

**STATE OF WASHINGTON  
DEPARTMENT OF ECOLOGY**

In the Matter of Remedial Action by:

The City of Richland

AGREED ORDER

No. DE 13717

TO: Ms. Heather Kintzley,  
Richland City Attorney  
975 George Washington Way  
Richland, WA 99352

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## I. INTRODUCTION

The mutual objective of the State of Washington, Department of Ecology (Ecology) and the City of Richland (City) under this Agreed Order (Order) is to provide for remedial action at a facility where there has been a release or threatened release of hazardous substances. This Order requires the City to conduct a Remedial Investigation to determine the nature and extent of contamination and to prepare and submit a Remedial Investigation and Feasibility Study (RI/FS) Report. Ecology believes the actions required by this Order are in the public interest.

## II. JURISDICTION

This Agreed Order is issued pursuant to the Model Toxics Control Act (MTCA), RCW 70.105D.050(1).

## III. PARTIES BOUND

This Agreed Order shall apply to and be binding upon the Parties to this Order, their successors and assigns. The undersigned representative of each party hereby certifies that he or she is fully authorized to enter into this Order and to execute and legally bind such party to comply with this Order. The City agrees to undertake all actions required by the terms and conditions of this Order. No change in ownership or corporate status shall alter the City's responsibility under this Order. The City shall provide a copy of this Order to all agents, contractors, and subcontractors retained to perform work required by this Order, and shall ensure that all work undertaken by such agents, contractors, and subcontractors complies with this Order.

## IV. DEFINITIONS

Unless otherwise specified herein, the definitions set forth in RCW 70.105D and WAC 173-340 shall control the meanings of the terms in this Order.

A. Site: The Site is referred to as the Richland Horn Rapids Landfill. The Site constitutes a facility under RCW 70.105D.020(8). The Site is defined by where a hazardous substance, other than a consumer product in consumer use, has been deposited, stored, disposed of, placed, or otherwise come to be located. Based upon factors currently known to Ecology, the

Site is generally located at 3102 Twin Bridges Road, Richland, WA, 99352, as shown in the Site Location Diagram (Exhibit A).

B. Parties: Refers to the State of Washington, Department of Ecology (Ecology) and the City of Richland (City).

C. Potentially Liable Person (PLP): Refers to the City.

D. Agreed Order or Order: Refers to this Order and each of the exhibits to this Order.

All exhibits are integral and enforceable parts of this Order. The terms “Agreed Order” or “Order” shall include all exhibits to this Order.

#### V. FINDINGS OF FACT

Ecology makes the following findings of fact, without any express or implied admissions of such facts by the City:

- A. The Site is generally located at 3102 Twin Bridges Road, Richland, WA, 99352, Benton County Assessor’s Parcel Number 117083000001001. The Site as depicted in Exhibit A is owned by the City.
- B. The City of Richland Public Works Department operates a 46-acre municipal solid waste landfill at the Site (Landfill). The Landfill began receiving waste in 1974. The Landfill is permitted by Benton-Franklin Health District (Permit No. BFHD 16-17 MSWLF).
- C. In 1987, the City installed four groundwater monitoring wells (MW-1, MW-2, MW-3, and MW-4) at the Site. MW-1 was installed upgradient from the Landfill, along the western boundary of the Landfill. MW-2, MW-3, and MW-4 were installed approximately 2,800 feet downgradient from the Landfill, along the eastern boundary of the Landfill. The City began conducting groundwater monitoring pursuant to WAC 173-304-490.
- D. In 1998, the City installed two additional groundwater monitoring wells (MW-5, MW-6) along the eastern boundary of the Landfill. Groundwater contamination was identified in both wells, and the City continued conducting groundwater

monitoring. Contaminants present in the wells above the WAC 173-200-040 Groundwater Quality Criteria include the following volatile organic compounds (VOCs): perchloroethylene (PCE), trichloroethene (TCE), and vinyl chloride (VC).

- E. On May 18, 1999, Benton-Franklin Health District (BFHD) approved the *Closure and Post-Closure Plan for the Horn Rapids Landfill* that was prepared by EMCON for the City of Richland (Landfill Closure Plan).
- F. By letter dated February 18, 2000, the City notified BFHD and Ecology that statistically significant increases in groundwater contaminants were confirmed during monitoring activities and that the increase in concentration would be addressed through a formal corrective action process under MTCA.
- G. Ecology sent the City an Early Notice letter on March 6, 2000. The Richland Horn Rapids Landfill was placed on Ecology's Known or Suspected Contaminated Sites list for groundwater contamination. (Facility/Site No. 308)
- H. The City chose to conduct a MTCA independent cleanup of the groundwater by performing a remedial investigation and feasibility study. The City submitted to Ecology the *Horn Rapids Landfill Remedial Investigation Work Plan* dated November 8, 2000.
  - a. In January 2001, as part of the initial remedial investigation, the City installed four groundwater monitoring wells (MW-7, MW-8, MW-9, MW-10). MW-7 was installed on the northern boundary of the Landfill; MW-8 and MW-9 were installed along the southern boundary of the Site; and MW-10 was installed along the eastern boundary of the Landfill. Groundwater contamination was detected in all four of these wells and was above Groundwater Quality Criteria in all wells except MW-8. No additional wells have been installed to establish the full nature and extent of contamination at the Site.

- b. In May 2010, the City installed an additional upgradient groundwater monitoring well (MW-11) to provide background groundwater quality data.
  - c. *Phase 2 Remedial Investigation Report, Horn Rapids Landfill, Richland WA*, dated April 2, 2004, was prepared for the City by Shaw Environmental & Infrastructure, Inc. (Shaw), and submitted to Ecology. In August 2003, Shaw installed a nested gas probe near MW-6 along the eastern boundary of the Landfill to determine if landfill gas was impacting groundwater quality. The report concluded that landfill gas was likely impacting groundwater quality and recommended performing a pilot landfill gas extraction test.
  - d. In August 2004, Shaw conducted a pilot-scale landfill gas extraction test at the Landfill. Shaw's May 25, 2005, letter report concluded that the test was effective at removing VOCs from the subsurface before gas migrates and impacts groundwater.
- I. The City chose to close the west 18 acres of the Landfill and construct the Site's Landfill Gas Control System (LFGCS) as an independent remedial action under MTCA.
- a. In August 2005, Parametrix prepared for the City a *Draft Horn Rapids Landfill, Landfill Gas Control System (LFGCS), Preliminary Design, Technical Memorandum*. This memorandum presents the design and cost of constructing a LFGCS in 2005 dollars.
  - b. In August 2006, the City submitted an Addendum to the Landfill Closure Plan. BFHD approved the revised Landfill Closure Plan in September 2006.
  - c. On December 3, 2008, the City submitted a second revised Landfill Closure Plan that incorporated the revisions requested by Ecology.

Additional comments were provided by BFHD and Ecology on March 9, 2009, and Parametrix responded on April 1, 2009.

- d. The LFGCS is being implemented in two phases as part of Landfill closure.
  - i. Phase 1: In 2011, the western portion of the permitted area of the landfill was closed as described in *Horn Rapids Landfill Contract Documents and Specifications, Phase 1 Closure Project Contract SB 11-01PW, and Horn Rapids Landfill Phase 1 Closure Construction Quality Assurance Report*, reports prepared by Parametrix for the City. The City has continuously operated the LFGCS since September 2011. The system has successfully reduced the landfill gas source of contamination along the southern boundary.
  - ii. Phase 2: The eastern portion of the permitted area is currently being filled to grade, and closure is expected to occur in 2020. The combination of the landfill cover system and the LFGCS are expected to reduce volatile organic compounds and other inorganic parameters in groundwater.
- J. The *Horn Rapids Landfill Environmental Monitoring Report* for 2015, dated March 2016, identifies the following VOCs as still present in groundwater wells located downgradient of the Landfill in concentrations above Groundwater Quality Standards (WAC 173-200): 1,1-Dichloroethane; 1,2-Dichloroethane; PCE; TCE; and VC. Cleanup levels for the Site have not been selected.

## VI. ECOLOGY DETERMINATIONS

Ecology makes the following determinations, without any express or implied admissions of such determinations (and underlying facts) by the City.

A. The City is an “owner or operator” as defined in RCW 70.105D.020(22) of a “facility” as defined in RCW 70.105D.020(8).

B. Based upon all factors known to Ecology, a “release” or “threatened release” of “hazardous substance(s)” as defined in RCW 70.105D.020(32) and (13), respectively, has occurred at the Site.

C. Based upon credible evidence, Ecology issued a PLP status letter to the City dated March 22, 2016, pursuant to RCW 70.105D.040, .020(26), and WAC 173-340-500. By letter dated April 19, 2016, the City voluntarily waived its rights to notice and comment and accepted Ecology’s determination that the City is a PLP under RCW 70.105D.040.

D. Pursuant to RCW 70.105D.030(1) and .050(1), Ecology may require PLPs to investigate or conduct other remedial actions with respect to any release or threatened release of hazardous substances, whenever it believes such action to be in the public interest. Based on the foregoing facts, Ecology believes the remedial actions required by this Order are in the public interest.

E. Under WAC 173-340-430, an interim action is a remedial action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance, that corrects a problem that may become substantially worse or cost substantially more to address if the remedial action is delayed, or that is needed to provide for completion of a site hazard assessment, RI/FS, or design of a cleanup action plan. Either party may propose an interim action under this Order. If the Parties are in agreement concerning the interim action, the Parties will follow the process in Section VII.E (Work to Be Performed). If the Parties are not in agreement, Ecology reserves its authority to require interim action(s) under a separate order or other enforcement action under RCW 70.105D, or to undertake the interim action itself.

F. Ecology hereby incorporates into this Order the previous independent remedial actions described in Sections V.H and V.I (Findings of Fact). With regards to the costs incurred by the City in performing these independent remedial actions, Ecology has determined that

(1) the work performed complies with the substantive requirements of WAC 173-340; (2) the work performed is consistent with the remedial actions required under this Order; and (3) the City's retroactive costs are eligible for partial reimbursement under WAC 173-322A-320(6). Reimbursement of the City's retroactive costs will be contingent upon Ecology's funding capacity and the competitive allocation of funds. The costs associated with Ecology's determination of the City's eligibility for partial reimbursement under WAC 173-322A-320(6) are recoverable under this Order and are included in the sum described below in Section VIII.A (Payment of Remedial Action Costs).

## **VII. WORK TO BE PERFORMED**

Based on the Findings of Fact and Ecology Determinations, it is hereby ordered that the City take the following remedial actions at the Site and that these actions be conducted in accordance with WAC 173-340 unless otherwise specifically provided for herein:

A. The City has prepared a Remedial Investigation (RI) Work Plan to identify the nature and extent of groundwater contamination at the southern and southeastern boundaries of the Site. The RI Work Plan was approved by Ecology by letter dated April 28, 2017, and is attached as Exhibit C to this Order. The RI Work Plan includes a sampling and analysis plan, quality assurance/quality control (QA/QC) plan, and health and safety plan. The RI Work Plan also includes a reporting mechanism to inform Ecology of analytical results to ensure Ecology agrees with each subsequent characterization step.

B. The City will also prepare a Remedial Investigation and Feasibility Study (RI/FS) Report. The Draft RI/FS Report will be submitted to Ecology within ninety (90) days of field work completion. A Final RI/FS Report will be submitted to Ecology within ninety (90) days of the City's receipt of Ecology's comments.

C. All plans or other deliverables submitted by the City for Ecology's review and approval under the Schedule (Exhibit B) shall, upon Ecology's approval, become integral and enforceable parts of this Order.



D. If the Parties agree on an interim action under Section VI.E (Ecology Determinations), the City shall prepare and submit to Ecology an Interim Action Work Plan, including a scope of work and schedule, by the date determined by Ecology. Ecology will provide public notice and opportunity to comment on the Interim Action Work Plan in accordance with WAC 173-340-600(16). The City shall not conduct the interim action until Ecology approves the Interim Action Work Plan. Upon approval by Ecology, the Interim Action Work Plan becomes an integral and enforceable part of this Order, and the City is required to conduct the interim action in accordance with the approved Interim Action Work Plan.

