native soil microflora, as described for Cd. In the autoclaved soil, there was a range of sensitivities of the *Pseudomonas* species to Cu. LOECs ranged from 10 (lowest concentration tested) to 250 ppm (highest concentration tested). The organism most sensitive to the effects of Cd and Zn was also more sensitive to the toxic effects of Cu on denitrification. Denitrification by the native soil population was reduced 44% by 250 ppm Cu.

The effects of adding Cu, as $CuSO_4$, to a sandy loam adjusted to three pH levels on N mineralization during a 21-day incubation was assessed by Quraishi and Cornfield (1973). Mineralization was decreased by 1000 ppm Cu at all three pH levels (5.1, 5.9, and 7.3) with inhibitory effect increasing with decreasing pH from 39% to 100%.

Premi and Cornfield (1969, 1969/1970) investigated the effects of several metals added to a sandy loam soil on nitrogen transformations by native soil microflora. In a 21-day experiment (1969), nitrification was severely inhibited at 10,000 ppm Cu, added as $CuSO_4$, but unaffected at 1000 ppm. Copper added in carbonate form was ineffective at 10,000 ppm (highest concentration tested), probably because of the increase in soil pH caused by addition of this form. In an 8-week experiment (1969/1970) with sucrose and ammonium nitrate added to the soil, nitrification was decreased at 1000 ppm Cu but unaffected at 100 ppm. Possible reasons for the differences in results between the two experiments are differences in exposure duration and effects of amendments.

Bhuiya and Cornfield (1972) assessed the effects of several metals on C mineralization by native microflora in a sandy soil, with or without added organic matter. Metals were added to the soil as oxides to achieve a concentration of 1000 ppm and a small amount of ground oat straw was added to part of the soil before a 2-month equilibration period. After a further 12 weeks, soil respiration was reduced in the Cu-treated soil with amendment but not in the unamended soil.

The influence of soil characteristics on effects of Cu on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) using methods described previously for Al. In the soil with the highest pH (7.6), Cu had no effect. Arylsulfatase activity in the other three soils was reduced by Cu at a concentration of 1590 ppm. Reductions were the least severe in the soil having the highest organic carbon and clay content.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effects of two forms of Cu on soil acid and alkaline phosphatase activities. Acid phosphatase activity was affected by Cu(I) and Cu(II) in all three soils about equally at a concentration of 1590 Cu (lowest concentration tested). The greatest reduction occurred in the soil with the lowest pH and the lowest contents of organic matter and clay. Alkaline phosphatase activity was more sensitive to Cu(I) than Cu(II).

Haanstra and Doelman (1991) investigated short- and long-term effects of Cu on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) for native soil microflora in five soils, as described for Cd. In the 6-week study, data were not available for phosphatase activity in the sandy loam or for urease activity in the silt loam. The highest EC_{50}s for arylsulfatase and phosphatase activities (14,946 and 6424 ppm) was found in the soil with the highest pH (silt loam). The highest EC_{50} for urease activity (4200 ppm) was found in the soil with the greatest content of organic matter and the lowest pH (sandy peat). The lowest EC_{50}s, all found in the sand, were 390, 140, and 260 ppm for arylsulfatase, phosphatase, and urease. In the 18-month incubation study, the highest EC_{50}s were 6996 and 4200 ppm Cu in the soil with the greatest percentage organic matter for arylsulfatase and urease activities and 2773 ppm for phosphatase in the clay soil. Lowest EC_{50}s were 203, 170, and 680 ppm in the sand for arylsulfatase, phosphatase, and urease activities, respectively.

The effects of Cu (as $CuCl_2$) on carbon and nitrogen mineralization and nitrogen transformations in alfalfa-amended sieved soil were determined by Suter and Sharples (1984). The silt loam soil had a pH of 4.7. At 10 days, respiration was reduced by 24% at 100 ppm, but significant reductions occurred at 500 ppm on days 3 and 14 and at 1000 ppm on all dates. Ammonia concentration was decreased significantly by 58% on days 4 and 11 at 10 ppm, but there was no increase of effects with concentration on those dates, and ammonia concentrations were unchanged or increased at those concentrations on later dates. Ammonia concentrations were significantly increased at 500 and 1000 ppm from day 18 to 53, and after day 18 there were regular patterns of increasing ammonia at increasing Cu levels. Nitrate levels were reduced by 21% on day 4 at a concentration of 10 ppm, but not on later dates. On day 11, nitrate concentrations were significantly reduced to 50–1000 ppm (but increased at 10 ppm), and on days 18 to 53, they were significantly reduced only at 500 and 1000 ppm Cu. These results suggest that nitrification is highly sensitive to Cu, relative to C and N mineralization. If the chronic response is used as the basis for the benchmark, the threshold for significant effects in this test is 500 ppm Cu.

The benchmark for Cu has been established at 100 ppm. Confidence in this benchmark is high.

Fluoride. The effects of fluoride, added as potassium fluoride to poplar litter, on nitrogen and phosphorus mineralization by native microflora was investigated by van Wensem and Adema (1991). The newly fallen (2 months old) litter was air-dried, cut into small pieces, and rewetted with KF solutions of varying concentrations. After 9 weeks, K mineralization was reduced 22% in litter treated with 32.3 ppm F, the lowest concentration tested. Nitrogen mineralization was reduced 26% by 100.7 ppm, while 32.3 ppm had no effect.

The effects of F on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985) as described previously for Cd. A concentration of 5000 ppm F reduced dehydrogenase activity by 30% (3000 ppm had no effect).

The toxic concentration of 32 ppm (van Wensem and Adema, 1991) is the lowest of the two reported. Confidence in the benchmark of 30 ppm is low because of the limited amount and type of data available.

Iron. Liang and Tabatabai (1977) investigated the effects of Fe on N mineralization by native soil microflora in four soils, as described for Cd. Iron(III) reduced N mineralization in one soil at 280 ppm. This same soil showed an effect of added Cd.

The influence of soil characteristics on effects of Fe(III) on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In the soil with the highest pH (7.6), Fe(III) had no effect. Activity was reduced in all other soils at 1398 ppm Fe. The magnitude of reduction generally was inversely related to soil pH.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effects of Fe(II) and Fe(III) on soil acid and alkaline phosphatase activities. Iron(II) reduced acid phosphatase activity at 1398 ppm in only the soil with the lowest pH and organic matter and clay contents. Iron(III) reduced activity to a greater degree in this soil and also in the soil with the second lowest pH (but highest organic matter and clay contents). Iron(II) inhibited alkaline phosphatase activity in one of the soils tested and Fe(III) in the soil in which both forms of Fe inhibited acid phosphatase activity.

The effective concentration of 280 ppm (Liang and Tabatabai, 1977) is the lowest of the nine reported. Confidence in the benchmark of 200 ppm is low because of the limited amount and type of data available.

Lanthanum. Lighthart et al. (1977) evaluated the effects of La (as $LaCl_2$) at a single concentration on respiration of native soil microflora in soil/litter microcosms, as described for Cd. After 23 days, lanthanum at 57 ppm reduced respiration by 22%.

The benchmark of 50 ppm (Al-Khafaji and Tabatabai, 1979) is based on this work. Confidence in the benchmark is low because of the limited amount of data available.

Lead. Khan and Frankland (1984) used a dyed cellophane film technique to evaluate the effects of Pb on cellulolytic activity of native soil microflora in a Brown earth soil (pH 4.6), as described previously for Cd. A 23% reduction in percent cellulose decomposition was measured in pots containing 1000 ppm Pb, while 500 ppm had no effect.

The mediating influence of clay on effects of lead on soil respiration was assessed by Debosz et al. (1985). The sandy loam soil (9% clay) was amended with glucose and Pb acetate in solution. After 15 days, respiration was reduced 29% by 10,000 ppm Pb (1000 ppm had no effect). In the same soil amended with either 9% by weight kaolinite or montmorillonite, Pb up to 10,000 ppm had no effect.

Cole (1977) assessed the effects of various carbohydrate additions and Pb compounds on amylase synthesis and activity by native soil microflora in a silt loam soil. Carbohydrates were added to the soil in solution and Pb in dry salt form. With the addition of glucose and lead acetate, amylase activity was more sensitive than synthesis, with a 74% reduction at the lowest concentration tested (2000 ppm). With the addition of starch, amylase activity was reduced less by $PbCl_2$ than with lead acetate and lead sulfate. With the addition of lead acetate, amylase activity was more sensitive with the addition of starch than with glucose. Cole also investigated the effect of Pb acetate on alpha-glucosidase synthesis and bacterial population size. Both were reduced by the addition of 2000 ppm Pb (lowest concentration tested).

Liang and Tabatabai (1977) investigated the effects of Pb on N mineralization by native soil microflora in four soils, as described for Cd. Lead reduced N mineralization in one soil at 1035 ppm. This same soil showed an effect of added Cd.

Bhuiya and Cornfield (1972) assessed the toxic effects of Pb on C mineralization by native microflora in a sandy soil, with or without added organic matter, as described for Cu. After 12 weeks, soil respiration was reduced in the Pb-treated soil without oat straw, but not in the straw-amended soil.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effects of two forms of Pb (acetate and nitrate) to soil acid and alkaline phosphatase activities. The two forms had equal effect on acid phosphatase activity at 5175 ppm and that only in the soil with the lowest pH and organic matter and clay contents. They had equal effects on alkaline phosphatase activity at this concentration in one of the soils tested, and only Pb acetate was inhibitory in the soil with the highest organic matter and clay contents.

Haanstra and Doelman (1991) investigated short- and long-term effects of Pb on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils, as described for Cd. In the 6-week study on the effects of Pb, data from the sandy loam, clay, and sandy peat soils were not available for arylsulfatase, the sand, sandy loam and peat for phosphatase, and the sand for urease. The highest EC_{50}s for arylsulfatase and phosphatase activities (9138 and 1168 ppm) were found in the clay soil. The highest EC_{50} for urease activity (7190 ppm) was found in the silt loam (highest pH). The lowest were 8288, 8184, and 50 60 ppm Pb for arylsulfatase, phosphatase, and urease activities. In the 18-month study, data from the sandy peat soil were not available for arylsulfatase and phosphatase and from the clay and sandy loam for phosphatase. The highest EC_{50}s were 12,411 ppm in the soil with the highest clay for arylsulfatase, 78,943 ppm for phosphatase in the sand, and 8130 in the silt loam for urease. The lowest EC_{50}s were 3004, 7604, and 1340 ppm, in different soils.

Doelman and Haanstra (1979) evaluated the effects of Pb on soil respiration and dehydrogenase activity in several soils. After 24 hours, respiration in a sand (pH 5.7, percent organic matter 3) was reduced by 750 ppm Pb, the lowest concentration tested. Dehydrogenase activity was not affected at this concentration. After 40 months, respiration in this soil was reduced to approximately the same degree at 1500 ppm, the lowest concentration tested. Dehydrogenase activity was not evaluated. In another sandy soil, (pH 5.4, percent organic matter 6.7), dehydrogenase activity was severely inhibited by 1500 ppm, but not at 750 ppm Pb after 24 hours. Respiration was not affected at this concentration. In a clay soil, dehydrogenase activity was inhibited by 375 ppm, the lowest concentration tested. Respiration was not evaluated.

The benchmark of 900 ppm Pb is the 10th percentile of the 36 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Lithium. Lighthart et al. (1977) evaluated the effects of Li at a single concentration on respiration of native soil microflora in soil/litter microcosms, as described for Cd. Lithium at 17 ppm reduced respiration 43%.

The effective concentration of 10 ppm was derived from this study. Confidence in the benchmark is low because of the limited amount of data available.

Manganese. Liang and Tabatabai (1977) investigated the effects of Mn on N mineralization by native soil microflora in four soils, as described for Cd. Manganese at 275 ppm reduced N mineralization in one soil. This same soil showed an effect of added Cd.

Premi and Cornfield (1969) investigated the effects of Mn added to a sandy loam soil on nitrogen transformations by native soil microflora. In a 21-day experiment, nitrification was severely inhibited at 100 ppm, added as sulfate salt, the lowest concentration tested.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Mn on soil acid and alkaline phosphatase activities. Acid phosphatase activity was affected at 1375 ppm only in the soil with the lowest pH and organic matter and clay contents. Alkaline phosphatase activity was reduced in one of the soils tested by this same concentration.

The effective concentration of 100 ppm (Premi and Cornfield, 1969) the lowest of the four reported. Confidence in the benchmark of 100 ppm is low because of the limited amount and type of data available.

Mercury. van Fanssen (1973) investigated the effects of an inorganic and an organic mercury compound on N mineralization and nitrification by native soil microflora in two alkaline soils: a dune sand with 2% organic matter and a mix of two clay soils with 6% organic matter. Little information was provided concerning the experimental design. In the clay soil, both $HgCl_2$ and phenylmercury acetate reduced nitrification at 100 ppm Hg (10 ppm had no effect), but the organic form was more inhibitory than the inorganic form. Mineralization was not affected by the inorganic form but was decreased by phenylmercury acetate. In the dune sand, $HgCl_2$ severely reduced nitrification at 100 ppm (10 ppm had no effect) and phenylmercury acetate reduced nitrification at 10 ppm Hg (lowest concentration tested). Mineralization was not affected by the organic form but was decreased by $HgCl_2$ at 100 ppm Hg. This work indicates that the relative toxicity of various forms of Hg can be influenced by soil characteristics.

Landa and Fang (1978) investigated the effects of mercuric chloride (up to 100 ppm Hg) on carbon mineralization by native soil microflora in five agricultural topsoils varying in pH and organic matter content. The magnitude of effects varied greatly among the soils and were not related to those two soil characteristics. Effects ranged from an 87% reduction at 0.1 ppm (the lowest concentration tested) in one of the soils to no effect at 100 ppm in another soil.

Bremner and Douglas (1971) evaluated the effects of several metals on urease activity in two soils with similar pH, organic matter, and clay content characteristics. Metals were added individually in solution at a concentration of 50 ppm, and urease activity was determined after 5 hours. Mercury, added either as the chloride or sulfate salt, decreased urease activity by 36 to 42% in both soils.

Liang and Tabatabai (1977) investigated the effects of Hg on N mineralization by native soil microflora in four soils, as described for Cd. Mercury reduced N mineralization in all soils at 1003 ppm. The greatest magnitude of the toxic effect was seen in the soil having the lowest pH and organic matter and clay contents.

The influence of soil characteristics on effects of Hg on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In two soils tested with a lowest concentration of 502 ppm, arylsulfatase activity was greatly reduced. In the two soils tested with a lowest concentration of 5015 ppm, arylsulfatase activity was inhibited almost totally. No clear differences between the soils with regard to effects on toxicity of Hg could be discerned.

Frankenberger and Tabatabai (1981) investigated the effect of Hg on amidase activity in three soils in shaker flask assays as described previously. After 2 1/2 hours, amidase activity was reduced in all three soils at 5015 ppm. The greatest reduction occurred in the soil with the lowest pH and organic matter and clay contents.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Hg on soil acid and alkaline phosphatase activities. Acid and alkaline phosphatase activities were affected at 5015 ppm in all three soils to about the same degree.

The benchmark of 30 ppm Hg is the 10th percentile of the 27 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Molybdenum. Liang and Tabatabai (1977) investigated the effects of Mo on N mineralization by native soil microflora in four soils, as described for Cd. Molybdenum reduced N mineralization in three of the soils at 480 ppm. No toxic effect was seen in the soil having the lowest pH and organic matter and clay contents. No clear relationship between soil characteristics and magnitude of effects of Mo could be discerned.

The influence of soil characteristics on effects of Mo on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In the soil with the highest clay and organic matter contents, Mo had no effect. Activity was severely reduced at 2398 ppm (lowest concentration tested) in the soil with the lowest pH and organic matter content. It is possible that activity in this soil would have been inhibited to a somewhat lesser degree by 240 ppm Mo, as it was in the two remaining soils.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Mo on soil acid and alkaline phosphatase activities. Acid phosphatase activity in all three soils was reduced at 2398 ppm. In the soil with the lowest pH, and organic matter and clay contents, it was also inhibited at 240 ppm Mo. Alkaline phosphatase activity in both soils tested was reduced about the same degree at this concentration.

The benchmark for Mo was established at 200 ppm based on the work of Al-Khafaji and Tabatabai (1979). Confidence in this benchmark is moderate.

Nickel. The effects of Ni, as nickel sulfate, on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985) as described previously for Cd. After 6 days, a concentration of 30 ppm (lowest concentration tested) Ni reduced dehydrogenase activity by 39%.

Babich and Stotzky (1982) evaluated the effects of two forms of Ni on mycelial growth rate of a number of soil-dwelling fungi inoculated individually into autoclaved sandy loam soil. The concentrations at which growth was reduced ranged from 50 to 750 ppm for Ni (added in chloride or sulfate form).

Giashuddin and Cornfield assessed the effect of Ni added in oxide (1979) and sulfate (1978) forms on N and C mineralization by native soil microflora in a sandy soil. The metal salts were mixed into the soil in dry form. After 42 days incubation, soil respiration (C mineralization) was reduced in soil containing 10 ppm Ni from Ni sulfate (lowest concentration tested), and N mineralization was affected at 100 ppm. Soil respiration was reduced in soil containing 50 ppm Ni from Ni oxide (lowest concentration tested), and N mineralization was affected at 1000 ppm. Because of the test concentrations used, it is difficult to assess the relative toxicity of these two forms of Ni to C mineralization. When the soil pH was raised to 6.9 (from its normal 5.9), soil respiration was reduced in soil containing 250 ppm Ni from Ni oxide (lowest concentration tested), and N mineralization was affected at 1000 ppm. The effect of Ni from Ni sulfate was not tested at the higher pH. Raising the pH appeared to affect soil respiration but not N mineralization.

Bhuiya and Cornfield (1974) assessed the effects of Ni on C mineralization by native microflora in a sandy soil, with or without added organic matter, as described for Cu. After 12 weeks, soil respiration was reduced in the Ni-treated soil with or without oat straw, but to a greater degree in the straw-amended soil.

The influence of soil characteristics on effects of Ni on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In only one soil was the highest concentration tested, 1468 ppm, found to reduce arylsulfatase activity. This soil had the lowest pH and organic matter content of the four soils tested.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Ni on soil acid and alkaline phosphatase activities. Acid phosphatase activity was not affected at 1468 ppm only in the soil with the highest pH. Alkaline phosphatase activity was reduced in one of the soils tested by this same concentration.

Haanstra and Doelman (1991) investigated short- and long-term effects of Ni on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils, as described for Cd. In the 6-week study on the effects of Ni, data from the sandy peat soil were not available for arylsulfatase and phosphatase activities. The highest EC_{50}s (5659, 6516, and 3380 ppm for arylsulfatase, phosphatase, and urease activities) were found in the soil with the highest clay content. The lowest were 2119, 1109, and 100 ppm, for arylsulfatase, phosphatase, and urease activities found in the sand. In the 18-month study, data from the sandy loam soil were not available for arylsulfatase activity nor from clay and sandy peat for phosphatase activities. The highest EC_{50}s were 8101, 8042, and 2790 ppm Ni for arylsulfatase, phosphatase, and urease activities in different soils. The lowest LC_{50}s, 92, 769, and 370 ppm, were found in the sand.

A benchmark of 90 ppm Ni was established based on the 56 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Selenium. Lighthart et al. (1977) evaluated the effects of using methods at a single concentration on respiration of native soil microflora in soil/litter microcosms, as described for Cd. Selenium at 484 ppm reduced respiration 43%.

The influence of soil characteristics on effects of Se on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In the soil with the lowest clay content, activity was reduced by 198 ppm. In the other soils, arylsulfatase activity was reduced by 1975 ppm with the greatest reduction in the soil with the lowest pH and organic matter content.

Frankenberger and Tabatabai (1981) investigated the effect of Se on amidase activity in three soils in shaker-flask assays as described previously. After 2 1/2 hours, amidase activity was reduced in only one soil at 1975 ppm. This soil had the lowest pH and organic matter and clay contents of the soils tested.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Se(IV) to soil acid and alkaline phosphatase activities. Acid phosphatase activity in all three soils was reduced at 1975 ppm. Alkaline phosphatase activity in both soils tested was reduced about the same degree at this concentration.

