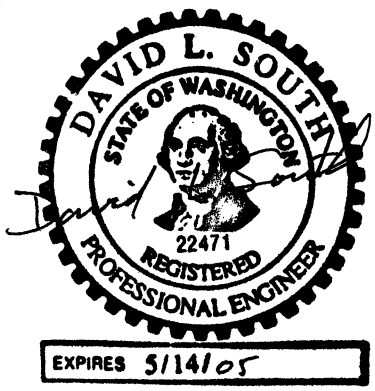
Periodic Review Report

Second Periodic Review
for
Kent Highlands Landfill Site
Kent, Washington

FINAL

September 23, 2003



PREPARED BY

Washington State Department of Ecology
Northwest Regional Office
Bellevue, Washington

Approved by: **Date:**

David L. South — Sept. 23, 2003

David L. South
Senior Engineer, Toxics Cleanup Program
Washington State Departement of Ecology

Michael F. Gearheard
Director, EPA Region 10 Environmental
Cleanup Office

Executive Summary

The purpose of this periodic review is to determine whether the cleanup remedy at the City of Seattle's Kent Highlands Landfill Superfund Site continues to be protective of human health and the environment. The review focuses on answering three questions. The answers to these questions are summarized below. See the *Technical Assessment* chapter for more detail.

Question A: Is the remedy functioning as intended by the decision documents?

- The remedy has reduced impacts, but it has not brought the landfill into compliance with respect to vinyl chloride and manganese in ground water in selected wells. Oxygen and ammonia concentrations in surface water being discharged to the Green River are out of compliance at the specified monitoring point. The source of these contaminants (the waste placed in the landfill) remains on site and continues to generate these contaminants. The out of compliance conditions are not considered to be emergency conditions.

- The City of Seattle has not been filing annual reports of the spring drain monitoring as required (CH2MHill, 1995, p. 10-3). The spring drain discharge monitoring data must be compiled and evaluated.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid?

Answer: In 1996 the Consent Order governing cleanup at this site was amended. The amendment provides that the site is being cleaned up pursuant to the Water Pollution Control Act [Ch. 90.48 RCW] and the Model Toxics Control Act [Ch. 70.105D RCW], as well as all other applicable state and federal laws. The exposure assumptions and remedial action objectives used at the time of remedy selection have not been reviewed with respect to the Model Toxics Control Act for this periodic review. This will be done for vinyl chloride and manganese in ground water as part of the Follow-Up Actions.

With respect to the toxicity data and cleanup levels, and considering the ground water parameters of primary interest:

Referring to *Cleanup Levels and Risk Calculation under the Model Toxics Control Act Cleanup Regulation* (Ecology, 2001), the vinyl chloride MTCA cleanup level has increased from 0.023 to 0.029 µg/L since preparation of the table of regulatory values in the *Ground Water Compliance Monitoring Plan*, (Seattle, 1996, Table 5-7).

Referring to *Cleanup Levels and Risk Calculation under the Model Toxics Control Act Cleanup Regulation* (Ecology, 2001), the manganese cleanup level, which is based on the Secondary Maximum Contaminant Limit of 50 µg/L under the Safe Drinking Water Act, has not changed. However, the 1994 MTCA health based cleanup level of 80 µg/L, given in the table of regulatory values in *Groundwater Compliance Monitoring Plan*

(Seattle, 1996, Table 5-7), has been increased to 747 μg/L to reflect EPA's updated reference dose and use of a modifying factor of 3 when assessing exposure from drinking water.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Not at this time.

A protectiveness determination of the remedy at the Kent Highlands Landfill cannot be made at this time. Further information will be obtained in the Follow-Up actions. It is expected that these actions will take until June 30, 2004, to complete, at which time a protectiveness determination will be made.

The City of Seattle has indicated to the Washington State Department of Ecology that the City of Seattle is not in agreement with the findings of this review.

Periodic Review Summary Form

SITE IDENTIFICATION		
Site Name *(from WasteLAN)*: Seattle Municipal Landfill (Kent Highlands)		
EPA ID *(from WasteLAN)*: 1000889		
Region: 10	State: WA	City/County: Kent/King
SITE STATUS		
NPL status: ☒ Final ☐ Deleted ☐ Other (specify)		
Remediation status (choose all that apply): ☐ Under construction ☒ Operating ☐ Complete		
Multiple OUs?* ☐ yes ☒ no	Construction completion date: 07SEP1995	
Has site been put into reuse? ☐ yes ☒ no		
Review Status		
Lead Agency: ☐ EPA ☒ State ☐ Other Federal Agency _____		
Author Name: David L. South		
Author Title: Remedial Project Manager	Author Affiliation: WA State Dpt. of Ecology	
Review Period**: September 1998 to September 2003		
Dates of site inspection: May 22, 2003		
Type of Review: ☐ Post-SARA ☐ Pre-SARA ☐ NPL – Removal Only ☐ Non-NPL Remedial Action Site ☒ NPL State/Tribe-lead ☐ Regional Discretion		
Review Number: ☐ First ☒ Second ☐ Third ☐ Other (specify)		
Triggering Action: ☐ Actual RA on-site Construction at OU# _____ ☐ Actual RA Start at OU# _____ ☐ Construction Completion ☒ Previous Five-Year Review Report ☐ Other (specify):		
Triggering action date *(from WasteLAN)*: September 1998		
Due date *(five years after triggering action date)*: Next periodic review due in 2008.		

* ["OU" refers to operable unit.]

** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

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Acronyms and Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
MTCA	Model Toxics Control Act
NPL	National Priorities List
O&M	Operations and Maintenance
RAO	Remedial Action Objective
WAC	Washington Administrative Code

Introduction

The purpose of this periodic review is to determine whether the cleanup remedy at the City of Seattle's Kent Highlands Landfill Superfund Site continues to be protective of human health and the environment.

The Kent Highlands Landfill was placed on the National Priorities List (NPL) on August 30, 1990. It is a state-lead site. The Washington State Department of Ecology (Ecology) is responsible for the oversight management of the site as stipulated by an agreement with Region 10 of the Environmental Protection Agency (EPA). The cleanup is managed by Ecology under the authority of the Model Toxics Control Act [Chapter 70.105D RCW], the Water Pollution Control Act [Ch. 90.48 RCW], and all other applicable state and federal laws.

WAC 173-340-420 provides for periodic review of post-cleanup conditions at sites where institutional controls are required as part of the cleanup action. Institutional controls are required at the landfill because waste is contained on site.

Reviews must be conducted at least every five years after the initiation of the cleanup action. The EPA performed a five year review in September 1998. This review has been conducted by the Toxics Cleanup Program, Northwest Regional Office, Washington State Department of Ecology.

The City of Seattle has indicated to Ecology that the City of Seattle is not in agreement with the findings of this review.

Site Chronology

2000	Gas collection system expanded
September 11, 1998	First periodic review (conducted by EPA)
July 1995	Remedial construction complete
August 30, 1990	Placed on the NPL
June 24, 1988	Proposed for the NPL
December 31, 1986	Landfill reaches capacity and closes to new waste
1983	Landfill begins accepting industrial wastes and construction and maintenance debris
June 1968	Landfill opens, accepting municipal waste

Background

Location

The Kent Highlands Landfill is in King County, Washington, at 23076 Military Road South, Kent, WA 98032. It can be reached by taking Exit 149 on Interstate 5 onto State Route 516 going east. Follow State Route 516 towards Kent and turn north at the light at Military Road. The landfill entrance is a short distance north of the intersection, on the east side of Military Road. Figure 1 shows the regional site location and Figure 2 shows the site and surrounding vicinity.

The location is in a geographic area known as the Puget Sound Lowland. The area has been glaciated several times and is underlain by a sequence of glacio-fluvial sediments. The area has a maritime climate characterized by cool, wet winters and drier, mild summers. Annual rainfall is about 40 inches per year, which falls mainly between November and June.

Owners and Operators

The landfill was operated by the City of Seattle. The City of Seattle continues to operate the post-closure systems.

The landfill was placed on land owned by the private owners (Kent Management Inc.), King County, and the City of Kent. Since closure, the City of Seattle has purchased the Kent Management Inc. and King County land, and now owns all but the City of Kent parcel. Figure 3 shows these parcels. Deed covenants have been placed on all parcels. The City of Seattle anticipates acquiring the City of Kent land in the future as part of a land swap. The City of Kent is planning to extend South 228th Street from across the Green River westward to connect with Military Road. The street would be immediately north of the northern landfill boundary. The City of Kent and the City of Seattle plan to swap land the City of Seattle owns north of the landfill boundary for the land the City of Kent owns within the landfill boundary.

Operating Characteristics

The majority of the waste received at the landfill was municipal waste. After Midway Landfill closed in 1983, increased amounts of industrial waste and construction and maintenance waste were delivered to the site. There are approximately 8 million cubic yards of waste in place at the Kent Highlands Landfill. The total quantity of industrial waste delivered to the site is estimated in the remedial investigation report to be less than half a percent (0.5 %) of the total quantity of waste delivered to the landfill. The remedial investigation report concludes that, " ... it is unlikely that significant quantities of hazardous wastes were delivered to the Kent Highlands landfill in the industrial-type wastes that were accepted there after Midway Landfill's closure." (Seattle, 1991, p. 1-16 ff.) The comparison standard for "significant quantities" is not specified. Less than 0.5%

of the total waste may not be significant on a volume comparison basis. On the other hand, 0.5% industrial waste in a large landfill may be a significant quantity in terms of its potential to impact ground water flowing beneath the landfill, which has no bottom liner (see below).

Physical Characteristics

The landfill was placed in a deep ravine which slopes downward from west to east to the Green River. The floor of the ravine was poorly drained and swampy with a thick cover of brush and trees. A stream also flowed through the ravine. It was fed by springs along the foot of the northern slope of the ravine and by runoff that drained into the ravine from the higher ground to the west. The stream flowed out of the ravine into a wetland area, which then flowed into the Green River. Figure 4 shows the ravine in which waste was placed and the surrounding area. Figure 5 shows the pre-landfill topography in 1968.

As the ravine was filled with municipal waste, offsite surface water from the uplands to the south, west, and north of the site was diverted around the site through ditches and pipes. Onsite storm water now drains to ditches along the north and south sides of the landfill to the surface water treatment pond located on the lower eastern part of the site, and then to the Green River.

Waste disposal at the site began in 1968. Solid waste was placed in lifts directly upon native soil and covered with soil taken from a borrow area north of the landfill. Landfilling started at the bottom of the ravine at the east end of the site and continued until the entire ravine was filled, leaving a terraced slope at the east end of the site. Landfilling stopped in December 1986.

Piping was installed along the walls of the ravine to intercept springs. Piping was also installed to collect leachate. This piping was eventually covered by waste. Upon completion of remedial construction in 1995 the spring drain and leach drain both flowed into a pretreatment aeration pond at the east end of the site, and thence via force main to the King County Renton Sewage Treatment plant. In 1996 the spring drain water was separated from the leachate flows.

The spring drain water is now discharged to the Green River. Water quality requirements are contained in *Technical Memorandum, Kent Highlands Landfill Spring Drain Separation*, dated September 13, 1995.

Leachate is discharged to the Renton Sewage Treatment plant and must meet the requirements of King County Waste Discharge Permit 7115.

Landfill gas was collected by vent pipes installed in the landfill during filling. Most of these pipes were connected to a forced exhaust system that discharges the gas to flares at two locations near the western and northern edges of the site. Gas migration west of the site was detected in 1984 and a series of perimeter gas extraction wells were installed in native soils along the site perimeter to bring the gas migration under control. This system

has been extended along the north and south sides of the landfill. No gas migration has been detected to the east of the site or south of SR 516.

Ground water flowing through and beneath the landfill discharges to the alluvial aquifer of the Green River.

Land and Resource Use

The Kent Highlands Landfill is located in the west part of the City of Kent. Figure 2 shows the general area of the landfill.

West of the landfill, along Military Road, nearby commercial activities include Timlick's Auto Rebuild and Lloyd's Auto immediately adjacent to the landfill. West of Military Road is the Kent – Des Moines Park and Ride lot for the bus and Poulsbo RV, a recreational vehicle dealer. A bit further north along the west side of Military Road is Gai's Bakery Thrift Shop.

To the north, there are three residences along Bolger Road. Land to the east of these residences, along the north boundary of the landfill, is currently unused. The City of Kent is planning to obtain the land and construct an extension of South 228th Street from across the Green River westward to connect with Military Road.

On the east the landfill is bounded by Frager Road and the Green River. There is a relatively new development across the river, comprised of townhomes. There are two residences and a nursery along Frager Road south of the landfill. Going north along Frager Road, the Green River meanders westward and the bottom land between the steep slope bounding the eastward upland becomes narrow. Further north the area of bottom land widens.

To the south the landfill is bounded by State Route 516 (SR516). South of SR516 is a well-established residential area, Green Valley Heights, on an upland area at an elevation higher than the landfill. The Century Motel and Public Storage, a rental storage room facility, are at the foot of the slope leading to the upland area.

The area is served by the City of Kent and Highline Water Districts. Seventeen wells were identified by the remedial investigation as completed in the Recent Alluvium Aquifere within 2 miles north or south of the site. Three were sampled. (Seattle, 1991, p. 2-14)

History of Contamination

In 1984 gas migration to the west of the site was detected, in the area of Timlick's Auto Rebuild and Lloyd's Auto. The EPA performed a preliminary assessment under its hazard ranking system, and performed a subsequent evaluation in 1990. The site was placed on the NPL on August 30, 1990, because of the presence of an unknown quantity of hazardous waste at the site. The City of Seattle entered into a consent order with

Ecology in on May 26, 1987, that called for the City to conduct a remedial response program in a manner consistent with the National Contingency Plan, beginning with a remedial investigation.

The remedial investigation (Seattle, 1991) found that offsite gas migration had occurred, primarily on the north and west sides of the landfill. Gas migration toward the south was prevented by subsurface hydrogeologic conditions. Gas migration to the east was prevented by a shallow water table. Air dispersion modeling indicated that estimated concentrations of trace gas compounds at the landfill boundaries did not exceed Acceptable Source Impact Levels.

With regard to ground water, the remedial investigation (Seattle, 1991) found that about 35% of the leachate within the landfill was not collected in the leachate collection system and migrated downward into the ground water and thence eastward to the Green River. The leachate had high specific conductance, high chemical oxygen demand, high concentrations of ammonia and iron, a neutral pH, and low concentrations of sulfate and trace metals. Major metals detected were iron, zinc, and manganese. Volatile organic compounds detected were primarily ketones, aromatic hydrocarbons, and chlorinated hydrocarbons. The primary semivolatile organic compounds were low molecular weight polycyclic hydrocarbons, alkyl phenols, benzoic acid, and chlorinated benzene. The remedial investigation report concluded (p. ES-12) that the presence of the volatile and semivolatile organic compounds was consistent with the disposal of household products in the landfill.

