Minnesota Pollution Control Agency's

Closed Landfill Program

Annual Report 2003

Washington County Sanitary Landfill

SW-001

Minnesota Pollution Control Agency

Compiled By

The Closed Landfill Program
Petroleum & Landfill Remediation Section
Majors & Remediation Division
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Table of Contents

Figures

Figure 24 Stratigraphic Column of Quaternary Deposits (Figure 2 from *Hydrogeologic Site Characterization Near Well "I" at the Closed Washington County Landfill Lake Elmo, Minnesota*, Earthtech June 2003)

Appendix A

Quarterly inspection reports for Year 2003 from Conestoga Rovers and Associates (on CD in PDF format, available upon request to MPCA, 30.58 MB and 141 pages when printed)

Tables

Note: The tables are located in a Microsoft Excel workbook titled Tables for Washington Co 2003.xls that can be downloaded from the web page.

I. Site Background

The Washington County Sanitary Landfill (Landfill) located in Washington County, City of Lake Elmo (T29N, R21W, Sect. 10), received its first permit to accept waste on 5/12/69, and continued operating until 5/1/75. The Washington County Sanitary Landfill is 35 Acres in size and contains approximately 2,570,000 cubic yards of waste (1.95 million cubic meters). The Landfill was under public ownership when in operation. A map showing the approximate location is included in Figure 1, below.

An abbreviated CERCLA (Comprehensive Environmental Response and Compensation and Liability Act of 1980) history of the site follows. Washington and Ramsey Counties (Counties) performed a Remedial Action at the site in accordance with a Response Order by Consent, dated October 24, 1984, between the MPCA and the Counties and in accordance with an Administrative Order issued by US EPA to the Counties pursuant to Section 106 (a) of CERCLA (Administrative Order), dated January 16, 1992 and amended February 17, 1993. The major component of the Remedial Action was the installation and operation of a ground water gradient control and treatment system. The Consent Order was executed under authority given to the MPCA by the Minnesota Environmental Response and Liability Act (MERLA). The Consent Order contained a liability limit for response actions taken by the Counties at the Site. The Counties reached the liability limit and the MPCA terminated the Consent Order on February 2, 1992. The US EPA issued the Administrative Order on January 16, 1992 in order to ensure that the response actions continue at the Site. The Administrative Order was amended on February 17, 1993 to address an explosive methane gas problem associated with the site. The first Five-Year Report was written in January 1994 to address the ground water remedial action taken in 1989. The second Five-Year Report addressed the ground water remedial action, the affect of the active gas extraction system and the enhanced cover in addressing public health and environmental issues around the Site and was written in 1999.

In accordance with the legislation enacted in 1992 (Minn. Laws 1992, Ch. 513, Art. 2, Sec. 2, Subd.3), each year at an Annual Forum, Minnesota Pollution Control Agency (MPCA) staff assesses, classifies and discusses ongoing issues at landfills in the Closed Landfill Program. According to that assessment and classification, the Washington County Sanitary Landfill was given a ranking of D and a score of 11. The rank of D indicates that this landfill currently poses no threat to public health or the environment and may meet current MPCA closure standards.

The binding agreement was signed in November 1995 and the Notice of Compliance was issued January 8, 1996. The US EPA terminated the Administrative Order on March 15, 1996.

At the Annual Forum held January 13, 1998, the site score and classification was not changed. At the Annual Forum held February 9, 1999, the site score and classification was not modified. At the Metro District Forum held March 30, 2000 the site was reclassified. The new rank and score is B/11. An annual forum was held on the site on December 19, 2000, the site was not rescored at this forum.

Additional information regarding the Closed Landfill Assessment can be found in the Closed Landfill Assessment Report (January 1995). (This information is also available from the Closed Landfill Program's web page: http://www.pca.state.mn.us/cleanup/landfill-metro.html#Washington County).

II. Site Engineering Summary

A. Landfill Cover Maintenance/Construction Summary

When the landfill closed on 5/1/75, 2 feet or more of final cover was in place. In 1996, the cover was upgraded to current standards including a geomembrane, sand drainage layer, rooting zone, and topsoil with shallow rooted grasses.

Major settlement has occurred on the cover in several areas. Drainage is not occurring in the areas of settlement. Ponded water and wet/soft conditions exist in the settlement areas that prevent them from being mowed. The settlement areas also prevent accessibility to the cover by vehicles.

B. Leachate Management System Summary

1. Leachate Management System Maintenance Summary

The Washington County Sanitary Landfill does not have a Leachate Management System for leachate collection. The landfill is unlined.

2. Leachate Monitoring Summary

There are no leachate monitoring points at the Washington County Sanitary Landfill.

C. Landfill Gas Management System Summary

1. Landfill Gas Management System Maintenance Summary

The barrier extraction vent system extraction well manhole covers were welded closed to restrict access to the buried wellheads, and the blowers were disconnected in 2000. The blower piping can be easily reconnected if this system needs to be reactivated.

Fourteen active gas extraction wells are located throughout the facility which extracts methane and other gases from the waste that are burned in an enclosed flare. At the end of 2002, 11 of the 14 gas extraction wells were operating. The flare destroyed 1,622,034 pounds of methane in 2001 and 1,460,250 pounds of methane in 2002.

Landfill gas condensate is collected in one of three buried double-walled storage tanks.

2. Landfill Gas Monitoring Summary

There are 27 gas monitoring points to monitor for the presence of landfill gas generated by the Washington County Sanitary Landfill. Landfill gas migration was controlled adequately by the active gas extraction system. Table 1 summarizes the results of operating the flare including the hours the flare ran for the past two years. The flare has operated 95 percent of the time in the last year. Table 2 summarizes methane readings collected in 2003 in the gas. The Operation and Maintenance contractor, Conestoga-Rovers & Associates (CRA), monitors the probes quarterly. Methane was not detected in the probes in 2003
Inlet and Outlet Gas was sampled from the flare in November 2003. The results have not been reported by the sampling contractor as of this date.

3. Landfill Gas Condensate Summary

MPCA has an Industrial Discharge Permit Number 2192 issued by the Metropolitan Council Environmental Services (MCES) to allow discharge of landfill gas condensate from the Washington County Landfill to their wastewater treatment facility. The permit requires monthly monitoring (at the time when a discharge will occur) and quarterly reporting to MCES to remain in compliance with their discharge permit. 1,968 gallons of condensate was discharged at the MCES disposal site at Third Street and Commercial Avenue in Saint Paul in June 2001 and 1,246 gallons was disposed in October 2002The discharge was in compliance with the MCES permit limitations. Table 3 lists detections in the condensate tank samples from 2003. No discharge occurred in 2003.

D. Electricity Generated

No Energy Recovery system was in effect or no energy was recovered this year at the Washington County Landfill.

E. Additional Maintenance Summary

Three gas probes were abandoned in August 2001 (GP-3A, GP-3B, and GP-14). The flare column was painted in September 2001. CRA hired a contractor in August of 2002 to haul additional fill in to correct the settlement/drainage problem in four separate areas of the cover. The four areas were seeded and accepted in September 2002. CRA also improved the driveway that surrounds the old blower building to provide better access and drainage. Additional Class 5 material was also added to the south access road. CRA is monitoring a potential soil shear failure occurring on the north and south banks on the Northwest storm water pond. The Northwest storm water pond slopes appear to have stabilized in 2003.

F. Site Engineering Recommendations

- Quarterly routine inspection of the final cover system is performed by CRA to assure that erosion has been adequately controlled. Any erosion observed on the final cover will be evaluated and appropriate steps taken to repair the damage before it becomes worse.
- Soil should be added to low areas on the landfill cover.
- Pipes should be installed west of the cable concrete to drain the area and protect the cover.

III. Site Hydrologic Monitoring Summary

A. Ground Water Monitoring/Remediation System Maintenance Summary

1. Ground Water Monitoring System Maintenance Summary

All monitoring wells were developed in the spring of 2000 and the submersible pumps were removed so that dedicated Grundfos pumps could be installed in the wells. Dedicated Grundfos RediFlo pumps were installed in wells I, J, D1, D, V2, V, Q1, Q2, Q3, R1, R2, R3, and L in the spring and summer of 2000. In the summer of 2001 the dedicated Grundfos in D was moved to well A. The dedicated Grundfos in J was moved to E in the spring of 2002.

2. Ground Water Monitoring Summary

by Interpoll Laboratories, Inc. (Interpoll) collected 3 rounds of water quality samples in 2003 at the Washington County Landfill. The landfill monitoring system consists of 38 wells and 1 surface water sampling points. The Environmental Monitoring System includes 38 monitoring wells. Of these, 10 wells are located in an upgradient direction, 23 are downgradient and 5 are sidegradient. A map showing the locations of each of the monitoring points is presented in Figure 2. A list of the wells and dates sampled during 2003 is included in Table 4.

Tables 4, 5, and 6 have been prepared to show parameters analyzed, groundwater elevation data, and total concentrations of Volatile Organic Compounds (VOCs) for each of the wells monitored. Review of ground water data indicates that the groundwater flow direction in the surficial aquifer was to the southMeasurements collected December 2003 in the water table wells north of the landfill verify the flow observed in October. Flow from the northwest side flows to the east-southeast and from the northeast side flows to the west-southwest. There is mounding visible near the treatment area and around well nest D/D1 and GC2R. At the base of the surficial aquifer, the flow direction is to the south-southeast during the spring but to the southwest under the fill area and southeast downgradient of the fill area in October. There is mounding at V/V2 nest in the spring but the mound increases to the east in the fall. The irregular components of flow near the landfill may be due to influx of water into the aquifer upgradient of well E. In the Prairie du Chien the flow is to the south. The maps developed for the base of the surficial aquifer indicate that pumping at GC-1 and the infiltration of treated water creates ponding around well V/V2 and the treatment area at different times during the year.

The horizontal hydraulic gradient at the water table averaged 0.008 upgradient to the northeast; the reading upgradient to the northwest was 0.0009. These gradients suggest that direction can easily change based on infiltration. The gradients downgradient of the fill were 0.056 to the northeast and

0.032 to the southwest. The horizontal hydraulic gradient in mid-levels of the surficial aquifer was constant despite the season but varied based on proximity to the fill area. The gradient was 0.033 upgradient and to the northwest. The gradient averaged 0.066 downgradient to the southeast and averaged 0.049 downgradient to the southwest. These values are consistent with gradients measured in previous years. In all the other aquifers beneath the site the gradients remained very flat and explain why flow directions change easily with the influx of treated water. The horizontal hydraulic gradient at the base of the surficial aquifer averaged 0.0007 (an order of magnitude less than seen in 2001-2002). The gradient in the Prairie du Chien aquifer was 0.0057 (this is an order of magnitude steeper than observed in 2001-2002).

