REMEDIAL ACTION EVALUATION

PREPARED FOR:

HERCULES, INC.

CHEMICAL SPECIALTIES

HATTIESBURG, MISSISSIPPI

JULY, 2004

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1.0 INTRODUCTION

Eco-Systems, Inc. (Eco-Systems) has been retained by Hercules, Incorporated (Hercules) to prepare this Remedial Action Evaluation (RAE) for the Hercules, specialty chemical manufacturing facility located in Hattiesburg, Mississippi. The location of the Hercules facility is shown on Figure 1. This RAE has been prepared in response to a request from the Mississippi Department of Environmental Quality (MDEQ) to address environmental concerns at the Hercules facility located in Hattiesburg, Mississippi.

The contents of this RAE have been compiled based on existing site information from historical site investigations and communication between representatives of Hercules and the MDEQ. A summary of historical site investigations is provided in Section 1.3. This RAE includes discussion of remedial action related to the following areas of the Hercules facility based on the data available:

- The sludge pits,
- The former landfill,
- The groundwater containing volatile organic compounds (VOCs), semi-volatile organic compounds (SVOC), Dioxathion, and Dioxenethion, and
- Green's Creek.

These four areas are shown on the site plan, which is included as Figure 2. Each of the remedial options considered for the four areas at the Hercules facility is evaluated based on the following criteria:

- Long-term effectiveness,
- Potential to reduce the mobility, toxicity or volume,
- Short-term effectiveness,
- Implementability, and
- Cost efficiency.

These criteria are evaluated with respect to protection of human health and the environment. The Target Remediation Goals (TRGs) identified in the MDEQ Brownfields program are used as a benchmark to evaluate the protection of human health and the environment. The TRGs are found in the Tier 1 Target Remedial Goal Table of the Final Regulations Governing Brownfields Voluntary Cleanup And Redevelopment In Mississippi, published by the Mississippi Commission on Environmental Quality and adopted May 1999 and revised March 2002. For each of the four areas at the Hercules facility, the most cost efficient remedial action that is protective of human health and the environment and that may be reasonably implemented has been selected for implementation at the site.

1.1 Background

Site investigations at the Hercules facility in Hattiesburg, Mississippi, which were conducted between April 1999 and November 2003, are discussed in the Interim Groundwater Monitoring Report (Eco-Systems, January 2003), the Hercules Site Investigation Report (Eco-Systems, April 2003), and the Supplemental Site Investigation Report (Eco-Systems, November 2004). The findings of the site investigations include the following:

- Detection of volatile organic compounds (VOCs) in groundwater at concentrations above Target Remediation Goals (TRGs) in portions of the site,
- Delineation of the lateral limits of the Landfill based on geophysical investigation,
- Presence of VOCs and Dioxathion at concentrations less than TRGs in surface water and sediment samples collected from Green's Creek, and
- Presence of VOCs and Dioxathion in one of three groundwater monitoring wells located hydraulically downgradient of the sludge pits.

Site investigations indicated that neither VOCs nor Dioxathion at concentrations above TRGs are migrating via groundwater or surface water onto off-site properties. Some of the VOCs detected in Green's Creek were detected in samples collected from the location where Green's Creek enters the property, which indicates that, at least, some of the VOCs are due to upstream, off-site, sources.

1.2 Purpose and Scope

The purpose of this RAE is to evaluate the most practical potential remedial options for each of the four areas of the site to be considered and identify the most cost effective remedial option that can be readily implemented and is protective of human health and the environment. The scope of this RAE involves a preliminary review of standard methods and technologies for remediation of each of the four areas of the site to be considered. Each potential remedial option has been reviewed for the following criteria:

- Long-term effectiveness of the method in protecting human health and the environment,
- Reduction of mobility, toxicity or volume of contamination,
- Near-term effectiveness in minimizing exposure to contamination,
- Implementability of proposed remedial options, and
- Cost effectiveness of the remedial option.

The cost evaluations are considered in terms of start-up costs and operations and maintenance costs. Operations and maintenance costs are shown in terms of present value assuming 5-year project life span and a 30-year project lifespan.

1.3 Site Overview

The Hercules facility is located on approximately 200 acres of land north of West Seventh Street in Hattiesburg, Forrest County, Mississippi. More specifically, the Site is located in Sections 4 and 5, Township 4 North, Range 13 West, just north of Hattiesburg, Mississippi (Figure 1). The facility has been in operation since 1923. The facility is bordered to the north by Highway 43 and Illinois-Central & Gulf Railroad, along with various residential and commercial properties. The southern property boundary is bordered by 7th Avenue; and by a cemetery and Zeon Chemical Company to the southwest. Across from these locations are residential areas. The eastern and western boundaries are bordered by sparsely populated residential areas.

The facility's historical operations consisted of wood grinding, shredding, extraction, fractionation, refining, distillation, and processing of rosin from pine tree stumps. Historically, over 250 products were produced from the above-referenced operations and included: modified resins, polyamides, ketene dimer, crude tall oil wax emulsions, and Delnav, an agricultural miticide. Structures at the facility include offices, a laboratory, a powerhouse, production buildings, a wastewater treatment plant, settling ponds, a landfill, and central loading and packaging areas.

Previous investigations at the Hercules facility have centered on efforts to determine whether the miticide, Dioxathion, was present in site soil and groundwater. The work has included soil, groundwater, surface water, and stream sediment sampling and analysis. The work has also included geophysical investigation to delineate the limits of the landfill and to investigate the potential for buried metal in a location identified by the MDEQ. The results of previous investigations are discussed in reports, which have been submitted to the MDEQ. The reports listed below have been previously submitted to the MDEQ and form the basis for the site model on which this remedial action evaluation has been developed.

1. <u>Site Inspection Report</u>, B&V Waste Science and Technology Corp., April, 1993.
2. <u>Work Plan for Well Installation</u>, Bonner Analytical Testing Company; June, 1997.
3. <u>Installation, Sampling, and Analysis Report</u>, Bonner Analytical Testing Company; December, 1997.
4. <u>Quarterly Monitor Well Sampling Event Reports</u>, Bonner Analytical Testing Company; June, 1998 through October, 1998.
5. <u>Site Investigation Work Plan</u>, Eco-Systems, Inc., February 1999.
6. <u>Interim Groundwater Monitoring Report</u>, Eco-Systems, Inc. January 2003.

7. Site Investigation Report, Eco-Systems, Inc., April 2003.
8. Work Plan for Supplemental Site Investigation, Eco-Systems, Inc., June 2003.
9. Supplemental Site Investigation Report, Eco-Systems, Inc., November 2003.

This list of documents is not intended to be an exhaustive list of communications between Hercules and the MDEQ. However, review of these documents would provide a more comprehensive understanding of the facility history and site conceptual model than is presented in this remedial action evaluation.

The information discussed in the listed documents indicates that sources, source area concentrations, and vertical and horizontal extent of groundwater containing constituents of concern have been defined sufficiently for site modeling and remedial planning purposes. The existing data do not indicate that the site poses a significant threat to human health and the environment in its current use as a chemical production facility. However, if changes in land use occur or additional information is obtained, the current risk scenario for the site could also change.

The following sections discuss the four areas of environmental concern at the Hercules facility and the various remedial options that have been considered for each area. Remedial options for the sludge pits are discussed in Section 2.0. Remedial options for the landfill are discussed in Section 3.0. Remedial options for groundwater are discussed in Section 4.0, and remedial options for Green's Creek are discussed in Section 5.0. The recommended options for each of the four areas are discussed in Section 6.0.

2.0 SLUDGE PITS

The sludge pits, which were used to dispose of solids generated in Hercules wastewater treatment plant, are shown on Figure 3. Use of the sludge pits was discontinued in 2001 as agreed upon with MDEQ. The most recent groundwater monitoring data collected from monitoring wells downgradient of the sludge pits do not indicate that concentrations of VOCs, Dioxathion and Dioxenethion above TRGs are migrating from the sludge pits. Direct exposure to potential constituents in the sludge could exist for workers at the site and for wildlife. The potential exists for indirect exposure from potential constituents in the sludge due to natural weather events overflowing the berms of the pits.

Data collected in support of this RAE found that the sludge in the pits, which extend over an area of approximately 4 acres, ranges from approximately three feet to five feet deep, depending on location. The sludge is underlain by alluvial soils of varying thickness. The alluvial soils are underlain by the Hattiesburg Formation. The Hattiesburg Formation, which has been described as dense, gray, silty clay, has been encountered in all site borings that have penetrated the overlying alluvial material. Site soil boring data indicate that the lithology of the Hattiesburg Formation is consistent across the site. In preparation for this RAE, exploratory boring EB-1 was installed in the northern extremity of the site to obtain site specific information for thickness and vertical permeability of the Hattiesburg Formation. Information obtained from boring EB-1 indicates that the Hattiesburg formation is at least 20 feet thick beneath the site and has a hydraulic conductivity of approximately 1.28×10^{-7} centimeters per second (cm/sec). Copies of the geotechnical laboratory report for the sample collected from the Hattiesburg Formation is included in Appendix A. Copies of boring logs from the exploratory borings installed during preparation for this RAE are included in Appendix B. The Hattiesburg formation would, therefore, serve as a barrier to vertical migration of groundwater at the site.

In preparation for this RAE, three borings, PB-1, PB-2, and PB-3 were installed within the sludge pits to obtain geotechnical information for the sludge. Locations of the pit borings are shown on Figure 2. Shear vane testing was conducted on the sludge in the borings, and samples of the sludge were submitted for grain size analysis and consolidation testing.

Geotechnical evaluations of the sludge material indicates that the materials vary in consistency, depending on moisture content. The drier sludge samples exhibited higher strength characteristics and easily supported drilling equipment.

2.1 No Action

By definition, the "No Action" remedial option would not involve any further investigation, monitoring, or other remedial action.

2.1.1 Long-Term Effectiveness

Due to the age of the site and presence of sludge in the sludge pits for over 20 years, it is reasonable to assume that, any leaching of regulated chemical constituents present in the sludge has either already occurred or is in progress. The most recent groundwater monitoring data from monitoring wells downgradient of the sludge pits (MW-4, MW-10, and MW-11) and surface water and stream sediment monitoring data from Green's Creek do not indicate the presence of VOCs or dioxathion at concentrations above TRGs in either groundwater or surface water. Therefore, unless there are changes in groundwater use, surface water use or land use that would mobilize sludge constituents into the groundwater, a no action remedial option should not result in greater risk to human health and the environment than is currently present at the site. Current potential risks include exposure to workers and wildlife, and the potential for release related to natural weather events and leaching.

2.1.2 Reduction of Mobility, Toxicity, or Volume

A "No Action" remedial option would not result in reduction of mobility or toxicity of any chemical constituents that may be present in the sludge.

2.1.3 Near-Term Effectiveness

A "No Action" option would not result in any greater near-term risk to human health and the environment than currently exists at the site. Since neither workers nor the public would be exposed to the sludge from activity related to remedial action, near-term risks are no different than those that currently exist. Current risks are discussed in Section 2.1.1.

2.1.4 Implementability

A "No Action" remedial option would be the most easily implemented option.

2.1.5 Cost Efficiency

Since there would be no remediation, a "No Action" remedial option would be the most cost efficient option.

2.2 INSTITUTIONAL CONTROLS

Institutional controls protect human health and the environment by limiting access to areas where exposure can occur (e.g. fence) and limiting the potential use of the affected areas (e.g. deed restriction). With respect to the Hercules site, it is surrounded by a chain link fence that limits public access to the entire Hercules site. However, the perimeter fence for the facility may be insufficient to prevent accidental access by site workers or site intruders. Therefore, consideration of institutional controls for this RAE would include a deed restriction to limit future use of the sludge pits and nearby surrounding areas and the installation of a chain link fence around the perimeter of the sludge pits to further control access to the sludge pits. A fence around the perimeter of the sludge pits would also serve as a marker of the edge of the deed restricted area and minimize accidental violations of the deed restriction.

A deed restriction would require agreement between Hercules and the MDEQ regarding the exact boundaries of the area to be subject to the restriction. A physical survey of the agreed on boundaries and a plat drawing by a registered surveyor would then be submitted with a revised deed to Forest County.

2.2.1 Long-Term Effectiveness

The deed restriction would effectively limit exposure to the sludge pits by prohibiting excavation, intrusive activities, or any other use of the land surface or subsurface in the restricted area until such time as the deed restriction was lifted. The fence surrounding the perimeter of the sludge pits would restrict access to the sludge pits and serve as a marker of the edge of the deed restricted area. However, neither the fence nor the deed restriction would prevent wildlife exposure, or potential release from the pits due to weather events.

2.2.2 Reduction of Mobility, Toxicity, or Volume

Institutional controls would restrict exposure to the sludge pits but would not affect the mobility, toxicity, or volume of any potential chemical constituents present in the sludge pits.

2.2.3 Near-Term Effectiveness

Implementation of institutional controls would result in a decrease in potential for near-term exposure of workers or the public to any constituents that may be present in the sludge pits.

2.2.4 Implementability

Fence construction and the deed restriction could be readily implemented.

2.2.5 Cost Efficiency

Fence construction, deed restriction, and five years of fence maintenance would have an estimated present value of $44,850.00. Fence construction, deed restriction, and 30 years of fence maintenance would have an estimated present value of $53,159.00.

2.3 MONITORED NATURAL ATTENUATION

Monitored natural attenuation protects human health and the environment by allowing natural processes, such as biological activity and inorganic geochemical processes, to reduce the concentrations of any constituents that may be present in the sludge. Periodic groundwater monitoring is conducted to ensure that concentrations of constituents above the regulated concentrations do not migrate via groundwater beyond site boundaries or otherwise pose a risk to human health and the environment.

The most recent groundwater monitoring data indicates that neither VOCs nor dioxathion are present in concentrations above regulatory limits in groundwater samples collected from monitoring wells installed in the vicinity of the sludge pits. Therefore, the constituent concentrations at the Hercules site are well suited for application of monitored natural attenuation. This evaluation of monitored natural attenuation includes use of the existing monitoring wells, MW-2, MW-3, MW-4, MW-10 and MW-11. For cost purposes, monitored natural attenuation also includes a deed restriction to reduce the potential exposure to human health and the environment during the groundwater monitoring time period and construction of a fence to restrict access to the sludge pits .

Groundwater monitoring would be conducted annually for two years to establish groundwater quality and hydrogeological parameters. Assuming that the results of the annual groundwater monitoring demonstrate that groundwater quality and hydrogeological parameters are stable or decreasing, the groundwater monitoring schedule would be decreased to a frequency appropriate to monitor changes in site conditions. For this evaluation, it is assumed that groundwater monitoring frequency would continue on an annual schedule after completing the first two years of annual sampling. It is also assumed that groundwater monitoring would be required for a period of at least 5 years and no more than 30 years. Data would be submitted to the MDEQ after each monitoring event, and annual reports of the effectiveness of the remedial option would also be submitted the MDEQ. In practice, the number of wells required for monitoring as well as the frequency of monitoring would vary depending on changes in site conditions and regulatory requirements.

