DRAFT

Department of Public Works
King County Solid Waste Division

PHASE II HYDROGEOLOGIC AND LANDFILL GAS INVESTIGATION

PUYALLUP/KIT CORNER CUSTODIAL LANDFILL
KING COUNTY, WASHINGTON

July 1994

Prepared by

AGI TECHNOLOGIES

Sorting It Out Together

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A Report Prepared For :

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DRAFT

PHASE II HYDROGEOLOGIC AND LANDFILL GAS INVESTIGATION PUYALLUP/KIT CORNER CUSTODIAL LANDFILL KING COUNTY, WASHINGTON

July 7, 1994

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LIST OF ACRONYMS

AESI	Associated Earth Sciences, Inc.
AGI	AGI Technologies
ARI	Analytical Resources, Inc.
BETX	benzene, ethylbenzene, toluene, and total xylenes
bgs	below ground surface
CCN	Converse Consultants Northwest
CGM	combustible gas meter
cm/s	centimeters per second
COD	chemical oxygen demand
DOT	Department of Transportation
EPA	United States Environmental Protection Agency
GP	gas probe
gpm	gallons per minute
H^2S	hydrogen sulfide
HASP	Health and Safety Plan
I-5	Interstate 5
J	estimated and flagged
LEL	lower explosive limit
MCLs	maximum contaminant limits
MFS	Minimum Functional Standards for Solid Waste Handling
mg/m^3	milligrams per cubic meter
mg/L	milligrams per liter
MRLs	method reporting limits

LIST OF ACRONYMS

MS	matrix spike
MSD	matrix spike duplicate
MSL	Mean Sea Level
OVA	organic vapor analyzer
OVM-PID	organic vapor meter equipped with a photoionization detector
ppm	parts per million
QA	Quality Assurance
R	rejected and flagged
RPDs	relative percent differences
SINCO	Slope Indicator Company
SKCDPH	Seattle-King county Department of Public Health
SWD	King County Solid Waste Division
TOC	total organic compounds
TSS	total suspended solids
UJ	estimated and flagged
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
µg/L	micrograms per liter
% vol	percent by volume
%v	percent volume
VOCs	volatile organic compounds
WAC	Washington Administrative Code

AGI
TECHNOLOGIES

EXECUTIVE SUMMARY

INTRODUCTION

In 1991 the King County Solid Waste Division contracted with AGI Technologies (AGI) to conduct a Phase II Hydrogeologic and Landfill Gas Investigation of the Puyallup/Kit Corner Custodial Landfill (the landfill). The landfill was operated between approximately 1947 and 1967 and reportedly served as the principal municipal landfill for southwest King County in the early to mid 1960s. The purpose of the Phase II investigation was to characterize groundwater, surface water, and landfill gas environments at the landfill.

BACKGROUND

The landfill is located near Federal Way, Washington, immediately southeast of the intersection of State Highway 18 and Interstate 5 in an incorporated area of southwest King County. This area lies within the south central portion of the Puget Sound Lowland near the southern end of the Des Moines Drift Plain.

The investigation site comprises approximately 29 acres, with the landfill comprising approximately 20 acres of the site. Two intermittent streams, designated the East and West Streams, pass near the landfill. The East Stream flows south along the east side of the landfill and through a culvert below the southeast corner of the landfill before exiting near the south end of the site. The West Stream flows southward west of the landfill. At its closest, the West Stream is approximately 500 feet from the landfill.

INVESTIGATION TASKS

The Phase II hydrogeologic and landfill gas investigation included drilling 14 borings around the perimeter of the landfill. Completions within the borings resulted in 9 groundwater monitoring points and 28 gas monitoring points.

Surface water sampling was conducted on two occasions during the 1993 wet season. Groundwater sampling was conducted during the 1993 wet and dry seasons (two occasions). Gas probe monitoring occurred between March and September 1993 and soil gas samples were collected from selected probes in June 1993.

INVESTIGATION RESULTS

The investigation confirmed that only the East Stream has the potential to be impacted by seepage from the landfill. However, surface water samples collected on two occasions indicate the landfill is not impacting surface water quality in the East Stream.

Four water-bearing zones were identified beneath the site during the Phase II investigation. Three of the zones are localized to the landfill vicinity; the remaining water-bearing zone, termed the Sand Aquifer, exists beneath the west half of the site and appears to extend to the west beyond the site boundary. Groundwater samples were collected from the four water-bearing zones on two separate occasions. The sampling results indicate the uppermost water-bearing zone, as well as the Sand Aquifer, have been impacted by the landfill. Of particular concern is the presence of vinyl chloride in the Sand Aquifer.

Methane gas was detected in all borings drilled around the landfill. The gas extends from near the land surface to the top of the Sand Aquifer. A landfill gas extraction system is currently being installed along the southern perimeter of the site to address possible gas migration to the south where residential development is located.

RECOMMENDATIONS

The results of the Phase II investigation indicate the need for the following supplemental work:

- Expand the southern perimeter gas extraction system to include the east side and part of the north side of the landfill. This expansion would help prevent gas migration into existing and new residential areas east and northeast of the landfill.
- Expand knowledge of the hydrogeology and hydrochemistry of the Sand Aquifer by installing five groundwater monitoring wells within it.
- Assess refuse thickness, bottom elevations, and moisture conditions by drilling five borings through the landfill and installing piezometers, if appropriate, in two of the borings.
- Conduct an engineering study of the East Stream corridor to determine whether and how much water is entering the landfill from this area.

AGI TECHNOLOGIES

1.0 INTRODUCTION

1.1 GENERAL

This report presents the results of a Phase II hydrogeologic and landfill gas investigation of the former Puyallup/Kit Corner Landfill (the landfill). This investigation was performed by AGI Technologies (AGI) on behalf of King County Solid Waste Division (SWD). The landfill is located near Federal Way, Washington, immediately southeast of the intersection of State Highway 18 and Interstate 5 (I-5) in an unincorporated area of southwest King County.

1.2 PROJECT DESCRIPTION

The Puyallup/Kit Corner Landfill was operated between approximately 1947 and 1967, and reportedly served as the principal municipal landfill for southwest King County in the early to mid 1960s. The landfill closed in 1967 without an engineered leachate control system. The final cover material was apparently local borrow consisting of silty sand with gravel (Seattle-King County Department of Public Health, 1985).

In 1991, SWD contracted with AGI to conduct the hydrogeologic and landfill gas investigation to determine the nature and extent of impacts from the landfill. SWD established a general outline of the investigation, including the following:

Phase I Investigation :

- Task A - Existing Data Analysis
- Task B - Investigative Report

Phase II Investigation :

- Task C - Installation of Monitoring Wells
- Task D - Summary Report

The results of the Phase I investigation were presented in AGI's Phase I Hydrogeologic Investigation Report dated August 11, 1992. The Phase I report recommended installing groundwater monitoring wells and outlined a methodology for conducting the Phase II investigation. Based on the Phase I investigation, Phase II was expanded to include installing and monitoring gas probes.

1.3 PURPOSE AND SCOPE

The purpose of the Phase II investigation was to characterize the groundwater and surface water environments at the landfill and to determine the potential for gas migration. The Phase II scope of services included:

- Drilling five deep borings and two shallow borings around the landfill perimeter. Within the borings, a total of nine groundwater monitoring wells and seven gas probes were constructed. The deep borings were constructed either as dual-completion groundwater monitoring wells with a single shallow gas probe or as single-completion groundwater monitoring wells with dual-completion gas probes. The two shallow borings were constructed as single-completion groundwater monitoring wells.

- Sampling the groundwater monitoring wells during the dry and wet seasons (two events) and analyzing the samples for a variety of chemical indicators and compounds.

- Collecting four surface water samples on two separate occasions and analyzing the samples for the same suite of chemical indicators and compounds.

- Monitoring water levels in the groundwater monitoring wells biweekly for a period of 6 months. Surface water levels were also monitored biweekly for the same period at two staff gauges installed near each end of a culvert passing below the landfill.

- Developing a landfill gas technical memorandum summarizing monitoring data for pre-existing gas probes and providing recommendations for the Phase II gas probe placement.

- Drilling seven borings for gas monitoring purposes around the perimeter of the landfill and completing six of them as dual-completion gas probes (12 probes total) and one as a single-completion gas probe.

- Monitoring landfill gas parameters biweekly for a period of 6 months within the 19 gas probes and 9 dual-purpose gas probe/groundwater monitoring wells installed by AGI (total 28) and the 7 gas probes previously installed by Associated Earth Sciences, Inc. (AESI).

- Collecting air samples from four gas probes as part of the design phase of an interim gas extraction system.

- Evaluating all data collected and generating this Phase II report.

2.0 STUDY AREA DESCRIPTION

2.1 LANDFILL LOCATION AND REGIONAL SETTING

The landfill lies within the southcentral portion of the Puget Sound lowland near the southern end of the Des Moines Drift Plain. The Des Moines Drift Plain consists of a gently rolling upland, generally ranging in elevation from 300 to 500 feet above Mean Sea Level (MSL). The drift plain extends from West Seattle southward to the Puyallup Valley. The southern portion of the Des Moines Drift Plain is bordered on the northwest by Puget Sound, on the east by the Duwamish Valley, and on the southwest by the Puyallup Valley, as shown on **Figure 2.1**, Vicinity Map. These features are at or near sea level.

The Des Moines Drift Plain contains numerous small lakes and is drained by several small streams. The landfill is located within the Hylebos Creek drainage, which discharges south to the Puyallup Valley. Two Hylebos Creek tributaries pass near the landfill, as shown on **Figure 2.2**, Site and Adjacent Area Map. One extends along the I-5 corridor, west of the landfill, and the other passes through the southeastern corner of the landfill. Both are intermittent streams, flowing in the winter and dry in the summer. For purposes of this report, the I-5 stream is termed "West Stream" and the other stream is termed "East Stream."

The landfill is generally bordered on the west by I-5, on the north by State Highway 18, and on the east and south by the residential streets shown on **Figure 2.2**.

2.2 CURRENT SITE CONDITIONS

The investigation site comprises approximately 29 acres and is surrounded by a 6-foot perimeter fence as shown on **Figure 2.3**, Site Plan. The landfilled area itself comprises approximately 20 acres of the site.

The landfill surface forms a mound, with the top of the mound ranging from 10 to 40 feet above surrounding grade. The landfill cover slopes gently to the northwest and west and more steeply to the northeast, east, and south from the broad, relatively flat top. Site topography is shown on **Figure 2.3**. The landfill surface is somewhat irregular, resulting from differential settlement. Small basins, or "sag ponds," collect standing water during the wet season. These basins have apparently developed since the last grading of the cover, reportedly in the 1970s (Kinney, 1992). Numerous small fissures, typically less than 1/8 inch across and several feet long, also occur in the landfill cover. Larger fissures up to 6 inches across are present near the southwest corner of the landfill in an area which has settled approximately 6 feet.

The landfill is transected by numerous dirt trails and is surrounded by an unpaved perimeter road. A portion of the perimeter road and dirt trails was upgraded with quarry spalls to accommodate equipment access during drilling activities in early 1993. Official access to the landfill is from a paved road extending along the west side of the site. A vehicle access gate is located at the end of the landfill access road near the northwest corner of the site.

The landfill cover currently supports sparse vegetation. Some trees are present near the northeast corner of the landfill and in the central and southcentral portion, but most of the landfill is covered with grasses, scotch broom, and blackberries. Areas outside the landfill border are generally forested, except where development or recent filling and clearing for development has occurred. The vegetation pattern can be seen on **Figure 2.3**.

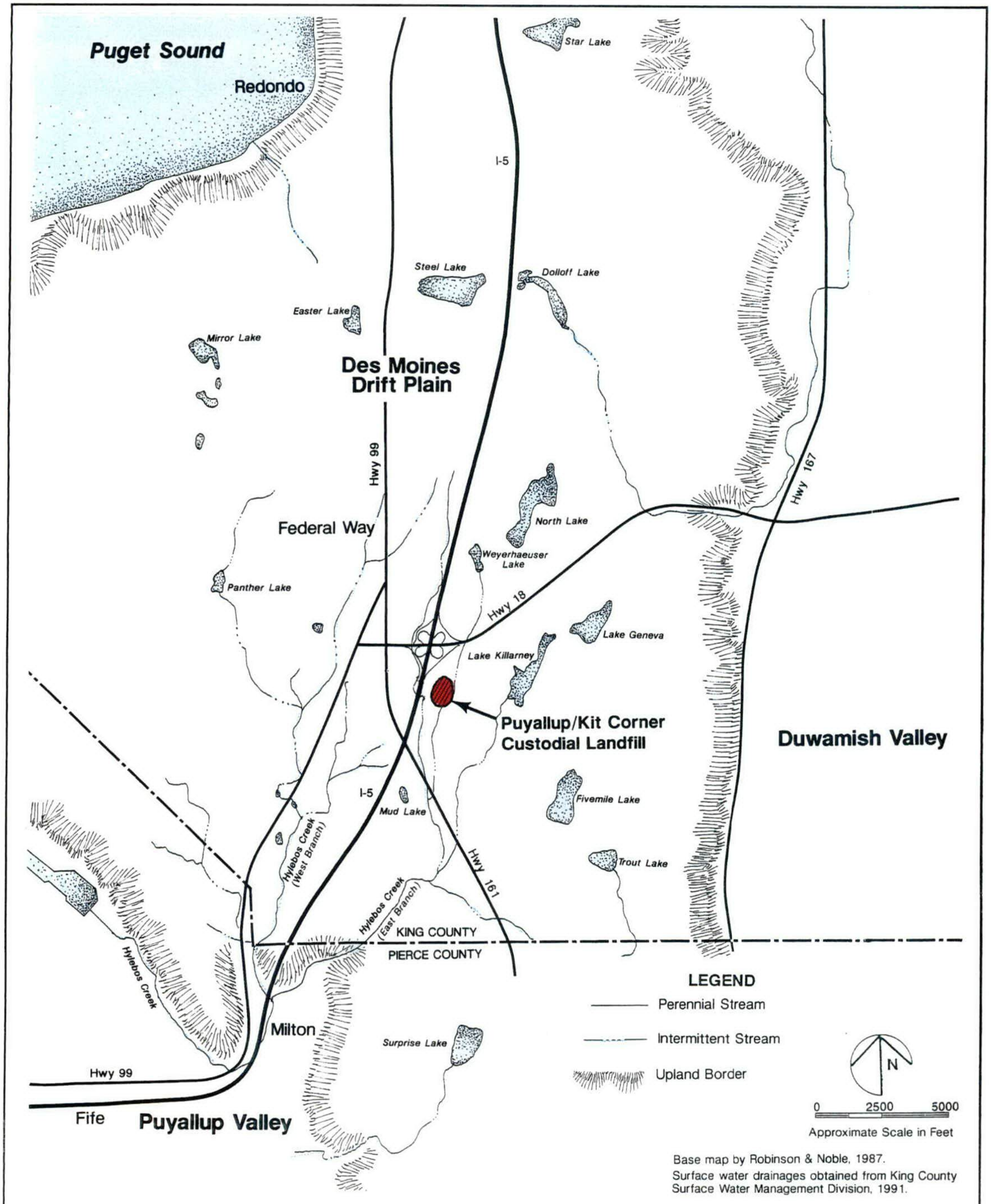
One drainage ditch is located along the northern site border and another along the landfill access road. Both ditches were dry during the Phase II investigation.

Two intermittent streams pass near the landfill, as mentioned previously. The East Stream flows to the south along the east side of the landfill and then through a culvert below the southeast corner of the landfill before exiting near the south end of the site. The culvert is a 3-foot-diameter corrugated metal pipe with grated entrance and exit points. A manhole provides access to the culvert near the middle of its run (see **Figure 2.3**).

The West Stream passes along the west side of I-5 before crossing to the east side in a culvert. Like the East Stream, the West Stream flows to the south. The West Stream is in a culvert on the west side of I-5 from approximately 1,000 feet north of Highway 18 to approximately 2,000 feet south of the highway.

The two streams merge south of Highway 161 (see **Figure 2.1**). Both streams were dry in June 1992. Intermittent flow was noted in the West Stream during late 1992 and early 1993. Continuous flow was noted in the East Stream from late 1992 until July 1993, at which time it became dry.

Development surrounding the site consists of a house near the northeast corner, single-family housing on the east and southeast sides, and multi-family apartments and townhouses on the south side. A housing development is currently under construction along the east landfill property boundary. A water supply line for the Federal Way Water and Sewer District was installed along the landfill's northern border in early 1992.



AGI TECHNOLOGIES

Vicinity Map
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **2.1**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	31 May 94			

Aerial photo base from Walker & Associates, Inc., dated 7/10/90

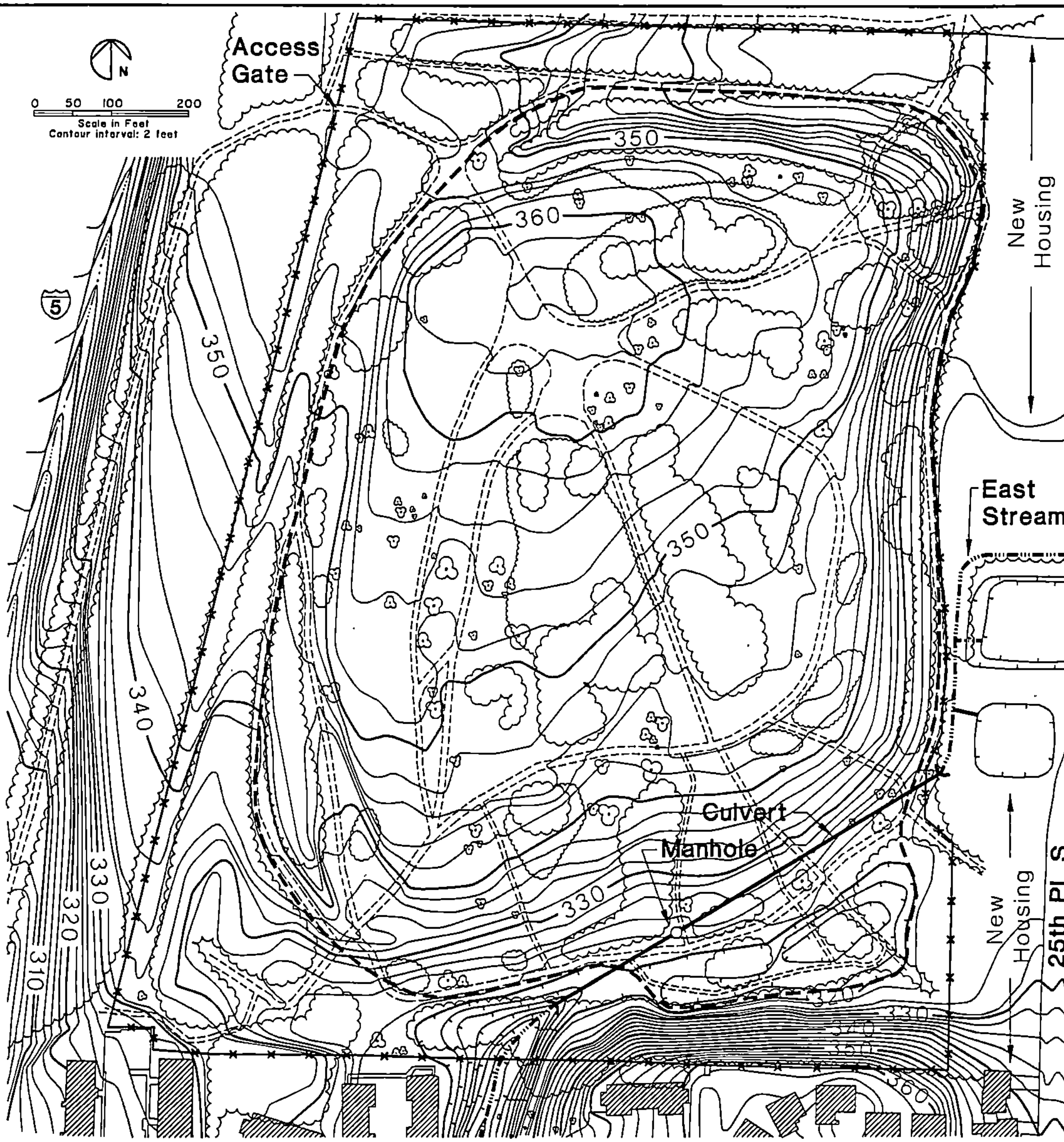
AGI TECHNOLOGIES

Site and Adjacent Area Map

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **2.2**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	31 May 94			



LEGEND

Building	Trees
Inferred edge of refuse	Brush
Fence (approximate Landfill property boundary)	

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Site Plan
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **2.3**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
Site2.dwg	14,621.114	JFL				

3.0 BACKGROUND

3.1 SITE HISTORY

A 1936 aerial photograph shows the landfill site as undeveloped with sparse vegetation. The area had likely been logged sometime prior to 1936. Minor residential and small-scale agricultural development was present in the area. The site was reportedly developed as a gravel pit sometime after 1936 (Fujii, 1992).

Landfilling reportedly began in 1947 under the direction of the Seattle-King County Department of Public Health (Seattle-King County Department of Public Health [SKCDPH], 1985). Access to the landfill was from a road extending eastward from 16th Avenue South across present-day I-5.

During the landfill's operation no records were maintained of the type or volume of waste (Nyblom, 1992). Landfilling was initiated on the northwest side of the East Stream. Excavation of borrow reportedly occurred as landfilling progressed to the south (Kinney, 1992). Areas in the northern and central portions of the landfill were subsequently raised with new refuse during later phases of landfilling (SKCDPH, 1985).

In 1959, 9.55 acres of the original 40-acre landfill property were deeded to the State of Washington Department of Highways to allow construction of I-5. Some refuse was reportedly moved from the deeded area to the area of active landfilling (Kinney, 1992). After the construction of I-5, a new paved access road was constructed along the west side of the landfill from the corner of 20th Avenue South and South 360th Street to the northwest corner of the site as shown on **Figure 2.2**.

The greatest activity at the landfill occurred during the early to mid 1960s. Refuse volumes increased substantially as other nearby landfills closed (Bow Lake, Pacific, Renton Junction) and further development occurred in southwestern King County. Aerial photographs from 1960 and 1965 show the active landfill area more than doubled in size during this 5-year period. The base of the landfill was reportedly excavated below the base of the East Stream during this period (Kinney, 1992).

By 1965, the landfill extended south such that the East Stream was rerouted approximately 200 feet to the southeast through a culvert. A petroleum pipeline extending from Ferndale, Washington to Portland, Oregon was installed along the western border of the landfill in 1965.

At the completion of landfilling in 1967, a 4-foot-thick cover of locally derived soil was placed over the refuse (Kinney, 1992). No formal provisions for gas or leachate collection were made. The thickness of the main body of the landfill is not known, but is a minimum of 30 to 40 feet based on the elevation difference between the top of the landfill and the landfill perimeter road. Explorations in the extreme southeast corner of the landfill showed a maximum refuse thickness of approximately 30 feet.

No significant development occurred around the landfill until the 1980s, when the area south and east of the landfill was intensely developed for single-family and multi-family residential use (see **Figure 2.2**).

3.2 PREVIOUS INVESTIGATIONS

SKCDPH conducted a study of 23 abandoned (inactive) landfills in King County, including the Puyallup/Kit Corner Landfill, in 1985. The study assessed what potential problems may exist at the landfill, based on potential contents and closure methods. Field explorations were also conducted, including surface water sampling and soil gas testing in 22 shallow holes. Methane within or above explosive range concentrations was detected in 10 of the shallow test holes. Fissures and areas of dead vegetation were observed on the landfill cover. Two surface water samples were collected (A and B)–one from the West Stream and the other at the upgradient end of the East Stream culvert (see **Figure 3.1**). The samples were checked for leachate indicator parameters, including pH, temperature, dissolved oxygen, conductivity, and turbidity. No evidence of leachate was detected. Details of the investigation are described in the SKCDPH report, *Abandoned Landfill Study in King County* (SKCDPH, 1985).

SKCDPH later conducted a supplemental assessment at six selected abandoned landfills in 1986. The Puyallup/Kit Corner Landfill was included in the latter investigation. The study sought to determine if chemical compounds in surface waters, site surface soils, and landfill gases were present in sufficient concentrations to present human health risks to casual users of the site. Three surface water samples (1, 2, and 3) were obtained from the locations shown on **Figure 3.1**. SKCDPH reported "Analysis of the surface water samples taken in August did not yield any priority pollutant concentrations of concern." Details of the investigation are described in the SKCDPH report *Seattle-King County Abandoned Landfill Toxicity/Hazard Assessment Project* (SKCDPH, 1986).

The 1986 SKCDPH study included installing and monitoring 15 shallow landfill gas probes. The gas probes were installed around the perimeter of the landfill by first driving a 1-inch-diameter bar to a depth of 36 inches or until refusal. A 3/4-inch-diameter gas probe with a stop cock valve was then installed in each bar hole after the bar was removed. The completed gas probes ranged in depth from 12 to 36 inches below ground surface (bgs). The gas probe locations are shown on **Figure 3.1.** The gas probes have been monitored regularly by SWD since October 1986. Data collected through September 1992 show that most of the gas probes contain low, nonexplosive concentrations (1 to 15 percent lower explosive limit [LEL]) of combustible gas. The LEL is the lowest concentration of combustible gas in or at which the mixture becomes explosive, and corresponds to approximately 5.3 percent methane by volume. Four gas probes (GP-5, GP-9, GP-13, and GP-14) have periodically contained explosive levels of gas. Lower gas concentrations (1 to 10 percent LEL) were also commonly recorded in these four probes.

AESI conducted a subsurface landfill gas investigation in April 1989 along the south property boundary as part of the Evergreen Vale development. This multifamily residential development is located adjacent to the south end of the landfill property. AESI's investigation was undertaken to evaluate the presence of landfill gas prior to development. The closest buildings for this development are currently within 100 to 200 feet of the landfill. Five borings were drilled to depths ranging from 22 to 45 feet bgs. Four of the borings were completed as dual-completion gas monitoring wells and the remaining boring was completed as a single-completion gas monitoring well. The wells are denoted GMW-1 through GMW-5 on **Figure 3.1.** AESI's geologic logs and well construction details are included in **Appendix I.** Groundwater was reportedly encountered in perched zones while drilling GMW-2, GMW-4, and GMW-5 at depths of 17, 16, and 32 feet bgs, respectively. Gas parameter monitoring during drilling showed gas present at explosive concentrations in two borings, as did later well monitoring on three separate occasions. AESI concluded the source of the explosive gas was the former Puyallup/Kit Corner Landfill. Details of the AESI investigation are presented in a report titled *Landfill Gas Migration Assessment - Evergreen Vale, King County, Washington* (AESI, 1989).

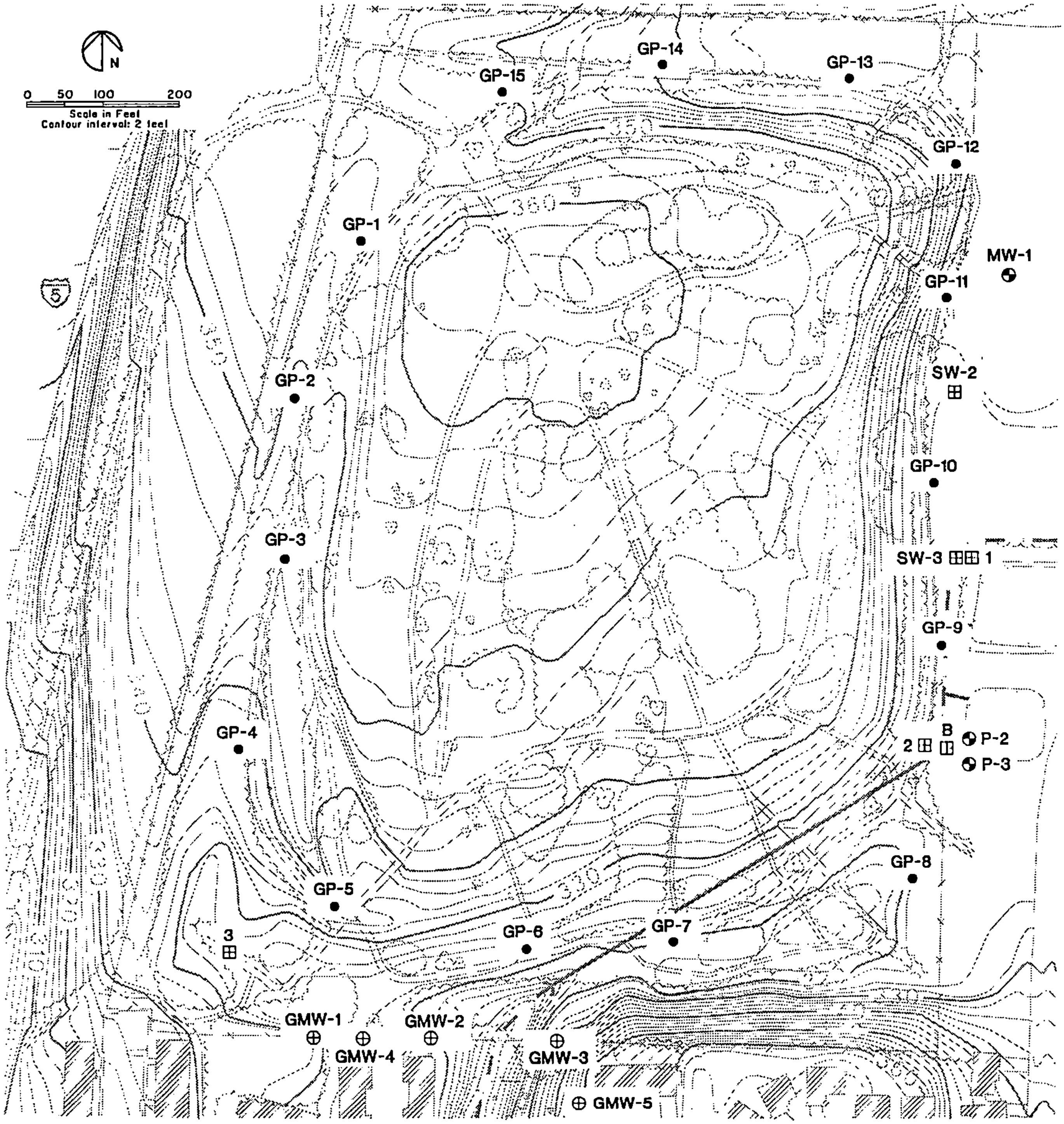
Converse Consultants Northwest (CCN) conducted a surface water/groundwater investigation in early 1991 for the Alder Glen development, located on the east side of the landfill. The purpose of the study was to investigate surface water and groundwater occurrence in the area of the proposed residential development. CCN drilled four borings to depths ranging from 10 to 50 feet bgs. One boring was completed as a 2-inch-diameter groundwater monitoring well, one boring was completed as a 3/4-inch-diameter quadruple-completion gas monitoring well, and two borings were completed as 1-inch-diameter double-completion gas monitoring wells. The wells are denoted MW-1 (groundwater monitoring well) and P-2 through P-4 (gas probes) on **Figure 3.1.** CCN's geologic logs and well/probe construction details are presented in **Appendix I.** Soil gas within the drill casing was monitored at 5-foot intervals during drilling using an organic vapor analyzer (OVA), hydrogen sulfide meter, and explosimeter. Elevated OVA readings were obtained at approximately 50 feet bgs in MW-1. Hydrogen sulfide gas was not detected during drilling. No explosimeter results were reported. A wet zone indicating the presence of perched groundwater was encountered at 28 feet bgs while drilling MW-1, so the well was screened at this depth. No measurable groundwater accumulated in the well after its completion. Groundwater was not encountered in the other borings. The East Stream was dry during CCN's investigation. CCN concluded that no groundwater discharge was occurring to the stream during the investigation and the perched groundwater encountered in MW-1 was seasonal with the uppermost regional aquifer occurring at a depth of greater than 50 feet. Details of the CCN investigation are presented in a report titled *Surface Water/Groundwater Investigation, Alder Glen Property, King County, Washington* (CCN, 1991). The monitoring well and gas probes installed as part of the CCN investigation were destroyed during property development grading in early 1993.

CCN also conducted a surface water quality investigation of the proposed Alder Glen development in early February 1992. The purpose of the investigation was to test surface water samples for possible leachate impact from the landfill. Two surface water samples, designated SW-1 and SW-3, were collected from the East Stream where it passes through the Alder Glen property (see **Figure 3.1).** A third sample, SW-2, was collected from a swale that was thought to receive minor surface water runoff from the landfill perimeter road. The samples were submitted for analysis of priority pollutant organics and metals, and for compounds and parameters required to be monitored under Washington Administrative Code (WAC) 173-304-490(2c) (Minimum Functional Standards for Solid Waste Handling). The CCN report concluded no health-based drinking water standards were exceeded in any surface water samples. Secondary maximum contaminant levels for iron and manganese were exceeded in the East Stream; however, the analytical results indicated no leachate impact to the surface waters investigated. Details of the CCN investigation are contained in a report titled *Surface Water Quality Investigation, Alder Glen Property, King County, Washington* (CCN, 1992).

A surface water runoff sample was collected in early 1992 by SWD in an area of orange staining on the north side of the landfill and analyzed as a monthly surface water sample. The analytical results are contained in a letter to SKCDPH dated July 9, 1992 and presented in Appendix B of AGI's Phase I report. Based on the analytical data, SWD concluded that surface water at this location had not been impacted.

In mid-1992, AGI conducted an analysis of existing information on the landfill for SWD. The investigation concluded that the landfill is located within a hydrogeologically vulnerable area and that leachate generation from the landfill is probable; however, migration pathways were unknown. Data analyses results and recommendations for a Phase II investigation were presented in our report titled *Phase I Hydrogeologic Investigation, Puyallup/Kit Corner Abandoned Landfill* (AGI, 1992a).

In late 1992, AGI prepared a landfill gas technical memorandum for SWD that summarized and evaluated gas monitoring data collected at the landfill between October 1984 and September 1992. The gas monitoring data indicated explosive gas levels were present throughout the landfill cover in 1985. However, the 15 shallow landfill gas perimeter gas probes monitored from 1986 to 1992 by SWD showed explosive gas to be present only in selected areas. Four of the nine off-site monitoring wells installed by AESI have contained explosive levels of combustible gas. The data evaluation was used to assist in the placement of gas probes for the Phase II field investigation. Details of the data evaluation are contained in our letter titled *Landfill Gas Technical Memorandum, Phase II Hydrogeologic and Landfill Gas Investigation, Puyallup/Kit Corner Landfill, King County, Washington* (AGI, 1992b).



LEGEND

MW-1, P-2	Monitoring Well number and approximate location (Converse Consultants NW, 1991) (P-4 not shown)
GMW-1	Gas Probe number and approximate location (Associated Earth Sciences, Inc. 1987)
GP-1	Shallow gas probe number and approximate location (Seattle-King County Department of Public Health, 1986)
B	Surface water sample (Seattle-King County Health Dept., 1985) (Sample A not shown)
1	Surface water sample (Seattle-King County Health Dept., 1986)
SW-2	Surface water sample (Converse Consultants NW, 1992) (SW-1 not shown)

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Previous Investigation Locations

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **3.1**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
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4.0 PHASE II INVESTIGATION TASKS

This section summarizes field and chemical analysis activities conducted for the Phase II surface water, groundwater, and gas investigations. **Appendix A** discusses field investigation procedures for the Phase II investigation.

4.1 SURFACE WATER INVESTIGATION

4.1.1 Objectives and Scope

The objective of the surface water investigation was to determine surface water elevations relative to groundwater elevations, provide background water quality data for the East and West Streams, and determine if impacts to surface water quality from the landfill are occurring. Field investigation data indicated no groundwater or surface water connection between the West Stream and the landfill. These data are based on an absence of shallow water-bearing zones along the west side of the landfill, a topographic analysis, and direct observations during periods of heavy rainfall. Consequently, the West Stream was not sampled.

4.1.2 Surface Water Sampling

Surface water samples were collected from the East Stream and vicinity on March 24, 1993 (Round 1) and May 26, 1993 (Round 2). Surface water sample locations are shown on **Figure 4.1**. The East Stream was observed to be intermittent (i.e., water was only flowing during the winter wet season). Round 1 and Round 2 data represent the middle of the wet season and the end of the wet season, respectively.

Surface water samples were analyzed for volatile organic compounds (VOCs), total and dissolved metals, total suspended solids (TSS), chloride, sulfate, nitrate/nitrite and ammonia, chemical oxygen demand (COD), and total organic carbon (TOC). These analyses were chosen as an indicator list for the presence of leachate. **Table 4.1** lists analytes, chemical analysis methods, and method reporting limits (MRLs) for surface water samples. **Appendix E** presents a sample key and analytical schedule, Quality Assurance (QA) summary, QA reports, and laboratory analytical reports.

4.1.3 Surface Water Level Monitoring

Surface water elevations were monitored from March 1993 through August 1993 at staff gauges located at each end of the culvert through which the East Stream flows below the southeast corner of the landfill. The data were collected to evaluate the hydraulic relationship between the East Stream and adjacent shallow groundwater. Sitts and Hill Engineers Inc. (subconsultants to AGI) surveyed staff gauge elevations to the nearest 0.1 foot referenced to the National Geodetic Vertical Datum of 1929 as presented in **Appendix C**. Surface water elevation monitoring was performed concurrently with groundwater elevation monitoring. **Figure 4.1** shows the surface water monitoring station (staff gauge) locations. **Appendix D** presents surface water elevation data.

4.2 HYDROGEOLOGIC INVESTIGATION

4.2.1 *Objectives and Scope*

The objectives of the Phase II hydrogeologic investigation were to characterize the hydrogeologic conditions around the landfill and evaluate landfill impacts on groundwater. The hydrogeologic investigation included:

- Drilling seven borings around the perimeter of the landfill and installing three shallow groundwater monitoring wells and six deep groundwater monitoring wells. Data gathered during drilling enabled us to determine subsurface geology and hydrostratigraphy.

- Monitoring groundwater levels on a biweekly schedule from March 1993 through August 1993.

- Analyzing hydrogeologic data and characterizing groundwater recharge, occurrence, and movement.

- Collecting groundwater samples from wells for analysis of VOCs, total and dissolved metals, TSS, chloride, sulfate, nitrate/nitrite and ammonia, COD, and TOC.

4.2.2 *Drilling and Well Installation*

Borings were typically drilled for multiple purposes during the Phase II investigation. Monitoring/exploration locations were identified as follows:

- PKC-B — Soil boring with no well completion.
- PKC-MW GP — Single shallow gas probe completed in a groundwater monitoring well boring.
- PKC-MW GPa — Upper gas probe completed in a groundwater monitoring well boring.
- PKC-MW GPb — Lower gas probe completed in a groundwater monitoring well boring.
- PKC-MWa — Upper groundwater monitoring well in a multiple-completion.
- PKC-MWb — Lower groundwater monitoring well in a multiple-completion.
- PKC-MW — Single groundwater monitoring well.
- PKC-GP — Single gas probe.
- PKC-GPa — Upper gas probe in a dual-probe completion.
- PKC-GPb — Lower gas probe in a dual-probe completion.

A total of 14 borings were drilled between December 11, 1992 and March 11, 1993. In these borings, 9 groundwater monitoring wells and 20 gas probes were installed. Eight of the groundwater monitoring wells were also used for gas monitoring since they were screened across the water table. Two gas extraction wells (EW8D and EW10D) were installed as part of the southern perimeter landfill gas extraction system. **Figure 4.1** shows the groundwater monitoring locations and **Table 4.2** presents groundwater monitoring location data. **Figure 4.2** shows the gas monitoring locations and **Table 4.3** presents gas monitoring location data.

All of the groundwater monitoring wells were installed in saturated water-bearing zones except three: PKC-MW3a, PKC-MW4, and PKC-MW7. PKC-MW3a and PKC-MW4 were drilled on either side of the East Stream near its exit from the culvert south of the landfill. Because this area is downstream from the landfill and was thought to represent a potentially significant pathway for off-site shallow groundwater migration, the area was targeted for several shallow groundwater monitoring wells. When borings were drilled in the area, some shallow groundwater was detected, although of limited quantity. It appeared likely that monitoring wells installed in this shallow zone would be dry most of the time. Despite this, PKC-MW3a and PKC-MW4 were installed to provide important data on groundwater conditions in the area. Groundwater was only sporadically present in one of the wells (PKC-MW3a) and never present in the other (PKC-MW4) during the Phase II investigation.

PKC-MW7 was also installed deliberately as a dry well. No groundwater was encountered in this boring to a total drilled depth of 185 feet bgs. However, a monitoring well was installed and screened in this boring on top of an inferred site-wide aquitard and at the base of the same geologic deposit that had been water-bearing and screened at other locations around the landfill. The screened interval was at a point which we believed would be the first to become saturated should the regional water table rise. Later evaluations indicated the water table would need to rise approximately 15 feet before inundating the base of the screen.

Sitts and Hill Engineers Inc. surveyed the elevations of the top of all groundwater monitoring well steel protective casings to the nearest 0.01 foot (referenced to the 1929 National Geodetic Vertical Datum). **Appendix C** presents survey data.

Our understanding of site stratigraphy and hydrostratigraphy was developed from information obtained during drilling. Driven soil samples were obtained at intervals of at least 5 feet, described and classified in accordance with the Unified Soil Classification System (USCS), and recorded on borings logs. Boring logs were also used to record groundwater conditions encountered during drilling, including water levels and degree of soil saturation. **Appendix B** presents logs and as-built diagrams for soil borings and installed gas probes and monitoring wells.

4.2.3 *Water Level Monitoring*

Groundwater levels were monitored biweekly from March 17 to August 26, 1993. Groundwater elevations calculated from these measurements are referenced to the 1929 National Geodetic Vertical Datum. **Appendix D** presents groundwater elevation data.

4.2.4 *Groundwater Sampling and Analysis*

Groundwater samples were collected from PKC-MW1a, PKC-MW1b, PKC-MW2, PKC-MW3b, PKC-MW5, and PKC-MW6 during March 22 through 25, 1993 (Round 1) and August 16 through 20, 1993 (Round 2). No groundwater was present in monitoring wells PKC-MW3a, PKC-MW4, and PKC-MW7 during the Round 1 and 2 sampling as described above; consequently, the wells were not sampled.

Round 1 data represent conditions during the wet season. Round 2 data represent conditions during the dry season. Groundwater samples were analyzed for VOCs, total and dissolved metals, TSS, chloride, sulfate, nitrate/nitrite and ammonia, COD, and TOC. **Table 4.1** lists analytes, chemical analysis methods, and MRLs for groundwater samples. **Appendix F** presents a sample key and analytical schedule, QA summary, QA reports, and laboratory analytical reports.

4.3 LANDFILL GAS INVESTIGATION

4.3.1 *Objectives and Scope*

The landfill gas investigation objective was to evaluate gas generation and identify areas where off-site gas migration may be occurring. A total of 28 gas monitoring points were installed during the Phase II investigation. Seven additional probes installed by AESI in 1987 were also available for use. These 35 points included gas probes, gas probes installed in monitoring well borings, and groundwater monitoring wells screened across the water table. Gas monitoring locations are shown on **Figure 4.2** and location data are summarized in **Table 4.3.**

4.3.2 *Gas Probe Monitoring*

The 28 probes installed for Phase II were monitored for selected physical parameters biweekly from March 31, 1993 through September 3, 1993. Seven additional gas probes installed by AESI in 1987 were monitored biweekly from March 31, 1993 to June 15, 1993. Portable field instruments were used to monitor the 35 gas probes. Monitored parameters included combustible gases; oxygen; carbon dioxide; hydrogen sulfide; pressure differential (gauge pressure); total volatile organic compounds; and downhole, ground surface, and ambient air temperatures. **Appendix G** presents gas probe monitoring data.

4.3.3 *Gas Probe Sampling*

Soil gas samples were collected from PKC-MW2GPa, PKC-MW2GPb, PKC-GP16a, and PKC-GP17b on June 26, 1993. The soil gas samples were collected to provide data for the preliminary design of a gas extraction system along the southern perimeter of the site. The samples were analyzed for atmospheric gases (nitrogen, oxygen, carbon dioxide, and methane) by ASTM Method D1946 and VOCs by EPA Method TO14. A memorandum summarizing the gas probe sampling is provided in **Appendix H.**

Table 4.1
Analytes and Detection Limits – Surface Water and Groundwater
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compounds	Method Reporting Limit	EPA Method Number
Volatile Organic Compounds	µg/L	
Benzene	0.20	8240 Modified
Chlorobenzene	0.20	8240 Modified
1,2–Dichlorobenzene	0.20	8240 Modified
1,3–Dichlorobenzene	0.20	8240 Modified
1,4–Dichlorobenzene	0.20	8240 Modified
Ethylbenzene	0.20	8240 Modified
Styrene	0.20	8240 Modified
Toluene	0.20	8240 Modified
o–Xylene	0.20	8240 Modified
Total Xylenes	0.40	8240 Modified
Acetone	4.0	8240 Modified
Acrolein	10	8240 Modified
Acrylonitrile	10	8240 Modified
Bromodichloromethane	0.20	8240 Modified
Bromoethane	0.20	8240 Modified
Bromoform	0.50	8240 Modified
Bromomethane	0.20	8240 Modified
2–Butanone (MEK)	4.0	8240 Modified
Carbon Disulfide	0.20	8240 Modified
Carbon Tetrachloride	0.20	8240 Modified
Chloroethane	0.20	8240 Modified
2–Chloroethyl vinyl ether	1.0	8240 Modified
Chloroform	0.20	8240 Modified
Chloromethane	0.20	8240 Modified
Dibromochloromethane	0.20	8240 Modified
Dibromomethane	0.20	8240 Modified
1,1–Dichloroethane	0.20	8240 Modified
1,2–Dichloroethane	0.20	8240 Modified
1,1–Dichloroethene	0.20	8240 Modified
cis–1,2–Dichloroethene	0.20	8240 Modified
trans–1,2–Dichloroethene	0.20	8240 Modified
1,2–Dichloropropane	0.20	8240 Modified
1,1–Dichloropropene	1.0	8240 Modified
cis–1,3–Dichloropropene	0.20	8240 Modified
total–1,3–Dichloropropene	0.40	8240 Modified
trans–1,3–Dichloropropene	0.20	8240 Modified
2–Hexanone (MBK)	4.0	8240 Modified
Methylene Chloride	0.20	8240 Modified
Methyl Iodide	0.20	8240 Modified

Table 4.1
Analytes and Detection Limits – Surface Water and Groundwater
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compounds	Method Reporting Limit	EPA Method Number
Volatile Organic Compounds (cont.)	**µg/L**	
4-Methyl-2-Pentanone (MIBK)	4.0	8240 Modified
1,1,1,2-Tetrachloroethane	0.20	8240 Modified
1,1,2,2-Tetrachloroethane	0.20	8240 Modified
Tetrachloroethene	0.20	8240 Modified
1,1,1-Trichloroethane	0.20	8240 Modified
1,1,2-Trichloroethane	0.20	8240 Modified
Trichloroethene	0.20	8240 Modified
Trichlorofluoromethane	0.20	8240 Modified
1,2,3-Trichloropropane	1.0	8240 Modified
Vinyl Acetate	0.50	8240 Modified
Vinyl Chloride	0.20	8240 Modified
Metals	**mg/L**	
Aluminum	0.020	6010
Arsenic	0.001	7060
Barium	0.001	6010
Beryllium	0.001	6010
Cadmium	0.002	6010
Calcium	0.010	6010
Chromium	0.005	6010
Cobalt	0.003	6010
Copper	0.002	6010
Iron	0.005	6010
Lead	0.001	6010
Magnesium	0.020	6010
Manganese	0.001	6010
Mercury	0.0001	7470
Nickel	0.010	6010
Potassium	0.400	6010
Selenium	0.001	7740
Silver	0.003	6010
Sodium	0.010	6010
Thallium	0.050	6010
Tin	0.01	6010
Vanadium	0.002	6010
Zinc	0.004	6010

Table 4.1
Analytes and Detection Limits – Surface Water and Groundwater
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compounds	Method Reporting Limit	EPA Method Number
<u>General Parameters</u>	<u>mg/L</u>	
Ammonia as Nitrogen	0.01	350.1
Chemical Oxygen Demand	5.0	410.4
Chloride	1.0	325.3
Nitrate + Nitrite as Nitrogen	0.01	353.1
Sulfate	2.5	9035
Total Organic Carbon	1.0	9060
Total Suspended Solids	1.0	160.2

Notes:

mg/L – Milligrams per liter.
µg/L – Micrograms per liter.

AGI TECHNOLOGIES

Table 4.2
Groundwater Monitoring Location Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Monitoring Well or Gas Probe Designation	Aquifer Monitored	Screened Interval Elevation [a] (ft above MSL)	Phase II Use
PKC–MW1a	Lower Perched Zone	262–234	Water quality and water level monitoring.
PKC–MW1b	Gravel Water–Bearing Zone	177–172	Water quality and water level monitoring.
PKC–MW2	Sand Aquifer	214–189	Water quality and water level monitoring.
PKC–MW3a	Upper Perched Zone	311–305	Water level monitoring (dry during most of Phase II investigation).
PKC–MW3b	Sand Aquifer	211–196	Water quality and water level monitoring.
PKC–MW4	Upper Perched Zone	316–306	Water level monitoring (dry during most of Phase II investigation).
PKC–MW5	Upper Perched Zone	318–303	Water quality and water level monitoring.
PKC–MW6	Sand Aquifer	215–190	Water quality and water level monitoring.
PKC–MW7	Sand Aquifer	235–220	Water level monitoring (dry during entire of Phase II investigation).
PKC–GP16a	Upper Perched Zone	299–314	Water level monitoring.
PKC–GP17a	Upper Perched Zone	290–310	Water level monitoring.

Notes:

a) Elevations rounded to nearest foot.
MSL – Mean Sea Level.

AGI TECHNOLOGIES

Table 4.3
Gas Monitoring Location Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

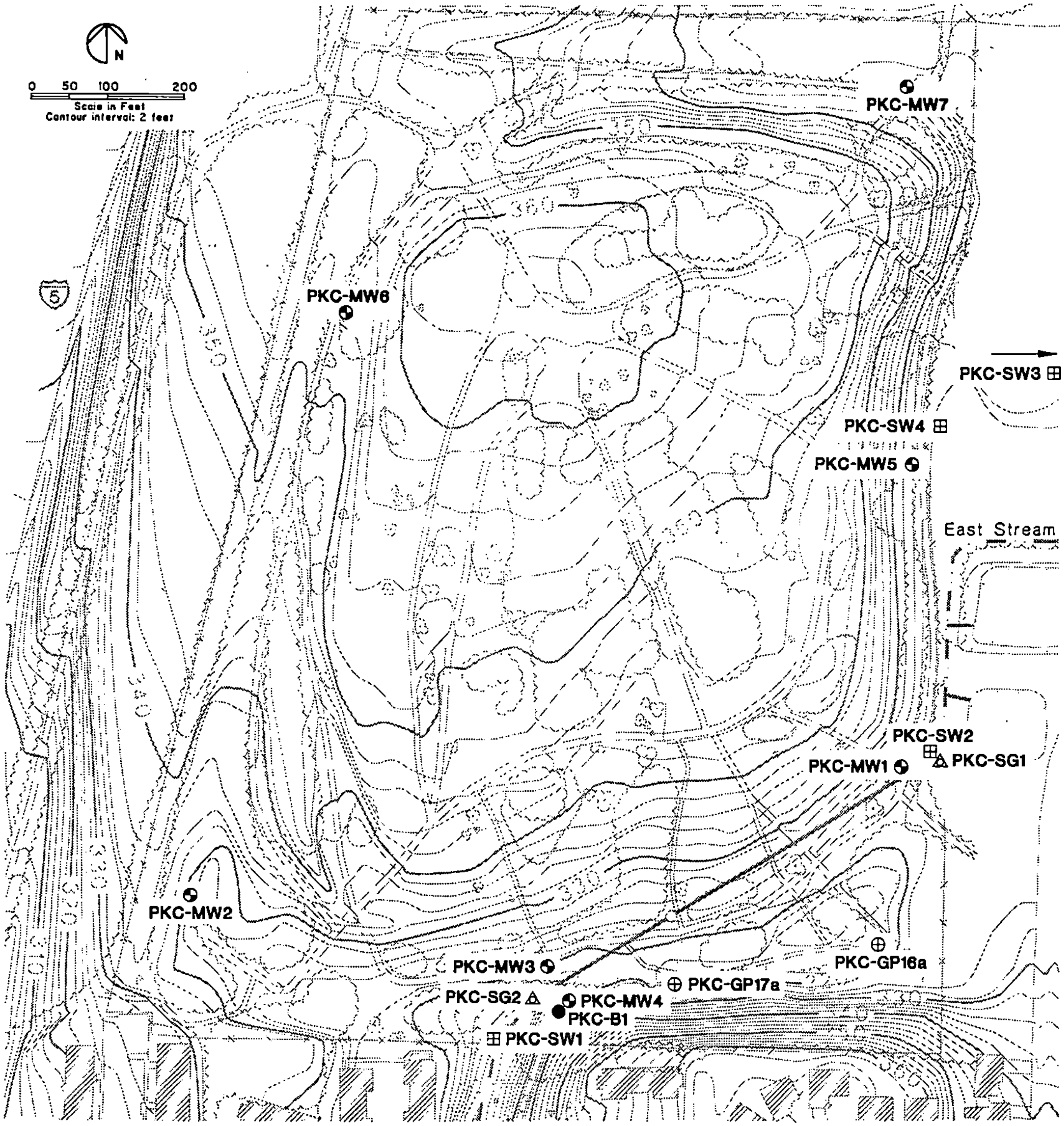
Monitoring Well or Gas Probe Designation	Completion Zone	Screened Interval Elevation [a] (ft above MSL)	Phase II Use
PKC–MW1GP	Lower Sand	296–281	Monitoring
PKC–MW1a	Lower Sand	262–172	Monitoring
PKC–MW2GPa	Upper Gravel	307–292	Monitoring, sampling
PKC–MW2GPb	Upper Sand	262–242	Monitoring, sampling
PKC–MW2	Lower Sand	214–189	Monitoring
PKC–MW3a	Upper Gravel	311–305	Monitoring
PKC–MW3b	Lower Sand	211–196	Monitoring
PKC–MW4	Upper Gravel	316–306	Monitoring
PKC–MW5	Upper Gravel	318–303	Monitoring
PKC–MW6GPa	Upper Gravel	313–303	Monitoring
PKC–MW6GPb	Upper Sand	277–267	Monitoring
PKC–MW6	Lower Sand	215–190	Monitoring
PKC–MW7GPa	Upper Sand	303–293	Monitoring
PKC–MW7GPb	Lower Sand	263–253	Monitoring
PKC–MW7	Lower Sand	235–220	Monitoring
PKC–GP16a	Refuse	314–299	Monitoring, sampling
PKC–GP16b	Lower Sand	274–259	Monitoring
PKC–GP17a	Refuse	310–290	Monitoring
PKC–GP17b	Lower Sand	275–257	Monitoring, sampling
PKC–GP18	Upper Gravel	322–312	Monitoring
PKC–GP19a	Upper Gravel	339–329	Monitoring
PKC–GP19b	Upper Sand	268–263	Monitoring
PKC–GP20a	Upper Gravel	333–318	Monitoring
PKC–GP20b	Upper Sand	293–278	Monitoring
PKC–GP21a	Upper Sand	298–288	Monitoring

Table 4.3
Gas Monitoring Location Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Monitoring Well or Gas Probe Designation	Completion Zone	Screened Interval Elevation [a] (ft above MSL)	Phase II Use
PKC–GP21b	Lower Sand	273–258	Monitoring
PKC–GP22a	Upper Sand	281–276	Monitoring
PKC–GP22b	Lower Sand	261–251	Monitoring
GMW–1A	Upper Gravel	322–317	Monitoring
GMW–1B	Upper Gravel	307–297	Monitoring
GMW–2A	Upper Gravel	315–310	Monitoring
GMW–2B	Upper Gravel	305–300	Monitoring
GMW–3A	Upper Gravel	324–319	Monitoring
GMW–3B	Upper Gravel	312–302	Monitoring
GMW–4	Upper Gravel	320–310	Monitoring

Notes:

a) Screened interval rounded to nearest foot.
MSL – Mean Sea Level.



LEGEND

PKC-MW6 ⊕	Groundwater Monitoring Well number and approximate location (PKC-MW7 dry throughout duration of investigation)
PKC-GP16a ⊕	(PKC-SW3 collected approximately 200' east of location shown) (used for gas monitoring and groundwater elevation data)
PKC-B1 ●	Soil Boring number and approximate location (boring abandoned and redrilled at PKC-MW4)
PKC-SW4 ⊞	Surface water sample approximate location (PKC-SW3 collected approximately 200' east of location shown)
PKC-SG2 △	Staff Gauge number and approximate location

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

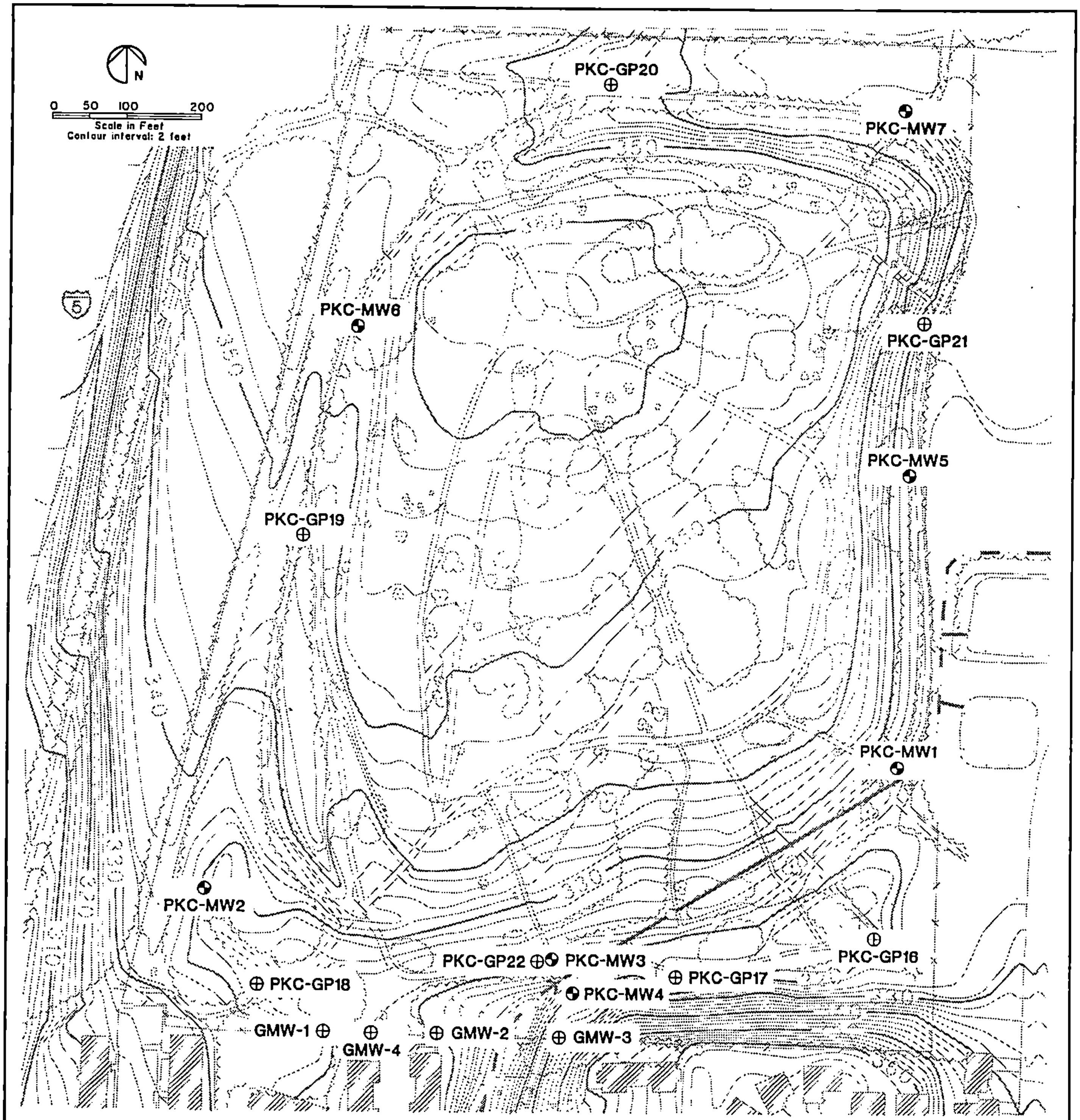
AGI TECHNOLOGIES

Groundwater and Surface Water Monitoring Locations

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **4.1**

H2OInfo.dwg	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
	14,621.114	JFL				



LEGEND

PKC-GP21 ⊕ Gas Probe number and approximate location

GMW-3 ⊕ Gas Probe number and approximate location (Associated Earth Sciences, Inc., 1987)

PKC-MW6 Groundwater Monitoring Well number and approximate location (used for gas and groundwater monitoring)

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Gas Monitoring Locations

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **4.2**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
GasMon.dwg	14,621.114	JFL				

5.0 PHYSICAL CHARACTERISTICS

5.1 SURFACE WATER

5.1.1 Surface Water Bodies

East Stream : The East Stream is located along the east side of the site, passing through a 3-foot-diameter corrugated metal pipe culvert below the southeast corner of the landfill. There is a 6- to 7-foot elevation difference between the upstream (northeast) end and downstream (southwest) ends of the culvert. The stream channel width in the vicinity of the site is approximately 5 feet.

A primary source of water to the East Stream is overflow from an earthen dam at the south end of Weyerhaeuser Lake, located approximately 1 mile north of the site (**Figure 2.1**). Surface water runoff in the East Stream drainage basin also contributes significantly to the total stream flow. During periods of high flow, the East Stream bifurcates, with one branch flowing through a small wetland area on the east side of the site shown on **Figure 5.1**. The East Stream maintained a continuous flow between December 1992 and July 1993.

West Stream : The West Stream begins approximately 1.5 miles north of the site on the west side of I-5. The stream's source of water is stormwater runoff from surrounding areas. The stream passes through a culvert from approximately 1,000 feet north of Highway 18 to approximately 2,000 feet south of the highway. The stream then flows southward in an open channel until again entering a culvert which extends beneath I-5. The stream exits from the culvert beneath I-5 near the southwest corner of the site and continues southward along the west side of the landfill access road. The West Stream channel is typically 5 to 10 feet wide. In the site vicinity, the West Stream flows only in response to precipitation events, and generally is dry within several days after a heavy rainfall.

5.1.2 Runoff Patterns

Surface water runoff patterns at the site are shown in schematic form on **Figure 5.1**. This figure summarizes observations made during the 1992-1993 winter, and shows areas of standing water, channelized runoff, and seeps. The figure also shows surface water conductivity values obtained on February 22, 1993 in some of the areas of standing water or seeps. The general pattern of downslope surface water runoff which occurs during heavy rainstorms may be visualized by following the topographic contours.

After storm events, surface water collects and forms numerous bodies of standing water within depressions on the landfill cap. Only the major areas of standing water are shown on **Figure 5.1**. Most areas of standing water are only temporary features due to either evaporation or infiltration. Two areas where standing water persists for longer periods of time were noted; one is located near the southwest corner of the landfill and the other is along the perimeter road on the east side of the landfill, near the East Stream. A portion of the standing water in these two areas is likely contributed by seepage.

Channelized runoff occurs in only a few areas. One well-developed area of overland flow is located along the north side of the landfill on the perimeter road. In this area, runoff flows down the perimeter road until it reaches the northeast corner of the landfill where it either ponds or discharges off site into a small drainage ditch. The ditch extends along the east side of the landfill property. There is no significant direct discharge of runoff into the East Stream. Only a small area of runoff discharges over the bank near the wetland (see **Figure 5.1**), and some runoff may enter the East Stream near the south property line.

The area immediately east of the landfill is a collection point for stormwater. A small wetland collects direct precipitation as well as excess water from the East Stream during high flow events. Two stormwater detention ponds are also present to the south of the wetland. The detention ponds collect stormwater from the nearby residential development. A small portion of the water which collects on the east side of the landfill also enters the wetland area as discussed previously.

There is a topographic divide along the west side of the landfill between the landfill and the area to the west. This topographic high prevents surface runoff from the landfill from flowing to the west. Vegetation-lined ditches are present along the landfill access road and along the northern property border. The ditches were dry during the Phase I and II investigations.

5.1.3 <u>Seepage</u>

Several areas of consistent, noticeable seepage were noted around the landfill perimeter during the spring of 1993. These areas are shown on **Figure 5.1**. Reddish-orange staining and an iridescent sheen are associated with the seepage at the north end, south end, and near the northeast end of the culvert. The surface water investigation described in Section 6.1.1 addressed potential impacts of seepages to surface water quality.

5.2 GEOLOGY

5.2.1 <u>Regional Geology</u>

Regional geologic conditions are discussed in detail in **Appendix J**. Regional geology is summarized here as background for site geologic conditions discussed in the following section.

The landfill is located within the southern part of the Puget Sound lowland, a north-south trending topographic and structural depression filled with Quaternary glacial and nonglacial sediments. The southern lowland has been influenced by at least four Pleistocene glaciations (Crandall, et al., 1958). These include, from oldest to youngest, the Orting, Stuck, Salmon Springs, and Fraser glaciations. Fluvial, lacustrine, and direct ice contact processes associated with the advance and retreat of the last (Vashon) glacier are responsible for the majority of the surficial deposits and landforms present today throughout the lowland.

Three major Vashon deposits and two pre-Vashon deposits have been mapped as occurring at the southern end of the Des Moines Drift Plain (Waldron, 1961). The Vashon deposits include Till, Advance Meltwater deposits, and Glaciolacustrine Silt and Clay. The pre-Vashon deposits include Salmon Springs Drift and Puyallup Formation.

Vashon Till consists of a dense mixture of gravel, sand, silt, and clay deposited directly beneath the glacier. The Till overlies Advance Meltwater deposits, which consist of sands and gravels deposited by meltwater streams in front of the advancing Vashon glacier. These coarse-grained sediments are in turn underlain by the Glaciolacustrine Silts and Clays, which are fine-grained sediments deposited at the bottom of a former lake dammed by the Vashon glacier.

The pre-Vashon Salmon Springs Drift consists of a thick deposit of silty, sandy gravel. The underlying Puyallup Formation is thought to represent sediment deposition during a nonglacial period and consists predominantly of fine-grained silts and clays.

5.2.3 Site Geology

The geologic relationships discussed in this section are based on analysis of data from borings drilled for this project and for previous investigations, reconnaissance activities performed during the Phase I and II investigations, and extrapolation from the local and regional geologic studies referenced in **Appendix J.** Based on these, seven geologic units were identified as occurring beneath the site to the depth explored. They include six deposits interpreted as being Vashon glacial sediments (Vashon drift) and one interpreted as being a pre-Vashon deposit. From youngest to oldest, they are as follows:

Geologic Unit	Regional Correlation
Till	Vashon Drift
Upper Gravel	Vashon Drift
Upper Sand	Vashon Drift
Lower Gravel	Vashon Drift
Lower Sand	Vashon Drift
Lacustrine Silt	Vashon Drift
Pre-Vashon Gravel	Pre-Vashon Drift

The relationship between these deposits is shown schematically in **Figure 5.2**, Generalized Geologic Section. Actual subsurface conditions are shown on Hydrogeologic Sections A-A' through D-D', **Figures 5.5 through 5.8.**

Till : Till was not encountered in borings completed for the Phase II investigation; however, a reconnaissance of the study area shows Till to be present in a road cut along South 360th Street, south of the landfill, as well as in a cut bank at the southwest corner of the site. We expect Till mantles much of the area surrounding the landfill.

Upper Gravel, Upper Sand, Lower Gravel, Lower Sand : Four distinct sand and gravel deposits were identified below the landfill. From youngest to oldest these are the Upper Gravel, Upper Sand, Lower Gravel, and Lower Sand. The Upper Gravel and Lower Sand are the thickest of the four units, with an average thickness of 50 feet or more. The Upper Sand and Lower Gravel are generally 25 feet or less in thickness.

The Upper and Lower Gravels consist primarily of silty sandy gravel and are interpreted as being deposited by high energy glacial outburst floods. The Upper Sand and Lower Sand consist of finer-grained sand and silty sand, and are interpreted as being deposited by lower energy proglacial meltwater streams. All four deposits dip generally to the west and are interpreted as Vashon Advance Meltwater Deposits.

Lacustrine Silt : A silt deposit was consistently found below eastern and southern portions of the landfill. The silt is brown, moist, and very stiff to very hard, with zones containing minor sand and gravel. This deposit ranges from 25 to 40 feet thick and is interpreted as being proglacial lake sediment. The Lacustrine Silt appears to dip to the west; however, exploratory borings along the west side of the site were not sufficiently deep to reach this deposit. Consequently, its presence and continuity on the north and west side of the site has not been confirmed.

Pre-Vashon Gravel : The Phase II investigation encountered a silty sand and gravel deposit, which has been termed the pre-Vashon Gravel, below the Lacustrine Silt. The pre-Vashon Gravel consists primarily of silty sandy gravel with varying proportions of silt and sand. Some beds of clean sand and gravel exist within this deposit. The upper surface of the pre-Vashon Gravel slopes downward to the west, suggesting the observed dip in the overlying Vashon sediments is due to deposition on the sloped surface. The base of the pre-Vashon unit was not reached during the Phase II investigation.

5.3 HYDROGEOLOGY

5.3.1 Introduction

Study area groundwater occurrence and movement are influenced by the geometry and varying hydraulic properties of the geologic deposits discussed in Section 5.2. The following sections discuss study area groundwater by: 1) presenting background information on regional groundwater conditions; 2) defining study area hydrostratigraphic units based on groundwater occurrence and stratigraphic position; and 3) discussing groundwater recharge, movement, and discharge within the study area water-bearing zones.

5.3.2 Regional Groundwater Conditions

The principal aquifers beneath the Des Moines Drift Plain reportedly occur within Vashon Advance Outwash deposits and Salmon Springs Drift (Luzier, 1969). Robinson and Noble (1987) identified and more clearly defined one of the primary Advance Outwash aquifers in the Federal Way area as the Redondo-Milton Channel Aquifer. This aquifer occurs under water table conditions and provides relatively high yields to production water supply wells in the Federal Way area. **Figure 5.3**, Well Location Map, shows the approximate lateral boundaries of the Redondo Milton Channel Aquifer and the location of water supply wells in the area. Many of the wells are completed in this aquifer, including the Federal Way Water District wells. The well locations shown on **Figure 5.3** were obtained from well logs contained in Washington State Department of Ecology files or existing documents.

Salmon Springs Drift occurs predominantly as coarse sand and gravel with lesser amounts of sand, silt, and till beneath the Des Moines Drift Plain. Much of the drift is densely consolidated, with interstices filled by silt and clay. In some areas, this material acts as an aquitard and is not suitable for groundwater production. However, highly permeable zones of coarse, sandy gravel or open-work gravel occur throughout the Salmon Springs Drift. These zones are capable of yielding up to several thousand gallons per minute (gpm) to production water supply wells. Little is known of potential aquifers located in older Pleistocene deposits below Salmon Springs Drift. Some production water supply wells are completed in more permeable zones of the pre-Salmon Springs deposits; however, there does not appear to be any widespread distribution of a single aquifer within these older deposits.

Groundwater flow beneath the Des Moines Drift Plain is complex, reflecting the interlayering of glacial and nonglacial deposits with widely varying geometry and hydraulic properties. Groundwater generally moves both downward from one water-bearing zone to another, as well as laterally toward the margins of the upland (Cline, 1969). A progressive decline in static water level with increasing depth in upland wells indicates the Federal Way area is a zone of groundwater recharge (Cline, 1969).

The only area where regional groundwater flow is currently documented is within the Redondo-Milton Channel, where the flow is generally to the south, as shown on **Figure 5.3** (Robinson & Noble, 1987). Regional flow within the channel is reportedly disrupted in the Federal Way area by groundwater withdrawal from the Federal Way Water and Sewer District municipal supply wells. A static water level decline of approximately 18 feet has occurred near these wells (Robinson & Noble, 1987).

5.3.3 *Site Hydrostratigraphy*

Five hydrostratigraphic units were identified beneath the site during the Phase II investigation. The relationship between the hydrostratigraphic and geologic units is as follows:

Hydrostratigraphic Unit	Geologic Unit
Upper Perched Zone	Refuse, Upper Gravel
Lower Perched Zone	Base of Lower Sand
Sand Aquifer	Lower Sand
Silt Aquitard	Lacustrine Silt
Gravel Water-bearing Zone	Pre-Vashon Gravel

Figures 5.5 through 5.8 show our interpretation of study area groundwater conditions as hydrogeologic sections. The location of the cross sections is shown on **Figure 5.4**. Water-bearing zones are shaded blue for illustrative purposes.

Upper Perched Zone : The Upper Perched Zone is located along the eastern and southeastern margins of the landfill as shown on **Figure 5.9**. Groundwater occurs as discrete, discontinuous saturated zones of limited lateral extent within less permeable areas of the Upper Gravel and refuse. PKC-MW5, PKC-GP16a, and PKC-GP17a are completed within the Upper Perched Zone. Stabilized water levels at these monitoring points were at approximately 300 feet MSL during the Phase II investigation.

Recharge to the Upper Perched Zone occurs by infiltration of surface water from direct precipitation or from water which accumulates in the wetland and East Stream channel area. Direct precipitation is believed to be the primary source of recharge in the vicinity of PKC-GP16a and PKC-GP17a, which are located in a topographic depression in the southeast corner of the landfill. The depression is apparently due to refuse settlement since refuse was encountered during drilling of PKC-GP16a and PKC-GP17a. Surface water infiltration is believed to be the primary source of recharge along the eastern margin of the landfill. Leakage likely occurs from the base of the East Stream and from accumulated stormwater within the wetland area and the two stormwater detention ponds. The perimeter road on the east side of the landfill also contained standing water during much of the 1993 wet season.

Water movement within the Upper Perched Zone is likely primarily vertical with some lateral spreading into more permeable areas as the water moves downward. The water level within monitoring points completed in the Upper Perched Zone declined up to 10 feet during the Phase II investigation as shown on **Figure 5.10**. This water level decline corresponded with precipitation decreases, suggesting a direct hydraulic link between surface water and groundwater in the Upper Perched Zone.

Lower Perched Zone : The Lower Perched Zone is located in the southeast corner of the landfill as shown on **Figure 5.11**. Groundwater occurs under unconfined conditions in what is inferred to be a small local channel at the base of the Lower Sand scoured into the underlying silt aquitard and filled with silty sandy gravel outwash (see **Figures 5.5 and 5.7**). The stabilized water level occurs at approximately 248 feet MSL. Only one well, PKC-MW1a, is completed within the Lower Perched Zone, and therefore the direction of water movement cannot be determined. However, groundwater likely spills out of this channel recharging underlying groundwater. During the study period, water level data from PKC-MW1a (see **Figure 5.12**) show a distinct spring to late summer fluctuation of over 3 feet, with the highest water elevations lagging approximately 2 months behind the highest precipitation levels.

Silt Aquitard : The Silt Aquitard is a low permeability deposit which locally inhibits the vertical migration of water. The aquitard serves as a base for the Lower Perched Zone and the Sand Aquifer and acts as a confining unit for underlying aquifers. Although only three wells penetrated the Silt Aquitard, it is believed to underlie the entire site.

Sand Aquifer : The Sand Aquifer is located beneath the western portion of the landfill as shown on **Figure 5.13**. The Sand Aquifer occurs within the Lower Sand under unconfined conditions. Due to the slope of the underlying Silt Aquitard, the margin of the Sand Aquifer runs generally north-south below the central portion of the landfill. PKC-MW2, PKC-MW3b, and PKC-MW6 are completed in the Sand Aquifer. Groundwater elevations (water table) measured at these wells ranged from approximately 200 to 205 feet MSL.

Groundwater flow in the Sand Aquifer is to the west at an approximate gradient of 0.01 as indicated on the potentiometric surface map shown on **Figure 5.13** This flow direction and gradient remained essentially constant throughout the monitoring period (March through September 1993), although water elevations at individual wells varied slightly. Given the westerly groundwater flow direction, a substantial component of the recharge in the vicinity of the landfill must result from discharge from the Upper and Lower Perched Zones, and from directly infiltrating precipitation.