E. If Ecology determines that the City has failed to make sufficient progress or failed to implement the remedial action, in whole or in part, Ecology may, after notice to the City, perform any or all portions of the remedial action or at Ecology's discretion allow the City opportunity to correct. The City shall reimburse Ecology for the costs of doing such work in accordance with Section VIII.A (Remedial Action Costs). Ecology reserves the right to enforce requirements of this Order under Section X (Enforcement).

F. Except where necessary to abate an emergency situation, the City shall not perform any remedial actions at the Site outside those remedial actions required by this Order, unless Ecology concurs, in writing, with such additional remedial actions.

### **VIII. TERMS AND CONDITIONS**

#### **A. Payment of Remedial Action Costs**

The City shall pay to Ecology costs incurred by Ecology pursuant to this Order and consistent with WAC 173-340-550(2). These costs shall include work performed by Ecology or its contractors for, or on, the Site under RCW 70.105D, including remedial actions and Order preparation, negotiation, oversight, and administration. These costs shall include work performed both prior to and subsequent to the issuance of this Order. Ecology's costs shall include costs of direct activities and support costs of direct activities as defined in WAC 173-340-550(2). Ecology has accumulated \$5,080.92 in remedial action costs related to this Site as of March 31, 2017. For all Ecology costs incurred, the City shall pay the required amount within

thirty (30) days of receiving from Ecology an itemized statement of costs that includes a summary of costs incurred, an identification of involved staff, and the amount of time spent by involved staff members on the project. A general statement of work performed will be provided upon request. Itemized statements shall be prepared quarterly. Pursuant to WAC 173-340-550(4), failure to pay Ecology's costs within ninety (90) days of receipt of the itemized statement of costs will result in interest charges at the rate of twelve percent (12%) per annum, compounded monthly.

In addition to other available relief, pursuant to RCW 19.16.500, Ecology may utilize a collection agency and/or, pursuant to RCW 70.105D.055, file a lien against real property subject to the remedial actions to recover unreimbursed remedial action costs.

**B. Designated Project Coordinators**

The project coordinator for Ecology is:

Patricia Shanley  
Department of Ecology  
Waste 2 Resources  
1250 West Alder St.  
Union Gap, WA 98903  
(509) 454-7293

The project coordinator for the City is:

Pete Rogalsky  
City of Richland  
Public Works Department  
840 Northgate Dr.  
Richland, WA 99352  
(509) 942-7500

Each project coordinator shall be responsible for overseeing the implementation of this Order. Ecology's project coordinator will be Ecology's designated representative for the Site. To the maximum extent possible, communications between Ecology and the City, and all documents, including reports, approvals, and other correspondence concerning the activities performed pursuant to the terms and conditions of this Order shall be directed through the project

coordinators. The project coordinators may designate, in writing, working level staff contacts for all or portions of the implementation of the work to be performed required by this Order.

Any party may change its respective project coordinator. Written notification shall be given to the other party at least ten (10) calendar days prior to the change.

**C. Performance**

All geologic and hydrogeologic work performed pursuant to this Order shall be under the supervision and direction of a geologist or hydrogeologist licensed by the State of Washington or under the direct supervision of an engineer registered by the State of Washington, except as otherwise provided for by RCW 18.43 and 18.220.

All engineering work performed pursuant to this Order shall be under the direct supervision of a professional engineer registered by the State of Washington, except as otherwise provided for by RCW 18.43.130.

All construction work performed pursuant to this Order shall be under the direct supervision of a professional engineer or a qualified technician under the direct supervision of a professional engineer. The professional engineer must be registered by the State of Washington, except as otherwise provided for by RCW 18.43.130.

Any documents submitted containing geologic, hydrologic, or engineering work shall be under the seal of an appropriately licensed professional as required by RCW 18.43 and 18.220.

The City shall notify Ecology in writing of the identity of any engineer(s) and geologist(s), contractor(s) and subcontractor(s), and others to be used in carrying out the terms of this Order, in advance of their involvement at the Site.

**D. Access**

Ecology or any Ecology authorized representative shall have access to enter and freely move about all property at the Site that the City either owns, controls, or has access rights to at all reasonable times for the purposes of, *inter alia*: inspecting records, operation logs, and contracts related to the work being performed pursuant to this Order; reviewing the City's progress in carrying out the terms of this Order; conducting such tests or collecting such samples

as Ecology may deem necessary; using a camera, sound recording, or other documentary-type equipment to record work done pursuant to this Order; and verifying the data submitted to Ecology by the City. The City shall make all reasonable efforts to secure access rights for those properties within the Site not owned or controlled by the City where remedial activities or investigations will be performed pursuant to this Order. Ecology or any Ecology authorized representative shall give reasonable notice before entering any Site property owned or controlled by the City unless an emergency prevents such notice. All persons who access the Site pursuant to this section shall comply with any applicable health and safety plan(s). Ecology employees and their representatives shall not be required to sign any liability release or waiver as a condition of Site property access.

**E. Sampling, Data Submittal, and Availability**

With respect to the implementation of this Order, the City shall make the results of all sampling, laboratory reports, and/or test results generated by it or on its behalf available to Ecology. Pursuant to WAC 173-340-840(5), all sampling data shall be submitted to Ecology in both printed and electronic formats in accordance with Section VII (Work to be Performed), Ecology's Toxics Cleanup Program Policy 840 (Data Submittal Requirements), and/or any subsequent procedures specified by Ecology for data submittal.

If requested by Ecology, the City shall allow Ecology and/or its authorized representative to take split or duplicate samples of any samples collected by the City pursuant to implementation of this Order. The City shall notify Ecology seven (7) days in advance of any sample collection or work activity at the Site. Ecology shall, upon request, allow the City and/or its authorized representative to take split or duplicate samples of any samples collected by Ecology pursuant to the implementation of this Order, provided that doing so does not interfere with Ecology's sampling. Without limitation on Ecology's rights under Section VIII.D (Access), Ecology shall notify the City prior to any sample collection activity unless an emergency prevents such notice.

In accordance with WAC 173-340-830(2)(a), all hazardous substance analyses shall be conducted by a laboratory accredited under WAC 173-50 for the specific analyses to be conducted, unless otherwise approved by Ecology.

**F. Public Participation**

RCW 70.105D.030(2)(a) requires that, at a minimum, this Order be subject to concurrent public notice. Ecology shall be responsible for providing this public notice and reserves the right to modify or withdraw any provisions of this Order should public comment disclose facts or considerations which indicate to Ecology that this Order is inadequate or improper in any respect.

A Public Participation Plan is required for this Site. Ecology shall review any existing Public Participation Plan to determine its continued appropriateness and whether it requires amendment, or if no plan exists, Ecology shall develop a Public Participation Plan alone or in conjunction with the City.

Ecology shall maintain the responsibility for public participation at the Site. However, the City shall cooperate with Ecology, and shall:

1. If agreed to by Ecology, develop appropriate mailing lists and prepare drafts of public notices and fact sheets at important stages of the remedial action, such as the submission of work plans, RI/FS reports, cleanup action plans, and engineering design reports. As appropriate, Ecology will edit, finalize, and distribute such fact sheets and prepare and distribute public notices of Ecology's presentations and meetings.

2. Notify Ecology's project coordinator prior to the preparation of all press releases and fact sheets, and before meetings related to remedial action work to be performed at the Site with the interested public and/or local governments. Likewise, Ecology shall notify the City prior to the issuance of all press releases and fact sheets related to the Site, and before meetings related to the Site with the interested public and/or local governments. For all press releases, fact sheets, meetings, and other outreach efforts by the City that do not receive prior Ecology approval, the City shall clearly

indicate to its audience that the press release, fact sheet, meeting, or other outreach effort was not sponsored or endorsed by Ecology.

3. When requested by Ecology, participate in public presentations on the progress of the remedial action at the Site. Participation may be through attendance at public meetings to assist in answering questions or as a presenter.

4. When requested by Ecology, arrange and/or continue information repositories to be located at the following locations:

- a. Benton Franklin Health District  
7102 W Okanogan Pl.  
Kennewick, WA 99336
- b. Richland Public Library  
955 Northgate Dr.  
Richland, WA 99352

At a minimum, copies of all public notices, fact sheets, and documents relating to public comment periods shall be promptly placed in these repositories. A copy of all documents related to this Site shall be maintained in the repository at Ecology's Central Regional Office in Union Gap, Washington.

#### **G. Retention of Records**

During the pendency of this Order, and for ten (10) years from the date of completion of work performed pursuant to this Order, the City shall preserve all records, reports, documents, and underlying data in its possession relevant to the implementation of this Order and shall insert a similar record retention requirement into all contracts with project contractors and subcontractors. Upon request of Ecology, the City shall make all records available to Ecology and allow access for review within a reasonable time.

Nothing in this Order is intended to waive any right the City may have under applicable law to limit disclosure of documents protected by the attorney work product privilege and/or the attorney-client privilege. If the City withholds any requested records based on an assertion of privilege, the City shall provide Ecology with a privilege log specifying the records withheld and

the applicable privilege. No Site-related data collected pursuant to this Order shall be considered privileged.

#### **H. Resolution of Disputes**

1. In the event that the City elects to invoke dispute resolution the City must utilize the procedure set forth below.

a. Upon the triggering event (receipt of Ecology's project coordinator's written decision or an itemized billing statement), the City has fourteen (14) calendar days within which to notify Ecology's project coordinator in writing of its dispute (Informal Dispute Notice).

b. The Parties' project coordinators shall then confer in an effort to resolve the dispute informally. The parties shall informally confer for up to fourteen (14) calendar days from receipt of the Informal Dispute Notice. If the project coordinators cannot resolve the dispute within those 14 calendar days, then within seven (7) calendar days Ecology's project coordinator shall issue a written decision (Informal Dispute Decision) stating: the nature of the dispute; the City's position with regards to the dispute; Ecology's position with regards to the dispute; and the extent of resolution reached by informal discussion.

c. The City may then request regional management review of the dispute. This request (Formal Dispute Notice) must be submitted in writing to the CRO Region Waste 2 Resources Section Manager within seven (7) calendar days of receipt of Ecology's Informal Dispute Decision. The Formal Dispute Notice shall include a written statement of dispute setting forth: the nature of the dispute; the disputing Party's position with respect to the dispute; and the information relied upon to support its position.

d. The Section Manager shall conduct a review of the dispute and shall issue a written decision regarding the dispute (Decision on Dispute) within thirty (30) calendar days of receipt of the Formal Dispute Notice. The Decision on Dispute shall be Ecology's final decision on the disputed matter.

2. The Parties agree to only utilize the dispute resolution process in good faith and agree to expedite, to the extent possible, the dispute resolution process whenever it is used.

3. Implementation of these dispute resolution procedures shall not provide a basis for delay of any activities required in this Order, unless Ecology agrees in writing to a schedule extension.

4. In case of a dispute, failure to either proceed with the work required by this Order or timely invoke dispute resolution may result in Ecology's determination that insufficient progress is being made in preparation of a deliverable, and may result in Ecology undertaking the work under Section VII (Work to be Performed) or initiating enforcement under Section X (Enforcement).

**I. Extension of Schedule**

1. The City's request for an extension of schedule shall be granted only when a request for an extension is submitted in a timely fashion, generally at least thirty (30) days prior to expiration of the deadline for which the extension is requested, and good cause exists for granting the extension. All extensions shall be requested in writing. The request shall specify:

- a. The deadline that is sought to be extended;
- b. The length of the extension sought;
- c. The reason(s) for the extension; and
- d. Any related deadline or schedule that would be affected if the extension were granted.

2. The burden shall be on the City to demonstrate to the satisfaction of Ecology that the request for such extension has been submitted in a timely fashion and that good cause exists for granting the extension. Good cause may include, but may not be limited to:

- a. Circumstances beyond the reasonable control and despite the due diligence of the City including delays caused by unrelated third parties or Ecology, such as (but not limited to) delays by Ecology in reviewing, approving, or modifying documents submitted by the City;



b. Acts of God, including fire, flood, blizzard, extreme temperatures, storm, or other unavoidable casualty; or

c. Endangerment as described in Section VIII.K (Endangerment).