2.3.1 Long-Term Effectiveness

Monitored natural attenuation would be effective in the long-term at ensuring that regulated chemical constituents potentially present in the sludge do not migrate via groundwater onto surrounding properties. Monitored natural attenuation also ensures that adequate advance warning is provided if the constituents potentially present in the sludge begin migrating towards site boundaries or other potential receptors. However, monitored natural attenuation would not prevent wildlife exposure, or potential release from the pits due to weather events.

2.3.2 Reduction of Mobility, Toxicity, or Volume

If regulated chemical constituents are present in the sludge, natural attenuation may reduce the concentrations of those constituents. The time required for complete degradation of any chemical constituents that may be present in the sludge would vary depending on the nature of those constituents.

2.3.3 Near-Term Effectiveness

There would be little adverse, near-term impacts due to groundwater monitoring. Existing groundwater monitoring data indicates that groundwater sampling technicians would not be exposed to contaminated groundwater. However, appropriate health, safety and engineering precautions, would be taken to keep such risks that may arise in the future to a minimum.

2.3.4 Implementability

Groundwater monitoring could be readily implemented. The technologies are well demonstrated and reliable. Standard equipment and sampling practices can be used for implementation of sample collection and analysis.

2.3.5 Cost Efficiency

The estimated present value to conduct monitored natural attenuation, including the cost for the institutional controls discussed in Section 2.2, for a period of 5 years is approximately $78,800.00. The estimated present value for 30 years of monitored natural attenuation is approximately $155,906.00.

2.4 CAPPING/CAPPING AND CONTAINMENT

For this alternative, the sludge pits would be graded and a soil cap would be installed to reduce the infiltration rate of water and, thus, the potential migration to groundwater of potential chemical constituents in the sludge. For this evaluation, the cap consisted of an 18-inch thick clay infiltration layer overlain by a 6-inch thick erosion layer was considered. The cap would be installed by grading the surface of sludge, installing the clay infiltration layer, installing the topsoil erosion layer, and seeding and mulching the topsoil. The erosion layer would have a minimum grade of 4% grade. The configuration of the cap is illustrated in Figures 4 and 5. Periodic maintenance would be required to ensure that the cap does not become compromised due to erosion or the roots of trees and other large vegetation.

For this evaluation, the cap would be augmented by a deed restriction to limit future use of the capped area and installation of a fence to restrict unauthorized access to the capped area. A groundwater monitoring program would also be instituted to ensure that constituents potentially present in the sludge do not migrate via groundwater into surrounding areas.

If groundwater monitoring detects a significant release from the sludge pits, a containment wall could also be installed around the perimeter of the sludge pits. The containment wall would minimize migration of groundwater from beneath the sludge pits into surrounding areas. The containment wall would consist of a perimeter trench backfilled with bentonite-slurry. The containment wall would extend from the surface and key into the upper surface of the Hattiesburg Formation. Conceptual drawings showing the cap and containment wall are included as Figures 6 and 7. Boring information indicates that the upper surface of the Hattiesburg Formation is approximately 12 to 17 feet below ground surface in the vicinity of the sludge pits.

2.4.1 Long-Term Effectiveness

A soil cap combined with a deed restriction, a fence, and a groundwater monitoring program would be reliable and effective over the long term in minimizing exposure and potential release of constituents potentially present in the sludge. If site conditions warrant, a containment wall would increase the effectiveness of this option by restricting the migration of groundwater between the pit areas and surrounding areas.

2.4.2 Reduction of Mobility, Toxicity, or Volume

The cap and, if necessary, the containment wall would minimize mobility of any constituents that may be present in the sludge pits.

2.4.3 Near-Term Effectiveness

There would be little, if any, near-term exposure to constituents that may be present in the sludge pits due to installation of the cap or the containment wall. However, appropriate health, safety and engineering precautions, would be taken to keep such risks that may arise to a minimum.

2.4.4 Implementability

Both the cap and the containment wall could be readily implemented. The technologies are well demonstrated and reliable.

2.4.5 Cost Efficiency

The estimated cost to install the cap, as described, would be approximately $542,500.00 which includes deed restriction and fence construction. The estimated operations and maintenance cost for this option, including cap inspection and maintenance, groundwater monitoring, and fence maintenance would be approximately $19,280.00 per year. The present value for cap installation, deed restriction, and fence construction plus cap maintenance, fence maintenance, and groundwater monitoring would be approximately $621,552.00 for a 5-year period and $781,746.00 for a 30 year period.

Installation of a containment wall, if necessary would increase startup costs by $528,000.00. Operations and maintenance in addition to those required for the cap would not be required.

3.0 LANDFILL

The former industrial landfill is located immediately north of the main production areas of the plant. The layout of the landfill area is shown on Figure 8. The landfill received non-hazardous waste for a period of time that reportedly began in the 1950's and ended in the early 1970's. The landfill was then covered with soil to minimize exposure of the waste matrix. Waste in the landfill, as demonstrated by the recent geophysical survey and more recent excavation related to an adjacent water pipe, includes scrap metal, resin, fill dirt, and other solid waste historically generated by the facility. The aerial extent of the landfill is approximately 3.5 acres. Existing groundwater monitoring data indicate that concentrations of VOCs and Dioxathion above TRGs are not migrating from the former landfill area.

Site geological information indicates that the landfill is underlain by alluvial soils. The alluvial soils are underlain by the Hattiesburg Formation. The Hattiesburg Formation, which has been described as dense, gray, silty clay, has been encountered in all site borings that have penetrated the overlying alluvial material. Site soil boring data indicate that the lithology of the Hattiesburg Formation is consistent across the site. In preparation for this RAE, exploratory boring EB-1 was installed in the northern extremity of the site to obtain site specific information for thickness and vertical permeability of the Hattiesburg Formation. Information obtained from boring EB-1 indicates that the Hattiesburg formation is at least 20 feet thick beneath the site and has a hydraulic conductivity of 1.28×10^{-7} cm/s. Copies of the geotechnical laboratory report for the sample collected from the Hattiesburg Formation is included in Appendix A. Three additional exploratory soil borings, EB-2, EB-3, and EB-4, were installed on the north and east sides of the landfill, which confirmed the presence of the Hattiesburg formation in the vicinity of the landfill. Copies of the boring logs for the exploratory borings are included in Appendix B. The Hattiesburg formation would, therefore, serve as a barrier to vertical migration of constituents that may potentially migrate from the landfill materials.

3.1 No Action

By definition, the "No Action" remedial option would not involve any further investigation, monitoring, or other remedial action.

3.1.1 Long-Term Effectiveness

Due to the age of the site and closure of the landfill over 30 years ago, it is reasonable to assume that, any leaching of regulated chemical constituents potentially present in the landfill has either already occurred or is in progress. The most recent groundwater monitoring data from monitoring well MW-5, which is located downgradient of the landfill, does not indicate the presence of VOCs or dioxathion at concentrations above TRGs. However, future changes in land use could expose landfill materials at the surface and/or mobilize constituents from the landfill into the groundwater or nearby surface water. Therefore, a "no action" remedial option could result in greater risk to human health and the environment than is currently present at the site.

3.1.2 Reduction of Mobility, Toxicity, or Volume

A "No Action" remedial option would not result in reduction of mobility or toxicity of any chemical constituents that may be present in the landfill.

3.1.3 Near-Term Effectiveness

A "No Action" option would not result in any greater near-term risk to human health and the environment than currently exists at the site. Since neither workers nor the public would be exposed to landfill materials from activity related to remedial action, near-term protection of human health and the environment would be achieved.

3.1.4 Implementability

Since there would be nothing to implement, a "No Action" remedial option would be the most easily implemented option.

3.1.5 Cost Efficiency

Since there would be no remediation, a "No Action" remedial option would be the most cost efficient option.

3.2 Institutional Controls

Institutional controls protect human health and the environment by limiting access to areas where exposure can occur (e.g. fence) and limiting the potential use of the affected areas (e.g. deed restriction). With respect to the Hercules site, it is surrounded by chain link fence that limits public access to the entire Hercules site. Since the landfill poses no immediate hazard at the surface, additional fencing around the perimeter of the landfill is not considered to be necessary.

A deed restriction would require agreement between Hercules and the MDEQ regarding the exact boundaries of the area to be subject to the restriction. A physical survey of the agreed on boundaries and a plat drawing by a registered surveyor would then be submitted with a revised deed to Forest County.

3.2.1 Long-Term Effectiveness

The deed restriction would effectively limit exposure to the landfill by prohibiting excavation, intrusive activities, or any other use of the land surface or subsurface in the restricted area until such time as the deed restriction was lifted. The fence surrounding the perimeter of the Hercules site restricts access to the landfill by all except Hercules employees and others admitted to the site by Hercules.

3.2.2 Reduction of Mobility, Toxicity, or Volume

Institutional controls would restrict exposure to the landfill and damage to the soil cover but would not affect the mobility, toxicity, or volume of any potential chemical constituents present in landfill materials.

3.2.3 Near-Term Effectiveness

Implementation of institutional controls would not result in increased, near-term exposure of workers or the public to any constituents that may be present in the landfill.

3.2.4 Implementability

A deed restriction could be readily implemented.

3.2.5 Cost Efficiency

Deed restriction would have an estimated start-up cost of approximately $10,000.00 with no maintenance costs.

3.3 Monitored Natural Attenuation

Monitored natural attenuation protects human health and the environment by allowing natural processes, such as biological activity and inorganic geochemical processes, to reduce the concentrations of any constituents that may be present in landfill materials.

The most recent groundwater monitoring data indicates that neither VOCs nor dioxathion are present in concentrations above regulatory limits in groundwater samples collected from monitoring well MW-5, which is located downgradient of the landfill. Therefore, in consideration of constituent concentrations the Hercules site is suitable for application of monitored natural attenuation. This evaluation of monitored natural attenuation includes the use of existing monitoring wells, MW-5, and MW-6, and installation of three new monitoring wells to be installed on the north, east, and west sides of the landfill.

For cost purposes, this evaluation of monitored natural attenuation also includes a deed restriction to limit future use of the landfill.

This evaluation assumes that groundwater and surface water monitoring would be conducted annually for two years to establish groundwater quality and hydrogeological parameters. Assuming that the results of the annual groundwater monitoring demonstrate that groundwater quality and hydrogeological parameters are stable or decreasing, the groundwater monitoring schedule would be decreased to a frequency appropriate to monitor changes in site conditions. For this evaluation, it is assumed that groundwater monitoring frequency would continue on an annual schedule after completing the first two years of annual sampling. It is also assumed that groundwater monitoring would be required for a period of at least 5 years and no more than 30 years. Data would be submitted to the MDEQ after each monitoring event, and annual reports of the effectiveness of the remedial option would also be submitted the MDEQ. In practice, the number of wells required for monitoring, as well as the frequency of monitoring, would vary depending on changes in site conditions and regulatory requirements.

3.3.1 Long Term Effectiveness

Monitored natural attenuation would be effective in the long-term at ensuring that regulated chemical constituents potentially present in the landfill do not migrate via groundwater or surface runoff onto surrounding properties. Monitored natural attenuation also ensures that adequate advance warning is provided if the constituents potentially present in the landfill begin migrating towards site boundaries or other potential receptors.

3.3.2 Reduction of Mobility, Toxicity, or Volume

If regulated chemical constituents are present in the landfill, natural attenuation may reduce the concentrations of those constituents. The time required for complete degradation of any chemical constituents that may be present in the landfill would vary depending on the nature of those constituents.

3.3.3 Near-Term Effectiveness

There would be little adverse, near-term impacts related to groundwater monitoring. Existing groundwater monitoring data indicates that groundwater sampling technicians would not be exposed to contaminated groundwater. However, appropriate health, safety and engineering precautions, would be taken to keep such risks that may arise in the future to a minimum.

3.3.4 Implementability

Groundwater monitoring could be readily implemented. The technologies are well demonstrated and reliable. Standard equipment and sampling practices can be used for implementation of sample collection and analysis.

3.3.5 Cost Efficiency

The estimated present value to install three additional monitoring wells and conduct monitored natural attenuation as described in Section 3.3 for a period of 5 years is approximately $48,950.00. The estimated present value to install three monitoring wells and conduct monitored natural attenuation for a period of 30 years is approximately $117,747.00.

3.4 HORIZONTAL CONTAINMENT

For this alternative, a containment wall could also be installed around the approximately 1,530 feet long perimeter of the landfill. The containment wall would minimize migration of groundwater from beneath the landfill into surrounding areas. The containment wall would consist of a perimeter trench backfilled with bentonite-slurry. The containment wall would extend from the surface to a depth of approximately 2 feet below the upper surface of the Hattiesburg Formation. Conceptual drawings of the landfill cap and containment wall are included as Figures 9 and 10. Boring information indicates that the upper surface of the Hattiesburg Formation is approximately 12 to 22 feet below ground surface in the vicinity of the landfill.

For this evaluation, the containment wall would be augmented by a deed restriction to limit future use of the landfill and installation of a fence to restrict unauthorized access to the capped area. A groundwater monitoring program would also be instituted to ensure the containment wall adequately mitigates migration of constituents potentially contained in the landfill via groundwater into surrounding areas.

3.4.1 Long Term Effectiveness

A containment wall would be reliable and effective reducing horizontal groundwater migration over the long-term.

3.4.2 Reduction of Mobility, Toxicity, or Volume

The containment wall would minimize mobility of any constituents that may be present in the landfill.

3.4.3 Near-Term Effectiveness

There would be little, if any, near-term exposure to constituents that may be present in the landfill due to installation of a containment wall. However, appropriate health, safety and engineering precautions, would be taken to keep such risks that may arise to a minimum.

3.4.4 Implementability

A containment wall could be readily installed. The technologies are well demonstrated and reliable.

3.4.5 Cost Efficiency

The estimated cost to install a containment wall around the landfill, including the cost of monitoring well installation and deed restriction would be approximately $572,800.00. The estimated operations and maintenance cost for this option, which includes groundwater monitoring would be approximately $8,280.00 per year. The present value for installation of the containment wall, well installation, deed restriction, and fence construction plus fence maintenance and groundwater monitoring would be approximately $596,750.00 for a 5-year period and $665,547.00 for a 30 year period.

4.0 GROUNDWATER CONTAMINATION

While isolated detections of VOCs in groundwater samples have occurred in other areas of the site, this RAE is concerned primarily with the area of the Hercules facility that is located north of the main plant area and south of the landfill area. Concentrations of VOCs above their respective TRGs have been detected in groundwater samples collected from permanent and temporary monitoring located in this area. Various other VOCs and semi-volatile organic compounds (SVOCs), including Dioxathion, have been detected in groundwater at concentrations less than TRGs. The extent of groundwater containing concentrations of VOCs above their respective TRGs was generally confined laterally to an area of the site that includes the northern portion of the active plant area and the southern portion of the former landfill. Benzene, which has a relatively low TRG, is the most widespread VOC detected in groundwater samples collected from the site. Therefore, the area in which benzene was detected (Figure 13) is used as an indicator of the limits of the area addressed by this evaluation.