An estimate of the groundwater flow velocity within the Sand Aquifer was obtained using the following equation (Freeze and Cherry, 1979).

$$v = \frac{Ki}{n}$$

where:

v = average linear velocity through a saturated porous media.
K = hydraulic conductivity
i = hydraulic gradient
n = porosity

The following values were estimated or calculated for the equation variables:

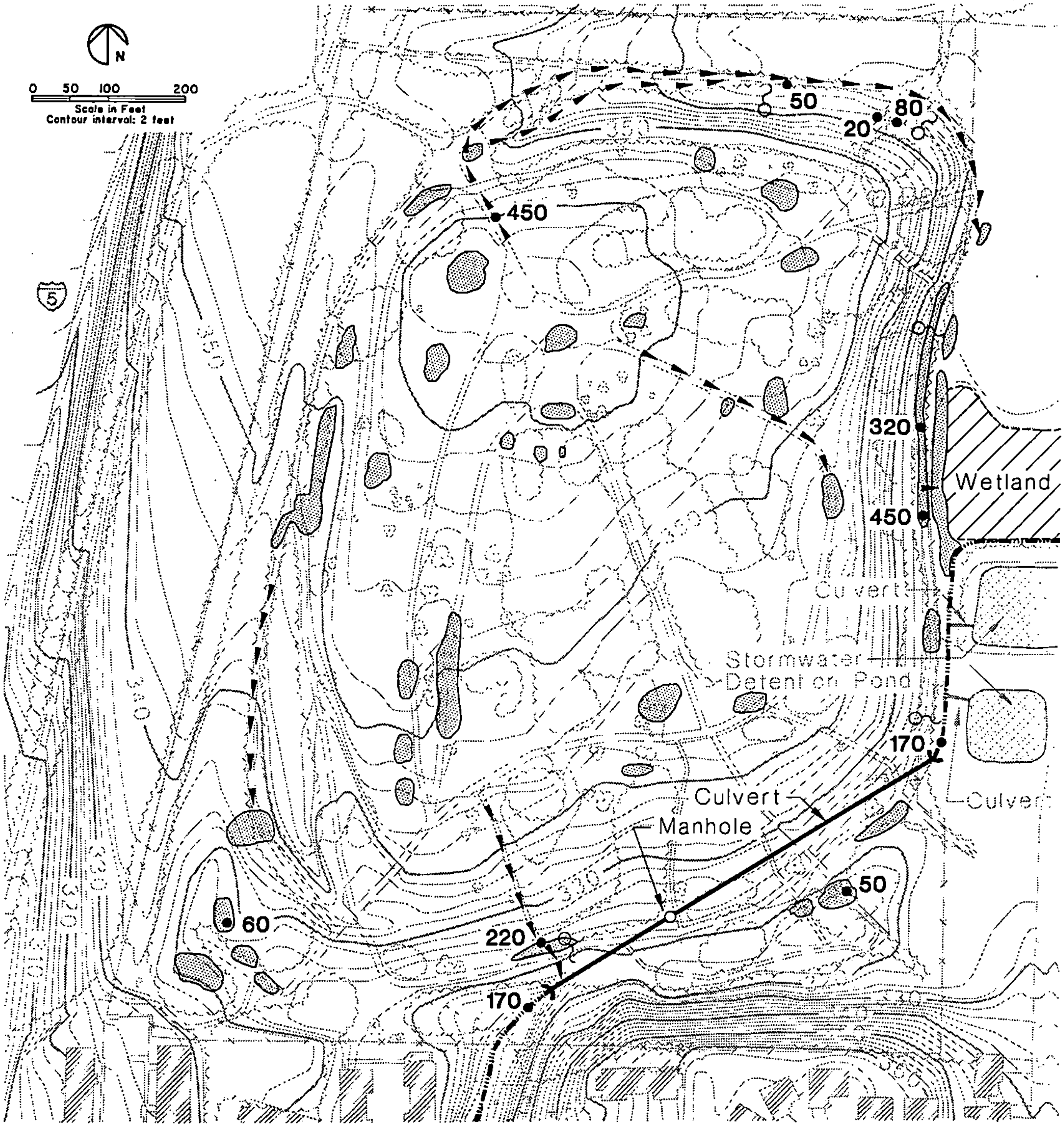
$K = 10^{-2}$ to 10^{-4} cm/s (Freeze and Cherry, 1979)
$i = \frac{2\ \text{ft}}{200\ \text{ft}} = 0.01$ (from **Figure 5.13**)
$n = 0.41$ (Todd, 1980)

The 10^{-2} to 10^{-4} centimeters per second (cm/s) range in hydraulic conductivity was chosen as representative of the lower and upper limits for the Sand Aquifer based on professional judgment and values reported in the literature. This hydraulic conductivity range results in flow velocities from approximately 3 to 250 feet per year. Assuming an average of 10^{-3} cm/s results in a flow velocity of approximately 25 feet per year.

Water elevations in the sand aquifer varied only slightly during the monitoring period, with both of the wells located farthest downgradient showing the least variation as shown on **Figure 5.14**. Both PKC-MW2 and PKC-MW6 declined approximately 0.5 foot, indicating a fairly constant source of recharge and weak relationship to precipitation. Water elevations at PKC-MW3b, on the other hand, increased by about 1.5 feet, with maximum water elevations lagging behind maximum precipitation levels by approximately 4 months.

Gravel Water-Bearing Zone : Groundwater occurring under confined conditions within sand and gravel beds in the pre-Vashon Gravel is defined as the Gravel Water-Bearing Zone. PKC-MW1b is completed within this zone; its areal extent is shown on **Figure 5.15** and its vertical distribution is shown on **Figures 5.5 and 5.7**. The Gravel Aquifer potentiometric surface, as measured at PKC-MW1b, ranged from approximately 220 to 223 feet MSL during the Phase II investigation. The sand and gravel bed observed at PKC-MW1b is inferred to be a permeable zone within the otherwise generally low permeability pre-Vashon Gravel. Other water-bearing zones likely exist within the pre-Vashon Gravel; one was encountered near the bottom of the boring for PKC-MW3.

Recharge occurs to the Gravel Water-Bearing Zone on a seasonal basis as indicated by the rise in water levels at PKC-MW1b. Peak water elevations appeared to occur in late August, some 4 months after peak precipitation levels, indicating delayed recharge. The recharge probably occurs through vertical flow from overlying water-bearing zones and through lateral flow from off-site areas. However, upgradient areas (and downgradient areas) cannot currently be identified since flow directions within this zone are not known.



LEGEND

East Stream
Channelized runoff
Standing water (numerous smaller areas of standing water not mapped)
Seeps
170 ● Surface water conductivity measured on 2/22/93 in umho/cm

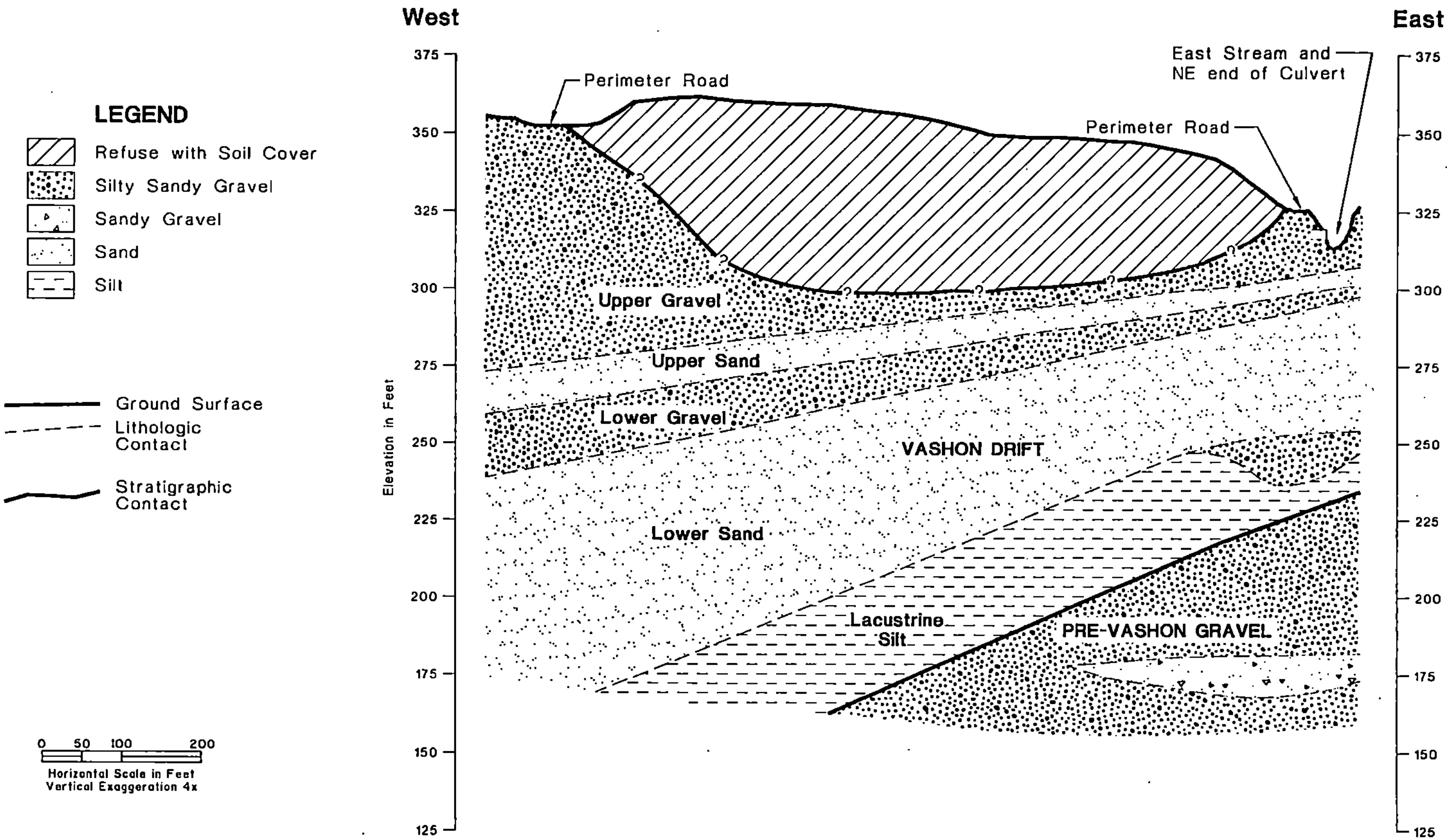
Reference: Observations made during 1992-93 wet season. Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Surface Water Features Map
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.1**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
SurH2O2.dwg	14,621.114	JFL				



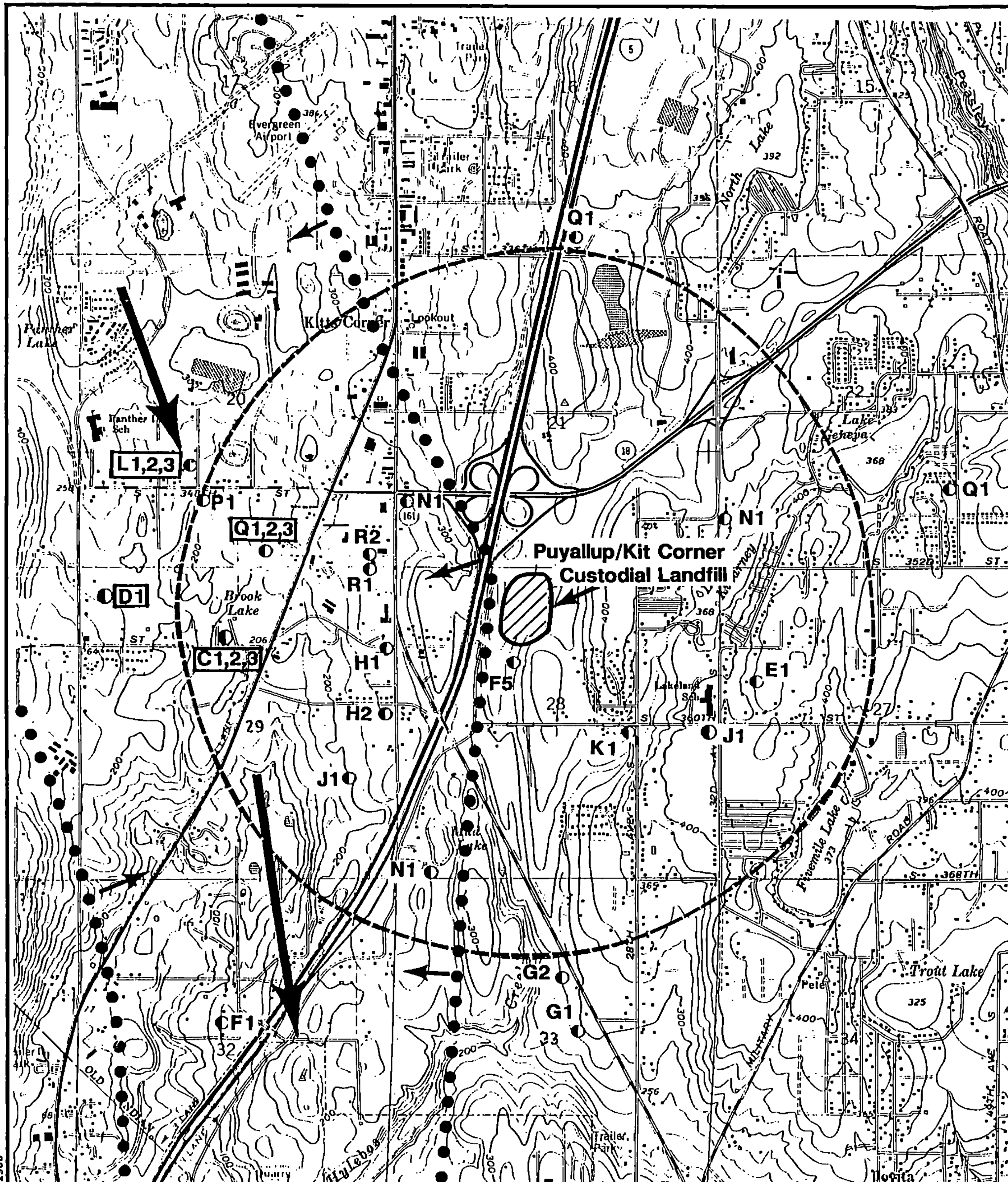
AGI TECHNOLOGIES

Generalized Geologic Section

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.2**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
xSec.dwg	14,621.114	JFL				



LEGEND

Q1 ◐ — Well designation and approximate location (well locations accurate to the nearest quarter-quarter section) (well logs obtained from Cline, 1969; Robinson & Noble, 1987; and Washington State Department of Ecology)

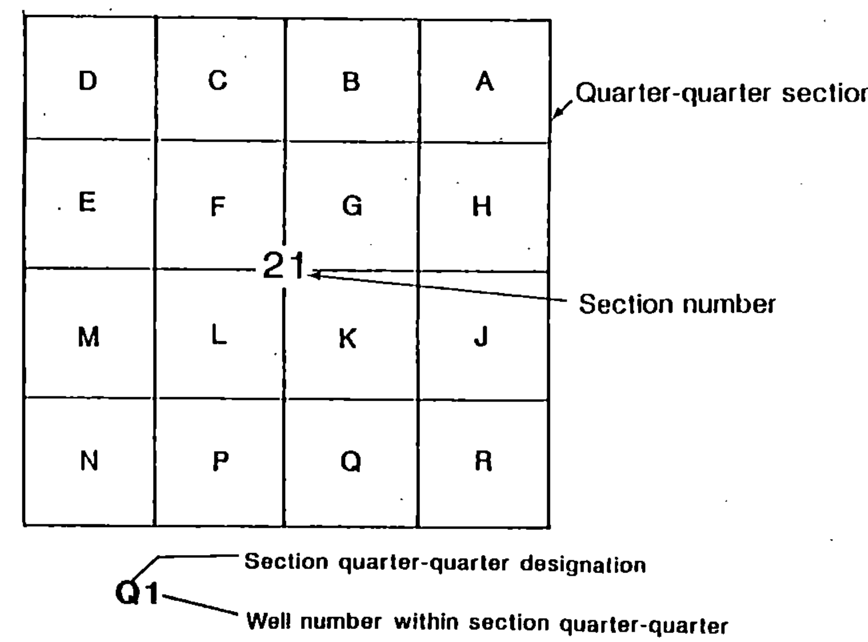
D1 ◐ — Indicates the presence of one or more Federal Way Water and Sewer District municipal supply wells

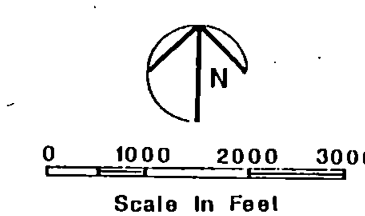
● ● ● — Lateral boundary of Redondo-Milton Channel (Robinson & Noble, 1987) (arrows point toward axis of channel)

Regional groundwater flow direction within Redondo-Milton Channel Aquifer (Robinson & Noble, 1987)

Approximate 1-mile radius around landfill

Well Designation System





Base topographic map from U.S. Geological Survey, Poverty Bay quadrangle, 1961, photorevised 1981.

AGI TECHNOLOGIES

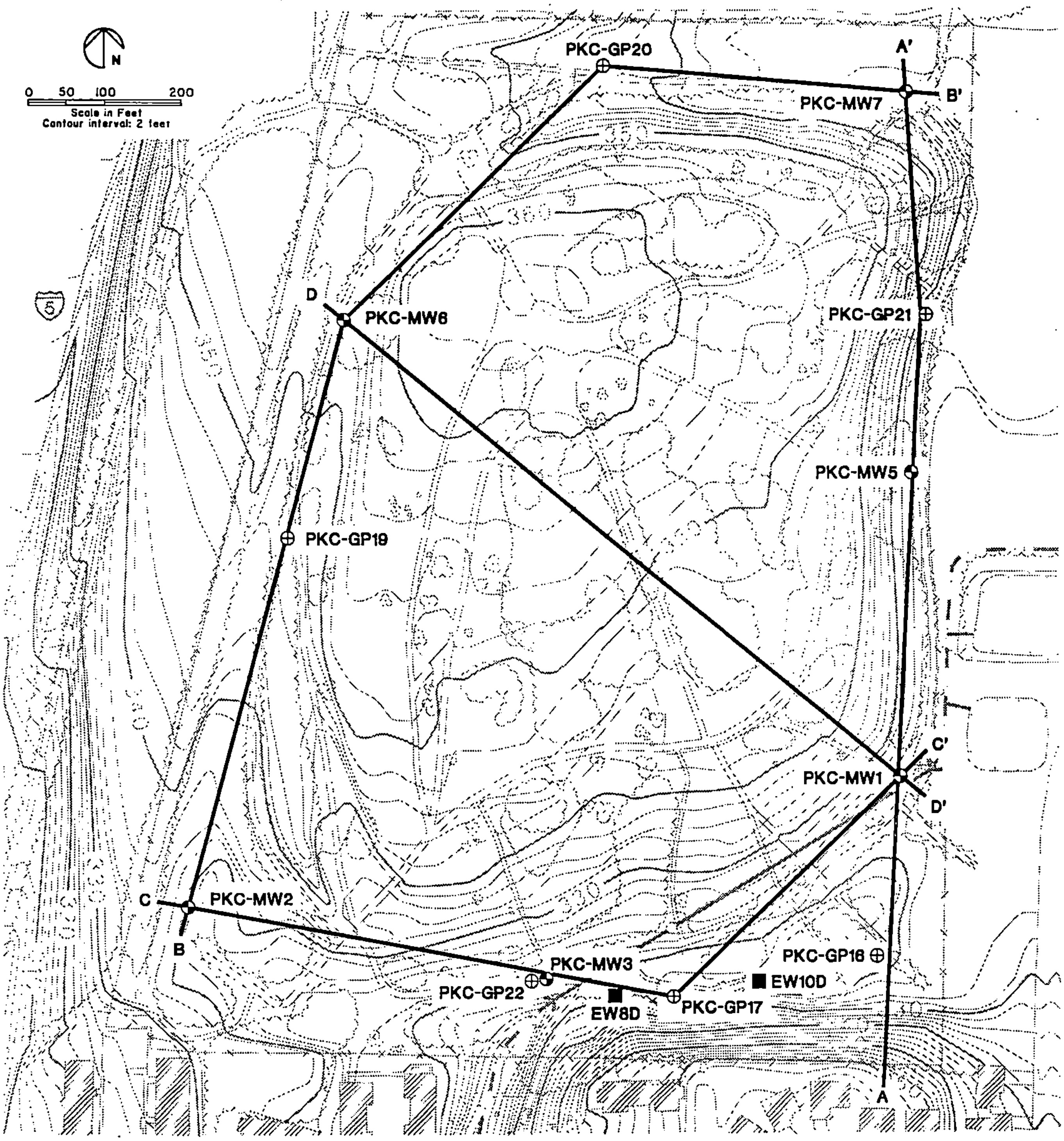
Well Location Map

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.3**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	7 Jun 94			

552900



LEGEND

PKC-MW2 ◎ Monitoring Well number and approximate location

PKC-GP22 ⊕ Gas Probe number and approximate location

EW8D ■ Gas Extraction Well number and approximate location

A ——— A' Cross section location

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

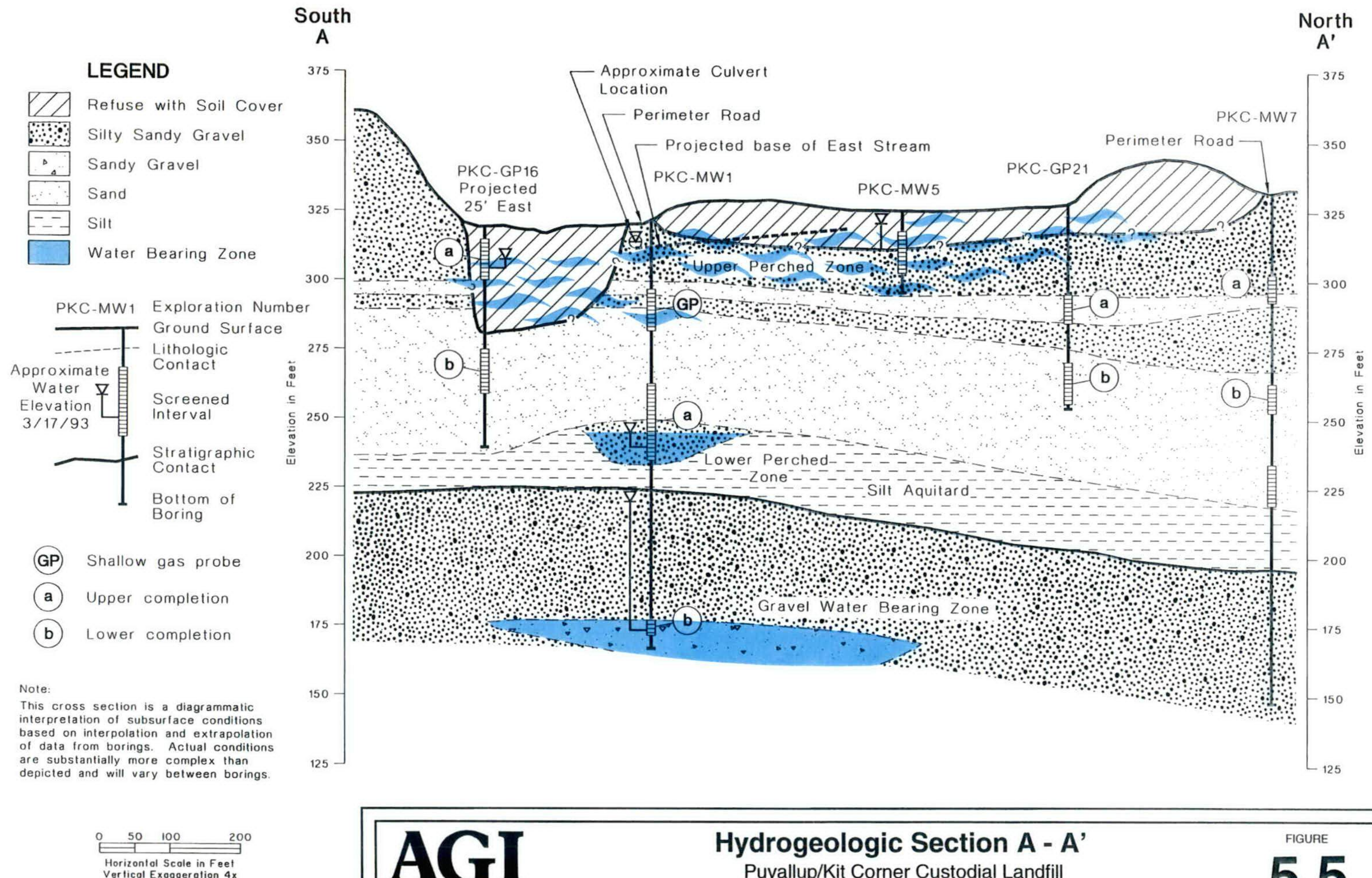
AGI TECHNOLOGIES

Cross Section Location Map

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.4**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
CrosSec.dwg	14,621.114	JFL				



Note:
This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings. Actual conditions are substantially more complex than depicted and will vary between borings.

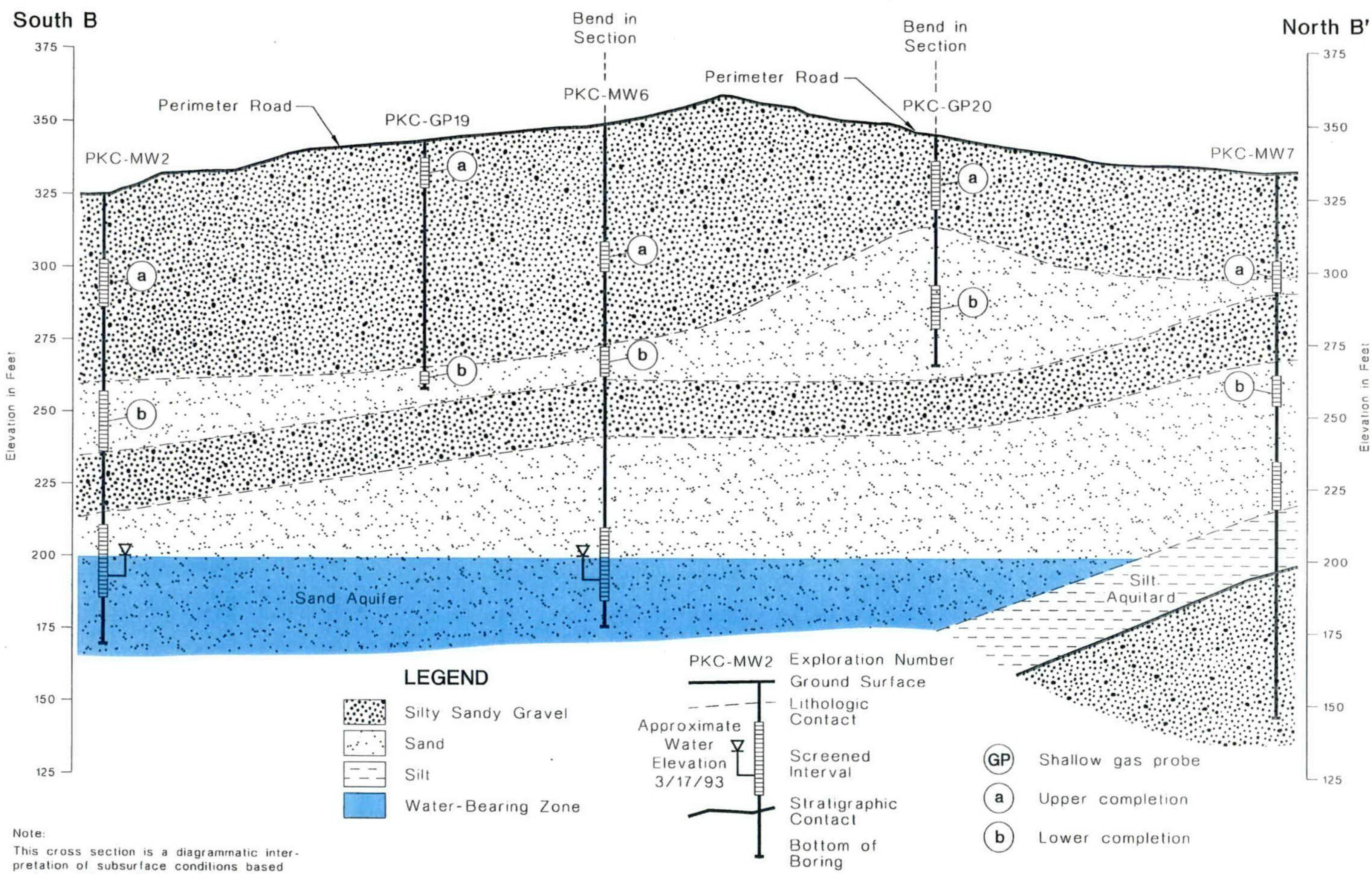
AGI TECHNOLOGIES

Hydrogeologic Section A - A'

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.5**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
xSec1H.dwg	14,621.114	JFL				



Note:
This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings. Actual conditions are substantially more complex than depicted and will vary between borings.

0 50 100 200
Horizontal Scale in Feet
Vertical Exaggeration 4x

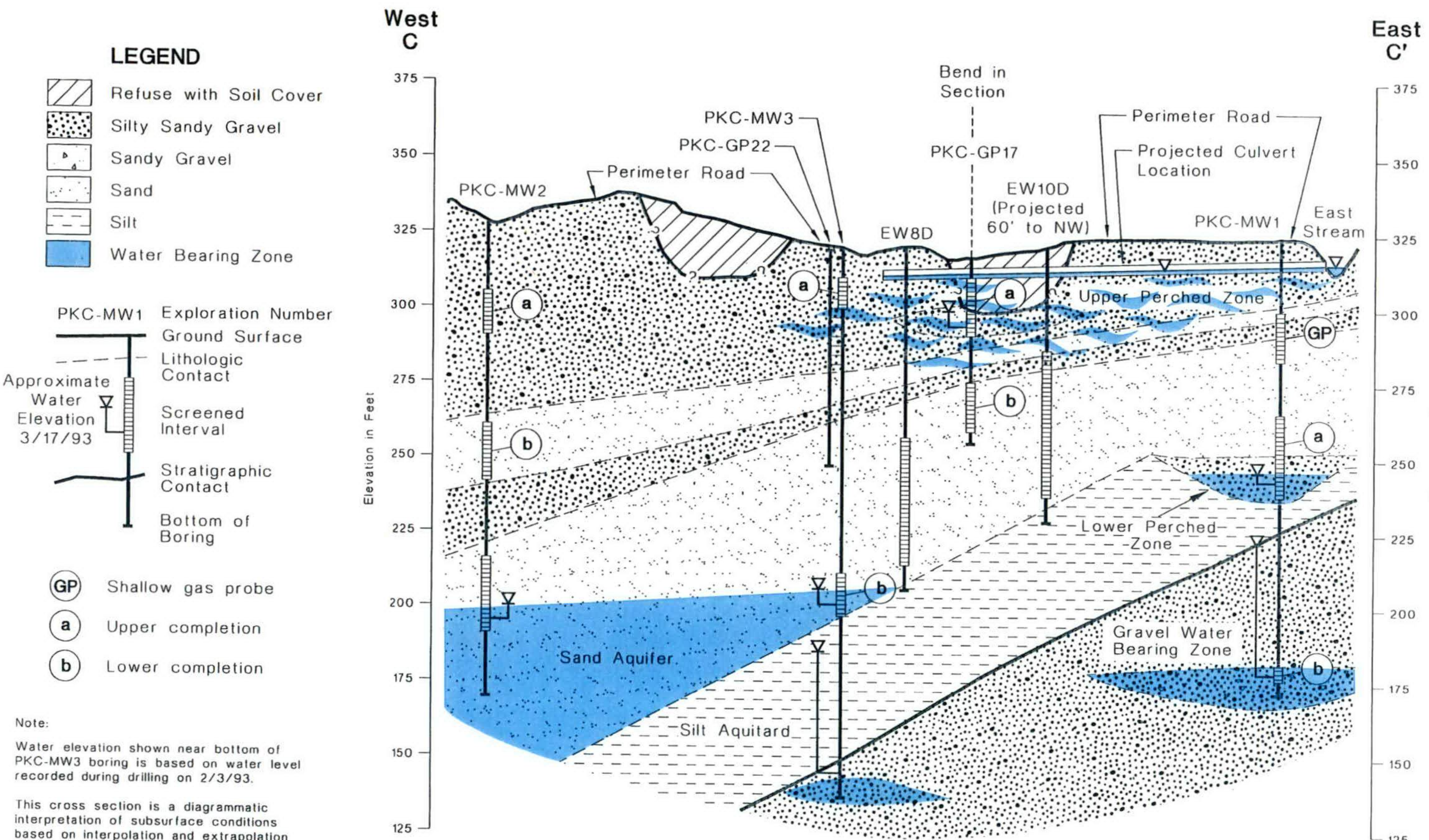
AGI TECHNOLOGIES

Hydrogeologic Section B - B'

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE
5.6

xSec2H.dwg	PROJECT NO. 14,621.114	DRAWN JFL	DATE	APPROVED	REVISED	DATE



Note:

Water elevation shown near bottom of PKC-MW3 boring is based on water level recorded during drilling on 2/3/93.

This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings. Actual conditions are substantially more complex than depicted and will vary between borings.

0 50 100 200

Horizontal Scale in Feet
Vertical Exaggeration 4x

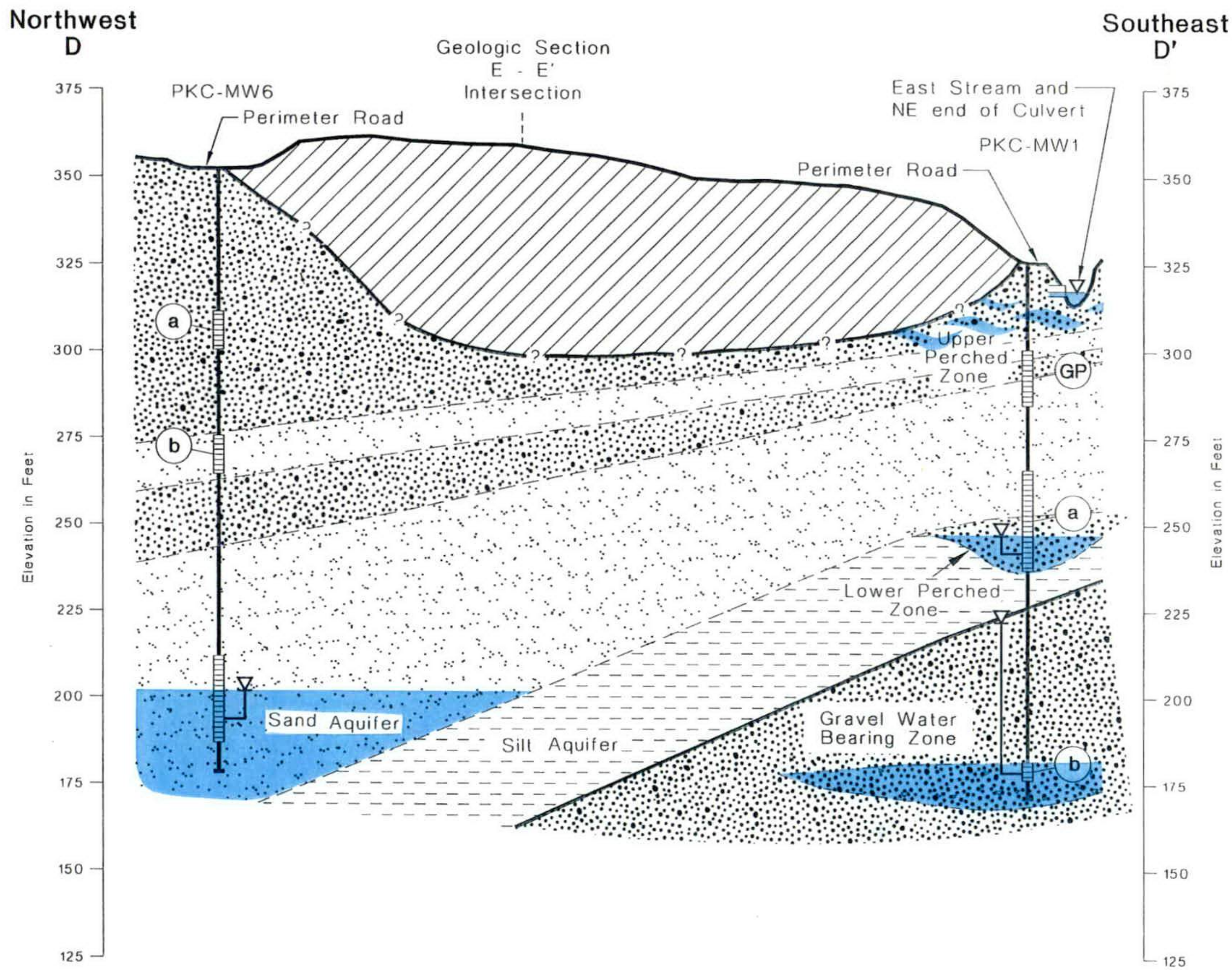
AGI TECHNOLOGIES

Hydrogeologic Section C - C'

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE 5.7

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
xSec3H.dwg	14,621.114	JFL				



LEGEND

- Refuse with Soil Cover
- Silty Sandy Gravel
- Sandy Gravel
- Sand
- Silt
- Water-Bearing Zone

PKC-MW1 Exploration Number
Ground Surface
Lithologic Contact
Approximate Water Elevation 3/17/93
Screened Interval
Stratigraphic Contact
Bottom of Boring

GP Shallow gas probe
a Upper completion
b Lower completion

Note:
This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings. Actual conditions are substantially more complex than depicted and will vary between borings.

0 50 100 200
Horizontal Scale in Feet
Vertical Exaggeration 4x

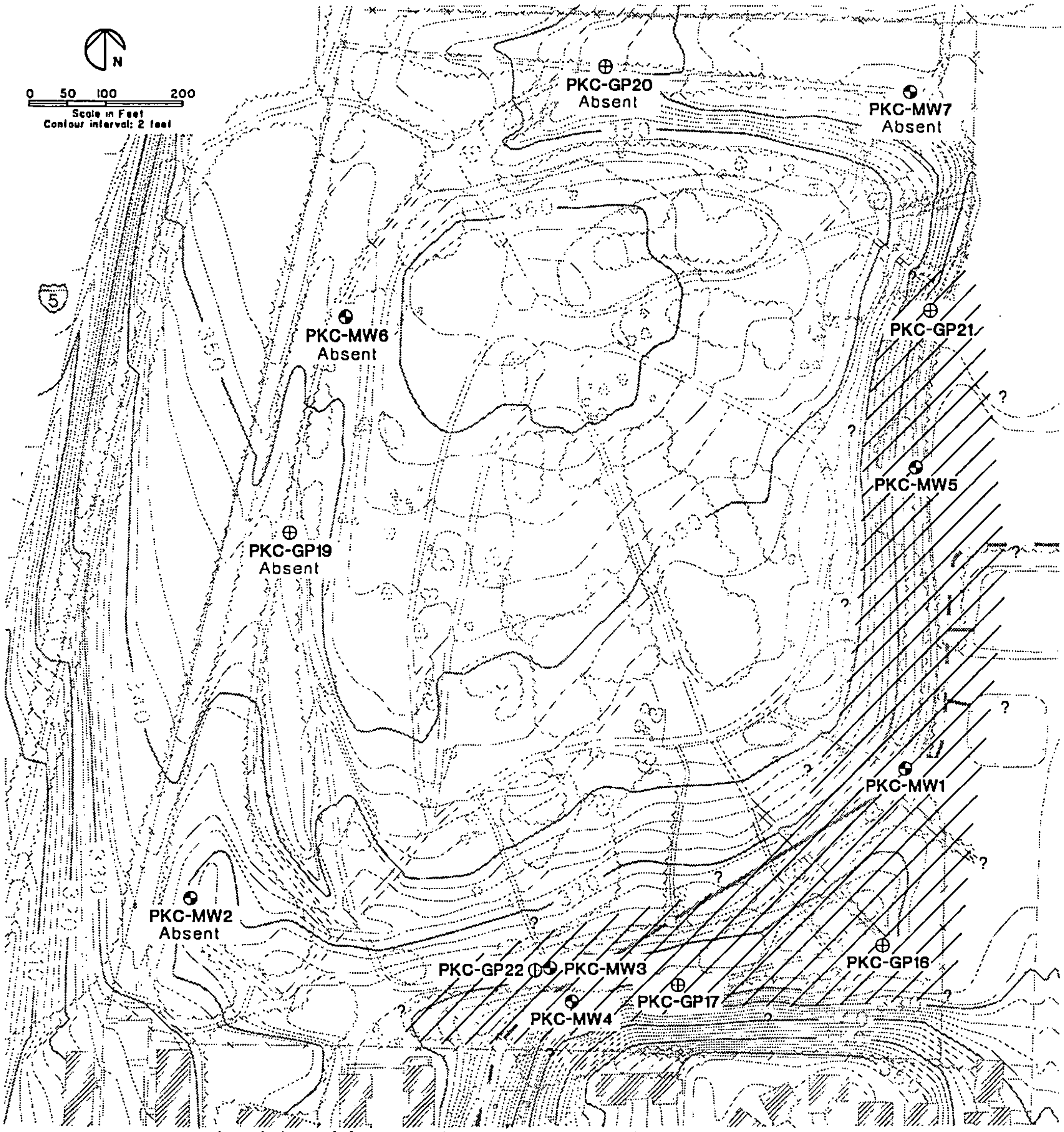
AGI TECHNOLOGIES

Hydrogeologic Section D - D'

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.8**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
xSec4H.dwg	14,621.114	JFL				



LEGEND

PKC-GP20 ⊕ Gas Probe number and approximate location

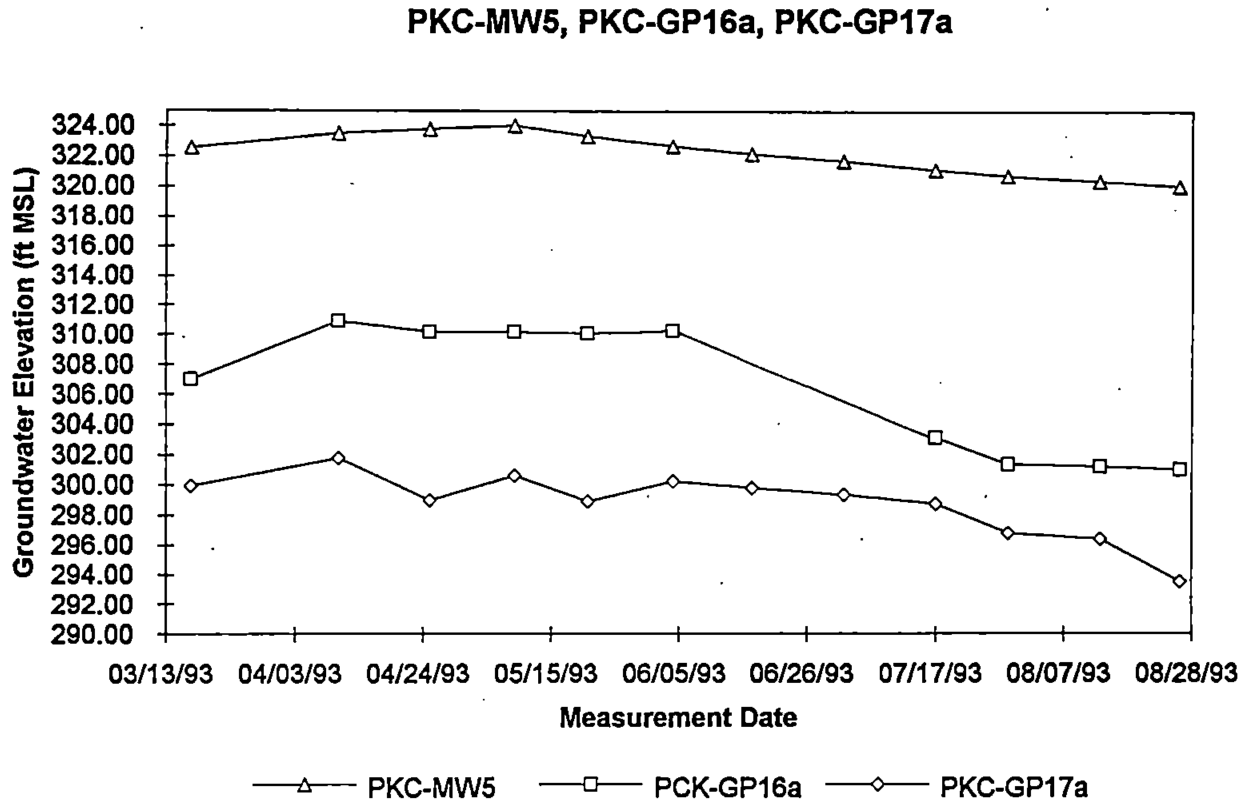
PKC-MW6 Groundwater Monitoring Well number and approximate location

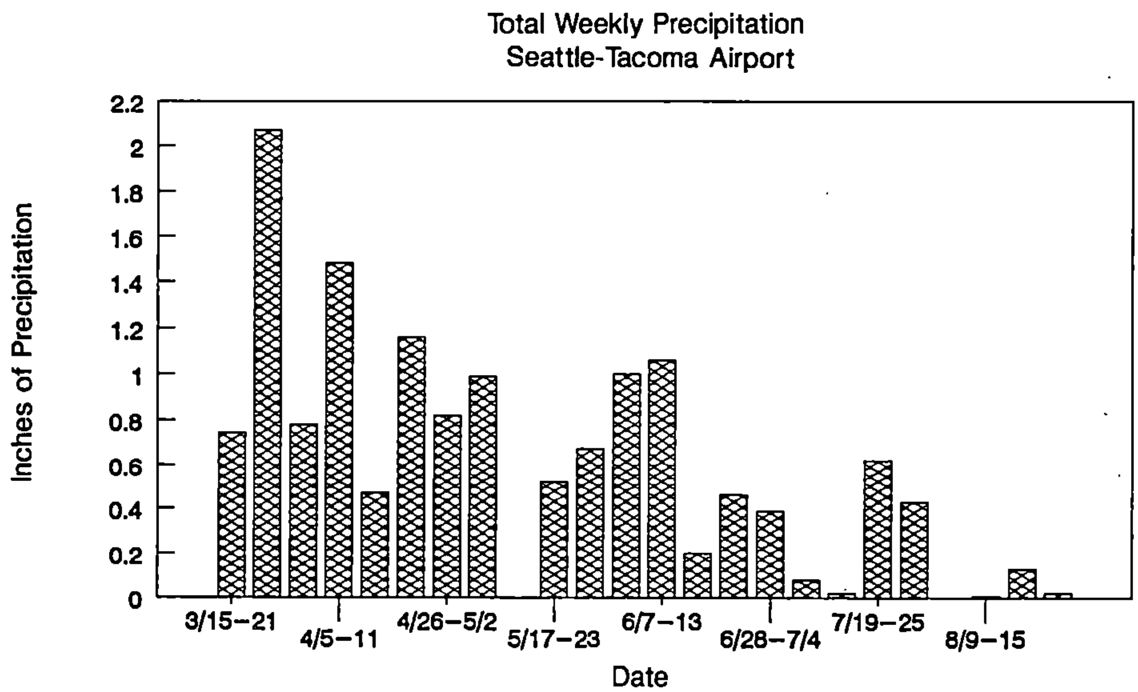
Inferred areal extent of saturation

Absent Deep exploration showing Upper Perched Zone to be not present

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES	**Upper Perched Zone Areal Extent** Puyallup/Kit Corner Custodial Landfill King County, Washington					FIGURE **5.9**
UpPerch.dwg	PROJECT NO. 14,621.114	DRAWN JFL	DATE	APPROVED	REVISED	DATE





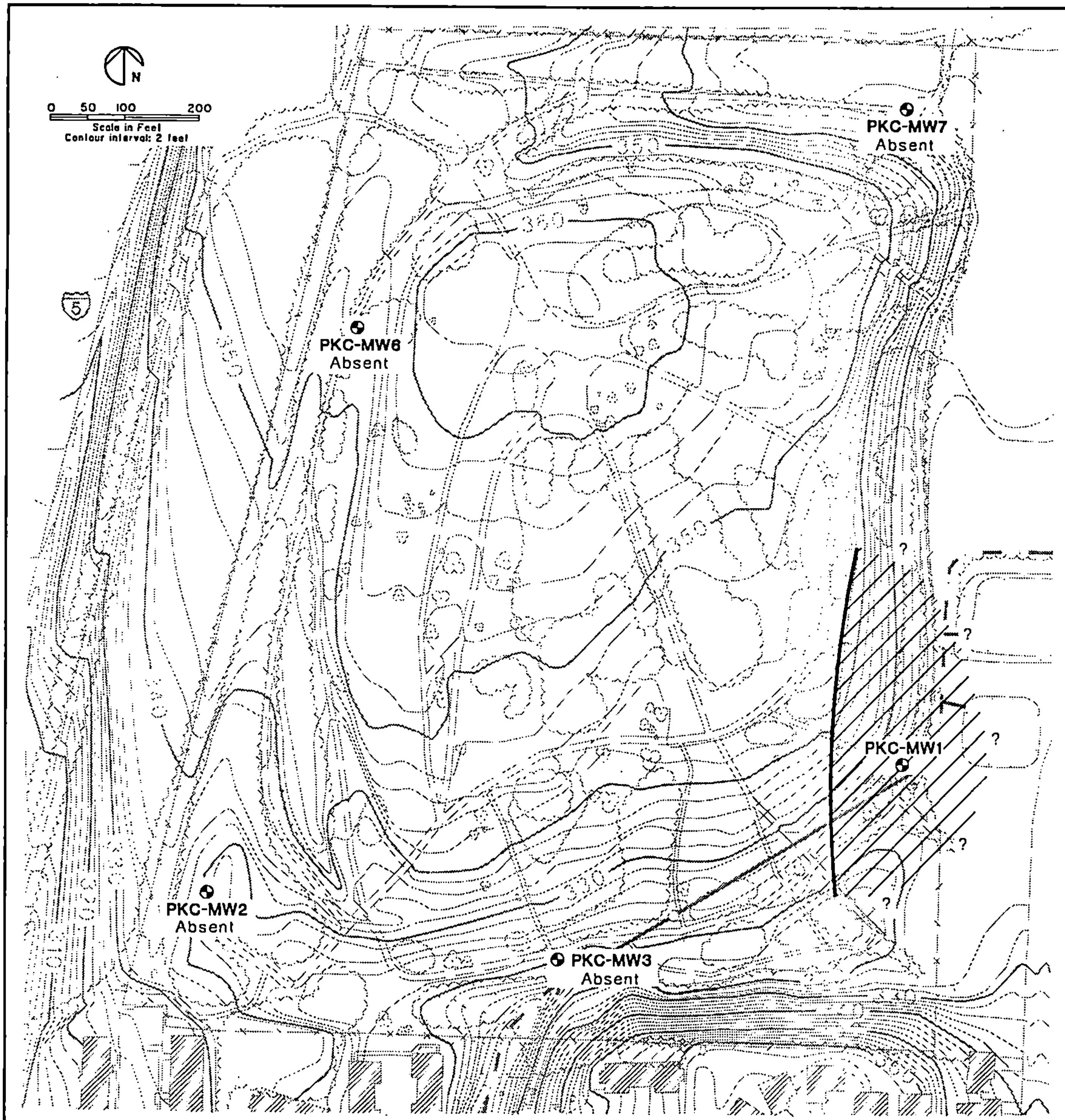
Source: National Oceanic & Atmospheric Administration
Local Climatological Data Monthly Summary for
March through August, 1993.

AGI TECHNOLOGIES

Upper Perched Zone Hydrographs:
PKC-MW5, PKC-GP16a, & PKC-GP17a
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.10**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	7 Jun 94			



LEGEND

PKC-MW6 ⊕ Groundwater Monitoring Well number and approximate location

Inferred areal extent of saturation

Absent Deep exploration showing Lower Perched Zone to be not present

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

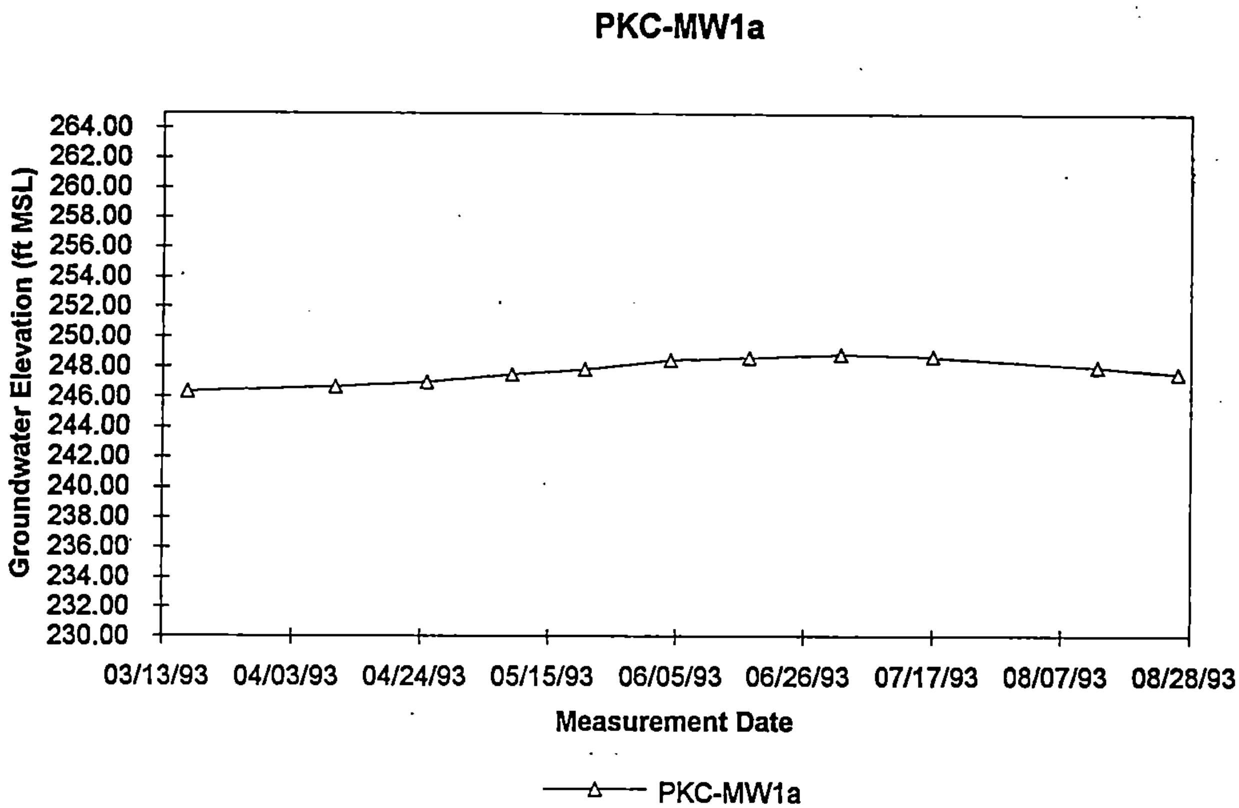
AGI TECHNOLOGIES

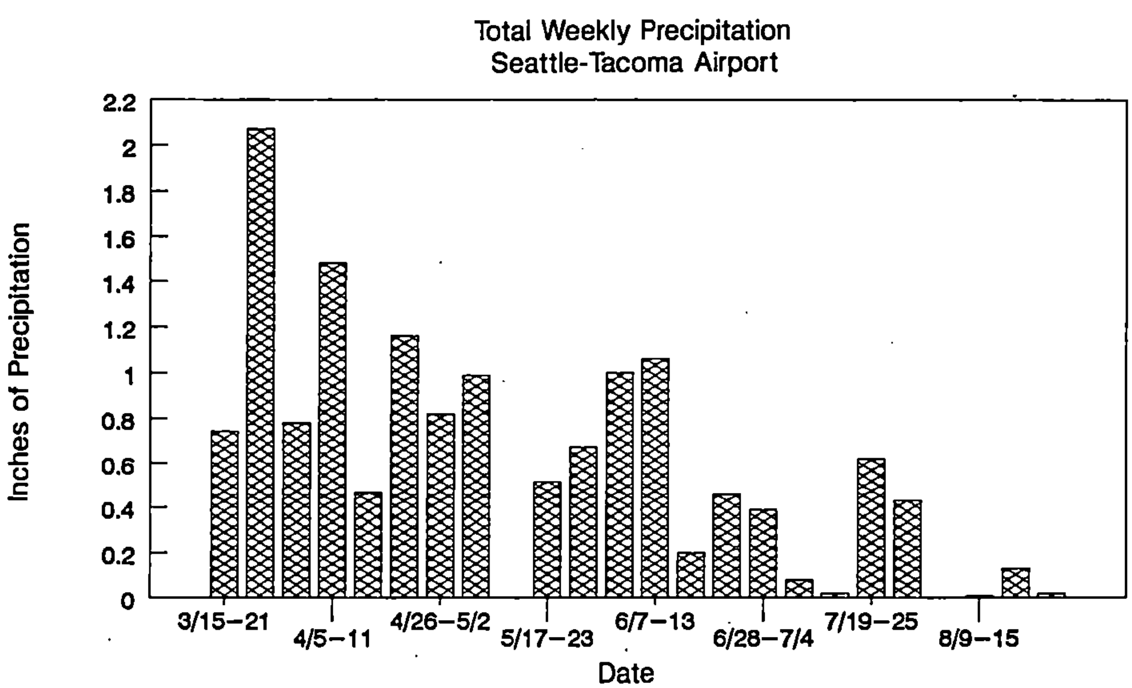
Lower Perched Zone Areal Extent

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.11**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
LowPerch.dwg	14,621.114	JFL				





Source: National Oceanic & Atmospheric Administration Local Climatological Data Monthly Summary for March through August, 1993.

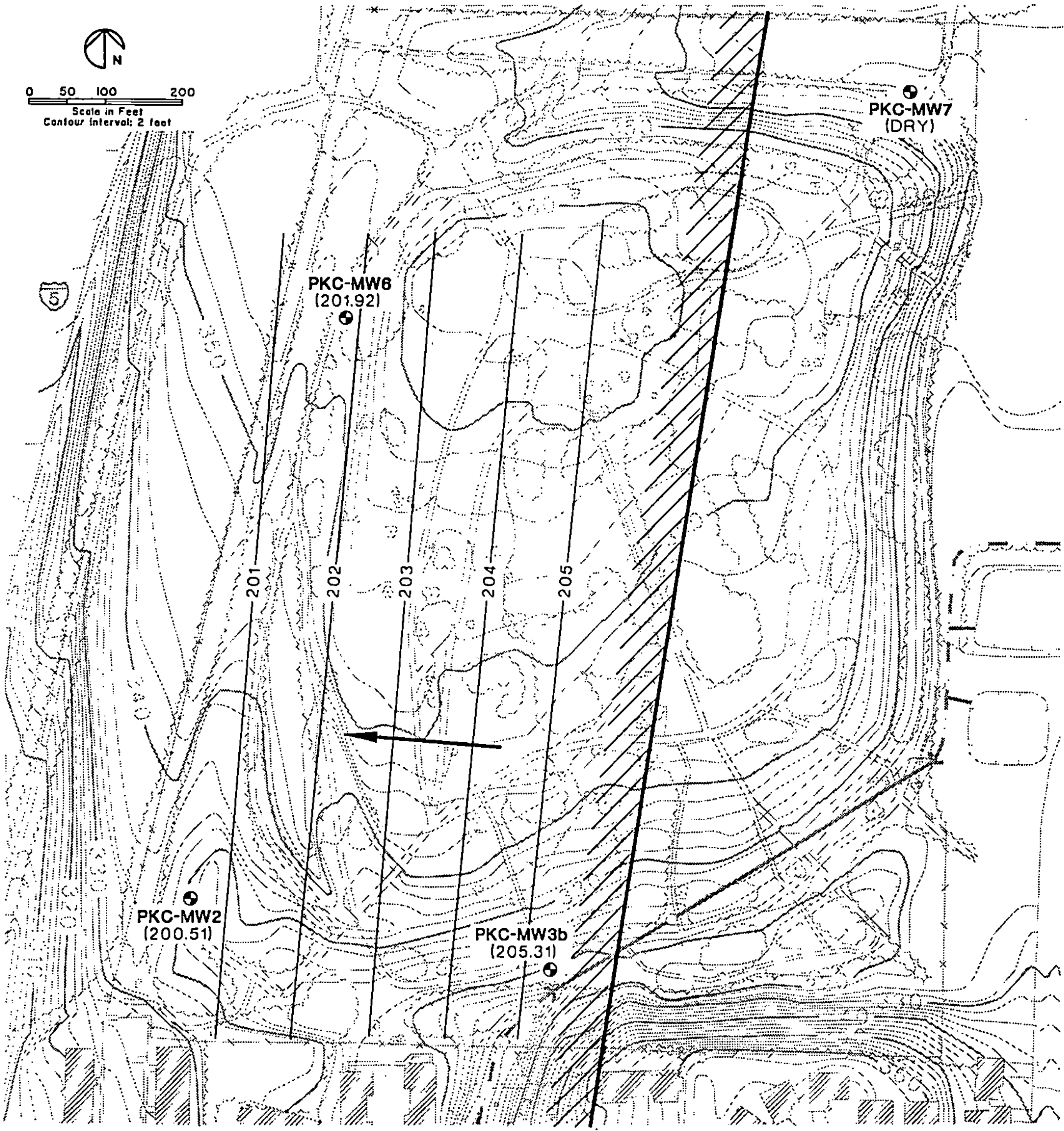
AGI TECHNOLOGIES

Lower Perched Zone Hydrographs: PKC-MW1a

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.12**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	7 Jun 94			



LEGEND

PKC-MW6 (201.92) Groundwater Monitoring Well number, approximate location, and groundwater elevation (feet)

—203— Potentiometric surface; 1-foot contour interval (NGVD 1929 MSL)

Inferred areal extent of saturation

General direction of groundwater flow

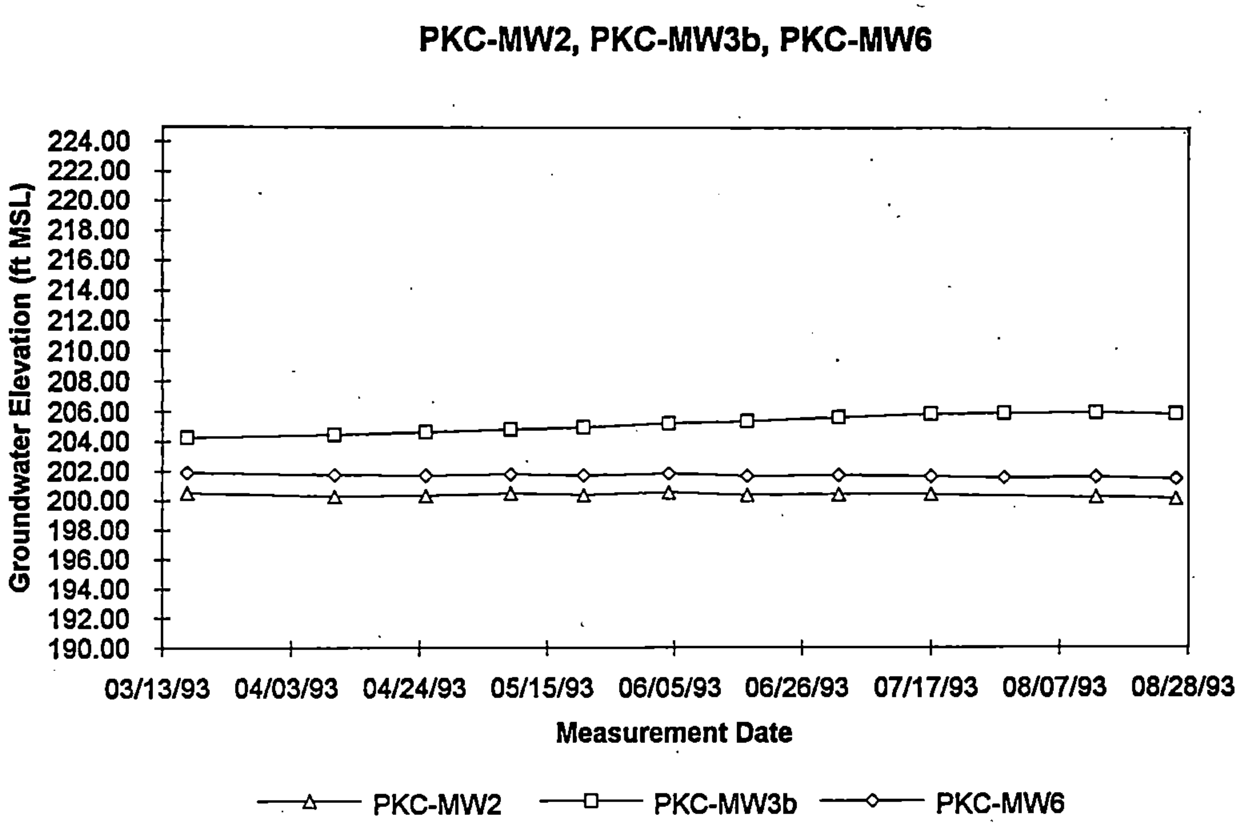
Reference: Base map and topography by DeGross Aerial Mapping, 1992.

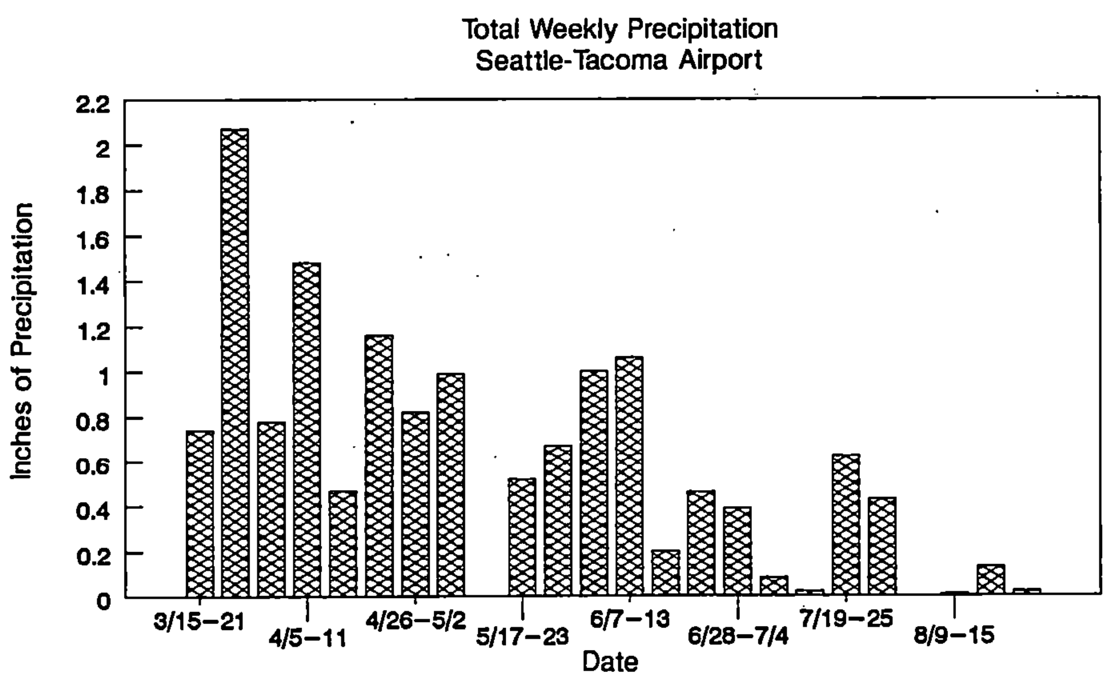
AGI TECHNOLOGIES

Sand Aquifer Potentiometric Surface for March 17, 1993
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.13**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
PotMar17.dwg	14,621.114	JFL				





Source: National Oceanic & Atmospheric Administration Local Climatological Data Monthly Summary for March through August, 1993.

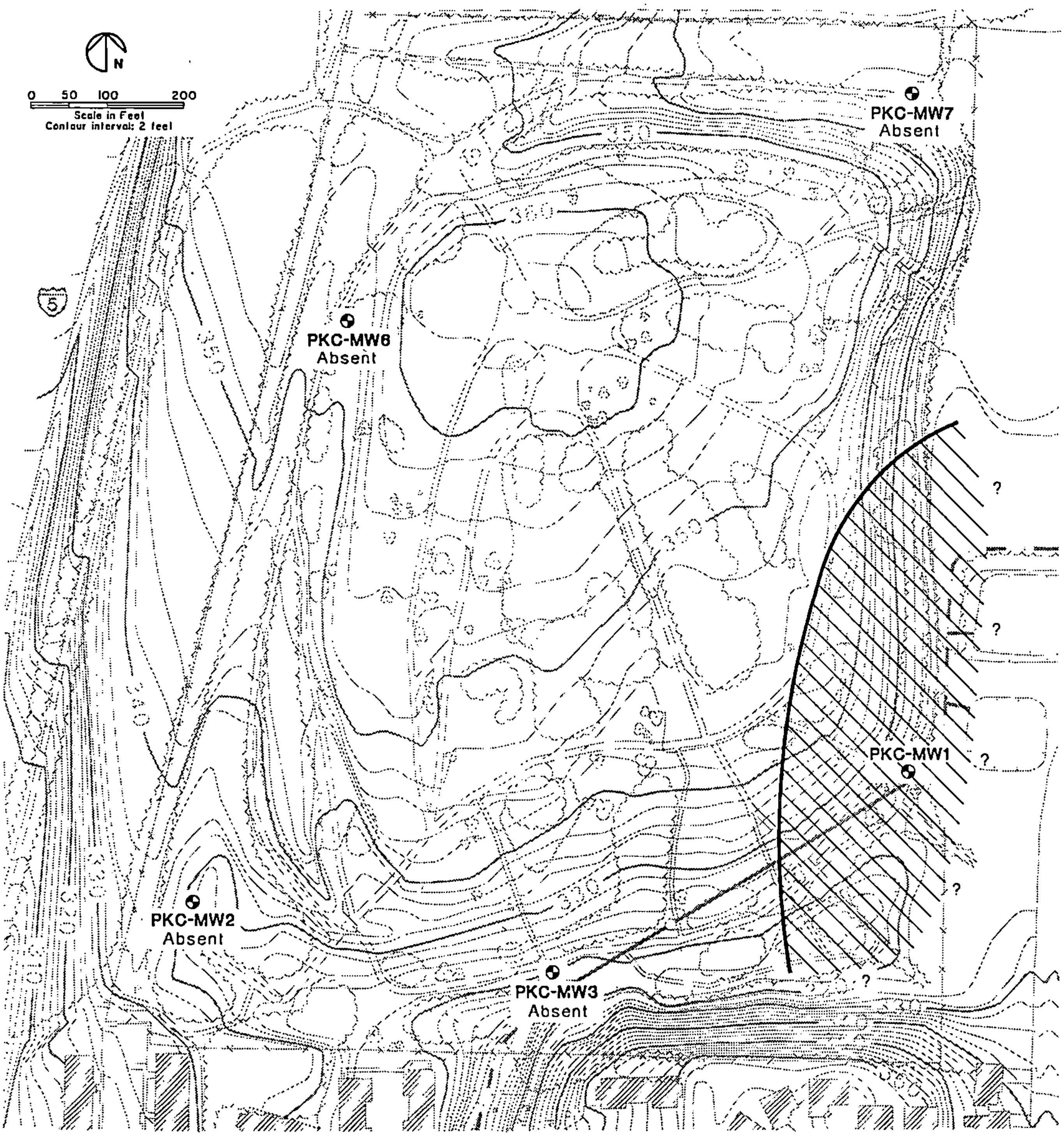
AGI TECHNOLOGIES

Sand Aquifer Hydrographs: PKC-MW2, PKC-MW3b, & PKC-MW6

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **5.14**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	7 Jun 94			



LEGEND

PKC-MW6 — Groundwater Monitoring Well number and approximate location

Inferred areal extent of saturation

Absent — Deep exploration showing Gravel Aquifer to be not present

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Gravel Water-Bearing Zone Areal Extent

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE 5.15

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
PreVasAq.dwg	14,621.114	JFL				

6.0 WATER QUALITY

6.1 SURFACE WATER

6.1.1 General

Four surface water samples (PKC-SW1 to PKC-SW4) were collected from the East Stream and vicinity on March 24, 1993 (Round 1) and May 26, 1993 (Round 2) at the locations shown on **Figure 4.1.** Three of the four surface water sample locations were from the East Stream, which runs along the perimeter of east side of the landfill. All of these locations were specifically selected to evaluate if the landfill was impacting surface water quality: PKC-SW4 is sited in an area which may receive seepage from the east side of the landfill. PKC-SW1 and PKC-SW2 are sited near opposite ends of the landfill culvert, PKC-SW2 near the upstream end and PKC-SW1 near the downstream end where the East Stream exits the landfill property. PKC-SW3 is located upstream of the landfill and is considered a background sample. To establish surface water quality, samples were analyzed for the following:

- Physical and general chemical properties: COD, TOC, TSS, pH, temperature, and specific conductance.
- Chemical constituents: VOCs, total and dissolved metals, chloride, sulfate, nitrate/nitrite, and ammonia.

The results of these analyses are presented in **Tables 6.1 through 6.3** and summarized below.

6.1.2 Surface Water Sampling Results

The quality of surface water at downgradient sampling locations was essentially the same as that at the upgradient sampling location during both rounds. Although some variation in chemical composition existed between locations and rounds, there was no significant difference between upgradient and downgradient samples. These data indicate the landfill is not impacting surface water quality in the East Stream.

Specific chemical characteristics of the water samples are discussed below:

- Field parameters (pH, temperature, and specific conductance) show consistent measurements between the two sampling rounds: pH ranged from 6.8 to 7.8, specific conductance ranged from 85 to 198 umhos/cm; and temperature ranged from 8.1 to 9.4°C. (Temperatures were elevated for the second round due to a higher ambient temperature and decreased volume of surface water.) Samples appeared generally clear with some visibly suspended solids. Samples PKC-SW1 and PKC-SW2, located near each end of the landfill culvert, appeared slightly yellow.
- COD, TOC, and TSS concentrations were consistent within the two sampling rounds for PKC-SW1, PKC-SW2, and PKC-SW3. COD, TOC, and TSS concentrations in PKC-SW4 changed; however, the concentrations were not significantly different from the other samples.

- Major metals (aluminum, calcium, iron, magnesium, manganese, potassium, and sodium) were detected in unfiltered and filtered samples (total and dissolved, respectively). Total and dissolved trace metals such as arsenic, barium, copper, and zinc were also detected in the surface water samples at very low concentrations. Trace dissolved arsenic was found only in the background sample PKC-SW3. Trace dissolved mercury was found only on one occasion in sample PKC-SW2.

- Several VOCs were detected in the surface water samples. None were consistently detected in both rounds. Carbon disulfide, chloroform, and toluene were detected in the upgradient sample (PKC-SW3) at concentrations ranging from .66 to 1.1 micrograms per liter (µg/L). Toluene was also detected in the second round at PKC-SW4.

6.2 GROUNDWATER

6.2.1 General

Groundwater samples were collected from March 22 through 25, 1993 (Round 1) and August 16 through 20, 1993 (Round 2), and analyzed for the following:

- Physical properties: COD, TOC, TSS, pH, temperature, and specific conductance.

- Chemical constituents: VOCs, total and dissolved metals, chloride, sulfate, nitrate/nitrite, and ammonia.

Six groundwater monitoring wells were sampled during each round. Monitoring well identification, sampling dates, and corresponding hydrostratigraphic units are tabulated below:

Well Identification	Dates Sampled	Hydrostratigraphic Unit
PKC-MW1a	3/23/93 & 8/19/93	Lower Perched Zone
PKC-MW1b	3/22/93 & 8/16/93	Gravel Water-Bearing Zone
PKC-MW2	3/25/93 & 8/20/93	Sand Aquifer
PKC-MW3b	3/23/93 & 8/19/93	Sand Aquifer
PKC-MW5	3/24/93 & 8/20/93	Upper Perched Zone
PKC-MW6	3/24/93 & 8/20/93	Sand Aquifer

Groundwater chemical analysis results focused on analytes typically associated with landfill impacts are summarized in **Table 6.4**. Detailed groundwater chemical analysis results follow on **Tables 6.5 through 6.7.**

Background water quality was not determined for any of the aquifers due to site hydrogeological conditions. Only one well was completed in the Upper and Lower Perched Zones and the Gravel Water-Bearing Zone. There was no upgradient or sidegradient well available for sampling in the Sand Aquifer.

6.2.2 *Groundwater Sampling Results*

Upper Perched Zone : Groundwater sampling results show that the Upper Perched Zone (PKC-MW-5) had elevated (with respect to other water-bearing zones investigated) concentrations of ammonia, TOC, COD, conductivity, and iron. The major metal cations (sodium, calcium, and magnesium) may also have been elevated. Several VOCs--specifically benzene, ethylbenzene, toluene, and xylenes (BETX) and chlorobenzene, dichlorobenzenes, trichlorofluormethane, and carbon disulfide--were also detected. The concentrations of general parameters and selected metals and VOCs at PKC-MW5 are shown for comparison purposes on **Figure 6.1.**

The groundwater sampling data suggest the Upper Perched Zone at PKC-MW5 has been impacted by the landfill. The high concentrations of ammonia and iron indicate a reducing environment, characteristic of near-landfill conditions, and the presence of the BETX group at low concentrations is consistent with municipal refuse. The fact that PKC-MW5 is partially screened across a refuse layer also strongly supports landfill impact on groundwater quality. Other supporting data include observation of a "silage" odor and orange-colored water when purging the well.

However, the groundwater chemistry at PKC-MW5 was not fully consistent with that typically associated with landfill leachate impact. Chloride concentrations, which are usually elevated, were low: less than 10 milligrams per liter (mg/L). Arsenic was also present at lower-than-average concentrations.

We interpret the apparently conflicting chemical data to indicate that the landfill impact at PKC-MW5 is primarily associated with the existence of a strongly reducing environment (due to proximity to the landfill) and a local volatile source of BETX compounds, rather than as direct leachate migration. A strongly reducing environment would provide dissolution of iron and transformation of organic nitrogen to ammonia. A local BETX source in the refuse would allow gas transport of these volatile compounds. High COD and TOC may have been present simply because PKC-MW5 is screened in refuse, or may have been due to the high suspended solid concentrations in the groundwater samples.

Lower Perched Zone : Groundwater sampling results from the one monitoring well completed in the Lower Perched Zone (PKC-MW1a) indicate this zone is characterized by relatively low concentrations of anions and cations (chloride, calcium, sodium, ammonia, etc.) and low COD, TOC, and conductivity compared to other water-bearing zones at the site. No VOCs were detected in either sampling round and major metals were not elevated with respect to other water-bearing zones investigated. Nitrate/nitrite was detected in both sampling rounds, suggesting an aerobic environment typical of natural groundwater conditions. The groundwater sampling data suggest the Lower Perched Zone at PKC-MW1a has not been impacted by the landfill.