The effective concentration of 198 ppm (Al-Khafaji and Tabatabai, 1979) is the lowest of the 10 reported. Confidence in the benchmark of 100 ppm is moderate.

Silver. Bremner and Douglas (1971) evaluated the effects of Ag on urease activity in two soils, as described for Hg. After 5 hours, silver, added as either nitrate or sulfate salt, decreased urease activity by 60 to 65% in both soils.

Liang and Tabatabai (1977) investigated the effects of Ag on N mineralization by native soil microflora in four soils, as described for Cd. Silver at 540 ppm reduced N mineralization in all soils. The greatest magnitude of the inhibitory effect was seen in the soil having the lowest pH and organic matter and clay contents.

The influence of soil characteristics on effect of Ag on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In two soils tested with a lowest concentration of 270 ppm, arylsulfatase activity was greatly reduced. In the two soils tested with a lowest concentration of 2698 ppm, arylsulfatase activity was almost totally inhibited.

Frankenberger and Tabatabai (1981) investigated the effect of Ag on amidase activity in three soils in shaker-flask assays as described previously. After 2 1/2 hours, amidase activity was severely reduced in all three soils at 2698 ppm. The greatest reduction occurred in the soil with the lowest pH and organic matter and clay contents.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of silver on soil acid and alkaline phosphatase activities. Acid phosphatase activity was affected at 2698 ppm only in the soil with the highest pH (7.8). Alkaline phosphatase activity was reduced 28% in the loam soil at an Ag concentration of 270 ppm and 93% at 2698 ppm in a clay loam soil.

A benchmark of 50 ppm Ag was established based on the 17 reported effective values. Confidence in this benchmark is moderate.

Tin. The influence of soil characteristics on effect of Sn on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In the soil with the highest pH (7.6), Sn had no effect. Arylsulfatase activity in the other three soils was reduced by 2968 ppm Sn. The reductions were the least severe in the soil having the highest organic C and clay content.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of Sn on soil acid and alkaline phosphatase activities. Acid phosphatase activity was affected at 2968 ppm only in the soil with the lowest pH and organic matter and clay contents. Alkaline phosphatase activity was reduced in both soils tested by this same concentration.

The effective concentration of 2968 ppm (Al-Khafaji and Tabatabai, 1979) is the lowest of the seven reported. Confidence in the benchmark of 2000 ppm is low because of the limited amount and type of data available.

Titanium. The influence of soil characteristics on effect of Ti (as $TiSO_4$) to arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In two soils tested with a lowest concentration, arylsulfatase activity was reduced by 1198 ppm. These two soils had the lowest pH and organic matter and clay contents of the four tested.

The effective concentration of 1198 ppm (Al-Khafaji and Tabatabai, 1979) is the lowest of the two reported. Confidence in the benchmark of 1000 ppm is low because of the limited amount and type of data available.

Tungsten. The influence of soil characteristics on effects of tungsten (W) (Na_2WO_4) on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In the soil with the highest clay and organic matter contents, W had no effect. Activity was reduced in all other soils at 4598 ppm, with the greatest reduction in the soil with the lowest clay content.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of tungsten on soil acid and alkaline phosphatase activities. Acid phosphatase activity in all three soils was reduced at 4598 ppm. In the soil with the lowest pH and organic matter and clay content, it was also inhibited at 460 ppm W. Alkaline phosphatase activity in both soils tested was reduced about the same amount at this concentration.

The effective concentration of 460 ppm (Juma and Tabatabai, 1977) is the lowest of the seven reported. Confidence in the benchmark of 400 ppm is low because of the limited amount and type of data available.

Vanadium. Tyler (1976) evaluated the effect of V, added in a solution of sodium vanadate to fresh needles from a white pine stand, on acid phosphatase activity of the native microflora. After 3 hours of exposure, activity was reduced 40% by 50 ppm V, while 30 ppm had no effect.

The influence of soil characteristics on effect of V on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. In two soils tested with a lowest concentration of 127 ppm, arylsulfatase activity was reduced with the greatest reduction in the soil with the lowest clay content. In the two soils tested with a lowest concentration of 1273 ppm, arylsulfatase activity was severely inhibited.

Juma and Tabatabai (1977) used the system described for Al to evaluate the effect of V on soil acid and alkaline phosphatase activities. Acid phosphatase activity in all three soils was reduced about the same degree at 1273 ppm. In the soil with the lowest pH and organic matter and clay contents, it was also inhibited at 127.3 ppm V. Alkaline phosphatase activity in both soils tested was reduced about the same degree at 1273 ppm. In the soil with the highest organic matter and clay contents, it was also inhibited at 127.3 ppm V.

Lighthart et al. (1977) evaluated the effects of V at a single concentration on respiration of native soil microflora in soil/litter microcosms, as described for Cd. Vanadium at 23 ppm reduced respiration 21%.

The effective concentration of 23 ppm (Lighthart et al., 1977) is the lowest of the 10 reported. Confidence in the benchmark of 20 ppm is moderate.

Zinc. Wilson (1977) evaluated the effect of Zn, as zinc sulfate solution, on nitrification by native soil microflora in three soils. The soils ranged in pH from 5.1 to 6.2, percent organic matter from 1.1 to 2.4, and percent clay from 2 to 28. After 49 days, nitrification was severely inhibited in all three soils (98 to 100%) by 1000 ppm Zn, while Zn at 100 ppm had no effect.

Haanstra and Doelman (1991) investigated short- and long-term effects of Zn on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils, described for Cd. In the 6-week study on the effects of Zn, data from the sandy peat soil were not available for any of the enzymes. The highest EC_{50}s were 5559, 3623, and 1780 ppm for arylsulfatase, phosphatase, and urease activities, all in the soil with the greatest content of clay. The lowest EC_{50}s of 909, 220, and 420 ppm Zn were all found in the sand. In the 18-month study, data were not available from the sandy peat for phosphatase or the silt loam for urease. The highest EC_{50}s were 9679, 4872, and 290 ppm Zn in different soils. The lowest EC_{50}s were 375, 170, and 70 ppm in different soils.

Juma and Tabatabai (1977) used the system described for Al to evaluate the toxicity of Zn to soil acid and alkaline phosphatase activities. Acid and alkaline phosphatase activities were affected at 1635 ppm in all three soils to about the same degree, except increased inhibition of alkaline phosphatase activity in the soil with the highest pH.

The influence of soil characteristics on effects of Zn on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979) as described previously for Al. A reduction in activity was measured in two soils tested at a concentration of 1635 ppm. No clear differences between the soils with regard to influence on effects of Zn could be discerned.

Bhuiya and Cornfield (1974) investigated the effects of Zn on N mineralization and nitrification by native soil microflora in a sandy soil at different pH levels, as described for Cr. After 12 weeks, both mineralization and nitrification were reduced by 1000 ppm Zn at pH 7, but not at pH 6. After 6 weeks, neither mineralization nor nitrification was affected by Zn at either pH.

Bhuiya and Cornfield (1974) investigated the effects of 1000 ppm Zn added as Zn oxide to a sandy soil at three pH levels on nitrogen mineralization by native soil microflora. After 42 days, N mineralization was reduced in the pH 7.7 soil but not in soils at pH 6 and 7.

The effects of Zn on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985) as described previously for Cd. A concentration of 300 ppm Zn reduced dehydrogenase activity by 30%; Zn at 150 ppm had no effect.

Laskowski et al. (1994) looked at the effects of several metals at low to moderate levels on the respiration rate of acid-mixed forest litter. The fresh litter was treated with solutions of $CdCl_2$ (up to 250 ppm Cd), $Pb(NO_3)_2$ (up to 2500 ppm Pb), or $ZnCl_2$. Only zinc had an effect at the concentrations tested. A concentration of 1000 ppm Zn reduced respiration by 26%; Zn at 200 ppm had no effect.

The effect of Cd and Zn on respiration of soil microflora in field-collected black oak forest soil/litter microcosms was evaluated by Chaney et al. (1978). The metals, in solutions of chloride salts, were sprinkled over the litter layer of the chamber. After 23 days, Cd at a concentration up to 6 ppm had no effect. Respiration was decreased 21% by Zn at 479 ppm; Zn at 47 ppm had no effect.

Bollag and Barabasz (1979) evaluated the effects of Zn on denitrification by three soil-dwelling *Pseudomonas* (bacteria) in autoclaved soil and by native soil microflora, as described for Cd. In the autoclaved soil, two of the three species had reductions in activity at 250 ppm Cd, while the organism most sensitive to the effects of Cd and Cu was also more sensitive to the toxic effects of Zn on denitrification. Denitrification by the native soil population was reduced 31% by 250 ppm Zn.

Lighthart et al. (1977) evaluated the effects of Zn at a single concentration on respiration of native soil microflora in soil/litter microcosms, as described for Cd. Zinc at 3600 ppm reduced respiration 66%.

Premi and Cornfield (1969, 1969/1970) investigated the effects of Zn added to a sandy loam soil on nitrogen transformations by native soil microflora. In a 21-day experiment (1969), nitrification was severely inhibited at 100 ppm Zn, added as sulfate salt, the lowest concentration tested. Zinc added in carbonate form was ineffective at 10,000 ppm (highest concentration tested), probably because of the increase in soil pH caused by addition of this form. In the 8-week experiment (1969/1970) with sucrose and ammonium nitrate added to the soil, nitrification was decreased only slightly less at 100 ppm Zn than it was in the 21-day study.

The benchmark of 100 ppm Zn is the 10th percentile of the 46 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional response factors.

4.3.2 Organic Chemicals

Acrylonitrile. The effects of several organic compounds on respiration of native soil microflora in a sandy loam and a silt loam soil were evaluated by Walton et al. (1989). Both soils were acid (pH 4.9 and 5.3) and low in organic matter (1.4 and 3%) but differed with respect to amounts of clay (5% vs and 30%). Respiration was measured after 6-day exposure to 1000 ppm of each chemical. Chemicals tested at 1000 ppm had no effect and include methyl ethyl ketone, benzene, toluene, p-xylene, chlorobenzene, chloroform, and other chlorinated benzenes. Acrylonitrile reduced respiration by 59% in the sandy loam soil and 41% in the silt loam. Clay appeared to have an ameliorating influence on the effects of acrylonitrile.

The benchmark of 1000 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Carbon tetrachloride. The effects of 1000 ppm carbon tetrachloride on respiration of native soil microflora in a sandy loam and a silt loam soil was evaluated by Walton et al. (1989) as described for acrylonitrile. Carbon tetrachloride reduced respiration by 21% in the sandy loam but did not lower respiration in the silt loam soil. Clay may have had an ameliorating influence on the effects of this compound.

The benchmark of 1000 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Cis-1,4-dichloro-2-butene. The effects of cis-1,4-dichloro-2-butene on respiration of native soil microflora in a sandy loam and a silt loam soil was evaluated by Walton et al. (1989) as described for acrylonitrile. Cis-1,4-dichloro-2-butene reduced respiration by 48% in the sandy loam soil and 44% in the silt loam by 1000 ppm. Clay did not appear not to have an ameliorating influence on the effects of this compound.

The benchmark of 1000 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Hexachlorobenzene. The effects of 1000 ppm hexachlorobenzene on respiration of native soil microflora in a sandy loam and a silt loam soil was evaluated by Walton et al. (1989) as described for acrylonitrile. Hexachlorobenzene reduced respiration by 37% in the silt loam but did not lower respiration in the sandy loam soil. Clay did not appear to have an ameliorating effect on the toxicity of this compound.

The benchmark of 1000 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Nitrobenzene. The effects of 1000 ppm nitrobenzene on respiration of native soil microflora in a sandy loam and a silt loam soil was evaluated by Walton et al. (1989) as described for acrylonitrile. Nitrobenzene reduced respiration by 61% in the sandy loam soil and by 22% in the silt loam. Clay appears to have an ameliorating influence on the effect of nitrobenzene.

The benchmark of 1000 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Pentachlorophenol. van Beelen and Fleuren-Kemila (1993) evaluated the effect of pentachlorophenol (PCP) on mineralization of added acetate by native soil microflora in an acid agricultural soil and an acid dune sand. After 1.8 days, CO_2 evolved was reduced 50% (EC_{50}) by 460 ppm in the agricultural soil (percent organic matter, 10.4; percent clay, 5) and by 1500 ppm in the dune sand (percent organic matter, 1.2; percent clay, 0.4).

The benchmark of 400 ppm for PCP is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Phenol. Effects of phenol on carbon and nitrogen mineralization and nitrogen transformations in alfalfa-amended, sieved soil were determined by Suter and Sharples (1984). The silt loam soil had a pH of 4.7. Carbon dioxide production was increased at 10 ppm and 100 ppm on days 1 and 7 but not on later dates or at higher concentrations. CO_2 production was decreased at 1000 ppm phenol on day 1, but not thereafter, and at 5000 ppm phenol on days 1 through 55. On all dates (days 7 through 42), ammonia concentrations were significantly increased and nitrate significantly decreased by 1000 and 5000 ppm phenol. At 10 and 100 ppm on day 7 and at 100 ppm on day 42, but not on intermediate dates, ammonia was significantly increased and nitrate decreased. If the lowest chronic response is used as the basis for the benchmark, the threshold for significant effects in this test is 100 ppm phenol.

The benchmark of 100 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

Trans-1,4-dichloro-2-butene. The effects of 1000 ppm trans-1,4-dichloro-2-butene on respiration of native soil microflora in a sandy loam and a silt loam soil was evaluated by Walton et al. (1989) as described for acrylonitrile. Trans-1,4-dichloro-2-butene reduced respiration by 44% in the sandy loam soil and 58% in the silt loam. Clay did not appear not to have an ameliorating influence on the effect of this compound.

The benchmark of 1000 ppm is based on this work. Confidence in the benchmark is low because of the limited amount and type of data available.

5. INVERTEBRATES OTHER THAN EARTHWORMS AND MICROBIAL HETEROTROPHS

5.1 INTRODUCTION

Interest in the toxic effects of soil pollutants on soil and litter dwelling invertebrates other than earthworms and microorganisms stems from concern for negative effects on nutrient cycling and availability and quality of food for animals feeding on soil and litter dwelling invertebrates. In general, the most important route for assimilation of metals by soil invertebrates is through the digestive tract (Beeby, 1991). Assimilation of toxic metals depends on diet and the animal's essential metal demand. In general, invertebrates with a high calcium demand tend to accumulate higher concentrations of toxic metals. The metals are often bound in intracellular granules, structural tissues, and membrane-bound vesicles. There is no clear relationship between the bioconcentration potential of a species and its susceptibility to metal intoxication (van Straalen, 1991).

Toxic effects of metals on invertebrates result in part from their interactions with nutritionally significant metals. van Straalen et al. (1989) suggest that the negative impact of cadmium on mite (*Platynothrus peltifer*) egg production results from disruption of the role of zinc in reproductive metabolism. Cadmium also blocks the calcium current of *Helix* neurons (Akaike et al., 1978), possibly leading to tissue damage and reduced reproduction (Russell et al., 1981). The interrelationships between metals, both essential and nonessential, appear to be quite complex and variable among species of invertebrates. Other effects may result from the binding of metals to proteins and enzymes with consequent functional disruption.

5.2 INVERTEBRATE DATA SELECTION

The experimental approaches are too diverse and the data too meager to allow for the establishment of benchmarks for the toxicity of contaminants in soil to soil-dwelling invertebrates other than earthworms. Most experiments evaluating the effects on nematodes are conducted in solution because these organisms inhabit the water films around soil particles and roots. The experiments using Collembola and mites are often conducted by feeding the organisms on algae that were reared on contaminated media. Perhaps the most common method for other organisms is to surface apply a solution, or soluble powder, of the chemical to the organic substrate on which it is to feed during the experiment. At most contaminated sites, concentrations of chemicals in soil are measured while concentrations in soil algae, litter, and pore water are not. Surface-applied chemicals are only appropriate when evaluating sites where deposition of air-borne contaminants onto vegetation and litter is the only route by which these food sources become contaminated. The bioavailability of chemicals introduced to food by these methods is not directly comparable to that of chemicals bound in organic form inside plant material or microflora. Furthermore, it would be difficult to assess the food preferences of these diverse and opportunistic organisms in any specific field situation (Hopkin, 1989) to allow appropriate sampling and analysis.

For the previously described reasons, no benchmarks have been established for these organisms. The information in this part of the document is provided as reference and support material. Experimental data are given in Appendix C.

5.3 INVERTEBRATE TEST SPECIES

The literature on toxicity of chemicals to soil and litter-dwelling invertebrates presents experimental results using microarthropods, macroarthropods, nematodes, and terrestrial gastropods and crustaceans. These organisms represent diverse morphological, physiological, and behavioral groups. The following general information is derived mainly from works edited by Dindal (1990) and Dickinson and Pugh (1974).

Collembola (springtails) are small, wingless microarthropods that live mainly in the soil litter layer. With the mites, springtails make up the majority of the soil litter arthropod fauna. Most soil forms live on partially decomposed vegetation or microflora, especially fungi. The importance of Collembola to soil organic matter breakdown and nutrient cycling results from the comminution of organic matter fragments, feeding on humus and feces in the litter, and on decaying roots. Collembola commonly used as test species are *Folsomia candida*, *Onychiurus armatus*, and *Orchesella cincta*. *Folsomia candida* is considered well-suited for the study of effects of contaminants on population parameters because it is easy to culture and has a relatively short generation time. This allows the study of individual and population parameters in the same experiment (Crommentuijn et al., 1993).

The Acarina (mites) are a diverse group of arthropods in the suborders *Prostigmata*, *Mesostigmata*, *Astigmata*, and *Oribatida*. Each suborder contains representatives living in a wide range of habitats. In the soil and litter, mites may be detritivores eating dead plant material, predatory, or fungivores/algivores. Oribatid mites are found in large numbers in organic horizons of soils. They are represented in toxicity tests by *Platynothrus peltifer*. Like the springtails, mites act to increase the rate of organic matter decomposition by reducing the size of organic matter fragments and feeding on microflora involved in decomposition. Mites, especially oribatids, are considered suitable for the study of effects of contaminants on population parameters because they are easy to culture and have a relatively short generation time (1 per year), although it is longer than that of the Collembola (2 per year).

Terrestrial crustaceans are represented in the toxicity literature by woodlice, also known as pill bugs (Isopoda, *Porcellio scaber* and *Oniscus asellus*). They are common in deciduous woodland, living in the litter layer and on decaying wood. Woodlice are omnivorous, feeding mainly on dead and decaying plants. They increase organic matter decomposition by comminuting the fragments and feeding on microflora involved in primary decomposition. As leaf litter feeders, isopods are considered good candidates for standard organisms in ecotoxicological testing (van Wensem, 1989). *Porcellio scaber* is common in many countries and is easy to maintain in the laboratory.

The snail *Helix aspersa* and the slug *Arion ater* represent terrestrial gastropods. They are generalized feeders (living and dead plant materials) inhabiting the soil surface, the litter layer, and standing vegetation. Their use in ecotoxicological testing stems from their potential importance for accumulation of contaminants in the food chain (Russell et al., 1981).

Nematodes (roundworms) are significantly different from other soil and litter-dwelling organisms discussed herein because they require a continuous water film for survival. They feed on a wide variety of foods although some are specialized parasites. The effects of chemicals on fungivores, bactivores, herbivores, and omnivores/predators have been evaluated. *Caenorhabditis elegans* used in experiments is a widespread free-living, soil-dwelling nematode. Nematodes have been used in ecotoxicological work for a number of reasons. They are abundant, easily retrieved from soil, and reared in the laboratory. Nematodes live in the interstitial water of the soil so experiments can be conducted in water. They may be exposed to higher concentrations of contaminants by this route than earthworms and other invertebrates not constantly in contact with the soil solution. Uptake of chemicals is mainly through the cuticle, and differences in cuticle permeability are thought to be the primary source of variability in response of various nematodes to toxic chemicals (Kammenga et al., 1994).