The vertical hydraulic gradient may be influenced by proximity to the gradient control well and to the infiltration basin (see Table 7). GC-1 was the only gradient control well operating in 2003. The vertical gradients measured between the water table and the next lower level all indicate a downward gradient regardless of whether the wells are up- or downgradient of the fill area. However, the gradients measured downgradient are steeper by one to three orders of magnitude. Treated water infiltrating back into the aquifer flows to the west and this is reflected by strong vertical gradients seen at well nest V and well nest R. The vertical gradients measured between mid-depth and the base of the surficial aquifer downgradient of the fill area indicated upward gradients to the west and a downward gradient to the east. The data is not as strong as seen at the water table with the exception of the gradient measured in the V nest which is very strong and is two orders of magnitude stronger than seen previously. The vertical gradient near Q at the bedrock interface resembles data seen in the previous years. At well nest R the vertical gradient was downward and continued a trend seen in previous years. Vertical gradients at R reflect influence by recharge in Treatment Area 1. The gradient calculated was 0.0035 in the upper portions of the surficial aquifer and 0.0035 at the Prairie du Chien interface. This continues the trends seen historically in this area.

Ground water quality data collected from the monitoring system at the landfill site is tabulated and presented in Table 4. Laboratory analyses of inorganic and organic parameters were performed by Minnesota Department of Health (MDH). Graphs showing trends in water quality and ground water elevations are included in Figures 10 through 22. As ground water concentrations of contaminants drop below the Health Risk Limits (HRLs), the ground water pumpout system can be reevaluated. Ground water samples collected from monitoring wells have shown impacts from both parameters.(Table 8). Infiltration standards for inorganic parameters were not exceeded in Treatment Area 1 in 2003. The manganese standard is exceeded in monitoring wells V, V2, and R3 in 2003. In each exceedance there were reducing conditions in the well (i.e. the oxidation reduction potential was negative). Plots of Eh trends compared to the precipitation graph suggest that precipitation affects the oxidation reduction potential conditions. When there is less precipitation the geochemical conditions become reducing in the aquifer.

Vinyl chloride was the only organic parameter that exceeded the Health Risk Limit in 2003. The standard was exceeded upgradient during each event but downgradient only during the spring and summer. The violation upgradient does not appear to be related to the fill area since the flow at the northwest corner is to the east-northeast. Vinyl chloride exceeded the standard in V but not at V2. Vinyl chloride was also a parameter of concern at EE (the southern edge of the plume) averaging 1.1 micrograms per liter. This is a reduction from the previous two year period.

3. Ground Water Remediation System Maintenance Summary

A ground water remediation system is in operation at the Washington County Landfill. The ground water remediation system includes 4 pumpout wells. See Table 9 for pumping rates and volume pumped of the gradient control wells. In 2003, 48,043,155 gallons were pumped from GC-1 and treated by the spray irrigator.

4. Ground Water Remediation Summary

Gradient control was accomplished with GC-1 in 2003. The volume of ground water removed in 2001 was 52,443,809 gallons, in 2002 was 67,700,201 gallons, and in 2003 was 48,043,155 gallons. Using concentrations of Volatile Organic Compounds (VOCs) found in the gradient control wells, it was estimated that 27.5 pounds of VOCs were removed from the ground water in 2000, 11.9 pounds in 2001, 12.9 pounds in 2002, and 9.9 pounds in 2003. The reduction reflects the greater volume of uncontaminated ground water captured near GC-1. A summary is included in Table 9.

The site was developed on an old gravel mining operation that had several active pits. An aerial photograph taken of the site in 1969 (at the end of the site's life as a gravel mining operation and the beginning of the site as a solid waste facility) shows several pits with ground water in them and garbage placed in ground water. Ground water remediation is challenging when the source may be below the garbage. Active gas extraction stabilizes waste above the water table and has little impact on waste in ground water.

A graph of total volatile organic compounds in the gradient control well indicates several things (see Figures 12). The trend observed at GC-1 (shown in Figure 12) indicates increasing contamination with increasing ground water elevation for data through 2003. This may reflect capture in the gradient control well. A graph at EE can be used as a measure of the behavior of wells outside of the fill area and still impacted by contamination (Figure 11). The trend at EE during 2003 has been a declining trend with a small peak during the first sampling event of the year. However, the plume appears to be stable at EE because the concentration range since 2000 has been less than 50.

GC-1 appears to be having an impact on the plume in the downgradient direction and may be stabilizing the plume around well EE. The concentration of manganese is problematic (Figure 14) and may be partially related to the infiltration of treated water. The gradient control well and treatment system must continue to operate to prevent the migration of a plume downgradient but a new gradient control well will be installed in 2004 to pump directly in the plume and discharged outside of the plume.

Upgradient Study near Well I

Earthtech under contract to the Closed Landfill Program completed a hydrogeologic site characterization near well I in two phases. The study was completed at the end of June 2003. The characterization included a literature review, a geophysical survey assessment, a direct push investigation, stratigraphic characterization and well installation, and in-situ horizontal hydraulic conductivity tests. The geophysical survey and direct push investigation were completed in the first phase and were used to determine the presence of buried drums. Geophysical anomalies were noted but were not confirmed with the direct push investigation. Phase 2 consisted of characterizing the glacial stratigraphic sequence in the vicinity of well I with three rotosonic borings. The placement of these borings was based on the results from Phase 1. The hydrostratigraphic sequence near well I was found to be 131 feet thick and is depicted by Figure 24. The Quaternary-age column includes thin local construction fill material, Superior Lobe Deposits, and Keewatin Deposits. The Superior Lobe Deposits in the vicinity of Well I are approximately 124 feet thick and comprised of one formation, the Cromwell Formation. The Cromwell Formation is subdivided into a vertical succession of six informal distinctive facies that include, from the top down, the Surficial Glaciofluvial Facies, the Glaciolacustrine Facies, the Resedimented Till Facies (Upper Unit), the Glaciofluvial Facies (Upper Unit), the Resedimented Till Facies (Lower Unit), and the Glaciofluvial Facies (Lower Unit). The Keewatin Deposits include a resedimented till deposited during a pre-late Wisconsinan glacial advance.

The uppermost bedrock is Middle Ordovician-age St. Peter's Sandstone Formation found at approximately 131.0 feet below the ground surface at an elevation of 822.5 NGVD.

Water levels were collected on June 19, 2003 from five Shallow Drift wells at the northwest side of the site and the three newly installed wells. Ground water flowed northeastward with a gradient of approximately 0.004 ft/ft. Flow direction was confirmed by quarterly ground water sampling events and by water levels measured in December 2004.

Variable head tests performed in the three newly installed wells yielded horizontal hydraulic conductivity ranging from 8.43 to 40.6 to ft/day (2.97x10-3 to 1.43x10-2 cm/sec) with a geometric mean horizontal hydraulic conductivity of 17.7 ft/day (6.22x10-3 cm/sec). Using the calculated average horizontal gradient between the wells of 0.004 ft/ft, the estimated mean horizontal hydraulic conductivity of 17.7 ft/day, and an average effective porosity of 0.30 based on an average porosity for sand and gravel, the average linear ground water velocity in this area is 0.23 ft/day.

A perched water table occurs within the Glaciolacustrine Facies. However, this unit may not readily transmit water into an open borehole due to its cohesive nature and dominating capillary forces. The clayey subfacies of the Resedimented Facies (Upper Unit) may serve as an aquitard at boring B1; however the deposits directly above and below the unit are dry.

The study indicates that impacts to Well I appear to be coming from the west. However, the flat gradient in the area around well I suggests that flow can change direction. Continuous water level indicators should be installed in these wells for a year to track flow and to determine how flow changes between seasons.

5. Monitoring System Modifications

Three water table wells were installed at the northwest corner of the landfill property during May 2003 in order to assess contamination found at well I. Six water table wells were installed in August 2003 to monitor flow at the water table. Logs of the wells installed are detailed in Tables 10 through 15. These logs indicated that the stratigraphy of the aquifer is more complex than depicted in 1993 cross sections. The well completed at C-WT indicates that there are sand laminations in the Silty Clay sequence and that the Fine to Coarse Sand sequence contains cobbles, fine gravel and clay. The Sand in the upper portion of R-WT is both silty sand and coarse sand (fining upward) and the Till also consists of coarse sand grading to pebbles. These logs also correlated with the stratigraphy depicted in Figure 24.

B. Surface Water Monitoring Summary

The pumpout water from gradient control wells GC-1 is discharged to Treatment Area 1 through a spray irrigator. The pumpout water infiltrates to ground water and mounds around the treatment area and around the R and V nest at different times of the year. Since the ground water infiltrates on-site and the site is operated by the MPCA, the NPDES permit had been allowed to expire.

However, NPDES monitoring still occurs to ensure that pumpout water meets Health Risk Limits (or in their absence MCLs or HBVs) prior to infiltration and complies with nondegradation statutes (Minn. ch. 7060).

There were no standards exceeded in 2003. This reduction may reflect pumping of both contaminated and uncontaminated ground water that is discharged to Treatment Area 1.

C. Additional Monitoring Summary

1. Residential Well Sampling

Residential wells were not sampled during 2003.

IV. Inspections

Inspections were conducted on a weekly basis by MPCA staff and the Operation and Maintenance (O&M) contractor hired by the MPCA. Appendix A contains the quarterly reports from the O & M contractor.

V. Costs

The cost for full service operation and maintenance of the landfill including mowing and sampling was $127,641.00 for the fiscal year from July 1, 2002 through June 30, 2003. (This does not include cost of analysis at MDH).

VI. Required Permits

The National Pollutant Discharge Elimination System (NPDES) permit expired in 1994.
The Metropolitan Council Environmental Services (MCES) discharge permit for gas condensate expires November 30, 2005.

VII. Conclusions and Recommendations

The gradient control system provides adequate gradient control in the area from V/V2 to EE but appears to pump out more ground water than is necessary. Ground water performance standards continue to be exceeded at these wells. The trend at EE during 2003 has been a declining trend with a small peak during the first sampling event of the year. However, the plume appears to be stable at EE because the concentration range since 2000 has been less than 50. The manganese standard is exceeded in monitoring wells V, V2, and R3 in 2003. In each exceedance there were reducing conditions in the well (i.e. the oxidation reduction potential was negative). Plots of Eh trends compared to the precipitation graph suggest that precipitation affects the oxidation reduction potential conditions. When there is less precipitation the geochemical conditions become reducing in the aquifer. The vinyl chloride standard was exceeded downgradient only during the spring and summer. Vinyl chloride exceeded the standard in V but not at V2. Vinyl chloride was also a parameter of concern at EE (the southern edge of the plume) averaging 1.1 micrograms per liter. This is a reduction from the previous two year period.