Sand Aquifer : Groundwater sampling results show that conductivity, COD, and dissolved iron, calcium, sodium, and magnesium were elevated with respect to the Lower Perched Zone and Gravel Water-Bearing Zone in all Sand Aquifer wells, with PKC-MW2 having the highest concentrations. Chloride, TOC, arsenic, and manganese were also elevated with respect to the Lower Perched Zone and Gravel Water-Bearing Zone at PKC-MW2 and PKC-MW3, but less so at PKC-MW3. The nitrogen species nitrate/nitrite or ammonia were detected in all the Sand Aquifer wells. PKC-MW6 consistently had the lowest chemical concentrations, except for the metals calcium and magnesium. Some of these concentration relationships are displayed graphically for comparison purposes on **Figure 6.1.**

VOCs were also detected in all three Sand Aquifer wells. The detected VOCs were primarily those within the chlorinated ethene and ethane group and associated breakdown products. These include chloroethane; 1,1-dichloroethane; 1,2-dichloroethane; trans-1,2-dichloroethene; cis-1,2-dichloroethene; and vinyl chloride. Vinyl chloride was most consistently detected and was present at much higher concentrations than the other chlorinated VOCs. None of the higher order precursor compounds (trichloroethene or tetrachloroethane) were detected. The highest vinyl chloride concentrations were detected at PKC-MW6 (80 and 67 micrograms per liter [µg/L] during first and second sampling rounds, respectively).

The chemical analysis results suggest that the Sand Aquifer has been impacted by the landfill. The impact is characterized by elevated indicator parameters (COD, TOC, conductivity, chloride) and metals (arsenic, iron, manganese, sodium), and the presence of VOCs (principally vinyl chloride). However, the type and degree of impact vary. Groundwater at PKC-MW2 and PKC-MW3 at the south end of the landfill typifies the type of impact associated with landfill leachate (i.e., high COD, chloride, conductivity, arsenic, and iron). Groundwater at PKC-MW6, by contrast, showed only a few of the typical leachate indicators (high COD, conductivity, and perhaps sodium and iron) and was highest in vinyl chloride. Although it is not possible to truly determine whether PKC-MW6 has been impacted by leachate without a background well, the chloride concentrations at this well were sufficiently low to suggest no impact. The data further suggest that the vinyl chloride detected at this well may not be a result of fluid transport, but of landfill gas migration.

Gravel Water-Bearing Zone : Groundwater sampling results from the one monitoring well completed in the Gravel Water-Bearing Zone (PKC-MW1b) show this water-bearing zone has a chemistry similar to that in the Lower Perched Zone (i.e., relatively low concentrations of anions, including chloride and low COD, TOC, and conductivity when compared to the Upper Perched Zone and the Sand Aquifer). Three VOCs–acetone, toluene, and total xylenes--were detected at low concentrations, but only during the first sampling round.

The groundwater sampling data suggest that the Gravel Water-Bearing Zone has not been impacted by the landfill.

6.3 CONCEPTUAL MODEL OF LANDFILL IMPACT

AGI's Phase I investigation included development of a conceptual model of landfill impact on groundwater at the landfill. The results of AGI's Phase II investigation indicate only minor adjustments are required for the conceptual model. The primary source of water entering the landfill is precipitation infiltrating through the landfill cap. Only a small percentage of stormwater appears to run off the site during storm events. Most rainfall infiltrates or ponds in various flat-lying areas. These observations suggest that of the 39 inches of average annual precipitation, a high percentage (on the order of 50 to 70 percent) infiltrates and passes downward through the landfill refuse.

A potential additional source of water is groundwater inflow from the Upper Perched Zone on the south and east side of the landfill. The inflow volume associated with this source is expected to be less than stormwater infiltration through the surface of the landfill.

Water movement through the landfill is believed to be primarily vertical; however, the seeps observed around the perimeter of the landfill in the spring of 1993 indicate some lateral movement within or near the landfill cap. The primary mode of water migration out of the landfill appears to be vertically downward into unsaturated soils below the landfill and eventually into the Sand Aquifer. Some near-surface lateral flow may occur to the east and south into the Shallow Perched Zone.

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Table 6.1
General Anions and Physical Parameters in Surface Water
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Parameter	LQL mg/L	Date	PKC-SW1	PKC-SW2	Background Sample PKC-SW3	PKC-SW4	Dup PKC-SW4
Specific Conductivity (µmhos/cm)	--	3/93	113	126	125	85	--
	--	5/93	151	198	127	180	--
Temperature (°C)	--	3/93	8.1	8.6	9.3	9.4	--
	--	5/93	16.5	15.9	17.2	21.7	--
pH	--	3/93	7.5	7.3	7.3	6.8	--
	--	5/93	7.3	6.9	7.1	7.8	--
Ammonia as Nitrogen (mg/L)	0.01	3/93	0.012	0.012	0.019	0.019	0.013
	0.01	5/93	ND	0.233	ND	0.170	0.241
Nitrate + Nitrite as Nitrogen (mg/L)	0.01	3/93	0.825	0.807	0.790	0.797	0.720
	0.01	5/93	0.292	0.270	0.306	ND	ND
Chloride (mg/L)	1.0	3/93	17.6	16.6	17.7	3.5	3.2
	1.0	5/93	16.1	16.3	16.0	14.0	13.8
Sulfate (mg/L)	2.5	3/93	7.8	7.7	7.3	7.5	7.3
	2.5	5/93	5.9	5.9	6.3	4.3	5.1
Chemical Oxygen Demand (mg/L)	5.0	3/93	21.5	20.5	20.9	11.2	15.7
	5.0	5/93	19.2	17.6	22.3	23.5	27.6
Total Organic Carbon (mg/L)	1.0	3/93	6.23	6.39	6.52	3.57	3.93
	1.0	5/93	6.32	6.48	6.27	7.78	7.49
Total Suspended Solids (mg/L)	1.0	3/93	ND	ND	ND	ND	ND
	1.0	5/93	ND	6.0	ND	6.0	7.6

Notes:

Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
mg/L – Milligrams per liter.
ND – Not detected.

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Table 6.2
Total and Dissolved Metals in Surface Water
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

							Background Sample				Dup	
	LQL		PKC-SW1		PKC-SW2		PKC-SW3		PKC-SW4		PKC-SW4	
Metal	mg/L	Date	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
			mg/L									
Major Metals												
Aluminum	0.020	3/93	0.440	0.07	0.420	0.07	0.390	0.08	0.150	0.07	0.150	0.06
	0.020	5/93	0.330	0.03	0.270	ND	0.080	0.04	0.370	0.05	0.190	0.04
Calcium	0.010	3/93	7.30	7.18	7.17	6.95	7.05	6.81	8.03	8.16	8.02	8.11
	0.010	5/93	10.3	9.97	10.3	9.77	10.5	10.1	7.54	7.40	7.55	7.27
Iron	0.005	3/93	0.371	0.085	0.356	0.073	0.351	0.093	0.108	0.033	0.114	0.027
	0.005	5/93	0.584	0.158	0.575	0.059	0.472	0.166	3.87	0.259	3.93	0.117
Magnesium	0.020	3/93	2.19	2.12	2.17	2.10	2.17	2.08	2.46	2.5	2.42	2.55
	0.020	5/93	3.26	3.09	3.24	3.02	3.69	3.49	2.44	2.39	2.40	2.33
Potassium	0.400	3/93	1.2	1.0	1.1	0.9	1.3	1.0	1.5	1.0	1.2	0.9
	0.400	5/93	0.8	0.9	1.1	0.9	1.0	1.2	1.2	0.9	1.0	1.2
Sodium	0.010	3/93	12.6	12.4	12.8	12.6	12.9	12.7	3.25	3.38	3.16	3.46
	0.010	5/93	12.7	12.3	12.7	12.1	12.8	12.4	12.6	12.5	12.1	12.5
Trace Metals												
Arsenic	0.001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	0.001	ND	0.001	0.001	0.001	ND	0.001	ND
Barium	0.001	3/93	0.014	0.012	0.014	0.012	0.013	0.012	0.021	0.021	0.021	0.021
	0.001	5/93	0.013	0.010	0.017	0.010	0.012	0.010	0.019	0.015	0.020	0.016
Beryllium	0.001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	0.002	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.002	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.005	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.005	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	0.003	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.003	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Table 6.2
Total and Dissolved Metals in Surface Water
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-SW1 Total	PKC-SW1 Dissolved	PKC-SW2 Total	PKC-SW2 Dissolved	Background Sample PKC-SW3 Total	Background Sample PKC-SW3 Dissolved	PKC-SW4 Total	PKC-SW4 Dissolved	Dup PKC-SW4 Total	Dup PKC-SW4 Dissolved
			mg/L									
Trace Metals (cont.)												
Copper	0.002	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.002	5/93	0.007	ND	ND	ND	0.002	ND	0.002	ND	0.004	ND
Lead	0.020	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	0.001	3/93	0.014	0.010	0.016	0.011	0.020	0.017	0.031	0.028	0.034	0.025
	0.001	5/93	0.123	0.036	0.132	0.073	0.173	0.138	0.245	0.280	0.336	0.268
Mercury	0.0001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.0001	5/93	ND	ND	ND	0.0003	ND	ND	ND	ND	ND	ND
Nickel	0.010	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.010	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.003	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.003	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	0.050	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.050	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tin	0.010	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.010	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	0.002	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.002	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	0.004	3/93	0.013	ND	0.020	ND	0.011	ND	0.027	0.033	0.030	0.028
	0.004	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
mg/L – Milligrams per liter.
ND – Not detected.

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Table 6.3
Volatile Organic Compounds Detected in Surface Water
Quantified by EPA Method 8240 Modified
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compound	LQL µg/L	Date	PKC-SW1	PKC-SW2	Background Sample PKC-SW3	PKC-SW4	Dup PKC-SW4
			µg/L				
Carbon disulfide	0.20	3/93	ND	ND	0.82	ND	ND
	0.20	5/93	ND	ND	ND	ND	ND
Toluene	0.20	3/93	ND	ND	1.1	ND	ND
	0.20	5/93	ND	ND	ND	0.74	0.76
Chloroform	0.20	3/93	ND	ND	ND	ND	ND
	0.20	5/93	ND	ND	0.66	ND	ND

Notes:

Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
ND – Not detected.
µg/L – Micrograms per liter.

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Table 6.4
Groundwater Quality Summary
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Parameters	Dates	Upper Perched Zone	Lower Perched Zone	Sand Aquifer			Gravel Water-Bearing Zone
		PKC-MW5	PKC-MW1a	PKC-MW2	PKC-MW3b	PKC-MW6	PKC-MW1b
COD (mg/L)	3/93,8/93	117.6	ND	70.0	32.2	27.3	15
TOC (mg/L)	3/93,8/93	12.5	ND	17.7	1.4	1.2	3.2
Specific Conductivity (μmhos/cm)	3/93,8/93	810	250	1,700	520	620	290
Ammonia (mg/L)	3/93,8/93	27.2	ND	ND	1.85	ND	ND
Nitrate/Nitrite (mg/L)	3/93,8/93	0.04	2.7	0.03	0.03	0.02	1.7
Chloride (mg/L)	3/93,8/93	7.7	11.2	89.0	15.0	5.3	12.1
Sulfate (mg/L)	3/93,8/93	3.4	13.3	5.1	14.6	10.7	10.6
Calcium (mg/L)	3/93,8/93	68.5	27.6	144	41.6	66.3	26.3
Iron (mg/L)	3/93,8/93	95.8	0.006	6.15	12.6	1.99	0.014
Magnesium (mg/L)	3/93,8/93	9.73	15.1	70.8	28.4	38.5	15.4
Sodium (mg/L)	3/93,8/93	6.47	8.8	159	13.4	12.5	8.91
Arsenic (mg/L)	3/93,8/93	0.003	ND	0.071	0.023	0.001	ND
Manganese (mg/L)	3/93,8/93	0.09	0.163	8.81	4.30	1.78	0.02
Benzene (mg/L)	3/93,8/93	5.7	ND	1.2	0.27	ND	ND
Ethylbenbzene (mg/L)	3/93,8/93	52	ND	ND	ND	ND	ND
Vinyl Chloride (mg/L)	3/93,8/93	ND	ND	1.0	3.1	74	ND

Notes:

Values listed in this table are an average of concentrations measured during the two sampling events.
Filtered metal results are reported in this table.
mg/L – Milligrams per liter.
ND – Not detected.
μmhos/cm – Micromhos per centimeter at 25 °C.

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Table 6.5
General Anions and Physical Parameters in Groundwater
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Parameter	LQL mg/L	Date	PKC–MW1a	PKC–MW1b	PKC–MW2	Dup PKC–MW2	PKC–MW3b	PKC–MW5	PKC–MW6
Specific Conductivity (µmhos/cm)	--	3/93	247	300	1,681	--	476	710	510
		8/93	254	278	1,702	--	555	905	734
Temperature (°C)	--	3/93	10.5	11.2	12.5	--	11.2	8.9	10.8
		8/93	14.4	11.3	14.2	--	14.2	14.0	13.3
pH	--	3/93	6.4	7.5	7.6	--	7.0	6.5	6.5
		8/93	6.5	6.5	6.8	--	6.5	6.4	6.5
Ammonia as Nitrogen (mg/L)	0.010	3/93	ND	ND UJ	ND UJ	ND UJ	1.19	22.9	ND
	0.010	8/93	ND UJ	ND UJ	ND UJ	ND UJ	2.50 J	31.5 J	ND UJ
Nitrate + Nitrite as Nitrogen (mg/L)	0.01	3/93	2.61	1.56	ND	ND	0.042	ND	ND
	0.01	8/93	2.86	1.88	0.050	0.051	ND	0.067	0.026
Chloride (mg/L)	1.0	3/93	11.3	12.2	95.7	81.6	18.4	9.7	5.8
	1.0	8/93	11.0	12.0	86.9	91.7	11.5	5.7	4.7
Sulfate (mg/L)	2.5	3/93	12.7	10.4	4.0	4.4	13.4	3.0	9.3
	2.5	8/93	13.8	10.7	6.2	5.8	15.8	3.8	12.0
Chemical Oxygen Demand (mg/L)	5.0	3/93	ND	25.0	61.1	50.5	46.9	162	18.0
	5.0	8/93	ND	ND	85.7	82.8	17.6	73.1	36.6
Total Organic Carbon (mg/L)	1.0	3/93	ND	5.39	15.7	15.4	1.72	12.9	ND
	1.0	8/93	ND	ND	18.4	21.3	ND	12.0	1.37
Total Suspended Solids (mg/L)	1.0	3/93	133 J	6.4	1,100	1,030	2,420 J	1,300	1,880
	1.0	8/93	22	ND UJ	2,580	3,010	1,390	549	2,870

Notes:

Dup – Duplicate sample.
J – Estimated value; see Quality Assurance Report.
UJ – Estimated value; see Quality Assurance Report.
LQL – Lowest practical quantitation limit.
mg/L – Milligrams per liter.
NA – Not analyzed.
ND – Not detected.

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Table 6.6
Volatile Organic Compounds Detected in Groundwater
Quantified by EPA Method 8240 Modified
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compound	LQL µg/L	Date	PKC-MW1a	PKC-MW1b	PKC-MW2	Dup PKC-MW2	PKC-MW3b	PKC-MW5*	PKC-MW6*
			µg/L						
Acetone	4.0	3/93	ND	12	ND	ND	ND	ND	ND
	4.0	8/93	ND	ND	ND	ND	ND	ND	ND
Benzene	0.20	3/93	ND	ND	1.3	1.3	ND	5.5	ND
	0.20	8/93	ND	ND	1.2	1.2	0.27	5.8	ND
Carbon disulfide	0.20	3/93	ND	ND	ND	ND	ND	2.7	ND
	0.20	8/93	ND	ND	0.21	0.28	ND	ND	ND
Chlorobenzene	0.20	3/93	ND	ND	ND	ND	ND	8.6	ND
	0.20	8/93	ND	ND	ND	ND	ND	10	ND
Chloroethane	0.20	3/93	ND	ND	0.22 J	0.23 J	ND	ND	ND
	0.20	8/93	ND	ND	0.34	0.34	ND	ND	ND
1,2-Dichlorobenzene	0.20	3/93	ND	ND	ND	ND	ND	1.7	ND
	0.20	8/93	ND	ND	ND	ND	ND	1.6	ND
1,4-Dichlorobenzene	0.20	3/93	ND	ND	ND	ND	ND	8.1	ND
	0.20	8/93	ND	ND	ND	ND	ND	8.9	ND
1,1-Dichloroethane	0.20	3/93	ND	ND	0.64	0.64	ND	ND	ND
	0.20	8/93	ND	ND	0.50	0.50	0.22	ND	ND
1,2-Dichloroethane	0.20	3/93	ND	ND	1.5	1.5	ND	ND	ND
	0.20	8/93	ND	ND	1.7	1.7	ND	ND	ND
trans-1,2-Dichloroethene	0.20	3/93	ND	ND	0.59	0.61	ND	ND	ND
	0.20	8/93	ND	ND	0.63	0.58	0.27	ND	ND
cis-1,2-Dichloroethene	0.20	3/93	ND	ND	0.36	0.37	0.52	ND	ND
	0.20	8/93	ND	ND	0.40	0.32	1.1	ND	ND
1,2-Dichloropropane	0.20	3/93	ND	ND	0.70	0.72	ND	ND	ND
	0.20	8/93	ND	ND	0.75	0.74	ND	ND	ND
Ethylbenzene	0.20	3/93	ND	ND	ND	ND	ND	54	ND
	0.20	8/93	ND	ND	ND	ND	ND	50	ND
Methylene chloride	0.20	3/93	ND	ND	0.20	0.23	ND	ND	0.82 J
	0.20	8/93	ND	ND	0.28	0.24	ND	ND	2.2

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Table 6.6
Volatile Organic Compounds Detected in Groundwater
Quantified by EPA Method 8240 Modified
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compound	LQL µg/L	Date	PKC–MW1a	PKC–MW1b	PKC–MW2	Dup PKC–MW2	PKC–MW3b	PKC–MW5*	PKC–MW6*
			µg/L						
Toluene	0.20	3/93	ND	0.61	ND	ND	0.22	0.65	ND
	0.20	8/93	ND	ND	ND	ND	ND	ND	ND
Trichlorofluormethane	0.20	3/93	ND	ND	ND	ND	ND	7.2	ND
	0.20	8/93	ND	ND	ND	ND	ND	3.4	ND
Vinyl chloride	0.20	3/93	ND	ND	1.2	1.3	3.6	ND	80
	0.20	8/93	ND	ND	0.72	0.72	2.5	ND	67
o–Xylene	0.20	3/93	ND	ND	ND	ND	ND	1.0	ND
	0.20	8/93	ND	ND	ND	ND	ND	1.1	ND
Total Xylenes	0.40	3/93	ND	0.64 J	ND	ND	ND	ND	ND
	0.40	8/93	ND	ND	ND	ND	ND	8.3	ND

Notes:

*Detection limit is elevated 5 times due to matrix effect.
Dup – Duplicate sample.
J – Estimated value; see Quality Assurance Report.
LQL – Lowest practical quantitation limit.
ND – Not detected.
µg/L – Micrograms per liter.

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Table 6.7
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW1a Total	PKC-MW1a Dissolved	PKC-MW1b Total	PKC-MW1b Dissolved	PKC-MW2 Total	PKC-MW2 Dissolved	Dup PKC-MW2 Total	Dup PKC-MW2 Dissolved
			mg/L							
Major Metals										
Aluminum	0.020	3/93	4.21	ND	0.260	ND	95.3	ND	90.2	ND
	0.020	8/93	2.16	ND	0.060	ND	80.3	ND	110	ND
Calcium	0.010	3/93	28.1	27.0	25.9	26.0	167	148	166	148
	0.010	8/93	28.2	28.2	25.9	26.6	154	138	159	141
Iron	0.005	3/93	4.94	0.007	0.392	ND	109	6.25	108	5.36
	0.005	8/93	3.17	0.006	0.113	0.022	92.4	6.33	123	6.66
Magnesium	0.020	3/93	15.6	14.7	15.7	15.1	92.6	71.7	91.4	72.4
	0.020	8/93	15.8	15.4	15.5	15.6	88.8	69.4	95.7	69.6
Potassium	0.400	3/93	2.6	0.9	3.2	2.8	13.5	6.4	13.2	6.4
	0.400	8/93	2.0	1.6	2.8	2.8	12.6	6.6	14.2	6.1
Sodium	0.010	3/93	9.16	8.65	9.04	8.86	161	158	161	159
	0.010	8/93	9.32	9.10	8.83	8.95	164	159	165	161
Trace Metals										
Arsenic	0.001	3/93	0.001	ND	ND	ND	0.086	0.072	0.088	0.068
	0.001	8/93	0.001	ND	ND	ND	0.088	0.072	0.076	0.072
Barium	0.001	3/93	0.046	0.010	0.007	0.008	0.554	0.070	0.534	0.070
	0.001	8/93	0.022	0.007	0.006	0.006	0.485	0.075	0.624	0.073
Beryllium	0.001	3/93	ND	ND	ND	ND	0.002	ND	0.002	ND
	0.001	8/93	ND	ND	ND	ND	0.002	ND	0.003	ND
Cadmium	0.002	3/93	ND	ND	ND	ND	0.003	ND	ND	ND
	0.002	8/93	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.005	3/93	0.006	ND	0.011	ND	0.158	ND	0.150	ND
	0.005	8/93	ND	ND	ND	ND	0.116	ND	0.158	ND
Cobalt	0.003	3/93	ND	ND	ND	ND	0.030	0.004	0.030	ND
	0.003	8/93	ND	ND	ND	ND	0.028	0.005	0.036	0.005

AGI TECHNOLOGIES

Table 6.7
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW1a Total	PKC-MW1a Dissolved	PKC-MW1b Total	PKC-MW1b Dissolved	PKC-MW2 Total	PKC-MW2 Dissolved	Dup PKC-MW2 Total	Dup PKC-MW2 Dissolved
			mg/L							
Trace Metals (cont.)										
Copper	0.002	3/93	0.004	ND	0.017	ND	0.128	ND	0.129	ND
	0.002	8/93	ND	ND	0.002	ND	0.139	0.003	0.176	ND
Lead	0.020	3/93	ND	ND	ND	ND	0.02	ND	0.03	ND
	0.001	8/93	ND	ND	0.002	ND	0.034	ND	0.048	ND
Manganese	0.001	3/93	0.146	0.100	0.017	0.023	10.6	8.95	10.5	9.00
	0.001	8/93	0.233	0.226	0.026	0.027	10.0	8.57	10.5	8.72
Mercury	0.0001	3/93	ND	ND	ND	ND	0.0003	ND	0.0003	ND
	0.0001	8/93	ND	ND	ND	ND	0.0003	ND	0.0004	ND
Nickel	0.010	3/93	ND	ND	ND	ND	0.19	0.02	0.20	0.02
	0.100	8/93	ND	ND	ND	ND	0.17	0.01	0.23	0.02
Selenium	0.001	3/93	ND	ND	ND	ND	ND a	ND	ND a	ND a
	0.001	8/93	ND	ND	ND	ND	ND a	ND a	ND b	ND a
Silver	0.003	3/93	ND	ND	ND	ND	ND	ND	ND	ND
	0.003	8/93	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	0.050	3/93	ND	ND	ND	ND	0.07	ND	0.08	ND
	0.050	8/93	ND	ND	ND	ND	ND	ND	0.05	ND
Tin	0.010	3/93	ND	ND	ND	ND	ND R	ND R	ND R	ND R
	0.010	8/93	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	0.002	3/93	0.006	ND	0.003	0.002	0.142	0.003	0.142	0.003
	0.002	8/93	0.007	0.002	0.002	0.003	0.131	0.004	0.180	0.004
Zinc	0.004	3/93	0.011	0.016	0.022	0.059	0.166	ND	0.167	ND
	0.004	8/93	ND	ND	ND	0.034	0.150	ND	0.205	ND

AGI TECHNOLOGIES

Table 6.7
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

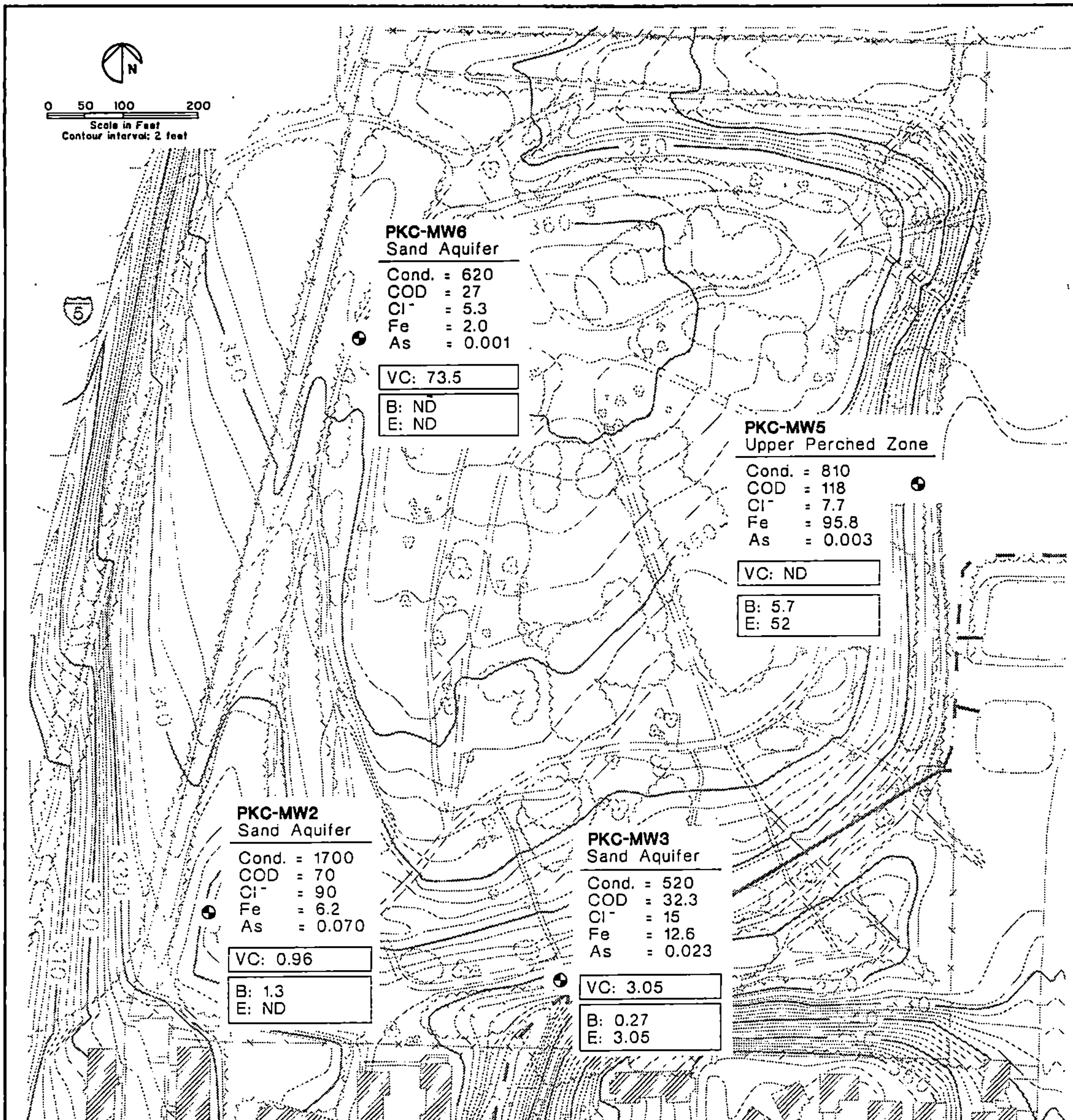
Metal	LQL mg/L	Date	PKC-MW3b Total	PKC-MW3b Dissolved	PKC-MW5 Total	PKC-MW5 Dissolved	PKC-MW6 Total	PKC-MW6 Dissolved
			mg/L					
Major Metals								
Aluminum	0.020	3/93	95.5	ND	74.6	ND	80.1	ND
	0.020	8/93	49.1	ND	33.4	0.03	123	ND
Calcium	0.010	3/93	64.2	37.0	81.1	68.6	80.7	59.4
	0.010	8/93	59.5	46.2	76.2	68.4	105	73.2
Iron	0.005	3/93	135	8.9	161	97.4	133	2.46
	0.005	8/93	78.2	16.2	119	94.2	194	1.52
Magnesium	0.020	3/93	63.9	25.2	20.7	9.77	66.4	34.7
	0.020	8/93	50.1	31.5	14.4	9.69	90.6	42.3
Potassium	0.400	3/93	11.8	3.2	15.8	12.4	9.7	2.7
	0.400	8/93	9.8	5.5	17.2	14.7	12.6	2.6
Sodium	0.010	3/93	18.6	12.7	9.36	6.36	17.4	11.9
	0.010	8/93	17.6	14.1	9.09	6.58	20.6	13.0
Trace Metals								
Arsenic	0.001	3/93	0.028	0.017	0.009	0.002	0.007	ND
	0.001	8/93	0.033	0.029	0.007	0.003	0.014	0.001
Barium	0.001	3/93	0.508	0.031	0.551	0.156	0.383	0.024
	0.001	8/93	0.280	0.043	0.376	0.189	0.549	0.028
Beryllium	0.001	3/93	0.003	ND	ND	ND	0.003	ND
	0.001	8/93	0.001	ND	ND	ND	0.004	ND
Cadmium	0.002	3/93	ND	ND	0.003	ND	ND	ND
	0.002	8/93	ND	ND	ND	ND	0.005	ND
Chromium	0.005	3/93	0.210	ND	0.104	ND	0.184	ND
	0.005	8/93	0.113	ND	0.047	ND	0.294	ND
Cobalt	0.003	3/93	0.061	0.007	0.027	0.008	0.056	0.013
	0.003	8/93	0.037	0.012	0.016	0.008	0.082	0.015

Table 6.7
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW3b Total	PKC-MW3b Dissolved	PKC-MW5 Total	PKC-MW5 Dissolved	PKC-MW6 Total	PKC-MW6 Dissolved
			mg/L					
Trace Metals (cont.)								
Copper	0.002	3/93	0.208	0.003	0.094	ND	0.126	ND
	0.002	8/93	0.098	ND	0.038	ND	0.200	ND
Lead	0.020	3/93	0.04	ND	0.15	ND	0.03	ND
	0.001	8/93	0.024	ND	0.088	ND	0.062	ND
Manganese	0.001	3/93	5.34	3.37	1.71	1.12	2.92	1.58
	0.001	8/93	6.14	5.22	0.902	0.652	3.86	1.97
Mercury	0.0001	3/93	0.0003	ND	0.0003	ND	0.0002	ND
	0.0001	8/93	0.0002	ND	0.0001	ND	0.0004	ND
Nickel	0.010	3/93	0.25	ND	0.11	0.02	0.24	0.02
	0.100	8/93	0.13	ND	0.07	0.02	0.38	0.03
Selenium	0.001	3/93	ND [a]	ND	ND [a]	ND	ND [a]	ND
	0.001	8/93	ND [a]	ND [a]	ND	ND	ND [b]	ND
Silver	0.003	3/93	ND	ND	ND R	ND R	ND R	ND R
	0.003	8/93	ND	ND	ND	ND	ND	ND
Thallium	0.050	3/93	ND	ND	ND	ND	ND	ND
	0.050	8/93	ND	ND	ND	ND	ND	ND
Tin	0.010	3/93	ND	ND	0.04	ND	ND	ND
	0.010	8/93	ND	ND	0.03	ND	ND	ND
Vanadium	0.002	3/93	0.238	ND	0.120	0.005	0.180	ND
	0.002	8/93	0.115	0.003	0.050	ND	0.311	ND
Zinc	0.004	3/93	0.258	0.010	0.548	ND	0.228	ND
	0.004	8/93	0.132	ND	0.273	ND	0.337	ND

Notes:

a) Lowest practical quantitation limit elevated 5 times due to matrix interference.
b) Lowest practical quantitation limit elevated10 times due to matrix interference.
Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
R – Rejected value. See Quality Assurance Report.



LEGEND

PKC-MW6 ⊕	Groundwater Monitoring Well number and approximate location
Cond.	Conductivity, umhos/cm
COD	Chemical oxygen demand, mg/L
Cl^-	Chloride, mg/L
Fe	Iron (dissolved), mg/L
As	Arsenic (dissolved), mg/L
ND	Not detected
VC:	Vinyl chloride, ug/L
B:	Benzene, ug/L
E:	Ethylbenzene, ug/L

Note: General parameter, metal, and volatile organic compound results are averaged values from 3/93 and 8/93 sampling events.

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Selected Chemistry Data for Sand Aquifer and Upper Perched Zone

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **6.1**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
ChemData.dwg	14,621.114	JFL				

7.0 LANDFILL GAS INVESTIGATION

7.1 PHASE II INVESTIGATION

AGI's Phase II investigation included installation of 28 gas probes or combination gas probes/groundwater monitoring wells. The probes were installed around the perimeter of the landfill, with a focus on assessing gas conditions immediately outside the landfill boundary. The probes were placed within gas-bearing zones encountered during drilling. The gas-bearing units consist of refuse, Upper Gravel, Upper Sand, and Lower Sand. Two gas probes were completed in refuse, 8 in the Upper Gravel, 7 in the Upper Sand, and 11 in the Lower Sand. Because the unsaturated portion of the Lower Sand averaged approximately 50 feet thick, gas probes were typically installed both at the top and the base of the unit. Gas probe locations are shown on **Figure 4.2.** **Appendix A** describes gas probe installation and monitoring procedures. Gas probe logs and installation diagrams are included in **Appendix B**.

All 28 gas probes were monitored biweekly from March 31 through September 3, 1993. An additional seven off-site gas probes were monitored from March 31 through June 11, 1993. Monitoring parameters included combustible gases (methane); oxygen; carbon dioxide, hydrogen sulfide, pressure differential (gauge pressure); total volatile organic compounds; and downhole, ground surface, and ambient air temperatures. Gas probe monitoring data are presented in **Appendix G**. In addition, four gas probes were sampled and analyzed for atmospheric gases and specific VOC compounds in June 1993. The sampling results are presented in **Appendix H**.

7.2 LANDFILL GAS GENERATION

7.2.1 General

The earth's atmosphere at ground level contains approximately 78 percent volume (%v) nitrogen, 21%v oxygen, 0.9%v argon, 0.032%v carbon dioxide, and 0.168%v other noble gases, hydrogen, and nitrous oxides. Methane, carbon monoxide, and hydrogen sulfide are also present at ground level as variable trace constituents due to both natural and anthropogenic processes. The methane concentration in ambient air due to natural processes is typically 0.00014%v; carbon monoxide and hydrogen sulfide concentrations are lower (Manahan, 1984).

Soil gas contains the same gases as the atmosphere, but at different concentrations. Soil gas composition is affected by the rate of organic matter decay. Aerobic microbial decomposition of organic matter consumes oxygen and produces carbon dioxide. As a result, the oxygen level in soils is typically lower than in the atmosphere, and carbon dioxide levels are higher (Manahan, 1984). Anaerobic soil conditions can also generate carbon monoxide, methane, and hydrogen sulfide.

Aerobic and anaerobic microbial decomposition processes are usually more intense in a landfill than in soil because of the increased organic material, which acts as a food source for the organisms and as a sponge to retain moisture (which is also necessary for microbial decay)(Emcon Associates, 1980). Because of increased aerobic microbial activity, oxygen levels are even lower than those found in soil, and methane and carbon dioxide levels are higher. **Table 7.1** lists concentrations of atmospheric gases found within typical municipal solid waste landfills.

7.2.2 *Typical Solid Waste Landfill Gas Generation Stages and Composition*

Atmospheric Gases : Municipal solid waste landfills generally undergo five gas generation stages, as shown on **Figure 7.1** (Augenstein, 1990). These stages are related to biological decomposition of organic matter within the landfill. Generation rates are influenced by type and age of refuse, internal temperature, moisture content, and available nutrients (Augenstein, 1990; Dimmick, et al., 1990; EPA, 1991).

During stage 1, aerobic decomposition occurs, oxygen is consumed, and carbon dioxide is produced; this stage typically lasts days to weeks. Landfill leachate is most likely to be acidic during stage 1 due to the production of organic acids as an intermediate product of refuse decomposition. When available oxygen within the refuse decreases to less than 5%v, a new group of microorganisms becomes active, initiating the second, or anaerobic, nonmethanogenic stage. During stage 2, more carbon dioxide is generated and available oxygen decreases to zero. This stage converts organic acids to carbon dioxide, and landfill leachate starts to become less acidic.

When oxygen is fully depleted, stage 3, or the methane generation stage, begins. Methanogenic bacteria become dominant and methane production increases to an approximate maximum of 55%v; carbon dioxide production decreases from 65%v to a near-constant level of approximately 40%v. As long as this stage is active, the oxygen concentration will be held at zero and nitrogen will decrease due to volume displacement by landfill-generated gases and some nitrogen fixation by microorganisms. Leachate pH shifts from slightly acidic to slightly alkaline.

Stage 4 occurs when methane and carbon dioxide production remain nearly constant with time. The time duration of this stage depends on landfill size and type of refuse. Stage 4 typically begins within 6 years of refuse disposal, and in an operating landfill will last for several years because of fresh input of degradable materials. Once this input ceases, methane and carbon dioxide production begin to decrease. This gas production decay interval is stage 5. During stage 5, the nitrogen concentration begins to rise from an approximate low of 5%v to near its atmospheric concentration as atmospheric gases reenter the gas generation zone. Oxygen will also increase to its atmospheric concentration near the end of stage 5. The reported time interval from the beginning of stage 4 to the end of stage 5 is 17 to 57 years (EPA, 1991).

Volatile Organic Compounds : Landfill gases also typically contain various VOCs unrelated to organic matter decomposition but released from wastes within the landfill. **Table 7.1** lists typical VOCs detected at municipal solid waste landfills. Various physical, chemical, or biological processes can release the VOCs into gaseous form, which is transported with other landfill gases. These VOCs may also partition into leachate and move into underlying groundwater.

The VOCs can also be degraded by the same microorganisms responsible for landfill gas generation. During stage 1 (aerobic decomposition), many hydrocarbons, including aromatics such as benzene, are converted into organic acids and eventually to carbon dioxide. Stage 1, however, is usually short-lived due to the rapid consumption of oxygen, and the degradation of these hydrocarbons slows down. Once methane production begins, chlorinated ethenes (such as TCE) and ethanes are rapidly degraded to vinyl chloride and chloroethane, both of which are moderately resistant to further anaerobic degradation.

7.2.3 *Gas Generation at Puyallup/Kit Corner Landfill*

The landfill has been closed for approximately 25 years. Based on this age, the landfill should be in stage 4 or 5 of landfill gas generation. Monitoring data collected during the Phase II investigation suggest the landfill is in stage 5. This inference is based on differential pressure and gas sample data. The two probes completed within refuse (PKC-GP16a and PKC-GP17a) generate little or no positive pressure differential, indicating either a low gas generation rate within the refuse or direct communication of refuse with the atmosphere. Monitoring data for probes installed around the perimeter of the landfill also show no consistent positive pressure. The pressure differential fluctuates with changes in the atmospheric barometric pressure as the subsurface gas seeks to equilibrate with the atmosphere. The atmospheric gas concentrations in a sample collected from PKC-GP16a in June 1993 generated the following results: carbon dioxide at 31%v, methane at 52%v, nitrogen at 17%v, and oxygen at 0.3%v. These gas concentrations are indicative of the beginning of stage 5 gas generation (See **Figure 7.1**).

The monitoring results for probes installed around the landfill show zones of high methane concentrations, which may indicate active gas generation is still occurring within the main body of refuse.

7.3 LANDFILL GAS MIGRATION

7.3.1 *Migration Mechanisms*

Once landfill gas has been produced, it can migrate via convection, diffusion, or barometric displacement. Each of these mechanisms is occurring or has occurred historically at the Puyallup/Kit Corner Landfill.

Convection : Convective migration is the dominant migration mechanism in relatively young landfills. Young landfills generate large amounts of methane, resulting in pressure gradients. Perimeter gas probes at young landfills typically exhibit consistent positive differential pressures.

Gas probes around the perimeter of the landfill do not exhibit consistent positive differential pressures. This indicates convection, while possibly present, is likely not the current dominant gas migration mechanism. However, convection was likely the driving force of historical subsurface lateral migration.

Diffusion : Diffusion is the movement of gas in response to a chemical concentration gradient. High concentrations of landfill gas will defuse toward areas of low concentration, even in the absence of a pressure gradient. Because diffusion rate is less affected by permeability than convection, gas concentrations, even in low permeability soils surrounding a landfill, can be similar to those within the landfill. Diffusive flow is generally much slower than convective flow and is usually not responsible for significant gas flux from a landfill. However, diffusion may currently be an important gas migration mechanism at the landfill.

Barometric Displacement : If subsurface gases have limited communication with the atmosphere, positive and negative pressure differentials can be created as atmospheric pressure rises and falls. The positive or negative pressure differential occurs as pore gas seeks to equilibrate with the air at the ground surface. Rapidly falling barometric pressures occurring during storms cause subsurface gas to expand. This expansion results in a pressure differential between the atmosphere and subsurface soil gas, inducing gas to flow toward ground surface along the path of least resistance. During rising atmospheric pressures, which typically occur during the onset of sunny, dry weather, similar air movements take place, but in a reverse direction. Air from the atmosphere tends to move down into the ground. However, this reverse movement is not sufficient to push back all the gas that has diffused through the soil pores during the expansion phase. The barometric displacement mechanism likely accounts for some gas migration away from the landfill.

7.3.2 *Migration Pathways*

Gas migration pathways at the Puyallup/Kit Corner Landfill include:

- Upward venting through the landfill cap.
- Downward and outward movement through the subsurface soils beneath the landfill.

Migration is occurring along both pathways; gas has been observed venting from cracks in the landfill cover and is extensively distributed in the subsurface. Although there are no direct data available concerning which of these two pathways dominates, we expect more gas travels through the subsurface than through the cap. This assumption is based on reports that the landfill is covered with up to 4 feet of native material and our observation that the cap surface is relatively intact (few cracks) and consists of low permeability silty sand and gravel.

Gas migration in the subsurface is controlled in part by the distribution of groundwater. Shallow groundwater on the east and south sides of the site (Upper Perched Zone) should inhibit shallow gas migration in these areas; however, gas can pass beneath the perched groundwater. The Sand Aquifer water table forms a barrier for gas migration at a depth of approximately 100 feet below the bottom of the landfill.

Gas migration in the subsurface is also controlled by variations in the permeability of the sediments beneath the landfill; gas preferentially migrates within areas of higher permeability. The permeability of the geologic deposit directly underlying the landfill (Upper Gravel) is quite variable, with highly permeable sand and gravel beds interlayered with lower permeability silty sands and gravels. The silty zones predominate, however, suggesting that on the whole, this deposit is not a major conduit for gas migration. In contrast, the underlying deposits (Upper Sand and Lower Sand) have a higher and more uniform permeability. We therefore expect these lower deposits are the primary subsurface migration pathway at the landfill.

7.4 LANDFILL GAS DISTRIBUTION

Methane was detected in all borings around the landfill. Probes completed within refuse contained the highest methane concentrations. Methane concentrations within the Upper Gravel are highly variable, reflecting the heterogeneous nature of the unit. The Upper and Lower Sand units contain relatively uniform methane concentrations; however, the methane concentrations decreased with depth (lowest near the water table) and were generally lower along the south side of the landfill. The highest concentration of combustible gas generally occurred beneath the northwestern corner of the landfill. Landfill gas cross sections showing the distribution of combustible gas around the landfill are shown on **Figures 7.2 through 7.4.**

Refuse : Two gas probes, PKC-GP16 and PKC-GP17a, are completed within the refuse (see **Figures 7.2 and 7.4**). These probes contain the highest combustible gas concentrations observed at the landfill. Concentrations observed in PKC-GP16 ranged from 35 to 58%v, while those in PKC-GP17 ranged from 11 to 37%v. The temperature in the probes generally ranged from 10 to 18°C, indicating heat generation from bacterial activity. In addition, oxygen levels were low and carbon dioxide and hydrogen sulfide levels high, consistent with methanogenic gas production. However, little pressure differential was observed in the probes, indicating either the refuse is in good communication with the atmosphere or gas production is not at high levels.

Upper Gravel : Combustible gas occurs within the Upper Gravel in discontinuous zones of varying permeability, resulting in a wide range of combustible gas concentrations between probes. It should be noted that gas probes were installed in zones showing the highest combustible gas concentrations during drilling. Other areas within the Upper Gravel should have lower combustible gas concentrations. Temperatures within the Upper Gravel were not elevated, generally ranging from 8 to 12°C, and pressure differentials fluctuated from positive to negative in response to changes in barometric pressure changes. The percent volume of oxygen was at or near 0 in most probes, indicating oxygen depletion by methanogenic bacteria. However, oxygen content indicative of natural soil conditions was present in groundwater gas probes PKC-MW4 and PKC-MW5, and most of the off-site gas probes (GMW-1 through GMW-4) along the southern landfill perimeter. Most gas probes showed elevated carbon dioxide levels up to 14%v. Carbon dioxide levels were generally lowest in the same probes with elevated oxygen content. No hydrogen sulfide was detected in gas probes completed in the Upper Gravel.

Upper Sand : The occurrence of combustible gas is relatively uniform within the Upper Sand (12 to 43%v) with the exception of the south end of the landfill, where gas probes PKC-MW2GPb and PKC-GP22a contained lower gas concentrations (5 to 22%v). The uniform distribution of gas is likely a reflection of the unit's fine to medium-grained sand composition. The temperature range observed was 9 to 11.5°C. The pressure differential changed from positive to negative, likely in response to changes in atmospheric barometric pressure. The oxygen content was at or near 0 percent throughout the duration of monitoring, with the concentration of carbon dioxide ranging from 3 to 13%v. Gas probes PKC-GP21a and PKC-GP22a provided the only indication of the presence of hydrogen sulfide.

Lower Sand : The distribution of combustible gas within the Lower Sand is similar to that observed in the Upper Sand. Gas concentrations ranged from 13 to 24%v, except probes PKC-MW1GP, PKC-GP17b, PKC-GP22b, and PKC-GP17b, located at the south perimeter. These probes had gas concentrations from 2 to 10%v. Gas probes screened across the water table also had lower combustible gas concentrations. These probes include PKC-MW1a, PKC-MW2, PKC-MW3b, and PKC-MW6, and had concentrations ranging from below detection limits to 9%v. Temperatures recorded from probes completed in the Lower Sand generally ranged from 9 to 12°C, with the exception of PKC-MW3, which had a range of 6 to 11°C, and PKC-GP16b and PKC-GP17b, which had a range of 9 to 17.5°C. The pressure differentials observed changed from positive to negative, likely in response to changes in atmospheric barometric pressure. Oxygen concentrations were low or near 0%v and carbon dioxide concentrations ranged from 3 to 15%v, with the exception of PKC-GP16b, which had a carbon dioxide range of 20 to 24%v. No hydrogen sulfide was detected during the monitoring period, with the exception of PKC-GP16b, where up to 3 parts per million (ppm) was detected. PKC-GP17b showed a concentration of 7 ppm during one monitoring event.

7.5 LANDFILL GAS TRENDS

Methane concentrations within individual probes were either stable or fluctuated over a relatively narrow range during over the 6-month monitoring period. Stable probes typically varied within 2%v methane, whereas those with minor fluctuations exhibited variation over a 6 to 8%v methane range.

One gas probe (PKC-MW2GPb, completed in the Upper Sand) showed a wide range in methane concentrations with no apparent trend evident. Monitoring results from two gas probes indicated possible trends. PKC-GP16a and PKC-GP17a are both completed in refuse and showed a general decrease in methane concentrations over the monitoring period. No trends were observed in the methane data summarized for 15 shallow landfill perimeter gas probes (AGI, 1992b).

7.6 GAS PROBE SAMPLING

Soil gas samples were collected by AGI from four gas probes located along the southern perimeter of the landfill as part of preliminary design work for a gas extraction system (the gas extraction system design is proceeding concurrently with, but separately from, the Phase II investigation). Specifically, PKC-MW2GPa, PKC-MW2GPb, PKC-GA16a, and PKC-GP17b were sampled. Samples were analyzed for atmospheric gases (nitrogen, oxygen, carbon dioxide, and methane) by ASTM Method D1946 and VOCs by EPA Method TO14. **Tables 7.2 and 7.3** summarize the testing results; a memorandum summarizing the gas probe sampling is presented in **Appendix** H. The gas samples were collected pursuant to the work plan prepared for the southern perimeter gas extraction system (AGI, 1993).

All soil gas collected from native soil (PKC-MW2GPa, PKC-MW2GPb, and PKC-GP17b) contained Freon 12 and Freon 114 in concentrations ranging from 1.6 to 140 milligrams per cubic meter (mg/m^3) and 6.8 to 53 mg/m^3, respectively. Vinyl chloride was detected in the Upper and Lower Sand at concentrations ranging from 0.4 to 4.3 mg/m^3. Benzene was detected in the Lower Sand at 0.6 mg/m^3.

VOCs detected in refuse (PKC-GP16a) included vinyl chloride (1.3 mg/m^3) and aromatic hydrocarbons such as BETX. Aromatic hydrocarbon concentrations ranged from 0.8 mg/m^3 (benzene) to 18 mg/m^3 (m, p-xylene). Freon 12 and 114 were also detected.

AGI TECHNOLOGIES

Table 7.1
Typical Landfill Gas Constituents Detected at Municipal Solid Waste Landfills
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Major Components	% Volume [a]
Methane	44.0–53.4
Carbon dioxide	34.2–47.0
Nitrogen	3.7–20.8
Oxygen	0.05–1.7
Paraffin hydrocarbons	0.1–0.17
Aromatic and cyclic hydrocarbons	0–0.2
Hydrogen	0.005–0.3
Hydrogen sulfide	0.005–0.9
Carbon monoxide	0.005–0.1
Trace compounds	0–0.5
Typical Volatile Organic Compounds	**mg/m^3 [b]**
Toluene	215
Ethybenzene	95
Propane	35
Methylene chloride	67
Total xylene isomers	78
Dichlorodifluoromethane	87
2–butanone	30
Butane	22
Acetone	21
Pentane	25
Tetrachloroethane	56
Vinyl chloride	20
Hexane	26
1,2–dichloroethene	27
Carbon tetrachloride	40
1,1–dichloroethane	17
Trichloroethene	21
Chloromethane	8
Benzene	12
Chlorodifluoromethane	11
1,2–dichloroethane	9
Chlorobenzene	9
Chloroethane	5
2–hexanone	8
Dichlorofluoromethane	6
1,1,1–trichloroethane	6
1,1,2,2–tetrachloroethane	8
Trichlorofluoromethane	5
1,1–dichloroethene	1
1,2–dichloropropane	2
Chloroform	2

Sources: USEPA Subtitle D Study, Phase I Report (EPA 530/SW–86/054, 1986); Proceedings of the Government Refuse Collection and Disposal Association 13th Annual International Landfill Gas Symposium, March 1990.

Notes:

a) Listed values are typical ranges.
b) Listed values are arithmetic means.
mg/m^3 – Milligrams per cubic meter.

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Table 7.2
Atmospheric Gas Sampling Results – June 1993
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Gas	Lowest Practical Quantitation Limit (%v)	Gas Probes (%v)				
		PKC–MW2GPa	PKC–MW2GPb	Dup PKC–MW2GPb	PKC–GP16a	PKC–GP17b
Carbon Dioxide	0.05	4.5	5.9	6.0	31	17
Methane	0.05	14	16	17	52	8.2
Nitrogen	0.05	81	77	76	17	76
Oxygen	0.05	1.2	1.0	0.9	0.3	1.0

Notes:

Dup – Duplicate.

%v equivalencies:
1% = 10,000 ppm (v).
0.1% = 1,000 ppm (v).
0.01% = 100 ppm (v).
0.001% = 10 ppm (v).
0.0001% = 1 ppm (v).

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Table 7.3
Volatile Organic Compounds Detected in Gas – June 1993
Puyallup/Kit Corner Custodial Landfill
King County, Washington

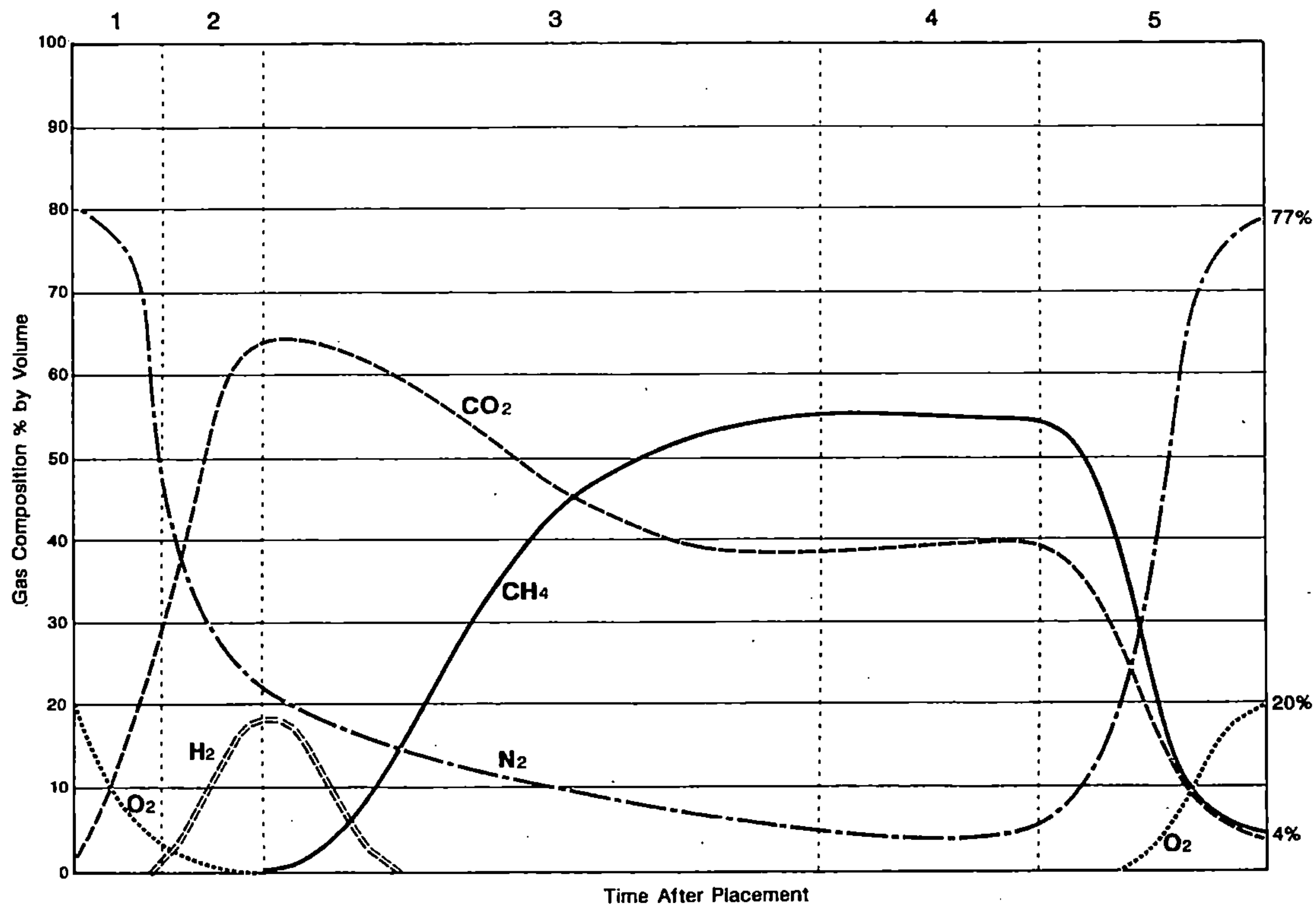
Compound	Lowest Practical Quantitation Limit (mg/m^3)	Gas Probes (mg/m^3)					ASILs
		PKC–MW2GPa[a]	PKC–MW2GPb[b]	Dup PKC–MW2GPb[c]	PKC–GP16a[d]	PKC–GP17b[e]	
Benzene	0.03	ND	ND	ND	0.8	0.6	0.00012
Dichlorodifluoromethane (Freon 12)	0.03	65 [f]	140 [g]	140 [g]	5.7	1.6	N/A
Dichlorotetrafluoroethane (Freon 114)	0.03	17 J	55 J	50 J	5.1 J	6.8 J	1.4486
Ethylbenzene	0.03	ND	ND	ND	2.4	ND	N/A
1–Ethyl–4–methylbenzene	0.03	ND	ND	ND	1.6	ND	N/A
Toluene	0.03	ND	ND	ND	3.3	ND	1.2448
1,2,4–Trimethylbenzene	0.03	ND	ND	ND	1.7	ND	N/A
1,3,5–Trimethylbenzene	0.03	ND	ND	ND	1.0	ND	N/A
Vinyl Chloride	0.03	ND	4.2	4.4	1.3	0.40	0.00023
m,p–Xylene	0.03	ND	ND	ND	18	ND	1.4486
o–Xylene	0.03	ND	ND	ND	1.3	ND	N/A

Notes:

a) Lowest practical quantitation limit is elevated 20.6 times.
b) Lowest practical quantitation limit is elevated 20.9 times.
c) Lowest practical quantitation limit is elevated 21.0 times.
d) Lowest practical quantitation limit is elevated 20.7 times.
e) Lowest practical quantitation limit is elevated 2 times.
f) Lowest practical quantitation limit is elevated 40 times.
g) Lowest practical quantitation limit is elevated 103 times.
ASIL – Acceptable Source Impact Levels; Regulation III of the Puget Sound Air Pollution Control Agency (PSAPCA).
Dup – Duplicate.
J – Estimated value; see Quality Assurance Report.
mg/m^3 – Milligrams per cubic meter.
N/A – Not applicable; Regulation III of PSAPCA.
ND – Not detected.

Stage	Condition
1	Aerobic
2	Anaerobic, no methane generation
3	Anaerobic, methane generation increasing
4	Anaerobic, methane generation constant
5	Methane generation decreasing to atmospheric equilibrium

O_2 : Oxygen
H_2 : Hydrogen
N_2 : Nitrogen
CH_4 : Methane
CO_2 : Carbon Dioxide



Reference: Augenstein, D. "Greenhouse Effect Contributions of U.S. Landfill Methane" (Figure 5), in "Proceedings from the 13th Annual International Landfill Gas Symposium", July 1990.

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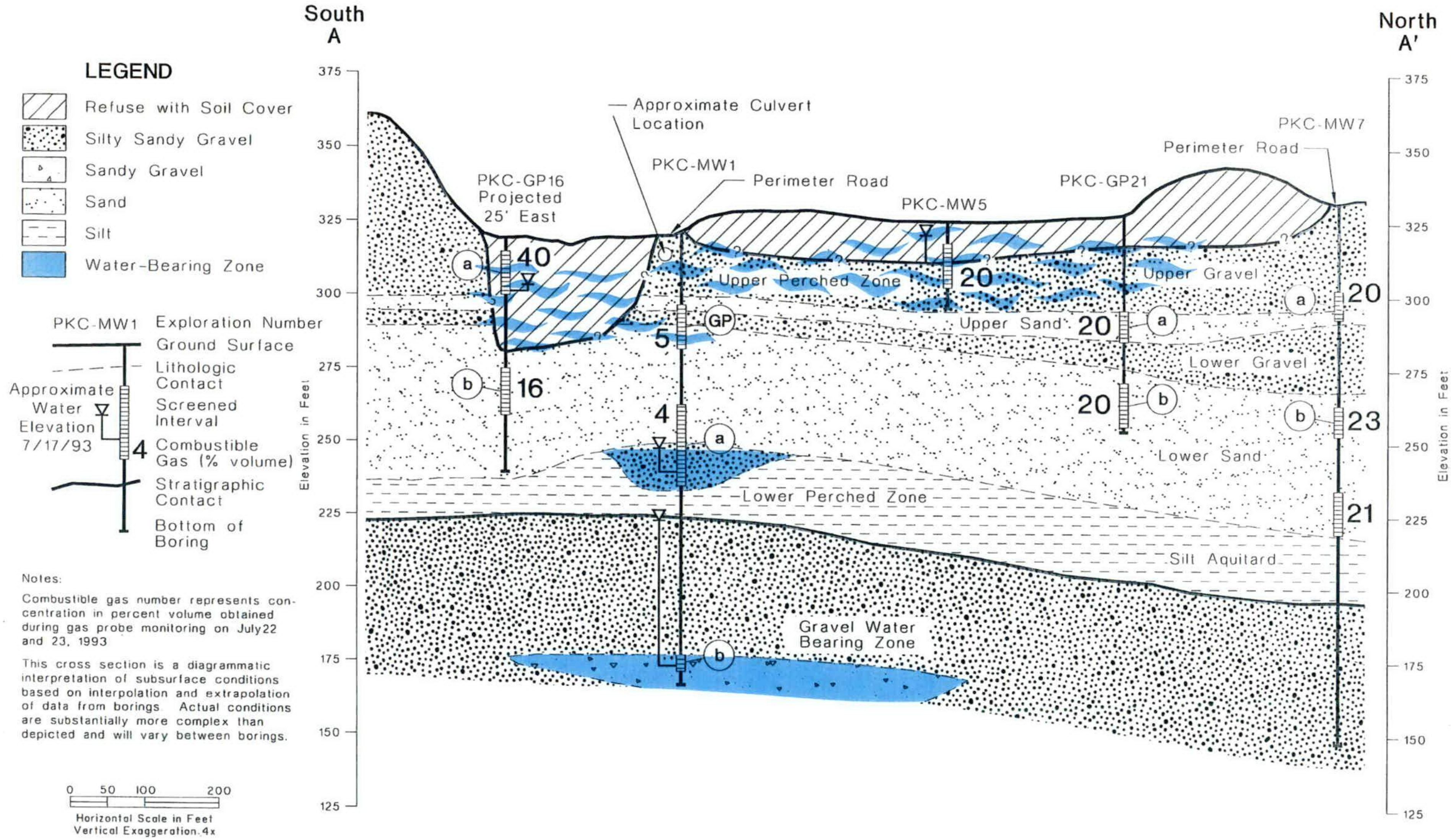
Typical Landfill Gas Generation Stages

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **7.1**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	7 Jun 94			



Landfill Gas Section A - A' for July 22 and 23, 1993

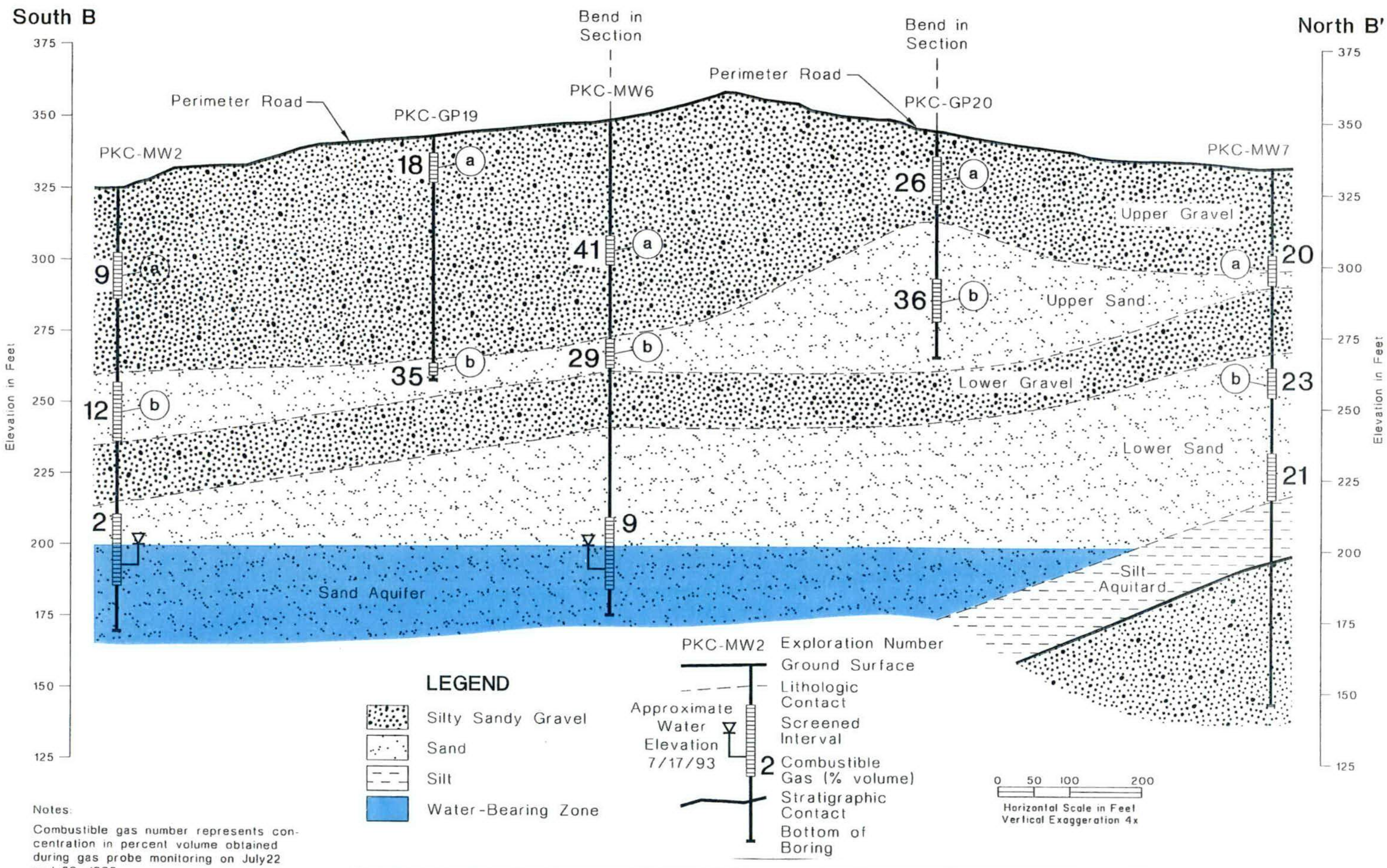
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE
7.2

AGI TECHNOLOGIES

xSec1L.dwg

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	JFL				



Notes:

Combustible gas number represents concentration in percent volume obtained during gas probe monitoring on July22 and 23, 1993.

This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings. Actual conditions are substantially more complex than depicted and will vary between borings.

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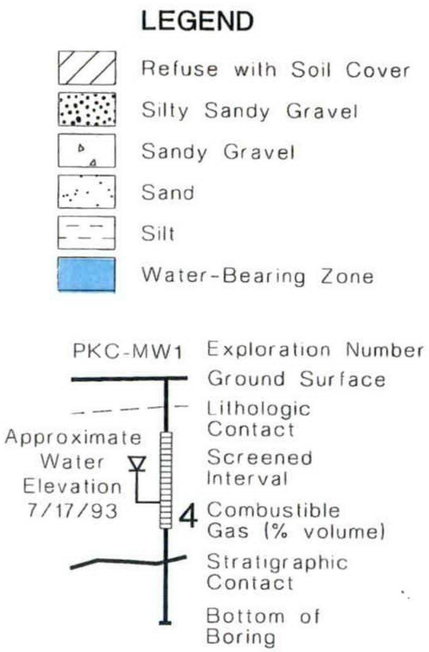
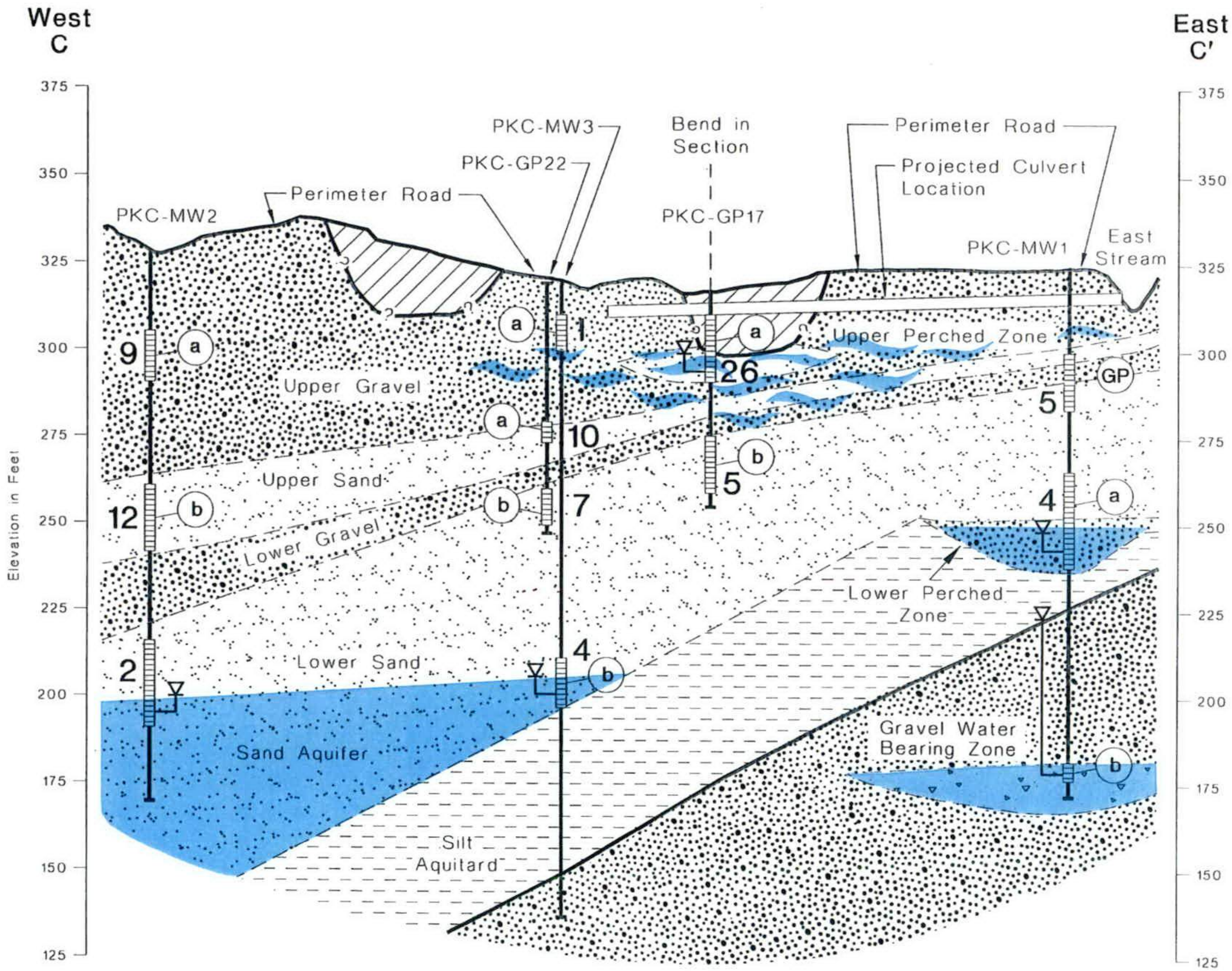
Landfill Gas Section B - B' for July 22 and 23, 1993

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **7.3**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
xSec2L.dwg	14,621.114	JFL				





Notes:

Combustible gas number represents concentration in percent volume obtained during gas probe monitoring on July22 and 23, 1993.

This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings. Actual conditions are substantially more complex than depicted and will vary between borings.

0 50 100 200

Horizontal Scale in Feet
Vertical Exaggeration 4x

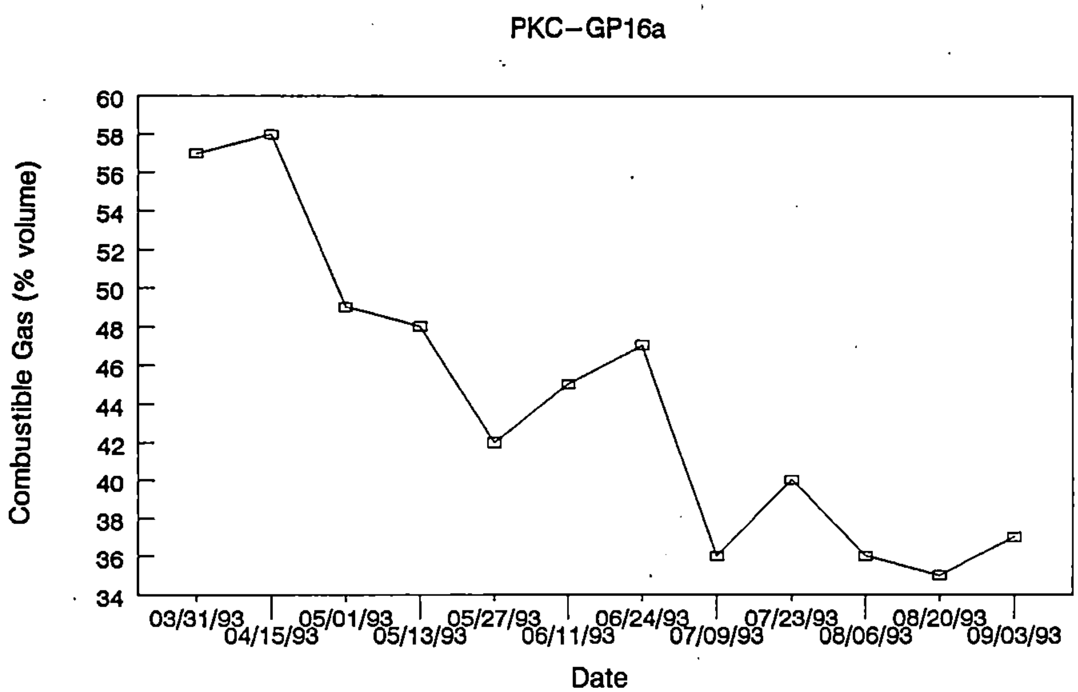
AGI TECHNOLOGIES

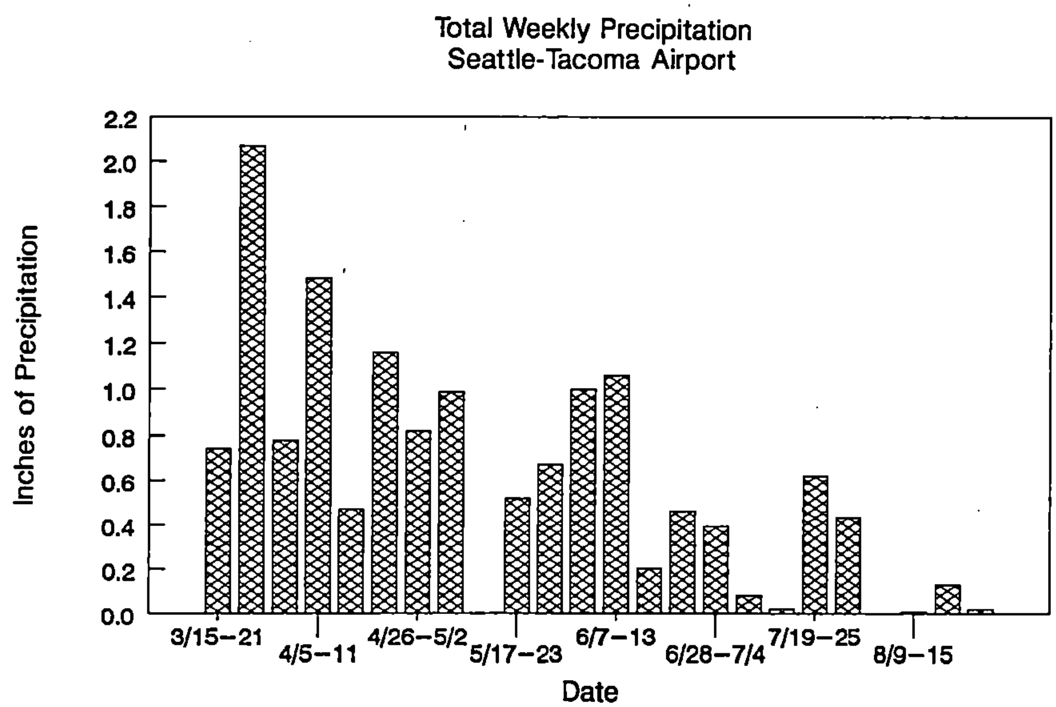
Landfill Gas Section C - C′ for July 22 and 23, 1993

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **7.4**

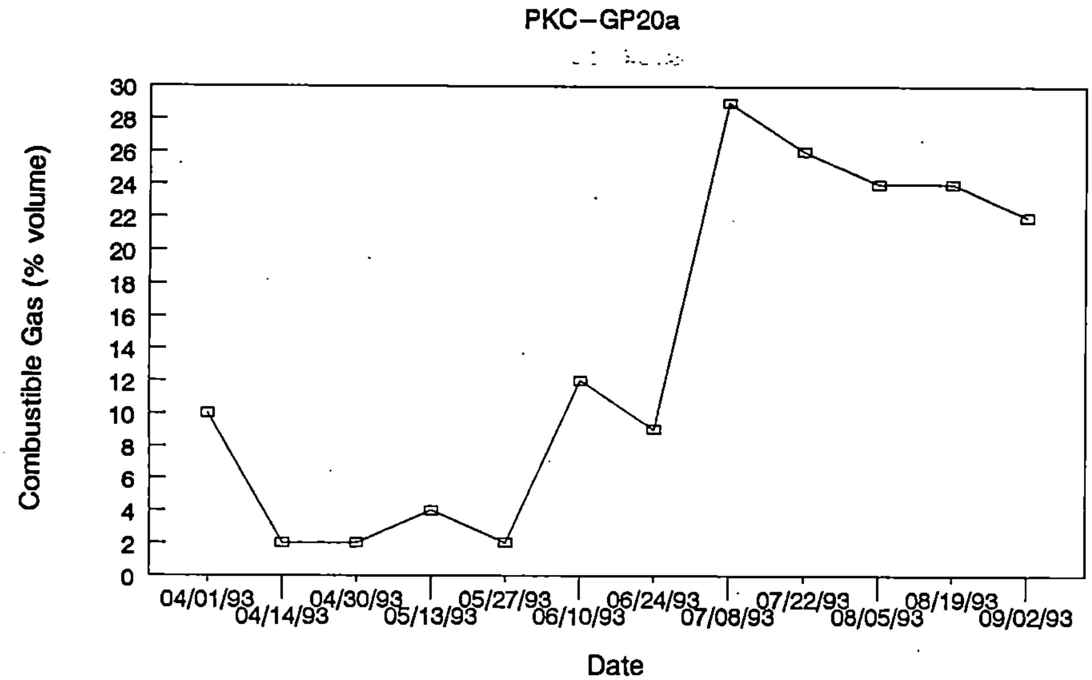
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
xSec3L.dwg	14,621.114	JFL				

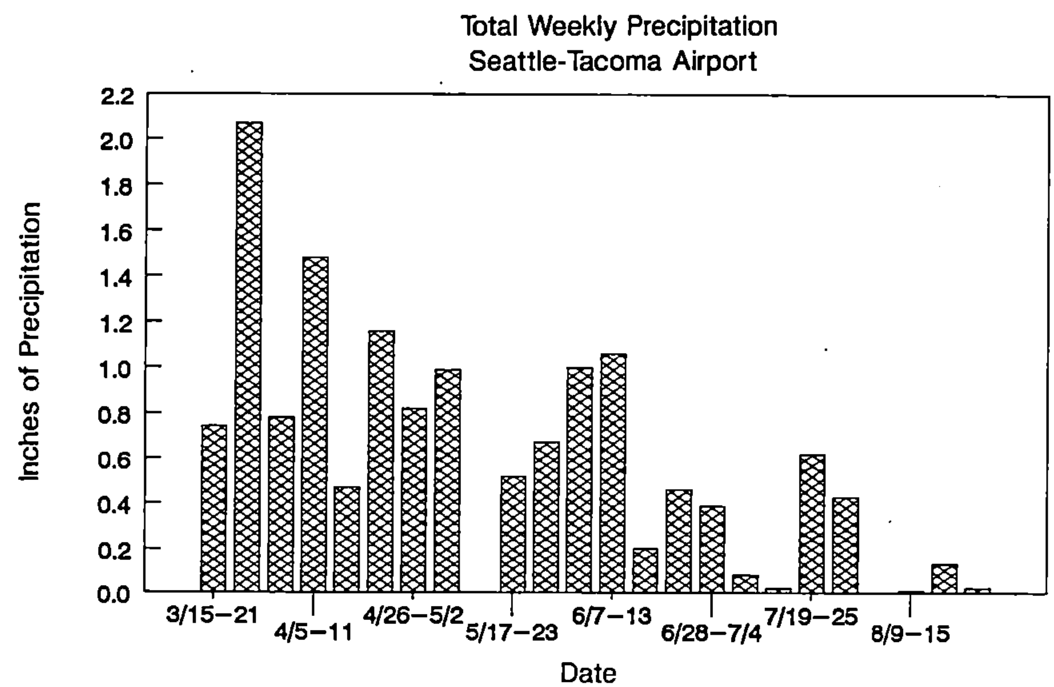




Source: National Oceanic & Atmospheric Administration Local Climatological Data Monthly Summary for March through August, 1993.