The Hattiesburg Formation, which has been described as dense, gray, silty clay, has been encountered in all site borings that have penetrated the overlying alluvial material. Site soil boring data indicate that the Hattiesburg Formation is consistent across the site. In preparation for this RAE, exploratory boring EB-1 was installed in the northern extremity of the site to obtain site specific information for thickness and vertical permeability of the Hattiesburg Formation. Information obtained from boring EB-1 indicates that the Hattiesburg formation is at least 20 feet thick beneath the site and has a hydraulic conductivity of 1.28×10^{-7} cm/sec. Copies of the geotechnical laboratory report for the sample collected from the Hattiesburg Formation is included in Appendix A. Copies of boring logs for borings installed in preparation of the RAE are included in Appendix B. The Hattiesburg formation would, therefore, serve as a barrier to vertical migration of groundwater at the site.

In preparation for this RAE, Eco-Systems conducted slug testing on three site monitoring wells, MW-2, MW-6, and MW-7. Estimates of hydraulic conductivity were calculated using methods described by Bouwer & Rice[1,2]. Hydraulic conductivity estimates fell into a relatively narrow range from 1.31×10^{-3} cm/sec for MW-7 to 4.19×10^{-3} cm/sec for MW-2. Hydraulic conductivity calculations are included in Appendix C. Using the mean of the hydraulic conductivity estimates and potentiometric data from October 31, 2003, horizontal seepage velocities from three areas of the site were estimated using the equation $Q=ki/n$, where Q is the horizontal seepage velocity, k is hydraulic conductivity, i is the hydraulic gradient, and n is the porosity. A porosity of 35% was used based on

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[1] Bouwer, H & Rice, R.C., A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells, Water Resources Research, Vol. 12, No. 3, June 1976.
[2] Bouwer, H, The Bouwer and Rice Slug Test – An Update, Groundwater, Vol. 27, No. 3, May-June 1989.

typical porosity values published by Freeze and Cherry[3]. The estimated seepage velocity for the portion of the site that includes the landfill and the northern areas of the active plant is approximately 179 feet/year. Seepage velocity calculations are included in Appendix C.

Using the estimated horizontal seepage velocity of 179 feet/year, groundwater constituents detected in monitoring well MW-8 would migrate the approximately 800 feet to Green's Creek in approximately 4 ½ years. (Monitoring well MW-8 was used for this hypothetical discussion due to the relatively high concentrations of VOCs that have been detected in groundwater samples collected from MW-8.) However, as discussed in the Supplemental Site Investigation Report, except for a detection of naphthalene in in one location, groundwater containing VOCs above TRGs was not detected in groundwater samples collected from sampling locations located on the east side of the railroad track that runs adjacent to the west side of the landfill. Analytical data indicate that groundwater containing VOCs migrates considerably slower than calculated hydrogeological parameters would indicate. Possible mechanisms for the slower constituent migration could include inhomogeneity in the soils, biological activity, and geochemical reactions with inorganic constituents (e.g. iron) in soil and fill materials beneath the site.

4.1 No Action

By definition, the "No Action" remedial option would not involve any further investigation, monitoring, or other remedial action.

4.1.1 Long-Term Effectiveness

Due to the age of the site and the likelihood that the VOCs detected in groundwater samples at the site have been present for over 20 years, it is reasonable to assume that, if additional constituents are not introduced to the groundwater, groundwater conditions either remain constant or, possibly, improve. Therefore, unless there are changes in groundwater use or land use, a no action remedial option should not result in greater risk to human health and the environment than is currently present at the site. If, over time, natural attenuation results in reduced concentrations of VOCs in groundwater, the risk to human health and the environment from groundwater constituents at the site would decrease. However, a "no action" would not provide any advance warning of migration caused by site changes, nor would it prevent accidental exposure due to excavation or construction in the area.

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[3] Freeze, R.A. & Cherry, J, Groundwater, p. 37, 1979.

4.1.2 Reduction of Mobility, Toxicity, or Volume

A "No Action" remedial option would not result in reduction of mobility or toxicity of the VOCs detected in groundwater. However, natural attenuation would cause a reduction in concentration (volume) of the VOCs detected in groundwater. The time required for natural attenuation of the VOCs detected in groundwater to concentrations less than their respective TRGs is not known.

4.1.3 Near-Term Effectiveness

A "No Action" option would not result in any greater near-term risk to human health and the environment than currently exists at the site. Since neither workers nor the public would be exposed to the affected groundwater from activity related to remedial action, near-term protection of human health and the environment would be achieved.

4.1.4 Implementability

Since there would be nothing to implement, a "No Action" remedial option would be most easily implemented option.

4.1.5 Cost Efficiency

Since there would be no remediation, a "No Action" remedial option would be the most cost efficient option.

4.2 INSTITUTIONAL CONTROLS

Institutional controls protect human health and the environment by limiting access to areas where exposure can occur (e.g. fence), limiting the potential use of the affected areas (e.g. deed restriction), and isolation of the affected area to reduce the mobility of the constituents and exposure pathways (e.g. engineered cap). With respect to the Hercules site, it is already surrounded by chain link fence that limits public access to the entire Hercules site. Access to affected groundwater is further limited by the presence of several feet of overlying, unsaturated soils. Therefore, consideration of institutional controls for this RAE would be confined to use of a deed restriction to limit future use of affected area.

A deed restriction would require agreement between Hercules and the MDEQ regarding the exact boundaries of the area to be subject to the restriction. A physical survey of the agreed on boundaries and a plat drawing by a registered surveyor would then be submitted with a revised deed to Forest County.

4.2.1 Long-Term Effectiveness

The deed restriction would limit exposure of affected groundwater by prohibiting excavation or other intrusive activities in the restricted area until such time as the deed restriction was lifted. However, the deed restriction would not provide advance warning of migration caused by site changes.

4.2.2 Reduction of Mobility, Toxicity, or Volume

Institutional controls would restrict exposure to the affected groundwater but would not affect the mobility, toxicity, or volume of affected groundwater.

4.2.3 Near-Term Effectiveness

Implementation of institutional controls would not result in increased, near-term exposure of workers or the public to affected groundwater.

4.2.4 Implementability

The fence is already in place. The deed restriction could be readily implemented.

4.2.5 Cost Efficiency

The estimated present value to implement the deed restriction and maintain the fence is approximately $14,100.00 for a 5-year period and approximately $22,409.00 for a 30-year period.

4.3 MONITORED NATURAL ATTENUATION

Monitored natural attenuation protects human health and the environment by allowing natural processes, such as biological activity and inorganic geochemical processes, to reduce the concentrations of groundwater constituents. Periodic groundwater monitoring is conducted to ensure that concentrations of constituents above the regulated concentrations do not migrate beyond site boundaries or otherwise pose a risk to human health and the environment.

Since groundwater quality information for the Hercules site indicates that groundwater containing VOCs above regulatory limits is confined to site boundaries, the Hercules site is suitable for application of monitored natural attenuation. This evaluation of monitored natural attenuation includes use existing monitoring wells, MW-7, MW-8, and MW-9 and the installation and monitoring of two new downgradient monitoring wells. For cost estimating purposes, the monitored natural attenuation alternative also includes a deed restriction to reduce the potential exposure to human health and the environment during the groundwater monitoring time period.

This evaluation assumes that groundwater monitoring would be conducted annually for two years to establish groundwater quality and hydrogeological parameters. Assuming that the results of the annual groundwater monitoring demonstrate that groundwater quality and hydrogeological parameters are stable or decreasing, the groundwater monitoring schedule would be decreased to a frequency appropriate to monitor changes in site conditions. For this evaluation, it is assumed that groundwater monitoring frequency would continue on an annual schedule. It is also assumed that groundwater monitoring would be required for a period of at least 5 years and no more than 30 years. Data would be submitted to the MDEQ after each monitoring event, and annual reports of the effectiveness of the remedial option would also be submitted the MDEQ. In practice, the number of wells required for monitoring, as well as the frequency of monitoring, would vary depending on changes in site conditions and regulatory requirements.

4.3.1 Long-Term Effectiveness

Monitored natural attenuation would be effective in the long term at ensuring that natural degradation of VOCs is occurring and that adequate advance warning is provided if the groundwater constituents, for whatever reasons, begin migrating towards, or beyond, site boundaries or other potential receptors.

4.3.2 Reduction of Mobility, Toxicity, or Volume

Natural attenuation has been shown, in most cases, to reduce the concentrations of groundwater constituents. The time required for complete success of natural attenuation varies greatly from site to site, but the time required is usually measured in years.

4.3.3 Near-Term Effectiveness

There would be little adverse, near-term impacts due to well installation and groundwater monitoring. Drilling subcontractor personnel and groundwater sampling technician may temporarily be exposed to groundwater containing VOCs. However, with appropriate health, safety and engineering precautions, such risks are kept to a minimum.

4.3.4 Implementability

Well installation and groundwater monitoring could be readily implemented. The technologies are well demonstrated and reliable. Standard equipment and construction practices can be used for implementation of the monitoring wells and collecting the samples.

4.3.5 Cost Efficiency

The estimated present value to install two additional monitoring wells and conduct monitored natural attenuation as described in Section 4.3 for a period of 5 years is approximately $43,950.00. The present value to install two monitoring wells and conduct monitored natural attenuation for a period of 30 years is approximately $112,747.00.

4.4 In-Situ Treatment

In-situ groundwater remediation includes several recently developed methods of reducing the toxicity and/or volume of the constituents of concern in groundwater. Typically, In-Situ treatment for VOCs includes methods such as air-sparging, thermal treatment by steam injection, enhanced bioremediation, chemical oxidation, and permeable reactive barriers. For the Hercules facility, in-situ treatment by chemical oxidation using injected chemical oxidents, such as potassium permanganate, hydrogen peroxide, and Fenton's Reagent was evaluated.

Chemical oxidation was chosen for evaluation for the Hercules site due to its adaptability to a variety of hydrogeological conditions, relatively rapid remediation time, effectiveness treating organic compounds in soil or water, effectiveness treating a wide variety of VOCs at varying concentrations, and it's relatively lower expense.

The volume of soil and groundwater where previous investigations have detected concentration of VOCs above TRGs is considered for treatment. An estimated 50,000 cubic yards of soil and groundwater are included in this evaluation. The volume estimate assumes an area treated that is approximately the area encompassed by the concentration of benzene in groundwater (Figure 11) that is above the TRG that has been multiplied by an estimated average thickness of the saturated interval. The area is somewhat irregular and the depth to the top of the Hattiesburg formation varies. The 50,000 cubic yard estimate may be somewhat overstated, but it includes some additional volume to provide for any potential areas of contaminated soils and local variations in the thickness of the saturated interval.

Treatment would be accomplished by injection of the chemical oxidant into the subsurface and allowing time for the oxidant to react with the organic compounds. Oxidation typically is complete within the three to six days after injection. However, VOCs may be present in low permeability areas within the subsurface, and concentrations of VOCs may rebound in the groundwater over time. Often, up to three injections of the chemical oxidant are required to reduce the concentrations of VOCs to the point where re-bound of concentrations above regulatory limits does not occur. For this evaluation, it is assumed that after the initial treatment of the affected area, two additional treatments of "hotspot" areas would also be required. This evaluation also includes five years of annual groundwater monitoring to provide detection of potential rebound after the final treatment.

A variety of chemical oxidation products are currently available for treating soil and/or groundwater, and, should this remedial option be selected, bench-scale testing would be conducted to select the best available product. However, for purposes of discussion and budget preparation in this RAE, the chemical oxidant used would be either normal hydrogen peroxide or Fenton's Reagent. Fenton's reagent, which is a hydrogen peroxide solution containing soluble iron, is a very strong oxidizer and is often more effective than hydrogen peroxide when treating chlorinated hydrocarbons.

4.4.1 Long-Term Effectiveness

Chemical oxidation would permanently reduce the volume of organic compounds present in the subsurface, and would, therefore, be effective in the long-term. Long term maintenance of the remedial system would not be required.

4.4.2 Reduction of Mobility, Toxicity, or Volume

Chemical oxidation permanently reduces the volume of organic contaminants by oxidizing the organic compounds in the subsurface.

4.4.3 Near-Term Effectiveness

Strong oxidizers in the presence of organic materials are a fire hazard, and workers handling strong oxidizing chemicals, such as Fenton's Reagent, must exercise diligent care. Also, chemical oxidation is an exothermic reaction, mixture of the oxidizing chemicals in the wrong concentration may result in vigorous reactions in the subsurface. There is also a near-term risk of exposure to subsurface constituents during installation of injection points and injection of the oxidizing chemicals. However, with appropriate health, safety and engineering precautions, such risks are kept to a minimum.

4.4.4 Implementability

Chemical oxidation could be readily implemented at the site. Standard equipment would be used to install injection points. Bench scale testing would be required to determine the correct concentration of chemical oxidant to inject.

4.4.5 Cost Efficiency

For an estimated 50,000 cubic yards of soil and groundwater to be treated, the cost to conduct chemical oxidation would be approximately $1,098,250.00. The cost to install two additional monitoring wells and conduct annual groundwater monitoring for 5 years following the groundwater treatment would be approximately $43,950.00. Assuming that this remedial option performs as designed, additional monitoring would not be required.

4.5 GROUNDWATER RECOVERY/ RECOVERY AND TREATMENT

Groundwater recovery entails installation and pumping of a series of groundwater production wells. When groundwater is pumped from the wells, contaminants contained in the groundwater are removed from the subsurface and the normal downgradient migration of groundwater containing contaminants is interrupted. Depending on the concentrations of contaminants, the groundwater recovered by the system may be either discharged directly to the municipal wastewater system or treated on site prior to discharge. For this RAE, both scenarios are considered.

Based on existing hydrogeologic and geologic information for the site, and estimated five recovery wells pumped at a combined rate of approximately 7, 500 gallons per day (gpd) would be necessary to capture groundwater migrating from the area where VOCs have been detected above TRGs. However, variations in site geology could either increase or decrease the number of wells and the estimated discharge.

Treatment of groundwater containing VOCs is accomplished by a variety of means, which include air stripping, thermal and chemical oxidation, and carbon filtration. For this evaluation, it is assumed that, that groundwater recovered by the system could be treated using air stripping technology. Air stripping entails aerating water to allow VOCs contained in the water to volatalize. For cost estimating purposes, it is assumed that total VOC concentrations in the effluent gas from the air stripper could be released directly to the atmosphere. However, treatment of effluent gas from the air stripper may be required if VOC concentrations exceed regulatory limits.