A new gradient control well placed in the plume, a new lined sedimentation basin and infiltration basin are recommended for design and construction in 2004. Ground water quality will continue to be monitored closely. More frequent sampling at the gradient control wells, in the treatment area, and at Well E will elucidate the manganese contamination around the landfill. Continuous water level recorders should be used at the northwest side of the landfill to track whether seasonal changes occur in the groundwater direction at that location.

The MPCA should research the feasibility of obtaining 5 acres of land south of well E to provide a buffer against future development.

VIII. Certifications

A. Hydrogeologic Certification

Based upon my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Geologist under the laws of the State of Minnesota.

Name: Ingrid J. Verhagen	**Title:** Senior Hydrogeologist	**Date:** 7-May-04
Mailing Address: 520 Lafayette Road, St. Paul, MN 55155		**Phone:** 651-296-7266
Signature:	**Reg. Number:** 30119	

B. Engineering Certification

I certify, that the engineering portions of this report and all attachments were prepared under my direction or supervision under a system designed to assure that qualified personnel gathered and evaluated the information submitted. Based upon my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

Name: Peter Tiffany	**Title:** Senior Engineer	**Date:** 7-May-04
Mailing Address: 520 Lafayette Road, St. Paul, MN 55155		**Phone:** 651-296-7274
Signature:		

C. Field Certification

I certify, that the field portions of this report were prepared under my direction or supervision under a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based upon my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

Name: Pat Hanson	**Title:** Field Representative	**Date:** 7-May-04
Mailing Address: 520 Lafayette Road, St. Paul, MN 55155		**Phone:** 651-296-7740
Signature:		

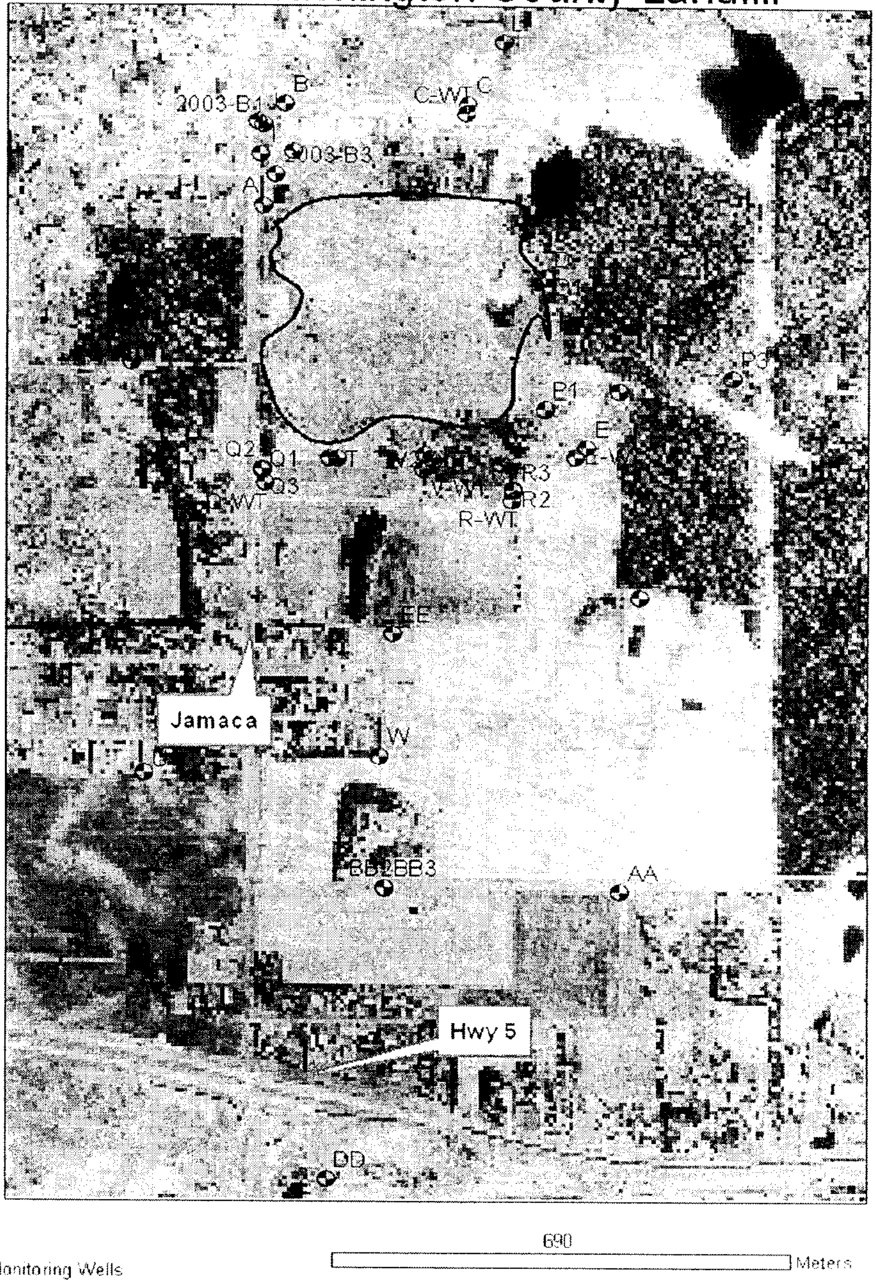
D. Annual Report Certification

Based upon my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

Name: Ron Schwartz	**Title:** Project Leader	**Date:** 7-May-04
Mailing Address: 520 Lafayette Road, St. Paul, MN 55155		**Phone:** 651-297-2915
Signature:		