AGI TECHNOLOGIES	**Combustible Gas and Precipitation** Puyallup/Kit Corner Custodial Landfill King County, Washington					FIGURE **7.5**
PROJECT NO. 14,621.114	DRAWN DFF	DATE 31 May 94	APPROVED	REVISED	DATE	





Source: National Oceanic & Atmospheric Administration Local Climatological Data Monthly Summary for March through August, 1993.

AGI TECHNOLOGIES

Combustible Gas and Precipitation

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **7.6**

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
14,621.114	DFF	31 May 94			

8.0 REMEDIAL ACTION ALTERNATIVES

8.1 BASIS FOR REMEDIAL ACTION

Results of the Phase II investigation indicate explosive gases are distributed in soils beneath the landfill and that groundwater below the landfill contains organic and inorganic compounds at levels expected to be above background concentrations. Significant uncertainties remain in characterizing the magnitude and extent of impacts to groundwater. The following discussion focuses primarily on remedial action alternatives to address gas at the landfill.

8.2 LANDFILL GAS CONTROL ALTERNATIVES

8.2.1 Southern Perimeter Gas Extraction System

A gas extraction system is scheduled to be installed along the landfill's southern perimeter during the summer of 1994. This system is necessary due to reported detections of gas (less than 20 percent LEL) beyond the southern property boundary. This system will consist of 18 extraction wells, a blower, and activated carbon station. Design testing of the extraction well systems indicated there is insufficient gas to sustain a flare. The estimated construction cost for this system is $500,000. The southern landfill perimeter was chosen for the interim remedial action due to the presence of nearby residential development. The system is designed to capture landfill gas migrating primarily within the Upper Gravel and Lower Sand and to pull back some of the gas that has migrated south of the landfill. The existing gas probe network will be used to monitor the effects of the extraction system.

8.2.2 Extended Gas Extraction System

This option involves extending the southern perimeter gas extraction system along the east side of the landfill, thereby cutting off gas migration in the direction of nearby development. The system would also focus on gas extraction from the Upper Gravel and Lower Sand, similar to the design goal of the southern system. Gas extraction wells would be installed along the eastern side of the landfill and be connected to an expanded blower and flare station as installed for the southern system. The estimated costs for this system are $135,000 for engineering and $350,000 for construction.

The extraction system could also be extended around the remaining landfill perimeter (north and west sides). The additional future cost to extend the gas extraction system would be for extraction wells only and would amount to approximately $150,000.

The gas extraction system may also serve to address volatile organic (specifically vinyl chloride) concentrations in groundwater within the Sand Aquifer. The extraction system would induce soil gas movement in soils below the landfill, and potentially reduce vinyl chloride concentrations by three mechanisms. First, vinyl chloride contained within soil gas in the unsaturated zone would be captured before it could partition from the gas into the groundwater. Second, vinyl chloride concentrations in water percolating downward through the unsaturated zone may be reduced through the stripping action of soil gas movement. Third, enhanced evaporation and volatilization of vinyl chloride from the water table surface may occur.

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9.0 SUMMARY AND RECOMMENDATIONS

9.1 SUMMARY

AGI's Phase II hydrogeologic and landfill gas investigation included drilling 14 borings around the perimeter of the landfill. Completions within the borings resulted in 9 groundwater monitoring points and 28 gas monitoring points. Three geologic units were identified during the investigation. From youngest to oldest, they are Advance Outwash, Lacustrine Silt, and pre-Vashon Gravel. The Advance Outwash was further divided into Upper Gravel, Upper Sand, Lower Gravel, and Lower Sand. Four water-bearing zones were identified within the geologic units. These are the Upper Perched Zone, Lower Perched Zone, Sand Aquifer, and Gravel Water-Bearing Zone.

No landfill impact on surface water quality was identified during the investigation. Groundwater quality results suggest that the landfill has impacted the Upper Perched Zone and Sand Aquifer. The Upper Perched Zone is characterized by low level VOCs, specifically BETX. The Sand Aquifer contains up to 80 µg/L vinyl chloride, and has elevated concentrations of some metals and indicator parameters.

Landfill gas is likely still being generated. Methane concentrations up to 50%v were detected in sediments below the landfill during the investigation. The Upper Sand, Lower Gravel, and Lower Sand are the primary pathways for subsurface landfill gas migration. Gas migration toward the southern portion of the site is currently being addressed through installation of a southern perimeter gas extraction system.

9.2 RECOMMENDATIONS

The results of our Phase II investigation indicate the need for the following supplemental work:

Gas Extraction : Expand the southern perimeter gas extraction system to include all of the east side and part of the north side of the landfill. This expansion would help prevent gas migration into residential areas east and northeast of the landfill. As part of this activity, we recommend the system be designed to optimize airflow through the subsurface and thus optimize vinyl chloride capture and reduction. As described in Section 8.2.2, the cost for the expanded gas extraction system is approximately $485,000.

Hydrogeology and Hydrochemistry of the Sand Aquifer : Significant uncertainties remain regarding the geometry, hydraulic characteristic, and water quality of the Sand Aquifer. These uncertainties need to be addressed because the Sand Aquifer represents the uppermost continuous aquifer beneath the landfill and is of greatest significance in terms of off-site contaminant transport.

Note that we believe no further hydrogeologic investigation is warranted of the Upper and Lower Perched Zones or the Gravel Water-Bearing Zone. The perched zones are of limited lateral extent and appear to discharge vertically downward into the underlying Sand Aquifer. The Gravel Water-Bearing Zone is also of limited extent beneath the landfill and appears to be protected by the overlying Silt Aquitard. Further, the Phase II investigation provided no evidence of an impact to the

Gravel Water-Bearing Zone. If this zone were hydraulically connected to the laterally adjacent Sand Aquifer, then groundwater flow would be from the Gravel Water-Bearing Zone into the Sand Aquifer due to an approximately 20-foot hydraulic head difference.

We recommend the Sand Aquifer be further defined by:

- Installing a sidegradient monitoring well several hundred feet north of the landfill to provide background water quality data.

- Installing one groundwater monitoring well at the northwest corner of the landfill near the location shown on **Figure 9.1**. The closest existing monitoring well in the Sand Aquifer is located approximately 400 feet south of the north landfill border. A new well at the location proposed would establish whether the Sand Aquifer is present at the north end of the landfill, help define the Sand Aquifer potentiometric surface, and provide an additional water quality monitoring point.

- Installing one groundwater monitoring well between the existing PKC-MW2 and PKC-MW6; these two wells are approximately 800 feet apart and only allow for monitoring of the extreme southern end and the middle northern portion of the landfill. There is currently no downgradient monitoring capability available for the main central and southern central portions of the landfill. A new well at the proposed location would be helpful in defining water quality impacts for the central portion of the landfill and would likely be useful for long-term monitoring purposes (only two existing wells, PKC-MW6 and PKC-MW2, are appropriate for inclusion in a long-term monitoring program.

- Installing two groundwater monitoring wells in the Sand Aquifer hydraulically downgradient of the landfill along the access road or west of I-5. These wells would provide data on the attenuation rate of dissolved substances in the Sand Aquifer as they travel downgradient.

- Drilling several of the new monitoring well borings (not the background well) to a depth sufficient to reach and penetrate the Silt Aquitard. This aquitard is thought to underlie the Sand Aquifer beneath the entire site and surrounding area. However, its existence has only been confirmed along the eastern and southeastern edge of the landfill. It is important that the Silt Aquitard distribution and geometry be determined as it represents a potentially significant barrier to vertical groundwater flow and contaminant transport out of the Sand Aquifer into underlying aquifers.

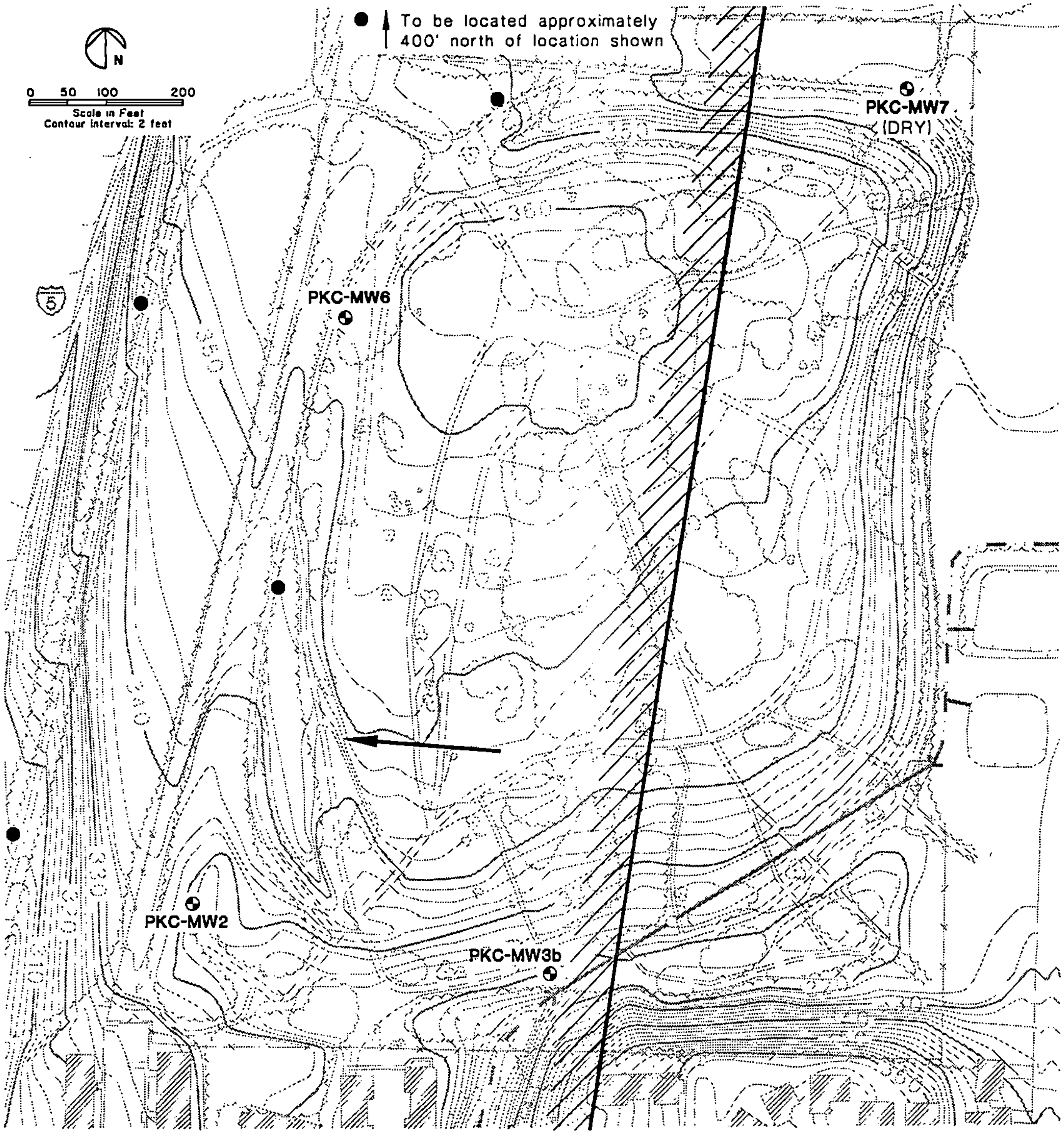
- Sampling selected Sand Aquifer groundwater monitoring wells periodically and analyzing the samples for VOCs, selected metals, and indicator parameters. These data would provide an indication of long-term trends and help monitor effects of the interim gas extraction system.

The estimated cost to install the five monitoring wells in the Sand Aquifer is $75,000. Two groundwater sampling events would require an additional estimated $25,000.

Surface Water Leakage: Conduct an engineering study of the source and volume of water input into the landfill on the east side of the site. The study would determine if water is leaking from the culvert and whether rerouting is necessary. The study would also investigate the amount of water entering the landfill from the wetland and two stormwater detention ponds and whether these features should be isolated from the landfill. The engineering study would cost an estimated $40,000.

Refuse Geometry : Assess refuse thickness, bottom elevations, and moisture conditions by drilling five borings through the landfill and installing piezometers (if appropriate) in two of the borings. The piezometers would be used in helping define water levels within refuse along the east side of the landfill relative to adjacent East Stream surface water elevations. The refuse geometry assessment would cost an estimated $35,000.

Compiling the Sand Aquifer well installation, surface water leakage, and refuse geometry activities into a supplemental Phase II report would cost an estimated $25,000.



LEGEND

PKC-MW6 ⊕ Sand Aquifer Groundwater Monitoring Well number and approximate location

● Proposed Sand Aquifer Groundwater Monitoring Well

Inferred areal extent of saturation

General direction of groundwater flow

Reference: Base map and topography by DeGross Aerial Mapping, 1992.

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Proposed Sand Aquifer Well Locations

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE 9.1

SandWell.dwg	PROJECT NO. 14,621.114	DRAWN JFL	DATE	APPROVED	REVISED	DATE

AGI TECHNOLOGIES

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Quality Assurance/Technical Review by:

____

Mackey Smith, C.E.G.
Vice President

LEP/MAA/tag

APPENDIX A

Field Investigation Methods

APPENDIX A

Field Investigation Methods

The following is a description of the field investigation methods used during the Phase II Investigation at the Puyallup/Kit Corner Custodial Landfill (the landfill) in King County, Washington.

MONITORING WELL DRILLING, INSTALLATION, AND DEVELOPMENT

A total of nine groundwater monitoring wells were installed in seven borings as part of the Phase II investigation. Multiple-completion monitoring wells were identified with a "GP," indicating an upper gas probe; an "a," indicating an upper monitoring well; or a "b," indicating a lower monitoring well (e.g., PKC-MW1GP). Single-completion monitoring wells were identified similarly, but without the appended letters (e.g., PKC-MW3). Three of the monitoring wells (PKC-MW3, PKC-MW4, and PKC-MW7) did not accumulate groundwater after installation and, consequently, are used solely as gas probes.

Groundwater monitoring well drilling began on December 11, 1992 and concluded on March 11, 1993. Boreholes were drilled and monitoring wells were installed by Hokkaido Drilling & Developing Corporation of Graham, Washington under the direction of AGI Technologies (AGI) in accordance with the Washington Administrative Code (WAC) Chapter 173-160. Construction details and depths were recorded for each monitoring well.

The borings for monitoring wells PKC-MW4 and PKC-MW5 were drilled using a Mobile Drill B-61 auger drill rig and an 8-inch-outside-diameter, 4-1/4-inch-inside-diameter, hollow-stem auger casing. The borings for monitoring wells PKC-MW1, PKC-MW2, PKC-MW3, PKC-MW6, and PKC-MW7 were drilled using a Speed Star 71 cable tool drill rig. Eight-inch outside-diameter steel casing was driven to temporarily line the borehole. Potable water from the Federal Way Water and Sewer District water system was added to the borehole as needed to facilitate well drilling and installation. The five cable tool borings were completed with seven gas probes.

Geologic samples were collected by driving a standard 2.5-inch inside-diameter split-barrel sampler (Dames & Moore sampler) into the ground at each sampling location using a 300-pound downhole hammer with a drop height of about 30 inches. Geologic samples were also collected from the cable tool rig bailer. Samples were collected at approximately 5-foot intervals and at points of major stratigraphic change. The soil in the sampler was classified in accordance with the Unified Soil Classification System.

A representative portion of each sample was placed in a plastic bag and labeled with the boring number, sampling depth, and the date collected. Each sample was reviewed and compared to samples from other borings to aid in drilling log editing.

Groundwater monitoring wells were designed for each borehole after drilling. Well designs were prepared by the AGI field manager in consultation with the AGI project manager. Well design specifications included the length and location of seals and the screened interval for each well.

Information Recorded During Drilling

Subsurface stratigraphy and groundwater conditions were logged for each borehole. These conditions were determined by:

- Obtaining soil samples with a split-barrel sampler at 5-foot intervals.
- Observing the resistance to drilling as indicated by the drilling rate, the overall rig behavior, and the resistance to driving the casing (cable tool only).
- Maintaining casing tallies.
- Measuring and marking line lengths to ensure accurate depth determination.
- Recording groundwater levels during drilling.
- Measuring specific conductance, pH, and temperature of groundwater samples obtained from the borehole by bailing.

Well Installation Procedures

Well construction procedures are described below. Minor departures from these procedures occurred from well to well, depending on downhole conditions.

- The completed borehole was bailed until relatively free of cuttings (cable tool only).
- The drive shoe was cut off using a downhole cutter (cable tool only).
- The completed borehole was backfilled to achieve a specific bottom depth for the well. Sand or bentonite chips were used as backfill.
- Well backfill material depths were measured frequently using a weighted fiberglass surveying tape.
- The temporary casing was extracted as the well was constructed. Backfill material was added to the casing, generally in increments of 2 feet or less to prevent bridging. Well construction materials were poured into the annulus between the monitoring well and the temporary casing. A portion of the bottom of the boring for PKC-MW3 was backfilled with bentonite grout which was tremmied (conducted to the bottom of the borehole) through a small-diameter tremmie pipe.
- Bentonite chip seals, a minimum of 1 foot thick, were installed above the filter pack. These seals were hydrated subsequent to placement, if not placed directly in water.

- Groundwater monitoring well screens were constructed of 2-inch-diameter, flush-threaded Schedule 40 PVC pipe with 0.020-inch milled slots. The cable tool boring gas probes were constructed with 0.75-inch-diameter Schedule 80 PVC pipe with 0.020-inch milled slots. Threaded end caps were used at the bottom of each well. Unslotted flush-threaded PVC casing was attached above the well screen to approximately 2 feet above ground surface. All screen, casing, and end caps were precleaned and stored in plastic by the manufacturer prior to site delivery. Monitoring well screened interval lengths ranged from 5 to 28 feet. A slip cap fitted with a 1/4-inch PVC labcock valve was installed on each monitoring well casing, with the exception of PKC-MW1B, which contains only a slip cap. The labcocks allow for gas monitoring.

- Stainless steel centralizers were generally installed just above and below the well screen.

- Colorado 8-12 silica sand was used as a filter pack around 0.020-inch slot screens. Pea gravel was substituted for sand for the cable tool boring gas probes.

- Protective steel casings with locking caps were installed over the PVC well casings upon completion of construction. The protective casings were set in concrete, painted, and clearly labeled. A 3-foot by 3-foot concrete surface pad was constructed around each monument. Two steel posts were installed around each surface pad to protect the monument against vehicle damage.

Problems Encountered During Well Installation

Typical well installation problems, such as bridging of bentonite chips near the bottom of the temporary steel casing or the hollow stem auger, were encountered and resolved. Formation instability within the boring for PKC-MW3 prevented the installation of a groundwater monitoring well in the lowermost aquifer encountered.

Health and Safety Monitoring

The health and safety requirements as outlined in the site Health and Safety Plan (HASP), dated November 5, 1992, were followed during all field activities. Level D protection was required during all field activities.

A combustible gas meter (CGM) and an organic vapor meter equipped with a photoionization detector (OVM-PID) were used to measure combustible gas and organic vapor during drilling. Use of this equipment helped protect on-site personnel from potential inhalation and explosion hazards. Measurements were made within the casing at each sampling interval unless the temporary casing extended more than 8 feet above ground surface. Measurements for combustible gas were also performed within the casing prior to commencing any steel casing welding or cutting.

Equipment Decontamination and Drilling Site Cleanup

All drilling equipment and accessories were thoroughly decontaminated using a high-pressure steam cleaner prior to drilling the first boring and after completion of each well installation. A decontamination pad with a pea gravel base was established near the northwest corner of the landfill. Wash water drained off the pad and off the landfill cap, while remaining on the landfill property. Waste generated on site, such as used personal protective clothing, was placed in plastic bags and disposed of off site.

Soil cuttings generated while drilling through water-bearing zones were placed in Department of Transportation (DOT)-certified 55-gallon drums. The drums were sealed and labeled to identify the boring number, volume, and date, and placed in one area on the landfill. Soil generated while drilling through the unsaturated zone and aquitards was left at each drilling site for hollow-stem auger borings and transported to one location on the landfill cover for the cable tool borings.

Well Development

Monitoring wells were developed at least 2 weeks prior to sampling. The wells were developed by a combination of surging and bailing. The initial phase of well development consisted of surging the well to loosen sediment within the sandpack, and removing the water and sediment with a 3-foot-long stainless steel bailer. The well was considered developed after pH, conductivity, and temperature were within 10 percent for three successive readings.

Development water was placed in 55-gallon drums. Following well development, drums were labeled with the well number, volume, and date, and left at the well site.

The bailer and parameter monitoring equipment were decontaminated prior to and following each use. Decontamination procedures are described in the Groundwater Sampling section.

GROUNDWATER AND SURFACE WATER SAMPLING

Two rounds of groundwater and surface water samples were collected during the Phase II Investigation. Round one groundwater and surface water samples were collected during the week of March 22, 1993. Groundwater samples were collected from PKC-MW1a, PKC-MW1b, PKC-MW2, PKC-MW3b, PKC-MW5, and PKC-MW6. Monitoring wells PKC-MW3a, PKC-MW4, and PKC-MW7 contained no measurable groundwater during the round one and two sampling events. Four surface water samples were collected: three from the East Stream and one along the east side of the landfill. Round two groundwater samples were collected during the week of August 16, 1993. Groundwater samples were collected from the same seven-well network during both sampling rounds. Round two surface water samples were collected on May 26, 1993 from the same four locations sampled for round 1.

Prior to each sampling, AGI prepared a sample identification matrix summarizing sampling requirements for each well. The matrix included sample identifications, station numbers, analysis types and method numbers, types of sample containers, preservation codes, laboratory holding times, and appropriate field QA/QC samples.

Health and safety procedures followed during groundwater and surface water sampling were in compliance with the HASP. Level D protection was used during all groundwater and surface water sampling activities.

Groundwater sampling procedures were in accordance with EPA recommendations and protocols as presented in the *Ground Water Technical Enforcement Guidance Document* (EPA, 1986) and *Practical Guide for Ground Water Sampling* (Barcelona, et al., 1985). The following field sampling procedures were used throughout the sampling program.

Initial Water Level Measurements

Monitoring well water levels were measured prior to purging the wells for sampling. Water levels were measured to the nearest 0.01 foot with a Slope Indicator Company (SINCO) electronic water level sounder. The water level measurements were made from the top of the 8-inch-diameter steel protective casing.

Well Purging

All groundwater monitoring wells were purged prior to sampling to remove stagnant water from the well casings. Shallow monitoring well PKC-MW5 was purged with a stainless steel bailer. A 2-inch-diameter Grundfos submersible pump was used to purge the remaining wells. A well was considered purged when at least three standing-water casing volumes were removed and when three successive indicator water quality parameter measurements varied by less then 10 percent. Parameter measurements are discussed below.

All purge and decontamination water was placed in DOT-certified 55-gallon drums. The drums were sealed and labeled identifying the well number, volume, and date. The drums were placed near each well site.

Water Quality Parameter Measurements

Water quality parameters (pH, conductivity, and temperature) were measured during monitoring well purging using hand-held field instruments. Parameters were also recorded for all surface water samples. Instrument calibration and repair followed manufacturer specifications. The pH meter was calibrated in the field with standard stock solutions prior to purging.

Sample Collection and Filtration

All groundwater samples were collected using a stainless steel bailer suspended on nylon cord. New cord was used between wells. Surface water samples were collected using a glass beaker. Water samples scheduled for dissolved metals analysis were field-filtered through disposable 0.45-micron cellulose acetate filters prior to being placed in the sample containers.

Sample Preservation and Containers

Water samples were placed in precleaned, chemically inert containers provided by the analytical laboratory (Analytical Resources Inc. of Seattle, Washington). Containers without preservatives were rinsed with sample water prior to filling. Most preservatives were added to appropriate containers by the analytical laboratory.

Preprinted sample container labels were provided by AGI. Each sample label was completed with the following information:

- Project name
- Project number
- King County sample identification number
- Date and time of collection
- Initials of person collecting the sample

After collection, the outside of each sample container was wiped down. An AGI chain-of-custody seal was then affixed securely over the lid of the sample container, the container was placed in a resealable zip-lock plastic bag, and the bag was placed in an iced cooler. Samples were delivered in the coolers to the analytical laboratory.

__Sample Custody__

Chain-of-custody seals were placed on each sample container and cooler. A chain-of-custody form was prepared for each cooler; this form included a sample container list, analysis request, sample collection date and times, and the signature of the person who packed the cooler. Chain-of-custody records were maintained for each sample from the time of collection to the time of delivery at the analytical laboratory.

__Documentation__

Field personnel kept a detailed log for all samples, including sampling station number, King County sample identification number, water level data, purging method, volume of water removed, odor and appearance of the sample, water quality parameter measurements, filtration/preservation methods, and the date and time of the measurements and sampling. A copy of the chain-of-custody form for each sample cooler was kept with the field sampling log.

__Decontamination Procedures__

All nondisposable sampling equipment--bailers, Teflon bailer inserts, electric downrigger, glass beakers, and the Grundfos pump--was decontaminated between each sampling. The decontamination procedure was as follows:

- Rinse and preclean with potable water.
- Wash in a solution of laboratory-grade, nonphosphate-based soap (e.g., Alconox) and potable water.
- Dip rinse in potable water.
- Rinse with laboratory-grade isopropyl alcohol.
- Rinse with distilled water.
- Rinse with dilute nitric acid.
- Rinse with distilled water.
- Place on or within polyethylene sheeting (small items).

WATER LEVEL MONITORING

Groundwater levels were monitored from nine monitoring wells and two gas probe piezometers. Surface water levels were monitored from two staff gauges, one of which was located near each end of the culvert which runs below the southeast portion of the landfill.

Water levels were monitored on a biweekly schedule from March 17, 1993 to August 26, 1993.

All groundwater level measurements were made using a SINCO electronic water level sounder. Groundwater levels were measured from the top of the 8-inch-diameter steel protective casing. All measurements were recorded to the nearest 0.01 foot. Surface water level measurements were made to the nearest 0.1 foot using staff gauges installed at each location. Groundwater elevation data are presented in **Appendix C**.

Vertical survey control for the nine groundwater monitoring well stations and two staff gauges was provided by Sitts & Hill Engineers, Inc. Elevations were measured to the nearest 0.01 foot for the top of each steel protective casing. Elevations were referenced to the National Geodetic Vertical Datum of 1929. **Appendix B** discusses the elevation survey completed at the landfill.

LANDFILL GAS INVESTIGATION FIELD METHODS

Seven borings were drilled specifically for the purpose of installing 20 gas probes during the Phase II Investigation. Dual-completion gas probes were identified with an "a" (indicating an upper gas probe) or a "b" (indicating a lower gas probe). Single completion gas probes were identified similarly, but without the appended letters. The five cable tool borings were completed with seven gas probes. In addition, all monitoring wells with the exception of PKC-MW1b serve as dual-purpose groundwater/gas monitoring wells. The gas probes' screened intervals were located so that each probe would encounter gases representative of the surrounding refuse or geological unit. Following gas probe installation, a monitoring program was conducted to obtain physical property data for the subsurface gas in the soil pore space surrounding each probe.

Gas Probe Drilling and Installation

Gas probe borings were drilled by a Mobil Drill B-61 auger drill rig using 8-inch outside-diameter, 4-1/4-inch inside-diameter hollow-stem auger casing. Geologic conditions were characterized using the following procedures:

- Drill cuttings were regularly examined during removal from the borehole.
- Resistance to drilling, as indicated by drilling rate and drill rig behavior, was observed.
- Soil samples were collected at 5-foot intervals using the split-barrel sample method described earlier.

All boreholes were logged by an AGI geologist. Soils were classified in the field in accordance with the Unified Soil Classification System.

Ambient air quality monitoring at borehole locations was performed to ensure volatile organic compound (VOC) vapors and combustible gases did not exceed action levels established in the HASP. Prior to drilling, an OVM-PID and CGM were used to establish background air quality at each drill site. During drilling, ambient air quality parameters were measured at the top of each new casing section.

Well designs were prepared by the AGI field geologist upon completion of drilling. Screens were placed in unsaturated soils considered most likely to be landfill gas subsurface migration pathways based on soils encountered and CGM data.

General procedures for gas probe construction are summarized below; minor departures occurred from probe to probe.

- When necessary, borings were backfilled to achieve the base depth for the PVC probe casing. Sand or bentonite chips were used as backfill.
- Well backfill material depths were measured frequently using a weighted fiberglass surveying tape.
- The amount of backfill material in the casing was kept at less than 2 feet to decrease the possibility of bridging. All probe construction materials were placed dry from the top of the hollow-stem auger. The hollow-stem auger was removed to expose backfill materials.
- Gas probes were constructed of 3/4-inch-diameter, flush-threaded, coupled Schedule 80 PVC blank pipe or well screen with 0.02-inch milled slots. Screen length varied according to geologic conditions. Bottom caps were flush threaded. A threaded 1/4-inch PVC labcock valve was installed at the top of the 3/4-inch casing to allow gas sampling.
- Pea gravel was placed as a filter pack between the boring sidewall and the well screen. The filter pack extended a minimum of 1 foot above the screen.
- Bentonite chips were placed above the filter pack and hydrated with potable water to form a hydraulic seal. Seals extended from the top of the filter pack to the surface casing.
- Steel monument cases with locking caps were installed over the tops of probes upon completion of construction. Monuments were set in concrete, painted, and clearly labeled. A 3-foot by 3-foot concrete surface pad was constructed around each monument. Two to three steel posts were installed around each surface pad to protect the monument from vehicle damage.

GAS PROBE MONITORING

Soil gas parameters were monitored biweekly at 35 gas probes from April 1, 1993 through September 3, 1993. Seven off-site gas probes along the southern border of the site were monitored between April 1 and June 11, 1993. During each monitoring round, barometric pressure data were obtained from the weather station at Sea-Tac International Airport.

AGI TECHNOLOGIES

Gas Probe Purging

All field measurements were made by attaching the sampling port on the field instrument to the gas probe's 1/4-inch labcock valve hose fitting via a 1/4-inch flexible Teflon tube. Prior to purging, differential pressure measurements were obtained by making an airtight connection between the probe and the pressure gauge, and then opening the probe valve. After measuring differential pressure, the probe was purged using the CGM's high-volume pump; the probe was purged until the value for oxygen stabilized for 1 to 2 minutes. When a significant negative differential pressure was present, the probe was purged using a vacuum pressure pump (Barnant Model 400-1903, 9.5 cubic feet per minute). Stabilized oxygen concentration was then recorded and the probe monitored for combustible gas, VOCs, H_2S, and CO_2.

Differential Pressure

Pressure within each gas probe was measured with respect to the ambient atmospheric pressure using a high-sensitivity differential pressure gauge. A 0-2 or 0- to 20-inch scale water column range pressure gauge was used.

Oxygen

Following gas probe purging, oxygen was measured using a portable instrument that measures oxygen content in the 0 to 25 percent by volume (% vol) range using an electrochemical cell.

Combustible Gas

Combustible gas concentrations were measured with two different sensors housed in a single instrument. For low concentrations (less than 5% vol), measurements were made using a high-sensitivity (0 to 100% lower explosive limit [LEL] range) CGM. For combustible gas concentrations higher than 5 percent by volume, a thermal conductivity element CGM capable of reading up to 100% vol was used.

Volatile Organic Compounds

VOC concentrations were measured using an OVM-PID. Stable values were recorded.

Hydrogen Sulfide

Hydrogen sulfide (H_2S) concentrations were measured using a portable meter containing an electrochemical indicator with a sensitivity range between 0 and 50 parts per million (ppm) H_2S.

Carbon Dioxide

Fyrite brand indicators using liquid absorbent were used to measure carbon dioxide concentrations. Two indicators, with ranges of 0 to 20 and 0 to 100% vol, were used.

Temperature

Three temperatures--ambient, ground, and downhole--were measured at each gas probe. A remote temperature indicator with a 25-foot thermistor/sensor was used to measure ambient temperature in the shade (or in direct sunlight if no shade was available), as well as ground and downhole temperatures. The ground temperature was measured by inserting the thermistor probe approximately 4 to 6 inches into the soil. The downhole temperature was measured by lowering the flexible thermistor probe a maximum of 25 feet or to the bottom of the gas probe. For all temperature measurements, the sensor was allowed to equilibrate until no change was observed for 30 seconds.

APPENDIX B

Monitoring Well, Gas Probe, and Boring Logs and Installation Diagrams

APPENDIX B

Monitoring Well, Gas Probe, and Boring Logs and Installation Diagrams

This appendix includes summary logs and completion diagrams for all borings, groundwater monitoring wells, and gas probes installed by AGI Technologies (AGI) as part of the Phase II Investigation at the Puyallup/Kit Corner Custodial Landfill in King County, Washington. Summary logs and completion diagrams for two gas extraction wells (EW8D and EW10D) used in interpreting study area hydrogeology are included. These two wells were installed as part of the southern perimeter landfill gas extraction system. Summary logs and completion diagrams for wells installed to the east and south of the landfill prior to this investigation are not included, although these wells are listed in the data summary tables.

Table B1 summarizes well installation details (design engineer, status, installation date, drilling method, total depth, screen specifications, and sand pack composition). **Table B2** lists reference elevations for surveyed wells, and **Table B3** lists reference elevations for gas probes. Monitoring wells installed by AGI are designated with the prefix PKC-MW. Gas probes installed by AGI are designated with the prefix PKC-GP.

Plate B1, Soil Classification/Legend, provides a guide to the soil classification system and symbols used in the logs. **Plate B2,** Well and Probe Construction, shows typical monitoring well and gas probe completion details and a guide to the symbols used regarding groundwater observations. **Plates B3 through B17,** Summary Logs, provide detailed descriptions of the geologic conditions encountered at each drilling location.

AGI TECHNOLOGIES

Table B1
Monitoring Well and Gas Probe Installation Summary
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Well Designation	Design Engineer	Geologic Log Available	Well As Built Available	Well Status	Date Completed	Drill Method	Total Boring Depth (ft bgs)	Screened Interval (ft bgs)	Screened Interval (Top of PVC Casing)	Screen Diameter (inches)	Screen Type	Slot Size (inches)	Sand Pack Gradation
PKC-MW1GP	AGI	Yes	Yes	Functional	01/06/93	Cable Tool	155	26-41	27.33-42.33	0.75	PVC	0.020	PG
PKC-MW1a	AGI	Yes	Yes	Functional	01/06/93	Cable Tool	155	60-88	61.92-89.92	2	PVC	0.020	10/20/PG
PKC-MW1b	AGI	Yes	Yes	Functional	01/06/93	Cable Tool	155	145-150	146.78-151.78	2	PVC	0.020	10/20
PKC-MW2GPa	AGI	Yes	Yes	Functional	01/22/93	Cable Tool	156	22-37	23.17-38.17	0.75	PVC	0.020	PG
PKC-MW2GPb	AGI	Yes	Yes	Functional	01/22/93	Cable Tool	156	67-87	67.81-87.81	0.75	PVC	0.020	PG
PKC-MW2	AGI	Yes	Yes	Functional	01/22/93	Cable Tool	156	115-140	116.31-141.31	2	PVC	0.020	10/20
PKC-MW3a	AGI	Yes	Yes	Functional	02/11/93	Cable Tool	185	11-21	13.05-23.05	2	PVC	0.020	10/20
PKC-MW3b	AGI	Yes	Yes	Functional	02/11/93	Cable Tool	185	60-70	111.24-126.24	2	PVC	0.020	10/20
PKC-MW4	AGI	Yes	Yes	Functional	02/04/93	Auger	16	5-15	7.05-17.05	2	PVC	0.020	10/20
PKC-MW5	AGI	Yes	Yes	Functional	02/12/93	Auger	29	7-22	8.51-23.51	2	PVC	0.020	10/20
PKC-MW6GPa	AGI	Yes	Yes	Functional	02/25/93	Cable Tool	173	40-50	41.70-51.70	0.75	PVC	0.020	PG
PKC-MW6GPb	AGI	Yes	Yes	Functional	02/25/93	Cable Tool	173	76-86	77.57-87.57	0.75	PVC	0.020	PG
PKC-MW6	AGI	Yes	Yes	Functional	02/25/93	Cable Tool	173	138-163	139.55-164.55	2	PVC	0.020	10/20
PKC-MW7GPa	AGI	Yes	Yes	Functional	03/11/93	Cable Tool	185	30-40	31.79-41.79	0.75	PVC	0.020	PG
PKC-MW7GPb	AGI	Yes	Yes	Functional	03/11/93	Cable Tool	185	70-80	71.85-81.85	0.75	PVC	0.020	PG
PKC-MW7	AGI	Yes	Yes	Functional	03/11/93	Cable Tool	185	99-114	100.84-115.84	2	PVC	0.020	10/20
PKC-GP16a	AGI	Yes	Yes	Functional	01/28/93	Auger	78	4-19	6.11-21.11	0.75	PVC	0.020	PG
PKC-GP16b	AGI	Yes	Yes	Functional	01/28/93	Auger	78	44-59	45.96-60.98	0.75	PVC	0.020	PG
PKC-GP17a	AGI	Yes	Yes	Functional	02/02/93	Auger	63	7-27	9.39-29.39	0.75	PVC	0.020	PG
PKC-GP17b	AGI	Yes	Yes	Functional	02/02/93	Auger	63	42-60	44.19-62.19	0.75	PVC	0.020	PG
PKC-GP18	AGI	Yes	Yes	Functional	02/09/93	Auger	15.5	5-15	7.20-17.20	0.75	PVC	0.020	PG
PKC-GP19a	AGI	Yes	Yes	Functional	02/03/93	Auger	83	6-16	7.95-17.95	0.75	PVC	0.020	PG
PKC-GP19b	AGI	Yes	Yes	Functional	02/03/93	Auger	83	77-82	78.85-83.85	0.75	PVC	0.020	PG
PKC-GP20a	AGI	Yes	Yes	Functional	02/10/93	Auger	78	10-25	11.74-26.74	0.75	PVC	0.020	PG
PKC-GP20b	AGI	Yes	Yes	Functional	02/10/93	Auger	78	50-65	51.58-66.58	0.75	PVC	0.020	PG
PKC-GP21a	AGI	Yes	Yes	Functional	02/17/93	Auger	73	32-42	33.55-43.55	0.75	PVC	0.020	PG
PKC-GP21b	AGI	Yes	Yes	Functional	02/17/93	Auger	73	57-72	58.23-73.23	0.75	PVC	0.020	PG
PKC-GP22a	AGI	Yes	Yes	Functional	02/19/93	Auger	71	40-45	41.76-46.76	0.75	PVC	0.020	PG
PKC-GP22b	AGI	Yes	Yes	Functional	02/19/93	Auger	71	60-70	61.55-71.55	0.75	PVC	0.020	PG

AGI TECHNOLOGIES

Table B1
Monitoring Well and Gas Probe Installation Summary
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Well Designation	Design Engineer	Geologic Log Available	Well As Built Available	Well Status	Date Completed	Drill Method	Total Boring Depth (ft bgs)	Screened Interval (ft bgs)	Screened Interval (Top of PVC Casing)	Screen Diameter (inches)	Screen Type	Slot Size (inches)	Sand Pack Gradation
Gas Probes Drilled by Others													
GMW-1A	AESI	Yes	Yes	Functional	05/11/89	Auger	31.5	5-10	Unknown	2	PVC	0.010	Unknown
GMW-1B	AESI	Yes	Yes	Functional	05/11/89	Auger	31.5	20-30	Unknown	2	PVC	0.010	Unknown
GMW-2A	AESI	Yes	Yes	Functional	05/12/89	Auger	22.0	5-10	Unknown	2	PVC	0.010	Unknown
GMW-2B	AESI	Yes	Yes	Functional	05/12/89	Auger	22.0	15-20	Unknown	2	PVC	0.010	Unknown
GMW-3A	AESI	Yes	Yes	Functional	05/14/89	Auger	30.0	7-12	Unknown	2	PVC	0.010	Unknown
GMW-3B	AESI	Yes	Yes	Functional	05/14/89	Auger	30.0	19-29	Unknown	2	PVC	0.010	Unknown
GMW-4	AESI	Yes	Yes	Functional	05/13/89	Auger	25.0	5-15	Unknown	2	PVC	0.010	Unknown

Notes:

ft bgs - Feet below ground surface.
PG - 3/8-inch pea gravel.
PVC - Schedule 40 polyvinyl chloride plastic.

AGI TECHNOLOGIES

Table B2
Groundwater Monitoring Well Elevation Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Well Designation	Coordinates		PVC Well Casing Stickup Relative to Ground Surface (ft)	Elevations (ft) [a]			Screen Zone (ft)			QED Well Wizard Intake Depth from Top of PVC Casing (ft)	QED Well Wizard Pump Intake Elevation [a] (ft)	Hydrostratigraphic Unit
	North (Y)	East (X)		Land Surface [b]	Top of PVC Casing	Bottom of Exploration	Screen Length	Elevations [a] Bottom	Top			
PKC-MW1a	106981.46	1635463.83	1.92	322	323.68	177	28	234	262	87.83	253.85	Lower Perched Zone
PKC-MW1b	106981.46	1635463.83	1.78	322	323.54	177	5	172	177	150.23	173.31	Gravel Water-Bearing Zone
PKC-MW2	106810.16	1634533.62	1.31	329	330.10	173	25	189	214	139.77	190.33	Sand Aquifer
PKC-MW3a	106712.47	1634969.30	2.05	321	322.81	136	10	300	310	--	--	None present
PKC-MW3b	106712.47	1634969.30	1.74	321	322.50	136	15	196	211	125.3	197.20	Sand Aquifer
PKC-MW4	106660.75	1634990.89	2.05	321	323.37	305	10	306	316	--	--	None present
PKC-MW5	107361.61	1635470.33	1.51	325	326.59	296	15	303	318	20.15	306.39	Lower Perched Zone
PKC-MW6	107555.69	1634710.96	1.55	353	354.25	180	25	190	215	162.19	192.06	Sand Aquifer
PKC-MW7	107869.97	1635466.17	1.84	333	334.37	148	15	220	235	--	--	None present

Notes:

Coordinates with two significant figures beyond the decimal point were surveyed by Sitts & Hill Engineers, Inc.
a) Elevations reported in feet above Mean Sea Level based on the National Geodetic Vertical Datum, 1929.
b) Land surface elevations estimated from a topographic base map prepared for King County Solid Waste Division by DeGross Aerial Mapping, 1992.

AGI TECHNOLOGIES

Table B3
Gas Probe Elevation Data
Puyallup/Kit Corner CustodialLandfill
King County, Washington

Gas Probe Designation	Date Completed	Elevations [a] (ft)		Screen Zone (ft)			PVC Well Casing Stickup Relative to Ground Surface (ft)	Completion Zone
		Land Surface [b]	Bottom of Exploration	Screen Length	Elevations [a] Bottom	Top		
PKC–MW1GP	01/06/93	322	166.5	15	281	296	1.33	Lower Sand
PKC–MW1a	01/06/93	322	166.5	28	234	262	1.92	Lower Sand
PKC–MW2GPa	01/22/93	329	173	15	292	307	1.17	Upper Gravel
PKC–MW2GPb	01/22/93	329	173	20	242	262	0.81	Upper Sand
PKC–MW2	01/22/93	329	173	25	189	214	1.31	Lower Sand
PKC–MW3a	02/11/93	321	136	10	300	310	2.05	Upper Gravel
PKC–MW3b	02/11/93	321	136	15	196	211	1.74	Lower Sand
PKC–MW4	02/04/93	321	305	10	306	316	2.05	Upper Gravel
PKC–MW5	02/12/93	325	296	15	303	318	1.51	Upper Gravel
PKC–MW6GPa	02/25/93	353	180	10	303	313	1.70	Upper Gravel
PKC–MW6GPb	02/25/93	353	180	10	267	277	1.57	Upper Sand
PKC–MW6	02/25/93	353	180	25	190	215	1.55	Lower Sand
PKC–MW7GPa	03/11/93	333	148	10	293	303	1.79	Upper Sand
PKC–MW7GPb	03/11/93	333	148	10	253	263	1.85	Lower Sand
PKC–MW7	03/11/93	333	148	15	219	234.	1.84	Lower Sand
PKC–GP16a	01/28/93	318	240	15	299	314	2.11	Refuse
PKC–GP16b	01/28/93	318	240	15	259	274	1.96	Lower Sand
PKC–GP17a	02/02/93	317	254	20	290	310	2.39	Refuse
PKC–GP17b	02/02/93	317	254	18	257	275	2.19	Lower Sand
PKC–GP18	02/09/93	327	311.5	10	312	322	2.20	Upper Gravel
PKC–GP19a	02/03/93	345	262	10	329	339	1.95	Upper Gravel
PKC–GP19b	02/03/93	345	262	5	263	268	1.85	Upper Sand
PKC–GP20a	02/10/93	343	265	15	333	318	1.74	Upper Gravel
PKC–GP20b	02/10/93	343	265	15	293	278	1.58	Upper Sand
PKC–GP21a	02/17/93	330	257	10	298	288	1.55	Upper Sand
PKC–GP21b	02/17/93	330	257	15	273	258	1.23	Lower Sand
PKC–GP22a	02/19/93	321	250	5	281	276	1.76	Upper Sand
PKC–GP22b	02/19/93	321	250	10	261	251	1.55	Lower Sand
GMW–1A	05/11/89	330	298	5	320	325	Unknown	Upper Gravel
GMW–1B	05/11/89	330	298	10	300	310	Unknown	Upper Gravel
GMW–2A	05/12/89	320	298	5	310	315	Unknown	Upper Gravel
GMW–2B	05/12/89	320	298	5	300	305	Unknown	Upper Gravel
GMW–3A	05/14/89	330	300	5	318	323	Unknown	Upper Gravel
GMW–3B	05/14/89	330	300	10	300	310	Unknown	Upper Gravel
GMW–4	05/13/89	322	297	10	307	317	Unknown	Upper Gravel

Notes:

a) Elevations reported in feet above Mean Sea Level based on Geodetic Vertical Datum, 1929.
b) Land surface elevations are estimated from a topographic base map prepared for King County Solid Waste Division by DeGross Aerial Mapping, 1992.

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS MORE THAN HALF IS LARGER THAN NO. 200 SIEVE	**GRAVELS** MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LESS THAN 5% FINES	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 5% FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN HALF IS SMALLER THAN NO. 200 SIEVE	**SILTS AND CLAYS** LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASITICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

LEGEND

SAMPLE

- "Undisturbed"
- Bulk/Grab
- Not Recovered

CONTACT BETWEEN UNITS

- Well Defined Change
- Gradational Change
- Obscure Change
- End of Exploration

BLOWS/FOOT

Hammer is 300 pounds with 30-inch drop, unless otherwise noted

S - SPT Sampler (2.0-Inch O.D.)
T - Thin Wall Sampler (2.8-Inch Sample)
H - Split Barrel Sampler (2.5-Inch Sample)

MOISTURE DESCRIPTION

Dry	Considerably less than optimum for compaction
Moist	Near optimum moisture content
Wet	Over optimum moisture content
Saturated	Below water table, in capillary zone, or in perched groundwater

LABORATORY TESTS

Consol	Consolidation
LL	Liquid Limit
PL	Plastic Limit
Gs	Specific Gravity
SA	Size Analysis
TxS	Triaxial Shear
TxP	Triaxial Permeability
Perm	Permeability
Po	Porosity
MD	Moisture/Density
DS	Direct Shear
VS	Vane Shear
Comp	Compaction

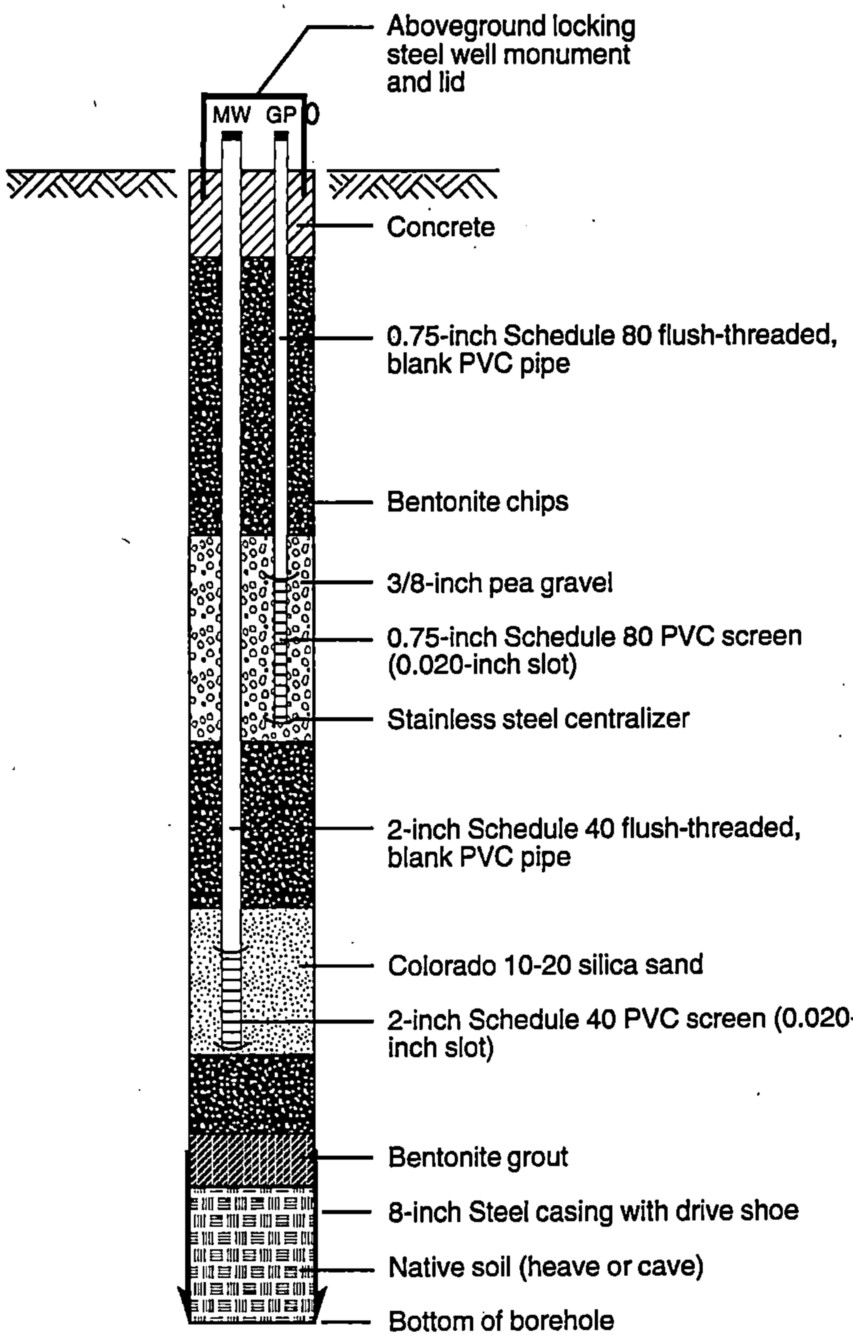
UU - Unconsolidated, Undrained
CU - Consolidated, Undrained
CD - Consolidated, Drained

AGI TECHNOLOGIES

Soil Classification/Legend
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		17 June 94		



Notes regarding groundwater observations:

Static water level measured in monitoring well on March 17, 1993.

Water level observed during drilling with boring at indicated depth. Water levels noted represent "stabilized" levels or overnight levels.

Water bearing zone where sediments yielded groundwater freely to the borehole during drilling.

Notes regarding field measurements:

Water conductivity measurements made on samples of groundwater bailed from well boring during drilling. Values reported in micromhos per centimeter (mmhs/cm).

Gas concentration measurements taken inside casing approximately 2 to 3 feet below top of casing. Measurements in percent lower explosive limit (%LEL)

MW Monitoring Well
GP Gas Probe

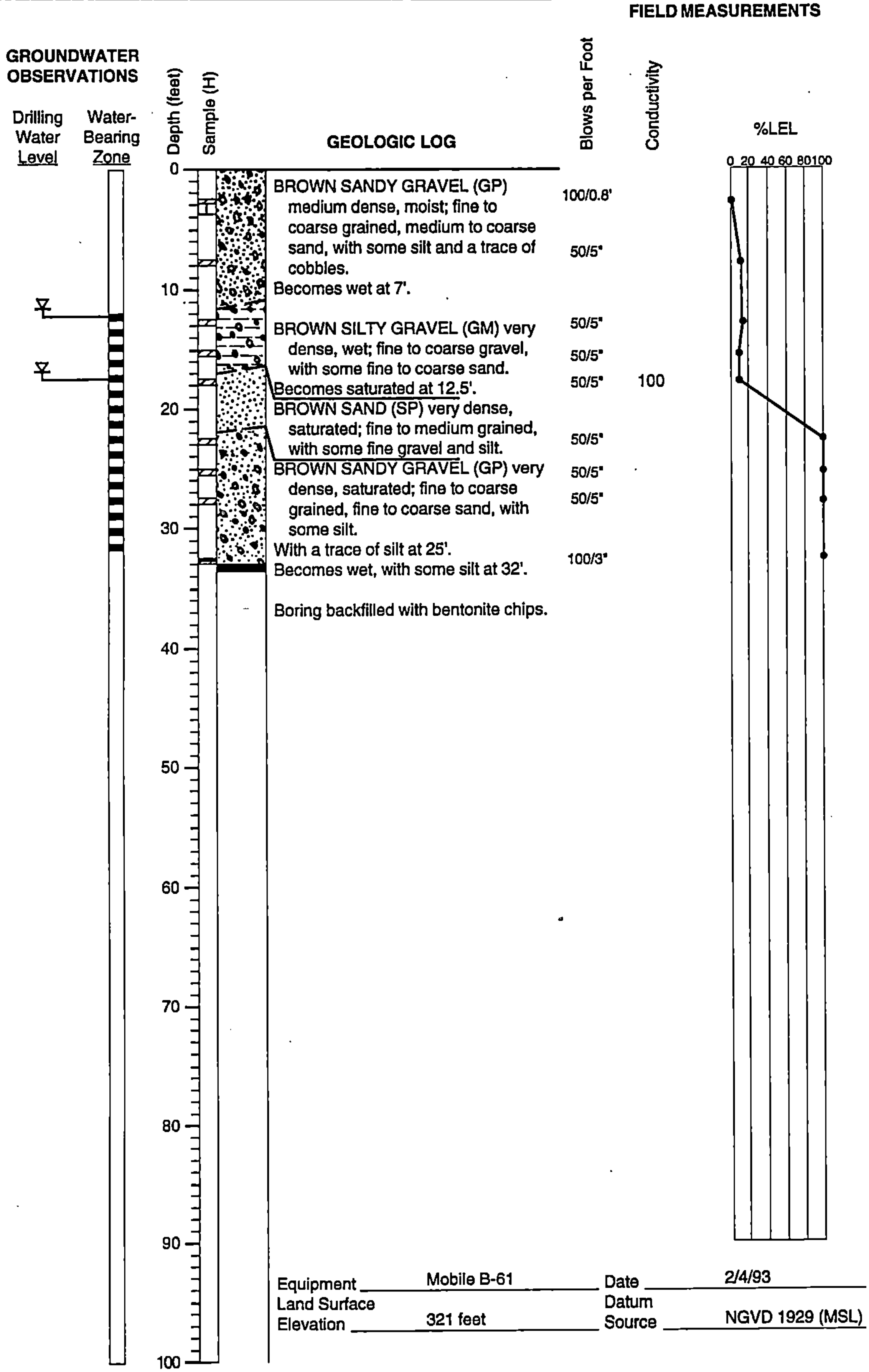
AGI TECHNOLOGIES

Well and Probe Construction

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		17 June 94		



BROWN SANDY GRAVEL (GP) medium dense, moist; fine to coarse grained, medium to coarse sand, with some silt and a trace of cobbles.
Becomes wet at 7'.

BROWN SILTY GRAVEL (GM) very dense, wet; fine to coarse gravel, with some fine to coarse sand.
Becomes saturated at 12.5'.

BROWN SAND (SP) very dense, saturated; fine to medium grained, with some fine gravel and silt.

BROWN SANDY GRAVEL (GP) very dense, saturated; fine to coarse grained, fine to coarse sand, with some silt.
With a trace of silt at 25'.
Becomes wet, with some silt at 32'.

Boring backfilled with bentonite chips.

Equipment	Mobile B-61	Date	2/4/93
Land Surface Elevation	321 feet	Datum Source	NGVD 1929 (MSL)

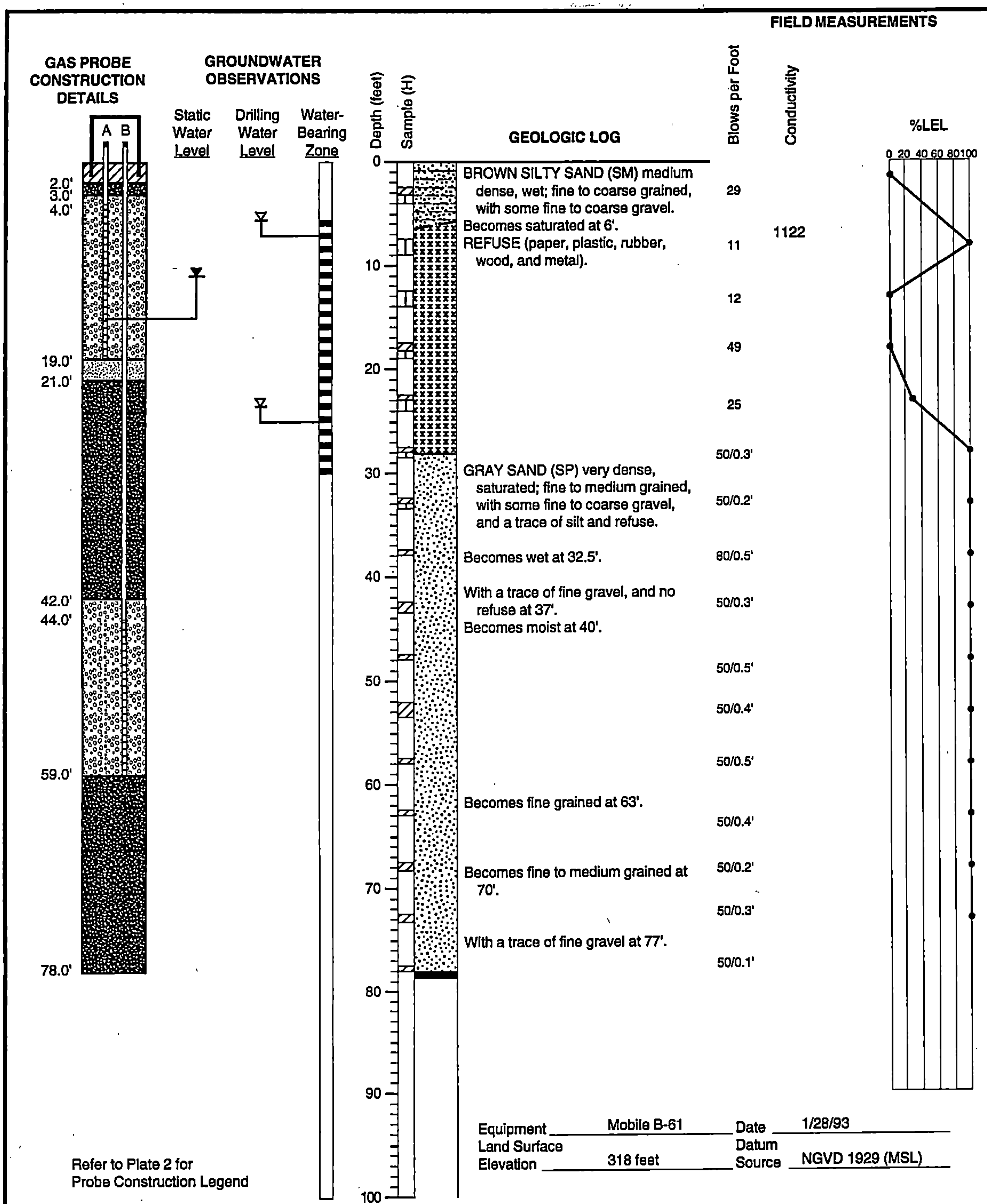
AGI TECHNOLOGIES

Summary Log of PKC-B1

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



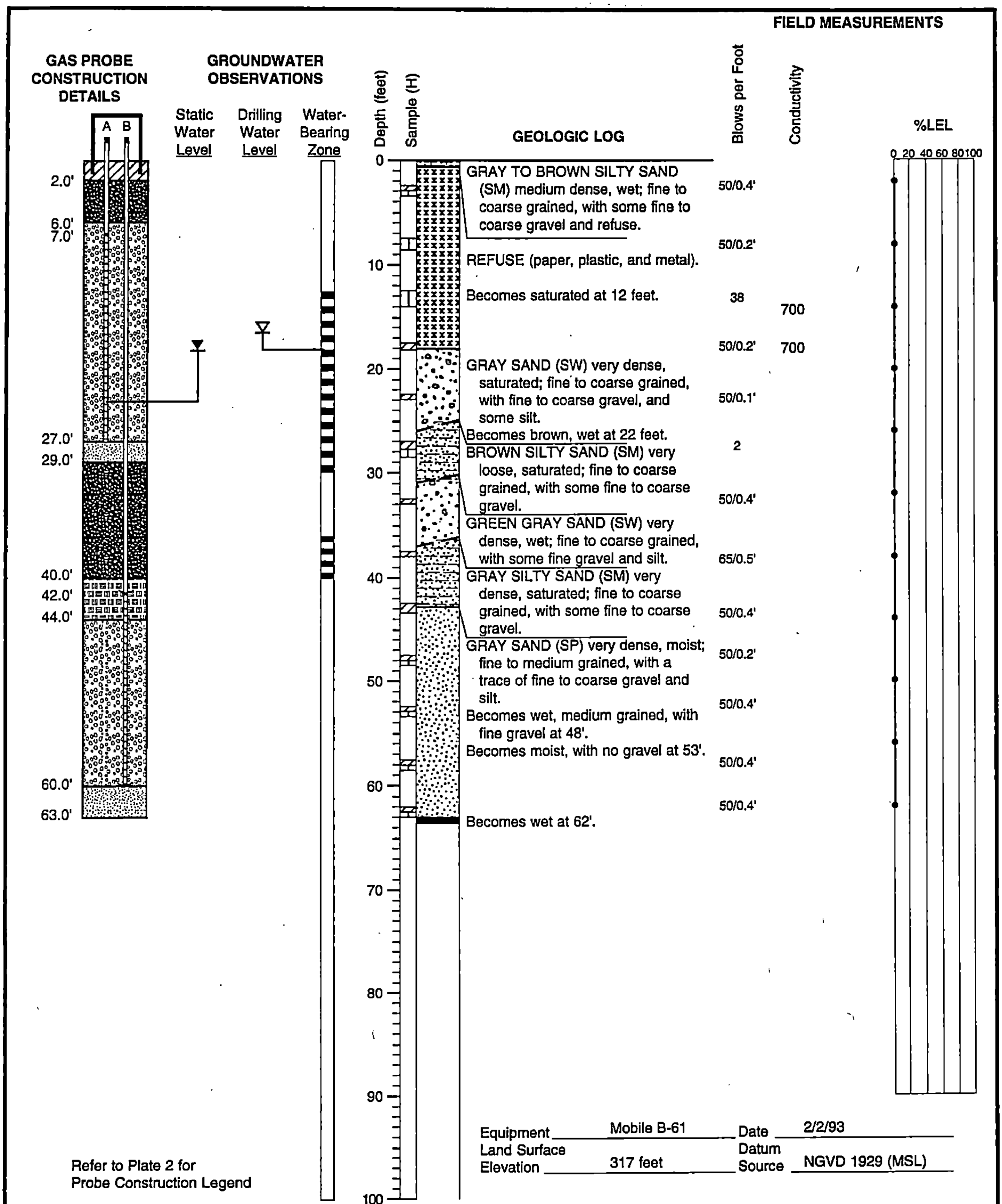
AGI TECHNOLOGIES

Summary Log of PKC-GP16

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B4**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



AGI TECHNOLOGIES

Summary Log of PKC-GP-17

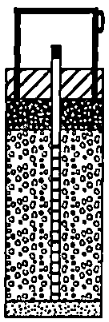
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B5**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

FIELD MEASUREMENTS

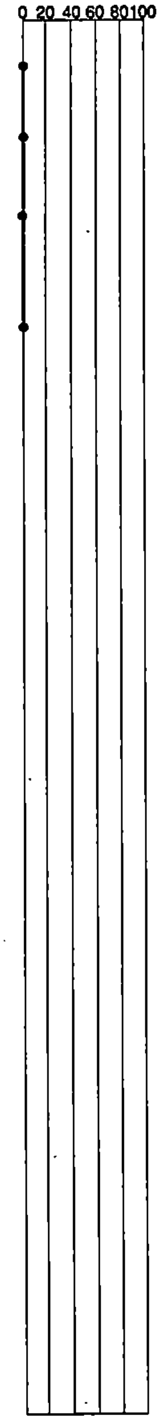
GAS PROBE CONSTRUCTION DETAILS



GROUNDWATER OBSERVATIONS

Static Water Level	Drilling Water Level	Water-Bearing Zone	Depth (feet)	Sample (H)	GEOLOGIC LOG	Blows per Foot	Conductivity
			0		BROWN SILTY SAND (SM) very dense, moist; fine grained, with some fine to coarse gravel.	66	
						75/0.25'	
			10			50/0.4'	
						50/0'	
			20				
			30				
			40				
			50				
			60				
			70				
			80				
			90				
			100				

%LEL



Refer to Plate 2 for Probe Construction Legend

Equipment: Mobile B-61
Date: 2/9/93
Land Surface Elevation: 327 feet
Datum Source: NGVD 1929 (MSL)

AGI TECHNOLOGIES

Summary Log of PKC-GP18

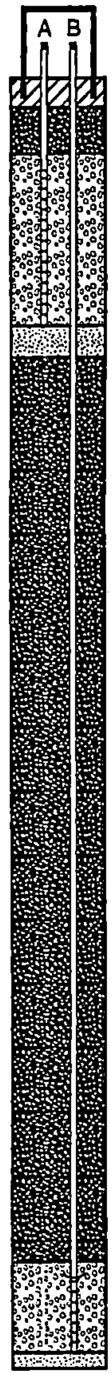
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B6**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

FIELD MEASUREMENTS

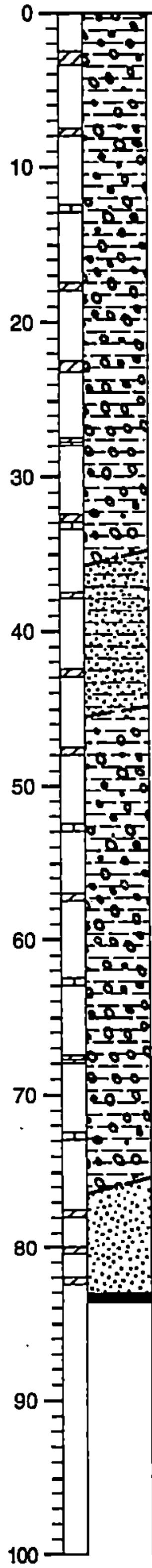
GAS PROBE CONSTRUCTION DETAILS



GROUNDWATER OBSERVATIONS

Static Water Level | Drilling Water Level | Water-Bearing Zone

Depth (feet) | Sample (H) | GEOLOGIC LOG | Blows per Foot | Conductivity | %LEL



BROWN SILTY GRAVEL (GM) very dense, moist; fine to coarse grained, with some fine to coarse sand.

With a trace of cobbles at 10'.

BROWN SILTY SAND (SM) very dense, moist; with some fine to coarse gravel.

With a trace of cobbles at 40'.

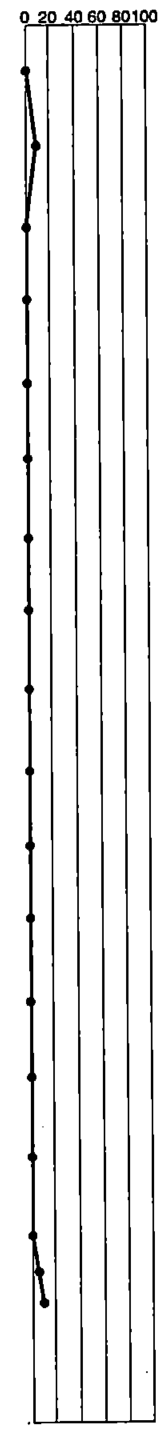
BROWN SILTY GRAVEL (GM) very dense, moist; fine to coarse grained, with some fine to coarse sand.

With a trace of cobbles at 57'.

BROWN SAND (SP) very dense, moist; fine to medium grained, with a trace of fine gravel.

Blows per Foot:

50/0.4'
90/0.5'
50/0.3'
80/0.2'
50/0.2'
50/0.4'
50/0.2'
85/0.3'
50/0.3'
50/0.3'
100/0.1'
75/0.3'
50/0.3'
75/0.5'
100/0.2'
75/0.3'
75/0.3'
100/0.1'



Equipment Mobile B-61 Date 2/3/93

Land Surface Elevation 345 feet Datum Source NGVD 1929 (MSL)

Refer to Plate 2 for Probe Construction Legend

AGI TECHNOLOGIES

Summary Log of PKC-GP19

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B7**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

FIELD MEASUREMENTS

GAS PROBE CONSTRUCTION DETAILS

A B

2.0'
9.0'
10.0'
25.0'
26.0'
49.0'
50.0'
65.0'
67.5'
78.0'

GROUNDWATER OBSERVATIONS

Static Water Level | Drilling Water Level | Water-Bearing Zone

Depth (feet) | Sample (H)

GEOLOGIC LOG

Blows per Foot | Conductivity | %LEL (0 20 40 60 80 100)

Depth: 0 10 20 30 40 50 60 70 80 90 100

BROWN SILTY GRAVELLY SAND (SM) very dense, moist; fine grained, with a trace of cobbles. Proportion of gravel varies.

BROWN SAND (SP) very dense, moist; fine to medium grained, with some silt and fine to coarse gravel.
Becomes medium grained, wet at 36'.
Becomes saturated at 40'.

Becomes wet, with a trace of silt and gravel.

Becomes gravelly.

Becomes moist, with a trace of gravel.

Becomes gray brown, wet at 65'.

GRAY BROWN SANDY GRAVEL (GP) very dense, saturated; fine to coarse grained, fine to coarse sand, with some silt.
Becomes wet at 77'.