5.4 OTHER INVERTEBRATES LITERATURE REVIEW

Cadmium. Kammenga et al. (1994) compared the acute toxicity of Cd ($CdCl_2$) to seven terrestrial nematode species belonging to different taxonomic and ecological groups. The nematodes were extracted from the surface horizon of an arable soil and a forest floor and identified and selected on the basis of different trophic levels: *Rhabditis* species and *Diplogasteritus* species; *Cephalobus persegnis*, *Acrobeloides buetschlii*, and *Caenorhabditis elegans*, bacteria feeders; *Aphelenchus avenae*, fungus feeder; and *Tylenchus elegans*, plant feeder. Solutions were mixed to mimic the mineral concentrations of soil solution in a sandy forest surface soil plus Cd at different concentrations. LC_{50} values were determined after 72 hours. The nematodes *T. elegans* and *A. avenae* had LC_{50} values of greater than 90 ppm after 96 hours (termination of experiment); that is, they were essentially unaffected by the experimental treatment. Among the bacterial feeders the LC_{50} ranged from approximately 3 to 60 ppm Cd after 72 hours.

The nematode *C. elegans* was used by van Kessel et al. (1989) to test the effects of Cd (as $CdCl_2$) on growth (length) and reproduction (number of juveniles per adult) of this soil-dwelling group. Juvenile (J-1) nematodes were cultured for 168 hours in microtiter plates containing solutions with different levels of Cd. Reproduction, the more sensitive parameter, was reduced 36% by 3.6 ppm.

The influence of Cd (as $CdCl_2$) on life-history characteristics of the collembolan *Folsomia candida* was investigated by Crommentuijn et al. (1993). One-week old animals were placed on OECD artificial soil (containing, in percent dry weight, 10 sphagnum peat, 20 kaolin clay, 70 quartz sand; pH 6) containing a series of concentrations of Cd and fed baker's yeast. Number and weight of adults and number of offspring were determined. A soil concentration ($HCl+HNO_3$ extractable) of 326 ppm Cd reduced the number of offspring produced by 21% after 42 days. Weight of the individual animals was not affected at this concentration.

Representatives of Collembola and mites were used by van Straalen et al. (1989) to assess the effect of Cd in diets of soil microarthropods on population growth rates. Three-day old *Orchesella cincta* (Collembola) were fed green algae containing Cd ($CdSO_4$). A concentration of 15 ppm Cd caused an approximate 56% reduction in calculated population growth rate after 61 days, while 4.7 ppm had no effect. Adult mites (*P. peltifer*) fed the same diet for 84 days experienced a 23% reduction in population growth rate at a concentration of 9 ppm Cd, while 3 ppm had no effect.

Hopkin and Hames (1994) investigated the effects of Cd (as $CdNO_3$) in food on survival and reproduction of the terrestrial isopod *Porcellio scaber*. Leaves of field maple (*Acer campestre*) were sprayed with solutions containing Cd and placed in plastic containers with juvenile woodlice. After 360 days, the number of surviving isopods and the number of juveniles were determined. The number of juveniles produced was decreased 47% by 10 ppm Cd (lowest concentration tested) while 50 ppm was required to reduce total survival.

The effects of Cd on individual weight, new shell growth, and reproductive behavior of the snail *Helix aspersa* was evaluated by Russell et al. (1981). The diet fed to the sub-adult (4-month- old) snails for 30 days was ground Purina Lab Chow (for rats, mice, and hamsters) with Cd (as $CdCl_2$) added. Snails were raised in plastic containers with sand bottoms. Reproductive activity, as measured by the number of individuals mating or with spermatophores in place, was reduced 28% by 25 ppm Cd while 10 ppm had no effect. New shell growth and weight were not affected at this concentration.

The experimental approaches described in the previous paragraphs are too diverse to allow comparison of results, as discussed in the Introduction. There is agreement between the two studies on the effects of Cd on nematodes in that approximately 3 ppm in solution is detrimental to the organisms. This number may be useful when soil solution concentration values for Cd are available.

The one study conducted in soil yielded a toxic concentration of 326 ppm, which is higher than the earthworm and microbe benchmarks for soil (Tables 1 and 2).

Copper. The acute toxicity of Cu to the nematode *C. elegans* in four soils and in solution was evaluated by Donkin and Dusenbery (1993). The soils included two silt loams, a loam, and a clay loam. Adult nematodes were placed in the soil with Cu added as $CuCl_2$ and native soil organic matter as food. After 24 hours, surviving animals were counted, and an LC_{50} concentration calculated. Toxicity was also tested in solutions containing Cu. A concentration of 105 ppm Cu in solution caused 50% mortality while at least 400 ppm (sandy loam soil) was required in soil. The highest LC_{50} (1061 ppm) was associated with the highest percentage organic matter in the loam soil.

Parmalee et al. (1993) used a soil microcosm to test the effects of Cu on survival of nematodes and microarthropods feeding on native soil organic matter. Cu was added as $CuSO_4$ to the A horizon of an acid sandy forest soil where native soil nematode and microarthropod populations were exposed for 7 days. There was an average reduction of approximately 70% in number of individuals of most categories of nematodes (fungivores, bactivores, herbivores, hatchlings) at 400 ppm total Cu, while 185 ppm had no effect. The number of individuals of the omnivores/predators category was reduced 85% by the lowest concentration of Cu tested, 72 ppm. Total microarthropod numbers were reduced about 50% by 400 ppm. The oribatid and Mesostigmata mites appeared to be more sensitive, and the Collembola population was too small to evaluate.

Streit (1984) exposed microarthropod communities for six weeks to copper sulfate in 27-L microcosms containing a loess-derived brown earth soil with local gley horizons from a forest site in northern Switzerland. From 40 to 150 ppm Cu, no significant effects on the mite community were observed. At 200 ppm, a reduction in juvenile mites was observed. The effect was primarily due to a decrease in the species *Platynothrus peltifer*. The authors concluded that 200 ppm did not conclusively cause adverse effects at the community level, since only one of seven species was affected. The mites were less sensitive than earthworms to the copper concentrations in soil.

Korthals et al. (1996) investigated the effects of copper on the nematode community in an agroecosystem in the Netherlands after 10 years of exposure. The mean total number of nematodes was reduced at least 20% in soil containing 100 ppm of Cu (pH adjusted to 4.0), 104 ppm of Cu (pH adjusted to 4.7), and 160 ppm of Cu (pH adjusted to 5.4). The abundance of different species and trophic groups was more sensitive a parameter than the total number of nematodes. Copper was extracted from the top 10 cm of soil with 0.43 M nitric acid; thus, total concentrations of the metal may be higher than those reported.

Hopkin and Hames (1994) investigated the effects of Cu (as $CuNO_3$) in food on survival and reproduction of the terrestrial isopod *Porcellio scaber*. The experimental design used by the authors is described in the discussion of the effects of Cd on this animal. After 360 days, the number of surviving isopods and the number of juveniles were determined. The number of juveniles produced was decreased 53% by 50 ppm Cu while 100 ppm of Cu was required to reduce total survival.

The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effects of several pollutants on terrestrial mollusks. Slugs collected from the field were reared in plastic boxes and fed a diet of a pulverized mixture of lettuce, apple, carrot, and pumpkin mixed with $CuSO_4$. After 27 days on this diet, the animals experienced a 55% decrease in growth at 1000 ppm Cu, while 300 ppm had no effect.

The studies of Donkin and Dusenbery (1993) and Parmalee et al. (1993) taken together show a higher concentration in soil than in solution is required to affect the survival of nematodes. Differences among groups of nematodes in sensitivity to Cu is shown by Parmalee et al. (1993). The application of soluble form of Cu to food material by Hopkin and Hames (1994) and Marigomez et al. (1986) show very distinct sensitivities of woodlice and slugs to Cu.

The lowest toxic concentration reported in these two studies (72 ppm Cu) is higher than the benchmarks for earthworms (50 ppm) and microbes (30 ppm).

Iron. The effect of iron on the Collembola *Orchesella cincta* was investigated by Nottrot et al. (1987). The springtails were grown in plastic dishes and fed green algae (*Pleurococcus* spp.) containing various concentrations of Fe for 21 days. Percent growth, feeding activity, and molting were determined. Growth of the springtails was reduced 42% by a diet of 7533 ppm, while 3515 ppm had no effect.

Lead. Bengtsson et al. (1983) evaluated the effects of lead, in the fungus *Verticillium bulbillosum*, on growth rate of a fungus-feeding collembolan, *O. armatus*. Adult springtails were fed the fungus for 125 days and their lengths were recorded for calculation of growth rate. Lead at 3089 ppm in the fungus caused a 25% reduction in *O. armatus* growth rate. fungus.

Hopkin and Hames (1994) investigated the effects of Pb (as $PbNO_3$) in food on survival and reproduction of the terrestrial isopod *Porcellio scaber*. The experimental design used by the authors is described in the discussion of the effects of Cd on this animal. After 360 days, the number of surviving isopods and the number of juveniles were determined. Survival and the number of juveniles produced were decreased 100% by 2000 ppm Pb while 1000 ppm had no effect.

Beyer and Anderson (1985) also used *Porcellio scaber* in experiments to determine the effect of Pb, added as PbO to ground deciduous leaf litter, on several population parameters. The woodlice were reared in plastic containers and fed this diet for 448 days. During this time, the following were measured: lifespan of generation 1, maximum number of individuals in generation 2, and survival of generation 2. These parameters were decreased 27, 68, and 84%, respectively, by 12,800 ppm Pb in the diet, while 6400 ppm had no effect.

The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effect of lead on terrestrial mollusks. Field collected slugs were reared in plastic boxes and fed a diet of a pulverized mixture of lettuce, apple, carrot, and pumpkin mixed with $PbNO_3$. After 27 days on this diet, the animals experienced a 51% decrease in growth at 1000 ppm Pb, while 300 ppm had no effect.

The studies indicate a high tolerance to Pb in the diets of the tested woodlouse, springtail, and slug species. The discrepancy between the Hopkin and Hames (1994) and Beyer and Anderson (1985) levels of Pb required to affect the woodlouse may be due to differences in bioavailability of the added Pb compounds.

Mercury. The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effect of mercury (as $HgCl_2$) on terrestrial mollusks, as described for Pb. After 27 days on this diet, the animals experienced a 26% decrease in growth at 1000 ppm Hg, while Hg at 300 ppm had no effect.

Zinc. Hopkin and Hames (1994) investigated the effects of Zn (as $ZnNO_3$) in food on survival and reproduction of the terrestrial isopod *Porcellio scaber*. The experimental design used by the authors is described in the discussion of the effects of Cd on this animal. After 360 days, the number of surviving isopods and number of juveniles were determined. Survival and number of juveniles produced were decreased 100% by 1000 ppm Zn while 500 ppm had no effect.

Smit and van Gestel (1996) investigated the toxicity of zinc chloride to the springtail *Folsomia candida* in two soils and compared the results to results from contaminated soils near a zinc smelter. EC50s for the effect of zinc on the population size of springtails were 185 and 348 ppm for the two soils after 4 weeks of exposure and 210 and 363 ppm for the soils after 6 weeks of exposure. The EC50 for growth in one of the soils (pH corrected from 3.46 to 6.0 with $CaCO_3$, 3% organic matter, 1.38% clay) was 462 ppm, and an EC50 for growth could not be calculated for the other soil. In the field soil, no relationship was observed between zinc concentrations and either growth or reproduction.

Zinc (as ZnO) was added to litter from the O2 layer under woodlands to evaluate the effects of that metal on *Porcellio scaber* (Beyer et al. 1984). Adult animals kept in plastic boxes were fed this diet for 56 days before survival was determined. The only concentration tested, 5000 ppm, caused a 26% decrease in survival.

Beyer and Anderson (1985) also used *Porcellio scaber* in experiments to determine the effect of Zn, added ZnO to ground deciduous leaf litter, on several population parameters. The woodlice were reared in plastic containers and fed this diet for 448 days. During this time the following were measured: lifespan of generation 1, maximum number of individuals in generation 2, and survival of generation 2. The maximum number of individuals in generation 2 and the survival rate for generation 2 were decreased 22 and 27% by 1600 ppm Zn in the diet, while 800 ppm had no effect.

The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effect of Zn (as $ZnCl_2$) on terrestrial mollusks, as described previously. After 27 days on this diet the animals experienced a 38% decrease in growth at 10 ppm Zn, the lowest concentration tested.

The experiments evaluating the toxicity of Zn to the woodlouse *Porcellio scaber* show a high tolerance to the metal when it is added to the food in soluble form. The work with *Arion ater* (Marigomez et al., 1986) indicates that this organism is more sensitive than *P. scaber* to Zn. On the other hand, growth of individual woodlice was not evaluated and may be more sensitive than survival and reproduction.

Benzo(a)pyrene (BaP). The woodlouse *P. scaber* was chosen by van Straalen and Verweij (1991) to determine the effects of this PAH on the soil invertebrate community. Polynuclear aromatic hydrocarbons are strongly sorbed onto soil organic matter which serves as the main food for many of these organisms. Adult woodlice were reared in plastic boxes for 28 days and fed ground poplar leaf litter mixed with benzo(a)pyrene. Growth efficiency was determined as dry weight increase divided by net food consumption (consumption minus defecation). Respiration, food consumption, and food assimilation were also measured. Growth efficiency of the males of the group was reduced 82% by 125 ppm BaP in the food, while 25 ppm had no effect. Growth efficiency of the females, respiration, food consumption, and food assimilation were not affected.

Two isopods, *Porcellio scaber* and *Oniscus asellus*, were used by van Brummelen and Stuijfzand (1993) to determine the effects of BaP on litter layer-dwelling soil invertebrates. Weight and length changes and energy reserves were measured in individuals reared in plastic boxes and fed a combination of ground poplar leaves and ground dog food spiked with BaP for 63 days. Dry weight of *P. scaber* was reduced 30% with a diet containing 100 ppm BaP, while 32 ppm had no effect. Length and energy reserves (lipids+glycogen+protein) were not affected. Dry weight and length of *O. asellus* were reduced 58 and 48% with a diet containing 316 ppm BaP, while 100 ppm had no effect. Energy reserves were not affected.

These experiments with woodlice indicate that growth may be affected by BaP at concentrations of about 100 ppm applied to food.

p-nitrophenol (PNP). Parmalee et al. (1993) tested the effects of PNP on survival of nematodes and microarthropods in soil microcosms, as described for Cu. There was an average reduction of approximately 55% in number of individuals of most categories of nematodes (fungivores, herbivores, herbivores/predators, and hatchlings) at 40 ppm total PNP, while 20 ppm had no effect. The number of individuals of the bacterivore category was reduced 40% by the lowest concentration of PNP tested, 20 ppm. Total microarthropod numbers were reduced about 35% by 176 ppm, mainly as the result of reductions in oribatids. P-nitrophenol up to 176 ppm had no effect on numbers of Mesostigmata or unclassified microarthropods, and there were no Collembola were present.

Pentachlorophenol. Kammenga et al. (1994) compared the acute toxicity of PCP in solution culture to seven terrestrial nematode species belonging to different taxonomic and ecological groups. The nematodes and experimental design are the same as described previously for Cd. *Aphelenchus avenae*, *Caenorhabditis elegans*, and *Acrobeloides beutschlii* had LC_{50} values greater than 9 ppm after 96 hours (that is, experimental concentrations killed fewer than half of the nematodes). LC_{50} values for the remaining nematodes ranged from approximately 1 to 7 ppm PCP.

Trinitrotoluene (TNT). Parmalee et al. (1993) used a soil microcosm to test the effects of TNT on survival of nematodes and microarthropods in soil microcosms, as described previously for Cu. Trinitrotoluene additions up to 200 ppm had no effect on numbers of nematodes. Total microarthropod numbers were reduced about 58% by 200 ppm, while 100 ppm had no effect. Trinitrotoluene up to 200 ppm had no effect on numbers of Mesostigmata, Collembola, or unclassified microarthropods.

6. RELATIONSHIP BETWEEN SOIL TOXICITY BENCHMARKS AND OTHER ECOTOXICOLOGICAL CRITERIA

6.1 COMPARISON OF TOXICITY BENCHMARKS FOR CONTAMINANTS IN SOIL TO CANADIAN ENVIRONMENTAL QUALITY CRITERIA FOR CONTAMINATED SITES

The Canadian Council of Ministers of the Environment has developed Environmental Quality Criteria for contaminated sites. These are "numerical limits for contaminants in soil and water intended to maintain, improve, or protect environmental quality and human health at contaminated sites in general" (CCME, 1991). Remediation criteria are presented for comparison to the toxicity benchmarks presented herein because they represent levels considered generally protective of human health and the environment for specified uses of soil (in this case the most conservative use—which is agriculture—has been chosen) without taking into account site-specific conditions. If contaminant concentrations exceed the remediation criteria for a current or future land use, further investigation or remediation is needed. These criteria have an interim status, and final criteria will be included in future revisions of this document. They have been adopted from several Canadian jurisdictions and many lack supporting rationale (CCME, 1991). The remediation criteria are not strictly comparable to the toxicity benchmarks developed herein because they also take into account human health and, presumably, plants and the entire food web dependent upon the soil. A comparison of the toxicity benchmarks presented in this report with the CCME Remediation Criteria is given in Table 3.

For 7 of 18 chemicals, one or both of the soil toxicity benchmarks derived by the method used in this report is lower than the CCME criterion. There is no indication in the source publication as to the level of protection being afforded by the CCME Remediation Criteria. However, because human health is considered in the conservative agriculture land-use scenario, one would expect it to be high. This level of protection is seen in the organic chemicals which are known to be toxic to mammals at relatively low levels.

6.2 COMPARISON OF TOXICITY BENCHMARKS FOR CONTAMINANTS IN SOIL TO RIVM (NETHERLANDS) ECOTOXICOLOGICAL INTERVENTION VALUES FOR CONTAMINANTS IN SOILS

The Dutch National Institute of Public Health and Environmental Protection (RIVM) developed Ecotoxicological Intervention Values (EIVs) that represent concentrations of contaminants in soil causing 50% of the species potentially present in an ecosystem to experience adverse effects (van den Berg et al., 1993). The EIVs take into account plants, soil fauna, and microorganisms. The method for deriving the EIVs is described by Denneman and van Gestel in several RIVM publications in Dutch. To take the influence of soil characteristics on the bioavailability of compounds, data were adjusted for organic matter and clay content as described by van den Berg et al. (1993). Risks resulting from biomagnification were included.

Although these EIVs are based on purely "ecological" endpoints, they take into account many more types of organisms than the authors' earthworm and microbe toxicity benchmarks. For metals, benchmarks presented herein are more conservative than the RIVM EIVs in about half of the cases. For organic chemicals, most of benchmarks presented herein for earthworms are in fairly good agreement with the RIVM values. Differences here may stem from the RIVM report of values for undefined compounds of particular classes rather than for particular compounds.