Figure 6 shows the generalized regional hydrogeology. Contamination was found in the Sand Aquifer and in the Recent Alluvium Aquifer. Leachate in the landfill and contamination in the Sand Aquifer both discharge to the Recent Alluvium Aquifer, which is in hydraulic connection with the Green River.

Surface water in Midway Creek was found to be degraded by the landfill; no effects of the landfill on the water quality of the Green River were observed.

Based on the results of the remedial investigation and further work, ground water monitoring at the site is being done for field parameters, conventional chemical parameters, dissolved metals, volatile organic compounds, herbicides, and pesticides. (See Seattle, 1996, Table 5-1).

For More Detailed Information

Documents which include detailed information on landfill conditions and cleanup activities include:

- *Final Remedial Investigation Report for the Kent Highlands Landfill* (Seattle, 1991);
- *Closure Action Report for the Kent Highlands Landfill* (Seattle, 1992);

- *Cleanup Action Plan* (Ecology, 1993);
- *Waste Discharge Permit 7115 for City of Seattle, Public Utilities – Kent Highlands Landfill* (King County, 1999);
- *Kent Highlands Spring Drain Separation Technical Memorandum* (CH2MHill, 1995);
- *Ground water Compliance Monitoring Plan for the Kent Highlands Landfill* (Seattle, 1996);
- *Kent Highlands Landfill 2002 Annual Report, Ground Water Monitoring* (Seattle, 2003a); and
- *Quarterly Progress Report for the Kent Highlands Landfill* (Seattle, 2003b)

The last two documents are the most recent in a series of reports of a similar nature. These documents as well as the complete file for the landfill may be reviewed at Central Records, Washington State Department of Ecology, Northwest Regional Office 3190 160th Avenue SE, Bellevue, WA (Call 425-649-7000 to make and appointment for record review).

Remedial Actions

Remedy Selection and Implementation

Proposed remedies were evaluated in the *Closure Action Report* (Seattle, 1992) and the remedy to be implemented selected in the *Cleanup Action Plan* (Ecology, 1993). The remedy selected consisted of the following components (see Ecology, 1993, p. 8 ff.):

- Access Controls – a 6-foot-high chain link fence provides primary access control.
- Site Grading – The site was graded to achieve adequate drainage slopes.
- Landfill Cover – A geomembrane cover was placed on top of the existing cap, with a prepared soil base. A drainage layer was placed on top of the geomembrane to direct water away from the landfill. Topsoil was placed as the final layer and vegetated.
- Surface Water – A surface water conveyance system was installed, consisting of a perimeter ditch system with runoff control berms and ditches used to intercept sheet flow runoff on the landfill itself and divert it to the perimeter system. Storm water detention facilities were upgraded.
- Leachate Collection System – The existing leachate collection system was completely rebuilt during remedial construction. A subcover seep collection system was constructed as part of the final system design. Much of the water intercepted by the existing leachate collection system was water from a series of springs on the north slope of the ravine in which the landfill was built. Although the cleanup action plan concluded that construction of a separate spring drain treatment and discharge system would not be cost-effective, the spring drain separation was later put into place. Diagrams of the leachate collection system and the spring drain system are shown on Figure 7, Major Systems Diagrams.
- Landfill Gas – The gas collection system was upgraded and connected to a thermal incinerator which uses enclosed flares. A diagram of the landfill gas control system is shown on Figure 7, Major Systems Diagrams. The initial upgrade of the gas collection system was completed as part of the remedial construction. Subsequent monitoring data indicated exceedances of compliance standards at the property boundary at the southeast corner of the landfill. The gas collection system was extended farther into this area in 2000, bringing the landfill into compliance.

System Operations/Operation and Maintenance (O&M)

Site Inspection

The site was visited on May 22, 2003, by David L. South of the Washington State Department of Ecology. Both the landfill cover and fence were in good repair and all systems were functioning normally. Conversation with Min Soon Yim of the City of Seattle indicates landfill operations have been routine. Conversation with Gary Crescione, inspector for Public Health – Seattle & King County, indicates monthly

inspections have shown no significant problems to date. One aspect of future evaluations of the landfill will be the degree to which it has stabilized over time. Toward this end, Ecology will require the City of Seattle to begin submitting the following data/evaluations with the annual monitoring report:

- Settlement rates based upon topographic surveys of settlement plates;
- Evaluation of leachate strength and quality over time;
- Landfill gas quantity and quality over time (using methane, carbon dioxide, carbon monoxide, and oxygen for selected wells).

In addition, the integrity of the leachate and spring drain pipes which convey leachate and spring drain water from the collection system to the leachate pond and the storm water detention pond should be inspected using pressure testing and/or a camera. The integrity of the leachate pond liner should be verified.

Gas control

Gas is controlled by maintaining a vacuum in gas extraction wells installed within the landfill. Gas generated within the landfill thus flows toward and into the extraction wells. The extraction wells are manifolded to the flare station located in the eastern part of the property. (See Figure 7)

The system is monitored by compliance probes in which the gas level is measured monthly. For the landfill to be in compliance, gas concentrations must not exceed the lower explosive limit for methane (5% by volume) at the landfill boundary.

Gas monitoring probes are located about the site. Some probes have been abandoned and some new probes installed over the years. Most recently the gas monitoring network has been revised to accommodate the planned extension of South 228th Street to the north of the landfill. Figure 8 shows the gas control system plan and current monitoring wells. Figure 9 shows the gas monitoring network as it will exist after that reconfiguration.

Exceedance of the lower explosive limit for methane in any compliance probe indicates an out of compliance condition. Gas monitoring data is submitted in quarterly reports and kept in an electronic database. Data for the first quarter of 2003 indicates all compliance probes have had gas concentrations of less than the lower explosive limit for methane. All but three wells have had gas concentrations of less than 500 ppm. Probes 35-S, 36-S, and 8-S has a gas concentrations of 1.2%, 0.1%, and 1.8%, respectively.[1] The allowable gas concentration is 5%.

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[1] Probes KGP-35 and KGP-36 are on the west side of the landfill; probe KGP-8 is on the southeast corner of the landfill, Figures 8 and 9. The 'S' designation indicates a shallow completion (multiple probes exist at these locations, completed at shallow, mid, and deep levels).

Leachate control

Leachate generated by the landfill is collected and discharged into the King County sewer in accordance with effluent limitations and monitoring requirements set forth by King County Waste Discharge Permit 7115. The permit requires monitoring for several metals[2], pH, total dissolved sulfides, and daily maximum flow. The leachate is monitored annually by King County for volatile organic compounds.

Leachate flows from two separate collection systems: the south leachate system and the toe buttress system. Flows from the south leachate systems are measured by a flume in the flow monitoring and diversion structure. A flow meter on the toe buttress system force main measures flows from that system.

The total leachate discharged to the Metro system is measured by a flow meter in the leachate transmission pump station. (See Figure 7). Leachate quality samples are collected monthly from the leachate transmission pump station wet well.

Ms. Barbara Badger [(206)263-3024], the King County Industrial Waste Program's permit manager for the landfill, indicated the landfill has been has for several years received King County Industrial Waste Gold Awards for being in total compliance with all permit requirements. (Personal communication, May 20, 2004)

Spring drain and NPDES permit

Flow from the spring drain normally is discharged to the surface water treatment pond and thence to the Green River (Figure 7). Water quality of the combined surface water and spring drain flow is measured at the outlet structure of the surface water treatment pond. Once a month the flow rate is measured by diverting the spring drain flow through a flow measurement flume into the leachate treatment pond.

The collection of ground water and discharge to the Green River is discussed in a technical memorandum, *Kent Highlands Spring Drain Separation* (CH2MHill, 1995). Regulatory requirements are discussed in Section 4 of that memorandum. The document notes that in order to discharge ground water from the spring drain as a point discharge to the Green River a National Pollutant Discharge Elimination System (NPDES) permit is normally required, but that since the site is undergoing cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and MTCA, the site is exempt from the administrative requirements of the NPDES permit. The substantive requirements must be met. [See RCW 70.105D.090]

The primary regulatory requirements which must be met are the Water Quality Standards for the State of Washington [Chapter 173-201A WAC] and Green River Surface Water Discharge Regulations. Monitoring requirements include (1) monthly flow monitoring;

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[2] Cadmium, chromium, copper, lead, nickel, and zinc.

(2) quarterly monitoring for biological oxygen demand, total suspended solids, ammonia, dissolved oxygen, pH, and temperature; and (3) annual monitoring for total priority pollutant metals, dissolved priority pollutant metals, and volatile organic compounds.

Section 10.6 of the technical memorandum discusses reporting requirements. Annual reports are to be prepared which include the following (CH2MHill, 1995, p. 10-3):

- Comparison of monitoring data to applicable surface water quality standards;
- Evaluation of the adequacy of the monitoring program; and
- Conclusions and recommendations.

The City of Seattle has been submitting basic monitoring data with quarterly reports, but has not been submitting an annual report with the required comparisons, evaluations, and conclusions and recommendations. The quarterly reports include a statement that spring drain discharge remains within acceptable limits, but provides no supporting comparisons or evaluations.

Table 1(following text) presents the eight most recent quarters of monitoring data for the conventional parameters. As can be seen, dissolved oxygen concentrations are low, and consistently failthe required standard of being greater than 8 mg/L. Ammonia exceeds and hence fails the chronic standard six out of eight quarters.

Annual monitoring data from the third quarter of 2001and 2002 was reviewed. Of the volatile organic compound, only 1,4 dichlorobenzene was detected, 0.4 μg/L in 2001 and 0.3 μg/L in 2002. The federal ambient water quality criteria is 400 μg/L.

Metals data are available only for the third quarter of 2001. Only iron and manganese were detected, at 0.67 and 1.31 mg/L, respectively.

Turbidity should be added to the list of spring drain monitoring parameters.

Ground water monitoring

Monitoring Plan

Ground water monitoring is carried out in accordance with the *Kent Highlands Landfill Groundwater Compliance Monitoring Plan* (Seattle, 1996). Ground water beneath the landfill flows toward the Green River in the Sand Aquifer (See Figure 6). At the base of the landfill, the Sand Aquifer abuts the Recent Alluvium Aquifer and ground water from the Sand Aquifer enters the Recent Alluvium Aquifer.

Wells at the landfill are monitoring quarterly for water levels and water quality. The water levels are used to prepare potentiometric maps. The wells used for water level monitoring are shown in the *Groundwater Compliance Monitoring Plan* (Seattle, 1996, Figures 4-1, 4-2, and 4-3).

With regard to water quality, conventional and inorganic parameters are measured quarterly. Volatile organic parameters, herbicides, and pesticides are measured annually unless detected in excess of the regulatory value. If an organic parameter exceeds its regulatory value, the monitoring frequency is changed to quarterly.[3]

The standard point of compliance for landfills is, "that part of ground water that lies beneath the perimeter of a solid waste facility's active area as that active area would exist at closure of the facility". [WAC 173-304-100(58)] A conditional point of compliance has been set for monitoring ground water at the Kent Highlands Landfill at the eastern property boundary. This conditional point of compliance varies from about 400 to 900 feet from the eastern edge of the solid waste facilities' active area at closure of the facility.

Wells KMW-17, KMW-10A, and KMW-19A are the compliance monitoring wells. These wells are located at the eastern boundary of the landfill property and completed in the Recent Alluvium Aquifer, Figure 10.

The water quality in the compliance wells is evaluated to determine whether the remedy is functioning as intended by the decision documents with respect to ground water quality. Well KMW-15A is monitored to provide information on the background water quality in the Recent Alluvium Aquifer.

Monitoring Results

Water Level Monitoring

Figures 11 and 12 show the results of the December 2002 water level monitoring round. Other results are similar. Ground water flows eastward in the Sand Aquifer toward the Recent Alluvium Aquifer. The ground water enters the Recent Alluvium Aquifer and continues flowing eastward to the Green River.

Water Quality Monitoring

The Cleanup Action Plan for the site states that cleanup standards have been met at the Kent Highlands Landfill (Ecology, 1993, p. 55). Ground water quality is monitored to assess whether or not it has deteriorated from the conditions measured during the remedial investigation for the site. The chemicals being monitored and the relevant regulatory values are listed in Table 5-7 of the *Ground Water Compliance Monitoring Plan*, (Seattle, 1996).

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[3] Conventional parameters are compounds such as ammonia, chloride, nitrate, nitrite, and sulfate, as well as chemical oxygen demand, pH, total coliform bacteria, and total organic carbon. Inorganic compounds measured are eight metals. Volatile organic compounds measured are a suite of many different chemicals. Herbicides and pesticides are measured as well. The complete list is given in Table 5-6 of the *Groundwater Compliance Monitoring Plan.*

Water quality data is evaluated according to a statistical protocol specified in the *Ground Water Compliance Monitoring Plan.* Conventional parameters and metals are compared to calculated statistical parameters and their regulatory values to assess whether ground water quality has deteriorated from that of the remedial investigation. The statistical parameters are:

- Shewart control limit: A statistical parameter which statistically evaluates whether a chemical concentration has deteriorated from the conditions measured during the remedial investigation for the site.

- Tolerance limit: A statistical parameter which statistically evaluates whether a chemical concentration is above its background concentration.

An information statistical parameter, the "cumulative sum", or CUSUM is also calculated to evaluate whether gradual increases are occurring.

Since the limited ground water data collected during the remedial investigation were insufficient to develop the Shewart control limits[4], additional baseline data were collected in 1995 and 1996. These data were evaluated by chemical and by well to assess whether or not a deterioration in water quality had occurred since the remedial investigation. For those chemical/well combinations for which deterioration had occurred, no Shewart control limit was calculated.

When a conventional or inorganic parameter of metal exceeds its Shewart control limit, its tolerance limit, and its regulatory value, and that exceedance is confirmed by verification sampling, the City of Seattle, with input from the regulatory agencies, is to assess on a case-by-case basis additional actions, if any, that may be taken.

For those chemicals in a well which the baseline data found that water quality had deteriorated since the remedial investigation, the Shewart control limit does not apply. For such chemical/well combinations, when a conventional or inorganic parameter of metal exceeds its tolerance limit and its regulatory value, and that exceedance is confirmed by verification sampling, the City of Seattle, with input from the regulatory agencies, is to assess on a case-by-case basis additional actions, if any, that may be taken.

Volatile organic compounds, herbicides, and pesticides are compared to their regulatory values for the specific compound. When a volatile organic compound exceeds its tolerance limit and regulatory value, and that exceedance is confirmed by verification sampling, the City of Seattle, with input from the regulatory agencies, is to assess on a case-by-case basis additional actions, if any, that may be taken.

Contingency response actions are discussed in the *Groundwater Compliance Monitoring Plan*, §8, and include (1) verification of laboratory procedures and analytical reporting;

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[4] Insufficient number of monitoring rounds.