However, neither increased costs of performance of the terms of this Order nor changed economic circumstances shall be considered circumstances beyond the reasonable control of the City.

3. Ecology shall act upon any written request for extension in a timely fashion. Ecology shall give the City written notification of any extensions granted pursuant to this Order. A requested extension shall not be effective until approved by Ecology. Unless the extension is a substantial change, it shall not be necessary to amend this Order pursuant to Section VIII.J (Amendment of Order) when a schedule extension is granted.

4. An extension shall only be granted for such period of time as Ecology determines is reasonable under the circumstances. Ecology may grant schedule extensions exceeding ninety (90) days only as a result of:

a. Delays in the issuance of a necessary permit which was applied for in a timely manner;

b. Other circumstances deemed exceptional or extraordinary by Ecology; or

c. Endangerment as described in Section VIII.K (Endangerment).

#### **J. Amendment of Order**

The project coordinators may verbally agree to minor changes to the work to be performed without formally amending this Order. Minor changes will be documented in writing by Ecology within seven (7) days of verbal agreement.

Except as provided in Section VIII.L (Reservation of Rights), substantial changes to the work to be performed shall require formal amendment of this Order. This Order may only be formally amended by the written consent of both Ecology and the City. Ecology will provide its consent to a formal amendment only after public notice and opportunity to comment on the formal amendment.

When requesting a change to the Order, the City shall submit a written request to Ecology for approval. Ecology shall indicate its approval or disapproval in writing and in a timely manner after the written request is received. If the change is a substantial, then the Order must be formally amended. Reasons for the disapproval of a proposed change to this Order shall be stated in writing. If Ecology does not agree to a proposed change, the disagreement may be addressed through the dispute resolution procedures described in Section VIII.H (Resolution of Disputes).

**K. Endangerment**

In the event Ecology determines that any activity being performed at the Site under this Order is creating or has the potential to create a danger to human health or the environment on or surrounding the Site, Ecology may direct the City to cease such activities for such period of time as it deems necessary to abate the danger. The City shall immediately comply with such direction.

In the event the City determines that any activity being performed at the Site under this Order is creating or has the potential to create a danger to human health or the environment, the City may cease such activities. The City shall notify Ecology's project coordinator as soon as possible, but no later than twenty-four (24) hours after making such determination or ceasing such activities. Upon Ecology's direction, the City shall provide Ecology with documentation of the basis for the determination or cessation of such activities. If Ecology disagrees with the City's cessation of activities, it may direct the City to resume such activities.

If Ecology concurs with or orders a work stoppage pursuant to this section, the City's obligations with respect to the ceased activities shall be suspended until Ecology determines the danger is abated, and the time for performance of such activities, as well as the time for any other work dependent upon such activities, shall be extended in accordance with Section VIII.I (Extension of Schedule) for such period of time as Ecology determines is reasonable under the circumstances.

Nothing in this Order shall limit the authority of Ecology, its employees, agents, or contractors to take or require appropriate action in the event of an emergency.

**L. Reservation of Rights**

This Order is not a settlement under RCW 70.105D. Ecology's signature on this Order in no way constitutes a covenant not to sue or a compromise of any of Ecology's rights or authority. Ecology will not, however, bring an action against the City to recover remedial action costs paid to and received by Ecology under this Order. In addition, Ecology will not take additional enforcement actions against the City regarding remedial actions required by this Order, provided the City complies with this Order.

Ecology nevertheless reserves its rights under RCW 70.105D, including the right to require additional or different remedial actions at the Site should it deem such actions necessary to protect human health and the environment, and to issue orders requiring such remedial actions. Ecology also reserves all rights regarding the injury to, destruction of, or loss of natural resources resulting from the release or threatened release of hazardous substances at the Site.

By entering into this Order, the City does not admit to any liability for the Site. Although the City is committing to conducting the work required by this Order under the terms of this Order, the City expressly reserves all rights available under law, including but not limited to the right to seek cost recovery or contribution against third parties, and the right to assert any defenses to liability in the event of enforcement.

**M. Transfer of Interest in Property**

No voluntary conveyance or relinquishment of title, easement, leasehold, or other interest in any portion of the Site shall be consummated by the City without provision for continued implementation of all requirements of this Order and implementation of any remedial actions found to be necessary as a result of this Order.

Prior to the City's transfer of any interest in all or any portion of the Site, and during the effective period of this Order, the City shall provide a copy of this Order to any prospective purchaser, lessee, transferee, assignee, or other successor in said interest; and, at least thirty (30) days prior to any transfer, the City shall notify Ecology of said transfer. Upon transfer of any

interest, the City shall notify all transferees of the restrictions on the activities and uses of the property under this Order and incorporate any such use restrictions into the transfer documents.

**N. Compliance With Applicable Laws**

1. All actions carried out by the City pursuant to this Order shall be done in accordance with all applicable federal, state, and local requirements, including requirements to obtain necessary permits or approvals, except as provided in RCW 70.105D.090. At this time, no federal, state, or local requirements have been identified as being applicable to the actions required by this Order. The City has a continuing obligation to identify additional applicable federal, state, and local requirements which apply to actions carried out pursuant to this Order, and to comply with those requirements. As additional federal, state, and local requirements are identified, Ecology will document in writing if they are applicable to actions carried out pursuant to this Order.

2. All actions carried out by the City pursuant to this Order shall be done in accordance with relevant and appropriate requirements identified by Ecology. At this time, no relevant and appropriate requirements have been identified as being applicable to the actions required by this Order. If additional relevant and appropriate requirements are identified, Ecology will document in writing if they are applicable to actions carried out pursuant to this Order.

3. Pursuant to RCW 70.105D.090(1), the City is exempt from the procedural requirements of RCW 70.94, 70.95, 70.105, 77.55, 90.48, and 90.58 and of any laws requiring or authorizing local government permits or approvals. However, the City shall comply with the substantive requirements of such permits or approvals. For permits and approvals covered under RCW 70.105D.090(1) which have been issued by local government, the Parties agree that Ecology has the ability under this Order to enforce those local government permits and/or approvals. At this time, no state or local permits or approvals have been identified as being applicable but procedurally exempt under this section.

4. The City has a continuing obligation to determine whether additional permits or approvals addressed in RCW 70.105D.090(1) would otherwise be required for the remedial action under this Order. In the event either Ecology or the City determines that additional permits or approvals addressed in RCW 70.105D.090(1) would otherwise be required for the remedial action under this Order, it shall promptly notify the other party of its determination. Ecology shall determine whether Ecology or the City shall be responsible to contact the appropriate state and/or local agencies. If Ecology so requires, the City shall promptly consult with the appropriate state and/or local agencies and provide Ecology with written documentation from those agencies of the substantive requirements those agencies believe are applicable to the remedial action. Ecology shall make the final determination on the additional substantive requirements that must be met by the City and on how the City must meet those requirements. Ecology shall inform the City in writing of these requirements. Once established by Ecology, the additional requirements shall be enforceable requirements of this Order. The City shall not begin or continue the remedial action potentially subject to the additional requirements until Ecology makes its final determination.

Pursuant to RCW 70.105D.090(2), in the event Ecology determines that the exemption from complying with the procedural requirements of the laws referenced in RCW 70.105D.090(1) would result in the loss of approval from a federal agency that is necessary for the state to administer any federal law, the exemption shall not apply and the City shall comply with both the procedural and substantive requirements of the laws referenced in RCW 70.105D.090(1), including any requirements to obtain permits.

**O. Indemnification**

The City agrees to indemnify and save and hold the State of Washington, its employees, and agents harmless from any and all claims or causes of action (1) for death or injuries to persons, or (2) for loss or damage to property, to the extent arising from or on account of acts or omissions of the City, its officers, employees, agents, or contractors in entering into and implementing this Order. However, the City shall not indemnify the State of Washington nor

save nor hold its employees and agents harmless from any claims or causes of action to the extent arising out of the negligent acts or omissions of the State of Washington, or the employees or agents of the State, in entering into or implementing this Order.

**IX. SATISFACTION OF ORDER**

The provisions of this Order shall be deemed satisfied upon the City's receipt of written notification from Ecology that the City has completed the remedial activity required by this Order, as amended by any modifications, and that the City has complied with all other provisions of this Agreed Order.

**X. ENFORCEMENT**

Pursuant to RCW 70.105D.050, this Order may be enforced as follows:

A. The Attorney General may bring an action to enforce this Order in a state or federal court.

B. The Attorney General may seek, by filing an action, if necessary, to recover amounts spent by Ecology for investigative and remedial actions and orders related to the Site.

C. A liable party who refuses, without sufficient cause, to comply with any term of this Order will be liable for:

1. Up to three (3) times the amount of any costs incurred by the State of Washington as a result of its refusal to comply.

2. Civil penalties of up to twenty-five thousand dollars (\$25,000) per day for each day it refuses to comply.

D. This Order is not appealable to the Washington Pollution Control Hearings Board. This Order may be reviewed only as provided under RCW 70.105D.060.

Effective date of this Order: 07-09-2017 (52)

CITY OF RICHLAND



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CYNTHIA D. REENTS, ICMA-CM  
Richland City Manager  
Richland, WA

STATE OF WASHINGTON  
DEPARTMENT OF ECOLOGY



---

JAMES RIVARD  
Section Manager  
Waste 2 Resources  
Central Regional Office  
(509) 457-7123

ATTEST:



---

MARCIA HOPKINS  
Richland City Clerk

APPROVED AS TO FORM:



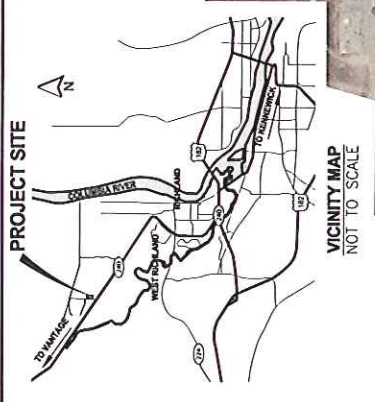
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HEATHER KINTZLEY  
Richland City Attorney