Figure 1 Gas Probe Monitoring Network around Washington County Landfill

Figure 2 Groundwater Monitoring Network around Washington County Landfill



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2752.0014

Figure 3 Flow in the Surficial Aquifer, April 2003

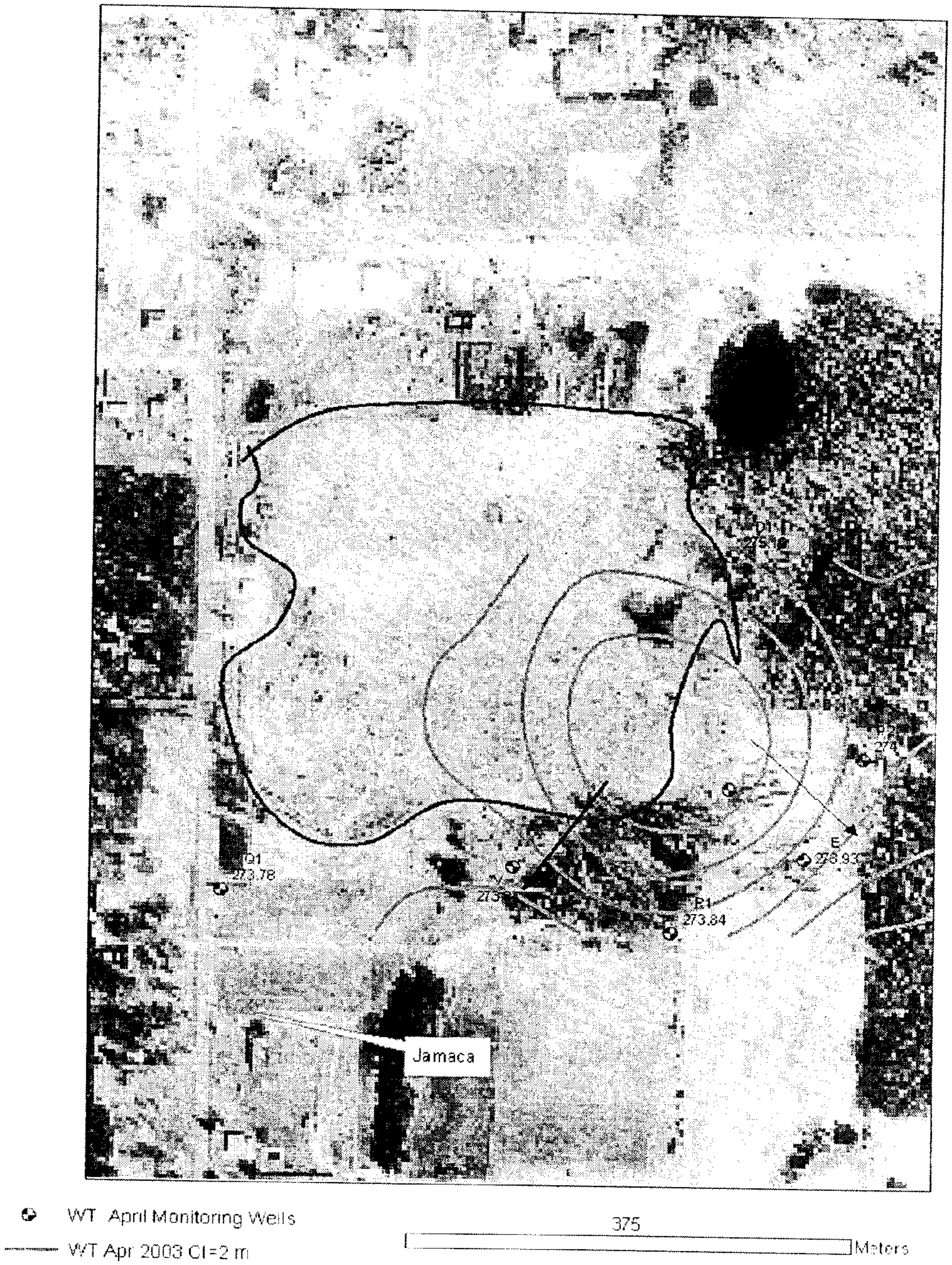

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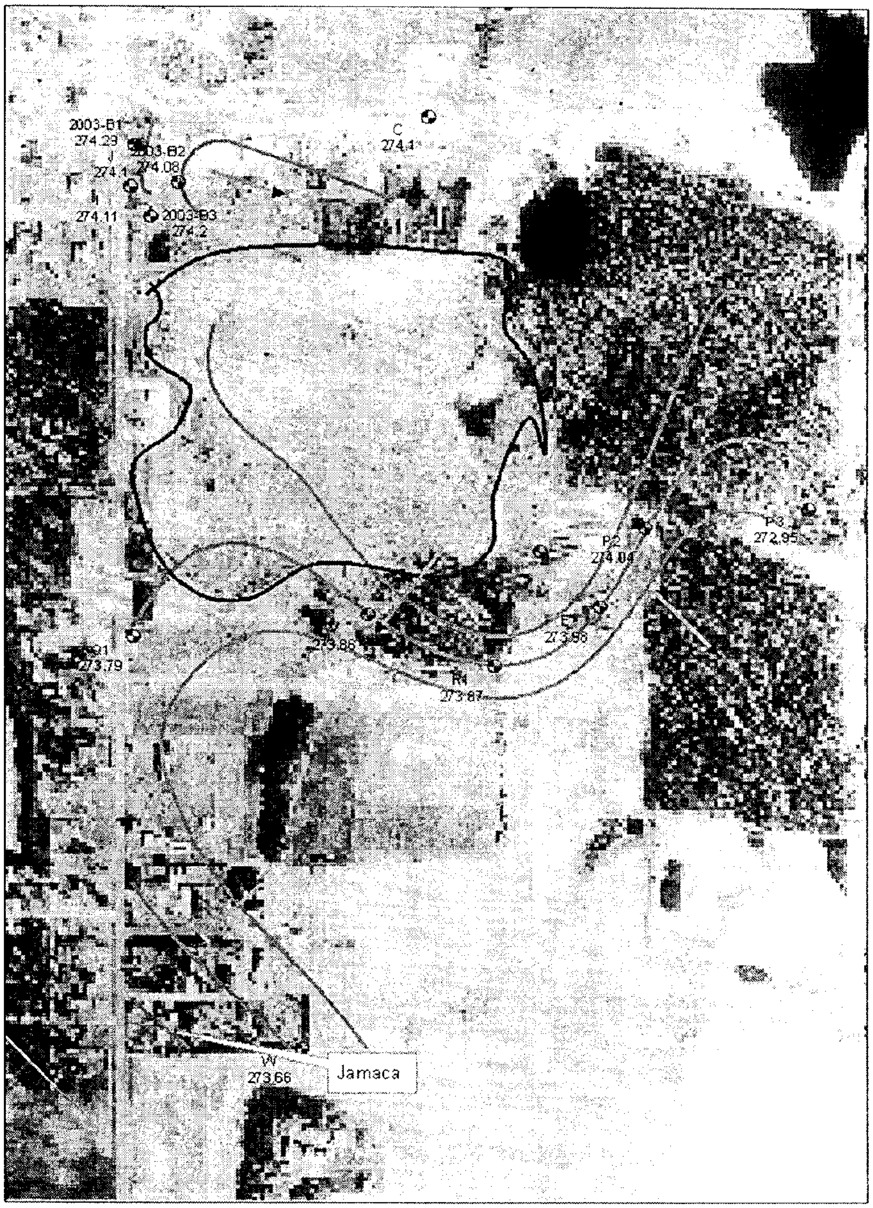
Figure 4 Flow in the Surficial Aquifer, July 2003



WT July 2003 CI=2 m

WT July MWs

480

Meters

Figure 5 Flow at the water table October 2003

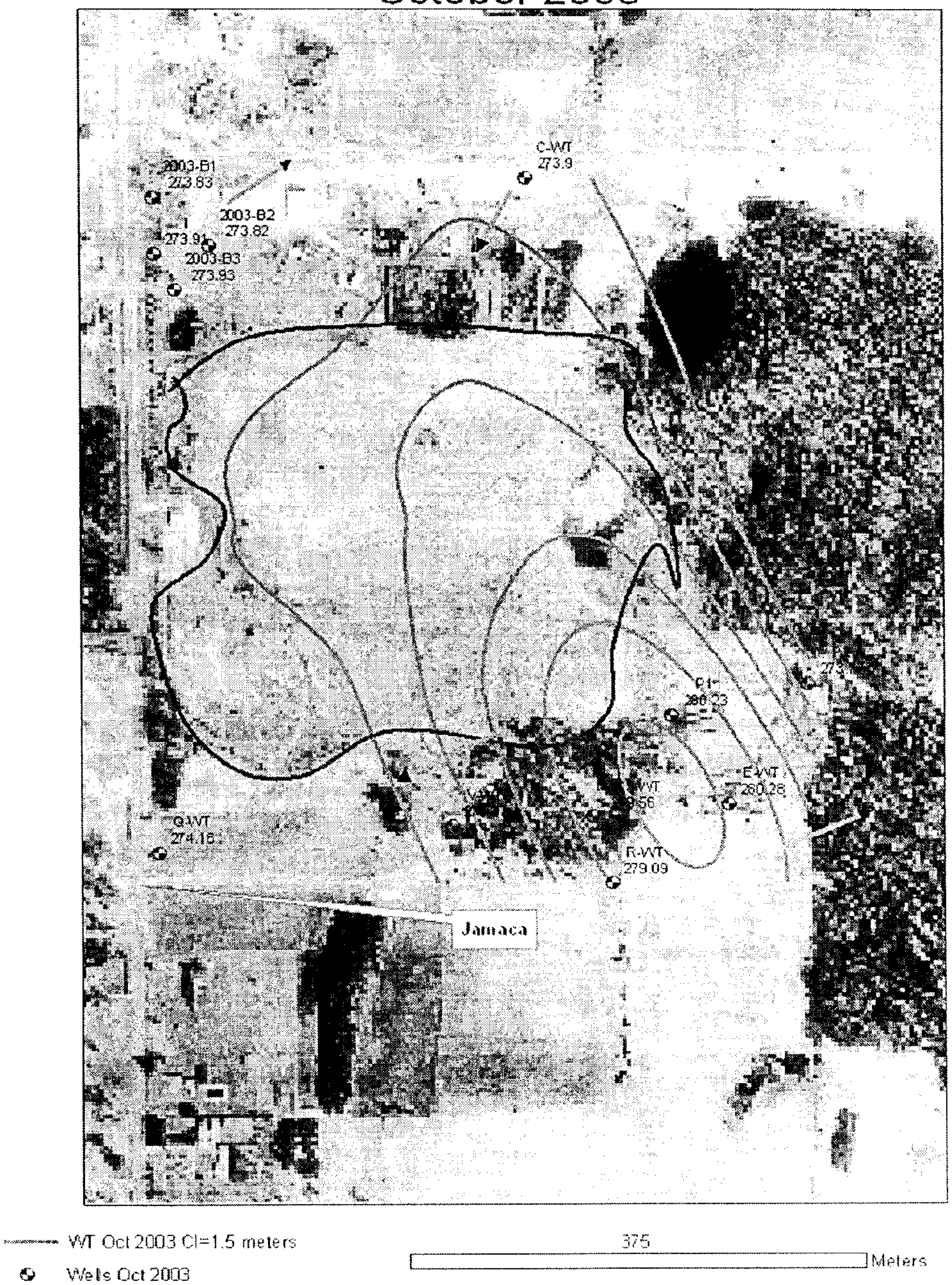
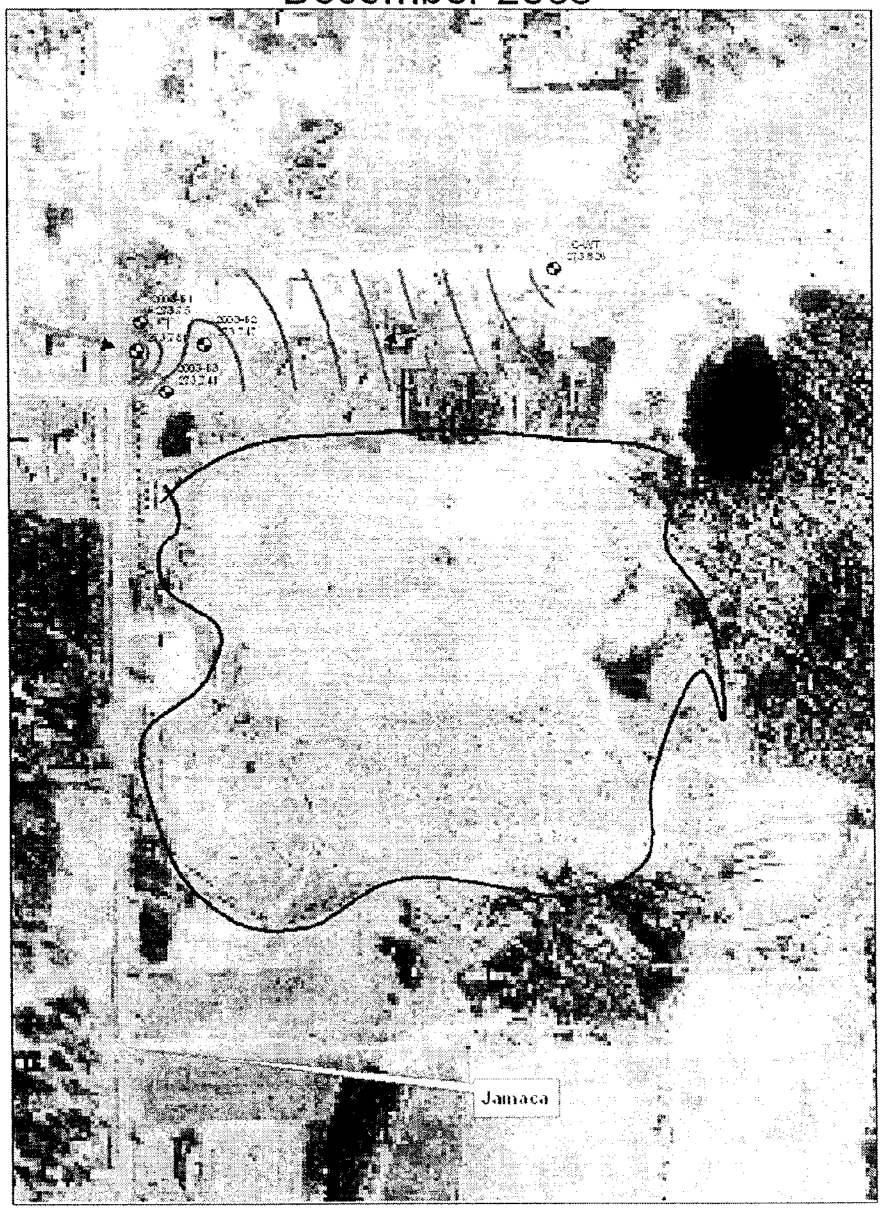