4.5.1 Long-Term Effectiveness

Groundwater recovery has been proven effective at minimizing downgradient migration of groundwater contamination. Treatment of groundwater containing VOCs by air stripping has been proven effective at reducing the volume of VOCs in the treated water. Periodic groundwater monitoring of the effectiveness of both the groundwater recovery system and the groundwater treatment system is necessary to ensure that the groundwater recovery system is effective and minimizing downgradient migration of contaminants.

It should be noted that halogenated hydrocarbon solvents, like many of the VOCs detected in groundwater samples collected from the Hercules site, have proven difficult to remove from the subsurface using groundwater recovery systems. Typically, concentrations of halogenated hydrocarbon solvents rebound quickly after groundwater recovery has ceased. While pump and treat systems are effective at controlling migration of contaminated groundwater, cleanup of groundwater using pump and treat systems may require 10 years or more to complete, depending on site specific factors.

4.5.2 Reduction of Mobility, Toxicity, or Volume

By pumping groundwater from the production wells, groundwater containing regulated constituents above regulatory limits is removed from the subsurface. Groundwater recovery also creates a cone of depression in the vicinity of each of the production wells, which limits downgradient migration of groundwater.

4.5.3 Near-Term Effectiveness

There would be little adverse, near-term impacts due to well installation and groundwater monitoring. Drilling subcontractor personnel and groundwater sampling technicians would temporarily be exposed to groundwater containing VOCs. However, with appropriate health, safety and engineering precautions, such risks are kept to a minimum.

4.5.4 Implementability

The technologies are well demonstrated and reliable. Standard equipment and construction practices can be used for implementation of the components of this alternative.

4.5.5 Cost Efficiency

The cost to install a groundwater recovery system and two additional monitoring wells would be approximately $118,100.00. If it is necessary to treat the recovered groundwater, the groundwater treatment system would cost an estimated $250,700.00 to install. The estimated operations and maintenance cost for this option, which includes groundwater pumping system maintenance, effluent disposal, and groundwater monitoring would be approximately $93,825.00 per year, and maintenance of a treatment system, if required, would increase the annual maintenance cost by approximately $10,000.00 per year. The present value for installation of a pumping system and monitoring well installation plus pumping system maintenance and groundwater monitoring would be approximately $536,751.00 for a 5-year period and $1,385,125.00 for a 30 year period. The present value for installation of a groundwater treatment system in addition to the pumping system and monitoring well installation plus pumping and treatment system maintenance and groundwater monitoring would be approximately $828,453.00 for a 5-year period and $1,759,916.00 for a 30 year period.

5.0 GREEN'S CREEK

Concentrations of VOCs and dioxathion have been detected in surface water and stream sediment samples collected from Green's Creek at concentrations less than their respective TRGs. TRGs are intended to apply to groundwater and soil, and are not intended to apply to surface water and stream sediment. However, TRGs are risk-based values that represent concentrations that should be protective of human health and the environment.

Many of the VOCs detected in the surface water and stream sediment samples collected from Green's Creek were also detected in samples collected from location CM-00, which is located within a few feet of the point where Green's Creek enters the Hercules property. The presence of the VOCs at the CM-00 location indicates that some, or all, of the VOCs detected in the surface water and stream sediment of Green's Creek collected from locations on the Hercules property may be due to a source area upstream of the Hercules property.

5.1 NO ACTION

By definition, the "No Action" remedial option would not involve any further investigation, monitoring, or other remedial action.

5.1.1 Long-Term Effectiveness

Due to the likelihood that many VOCs detected in samples from Green's Creek may be due to an upstream, offsite source, it is reasonable to assume that, if additional constituents are not introduced to Green's Creek from sources on the Hercules property, surface water and stream sediment conditions would be determined by off-site sources. If the off-site sources are addressed, the surface water quality and stream sediment quality should either remain constant or improve in the long term. Therefore, unless there are changes on the Hercules property or on upstream properties that result in increased risk to Green's Creek, a "No Action" remedial option should not result in greater risk to human health and the environment than is currently present at the site.

5.1.2 Reduction of Mobility, Toxicity, or Volume

A "No Action" remedial option would not result in reduction of mobility or toxicity of the VOCs or dioxathion detected in surface water or stream sediment samples.

5.1.3 Near-Term Effectiveness

A "No Action" option would not result in any greater near-term risk to human health and the environment than currently exists in Green's Creek.

5.1.4 Implementability

Since there would be nothing to implement, a "No Action" remedial option would be most readily implemented option.

5.1.5 Cost Efficiency

Since there would be no remediation, a "No Action" remedial option would be the most cost-efficient option.

5.2 INSTITUTIONAL CONTROLS

Institutional controls protect human health and the environment by limiting access to areas where exposure can occur (e.g. fence) and limiting the potential use of the affected areas (e.g. deed restriction). With respect to the Hercules site, it is already surrounded by chain link fence that limits public access to the entire Hercules site. Consideration of institutional controls for this RAE would be confined to use of a deed restriction to limit future use of Green's Creek on the Hercules property and use of the existing perimeter fence.

A deed restriction would require agreement between Hercules and the MDEQ regarding the exact boundaries of the area to be subject to the restriction. A physical survey of the agreed on boundaries and a plat drawing by a registered surveyor would then be submitted with a revised deed to Forest County.

5.2.1 Long-Term Effectiveness

The deed restriction would limit exposure to Green's Creek by prohibiting excavation, use of surface water for any purpose, or intrusive activities in the restricted area until such time as the deed restriction was lifted. However, stream sediment and surface water are mobile media, and may move onto, and off of, Hercules property with the natural flow of the creek. Therefore, a deed restriction would have limited effect in isolating surface water and stream sediment.

5.2.2 Reduction of Mobility, Toxicity, or Volume

Institutional controls would restrict exposure to Green's Creek but would not affect the mobility, toxicity, or volume of any contamination in Green's Creek.

5.2.3 Near-Term Effectiveness

Implementation of institutional controls would not result in increased, near-term exposure of workers or the public to constituents in Green's Creek.

5.2.4 Implementability

The fence is already in place and the deed restriction could be readily implemented.

5.2.5 Cost Efficiency

The estimated present cost to implement the deed restriction and maintain the fence is approximately $14,100.00 for a 5-year period and approximately $22,409.00 for a 30-year period.

5.3 MONITORED NATURAL ATTENUATION

Monitored natural attenuation protects human health and the environment by allowing natural processes, such as biological activity and inorganic geochemical processes, to reduce the concentrations of VOCs and dioxathion in Green's Creek. Periodic surface water monitoring is conducted to ensure that concentrations of constituents above the regulated concentrations are not migrating beyond site boundaries or otherwise pose a risk to human health and the environment.

Since surface water and stream sediment quality information for the Hercules site indicates that surface water and stream sediment containing VOCs and dioxathion above the risk-based TRGs are not present in Green's Creek on the Hercules property, the Hercules site is suitable for application of monitored natural attenuation. This evaluation of monitored natural attenuation includes use of previous stream sampling locations, CM-00 through CM-05, and staff gauges SG-1 through SG-4. Since surface water is the most mobile media in a stream, surface water should be indicative of the stream conditions as water in the stream enters and leaves the Hercules site. Therefore, this evaluation of monitored natural attenuation of Green's Creek includes sampling of surface water only.

This evaluation assumes that surface monitoring would be conducted annually for two years to establish surface water quality and hydrological parameters. Assuming that the results of the annual monitoring demonstrate that surface water quality parameters are stable or decreasing, the frequency of surface water monitoring would be decreased to a frequency appropriate to monitor changes in site conditions. For this evaluation, it is assumed that surface water monitoring frequency would continue on an annual schedule. It is also assumed that surface water monitoring would be required for a period of at least 5 years and no more than 30 years. Data would be submitted to the MDEQ after each monitoring event, and annual reports of the effectiveness of the remedial option would also be submitted the MDEQ. In practice, the number of sampling points required for monitoring, as well as the frequency of monitoring, would vary depending on changes in site conditions and regulatory requirements.

5.3.1 Long-Term Effectiveness

Monitored natural attenuation would be effective in the long-term at ensuring that adequate advance warning is provided if the surface water constituents due to on-site or off site sources, begin migrating via Green's Creek towards potential receptors.

5.3.2 Reduction of Mobility, Toxicity, or Volume

Since both stream sediment and surface water are mobile media, it would be difficult to measure whether any reduction in contaminant concentration that is detected in samples collected at the site is related to natural attenuation or to downstream migration.

5.3.3 Near-Term Effectiveness

There would be little adverse, near-term impacts due to surface water monitoring. Sampling technicians may temporarily be exposed to water containing VOCs and/or dioxathion. However, with appropriate health, safety and engineering precautions, such risks are kept to a minimum

5.3.4 Implementability

Surface water monitoring could be readily implemented. The technologies are well demonstrated and reliable. Standard equipment can be used for sample collection.

5.3.5 Cost Efficiency

The estimated present value to conduct annual surface water monitoring for a period of 5 years is approximately $33,950.00. The estimated present value to conduct surface water monitoring for a period of 30 years is approximately $102,747.00.

6.0 SUMMARY AND CONCLUSIONS

For each of the remedial options considered for each area of the Hercules site, the least cost option that can be readily implemented and is protective of human health and the environment has been recommended. These recommendations are based on the currently available data and reflect Eco-Systems' professional judgement. If additional data is collected these recommendations may need to be modified to reflect changed conditions.

6.1 Sludge Pits

Existing chemical and site data do not indicate that the sludge pits pose a significant risk to human health and/or the environment. However, direct exposure to potential constituents in the sludge could exist for workers at the site and for wildlife. The potential also exists for indirect exposure from of potential constituents in the sludge and from natural weather events overflowing the berms of the pits. To address the potential direct and indirect risks associated with the sludge pits, it is recommended that the monitored natural attenuation option discussed in Section 2.3 combined with the institutional controls discussed in Section 2.2 be implemented for the sludge pits. Implementation of the monitored natural attenuation and institutional controls options would restrict future land use, limit access to the pits, and provide detection monitoring for constituents that may migrate from the pits via groundwater in the future. The estimated present value for deed restriction, and fence construction plus fence maintenance and groundwater monitoring would be approximately $78,800.00 for a 5-year period and $155,906.00 for a 30 year period.

6.2 Landfill

Existing data do not indicate that the landfill currently poses a risk to human health and the environment. However, to minimize potential future risk that may be posed by the landfill, it is recommended that monitored natural attenuation as discussed in Section 3.2 be implemented for the landfill. The monitored natural attenuation option would restrict land use in the landfill area and provide detection monitoring for constituents that may migrate from the pits via groundwater or surface water in the future. The estimated present value to install three additional monitoring wells and conduct monitored natural attenuation as described in Section 3.3 for a period of 5 years is approximately $48,950.00. The estimated present value to install three monitoring wells and conduct monitored natural attenuation for a period of 30 years is approximately $117,747.00.

6.3 GROUNDWATER

VOCs have been detected at concentrations above TRGs in groundwater samples primarily collected from the portion of the Hercules facility located between the main plant area and the landfill area. However, existing groundwater quality information indicates that groundwater containing VOCs above regulatory limits is confined to the Hercules property. Since the existing groundwater data do not indicate that groundwater containing VOCs above regulatory limits is currently migrating off site or that off site migration is imminent, a program of monitored natural attenuation could be implemented as a remedial alternative. Monitored natural attenuation would be effective in the long-term at ensuring that natural degradation of VOCs is occurring and that adequate advance warning is provided if the groundwater constituents begin migrating towards site boundaries. Given sufficient time, VOCs present in the groundwater should degrade. Minimal near-term exposure would occur due to monitoring well installation and groundwater sampling, but should be minimized by the use of proper health and safety practices in the field. Monitored natural attenuation could be readily implemented. The estimated present value to install two additional monitoring wells and conduct monitored natural attenuation as described in Section 4.3 for a period of 5 years is approximately $43,950.00. The estimated present value to install two monitoring wells and conduct monitored natural attenuation for a period of 30 years is approximately $112,747.00.

6.4 GREEN'S CREEK

Existing chemical and site data do not indicate that either surface water or stream sediment in Green's Creek pose a significant risk to human health and the environment. However, to minimize potential future risk that may be posed by constituents in Green's Creek, it is recommended that monitored natural attenuation, as described in Section 5.3, be conducted for Green's Creek. The estimated present cost to implement the deed restriction and maintain the fence is approximately $14,100.00 for a 5-year period and approximately $22,409.00 for a 30-year period.

TABLES

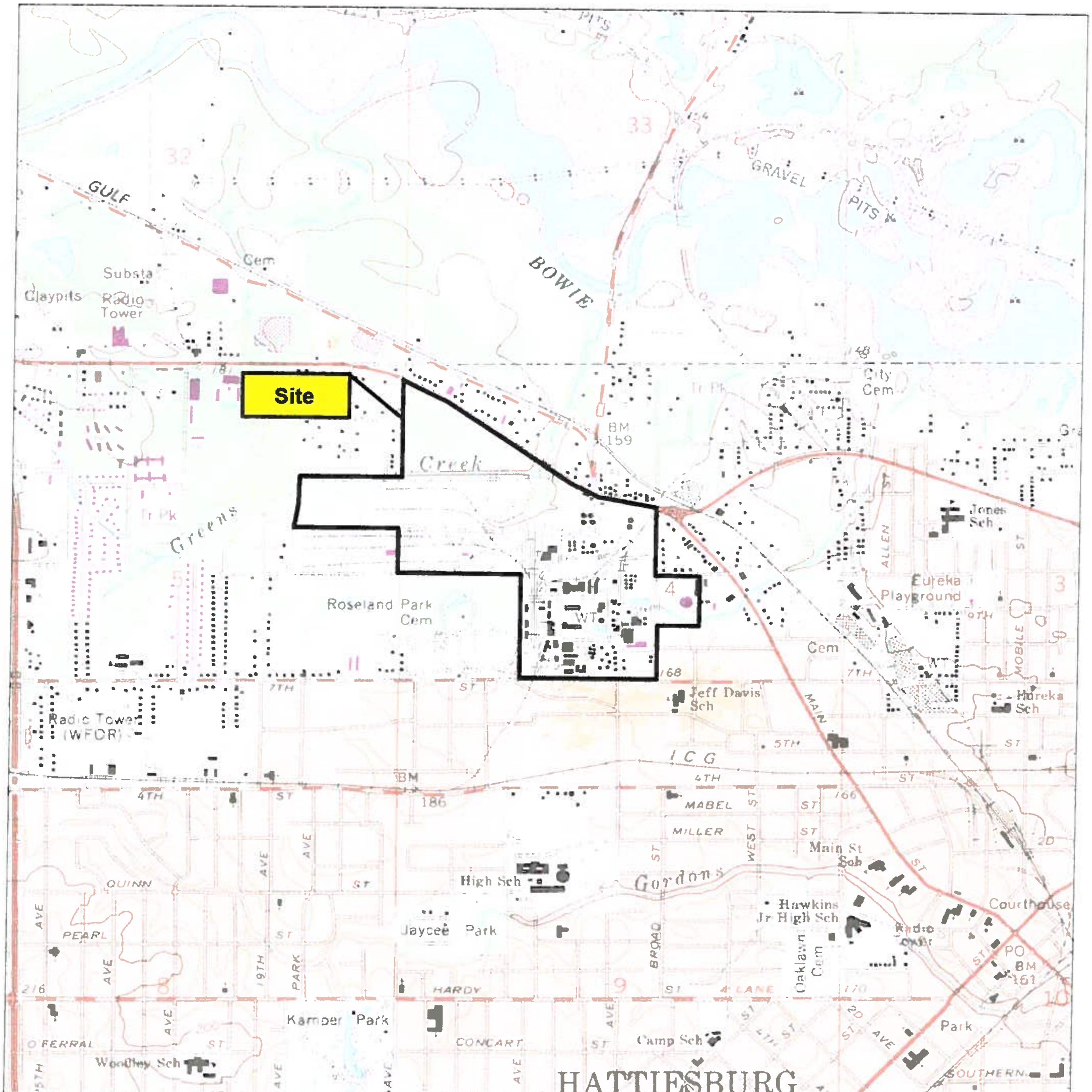
Table 1
Summary of Cost Estimates
Remedial Action Evaluation
Hercules, Incorporated
Hattiesburg, Mississippi
July 2004