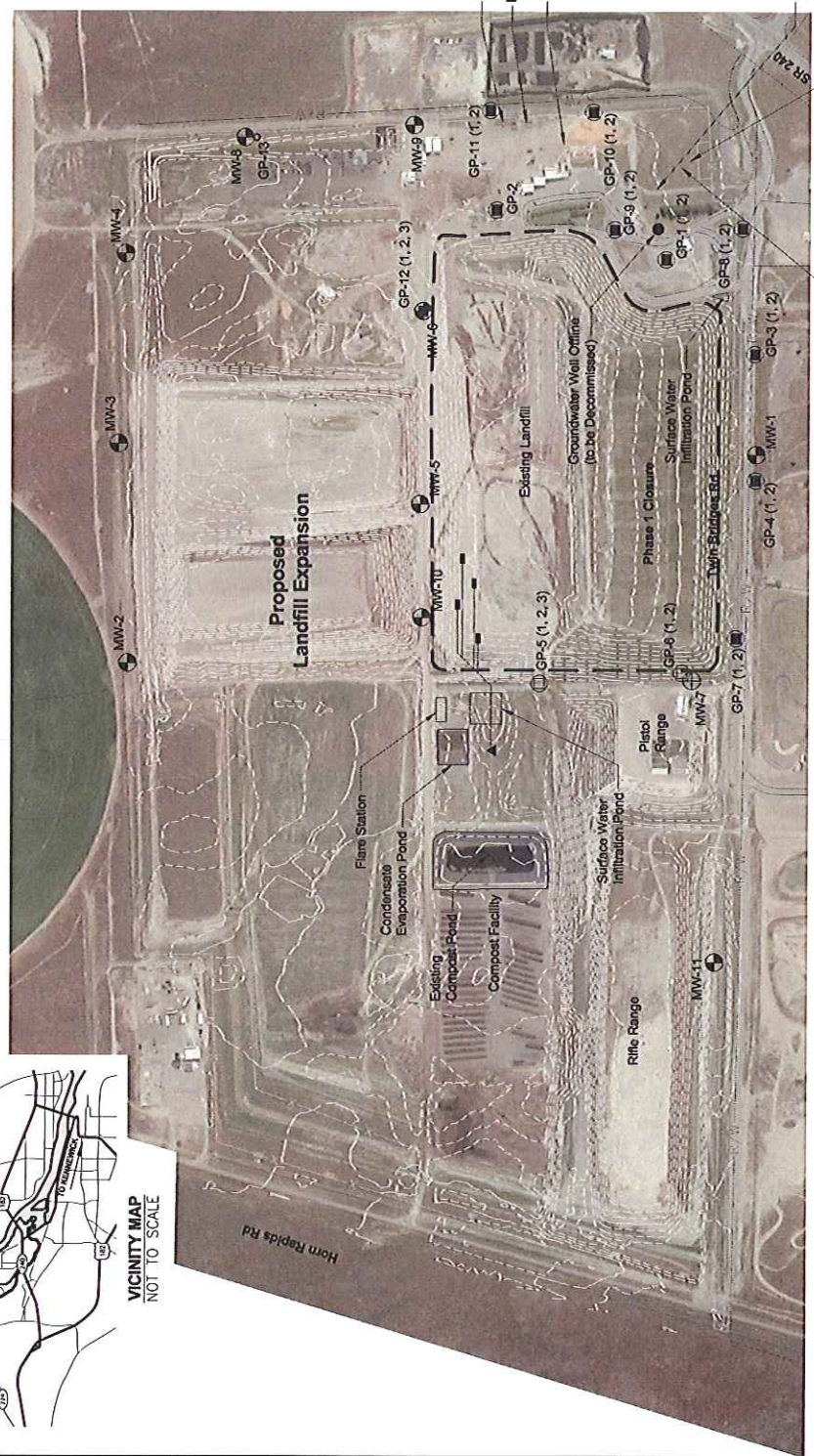
EXHIBIT A: Site Location Diagram







- LEGEND:**
- WATER SUPPLY WELL LOCATION
  - ⊕ EXISTING GROUNDWATER WELL LOCATION
  - ⊖ DECOMMISSIONED EXISTING GAS PROBE (1,2,3) WITH VARIABLE-DEPTH
  - ⊖ DECOMMISSIONED LYSIMETER PORT
  - ▲ LYSIMETER
  - LANDFILL BOUNDARY



**Exhibit A  
Horn Rapids Landfill  
Site Location Diagram**

Parametrix DATE: October 19, 2016 FILE: P10302004P0102760.SITE

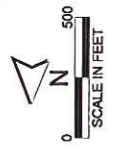


EXHIBIT B: Schedule

Draft RI/FS Report	90 days after field work completion
Final RI/FS Report	90 days after review of Ecology comments

EXHIBIT C: Remedial Investigation (RI) Work Plan

# Horn Rapids Landfill Remedial Investigation Work Plan

Prepared for  
City of Richland Public Works Department



February 2017

Prepared by  
**Parametrix**

# Horn Rapids Landfill Remedial Investigation Work Plan

*Prepared for*

**City of Richland Public Works Department**



840 Northgate Drive  
P.O. Box 190 MS-26  
Richland, WA 99352

*Prepared by*

**Parametrix**

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Seattle, WA 98104

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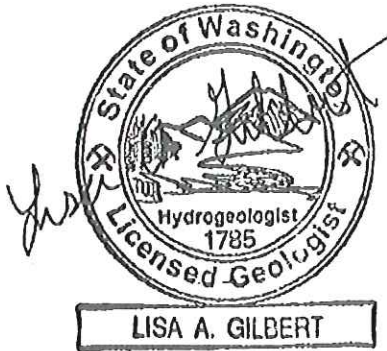
[www.parametrix.com](http://www.parametrix.com)

## CITATION

Parametrix. 2017. Horn Rapids Landfill  
Remedial Investigation Work Plan. Prepared by Parametrix,  
Seattle, WA. February 2017.


## CERTIFICATION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional hydrogeologist licensed to practice as such, is affixed below.



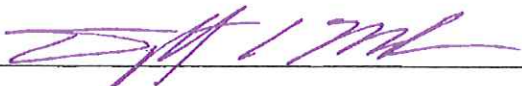
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Prepared by Lisa Gilbert, LHG



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Checked by Steve Emge, PE



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Approved by Dwight Miller, PE

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## ACRONYMS AND ABBREVIATIONS

BFHD	Benton-Franklin Health District
COCs	Chemicals of Concern
City	City of Richland
City Facility	275-acre permitted waste facility, including Landfill
City Property	Contiguous property owned by the City of Richland, including the City Facility (approximately 2,306 total acres)
DCA	Dichloroethane
DCE	Dichloroethene
DO	dissolved oxygen
Ecology	Washington Department of Ecology
Expansion	proposed 104-acre expansion of the Horn Rapids Landfill located within the City Facility east of the Landfill
GWQSS	groundwater quality standards (Chapter 173-200 WAC)
Landfill	46-acre permitted area where MSW has been placed within the City Facility
LFG	landfill gas
MCL	maximum contaminant level (Chapter 246-290 WAC)
MSW	municipal solid waste
MTCA	Model Toxics Control Act (Chapter 173-340 WAC)
ORP	oxidation-reduction potential
ORV	off-road vehicle
PCE	Tetrachloroethene
QAPP	Quality Assurance Project Plan
RI/FS	remedial investigation and feasibility study
TCE	Trichloroethene
TDS	Total Dissolved Solids
VC	Vinyl Chloride
VOCs	volatile organic compounds

# 1. INTRODUCTION

## 1.1 Objectives

This work plan is intended to be an exhibit to the anticipated Agreed Order to be entered into between the City of Richland (City) and the Washington State Department of Ecology (Ecology). The objective of the work plan is to define the investigation activities necessary to supplement existing data, fill remaining data gaps identified by the City and Ecology, and define the nature and extent of contamination at the Horn Rapids Landfill in accordance with Chapter 173-340 WAC, the Model Toxics Control Act (MTCA). This Work Plan was prepared in accordance with MTCA and its implementing regulations.

For the purposes of this work plan, the following terminology related to the Horn Rapids Landfill has been developed, as further described in Sections 1.2 and 1.3:

- City Facility: 275-acre permitted waste facility, including Landfill
- Landfill: 46-acre permitted area where municipal solid waste (MSW) has been placed within the City Facility
- City Property: Contiguous property owned by the City of Richland, including the City Facility (approximately 2,306 total acres)
- Expansion: proposed 104-acre expansion of the Horn Rapids Landfill located within the City Facility east of the Landfill

## 1.2 Horn Rapids Landfill Setting

The Horn Rapids Landfill is owned and operated by the City Public Works Department. It is located northwest of and within the City limits of Richland, Washington in an area bounded by Twin Bridges Road on the west, Horn Rapids Road on the north, and State Route 240 on the south.

The Horn Rapids Landfill is located within the southwest quadrant of a larger 275-acre parcel of City-owned property (City Facility, see Figure 1) that includes the 46-acre existing landfill (Landfill) permitted for disposal of MSW, a support facility, a 9-acre composting facility, and a moderate-risk hazardous waste receiving facility, which was destroyed by a fire in 2010.

As shown on Figure 1, the City also owns contiguous property (City Property) to the west, south and east of the City Facility (a total of approximately 2,306 total acres), with the exception of several small privately owned parcels, two located along the southwest corner of the City Facility, and one within the northeast corner of the City Facility. East of the City Facility are circle-irrigated agricultural fields used to grow alfalfa hay, corn, and potatoes. Irrigation water for these fields is obtained from the Columbia River and not from a groundwater source. Irrigated fields are also located west of the City Facility across State Highway 240. These fields have been in use since 1987, with irrigation occurring between the months of April and October (Shaw Environmental Inc. 2003). The remaining City Property south and southeast of the Landfill is undeveloped.

As shown on the Site Vicinity Map (Figure 2), the City Property immediately west of the City Facility has been developed as an off-road vehicle (ORV) park, which includes a road racing track and a motocross track facility. A portion of the ORV Park is designated as public facilities with restrooms and picnic areas.

The Site Plan (Figure 3) shows the City Facility Boundary, the Landfill and other City Facility features, and monitoring locations including gas probes, groundwater monitoring wells, and lysimeters. The area within the City Facility east of the currently permitted 46 acres is the proposed Horn Rapids Landfill Expansion (Expansion).

### 1.3 Landfill Description

The Landfill began receiving MSW in 1974. The Landfill historically accepted only municipal wastes and was initially developed by placing waste into a series of north-south oriented trenches in the Phase 1 western portion of the Landfill. The waste depths in the trenches ranged from 12 to 30 ft.

The Landfill (refuse) boundary is shown on Figure 3. Phase 1 (the western portion of the permitted area) was closed in 2011, including installation of a landfill gas (LFG) collection system. From 2005 to 2010, the Landfill was filled and graded to the proposed closure grading plan. During the 2011 construction season, Phase 1 closure was installed over the western portion of the Landfill, which included the installation of the active LFG system.

MSW is currently being accepted in Phase 2 of the permitted area, and closure of Phase 2 is expected to occur in 2020. The proposed 104-acre, Horn Rapids Landfill Expansion is located east of the currently permitted 46-acres. Engineering plans for the proposed Expansion are presented in the Preliminary Conceptual Engineering Report (Parametrix 2016a).

The City has operated a compost facility at the City Facility since 2010. The Compost Facility is situated on 9 acres just north of the Landfill, approximately 500 ft south of Horn Rapids Road, and was permitted under WAC 173-350-220, WAC 173-350-710, and WAC 173-350-715. The compost facility receives and processes regional municipal and commercial green waste materials and produces compost from acceptable materials such as vegetative yard or agricultural waste, wood waste, lawn clippings, sawdust, straw, manure, Class A biosolids, and compostable winery waste.

### 1.4 Regulatory History and Interim Actions

The Horn Rapids Landfill was originally permitted under Chapter 173-301 WAC, and currently operates under the Criteria for Municipal Solid Waste Landfills, Chapter 173-351 WAC and the current Solid Waste Permit (Permit) issued by the Benton-Franklin Health District (BFHD).

Concentrations of volatile organic compounds (VOCs) above MTCA cleanup levels were detected in new groundwater monitoring wells MW-5 and MW-6 (Shannon and Wilson, Inc. 1998). An Early Notice letter was submitted in March 2000, and the City Facility was placed on Ecology's Known or Suspected Contaminated Site List based on notification by the City that groundwater results were statistically elevated compared to background. The City Facility has been in assessment monitoring since that notification. The primary VOCs of concern in groundwater are chlorinated ethenes and ethanes.

In 2004 and 2005, the City performed an independent two-phased remedial investigation and a pilot study/feasibility study (RI/FS, Shaw Environmental, Inc. 2003, 2004, 2005). The RI determined that LFG is the likely source of the VOCs impacting groundwater. A LFG extraction system was designed (Parametrix 2005) based on pilot study results that showed LFG extraction would effectively remove VOCs from the subsurface, and closure including a LFG extraction system is being implemented in two phases (Parametrix 2011, 2012a, 2012b).

Between 2005 and 2010, Phase 1 (the western portion of the permitted area) of the landfill was filled and graded to approved closure grading plans (EMCON 1999; Parametrix 2006, 2008, 2011), and was closed in 2011 (Parametrix 2011, 2012a, 2012b) as an independent remedial action in accordance with Chapter 173-340 WAC. The Phase 1 closure included a final cover and gas collection system consisting of in-refuse wells, collection manifold and laterals, a condensate manhole, and a flare station. Vertical gas collection wells were installed as part of the Phase 1 landfill closure. The wells are typically spaced at 150 ft apart around the perimeter and 200 ft apart in the interior of the landfill. The gas collection system was started up in September 2011 to prevent subsurface LFG migration beyond the landfill perimeter and to remove VOCs from groundwater beneath the landfill. The collection system has operated 24 hours a day since startup. The applied vacuum from the permanent blower/flare facility produces a pressure gradient within the MSW that causes LFG to flow into the collection field rather than migrate.

Phase 2 (the eastern portion of the permitted area) is currently being filled to grade and closure is expected to occur in 2020. Additionally, since the RI/FS, quarterly environmental monitoring has been conducted in accordance with Chapter 173-351 WAC, including Assessment Monitoring, and the current Permit. Periodic monitoring that has been performed at the Landfill is described in more detail in section 1.5.