Figure 6 Flow at the water table north of the site December 2003

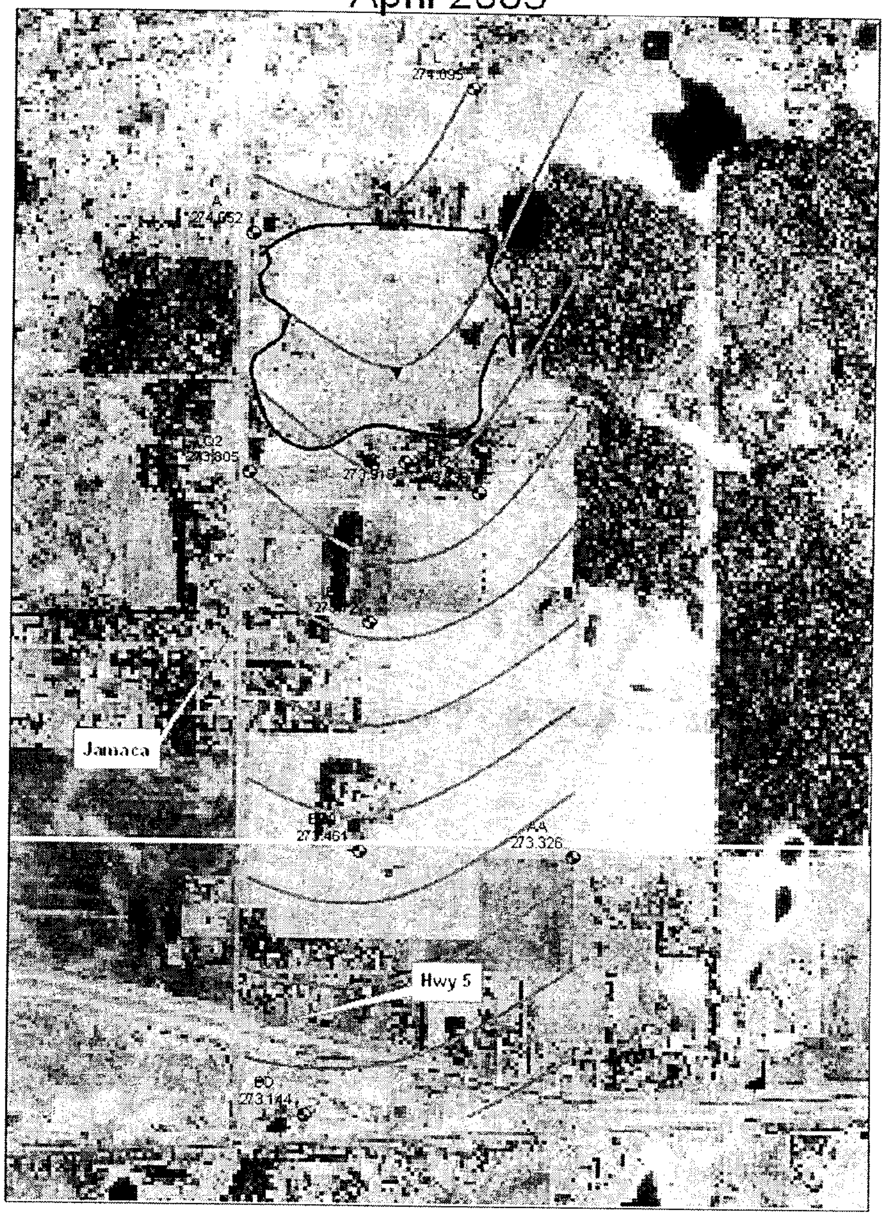


North WT Dec 2003 CI=0.01 m

North side MWs

340 Meters

Figure 7 Flow at the base of the surficial aquifer April 2003



Basal Aquifer wells

Base of surficial aquifer, CI=0.1

770 Meters

Figure 8 Flow at the base of the surficial aquifer October 2003

Figure 9 Flow in the Prairie du Chien aquifer
April 2003

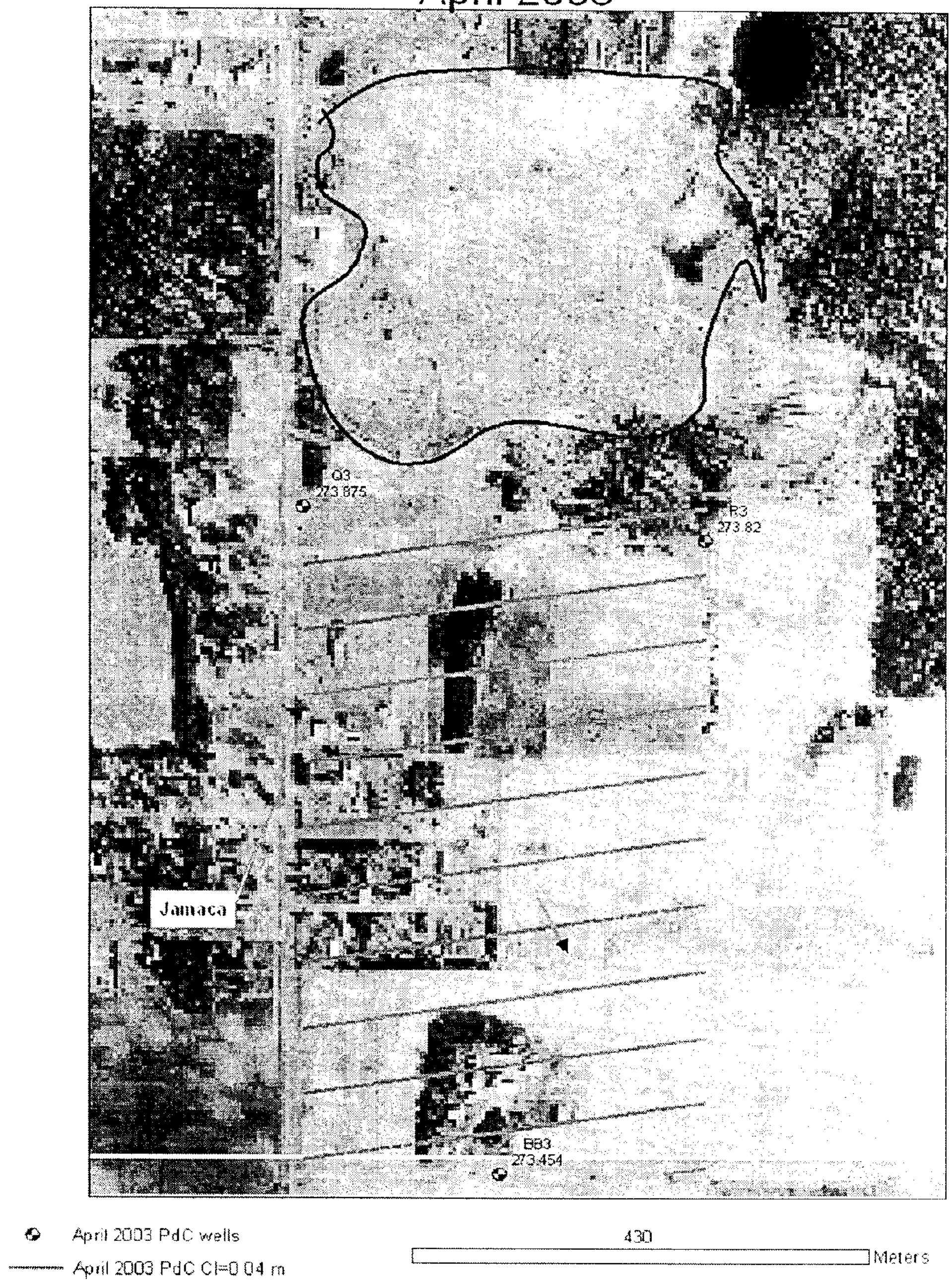


Figure 10. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well D1

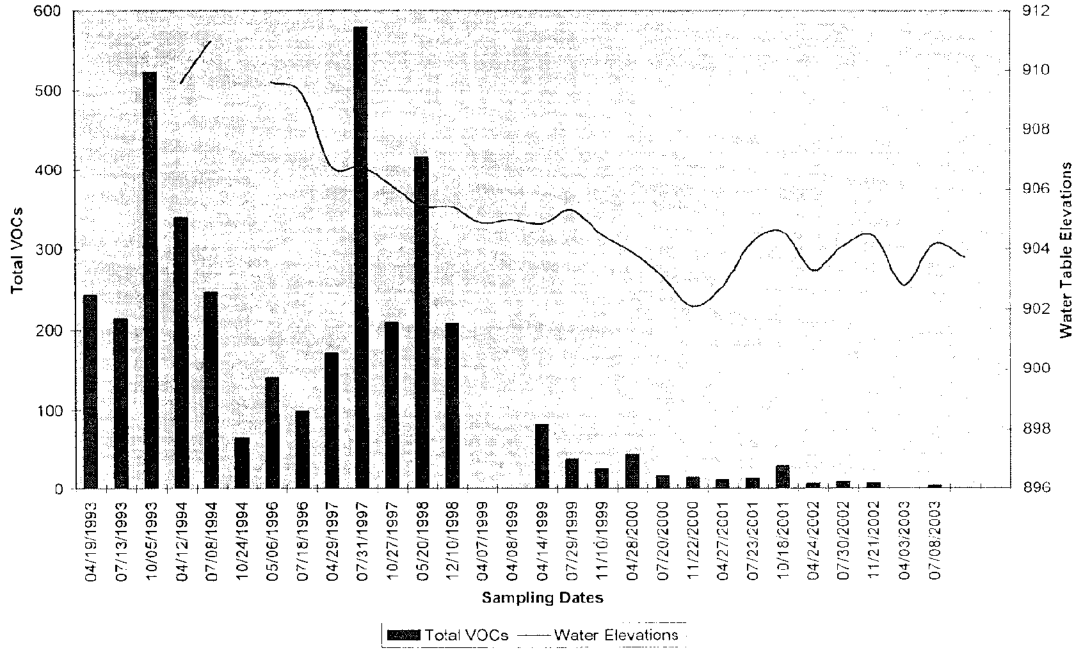


Figure 11. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well EE (Deep)

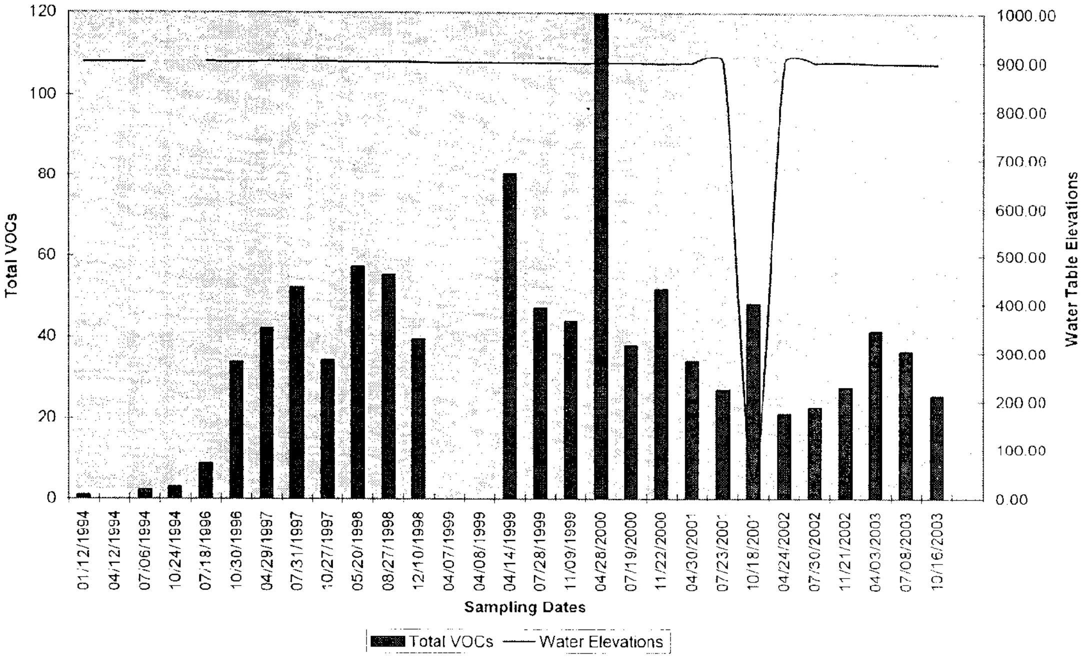


Figure 12. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well GC-1 (Gradient Control)