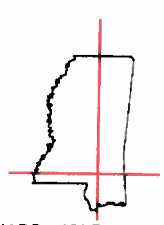
	Startup Cost	O&M	Lifespan	PV	5 Yr Total	Lifespan	PV	30 Yr Total
	discount rate 7%							
Sludge Pits	4.2 acres							
Fence & Deed Restrictions	$ 40,750.00	$ 1,000.00	5	$ 4,100.20	$ 44,850.20	30	$ 12,409.04	$ 53,159.04
MNA	$ -	$ 8,280.00	5	$ 33,949.63	$ 33,949.63	30	$ 102,746.86	$ 102,746.86
Cap	$ 501,750.00	$ 10,000.00	5	$ 41,001.97	$ 542,751.97	30	$ 124,090.41	$ 625,840.41
Containment Wall	$ 528,000.00		5	$ -	$ 528,000.00	30	$ -	$ 528,000.00
Cap & Containment Wall	$ 1,029,750.00	$ 10,000.00	5	$ 41,001.97	$ 1,070,751.97	30	$ 124,090.41	$ 1,153,840.41
Landfill	3.4 acres							
Deed Restrictions	$ 10,000.00		5	$ -	$ 10,000.00	30	$ -	$ 10,000.00
MNA	$ 15,000.00	$ 8,280.00	5	$ 33,949.63	$ 48,949.63	30	$ 102,746.86	$ 117,746.86
Containment Wall	$ 547,800.00		5	$ -	$ 547,800.00	30	$ -	$ 547,800.00
Groundwater								
Fence & Deed Restrictions	$ 10,000.00	$ 1,000.00	5	$ 4,100.20	$ 14,100.20	30	$ 12,409.04	$ 22,409.04
MNA	$ 10,000.00	$ 8,280.00	5	$ 33,949.63	$ 43,949.63	30	$ 102,746.86	$ 112,746.86
ISCO	$ 1,098,250.00	$ 8,280.00	5	$ 33,949.63	$ 1,132,199.63	30	$ 102,746.86	$ 1,200,996.86
Groundwater Recovery System & Sewer Discharge	$ 108,100.00	$ 93,825.00	5	$ 384,701.02	$ 492,801.02	30	$ 1,164,278.29	$ 1,272,378.29
Groundwater Treatment	$ 250,700.00	$ 10,000.00	5	$ 41,001.97	$ 291,701.97	30	$ 124,090.41	$ 374,790.41
Total Grooundwater Pump & Treat	$ 358,800.00	$ 103,825.00	5	$ 425,703.00	$ 784,503.00	30	$ 1,288,368.70	$ 1,647,168.70
Greens Creek								
Fence & Deed Restrictions	$ 10,000.00	$ 1,000.00	5	$ 4,100.20	$ 14,100.20	30	$ 12,409.04	$ 22,409.04
MNA	$ -	$ 8,280.00	5	$ 33,949.63	$ 33,949.63	30	$ 102,746.86	$ 102,746.86

PV - Present Value

ESI

FIGURES





QUADRANGLE LOCATION

HERCULES

CHEMICAL SPECIALTIES

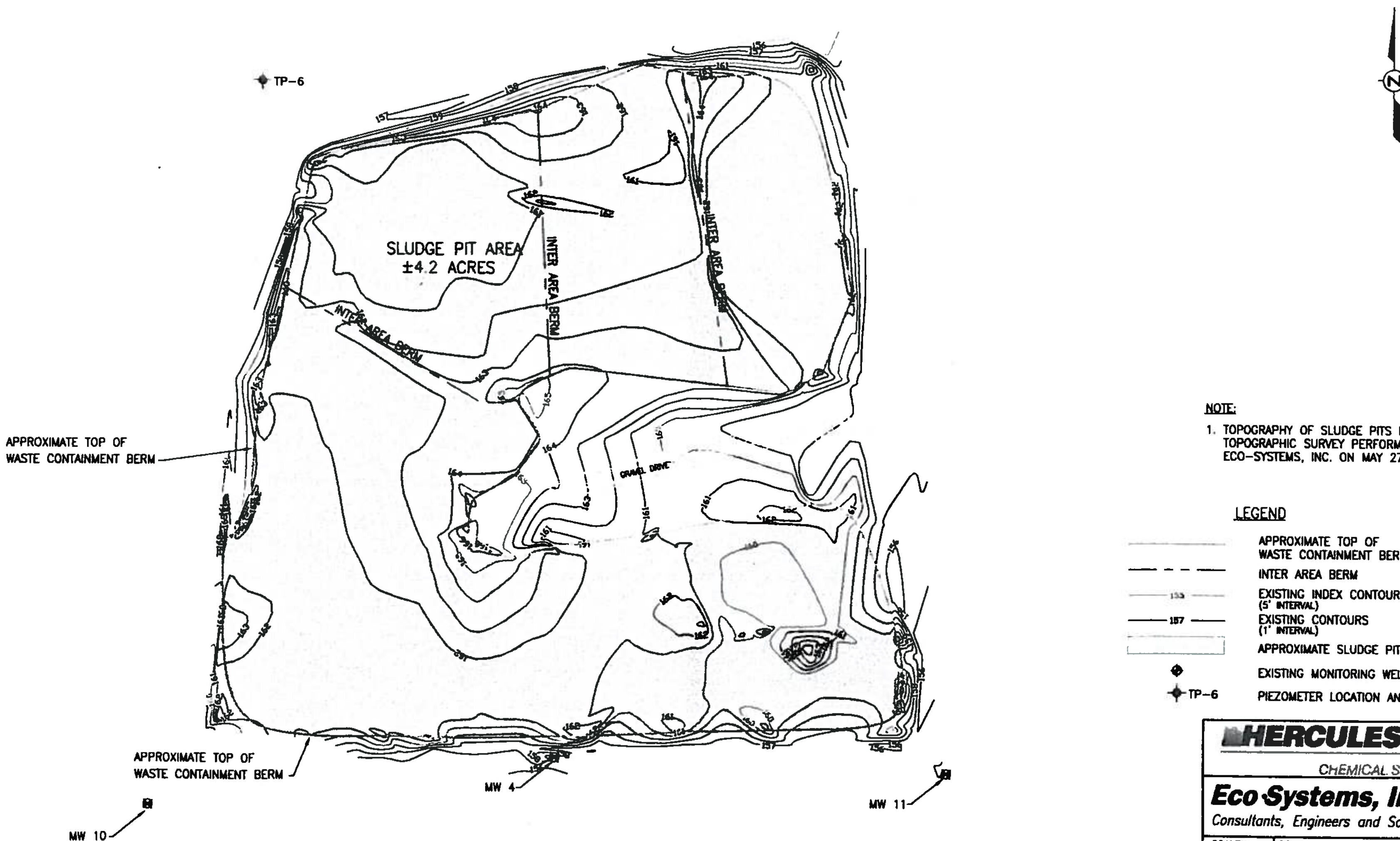
Eco·Systems, Inc.

Consultants, Engineers and Scientists

SCALE: N.T.S.	DRAWN BY: C. Coulter	DATE: 07/15/04
	CHKD. BY:	DATE:
PROJECT NO. HER24069	CAD FILE Figure 1 - Site Location Map.ppt	

SITE LOCATION MAP

FIGURE 1



NOTE:

1. TOPOGRAPHY OF SLUDGE PITS BASED ON TOPOGRAPHIC SURVEY PERFORMED BY ECO-SYSTEMS, INC. ON MAY 27, 2004.

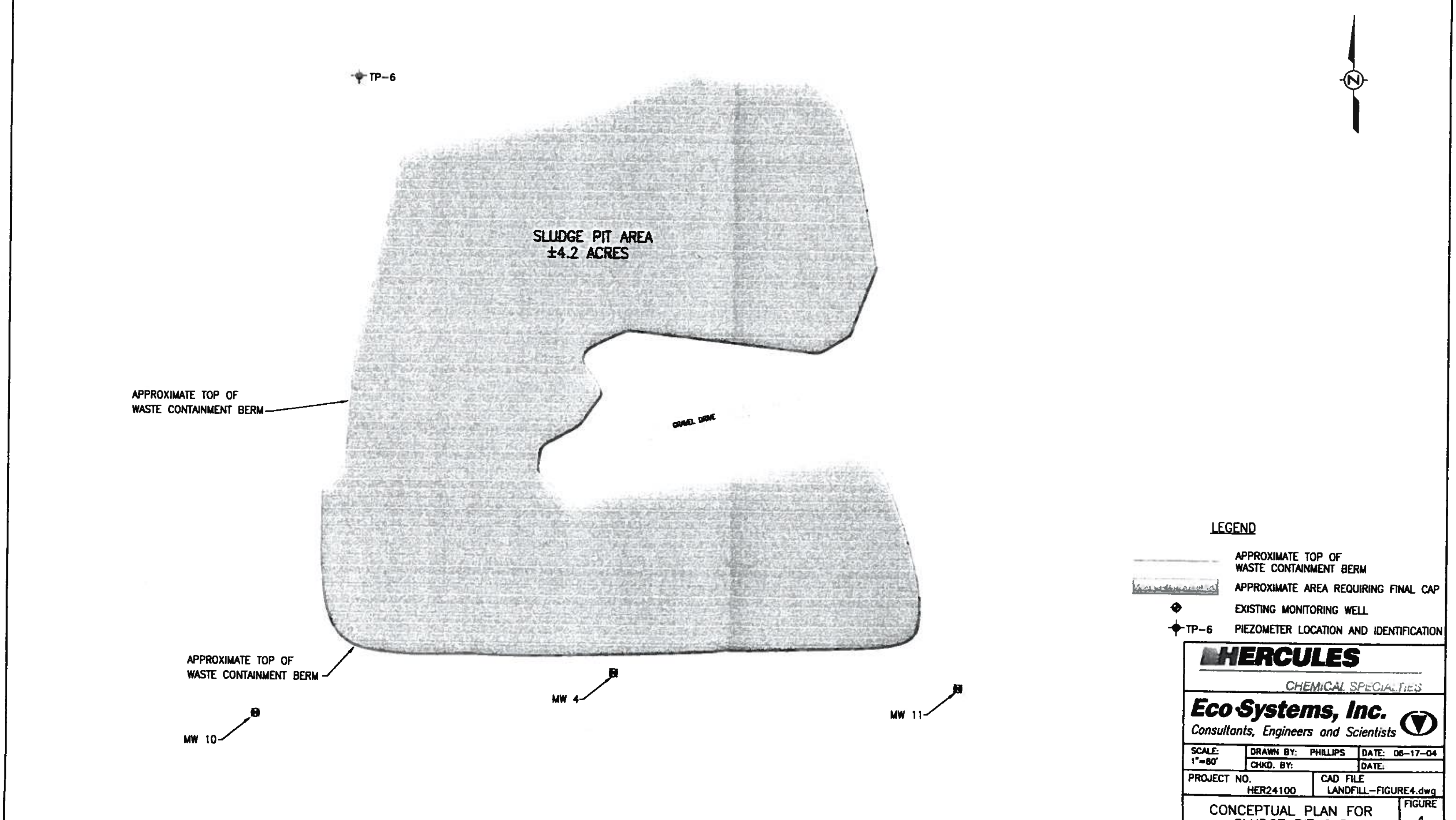
LEGEND

(solid line)	APPROXIMATE TOP OF WASTE CONTAINMENT BERM
(dashed line)	INTER AREA BERM
153	EXISTING INDEX CONTOURS (5' INTERVAL)
157	EXISTING CONTOURS (1' INTERVAL)
(shaded area)	APPROXIMATE SLUDGE PIT AREA
(well symbol)	EXISTING MONITORING WELL
TP-6	PIEZOMETER LOCATION AND IDENTIFICATION

HERCULES
CHEMICAL SPECIALTIES

Eco-Systems, Inc.
Consultants, Engineers and Scientists

SCALE: 1"=80'	DRAWN BY: PHILLIPS	DATE: 08-17-04
	CHKD. BY:	DATE:
PROJECT NO. HER24100	CAD FILE LANDFILL-FIGURE3.dwg	
EXISTING CONDITIONS OF SLUDGE PITS		FIGURE 3