## 1.5 History of Environmental Monitoring

Environmental monitoring at the City Facility has included LFG, leachate, and groundwater, at the locations shown on Figure 3. No surface water monitoring is conducted since any surface runoff is collected in perimeter ditches and routed to infiltration facilities discussed in the Permanent Stormwater Control Plan (Parametrix 2008).

### 1.5.1 Landfill Gas Monitoring

LFG probes (currently GP-1 through GP-4; GP-7 through GP-12) are used to monitor the potential for subsurface LFG migration adjacent to the waste and along the Landfill and City Facility Boundary (see locations on Figure 3). Results of quarterly LFG monitoring are described in Section 2.4.1.

Construction details for each gas probe, including the depth relationship of each screened interval to the adjacent waste, are presented in Table 1. All gas probes are completed in alluvium outside the Landfill, and each gas probe is screened at two subsurface intervals, with the exception of GP-12, which is screened at three separate intervals. Gas probes GP-5 and GP-6 were decommissioned in May 2010 because they were located within the construction footprint of the closure of the Phase 1 portion of the Landfill.

**Table 1. Landfill Gas Probe Construction, Horn Rapids Landfill**

Probe	Port	Ground Surface Elevation (ft)	Top of Screen Depth (ft bgs)	Bottom of Screen Depth (ft bgs)	Bottom Elevation of Probe (ft bgs)	Waste Depth (ft bgs)	Bottom Elevation of Waste (ft bgs)	Probe Depth Below Waste (ft bgs)	Probe Depth Above Groundwater (ft bgs)
GP-1	1	485.3	18.5	20.0	465.3	25	460.3	-5.0	79.3
	2	485.3	8.5	10.0	475.3	25	460.3	-15.0	89.3

**Table 1. Landfill Gas Probe Construction, Horn Rapids Landfill (continued)**

Probe	Port	Ground Surface Elevation (ft)	Top of Screen Depth (ft bgs)	Bottom of Screen Depth (ft bgs)	Bottom Elevation of Probe (ft bgs)	Waste Depth (ft bgs)	Bottom Elevation of Waste (ft bgs)	Probe Depth Below Waste (ft bgs)	Probe Depth Above Groundwater (ft bgs)
GP-2	1	489.1	36.5	38.0	451.1	30	459.1	8.0	65.1
	2	489.1	18.5	20.0	469.1	30	459.1	-10.0	83.1
GP-3	1	477.1	36.5	38.0	439.1	12	465.1	26.0	53.1
	2	477.1	18.5	20.0	457.1	12	465.1	8.0	71.1
GP-4	1	477.5	36.5	38.0	439.5	12	465.5	26.0	53.5
	2	477.5	18.5	20.0	457.5	12	465.5	8.0	71.5
GP-5 (former)	1	479.4	56.5	58.0	421.4	25	454.4	33.0	35.4
	2	479.4	36.5	38.0	441.4	25	454.4	13.0	55.4
	3	479.4	18.5	20.0	459.4	25	454.4	-5.0	73.4
GP-6 (former)	1	479.4	36.5	38.0	441.4	25	454.4	13.0	55.4
	2	479.4	18.5	20.0	459.4	25	454.4	-5.0	73.4
GP-7	1	479.4	24.0	28.0	451.4	12	467.4	16.0	65.4
	2	479.4	11.0	15.0	464.4	12	467.4	3.0	78.4
GP-8	1	478.8	26.0	30.0	448.8	12	466.8	18.0	62.8
	2	478.8	11.0	15.0	463.8	12	466.8	3.0	77.8
GP-9	1	489.3	26.0	30.0	459.3	25	464.3	5.0	73.3
	2	489.3	11.0	16.0	473.3	25	464.3	-9.0	87.3
GP-10	1	484.5	26.0	30.0	454.5	30	454.5	0.0	68.5
	2	484.5	11.0	15.0	469.5	30	454.5	-15.0	83.5
GP-11	1	486.0	36.0	39.0	447.0	30	456.0	9.0	61.0
	2	486.0	14.0	17.0	469.0	30	456.0	-13.0	83.0
GP-12	1	480.3	22.5	32.5	447.8	30	450.3	2.5	61.8
	2	480.3	49.5	59.5	420.8	30	450.3	29.5	34.8
	3	480.3	76.5	86.5	393.8	30	450.3	56.5	7.8

### 1.5.2 Leachate Monitoring

Leachate is collected in four lysimeters that monitor the vadose zone directly beneath the MSW in the northeast corner of the Landfill. Drains from each lysimeter are connected to a common sampling vault where discrete samples of leachate are collected from four sampling ports. The approximate location of the lysimeters and sampling vault are shown in Figure 3. The lysimeters were installed in 1993, and samples of leachate were collected and analyzed between 1994 and 2002 (Shaw Environmental 2004). Initially, the monitoring frequency was quarterly, but was decreased to semiannually in 1995 due to the declining volumes of leachate observed. No leachate was collected in the lysimeters between 2006 and

2014. In November 2014, June 2015, and June 2016, small quantities of leachate were observed in one of the lysimeter ports and samples were collected. Leachate quality is discussed in Section 2.4.2.

Correspondence between the City and the Health District discussing the lysimeters indicates that the lowest elevation of waste is approximately 422 ft MSL, and the lysimeters are somewhere below that. Groundwater is present at an elevation of approximately 378 ft MSL.

### 1.5.3 Groundwater Monitoring

Groundwater monitoring has been performed at the landfill since 1987 and documented in quarterly and annual groundwater monitoring reports. Results of the groundwater monitoring are discussed in Section 2.4.3.

The initial groundwater monitoring network consisted of one upgradient well (MW-1) located on the western boundary of the City Facility, and three downgradient monitoring wells (MW-2, MW-3, and MW-4) located along the eastern boundary of the City Facility, approximately 1,400 ft east of the Landfill. Groundwater monitoring was conducted in accordance with a groundwater monitoring plan (SCS Engineers 1996). In 1998, two additional wells (MW-5 and MW-6) were installed less than 50 ft from the eastern edge of the Landfill, and VOCs were detected in these wells. Additional downgradient wells MW-7 through MW-10 were installed in 2001 (Shaw Environmental, Inc. 2003, 2004). A brief summary of each phase of the RI is presented in Section 2.1.

Groundwater monitoring well MW-7 was decommissioned in May 2010 because it was located within the construction footprint of the closure of the Phase 1 portion of the Landfill. Well MW-7, although in an upgradient position with respect to groundwater flow, had not been used to characterize upgradient groundwater quality because it showed Landfill impacts due to its close proximity to the MSW. Instead, MW-1, located west of the Landfill, has been used to characterize upgradient groundwater quality, although it also shows some water quality impacts, including those seen area-wide.

An additional upgradient well MW-11 was installed in May 2010 at the location shown on Figure 3. Groundwater flow is toward the southeast and this location was selected to be upgradient of the Landfill and the proposed Expansion. The City Facility extends approximate 2,800 ft to the north of the Landfill and is vacant except for the shooting range just northwest of the Landfill.

Monitoring well construction details are shown on Table 2. Wells MW-7 through MW-11 are constructed with screened intervals across the water table, and the other wells are constructed with the top of their screen between 8 to 16 ft below the top of the water table.

## 1.6 Hydrogeologic Setting

The hydrogeologic setting in the vicinity of the Landfill is described below, including a description of the hydrogeologic units, groundwater flow, and groundwater flow direction and gradient.

### 1.6.1 Hydrogeologic Units

The local and regional geology and hydrogeology in the vicinity of the Landfill is detailed in reports documenting previous investigations (Hong West 1991; Shannon & Wilson 1998; Shaw Environmental Inc. 2003; Parametrix 2016c) and summarized in the following paragraphs.

Table 2. Groundwater Monitoring Well Construction Information, Horn Rapids Landfill

Monitoring Well	Northing	Easting	Elevation of TOC (ft NAVD88)	Screen Length (ft)	Screened Interval (ft below top of well seal <sup>a</sup> )	Depth to Groundwater December 2015 (ft)	Groundwater Elevation December 2015 (ft NAVD88)	Water level and top of screen [negative is below top of screen] ft
MW-1	371,572.00	2,291,691.97	489.68	25	114-139	103.04	386.64	-10.96
MW-2	372,460.09	2,294,368.28	469.73	25	98-123	83.91	385.82	-14.09
MW-3	371,529.10	2,294,408.23	481.28	25	111-136	95.44	385.84	-15.56
MW-4	370,722.92	2,294,379.43	462.52	25	90-115	76.78	385.74	-13.22
MW-5	371,784.64	2,293,120.19	469.94	10	91-101	83.90	386.04	-7.1
MW-6	370,965.00	2,293,109.43	484.54	10	106-116	98.71	385.83	-7.29
MW-7 (former)	NA	NA	479.03	21.5	86.5-108	91 <sup>b</sup>		
MW-8	370,228.88	2,293,869.87	476.47	15	87.5-102.5	90.92	385.55	3.42
MW-9	370,175.53	2,293,150.76	490.75	15	100.5-115.5	105.02	385.73	4.52
MW-10	372,265.23	2,293,111.61	460.85	15	72.5-87.5	74.72	386.13	2.22
MW-11	373,725.48	2,291,860.98	481.16	15	90-105	94.27	386.89	4.27

Notes: All wells are constructed of 2-inch-diameter PVC casing and slotted well screen.

TOC - Top of PVC casing.

<sup>a</sup> Assumes 3 ft of stickup above ground surface

<sup>b</sup> Typical historical value (well decommissioned)



Groundwater in the uppermost aquifer occurs under water table conditions in the sand, silt and gravel sediments of the middle Ringold Formation. The water table beneath the Landfill occurs at depths of approximately 75 to 105 ft bgs and elevations of approximately 385 to 388 ft NAVD88, and typically fluctuates less than a foot throughout the year. Based on the geologic logs of the on-site water well and the adjacent ORV-2 well, the aquifer thickness is approximately 80 to 110 ft.

Geologic cross sections (A-A' through E-E') are presented in Appendix A. Geologic cross section B-B' extends through the off-site wells illustrating deeper subsurface units. Geologic information is available from the following subsurface explorations:

- Eleven on-site groundwater monitoring wells and one deep gas probe drilled to total depths of 102 to 139 ft (see well locations on Figure 3).
- Water supply well (nonpotable use) drilled to a depth of 312 ft, located in the southwest corner of the City Facility.
- Two water supply wells (nonpotable use) constructed for the ORV Park west of the City Facility, ORV-1 drilled to a depth of 386 ft, and ORV-2 drilled to a depth of 485 ft.

The uppermost geologic unit consists of sand, varying from fine to coarse-grained with some silt, to depths varying from 68 to 101 ft below ground surface. The sand unit is underlain by a deposit consisting of gravel with varying proportions of sand and some silt to the total depths of the monitoring wells. The geologic logs for monitoring wells MW-4, MW-8, and MW-9, located closest to the area of investigation, indicate soils within the water bearing zone are expected to be gravel with approximately 10 to 15 percent silt.

The City Facility water supply well encountered sand to a depth of 86 ft, underlain by water-bearing gravel to a depth of 171 ft. Below the gravel is broken basalt and clay to a depth of 202 ft, underlain by clay to a depth of 248 ft, followed by basalt.

## 1.6.2 Groundwater Flow Gradient and Direction

Regionally, groundwater flow has been documented to be eastward toward the Columbia River (Shaw 2003, Liikala 1994). However, historical groundwater measurements have indicated the flow direction at the Landfill to be locally influenced by groundwater mounding from irrigated crop circles on the City Facility's eastern boundary, deflecting the flow in the eastern portion of the City Facility seasonally toward the southeast. The general directions of regional groundwater flow and flow observed at and in the vicinity of the City Facility are shown on Figure 1. Crop circles have been used to grow alfalfa hay, corn and potatoes since 1987. The source of the irrigation water is from the Columbia River and irrigation occurs seasonally between the months of April and October. Irrigated fields are also located west of the City Facility across State Route 240.

Groundwater is recharged by depletion of the Yakima River west and southwest of the Landfill, irrigation, and by precipitation. However actual recharge to the sediments from precipitation is significantly less due to the high rate of evapotranspiration. Precipitation in the Richland area from May 1944 to March 2013 indicate an average annual precipitation of 7.15 inches and an average total annual snowfall of 7.1 inches (Western Regional Climate Center 2013).