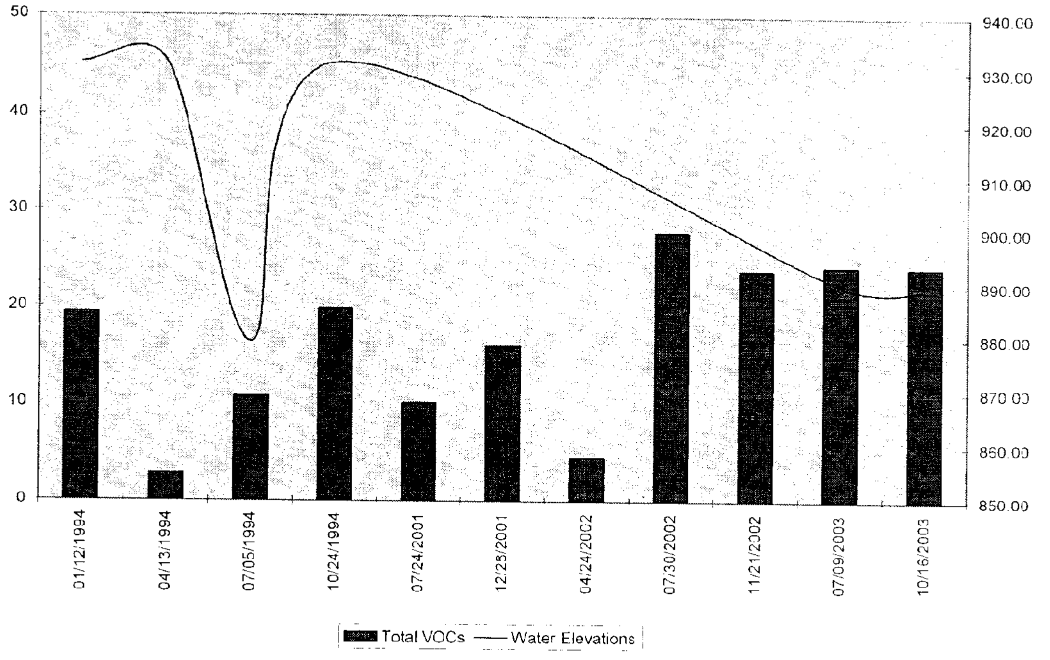


Figure 13. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well I

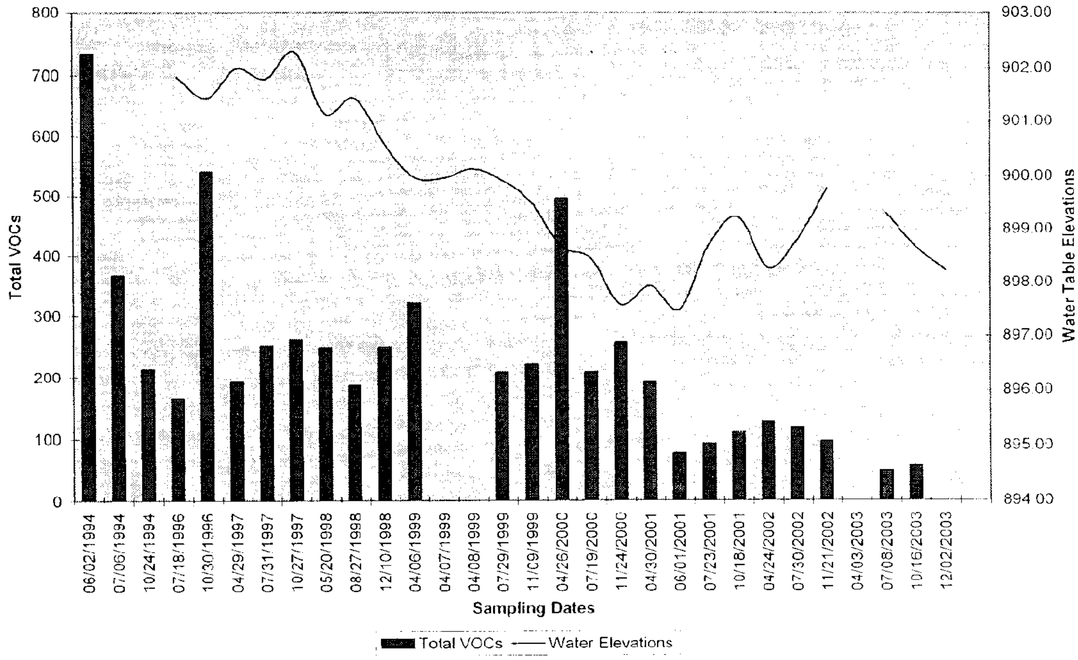


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Figure 14.
Manganese at selected wells

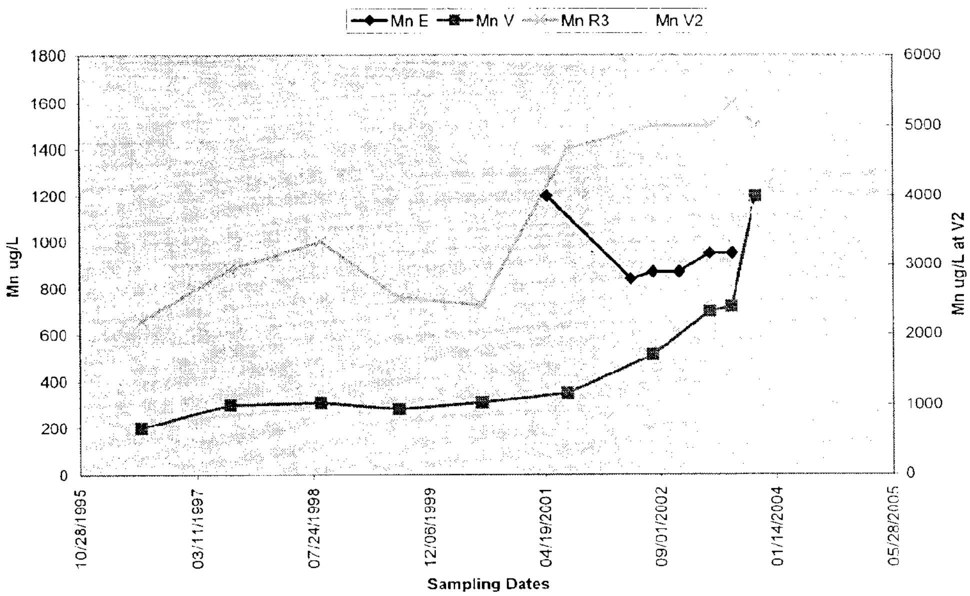
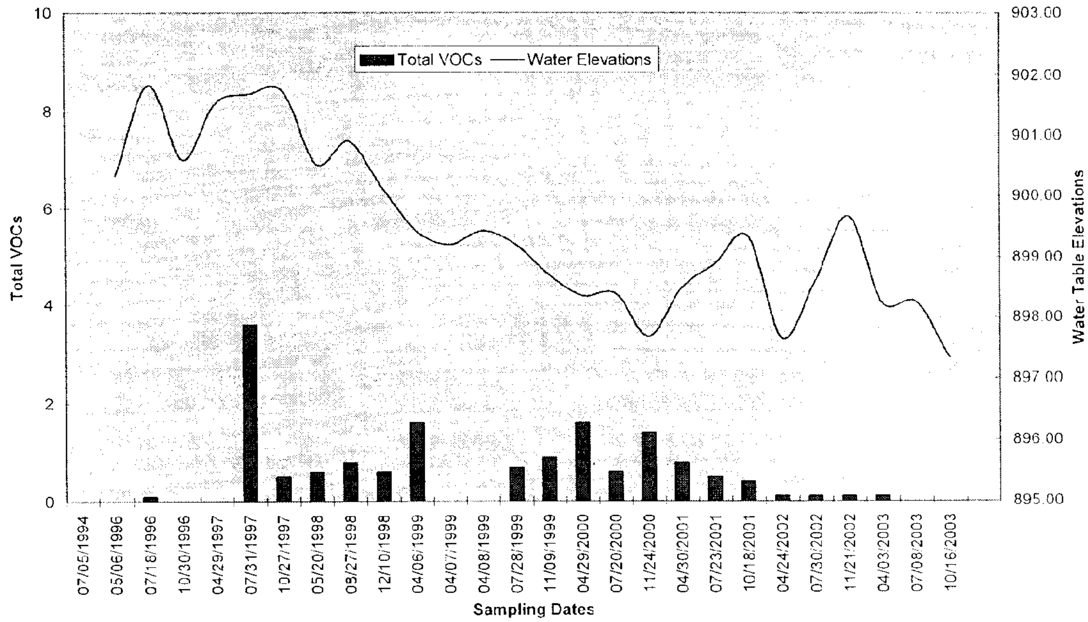