(2) more frequent sampling of the suspect well(s); (3) Sampling for additional parameters; (4) reassessment of the ground water pathways for human exposure to landfill-derived contaminants; (5) recalculation of the baseline risk assessment; (6) evaluation of environmental hazards; (7) continued monitoring; (8) additional monitoring locations; and (9) additional remedial actions.

Ground water monitoring results are presented in annual reports. The most recent report available at this writing is for 2002 (Seattle, 2003a). Results are discussed and presented in a series of tables and charts.

The *2002 Annual Report* discusses the compliance status of ground water at the landfill, stating (p. 1-1),

> "The 2002 groundwater results for the Kent Highland Landfill indicate that the landfill is in compliance with the conditions for conventional and inorganic parameters stated in the *Kent Highlands Landfill Groundwater Compliance Monitoring Plan.* An out-of-compliance conditions occurs when the baseline conditions (Shewart control limit[SCL]), background conditions (tolerance limit [TL]), and regulatory standards (regulatory value [RV] are all exceeded in any of the compliance wells (Recent Alluvium Aquifer wells KMW-10A, KMW-17, and KMW-19A) for two consecutive quarters. This condition did not occur during 2002.
>
> "The volatile organic compound vinyl chloride continued to exceed the RV during 2002 in five wells (KMW-10A, KMW-12A, KMW-16B, KMW-17, and KMS-18A). Upper confidence limits (UCLs on the mean of the data for these wells were calculated and indicate that the UCLs for all five wells remain above the RV. Therefore, vinyl chloride in all five wells will continue to be monitored quarterly until the UCL is less than the RV."

The Annual Report notes that the concentrations of vinyl chloride, "... appear to have increased slightly in the last few years."

The statement in the *2002 Annual Report* that no out-of-compliance conditions have occurred for conventional and inorganic parameters is not correct. As shown in Appendix E of the report, manganese has consistently exceeded both its tolerance limit and its regulatory value in compliance well KMW-19A. Manganese in well KMW-19A has no Shewart control limit as the baseline data assessment *presented in the 1996 Groundwater Monitoring Report* concluded manganese concentrations in compliance well KMW-19A had deteriorated since the remedial investigation Table 4-11 of the 1996 Ground water Monitoring Report lists Limits for Control Charts without CUSUM Chart. Manganese for well KMW-19A is listed on the bottom of the third page of that table (p. 4-33 of the report). The entry for the Shewart Control Limit states (footnote a), "Parameter in this well has increased since the RI, so no control limit is assigned. Will be compared to RV and TL only." (RV = regulatory value; TL = Tolerance Limit). (Seattle, 1997, see Table 4-7, p. 5 of 5, manganese in KMW-10A, last column, Table 4-

11, and Appendix D, p. 15, box plot for manganese in alluvium). Figure 13 shows the control charts for manganese for the background well, KMW-15A, compliance well KMW-19A, and several other wells.

Manganese concentrations in Well KMW-19A indicate manganese concentrations in ground water passing the point of compliance exceed regulatory limits. In this case the regulatory limit is the tolerance limit in the background well in the Recent Alluvium Aquifer, Well KMW-15A The landfill is out of compliance with respect to manganese in Well KMW-19A.

Prior to 1998 vinyl chloride was not detected due to elevated detection limits (10 or 5 μg/L). In 1998 Ecology directed the City of Seattle to lower vinyl chloride detection limits.

Figures 14 and 15 show plots of vinyl chloride concentrations with time since 1998 in wells KMW-10A and KMW-17.[5] Where duplicate samples were analyzed, the maximum value is plotted. In both of these compliance wells, vinyl chloride concentrations have exceeded the current regulatory value of 0.029 μg/L since 1998, when the detection limits were lowered.[6] In Well KMW-17 vinyl chloride concentrations have exceeded the Safe Drinking Water Act Maximum Contaminant Limit of 2 μg/L twice, and the most recent data show an increasing trend.

Vinyl chloride has only been detected once in Well KMW-19, at a concentration of 0.031 μg/L in the first quarter of 1999. The detection limit has been either 0.02 or 0.2 μg/L in all quarters since the third quarter of 1998.

The *2002 Annual Report* presents calculations for the upper 95% confidence limit (UCL_{95}) for the mean of the vinyl chloride concentrations in compliance wells KMW-10A and KMW-17, as well as two of the indicator wells (Seattle, 2003, Appendix I. The calculation was done using methods described by Sokal and Rohlf (1981, p. 491 ff.). The Model Toxics Control Act requires that Land's method be used for this calculation when the data are log normally distributed. [WAC 173-340-720(9)(d)(i)(A)] In addition, errors were made in the calculation (South to Woodhouse, et al., 2003).

Ecology has performed these UCL95 calculations using Ecology's spreadsheet MTCAStat.[7] The eight most recent data points shown on Figures 14 and 15 were used;

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[5] Note that the data point for the third quarter of 2002 in the time series for KMW-17 for vinyl chloride presented in Appendix D of the 2002 Annual Report is incorrectly plotted. This value should be 1.9 μg/L.

[6] As discussed in the Technical Assessment chapter, Question B, the vinyl chloride regulatory value has increased from 0.023 to 0.029 μg/L since the Ground Water Compliance Monitoring Plan was prepared.

[7] This spreadsheet may be downloaded from http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html.

that is, the quarterly data from 2001 and 2002. The results are that the UCL95 in these two wells are:

- KMW-10A – 0.085 μg/L, which exceeds the regulatory value of 0.029 μg/L.
- KMW-17 – 13.5 μg/L, which exceeds the regulatory value of 0.029 μg/L.[8]

Regulatory monitoring requirements for ground water also specify that no single sample concentration shall be greater than two times the cleanup level and that less than ten percent of the sample concentrations shall exceed the ground water cleanup level during a representative sampling period. [WAC 173-340-720(8)(e)in the 1996 Amendment to the MTCA Cleanup Regulation] Vinyl chloride concentrations in compliance wells KMW-10A and KMW-17A are out of compliance with both of these requirements as well.

Vinyl chloride concentrations in Wells KMW-10A and KMW-19A indicate vinyl chloride concentrations in ground water passing the point of compliance exceed regulatory limits. The landfill is out of compliance with respect to vinyl chloride in Wells KMW-10A and KMW-17.

The monitoring results for manganese and vinyl chloride will be further discussed in the Technical Assessment chapter.

Institutional Controls

Institutional controls for the Kent Highlands Landfill are described in the *Cleanup Action Plan* (Ecology, 1993, Chapter 7). The two most relevant institutional controls for the purposes of this review are the ones concerning restrictive covenants to be written into the property deed and financial assurances that postclosure landfill operations can be funded.

With respect to restrictive covenants, the City of Seattle owns all of the parcels except the City of Kent parcel within the landfill boundary and has executed the required restrictive covenants. The City of Kent has executed the required restrictive covenants on the parcel which they own as well. With respect to financial assurances that postclosure landfill operations can be funded, the *Cleanup Action Plan* states that, "Financial assurance is provided by ordinances adopted by the Seattle City Council. The ordinance establish a business and occupation tax on garbage and solid waste handlers for landfill closure

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[8] The value of 13.5 μg/L for KMW-17 as a 95% upper confidence limit on the population mean for a sample data set of eight measurements which range from 0.06 to 3 μg/L reflects the large statistical uncertainty when using only eight data points which range over more than an order of magnitude when estimating the 95% upper confidence limit on the mean for a lognormal population. In practical terms, this means that Land's method is a sensitive alarm bell.

cost." Hence, the City of Seattle has a source of funds for continuing postclosure operations.

Progress Since Last Review

The first periodic review identified two issues which needed further work. The first was the blockage of a number of landfill gas probes wells by water. The second was that the sampling method being used at the time to measure landfill gas concentrations in the probes was obtaining high gas concentrations because a high vacuum was applied to the wells during the sampling.

With respect to the first issue, the gas probe network surrounding the landfill has been reviewed and is considered adequate. Where water is blocking the probes, shallower probes measure gas at a higher elevation in the same location.

With respect to the second issue, the sampling method was modified. The old method used a high-powered pump to pull gas from the probes until a stable reading was obtained. This method drew gas from the landfill toward the probe, thus providing a reading which was not representative of actual conditions. The new method purges the probe volume once; a gas concentration is the taken. This new technique has addressed the issue of pulling landfill gas toward the gas probe as a result of the measurement technique. (Reference: 1998 Fourth Quarter Consent Order Progress Report for the Kent Highlands Landfill, Ecology File# Kent Highlands/SIT1.4)

Five Year Review Process

This Period Review was performed by David L. South, Washington State Department of Ecology site manager for the Kent Highlands Landfill. The draft review was presented to Ecology, Public Health – Seattle & King County, EPA staff for comment in June 2003.

Also in June 2003 the draft review was transmitted to the City of Seattle, Jensen and Griffin, and the City of Kent for review and comment. A public comment period was held from August 6 to September 4, 2003. The comment period including mailing a fact sheet to the interested public, placing the draft periodic review in public repositories for review, and placing the draft periodic review on the web.

No comments were received during the public comment period. Comments were received from the City of Kent on a previous draft. These comments are included in Appendix A.

Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

- The remedy has reduced impacts, but it has not brought the landfill into compliance with respect to vinyl chloride and manganese in ground water in selected wells. Oxygen and ammonia concentrations in surface water being discharged to the Green River are out of compliance at the specified monitoring point. The source of these contaminants (the waste placed in the landfill) remains on site continues to generate these contaminants. The out of compliance conditions are not considered to be emergency conditions.

- The City of Seattle has not been filing annual reports of the spring drain monitoring as required (CH2MHill, 1995, p. 10-3). The spring drain discharge monitoring data must be compiled and evaluated.

These issues are summarized in Table 2, located at the end of this chapter.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy still valid?

In 1996 the Consent Order governing cleanup at this site was amended. The amendment provides that the site is being cleaned up pursuant to the Water Pollution Control Act [Ch. 90.48 RCW] and the Model Toxics Control Act [Ch. 70.105D RCW], as well as all other applicable state and federal laws. The exposure assumptions and remedial action objectives used at the time of remedy selection have not been reviewed with respect to the Model Toxics Control Act for this periodic review. This will be done as part of the Follow-Up Actions, discussed in the next chapter. With respect to the toxicity data and cleanup levels, and considering the ground water parameters of primary interest:

Referring to *Cleanup Levels and Risk Calculation under the Model Toxics Control Act Cleanup Regulation* (Ecology, 2001), the vinyl chloride MTCA cleanup level has increased from 0.023 to 0.029 µg/L since preparation of the table of regulatory values in the *Ground Water Compliance Monitoring Plan*, (Seattle, 1996, Table 5-7).

Referring to *Cleanup Levels and Risk Calculation under the Model Toxics Control Act Cleanup Regulation* (Ecology, 2001), the manganese cleanup level, which is based on the Secondary Maximum Contaminant Limit of 50 µg/L under the Safe Drinking Water Act, has not changed. However, the 1994 MTCA health based cleanup level of 80 µg/L, given in the table of regulatory values in *Groundwater Compliance Monitoring Plan* (Seattle, 1996, Table 5-7), has been increased to 747 µg/L to reflect EPA's updated reference dose and use of a modifying factor of 3 when assessing exposure from drinking water.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Not at this time.

Table 2: Listing of Issues

Issues	Affects Protectiveness (Y/N)	
	Current	Future
1. Vinyl chloride concentrations in ground water exceed the applicable standard in compliance Wells KMW-17 and KMW-10A.	Y	Y
2. Manganese concentrations in ground water exceed the applicable standard in compliance Well KMW-19A.	Y	Y
3. Oxygen concentrations in surface water discharge to the Green River are below state minimum concentrations at the specified discharge monitoring point	Y	Y
4. Ammonia concentrations in surface water discharge to the Green River exceed state standards at the specified discharge monitoring point	Y	Y
5. Begin filing annual monitoring reports for spring drain data as required by the Consent Order	Y	Y

Follow-up Actions

The City of Seattle is to prepare a task-oriented work plan, with deliverables and schedule, to address the issues in Table 2. A draft work plan for addressing Issues 1 through 4 of Table 2 is to be submitted to Ecology by November 10th, 2003, for Ecology review and approval. After Ecology returns review comments, the City of Seattle is to revise the work plan according the comments and submit a final work plan to Ecology for approval no later than 30 days after receipt of Ecology's comments, unless otherwise approved by Ecology. The schedule is to provide for completion of the work plan by June 30, 2004, unless otherwise approved by Ecology. The City of Seattle will implement the work plan as approved by Ecology.

The work plan is to include the following tasks:

The *Groundwater Compliance Monitoring Plan* includes a set of contingency response actions to be taken if exceedance of applicable standards by a parameter in a compliance well persists over time, as is the case for vinyl chloride and manganese in selected wells (Seattle, 1996, p. 8-3). Of these, Ecology believes the City of Seattle has verified laboratory procedures and analytical reporting and that more frequent sampling of the out-of-compliance wells will not add significant information. The work plan is to include a task or tasks which will:

- Provide for reassessment of the ground water pathways for human exposure to landfill-derived contaminants;

- Recalculate the baseline risk assessment, according to applicable regulatory guidance[9], to evaluate if the parameters of concern (vinyl chloride and manganese) produce an excess lifetime cancer risk that exceeds one-in-one-million or a noncancer hazard quotient greater than one at any point along the ground water point of compliance for the landfill, which is the property boundary;

- Evaluate environmental hazards; and

- Identify subsequent response actions for consideration and development consistent with findings of the above studies.

The *Kent Highlands Spring Drain Separation Technical Memorandum* provides that, "The City will have to demonstrate to the satisfaction of Ecology that the treatment processes that are proposed, combined with following best management practices on site, meet the requirements for AKART" (CH2MHill, 1995, p. 4-3). As discussed above,

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[9] Applicable guidance includes regulations and guidance developed for implementation of Ch. 70.105D RCW, Ch. 90.48 RCW, as well as all other applicable state and federal regulations and their supporting guidance.

oxygen and ammonia are not in compliance with regulatory standards at the monitoring point specified in the technical memorandum. The work plan is to include a task to :

- Assess all known, available and reasonable treatment technology in addition to that currently being applied which may bring the oxygen and ammonia into compliance at the monitoring point specified in the technical memorandum.

Ecology is concerned that deterioration of landfill systems or buildup of water within the landfill may be contributing to the issues related to vinyl chloride and manganese in ground water. The work plan is to include a task or tasks to:

- Assess the integrity of the leachate piping and leachate pond liner; and
- Assess the water levels within the landfill.[10]

The work plan is also to include a task to:

- Obtain and compile data regarding settlement rates, leachate generation, and gas production in such a manner as to document changes over time. Such data are part of the evaluation of whether a site has become stabilized when assessing whether, after at least twenty years of post-closure maintenance and monitoring, monitoring of ground water, surface water, and gases can be safely discontinued. [WAC 173-304-407(7)(a)] Ecology anticipates leachate and gas data currently being obtained will be sufficient. However, the City should consider how it will present such data at the end of the minimum twenty-year monitoring period. Ecology is not aware that the necessary settlement data is being collected.