Groundwater discharge is to the Columbia River about 3 miles east of the Landfill. Insufficient data are available to determine the hydraulic relationship between the uppermost aquifer and the deeper basalt aquifers. However, Liikala (1994) described the aquitard underlying the uppermost aquifer as being

regionally present, and calculated an overall upward vertical gradient in the vicinity of the Landfill based on a measured hydraulic head in the upper confined aquifer that was higher than in the uppermost unconfined aquifer. The uppermost aquifer thins toward the east.

Hydrographs presented in the Phase 1 RI (Shaw 2003) indicate a steady rise in water-level elevations from 1986 through 2002 with observed increases of approximately 5 to 7 ft. These changes were attributed to influences from irrigated crop circles on the City Facility's eastern boundary. Historical water elevation maps (presented in Appendix B) also show that the flow direction and gradient have changed in response to these increasing water levels. In 1987, the flow direction was eastward with a gradient of approximately 0.001 ft/ft, consistent with the regional groundwater flow direction. In 1995, the flow direction changed to southeasterly, with a gradient of 0.0004 ft/ft. The additional wells installed in 2002 allowed further refinement of the flow direction and gradient, and the data showed easterly flow in the western portion of the City Facility, changing to southeasterly flow in the central portion of the City Facility, a pattern that continues to be observed.

Historical influences at the ORV park west of the City Facility may have also temporarily altered local flow direction by periodically flooding shallow unlined waterways for boat racing, and allowing the water to seep out after each race. The ponds were constructed in 1999 and racing was discontinued in the mid 2000's. Other sources of artificial recharge include four septic systems at the ORV park, one recently installed for a new bathroom/shower facility designed for 4,000 uses per day.

2015 groundwater flow contours are provided in Appendix B for the wet (First Quarter) and dry (Third Quarter) seasons. Although groundwater flow across the City Facility is generally toward the southeast, during the dry season groundwater flow in the eastern portion of the City Facility shifts slightly more toward the south-southeast due to the mounding effect of the crop circles on the eastern edge of the City Facility.

The overall groundwater gradient at the City Facility is low, approximately 0.0005 ft/ft over the past few years, and the calculated rate of groundwater flow is less than 20 ft per year.

## 1.7 Beneficial Water Use

Logs for water wells and water rights within 2,000 ft of the Landfill were researched on the Ecology website and are presented in the Hydrogeologic Report (Parametrix 2016c). There are no drinking water wells within over a mile from the Landfill. The only wells within a mile of the Landfill are the two wells in the ORV park west of the Landfill in an upgradient direction, and the on-site water well, and these three wells are not used for drinking. The closest water well identified in a downgradient direction in the Ecology database is located approximately 2 miles from the Landfill, and it is also believed to be used for non-potable purposes.

No on-site water features were identified on the USGS map and the nearest adjacent surface water features are the Yakima River located approximately 1.3 miles to the south and the Columbia River approximately 3 miles to the east. According to US Department of Interior National Wetland Inventory maps, no wetlands are located in the vicinity of the Landfill and it is assumed that all water on the Landfill infiltrates based on the NRCS Soil Survey Drainage Class Rating (excessively drained).

## 2. BASIS FOR SUPPLEMENTAL REMEDIAL INVESTIGATION SCOPE

In addition to routine quarterly environmental monitoring conducted in accordance with Chapter 173-351 WAC, independent cleanup actions have been conducted at the Landfill including a remedial investigation conducted in two phases, a pilot study/feasibility study, and completion of interim actions including landfill closure and LFG collection. In addition, assessment monitoring activities have been conducted in accordance with Chapter 173-351 WAC. The findings of these previous studies and a summary of the current status of the environmental monitoring data are described below.

### 2.1 Remedial Investigation

In 1998, the City installed two additional groundwater monitoring wells (MW-05 and MW-06) (Shannon and Wilson, Inc. 1998). VOCs were detected above applicable MTCA cleanup levels, and in 2000, the Landfill was listed by Ecology on the Confirmed or Suspected Sites List. The City subsequently implemented an independent cleanup action beginning with a phased RI/FS (Shaw Environmental, Inc. 2003, 2004) over the next approximately five years.

Phase 1 of the RI (Shaw Environmental, Inc. 2003) included installing and sampling four additional groundwater monitoring wells to delineate the extent of VOC-impacted groundwater. The new wells were MW-7 upgradient of the Landfill's waste cells to refine the upgradient groundwater flow direction, MW-8 and MW-9 along the southern City Facility Boundary to determine whether VOCs had migrated off the City Facility, and MW-10 north of wells MW-5 and MW-6 to further evaluate the extent of groundwater impacts.

Phase 2 of the RI (Shaw Environmental Inc. 2004) included an assessment of whether leachate and/or LFG were the source of VOCs impacting groundwater. Activities included installing multilevel deep gas probe GP-12, measuring LFG concentrations in gas probes, collecting and analyzing discrete gas samples, and evaluating historical leachate data collected from lysimeters. In addition, a potential undocumented upgradient waste disposal site located approximately 1,200 ft northwest of the northwest corner of the Landfill was evaluated. The undocumented disposal site was found to be limited in extent, with an estimated MSW volume of 4,800 cubic yards, and it was concluded that the undocumented waste site was likely not the source of the VOCs impacting groundwater.

The RI concluded that LFG is the likely source of the VOCs impacting groundwater via vertical migration of LFG through the unsaturated soil to the capillary fringe zone. This conclusion was based on the presence of the same suite of VOCs detected in groundwater in hydraulically upgradient wells and in the vapor phase in the vadose zone including the deep screened zone of GP-12 immediately above the water table. The findings of the RI are summarized as follows:

- Significant concentrations of LFG, as measured in GP-12, occur in the shallow unsaturated subsurface to a depth of at least 90 ft bgs in the MW-6 area and high concentrations of LFG were detected in the casings of MW-5, MW-6, and MW-7, even though MW-7 is located hydraulically upgradient from the waste cells.
- The same suite of VOCs detected in groundwater samples were also detected in headspace gas samples from the monitoring wells and gas probe GP-12.
- Dissolved methane was present in groundwater samples.

- A subset of VOCs frequently detected in the lysimeters representative of Landfill leachate at high concentrations were either not detected in any of the groundwater samples, or detected infrequently at low concentrations.
- Geochemistry of the groundwater samples has a different chemical composition than the leachate. The observed decreases in pH and increases in alkalinity and calcium are indicative of the interaction of LFG and groundwater.

## 2.2 Pilot Study/Feasibility Study

A pilot-scale LFG extraction test was performed to assess the feasibility of implementing an active LFG collection system as a method for mitigating the LFG source of vapor-phase VOCs (Shaw EMCON/OWT, Inc. 2005). One LFG extraction well and three LFG observation wells and temporary probes were installed. The results of the extraction test indicated that LFG collection would be effective as a remedy to remove vapor phase VOCs within the waste before they migrate vertically through the underlying subsurface soil and partition into groundwater.

## 2.3 Assessment Monitoring Program

In 2013, Ecology requested that additional activities be conducted to comply with the assessment monitoring requirements of WAC 173-351, and the following activities were completed:

- In March 2014, a groundwater sample was collected from monitoring well W-1 on the east side of the Weidle neighborhood and analyzed for the Landfill analyte parameters. This well was installed in 1993 as part of the Triangle Development located approximately one mile south of the Landfill and previously sampled by the Health District. These data indicate that the Landfill has not impacted drinking water wells in the Weidle neighborhood.
- Testing for Appendix III parameters was conducted annually in phases, including one well near the active cell and one well at the City Facility Boundary each year. The tested wells were wells MW-6 and MW-9 (June 2014), MW-5 and MW-8 (June 2015), and MW-4 and MW-10 (June 2016). No Appendix III parameters were detected in any of the wells with the exception of cyanide, detected in well MW-9 at a concentration slightly above the reporting limit and below the MCL. No cyanide was detected in MW-9 during the retesting in September 2014.

Appendix III monitoring parameter testing has not detected any compounds other than the VOCs identified during the RI. Therefore it is recommended that testing for the additional Appendix III parameters be continued annually on a rotating schedule at one of the three wells located closest to the Landfill (MW-5, MW-6, and MW-10), or at well MW-9 located at the City Facility Boundary. If Appendix III data for leachate becomes available in the future, the City will apply for an alternative monitoring program under WAC 173-351-450 to eliminate or reduce the subset of Appendix III parameters to be tested in the assessment monitoring wells.

## 2.4 Environmental Monitoring Data Summary

A summary of recent LFG, leachate, and groundwater data is presented in the Calendar Year 2015 Environmental Monitoring Report (Parametrix 2016d). Data presented in this report are summarized in the sections below by media.

### 2.4.1 Landfill Gas

Historical LFG data and a cross section showing the typical configuration of the LFG probes and extraction wells with respect to the waste are presented in Appendix C. The extent of LFG migration remains within close proximity of the MSW and concentrations have not exceeded the 5 percent by volume regulatory action limit at the City Facility Boundary. No LFG has ever been detected in any of the on-site buildings.

Methane has been detected in gas probes GP-2, GP-9, and GP-12, all located in close proximity to the MSW. Since 2015, all concentrations in these probes have been less than 5 percent by volume except for GP-2-1 and GP-2-2 where concentrations of over 25 percent by volume continue to be periodically observed.

Trends in probes where methane has historically been observed (GP-2, GP-9, and GP-12) are shown on the time-series plot in Appendix C. The data indicate that despite limited spikes, overall substantial decreases have been observed since the closure activities started in 2011 that included installation and operation of an active LFG collection system. For example, methane concentrations in GP-12 decreased from over 30 percent by volume prior to the 2011 Phase 1 Closure, to 5 percent or less during 2015. The LFG source is expected to be further reduced upon full closure of the Landfill that is anticipated in 2020 which will include an expanded LFG extraction system, thus reducing or eliminating future VOC impacts to groundwater.

### 2.4.2 Leachate

Leachate quality data and correspondence related to leachate quantities observed during the first years following lysimeter installation were presented in the Phase 2 RI Report. No leachate was observed in the leachate ports between 2006 and 2014. The most likely scenario for the observed lack of leachate in the lysimeters during the period beginning in 2006 is as follows: Leachate was initially generated due to infiltrating precipitation while the waste was thin, and as additional waste was placed the increasing thickness of waste became adequate to absorb the small amount of infiltrating precipitation. This eventually resulted in leachate not reaching the lysimeters. The correspondence documents the gradual difficulty in getting samples and indicates that the volume of leachate diminished as the waste depth increased over the lysimeters. It was likely a coincidence that the measurable leachate ceased at the same time as the ports were moved.

Phase 2 of the RI included a comparison of leachate data collected between 1993 and 2002 to groundwater data. Geochemistry of the leachate was determined to be different than typical groundwater samples as shown on the geochemical plots presented in Appendix D.

In the fourth quarter of 2014, liquid was observed in one of the ports, designated Port 3, and samples of the liquid were collected and analyzed for Appendix I and II parameters. The volume of the liquid drained was approximately 2 liters. The geochemical plot for this sample, presented in Appendix D, indicated the geochemistry of the leachate was different than typical groundwater samples. Some parameter concentrations in the leachate sample were higher than in the groundwater samples, notably ammonia, chloride, and TOC, and the total metals barium, iron, manganese, and zinc. Concentrations of nitrate and sulfate were lower than in the groundwater samples.

The ports were rechecked semiannually, and only small quantities of liquid (less than a liter) were present in the second quarters of 2015 and 2016. Samples were collected and tested for VOCs.

The 2014 through 2016 Port 3 leachate data were compared to groundwater quality data as shown on the selected time-series plots in Appendix D. Concentrations of some VOCs in the leachate were comparable to those in groundwater samples from wells near the active landfill (including 1,1-DCA, 1,2-DCA, cis 1,2-DCE, and VC). However, relative to groundwater, the leachate had lower concentrations of TCE and PCE, and higher concentrations of BTEX (benzene, ethylbenzene, toluene, total xylenes), and ketones (acetone and 4-methyl-2-pentanone).