Table 3. Comparison of screening benchmark concentrations for the toxicity to earthworms and soil microbes of chemicals in soil to CCME remediation criteria (RC), RIVM ecotoxicological intervention values (EIV's), arithmetic means of elements in uncontaminated soils of the Oak Ridge Reservation (ORR), and geometric means of elements in soils and surficial materials of the eastern United States

Chemical	Earthworm benchmark (mg/kg)	Microbial benchmark (mg/kg)	CCME RC[a] (mg/kg)	RIVM EIVs (mg/kg)	ORR (mg/kg)	Eastern United States (mg/kg)
Aluminum	---	600	---	---	15700	33000
Arsenic	60	100	20	40	9.7	4.8
Barium	---	3000	750	625	87.9	290
Boron	---	20	2[b]	---	10.4	---
Cadmium	20	20	3	12	0.22	---
Chromium	0.4	10	750[c]	230	24	33
Cobalt	---	1000	40	240	15.6	5.9
Copper	60	100	150	190	11.2	13
Fluorine	---	30	200	---	---	130
Iron	---	200	---	---	22650	14000
Lanthanum	---	50	---	---	---	29
Lead	500	900	375	290	26.8	14
Lithium	---	10	---	---	9.4	17
Manganese	---	100	---	---	1318	260
Mercury	0.1[d]	30	0.8[e]	10[e]	0.20[e]	0.08[e]
Molybdenum	---	200	5	<480	3.9	0.32
Nickel	200	90	150	210	15.1	11
Selenium	70	100	2	---	0.73	0.3
Silver	---	50	20	---	1.22	---
Tin	---	2000	2	---	---	0.86
Titanium	---	1000	---	---	---	2800

Table 3. (continued)

Chemical	Earthworm benchmark (mg/kg)	Microbial benchmark (mg/kg)	CCME RC[a] (mg/kg)	RIVM EIVs (mg/kg)	ORR (mg/kg)	Eastern United States (mg/kg)
Vanadium	---	20	200	---	32.3	43
Zinc	100	100	600	720	46.2	40
Phenol	30	100	0.01[f]	40	---	---
4-nitrophenol	7	---	0.01[f]	---	---	---
3-chlorophenol	10	---	0.05[g]	10[i]	---	---
3,4-dichlorophenol	20	---	0.05[g]	10[i]	---	---
2,4,5-trichlorophenol	9	---	0.05[g]	10[i]	---	---
2,4,6-trichlorophenol	10	---	0.05[g]	10[i]	---	---
2,3,4,5-tetrachlorophenol	20	---	0.05[g]	10[i]	---	---
Pentachlorophenol	6	400	0.05[g]	5	---	---
Chlorobenzene	40	---	0.1	30	---	---
1,4,-dichlorobenzene	20	---	0.1	30[j]	---	---
1,2,3-trichlorobenzene	20	---	0.05[h]	30[j]	---	---
1,2,4-trichlorobenzene	20	---	0.05[h]	30[j]	---	---
1,2,3,4-tetrachlorobenzene	10	---	0.05[h]	30[j]	---	---
Pentachlorobenzene	20	---	0.05[h]	30	---	---
Hexachlorobenzene	---	1000	0.05	30	---	---

[a] Agricultural land-use context
[b] Hot water soluble B
[c] Total Cr. Criterion for Cr (VI) is 8 ppm
[d] Combined inorganic and organic forms of Hg
[e] Does not indicate form (organic or inorganic)
[f] Each unspecified non-chlorinated phenolic compound is not to exceed 0.1 ppm
[g] Each unspecified chlorinated phenolic compound is not to exceed 0.05 ppm
[h] Each unspecified tri-, tetra-, and pentachlorinated benzene is not to exceed 0.05 ppm
[i] Unspecified chlorinated phenols
[j] Unspecified chlorinated benzenes

7. COMPARISON OF TOXICITY BENCHMARKS FOR CONTAMINANTS IN SOIL TO CONCENTRATIONS OF CHEMICALS IN UNPOLLUTED SOILS

7.1 COMPARISON TO USGS ELEMENT CONCENTRATIONS IN SOILS AND OTHER SURFICIAL MATERIALS OF THE EASTERN UNITED STATES

To place the four sets of critical values into a broader perspective, soil chemical concentrations are presented herein as reported by the United States Geological Survey (USGS) in a survey of soils of the eastern United States (Shacklette and Boerngen, 1984) (Table 3). These samples were collected and analyzed by the USGS to represent, as closely as possible, soils that supported native plants and which were altered very little from their natural condition.

It is interesting to compare the levels of elements cited in the literature as toxic against concentrations of the same elements found in natural (i.e., not known to be polluted) soils. This comparison is reasonable in most cases because benchmarks generally were based on nominal soil concentrations (i.e., those added to the soil by the experimenter) as opposed to a measure of either total concentration or of the bioavailable quantity of the element in the soil. Seldom was the background level of the "contaminant" element in the soil measured, the assumption being that very little of the element existed naturally in the soil compared to treatment levels added. This is often, but not always, a reasonable assumption. The USGS compilation contains concentrations of elements derived mainly from strong-acid extractions, although in the case of uranium, neutron activation was used to measure a true total concentration. Values for the eastern United States were used because surficial deposits of the western United States, especially in arid and mountainous regions, may contain unusually high concentrations of naturally-occurring trace elements.

For several of the metals, our toxicity benchmarks were below (Al, Cr, F, Fe, Mn, Ti, and V) or about equal to (Li) the geometric mean for the element in soils and surficial deposits in the eastern United States. The large difference between the USGS soil Fe and Al values and the low microbial benchmark based on a quantity of Fe or Al added to soil is likely due to the strong extractant used in the USGS study. The form of the element added or some other aspect of the experimental design may account for other low benchmark concentrations as compared to mean levels in soils.

7.2 COMPARISON TO DOE OAK RIDGE RESERVATION BACKGROUND SOIL CHARACTERIZATION ELEMENT CONCENTRATIONS IN SOILS

The Background Soil Characterization Project (BSCP) at the ORR was established to determine the background concentrations of organics, metals, and radionuclides in natural soils that are important to environmental restoration projects (Watkins et al., 1993). Soils were sampled, field classified, and analyzed for chemicals using several methods. The data presented in Table 3 show the arithmetic means of elements from 46 sampling sites. The elements were extracted from the soil samples using nitric acid and hydrogen peroxide (EPA, 1986). This standard EPA acid digestion for sediments, sludges, and soils is not explicitly meant to extract total elements from a sample. A comparison with total soil concentrations of elements measured by neutron activation analysis (NAA) shows that for many elements (e.g., Sb, As, Cr, Co, Mn, Si, V, Zn) the HNO_3-H_2O_2 extraction method was adequate for most of the elements in question (Watkins et al., 1993). Unfortunately, not all elements are amenable to measurement by NAA.

A large discrepancy was found between the BSCP soil Fe and Al values and the low soil toxicity benchmarks, based on a quantity of Fe or Al added to soil. At least one of our benchmarks is lower than background soil concentrations in the case of Cr, Mn, and V, and about equal for Li and Hg. The form of the element added or some other aspect of the experimental design may account for these differences.

8. RECOMMENDATIONS AND CONCLUSIONS

The values presented in Tables 1 and 2 are intended for use in contaminant screening during the hazard identification (problem formulation) phase of ecological risk assessments. Chemicals with soil concentrations that exceed both the toxicity benchmarks for soil and the background soil concentration for the soil type are contaminants of potential concern. Background soil concentrations have been derived for the ORR and should be generated for other Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites as well.

For baseline ecological risk assessments, and other assessments that may lead to regulatory actions, assessors should consult the primary sources of toxicity data and then determine the applicability of the data to their specific sites. In addition, assessments should not rely on laboratory toxicity data only. Where toxicity to soil invertebrates is suspected, toxicity tests should be performed with the contaminated soil. In addition, the abundance of earthworms in the soil of a particular site, determined during collection of earthworms for chemical analysis, may provide a rough indication of the likelihood of soil toxicity.

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APPENDIX A

TOXICITY DATA FOR EARTHWORMS

Table A.1. Toxicity data for earthworms

Chemical concentrations are mg of element/kg of growth medium

%OC - % organic carbon

% Dec - % decrease in measured parameter at LOEC as compared to controls.

OECD soil (% dry weight): sphagnum peat, 10; kaolin clay, 20; fine sand, 69; CaCO3, 1; pH 6.0

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
As	KH2AsO4	Eisenia fetida	soil & manure			56	cocoons/worm		68LCT	56	Fischer & Koszorus. 1992.
Cd	$CdSO_4$	Aporrectodea caliginosa	Egyptian	7.05	10.8	56	cocoon production		10	25	Khalil et al. 1996
Cd	CdCl2	Eisenia andrei	OECD soil	6	5	21	cocoons/worm;juveniles/worm	10	18	23,22	van Gestel, et al. 1992.
Cd	C4H6CdO4	Eisenia fetida	horse manure			56	cocoon production		25LCT	52	Malecki et al. 1982.
Cd	CdCl2	Eisenia andrei	OECD soil	6	5	84	sexual development EC50		27	50	van Gestel et al. 1991a.
Cd	CdCl2	Eisenia andrei	OECD soil	6	5	84	growth	10	32	40	van Gestel et al. 1991a.
Cd	Cd(NO3)2	Eisenia fetida	OECD soil	6		56	cocoon production EC50		46.3	50	Spurgeon et al. 1994.

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Cd	C4H6CdO4	Eisenia fetida	horse manure			140	cocoon production		50LCT	24	Malecki et al. 1982.
Cd	Soluble forms	Eisenia fetida	horse manure			42	growth;cocoon production		100LCT	25,100	Neuhauser et al. 1984.
Cd	CdCl2	Eisenia andrei	OECD soil	6	5	84	growth	32	100	44	van Gestel et al. 1991a.
Cd		Dendrobaena rubida	soil & dung	5	5.7	120	cocoons/worm	10	100	62	Bengtsson et al. 1986.
Cd		Dendrobaena rubida	soil & dung	6	5.7	120	cocoons/worm;hatchlings/ cocoon	10	100	78,71	Bengtsson et al. 1986.
							total hatchlings			74	
Cd		Dendrobaena rubida	soil & dung	7	5.7	120	% cocoon hatching success;	10	100	47	Bengtsson et al. 1986.
							hatchlings/coc; total hatchlings			38,30	Bengtsson et al. 1986.
Cd	CdCl2	Eisenia andrei	OECD soil	6	5	84	sexual development EC50		108	50	van Gestel et al. 1991a.
Cd	$Cd(NO_3)_2$	Eisenia fetida	OECD soil	6.1		21	growth		215	50	Spurgeon and Hopkin 1995

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Cd	CdCl2	Eisenia fetida	sandy soil	4	0.9	14	survival LC50		440	50	van Gestel & van Dis.1988
Cd	CdCl2	Lumbricus rubellas	sandy loam	7	4	84	survival	150	1000	82	Ma. 1982.
Cd	CdNO3	Eisenia fetida	OECD soil	6	5	14	survival LC50		1843	50	Neuhauser et al. 1985
Cr	K2Cr2O7	Octochaetus pattoni	soil & dung			60	survival		2LCT	75	Abbasi & Soni. 1983.
Cr	K2Cr2O7	Pheretima posthuma	paddy soil			61	survival		10LCT	100	Soni & Abbasi. 1981.
Cr	Cr(NO3)3	Eisenia andrei	OECD soil	6	5	21	growth	10	32	30	van Gestel et al. 1992.
Cr	KCr(SO4)2	Eisenia fetida	soil & manure			56	number cocoons and hatchlings		625LCT	55	Molnar et al. 1989.
Cr	K2Cr2O7	Eisenia fetida	soil & manure			14	weight gain of juveniles		625LCT	43	Molnar et al. 1989.
Cu	CuCl2	Allolobophora chlorotica	sandy loam	5	2.5		cocoon production		51	50	Ma. 1988.
Cu	Cu(NO3)2	Eisenia fetida	OECD soil	6		56	cocoon production EC50		53.3	50	Spurgeon et al. 1994.
Cu	CuCl2	Lumbricus rubellus	sandy loam	7	1.7	42	cocoon production	13	63	41	Ma. 1984.

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Cu	CuCl2	Apporectodea caliginosa	sandy loam	5	2.5		cocoon production		68	50	Ma. 1988.
Cu		Dendrobaena rubida	soil & dung	5	5.7	120	cocoons/worm;hatc hlings/ cocoon		100LCT	70,64	Bengtsson et al. 1986.
Cu	CuCl2	Eisenia andrei	OECD soil	6	5	84	growth	32	100	32	van Gestel et al. 1991a.
Cu	Cu-sulfate	Aporrectodea caliginosa	Egyptian	7.05	10.8	56	cocoon production	50	100	36	Khalil et al. 1996
Cu		Allolobophora caliginosa	polder soil			60	cocoon production		110LCT	27	van Rhee. 1975.
							total hatchlings			74	
Cu	CuCl2	Lumbricus rubellus	sandy loam	5	2.5		cocoon production		122	50	Ma. 1988.
Cu	CuCl2	Lumbricus rubellus	loamy sand	5	2.9	42	cocoon production	54	131	42	Ma. 1984.
Cu	CuSO4	Lumbricus rubellus	loamy sand	5	2.9	18	cocoon production	83	148	26	Ma. 1984.
Cu	CuSO4	Octolasium cyaneum	Brown soil		3	14	survival LC50		180	50	Streit & Jaggy. 1983.
Cu	CuCl2	Eisenia fetida	OECD soil	6	5	21	cocoon production	120	180	36	van Gestel et al. 1989.
Cu	CuSO4	Lumbricus rubellus	loamy sand	6	2.9	18	cocoon production	148	278	33	Ma. 1984.
Cu		Dendrobaena rubida	soil & dung	6	5.7	120	cocoons/worm;hatc hlings/ cocoon	100	500	96,100	Bengtsson et al. 1986.

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
							% hatching success			100	
Cu		Dendrobaena rubida	soil & dung	7	5.7	120	cocoons/worm;hatchlings/ cocoon	100	500	90,100	Bengtsson et al. 1986.
							% hatching success			100	
Cu	C4H6CuO4	Eisenia fetida	horse manure			56	cocoon production	300	500	24	Malecki et al. 1982
Cu	Cu-nitrate	Eisenia fetida	OECD soil	6.1		21	growth		601	50	Spurgeon and Hopkin 1995
Cu	CuNO3	Eisenia fetida	OECD soil	6	5	14	survival LC50		643	50	Neuhauser et al. 1985.
Cu	CuSO4	Octolasium cyaneum	Rendzina soil		14	14	survival LC50		850	50	Streit & Jaggy. 1983.
Cu	C4H6CuO4	Eisenia fetida	horse manure			140	cocoon production	500	1000	24	Malecki et al. 1982.
Cu	CuCl2	Lumbricus rubellus	sandy loam	7	4	84	survival	150	1000	82	Ma. 1982.
Cu	Soluble forms	Eisenia fetida	horse manure			42	growth;cocoon production	1000	2000	27,85	Neuhauser et al. 1984.
Cu	CuSO4	Octolasium cyaneum	Peat soil		43	14	survival LC50		2500	50	Streit & Jaggy. 1983.

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Pb		Dendrobaena rubida	soil & dung	5	5.7	120	cocoons/worm;hatchlings/ cocoon	100	500	75,100	Bengtsson et al. 1986.
Pb	Pb-nitrate	Eisenia fetida	OECD soil	6.1		21	growth		1629	50	Spurgeon and Hopkin 1995
Pb	Pb(NO3)2	Eisenia fetida	OECD soil	6		56	cocoon production EC50		1940	50	Spurgeon et al. 1994.
Pb	C4H6O4Pb	Eisenia fetida	horse manure			56	cocoon production	2000	4000	50	Malecki et al. 1982.
Pb	C4H6O4Pb	Eisenia fetida	horse manure			140	cocoon production	1000	5000	28	Malecki et al. 1982.
Pb	PbNO3	Eisenia fetida	OECD soil	6	5	14	survival LC50		5941	50	Neuhauser et al. 1985.
Pb	Sol forms	Eisenia fetida	horse manure			42	cocoon production		5000LCT	80	Neuhauser et al. 1984.
Hg	HgCl2	Octochaetus pattoni	soil & dung			60	survival;cocoon production		0.5LCT	65,40	Abbasi & Soni. 1983.
Hg	CH3HgCl	Eisenia fetida	potting soil			84	survival;segment regeneration	2.5	12.5	21,69	Beyer et al. 1985.

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Ni	C4H6NiO4	Eisenia fetida	horse manure			140	cocoon production	100	200	23	Malecki et al. 1982.
Ni	Soluble forms	Eisenia fetida	horse manure			42	cocoon production		250LCT	33	Neuhauser et al. 1984.
Ni	C4H6NiO4	Eisenia fetida	horse manure			56	cocoon production	200	300	41	Malecki et al. 1982.
Ni	NiNO3	Eisenia fetida	OECD soil	6	5	14	survival LC50		757	50	Neuhauser et al. 1985.
Ni	NiCl2	Lumbricus rubellus	sandy loam	7	4	84	survival	150	1000	31	Ma. 1982.
Se	Na2SeO3	Eisenia fetida	soil & manure			56	cocoons/worm		77LCT	69	Fischer & Koszorus. 1992.
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	6.0	2.5	21	cocoon production	ca. 97	136	50	Spurgeon and Hopkin 1996b
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	4.0	2.5	21	cocoon production	ca. 115	142	50	Spurgeon and Hopkin 1996b
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	4.0	5	21	cocoon production	ca. 161	189	50	Spurgeon and Hopkin 1996b

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Zn	$Zn(NO_3)_2$	Eisenia fetida	OECD soil	6		21	growth rate		190	69	Spurgeon and Hopkin 1996a
Zn	$Zn(NO_3)_2$	Aporrectodea rosea	OECD soil	6		21	growth rate		190	48	Spurgeon and Hopkin 1996a
Zn	$Zn(NO_3)_2$	Lumbricus rubellus	OECD soil	6		21	cocoon production		190	69	Spurgeon and Hopkin 1996a
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	5.0	2.5	21	cocoon production	ca. 85	199	50	Spurgeon and Hopkin 1996b
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	4.0	7.5	21	cocoon production	ca. 223	230	50	Spurgeon and Hopkin 1996b
Zn	Zn(NO3)2	Eisenia fetida	OECD soil	6		56	cocoon production EC50		276	50	Spurgeon et al. 1994.
Zn	Zn-sulfate	Aporrectodea caliginosa	Egyptian	7.05	10.8	56	cocoon production		300	20	Khalil et al. 1996
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	5.0	5	21	cocoon production	ca. 183	343	50	Spurgeon and Hopkin 1996b

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	6.0	5	21	cocoon production		462	50	Spurgeon and Hopkin 1996b
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	5.0	7.5	21	cocoon production	ca. 414	548	50	Spurgeon and Hopkin 1996b
Zn	ZnCl2	Eisenia andrei	OECD soil	6	5	21	cocoons/worm; juveniles/worm	320	560	31,42	van Gestel et al. 1993.
Zn	$Zn(NO_3)_2$	Eisenia fetida	artificial soil	6.0	7.5	21	cocoon production	ca. 484	592	50	Spurgeon and Hopkin 1996b
Zn	ZnNO3	Eisenia fetida	OECD soil			14	survival LC50		662	50	Neuhauser et al. 1985.
Zn	$Zn(NO_3)_2$	Eisenia fetida	OECD soil	6.1		21	growth		1078	50	Spurgeon and Hopkin 1995a
Zn		Allolobophora caliginosa	polder soil				body weight; cocoon production; mortality; sexual development		1100LCT	53,100, 22, 100	van Rhee. 1975.
Zn	C4H6O4Zn	Eisenia fetida	horse manure			56	cocoon production	1000	2000	36	Malecki et al. 1982.