Blows per Foot
50/0.4'
75/0.1'
100
100/0.8'
50/0.4'
100/0.8'
50/0.4'
78
50/0.4'
50/0.4'
100/0.7'
50/0.4'
50/0.4'
50/0.4'
50/0.2'
80/0.5'

Equipment Mobile B-61 Date 2/10/93

Land Surface Elevation 343 feet Datum Source NGVD 1929 (MSL)

Refer to Plate 2 for Probe Construction Legend

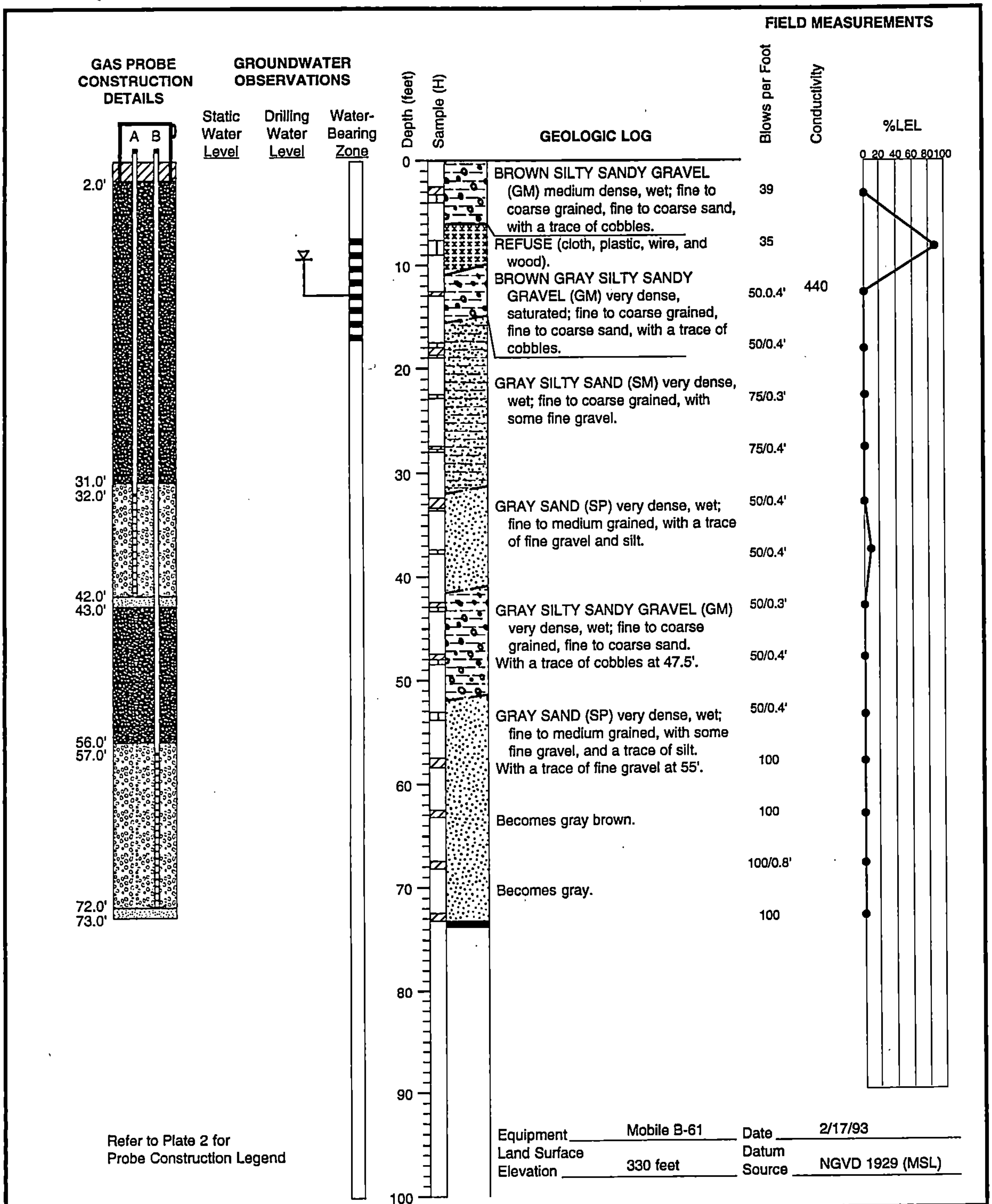
AGI TECHNOLOGIES

Summary Log of PKC-GP20

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B8**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



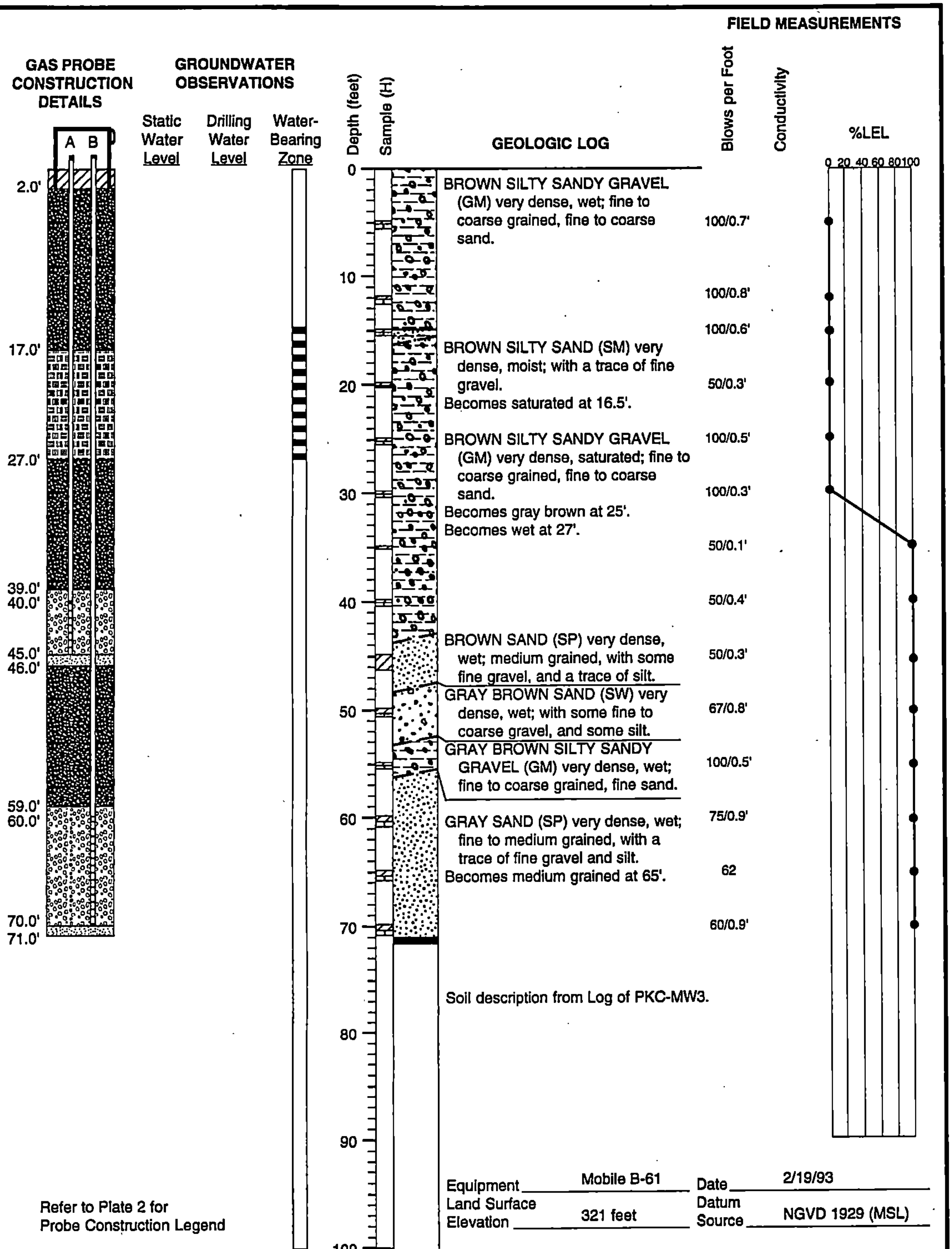
AGI TECHNOLOGIES

Summary Log of PKC-GP21

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
B9

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



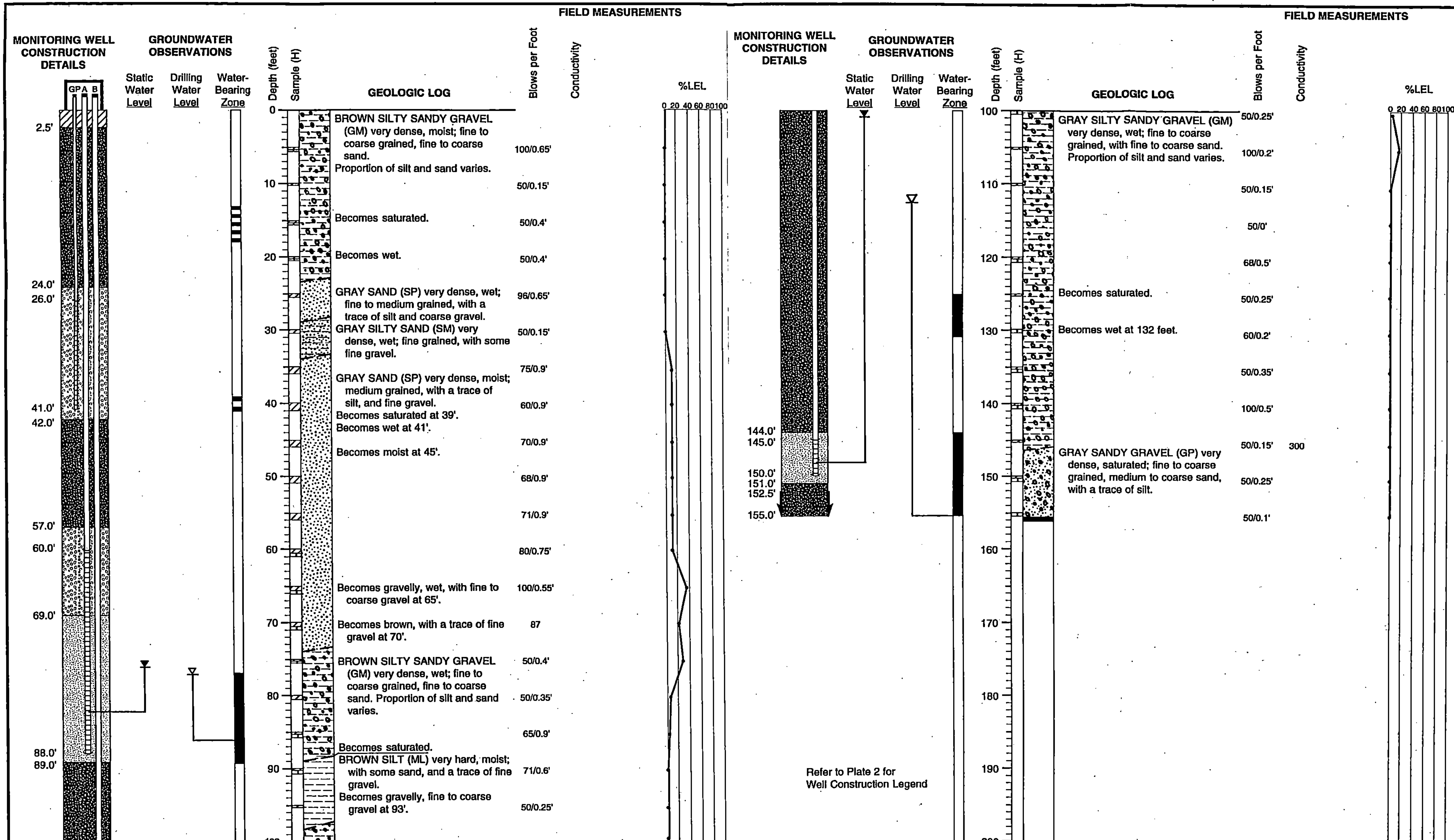
AGI TECHNOLOGIES

Summary Log of PKC-GP22

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B10**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



Equipment Speedstar 71 - 300 lb. hammer Date 12/11/92
Land Surface Elevation 322 feet Datum Source NGVD 1929 (MSL)

AGI TECHNOLOGIES

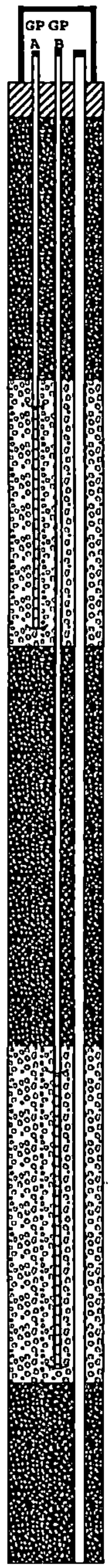
Summary Log of PKC-MW1
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B11**

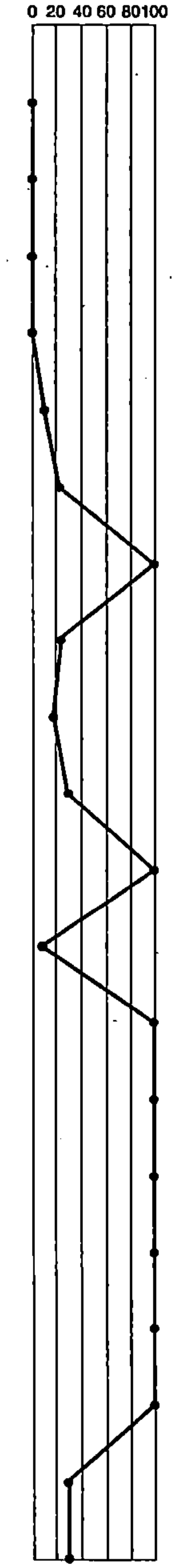
JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS | **GROUNDWATER OBSERVATIONS** (Static Water Level, Drilling Water Level, Water-Bearing Zone) | Depth (feet) | Sample (H) | **GEOLOGIC LOG** | Blows per Foot | Conductivity | %LEL



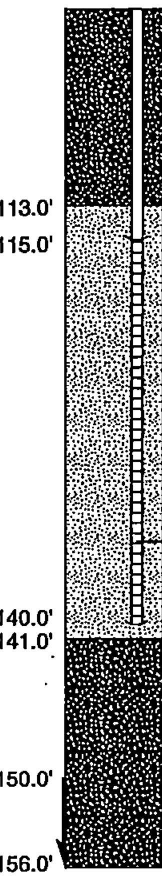
Depth (feet)	Geologic Log	Blows per Foot
0–5	BROWN SILTY SANDY GRAVEL (GM) very dense, moist; coarse grained, fine to coarse sand. Proportion of sand and gravel varies.	100/0.5'
10		50/0.25'
15		50/0.3'
20		50/0.25'
25		83/0.75'
30	Becomes wet.	100/0.5'
35		50/0.2'
40		50/0.25'
45		50/0.25'
50		50/0.25'
55		50/0.25'
60		100/0.3'
63	BROWN SAND (SP) very dense, moist; fine to medium grained, with some fine to coarse gravel.	100/0.7'
70	Trace of fine to coarse gravel.	50/0.35'
75		82/0.75'
80	Some fine to coarse gravel.	50/0.5'
85	Becomes gravelly, with medium to coarse grained sand and a trace of silt at 85'.	50/0.5'
88	BROWN SILTY SANDY GRAVEL (GM) very dense, wet; fine to coarse grained, medium to coarse sand.	100/0.6'
94	BROWN SILTY SAND (SM) very dense, wet; medium to coarse grained, with some fine to coarse gravel.	100/0.15'



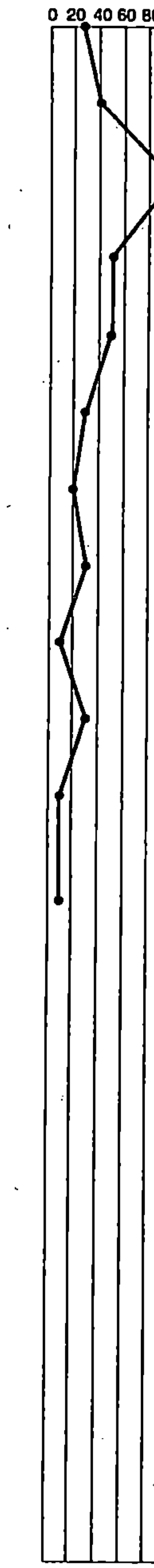
Equipment Speedstar 71 | Date 1/11/93

Land Surface Elevation 329 feet | Datum Source NGVD 1929 (MSL)

MONITORING WELL CONSTRUCTION DETAILS | **GROUNDWATER OBSERVATIONS** (Static Water Level, Drilling Water Level, Water-Bearing Zone) | Depth (feet) | Sample (H) | **GEOLOGIC LOG** | Blows per Foot | Conductivity | %LEL



Depth (feet)	Geologic Log	Blows per Foot	Conductivity
100	BROWN GRAVELLY SAND (SP) very dense, wet; medium to coarse grained, gravel is fine to coarse, with a trace of silt.	100/0.75'	
105	BROWN SANDY GRAVEL (GP) very dense, moist; fine to coarse grained, with a trace of silt.	73/0.65'	
110	BROWN SAND (SP) very dense, moist; fine grained, with a trace of silt.	75	
115	Becomes gray, medium grained, with a trace of fine gravel at 115'.	100/0.8'	
120		100	
125		100/0.95'	
130	Becomes saturated.	100	860
135		100/0.9'	
140		100/0.9'	860
145	Becomes fine to medium grained.	100/0.75'	
150		75	
155		50	



Refer to Plate 2 for Well Construction Legend

AGI TECHNOLOGIES

Summary Log of PKC-MW2
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B12**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS (A, B)	GROUNDWATER OBSERVATIONS: Static Water Level / Drilling Water Level / Water-Bearing Zone
2.5'	
7.5'	
10.5'	
20.5'	
21.5'	
40.0'	
58.0'	
60.0'	
70.0'	
71.0'	

Depth (feet)	GEOLOGIC LOG	Blows per Foot	Conductivity
0	BROWN SILTY SANDY GRAVEL (GM) very dense, wet; fine to coarse grained, fine to coarse sand.	100/0.7'	
10		100/0.8'	
		100/0.6'	
	BROWN SILTY SAND (SM) very dense, moist; with a trace of fine gravel.		
20	Becomes saturated at 16.5'.	50/0.3'	140
	BROWN SILTY SANDY GRAVEL (GM) very dense, saturated; fine to coarse grained, fine to coarse sand.	100/0.5'	
30	Becomes gray brown at 25'. Becomes wet at 27'.	100/0.3'	
		50/0.1'	
40		50/0.4'	
	BROWN SAND (SP) very dense, wet; medium grained, with some fine gravel, and a trace of silt.	50/0.3'	
50	GRAY BROWN SAND (SW) very dense, wet; with some fine to coarse gravel, and some silt.	67/0.8'	
	GRAY BROWN SILTY SANDY GRAVEL (GM) very dense, wet; fine to coarse grained, fine sand.	100/0.5'	
60	GRAY SAND (SP) very dense, wet; fine to medium grained, with a trace of fine gravel and silt.	75/0.9'	
	Becomes medium grained at 65'.	62	
70		60/0.9'	
	Becomes moist, fine to medium grained.	67/0.9'	
80		70/0.9'	
	Becomes gray brown.	57	
90	Becomes gray.	50/0.4'	
	Becomes wet.	50/0.5'	
100			

%LEL (0 20 40 60 80 100)

Equipment	Speedstar 71	Date	2/11/93
Land Surface Elevation (MSL)	321 feet	Datum Source	NGVD 1929

FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS	GROUNDWATER OBSERVATIONS: Static Water Level / Drilling Water Level / Water-Bearing Zone
106.5'	
109.5'	
124.5'	
125.0'	
165.0'	
179.0'	
180.3'	
185.0'	

Depth (feet)	GEOLOGIC LOG	Blows per Foot	Conductivity
100	Becomes moist.	50/0.5'	
		50/0.4'	
110		100	
		100	
120	GRAY SILTY SAND (SM) very dense, saturated.	77/0.9'	
	GRAY SILT (ML) very stiff, wet.	77/0.9'	
130	BROWN SILTY SAND (SM) very dense, saturated.	83/0.9'	
	GRAY SILT (ML) very stiff, moist.	100/0.9'	
140		85/0.7'	
		74/0.7'	
150		64/0.8'	
		65	
160		62	
		39	
170	Becomes hard. Becomes gravelly.	70/0.8'	
	BROWN SILTY SANDY GRAVEL (GM) very dense, saturated. Proportion of sand and silt varies.	50/0.4'	260
180	Becomes wet.	50/0.4'	
		100/0.6'	
190			
200			

%LEL (0 20 40 60 80 100)

Refer to Plate 2 for Well Construction Legend

AGI TECHNOLOGIES

Summary Log of PKC-MW3

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B13**

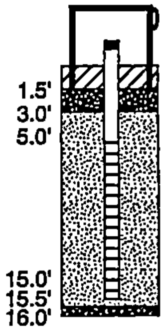
JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

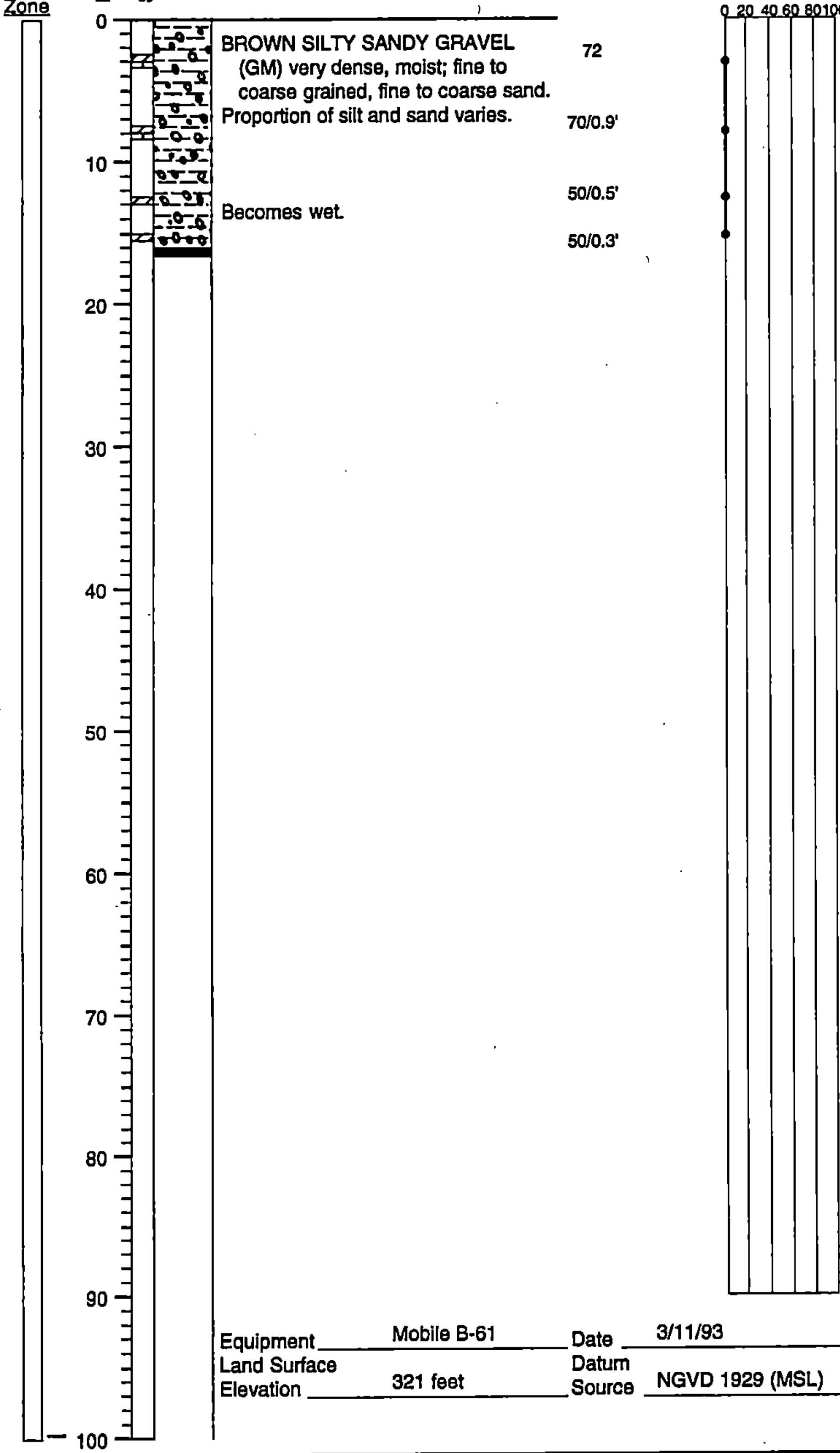
FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS

GROUNDWATER OBSERVATIONS

Static Water Level | Drilling Water Level | Water-Bearing Zone | Depth (feet) | Sample (H) | GEOLOGIC LOG | Blows per Foot | Conductivity | %LEL





BROWN SILTY SANDY GRAVEL (GM) very dense, moist; fine to coarse grained, fine to coarse sand. Proportion of silt and sand varies.

Becomes wet.

Blows per Foot
72
70/0.9'
50/0.5'
50/0.3'

Refer to Plate 2 for Well Construction Legend

Equipment	Mobile B-61	Date	3/11/93
Land Surface Elevation	321 feet	Datum Source	NGVD 1929 (MSL)

AGI TECHNOLOGIES

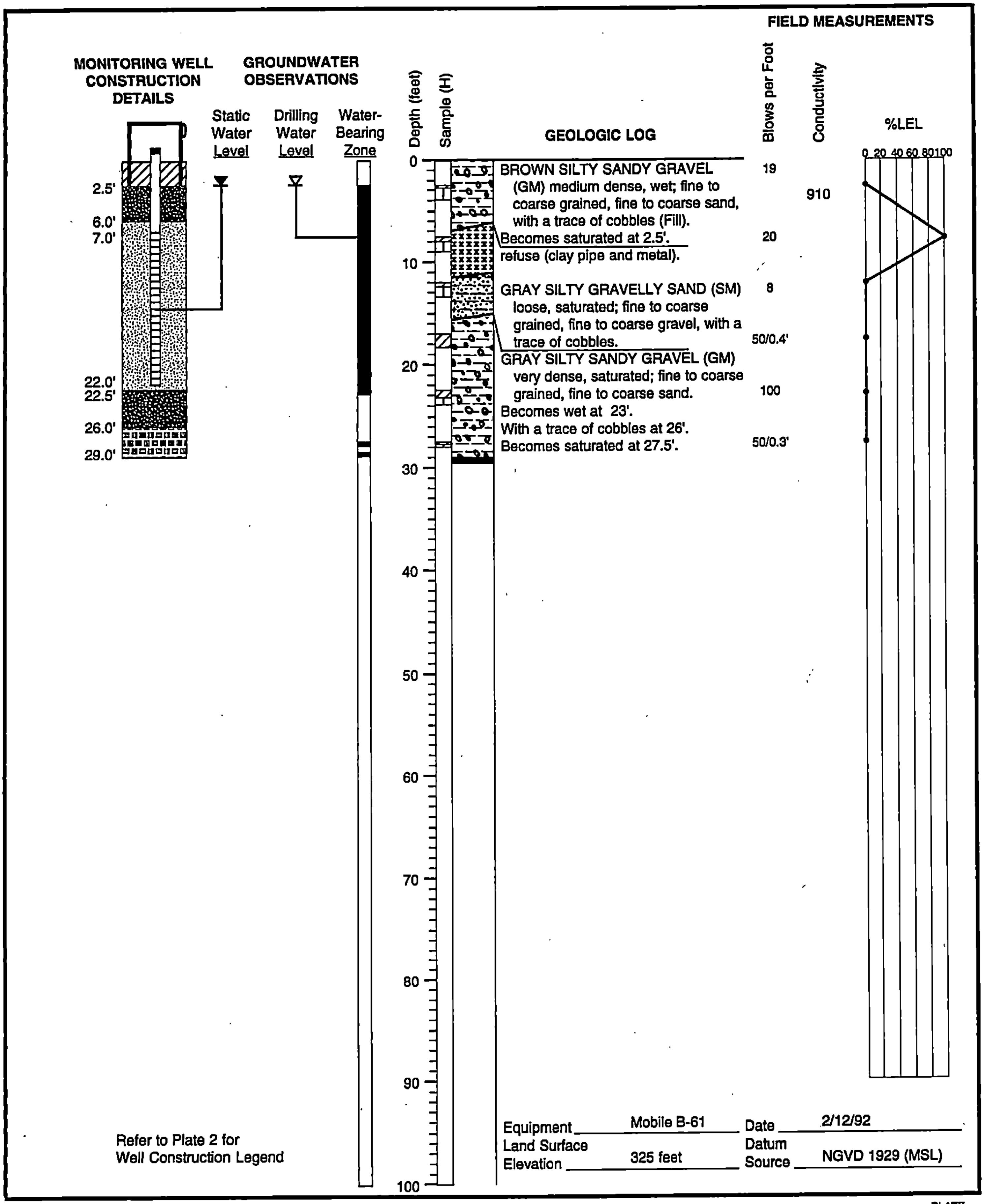
Summary Log of PKC-MW4

Puyallup/Kit Corner Custodial Landfill

King County, Washington

PLATE **B14**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



AGI TECHNOLOGIES

Summary Log of PKC-MW5

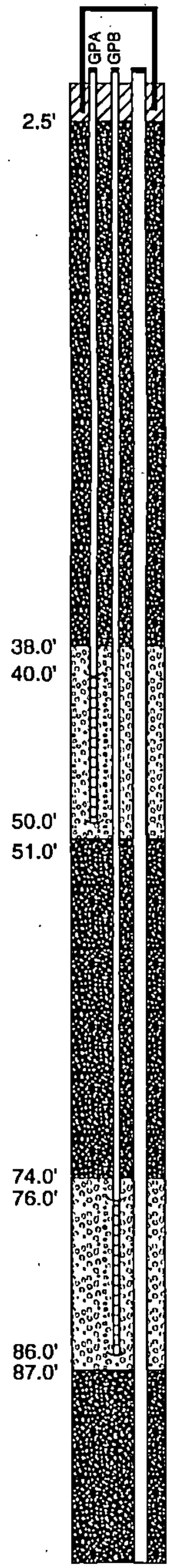
Puyallup/Kit Corner Custodial Landfill
King County, Washington

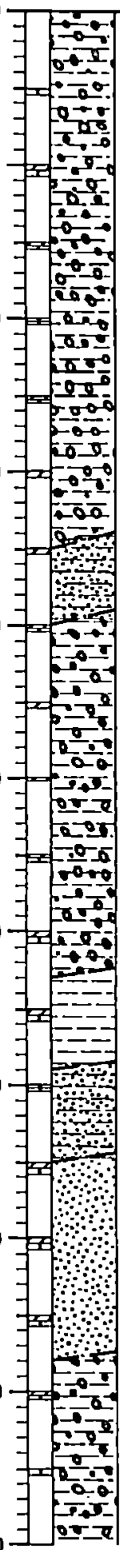
PLATE **B15**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

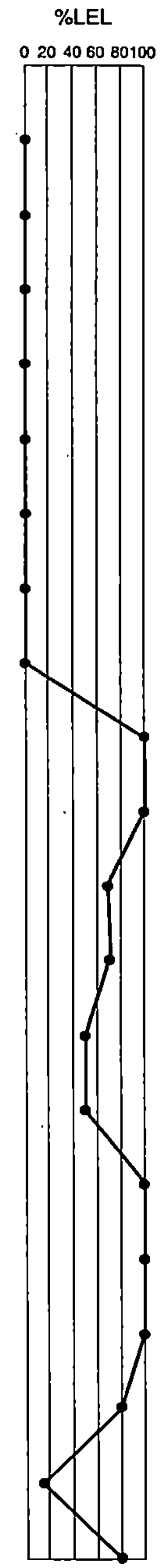
FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS | GROUNDWATER OBSERVATIONS: Static Water Level, Drilling Water Level, Water-Bearing Zone | Depth (feet) | Sample (H) | GEOLOGIC LOG | Blows per Foot | Conductivity | %LEL





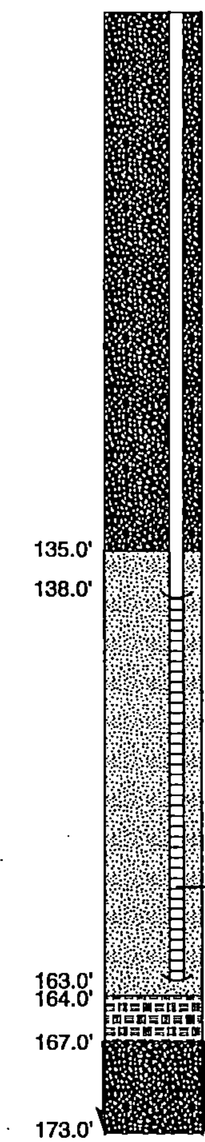
Depth (feet)	Geologic Log	Blows per Foot
0	BROWN SILTY SANDY GRAVEL (GM) very dense, moist; fine to coarse grained, fine to coarse sand. Proportion of silt and sand varies.	
5		50/0.3'
10		76/0.8'
15		50/0.4'
20		50/0.3'
	With a trace of cobbles.	
25		50/0.4'
30		50/0.3'
35	BROWN SILTY SAND (SM) very dense, moist; fine to coarse grained, with some fine to coarse gravel.	50/0.2'
40		50/0.4'
45	BROWN SILTY SANDY GRAVEL (GM) very dense, moist; fine to coarse grained, fine to coarse sand. Proportion of silt and sand varies.	50/0.2'
50		50/0.1'
55		50/0.4'
60		76/0.6'
65	BROWN SILT (ML) very stiff, moist.	57/0.8'
70		50/0.5'
75	BROWN SILTY SAND (SM) very dense, moist; fine grained, with a trace of fine gravel.	89/0.7'
80	BROWN SAND (SP) very dense, moist; fine to medium grained, with some fine gravel, and silt. With a trace of gravel at 80'.	72/0.8'
85	With a trace of silt at 85'.	60/0.8'
90		50/0.4'
95	BROWN SILTY SANDY GRAVEL (GM) very dense, wet; fine to coarse grained, fine to coarse sand. Proportion of silt and sand varies. With a trace of cobbles at 95'.	50/0.3'
100		

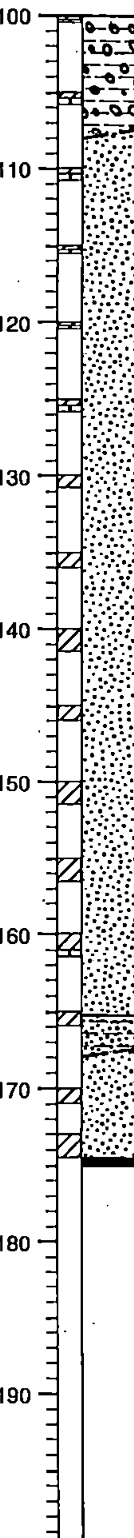


Equipment: Speedstar 71
Date: 2/25/93
Land Surface Elevation: 353 feet
Datum Source: NGVD 1929 (MSL)

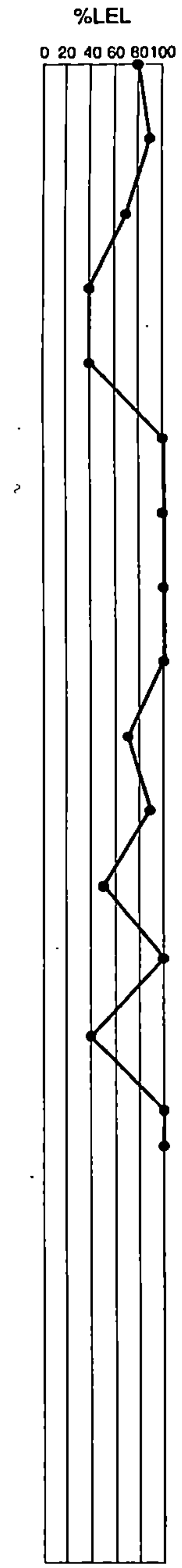
FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS | GROUNDWATER OBSERVATIONS: Static Water Level, Drilling Water Level, Water-Bearing Zone | Depth (feet) | Sample (H) | GEOLOGIC LOG | Blows per Foot | Conductivity | %LEL





Depth (feet)	Geologic Log	Blows per Foot
100		50/0.3'
105	Becomes moist.	67/0.8'
110	BROWN SAND (SP) very dense, moist; fine to medium grained, with a trace of silt.	70/0.9'
115	Becomes medium grained.	50/0.5'
120		89/0.6'
125		74/0.7'
130		59
135	Becomes fine to medium grained.	68/0.9'
140		54
145		67/0.1'
150	Becomes saturated at 150'.	67
155		60
160		5
165	BROWN SILTY SAND (SM) very dense, saturated; fine grained.	57
170	BROWN SAND (SP) very dense, saturated; fine to medium grained, with a trace of silt.	55
173		67/0.8'
180		
190		
200		



Refer to Plate 2 for Well Construction Legend

AGI TECHNOLOGIES

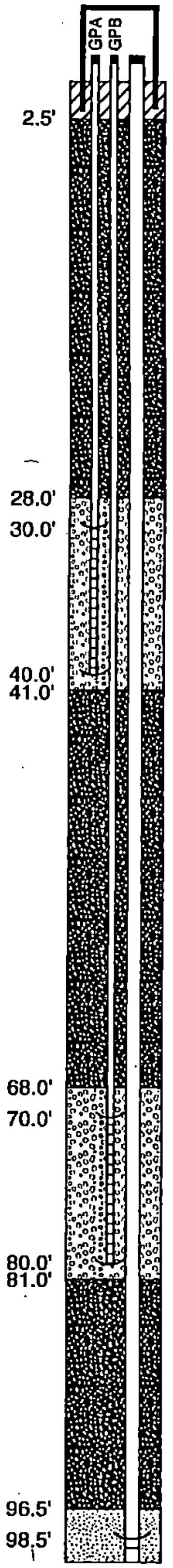
Summary Log of PKC-MW6
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B16**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94

FIELD MEASUREMENTS

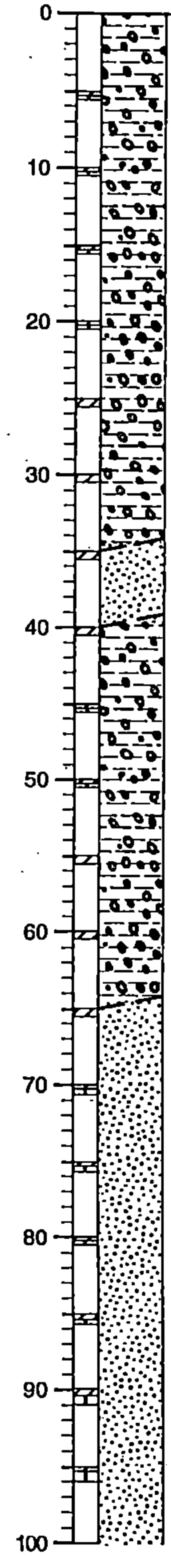
MONITORING WELL CONSTRUCTION DETAILS



GROUNDWATER OBSERVATIONS

Static Water Level | Drilling Water Level | Water-Bearing Zone

Depth (feet) | Sample (H)



GEOLOGIC LOG

BROWN SILTY SANDY GRAVEL (GM) very dense, moist; fine to coarse grained, fine to coarse sand.
Proportion of silt and sand varies.

BROWN SAND (SP) very dense, moist; medium grained, with a trace of fine gravel and silt.

BROWN SILTY SANDY GRAVEL (GM) very dense, moist; fine to coarse grained, fine to coarse sand.
Proportion of silt and sand varies.

BROWN SAND (SP) very dense, moist; fine to medium grained, with a trace of silt.

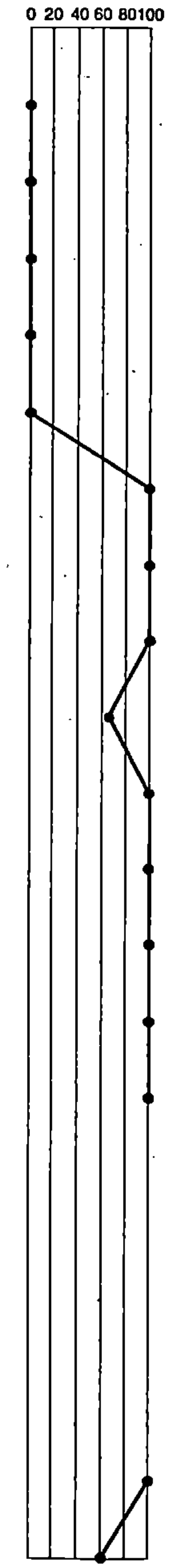
Becomes medium grianed, with a trace of fine gravel.

Becomes fine grained, with no gravel.

Blows per Foot: 50/0.4', 50/0.2', 50/0.2', 50/0.5', 50/0.2', 50/0.2', 50/0.2', 50/0.2', 50/0.2', 50/0.2', 50/0.2', 50/0.3', 50/0.4', 76/0.8', 90/0.8', 50/0.5', 80/0.8', 86, 86

Conductivity

%LEL

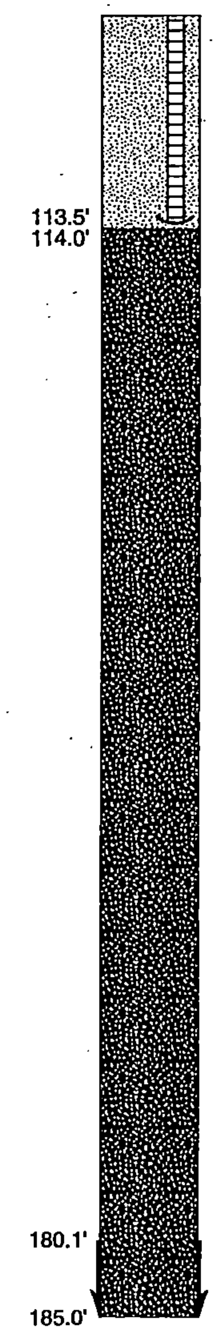


Equipment Speedstar 71 Date 3/11/93

Land Surface Elevation 333 feet Datum Source NGVD 1929 (MSL)

FIELD MEASUREMENTS

MONITORING WELL CONSTRUCTION DETAILS

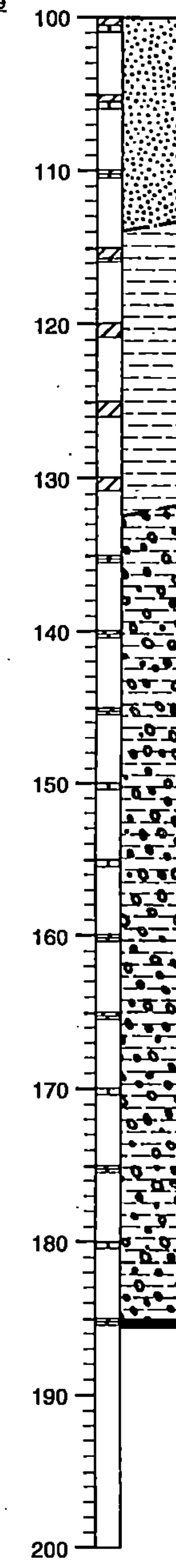


Refer to Plate 2 for Well Construction Legend

GROUNDWATER OBSERVATIONS

Static Water Level | Drilling Water Level | Water-Bearing Zone

Depth (feet) | Sample (H)



GEOLOGIC LOG

Becomes fine to medium grained.

Becomes fine grained.

BROWN SILT (ML) stiff, moist; with a trace of fine sand.

Becomes gray, very stiff, with no sand.

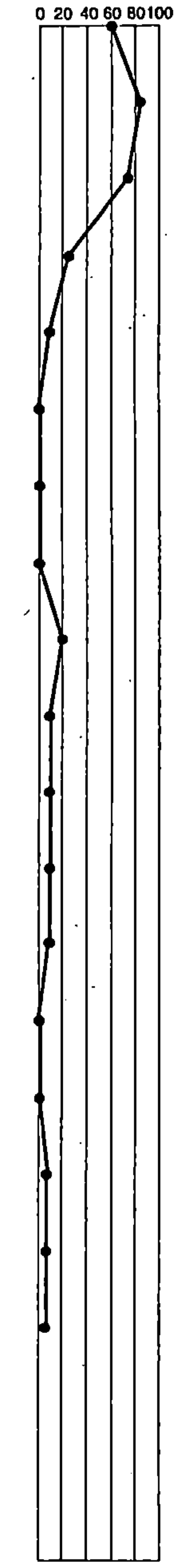
BROWN SILTY SANDY GRAVEL (GM) very dense, moist; fine to coarse grained, fine to coarse sand.
Proportion of silt and sand varies.

Becomes green brown.

Blows per Foot: 68/0.9', 68/0.9', 50/0.5', 60, 61/0.9', 62, 86/0.9', 50/0.2', 50/0.3', 50/0.3', 50/0.2', 50/0.2', 50/0.2', 50/0.3', 50/0.2', 100/0.3', 100/0.4', 100/0.4'

Conductivity

%LEL

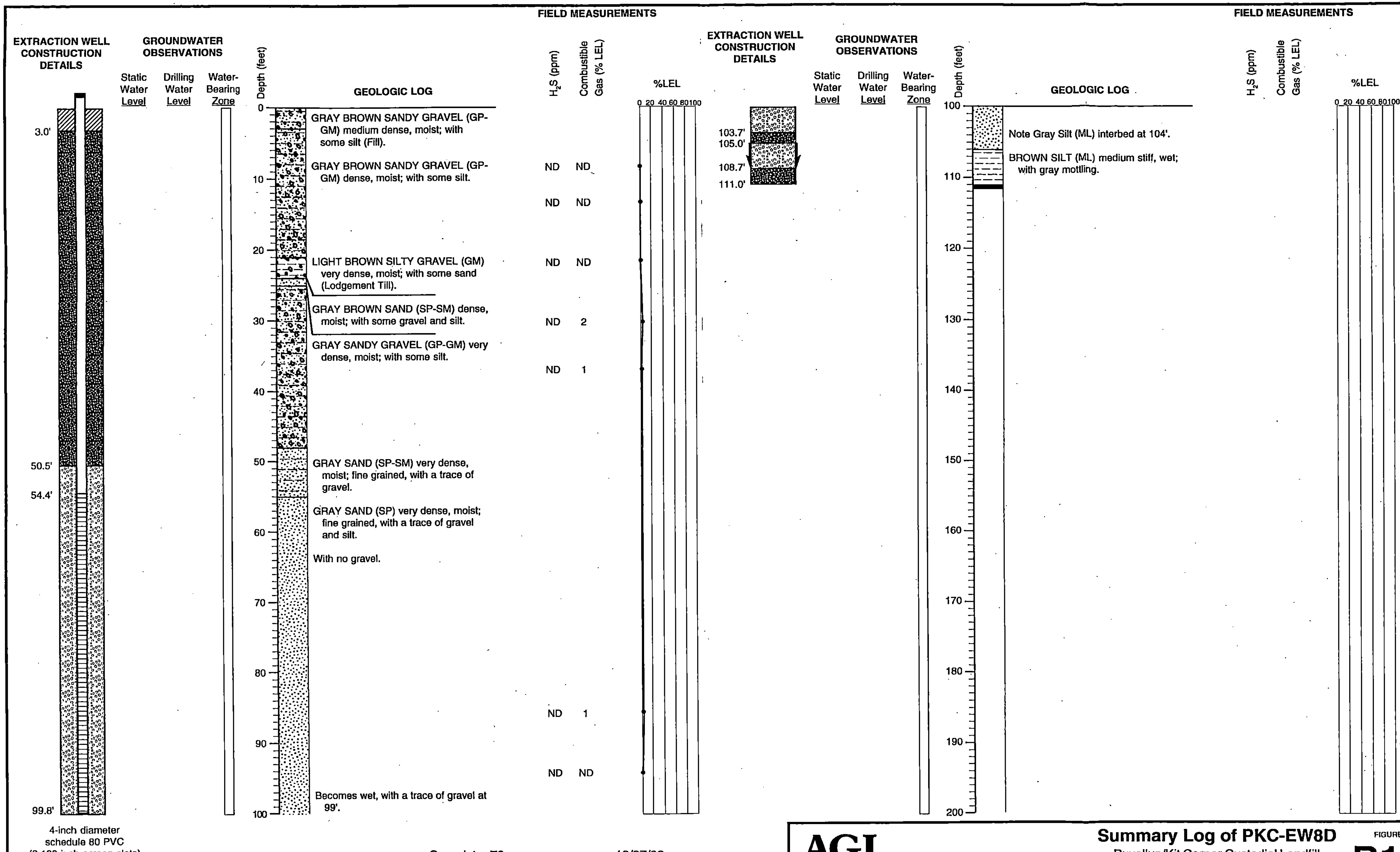


AGI TECHNOLOGIES

Summary Log of PKC-MW7
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE **B17**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		11 November 93		17 June 94



Equipment	Speedstar 72	Date	10/27/93
Land Surface Elevation	322.4 feet	Datum Source	NGVD 1929 (MSL)

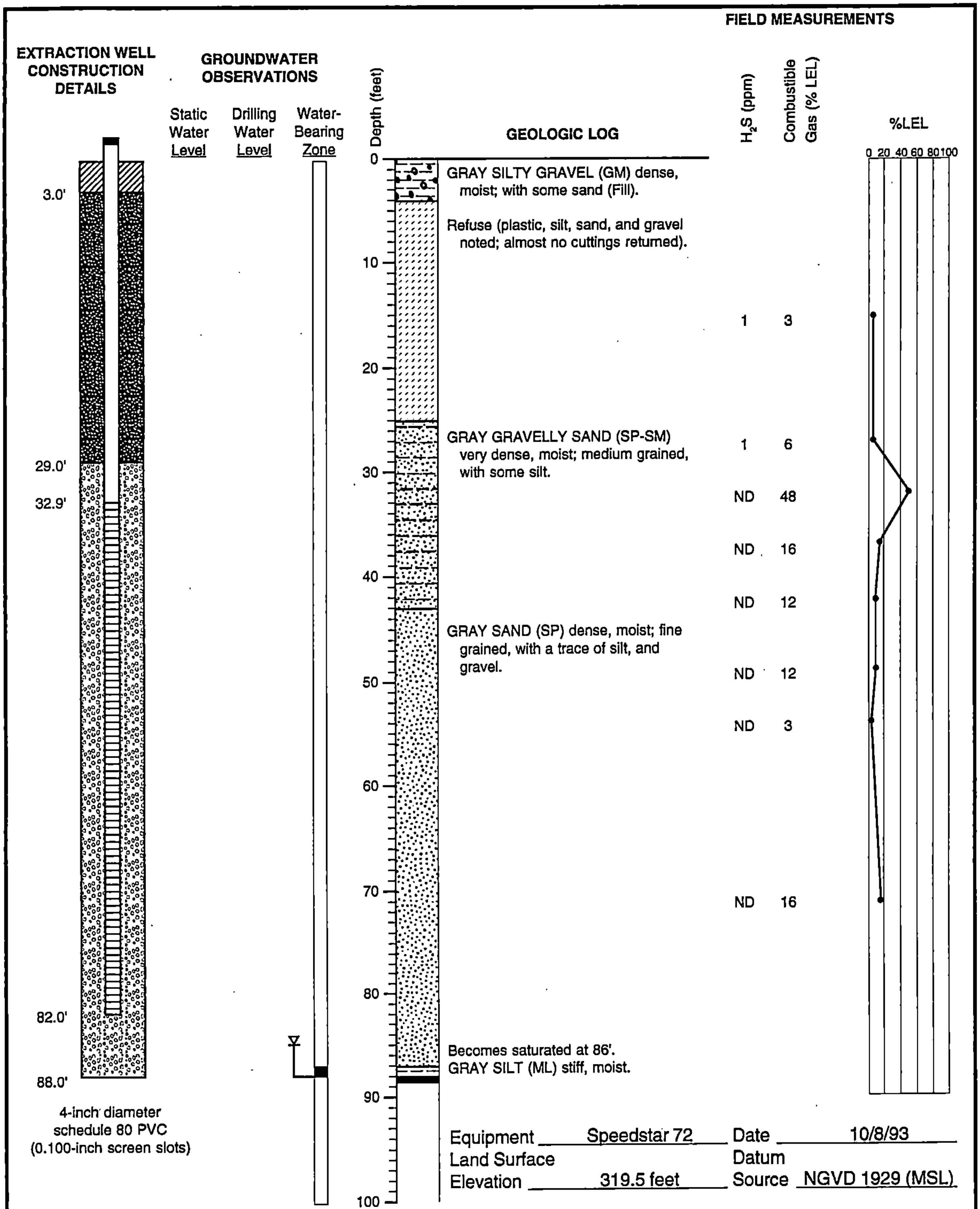
AGI TECHNOLOGIES

Summary Log of PKC-EW8D

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **B18**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		17 June 94		



AGI TECHNOLOGIES

Summary Log of PKC-EW10D

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE **B19**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	SES		17 June 94		

AGI TECHNOLOGIES

APPENDIX C

Survey Data

APPENDIX C

Survey Data

DeGross Aerial Mapping prepared a site topographic map of the Puyallup/Kit Corner Custodial Landfill in King County, Washington for the King County Solid Waste Division in 1992. The map was generated using established King County benchmarks and a November 23, 1992 aerial photo. The map was used as the basis for the Site Plan and base map for the Phase II investigation report.

Sitts & Hill Engineers, Inc. surveyed the elevations of all monitoring wells and surface water staff gauges installed by AGI Technologies (AGI) during the Phase II Investigation. Monitoring well elevations were established to the nearest 0.01 foot for the tops of the steel protective casings. Elevations were referenced to King County Benchmark GM-87, located near the northwest corner of the landfill (elevation 352.98 feet above Mean Sea Level). This benchmark was also used in the preparation of the site topographic map. The elevation of the top of the 2-inch diameter pvc casing for each groundwater monitoring well was calculated by AGI by subtracting the distance measured between the top of the steel protective casing and the top of the pvc casing from the top of steel protective casing elevation.

Surface water staff gauge elevations were established to 0.1 foot to a fixed arbitrary point on each gauge. The elevation of the top of each culvert at each end of its run below the landfill was also established to 0.1 foot for use as an alternative measuring point if the staff gauges were vandalized.

Table C1 summarizes elevation survey data for all AGI-installed monitoring wells and surface water staff gauges.

AGI
TECHNOLOGIES

Table C1
Survey Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Exploration Location	Elevation: Top of 2-Inch Diameter PVC Well Casing	Elevation: Top of Steel Protective Casing
PKC-MW1GP	323.09	324.46
PKC-MW1a	323.68	
PKC-MW1b	323.54	
PKC-MW2GPa	329.96	331.19
PKC-MW2GPb	329.60	
PKC-MW2	330.10	
PKC-MW3a	322.81	323.56
PKC-MW3b	322.50	
PKC-MW4	323.37	324.02
PKC-MW5	326.59	327.18
PKC-MW6GPa	354.39	354.99
PKC-MW6GPb	354.26	
PKC-MW6	354.25	
PKC-MW7GPa	334.32	335.23
PKC-MW7GPb	334.38	
PKC-MW7	334.37	
SG-1	317.78	
SG-2	311.84	

Note:

Datum is based on NGVD, 1929 (Mean Sea Level).

AGI TECHNOLOGIES

APPENDIX D

Surface Water and Groundwater Elevation Data

APPENDIX D

Surface Water and Groundwater Elevation Data

Tables D1 and D2 present water level data collected by AGI during the Phase II investigation at the Puyallup/Kit Corner Custodial Landfill in King County from March 17, 1993 through August 26, 1993. Water levels were monitored biweekly. In addition to the nine monitoring wells and two staff gauges, water level data were also collected from two gas probes (PKC-GP16a and PKC-GP17a).

Table D1 summarizes surface water elevation data from two staff gauges, one of which was placed at each end of the culvert which runs below the southeast corner of the landfill. The staff gauges were installed by AGI in February 1993.

Table D2 summarizes groundwater elevation data from monitoring wells. Wells installed by AGI are designated by the prefix PKC-MW followed by a one-digit number (e.g., PKC-MW4). Clustered well completions (two or more monitoring wells completed at different depths in the same vicinity) are further designated by the letters "a" or "b" following the well number (e.g., PKC-MW3a). The uppermost completion is designated by the letter "a," and the deeper wells by the letter "b."

Groundwater elevation data in **Tables D1 and D2** are presented as received from the field; questionable or inconsistent data have been flagged. Questionable data consist of a sudden increase or decrease in water elevation followed by an equally sudden return to previous water elevation trends; these measurements are flagged with an R to indicate rejected data.

AGI-installed staff gauge and monitoring well measuring point elevations were surveyed by Sitts & Hill Engineers, Inc. in March 1993.

Plate D1 shows surface water hydrographs. **Plates D2 through D6** show monitoring well hydrographs.

AGI TECHNOLOGIES

Table D1
Surface Water Elevation Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Location:	PKC–SG1 (north end of culvert)		PKC–SG2 (south end of culvert)	
Meas. Pt Elevation (ft above MSL)	317.8		311.8	
Date	Height of Water (ft)	Water Level Elev. (ft)	Height of Water (ft)	Water Level Elev. (ft)
03/17/93	1.4	316.2	0.5	309.0
04/10/93	1.7	316.5	0.6	309.1
04/25/93	1.7	316.5	0.6	309.1
05/09/93	1.1	315.9	0.4	308.9
05/21/93	0.9	315.7	2.0 [a]	310.2
06/04/93	0.7	315.5	2.1 [a]	310.1
06/17/93	0.7	315.5	2.4 [a]	309.8
07/02/93	0.5	315.3	2.8	309.4
07/17/93	Dry	--	Dry	--
07/29/93	0.9 [b]	315.7 R	Dry	--
08/13/93	Dry	--	Dry	--
08/26/93	Dry	--	Dry	--

Note:

a) PKC–SG1 destroyed; measuring point location is top of culvert (elevation = 312.2 feet MSL).
b) Standing water.
MSL – Mean Sea Level.
R – Data rejected.

Table D2
Groundwater Elevation Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Well No.	PKC–MW1a		PKC–MW1b		PKC–MW2		PKC–MW3a		PKC–MW3b		PKC–MW4	
Meas. Pt Elevation [a,b] (ft above MSL)	323.68		323.54		330.10		322.81		322.50		323.37	
Screen Depth [c]	61.92–89.92		146.78–151.78		116.31–141.31		13.05–23.05		111.24–126.24		7.05–17.05	
Date	Depth to Water (ft)	Water Level Elev. [a] (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)
03/17/93	77.34	246.34	102.46	221.08	129.59	200.51	21.34	301.47	118.22	204.28	Dry	--
04/10/93	77.01	246.67	102.80	220.74	129.83	200.27	20.64	302.17	118.05	204.45	16.24	307.13
04/25/93	76.70	246.98	102.54	221.00	129.79	200.31	Dry	--	117.88	204.62	16.33	307.04
05/09/93	76.19	247.49	102.18	221.36	129.62	200.48	21.88	300.93	117.70	204.80	16.32	307.05
05/21/93	75.84	247.84	102.03	221.51	129.77	200.33	21.89	300.92	117.58	204.92	16.34	307.03
06/04/93	75.22	248.46	101.31	222.23	129.58	200.52	21.90	300.91	117.34	205.16	16.34	307.03
06/17/93	75.05	248.63	101.37	222.17	129.75	200.35	Dry	--	117.19	205.31	16.35	307.02
07/02/93	74.83	248.85	100.82	222.72	129.73	200.37	Dry	--	116.94	205.56	16.38	306.99
07/17/93	74.99	248.69	100.60	222.94	129.73	200.37	Dry	--	116.72	205.78	16.34	307.03
07/29/93	78.91 R	--	100.72	222.82	128.91 R	--	21.49	301.32	116.67	205.83	Dry	--
08/13/93	75.71	247.97	100.33	223.21	129.89	200.21	21.92	300.89	116.61	205.89	16.35	307.02
08/26/93	76.14	247.54	100.38 [c]	223.16	130.00	200.10	Dry	--	116.70	205.80	16.38	306.99

Table D2
Groundwater Elevation Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

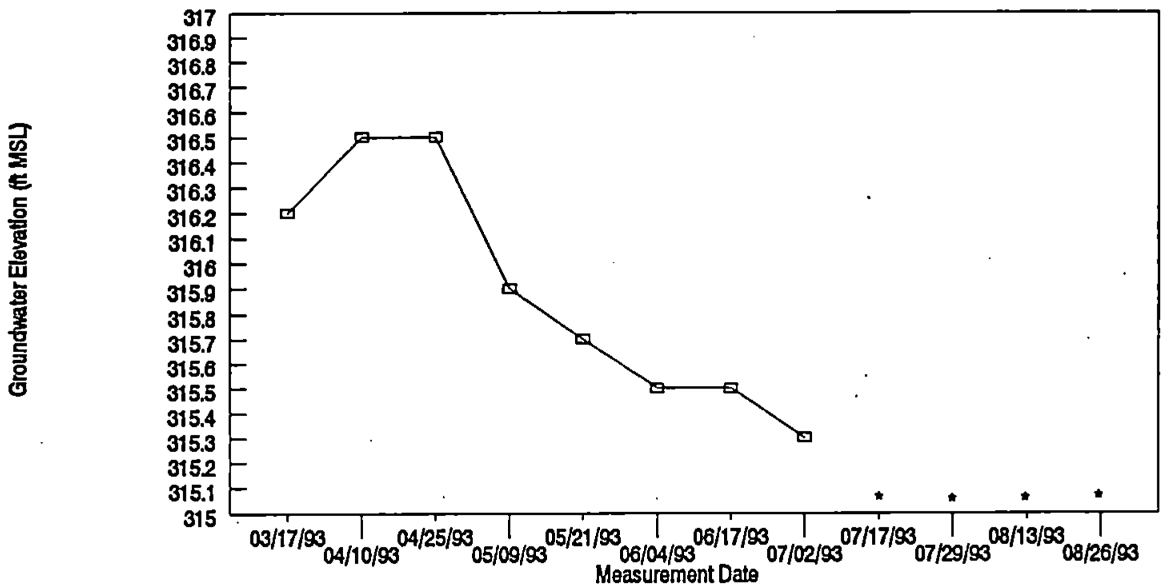
Well No.	PKC−MW5		PKC−MW6		PKC−MW7		PKC−GP16a		PKC−GP17a	
Meas. Pt Elevation [a,b] (ft above MSL)	326.59		354.25		334.37		320.41 *		319.49 *	
Screen Depth [c]	8.51−23.51		139.55−164.55		100.84−115.84		6.11−21.11		9.39−29.39	
Date	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)	Depth to Water (ft)	Water Level Elev. (ft)
03/17/93	4.03	322.56	152.32	201.93	Dry	−−	12.89	307	19.55	300
04/10/93	3.12	323.47	152.50	201.75	Dry	−−	9.52	311	17.69	302
04/25/93	2.84	323.75	152.54	201.71	Dry	−−	10.28	310	20.48	299
05/09/93	2.61	323.98	152.45	201.80	Dry	−−	10.27	310	18.90	301
05/21/93	3.31	323.28	152.54	201.71	Dry	−−	10.40	310	20.57	299
06/04/93	3.98	322.61	152.42	201.83	Dry	−−	10.22	310	19.30	300
06/17/93	4.48	322.11	152.59	201.66	Dry	−−	NM	−−	19.73	300
07/02/93	4.98	321.61	152.57	201.68	Dry	−−	NM	−−	20.17	299
07/17/93	5.60	320.99	152.62	201.63	Dry	−−	17.30	303	20.77	299
07/29/93	6.01	320.58	152.73	201.52	Dry	−−	19.10	301	22.71	297
08/13/93	6.39	320.20	152.66	201.59	Dry	−−	19.24	301	23.12	296
08/26/93	6.73	319.86	152.82	201.43	Dry	−−	19.44	301	26.01	293

Notes:

*Measuring point elevation estimated from landfill topographic map (DeGross Aerial Mapping, 1992).
Well considered dry if ≤0.25 feet of standing water in casing.
a) Elevations reported in feet above Mean Sea Level based on the National Geodetic Vertical Datum, 1929.
b) Measuring point is top of PVC casing.
c) Screen depth with respect to measuring point.
d) Accurate to 0.1 foot due to obstruction in well.
bgs − Below ground surface.
MSL − Mean Sea Level.
NM − Not measured.
R − Data rejected.

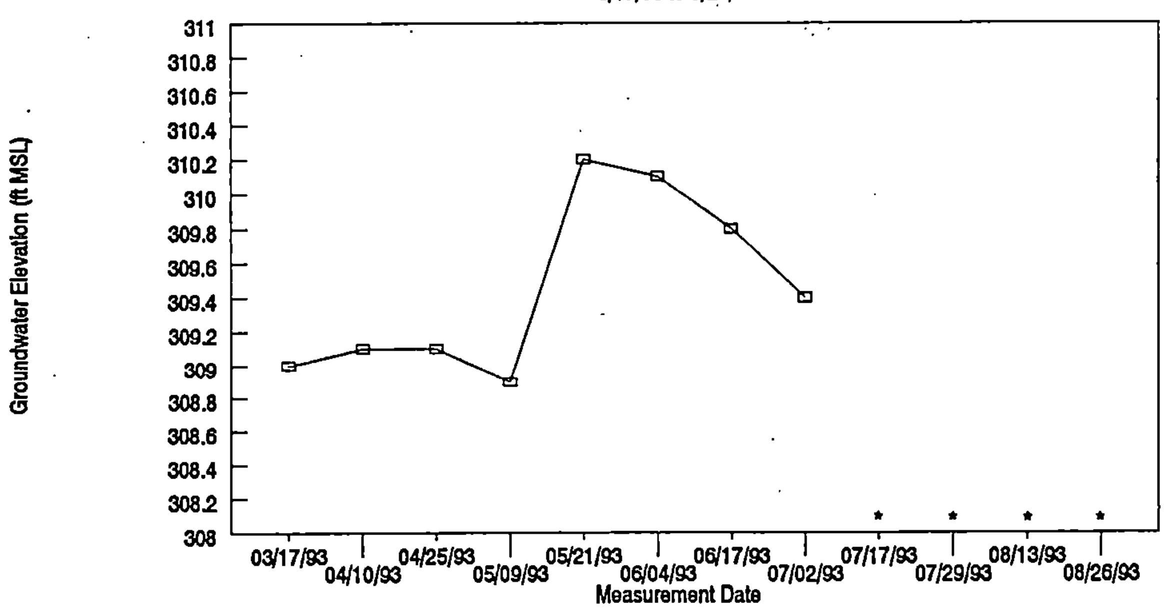
PKC-SG1

3/17/93 to 8/26/93



PKC-SG2

3/17/93 to 8/26/93



Note: *-East Stream dry.

Applied Geotechnology Inc.
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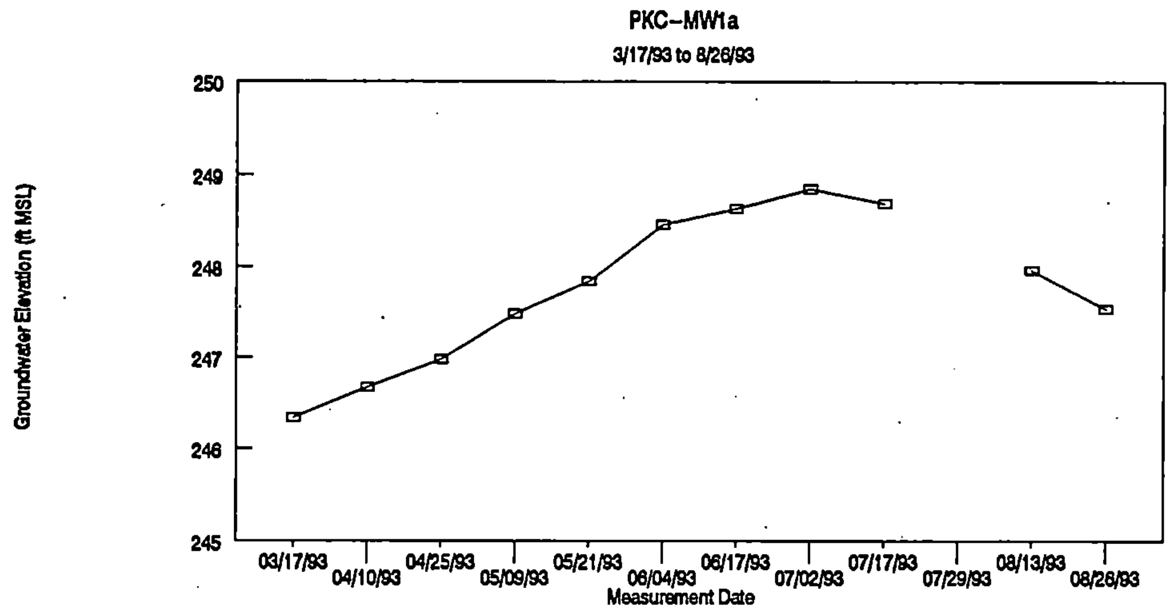
Hydrographs/PKC-SG1, PKC-SG2

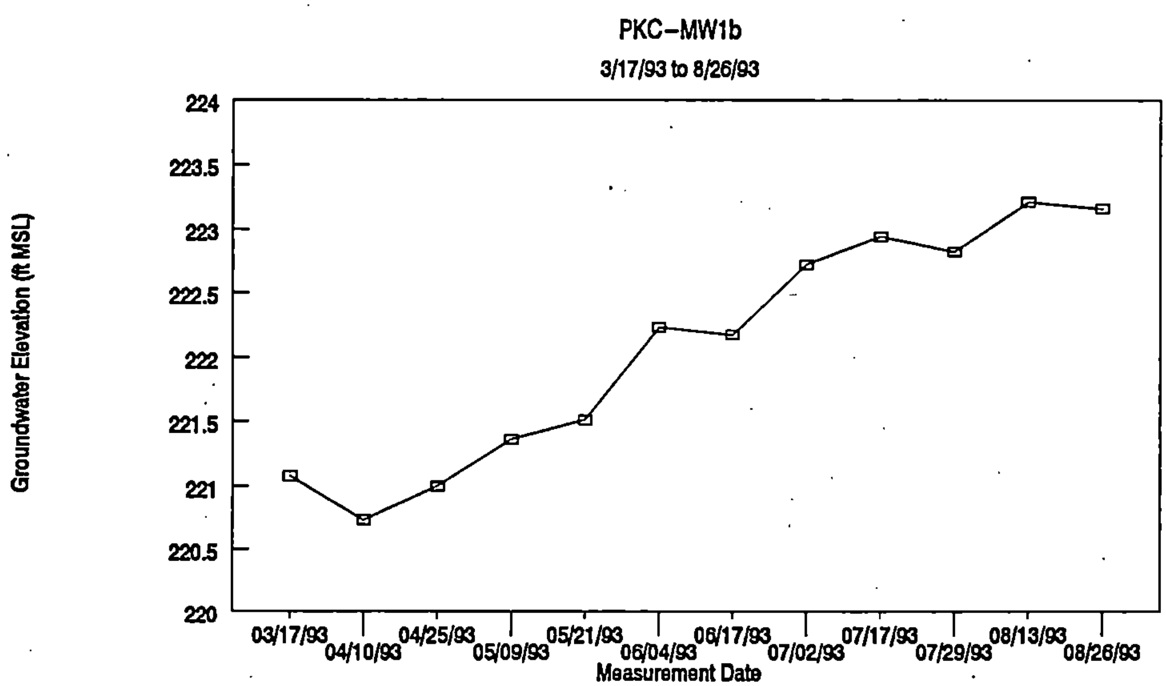
Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE

D1

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.113	DFF				





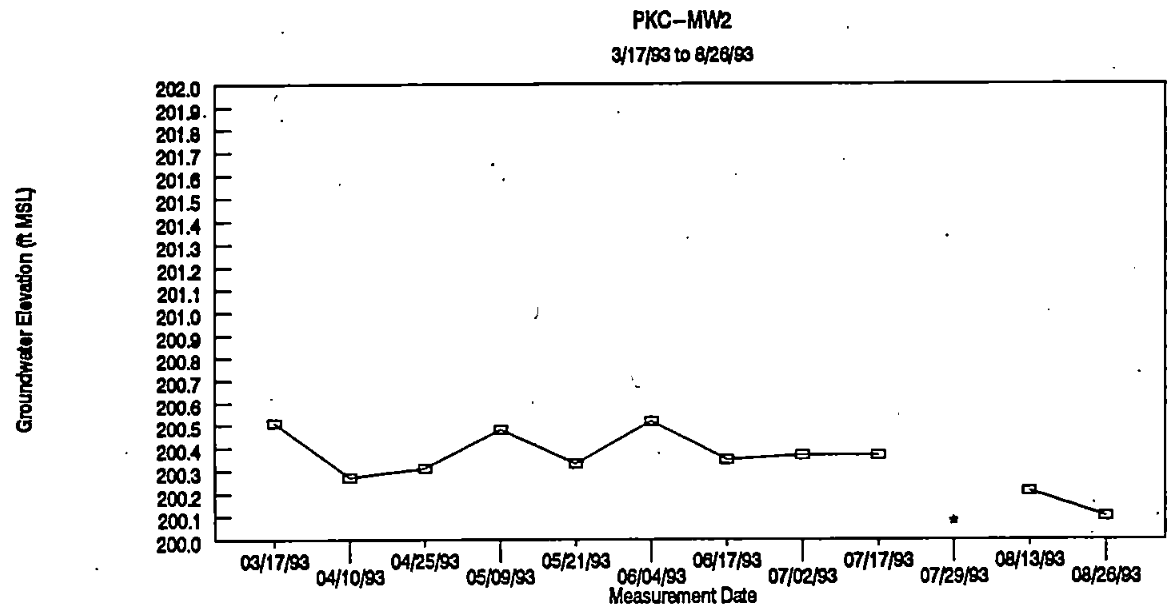
Applied Geotechnology Inc.
Geotechnical Engineering
Geology & Hydrogeology

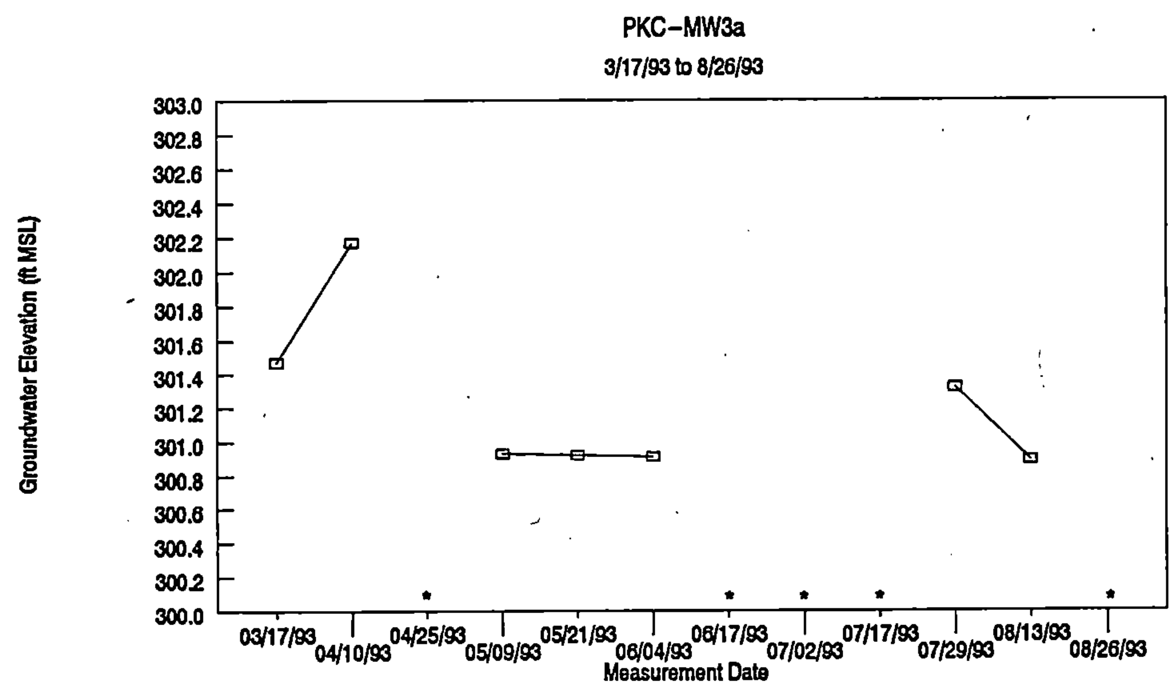
Hydrographs/PKC-MW1a, PKC-MW1b

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE
D2

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.113	DFF				





Note: *-Well dry.

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Hydrographs/PKC-MW2, PKC-MW3a

Puyallup/Kit Corner Custodial Landfill
King County, Washington

FIGURE
D3

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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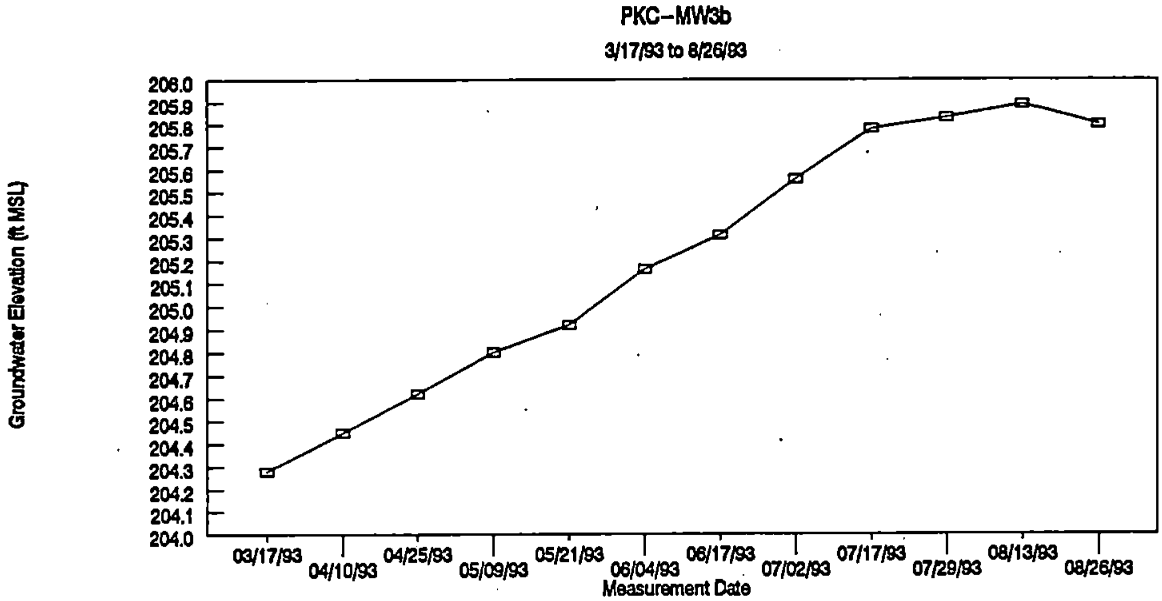

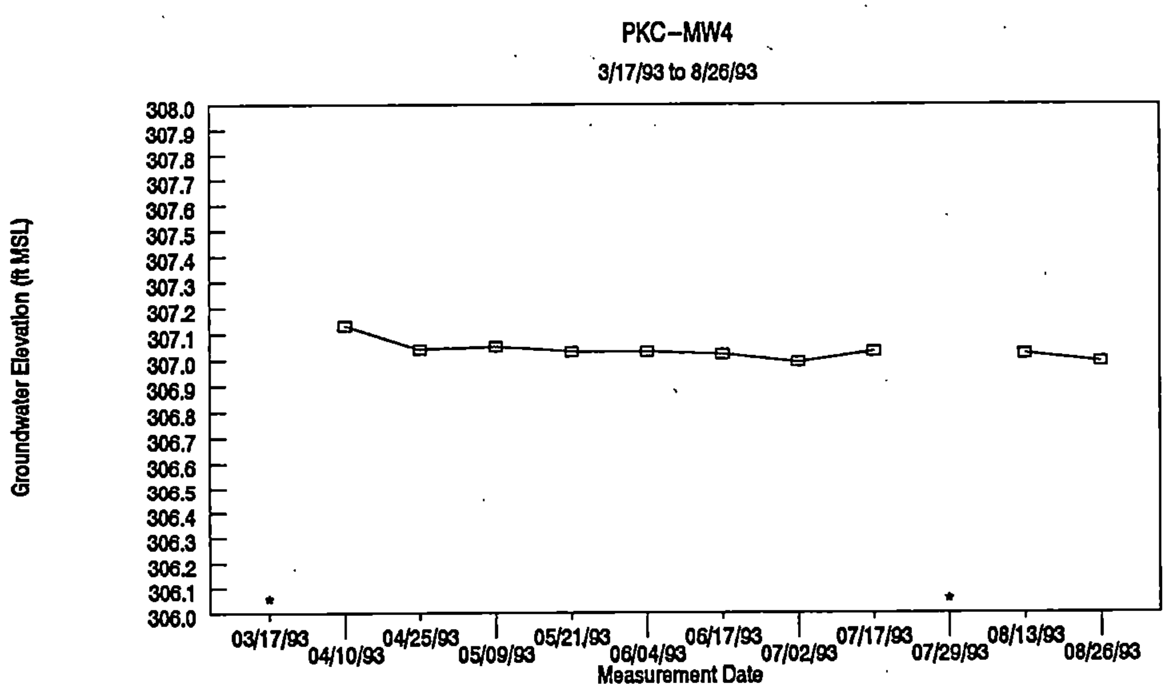

Note: *-Well dry.