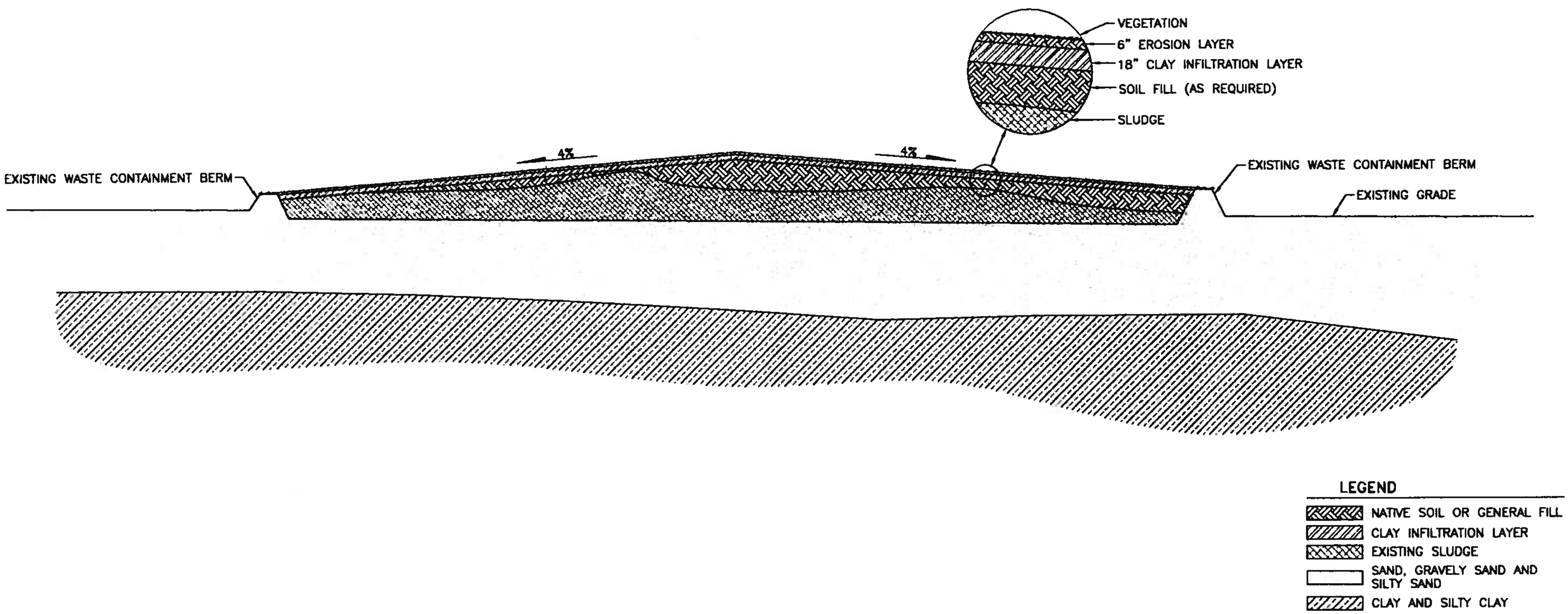
HERCULES
CHEMICAL SPECIALTIES

Eco-Systems, Inc.
Consultants, Engineers and Scientists

SCALE: 1"=80'	DRAWN BY: PHILLIPS	DATE: 06-17-04
	CHKD. BY:	DATE:
PROJECT NO. HER24100	CAD FILE LANDFILL-FIGURE4.dwg	

CONCEPTUAL PLAN FOR SLUDGE PIT CAP

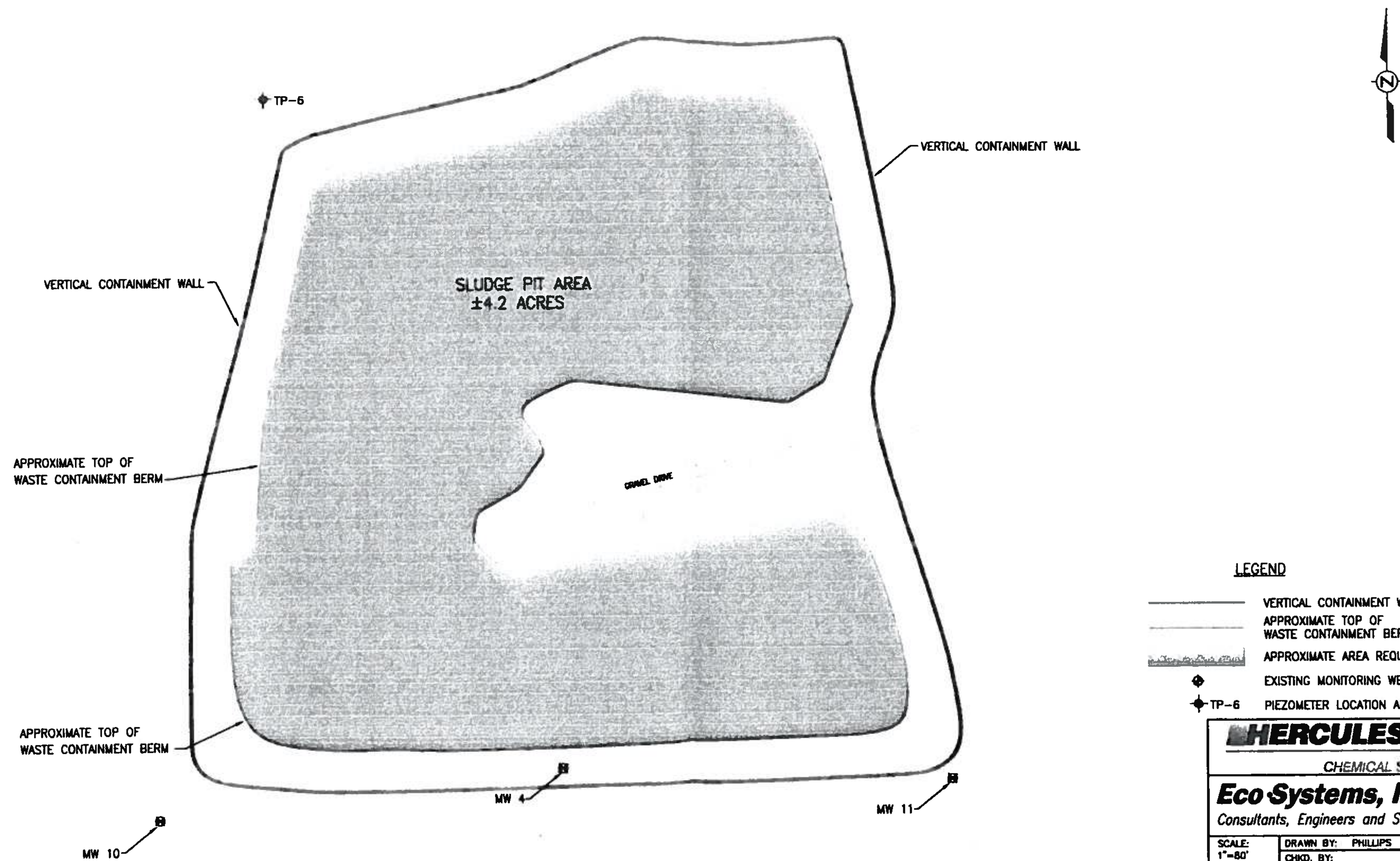
FIGURE 4



HERCULES
CHEMICAL SPECIALTIES

Eco·Systems, Inc.
Consultants, Engineers and Scientists

SCALE: N.T.S.	DRAWN BY: N. SISSON	DATE: 06/17/04
	CHKD. BY:	DATE:
PROJECT NO. HER24100	CAD FILE LANDFILL-FIGURE5.dwg	
CONCEPTUAL CROSS SECTION OF SLUDGE PIT CAP		FIGURE 5



LEGEND

VERTICAL CONTAINMENT WALL
APPROXIMATE TOP OF WASTE CONTAINMENT BERM
APPROXIMATE AREA REQUIRING FINAL CAP
EXISTING MONITORING WELL
TP-6 PIEZOMETER LOCATION AND IDENTIFICATION