Table A.1 (continued)

Chemical / Form		Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Zn	Soluble forms	Eisenia fetida	horse manure			42	cocoon production	1000	2500	50	Neuhauser et al. 1984.
Zn	C4H6O4Zn	Eisenia fetida	horse manure			140	cocoon production	2500	5000	53	Malecki et al. 1982.
Chloroacetamide		Eisenia andrei	sandy soil	4	0.9	14	survival LC50		>10<18	50	van Gestel & van Dis. 1988
Chloroacetamide		Eisenia fetida	artificial soil	7		28	survival LC50		24	50	Heimbach 1984.
Chloroacetamide		Eisenia andrei	sandy soil	7	0.9	14	survival LC50		>32<56	50	van Gestel & van Dis. 1988
Chloroacetamide		Eisenia andrei	OECD soil	7	3.9	14	survival LC50		40	50	van Gestel & van Dis. 1988
Chloroacetamide		Eisenia fetida	horse manure			56	growth	500	1000	100	Neuhauser & Callahan. 1990
3-chloroaniline		Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		195	50	van Gestel & Ma. 1993.
3-chloroaniline		Eisenia andrei	sandy soil	5	1.9	14	survival LC50		220	50	van Gestel & Ma. 1993.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
3-chloroaniline	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		332	50	van Gestel & Ma. 1993.
3-chloroaniline	Eisenia andrei	OECD soil	6	4	14	survival LC50		448	50	van Gestel & Ma. 1993.
2,4-dichloroaniline	Eisenia andrei	OECD soil	6	5	21	cocoon production	56	100	23	van Gestel et al. 1989.
2,4-dichloroaniline	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		142	50	van Gestel & Ma. 1990.
2,4-dichloroaniline	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		190	50	van Gestel & Ma. 1990.
2,4-dichloroaniline	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		201	50	van Gestel & Ma. 1990.
2,4-dichloroaniline	Eisenia andrei	sandy soil	6	3	14	survival LC50		285	50	van Gestel & Ma. 1990.
2,4-dichloroaniline	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		304	50	van Gestel & Ma. 1990.
2,4-dichloroaniline	Eisenia andrei	OECD soil	6	4	14	survival LC50		319	50	van Gestel & Ma. 1990.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
2,4-dichloroaniline	Lumbricus rubellus	peaty soil	4	7.8	14	survival LC50		580	50	van Gestel & Ma. 1990.
2,4-dichloroaniline	Eisenia andrei	peaty soil	4	7.8	14	survival LC50		824	50	van Gestel & Ma. 1990.
3,4-dichloroaniline	Eisenia andrei	sandy soil	7	0.9	6	survival LC50		140	50	van Gestel & van Dis. 1988
3,4-dichloroaniline	Eisenia andrei	sandy soil	4	0.9	6	survival LC50		140	50	van Gestel & van Dis. 1988
3,4-dichloroaniline	Eisenia andrei	OECD soil	7	3.9	11	survival LC50		250	50	van Gestel & van Dis. 1988
2,4,5-trichloroaniline	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		134	50	van Gestel & Ma. 1993.
2,4,5-trichloroaniline	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		174	50	van Gestel & Ma. 1993.
2,4,5-trichloroaniline	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		213	50	van Gestel & Ma. 1993.
2,4,5-trichloroaniline	Eisenia andrei	OECD soil	6	4	14	survival LC50		233	50	van Gestel & Ma. 1993.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
2,3,5,6-tetrachloroaniline	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		116	50	van Gestel & Ma. 1993.
2,3,5,6-tetrachloroaniline	Eisenia andrei	OECD soil	6	4	14	survival LC50		133	50	van Gestel & Ma. 1993.
2,3,5,6-tetrachloroaniline	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		159	50	van Gestel & Ma. 1993.
2,3,5,6-tetrachloroaniline	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		179	50	van Gestel & Ma. 1993.
Pentachloroaniline	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		825	50	van Gestel & Ma. 1993.
Pentachloroaniline	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		825	50	van Gestel & Ma. 1993.
Pentachloroaniline	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		1014	50	van Gestel & Ma. 1993.
Pentachloroaniline	Eisenia andrei	OECD soil	6	4	14	survival LC50		>3200	50	van Gestel & Ma. 1993.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
1,2-dichloropropane	Perionyx excavatus	OECD soil	6	5	14	survival LC50		3880	50	Neuhauser et al. 1986.
1,2-dichloropropane	Eisenia fetida	OECD soil	6	5	14	survival LC50		4240	50	Neuhauser et al. 1986.
1,2-dichloropropane	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		4272	50	Neuhauser et al. 1986.
1,2-dichloropropane	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		5300	50	Neuhauser et al. 1986.
1,2-dichloropropane	Eisenia fetida	horse manure			56	growth	80800	92300	death	Neuhauser & Callahan. 1990
Dimethylphthalate	Perionyx excavatus	OECD soil	6	5	14	survival LC50		1064	50	Neuhauser et al. 1986.
Dimethylphthalate	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		2000	50	Neuhauser et al. 1986.
Dimethylphthalate	Eisenia fetida	OECD soil	6	5	14	survival LC50		3160	50	Neuhauser et al. 1986.
Dimethylphthalate	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		3335	50	Neuhauser et al. 1986.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Dimethylphthalate	Eisenia fetida	horse manure			56	cocoon production	4720	70800	62	Neuhauser & Callahan. 1990
Fluorene	Perionyx excavatus	OECD soil	6	5	14	survival LC50		170	50	Neuhauser et al. 1986.
Fluorene	Eisenia fetida	OECD soil	6	5	14	survival LC50		173	50	Neuhauser et al. 1986.
Fluorene	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		197	50	Neuhauser et al. 1986.
Fluorene	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		206	50	Neuhauser et al. 1986.
Fluorene	Eisenia fetida	horse manure			56	cocoon production	500	750	49	Neuhauser & Callahan. 1990
N-nitrosodiphenylamine	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		109	50	Neuhauser et al. 1986.
N-nitrosodiphenylamine	Perionyx excavatus	OECD soil	6	5	14	survival LC50		128	50	Neuhauser et al. 1986.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
N-nitrosodiphenylamine	Eisenia fetida	OECD soil	6	5	14	survival LC50		151	50	Neuhauser et al. 1986.
N-nitrosodiphenylamine	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		155	50	Neuhauser et al. 1986.
N-nitrosodiphenylamine	Eisenia fetida	horse manure			56	cocoon production		1400 LCT	37	Neuhauser & Callahan. 1990
Phenol	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		188	50	Neuhauser et al. 1986.
Phenol	Perionyx excavatus	OECD soil	6	5	14	survival LC50		258	50	Neuhauser et al. 1986.
Phenol	Eisenia fetida	OECD soil	6	5	14	survival LC50		401	50	Neuhauser et al. 1986.
Phenol	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		450	50	Neuhauser et al. 1986.
Phenol	Eisenia fetida	horse manure			56	cocoon production	3900	4900	26	Neuhauser & Callahan. 1990

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
4-nitrophenol	Eisenia fetida	OECD soil	6	5	14	survival LC50		38	50	Neuhauser et al. 1986.
4-nitrophenol	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		40	50	Neuhauser et al. 1986.
4-nitrophenol	Perionyx excavatus	OECD soil	6	5	14	survival LC50		44	50	Neuhauser et al. 1986.
4-nitrophenol	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		56	50	Neuhauser et al. 1986.
4-nitrophenol	Eisenia fetida	horse manure			56	cocoon production		600 LCT	39	Neuhauser & Callahan. 1990
3-chlorophenol	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		75	50	van Gestel & Ma. 1990.
3-chlorophenol	Eisenia andrei	humic sand	5	1.9	14	survival LC50		78	50	van Gestel & Ma. 1988.
3-chlorophenol	Eisenia andrei	OECD soil	6	4	14	survival LC50		130	50	van Gestel & Ma. 1990.
3-chlorophenol	Eisenia andrei	sandy soil	6	3	14	survival LC50		134	50	van Gestel & Ma. 1990.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
3-chlorophenol	Eisenia andrei	humic sand	6	3	14	survival LC50		140	50	van Gestel & Ma. 1988.
3-chlorophenol	Lumbricus rubellus	humic sand	5	1.9	14	survival LC50		150	50	van Gestel & Ma. 1988.
3-chlorophenol	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		150	50	van Gestel & Ma. 1990.
3-chlorophenol	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		247	50	van Gestel & Ma. 1990.
3-chlorophenol	Lumbricus rubellus	humic sand	6	3	14	survival LC50		296	50	van Gestel & Ma. 1988.
3-chlorophenol	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		342	50	van Gestel & Ma. 1990.
3-chlorophenol	Eisenia andrei	peaty soil	4	7.8	14	survival LC50		423	50	van Gestel & Ma. 1990.
3-chlorophenol	Lumbricus rubellus	peaty soil	4	7.8	14	survival LC50		633	50	van Gestel & Ma. 1990.
3,4-dichlorophenol	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		134	50	van Gestel & Ma. 1990.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
3,4-dichlorophenol	Eisenia andrei	humic sand	5	1.9	14	survival LC50		140	50	van Gestel & Ma. 1988.
3,4-dichlorophenol	Eisenia andrei	OECD soil	6	4	14	survival LC50		172	50	van Gestel & Ma. 1990.
3,4-dichlorophenol	Eisenia andrei	sandy soil	6	3	14	survival LC50		240	50	van Gestel & Ma. 1990.
3,4-dichlorophenol	Eisenia andrei	humic sand	6	3	14	survival LC50		250	50	van Gestel & Ma. 1988.
3,4-dichlorophenol	Lumbricus rubellus	humic sand	5	1.9	14	survival LC50		303	50	van Gestel & Ma. 1988.
3,4-dichlorophenol	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		322	50	van Gestel & Ma. 1990.
3,4-dichlorophenol	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		352	50	van Gestel & Ma. 1990.
3,4-dichlorophenol	Eisenia andrei	peaty soil	4	7.8	14	survival LC50		423	50	van Gestel & Ma. 1990.
3,4-dichlorophenol	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		486	50	van Gestel & Ma. 1990.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
3,4-dichlorophenol	Lumbricus rubellus	humic sand	6	3	14	survival LC50		486	50	van Gestel & Ma. 1988.
3,4-dichlorophenol	Lumbricus rubellus	peaty soil	4	7.8	14	survival LC50		680	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		46	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Eisenia andrei	humic sand	5	1.9	14	survival LC50		52	50	van Gestel & Ma. 1988.
2,4,5-trichlorophenol	Eisenia andrei	OECD soil	6	4	14	survival LC50		63	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Eisenia andrei	sandy soil	6	3	14	survival LC50		76	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Eisenia andrei	humic sand	6	3	14	survival LC50		90	50	van Gestel & Ma. 1988.
2,4,5-trichlorophenol	Eisenia andrei	peaty soil	4	7.8	14	survival LC50		164	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Lumbricus rubellus	humic sand	5	1.9	14	survival LC50		201	50	van Gestel & Ma. 1988.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
2,4,5-trichlorophenol	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		235	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Lumbricus rubellus	humic sand	6	3	14	survival LC50		290	50	van Gestel & Ma. 1988.
2,4,5-trichlorophenol	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		316	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		362	50	van Gestel & Ma. 1990.
2,4,5-trichlorophenol	Lumbricus rubellus	peaty soil	4	7.8	14	survival LC50		875	50	van Gestel & Ma. 1990.
2,4,6-trichlorophenol	Eisenia fetida	OECD soil	6	5	14	survival LC50		58	50	Neuhauser et al. 1986.
2,4,6-trichlorophenol	Perionyx excavatus	OECD soil	6	5	14	survival LC50		78	50	Neuhauser et al. 1986.
2,4,6-trichlorophenol	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		85	50	Neuhauser et al. 1986.
2,4,6-trichlorophenol	Eisenia fetida	horse manure			56	cocoon production		100 LCT	28	Neuhauser & Callahan. 1990

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
2,4,6-trichlorophenol	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		108	50	Neuhauser et al. 1986.
2,3,4,5-tetrachlorophenol	Eisenia andrei	humic sand	5	1.9	14	survival LC50		116	50	van Gestel & Ma. 1988.
2,3,4,5-tetrachlorophenol	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		117	50	van Gestel & Ma. 1990.
2,3,4,5-tetrachlorophenol	Eisenia andrei	sandy soil	6	3	14	survival LC50		166	50	van Gestel & Ma. 1990.
2,3,4,5-tetrachlorophenol	Eisenia andrei	humic sand	6	3	14	survival LC50		176	50	van Gestel & Ma. 1988.
2,3,4,5-tetrachlorophenol	Lumbricus rubellus	humic sand	5	1.9	14	survival LC50		514	50	van Gestel & Ma. 1988.
2,3,4,5-tetrachlorophenol	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		515	50	van Gestel & Ma. 1990.
2,3,4,5-tetrachlorophenol	Lumbricus rubellus	humic sand	6	3	14	survival LC50		828	50	van Gestel & Ma. 1988.
2,3,4,5-tetrachlorophenol	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		875	50	van Gestel & Ma. 1990.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Pentachlorophenol	Eisenia andrei	sandy soil	7	0.9	14	survival LC50		16	50	van Gestel & van Dis. 1988
Pentachlorophenol	Eisenia fetida	artificial	7.5		14	mortality		27	50	Fitzgerald et al. 1996
Pentachlorophenol	Eisenia andrei	OECD soil	7	3.9	14	survival LC50		29	50	van Gestel & van Dis. 1988
Pentachlorophenol	Eisenia andrei	OECD soil	6	5	21	% cocoon hatch success	10	32	50	van Gestel et al. 1989.
Pentachlorophenol	Eisenia fetida	artificial	7.5		14	mortality		37	50	Fitzgerald et al. 1996
Pentachlorophenol	Eisenia andrei	sandy soil	4	0.9	14	survival LC50		52	50	van Gestel & van Dis. 1988
Pentachlorophenol	Eisenia fetida	clay	6.1		14	mortality		72	50	Fitzgerald et al. 1996
Pentachlorophenol	Eisenia andrei	OECD soil	6	4	14	survival LC50		83	50	van Gestel & Ma. 1990.
Pentachlorophenol	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		84	50	van Gestel & Ma. 1990.
Pentachlorophenol	Eisenia fetida	artificial soil	7		28	survival LC50		87	50	Heimbach 1984.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Pentachlorophenol	Eisenia andrei	humic sand	5	1.9	14	survival LC50		94	50	van Gestel & Ma. 1988.
Pentachlorophenol	Eisenia andrei	sandy soil	6	3	14	survival LC50		142	50	van Gestel & Ma. 1990.
Pentachlorophenol	Eisenia andrei	humic sand	6	3	14	survival LC50		143	50	van Gestel & Ma. 1988.
Pentachlorophenol	Eisenia eugeniae	artificial	7.5		14	mortality		168	50	Fitzgerald et al. 1996
Pentachlorophenol	Lumbricus terrestris	artificial	7.5		14	mortality		191	50	Fitzgerald et al. 1996
Pentachlorophenol	Eisenia andrei	peaty soil	4	7.8	14	survival LC50		502	50	van Gestel & Ma. 1990.
Pentachlorophenol	Lumbricus rubellus	humic sand	6	3	14	survival LC50		883	50	van Gestel & Ma. 1988.
Pentachlorophenol	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		1013	50	van Gestel & Ma. 1990.
Pentachlorophenol	Lumbricus rubellus	humic sand	5	1.9	14	survival LC50		1094	50	van Gestel & Ma. 1988.
Pentachlorophenol	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		1206	50	van Gestel & Ma. 1990.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Pentachlorophenol	Lumbricus rubellus	peaty soil	4	7.8	14	survival LC50		2298	50	van Gestel & Ma. 1990.
Chlorobenzene	Eisenia fetida	sandy soil	5	1.8	14	survival LC50		240	50	van Gestel et al. 1991b.
Chlorobenzene	Eisenia fetida	OECD soil	6	4	14	survival LC50		446	50	van Gestel et al. 1991b.
Chlorobenzene	Lumbricus rubellus	sandy soil	5	1.8	14	survival LC50		547	50	van Gestel et al. 1991b.
Chlorobenzene	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		1107	50	van Gestel et al. 1991b.
1,4-dichlorobenzene	Eisenia fetida	sandy soil	5	1.8	14	survival LC50		128	50	van Gestel et al. 1991b.
1,4-dichlorobenzene	Lumbricus rubellus	sandy soil	5	1.8	14	survival LC50		184	50	van Gestel et al. 1991b.
1,4-dichlorobenzene	Eisenia fetida	OECD soil	6	4	14	survival LC50		229	50	van Gestel et al. 1991b.
1,4-dichlorobenzene	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		615	50	van Gestel et al. 1991b.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
1,2,3-trichlorobenzene	Lumbricus rubellus	sandy soil	5	1.9	14	survival LC50		115	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Eisenia andrei	OECD soil	6	4	14	survival LC50		133	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Eisenia andrei	sandy soil	5	1.9	14	survival LC50		134	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		195	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Lumbricus rubellus	sandy soil	6	3	14	survival LC50		200	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Eisenia andrei	sandy soil	6	3	14	survival LC50		240	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Eisenia andrei	peaty soil	4	7.8	14	survival LC50		547	50	van Gestel & Ma. 1990.
1,2,3-trichlorobenzene	Lumbricus rubellus	peaty soil	4	7.8	14	survival LC50		563	50	van Gestel & Ma. 1990.
1,2,4-trichlorobenzene	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		127	50	Neuhauser et al. 1986.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
1,2,4-trichlorobenzene	Perionyx excavatus	OECD soil	6	5	14	survival LC50		180	50	Neuhauser et al. 1986.
1,2,4-trichlorobenzene	Eisenia fetida	OECD soil	6	5	14	survival LC50		197	50	Neuhauser et al. 1986.
1,2,4-trichlorobenzene	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		251	50	Neuhauser et al. 1986.
1,2,3,4-tetrachlorobenzene	Eisenia fetida	sandy soil	5	1.8	14	survival LC50		75	50	van Gestel et al. 1991b.
1,2,3,4-tetrachlorobenzene	Lumbricus rubellus	sandy soil	5	1.8	14	survival LC50		112	50	van Gestel et al. 1991b.
1,2,3,4-tetrachlorobenzene	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		201	50	van Gestel et al. 1991b.
1,2,3,4-tetrachlorobenzene	Eisenia fetida	OECD soil	6	4	14	survival LC50		223	50	van Gestel et al. 1991b.
Pentachlorobenzene	Lumbricus rubellus	sandy soil	5	1.8	14	survival LC50		115	50	van Gestel et al. 1991b.
Pentachlorobenzene	Eisenia fetida	sandy soil	5	1.8	14	survival LC50		134	50	van Gestel et al. 1991b.

Table A.1 (continued)

Chemical / Form	Earthworm Species	Growth Medium	pH	%OC	Exp (D)	Response Parameter	NOEC APPL	LOEC APPL	% Dec	Reference
Pentachlorobenzene	Lumbricus rubellus	OECD soil	6	4	14	survival LC50		201	50	van Gestel et al. 1991b.
Pentachlorobenzene	Eisenia fetida	OECD soil	6	4	14	survival LC50		238	50	van Gestel et al. 1991b.
Nitrobenzene	Eudrilus eugeniae	OECD soil	6	5	14	survival LC50		226	50	Neuhauser et al. 1986.
Nitrobenzene	Eisenia fetida	OECD soil	6	5	14	survival LC50		319	50	Neuhauser et al. 1986.
Nitrobenzene	Perionyx excavatus	OECD soil	6	5	14	survival LC50		343	50	Neuhauser et al. 1986.
Nitrobenzene	Allolobophora tuberculata	OECD soil	6	5	14	survival LC50		362	50	Neuhauser et al. 1986.

APPENDIX B

TOXICITY DATA FOR MICROORGANISMS

Table B.1. Toxicity Data for Microorganisms

Chemical concentrations are mg of element/kg of growth medium

% Dec - % decrease in measured parameter at LOEC as compared to controls.