The minimal quantity of leachate currently produced indicates that leachate is not a significant ongoing source of contaminants to groundwater.

### 2.4.3 Groundwater

The results of ongoing groundwater monitoring have documented that concentrations of inorganics and VOCs in both upgradient and downgradient wells exceed state groundwater quality standards (GWQs, WAC 173-200) and state drinking water standards (MCLs, WAC 246-290). However, inorganic compound concentrations reflect an elevated area-wide background, as described in Section 2.4.3.1.

The 2015 groundwater quality data and isoconcentration maps are presented in Appendix E. The maximum concentrations of chemicals detected during 2015 above GWQs and MCLs in upgradient/cross-gradient and downgradient wells are shown in Table 3 below.

#### 2.4.3.1 Area-Wide Background Groundwater Contamination

Groundwater quality data collected from wells in the northern portion of the Landfill, in particular upgradient well MW-11, former upgradient well MW-7 (decommissioned due to Phase 1 closure construction), and cross gradient well MW-2, indicate that sources upgradient of the Landfill are contributing to an area-wide background of elevated concentrations of inorganic compounds, including total dissolved solids (TDS), chloride, nitrate, and cations.

Data spikes observed in these wells (such as nitrate in 2003 in MW-7, and in MW-2 in 2008) suggest that more than one source may have contributed pulses of contaminants over time. Likely potential upgradient sources are those that involve application of water, such as the agricultural irrigation at the crop circles, and septic systems in the adjacent ORV park. Ongoing groundwater monitoring related to the Hanford Reservation has documented occurrences of nitrate plumes with concentrations of greater than the GWQS and MCL (10 mg/L nitrate as N) in the Richland area, with sources attributed to agricultural applications of fertilizer to irrigated fields (CH2M 2015). Biosolids applications in the northern portion of the City Facility have also been considered as a source, but are not presently believed to have had substantial impacts since precipitation at the City Facility is low, and the biosolids are dry and applied in thin layers and have largely already been scraped off for other City Facility uses.

#### 2.4.3.2 VOCs

Due to the area-wide background concentrations of inorganic indicator parameters, VOCs are the only chemicals that clearly reflect Landfill impacts. The groundwater monitoring wells located in close proximity to the MSW along the eastern edge of the Landfill (MW-5, MW-6, and MW-10) show the highest number and concentrations of VOCs. Further downgradient well MW-9, located along the southern City Facility Boundary approximately 500 ft from the waste, has also been impacted by the same suite of VOCs in lower concentrations. The other three further downgradient monitoring wells along the City Facility Boundary, MW-3, MW-4, and MW-8, each show slightly different distributions of VOCs and in generally lower concentrations.

Table 3. Maximum Concentrations of Parameters above Groundwater Quality Criteria during 2015, Horn Rapids Landfill

Parameter	Units	GWQS	MCL	Highest 2015 Observed Concentration Above Criteria					
				Upgradient or Cross Gradient (MW-1, -2, -11)		Adjacent to Active Cell (MW-5, -6, -10)		Downgradient Facility Boundary (MW-3, -4, -8, -9)	
				Concentration	Well	Concentration	Well	Concentration	Well
<b>FIELD PARAMETERS</b>									
Conductivity	umhos/cm	NA	700	1680	MW-11	1384	MW-5	1032	MW-9
pH		6.5-8.5	NA			6.46	MW-10		
<b>INORGANICS</b>									
Arsenic	mg/l	0.00005	0.01	0.0068	MW-11	0.0043	MW-5	0.0086	MW-8
Selenium	mg/L	0.01	0.05	0.011	MW-11				
Nitrate	mg/L	10	10	38	MW-11	35	MW-5	17	MW-8
Sulfate	mg/L	250	250	270	MW-11				
Total Dissolved Solids (TDS)	mg/L	500	500	1,300	MW-11	870	MW-5	650	MW-9
<b>VOCS</b>									
Bromodichloromethane	ug/L	0.3	80					0.78	MW-8
Chloroform	ug/L	7	80					9.8	MW-8
1,1-Dichloroethane (1,1-DCA)	ug/L	1	NA			9.6	MW-10	4.0	MW-4
1,2-Dichloroethane (1,2-DCA)	ug/L	0.5	5			1.1	MW-5		
Tetrachloroethene (PCE)	ug/L	0.8	5	4.9	MW-1	40	MW-6	13	MW-9
Trichloroethene (TCE)	ug/L	3	5			20	MW-6	6.8	MW-9
Vinyl Chloride (VC)	ug/L	0.02	2			7.8	MW-5	0.069	MW-4

MW-1 and MW-11 are upgradient from the landfill; MW-2 is cross-gradient from the landfill

GWQS = Water quality standards for groundwaters of the State of Washington (WAC 173-200).

MCL = Maximum Contaminant Level (WAC 246-290)

Isoconcentration maps of detected VOCs (1,1-DCA, PCE, TCE, cis 1,2-DCE, and VC) were previously presented in the RI (Shaw 2003) using data from 2002. These maps have been updated using maximum detected concentrations at each well during 2015. Both sets of isoconcentration maps are presented in Appendix E.

The areas impacted by VOCs extend to the south-southeast in a direction generally consistent with the direction of flow indicated by recent groundwater flow contours. Although concentrations of some VOCs (especially 1,1-DCA in wells MW-5, MW-6, and MW-10, and PCE, TCE, and VC at MW-6) in the central portion of the impacted area have decreased since 2002, 1,1-DCA, PCE, TCE, and VC concentrations above the GWQS extend beyond the City Facility's southern boundary. Compared to 2002, the concentration of PCE at well MW-9 has increased, TCE and cis 1,2-DCE are present at wells MW-9, MW-3 and MW-4, and VC is present intermittently in low concentrations at wells MW-9 and MW-4. The 2015 concentrations of 1,1-DCA at wells MW-9 and MW-4 are similar to those measured in 2002, but 1,1-DCA is also present at well MW-3.

The estimated extent of VOCs exceeding GWQSs beyond the City Facility Boundary for 1,1-DCA, PCE, TCE, and VC are shown on the 2015 isoconcentration maps. Except for 1,1-DCA, the estimated extent is limited to a distance of less than 400 ft from the City Facility Boundary.

Trend analyses indicate that VOC concentrations have shown significant decreases in some downgradient wells during the 5 years since Phase 1 Landfill closure, including 1,1-DCA in wells MW-3, MW-6, and MW-10, and chlorinated ethenes (TCE, trans 1,2-DCE, and VC) in well MW-6. Well MW-6 is located near the older portion of the Landfill that has completed Phase 1 closure. However, upward trends of cis 1,2-DCE, PCE and VC have been observed in well MW-10 located closest to the area of active filling, and PCE in well MW-9 located at the southern City Facility Boundary.

Additional parameters are being monitored to assess whether natural attenuation is occurring, including methane, ethene, and ethane, and dissolved oxygen (DO) and oxidation-reduction potential (ORP). DO and ORP measurements continue to indicate that conditions in groundwater near the Landfill source are consistent and favorable for biodegradation of chlorinated hydrocarbons. However, analysis of other evidence is inconclusive. The continuing presence of methane in groundwater could indicate biodegradation of organic carbon is occurring via methanogenesis; however natural attenuation via methanogenesis would be expected to result in production of ethene and ethane and these compounds have not been detected, and methane is also contributed directly by LFG. Trends in other parameters that might indicate that biodegradation is occurring, such as increases in chloride or alkalinity, or decreases in nitrate and sulfate, are somewhat ambiguous because concentrations of these parameters have been affected by influences from upgradient sources.



### 3. PRELIMINARY CONCEPTUAL SITE MODEL

The conceptual site (CSM) is presented for each media describes potential suspected sources, types, and concentrations of hazardous substances, and exposure pathways and receptors. The CSM provides a tool to identify data gaps and work to be conducted.

#### 3.1 Landfill Gas

LFG probe data are available since 1998. LFG in the vadose zone has historically been present only in gas probes GP-2, GP-5 (now decommissioned), GP-9, and GP-12. These probes are all within close proximity (within about 100 ft) of the Phase 2 Landfill refuse boundary. No LFG has been detected in probes along the Phase 1 Landfill perimeter (GP-1, GP-3, GP-4, GP-6, and GP-7); these probes are about 150 ft from the refuse boundary. No LFG has been detected in probes further from the Landfill (about 300 to 500 ft) along the City Facility Boundary (GP-8, GP-10, or GP-11). These data support the conceptual model that LFG does not migrate in the subsurface for large distances from the waste.

Most of the LFG probes have one screened interval near the center of the waste thickness and one at the approximate elevation of the bottom of the waste. Comparing methane levels between multi-screened probes suggests that LFG is present in the entire zone between the base of the MSW to the surface of the groundwater, although the highest concentrations are typically observed in the zone near the bottom of the MSW. Phase 2 of the RI found LFG present within the screened interval of MW-7 (83.5 to 105 ft bgs) and GP-12-3 (73.5 to 83.5 ft bgs).

These data indicate that LFG and groundwater have historically interacted only in a limited area immediately beneath the waste and in a limited zone surrounding the waste. LFG is expected to migrate laterally and upward through the sandy unsaturated soils due to pressure and concentration gradients and discharge to the atmosphere.

Since its startup in 2011, the Phase 1 LFG extraction system and cover are effectively removing the LFG within close proximity of the bottom of the MSW and the Landfill's downgradient lateral perimeter as demonstrated by the sharp decreases in methane concentrations observed at multilevel gas probes GP-2 and GP-12, including deep probe GP-12-3, screened immediately above the water table. Methane concentrations in GP-12 have decreased from over 30 percent by volume prior to closure to five percent or less during 2015. The LFG source is expected to be further reduced upon full closure of the Landfill that is anticipated in 2020 which will include an expanded LFG extraction system, thus reducing or eliminating future VOC impacts to groundwater.

#### 3.2 Leachate

Leachate is believed to be a minor overall contributor to historical groundwater impacts. Due to the arid environment, only minimal quantities of leachate were produced in the lysimeters in the early stages of landfilling when the waste was thin, and since then any leachate generated is being absorbed by the waste. The small quantities of leachate generated historically have contained a similar suite of VOCs at concentrations similar to those observed in groundwater. However, the geochemical signatures are slightly different than sampled groundwater, and some additional VOCs have been detected in leachate that are not present in groundwater.

### 3.3 Groundwater

Groundwater that has already been impacted by LFG containing VOCs will continue to move downgradient and will be naturally attenuated through processes such as advection, dispersion, sorption, and biodegradation. However, due to the relatively low flow rate and low rainfall, dilution is not expected to be significant, and sorption is likely to be low due to the low organic carbon in soils (typical total organic carbon concentrations are less than 5 mg/L). The primary VOCs of concern in groundwater at the Landfill are chlorinated ethenes (PCE, TCE, DCEs, and VC) and ethanes (1,1-DCA). An important potential mechanism for biodegradation of these compounds is reductive dechlorination whereby the more highly chlorinated compounds are reduced to less chlorinated compounds (EPA 1998, Jurgens et al 2009). Evaluation of natural attenuation parameters including reduced DO and ORP indicates degradation of chlorinated hydrocarbons is occurring at least near the Landfill source, although analysis of other indicator parameters is inconclusive.

Over the past 13 years, concentrations of some VOCs close to the Landfill have decreased, but the impacted area has expanded in the downgradient groundwater flow direction. The observed changes in impacted area dimensions are consistent with the measured flow direction, and the downgradient extent of impacts are consistent with the calculated groundwater flow rate of approximately 20 ft per year, or about 250 ft over the last 13 years. Monitoring data show that VOC impacts are limited to the hydraulically downgradient area in close proximity to the City Facility Boundary, consistent with the low rate of groundwater flow.

There are no downgradient users of groundwater or occurrences of surface water within over a mile downgradient of the Landfill. As shown on Figure 1, the City owns the property southeast of and hydraulically downgradient from the Landfill extending a distance of over 1,500 ft. It is expected that the movement of impacted groundwater will be restricted to an area within the City Property beyond the City Facility Boundary for many years, enhancing the potential for natural attenuation. Regional groundwater vertical gradients in the uppermost aquifer are believed to be upward, restricting the downward movement of contaminants to lower aquifers.