Figure 15. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well Q1



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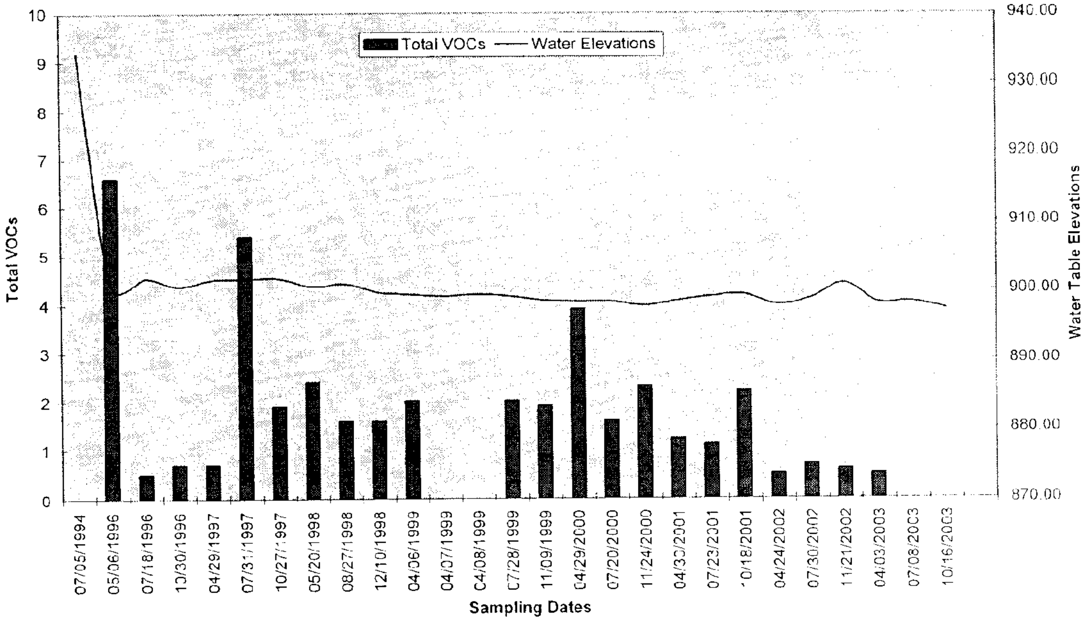
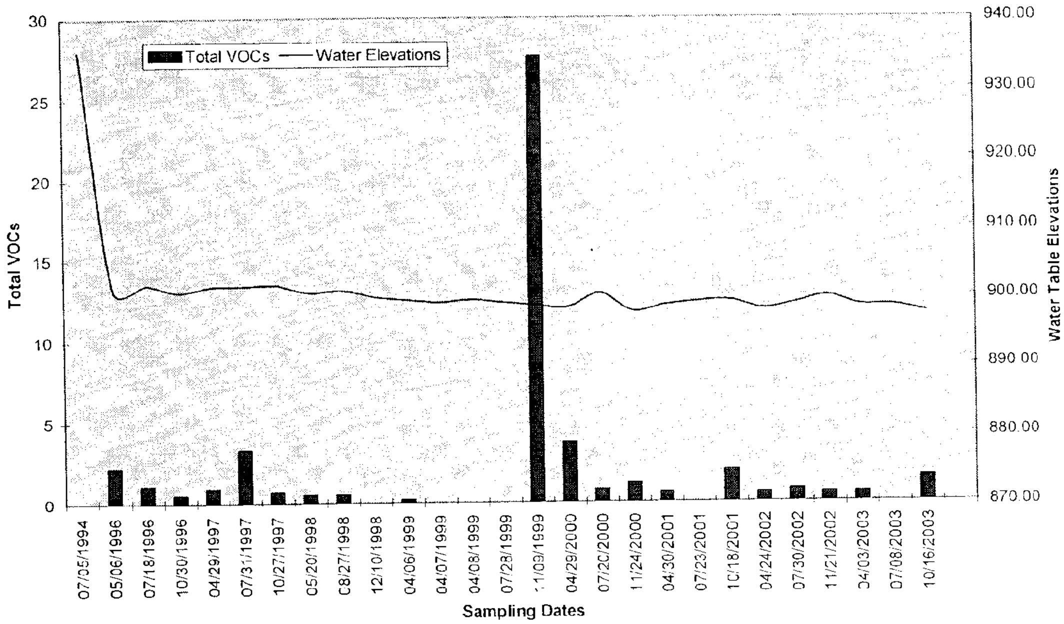
2752.0027

Figure 16. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well Q2



3MA00402230

Figure 17. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well Q3



3MA00402231

2752.0029

Figure 18. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well R1

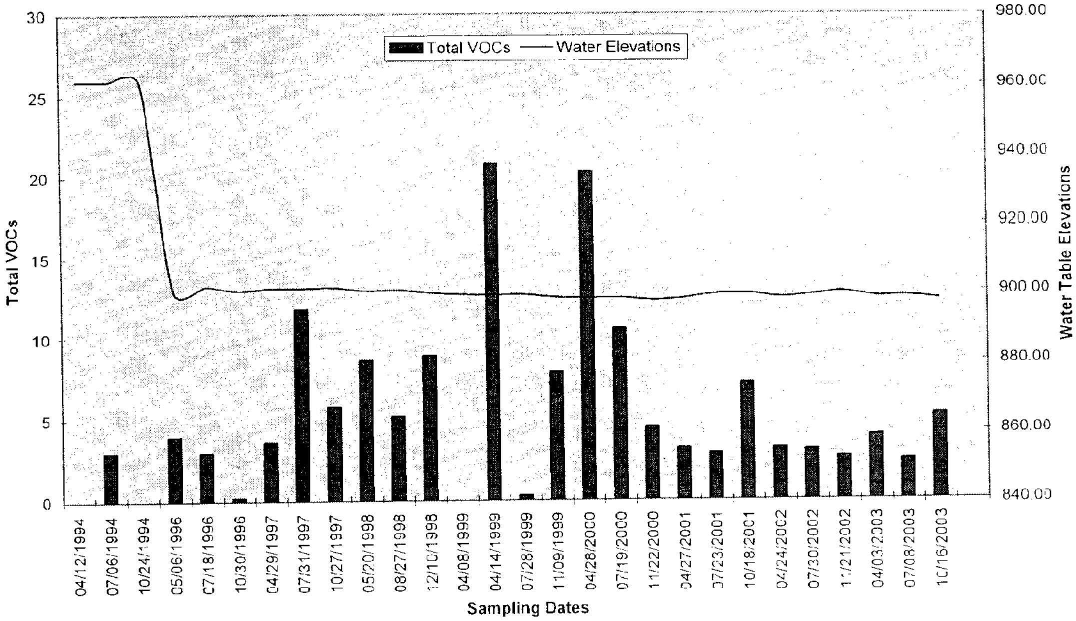
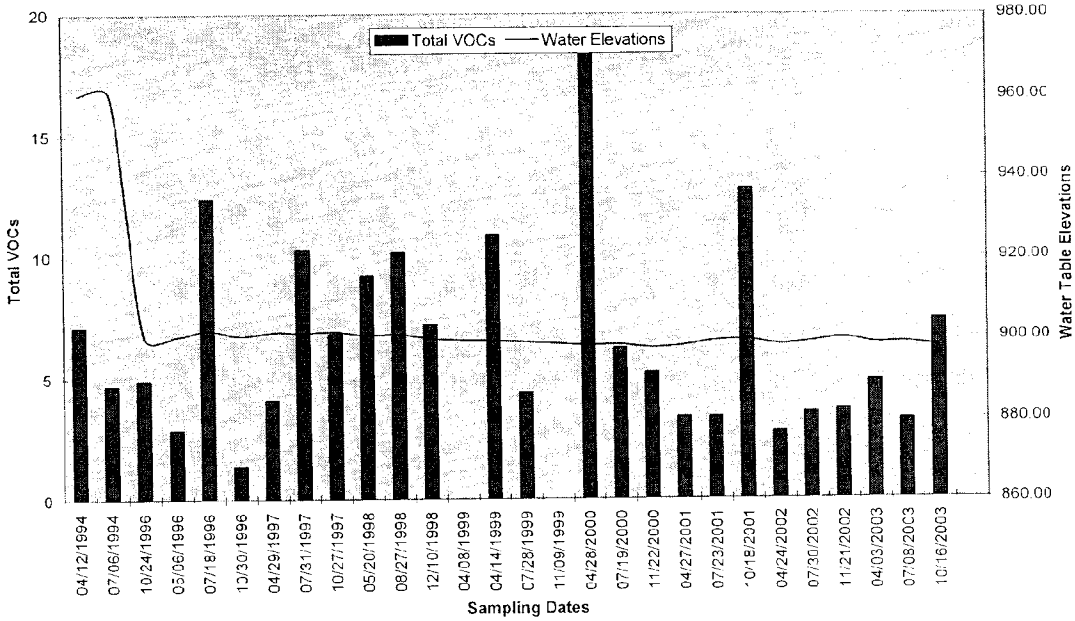