Exp Dur (d) - exposure duration in days

Growth Medium: Montmorill = mont = montmorillonite clay; Kaol = kaolinite clay

%OC - % organic carbon in growth medium

CEC = cation exchange capacity of growth medium (milliequivalents/100 g)

* denotes phenylmercury acetate

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Aluminum	AlCl3	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		675 LCT	43	Al-Khafaji & Tabatabai. 1979.
Aluminum	AlCl3	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		675 LCT	24	Al-Khafaji & Tabatabai. 1979.
Aluminum	AlCl3	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	67.5	675	34	Al-Khafaji & Tabatabai. 1979.
Aluminum	AlCl3	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	67.5	675	42	Al-Khafaji & Tabatabai. 1979.
Aluminum	AlCl3	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	67.5	675	34	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Aluminum	AlCl3	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	67.5	675	25	Juma & Tabatabai. 1977.
Arsenic	NaAsO2	native soil microflora	surface soil	6	2.6	0.1	Amidase activity		187.3 LCT	32	Frankenberger &Tabatabai. 1981
Arsenic	Na2HAsO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity		187.3 LCT	33	Juma & Tabatabai. 1977.
Arsenic	Na2HAsO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity		187.3 LCT	32	Juma & Tabatabai. 1977.
Arsenic	NaAsO2	native soil microflora	clay loam	8	3.2	0.1	Amidase activity		1873 LCT	98	Frankenberger &Tabatabai. 1981
Arsenic	NaAsO2	native soil microflora	loam	7	4.7	0.1	Amidase activity		1873 LCT	97	Frankenberger &Tabatabai. 1981
Arsenic	NaAsO2	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		1875 LCT	35	Juma & Tabatabai. 1977.
Arsenic	Na2HAsO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		1875 LCT	75,39	Juma & Tabatabai. 1977.
Arsenic	Na2HAsO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1875 LCT	62	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Barium	BaCl2	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		3433 LCT	24	Al-Khafaji & Tabatabai. 1979.
Boron	Na2B4O7	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity		27 LCT	31	Al-Khafaji & Tabatabai. 1979.
Boron	Na2B4O7	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		270 LCT	22	Juma & Tabatabai. 1977.
Boron	Na2B4O7	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		270 LCT	70	Al-Khafaji & Tabatabai. 1979.
Boron	Na2B4O7	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		270 LCT	60	Al-Khafaji & Tabatabai. 1979.
Boron	Na2B4O7	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	27	270	65	Al-Khafaji & Tabatabai. 1979.
Boron	Na2B4O7	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	27	270	33	Juma & Tabatabai. 1977.
Cadmium	CdCl2	native soil microflora	soil/litter microcosm			24	Respiration	.006	6.1	43	Lighthart & Bond. 1976.
Cadmium	Cd(NO3)2	Pseudomonas sp.	silt loam	7	2	4	Denitrification		10 LCT	23	Bollag & Barabasz. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Cadmium	C4H6CdO4	native soil microflora	phaeosem	7	1	84	Respiration	7	14	22	Reber. 1989.
Cadmium	C4H6CdO4	native soil microflora	sandy hortisol	7	1.5	84	Respiration	7	14	23	Reber. 1989.
Cadmium	CdCl2	native soil microflora	sandy loam	6	3	548	Urease activity		30 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdNO4	native soil microflora	surface soil		1.3	1	Dehydrogenase activity		30 LCT	47	Rogers & Li. 1985.
Cadmium	Cd(NO3)2	Pseudomonas denitrificans	silt loam	7	2	4	Denitrification	10	50	22	Bollag & Barabasz. 1979.
Cadmium	Cd(NO3)2	Pseudomonas aeruginosa	silt loam	7	2	4	Denitrification	10	50	25	Bollag & Barabasz. 1979.
Cadmium	CdCl2	native soil microflora	silt loam	5			Nitrification		50	>20	Suter and Sharples. 1984.
Cadmium	C4H6CdO4	native soil microflora	acid cambisol	6	1	84	Respiration	28	56	23	Reber. 1989.
Cadmium	CdCl2	native soil microflora	brown earth	5		30	Cellulolytic activity	50	100	35	Khan & Frankland. 1984.
Cadmium	Cd(NO3)2	native soil microflora	silt loam	7	2	21	Denitrification	50	100	27	Bollag & Barabasz. 1979.
Cadmium	CdCl2	native soil microflora	sandy soil	7	1	548	Urease activity		120 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdCl2	native soil microflora	sandy soil	7	1	548	Arylsulfatase activity		121 ED50	50	Haanstra & Doelman. 1991.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Cadmium	CdCl2	native soil microflora	silty loam	8	1	548	Arylsulfatase activity		137 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdCl2	native soil microflora	silty loam	8	1	548	Phosphatase activity		230 ED50	50	Doelman & Haanstra. 1989.
Cadmium	CdSO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity		281 LCT	27	Juma & Tabatabai. 1977.
Cadmium	CdCl2	native soil microflora	sandy soil	7	1	548	Phosphatase activity		330 ED50	50	Doelman & Haanstra. 1989.
Cadmium	CdCl2	native soil microflora	sandy soil	7	1	42	Urease activity		340 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdCl2	native soil microflora	sandy peat	4	6.5	548	Urease activity		490 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdCl2	native soil microflora	silty loam	8	1	548	Urease activity		520 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdCl2	native soil microflora	clay	8	1.5	548	Urease activity		520 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdSO4	Native soil microflora	silty clay	7	3	20	N mineralization		562 LCT	27	Liang & Tabatabai. 1977.
Cadmium	CdSO4	native soil microflora	clay loam	8	4	20	N mineralization		562 LCT	39	Liang & Tabatabai. 1977.
Cadmium	CdCl2	native soil microflora	sandy soil	7	1	42	Phosphatase activity		840 ED50	50	Doelman & Haanstra. 1989.
Cadmium	CdCl2	native soil microflora	soil/litter microcosm				Respiration		920 LCT	61	Lighthart et al. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Cadmium	CdCl2	native soil microflora	silty loam	8	1	42	Urease activity		970 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdSO4	native soil microflora	surface soil	6	2.9	35	Nitrification	500	1000	62	Bewley & Stotzky. 1983.
Cadmium	CdCl2	native soil microflora	clay	8	1.5	548	Arylsulfatase activity		1016 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdCl2	native soil microflora	sandy loam	6	3	548	Arylsulfatase activity		1798 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdCl2	native soil microflora	silt loam	8	1	42	Arylsulfatase activity		1888 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdCl2	native soil microflora	sandy soil	7	1	42	Arylsulfatase activity		2214 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdSO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		2810 LCT	78,51	Juma & Tabatabai. 1977.
Cadmium	CdSO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		2810 LCT	48	Juma & Tabatabai. 1977.
Cadmium	CdSO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		2810 LCT	27	Al-Khafaji & Tabatabai. 1979.
Cadmium	CdSO4	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		2810 LCT	42	Al-Khafaji & Tabatabai. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Cadmium	CdSO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	281	2810	44	Juma & Tabatabai. 1977.
Cadmium	CdSO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	281	2810	55	Al-Khafaji & Tabatabai. 1979.
Cadmium	CdSO4	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	281	2810	23	Al-Khafaji & Tabatabai. 1979.
Cadmium	CdCl2	native soil microflora	sandy peat	4	6.5	42	Arylsulfatase activity		3192 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdCl2	native soil microflora	sandy peat	4	6.5	42	Urease activity		3260 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdCl2	native soil microflora	clay	8	1.5	42	Urease activity		4460 ED50	50	Doelman & Haanstra. 1986.
Cadmium	CdCl2	Native soil microflora	clay	8	1.5	548	Phosphatase activity		5305 ED50	50	Doelman & Haanstra. 1989.
Cadmium	CdCl2	Native soil microflora	Silty loam	8	1	42	Phosphatase activity		5485 ED50	50	Doelman & Haanstra. 1989.
Cadmium	CdCl2	native soil microflora	clay	8	1.5	42	Arylsulfatase activity		9520 ED50	50	Haanstra & Doelman. 1991.
Cadmium	CdCl2	Native soil microflora	clay	8	1.5	42	Phosphatase activity		9779 ED50	50	Doelman & Haanstra. 1989.
Cadmium	CdCl2	native soil microflora	sandy loam	6	3	548	Phosphatase activity		9869 ED50	50	Doelman & Haanstra. 1989.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Chromium	CrCl3	native soil microflora	sandy loam	6	3	548	Urease activity		<1 ED50	50	Doelman & Haanstra. 1986.
Chromium	K2Cr2O7	native soil microflora	sandy loam	6		22	Respiration		10 LCT	33	Ross et al. 1981.
Chromium	K2Cr2O7	native soil microflora	loam	6		22	Respiration		10 LCT	27	Ross et al. 1981.
Chromium	CrCl3	native soil microflora	sandy loam	6	3	548	Arylsulfatase activity		12 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	sandy soil	7	1	42	Arylsulfatase activity		17 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrSO4	native soil microflora	surface soil		1.3	1	Dehydrogenase activity		30 LCT	54	Rogers & Li. 1985.
Chromium	CrCl3	native soil microflora	sandy loam	6		22	Respiration		100 LCT	48	Ross et al. 1981.
Chromium	CrCl3	native soil microflora	loam	6		22	Respiration		100 LCT	41	Ross et al. 1981.
Chromium	CrCl3	native soil microflora	sandy soil	7	1	548	Arylsulfatase activity		203 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	loam	6	3	20	N mineralization		260 LCT	20	Liang & Tabatabai. 1977.
Chromium	CrCl3	native soil microflora	silty clay loam	7	6	20	N mineralization		260 LCT	24	Liang & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Chromium	CrCl3	native soil microflora	clay	8	1.5	42	Arylsulfatase activity		281 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	sandy loam	6	3	42	Arylsulfatase activity		309 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	silty loam	8	1	548	Arylsulfatase activity		411 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	clay	8	1.5	548	Urease activity		420 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrCl3	native soil microflora	clay	8	1.5	42	Urease activity		490 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrCl3	native soil microflora	clay	8	1.5	548	Arylsulfatase activity		575 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	sandy soil	7	1	548	Urease activity		630 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrO	native soil microflora	sandy soil	7		42	N mineralization & nitrification		1000 LCT	22,24	Bhuiya & Cornfield. 1976.
Chromium	CuSO4	native soil microflora	sandy loam	7	2	21	Nitrification	100	1000	67	Premi & Cornfield. 1969.
Chromium	CrCl3	native soil microflora	silty loam	8	1	548	Urease activity		1110 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrCl3	native soil microflora	clay	8	1.5	42	Phosphatase activity		1170 ED50	50	Doelman & Haanstra. 1989.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Chromium	CrCl3	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1300 LCT	54	Al-Khafaji & Tabatabai. 1979.
Chromium	CrCl3	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		1300 LCT	32	Al-Khafaji & Tabatabai. 1979.
Chromium	CrCl3	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		1300 LCT	27,25	Juma & Tabatabai. 1977.
Chromium	CrCl3	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1300 LCT	27	Juma & Tabatabai. 1977.
Chromium	CrCl3	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	130	1300	43	Al-Khafaji & Tabatabai. 1979.
Chromium	CrCl3	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	130	1300	35	Al-Khafaji & Tabatabai. 1979.
Chromium	CrCl3	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	130	1300	30	Juma & Tabatabai. 1977.
Chromium	CrCl3	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	130	1300	39	Juma & Tabatabai. 1977.
Chromium	CrCl3	native soil microflora	sandy peat	4	6.5	42	Urease activity		1360 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrCl3	native soil microflora	clay	8	1.5	548	Phosphatase activity		2652 ED50	50	Doelman & Haanstra. 1989.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Chromium	CrCl3	native soil microflora	sandy loam	6	3	548	Phosphatase activity		2792 ED50	50	Doelman & Haanstra. 1989.
Chromium	CrCl3	native soil microflora	sandy peat	4	6.5	548	Arylsulfatase activity		3203 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	sandy soil	7	1	42	Phosphatase activity		3208 ED50	50	Doelman & Haanstra. 1989.
Chromium	CrCl3	native soil microflora	sandy peat	4	6.5	42	Phosphatase activity		3208 ED50	50	Doelman & Haanstra. 1989.
Chromium	CrCl3	native soil microflora	silty loam	8	1	42	Phosphatase activity		3728 ED50	50	Doelman & Haanstra. 1989.
Chromium	CrCl3	native soil microflora	sandy soil	7	1	42	Urease activity		3970 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrCl3	native soil microflora	silty loam	8	1	548	Phosphatase activity		4139 ED50	50	Doelman & Haanstra. 1989.
Chromium	CrCl3	native soil microflora	silty loam	8	1	42	Urease activity		4470 ED50	50	Doelman & Haanstra. 1986.
Chromium	CrCl3	native soil microflora	sandy loam	6	3	42	Phosphatase activity		5512 ED50	50	Doelman & Haanstra. 1989.
Chromium	CrCl3	native soil microflora	sandy peat	4	6.5	42	Arylsulfatase activity		5928 ED50	50	Haanstra & Doelman. 1991.
Chromium	CrCl3	native soil microflora	sandy soil	7	1	548	Phosphatase activity		20020 ED50	50	Doelman & Haanstra. 1989.
Cobalt	CoCl2	native soil microflora	soil/litter microcosm				Respiration		1362 LCT	23	Lighthart et al. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Copper	Cu(NO3)2	Pseudomonas sp.	silt loam	7	2	4	Denitrification		10 LCT	53	Bollag & Barabasz. 1979.
Copper	CuSO4	native soil microflora	surface soil		1.3	1	Dehydrogenase activity		30 LCT	28	Rogers & Li. 1985.
Copper	Cu(NO3)2	Pseudomonas aeruginosa	silt loam	7	2	4	Denitrification	10	50	43	Bollag & Barabasz. 1979.
Copper	CuSO4	native soil microflora	sandy loam	5	2	21	N mineralization		100 LCT	20	Quraishi & Cornfield. 1973.
Copper	CuCl2	native soil microflora	sandy soil	7	1	42	Phosphatase activity		140 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	sandy soil	7	1	548	Phosphatase activity		170 ED50	50	Doelman & Haanstra. 1989.
Copper	Cu(NO3)2	native soil microflora	silt loam	7	2	21	Denitrification	100	250	44	Bollag & Barabasz. 1979.
Copper	Cu(NO3)2	Pseudomonas denitrificans	silt loam	7	2	4	Denitrification	100	250	22	Bollag & Barabasz. 1979.
Copper	CuCl2	native soil microflora	sandy soil	7	1	42	Urease activity		260 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	sandy soil	7	1	548	Arylsulfatase activity		287 ED50	50	Haanstra & Doelman. 1991.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Copper	CuSO4	native soil microflora	silty clay loam	7	6	20	N mineralization		320 LCT	82	Liang & Tabatabai. 1977.
Copper	CuCl2	native soil microflora	sandy soil	7	1	42	Arylsulfatase activity		391 ED50	50	Haanstra & Doelman. 1991.
Copper	CuCl2	native soil microflora	silt loam	5			Nitrification		500	>2	Suter and Sharples. 1984.
Copper	CuCl2	native soil microflora	sandy loam	6	3	548	Arylsulfatase activity		548 ED50	50	Haanstra & Doelman. 1991.
Copper	CuCl2	native soil microflora	sandy loam	6	3	42	Urease activity		570 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	sandy soil	7	1	548	Urease activity		680 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	silty loam	8	1	548	Phosphatase activity		744 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	silty loam	8	1	548	Arylsulfatase activity		763 ED50	50	Haanstra & Doelman. 1991.
Copper	CuCl2	native soil microflora	sandy loam	6	3	42	Arylsulfatase activity		967 ED50	50	Haanstra & Doelman. 1991.
Copper	CuO	native soil microflora	sandy soil	6	2	84	C mineralization		1000 LCT	33	Bhuiya & Cornfield. 1972.
Copper	CuSO4	native soil microflora	sandy loam	8	2	56	Nitrification	100	1000	38	Premi & Cornfield. 1969/1970.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Copper	CuSO4	native soil microflora	sandy loam	6	2	21	N mineralization	100	1000	75	Quraishi & Cornfield. 1973.
Copper	CuSO4	native soil microflora	sandy loam	5	2	21	N mineralization	100	1000	100	Quraishi & Cornfield. 1973.
Copper	CuSO4	native soil microflora	sandy loam	7	2	21	N mineralization	100	1000	39	Quraishi & Cornfield. 1973.
Copper	CuCl2	native soil microflora	clay	8	1.5	548	Urease activity		1080 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	clay	8	1.5	42	Urease activity		1370 ED50	50	Doelman & Haanstra. 1986.
Copper	CuSO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1590 LCT	22	Al-Khafaji & Tabatabai. 1979.
Copper	CuCl2	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1590 LCT	43	Juma & Tabatabai. 1977.
Copper	CuSO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1590 LCT	36	Juma & Tabatabai. 1977.
Copper	CuCl2	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		1590 LCT	30,28	Juma & Tabatabai. 1977.
Copper	CuSO4	native soil microflora	clay loam	8	3.7	0.1	Acid phosphatase activity		1590 LCT	26	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Copper	CuSO4	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	159	1590	26	Al-Khafaji & Tabatabai. 1979.
Copper	CuSO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	159	1590	32	Al-Khafaji & Tabatabai. 1979.
Copper	CuCl2	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	159	1590	51	Juma & Tabatabai. 1977.
Copper	CuSO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	159	1590	44	Juma & Tabatabai. 1977.
Copper	CuCl2	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	159	1590	32	Juma & Tabatabai. 1977.
Copper	CuSO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	159	1590	23	Juma & Tabatabai. 1977.
Copper	CuCl2	native soil microflora	sandy loam	6	3	548	Phosphatase activity		1895 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	sandy peat	4	6.5	548	Urease activity		1970 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	silty loam	8	1	548	Urease activity		1990 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	sandy peat	4	6.5	548	Phosphatase activity		2442 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	sandy peat	4	6.5	42	Phosphatase activity		2639 ED50	50	Doelman & Haanstra. 1989.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Copper	CuCl2	native soil microflora	clay	8	1.5	42	Phosphatase activity		2722 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	clay	8	1.5	42	Arylsulfatase activity		2722 ED50	50	Haanstra & Doelman. 1991.
Copper	CuCl2	native soil microflora	clay	8	1.5	548	Phosphatase activity		2754 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	sandy peat	4	6.5	42	Urease activity		4200 ED50	50	Doelman & Haanstra. 1986.
Copper	CuCl2	native soil microflora	clay	8	1.5	548	Arylsulfatase activity		4853 ED50	50	Haanstra & Doelman. 1991.
Copper	CuCl2	native soil microflora	silty loam	8	1	42	Phosphatase activity		6424 ED50	50	Doelman & Haanstra. 1989.
Copper	CuCl2	native soil microflora	sandy peat	4	6.5	548	Arylsulfatase activity		6996 ED50	50	Haanstra & Doelman. 1991.
Copper	CuCl2	native soil microflora	sandy peat	4	6.5	42	Arylsulfatase activity		8904 ED50	50	Haanstra & Doelman. 1991.
Copper	CuSO4	native soil microflora	sandy loam	7	2	21	Nitrification	1000	10000	75	Premi & Cornfield. 1969.
Copper	CuCl2	native soil microflora	silty loam	8	1	42	Arylsulfatase activity		14946 ED50	50	Haanstra & Doelman. 1991.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Fluoride	KF	native soil microflora	leaf litter			63	P mineralization		32 LCT	22	van Wensem & Adema. 1991.
Fluoride	NaF	native soil microflora	surface soil		1.3	1	Dehydrogenase activity	3000	5000	30	Rogers & Li. 1985.
Iron	FeCl3	native soil microflora	clay loam	8	4	20	N mineralization		280 LCT	22	Liang & Tabatabai. 1977.
Iron	FeCl3	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1398 LCT	59	Al-Khafaji & Tabatabai. 1979.
Iron	FeCl3	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		1398 LCT	23	Al-Khafaji & Tabatabai. 1979.
Iron	FeSO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		1398 LCT	22	Juma & Tabatabai. 1977.
Iron	FeCl2	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1398 LCT	26	Juma & Tabatabai. 1977.
Iron	FeCl3	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	139.8	1398	45	Al-Khafaji & Tabatabai. 1979.
Iron	FeSO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	139.8	1398	27	Juma & Tabatabai. 1977.
Iron	FeCl2	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	139.8	1398	40	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Iron	FeCl2	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	139.8	1398	32	Juma & Tabatabai. 1977.
Lanthanum	LaCl3	native soil microflora	soil/litter microcosm				Respiration		57 LCT	22	Lighthart et al. 1977.
Lead	PbCl2	native soil microflora	clay	8	1.5	1	Dehydrogenase activity		375 LCT	29	Doelman & Haanstra. 1979.
Lead	PbCl2	native soil microflora	sandy soil	6	1.5	1	Respiration	375	750	35	Doelman & Haanstra. 1979.
Lead	PbC4H6O4	native soil microflora	silt loam			2	Amylase activity	450	900	31	Cole. 1977.
Lead	PbCl2	native soil microflora	silt loam			2	Amylase activity	450	900	21	Cole. 1977.
Lead	PbO	native soil microflora	sandy soil	6	2	84	C mineralization		1000 LCT	22	Bhuiya & Cornfield. 1972.
Lead	PbCl2	native soil microflora	brown earth	5		30	Cellulolytic activity	500	1000	23	Khan & Frankland. 1984.
Lead	PbC4H6O4	native soil microflora	clay loam	8	4	20	N mineralization		1035 LCT	28	Liang & Tabatabai. 1977.
Lead	PbCl2	native soil microflora	clay	8	1.5	548	Urease activity		1340 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	sandy soil	6	1.5	1217	Respiration		1500 LCT	30	Doelman & Haanstra. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Lead	PbCl2	native soil microflora	sandy soil	5	3	1	Dehydrogenase activity	750	1500	78	Doelman & Haanstra. 1979.
Lead	PbCl2	native soil microflora	sandy soil	7	1	548	Urease activity		1590 ED50	50	Doelman & Haanstra. 1986.
Lead	PbS	native soil microflora	silt loam			2	Amylase activity	900	1800	58	Cole. 1977.
Lead	PbC4H6O4	native soil microflora	silt loam			4	alpha-glucosidase synthesis		2000 LCT	38	Cole. 1977.
Lead	PbC4H6O4	native soil microflora	silt loam			2	Amylase activity		2000 LCT	74	Cole. 1977.
Lead	PbC4H6O4	native soil microflora	silt loam			5	Bacterial population size		2000 LCT	37	Cole. 1977.
Lead	PbCl2	native soil microflora	sandy loam	6	3	548	Urease activity		2870 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	sandy loam	6	3	548	Arylsulfatase activity		3004 ED50	50	Haanstra & Doelman. 1991.
Lead	PbCl2	native soil microflora	silty loam	8	1	548	Arylsulfatase activity		4538 ED50	50	Haanstra & Doelman. 1991.
Lead	PbCl2	native soil microflora	sandy loam	6	3	42	Urease activity		5060 ED50	50	Doelman & Haanstra. 1986.
Lead	PbC4H6O4	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		5175 LCT	33	Juma & Tabatabai. 1977.
Lead	PbNO3	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		5175 LCT	38	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Lead	PbNO3	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	517.5	5175	26	Juma & Tabatabai. 1977.
Lead	PbC4H6O4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	517.5	5175	24	Juma & Tabatabai. 1977.
Lead	PbC4H6O4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	517.5	5175	21	Juma & Tabatabai. 1977.
Lead	PbCl2	native soil microflora	clay	8	1.5	42	Urease activity		5730 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	sandy peat	4	6.5	42	Urease activity		6230 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	sandy peat	4	6.5	548	Urease activity		7050 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	silty loam	8	1	548	Phosphatase activity		7604 ED50	50	Doelman & Haanstra. 1989.
Lead	PbCl2	native soil microflora	silty loam	8	1	42	Urease activity		7190 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	silty loam	8	1	548	Urease activity		8130 ED50	50	Doelman & Haanstra. 1986.
Lead	PbCl2	native soil microflora	sandy soil	7	1	42	Arylsulfatase activity		8288 ED50	50	Haanstra & Doelman. 1991.