In addition to the work plan, the City of Seattle is to address Issue 5 of Table 2 by preparing annual spring drain reports in accordance with the requirements of the *Kent Highlands Spring Drain Separation Technical Memorandum* (CH2MHill, 1995, §10.6) The annual report is to include all data collected from January 1, 2003, forward in a relational electronic database, similar to what is now being done for the gas and ground water monitoring data. A CD-ROM with this data is to be included in a pocket bound into the report.

Ecology notes that annual ground water reports should be signed by a geologist with a specialty in hydrogeology or by a professional engineer licensed in Washington State. The electronic database of the ground water data is to be included in a pocket bound into the report.

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[10] The Minimum Functional Standards for Solid Waste Handling, an applicable regulation for the Kent Highlands Landfill, provides that water is not to accumulate within the landfill to a depth which exceeds two feet above the topographical low point of the landfilled area. [WAC 173-304-460(3)(b)(ii)]

The City of Seattle is to begin including leachate monitoring reports submitted to Metro with their quarterly reports.

These follow-up actions are summarized in Table 3, next page.

Table 3: Listing of Recommendations and Follow-up Actions

Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Follow-up Actions Affects Protectiveness (Y/N)	
				Current	Future
Submit draft work plan to address Issues 1 through 4 of Table 2	City of Seattle	Ecology	11/10/03	Y	Y
Submit final work plan to address Issues 1 through 4 of Table 2	City of Seattle	Ecology	30 days after receipt of Ecology comments	Y	Y
Complete execution of work plan	City of Seattle	Ecology	June 30, 2004	Y	Y
Prepare annual spring drain reports in accordance with the requirements of the *Kent Highlands Spring Drain Separation Technical Memorandum*, with included electronic database	City of Seattle	Ecology	Next Annual Report	Y	Y

Protectiveness Statement(s)

A protectiveness determination of the remedy at the Kent Highlands Landfill cannot be made at this time. Further information will be obtained in the Follow-Up actions. It is expected that these actions will take until June 30, 2004, to complete, at which time a protectiveness determination will be made.

Next Review

The next five year periodic review is due in 2008. The EPA will continue to track these reviews on their system.

References

CH2MHill, 1995, *Kent Highlands Spring Drain Separation Technical Memorandum*: Prepared by CH2MHill for City of Seattle.

Ecology, 2001, *Cleanup Levels and Risk Calculation under the Model Toxics Control Act Cleanup Regulation*: Washington State Department of Ecology, Toxics Cleanup Program, Publication No. 94-145, updated November 2001.

Ecology, 1993, *Cleanup Action Plan*: Washington State Department of Ecology, Bellevue, WA.

King County, 1999, Waste Discharge Permit 7115 for City of Seattle, Public Utilities – Kent Highlands Landfill: King County Department of Natural Resources. Issuance Date, 03/25/99; Effective Date, 04/-1/99; Expiration Date, 04/01/ 04.

Seattle, 2003a, *Kent Highlands Landfill 2002 Annual Report, Ground Water Monitoring*: Prepared by Parametrix for City of Seattle.

Seattle, 2003b, *2003 1st Quarter Progress Report for the Kent Highlands Landfill.*

Seattle, 1997, *1996 Groundwater Monitoring Report*: Prepared by CH2M Hill for the City of Seattle, Engineering Department, Solid Waste Utility.

Seattle, 1996, *Kent Highlands Landfill Groundwater Compliance Monitoring Plan*: Prepared by CH2M Hill for the City of Seattle, Engineering Department, Solid Waste Utility.

Seattle, 1992, *Closure Action Report for the Kent Highlands Landfill*: Prepared by CH2M Hill for the City of Seattle, Engineering Department, Solid Waste Utility.

Seattle, 1991, *Final Remedial Investigation Report for the Kent Highlands Landfill*: Prepared by CH2M Hill for the City of Seattle, Engineering Department, Solid Waste Utility.

Sokal & Rohlf, 1981(2nd Edition), W. H. Freeman & Co., New York, New York.

South to Woodhouse, Easthouse, Gilbert, and Bennett, 2003, Kent Highlands Landfill – upper confidence limit calculations, e-mail dated May 14, 2003.

TABLE 1

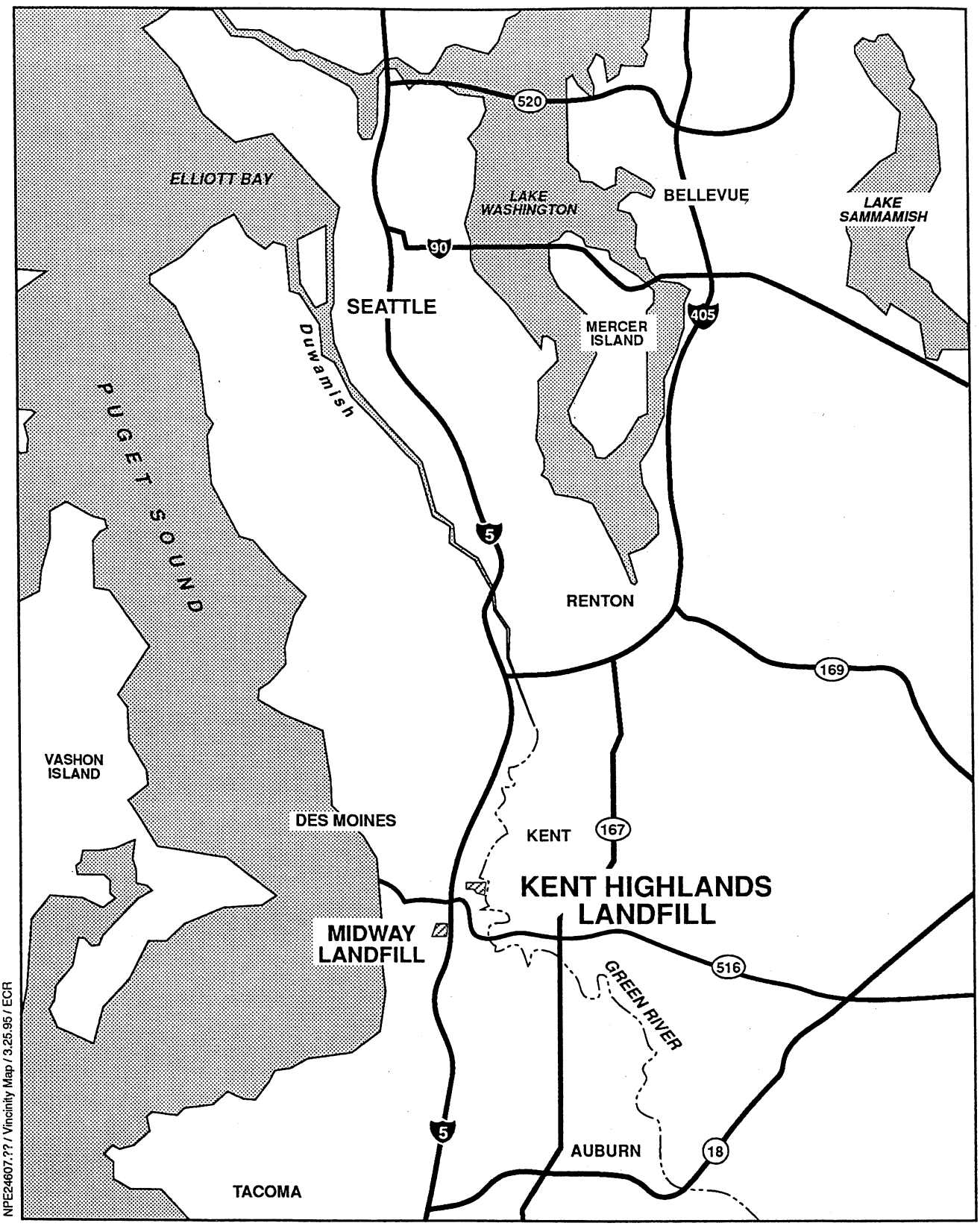
Table 1: Spring Drain Quarterly Data

Year and Quarter	Flow (gpm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Standard (mg/L)	pH	Temperature (°C)	Total Suspended Solids (mg/L)	Ammonia (mg-N/L)	Chronic Ammonia Standard, salmonids present (mg-N/L)	Biological Oxygen Demand (mg/L)
2001-1	107.59	7.05	> 8.0	7.88	11.6	6.5	0.2	1.6	8
2001-2	107.59	6.24	> 8.0	7.38	18.4	6.0	4.1	1.6	3
2001-3	107.59	6.49	> 8.0	7.67	19.2	2.6	6.1	1.6	8
2001-4	107.59	6.32	> 8.0	7.56	7.7	4.3	1.7	2.2	10
2002-1	107.59	7.65	> 8.0	7.40	9.7	9.0	4.8	2.2	5
2002-1	107.59	7.55	> 8.0	7.45	16.2	5.7	7.1	1.9	4
2002-3	107.59	6.31	> 8.0	7.40	16.6	3.0	4.0	1.9	12
2002-4	107.59	7.69	> 8.0	7.42	10.7	5.8	0.8	2.2	24
2003-1	99.36	7.46	> 8.0	7.02	11.9	3.6	2.8	2.2	6

Dissolved oxygen concentrations should exceed the standard of 8.0 mg/L.

Ammonia expressed as total nitrogen should be less than the indicated standard, which is pH and temperature dependent.