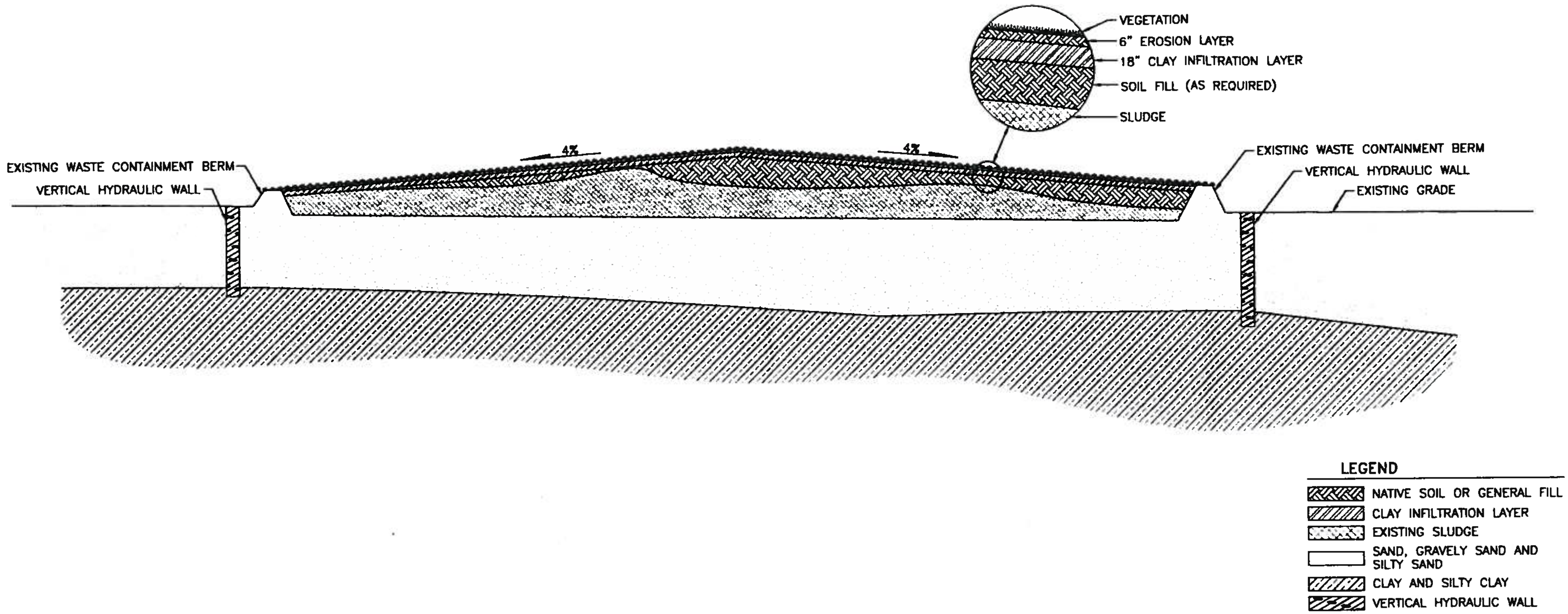
HERCULES
CHEMICAL SPECIALTIES

Eco-Systems, Inc.
Consultants, Engineers and Scientists

SCALE: 1"=80'	DRAWN BY: PHILLIPS	DATE: 06-17-04
	CHKD. BY:	DATE:
PROJECT NO. HER24100	CAD FILE LANDFILL-FIGURE6.dwg	

CONCEPTUAL PLAN FOR SLUDGE PIT CAP AND VERTICAL WALL

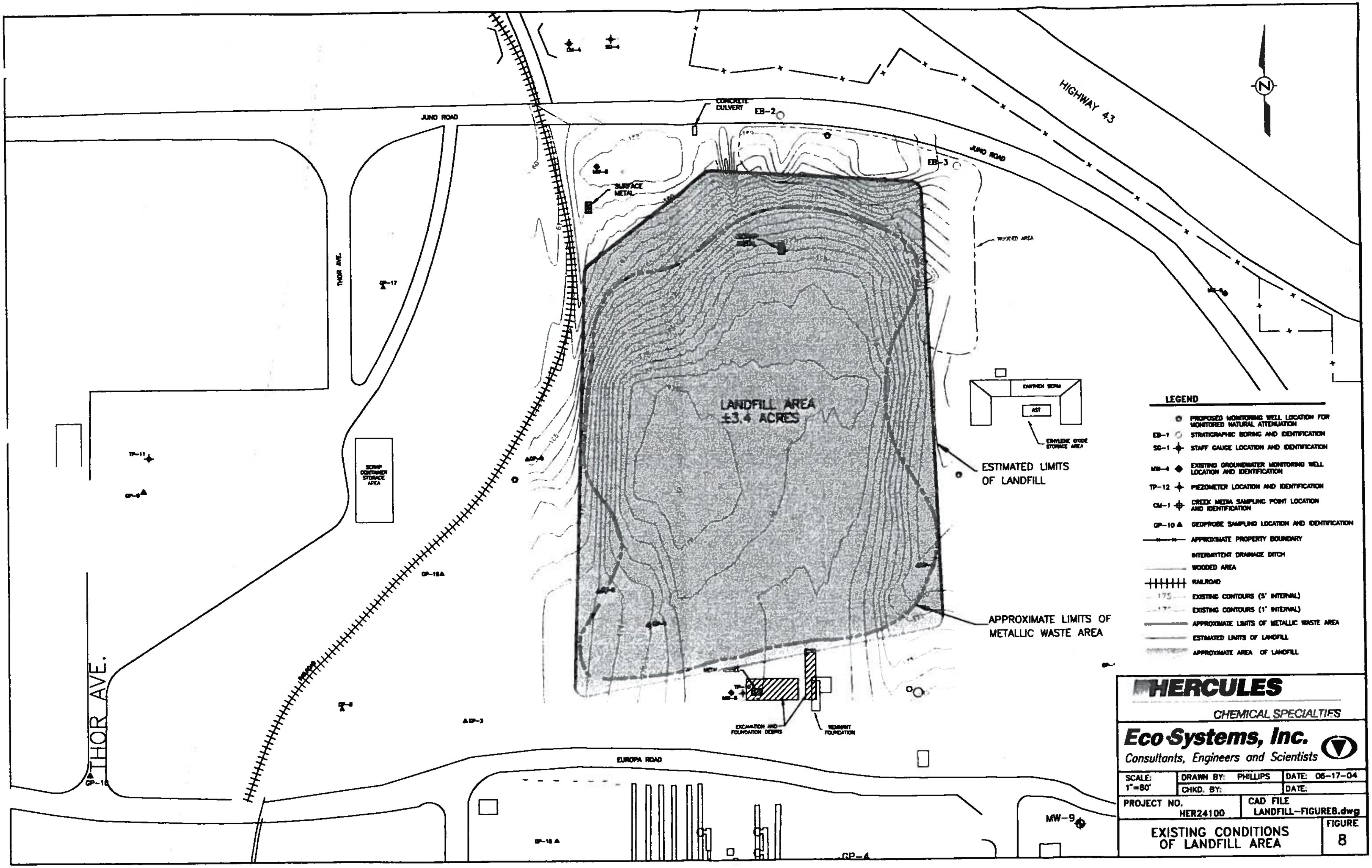
FIGURE 6



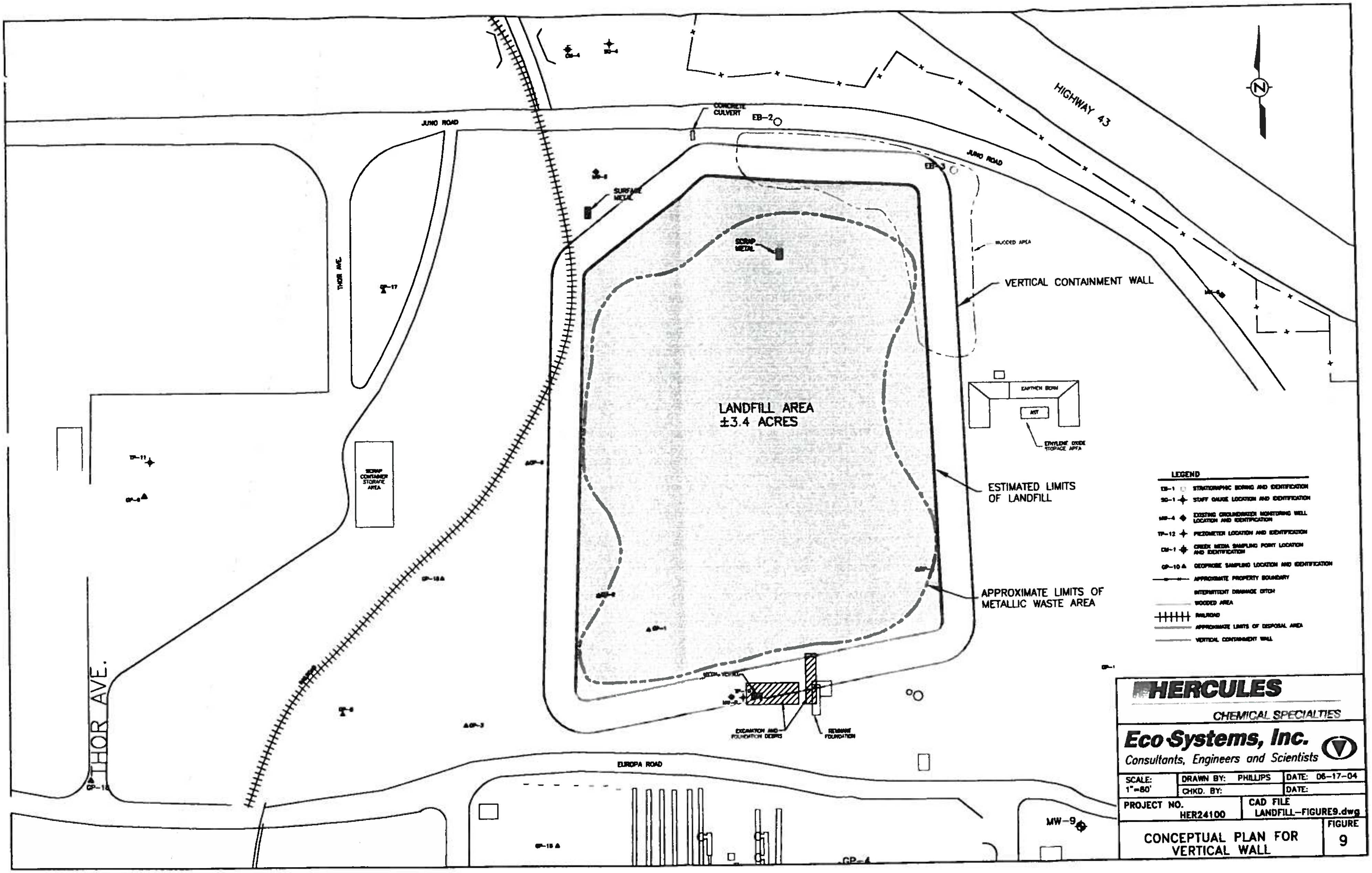
HERCULES
CHEMICAL SPECIALTIES

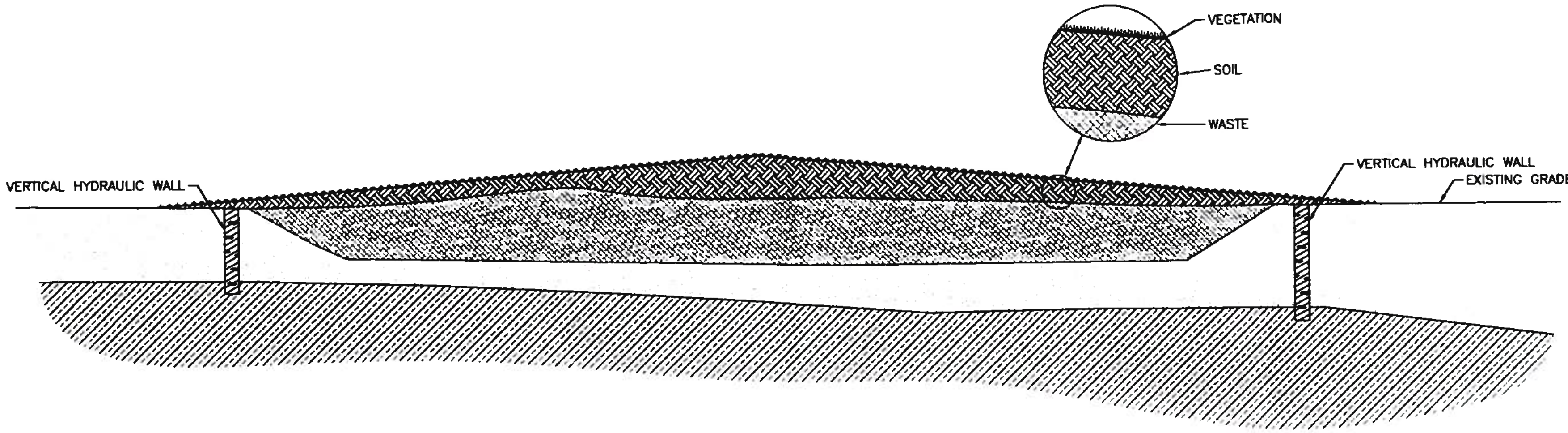
Eco-Systems, Inc.
Consultants, Engineers and Scientists

SCALE: N.T.S.	DRAWN BY: N. SISSON / CHKD. BY:	DATE: 06/17/04 / DATE:
PROJECT NO. HER24100	CAD FILE LANDFILL-FIGURE7.dwg	
CONCEPTUAL CROSS SECTION OF SLUDGE PIT CAP AND VERTICAL WALL		FIGURE 7



HIGHWAY 43
JUNO ROAD
CONCRETE CULVERT
EB-2
EB-3
SURFACE METAL
WOODED AREA
THOR AVE.
GP-17
TP-11
LANDFILL AREA
±3.4 ACRES
SCRAP CONTAINER STORAGE AREA
GP-15A
GP-3
EARTHEN BERM
AST
ETHYLENE OXIDE STORAGE AREA
ESTIMATED LIMITS
OF LANDFILL
APPROXIMATE LIMITS OF
METALLIC WASTE AREA
EXCAVATION AND FOUNDATION DEBRIS
REMNANT FOUNDATION
EUROPA ROAD
GP-18
GP-16
GP-4
MW-9
LEGEND
PROPOSED MONITORING WELL LOCATION FOR MONITORED NATURAL ATTENUATION
EB-1 STRATIGRAPHIC BORING AND IDENTIFICATION
SG-1 STAFF GAUGE LOCATION AND IDENTIFICATION
MW-4 EXISTING GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
TP-12 PIEZOMETER LOCATION AND IDENTIFICATION
CM-1 CREEK MEDIA SAMPLING POINT LOCATION AND IDENTIFICATION
GP-10 GEOPROBE SAMPLING LOCATION AND IDENTIFICATION
APPROXIMATE PROPERTY BOUNDARY
INTERMITTENT DRAINAGE DITCH
WOODED AREA
RAILROAD
175 EXISTING CONTOURS (5' INTERVAL)
EXISTING CONTOURS (1' INTERVAL)
APPROXIMATE LIMITS OF METALLIC WASTE AREA
ESTIMATED LIMITS OF LANDFILL
APPROXIMATE AREA OF LANDFILL
HERCULES
CHEMICAL SPECIALTIES
Eco-Systems, Inc.
Consultants, Engineers and Scientists
SCALE: 1"=80'
DRAWN BY: PHILLIPS
DATE: 06-17-04
CHKD. BY:
DATE:
PROJECT NO. HER24100
CAD FILE LANDFILL-FIGURE8.dwg
EXISTING CONDITIONS OF LANDFILL AREA
FIGURE 8


HIGHWAY 43
JUNO ROAD
CONCRETE CULVERT
EB-2
EB-3
WOODED AREA
VERTICAL CONTAINMENT WALL
SURFACE METAL
SCRAP METAL
LANDFILL AREA
±3.4 ACRES
EARTHEN BERM
AST
ETHYLENE OXIDE STORAGE AREA
ESTIMATED LIMITS
OF LANDFILL
APPROXIMATE LIMITS OF
METALLIC WASTE AREA
THOR AVE.
SCRAP CONTAINER STORAGE AREA
EXCAVATION AND FOUNDATION DEBRIS
REMNANT FOUNDATION
EUROPA ROAD
MW-9
GP-4
TP-11
GP-17
GP-18
LEGEND
STRATIGRAPHIC BORING AND IDENTIFICATION
STAFF GAUGE LOCATION AND IDENTIFICATION
EXISTING GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
PIEZOMETER LOCATION AND IDENTIFICATION
CREEK MEDIA SAMPLING POINT LOCATION AND IDENTIFICATION
GEOPROBE SAMPLING LOCATION AND IDENTIFICATION
APPROXIMATE PROPERTY BOUNDARY
INTERMITTENT DRAINAGE DITCH
WOODED AREA
RAILROAD
APPROXIMATE LIMITS OF DISPOSAL AREA
VERTICAL CONTAINMENT WALL
HERCULES
CHEMICAL SPECIALTIES
Eco-Systems, Inc.
Consultants, Engineers and Scientists
SCALE: 1"=80'
DRAWN BY: PHILLIPS
DATE: 06-17-04
CHKD. BY:
DATE:
PROJECT NO. HER24100
CAD FILE LANDFILL-FIGURE9.dwg
CONCEPTUAL PLAN FOR VERTICAL WALL
FIGURE 9



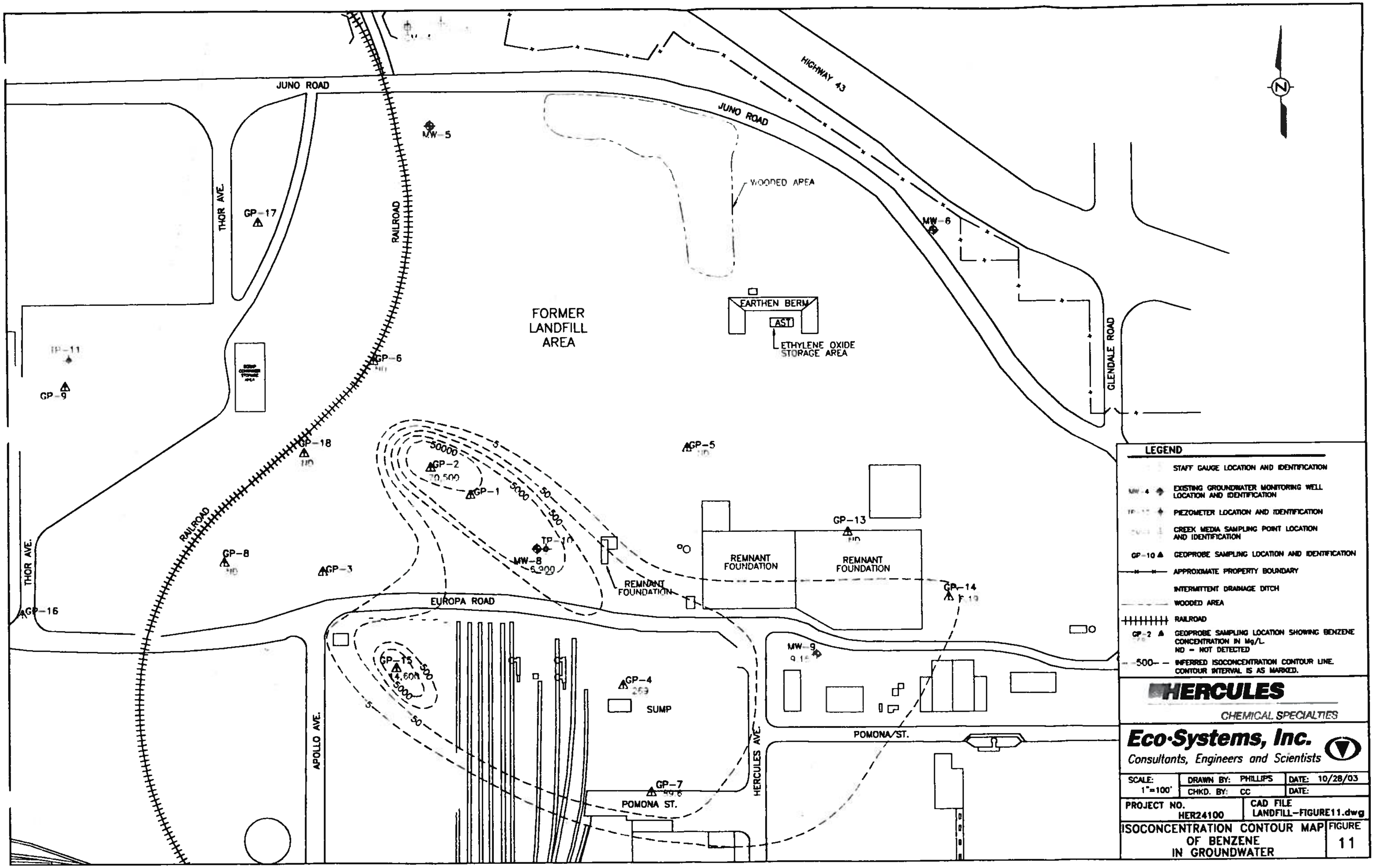
LEGEND

- NATIVE SOIL OR GENERAL FILL
- CLAY INFILTRATION LAYER
- EXISTING WASTE
- SAND, GRAVELY SAND AND SILTY SAND
- CLAY AND SILTY CLAY
- VERTICAL HYDRAULIC WALL