Lead	PbCl2	native soil microflora	sandy soil	7	1	548	Arylsulfatase activity		8785 ED50	50	Haanstra & Doelman. 1991.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Lead	PbCl2	native soil microflora	silty loam	8	1	42	Arylsulfatase activity		9138 ED50	50	Haanstra & Doelman. 1991.
Lead	Pb(NO3)2	native soil microflora	sandy loam	5		15	Respiration	1000	10000	29	Debosz et al. 1985.
Lead	PbCl2	native soil microflora	clay	8	1.5	42	Phosphatase activity		11168 ED50	50	Doelman & Haanstra. 1989.
Lead	PbCl2	native soil microflora	clay	8	1.5	548	Arylsulfatase activity		12411 ED50	50	Haanstra & Doelman. 1991.
Lead	PbCl2	native soil microflora	sandy soil	7	1	548	Phosphatase activity		78943 ED50	50	Doelman & Haanstra. 1989.
Lithium	LiCl	native soil microflora	soil/litter microcosm				Respiration		17 LCT	43	Lighthart et al. 1977.
Manganese	MnSO4	native soil microflora	sandy loam	7	2	21	Nitrification		100 LCT	67	Premi & Cornfield. 1969.
Manganese	MnCl2	native soil microflora	clay loam	8	4	20	N mineralization		275 LCT	26	Liang & Tabatabai. 1977.
Manganese	MnCl2	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		1375 LCT	25	Juma & Tabatabai. 1977.
Manganese	MnCl2	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	137.5	1375	62	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Mercury	HgCl2	native soil microflora	clay loam	8	2	28	C mineralization		0.1 LCT	87	Landa & Fang. 1978.
Mercury	PMA*	native soil microflora	dune sand	8	1		Nitrification		10 LCT	57	van Faassen. 1973.
Mercury	HgCl2	native soil microflora	clay loam	7	3	0.2	urease activity		50 LCT	38	Bremner & Douglas. 1971.
Mercury	HgSO4	native soil microflora	clay loam	7	3	0.2	urease activity		50 LCT	36	Bremner & Douglas. 1971.
Mercury	HgCl2	native soil microflora	silty clay loam	7	2.2	0.2	urease activity		50 LCT	42	Bremner & Douglas. 1971.
Mercury	HgSO4	native soil microflora	silty clay loam	7	2.2	0.2	urease activity		50 LCT	46	Bremner & Douglas. 1971.
Mercury	HgCl2	native soil microflora	clay loam	8	2	28	C mineralization	10	100	45	Landa & Fang. 1978.
Mercury	HgCl2	native soil microflora	silty clay	7	7	28	C mineralization	10	100	28	Landa & Fang. 1978.
Mercury	HgCl2	native soil microflora	clay	8	3		Nitrification	10	100	40	van Faassen. 1973.
Mercury	PMA*	native soil microflora	clay	8	3		Nitrification & ammonification	10	100	94,42	van Faassen. 1973.
Mercury	HgCl2	native soil microflora	dune sand	8	1		Nitrification & ammonification	10	100	95,34	van Faassen. 1973.
Mercury	HgCl2	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity		501.5 LCT	39	Al-Khafaji & Tabatabai. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Mercury	HgCl2	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity		501.5 LCT	34	Al-Khafaji & Tabatabai. 1979.
Mercury	HgCl2	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity		501.5 LCT	34	Al-Khafaji & Tabatabai. 1979.
Mercury	HgCl2	native soil microflora	loam	6	3	20	N mineralization		1003 LCT	73	Liang & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	silty clay	7	3	20	N mineralization		1003 LCT	39	Liang & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	clay loam	8	4	20	N mineralization		1003 LCT	35	Liang & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	silty clay loam	7	6	20	N mineralization		1003 LCT	32	Liang & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	clay loam	8	3.2	0.1	Amidase activity		5015 LCT	30	Frankenberger &Tabatabai. 1981
Mercury	HgCl2	native soil microflora	loam	7	4.7	0.1	Amidase activity		5015 LCT	27	Frankenberger &Tabatabai. 1981
Mercury	HgCl2	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		5015 LCT	96	Al-Khafaji & Tabatabai. 1979.
Mercury	HgCl2	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		5015 LCT	86	Al-Khafaji & Tabatabai. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Mercury	HgCl2	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		5015 LCT	53,52	Juma & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		5015 LCT	53	Juma & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	surface soil	6	2.6	0.1	Amidase activity	501.5	5015	46	Frankenberger &Tabatabai. 1981
Mercury	HgCl2	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	501.5	5015	63	Juma & Tabatabai. 1977.
Mercury	HgCl2	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	501.5	5015	41	Juma & Tabatabai. 1977.
Molybdenum	H2MoO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity		239.8 LCT	40	Al-Khafaji & Tabatabai. 1979.
Molybdenum	H2MoO4	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity		239.8 LCT	26	Al-Khafaji & Tabatabai. 1979.
Molybdenum	H2MoO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity		239.8 LCT	69	Juma & Tabatabai. 1977.
Molybdenum	H2MoO4	native soil microflora	silty clay	7	2	20	N mineralization		480 LCT	22	Liang & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Molybdenum	H2MoO4	native soil microflora	clay loam	8	4	20	N mineralization		480 LCT	22	Liang & Tabatabai. 1977.
Molybdenum	H2MoO4	native soil microflora	silty clay loam	7	6	20	N mineralization		480 LCT	54	Liang & Tabatabai. 1977.
Molybdenum	H2MoO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		2398 LCT	63	Al-Khafaji & Tabatabai. 1979.
Molybdenum	H2MoO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		2398 LCT	25,41	Juma & Tabatabai. 1977.
Molybdenum	H2MoO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		2398 LCT	68	Juma & Tabatabai. 1977.
Molybdenum	H2MoO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	239.8	2398	22	Juma & Tabatabai. 1977.
Nickel	NiSO4	native soil microflora	sand	6	2	42	Respiration		10 LCT	22	Giashuddin & Cornfield. 1979.
Nickel	NiSO4	native soil microflora	surface soil		1.3	1	Dehydrogenase activity		30 LCT	39	Rogers & Li. 1985.
Nickel	NiO	native soil microflora	sand	6	2	42	Respiration		50 LCT	22	Giashuddin & Cornfield. 1979.
Nickel	NiCl2	Aspergillus clavatus	sandy loam	5	3	7	Growth rate	10	50	36	Babich & Stotzky. 1982.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Nickel	NiCl2	native soil microflora	silt loam	8	1.2	548	Arylsulfatase activity		92 ED50	50	Haanstra & Doelman. 1991.
Nickel	NiCl2	native soil microflora	sand	7	0.8	548	Arylsulfatase activity		99 ED50	50	Haanstra & Doelman. 1991.
Nickel	NiSO4	Agrobacteerium radiobacter	sandy loam	5	3	7	Growth		250 LCT	98	Babich & Stotzky. 1982.
Nickel	NiSO4	Proteus vulgaris	sandy loam	5	3	7	Growth		250 LCT	54	Babich & Stotzky. 1982.
Nickel	NiSO4	Bacillus megaterium	sandy loam	5	3	7	Growth		250 LCT	100	Babich & Stotzky. 1982.
Nickel	NiSO4	Cryptococcus terreus	sandy loam	5	3	7	Growth		250 LCT	73	Babich & Stotzky. 1982.
Nickel	NiSO4	Torulopsis glabrata	sandy loam	5	3	7	Growth		250 LCT	84	Babich & Stotzky. 1982.
Nickel	NiO	native soil microflora	sand	7	2	42	Respiration	50	250	33	Giashuddin & Cornfield. 1979.
Nickel	NiCl2	Aspergillus flavus	sandy loam	5	3	7	Growth rate	100	250	30	Babich & Stotzky. 1982.
Nickel	NiCl2	Penicillium vermiculatum	sandy loam	5	3	7	Growth rate	100	250	41	Babich & Stotzky. 1982.
Nickel	NiCl2	Aspergillus flavipes	sandy loam	5	3	7	Growth rate	250	500	98	Babich & Stotzky. 1982.
Nickel	NiCl2	Aspergillus niger	sandy loam	5	3	7	Growth rate	250	500	42	Babich & Stotzky. 1982.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Nickel	NiCl2	Rhizopus stolonifer	sandy loam	5	3	7	Growth rate	250	500	84	Babich & Stotzky. 1982.
Nickel	NiCl2	Gliocladium sp.	sandy loam	5	3	7	Growth rate	250	500	23	Babich & Stotzky. 1982.
Nickel	NiSO4	Serratia marcescens	sandy loam	5	3	7	Growth	250	500	87	Babich & Stotzky. 1982.
Nickel	NiSO4	Nocardia rhodochrous	sandy loam	5	3	7	Growth	250	500	25	Babich & Stotzky. 1982.
Nickel	NiSO4	Aspergillus flavipes	sandy loam+montmo rill	6	2.5	7	Growth		750 LCT	44	Babich & Stotzky. 1982.
Nickel	NiSO4	Aspergillus clavatus	sandy loam+mont	6	2.5	7	Growth		750 LCT	31	Babich & Stotzky. 1982.
Nickel	NiSO4	Penicillium vermiculatum	sandy loam+mont	6	2.5	7	Growth		750 LCT	27	Babich & Stotzky. 1982.
Nickel	NiSO4	Trichoderma viride	sandy loam+mont	6	2.5	7	Growth		750 LCT	40	Babich & Stotzky. 1982.
Nickel	NiSO4	Aspergillus flavipes	sandy loam+kaol	6	2.5	7	Growth		750 LCT	64	Babich & Stotzky. 1982.
Nickel	NiSO4	Aspergillus clavatus	sandy loam+kaol	6	2.5	7	Growth		750 LCT	64	Babich & Stotzky. 1982.
Nickel	NiSO4	Rhizopus stolonifer	sandy loam+kaol	6	2.5	7	Growth		750 LCT	54	Babich & Stotzky. 1982.
Nickel	NiSO4	Penicillium vermiculatum	sandy loam+kaol	6	2.5	7	Growth		750 LCT	89	Babich & Stotzky. 1982.
Nickel	NiSO4	Trichoderma viride	sandy loam+kaol	6	2.5	7	Growth		750 LCT	73	Babich & Stotzky. 1982.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Nickel	NiSO4	Aspergillus flavipes	sandy loam	5	3	7	Growth rate		750 LCT	93	Babich & Stotzky. 1982.
Nickel	NiSO4	Aspergillus clavatus	sandy loam	5	3	7	Growth rate		750 LCT	84	Babich & Stotzky. 1982.
Nickel	NiSO4	Rhizopus stolonifer	sandy loam	5	3	7	Growth rate		750 LCT	78	Babich & Stotzky. 1982.
Nickel	NiSO4	Penicillium vermiculatum	sandy loam	5	3	7	Growth rate		750 LCT	82	Babich & Stotzky. 1982.
Nickel	NiSO4	Trichoderma viride	sandy loam	5	3	7	Growth rate		750 LCT	85	Babich & Stotzky. 1982.
Nickel	NiSO4	Gliocladium sp.	sandy loam	5	3	7	Growth rate		750 LCT	52	Babich & Stotzky. 1982.
Nickel	NiSO4	Bacillus cereus	sandy loam	5	3	7	Growth	500	750	32	Babich & Stotzky. 1982.
Nickel	NiSO4	Rhodotorula rubra	sandy loam	5	3	7	Growth	500	750	29	Babich & Stotzky. 1982.
Nickel	NiCl2	Trichoderma viride	sandy loam	5	3	7	Growth rate	500	750	85	Babich & Stotzky. 1982.
Nickel	NiCl2	native soil microflora	sand	7	0.8	548	Phosphatase activity		769 ED50	50	Doelman & Haanstra. 1989.
Nickel	NiSO4	Bacillus megaterium	sandy loam	8	1		Growth	750	1000	22	Babich & Stotzky. 1982.
Nickel	NiSO4	Cryptococcus terreus	sandy loam	8	1		Growth	750	1000	21	Babich & Stotzky. 1982.
Nickel	NiCl2	native soil microflora	sand	7	0.8	42	Phosphatase activity		1109 ED50	50	Doelman & Haanstra. 1989.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Nickel	NiCl2	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1468 LCT	26	Al-Khafaji & Tabatabai. 1979.
Nickel	NiCl2	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		1468 LCT	22	Juma & Tabatabai. 1977.
Nickel	NiCl2	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1468 LCT	21	Juma & Tabatabai. 1977.
Nickel	NiCl2	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	146.8	1468	23	Juma & Tabatabai. 1977.
Nickel	NiCl2	native soil microflora	sand	7	0.8	42	Arylsulfatase activity		2119 ED50	50	Haanstra & Doelman. 1991.
Nickel	NiCl2	native soil microflora	silt loam	8	1.2	548	Phosphatase activity		2131 ED50	50	Doelman & Haanstra. 1989.
Nickel	NiCl2	native soil microflora	sandy loam	6	2.8	42	Arylsulfatase activity		2348 ED50	50	Haanstra & Doelman. 1991.
Nickel	NiCl2	native soil microflora	clay	8	1.6	548	Arylsulfatase activity		2436 ED50	50	Haanstra & Doelman. 1991.
Nickel	NiCl2	native soil microflora	silt loam	8	1.2	42	Phosphatase activity		4232 ED50	50	Doelman & Haanstra. 1989.
Nickel	NiCl2	native soil microflora	silt loam	8	1.2	42	Arylsulfatase activity		5400 ED50	50	Haanstra & Doelman. 1991.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Nickel	NiCl2	native soil microflora	sandy loam	6	2.8	42	Phosphatase activity		5688 ED50	50	Doelman & Haanstra. 1989.
Nickel	NiCl2	native soil microflora	clay	8	1.6	42	Phosphatase activity		6516 ED50	50	Doelman & Haanstra. 1989.
Nickel	NiCl2	native soil microflora	sandy loam	6	2.8	548	Phosphatase activity		8042 ED50	50	Doelman & Haanstra. 1989.
Nickel	NiCl2	native soil microflora	sandy peat	4	6.4	548	Arylsulfatase activity		8101 ED50	50	Haanstra & Doelman. 1991.
Selenium	H2SeO3	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity		197.5 LCT	21	Al-Khafaji & Tabatabai. 1979.
Selenium	SeO2	native soil microflora	soil/litter microcosm				Respiration		484 LCT	43	Lighthart et al. 1977.
Selenium	H2SeO3	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1975 LCT	32	Al-Khafaji & Tabatabai. 1979.
Selenium	H2SeO3	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		1975 LCT	26	Al-Khafaji & Tabatabai. 1979.
Selenium	H2SeO3	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		1975 LCT	30,39	Juma & Tabatabai. 1977.
Selenium	H2SeO3	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1975 LCT	34	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Selenium	H2SeO3	native soil microflora	surface soil	6	2.6	0.1	Amidase activity	197.5	1975	27	Frankenberger &Tabatabai. 1981
Selenium	H2SeO3	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	197.5	1975	26	Al-Khafaji & Tabatabai. 1979.
Selenium	H2SeO3	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	197.5	1975	24	Juma & Tabatabai. 1977.
Selenium	H2SeO3	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	197.5	1975	35	Juma & Tabatabai. 1977.
Silver	AgSO4	native soil microflora	clay loam	7	3	0.2	urease activity		50 LCT	61	Bremner & Douglas. 1971.
Silver	AgNO3	native soil microflora	silty clay loam	7	2.2	0.2	urease activity		50 LCT	65	Bremner & Douglas. 1971.
Silver	AgSO4	native soil microflora		7	2.2	0.2	urease activity		50 LCT	63	Bremner & Douglas. 1971.
Silver	AgNO3	native soil microflora	clay loam	7	3	0.2	urease activity		50 LCT	60	Bremner & Douglas. 1971.
Silver	AgSO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity		269.8 LCT	53	Al-Khafaji & Tabatabai. 1979.
Silver	AgSO4	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity		269.8 LCT	80	Al-Khafaji & Tabatabai. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Silver	AgSO4	native soil microflora	loam	6	3	20	N mineralization		540 LCT	73	Liang & Tabatabai. 1977.
Silver	AgSO4	native soil microflora	silty clay	7	3	20	N mineralization		540 LCT	41	Liang & Tabatabai. 1977.
Silver	AgSO4	native soil microflora	clay loam	8	4	20	N mineralization		540 LCT	59	Liang & Tabatabai. 1977.
Silver	AgSO4	native soil microflora	silty clay loam	7	6	20	N mineralization		540 LCT	52	Liang & Tabatabai. 1977.
Silver	AgSO4	native soil microflora	loam	7	4.7	0.1	Amidase activity		2698 LCT	50	Frankenberger &Tabatabai. 1981
Silver	AgSO4	native soil microflora	clay loam	8	3.2	0.1	Amidase activity		2698 LCT	53	Frankenberger &Tabatabai. 1981
Silver	AgSO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		2698 LCT	94	Al-Khafaji & Tabatabai. 1979.
Silver	AgSO4	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		2698 LCT	95	Al-Khafaji & Tabatabai. 1979.
Silver	AgSO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		2698 LCT	93,38	Juma & Tabatabai. 1977.
Silver	AgSO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity		2698 LCT	28	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Silver	AgSO4	native soil microflora	surface soil	6	2.6	0.1	Amidase activity	269.8	2698	62	Frankenberger &Tabatabai. 1981
Tin	SnCl2	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		2968 LCT	60	Al-Khafaji & Tabatabai. 1979.
Tin	SnCl2	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		2968 LCT	32	Al-Khafaji & Tabatabai. 1979.
Tin	SnCl2	native soil microflora	clay loam	8	3.7	0.1	Alkaline phosphatase activity		2968 LCT	25	Juma & Tabatabai. 1977.
Tin	SnCl2	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		2968 LCT	21	Juma & Tabatabai. 1977.
Tin	SnCl2	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	296.8	2968	45	Al-Khafaji & Tabatabai. 1979.
Tin	SnCl2	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	296.8	2968	41	Juma & Tabatabai. 1977.
Tin	SnCl2	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	296.8	2968	38	Juma & Tabatabai. 1977.
Titanium	TiSO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1198 LCT	33	Al-Khafaji & Tabatabai. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Titanium	TiSO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	119.8	1198	31	Al-Khafaji & Tabatabai. 1979.
Tungsten	Na2WO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity		459.8 LCT	75	Juma & Tabatabai. 1977.
Tungsten	Na2WO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		4598 LCT	23	Al-Khafaji & Tabatabai. 1979.
Tungsten	Na2WO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		4598 LCT	29,45	Juma & Tabatabai. 1977.
Tungsten	Na2WO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		4598 LCT	69	Juma & Tabatabai. 1977.
Tungsten	Na2WO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	459.8	4598	38	Al-Khafaji & Tabatabai. 1979.
Tungsten	Na2WO4	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	459.8	4598	25	Al-Khafaji & Tabatabai. 1979.
Tungsten	Na2WO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	459.8	4598	32	Juma & Tabatabai. 1977.
Vanadium	V2O5	native soil microflora	soil/litter microcosm				Respiration		23 LCT	21	Lighthart et al. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Vanadium	NaVO3	native soil microflora	Forest mor (litter)		46	0.1	Acid phosphatase activity	30	50	40	Tyler. 1976.
Vanadium	VSO4	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity		127.3 LCT	76	Al-Khafaji & Tabatabai. 1979.
Vanadium	VSO4	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity		127.3 LCT	32	Al-Khafaji & Tabatabai. 1979.
Vanadium	VSO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity		127.3 LCT	30	Juma & Tabatabai. 1977.
Vanadium	VSO4	native soil microflora	clay loam	6	2.7	0.1	Arylsulfatase activity		1273 LCT	87	Al-Khafaji & Tabatabai. 1979.
Vanadium	VSO4	native soil microflora	loam	7	5.3	0.1	Arylsulfatase activity		1273 LCT	85	Al-Khafaji & Tabatabai. 1979.
Vanadium	VSO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		1273 LCT	61,45	Juma & Tabatabai. 1977.
Vanadium	VSO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1273 LCT	55	Juma & Tabatabai. 1977.
Vanadium	VSO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	127.3	1273	60	Juma & Tabatabai. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Zinc	Zn(NO3)2	Pseudomonas sp.	silt loam	7		4	Denitrification	10	50	29	Bollag & Barabasz. 1979.
Zinc	ZnCl2	native soil microflora	sandy peat	4	6.5	548	Urease activity		70 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnCl2	native soil microflora	clay	8	1.5	548	Urease activity		90 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnSO4	native soil microflora	sandy loam	7	2	21	Nitrification		100 LCT	57	Premi & Cornfield. 1969.
Zinc	ZnSO4	native soil microflora	sandy loam	8	2	56	Nitrification		100 LCT	43	Premi & Cornfield. 1969/1970.
Zinc	ZnCl2	native soil microflora	sandy loam	6	3	548	Urease activity		110 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnCl2	native soil microflora	sandy soil	7	1	548	Phosphatase activity		170 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	sandy soil	7	1	42	Phosphatase activity		220 ED50	50	Doelman & Haanstra. 1989.
Zinc	Zn(NO3)2	native soil microflora	silt loam	7		21	Denitrification	100	250	31	Bollag & Barabasz. 1979.
Zinc	Zn(NO3)2	Pseudomonas denitrificans	silt loam	7		4	Denitrification	100	250	22	Bollag & Barabasz. 1979.
Zinc	Zn(NO3)2	Pseudomonas aeruginosa	silt loam	7		4	Denitrification	100	250	35	Bollag & Barabasz. 1979.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Zinc	ZnCl2	native soil microflora	sandy soil	7	1	548	Urease activity		290 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnSO4	native soil microflora	surface soil		1.3	1	Dehydrogenase activity	150	300	30	Rogers & Li. 1985.
Zinc	ZnCl2	native soil microflora	sandy soil	7	1	548	Arylsulfatase activity		375 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnCl2	native soil microflora	sandy soil	7	1	42	Urease activity		420 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnCl2	native soil microflora	soil/litter microcosm			23	Respiration	47	479	21	Chaney et al. 1978.
Zinc	ZnCl2	native soil microflora	sandy loam	6	3	42	Urease activity		480 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnCl2	native soil microflora	sandy soil	7	1	42	Arylsulfatase activity		909 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnCl2	native soil microflora	sandy loam	6	3	548	Arylsulfatase activity		948 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnO	native soil microflora	sandy soil	7		84	N mineralization & nitrification		1000 LCT	28,31	Bhuiya & Cornfield. 1976.
Zinc	ZnO	native soil microflora	sandy soil	8		42	N mineralization		1000 LCT	32	Bhuiya & Cornfield. 1974.
Zinc	ZnCl2	native soil microflora	Forest mor (litter)	4		30	Respiration	200	1000	26	Laskowski et al. 1994.
Zinc	ZnSO4	native soil microflora	clay loam	6	1.2	49	Nitrification	100	1000	99	Wilson. 1977.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Zinc	ZnSO4	native soil microflora	sandy loam	6	0.8	49	Nitrification	100	1000	98	Wilson. 1977.
Zinc	ZnSO4	native soil microflora	loamy sand	5	0.6	49	Nitrification	100	1000	100	Wilson. 1977.
Zinc	ZnCl2	native soil microflora	silty loam	8	1	42	Urease activity		1030 ED50	50	Doelman & Haanstra. 1986.
Zinc	ZnCl2	native soil microflora	silty loam	8	1	42	Arylsulfatase activity		1295 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnSO4	native soil microflora	clay loam	8	3.7	0.1	Alkaline & acid phosphatase activity		1635 LCT	59,32	Juma & Tabatabai. 1977.
Zinc	ZnSO4	native soil microflora	loam	7	5.5	0.1	Acid phosphatase activity		1635 LCT	33	Juma & Tabatabai. 1977.
Zinc	ZnCl2	native soil microflora	loam	7	2.9	0.1	Arylsulfatase activity	163.5	1635	33	Al-Khafaji & Tabatabai. 1979.
Zinc	ZnCl2	native soil microflora	clay loam	8	3.2	0.1	Arylsulfatase activity	163.5	1635	36	Al-Khafaji & Tabatabai. 1979.
Zinc	ZnSO4	native soil microflora	loam	6	2.6	0.1	Acid phosphatase activity	163.6	1635	30	Juma & Tabatabai. 1977.
Zinc	ZnSO4	native soil microflora	loam	7	5.5	0.1	Alkaline phosphatase activity	163.5	1635	28	Juma & Tabatabai. 1977.
Zinc	ZnCl2	native soil microflora	clay	8	1.5	42	Urease activity		1780 ED50	50	Doelman & Haanstra. 1986.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Zinc	ZnCl2	native soil microflora	sandy loam	6	3	42	Arylsulfatase activity		2184 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnCl2	native soil microflora	clay	8	1.5	548	Arylsulfatase activity		2838 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnCl2	native soil microflora	clay	8	1.5	548	Phosphatase activity		2845 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	silty loam	8	1	42	Phosphatase activity		2963 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	sandy loam	6	3	548	Phosphatase activity		2969 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	sandy loam	6	3	42	Phosphatase activity		3342 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	soil/litter microcosm				Respiration		3600 LCT	66	Lighthart et al. 1977.
Zinc	ZnCl2	native soil microflora	clay	8	1.5	42	Phosphatase activity		3623 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	silty loam	8	1	548	Arylsulfatase activity		4349 ED50	50	Haanstra & Doelman. 1991.
Zinc	ZnCl2	native soil microflora	silty loam	8	1	548	Phosphatase activity		4872 ED50	50	Doelman & Haanstra. 1989.
Zinc	ZnCl2	native soil microflora	clay	8	1.5	42	Arylsulfatase activity		5559 ED50	50	Haanstra & Doelman. 1991.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
Zinc	ZnCl2	native soil microflora	sandy peat	4	6.5	548	Arylsulfatase activity		9679 ED50	50	Haanstra & Doelman. 1991.
acrylonitrile		native soil microflora	silt loam	5	1.5	4	Respiration		1000 LCT	41	Walton et al. 1989.
acrylonitrile		native soil microflora	sandy loam	5	0.7	4	Respiration		1000 LCT	59	Walton et al. 1989.
carbon tetrachloride		native soil microflora	sandy loam	5	0.7	4	Respiration		1000 LCT	21	Walton et al. 1989.
cis-1,4-dichloro-2-butene		native soil microflora	silt loam	5	1.5	4	Respiration		1000 LCT	44	Walton et al. 1989.
cis-1,4-dichloro-2-butene		native soil microflora	sandy loam	5	0.7	4	Respiration		1000 LCT	48	Walton et al. 1989.
hexachlorobenzene		native soil microflora	silt loam	5	1.5	4	Respiration		1000 LCT	37	Walton et al. 1989.
nitrobenzene		native soil microflora	silt loam	5	1.5	4	Respiration		1000 LCT	22	Walton et al. 1989.