FIGURES

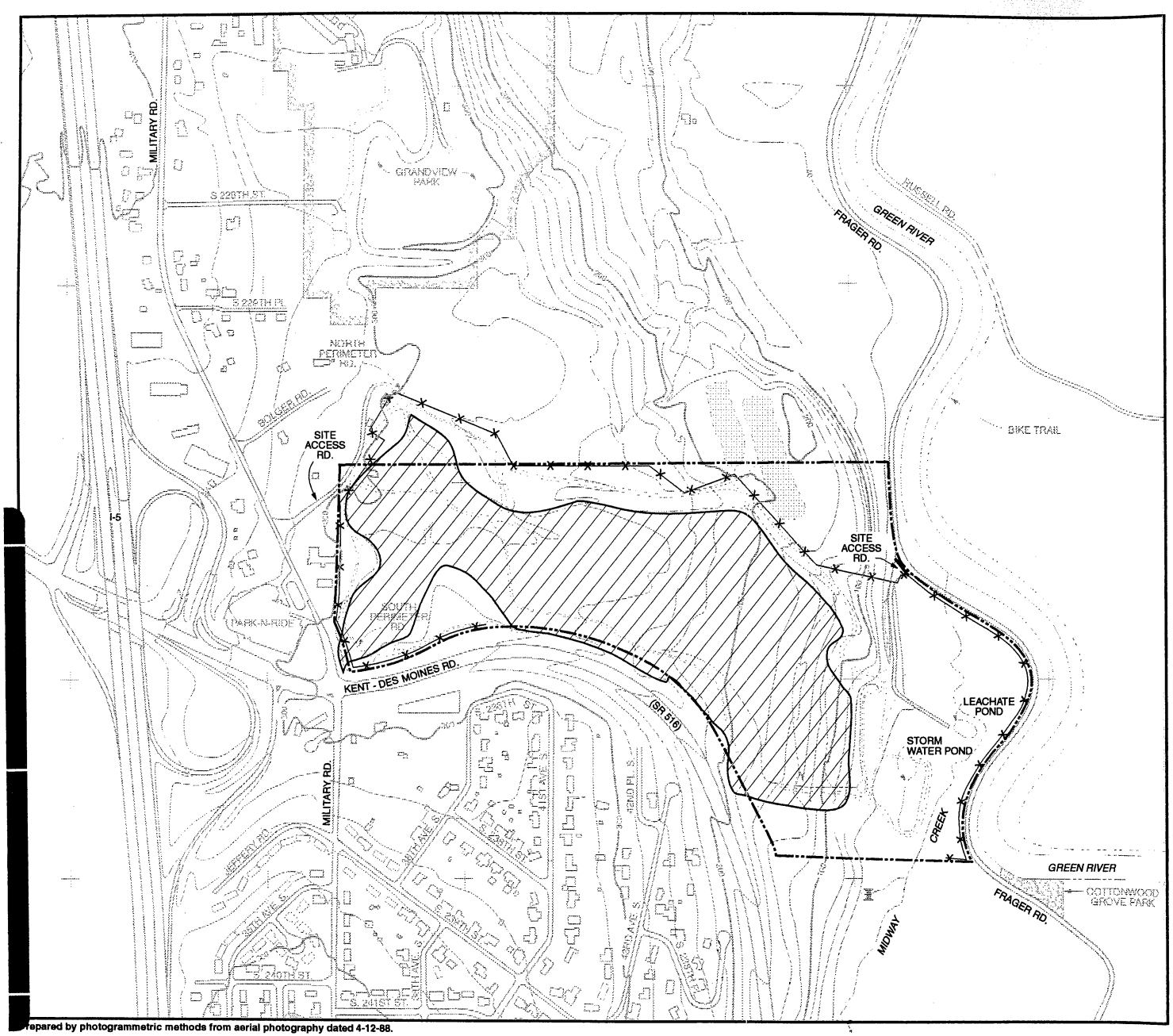


~~Figure 1-1~~

Regional Vicinity Map

~~12~~

FIGURE 1



LEGEND

- Approximate site boundary
- Approximate refuse limits
- Fence line

N

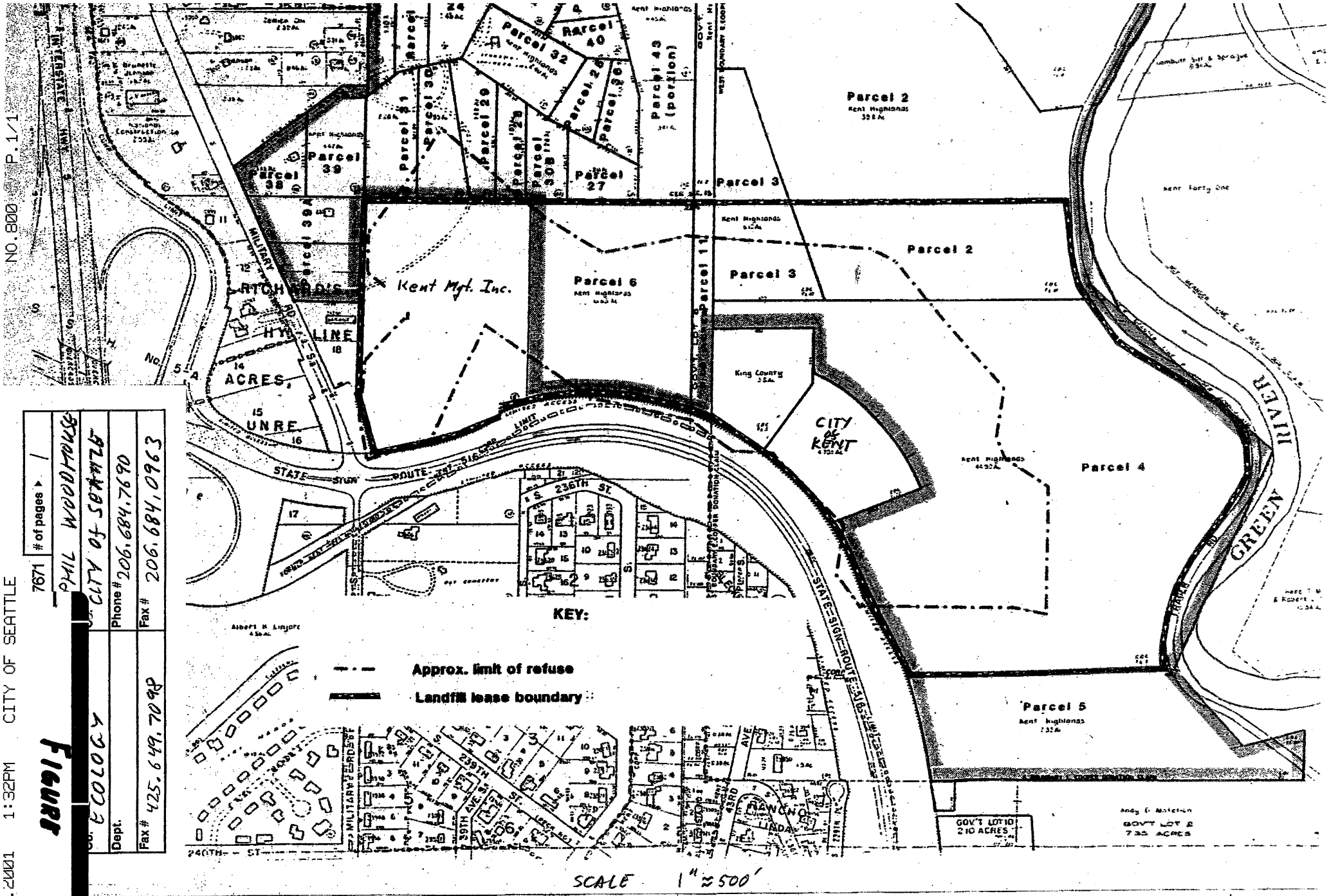
0 100 200 500
Scale in Feet

Topographic Contour Interval: 20ft
Elevation Datum: National Geodetic Vertical Datum

Prepared by photogrammetric methods from aerial photography dated 4-12-88.

Figure 1-2
Site Map

FIGURE 2



NOV. 29. 2001 1:32PM CITY OF SEATTLE NO. 800 P. 1/1

7671	# of pages ▸ 1
To: Phil Woodhouse	From: Jo Phelps
Co: Ecology	Co: City of Seattle
Dept.	Phone # 206.684.7690
Fax # 425.649.7098	Fax # 206.684.0963

Figure 3

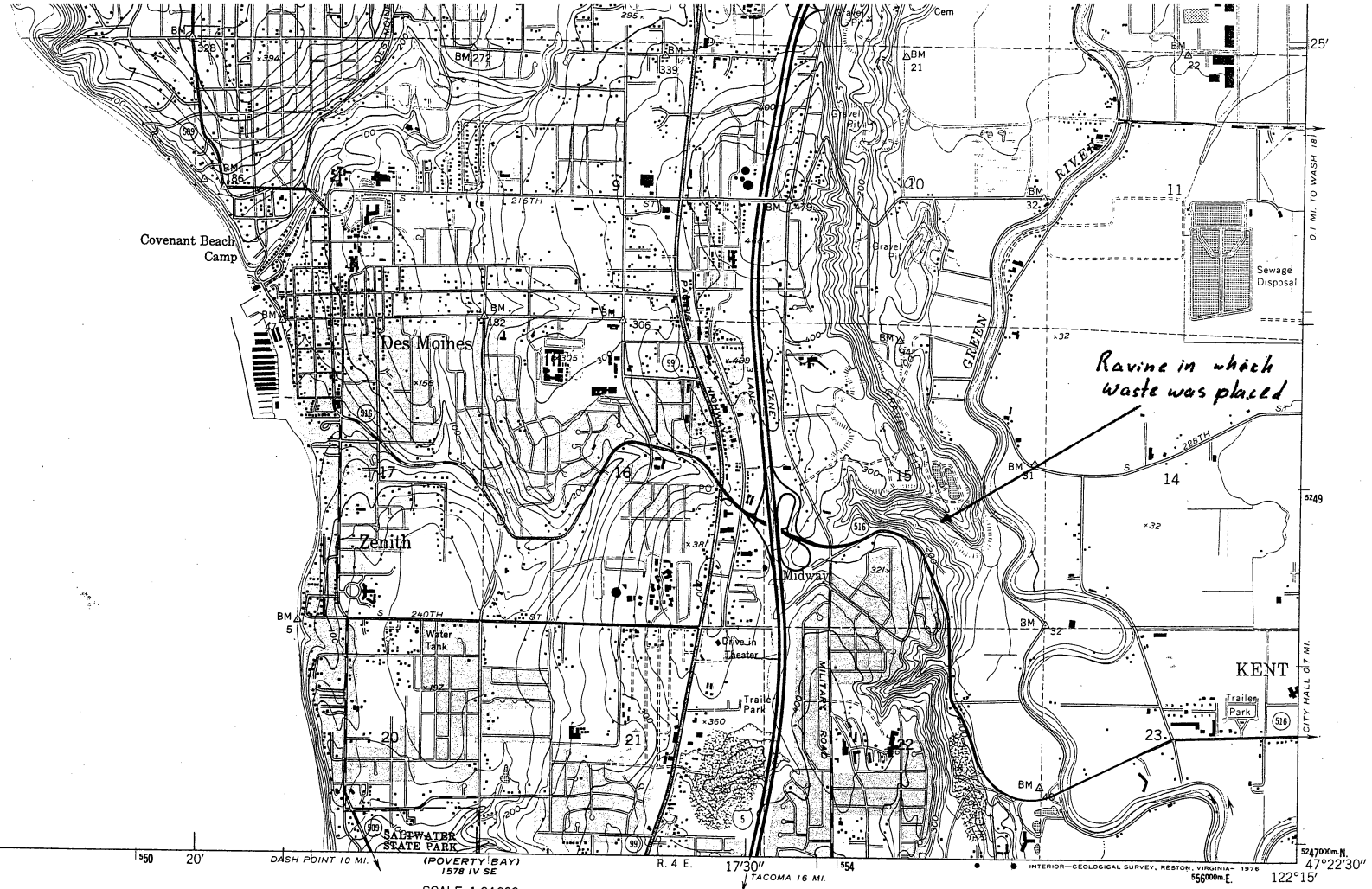
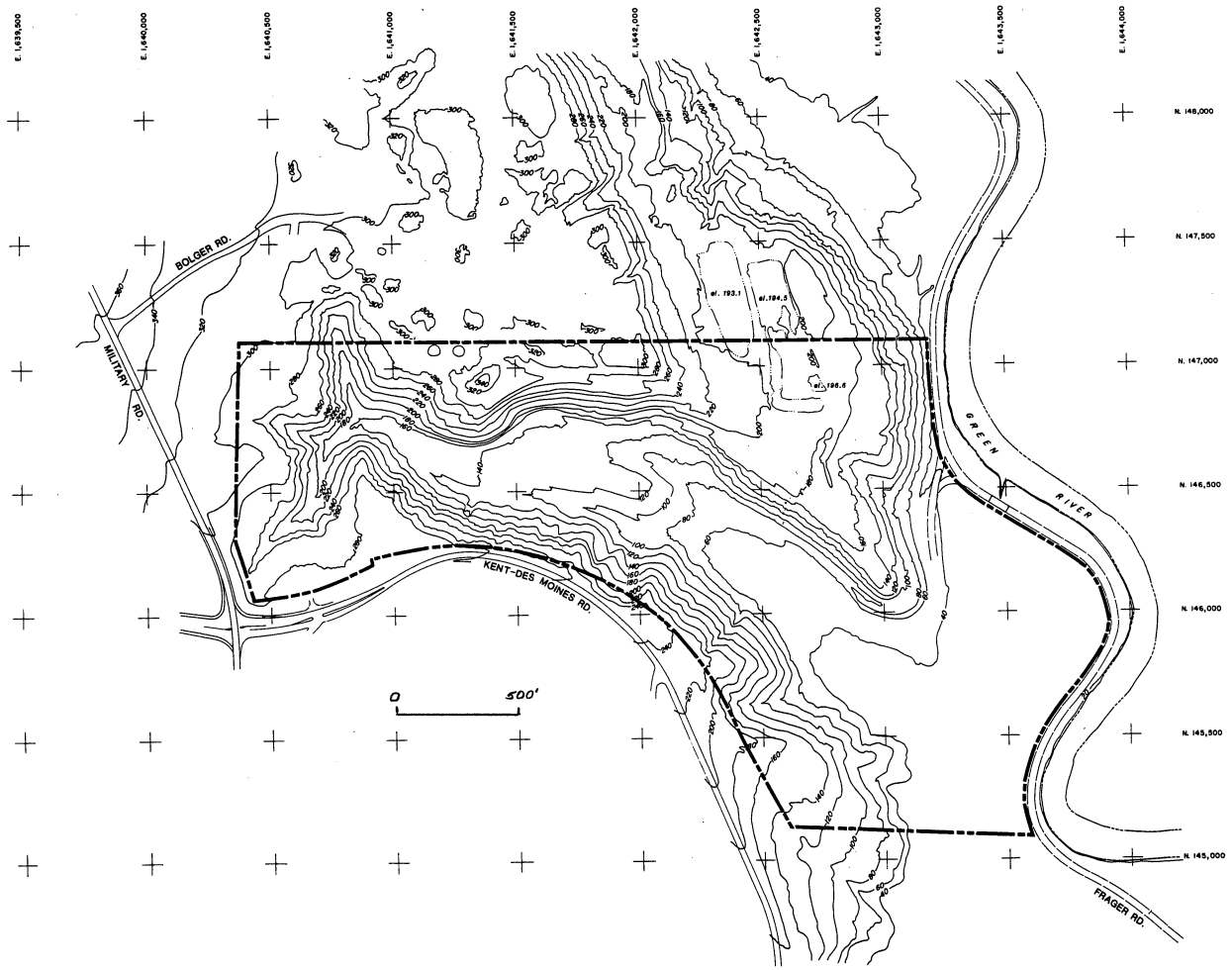

Covenant Beach Camp
Des Moines
Zenith
Midway
KENT
Ravine in which waste was placed
Sewage Disposal
Water Tank
Drive-in Theater
Trailer Park
SALTWATER STATE PARK
PACIFIC HIGHWAY
MILITARY ROAD
GREEN RIVER
216TH ST
240TH ST
228TH ST
DASH POINT 10 MI.
(POVERTY BAY) 1578 IV SE
R. 4 E.
TACOMA 16 MI.
(AUBURN) 1578 I SW
CITY HALL 0.7 MI.
0.1 MI. TO WASH 181
INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA— 1976
5247000m.N.
556000m.E.
47°22'30"
122°15'
17'30"
SCALE 1:24000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 25 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 12 FEET
UTM GRID AND 1973 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET
0°30'
9 MILS
21½°
382 MILS
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
ROAD CLASSIFICATION
Heavy-duty
Medium-duty
Light-duty
Unimproved dirt
U. S. Route
State Route
Interstate Route
WASHINGTON
QUADRANGLE LOCATION
Revisions shown in purple compiled by the Geological Survey from aerial photographs taken 1968 and 1973. This information not field checked
Purple tint indicates extension of urban areas
DES MOINES, WASH
N4722.5—W12215/7.5
1949
PHOTOREVISED 1968 AND 1973
AMS 1578 IV NE—SERIES V891

Figure 4



LEGEND

Approximate site boundary

N

0 100 200 500

Scale in Feet

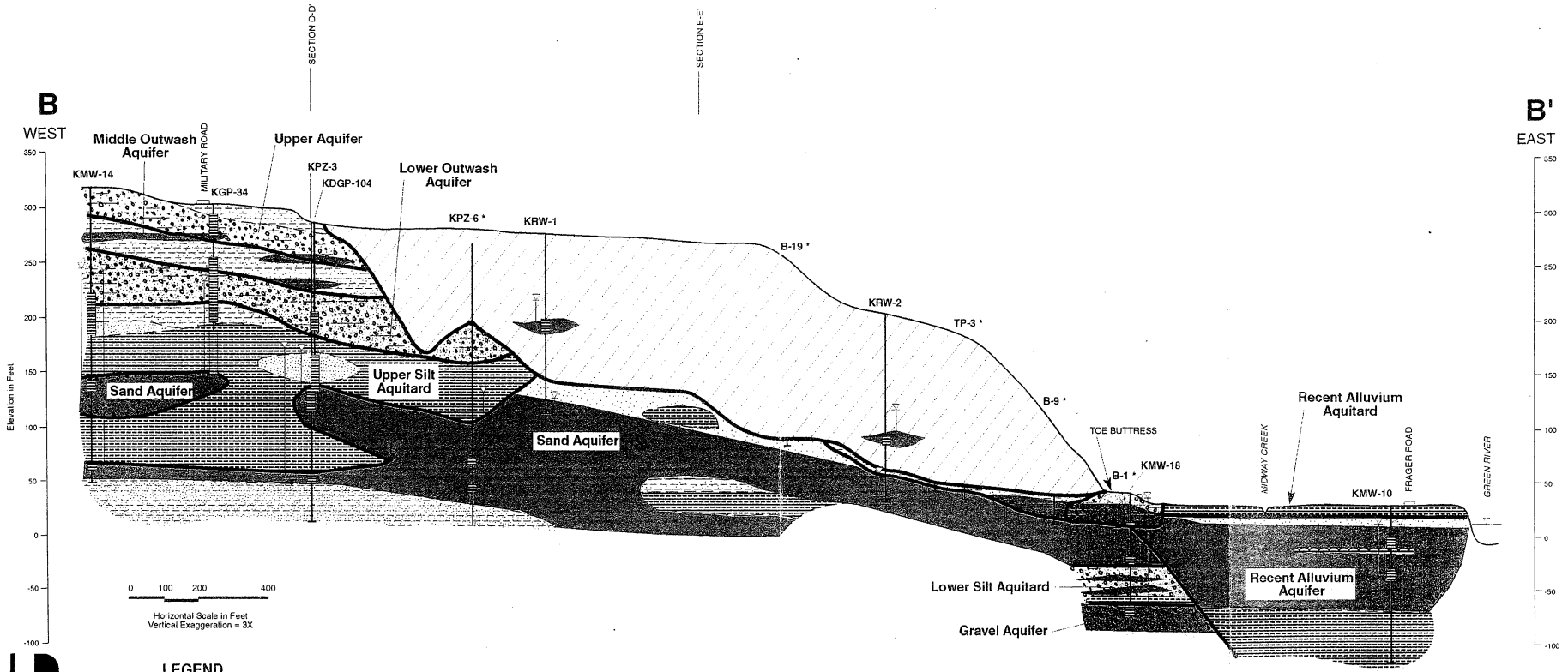
Topographic Conteur Interval: 20ft
Elevation Datum: National Geodetic Vertical Datum

Figure 1-2

Pre-Landfill Topography
(1968)

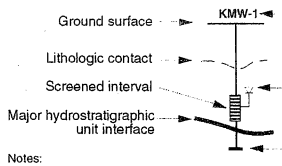
15

FIGURE 5



LEGEND

- Landfill
- Concrete rubble
- Organic sediments
- Poorly sorted mixture of silt, sand, and gravel
- Silt
- Sand and gravel
- Sand
- Silty sand to sandy silt
- Water-bearing zone



Notes:

This cross section is a schematic interpretation of subsurface conditions based on interpolation and extrapolation of data between borings. Geologic and hydrologic conditions are substantially more complex than depicted.