Figure 19. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well R2



3MA00402233

2752.0031

Figure 20. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well R3

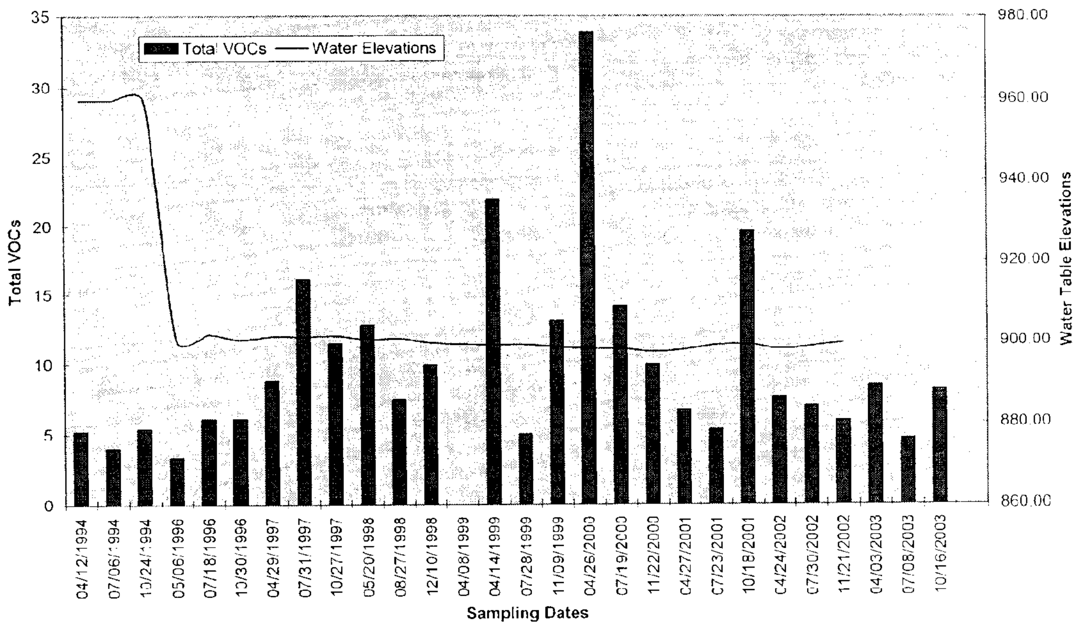


Figure 21. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well V

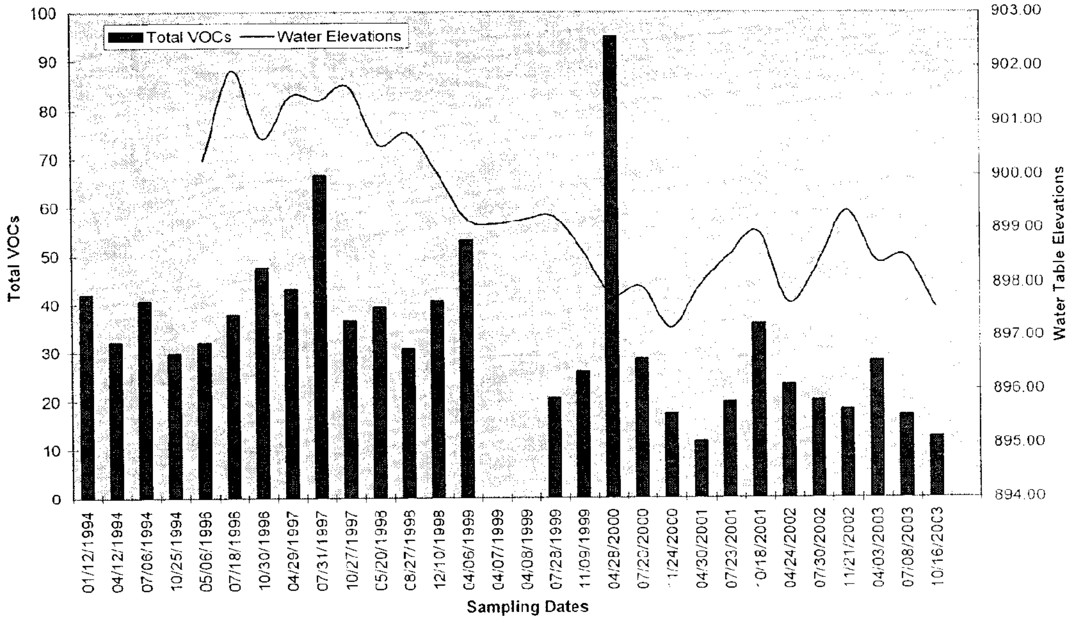


Figure 22. Washington County Sanitary Landfill
VOCs vs. Water Table Elevations - Well V2

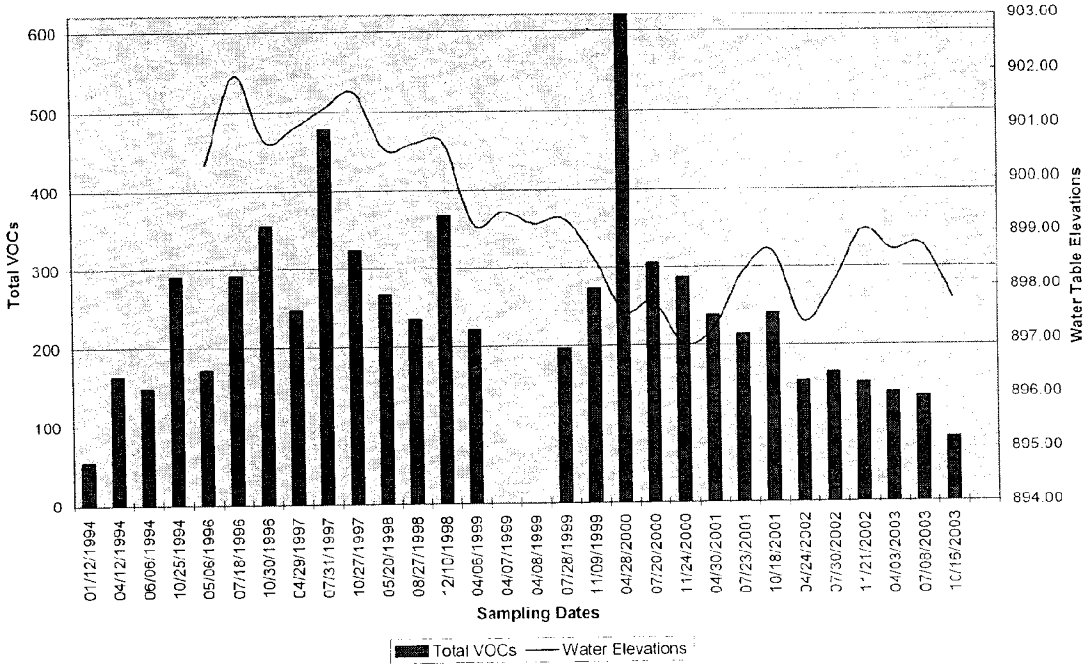
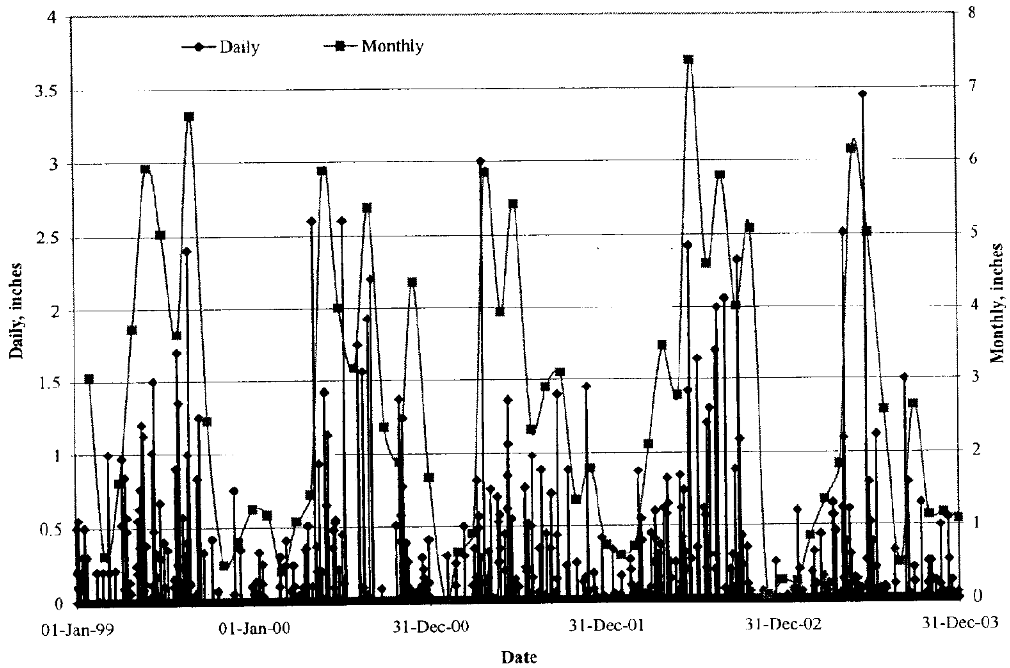


Figure 23. Daily and Monthly Precipitation around Washington County Landfill-1999 to 2003



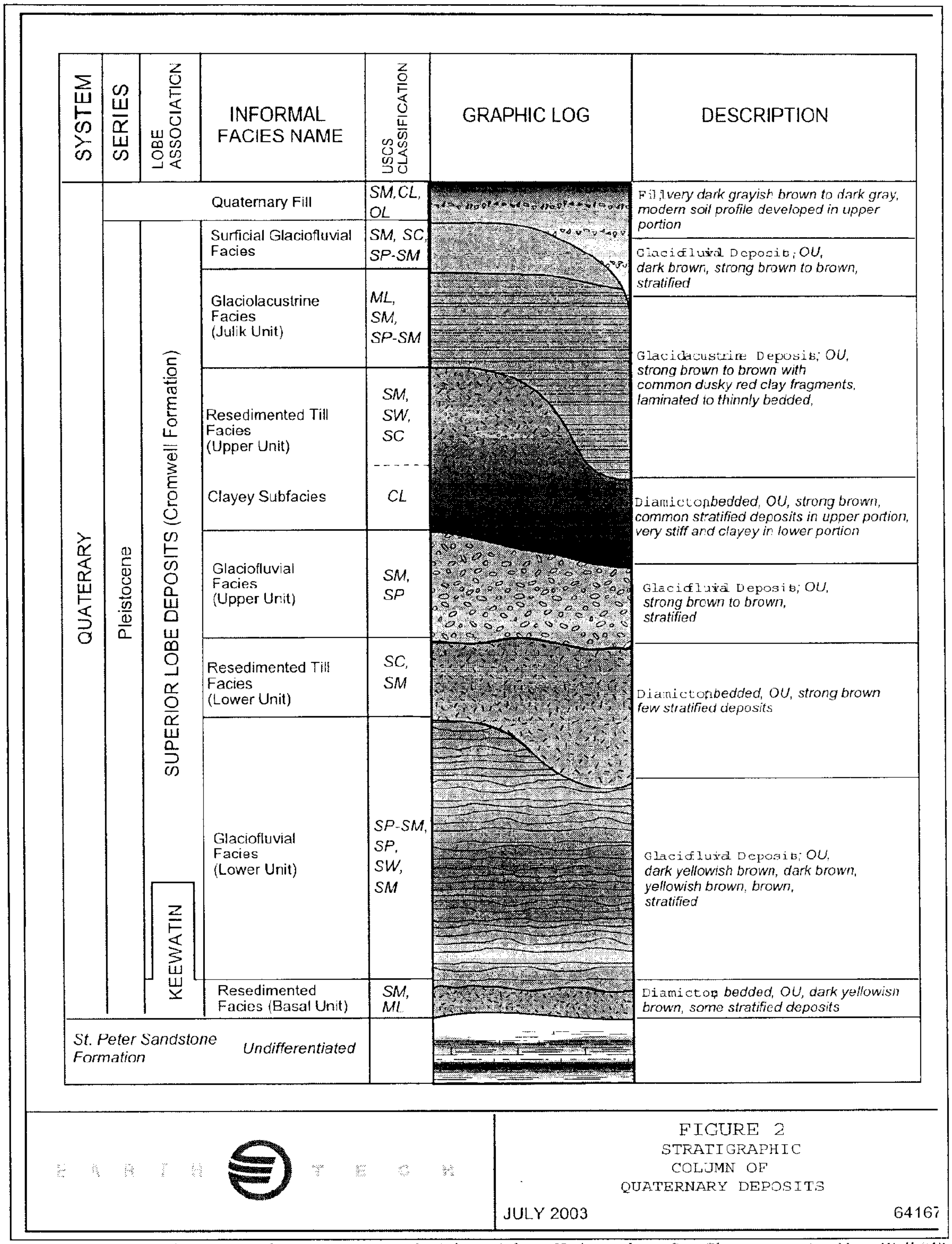


Figure 24 Stratigraphic Column of Quaternary Deposits (Figure 2 from *Hydrogeologic Site Characterization Near Well "I"*

at the Closed Washington County Landfill Lake Elmo, Minnesota, Earthtech June 2003)