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Hydrographs/PKC-MW3b, PKC-MW4

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
D4

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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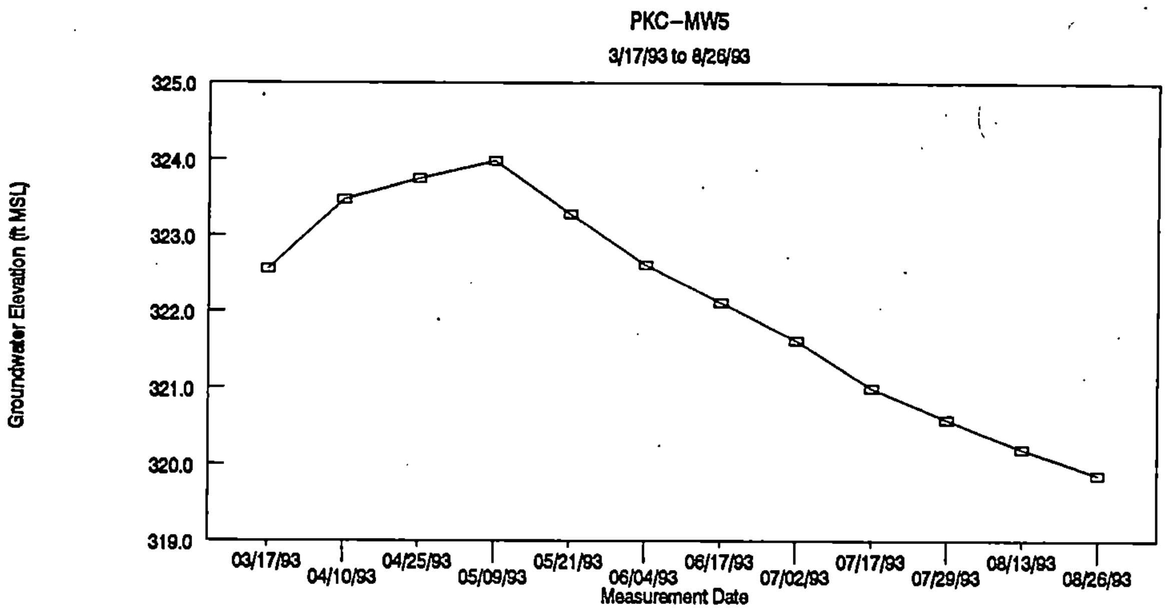

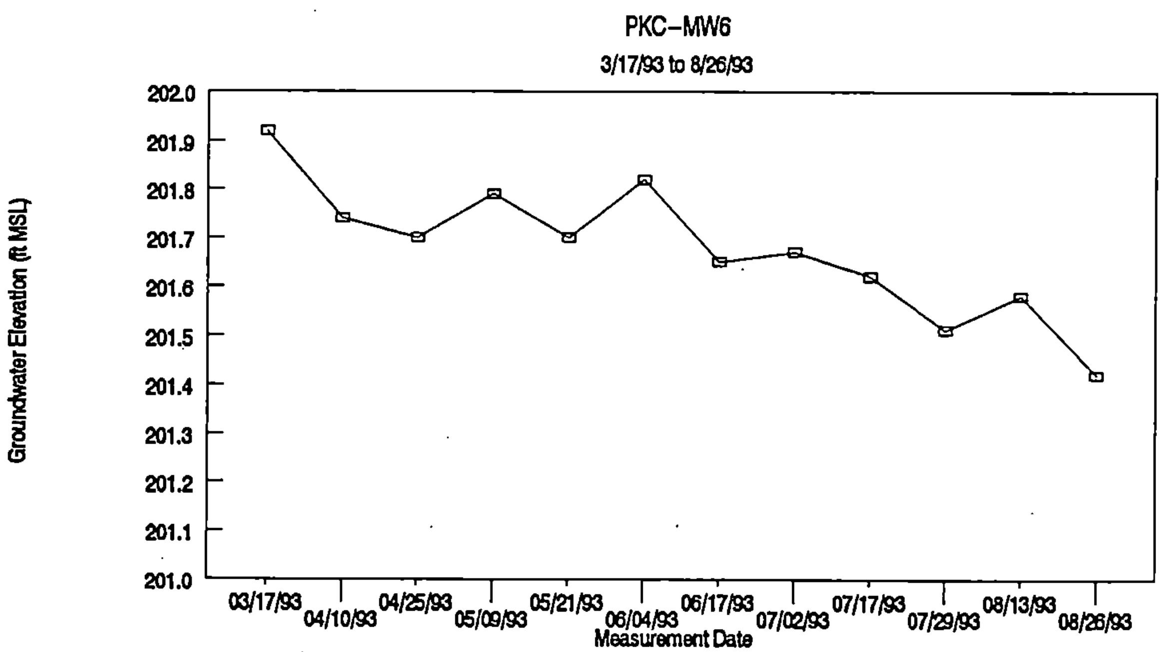

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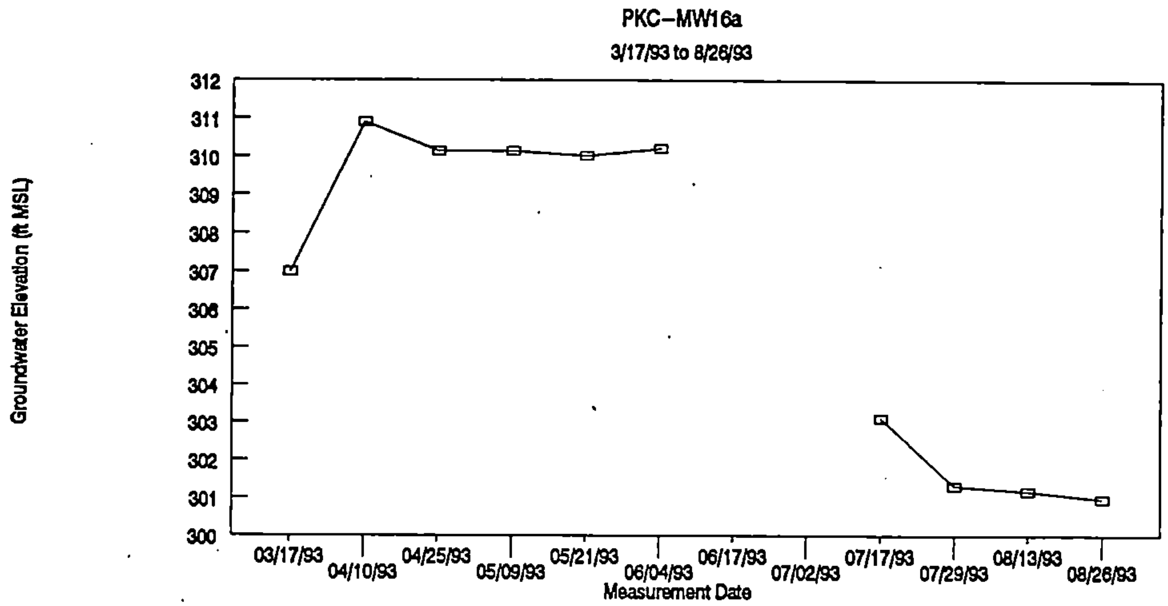
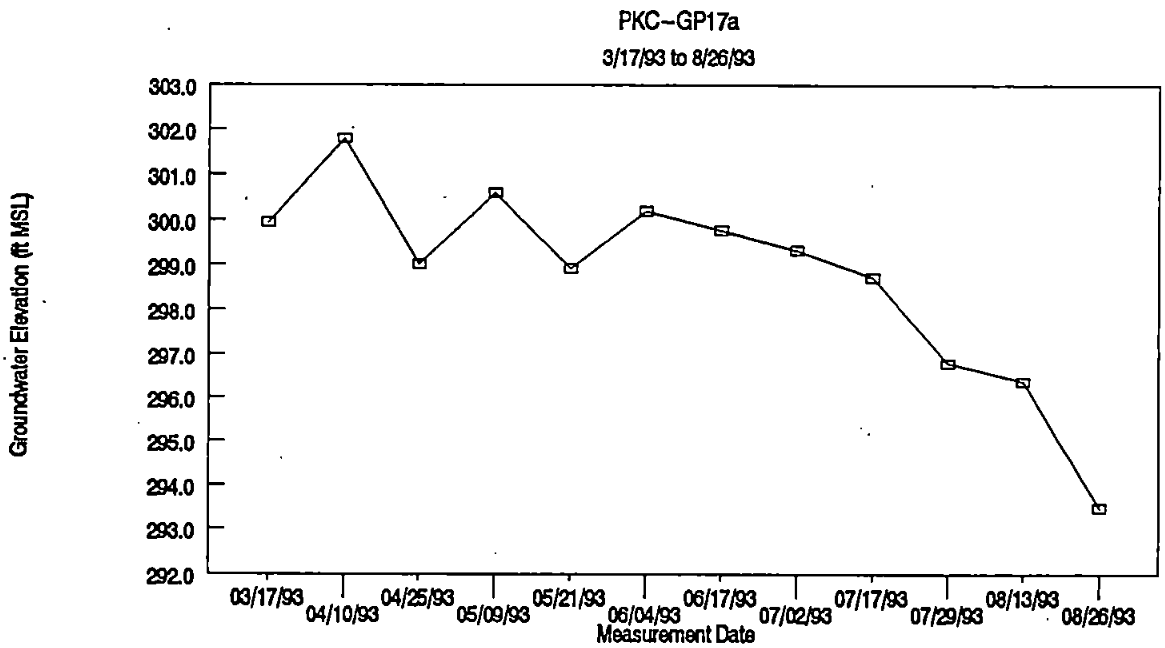
Hydrographs/PKC-MW5, PKC-MW6

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
D5

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





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Hydrographs/PKC-GP16a, PKC-GP17a

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
D6

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				

APPENDIX E

Surface Water Chemical Data

APPENDIX E

Surface Water Chemical Data

Sample keys for the two rounds of surface water samples collected by AGI Technologies (AGI) during March and May 1993 from King County Puyallup/Kit Corner Custodial Landfill are presented in Tables E1 and E2. Tables E3 through E5 summarize the analytical data for the two sampling rounds.

The following discussion summarizes EcoChem's quality assurance reviews of two rounds of surface water samples. Samples were analyzed by Analytical Resources, Inc. (ARI). Based on EcoChem's quality assurance review, some sample results were qualified. All qualified data are considered acceptable for use.

Method blanks, trip blanks, field blanks, and rinsates were generally free of contamination in Round 1. Occasional low level detections in the field quality control samples were attributed to laboratory contamination or impurities in the deionized water. Associated data considered affected were qualified as appropriate.

Method blanks, and trip blanks were generally free of contamination in Round 2. Volatile organic compounds (benzene, chloroform, toluene, and xylenes) were detected in the round 2 rinsate and field blank. After reviewing the sample results, associated method blank result, and all potential sources of contamination, it was determined that the likely source of contamination was the deionized water used to collect the rinsate and field blank. Sample results were not considered affected by field quality control results.

Laboratory quality control (lab duplicates, matrix spikes, and surrogates) were acceptable and within ARI quality control criteria.

The detection limits required by ARI's contract with King County were met for the majority of the sample parameters and compounds with a few exceptions, discussed in EcoChem's quality assurance reports.

AGI TECHNOLOGIES

Table E1
Groundwater and Surface Water Sample Key – Round 1
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Sample I.D.	King County Sample Name	Laboratory Number	Date Collected	Analytical Schedule: VOCs	6010/7000 Series METALS	Chloride Sulfate TSS	Nitrate/ Nitrite NH_3 as N	COD TOC
Groundwater Samples								
PKC–MW1A	WP1A93323–	D316	3/23/93	X	X	X	X	X
PKC–MW1B	WP1B93322–	D304	3/22/93	X	X	X	X	X
PKC–MW2	WP2–93325–	D344	3/25/93	X	X	X	X	X
PKC–MW3B	WP3B93323–	D316	3/23/93	X	X	X	X	X
PKC–MW5	WP5–93324–	D335	3/24/93	X	X	X	X	X
PKC–MW6	WP6–93324–	D335	3/24/93	X	X	X	X	X
PKC–MW2 Dup.	WP2–93325D	D344	3/25/93	X	X	X	X	X
Rinsate	WPE–93324E	D335	3/24/93	X	X	X	X	X
Field Blank	WPB193325B	D344	3/25/93	X	X	X	X	X
PKC–GWT1–3/93	WPT193322T	D304	3/22/93	X				
PKC–GWT2–3/93	WPT293323T	D316	3/23/93	X				
PKC–GWT3–3/93	WPT393324T	D335	3/24/93	X				
PKC–GWT4–3/93	WPT493325T	D344	3/25/93	X				
Surface Water Samples								
PKC–SW1	SP1–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW2	SP2–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW3	SP3–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW4	SP4–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW4 Dup.	SP4–93324D	D336	3/24/93	X	X	X	X	X
Rinsate	SPE393324E	D336	3/24/93	X	X	X	X	X
Field Blank	SPB193324B	D336	3/24/93	X	X	X	X	X
PKC–SWT1–3/93	SPT193324T	D336	3/24/93	X				

AGI
TECHNOLOGIES

Table E2
Groundwater and Surface Water Sample Key – Round 2
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Sample I.D.	King County Sample Name	Laboratory Number	Date Collected	Analytical Schedule: VOCs	6010/7000 Series METALS	Chloride Sulfate TSS	Nitrate/ Nitrite NH_3 as N	COD TOC
Groundwater Samples								
PKC–MW1A	WP1A93819–	E726	8/19/93	X	X	X	X	X
PKC–MW1B	WP1B93816–	E677	8/16/93	X	X	X	X	X
PKC–MW2	WP2–93820–	E739	8/20/93	X	X	X	X	X
PKC–MW3B	WP3B93819–	E726	8/19/93	X	X	X	X	X
PKC–MW5	WP5–93820–	E739	8/20/93	X	X	X	X	X
PKC–MW6	WP6–93820–	E739	8/20/93	X	X	X	X	X
PKC–MW2 Dup	WP2–93820D	E739	8/20/93	X	X	X	X	X
Rinsate	WU1–93820E	E739	8/20/93	X	X	X	X	X
Field Blank	WU1–93819B	E726	8/19/93	X	X	X	X	X
PKC–GWT1–3/93	VTRP93816–	E677	8/16/93	X				
PKC–GWT2–3/93	VTRP93819–	E726	8/19/93	X				
PKC–GWT3–3/93	VTRP93820–	E739	8/20/93	X				
Surface Water Samples								
PKC–SW1	SP1–93526–		5/26/93	X	X	X	X	X
PKC–SW2	SP2–93526–		5/26/93	X	X	X	X	X
PKC–SW3	SP3–93526–		5/26/93	X	X	X	X	X
PKC–SW4	SP4–93526–		5/26/93	X	X	X	X	X
PKC–SW__ Dup	SP4–93526D		5/26/93	X	X	X	X	X
PKC–SW__ Rinsate	SPE393526E		5/26/93	X	X	X	X	X
PKC–SW__ Field Blk	SPB193526B		5/26/93	X	X	X	X	X
PKC–SWT1–3/93	SPT193526T		5/26/93	X				

AGI TECHNOLOGIES

Table E3
Volatile Organic Compounds Detected in Surface Water
Quantified by EPA Method 8240 Modified
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compound	LQL µg/L	Date	PKC-SW1	PKC-SW2	Background Sample PKC-SW3	PKC-SW4	Dup PKC-SW4
			µg/L				
Carbon disulfide	0.20	3/93	ND	ND	0.82	ND	ND
	0.20	5/93	ND	ND	ND	ND	ND
Toluene	0.20	3/93	ND	ND	1.1	ND	ND
	0.20	5/93	ND	ND	ND	0.74	0.76
Chloroform	0.20	3/93	ND	ND	ND	ND	ND
	0.20	5/93	ND	ND	0.66	ND	ND

Notes:

Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
ND – Not detected.
µg/L – Micrograms per liter.

AGI TECHNOLOGIES

Table E4
Total and Dissolved Metals in Surface Water
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-SW1 Total	PKC-SW1 Dissolved	PKC-SW2 Total	PKC-SW2 Dissolved	Background Sample PKC-SW3 Total	Background Sample PKC-SW3 Dissolved	PKC-SW4 Total	PKC-SW4 Dissolved	Dup PKC-SW4 Total	Dup PKC-SW4 Dissolved
			mg/L									
Major Metals												
Aluminum	0.020	3/93	0.440	0.07	0.420	0.07	0.390	0.08	0.150	0.07	0.150	0.06
	0.020	5/93	0.330	0.03	0.270	ND	0.080	0.04	0.370	0.05	0.190	0.04
Calcium	0.010	3/93	7.30	7.18	7.17	6.95	7.05	6.81	8.03	8.16	8.02	8.11
	0.010	5/93	10.3	9.97	10.3	9.77	10.5	10.1	7.54	7.40	7.55	7.27
Iron	0.005	3/93	0.371	0.085	0.356	0.073	0.351	0.093	0.108	0.033	0.114	0.027
	0.005	5/93	0.584	0.158	0.575	0.059	0.472	0.166	3.87	0.259	3.93	0.117
Magnesium	0.020	3/93	2.19	2.12	2.17	2.10	2.17	2.08	2.46	2.5	2.42	2.55
	0.020	5/93	3.26	3.09	3.24	3.02	3.69	3.49	2.44	2.39	2.40	2.33
Potassium	0.400	3/93	1.2	1.0	1.1	0.9	1.3	1.0	1.5	1.0	1.2	0.9
	0.400	5/93	0.8	0.9	1.1	0.9	1.0	1.2	1.2	0.9	1.0	1.2
Sodium	0.010	3/93	12.6	12.4	12.8	12.6	12.9	12.7	3.25	3.38	3.16	3.46
	0.010	5/93	12.7	12.3	12.7	12.1	12.8	12.4	12.6	12.5	12.1	12.5
Trace Metals												
Arsenic	0.001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	0.001	ND	0.001	0.001	0.001	ND	0.001	ND
Barium	0.001	3/93	0.014	0.012	0.014	0.012	0.013	0.012	0.021	0.021	0.021	0.021
	0.001	5/93	0.013	0.010	0.017	0.010	0.012	0.010	0.019	0.015	0.020	0.016
Beryllium	0.001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	0.002	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.002	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.005	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.005	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	0.003	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.003	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

AGI TECHNOLOGIES

Table E4
Total and Dissolved Metals in Surface Water
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-SW1 Total	PKC-SW1 Dissolved	PKC-SW2 Total	PKC-SW2 Dissolved	Background Sample PKC-SW3 Total	Background Sample PKC-SW3 Dissolved	PKC-SW4 Total	PKC-SW4 Dissolved	Dup PKC-SW4 Total	Dup PKC-SW4 Dissolved
			mg/L									
Trace Metals (cont.)												
Copper	0.002	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.002	5/93	0.007	ND	ND	ND	0.002	ND	0.002	ND	0.004	ND
Lead	0.020	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese	0.001	3/93	0.014	0.010	0.016	0.011	0.020	0.017	0.031	0.028	0.034	0.025
	0.001	5/93	0.123	0.036	0.132	0.073	0.173	0.138	0.245	0.280	0.336	0.268
Mercury	0.0001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.0001	5/93	ND	ND	ND	0.0003	ND	ND	ND	ND	ND	ND
Nickel	0.010	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.010	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.001	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.001	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.003	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.003	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	0.050	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.050	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tin	0.010	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.010	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	0.002	3/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	0.002	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	0.004	3/93	0.013	ND	0.020	ND	0.011	ND	0.027	0.033	0.030	0.028
	0.004	5/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
mg/L – Milligrams per liter.
ND – Not detected.

AGI TECHNOLOGIES

Table E5
General Anions and Physical Parameters in Surface Water
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Parameter	LQL mg/L	Date	PKC-SW1	PKC-SW2	Background Sample PKC-SW3	PKC-SW4	Dup PKC-SW4
Specific Conductivity (µmhos/cm)	--	3/93	113	126	125	85	--
	--	5/93	151	198	127	180	--
Temperature (^{o}C)	--	3/93	8.1	8.6	9.3	9.4	--
	--	5/93	16.5	15.9	17.2	21.7	--
pH	--	3/93	7.5	7.3	7.3	6.8	--
	--	5/93	7.3	6.9	7.1	7.8	--
Ammonia as Nitrogen (mg/L)	0.01	3/93	0.012	0.012	0.019	0.019	0.013
	0.01	5/93	ND	0.233	ND	0.170	0.241
Nitrate + Nitrite as Nitrogen (mg/L)	0.01	3/93	0.825	0.807	0.790	0.797	0.720
	0.01	5/93	0.292	0.270	0.306	ND	ND
Chloride (mg/L)	1.0	3/93	17.6	16.6	17.7	3.5	3.2
	1.0	5/93	16.1	16.3	16.0	14.0	13.8
Sulfate (mg/L)	2.5	3/93	7.8	7.7	7.3	7.5	7.3
	2.5	5/93	5.9	5.9	6.3	4.3	5.1
Chemical Oxygen Demand (mg/L)	5.0	3/93	21.5	20.5	20.9	11.2	15.7
	5.0	5/93	19.2	17.6	22.3	23.5	27.6
Total Organic Carbon (mg/L)	1.0	3/93	6.23	6.39	6.52	3.57	3.93
	1.0	5/93	6.32	6.48	6.27	7.78	7.49
Total Suspended Solids (mg/L)	1.0	3/93	ND	ND	ND	ND	ND
	1.0	5/93	ND	6.0	ND	6.0	7.6

Notes:

Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
mg/L – Milligrams per liter.
ND – Not detected.

AGI TECHNOLOGIES

APPENDIX F

Groundwater Chemical Data

AGI TECHNOLOGIES

APPENDIX F

Groundwater Chemical Data

Sample keys for the two rounds of surface water samples collected by AGI Technologies (AGI) during March and May 1993 from King County Puyallup/Kit Corner Custodial Landfill are presented in **Tables F1 and F2. Tables F3 through F5** summarize the analytical data for the two sampling rounds.

The following discussion summarizes EcoChem's quality assurance reviews of two rounds of groundwater samples. Samples were analyzed by Analytical Resources Inc. (ARI). Based on EcoChem's quality assurance review, some sample results were qualified. In general, all data validation requirements were met except as noted in the following paragraphs.

All holding time criteria were met during rounds 1 and 2 for all parameters except as noted below:

> Round 1 - Samples WP1A9323- and WP3B9323- were analyzed 2 days outside of the required holding time for total suspended solids (7 days). Results were considered estimated and flagged (J).

Method blanks, trip blanks, field blanks, and rinsates were generally free of contamination. Occasional low level detections in the field quality control samples were attributed to laboratory contamination or impurities in the deionized water. Associated data considered affected were qualified as appropriate.

Field duplicate samples were collected during both sampling rounds. Relative percent differences (RPDs) indicate acceptable field and laboratory precision except as noted below:

> Round 2 - The RPD for ammonia was outside of the 50 percent acceptance criteria. Ammonia results for field duplicate samples WP2-93820- and WP2-93820D were qualified as estimated and flagged (J).

Laboratory quality control (lab duplicates, matrix spikes, and surrogates) were acceptable and within ARI quality control criteria except as noted below:

> Round 1 - Matrix spike (MS) and matrix spike duplicate (MSD) results for percent recovery of tin and silver were outside of ARI's control limit criteria. Filtered and unfiltered tin results for samples WP2-93325- and WP2-93325D were rejected and flagged (R). Filtered and unfiltered silver results for samples WP593324- and WP63324- were also rejected and flagged (R).

> Round 1 - MS percent recovery of ammonia was outside of ARI's control limit criteria. Ammonia results for samples WP1B93322, WP293325, and WP293325D were considered estimated and flagged (UJ).

> Round 2 - MS percent recovery of ammonia was outside of ARI's control limit criteria. All sample results were considered estimated and flagged (J or UJ).

The detection limits required by ARI's contract with King County were met for the majority of the sample parameters and compounds with a few exceptions, discussed in EcoChem's quality assurance reports.

AGI TECHNOLOGIES

Table F1
Groundwater and Surface Water Sample Key – Round 1
Puyallup/Kit Corner Custodial Landfill
King County, Washington

				Analytical Schedule				
Sample I.D.	King County Sample Name	Laboratory Number	Date Collected	VOCs	6010/7000 Series METALS	Chloride Sulfate TSS	Nitrate/ Nitrite NH_3 as N	COD TOC
Groundwater Samples								
PKC–MW1A	WP1A93323–	D316	3/23/93	X	X	X	X	X
PKC–MW1B	WP1B93322–	D304	3/22/93	X	X	X	X	X
PKC–MW2	WP2–93325–	D344	3/25/93	X	X	X	X	X
PKC–MW3B	WP3B93323–	D316	3/23/93	X	X	X	X	X
PKC–MW5	WP5–93324–	D335	3/24/93	X	X	X	X	X
PKC–MW6	WP6–93324–	D335	3/24/93	X	X	X	X	X
PKC–MW2 Dup.	WP2–93325D	D344	3/25/93	X	X	X	X	X
Rinsate	WPE–93324E	D335	3/24/93	X	X	X	X	X
Field Blank	WPB193325B	D344	3/25/93	X	X	X	X	X
PKC–GWT1–3/93	WPT193322T	D304	3/22/93	X				
PKC–GWT2–3/93	WPT293323T	D316	3/23/93	X				
PKC–GWT3–3/93	WPT393324T	D335	3/24/93	X				
PKC–GWT4–3/93	WPT493325T	D344	3/25/93	X				
Surface Water Samples								
PKC–SW1	SP1–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW2	SP2–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW3	SP3–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW4	SP4–93324–	D336	3/24/93	X	X	X	X	X
PKC–SW4 Dup.	SP4–93324D	D336	3/24/93	X	X	X	X	X
Rinsate	SPE393324E	D336	3/24/93	X	X	X	X	X
Field Blank	SPB193324B	D336	3/24/93	X	X	X	X	X
PKC–SWT1–3/93	SPT193324T	D336	3/24/93	X				

AGI TECHNOLOGIES

Table F2
Groundwater and Surface Water Sample Key – Round 2
Puyallup/Kit Corner Custodial Landfill
King County, Washington

				Analytical Schedule				
Sample I.D.	King County Sample Name	Laboratory Number	Date Collected	VOCs	6010/7000 Series METALS	Chloride Sulfate TSS	Nitrate/ Nitrite NH_3 as N	COD TOC
Groundwater Samples								
PKC–MW1A	WP1A93819–	E726	8/19/93	X	X	X	X	X
PKC–MW1B	WP1B93816–	E677	8/16/93	X	X	X	X	X
PKC–MW2	WP2–93820–	E739	8/20/93	X	X	X	X	X
PKC–MW3B	WP3B93819–	E726	8/19/93	X	X	X	X	X
PKC–MW5	WP5–93820–	E739	8/20/93	X	X	X	X	X
PKC–MW6	WP6–93820–	E739	8/20/93	X	X	X	X	X
PKC–MW2 Dup	WP2–93820D	E739	8/20/93	X	X	X	X	X
Rinsate	WU1–93820E	E739	8/20/93	X	X	X	X	X
Field Blank	WU1–93819B	E726	8/19/93	X	X	X	X	X
PKC–GWT1–3/93	VTRP93816–	E677	8/16/93	X				
PKC–GWT2–3/93	VTRP93819–	E726	8/19/93	X				
PKC–GWT3–3/93	VTRP93820–	E739	8/20/93	X				
Surface Water Samples								
PKC–SW1	SP1–93526–		5/26/93	X	X	X	X	X
PKC–SW2	SP2–93526–		5/26/93	X	X	X	X	X
PKC–SW3	SP3–93526–		5/26/93	X	X	X	X	X
PKC–SW4	SP4–93526–		5/26/93	X	X	X	X	X
PKC–SW__ Dup	SP4–93526D		5/26/93	X	X	X	X	X
PKC–SW__ Rinsate	SPE393526E		5/26/93	X	X	X	X	X
PKC–SW__ Field Blk	SPB193526B		5/26/93	X	X	X	X	X
PKC–SWT1–3/93	SPT193526T		5/26/93	X				

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Table F3
Groundwater Field Parameters
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Well I.D.	Date	Specific Conductance (µmhos/cm)	pH	Temperature (°C)
PKC–MW1A	3/93	250	6.4	10.5
	8/93	250	6.5	14.4
PKC–MW1B	3/93	300	7.5	11.2
	8/93	280	6.5	11.3
PKC–MW2	3/93	1,700	7.6	12.5
	8/93	1,700	6.8	14.2
PKC–MW3B	3/93	480	7.0	11.2
	8/93	560	6.5	14.2
PKC–MW5	3/93	710	6.5	8.90
	8/93	910	6.4	14.0
PKC–MW6	3/93	510	6.5	10.8
	8/93	730	6.5	13.3

Notes:

µmhos/cm – Micromhos per centimeter.

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Table F4
Volatile Organic Compounds Detected In Groundwater
Quantified by EPA Method 8240 Modified
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compound	LQL µg/L	Date	PKC–MW1a	PKC–MW1b	PKC–MW2	Dup PKC–MW2	PKC–MW3b	PKC–MW5*	PKC–MW6*
			µg/L						
Acetone	4.0	3/93	ND	12	ND	ND	ND	ND	ND
	4.0	8/93	ND	ND	ND	ND	ND	ND	ND
Benzene	0.20	3/93	ND	ND	1.3	1.3	ND	5.5	ND
	0.20	8/93	ND	ND	1.2	1.2	0.27	5.8	ND
Carbon disulfide	0.20	3/93	ND	ND	ND	ND	ND	2.7	ND
	0.20	8/93	ND	ND	0.21	0.28	ND	ND	ND
Chlorobenzene	0.20	3/93	ND	ND	ND	ND	ND	8.6	ND
	0.20	8/93	ND	ND	ND	ND	ND	10	ND
Chloroethane	0.20	3/93	ND	ND	0.22 J	0.23 J	ND	ND	ND
	0.20	8/93	ND	ND	0.34	0.34	ND	ND	ND
1,2–Dichlorobenzene	0.20	3/93	ND	ND	ND	ND	ND	1.7	ND
	0.20	8/93	ND	ND	ND	ND	ND	1.6	ND
1,4–Dichlorobenzene	0.20	3/93	ND	ND	ND	ND	ND	8.1	ND
	0.20	8/93	ND	ND	ND	ND	ND	8.9	ND
1,1–Dichloroethane	0.20	3/93	ND	ND	0.64	0.64	ND	ND	ND
	0.20	8/93	ND	ND	0.50	0.50	0.22	ND	ND
1,2–Dichloroethane	0.20	3/93	ND	ND	1.5	1.5	ND	ND	ND
	0.20	8/93	ND	ND	1.7	1.7	ND	ND	ND
trans–1,2–Dichloroethene	0.20	3/93	ND	ND	0.59	0.61	ND	ND	ND
	0.20	8/93	ND	ND	0.63	0.58	0.27	ND	ND
cis–1,2–Dichloroethene	0.20	3/93	ND	ND	0.36	0.37	0.52	ND	ND
	0.20	8/93	ND	ND	0.40	0.32	1.1	ND	ND
1,2–Dichloropropane	0.20	3/93	ND	ND	0.70	0.72	ND	ND	ND
	0.20	8/93	ND	ND	0.75	0.74	ND	ND	ND
Ethylbenzene	0.20	3/93	ND	ND	ND	ND	ND	54	ND
	0.20	8/93	ND	ND	ND	ND	ND	50	ND
Methylene chloride	0.20	3/93	ND	ND	0.20	0.23	ND	ND	0.82 J
	0.20	8/93	ND	ND	0.28	0.24	ND	ND	2.2

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Table F4
Volatile Organic Compounds Detected in Groundwater
Quantified by EPA Method 8240 Modified
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Compound	LQL µg/L	Date	PKC-MW1a	PKC-MW1b	PKC-MW2	Dup PKC-MW2	PKC-MW3b	PKC-MW5*	PKC-MW6*
			µg/L						
Toluene	0.20	3/93	ND	0.61	ND	ND	0.22	0.65	ND
	0.20	8/93	ND	ND	ND	ND	ND	ND	ND
Trichlorofluormethane	0.20	3/93	ND	ND	ND	ND	ND	7.2	ND
	0.20	8/93	ND	ND	ND	ND	ND	3.4	ND
Vinyl chloride	0.20	3/93	ND	ND	1.2	1.3	3.6	ND	80
	0.20	8/93	ND	ND	0.72	0.72	2.5	ND	67
o-Xylene	0.20	3/93	ND	ND	ND	ND	ND	1.0	ND
	0.20	8/93	ND	ND	ND	ND	ND	1.1	ND
Total Xylenes	0.40	3/93	ND	0.64 J	ND	ND	ND	ND	ND
	0.40	8/93	ND	ND	ND	ND	ND	8.3	ND

Notes:

*Detection limit is elevated 5 times due to matrix effect.
Dup – Duplicate sample.
J – Estimated value; see Quality Assurance Report.
LQL – Lowest practical quantitation limit.
ND – Not detected.
µg/L – Micrograms per liter.

Table F5
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW1a Total	PKC-MW1a Dissolved	PKC-MW1b Total	PKC-MW1b Dissolved	PKC-MW2 Total	PKC-MW2 Dissolved	Dup PKC-MW2 Total	Dup PKC-MW2 Dissolved
			mg/L							
Major Metals										
Aluminum	0.020	3/93	4.21	ND	0.260	ND	95.3	ND	90.2	ND
	0.020	8/93	2.16	ND	0.060	ND	80.3	ND	110	ND
Calcium	0.010	3/93	28.1	27.0	25.9	26.0	167	148	166	148
	0.010	8/93	28.2	28.2	25.9	26.6	154	138	159	141
Iron	0.005	3/93	4.94	0.007	0.392	ND	109	6.25	108	5.36
	0.005	8/93	3.17	0.006	0.113	0.022	92.4	6.33	123	6.66
Magnesium	0.020	3/93	15.6	14.7	15.7	15.1	92.6	71.7	91.4	72.4
	0.020	8/93	15.8	15.4	15.5	15.6	88.8	69.4	95.7	69.6
Potassium	0.400	3/93	2.6	0.9	3.2	2.8	13.5	6.4	13.2	6.4
	0.400	8/93	2.0	1.6	2.8	2.8	12.6	6.6	14.2	6.1
Sodium	0.010	3/93	9.16	8.65	9.04	8.86	161	158	161	159
	0.010	8/93	9.32	9.10	8.83	8.95	164	159	165	161
Trace Metals										
Arsenic	0.001	3/93	0.001	ND	ND	ND	0.086	0.072	0.088	0.068
	0.001	8/93	0.001	ND	ND	ND	0.088	0.072	0.076	0.072
Barium	0.001	3/93	0.046	0.010	0.007	0.008	0.554	0.070	0.534	0.070
	0.001	8/93	0.022	0.007	0.006	0.006	0.485	0.075	0.624	0.073
Beryllium	0.001	3/93	ND	ND	ND	ND	0.002	ND	0.002	ND
	0.001	8/93	ND	ND	ND	ND	0.002	ND	0.003	ND
Cadmium	0.002	3/93	ND	ND	ND	ND	0.003	ND	ND	ND
	0.002	8/93	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	0.005	3/93	0.006	ND	0.011	ND	0.158	ND	0.150	ND
	0.005	8/93	ND	ND	ND	ND	0.116	ND	0.158	ND
Cobalt	0.003	3/93	ND	ND	ND	ND	0.030	0.004	0.030	ND
	0.003	8/93	ND	ND	ND	ND	0.028	0.005	0.036	0.005

Table F5
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW1a Total	PKC-MW1a Dissolved	PKC-MW1b Total	PKC-MW1b Dissolved	PKC-MW2 Total	PKC-MW2 Dissolved	Dup PKC-MW2 Total	Dup PKC-MW2 Dissolved
			mg/L							
Trace Metals (cont.)										
Copper	0.002	3/93	0.004	ND	0.017	ND	0.128	ND	0.129	ND
	0.002	8/93	ND	ND	0.002	ND	0.139	0.003	0.176	ND
Lead	0.020	3/93	ND	ND	ND	ND	0.02	ND	0.03	ND
	0.001	8/93	ND	ND	0.002	ND	0.034	ND	0.048	ND
Manganese	0.001	3/93	0.146	0.100	0.017	0.023	10.6	8.95	10.5	9.00
	0.001	8/93	0.233	0.226	0.026	0.027	10.0	8.57	10.5	8.72
Mercury	0.0001	3/93	ND	ND	ND	ND	0.0003	ND	0.0003	ND
	0.0001	8/93	ND	ND	ND	ND	0.0003	ND	0.0004	ND
Nickel	0.010	3/93	ND	ND	ND	ND	0.19	0.02	0.20	0.02
	0.100	8/93	ND	ND	ND	ND	0.17	0.01	0.23	0.02
Selenium	0.001	3/93	ND	ND	ND	ND	ND [a]	ND	ND [a]	ND [a]
	0.001	8/93	ND	ND	ND	ND	ND [a]	ND [a]	ND [b]	ND [a]
Silver	0.003	3/93	ND	ND	ND	ND	ND	ND	ND	ND
	0.003	8/93	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	0.050	3/93	ND	ND	ND	ND	0.07	ND	0.08	ND
	0.050	8/93	ND	ND	ND	ND	ND	ND	0.05	ND
Tin	0.010	3/93	ND	ND	ND	ND	ND R	ND R	ND R	ND R
	0.010	8/93	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	0.002	3/93	0.006	ND	0.003	0.002	0.142	0.003	0.142	0.003
	0.002	8/93	0.007	0.002	0.002	0.003	0.131	0.004	0.180	0.004
Zinc	0.004	3/93	0.011	0.016	0.022	0.059	0.166	ND	0.167	ND
	0.004	8/93	ND	ND	ND	0.034	0.150	ND	0.205	ND

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Table F5
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW3b Total	PKC-MW3b Dissolved	PKC-MW5 Total	PKC-MW5 Dissolved	PKC-MW6 Total	PKC-MW6 Dissolved
			mg/L					
Major Metals								
Aluminum	0.020	3/93	95.5	ND	74.6	ND	80.1	ND
	0.020	8/93	49.1	ND	33.4	0.03	123	ND
Calcium	0.010	3/93	64.2	37.0	81.1	68.6	80.7	59.4
	0.010	8/93	59.5	46.2	76.2	68.4	105	73.2
Iron	0.005	3/93	135	8.9	161	97.4	133	2.46
	0.005	8/93	78.2	16.2	119	94.2	194	1.52
Magnesium	0.020	3/93	63.9	25.2	20.7	9.77	66.4	34.7
	0.020	8/93	50.1	31.5	14.4	9.69	90.6	42.3
Potassium	0.400	3/93	11.8	3.2	15.8	12.4	9.7	2.7
	0.400	8/93	9.8	5.5	17.2	14.7	12.6	2.6
Sodium	0.010	3/93	18.6	12.7	9.36	6.36	17.4	11.9
	0.010	8/93	17.6	14.1	9.09	6.58	20.6	13.0
Trace Metals								
Arsenic	0.001	3/93	0.028	0.017	0.009	0.002	0.007	ND
	0.001	8/93	0.033	0.029	0.007	0.003	0.014	0.001
Barium	0.001	3/93	0.508	0.031	0.551	0.156	0.383	0.024
	0.001	8/93	0.280	0.043	0.376	0.189	0.549	0.028
Beryllium	0.001	3/93	0.003	ND	ND	ND	0.003	ND
	0.001	8/93	0.001	ND	ND	ND	0.004	ND
Cadmium	0.002	3/93	ND	ND	0.003	ND	ND	ND
	0.002	8/93	ND	ND	ND	ND	0.005	ND
Chromium	0.005	3/93	0.210	ND	0.104	ND	0.184	ND
	0.005	8/93	0.113	ND	0.047	ND	0.294	ND
Cobalt	0.003	3/93	0.061	0.007	0.027	0.008	0.056	0.013
	0.003	8/93	0.037	0.012	0.016	0.008	0.082	0.015

Table F5
Total and Dissolved Metals in Groundwater
Quantified by EPA Methods 6010/7000 Series
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Metal	LQL mg/L	Date	PKC-MW3b Total	PKC-MW3b Dissolved	PKC-MW5 Total	PKC-MW5 Dissolved	PKC-MW6 Total	PKC-MW6 Dissolved
			mg/L					
Trace Metals (cont.)								
Copper	0.002	3/93	0.208	0.003	0.094	ND	0.126	ND
	0.002	8/93	0.098	ND	0.038	ND	0.200	ND
Lead	0.020	3/93	0.04	ND	0.15	ND	0.03	ND
	0.001	8/93	0.024	ND	0.088	ND	0.062	ND
Manganese	0.001	3/93	5.34	3.37	1.71	1.12	2.92	1.58
	0.001	8/93	6.14	5.22	0.902	0.652	3.86	1.97
Mercury	0.0001	3/93	0.0003	ND	0.0003	ND	0.0002	ND
	0.0001	8/93	0.0002	ND	0.0001	ND	0.0004	ND
Nickel	0.010	3/93	0.25	ND	0.11	0.02	0.24	0.02
	0.100	8/93	0.13	ND	0.07	0.02	0.38	0.03
Selenium	0.001	3/93	ND [a]	ND	ND [a]	ND	ND [a]	ND
	0.001	8/93	ND [a]	ND [a]	ND	ND	ND [b]	ND
Silver	0.003	3/93	ND	ND	ND R	ND R	ND R	ND R
	0.003	8/93	ND	ND	ND	ND	ND	ND
Thallium	0.050	3/93	ND	ND	ND	ND	ND	ND
	0.050	8/93	ND	ND	ND	ND	ND	ND
Tin	0.010	3/93	ND	ND	0.04	ND	ND	ND
	0.010	8/93	ND	ND	0.03	ND	ND	ND
Vanadium	0.002	3/93	0.238	ND	0.120	0.005	0.180	ND
	0.002	8/93	0.115	0.003	0.050	ND	0.311	ND
Zinc	0.004	3/93	0.258	0.010	0.548	ND	0.228	ND
	0.004	8/93	0.132	ND	0.273	ND	0.337	ND

Notes:

a) Lowest practical quantitation limit elevated 5 times due to matrix interference.
b) Lowest practical quantitation limit elevated10 times due to matrix interference.
Dup – Duplicate sample.
LQL – Lowest practical quantitation limit.
R – Rejected value. See Quality Assurance Report.

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Table F6
General Anions and Physical Parameters in Groundwater
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Parameter	LQL mg/L	Date	PKC–MW1a	PKC–MW1b	PKC–MW2	Dup PKC–MW2	PKC–MW3b	PKC–MW5	PKC–MW6
Specific Conductivity (μmhos/cm)	––	3/93	247	300	1,681	––	476	710	510
		8/93	254	278	1,702	––	555	905	734
Temperature (°C)	––	3/93	10.5	11.2	12.5	––	11.2	8.9	10.8
		8/93	14.4	11.3	14.2	––	14.2	14.0	13.3
pH	––	3/93	6.4	7.5	7.6	––	7.0	6.5	6.5
		8/93	6.5	6.5	6.8	––	6.5	6.4	6.5
Ammonia as Nitrogen (mg/L)	0.010	3/93	ND	ND UJ	ND UJ	ND UJ	1.19	22.9	ND
	0.010	8/93	ND UJ	ND UJ	ND UJ	ND UJ	2.50 J	31.5 J	ND UJ
Nitrate + Nitrite as Nitrogen (mg/L)	0.01	3/93	2.61	1.56	ND	ND	0.042	ND	ND
	0.01	8/93	2.86	1.88	0.050	0.051	ND	0.067	0.026
Chloride (mg/L)	1.0	3/93	11.3	12.2	95.7	81.6	18.4	9.7	5.8
	1.0	8/93	11.0	12.0	86.9	91.7	11.5	5.7	4.7
Sulfate (mg/L)	2.5	3/93	12.7	10.4	4.0	4.4	13.4	3.0	9.3
	2.5	8/93	13.8	10.7	6.2	5.8	15.8	3.8	12.0
Chemical Oxygen Demand (mg/L)	5.0	3/93	ND	25.0	61.1	50.5	46.9	162	18.0
	5.0	8/93	ND	ND	85.7	82.8	17.6	73.1	36.6
Total Organic Carbon (mg/L)	1.0	3/93	ND	5.39	15.7	15.4	1.72	12.9	ND
	1.0	8/93	ND	ND	18.4	21.3	ND	12.0	1.37
Total Suspended Solids (mg/L)	1.0	3/93	133 J	6.4	1,100	1,030	2,420 J	1,300	1,880
	1.0	8/93	22	ND UJ	2,580	3,010	1,390	549	2,870

Notes:

Dup – Duplicate sample.
J – Estimated value; see Quality Assurance Report.
UJ – Estimated value; see Quality Assurance Report.
LQL – Lowest practical quantitation limit.
mg/L – Milligrams per liter.
NA – Not analyzed.
ND – Not detected.

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APPENDIX G

Landfill Gas Monitoring Data

AGI TECHNOLOGIES

APPENDIX G

Landfill Gas Monitoring Data

Table E1 presents gas monitoring data collected by AGI Technologies (AGI) during the Phase II investigation at the Puyallup/Kit Corner Custodial Landfill in King County, Washington. The data were collected from March 31 through September 3, 1993. Parameters measured included temperature (ambient, ground, and downhole), differential pressure, and concentrations of oxygen, combustible gas, volatile organic compounds, hydrogen sulfide, and carbon dioxide.

Landfill gas monitoring data were collected biweekly. All 28 gas probes installed by AGI were monitored throughout the entire period. In addition, seven gas probes installed by Associated Earth Sciences, Inc. in 1989 were also monitored from March 31, 1993 to June 11, 1993.

Section 4.3 of this Phase II Investigation report discusses landfill gas investigation tasks; **Appendix A** presents a detailed summary of gas probe monitoring procedures and **Appendix B** presents gas probe logs and installation diagrams.

The following instruments were used for monitoring:

Parameter	Instrument
Temperature	Cole-Palmer Thermistor Thermometer Model 8402-00 using a YSI Series 700 temperature probe
Differential Pressure	Dwyer Magnahelic Pressure Gauge Model 2000; 0 to 2 and 0 to 20 inches of water vacuum
Oxygen and Combustible Gas	Gastechtor Gas Surveyor Model 1939 OX Three-range Oxygen and Combustible Gas Indicator
Volatile Organic Vapors	Organic Vapor Meter Datalogger Model 580B Photoionization Detector
Hydrogen Sulfide	MSA Portable Alarm Model 361
Carbon Dioxide	Bacharach FYRITE Carbon Dioxide Gas Analyzer Model 11-7032 (range: 0-20 percent by volume [%v]); Model 11-7034 (range: 0-60 %v)

Instruments were calibrated by trained personnel prior to each monitoring round. AGI's equipment manager and electrician performed thorough monthly calibrations.

The concentrations of specific gases used to calibrate or check the calibration of monitoring instruments were as follows:

- Oxygen/combustible gas meter: oxygen/ambient air for 20.8 %v check, pure nitrogen for 0.0 %v check, combustible gas (50.0 percent of the Lower Explosive Limit [%LEL] concentration of methane)

- Organic vapor meter equipped with photoionization detector: 100 parts per million (ppm) isobutylene

- Hydrogen sulfide detector: 10 ppm hydrogen sulfide

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC–MW1GP	04/01/93	16.0	13.4	10.2	1.55	0	6% Vol	8	0	14
	04/15/93	14.6	13.8	10.0	−0.15	0	4% Vol	1	1	10.5
	05/01/93	12.6	13.0	10.3	2.0	6	2% Vol	2	0	12
	05/14/93	18.4	16.6	11.9	−0.85	0	4% Vol	4	0	13
	05/28/93	18	18.5	11.7	−0.45	0	4% Vol	3	0	13
	06/11/93	NM	NM	NM	−0.15	0	4% Vol	3	0	12
	06/25/93	25.6	20.7	12.0	0.75	2	2% Vol	5	0	13
	07/09/93	13.4	20.1	11.8	−0.45	0	2% Vol	3	0	12
	07/23/93	22.0	19.0	11.8	−1.25	0	5% Vol	1	0	14
	08/06/93	23.8	24.4	11.6	0.25	0	3% Vol	2	0	13.5
	08/20/93	19.5	21.1	11.5	−0.80	0	4% Vol	2	0	14
	09/03/93	23.8	21.3	11.5	−0.75	0	2% Vol	2	0	13
PKC–MW1a	04/01/93	16.1	13.4	10.1	1.65	0	4% Vol	8	0	11
	04/15/93	14.7	13.7	9.9	−0.15	0	2% Vol	5	0	9
	05/01/93	12.8	13.0	10.2	2.0	20.8	0% LEL [a]	16 [a]	0 [a]	0 [a]
	05/14/93	18.6	16.8	11.6	−0.85	0	4% Vol	8	0	12.5
	05/28/93	18.4	18.6	11.6	−0.45	0	4% Vol	19	0	12
	06/11/93	NM	NM	NM	−0.12	0	4% Vol	3	0	12
	06/25/93	26.1	21.0	11.8	0.80	2	2% Vol	14	0	12
	07/09/93	14.9	20.1	11.7	−0.50	0	4% Vol	1	0	13
	07/23/93	21.1	19.0	11.6	−1.30	0	4% Vol	3	0	13
	08/06/93	24.1	24.4	11.5	0.25	0	3% Vol	2	0	13
	08/20/93	19.8	21.1	11.5	−0.90	0	3% Vol	6	0	9
	09/03/93	24.0	21.3	11.5	−0.75	0	2% Vol	0	0	13

Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature			Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
		Ambient (°C)	Ground (°C)	Downhole (°C)						
PKC–MW2GPa	04/01/93	12.4	9.1	10.1	1.30	0	8% Vol	5	0	4
	04/14/93	15.5	10.6	9.8	1.47	0	4% Vol	7	0	4.5
	04/30/93	16.4	16.4	11.0	−0.50	4	4% Vol	1	0	4
	05/13/93	19.7	20.1	11.2	−1.40	0	7% Vol	2	0	3.5
	05/27/93	26.2	20.3	11.0	0.55	0	10% Vol	1	0	3.5
	06/10/93	NM	NM	NM	−0.30	0	10% Vol	1	0	4.5
	06/24/93	28.7	20.5	10.8	−0.50	2	6% Vol	1	0	4
	07/08/93	22.9	19.1	10.7	0.35	0	8% Vol	0	0	3
	07/22/93	19.3	18.3	10.7	0.30	0	9% Vol	1	0	3
	08/05/93	31.3	25.9	10.8	−0.55	0	9% Vol	2	0	4
	08/19/93	26.9	22.4	11.0	0.70	0	9% Vol	0	0	3
	09/02/93	28.5	23.0	10.8	−0.1	0	9% Vol	0	0	2
PKC–MW2GPb	04/01/93	12.5	9.1	9.3	1.55	0	19% Vol	4	0	4
	04/14/93	18.7	11.0	10.0	2.0	0	22% Vol	14	0	3
	04/30/93	16.3	16.4	10.9	−0.75	0	5% Vol	1	0	4
	05/13/93	19.9	20.1	10.8	−1.70	0	10% Vol	4	0	4.5
	05/27/93	26.5	20.4	10.9	0.75	0	15% Vol	1	0	5
	06/10/93	NM	NM	NM	−0.45	0	16% Vol	3	0	4
	06/24/93	28.8	20.5	11.2	−0.80	0	20% Vol	1	0	4
	07/08/93	23.3	19.1	11.0	0.35	0	15% Vol	1	0	5
	07/22/93	19.5	18.5	11.1	0.60	0	12% Vol	1	0	5
	08/05/93	31.3	25.9	11.0	−0.70	0	12% Vol	0	0	5
	08/19/93	27.0	22.6	11.0	0.90	0	12% Vol	0	0	5
	09/02/93	28.4	23.0	11.0	−0.15	1	14% Vol	0	0	3.5

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature			Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
		Ambient (°C)	Ground (°C)	Downhole (°C)						
PKC–MW2	04/01/93	12.7	9.1	10.0	0.50	0	2% Vol	9	0	5
	04/14/93	17.8	11.0	9.8	1.95	0	2% Vol	15	0	7
	04/30/93	16.3	16.4	10.9	–0.75	NM	NM	0	0	0
	05/13/93	20.1	20.2	10.6	–1.70	20.8	0% LEL [a]	2 [a]	0 [a]	0 [a]
	05/27/93	27.0	20.6	10.8	0.60	0	4% Vol	3	0	7
	06/10/93	NM	NM	NM	–0.55	20.7	0% LEL [a]	1 [a]	0 [a]	0 [a]
	06/24/93	28.8	20.5	11.5	–0.90	20.7	0% LEL [a]	1 [a]	0 [a]	0 [a]
	07/08/93	24.9	19.3	11.1	0.50	0	2% Vol	1	0	7.5
	07/22/93	19.5	18.5	11.1	0.55	0	2% Vol	1	0	8
	08/05/93	31.4	26.0	11.1	–0.80	20.7	NM	NM	NM	NM
	08/19/93	27.3	22.6	11.0	1.00	0	2% Vol	0	0	8
	09/02/93	28.4	23.0	11.1	–0.25	20.8	NM	0 [a]	0 [a]	NM
PKC–MW3a	03/31/93	13.7	10.0	6.2	0.20	12	2% LEL	21	0	6
	04/14/93	15.9	10.0	7.5	0.20	9	2% Vol	27	0	8
	04/30/93	NM	NM	NM	–0.05	NM	NM	NM	NM	NM
	05/13/93	17.5	16.4	8.8	–0.20	0	5% Vol	0	0	13
	05/27/93	20.6	19.8	9.7	0.10	0	1% LEL	6	0	12
	06/10/93	NM	NM	NM	–0.05	12	0% LEL	15	0	0
	06/24/93	26.0	21.6	9.8	–0.10	17	0% LEL	1	0	4
	07/08/93	21.0	20.3	10.4	0.10	7	0% LEL	1	0	13
	07/22/93	18.6	18.2	11.1	0.10	0	1% Vol	5	0	14
	08/05/93	28.0	20.1	12.0	–0.15	3	19% LEL	2	0	10
	08/19/93	24.5	19.7	12.0	0.15	2	4% LEL	22	0	12
	09/03/93	13.0	15.2	12.2	–0.15	6	0% LEL	2	0	10

Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC–MW3b	03/31/93	13.7	10.0	6.5	3.75	0	2% LEL	9	1	8
	04/14/93	15.8	9.9	7.4	2.25	0	2% Vol	9	0	11
	04/30/93	NM	NM	NM	−0.45	NM	NM	NM	NM	NM
	05/13/93	17.7	16.2	10.8	−1.55	2	3% Vol	0	0	11
	05/27/93	20.9	19.8	9.1	0.80	0	2% LEL	5	0	13
	06/10/93	NM	NM	NM	−0.30	2	2% LEL	3	0	10
	06/24/93	26.0	21.6	9.7	−0.55	2	2% LEL	3	0	8
	07/08/93	21.0	20.2	10.5	0.60	0	3% Vol	0	0	12.5
	07/22/93	18.7	18.2	11.1	0.30	0	4% Vol	1	0	14
	08/05/93	28.1	20.2	11.1	−0.05	0	3% Vol	0	0	12
	08/19/93	24.6	19.6	11.5	1.15	0	3% Vol	2	0	13
	09/03/93	13.0	15.2	11.1	−1.15	3	2% Vol	0	0	11
PKC–MW4	04/01/93	16.0	9.1	7.9	Trace	18	2% LEL	4	0	2
	04/14/93	15.5	12.3	7.8	Trace	17	2% Vol	118	0	2
	05/01/93	10.2	10.1	8.3	Trace	16	0% LEL	39	0	4
	05/14/93	15.3	13.5	8.7	Trace	15	0% LEL	156	0	5
	05/28/93	20.6	17.2	9.1	Trace	15	1% LEL	98	0	5
	06/11/93	NM	NM	NM	Trace	15	1% LEL	125	0	4
	06/24/93	22.1	19.3	10.2	Trace	16	0% LEL	69	0	4
	07/08/93	23.0	19.0	10.8	Trace	17	0% LEL	1	0	2
	07/23/93	16.7	15.8	11.1	Trace	12	0% LEL	49	0	4
	08/05/93	27.8	21.5	11.5	−0.10	11	5% LEL	106	0	4
	08/19/93	24.4	19.2	11.8	0.05	12	0% LEL	97	0	5
	09/03/93	16.1	14.6	12.5	−0.05	18	0% LEL	17	0	2

Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC–MW5 [b]	04/01/93	13.8	9.1	10.0	Trace	18	2% LEL	23	0	0.05
	04/15/93	14.3	12.6	9.60	Trace	18	6% Vol	22	1	1
	05/01/93	12.6	12.8	10.2	Trace	16	1% Vol	16	0	0
	05/14/93	14.8	15.0	12.8	−0.10	20.8	2% LEL [a]	0 [a]	0 [a]	0 [a]
	05/28/93	16.3	16.6	11.5	Trace	15	12% Vol	7	0	2.5
	06/11/93	NM	NM	NM	2.0	11	24% Vol	5	0	5
	06/25/93	24.5	19.4	10.6	2.5	12	15% Vol	5	0	4.5
	07/09/93	16.3	17.2	13.7	Trace	12	20% Vol	1	0	5.5
	07/23/93	20.3	18.0	10.5	0.90	12	20% Vol	1	0	3
	08/06/93	20.6	20.8	11.1	0.07	14	14% Vol	2	0	4
	08/20/93	22.6	19.8	15.4	−0.50	20.6	2% LEL [a]	11 [a]	0 [a]	0 [a]
	09/03/93	28.1	19.5	10.9	Trace	18	2% Vol	0	0	2
PKC–MW6GPa	04/01/93	17.0	13.1	10.1	1.90	2	32% Vol	10	0	8
	04/14/93	10.5	6.8	9.2	0.94	0	44% Vol	4	0	7
	04/30/93	14.1	16.6	11.4	−1.15	2	30% Vol	6	0	6
	05/13/93	18.8	16.4	12.8	−1.65	2	37% Vol	0	0	7
	05/27/93	20.3	18.0	11.5	0.80	0	40% Vol	3	0	8
	06/10/93	NM	NM	NM	−0.80	0	35% Vol	3	0	7
	06/24/93	20.0	16.7	11.4	−1.35	1	37% Vol	5	0	8
	07/08/93	19.4	18.3	11.5	0.35	0	39% Vol	1	0	8
	07/22/93	18.1	18.0	11.4	0.80	0	41% Vol	1	0	9
	08/05/93	24.6	22.5	11.3	−1.05	0	38% Vol	0	0	9
	08/19/93	24.0	19.4	11.2	0.80	0	37% Vol	2	0	9
	09/02/93	22.6	20.4	11.6	−0.55	2	50% Vol	0	0	8

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature			Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM−PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
		Ambient (°C)	Ground (°C)	Downhole (°C)						
PKC−MW6GPb	04/01/93	17.1	13.0	10.0	1.95	2	30% Vol	7	0	11
	04/14/93	11.1	6.8	9.90	0.90	0	39% Vol	5	0	8
	04/30/93	14.3	16.7	11.0	−1.30	0	32% Vol	2	0	10
	05/13/93	19.0	16.5	11.5	−1.80	0	28% Vol	2	0	12
	05/27/93	19.1	17.7	11.2	0.90	0	28% Vol	3	0	13
	06/10/93	NM	NM	NM	−1.0	0	32% Vol	3	0	11
	06/24/93	20.2	16.8	11.4	−1.65	0	32% Vol	1	0	11
	07/08/93	19.4	18.2	11.2	0.35	0	30% Vol	0	0	13
	07/22/93	18.4	18.0	11.1	0.90	0	29% Vol	1	0	13
	08/05/93	25.2	22.5	11.4	−1.15	0	29% Vol	0	0	13
	08/19/93	23.8	19.5	11.2	0.90	0	26% Vol	0	0	13.5
	09/02/93	22.7	20.4	11.2	−0.60	0	28% Vol	0	0	13
PKC−MW6	04/01/93	17.3	12.9	10.2	1.85	7	8% Vol	7	0	6
	04/14/93	11.4	6.8	9.9	0.64	12	7% Vol	5	0	3.5
	04/30/93	14.3	16.8	10.9	−1.45	NM	NM	46	0	0
	05/13/93	19.1	16.6	10.8	−1.85	20.8	0% LEL [a]	64 [a]	0 [a]	0 [a]
	05/27/93	19.8	17.8	11.0	0.75	2	9% Vol	3	0	12
	06/10/93	NM	NM	NM	−1.10	20.7	2% LEL [a]	17 [a]	0 [a]	0 [a]
	06/24/93	21.8	16.8	11.4	−1.75	20.7	0% LEL [a]	35 [a]	0 [a]	0 [a]
	07/08/93	19.4	18.3	11.5	0.25	0	8% Vol	1	0	12.5
	07/22/93	18.4	18.0	11.3	0.80	0	9% Vol	1	0	13.5
	08/05/93	25.6	22.5	11.6	−1.30	20.4	NM	NM	NM	NM
	08/19/93	24.0	19.5	11.5	0.80	0	7% Vol	2	0	13.5
	09/02/93	22.7	20.4	11.4	−0.65	20.8	NM	0 [a]	0 [a]	NM

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC-MW7GPa	04/01/93	18.2	15.1	10.0	2.25	0	23% Vol	9	0	9
	04/14/93	2.9	6.4	9.6	0.40	0	17% Vol	9	0	4.5
	04/30/93	10.9	11.5	10.8	−2.0	0	18% Vol	4	0	0
	05/13/93	15.1	15.6	10.8	−1.50	3	16% Vol	0	0	0
	05/27/93	14.9	18.6	10.4	1.10	0	20% Vol	1	0	8
	06/10/93	NM	NM	NM	−1.30	2	19% Vol	1	0	2
	06/24/93	13.3	14.1	10.7	−1.75	2	19% Vol	3	0	5
	07/08/93	13.9	18.2	10.7	0.35	0	21% Vol	1	0	8
	07/22/93	17.5	17.3	10.9	1.20	0	20% Vol	1	0	8
	08/05/93	21.8	24.0	10.7	−1.15	2	18% Vol	6	0	6
	08/19/93	17.1	18.8	10.6	0.85	0	20% Vol	0	0	8
	09/02/93	14.1	17.6	10.8	−0.75	2	20% Vol	0	0	8
PKC-MW7GPb	04/01/93	18.0	15.0	10.0	2.25	2	18% Vol	7	0	5.5
	04/14/93	3.5	6.4	9.1	0.37	0	24% Vol	8	0	9
	04/30/93	10.8	11.5	10.3	−2.0	0	22% Vol	2	0	7
	05/13/93	15.3	15.7	10.6	−1.50	0	24% Vol	0	0	9.5
	05/27/93	15.3	18.6	10.3	1.20	0	24% Vol	1	0	8
	06/10/93	NM	NM	NM	−1.40	0	22% Vol	1	0	9
	06/24/93	13.5	14.1	12.1	−2.0	0	22% Vol	3	0	8
	07/08/93	14.0	17.7	10.7	0.35	0	22% Vol	1	0	9
	07/22/93	17.7	17.4	10.7	1.40	0	23% Vol	1	0	9.5
	08/05/93	21.8	24.0	11.4	−1.15	0	22% Vol	2	0	9
	08/19/93	17.4	18.9	10.3	0.90	0	22% Vol	0	0	9
	09/02/93	14.3	17.7	10.7	−0.75	11	19% Vol	0	0	3

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC-MW7	04/01/93	17.9	14.9	10.0	2.25	0	21% Vol	8	0	8.5
	04/14/93	5.0	6.4	9.8	0.37	0	17% Vol	11	0	4
	04/30/93	10.9	11.5	10.6	−2.0	12	8% Vol	0	0	0
	05/13/93	15.4	15.8	10.6	−1.60	5	14% Vol	0	0	0
	05/27/93	15.6	18.7	10.2	1.25	2	22% Vol	3	0	10
	06/10/93	NM	NM	NM	−1.50	4	14% Vol	1	0	2
	06/24/93	13.7	14.3	12.0	−1.50	4	14% Vol	1	0	2
	07/08/93	14.4	17.7	10.8	0.40	0	21% Vol	1	0	9.5
	07/22/93	17.7	17.4	10.8	1.50	0	21% Vol	1	0	10
	08/05/93	21.9	24.0	11.0	−1.20	4	14% Vol	2	0	5
	08/19/93	17.6	18.9	10.7	1.00	0	19% Vol	0	0	10
	09/02/93	14.6	18.0	10.6	−0.75	2	19% Vol	0	0	5
PKC-GP16a	03/31/93	11.9	8.0	11.3	0.10	0	57% Vol	14	20	28
	04/15/93	11.7	9.2	10.7	Trace	0	58% Vol	5	16	26
	05/01/93	11.0	11.6	11.8	Trace	0	49% Vol	4	19	28
	05/13/93	18.4	15.9	12.7	−0.05	0	48% Vol	18	14	26
	05/27/93	23.1	17.6	13.9	0.10	0	42% Vol	10	8	30
	06/11/93	NM	NM	NM	−0.05	0	45% Vol	20	6	28
	06/24/93	17.3	14.8	14.3	0.10	0	47% Vol	26	8	28
	07/09/93	13.7	14.8	14.8	Trace	0	36% Vol	0	8	28
	07/23/93	15.6	16.3	15.1	Trace	0	40% Vol	5	6	32
	08/06/93	18.9	18.7	15.3	−0.05	0	36% Vol	0	4	32
	08/20/93	18.1	17.1	15.4	−0.05	0	35% Vol	17	5	32
	09/03/93	16.8	15.2	15.6	−0.05	0	37% Vol	0	5	32

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC-GP16b	03/31/93	11.9	8.0	11.3	2.75	0	17% Vol	9	1	23
	04/15/93	11.5	9.3	9.7	−0.03	0	18% Vol	4	0	22
	05/01/93	11.0	11.6	10.9	2.0	0	15% Vol	3	0	22
	05/13/93	18.6	15.8	11.6	−1.10	0	15% Vol	4	0	22
	05/27/93	23.5	17.2	14.5	0.75	0	13% Vol	7	1	20
	06/11/93	NM	NM	NM	−0.05	0	15% Vol	6	1	22
	06/25/93	17.5	14.8	14.4	0.70	0	14% Vol	10	0	24
	07/09/93	14.0	14.8	14.9	−0.35	0	13% Vol	28	2	22
	07/23/93	15.6	16.3	15.4	−1.15	0	16% Vol	3	3	24
	08/06/93	19.5	18.7	14.3	−0.05	0	14% Vol	2	0	20
	08/20/93	18.1	17.1	16.5	−0.70	0	15% Vol	6	1	22
	09/03/93	17.1	15.2	16.1	−0.85	0	16% Vol	2	1	22
PKC-GP17a	03/31/93	16.5	9.5	17.4	Trace	0	21% Vol	11	1	23
	04/14/93	16.1	10.1	16.6	Trace	0	37% Vol	17	5	25
	04/30/93	20.6	16.1	10.1	Trace	0	37% Vol T	1	0	6.5
	05/13/93	21.0	15.9	16.4	−0.10	0	25% Vol	12	0	26
	05/27/93	24.9	18.5	17.5	0.10	0	18% Vol	7	9	24
	06/10/93	NM	NM	NM	−0.10	0	34% Vol	20	1	28
	06/25/93	15.5	15.4	17.6	0.05	0	30% Vol	14	8	28
	07/08/93	18.9	17.5	17.7	0.15	0	26% Vol	3	16	28
	07/23/93	16.5	17.3	17.7	Trace	0	26% Vol	1	4	30
	08/06/93	17.8	18.9	18.0	−0.05	0	22% Vol	0	1	26
	08/20/93	16.8	17.5	18.0	−0.05	0	11% Vol	15	4	24
	09/03/93	16.0	14.4	18.0	−0.15	0	31% Vol	0	2	30

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM−PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC−GP17b	03/31/93	16.5	9.5	17.4	2.50	0	7% Vol	6	0	16
	04/14/93	16.0	9.8	17.2	2.50	0	7% Vol	4	0	16
	04/30/93	20.8	16.0	11.5	−0.95	0	5% Vol T	1	0	15.5
	05/13/93	21.4	16.0	15.9	−1.30	0	5% Vol	2	0	14
	05/27/93	24.7	18.5	15.6	0.80	0	10% Vol	3	0	16
	06/10/93	NM	NM	NM	−0.25	0	4% Vol	3	7	14
	06/25/93	16.1	15.4	15.7	0.45	0	7% Vol	3	0	16
	07/08/93	19.0	17.5	15.7	0.70	0	5% Vol	5	0	16
	07/23/93	16.7	17.3	16.0	−1.20	0	5% Vol	1	0	16
	08/06/93	18.5	18.9	15.9	−0.15	1	5% Vol	0	0	16
	08/20/93	16.8	17.5	16.2	−0.75	0	4% Vol	2	0	16
	09/03/93	16.3	14.5	16.2	−1.00	0	4% Vol	0	0	14
PKC−GP18	04/01/93	12.9	9.3	8.3	0.80	3	19% LEL	8	0	2
	04/14/93	17.6	10.8	8.6	1.75	2	3% LEL	14	0	2
	04/30/93	15.1	15.5	8.8	0.15	2	2% LEL	2	0	2.5
	05/13/93	22	25.1	9.2	−0.80	0	8% LEL	2	0	2
	05/27/93	24.1	19.3	9.5	0.25	0	2% LEL	3	0	3
	06/10/93	NM	NM	NM	−0.15	0	0% LEL	5	0	3.5
	06/24/93	24.1	21.7	10.6	−0.15	7	0% LEL	1	0	4
	07/08/93	21.4	20.9	11.1	0.20	3	0% LEL	3	0	4.5
	07/22/93	19.7	18.8	11.5	−0.15	2	0% LEL	3	0	4
	08/05/93	29.5	21.9	12.0	0.10	4	0% LEL	2	0	5
	08/19/93	26.1	20.5	12.2	0.30	4	0% LEL	2	0	6
	09/02/93	26.1	18.5	12.5	0.10	7	0% LEL	0	0	4

Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC–GP19a	04/01/93	16.9	11.9	9.9	0.45	0	2% Vol	5	0	5
	04/14/93	13.1	10.3	9.4	0.75	0	4% Vol	7	0	5
	05/01/93	14.2	13.4	10.0	0.8	0	6% Vol	1	0	6
	05/13/93	20	17.4	10.2	−0.20	0	14% Vol	2	0	7
	05/27/93	23.6	18.6	10.5	0.10	0	12% Vol	3	0	7
	06/10/93	NM	NM	NM	−0.01	0	12% Vol	3	0	7
	06/24/93	27.7	18.2	11.1	−0.05	0	8% Vol	1	0	8
	07/08/93	22.2	18.7	11.7	0.10	0	10% Vol	1	0	9
	07/22/93	20.1	18.9	12.0	0.05	0	18% Vol	1	0	8
	08/05/93	28.6	24.7	12.5	−0.05	0	9% Vol	0	0	8.5
	08/19/93	26.9	20.0	12.5	0.10	0	8% Vol	0	0	10
	09/02/93	27.5	25.5	12.8	−0.05	0	9% Vol	0	0	12
PKC–GP19b	04/01/93	16.9	11.9	10.3	1.80	0	31% Vol	4	0	14.5
	04/14/93	13.3	10.3	10.2	1.20	0	38% Vol	9	0	14
	05/01/93	14.3	13.3	11.6	2.5	0	32% Vol	1	0	14
	05/13/93	21.2	17.6	9.8	−1.65	0	36% Vol	2	0	14
	05/27/93	23.8	18.7	11.5	0.75	0	36% Vol	3	0	14
	06/10/93	NM	NM	NM	−0.60	0	37% Vol	5	0	14
	06/24/93	26.8	18.2	11.2	−1.25	0	36% Vol	3	0	14
	07/08/93	22.5	18.7	11.5	0.45	0	35% Vol	1	0	14
	07/22/93	20.6	18.9	11.4	0.85	0	35% Vol	1	0	14.5
	08/05/93	30.0	24.7	11.4	−0.85	0	34% Vol	0	0	14
	08/19/93	27.6	20.1	11.4	0.90	0	34% Vol	0	0	15
	09/02/93	27.7	25.5	11.5	−0.3	2	31% Vol	0	0	14

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC–GP20a	04/01/93	17.6	12.2	8.6	2.25	0	10% Vol	10	0	3
	04/14/93	9.6	7.3	8.5	0.47	0	2% Vol	5	0	2.5
	04/30/93	14.3	13.1	9.3	−1.0	0	2% Vol	1	0	1
	05/13/93	18.4	15.5	10.6	−1.45	0	4% Vol	2	0	3
	05/27/93	16.7	17.0	9.9	0.25	3	2% Vol	3	0	3
	06/10/93	NM	NM	NM	−1.05	0	12% Vol	3	0	3
	06/24/93	19.0	16.4	9.9	−1.55	0	9% Vol	1	0	2
	07/08/93	17.6	17.8	10.2	0.15	0	29% Vol	1	0	2.5
	07/22/93	17.4	17.3	10.4	0.80	0	26% Vol	1	0	3
	08/05/93	21.4	21.9	10.4	−0.80	0	24% Vol	0	0	3
	08/19/93	23.0	18.2	10.6	0.60	0	24% Vol	0	0	3.5
	09/02/93	19.7	17.8	10.6	−0.35	0	22% Vol	0	0	4
PKC–GP20b	04/01/93	17.5	12.1	9.2	2.25	0	37% Vol	9	0	15
	04/14/93	10.0	7.4	8.8	0.65	0	43% Vol	7	0	13
	04/30/93	14.9	13.2	10.5	−1.50	0	38% Vol	2	0	13
	05/13/93	18.6	15.5	10.5	−1.60	0	35% Vol	2	0	14
	05/27/93	16.7	17.0	10.5	1.05	0	35% Vol	4	0	15
	06/10/93	NM	NM	NM	−1.20	0	38% Vol	3	0	12
	06/24/93	19.3	16.5	10.4	−1.85	0	38% Vol	4	0	11
	07/08/93	17.7	17.8	10.4	0.35	0	36% Vol	1	0	13
	07/22/93	17.5	17.3	10.4	1.15	0	36% Vol	1	0	14
	08/05/93	22.1	21.9	10.5	−1.20	0	35% Vol	2	0	12.5
	08/19/93	23.1	18.3	10.5	0.95	0	35% Vol	0	0	4
	09/02/93	20.0	17.8	10.4	−0.65	0	22% Vol	0	0	13

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC-GP21a	04/02/93	10.8	9.4	NM	-0.95	20	NM	NM	NM	NM
	04/15/93	12.4	14.9	10.5	-0.50	20.7	1% LEL [a]	0 [a]	1 [a]	0 [a]
	05/01/93	13.3	13.0	11.7	2.50	0	16% Vol	1	0	8
	05/14/93	23.4	21.3	11.6	-1.0	0	16% Vol	4	0	9
	05/28/93	16.3	16.9	11.6	-0.60	0	20% Vol	1	0	10
	06/11/93	NM	NM	NM	-0.35	0	19% Vol	8	0	10
	06/25/93	30.2	28.4	11.5	1.20	0	15% Vol	5	3	12
	07/09/93	19.3	19.5	11.5	-0.55	0	20% Vol	3	2	10
	07/23/93	18.5	19.8	11.4	-1.60	0	20% Vol	1	0	12
	08/06/93	24.3	23.4	11.3	0.45	0	21% Vol	0	4	12
	08/20/93	24.8	25.5	11.3	-0.65	0	20% Vol	2	0	12
	09/03/93	27.8	20.3	11.5	-0.70	0	18% Vol	0	0	12
PKC-GP21b	04/02/93	10.8	9.4	NM	-0.95	20	NM	NM	NM	NM
	04/15/93	12.3	14.8	10.4	-0.50	0	12% Vol	0	0	9.5
	05/01/93	13.2	13.0	11.7	2.50	0	14% Vol	1	0	10
	05/14/93	24.5	22.1	11.6	-1.05	0	13% Vol	0	0	12
	05/28/93	16.7	16.9	11.7	-0.60	0	16% Vol	1	0	12
	06/11/93	NM	NM	NM	-0.30	0	20% Vol	8	0	12
	06/25/93	30.2	28.5	11.6	1.20	0	15% Vol	5	0	12.5
	07/09/93	17.1	19.5	11.5	-0.60	0	19% Vol	5	0	12
	07/23/93	18.6	19.8	11.5	-1.65	0	20% Vol	1	0	13
	08/06/93	25.1	23.4	11.4	0.45	0	19% Vol	2	0	12
	08/20/93	25.1	25.5	11.3	-0.65	0	19% Vol	2	0	13
	09/03/93	27.9	20.3	11.3	-0.70	0	19% Vol	0	0	12

Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
PKC-GP22a	03/31/93	14.3	8.7	6.3	1.75	0	7% Vol	5	0	14
	04/14/93	15.3	8.2	7.0	2.0	0	11% Vol	7	10	16
	04/30/93	17.5	13.9	10.1	−0.45	0	8% Vol	4	0	16.5
	05/13/93	19.3	15.5	10.5	−1.50	0	14% Vol	2	0	17
	05/27/93	20.9	19.8	10.4	0.80	0	15% Vol	1	0	17
	06/10/93	NM	NM	NM	−0.40	0	8% Vol	3	0	16
	06/24/93	22.1	16.1	9.9	−0.60	0	9% Vol	1	0	16.5
	07/08/93	19.5	17.3	10.5	0.50	0	12% Vol	0	1	17
	07/22/93	18.6	18.1	10.6	0.30	0	10% Vol	1	0	17
	08/05/93	27.7	20.2	10.8	−0.25	0	10% Vol	0	0	16.5
	08/19/93	23.8	19.1	10.8	0.85	0	9% Vol	0	0	16
	09/02/93	24.4	17.4	10.8	Trace	0	9% Vol	0	0	17
PKC-GP22b	03/31/93	14.3	8.7	6.3	1.75	0	7% Vol	9	0	13
	04/14/93	15.6	8.3	7.1	2.25	0	9% Vol	4	0	15
	04/30/93	17.0	13.8	10.0	−0.50	0	7% Vol	3	0	15
	05/13/93	19.5	15.5	10.2	−1.60	0	8% Vol	2	0	15
	05/27/93	20.5	19.6	10.6	0.85	0	8% Vol	1	0	15
	06/10/93	NM	NM	NM	−0.45	0	8% Vol	5	0	15
	06/24/93	22.2	16.1	10.4	−0.65	0	8% Vol	1	0	16
	07/08/93	19.5	17.3	10.6	0.55	0	7% Vol	0	0	15
	07/22/93	18.7	18.2	10.5	0.30	0	7% Vol	1	0	15.5
	08/05/93	27.8	20.2	10.7	−0.35	0	7% Vol	0	0	15
	08/19/93	23.8	19.1	10.8	0.93	0	6% Vol	0	0	15
	09/02/93	24.4	17.4	10.8	Trace	0	7% Vol	0	0	15

Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
GMW–1A	05/06/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	19	0% LEL	NM	NM	NM
	03/09/90	40	NM	NM	NM	21	0% LEL	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	1% LEL	NM	NM	NM
	03/31/93	NM	NM	NM	NM	NM	NM	NM	NM	NM
	04/15/93	10.2	8.4	8.0	Trace	20.8	0% LEL [a]	0 [a]	0 [a]	0 [a]
	05/01/93	10.0	9.8	8.8	Trace	18	0% LEL	1	0	0
	05/14/93	21.8	13.3	10.3	–0.05	17	0% LEL	4	0	0
	05/28/93	18.9	17.1	10.2	Trace	17	0% LEL	1	0	1
	06/11/93*	NM	NM	NM	Trace	17	0% LEL	3	0	1
GMW–1B	05/06/89	NM	NM	NM	NM	NM	5% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	5% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	17	4% LEL	NM	NM	NM
	03/09/90	40	NM	NM	NM	7	8% Vol	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	1% LEL	NM	NM	NM
	03/31/93	NM	NM	NM	NM	NM	NM	NM	NM	NM
	04/15/93	10.4	8.4	9.3	–0.25	20.8	0% LEL [a]	0 [a]	0 [a]	0 [a]
	05/01/93	10.0	9.8	10.5	1.30	1	1% Vol	1	0	6
	05/14/93	22.6	13.1	10.2	–0.40	11	2% Vol	0	0	3
	05/28/93	18.9	17.0	10.3	0.25	2	2% Vol	1	0	2.5
	06/11/93*	NM	NM	NM	Trace	18	0% LEL	3	0	2

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM–PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
GMW–2A	05/06/89	NM	NM	NM	NM	NM	35% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	100% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	100% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	30% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	4	3% Vol	NM	NM	NM
	03/09/90	40	NM	NM	NM	1	4% Vol	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	13% Vol	NM	NM	NM
	03/31/93	NM	NM	NM	NM	NM	NM	NM	NM	NM
	04/15/93	11.3	10.5	8.0	Trace	20.7	2% LEL [a]	4 [a]	0 [a]	0 [a]
	05/01/93	10.8	10.6	9.8	0.10	18	0% LEL	1	0	2
	05/14/93	16.3	14.1	9.8	−0.25	15	0% LEL	8	0	5.5
	05/28/93	26.8	20.2	10.6	0.40	2	9% Vol	1	0	12
	06/11/93*	NM	NM	NM	0.20	2	7% Vol	3	0	11
GMW–2B	05/06/89	NM	NM	NM	NM	NM	75% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	50% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	2% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	21	0% LEL	NM	NM	NM
	03/09/90	40	NM	NM	NM	21	0% LEL	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	7.5% Vol	NM	NM	NM
	03/31/93	NM	NM	NM	NM	NM	NM	NM	NM	NM
	04/15/93	11.3	10.5	9.3	Trace	20.7	1% LEL [a]	2 [a]	0 [a]	0 [a]
	05/01/93	10.8	10.6	9.8	Trace	20.8	0% LEL [a]	1 [a]	0 [a]	0 [a]
	05/14/93	16.9	14.1	9.8	−0.10	17	0% LEL	8	0	0
	05/28/93	25.4	19.9	10.8	0.05	20	0% LEL	1	0	0
	06/11/93*	NM	NM	NM	0.55	0	2% Vol	3	0	10

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Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Temperature Ground (°C)	Temperature Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
GMW-3A	05/06/89	NM	NM	NM	NM	NM	100% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	18	2% LEL	NM	NM	NM
	03/09/90	40	NM	NM	NM	NM	Trace LEL	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	1% LEL	NM	NM	NM
	03/31/93	16.9	9.3	10.4	1.75	20.7	0% LEL [a]	1 [a]	0 [a]	0 [a]
	04/15/93	8.8	8.8	10.6	0.55	14	2% Vol	19	0	1
	05/01/93	9.5	10.8	11.6	1.35	11	1% LEL	4	0	4
	05/14/93	13.8	13.5	11.6	−0.80	8	0% LEL	6	0	3.5
	05/28/93	16.4	15.7	11.7	−0.15	4	0% LEL	3	0	5.5
	06/11/93*	NM	NM	NM	−0.30	15	0% LEL	3	0	10
GMW-3B	05/06/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	26% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	10	3% LEL	NM	NM	NM
	03/09/90	40	NM	NM	NM	NM	2.5% Vol	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	4% LEL	NM	NM	NM
	03/31/93	16.9	9.3	9.7	0.15	20.7	0% LEL [a]	1 [a]	0 [a]	0 [a]
	04/15/93	8.8	8.8	9.8	0	17	2% Vol	2	0	1
	05/01/93	9.5	10.8	10.0	0.05	17	0% LEL	2	0	2.5
	05/14/93	13.8	13.5	11.7	−0.10	15	0% LEL	4	0	3.0
	05/28/93	16.5	15.7	10.6	−0.05	14	0% LEL	3	0	4.5
	06/11/93*	NM	NM	NM	Trace	16	0% LEL	5	0	2

AGI TECHNOLOGIES

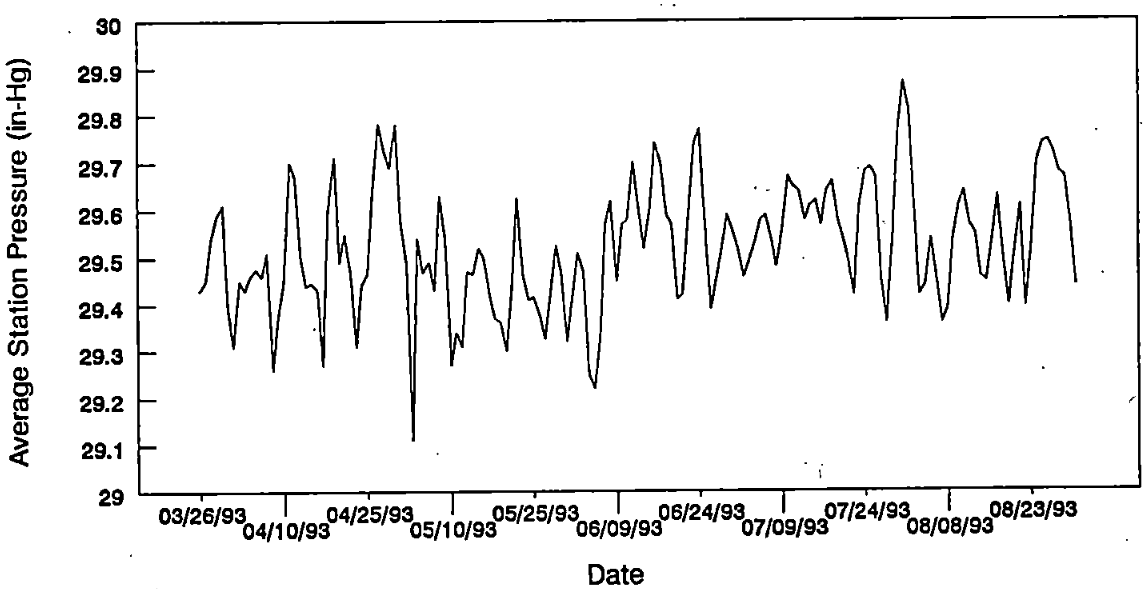
Table G1
Gas Probe Monitoring Data
Puyallup/Kit Corner Custodial Landfill
King County, Washington

Probe No.	Date	Temperature Ambient (°C)	Ground (°C)	Downhole (°C)	Pressure Differential (inches H_2O)	Oxygen (O_2) (% Vol)	Combustible Gas (%Vol or %LEL)	VOCs (OVM-PID) (ppm)	H_2S (ppm)	CO_2 (%Vol)
GMW-4	05/06/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	06/29/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	08/15/89	NM	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/07/90	45	NM	NM	NM	NM	0% LEL	NM	NM	NM
	03/08/90	35	NM	NM	NM	NM	NM	NM	NM	NM
	03/09/90	40	NM	NM	NM	NM	1% LEL	NM	NM	NM
	05/09/90	60	NM	NM	NM	NM	20% LEL	NM	NM	NM
	03/31/93	NM	NM	NM	NM	NM	NM	NM	NM	NM
	04/15/93	9.5	9.8	8.3	Trace	20.7	0% LEL [a]	0 [a]	0 [a]	0 [a]
	05/01/93	9.3	10.2	8.8	Trace	13	0% LEL	1	0	1
	05/14/93	15.9	13.8	9.1	-0.05	11	0% LEL	6	0	3.0
	05/28/93	18.5	15.4	9.6	Trace	16	0% LEL	1	0	2
	06/11/93*	NM	NM	NM	Trace	16	0% LEL	3	0	2

Notes:

*Cap off probe upon arrival; cap replaced for at least 30 minutes prior to monitoring.
a) Data unreliable; unable to purge probe due to elevated negative pressure differential.
b) Screen submerged during monitoring period. Gas data represents degassing of water within well casing.
For Probe Nos. GMW-1A through GMW-4: 1989 data collected by Associated Earth Sciences, Inc.; 1990 data collected by King County Public Works/ Solid Waste Division.
Trace indicates reading was less than ±0.01 inches H_2O.
5.3% Vol = 100% LEL for methane.
NM - Not measured.
T - PKC-GP17a and PKC-GP17b combustible gas data transposed.