Water elevations shown below the landfill at KRW-1 and KRW-2 are based on static water levels measured during drilling. The KPZ-6 water elevation was obtained from well log in Robinson & Noble (1977).

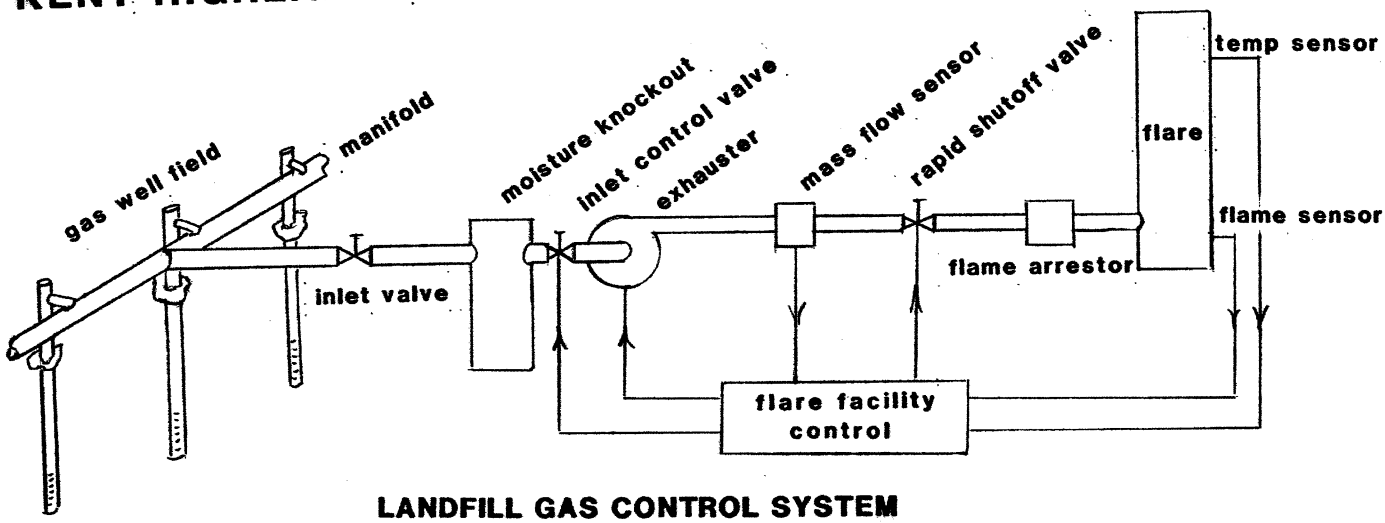
Approximate design and location of the toe buttress from Kent Highlands Landfill Closure Plan, (CH2M HILL, 1986), Appendix E, Figures 2 and 3.

* Installed prior to present landfill configuration.

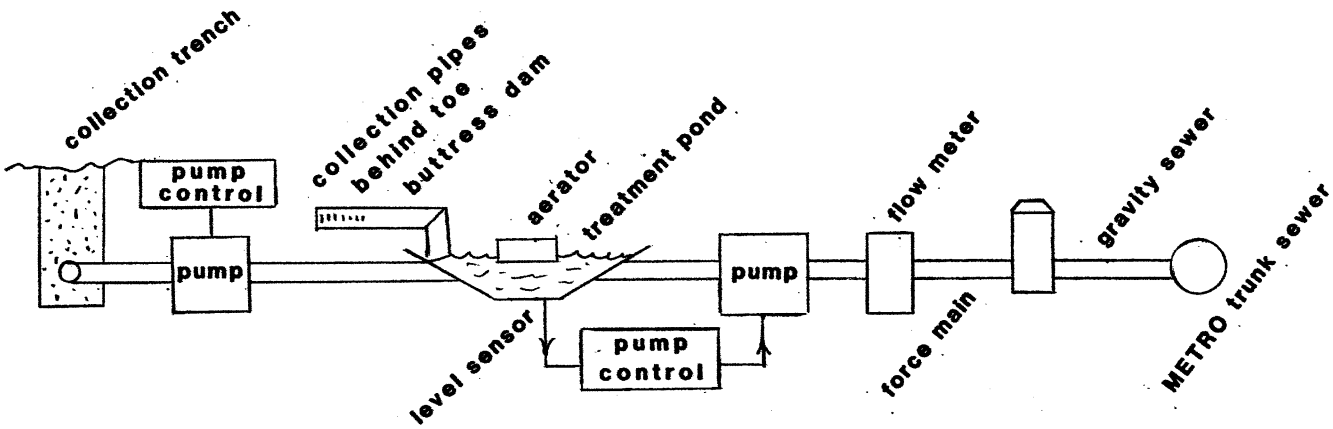
Figure 2-4
General Site
Hydrogeologic Section

Figure 6

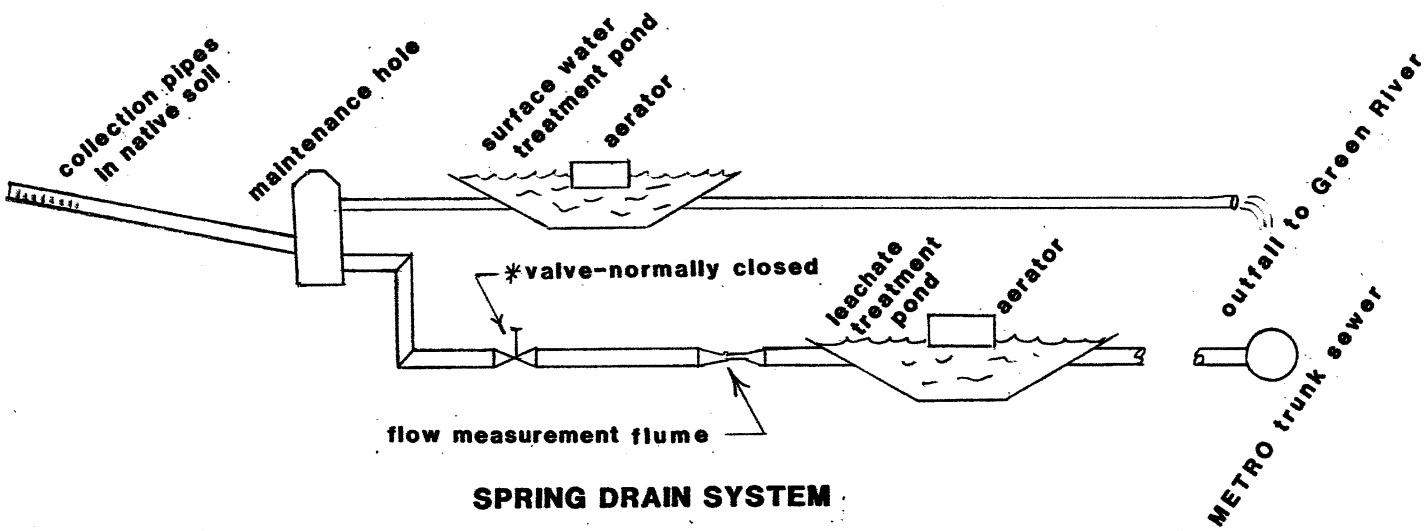
KENT HIGHLANDS LANDFILL MAJOR SYSTEM DIAGRAMS



LANDFILL GAS CONTROL SYSTEM



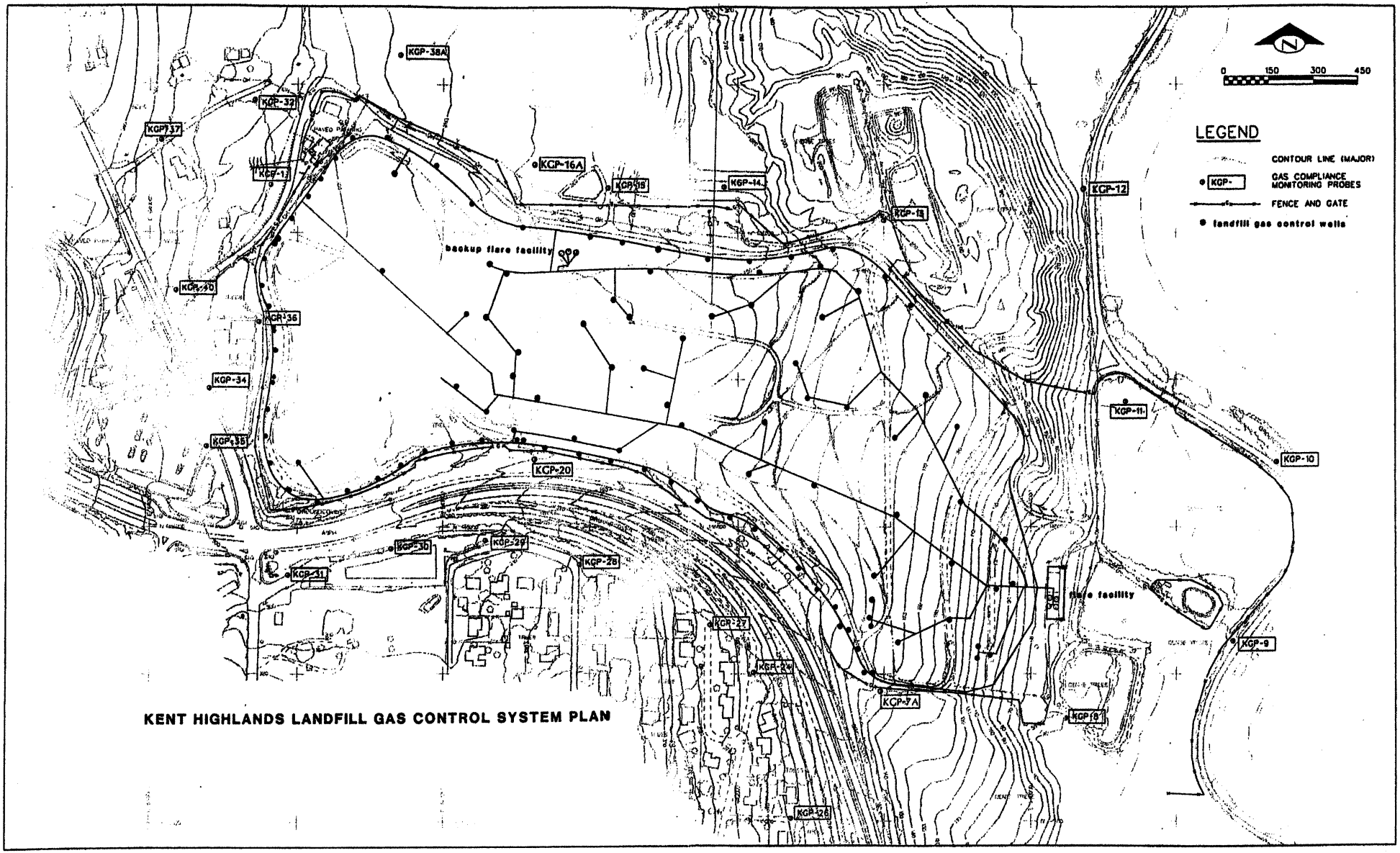
LEACHATE CONTROL SYSTEM



SPRING DRAIN SYSTEM

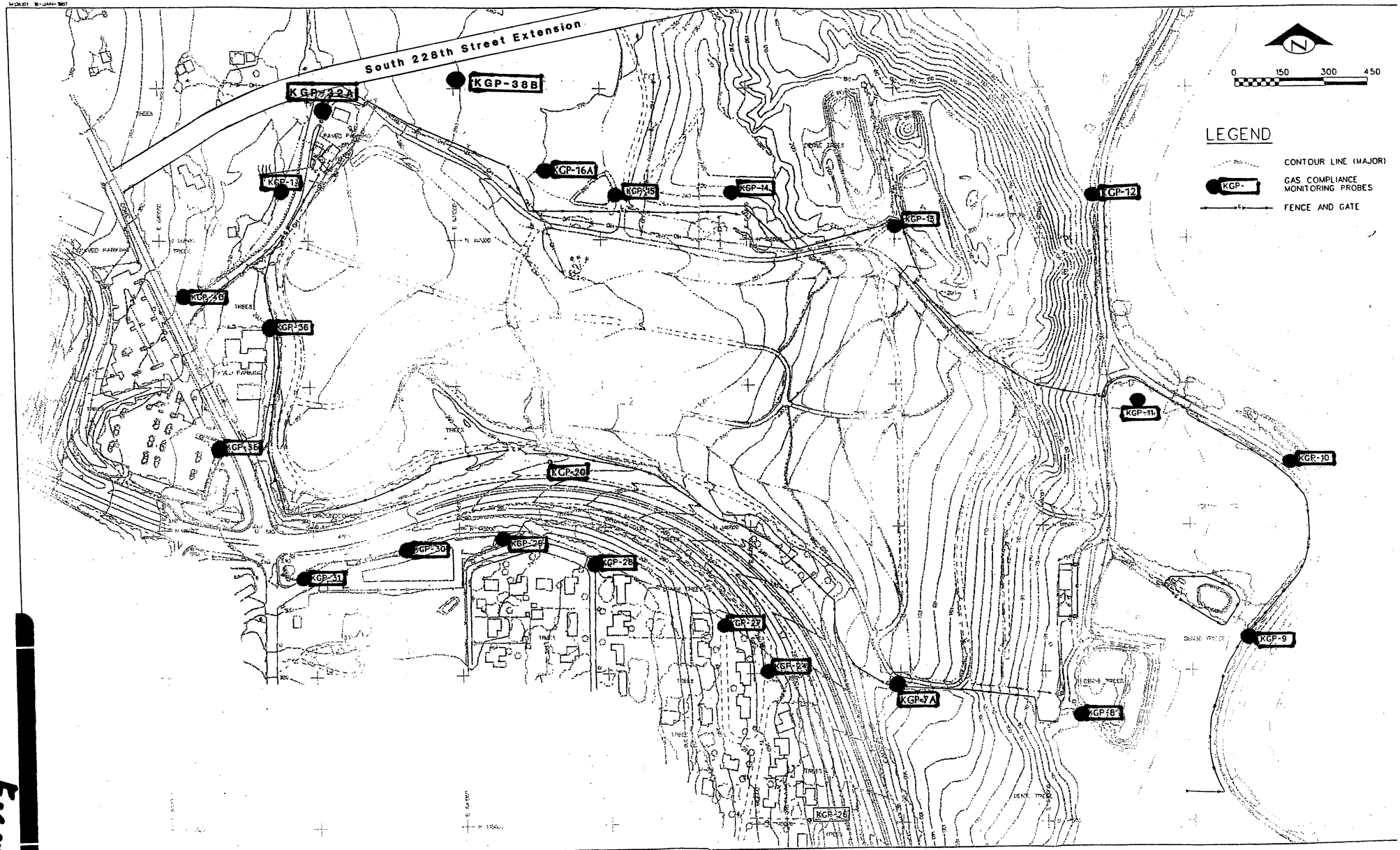
* Opened monthly to measure spring drain flow