Table B.1 (continued)

Chemical	Chemical Form	Organisms	Growth Medium	pH	%OC	Exp (d)	Response Parameter	NOEC	LOEC	% Dec	Reference
nitrobenzene		native soil microflora	sandy loam	5	0.7	4	Respiration		1000 LCT	61	Walton et al. 1989.
pentachlorophenol		native soil microflora	surface soil	5	5.2	1.8	Respiration		460 EC50	50	vanBeelen&Fleurin-Kemila.1993
pentachlorophenol		native soil microflora	dune sand	4	0.6	3	Respiration		800 EC50	50	vanBeelen&Fleurin-Kemila.1993
									1500 EC10	10	
phenol		native soil microflora	silt loam	5			Nitrification		100	>20	Suter and Sharples. 1984.
trans-1,4-dichloro-2-butene		native soil microflora	silt loam	5	1.5	4	Respiration		1000 LCT	58	Walton et al. 1989.
trans-1,4-dichloro-2-butene		native soil microflora	sandy loam	5	0.7	4	Respiration		1000 LCT	44	Walton et al. 1989.

APPENDIX C

TOXICITY DATA FOR OTHER SOIL AND LITTER INVERTEBRATES

Table C.1. Toxicity Data for Other Soil and Litter Invertebrates

Chemical concentrations are mg of element/kg of food or substrate

Exp (d) - exposure duration in days

LCT - lowest concentration tested

LC50 - concentration causing 50%mortality

% Dec - % decrease in measured parameter at LOEC as compared to controls.

Chemical	Form	Species	Food	Exp (d)	Response	NOEC Applied	LOEC Applied	% Dec	Reference
Cadmium	CdCl2	Diplogasteritus spp.	solution	3	survival LC50		3.3	50	Kammenga et al. 1994.
Cadmium	CdCl2	Caenorhabditis elegans	solution	7	reproduction	1.1	3.6	36	van Kessel et al. 1989.
Cadmium	CdCl2	Cephalobus persegnis	solution	3	survival LC50		9.3	50	Kammenga et al. 1994.
Cadmium	CdCl2	Rhabditis species	solution	3	survival LC50		14.1	50	Kammenga et al. 1994.
Cadmium	CdCl2	Caenorhabditis elegans	solution	3	survival LC50		14.7	50	Kammenga et al. 1994.
Cadmium	CdCl2	Acrobeloides buetschlii	solution	3	survival LC50		59.3	50	Kammenga et al. 1994.
Cadmium	CdNO3	Porcellio scaber-juv.	maple leaves	360	number of offspring		10LCT	47	Hopkin and Hames. 1994.
Cadmium	CdSO4	Orchesella cincta	green algae	61	population growth rate	4.7	15	56	van Straalen et al. 1989.
Cadmium	CdCl2	Folsomia candida	Baker's yeast	42	number of offspring	148	326	21	Crommentuijn et al. 1993.
Cadmium	CdSO4	Platynothrus peltifer	green algae	61	population growth rate	3	9	23	van Straalen et al. 1989.

Table C.1 (continued)

Chemical	Form	Species	Food	Exp (d)	Response	NOEC Applied	LOEC Applied	% Dec	Reference
Cadmium	CdCl2	Helix aspersa	Lab Chow	30	reproductive behavior	10	25	28	Russell et al. 1981.
Copper	CuSO4	nema-omnivore/predator	soil OM	7	survival		72 LCT	85	Parmalee et al. 1993.
Copper	$CuSO_4$	nematodes		3650	number of organisms		100	≥ 20	Korthals et al. (1996)
Copper	$CuSO_4$	nematodes		3650	number of organisms		104	≥ 20	Korthals et al. (1996)
Copper	CuCl2	Caenorhabditis elegans	solution	1	survival LC50		105	50	Donkin and Dusenbery. 1993.
Copper	$CuSO_4$	nematodes		3650	number of organisms		160	≥ 20	Korthals et al. (1996)
Copper	$CuSO_4$	Platynothrus peltifer		42	population	150	200		Streit 1984
Copper	CuSO4	nematode-bacterivores	soil OM	7	survival	185	400	80	Parmalee et al. 1993.
Copper	CuSO4	nematode-herbivores	soil OM	7	survival	185	400	57	Parmalee et al. 1993.
Copper	CuSO4	nematode-hatchlings	soil OM	7	survival	185	400	75	Parmalee et al. 1993.
Copper	CuCl2	Caenorhabditis elegans	soil OM	1	survival LC50		413	50	Donkin and Dusenbery. 1993.
Copper	CuCl2	Caenorhabditis elegans	soil OM	1	survival LC50		534	50	Donkin and Dusenbery. 1993.
Copper	CuCl2	Caenorhabditis elegans	soil OM	1	survival LC50		629	50	Donkin and Dusenbery. 1993.
Copper	CuCl2	Caenorhabditis elegans	soil OM	1	survival LC50		1061	50	Donkin and Dusenbery. 1993.

Table C.1 (continued)

Chemical	Form	Species	Food	Exp (d)	Response	NOEC Applied	LOEC Applied	% Dec	Reference
Copper	CuNO3	Porcellio scaber-juv.	maple leaves	360	number of offspring	20	50	53	Hopkin and Hames. 1994.
Copper	CuSO4	Mesostigmata	soil OM	7	survival		72 LCT		Parmalee et al. 1993.
Copper	CuSO4	Oribatida	soil OM	7	survival		72 LCT	48	Parmalee et al. 1993.
Copper	CuSO4	Prostigmata	soil OM	7	survival	185	400	37	Parmalee et al. 1993.
Copper	CuSO4	other microarthropods	soil OM	7	survival	185	400	60	Parmalee et al. 1993.
Copper	CuSO4	Arion ater	fruit & veg	27	percent growth	300	1000	55	Marigomez et al. 1986.
Iron	FeSO4	Orchesella cincta	green algae	21	percent growth	3515	7533	42	Nottrot et al. 1987.
Lead	PbO	Porcellio scaber	O1+O2 litter	448	gen 1 survival & repro; gen 2 survival	6400	12800	27,6884	Beyer and Anderson. 1985.
Lead	PbNO3	Porcellio scaber-juv.	maple leaves	360	survival; number of offspring	1000	2000	100, 100	Hopkin and Hames. 1994.
Lead		Onychiurus armatus	fungus	125	growth rate		3089 LCT	25	Bengtsson et al. 1983.
Lead	PbNO3	Arion ater	fruit & veg	27	percent growth	300	1000	51	Marigomez et al. 1986.

Table C.1 (continued)

Chemical	Form	Species	Food	Exp (d)	Response	NOEC Applied	LOEC Applied	% Dec	Reference
Mercury	HgCl2	Arion ater	fruit & veg	27	percent growth	300	1000	26	Marigomez et al. 1986.
Zinc	$ZnCl_2$	Folsomia candida		28	number of organisms		185	50	Smit and van Gestel (1996)
Zinc	$ZnCl_2$	Folsomia candida		28	number of organisms		348	50	Smit and van Gestel (1996)
Zinc	ZnO	Porcellio scaber	O1+O2 litter	448	gen 2 population size; generation 2 survival	800	1600	22,27	Beyer and Anderson. 1985.
Zinc	ZnO	Porcellio scaber	O2 litter	56	survival		5000 LCT	26	Beyer et al. 1984.
Zinc	ZnCl2	Arion ater	fruit & veg	27	percent growth		10 LCT	38	Marigomez et al. 1986.
benzo[a]pyrene		Porcellio scaber	leaf&dog food	63	change in dry weight	31.6	100	30	van Brummelen&Stuijfzand. 1993
benzo[a]pyrene		Porcellio scaber	poplar leaves	28	% growth efficiency	25	125	82	van Straalen and Verweij. 1991
benzo[a]pyrene		Oniscus asellus	leaf&dog food	63	change in dry weight	100	316	58,48	van Brummelen&Stuijfzand. 1993
					and length				

Table C.1 (continued)

Chemical	Form	Species	Food	Exp (d)	Response	NOEC Applied	LOEC Applied	% Dec	Reference
p-nitrophenol		nematode-bacterivores	soil OM	7	survival		20LCT	40	Parmalee et al. 1993.
p-nitrophenol		nematode-fungivores	soil OM	7	survival	20	40	55	Parmalee et al. 1993.
p-nitrophenol		nematode-herbivores	soil OM	7	survival	20	40	51	Parmalee et al. 1993.
p-nitrophenol		nema-omnivore/predator	soil OM	7	survival	20	40		Parmalee et al. 1993.
p-nitrophenol		nematode-hatchlings	soil OM	7	survival	20	40	61	Parmalee et al. 1993.
p-nitrophenol		nematode-total	soil OM	7	survival	20	40	56	Parmalee et al. 1993.
p-nitrophenol		Prostigmata	soil OM	7	survival	40	80	24	Parmalee et al. 1993.
p-nitrophenol		Oribatida	soil OM	7	survival	80	160	26	Parmalee et al. 1993.
p-nitrophenol		total microarthropods	soil OM	7	survival	80	160	35	Parmalee et al. 1993.
pentachlorophenol		Tylenchus elegans	solution	3	survival LC50		1.2	50	Kammenga et al. 1994.
pentachlorophenol		Rhabditis species	solution	3	survival LC50		2.4	50	Kammenga et al. 1994.
pentachlorophenol		Cephalobus persegnis	solution	3	survival LC50		2.6	50	Kammenga et al. 1994.
pentachlorophenol		Diplogasteritus spp.	solution	3	survival LC50		6.8	50	Kammenga et al. 1994.
trinitrotoluene		Prostigmata	soil OM	7	survival	100	200	71	Parmalee et al. 1993.

Table C.1 (continued)

Chemical	Form	Species	Food	Exp (d)	Response	NOEC Applied	LOEC Applied	% Dec	Reference
trinitrotoluene		Oribatida	soil OM	7	survival	100	200	58	Parmalee et al. 1993.
trinitrotoluene		total	soil OM	7	survival	100	200	58	Parmalee et al. 1993.

Attachment F
Conceptual Site Model

Primary Sources	Contaminants of Potential Concern	Media of Concern	Transport Mechanisms
Lawful application of pesticides	4,4-DDE, 4,4-DDT, B-BHC, D-BHC, Aldrin, Endosulfan I, Endrin, Dieldrin, Endrin, Endrin Aldehyde [X] Adsorbed onto soil [ ] Dissolved in water [ ] Non-aqueous phase	[X] Surface Soil (0–2 feet bgs)	[X] Direct release to soil [X] Migration to subsurface soil [ ] Migration to groundwater [ ] Volatilization [ ] Runoff or erosion [ ] Utake by plant or animal [ ] Other (list) ______________
		[X] Soil (> 2 feet bgs)	[X] Direct release to soil [ ] Migration to groundwater [ ] Volatilization [ ] Other (list) ______________
		[ ] Groundwater	[ ] Release to groundwater [ ] Volatilization [ ] Future migration to surface water [ ] Future migration to sediment [ ] Uptake by plant or animal [ ] Other (list) ______________
		[ ] Surface Water	[ ] Release to surface water [ ] Volatilization [ ] Sedimentation [ ] Uptake by plant or animal [ ] Other (list) ______________
		[ ] Sediment	[ ] Release to surface water [ ] Resuspension or erosion [ ] Uptake by plant or animal [ ] Other (list) ______________

Current (C) and Potential Future (F) Receptors

Exposure Media	Exposure Pathway	Commercial Industrial	Construction Worker	Residential/ Recreational	TEE Receptors
[x] Soil	[x] Ingestion		C/F	C/F	C/F
	[x] Dermal Exposure		C/F	C/F	C/F
[ ] Groundwater	[ ] Ingestion				
	[ ] Dermal Exposure				
[ ] Air	[ ] Inhalation				
[ ] Surface Water	[ ] Ingestion				
	[ ] Dermal Contact				
[ ] Sediment	[ ] Ingestion				
	[ ] Dermal Contact				
[ ] Indoor Air	[ ] Inhalation				

NOTES:
bgs = below ground surface

Attachment F
CONCEPTUAL SITE MODEL

PREPARED BY	ENVIRONMENTAL PARTNERS INC
REPORT	Cleanup Action Plan
LOCATION	1802 Brookdale Road East, Tacoma, Washington
PREPARED FOR	Ichijo Co. USA, LTD.

DATE	DRAWN BY	REVIEWED BY	PROJECT NUMBER
12/18/18	BJW	TCM	74001.1