Barometric Pressure
March 26 - August 31, 1993
Seattle-Tacoma International Airport



Source: National Oceanic & Atmospheric Administration
Local Climatological Data Monthly Summary for
March through August, 1993.

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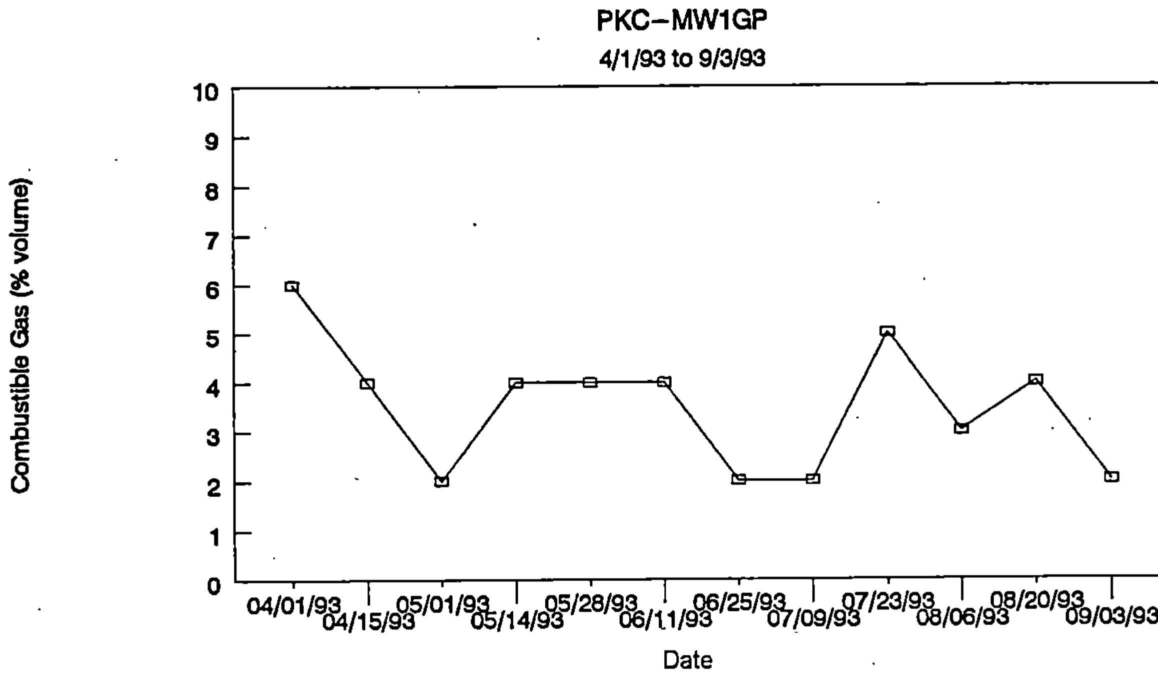
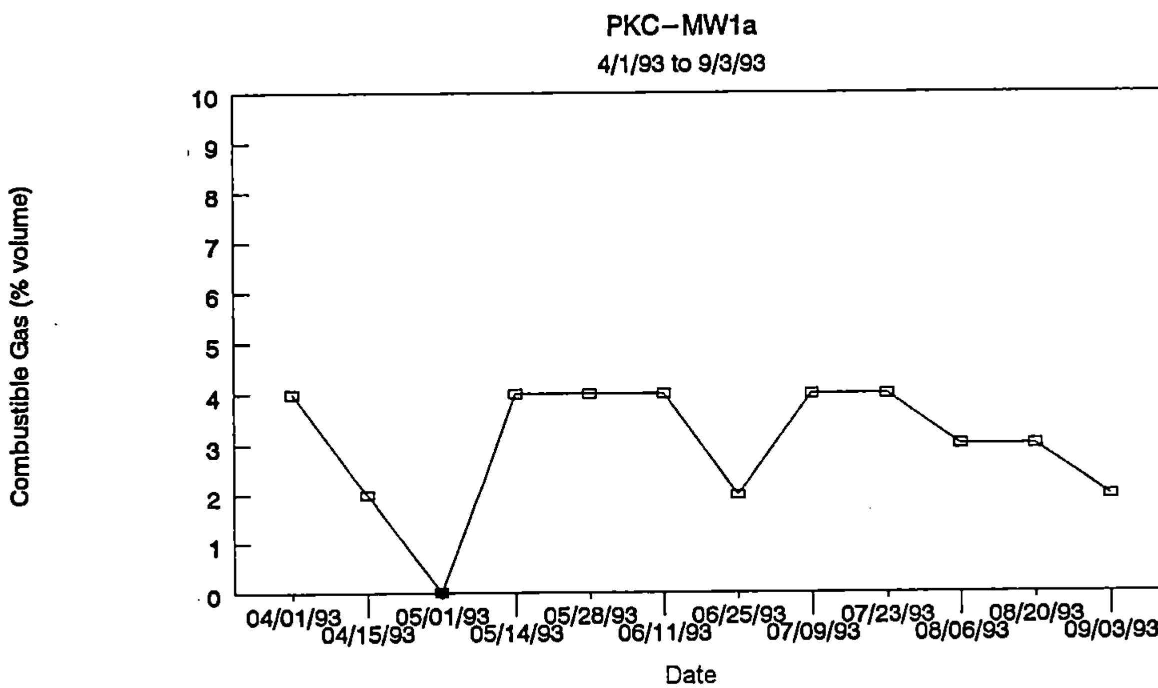
Barometric Pressure

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G1

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,621.114	DFF				





■ Data point unreliable, unable to purge probe due to elevated negative differential pressure.

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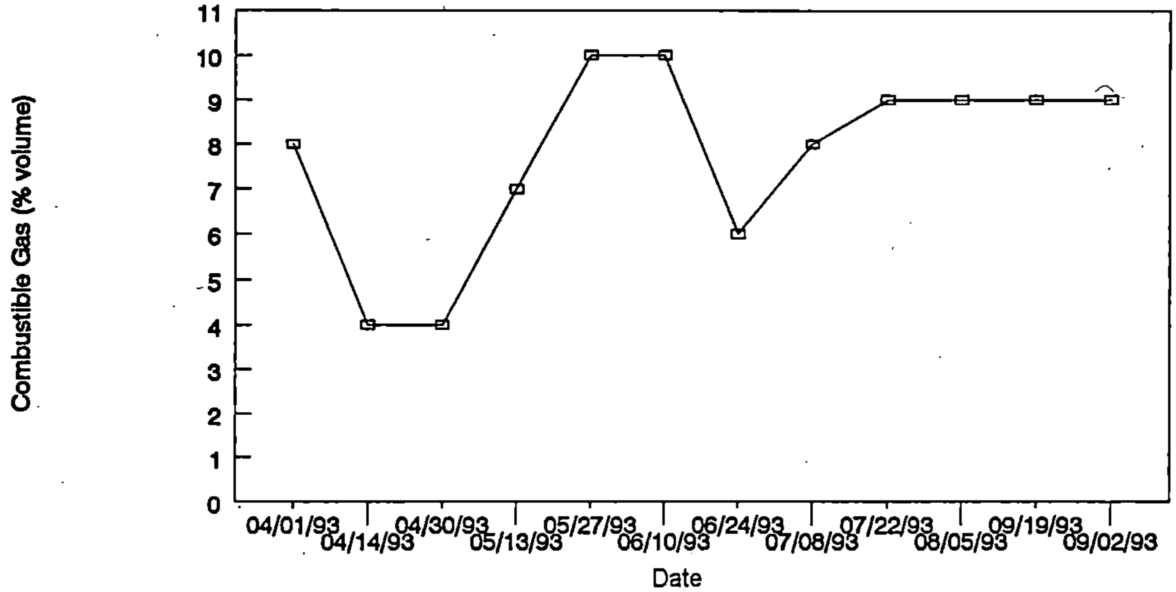
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

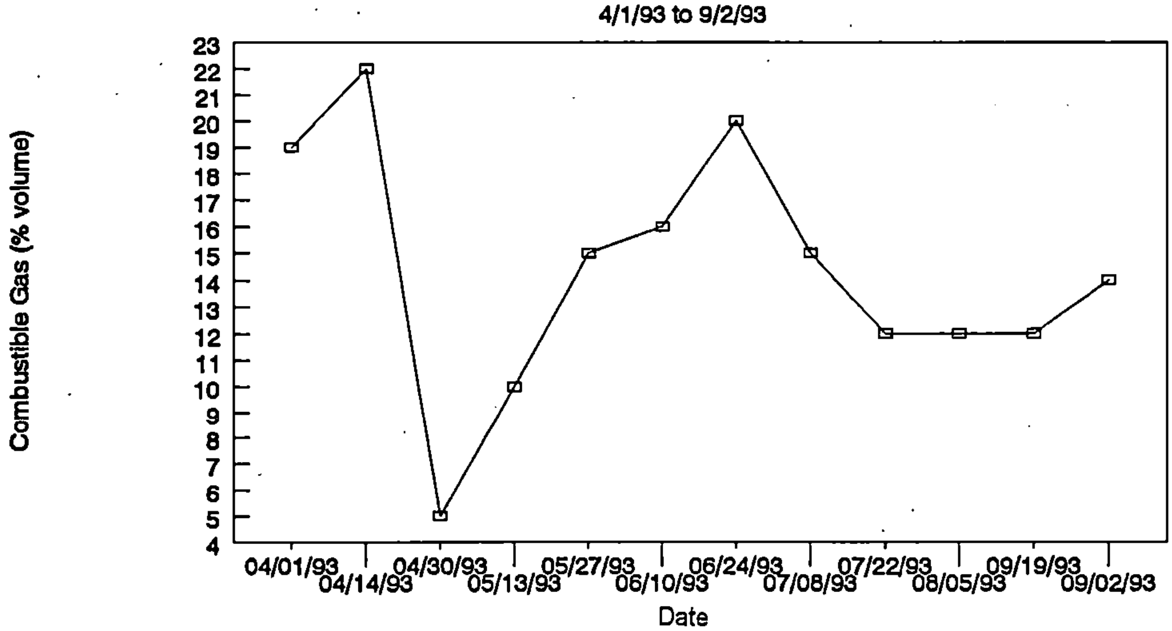
PLATE
G2

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				

PKC-MW2GPa
4/1/93 to 9/2/93



PKC-MW2GPb
4/1/93 to 9/2/93



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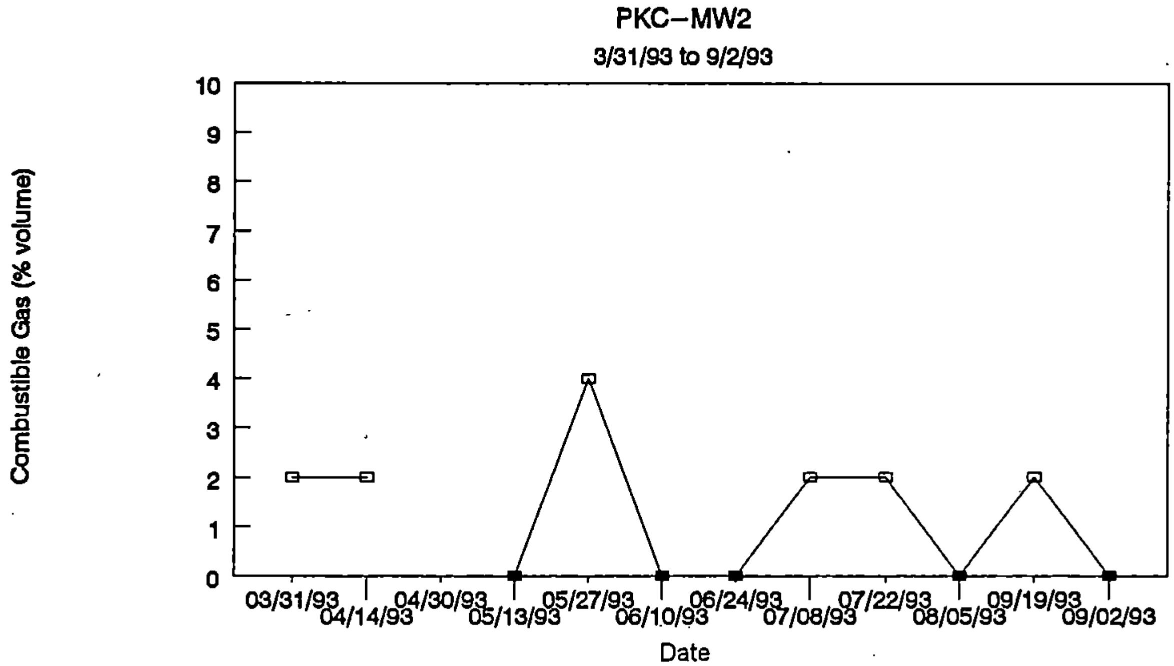
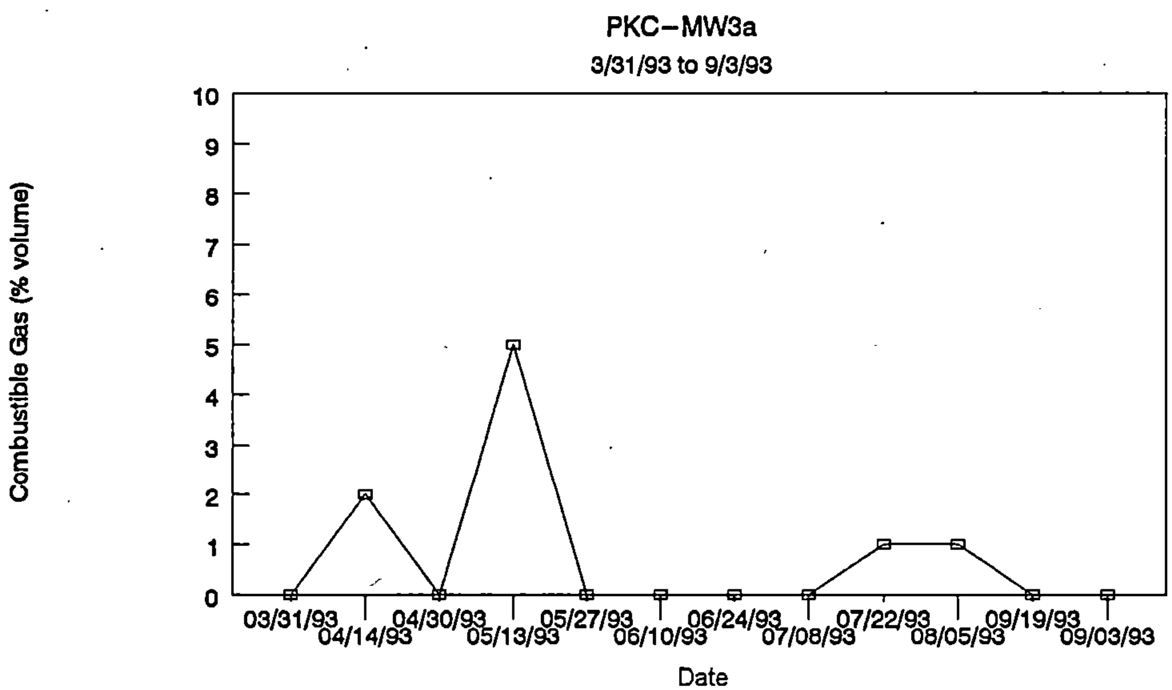
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G3

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621. 114	DFF				





■ Data point unreliable, unable to purge probe due to elevated negative differential pressure.

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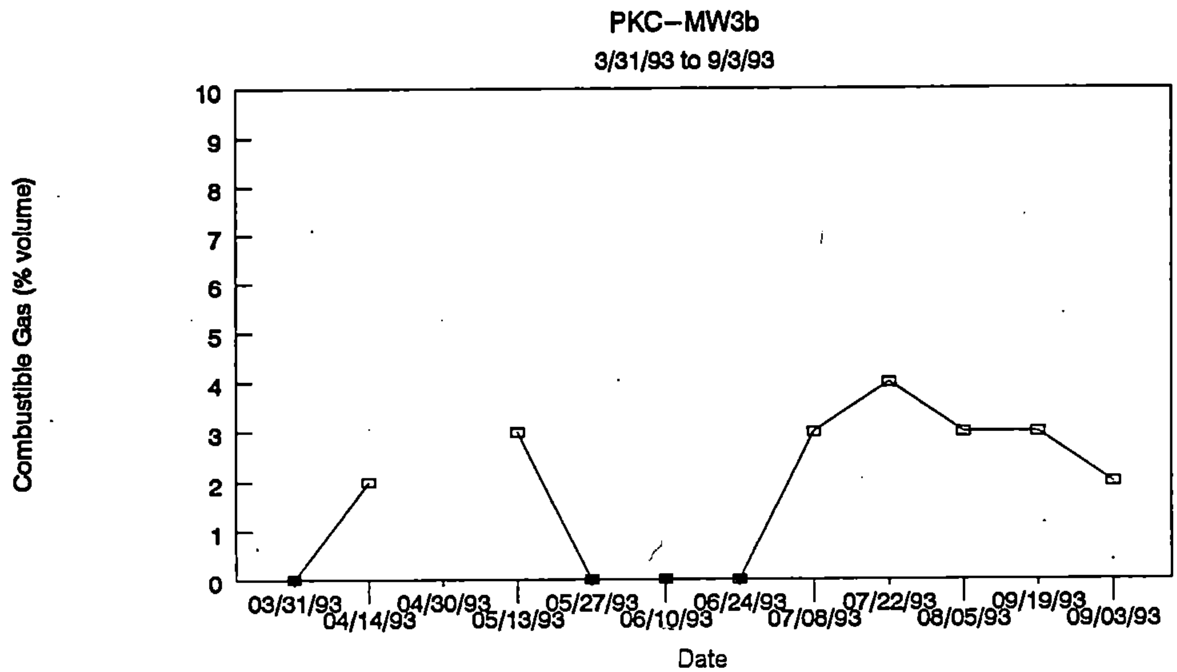
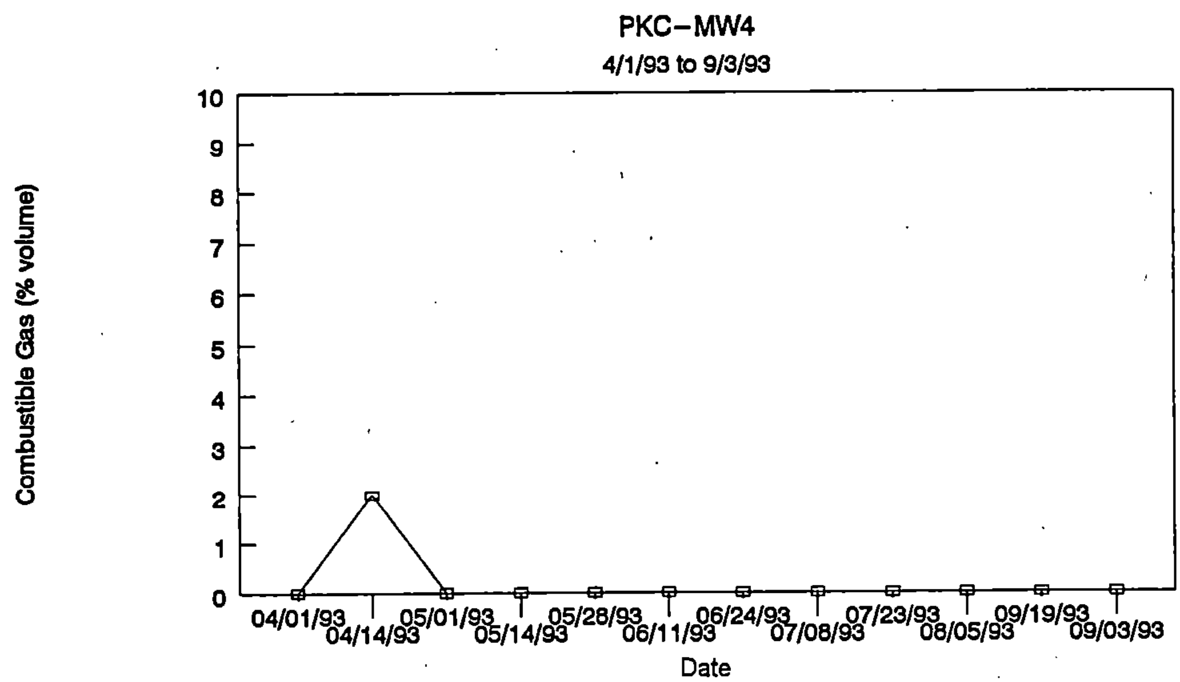
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G4

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





■ Data point unreliable, unable to purge probe due to elevated negative differential pressure.

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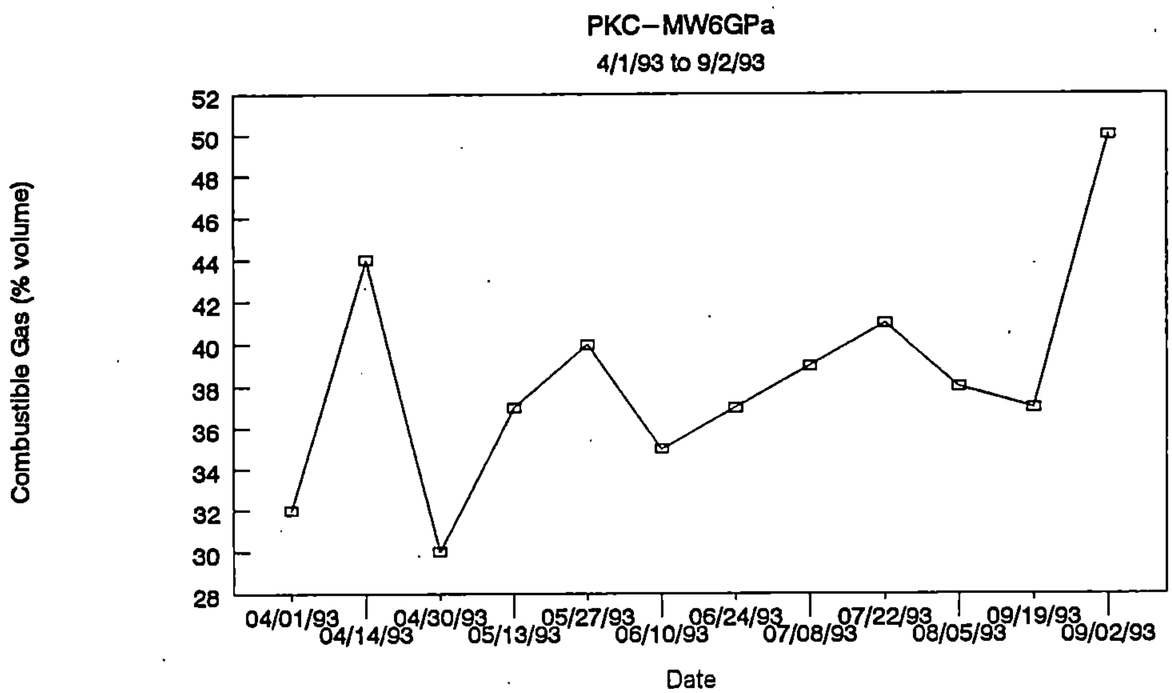
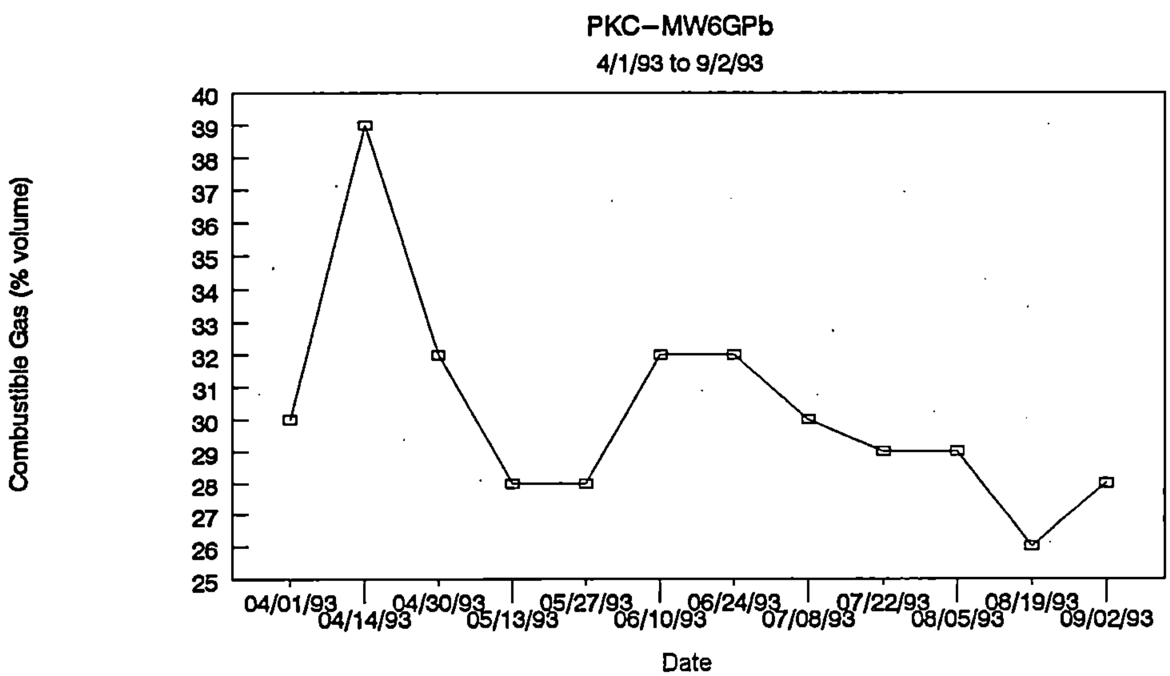
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G5

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





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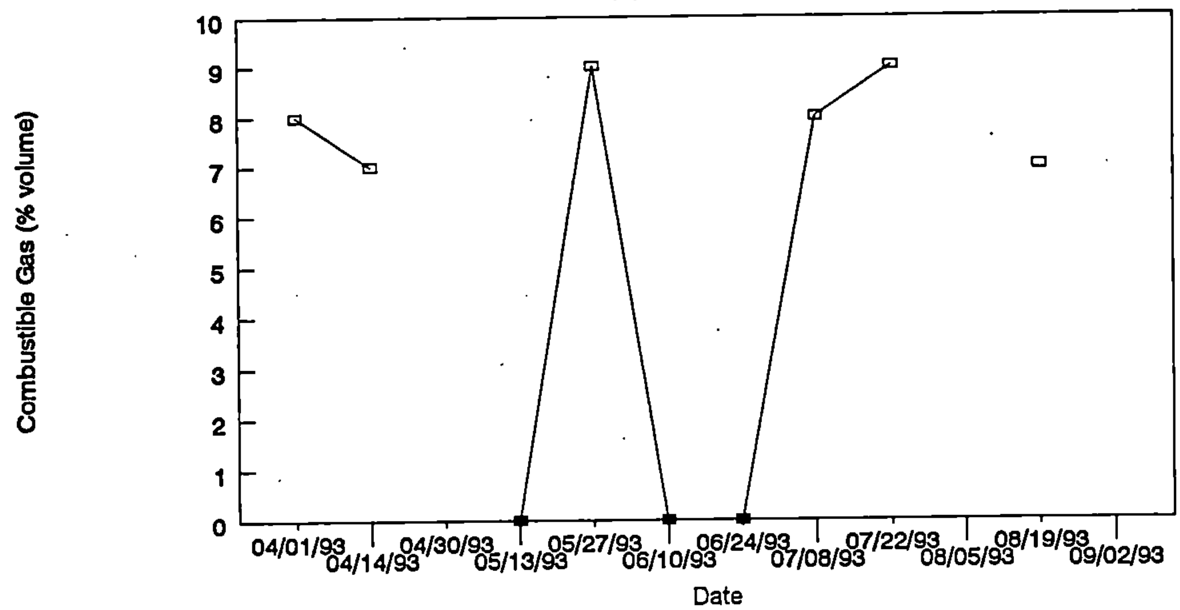
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

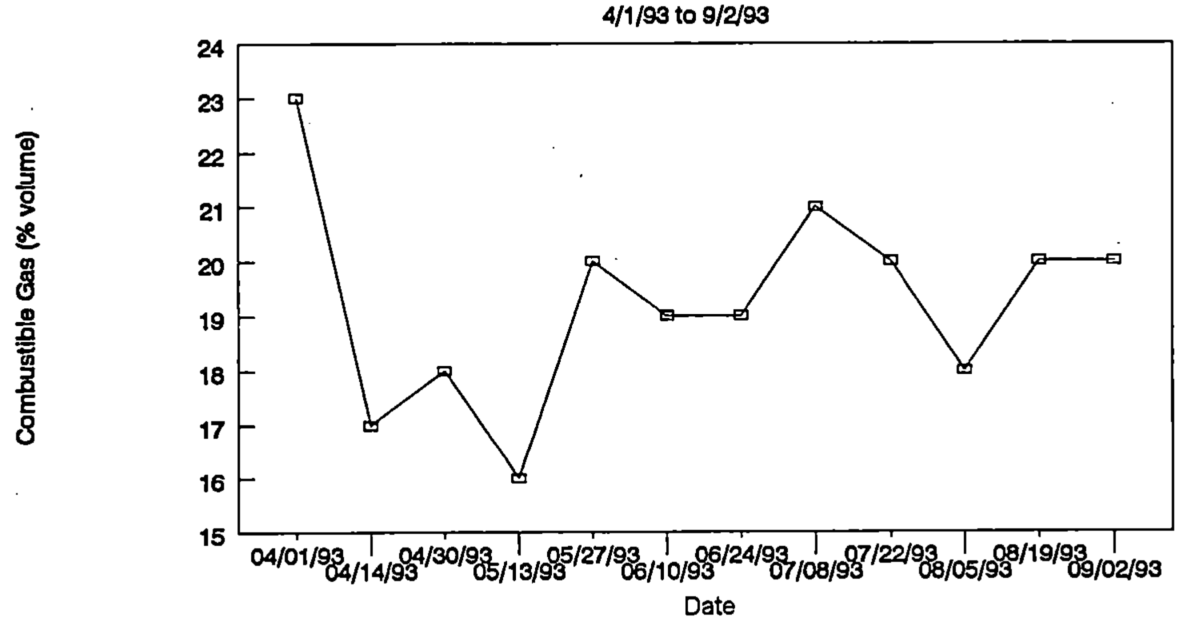
PLATE
G6

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				

PKC−MW6
4/1/93 to 9/2/93



PKC−MW7GPa
4/1/93 to 9/2/93



■ Data point unreliable, unable to purge probe due to elevated negative differential pressure.

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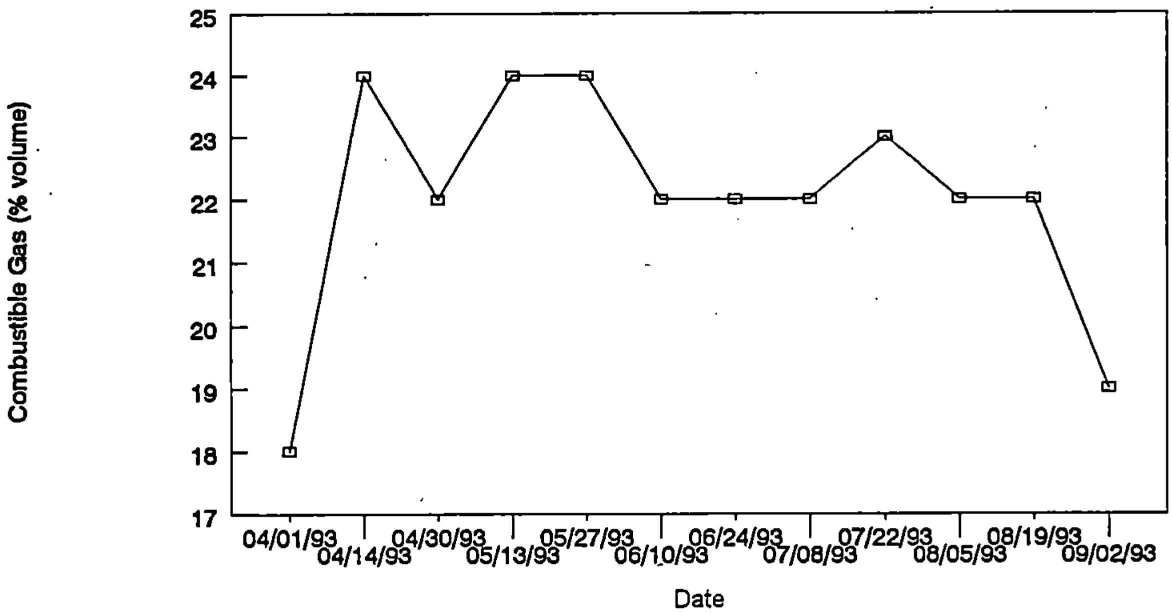
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

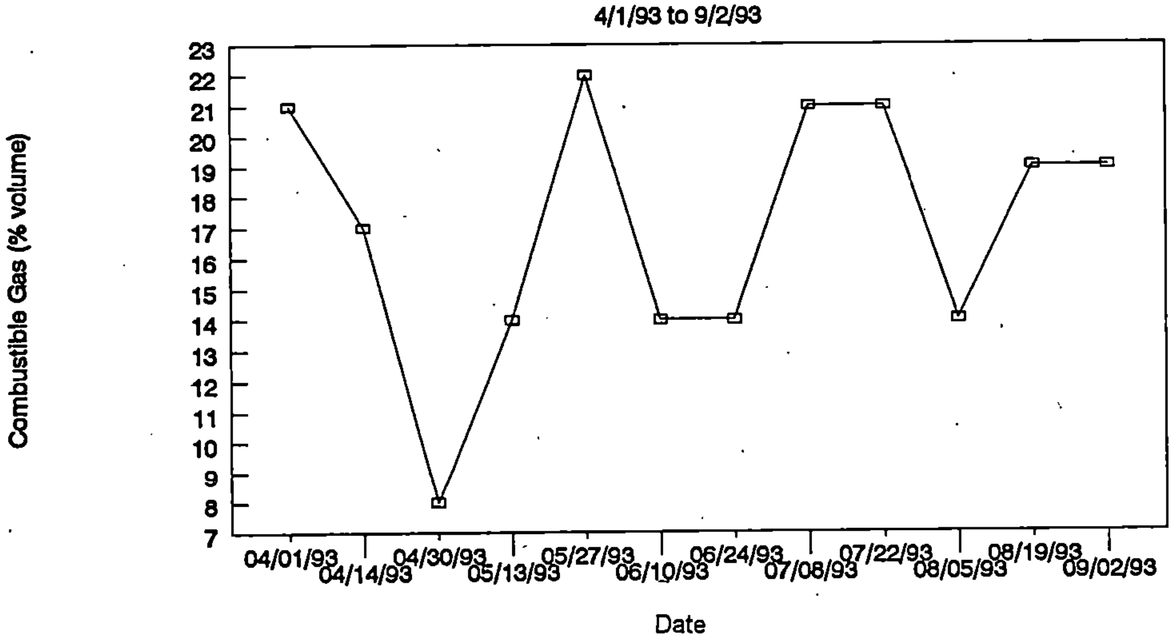
PLATE
G7

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				

PKC-MW7GPb
4/1/93 to 9/2/93



PKC-MW7
4/1/93 to 9/2/93



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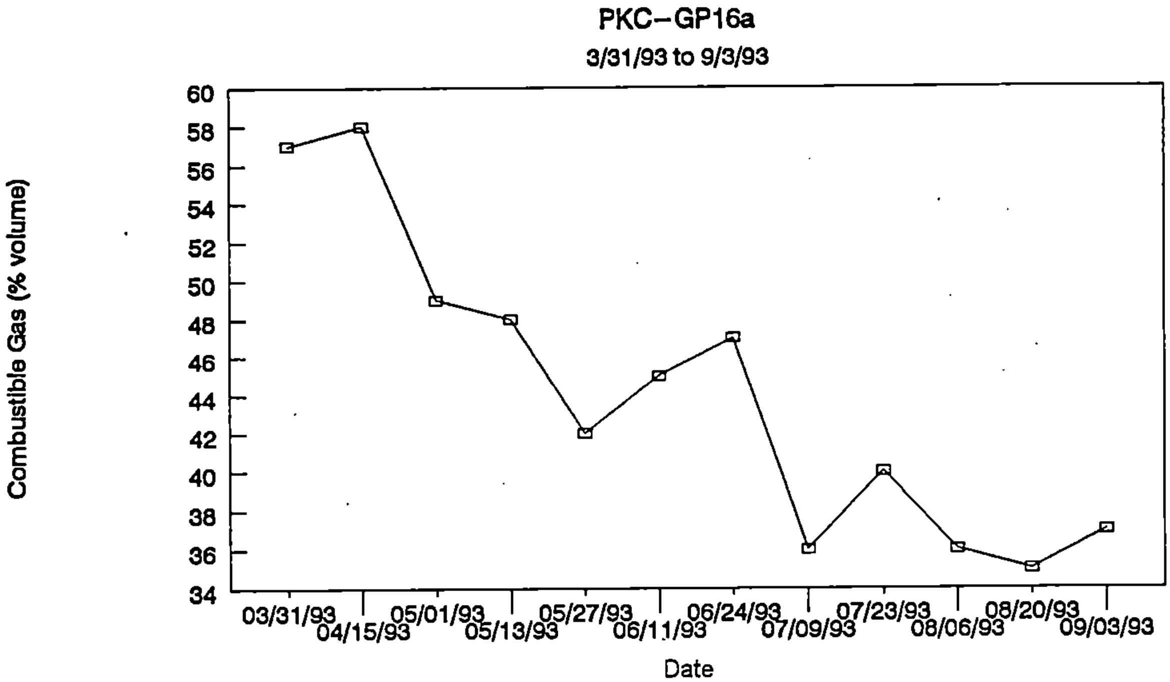
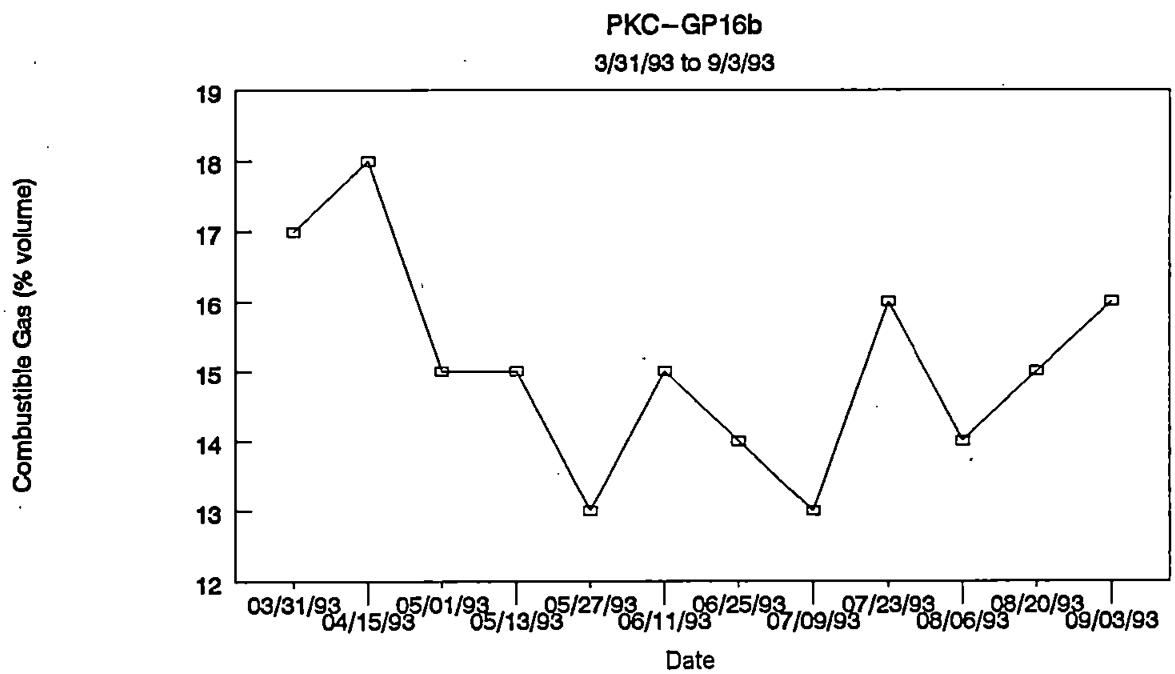
Combustible Concentration vs. Time
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G8

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15.621.114	DFF				





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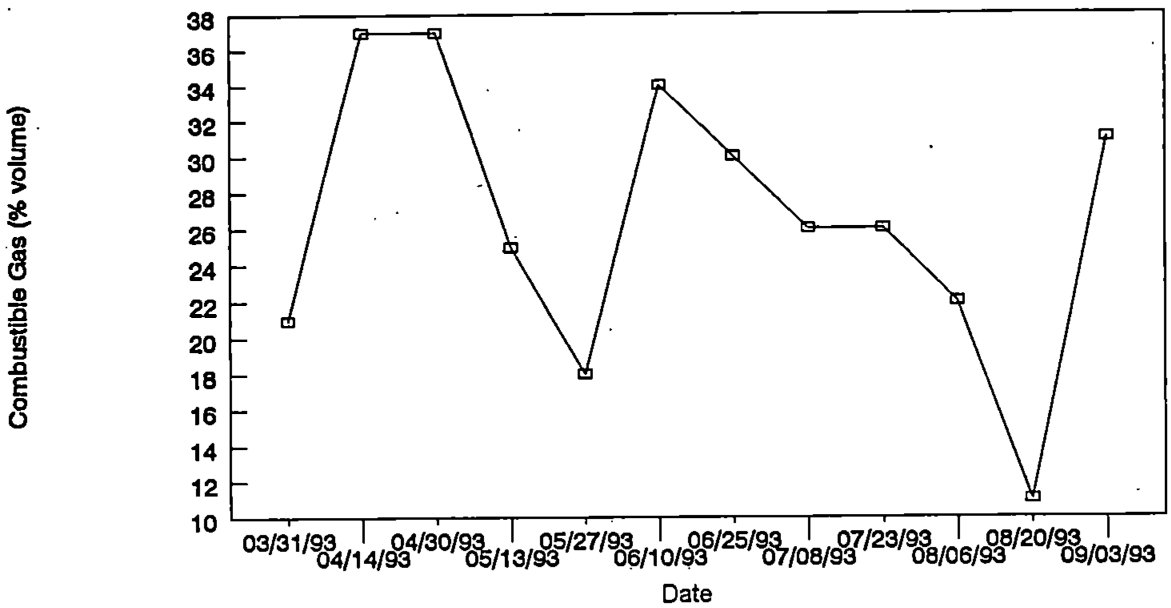
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

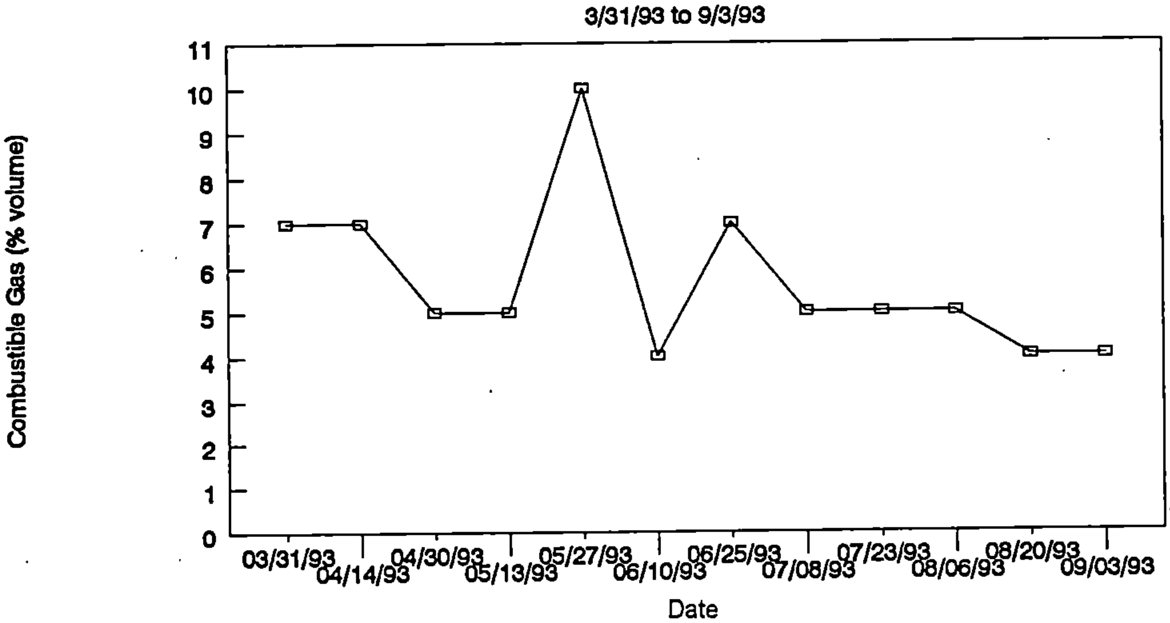
PLATE
G9

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				

PKC-GP17a
3/31/93 to 9/3/93



PKC-GP17b
3/31/93 to 9/3/93



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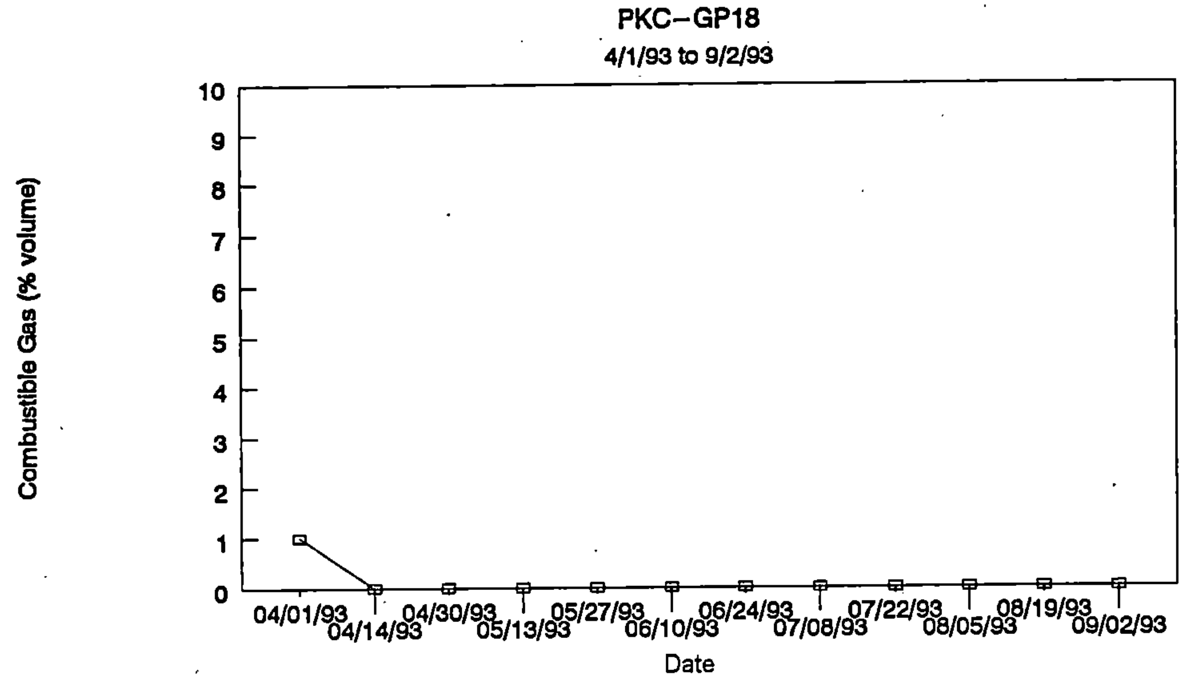
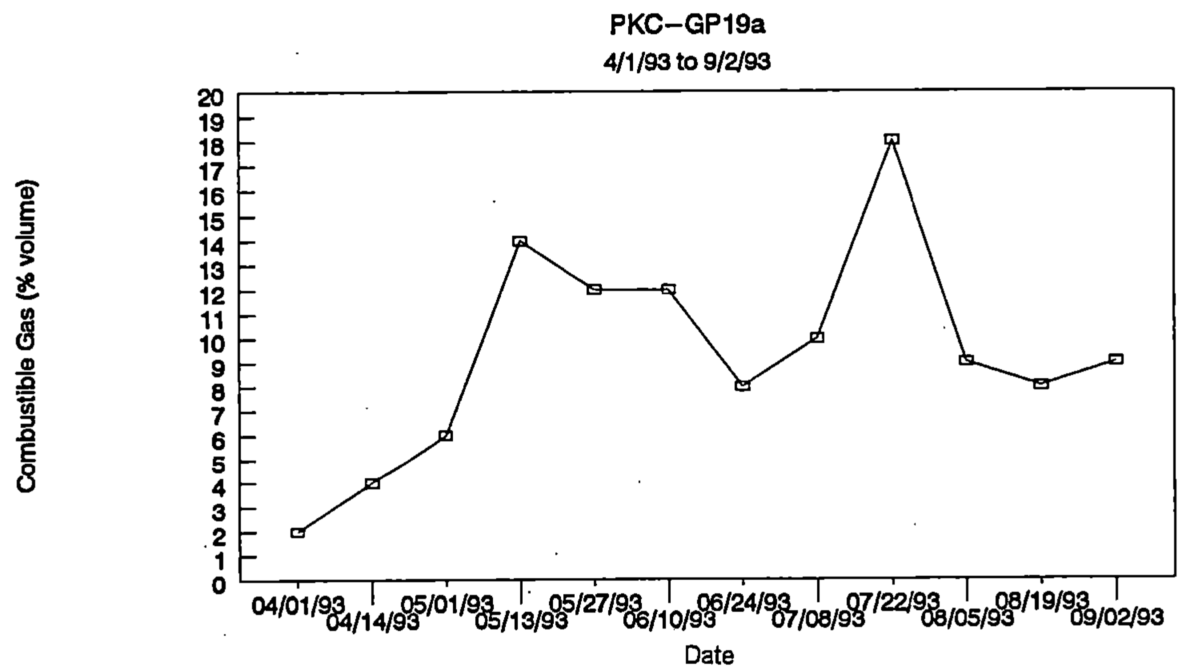
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G10

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





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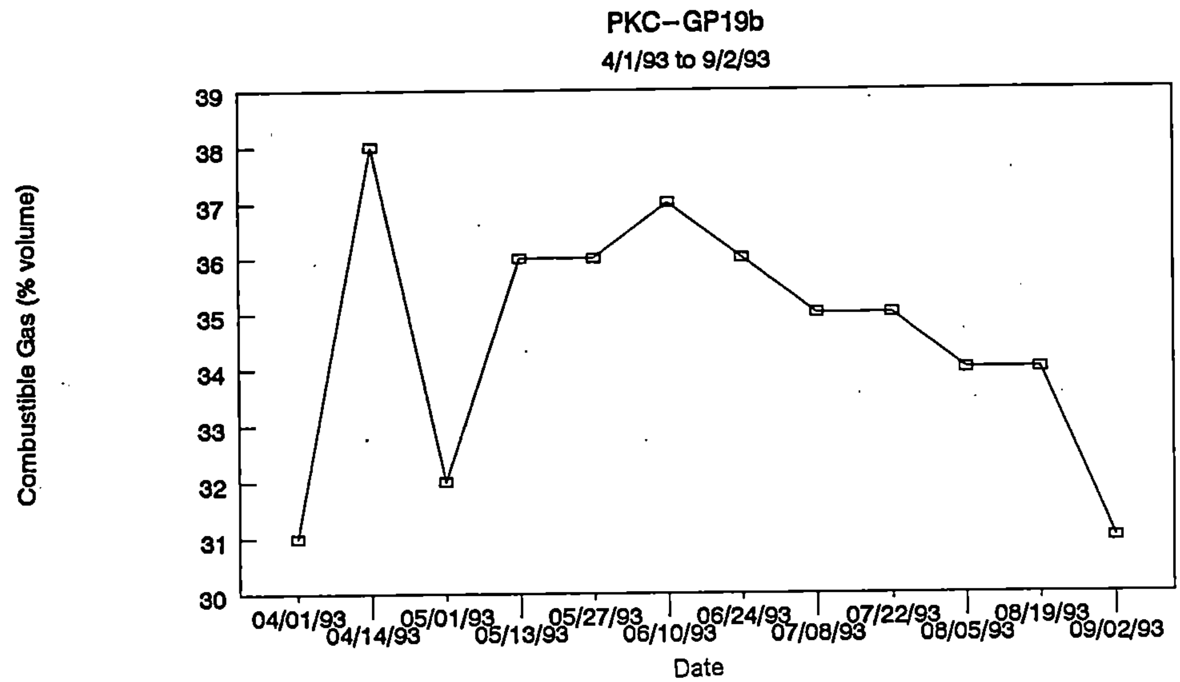
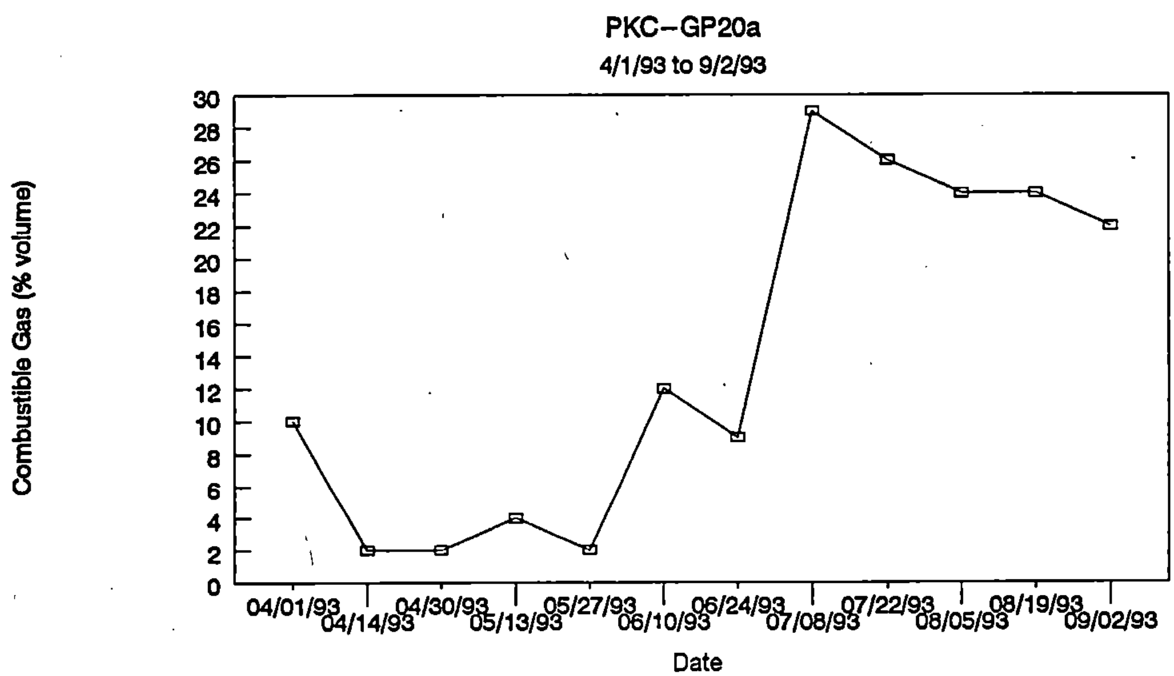
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G11

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





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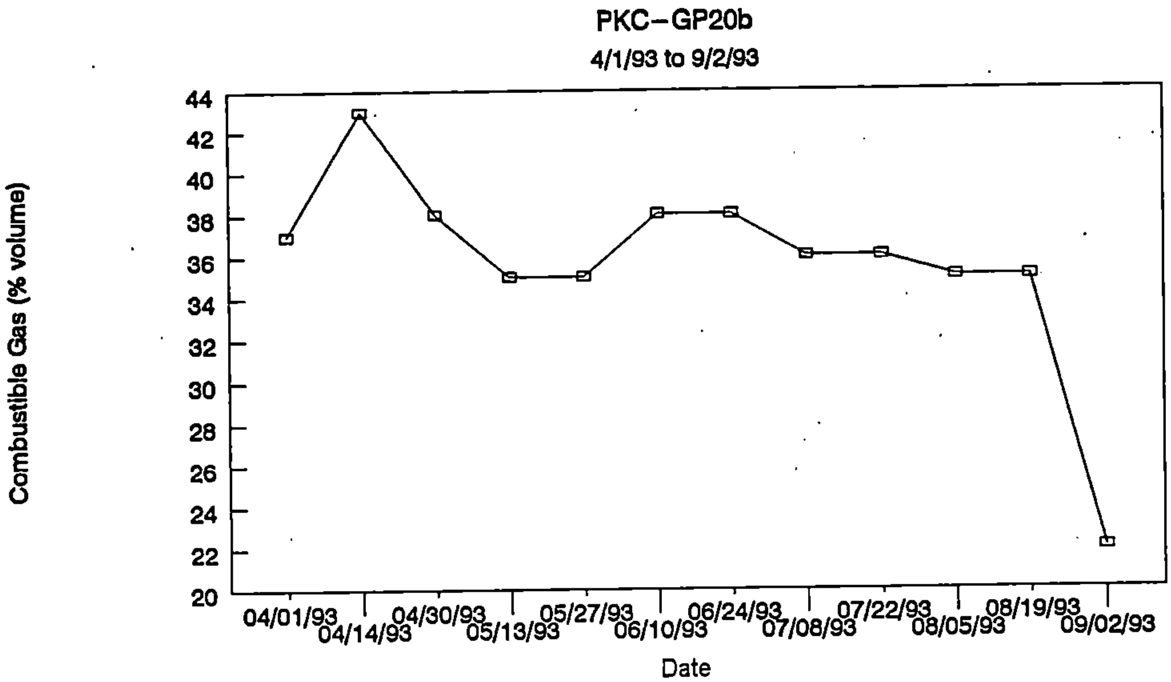
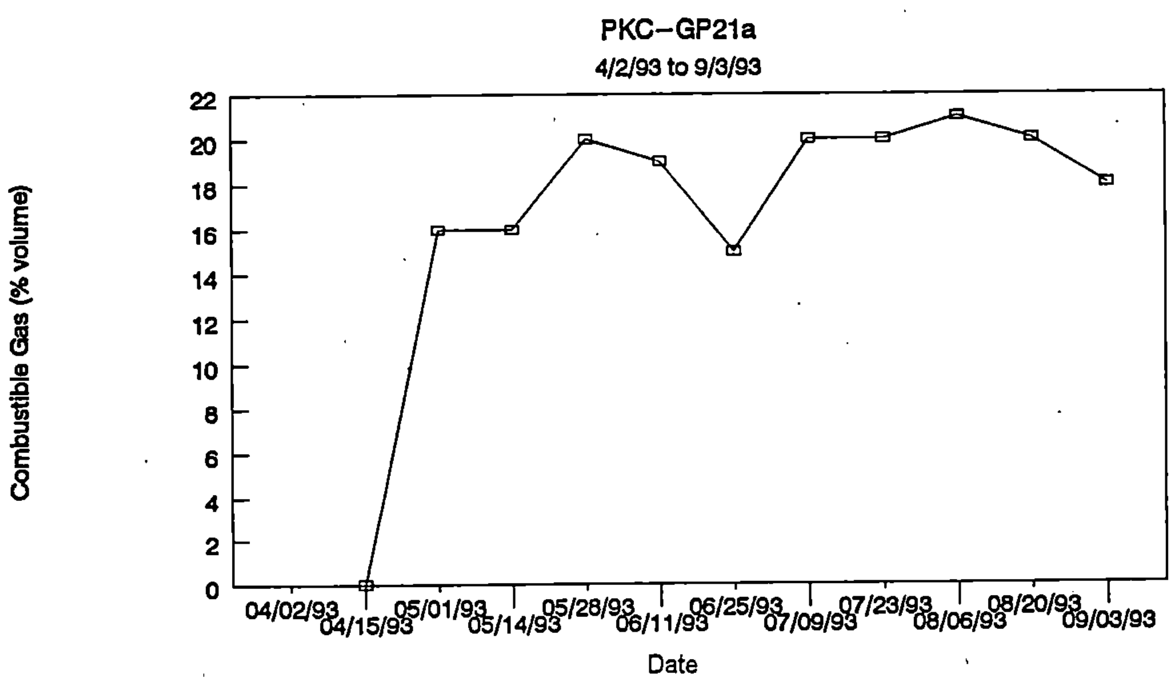
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G12

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





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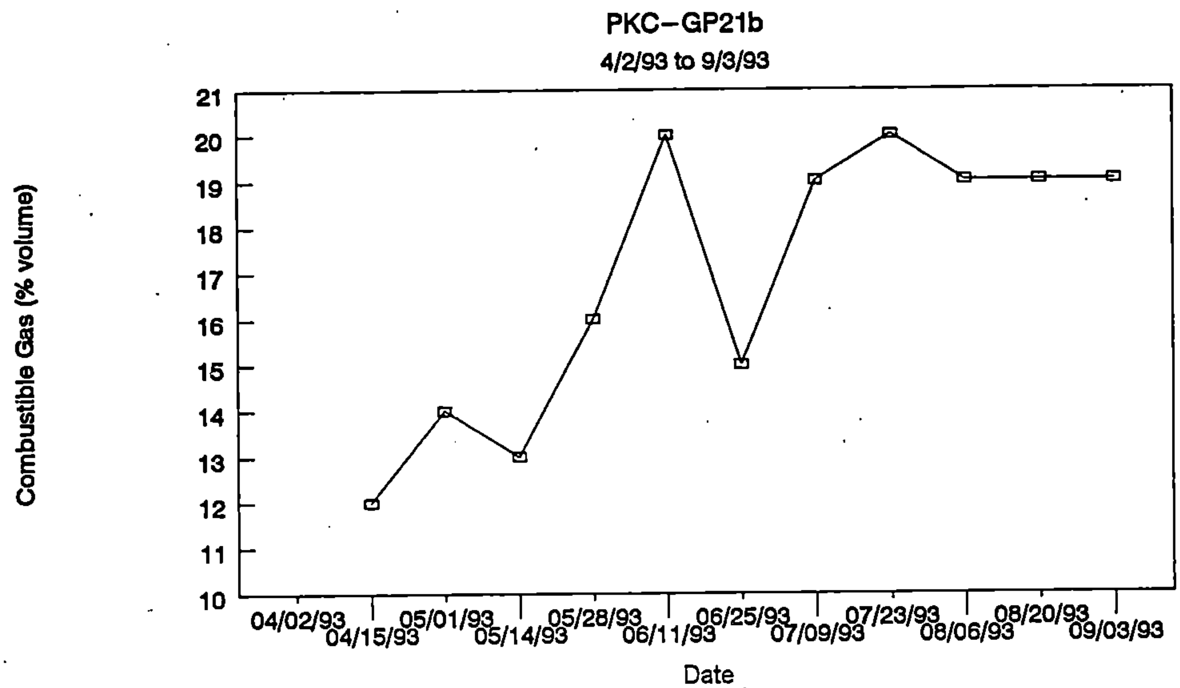
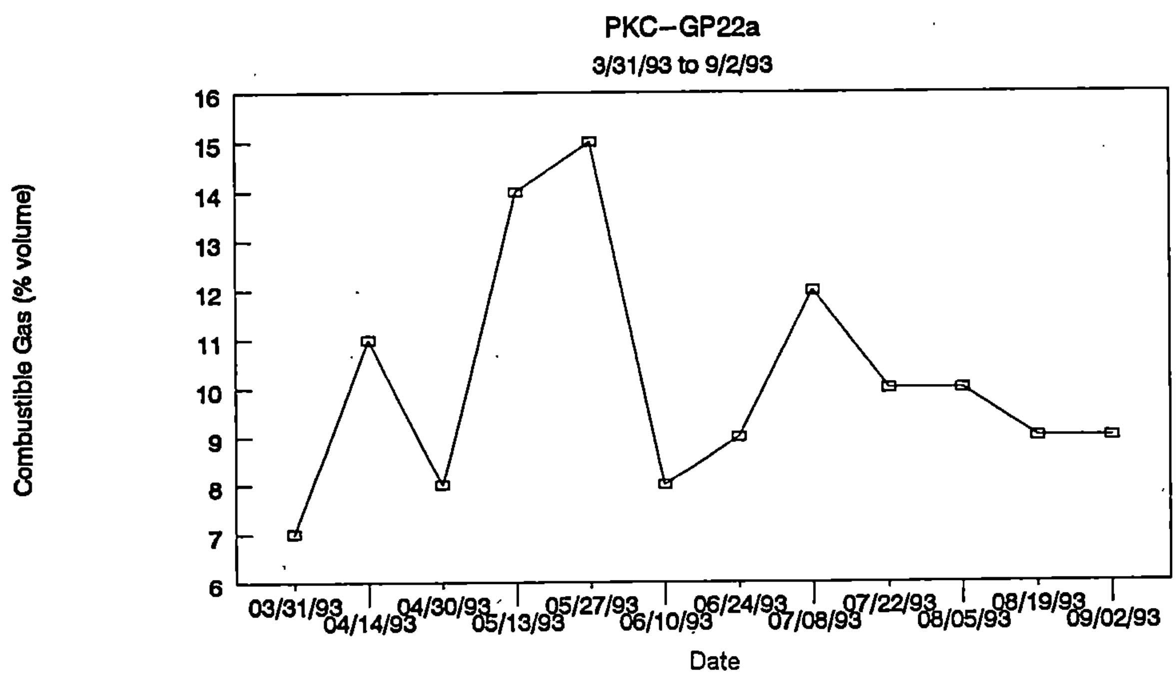
Combustible Concentration vs. Time
Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G13

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				





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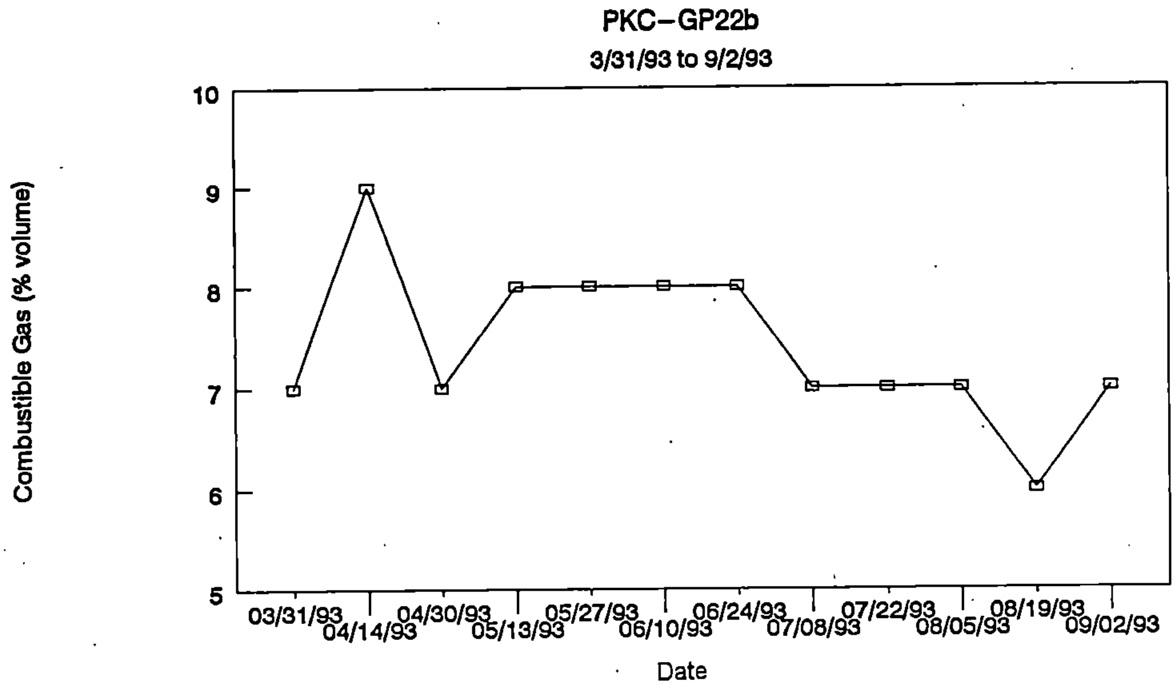
Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G14

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				



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Combustible Concentration vs. Time

Puyallup/Kit Corner Custodial Landfill
King County, Washington

PLATE
G15

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,621.114	DFF				

APPENDIX H

Gas Probe Sampling Data

OFFICE MEMORANDUM

To: Glen Bobnick, AGI

From: Alan Carey, AGI

Subj: PKC Landfill Gas Probe Sampling

Date: July 26, 1993

INTRODUCTION

This memorandum summarizes Applied Geotechnology Inc.'s (AGI) recent gas probe sampling at the Puyallup/Kit Corner Landfill (P/KC Landfill). This work comprises Task C2 of Phase IIIA, preliminary design of the southern perimeter gas extraction system. The purpose of this technical memorandum is to document rationale, field methods, and results of the gas probe sampling.