FIGURE 7



KENT HIGHLANDS LANDFILL GAS CONTROL SYSTEM PLAN

Figure 8

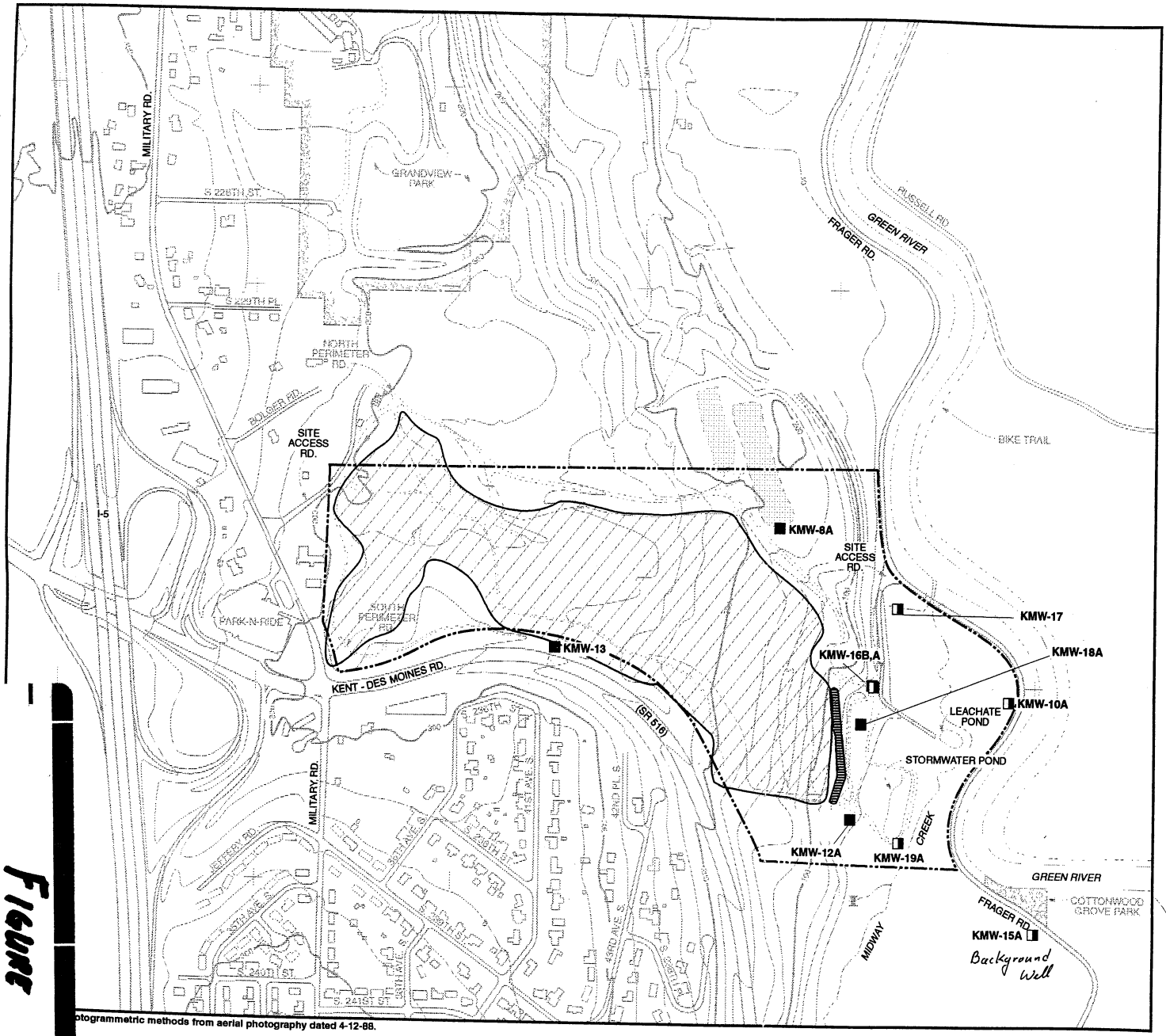


UPDATED 1/16/2003

Figure 11.4-1
Landfill Gas Compliance Monitoring Probes

FIGURE 9

LANDFILL GAS COMPLIANCE MONITORING PROBES AFTER RECONFIGURATION FOR SOUTH 228TH STREET EXTENSION



otogrammetric methods from aerial photography dated 4-12-88.

LEGEND

- Approximate site boundary
- Approximate extent of refuse
- Approximate location of toe buttress

Monitoring stations

Groundwater monitoring well and piezometer

- Sand Aquifer Completion
- Recent Alluvium Aquifer Completion

A = Shallow completion
B = Intermediate completion
C = Deep completion
PZ = Piezometer
(Absence of letter designation indicates a single completion)

N

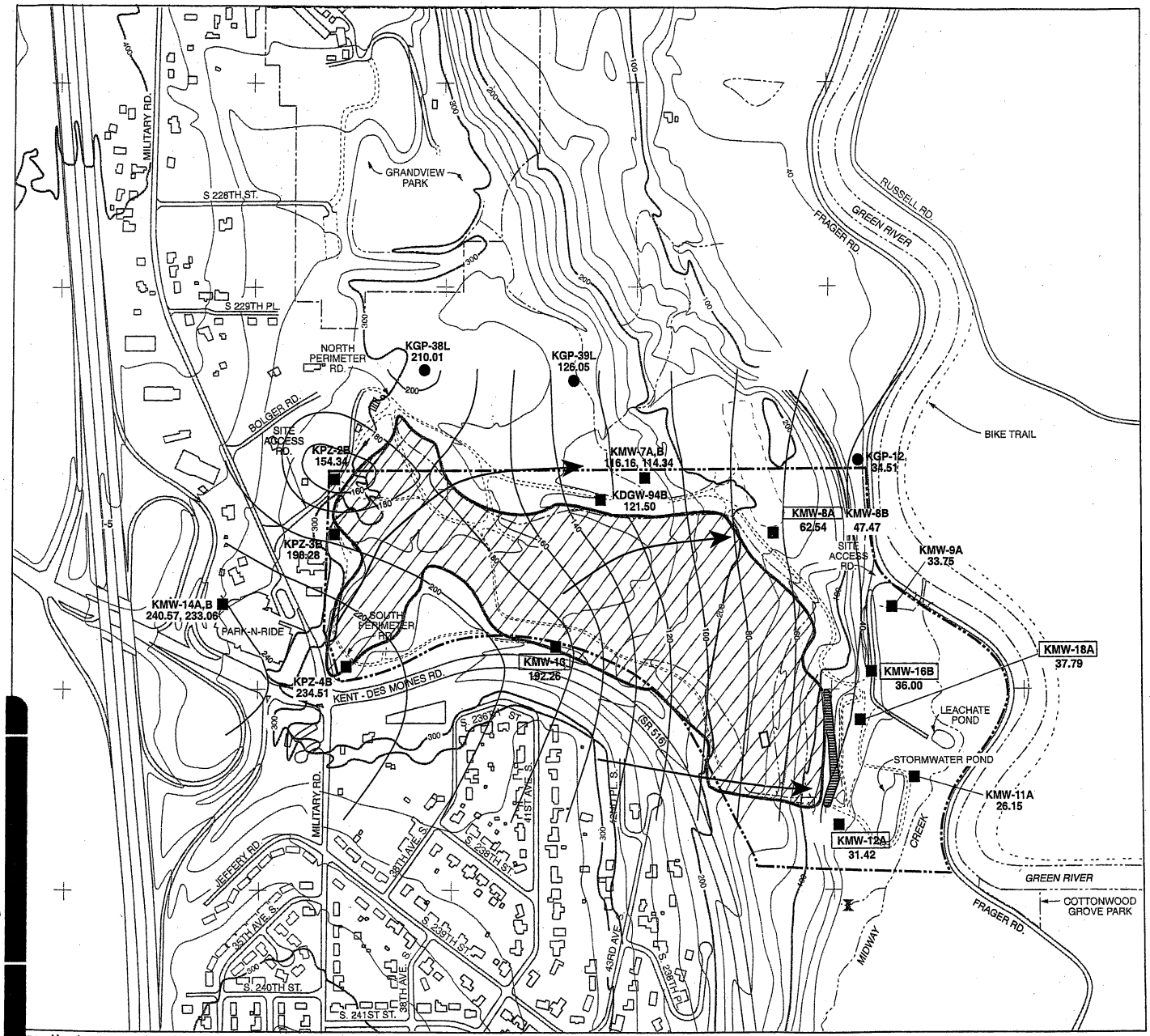
0 100 200 500
Scale in Feet

Topographic Contour Interval: 20ft
Elevation Datum: National Geodetic Vertical Datum

~~Figure 4-8~~

Groundwater Quality Monitoring Wells

Figure 10



pared by photogrammetric methods from aerial photography dated 4-12-88.

LEGEND

- 20 — Potentiometric surface elevation contour
- Approximate site boundary
- Approximate extent of refuse
- Approximate location of toe buttress
- General direction of groundwater flow

Monitoring stations

Groundwater monitoring well and piezometer

- ■ Recent Alluvium Aquifer Completion

  A = Shallow completion
  B = Intermediate completion
  C = Deep completion
  PZ = Piezometer
  (Absence of letter designation indicates a single completion)

- KMW-18A — Groundwater quality monitoring well
- 33.75 — Groundwater elevations measured December 23, 2002. Groundwater elevation from shallow completion used in contouring for multiple completion wells.

Gas probe

- ● Recent Alluvium Aquifer Completion
  L = Lower

Topographic Contour Interval: 20ft
Elevation Datum: National Geodetic Vertical Datum

Potentiometric contours generated using Surface^{R} for Windows

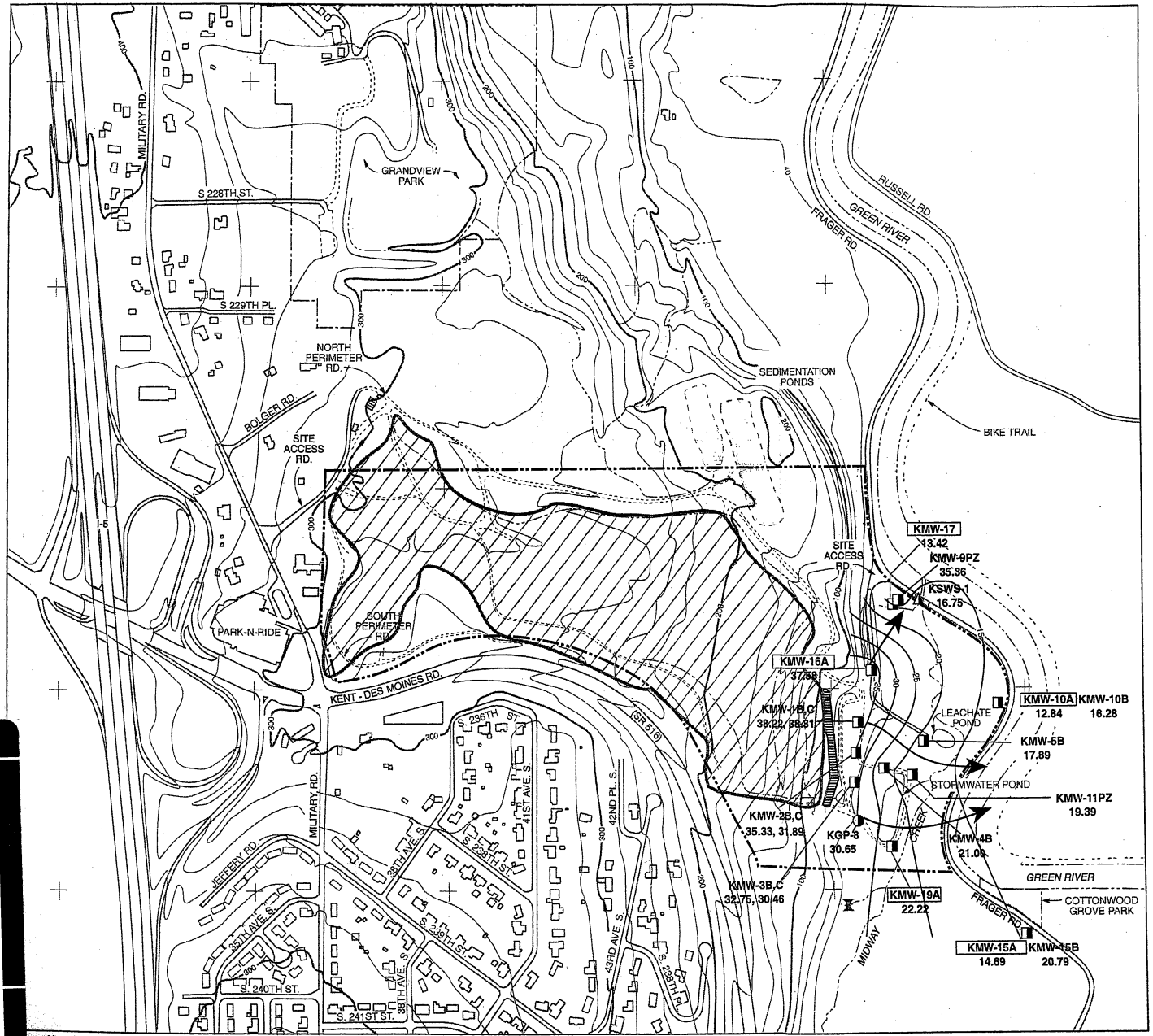
N

SCALE IN FEET
0 250 500

Parametrix, Inc. Kent Highlands/555-1550-041/01(01B2) 2/03 (K)

Potentiometric Surface for the Sand Aquifer, Kent Highlands Landfill, December 23, 2002

Figure 11



ared by photogrammetric methods from aerial photography dated 4-12-88.