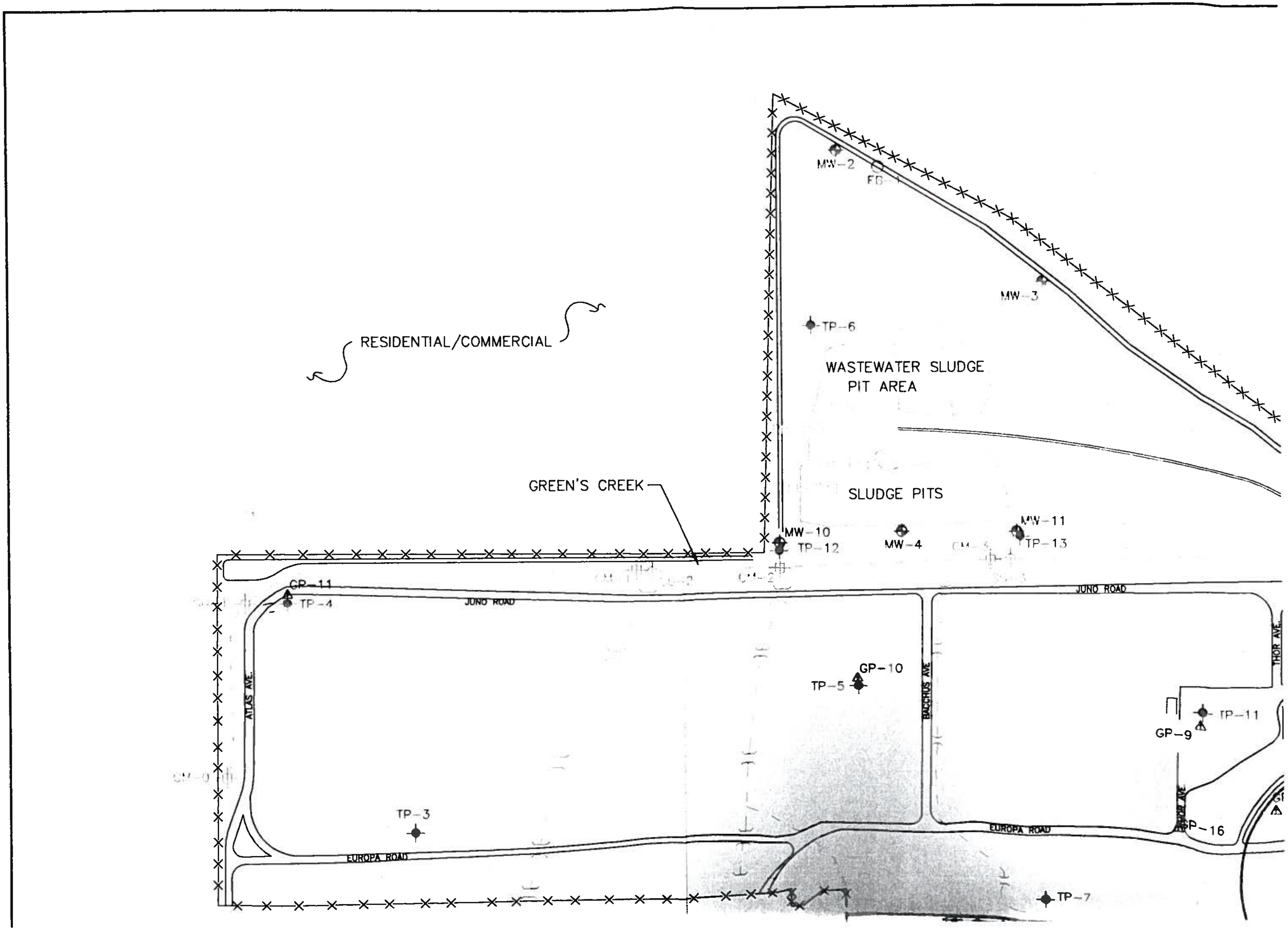
HERCULES
CHEMICAL SPECIALTIES

Eco·Systems, Inc.
Consultants, Engineers and Scientists

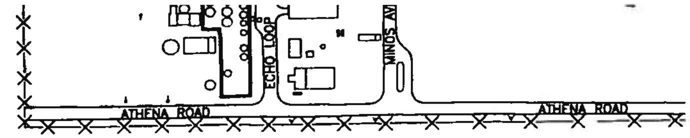
SCALE: N.T.S.	DRAWN BY: N. SISSON	DATE: 08/17/04
	CHKD. BY:	DATE:
PROJECT NO. HER24100	CAD FILE LANDFILL-FIGURE10.dwg	
CONCEPTUAL CROSS SECTION OF LANDFILL AND VERTICAL WALL		FIGURE 10



HIGHWAY 43
JUNO ROAD
GLENDALE ROAD
THOR AVE.
RAILROAD
WOODED AREA
FORMER LANDFILL AREA
EARTHEN BERM
AST
ETHYLENE OXIDE STORAGE AREA
MW-5
MW-6
GP-17
GP-6
GP-9
TP-11
GP-18
ND
GP-2
70,500
GP-1
50000
5000
500
50
5
TP-10
MW-8
6,300
GP-5
ND
GP-13
ND
GP-14
REMNANT FOUNDATION
GP-8
ND
GP-3
GP-16
EUROPA ROAD
GP-15
14,600
GP-4
269
SUMP
GP-7
POMONA ST.
APOLLO AVE.
HERCULES AVE.
MW-9
9.15
POMONA ST.
LEGEND
STAFF GAUGE LOCATION AND IDENTIFICATION
EXISTING GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
PIEZOMETER LOCATION AND IDENTIFICATION
CREEK MEDIA SAMPLING POINT LOCATION AND IDENTIFICATION
GP-10 GEOPROBE SAMPLING LOCATION AND IDENTIFICATION
APPROXIMATE PROPERTY BOUNDARY
INTERMITTENT DRAINAGE DITCH
WOODED AREA
RAILROAD
GP-2 GEOPROBE SAMPLING LOCATION SHOWING BENZENE CONCENTRATION IN Mg/L.
ND - NOT DETECTED
-500- INFERRED ISOCONCENTRATION CONTOUR LINE. CONTOUR INTERVAL IS AS MARKED.
HERCULES
CHEMICAL SPECIALTIES
Eco·Systems, Inc.
Consultants, Engineers and Scientists
SCALE: 1"=100'
DRAWN BY: PHILLIPS
DATE: 10/28/03
CHKD. BY: CC
DATE:
PROJECT NO. HER24100
CAD FILE LANDFILL-FIGURE11.dwg
ISOCONCENTRATION CONTOUR MAP OF BENZENE IN GROUNDWATER
FIGURE 11


RESIDENTIAL/COMMERCIAL
GREEN'S CREEK
WASTEWATER SLUDGE
PIT AREA
SLUDGE PITS
MW-2
MW-3
TP-6
MW-10
TP-12
MW-4
MW-11
TP-13
GP-11
TP-4
JUNO ROAD
ATLAS AVE.
EUROPA ROAD
TP-3
GP-10
TP-5
BACCHUS AVE
THOR AVE.
TP-11
GP-9
GP-16
TP-7

CORPORATION



ROSELAND PARK
CEMETARY

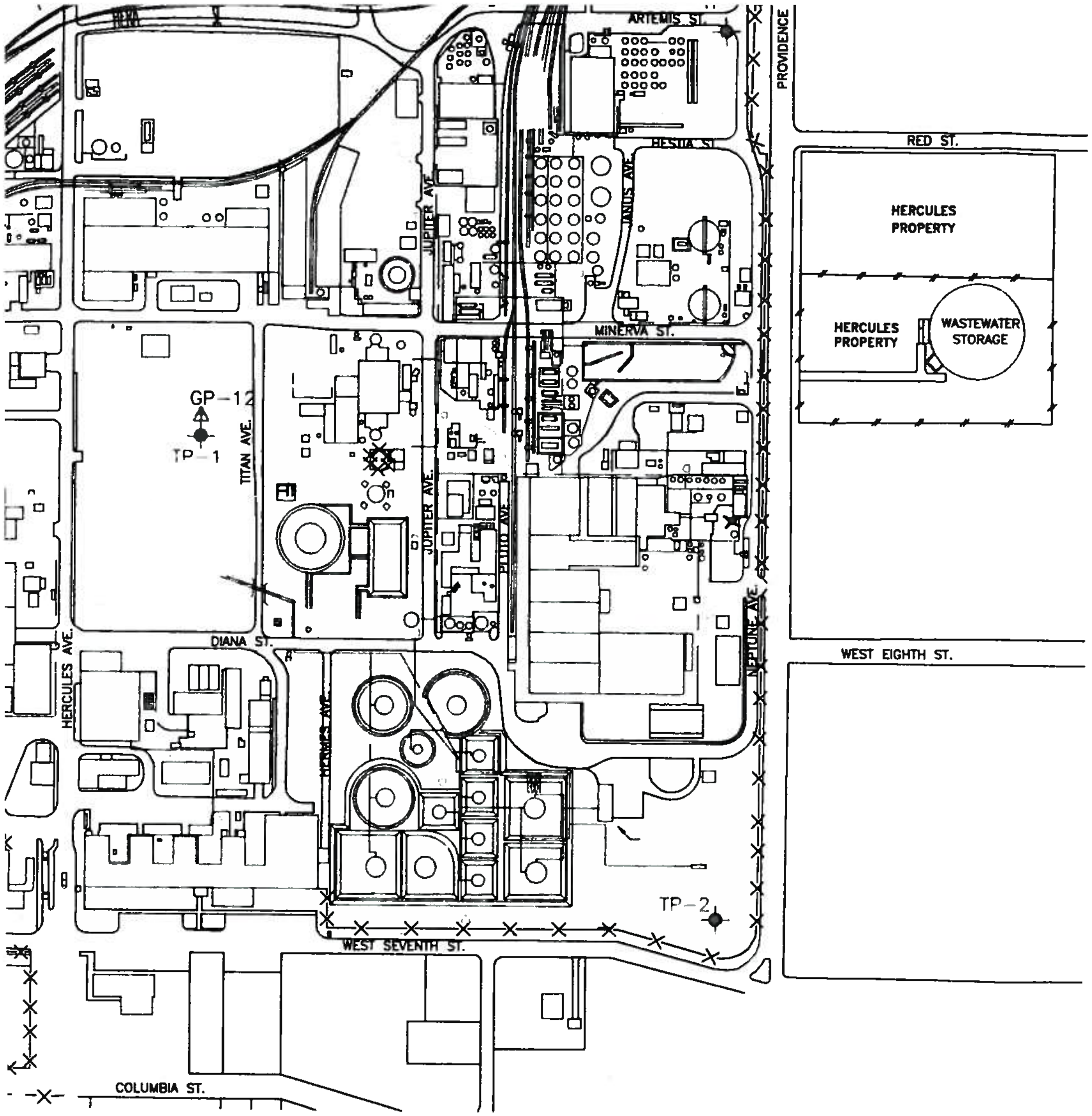
LEGEND

	GEOTECHNICAL BORING AND IDENTIFICATION
EB-1	STRATIGRAPHIC BORING AND IDENTIFICATION
	STAFF GAUGE LOCATION AND IDENTIFICATION
MW-4	EXISTING GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
TP-12	PIEZOMETER LOCATION AND IDENTIFICATION
	CREEK MEDIA SAMPLING POINT LOCATION AND IDENTIFICATION
GP-10	GEOPROBE SAMPLING LOCATION AND IDENTIFICATION
	APPROXIMATE PROPERTY BOUNDARY
	INTERMITTENT DRAINAGE DITCH
	APPROXIMATE BOUNDARY OF FORMER LANDFILL AREA

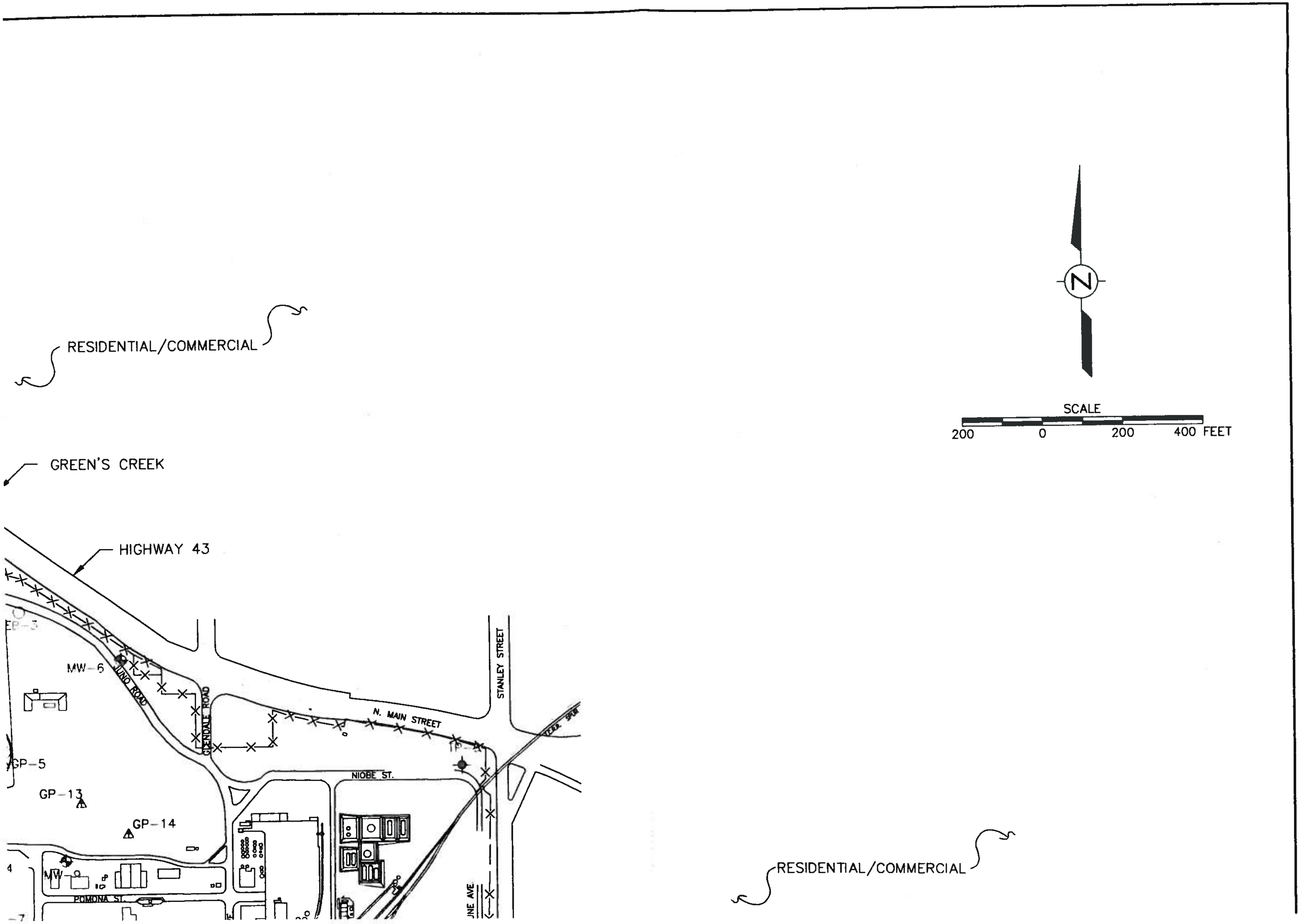
NOTES

1. BASE MAP PROVIDED BY HERCULES, INCORPORATED

0	
REV.	



10/14/03 CURRENT DATE	**HERCULES** *CHEMICAL SPECIALTIES*	SCALE: 1"=200' DRAWN: PHILLIPS CHECKED: REVIEWED: 10/14/03 PROJECT MANAGER: C. CONEY DATE: 10/14/03	**Eco·Systems, Inc.** *Consultants, Engineers and Scientists* *Jackson, MS • Mobile, AL • Houston, TX*	FIGURE 2 SITE PLAN SHOWING DATA POINT LOCATIONS HERCULES INCORPORATED HATTIESBURG, MISSISSIPPI	PROJECT No. HER24100 CAD FILE NAME LANDFILL-FIGURE2.dwg FIGURE 2	REVISION 0


RESIDENTIAL/COMMERCIAL
GREEN'S CREEK
HIGHWAY 43
MW-6
JUNO ROAD
GLENDALE ROAD
N. MAIN STREET
STANLEY STREET
NIOBE ST.
GP-5
GP-13
GP-14
POMONA ST.
JUNE AVE
RESIDENTIAL/COMMERCIAL
N
SCALE
200
0
200
400 FEET