BACKGROUND

Combustible gases have been detected in gas probes located on the southern property boundary immediately south of the limit of refuse. In response to these off-site detections, King County has initiated an accelerated design and construction program for a perimeter gas extraction system along the southern boundary of the landfill. This system will include wells designed to extract subsurface gas, a gas treatment system, and associated mechanical equipment.

The objectives of the gas probe sampling program are to provide data to support design and permitting of the landfill gas treatment system.

LANDFILL GAS OCCURRENCE AT THE P/KC LANDFILL

AGI is currently conducting the Phase 2 Hydrogeologic and Landfill Gas Investigation at the P/KC Landfill. The following discussion focuses on the southern perimeter and is based primarily on preliminary results from AGI's current investigation.

Landfill gas is encountered in both domestic refuse and glacial outwash sediments along the southern perimeter of the P/KC Landfill. AGI has identified and named four distinct deposits within the glacial outwash sequence; from youngest to oldest they are termed Upper Gravel, Upper Sand, Lower Gravel, and Lower Sand. In general, these deposits thicken and dip from east to west. Landfill gas bearing characteristics of the refuse and native soil are described below. Combustible gas results are from AGI's biweekly monitoring performed between March 31 and June 24, 1993.

Refuse

Domestic refuse, consisting mostly of paper, plastic, metal, and wood, was encountered beneath a thin soil cover on the eastern portion of the southern perimeter in borings PKC-GP16 and -GP17. Refuse thickness in the two borings averaged about 20 feet. Combustible gases (as measured by a hand-held instrument calibrated to a methane standard) ranging up to 58 percent by volume (v%) have been monitored in PKC-GP16a.

Upper Gravel

Upper Gravel is encountered at ground surface on the western portion of the southern perimeter and consists primarily of a silty gravel with varying sand content. Upper Gravel was not encountered in the eastern portion of the southern perimeter, where it was apparently mined and replaced with refuse. Where encountered on the western half of the southern perimeter, Upper Gravel ranges in thickness from 44 to 63 feet. Combustible gases ranging up to 10%v have been monitored in PKC-MW2GPa, completed in the thickest section of the Upper Gravel.

Upper Sand

Upper Sand underlies Upper Gravel and consists primarily of fine-grained sand. Upper Sand was not encountered in the southeast corner of the landfill and may have been mined. Where encountered on the southern perimeter, Upper Sand ranges in thickness from 6 to 25 feet. Combustible gases ranging up to 22%v have been monitored in PKC-MW2GP2b, completed in the thickest section of the Upper Sand encountered in the southern perimeter.

Lower Gravel

Lower Gravel underlies Upper Sand and consists primarily of silty gravel. Lower Gravel was not encountered in the southeast corner of the landfill and may have been mined. Where encountered on the southern perimeter, Lower Gravel ranges in thickness from 7 to 20 feet. Because of its relative thinness and low concentration of combustible gases observed during drilling, no gas probes were completed wholly in the Lower Gravel.

Lower Sand

Lower Sand underlies Lower Gravel except in the southeast corner of the landfill, where it directly contacts refuse. Lower Sand consists primarily of fine sand and is saturated at depth. Unsaturated thicknesses, where this deposit is fully penetrated, range from 20 to 60 feet. Combustible gases ranging up to 18%v have been monitored in PKC-16b (where the Lower Sand directly contacts refuse) and 10%v in PKC-17b (where Lower Sand is overlain by Lower Gravel).

SAMPLE LOCATION RATIONALE

Sample locations were chosen based on the primary gas-bearing strata (i.e., Refuse, Upper Gravel, Upper Sand, and Lower Sand). Individual gas probes within various strata were evaluated on the basis of combustible gas levels and screen placement. In general, gas samples were collected from probes with relatively high combustible gas levels and with screen depths which approximated those of potential gas extraction wells. The following table correlates stratigraphic unit, gas probe, and sample number:

Stratigraphic Unit	Gas Probe	Sample Number
Refuse	PKC-GP16a	PKC-GS5
Upper Gravel	PKC-MW2GPa	PKC-GS1
Upper Sand	PKC-MW2GPb	PKC-GS2, -GS3 (Dup)
Lower Sand	PKC-GP17b	PKC-GS4

SAMPLE COLLECTION PROCEDURES

Gas samples were collected on June 26, 1993 during a period of falling barometric pressure. Gas probe monitoring, purging, and sampling equipment and methods are described below.

Monitoring and Purging

Gas parameters were monitored to ensure gas probes were fully purged prior to sampling. Monitoring equipment and techniques are identical to those employed by AGI during the biweekly monitoring. The following instruments were used for monitoring:

Parameter	Instrument
Temperature	Cole-Parmer Thermistor Thermometer Model 8402-00
Differential Pressure	Dwyer Magnahelic Pressure Gauge
Oxygen/Combustible Gas	Gastechtor Gas Surveyor Concentration Model 1939
Hydrogen Sulfide	MSA Portable Alarm Concentration Model 361
Carbon Dioxide	Bacharach FYRITE CO2 Gas Analyzer Model 11 Series

All measurements (except temperature) were made by attaching the instrument sampling port to the gas probe's 1/4-inch labcock valve hose fitting via Teflon tubing.

Differential pressure measurements were made prior to purging. Purging was accomplished on PKC-MW2GPa, -MW2GPb, and -GP17b by opening the valve. This allowed the probe to vent due to the pressure differential between the gas probe screen and the atmosphere. PKC-GP16a was purged using the Gastechtor Model 1939's integral vacuum pump.

Oxygen and combustible gases were measured during purging. For all probes, purging was considered complete after two consecutive identical measurements of these parameters. Carbon dioxide and hydrogen sulfide were then measured and differential pressure remeasured.

<u>Sampling</u>

Six-liter Summa canisters were used to collect and contain the gas samples. Sampling equipment included a brass three-position valve, a pressure gauge, and Teflon tubing. Sample collection procedures were as follows:

- Attach the three-way valve with pressure gauge to the Summa canister.
- Connect the gas probe labcock valve and three-way valve with tubing.
- Commence well purging by opening the three-way valve and either withdrawing gas with the integral vacuum pump (PKC-GP16a), or allowing venting (PKC-MW2GPa, -MW2GPb, and -GP17b).
- Open valve on Summa canister. The Summa canisters are shipped under a vacuum, which registers on the pressure gauge.
- Switch three-way valve, allowing Summa canister to draw gas from the gas probe.
- Close Summa canister valve after pressures between the Summa canister and probes have equalized, as indicated by the pressure gauge. Immediately tighten swage-lock on Summa canister sample port.

Prior to beginning sampling and following the collection of each sample, the three-way valve and hose were decontaminated by a three-stage process of: 1) alcohol rinse, 2) distilled water rinse, and 3) blowing dry with compressed nitrogen.

ANALYTIC RESULTS

Gas samples were analyzed for atmospheric gases and volatile organic compounds (VOCs). The following sections discuss analytic results and sample quality assurance. Copies of laboratory reports are attached.

<u>Atmospheric Gas Results</u>

Gas samples were analyzed for nitrogen, oxygen, carbon dioxide, and methane by ASTM Method D1946; results are presented in Table 1.

Typical atmospheric gas consists of 79%v nitrogen, 21%v oxygen, 0.032%v carbon dioxide, and trace concentrations of other gases, including methane. The composition of soil gas varies, depending on a variety of physical and biological processes, but is often similar to the atmosphere.

Soil gas collected from native soil (Upper Gravel, Upper Sand, and Lower Sand) contained nitrogen at near typical atmospheric concentrations, ranging from 76 to 81%v. Oxygen concentrations were significantly less than atmospheric, ranging from 1.0 to 1.2%v. Methane and carbon dioxide concentrations in soil gas ranged from 8.2 to 16%v and 4.5 to 17%v, respectively. Methane and carbon dioxide are generated during bacterial decay of organic matter and are commonly found in soil gas; however, methane and carbon dioxide soil gas concentrations in areas not impacted by landfill gas are typically much lower than the results reported.

Gas collected from the gas probe completed in refuse (GP-16a) had 17%v nitrogen, 0.3%v oxygen, 52%v methane, and 31%v carbon dioxide. This compares to typical methanogenic decomposition landfill gas composition of 55 to 60%v methane and 40 to 45%v carbon dioxide. The presence of nitrogen in GP16a indicates the methanogenic decay rate is low and atmospheric gases are re-entering the refuse.

Volatile Organic Compound Gas Results

Samples were analyzed for VOCs by EPA Method TO14; results for compounds detected are presented in Table 2. Table 3 presents a complete list of analytes.

All soil gas collected from native soil contained Freon 12 and Freon 114 in concentrations ranging from 1.6 to 140 milligrams per cubic meter (mg/m^3) and 6.8 to 53 mg/m^3, respectively. Vinyl chloride was detected in the Upper and Lower Sand at concentrations ranging from 0.4 to 4.3 mg/m^3. Benzene was detected in the Lower Sand at 0.6 mg/m^3.

VOCs detected in refuse include vinyl chloride (1.3 mg/m^3) and aromatic hydrocarbons such as benzene, ethylbenzene, toluene, and xylenes. Aromatic hydrocarbon concentrations range from 0.8 mg/m^3 (benzene) to 18 mg/m^3 (m,p-xylene). Freon 12 and 114 were also detected.

Analytic results were compared to Puget Sound Air Pollution Control Agency (PSAPCA) Acceptable Source Impact Levels (ASILs). ASILs are toxic compound concentrations used to evaluate point source air quality impact. Exceedences of this very conservative criteria were found for vinyl chloride in PKC-MW2GPb, -GP16a and -GP17a, and benzene, ethylbenzene, toluene, toluene in -GP16a. ASILs for compounds of interest at the P/KC Landfill are listed in Table 2.

Quality Assurance Summary

All data are of known quality and acceptable with the following qualifications: dichlorotetrafluoroethane (Freon 114) results for all samples are considered estimated and flagged (J) because Freon 114 was not quantitated against a standard. Freon 114 was quantitated using a response factor of 1 and reported concentrations were calculated from target compound and internal standard quantification ions. A complete quality assurance report is attached.

cc: Mr. John Komorita; King County Solid Waste Division
Mr. Robert Healy; CH2M Hill
Mr. Matthew Hightree; CH2M Hill

Table 1
Atmospheric Gases – June 1993
Puyallup/Kit Corner Landfill
King County, Washington

Gas	Lowest Practical Quantitation Limit (%v)	Gas Probes (%v)				
		PKC–MW2GPa	PKC–MW2GPb	Dup PKC–MW2GPb	PKC–GP16a	PKC–GP17b
Carbon Dioxide	0.05	4.5	5.9	6.0	31	17
Methane	0.05	14	16	17	52	8.2
Nitrogen	0.05	81	77	76	17	76
Oxygen	0.05	1.2	1.0	0.9	0.3	1.0

Notes:

Dup – Duplicate.

%v equivalencies:
1% = 10,000 ppm (v).
0.1% = 1,000 ppm (v).
0.01% = 100 ppm (v).
0.001% = 10 ppm (v).
0.0001% = 1 ppm (v).

Table 2
Volatile Organic Compounds Detected in Gas – June 1993
Puyallup/Kit Corner Landfill
King County, Washington

Compound	Lowest Practical Quantitation Limit (mg/m³)	Gas Probes (mg/m³)					ASILs
		PKC–MW2GPa[a]	PKC–MW2GPb[b]	Dup PKC–MW2GPb[c]	PKC–GP16a[d]	PKC–GP17b[e]	
Benzene	0.03	ND	ND	ND	0.8	0.6	0.00012
Dichlorodifluoromethane (Freon 12)	0.03	65 [f]	140 [g]	140 [g]	5.7	1.6	N/A
Dichlorotetrafluoroethane (Freon 114)	0.03	17 J	55 J	50 J	5.1 J	6.8 J	1.4486
Ethylbenzene	0.03	ND	ND	ND	2.4	ND	N/A
1–Ethyl–4–methylbenzene	0.03	ND	ND	ND	1.6	ND	N/A
Toluene	0.03	ND	ND	ND	3.3	ND	1.2448
1,2,4–Trimethylbenzene	0.03	ND	ND	ND	1.7	ND	N/A
1,3,5–Trimethylbenzene	0.03	ND	ND	ND	1.0	ND	N/A
Vinyl Chloride	0.03	ND	4.2	4.4	1.3	0.40	0.00023
m,p–Xylene	0.03	ND	ND	ND	18	ND	1.4486
o–Xylene	0.03	ND	ND	ND	1.3	ND	N/A

Notes:

a) Lowest practical quantitation limit is elevated 20.6 times.
b) Lowest practical quantitation limit is elevated 20.9 times.
c) Lowest practical quantitation limit is elevated 21.0 times.
d) Lowest practical quantitation limit is elevated 20.7 times.
e) Lowest practical quantitation limit is elevated 2 times.
f) Lowest practical quantitation limit is elevated 40 times.
g) Lowest practical quantitation limit is elevated 103 times.
ASIL – Acceptable Source Impact Levels; Regulation III of the Puget Sound Air Pollution Control Agency (PSAPCA).
Dup – Duplicate.
J – Estimated value; see Quality Assurance Report.
mg/m³ – Milligrams per cubic meter.
N/A – Not applicable; Regulation III of PSAPCA.
ND – Not detected.

Table 3
Volatile Organic Compounds Quantified by EPA Method TO-14
Puyallup/Kit Corner Landfill
King County, Washington

Compounds	Lowest Practical Quantitation Limit (mg/m^3)
Benzene	0.03
Chlorobenzene	0.03
alpha-Chlorotoluene	0.03
Ethylbenzene	0.03
Styrene	0.03
Toluene	0.03
m,p-Xylene	0.03
o-Xylene	0.03
Bromomethane	0.03
Carbon Tetrachloride	0.03
Chloroethane	0.03
Chloroform	0.03
Chloromethane	0.03
1,2-Dibromoethane (EDB)	0.03
m-Dichlorobenzene	0.03
o-Dichlorobenzene	0.03
p-Dichlorobenzene	0.03
Dichlorodifluoromethane (Freon 12)	0.03
1,1-Dichloroethane	0.03
1,2-Dichloroethane	0.03
1,1-Dichloroethene	0.03
cis-1,2-Dichloroethene	0.03
1,2-Dichloropropane	0.03
trans-1,3-Dichloropropene	0.03
cis-1,3-Dichloropropene	0.03
Dichlorotetrafluoroethane (Freon 114)	0.03
Hexachlorobutadiene	0.03
Methylene Chloride	0.07
1-Ethyl-4-methylbenzene	0.03
1,1,2,2-Tetrachloroethane	0.03
Tetrachloroethene	0.03
1,2,4-Trichlorobenzene	0.03
1,1,1-Trichloroethane	0.03
1,1,2-Trichloroethane	0.03
Trichloroethene	0.03
Trichlorofluoromethane	0.03
Trichlorotrifluoroethane	0.03
1,2,4-Trimethylbenzene	0.03
1,3,5-Trimethylbenzene	0.03
Vinyl Chloride	0.03

Notes:

mg/m^3 – Milligrams per cubic meter.

QUALITY ASSURANCE REPORT

PROJECT AND SAMPLE INFORMATION

Project Name:	Puyallup/Kit Corner Landfill Gas Sampling
Project No.:	14,621.124
Lab Name:	Analytical Technologies, Inc. (ATI) - Pensacola, Florida
Lab Number:	306936
Sample No.:	PKC-GS1, PKC-GS2, PKC-GS3, PKC-GS4, PKC-GS5
Matrix:	Air

QUALITY ASSURANCE SUMMARY

All data are of known quality and acceptable with the following qualifications:

EPA Method TO14: Dichlorotetrafluoroethane (Freon 114) results for all samples are considered estimated and flagged (J) because this compound was not quantitated against a standard. Freon 114 was quantitated using an assigned response factor of 1.

ANALYTICAL METHODS

Parameter	Technique	Method
Atmospheric Gases	GC/FID/TCD	ASTM D1946
Volatile Organics	GC/MS	EPA TO14

TIMELINESS

Parameter	Date Sampled	Date Extracted	Date Analyzed	Time Until Extraction	Time Until Analysis
Atmospheric Gases	6/26/93	NA	7/01/93	NA	5 (30)
Volatile Organics	6/26/93	NA	7/07/93*	NA	11 (14)

* - Latest analyses date is reported.
NA - Not Applicable
Numbers in parentheses indicate recommended holding times in days for air.

All samples were extracted and analyzed within recommended holding times for air.

QUALITY ASSURANCE REPORT

PROJECT AND SAMPLE INFORMATION

Project Name:	Puyallup/Kit Corner Landfill Gas Sampling
Project No.:	14,621.124
Lab Name:	Analytical Technologies, Inc. (ATI) - Pensacola, Florida
Lab Number:	306936
Sample No.:	PKC-GS1, PKC-GS2, PKC-GS3, PKC-GS4, PKC-GS5
Matrix:	Air

FIELD CONTROL SAMPLES

Field Duplicates: Relative percent differences (RPDs) were acceptable for sample PKC-GS2 and duplicate PKC-GS3 for the following methods:

ASTM D1946
EPA TO14

Rinsate: None collected.

Trip Blank: None collected.

LAB QUALITY CONTROL SAMPLES

Method Blank: No analytes were detected at or above their method reporting limits for the following:

ASTM D1946
EPA TO14

Blank Spikes: Blank spike and blank spike duplicate percent recoveries and RPDs are within ATI's control limit criteria for the following methods:

ASTM D1946
EPA TO14

Surrogates: All surrogate percent recoveries are within ATI's control limit criteria for EPA Method TO14.

SIGNATURES

Prepared by Jessie Compeau **Date** 7/21/93

Checked by Katherine Bourbonan **Date** 7/21/93

Analytical Technologies, Inc. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

SIGNATURE PAGE

Reviewed by: Cathy Poeuleline
ATI Project Manager

Client: APPLIED GEOTECHNOLOGY INC
BELLEVUE, WASHINGTON

Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Number: 14621-124
Project Location: KING COUNTY
Accession Number: 306936

Project Manager: MARK ADAMS
Sampled By: ADC

AnalyticalTechnologies,Inc. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

CASE NARRATIVE

LABORATORY NAME: Analytical Technologies, Inc.

PROJECT NAME: PKC Landfill 1 Gas Probe Sampling

PROJECT NUMBER: 1462-124

Applied Geotechnology, INC Sample Number	ATI-Laboratory Sample Number
PKC GS1	306936-001
PKC GS2	306936-002
PKC GS3	306936-003
PKC GS3	306936-004
PKC GS4	306936-005

Dichlorotetrafluoroethane was flagged with a "J" (estimated value) for the TO14 analysis because this compound was not quantitated using a standard. The compound was quantitated using a relative response factor = 1. The calculation was based on the quant ions 85 for the target compound and 128 for the internal standard. The total ion chromatogram areas were not used (as in the TIC calculation) due to interference from the CO_2 peak.

Kelly S Swanson

Kelly S Swanson
QA Manager

July 16, 1993

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ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Date 02-Jul-93

"Method Report Summary"

Accession Number: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: METHANE PLUS FIXED GASES

Client Sample Id:	Parameter:	Unit:	Result:
PKC GS1	CARBON DIOXIDE	%	4.5
	METHANE	%	14
	NITROGEN	%	81
	OXYGEN	%	1.2
PKC GS2	CARBON DIOXIDE	%	5.9
	METHANE	%	16
	NITROGEN	%	77
	OXYGEN	%	1.0
PKC GS5	CARBON DIOXIDE	%	31
	METHANE	%	52
	NITROGEN	%	17
	OXYGEN	%	0.3
PKC GS3	CARBON DIOXIDE	%	6.0
	METHANE	%	17
	NITROGEN	%	76
	OXYGEN	%	0.9
PKC GS4	CARBON DIOXIDE	%	17
	METHANE	%	8.2
	NITROGEN	%	76
	OXYGEN	%	1.0

ANALYTICAL TECHNOLOGIES, INC.   11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: METHANE PLUS FIXED GASES
Analysis Method: ATI/GC/FIX
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 001   Sample Date/Time: 26-JUN-93 1105
Client Sample Id: PKC GS1   Received Date: 30-JUN-93

Batch: GEA223   Dilution Factor: 1   Extraction Date: N/A
Blank: A   Dry Weight %: N/A   Analysis Date: 01-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
CARBON DIOXIDE	%	4.5	0.05	
METHANE	%	14	0.05	
NITROGEN	%	81	0.05	
OXYGEN	%	1.2	0.05	
ANALYST	INITIALS	RP		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession:	306936
Client:	APPLIED GEOTECHNOLOGY INC
Project Number:	14621-124
Project Name:	PKC LANDFILL / GAS PROBE SAMPLING
Project Location:	KING COUNTY
Test:	METHANE PLUS FIXED GASES
Analysis Method:	ATI/GC/FIX
Extraction Method:	N/A
Matrix:	AIR
Qc Level:	I

Lab Id:	002	Sample Date/Time:	26-JUN-93 1143
Client Sample Id:	PKC GS2	Received Date:	30-JUN-93
Batch: GEA223	Dilution Factor: 1	Extraction Date:	N/A
Blank: A	Dry Weight %: N/A	Analysis Date:	01-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
CARBON DIOXIDE	%	5.9	0.05	
METHANE	%	16	0.05	
NITROGEN	%	77	0.05	
OXYGEN	%	1.0	0.05	
ANALYST	INITIALS	RP		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession:	306936
Client:	APPLIED GEOTECHNOLOGY INC
Project Number:	14621-124
Project Name:	PKC LANDFILL / GAS PROBE SAMPLING
Project Location:	KING COUNTY
Test:	METHANE PLUS FIXED GASES
Analysis Method:	ATI/GC/FIX
Extraction Method:	N/A
Matrix:	AIR
Qc Level:	I

Lab Id:	003	Sample Date/Time:	26-JUN-93 1254
Client Sample Id:	PKC GS5	Received Date:	30-JUN-93
Batch: GEA223	Dilution Factor: 1	Extraction Date:	N/A
Blank: A	Dry Weight %: N/A	Analysis Date:	01-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
CARBON DIOXIDE	%	31	0.05	
METHANE	%	52	0.05	
NITROGEN	%	17	0.05	
OXYGEN	%	0.3	0.05	
ANALYST	INITIALS	RP		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession:	306936
Client:	APPLIED GEOTECHNOLOGY INC
Project Number:	14621-124
Project Name:	PKC LANDFILL / GAS PROBE SAMPLING
Project Location:	KING COUNTY
Test:	METHANE PLUS FIXED GASES
Analysis Method:	ATI/GC/FIX
Extraction Method:	N/A
Matrix:	AIR
Qc Level:	I

Lab Id:	004	Sample Date/Time:	26-JUN-93 1215
Client Sample Id:	PKC GS3	Received Date:	30-JUN-93
Batch: GEA223	Dilution Factor: 1	Extraction Date:	N/A
Blank: A	Dry Weight %: N/A	Analysis Date:	01-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
CARBON DIOXIDE	%	6.0	0.05	
METHANE	%	17	0.05	
NITROGEN	%	76	0.05	
OXYGEN	%	0.9	0.05	
ANALYST	INITIALS	RP		

Comments:

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: METHANE PLUS FIXED GASES
Analysis Method: ATI/GC/FIX
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 005
Client Sample Id: PKC GS4

Sample Date/Time: 26-JUN-93 1223
Received Date: 30-JUN-93

Batch: GEA223
Blank: A

Dilution Factor: 1
Dry Weight %: N/A

Extraction Date: N/A
Analysis Date: 01-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
CARBON DIOXIDE	%	17	0.05	
METHANE	%	8.2	0.05	
NITROGEN	%	76	0.05	
OXYGEN	%	1.0	0.05	
ANALYST	INITIALS	RP		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-100[illegible]

"QC Report"

Title: Air Blank
Batch: GEA223
Analysis Method: ATI/GC/FIX
Extraction Method: N/A

Blank Id: A Date Analyzed: 01-JUL-93 Date Extracted: N/A

Parameters:	Units:	Results:	Reporting Limits:
CARBON DIOXIDE	%	ND	0.05
OXYGEN	%	ND	0.05
METHANE	%	ND	0.05

Comments:
ANALYST: ROB PEREZ

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

"QC Report"

Title: Air Reagent
Batch: GEA223
Analysis Method: ATI/GC/FIX
Extraction Method: N/A

RS Date Analyzed: 01-JUL-93 RS Date Extracted: N/A
RSD Date Analyzed: 01-JUL-93 RSD Date Extracted: N/A

Parameters:	Spike Added	Sample Conc	RS Conc	RS Rec%	RSD Conc	RSD Rec%	Rpd	Rpd Lmts	Rec Lmts
CARBON DIOXIDE	1.01	<0.05	0.97	96	1.00	99	3	50	50-150
OXYGEN	1.01	<0.05	0.89	88	0.96	95	8	50	50-150
METHANE	1.01	<0.05	1.01	100	1.02	101	1	50	50-150

Surrogates:

Comments:

Notes:

% = PERCENT PER VOLUME. < = LESS THAN REPORTING LIMIT.
* = VALUES OUTSIDE OF QUALITY CONTROL LIMITS.
SOURCE FOR CONTROL LIMITS ARE INTERNAL LABORATORY QUALITY ASSURANCE PROGRAM AND REFERENCE METHOD.
N/S = NOT SUBMITTED N/A = NOT APPLICABLE D = DILUTED OUT

Common notation for Organic reporting

N/S = NOT SUBMITTED
N/A = NOT APPLICABLE
D = DILUTED OUT
UG/L = PARTS PER BILLION.
UG/KG = PARTS PER BILLION.
MG/KG = PARTS PER MILLION.
MG/L = PARTS PER MILLION.
< = LESS THAN DETECTION LIMIT.
* = VALUES OUTSIDE OF QUALITY CONTROL LIMITS
SOURCES FOR CONTROL LIMITS ARE INTERNAL LABORATORY QUALITY ASSURANCE PROGRAM
AND REFERENCED METHOD.
ORGANIC SOILS ARE REPORTED ON A DRYWEIGHT BASIS.
ND = NOT DETECTED ABOVE REPORTING LIMIT.

LJT = LISA THOMASON
CD = CHRISTY DRAPER
JP = JOE POPE
IP = INGRID PITTMAN
RP = ROB PEREZ
SKR = SVETLANA RODKINA
DGH = DARREL HALSELL

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

"Method Report Summary"

Accession Number: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14

Client Sample Id:	Parameter:	Unit:	Result:
PKC GS1	DICHLORODIFLUOROMETHANE	MG/M3	65
	DICHLOROTETRAFLUOROETHANE	MG/M3	17
PKC GS2	DICHLORODIFLUOROMETHANE	MG/M3	140
	DICHLOROTETRAFLUOROETHANE	MG/M3	55
	VINYL CHLORIDE	MG/M3	4.2
PKC GS5	BENZENE	MG/M3	0.8
	DICHLORODIFLUOROMETHANE	MG/M3	5.7
	DICHLOROTETRAFLUOROETHANE	MG/M3	5.1
	ETHYL BENZENE	MG/M3	2.4
	M,P-XYLENE	MG/M3	18
	O-XYLENE	MG/M3	1.3
	TOLUENE	MG/M3	3.3
	VINYL CHLORIDE	MG/M3	1.3
	1,2,4-TRIMETHYLBENZENE	MG/M3	1.7
	1,3,5-TRIMETHYLBENZENE	MG/M3	1.0
	4-ETHYLTOLUENE	MG/M3	1.6
PKC GS3	DICHLORODIFLUOROMETHANE	MG/M3	140
	DICHLOROTETRAFLUOROETHANE	MG/M3	50
	VINYL CHLORIDE	MG/M3	4.4
PKC GS4	BENZENE	MG/M3	0.6
	DICHLORODIFLUOROMETHANE	MG/M3	1.6
	DICHLOROTETRAFLUOROETHANE	MG/M3	6.8
	VINYL CHLORIDE	MG/M3	0.4

ANALYTICAL TECHNOLOGIES, INC.   11 East Olive Road   Pensacola, Florida 32514   (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 001   Sample Date/Time: 26-JUN-93 1105
Client Sample Id: PKC GS1   Received Date: 30-JUN-93

Batch: MAB067   Dilution Factor: 20.6   Extraction Date: N/A
Blank: A   Dry Weight %: N/A   Analysis Date: 06-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.62	
BENZENE	MG/M3	ND	0.62	
BROMOMETHANE	MG/M3	ND	0.62	
CARBON TETRACHLORIDE	MG/M3	ND	0.62	
CHLOROBENZENE	MG/M3	ND	0.62	
CHLOROETHANE	MG/M3	ND	0.62	
CHLOROFORM	MG/M3	ND	0.62	
CHLOROMETHANE	MG/M3	ND	0.62	
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.62	
DICHLORODIFLUOROMETHANE	MG/M3	65	1.2	
1,1-DICHLOROETHANE	MG/M3	ND	0.62	
1,2-DICHLOROETHANE	MG/M3	ND	0.62	
1,2-DICHLOROPROPANE	MG/M3	ND	0.62	
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.62	
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.62	
DICHLOROTETRAFLUOROETHANE	MG/M3	17	0.62	J
ETHYL BENZENE	MG/M3	ND	0.62	
HEXACHLOROBUTADIENE	MG/M3	ND	0.62	
M-DICHLOROBENZENE	MG/M3	ND	0.62	
M,P-XYLENE	MG/M3	ND	0.62	
METHYLENE CHLORIDE	MG/M3	ND	1.4	
O-DICHLOROBENZENE	MG/M3	ND	0.62	
O-XYLENE	MG/M3	ND	0.62	
P-DICHLOROBENZENE	MG/M3	ND	0.62	
STYRENE	MG/M3	ND	0.62	
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.62	
TETRACHLOROETHYLENE	MG/M3	ND	0.62	
TOLUENE	MG/M3	ND	0.62	
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.62	
TRICHLOROETHYLENE	MG/M3	ND	0.62	
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.62	
VINYL CHLORIDE	MG/M3	ND	0.62	
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.62	
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.62	
1,2,4-TRIMETHYLBENZENE	MG/M3	ND	0.62	

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 001 | Sample Date/Time: 26-JUN-93 1105
Client Sample Id: PKC GS1 | Received Date: 30-JUN-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
1,3,5-TRIMETHYLBENZENE	MG/M3	ND	0.62	
1,1-DICHLOROETHENE	MG/M3	ND	0.62	
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.62	
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.62	
4-ETHYLTOLUENE	MG/M3	ND	0.62	
BROMOFLUOROBENZENE	%REC/SURR	103	82-118	
1,2-DICHLOROETHANE-D4	%REC/SURR	102	78-122	
TOLUENE-D8	%REC/SURR	109	81-127	
ANALYST	INITIALS	LL		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 002
Client Sample Id: PKC GS2
Sample Date/Time: 26-JUN-93 1143
Received Date: 30-JUN-93

Batch: MAB067
Blank: A
Dilution Factor: 20.9
Dry Weight %: N/A
Extraction Date: N/A
Analysis Date: 06-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.63	
BENZENE	MG/M3	ND	0.63	
BROMOMETHANE	MG/M3	ND	0.63	
CARBON TETRACHLORIDE	MG/M3	ND	0.63	
CHLOROBENZENE	MG/M3	ND	0.63	
CHLOROETHANE	MG/M3	ND	0.63	
CHLOROFORM	MG/M3	ND	0.63	
CHLOROMETHANE	MG/M3	ND	0.63	
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.63	
DICHLORODIFLUOROMETHANE	MG/M3	140	3.1	
1,1-DICHLOROETHANE	MG/M3	ND	0.63	
1,2-DICHLOROETHANE	MG/M3	ND	0.63	
1,2-DICHLOROPROPANE	MG/M3	ND	0.63	
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.63	
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.63	
DICHLOROTETRAFLUOROETHANE	MG/M3	55	0.63	J
ETHYL BENZENE	MG/M3	ND	0.63	
HEXACHLOROBUTADIENE	MG/M3	ND	0.63	
M-DICHLOROBENZENE	MG/M3	ND	0.63	
M,P-XYLENE	MG/M3	ND	0.63	
METHYLENE CHLORIDE	MG/M3	ND	1.5	
O-DICHLOROBENZENE	MG/M3	ND	0.63	
O-XYLENE	MG/M3	ND	0.63	
P-DICHLOROBENZENE	MG/M3	ND	0.63	
STYRENE	MG/M3	ND	0.63	
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.63	
TETRACHLOROETHYLENE	MG/M3	ND	0.63	
TOLUENE	MG/M3	ND	0.63	
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.63	
TRICHLOROETHYLENE	MG/M3	ND	0.63	
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.63	
VINYL CHLORIDE	MG/M3	4.2	0.63	
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.63	
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.63	
1,2,4-TRIMETHYLBENZENE	MG/M3	ND	0.63	

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 002 Sample Date/Time: 26-JUN-93 1143
Client Sample Id: PKC GS2 Received Date: 30-JUN-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
1,3,5-TRIMETHYLBENZENE	MG/M3	ND	0.63	
1,1-DICHLOROETHENE	MG/M3	ND	0.63	
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.63	
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.63	
4-ETHYLTOLUENE	MG/M3	ND	0.63	
BROMOFLUOROBENZENE	%REC/SURR	104	82-118	
1,2-DICHLOROETHANE-D4	%REC/SURR	105	78-122	
TOLUENE-D8	%REC/SURR	106	81-127	
ANALYST	INITIALS	LL		

Comments:

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 003 | Sample Date/Time: 26-JUN-93 1254
Client Sample Id: PKC GS5 | Received Date: 30-JUN-93

Batch: MAB067 | Dilution Factor: 20.7 | Extraction Date: N/A
Blank: A | Dry Weight %: N/A | Analysis Date: 06-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.62	
BENZENE	MG/M3	0.8	0.62	
BROMOMETHANE	MG/M3	ND	0.62	
CARBON TETRACHLORIDE	MG/M3	ND	0.62	
CHLOROBENZENE	MG/M3	ND	0.62	
CHLOROETHANE	MG/M3	ND	0.62	
CHLOROFORM	MG/M3	ND	0.62	
CHLOROMETHANE	MG/M3	ND	0.62	
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.62	
DICHLORODIFLUOROMETHANE	MG/M3	5.7	0.62	
1,1-DICHLOROETHANE	MG/M3	ND	0.62	
1,2-DICHLOROETHANE	MG/M3	ND	0.62	
1,2-DICHLOROPROPANE	MG/M3	ND	0.62	
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.62	
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.62	
DICHLOROTETRAFLUOROETHANE	MG/M3	5.1	0.62	J
ETHYL BENZENE	MG/M3	2.4	0.62	
HEXACHLOROBUTADIENE	MG/M3	ND	0.62	
M-DICHLOROBENZENE	MG/M3	ND	0.62	
M,P-XYLENE	MG/M3	18	0.62	
METHYLENE CHLORIDE	MG/M3	ND	1.4	
O-DICHLOROBENZENE	MG/M3	ND	0.62	
O-XYLENE	MG/M3	1.3	0.62	
P-DICHLOROBENZENE	MG/M3	ND	0.62	
STYRENE	MG/M3	ND	0.62	
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.62	
TETRACHLOROETHYLENE	MG/M3	ND	0.62	
TOLUENE	MG/M3	3.3	0.62	
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.62	
TRICHLOROETHYLENE	MG/M3	ND	0.62	
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.62	
VINYL CHLORIDE	MG/M3	1.3	0.62	
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.62	
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.62	
1,2,4-TRIMETHYLBENZENE	MG/M3	1.7	0.62	

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 003
Client Sample Id: PKC GS5
Sample Date/Time: 26-JUN-93 1254
Received Date: 30-JUN-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
1,3,5-TRIMETHYLBENZENE	MG/M3	1.0	0.62	
1,1-DICHLOROETHENE	MG/M3	ND	0.62	
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.62	
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.62	
4-ETHYLTOLUENE	MG/M3	1.6	0.62	
BROMOFLUOROBENZENE	%REC/SURR	108	82-118	
1,2-DICHLOROETHANE-D4	%REC/SURR	105	78-122	
TOLUENE-D8	%REC/SURR	106	81-127	
ANALYST	INITIALS	LL		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 003 Sample Date/Time: 26-JUN-93 1254
Client Sample Id: PKC GS5 Received Date: 30-JUN-93

"Sample Tic Report"

Number of Tics Found: 10
Concentration Units: MG/M3

Cas Number:	Compound Name:	RT:	Est Conc:	Q:
110-54-3	Hexane	6.39	5	J
108-87-2	Methyl Cyclohexane	11.09	3	J
	Unknown Hydrocarbon	11.84	4	J
	Isomer of Dimethyl Cyclohexane	12.99	2	J
111-65-9	Octane	13.13	3	J
	Unknown Hydrocarbon	15.24	4	J
	Unknown Hydrocarbon	16.72	2	J
	Isomer of Decane	17.85	3	J
	Unknown Hydrocarbon	18.72	8	J
	Unknown Hydrocarbon	20.20	22	J

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 004
Client Sample Id: PKC GS3
Sample Date/Time: 26-JUN-93 1215
Received Date: 30-JUN-93

Batch: MAB067
Blank: A
Dilution Factor: 21.0
Dry Weight %: N/A
Extraction Date: N/A
Analysis Date: 06-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.63	
BENZENE	MG/M3	ND	0.63	
BROMOMETHANE	MG/M3	ND	0.63	
CARBON TETRACHLORIDE	MG/M3	ND	0.63	
CHLOROBENZENE	MG/M3	ND	0.63	
CHLOROETHANE	MG/M3	ND	0.63	
CHLOROFORM	MG/M3	ND	0.63	
CHLOROMETHANE	MG/M3	ND	0.63	
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.63	
DICHLORODIFLUOROMETHANE	MG/M3	140	3.1	
1,1-DICHLOROETHANE	MG/M3	ND	0.63	
1,2-DICHLOROETHANE	MG/M3	ND	0.63	
1,2-DICHLOROPROPANE	MG/M3	ND	0.63	
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.63	
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.63	
DICHLOROTETRAFLUOROETHANE	MG/M3	50	0.63	J
ETHYL BENZENE	MG/M3	ND	0.63	
HEXACHLOROBUTADIENE	MG/M3	ND	0.63	
M-DICHLOROBENZENE	MG/M3	ND	0.63	
M,P-XYLENE	MG/M3	ND	0.63	
METHYLENE CHLORIDE	MG/M3	ND	1.5	
O-DICHLOROBENZENE	MG/M3	ND	0.63	
O-XYLENE	MG/M3	ND	0.63	
P-DICHLOROBENZENE	MG/M3	ND	0.63	
STYRENE	MG/M3	ND	0.63	
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.63	
TETRACHLOROETHYLENE	MG/M3	ND	0.63	
TOLUENE	MG/M3	ND	0.63	
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.63	
TRICHLOROETHYLENE	MG/M3	ND	0.63	
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.63	
VINYL CHLORIDE	MG/M3	4.4	0.63	
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.63	
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.63	
1,2,4-TRIMETHYLBENZENE	MG/M3	ND	0.63	

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 004   Sample Date/Time: 26-JUN-93 1215
Client Sample Id: PKC GS3   Received Date: 30-JUN-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
1,3,5-TRIMETHYLBENZENE	MG/M3	ND	0.63	
1,1-DICHLOROETHENE	MG/M3	ND	0.63	
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.63	
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.63	
4-ETHYLTOLUENE	MG/M3	ND	0.63	
BROMOFLUOROBENZENE	%REC/SURR	106	82-118	
1,2-DICHLOROETHANE-D4	%REC/SURR	105	78-122	
TOLUENE-D8	%REC/SURR	106	81-127	
ANALYST	INITIALS	LL		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 005 Sample Date/Time: 26-JUN-93 1223
Client Sample Id: PKC GS4 Received Date: 30-JUN-93

Batch: MAB067 Dilution Factor: 2.0 Extraction Date: N/A
Blank: B Dry Weight %: N/A Analysis Date: 07-JUL-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.06	
BENZENE	MG/M3	0.6	0.06	
BROMOMETHANE	MG/M3	ND	0.06	
CARBON TETRACHLORIDE	MG/M3	ND	0.06	
CHLOROBENZENE	MG/M3	ND	0.06	
CHLOROETHANE	MG/M3	ND	0.06	
CHLOROFORM	MG/M3	ND	0.06	
CHLOROMETHANE	MG/M3	ND	0.06	
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.06	
DICHLORODIFLUOROMETHANE	MG/M3	1.6	0.06	
1,1-DICHLOROETHANE	MG/M3	ND	0.06	
1,2-DICHLOROETHANE	MG/M3	ND	0.06	
1,2-DICHLOROPROPANE	MG/M3	ND	0.06	
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.06	
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.06	
DICHLOROTETRAFLUOROETHANE	MG/M3	6.8	0.06	J
ETHYL BENZENE	MG/M3	ND	0.06	
HEXACHLOROBUTADIENE	MG/M3	ND	0.06	
M-DICHLOROBENZENE	MG/M3	ND	0.06	
M,P-XYLENE	MG/M3	ND	0.06	
METHYLENE CHLORIDE	MG/M3	ND	0.1	
O-DICHLOROBENZENE	MG/M3	ND	0.06	
O-XYLENE	MG/M3	ND	0.06	
P-DICHLOROBENZENE	MG/M3	ND	0.06	
STYRENE	MG/M3	ND	0.06	
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.06	
TETRACHLOROETHYLENE	MG/M3	ND	0.06	
TOLUENE	MG/M3	ND	0.06	
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.06	
TRICHLOROETHYLENE	MG/M3	ND	0.06	
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.06	
VINYL CHLORIDE	MG/M3	0.4	0.06	
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.06	
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.06	
1,2,4-TRIMETHYLBENZENE	MG/M3	ND	0.06	

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

Accession: 306936
Client: APPLIED GEOTECHNOLOGY INC
Project Number: 14621-124
Project Name: PKC LANDFILL / GAS PROBE SAMPLING
Project Location: KING COUNTY
Test: TO14
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A
Matrix: AIR
Qc Level: I

Lab Id: 005
Client Sample Id: PKC GS4

Sample Date/Time: 26-JUN-93 1223
Received Date: 30-JUN-93

Parameter:	Units:	Results:	Rpt Lmts:	Q:
1,3,5-TRIMETHYLBENZENE	MG/M3	ND	0.06	
1,1-DICHLOROETHENE	MG/M3	ND	0.06	
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.06	
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.06	
4-ETHYLTOLUENE	MG/M3	ND	0.06	
BROMOFLUOROBENZENE	%REC/SURR	111	82-118	
1,2-DICHLOROETHANE-D4	%REC/SURR	119	78-122	
TOLUENE-D8	%REC/SURR	107	81-127	
ANALYST	INITIALS	LL		

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

"QC Report"

Title: Bag/Can Blank
Batch: MAB067
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A

Blank Id: A Date Analyzed: 06-JUL-93 Date Extracted: N/A

Parameters:	Units:	Results:	Reporting Limits:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.03
BENZENE	MG/M3	ND	0.03
BROMOMETHANE	MG/M3	ND	0.03
CARBON TETRACHLORIDE	MG/M3	ND	0.03
CHLOROBENZENE	MG/M3	ND	0.03
CHLOROETHANE	MG/M3	ND	0.03
CHLOROFORM	MG/M3	ND	0.03
CHLOROMETHANE	MG/M3	ND	0.03
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.03
DICHLORODIFLUOROMETHANE	MG/M3	ND	0.03
1,1-DICHLOROETHANE	MG/M3	ND	0.03
1,2-DICHLOROETHANE	MG/M3	ND	0.03
1,2-DICHLOROPROPANE	MG/M3	ND	0.03
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.03
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.03
DICHLOROTETRAFLUOROETHANE	MG/M3	ND	0.03
ETHYL BENZENE	MG/M3	ND	0.03
HEXACHLOROBUTADIENE	MG/M3	ND	0.03
M-DICHLOROBENZENE	MG/M3	ND	0.03
M,P-XYLENE	MG/M3	ND	0.03
METHYLENE CHLORIDE	MG/M3	ND	0.07
O-DICHLOROBENZENE	MG/M3	ND	0.03
O-XYLENE	MG/M3	ND	0.03
P-DICHLOROBENZENE	MG/M3	ND	0.03
STYRENE	MG/M3	ND	0.03
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.03
TETRACHLOROETHYLENE	MG/M3	ND	0.03
TOLUENE	MG/M3	ND	0.03
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.03
TRICHLOROETHYLENE	MG/M3	ND	0.03
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.03
VINYL CHLORIDE	MG/M3	ND	0.03
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.03
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.03
1,2,4-TRIMETHYLBENZENE	MG/M3	ND	0.03
1,3,5-TRIMETHYLBENZENE	MG/M3	ND	0.03
1,1-DICHLOROETHENE	MG/M3	ND	0.03
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.03
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.03
4-ETHYLTOLUENE	MG/M3	ND	0.03
BROMOFLUOROBENZENE	%REC/SURR	102	82-118
1,2-DICHLOROETHANE-D4	%REC/SURR	107	78-122
TOLUENE-D8	%REC/SURR	121	81-127
ANALYST	INITIALS	LL	

Comments:

ANALYTICAL TECHNOLOGIES, INC. 11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

"QC Report"

Title: Bag/Can Blank
Batch: MAB067
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A

Blank Id: B Date Analyzed: 07-JUL-93 Date Extracted: N/A

Parameters:	Units:	Results:	Reporting Limits:
ALPHA-CHLOROTOLUENE	MG/M3	ND	0.03
BENZENE	MG/M3	ND	0.03
BROMOMETHANE	MG/M3	ND	0.03
CARBON TETRACHLORIDE	MG/M3	ND	0.03
CHLOROBENZENE	MG/M3	ND	0.03
CHLOROETHANE	MG/M3	ND	0.03
CHLOROFORM	MG/M3	ND	0.03
CHLOROMETHANE	MG/M3	ND	0.03
CIS 1,2 DICHLOROETHYLENE	MG/M3	ND	0.03
DICHLORODIFLUOROMETHANE	MG/M3	ND	0.03
1,1-DICHLOROETHANE	MG/M3	ND	0.03
1,2-DICHLOROETHANE	MG/M3	ND	0.03
1,2-DICHLOROPROPANE	MG/M3	ND	0.03
CIS-1,3-DICHLOROPROPENE	MG/M3	ND	0.03
TRANS-1,3-DICHLOROPROPENE	MG/M3	ND	0.03
DICHLOROTETRAFLUOROETHANE	MG/M3	ND	0.03
ETHYL BENZENE	MG/M3	ND	0.03
HEXACHLOROBUTADIENE	MG/M3	ND	0.03
M-DICHLOROBENZENE	MG/M3	ND	0.03
M,P-XYLENE	MG/M3	ND	0.03
METHYLENE CHLORIDE	MG/M3	ND	0.07
O-DICHLOROBENZENE	MG/M3	ND	0.03
O-XYLENE	MG/M3	ND	0.03
P-DICHLOROBENZENE	MG/M3	ND	0.03
STYRENE	MG/M3	ND	0.03
1,1,2,2-TETRACHLOROETHANE	MG/M3	ND	0.03
TETRACHLOROETHYLENE	MG/M3	ND	0.03
TOLUENE	MG/M3	ND	0.03
1,1,2-TRICHLOROETHANE	MG/M3	ND	0.03
TRICHLOROETHYLENE	MG/M3	ND	0.03
TRICHLOROFLUOROMETHANE	MG/M3	ND	0.03
VINYL CHLORIDE	MG/M3	ND	0.03
1,2-DIBROMOETHANE (EDB)	MG/M3	ND	0.03
1,2,4 TRICHLOROBENZENE	MG/M3	ND	0.03
1,2,4-TRIMETHYLBENZENE	MG/M3	ND	0.03
1,3,5-TRIMETHYLBENZENE	MG/M3	ND	0.03
1,1-DICHLOROETHENE	MG/M3	ND	0.03
1,1,1-TRICHLOROETHANE	MG/M3	ND	0.03
TRICHLOROTRIFLUOROETHANE	MG/M3	ND	0.03
4-ETHYLTOLUENE	MG/M3	ND	0.03
BROMOFLUOROBENZENE	%REC/SURR	106	82-118
1,2-DICHLOROETHANE-D4	%REC/SURR	104	78-122
TOLUENE-D8	%REC/SURR	106	81-127
ANALYST	INITIALS	LL	

Comments:

ANALYTICAL TECHNOLOGIES, INC.   11 East Olive Road Pensacola, Florida 32514 (904) 474-1001

"QC Report"

Title: Bag/Can Reagent
Batch: MAB067
Analysis Method: TO 14 / Compendium of Methods, EPA-600/4-87-006, June 1988.
Extraction Method: N/A

RS Date Analyzed: 06-JUL-93   RS Date Extracted: N/A
RSD Date Analyzed: 06-JUL-93   RSD Date Extracted: N/A

Parameters:	Spike Added	Sample Conc	RS Conc	RS Rec%	RSD Conc	RSD Rec%	Rpd	Rpd Lmts	Rec Lmts
11-DICHLOROETHENE	2.0	<0.03	2.1	105	2.1	105	0	20	61-145
TRICHLOROETHENE	2.0	<0.03	2.1	105	2.0	100	5	20	71-120
BENZENE	2.0	<0.03	2.3	115	2.4	120	4	20	76-127
TOLUENE	2.0	<0.03	2.2	110	2.1	105	5	20	76-125
CHLOROBENZENE	2.0	<0.03	2.1	105	2.2	110	5	20	75-130
Surrogates:									
1,2-DICHLOROETHANE-D4				104		108			78-122
TOLUENE-D8				104		100			81-127
BROMOFLUOROBENZENE				100		104			82-118

Comments:

:es:
MG/M3 = MILLIGRAMS PER CUBIC METER. < = LESS THAN REPORTING LIMIT.
SOURCE FOR CONTROL LIMITS ARE INTERNAL LABORATORY QUALITY ASSURANCE PROGRAM AND REFERENCED METHODS.
N/S = NOT SUBMITTED. N/A = NOT APPLICABLE.

Common notation for Organic reporting

N/S = NOT SUBMITTED
N/A = NOT APPLICABLE
D = DILUTED OUT
NG = NANOGRAMS.
UG = MICROGRAMS.
MG/M3 = MILLIGRAMS PER CUBIC METER.
PPBV = PARTS PER BILLION/VOLUME.
PPMV = PARTS PER MILLION/VOLUME.
< = LESS THAN DETECTION LIMIT.
* = VALUES OUTSIDE OF QUALITY CONTROL LIMITS

ND = NOT DETECTED ABOVE REPORTING LIMIT.

SOURCES FOR CONTROL LIMITS ARE INTERNAL LABORATORY QUALITY ASSURANCE PROGRAM AND REFERENCED METHOD.

DH = DARREL HALSELL
LL = LANCE LARSON
CMV = COLLEEN MCVICAR
RW = RITA WINGO
LD = LARRY DILMORE
BR = BILL RUBERT

PROJECT INFORMATION

Accession Number ~~307003~~ 6936 Due to Client 15 JULY 93 Bottle Order ID

Client Code APP GEO TECH Office ID BELLEVUE PM CP

PO Number Project Number 1462-124

Project Name FKC LANDFILL / GAS PROBE SAMPLING

Project Location KING COUNTY

Report To MARK ADAMS

Sampled By ADC

Comment

Requirement Code 1 Number of Report Copies 1

Is there a Chain of Custody?	Y	N	Are samples correctly preserved?	Y	N
Was Chain of Custody signed?	Y	N	Is there sufficient volume for analysis requested	Y	N
Were samples received cold?	Y	N	Were samples received within holding time?	Y	N
Were samples received in proper containers?	Y	N	Were matrix spike bottles returned?	Y	N
			Is there headspace greater than ¼" in diameter in volatile bottles?	Y	N

Date Received 30 JUN 93 Tracking Number 1322713346

Shipped By FEDEX Cooler Number 1322713335

Discount %

INVOICE INFORMATION

Invoice Comment

Enter or Query Miscellaneous Charges? Y N

Out of Control events and inspection comments

ATI will perform the services in accordance with normal professional standards for the industry. The total liability of ATI, any and all officers and employees or successors, to clients for service provided, will not exceed the invoice amount for said service. Client acceptance of a proposal releases ATI from any liability in excess thereof.

PM Approval CP 7/1 Inspected By [signature] Date Inspected 15 Jul 93 Logged By [signature]

Applied Geotechnology Inc.
Geotechnical Engineering
Geology & Hydrogeology

306936
~~307003~~

CHAIN-OF-CUSTODY

Date 6/28/93 Page 1 of 1

PROJECT INFORMATION

Project Manager: Mark Adams
Project Name: PKC Landfill / Gas Probe Sampling
Project Number: 14621.124
Site Location: King County Sampled By: ADC

DISPOSAL INFORMATION

☒ Lab Disposal (return if not indicated) CA
Disposal Method: ______
Disposed by: ______ Disposal Date: ______

QC INFORMATION (check one)

☒ SW-846 ☐ CLP ☐ Screening ☐ AGI Std. ☐ Special

Laboratory Number:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	TPH-ID State:	TPH-G State:	TPH-D State:	TPH Special Instructions	418.1 State:	8015M	8010 Halogenated VOCs	8020 Aromatic VOCs	8020M - BETX only	8240 GCMS Volatiles	8270 GCMS Semivol.	8310 HPLC PAHs	8040 Phenols	DWS - Volatiles and Semivol.	8080 OC Pest/PCBs	8080M PCBs only	8140 OP Pesticides	8150 OC Herbicides	DWS - Herb/pest	Selected metals: list	Total Lead (Wa)	Organic Lead (Ca)	TCL Metals (23)	Priority Poll. Metals (13)	DWS - Metals	MFSP - Metals (Wa)	TCLP - Volatiles (ZHE)	TCLP - Semivolatiles	TCLP - Pesticides	TCLP - Metals	EPA method TO14	Atmospheric gases*			NUMBER OF CONTAINERS
PKC-GSM1	6/28/93	11:05	air																																X	X			1
PKC-GS2	"	11:43	"																																X	X			1
PKC-GS5	"	12:54	"																																X	X			1
PKC-GS3	"	12:15	"																																X	X			1
PKC-GS4	"	12:23	"																																X	X			1

Column groups: PETROLEUM HYDROCARBONS (TPH-ID to 8015M); ORGANIC COMPOUNDS (8010 to DWS - Volatiles and Semivol.); PESTS/PCBs (8080 to DWS - Herb/pest); METALS (Selected metals to MFSP - Metals); LEACHING TESTS (TCLP); OTHER.

LAB INFORMATION

Lab Name: ATI - Pensacola
Lab Address: 11 East Olive Rd
Pensacola Fl 32514
Via: Fed-Ex

SAMPLE RECEIPT

Total Number of Containers:
Chain of Custody Seals?: Y/N/NA
Intact?: Y/N/NA
Received in Good Condition/Cold:

Turn Around Time: ☒ Standard* ☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 1 wk.

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH DATA

Special Instructions: * TAT = 5-9 days. Fax data ASAP Thanx
** Analyze for CO_2, CH_4, O_2 and N_2

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.	RELINQUISHED BY: 3.
Signature: Alan D Carey Time: 1300	Signature: Time:	Signature: Time:
Printed Name: ALAN D. CAREY Date: 6/28/93	Printed Name: Date:	Printed Name: Date:
Company: AGI	Company:	Company:

RECEIVED BY: 1.	RECEIVED BY: 2.	RECEIVED BY: 3.
Signature: Richard Foote Time: 0930	Signature: Time:	Signature: Time:
Printed Name: RICHARD FOOTE Date: 3/30/93	Printed Name: Date:	Printed Name: Date:
Company: ATI	Company:	Company:

AGI OFFICES: Bellevue: (206) 453-8383 Tacoma: (206) 383-4380
Portland: (503) 222-2820 Pleasanton: (415) 460-5495

DISTRIBUTION: White, Canary to Analytical Laboratory; Pink to AGI Project Files; Gold to AGI Disposal Files

Rev. 12/91

Did NOT use T-099 (...Summa in separate box)

AGI
TECHNOLOGIES

APPENDIX I

Previous Investigations - Monitoring Well and Gas Probe Logs and Installation Diagrams

Converse Consultants N.W., 1991

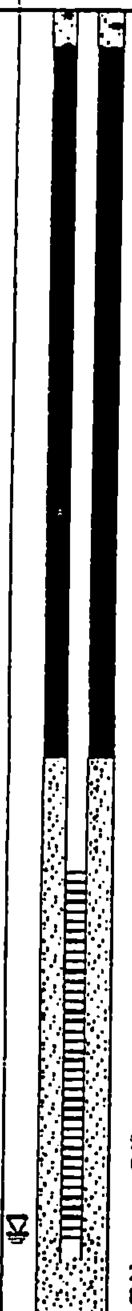
Monitoring Well Geologic & Construction Log
Monitoring Well Geologic & Construction Log

Converse NW

Project Number	Well Number	Sheet 1 of 1
90-35223-03	MW-1	

Project: ALDER GLEN INVESTIGATION
Elevation (Top of Well Casing): ~325
Water Level Elev.: 292.13
Drilling Contractor: Soil Sampling
Drilling Method: Top Drive Air Rotary

Location: King County, Washington
Surface Elevation: 325.00
Start Date: August 5, 1991
Finish Date: August 5, 1991



Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVA* ppm	Description
	flush, locking, metal monument; concrete annular seal					FILL SILTY SAND WITH GRAVEL; gray-brown, fine to medium, trace wood, concrete fragments, and organics; medium dense, moist
						becomes moist
5					11 ppm	
10	2" ID schedule 40 riser				11.5 ppm	OLD SOIL HORIZON ORGANIC SILT/SILTY SAND WITH GRAVEL; dark-brown, fine to medium, with layers of organic silt and peat; loose, very moist
						GLACIAL TILL (weathered) SILTY SAND WITH GRAVEL; gray-brown, fine to coarse, trace cobbles, very dense, very moist
15	granular bentonite seal					
						SILT; gray-brown, little sand, scattered gravel; hard, moist
20					0 ppm	SILTY SAND WITH GRAVEL; gray, fine to medium, scattered layer of silt; very dense, moist
25	10/20 silica sand filter pack					
						becomes wet
						ADVANCE OUTWASH DEPSOSITS SAND AND GRAVEL; gray, fine to coarse, trace silt; very dense, moist
30	2" ID schedule 40 screen, 0.020" slot size					
						GLACIAL TILL SILTY SAND WITH GRAVEL; gray, fine to coarse; very dense, moist
	2" ID schedule 40 end cap 8/10/91					SAND; gray, fine to medium trace silt; very dense, moist
35						Bottom of boring at depth 35 feet. OVA* = reads total organic vapor

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: DAY
Approved by: EWM

Figure No. A-1

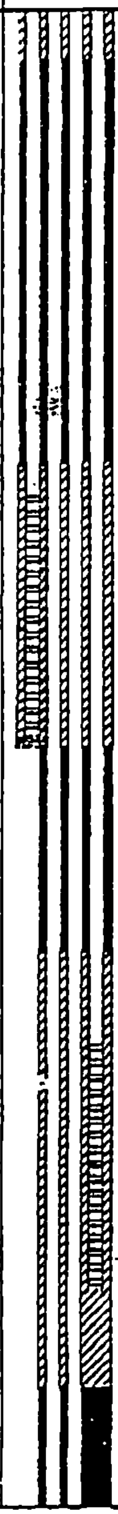
Monitoring Well Geologic & Construction Log

Converse NW

Project Number	Well Number	Sheet
90-35223-03	P-2	1 of 2

Project: ALDER GLEN INVESTIGATION
Elevation (Top of Well Casing): ~323
Water Level Elev.:
Drilling Contractor: Soil Sampling
Drilling Method: Top Drive Air Rotary

Location: King County, Washington
Surface Elevation: 323.00
Start Date: August 5, 1991
Finish Date: August 5, 1991



Depth Feet	Well Construction	Lab Tests	ST	Blows/6"	OVA* ppm	Description
	flush, locking, locking metal monument concrete annular seal 3/4"ID schedule 80 PVC riser					FILL SILTY SAND WITH GRAVEL; brown, fine to medium, trace wood, roots and organics; medium dense, moist
5					0 ppm	
	granular bentonite seal					RECENT ALLUVIUM SILTY SAND WITH GRAVEL; gray-brown, fine to medium, little organics trace wood; loose, very moist
10	10/20 silica sand filter pack				0 ppm	
	3/4" ID schedule 80 PVC screen, 0.020" slot size					GLACIAL TILL (weathered) SILTY SAND WITH GRAVEL; brown fine to medium. trace organics; medium dense, wet
15					0 ppm	
	granular bentonite seal					ADVANCE OUTWASH DEPOSITS SAND, brown, fine to medium, trace gravel; dense, moist
	3/4" ID schedule PVC riser					scattered gravels
20					0 ppm	
	10/20 silica sand filter pack 3/4" ID schedule 80 PVC screen, 0.020" slot size					
25					2 ppm	
	granular bentonite seal 3/4" ID schedule 80 riser					SAND; gray-brown, fine to coarse, trace silt; dense, very moist

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: DAY
Approved by: EWM

Figure No. A-2

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
90-35223-03	P-2	2 of 2

Project ALDER GLEN INVESTIGATION
Elevation (Top of Well Casing) ~323
Water Level Elev.
Drilling Contractor Soil Sampling
Drilling Method Top Drive Air Rotary

Location King County, Washington
Surface Elevation 323.00
Start Date August 5, 1991
Finish Date August 5, 1991

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVA* ppm	Description
					2 ppm	ADVANCE OUTWASH DEPOSITS SAND (cont.)
						SAND AND GRAVEL; gray-brown, fine to coarse, trace to little silt, thinly bedded with sand
	10/20 silica sand filter pack					
35	3/4" ID schedule 80 PVC screen, 0.020" slot size				2 ppm	
	3/4" ID schedule 80 PVC riser					
40	granular bentonite seal				100 ppm	
	10/20 silica sand filter pack					
						SAND; brown, fine to medium, trace silt; very dense, moist
45	3/4" ID schedule 80 PVC screen, 0.020" slot size				15 ppm	
					100 ppm to >1000 ppm	
50						Bottom of boring at depth 50.0 feet OVA* = reads total organic vapor
55						

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: DAY
Approved by: EWM

Figure No. A-2

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
90-35223-03	P-3	1 of 1

Project: ALDER GLEN INVESTIGATION
Elevation (Top of Well Casing): ~323
Water Level Elev.:
Drilling Contractor: Soil Sampling
Drilling Method: Top Drive Air Rotary

Location: KingCounty, Washington
Surface Elevation: 323.00
Start Date: August 6, 1991
Finish Date: August 6, 1991

Depth feet	Well Construction	Lab Tests	ST	Blows/ 6"	OVA* ppm	Description
	flush, locking, metal monument; concrete annular seal; 3/4" ID schedule 80 PVC riser; granular bentonite seal					FILL SILTY SAND WITH GRAVEL; gray-brown, fine to coarse, trace roots, brick fragments, and wood fragments; medium dense, moist
	3/4" ID schedule 80 PVC screen, 0.020" slot size; 10/20 silica sand filter pack					
5					0 ppm	
	granular bentonite seal					
	10/20 silica sand filter pack					SILTY SAND; brown, fine to medium, little gravel, trace gravel;loose, very moist
	3/4" ID schedule 80 PVC screen, 0.020" slot size					
10					0 ppm	Bottom of boring at depth 10.0 feet OVA* = reads total organic vapor

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: DAY
Approved by: EWM

Figure No. A-3

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
90-35223-03	P-4	1 of 1

Project: ALDER GLEN INVESTIGATION
Elevation (Top of Well Casing): ~325
Water Level Elev.:
Drilling Contractor: Soli Sampling
Drilling Method: Top Drive Air Rotary

Location: King County, Washington
Surface Elevation: 325.00
Start Date: August 6, 1991
Finish Date: August 6, 1991

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVA* ppm	Description
	flush, locking, metal metal monument concrete annular seal 3/4" ID schedule 80 PVC riser, granular bentonite seal 3/4" ID schedule 80 PVC, 0.020" slot size 10/20 silica sand filter pack					FILL SILTY SAND WITH GRAVEL; brown, fine to medium, trace wood and organics; medium dense, slightly moist
5	granular bentonite seal 3/4" ID schedule 80 PVC riser 10/20 silica sand filter pack 3/4" ID schedule 80 PVC, 0.020" slot size				0 ppm	ADVANCE OUTWASH DEPOSITS SAND WITH SILT; gray-brown, fine to medium, little gravel, thinly bedded with sand; very dense, moist
10					0 ppm	Bottom of boring at depth 10.0 feet. OVA* = reads total organic vapor

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: DAY
Approved by: EWM
Figure No. A-4

Associated Earth Sciences, Inc., 1989

EXPLORATION BORING LEGEND

SYMBOLS

SAMPLE TYPES

Split Spoon Sample

Grab Sample

GROUNDWATER LEVEL

SCREEN

ABREVIATIONS

STD. PEN.	N Value. After an initial set of 6", the number of blows required by a 140# weight falling 30" to drive the sample an additional 12"
H_2S	Hydrogen Sulphide
ppm	Parts per million
%LEL	Percent lower explosive level. The percent of total saturation (5%) of an explosive gas.
PVC	Polyvinyl chloride (plastic). Generally pertaining to standard pipes, casings, or screens.

%LEL	Approximate % Methane*
Non detected	
0 - 50	>0 - <4
50 - 200	≥4 - <11
200 - 500	≥11 - <26
500 - 750	≥26 - <40
750 - >1000	≥40 - <53

* Assumes explosive gas is methane

≥ - Equal to or greater than

< - Less than

ASSOCIATED EARTH SCIENCES, INC
903 - 5th Avenue, Kirkland, Washington 98033

EXPLORATION BORING LOG EB-2

GRAPH	STD. PEN.	SEDIMENT DESCRIPTION	DEPTH	SAMPLE	GROUND WATER	WELL CONST.	H_2S (ppm)	% LEL	Organic Volatiles (ppm)	% Oxygen
		24" Sand, moist, brown, with some small gravel ¼"					0.0	0.0	0.0	20.8
	21	Same as above	5				0.0	[illegible]	5	15.7
	68+	Very dense, dry, grey, silty sand with some gravel ¼"–½" Sand layer 12–13½'	10				0.0	2.2	2	20.0
	15	Sand, light brown with trace of small gravel.	15				0.0	15	0-1	20.2
	82+	Boring terminated at 22.5' bit sheared off Moved over 10' to east and redrilled.	20				0.0	38	0.0	19.7
		BOH 22.5	25							
			30							
			35							

8708-10V

Apr. 11, 1989

Evergreen Vale
King County, Washington.

ASSOCIATED EARTH SCIENCES, INC

EXPLORATION BORING LOG GMW-2

GRAPH	STD. PEN.	SEDIMENT DESCRIPTION	DEPTH	SAMPLE	GROUND WATER	WELL CONST.	H_2S (ppm)	% LEL	Organic Volatiles (ppm)	% Oxygen
		6" Brown silty sand.					0.0	0.0	0.0	20.8
						1/2" Bentonite				
		Loose, dry, dark brown, silty sand with some gravel.	5			Silica Sand	0.0	>100	0-1	18.0
		Same as above, dense at 11'	10			1/2" Bentonite chips	0.0	>100	0-1	16.3
		Same as above	15			Silica Sand	0.0	>100	0-1	16.5
		Sand layer 18'-19' loose dense below 19'								
		Same as above	20				0.0	>100	0-1	16.5
		Rock at 22' BOH 22.0								
			25							
			30							
			35							

Evergreen Vale
King County, Washinton.

8708-10V | May 12, 1989

ASSOCIATED EARTH SCIENCES, INC

EXPLORATION BORING LOG GMW-3

STD. PEN.	SEDIMENT DESCRIPTION	DEPTH	H_2S (ppm)	% LEL	Organic Volatiles (ppm)	% Oxygen
	Dense, moist, brown, sandy silty gravel, gravel ¼"-3"+ at 2½'		0.0	0.0	0.0	20.8
73+	Dense, moist, grey, silty sandy gravel, gravel ¼"-3"	5	0.0	5	0.0	20.1
61	Silt inc.; dry	10	0.0	10	0.0	20.0
	Less dense					
45	Same as above	15	0.0	2	0.0	20.4
77+	Same as above	20	0.0	19	0.0	19.2
	Same as above	25	0.0	>100	4	19.0
	Same as above		0.0	>100	1.0	14.0
	BOH 30'	30				
		35				

Well Const.: Silica Sand (approx. 7'–11'); Silica Sand (approx. 20'–30')

8708-10V | May 14, 1989

Evergreen Vale
King County, Washington.

ASSOCIATED EARTH SCIENCES, INC

EXPLORATION BORING LOG GMW-4

GRAPH	STD. PEN.	SEDIMENT DESCRIPTION	DEPTH	SAMPLE	GROUND WATER	WELL CONST.	H_2S (ppm)	% LEL	Organic Volatiles (ppm)	% Oxygen
						1/2" Bentonite				
		Dense, moist, light grey/brown, silty sand with some gravel, gravel ¼"-1", rock at 6'	5	☒			0.0	2	0.0	20.6
						Silica Sand				
		Very dense, dry, light grey/brown, silty, sandy, gravel ¼"-2"	10	☒		#10 Slot 2" PVC	0.0	5	0.0	18.5
		Same as above.	15	☒	▼		0.0	6	0.0	18.0
		Same as above	20	☒			0.0	0.0	0.0	20.8
		Same as above		☒			0.0	0.0	0.0	20.8
		BOH 25'	25							
		Terminated at 25' (Hole caved to 17')	30							
		Note: Drilled with solid stem auger. Pulled auger to monitor borehole and obtain sample	35							

8708-10V | May 13, 1989

Evergreen Vale
King County, Washington.

ASSOCIATED EARTH SCIENCES, INC

EXPLORATION BORING LOG GMW-5

GRAPH	STD. PEN.	SEDIMENT DESCRIPTION	DEPTH	SAMPLE	GROUND WATER	WELL CONST.	H_2S (ppm)	% LEL	Organic Volatiles (ppm)	% Oxygen
			0				0.0	0.0	0.0	20.8
		Dense, moist, light grey/brown, sandy silty gravel, gravel ¼"-3" some wood fragments.								
	7	Same as above	5	I		1/2" Bentonite	0.0	1	0.0	19.0
	50+	Same as above but very dense	10	I		Silica Sand	0.0	2	0.0	18.0
						10'x2" #10 slot screen. 40 PVC				
	62	Same as above but moist	15	I			0.0	0.0	0.0	20.5
						1/2" Bentonite				
		Same as above but moist	20	⊠		Pea Gravel 1/2" Bentonite	0.0	5	0.0	18.3
		(Spoon bent and scraped)				1/2" Bentonite				
		Same as above	25	⊠			0.0	0.0	0.0	20.8
						Silica Sand				
			30	⊠	▼		0.0	1	0.0	20.8
			35	⊠			0.0	2	0.0	20.2

8708-10V

May 17, 1989

Evergreen Vale
King County, Washington.

ASSOCIATED EARTH SCIENCES, INC

EXPLORATION BORING LOG GMW-5

GRAPH	STD. PEN.	SEDIMENT DESCRIPTION	DEPTH	SAMPLE	GROUND WATER	WELL CONST.	H_2S (ppm)	% LEL	Organic Volatiles (ppm)	% Oxygen
				X			0.0	2	0.0	20.4
		Dense, moist, light grey/brown, sandy silty gravel, ¼"-3"; some wood fragments.	45	X			0.0	0.0	0.0	20.8
		BOH 45'	50							
			55							
			60							
			65							
			70							
			75							
		Note: Had to pull auger before building well- could not beat out plug.								

Evergreen Vale
King County, Washington.

8708-10V

May 17, 1989

ASSOCIATED EARTH SCIENCES, INC

AGI TECHNOLOGIES

APPENDIX J

Regional Geology Description

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Regional Geology Description

The landfill lies within the Puget Sound lowland, a north-south trending topographic and structural depression located between the Cascade Range on the east to the Olympic Mountains on the west. The lowland is underlain by Tertiary volcanic and sedimentary bedrock and is filled to the present-day land surface with Quaternary glacial and nonglacial sediments. Depth to the Tertiary bedrock beneath the landfill area is thought to be over 1,000 feet (Hall and Othberg, 1974).

Deposits of at least four Pleistocene glaciations have been identified in the southern Puget Sound lowland (Crandall, et al., 1958). These include (from oldest to youngest) the Orting, Stuck, Salmon Springs, and Vashon Glaciations. Armstrong, et al. (1965) renamed the youngest glaciation the Fraser, and modified it to include two glacial advances, or stades, separated by one interstade. The youngest stade of the Fraser Glaciation is the Sumus and the oldest is the Vashon. Only deposits of the Vashon Stade are present in the southern Puget Sound lowland. Sumus Stade deposits are limited to the extreme northern Puget Sound lowland. During the Vashon Stade, a lobe of glacial ice emanating from the British Columbia coast ranges entered the lowland. The Vashon glacier covered the entire lowland with as much as several thousand feet of ice and, at its maximum, extended a few miles south of Olympia (Thorson, 1980).

Fluvial, lacustrine, and direct ice contact processes associated with the advance and recession of the Vashon glacier are responsible for the majority of the surficial deposits and landforms throughout the Puget Sound lowland and in the landfill area. Outwash streams of meltwater from the advancing glacier deposited sand and gravel over much of the area. Overriding glacial ice covered some areas of advance outwash with till, a nonsorted mixture of clay, silt, sand, and gravel, while other areas were simply eroded and sculpted by the moving ice. As the ice receded by melting and evaporation, large quantities of water flowed over the lowland, cutting meltwater channels and depositing sediments into low lying areas. These deposits are collectively known as Recessional Outwash.

Each glaciation preceding the Fraser had similar erosional and depositional processes. Consequently, the deposits of older glaciations often appear physically and hydraulically similar to those of the Vashon Stade. Older glacial deposits are frequently encountered in deeper boreholes and are often exposed in the lower sections of sea cliffs and valley walls throughout the Puget Sound lowland.

Drift from two older glaciations--the Salmon Springs and the Stuck--were mapped as occurring near the landfill (Waldron, 1961). Salmon Springs Drift is particularly widespread and occurs along the Duwamish Valley walls and Puget Sound sea cliffs. An extensive sequence of Salmon Springs Drift is exposed in the cliffs bordering Commencement Bay (Smith, 1976).

Erosional and depositional processes similar to those occurring today operated during periods between glaciations. These processes include sedimentation through overbank flooding in alluvial river valleys and delta building by rivers discharging into freshwater lakes and Puget Sound. Most sediments associated with these processes are finer-grained sands, silts, and clays. However, coarse sands and gravels were occasionally deposited in relatively high energy streams. Older interglacial deposits are encountered at depth within the geologic section. Waldron's (1961) geologic map of the Poverty Bay Quadrangle, in which landfill is located, shows only one interglacial deposit in the area–the Puyallup Formation. Localized outcrops of the Puyallup Formation occur along the Duwamish Valley walls and Puget Sound sea cliffs.

Waldron (1961) and Robinson & Noble (1987) have identified three major Vashon deposits and two major pre-Vashon deposits in the area of the Des Moines Drift Plain within which the landfill is located.

Vashon Deposits: Till consists of a dense mixture of gravel, sand, silt, and clay deposited beneath the Vashon glacier. It typically ranges from 25 to 75 feet thick, and corresponds to Vashon Till as described by Waldron (1961) and to hydrostratigraphic layer B of Robinson & Noble (1987). A thin mantle of sand and gravel overlies the till in some areas. The sand and gravel were deposited as the Vashon glacier melted and are collectively known as Recessional Outwash.

Glacial advance outwash sand and gravelly sand were deposited by the advancing Vashon glacier in a subsurface channel immediately west of the landfill. The Sand corresponds to the advance meltwater deposits of Waldron (1961) and Robinson & Noble's (1987) hydrostratigraphic layer C1. The common name for this sand deposit is the Esperance Sand (Crandell, et al., 1958).

The subsurface channel has been termed the Redondo-Milton Channel by Robinson & Noble (1987). It averages 1 to 2 miles wide and extends north-south from Redondo, approximately 4 miles north of the landfill, to Milton (Puyallup Valley), approximately 2-1/2 miles south of the landfill. The base of the channel has a southerly slope of approximately 45 feet per mile. At Redondo, the base is near Elevation 150 feet above Mean Sea Level (MSL) and at Milton, near 130 feet below MSL. The Sand has a maximum thickness of approximately 200 feet along the axis of the channel, but thins toward the sides.

In the area generally underlying the Redondo-Milton Channel are sediments deposited at the bottom of a former lake dammed behind the Vashon glacier. This deposit corresponds to the glaciolacustrine silt and clay of Waldron (1961). It also corresponds to Robinson & Noble's (1987) hydrostratigraphic layer C2. The common name for this unit is the Lawton Clay (Mullineaux, et al., 1965).

Pre-Vashon Deposits: A thick deposit of silty sand and gravel underlies much of the area. The proportion of silt and sand varies markedly. In some areas, the silty sand and gravel has a till-like character, while in others it is better sorted. This deposit can be several hundred feet thick. It may correspond to the Salmon Springs Drift of Waldron (1961) and to Robinson & Noble's (1987) hydrostratigraphic layer D and top of layer E.

A widespread deposit of fine-grained silt and clay occurs throughout the area beneath the sand and silty sand and gravel. Like the silty sand and gravel, it can be several hundred feet thick. It corresponds to the Puyallup Formation of Waldron (1961) and to Robinson & Noble's (1987) hydrostratigraphic unit E. Other Pleistocene sediments are present below the silt and clay and extend to Tertiary bedrock.