LEGEND

- –30– Potentiometric surface elevation contour
- Approximate site boundary
- Approximate extent of refuse
- Approximate location of toe buttress
- General direction of groundwater flow

Monitoring stations

- Groundwater monitoring well (MW) and piezometer (PZ)
  - A = Shallow completion
  - B = Intermediate completion
  - C = Deep completion
  - (Absence of letter designation indicates a single completion)
- KMW-17 Groundwater quality monitoring well
- 12.84 Groundwater elevations measured December 23, 2002. Groundwater elevation from shallow completion used in contouring for multiple completion wells.
- Gas probe (GP)
- Surface water station (SWS)

Topographic Contour Interval: 20ft
Elevation Datum: National Geodetic Vertical Datum

Potentiometric contours generated using Surface^{R} for Windows

Data from piezometers KMW-9PZ and KMW-11PZ not used in contouring

N

SCALE IN FEET
0 250 500

Parametrix, Inc. Kent Highlands 555-1550-041/01(0B2) 2/03 (K)

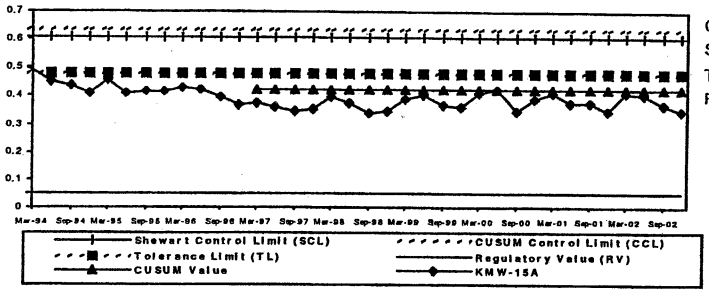
~~Figure 4-8~~
Potentiometric Surface for the Recent Alluvium Aquifer, Kent Highlands Landfill, December 23, 2002

Control Charts for

Manganese, Dissolved (mg/L)

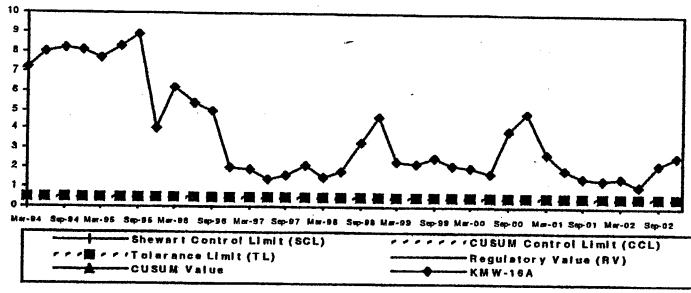
Recent Alluvium Aquifer

Shewart and CUSUM Control chart
Background Well KMW-15A



CCL = 0.633 units
SCL = 0.608 units
TL = 0.482 units
RV = 0.05 units

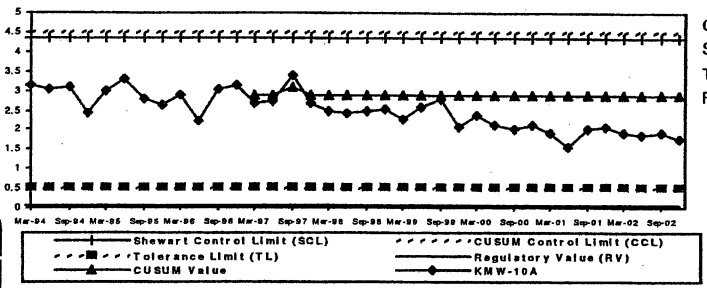
Time Series Chart
Indicator Well KMW-16A



TL = 0.482 units
RV = 0.05 units

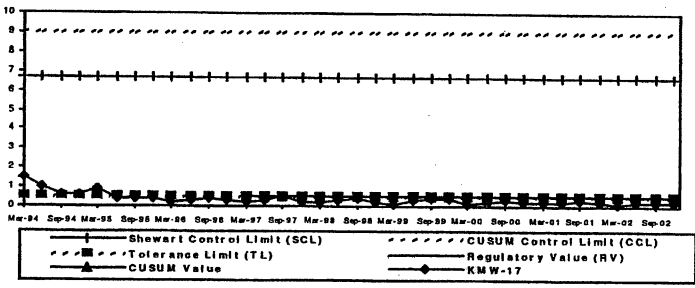
Distribution Assumption: Lognormal

Shewart and CUSUM Control chart
Compliance Well KMW-10A



CCL = 4.509 units
SCL = 4.347 units
TL = 0.482 units
RV = 0.05 units

Shewart and CUSUM Control chart
Compliance Well KMW-17

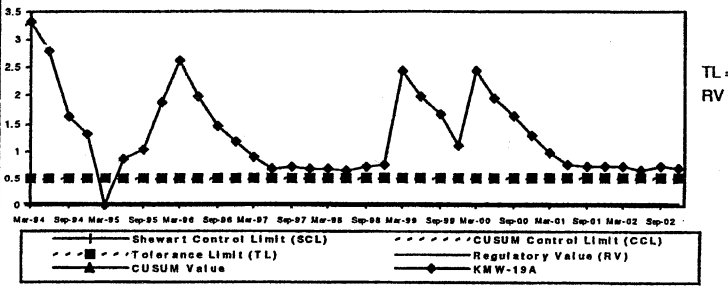


CCL = 8.974 units
SCL = 6.71 units
TL = 0.482 units
RV = 0.05 units

Distribution Assumption: Normal

Distribution Assumption: Lognormal

Time Series Chart
Compliance Well KMW-19A



TL = 0.482 units
RV = 0.05 units

Figure 13

Vinyl Chloride in Compliance Well KMW-10A

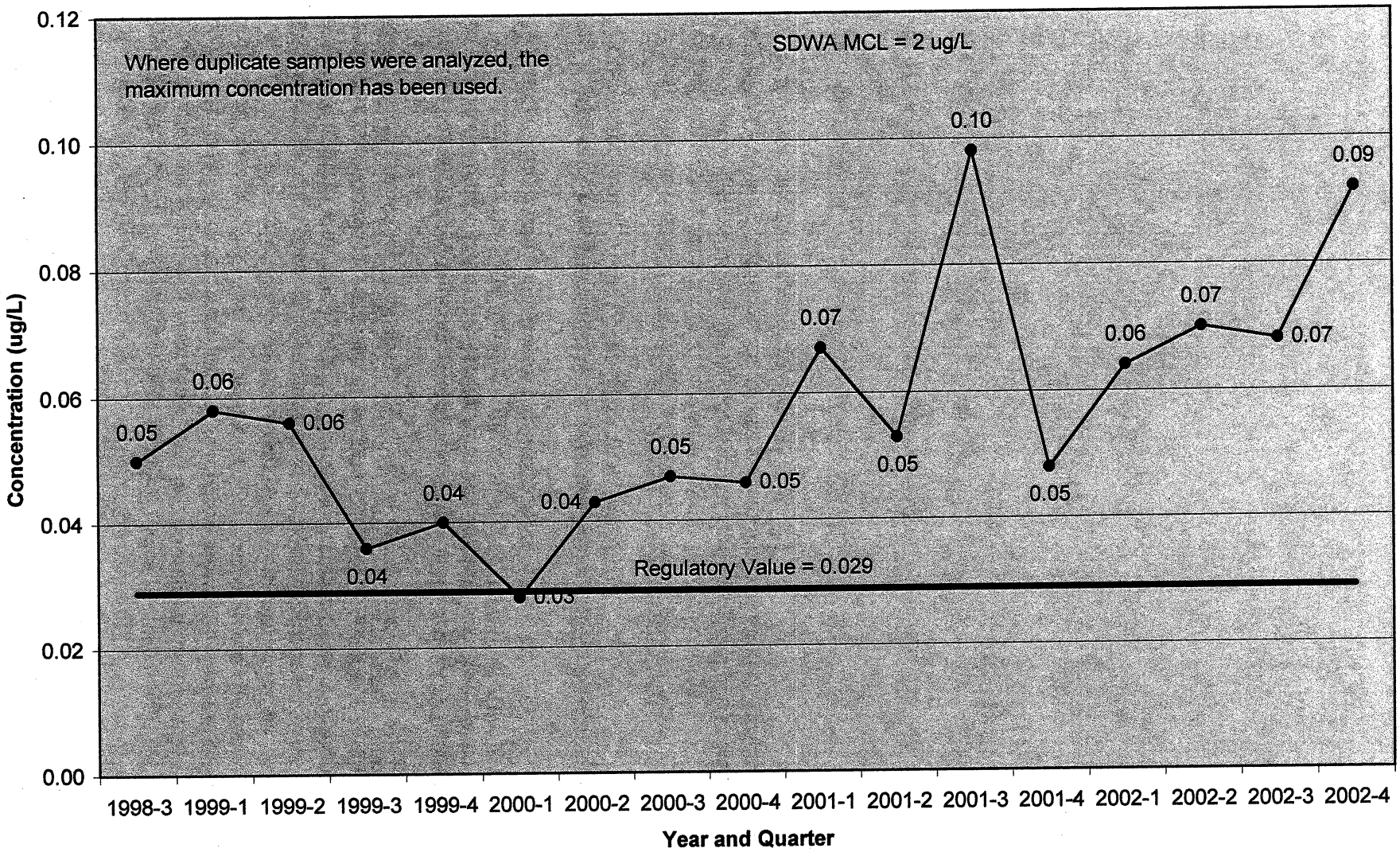


Figure 14

Vinyl Chloride in Compliance Well KMW-17

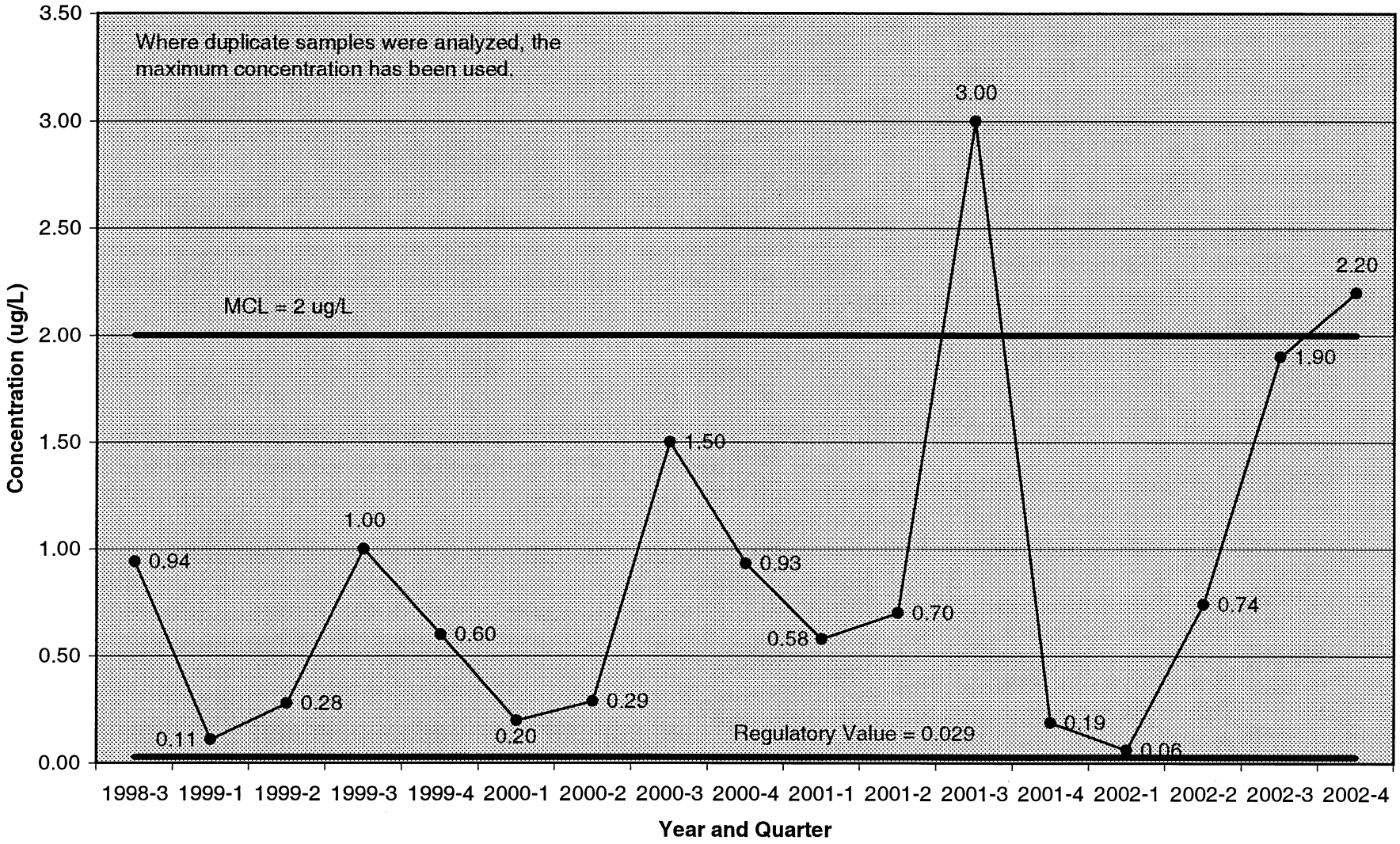


Figure 15

APPENDIX A

KENT
WASHINGTON

PUBLIC WORKS
Don Wickstrom, P.E.
Director of Public Works

Phone: 253-856-5500
Fax: 253-856-6500

220 Fourth Ave. S.
Kent, WA 98032-5895

July 9, 2003

Mr. David South
Senior Engineer
Toxics Cleanup Program
Department of Ecology
NW Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

RE: Kent Highlands Landfill

Dear Mr. South,

Thank you for the opportunity to comment on the Kent Highlands Landfill – second review draft report, dated June 13, 2003. The City of Kent is concerned with the findings in the report, most specifically with the release of vinyl chloride and manganese into the groundwater which flows to the Green River.

The City of Kent is very dedicated to preserving natural resources along the Green River Corridor and has implemented the development of the Green River Natural Resources Area, a Shoreline Management Plan and we are currently working on various projects to protect, restore and enhance salmonid habitat in the Green River Watershed. Release of vinyl chloride and manganese into the groundwater and low oxygen levels and ammonia in the spring drain all affect water quality that could have a detrimental effect on the ecology of the Green River and its tributaries, most notably aquatic species such as Chinook salmon.

The City of Kent supports the recommendations in the proposed Follow-up Actions beginning on page 25 of the report. Immediate implementation is critical to avoid any unnecessary impacts to the ecosystem.

If there is any additional information we might be able to provide, please feel free to contact Mr. William S. Wolinski, Environmental Engineering Manager, at (253) 856-5548.

Sincerely,

Don E. Wickstrom, P.E.
Public Works Director

c: Mr. Gary Gill, P.E., City Engineer
Mr. William S. Wolinski, P.E., Environmental Engineering Manager