### 3.4 Conceptual Site Model Summary

The RI concluded that LFG was the primary source of the contaminants observed in groundwater. LFG interacts with moisture in the vadose zone and with groundwater in the capillary zone of the water table, where it becomes dissolved in and transported with groundwater flow. The concentrations of VOCs measured in LFG during the RI were high enough to comprise the primary source of VOCs in groundwater. Although it is possible that some leachate may also be produced within the waste, the on-site lysimeters have demonstrated that little to no leachate is being accumulated below the waste, due to the arid conditions and the ability of the waste to store the moisture that is generated.

Groundwater with concentrations above GWQSS has moved beyond the City Facility Boundary onto additional City Property, and natural attenuation is expected to occur prior to movement off City Property due to low groundwater flow rate. There are no current or anticipated risks to human health or the environment based on the data obtained to date. The presumptive remedy is to continue removing LFG and leachate sources through the system already in progress and to enhance removal through the second phase of landfill closure.

### 3.5 Preliminary Chemicals of Concern

Based on the measured concentrations at the Facility Boundary, the following VOCs are present in concentrations greater than GWQSs and are considered to be the preliminary chemicals of concern (COCs) for the Landfill.

**Table 4. Preliminary Chemicals of Concern, Horn Rapids Landfill**

Parameter	Units	GWQS	MCL	Highest 2015 Concentration Observed at Facility Boundary	Monitoring Well
Bromodichloromethane	ug/L	0.3	80	0.78	MW-8
Chloroform	ug/L	7	80	9.8	MW-8
1,1-Dichloroethane (1,1-DCA)	ug/L	1	NA	4.0	MW-4
Tetrachloroethene (PCE)	ug/L	0.8	5	13	MW-9
Trichloroethene (TCE)	ug/L	3	5	6.8	MW-9
Vinyl Chloride (VC)	ug/L	0.02	2	0.069	MW-4

### 3.6 Receptors/Exposure Pathways by Media

A summary of the receptors and exposure pathways by media is provided below, based on the conceptual site model.

**LFG** – The presence of LFG in the vadose zone is limited vertically to the area between the bottom of the MSW and the water table, and laterally, to a limited zone surrounding the MSW. LFG has not migrated beyond the City Facility Boundary. LFG has not been detected in on-site buildings. Therefore, there are no direct exposure pathways to human receptors.

**Leachate** - There is minimal leachate generation from the Landfill as shown by the lack of leachate collected in the lysimeters, and therefore there are no exposure pathways.

**Groundwater** - Possible receptors for VOC contaminated groundwater would be downgradient domestic well users, either via drinking water or inhalation of VOCs. However, since the closest domestic water well in a downgradient direction is located more than 2 miles from the City Facility, there are no completed exposure pathways. In addition, natural attenuation is expected to occur prior to movement of groundwater off City Property due to the low flow rate.

**Surface Water** – There is no off-site runoff, and the closest surface water to the City Facility is the Yakima River, over 1 mile from the City Facility, and the Columbia River, over 3 miles from the City Facility. Therefore there are no exposure pathways.

**Soil** – There is no known soil contamination at the City Facility. A risk assessment to assess potential impacts to terrestrial plants and animals in accordance with Chapter 173-340-7491 WAC is not expected to be required, since there are no hazardous substances expected to be present in soils. Any potential soil contamination associated with contaminated groundwater would be located at a depth below the point of compliance of 15 ft bgs.

## 4. WORK PLAN APPROACH

This section provides a summary of the data gaps identified by the conceptual site model, and objectives and approach for the field investigation.

### 4.1 Data Gaps

A substantial amount of data has been collected at the City Facility for approximately the past 30 years. However, the following data gaps have been identified based on the information presented in previous sections.

- The downgradient extent of VOCs in groundwater on City Property beyond the City Facility Boundary needs to be determined.
- The groundwater flow gradient downgradient of the City Facility needs to be refined and confirmed.

### 4.2 Work Plan Objectives

The work outlined in this section of the work plan has the following objectives:

- Define the downgradient extent of contaminants in groundwater originating from the Landfill, and refine the groundwater flow direction.
- Locate and install an additional downgradient monitoring well to confirm that natural attenuation of VOCs in groundwater is occurring, and to monitor for future potential impacts from the existing Landfill and proposed Expansion.

In addition to the activities outlined in this work plan, the following ongoing activities will be conducted.

- Continue monitoring VOC trends in existing groundwater wells included in the monitoring network. Analysis should use methodology that achieves reporting limits below GWQSS.
- Continue operating LFG collection system and monitoring methane trends in gas probes.
- Due to the area-wide background concentrations of several analytes, focus future testing on COCs and reduce the frequency of testing for parameters other than COCs.

### 4.3 Investigation Phasing

A phased investigation approach will attempt to use direct push probes to collect groundwater samples, and use the concentrations of VOCs measured in the samples to select a location for an additional downgradient monitoring well to be installed during a second phase of work. The objective of the Phase 1 push probe sampling will be to locate the furthest extent of the contamination directly downgradient from the central portion of the contaminant plume so that a permanent groundwater monitoring well can be installed during Phase 2 at a location that has not been impacted. This well will be used as a sentinel well for the assessment monitoring program.

If the push probe procedure is not effective, one monitoring well will instead be installed at a pre-selected location during the first phase of work.

## 4.4 Phase 1 - Direct Push Probes

The City will contract with Atkins (formerly EnergySolutions, Inc.) to collect groundwater samples using direct push technology (EPA 2005) at up to six locations on City Property downgradient of the Landfill. Atkins has devised a sampling system that has been used successfully to sample soils and groundwater at the nearby Hanford Reservation to depths of over 200 ft. Atkins believes their direct push system can be used to sample groundwater downgradient and in the vicinity of the Landfill.

The planned Phase 1 investigation will consist of the following sequence of activities:

- Six push probe installations will be conducted until groundwater is encountered to approximate depths of 100 ft, and groundwater samples will be collected from each probe at the total depth. No soil samples will be collected for chemical analysis.
- A trial push probe installation will be conducted to test whether the technology will be successful. If the push probe technology is successful, five additional probes will be installed.
- If the push probe trial is not successful, a driller will be contracted and a new downgradient monitoring well will be installed at the location shown on Figure 4.
- Groundwater samples will be collected from each push probe using a portable bladder pump.
- The groundwater samples will be hand delivered to a local analytical laboratory, Energy Northwest Environmental Lab, in Richland, WA, and tested for VOCs.

### 4.4.1 Push Probe Locations

The isoconcentration maps for 2015, shown in Appendix E, illustrate that the area impacted by COCs extends to the south of well MW-9, but also to the southeast of well MW-4. Since the groundwater flow direction is toward the southeast, and varies seasonally to south-southeast, the impacted area downgradient from the existing MSW is expected to be wedge shaped and extend from due south of MW-9 to east-southeast of MW-3 and MW-4. Except for 1,1-DCA, the contaminant distribution indicates that concentrations exceeding GWQs are limited to an estimated distance of less than 400 ft from the City Facility Boundary.

Gas probe data indicates that LFG is only present in close proximity to the Landfill (less than about 100 ft), and only in gas probes GP-2, GP-9, and GP-12. Groundwater impacted by LFG in this area would generally flow toward existing wells MW-8 and MW-9. However due to groundwater impacts observed in MW-1, and lack of deeper screened gas probes in the southwestern portion of the City Facility, the push probe investigation has been planned to confirm the absence of LFG impacts to groundwater in the area downgradient from the southwesternmost portion of the Landfill.

Figure 4 shows the proposed locations of the first three push probes (PP-1 through PP-3), and possible locations for three additional probes (PP-4 through PP-6) to be installed only if VOCs are detected at the first three push probes. The rationale for selecting the first three push probe locations is outlined in Table 4-1. Probe numbers reflect the tentative order of installation. Decisions on subsequent probe locations will be based on VOC results that are expected to be available by the close of business of the following day. The schedule assumes one probe will be sampled each day.

It is important to note that the positions of the probes are tentative and provided for discussion purposes only, and the actual locations will be adjusted in the field based on ongoing results of VOC analyses. Probe locations may be adjusted based on the VOC results observed in previous probes, and all decisions will be agreed upon by consultation between representatives of Ecology, the City, and Parametrix.

**Table 5. Data Quality Objectives for Initial Push Probe Locations**

Probe Name	Location	Selection Criteria Notes	Data Quality Objective
PP-1	Near City Facility boundary between GP-10 and GP-11	Exact location to be determined in field based on logistics	Evaluate potential impacts to groundwater along City Facility Boundary due to LFG near the southern Landfill Refuse Boundary
PP-2	Downgradient from MW-9 (well with highest PCE concentrations at Facility Boundary)	Beyond projected extent of PCE concentrations above GWQs	Evaluate extent of VOCs beyond City Facility Boundary
PP-3	Downgradient from MW-6 and MW-8	Beyond projected extent of VOC concentrations above GWQs	Evaluate extent of VOCs beyond City Facility Boundary

#### 4.4.2 Push Probe Installation Procedures

Atkins will employ a hydraulic hammer probe driving unit that has the following features (see photographs of their equipment and specifications presented in Appendix F):

- Tractor unit mounted on Caterpillar 416C back-hoe tractor (small turning radius [19 ft] and have very low overall weights [less than 20,000 lbs])
- Mast with 6' 9" travel allowing for utilization of 4 foot length rods
- Eurodrill hydraulic driven hammer with 450 ft/lb striking force per blow, cycling between 500 and 2000 blows per minute, rotating head with swivel and 10,000 ft/lbs of torque for use to make up and break out pipe
- 12,000 lbs to 18,000 pull back force and a total down force on the hammer of 10,000 lbs
- Horizontal cradle on which a mast and hammer can be mounted to push from 15 degrees to horizontal.

Atkins-EnergySolution's Single String system driving and sampling system (used when only one sample is required at a given location) is deployed on 2.5-in. OD x 1.75-in. ID push rods and consists of three stainless steel liners contained within a rod-delivered sampler body. These three liners are each 1.66 in. OD x 1.53 in. ID x 6 in. long. The probe driving equipment is moved to the appropriate location and the sampler is advanced to the target depth. By use of a key release mechanism the removable tip is released and the open sampler is advanced through the targeting depth. The entire rod string and sampler are then retrieved to surface. The sampler is removed from the push tubing and the stainless steel liners are extracted from the sampler mechanism.

The proposed direct push tooling method for the Horn Rapids Landfill investigation project will be as follows.

- Drive down to target depth (100 to 120 ft bgs).
- Knock out drive tip and pull back a few inches to ensure tip is free.
- Run in a standard stainless steel well screen on tubing and place on the bottom of hole.
- Back pull direct push tubing approximately 5 ft.
- Run sampling pump and collect groundwater sample.
- Remove screen and tubing.
- Decommission push hole by introducing grout as drive tubing is removed.

The ground surface elevation at each of the proposed locations shown on Figure 4 will be surveyed in advance using GPS technology. The expected depth for encountering groundwater will be determined in advance based on projections from the calculated potentiometric groundwater surface as measured in the groundwater monitoring wells. The tooling will be driven to the targeted depth that will be 10 ft deeper than the calculated groundwater depth.

Under the assumption that the formation may not stand open, Atkins will install a 10-ft temporary standard stainless steel screen into each probe prior to sample collection. Since the formation is expected to contain approximately 10 to 15 percent fine-grained sand and/or silt, this screen will filter some of these particulates to reduce turbidity. The planned slot size of the screen will be 20 slot (0.2 inch) based on the anticipated sediment size in the screened zone. Although full development of the probe will not be possible, prior to sampling the portable bladder pump will be used to purge some water prior to sampling to reduce the amounts of fines. Potential impacts of sources of bias in concentrations of VOCs or dissolved gases during sampling are presented in Table 3.1 of EPA (2005). Turbidity present within the samples is not expected to cause significant bias in concentrations of VOCs or dissolved gases (EPA 2005, see Table 3.1).

Increases in temperature during sampling can potentially cause a negative bias in concentrations of VOCs or dissolved gases (EPA 2005, see Table 3.1). However, temperature increases related to the push probe drilling procedure are not expected to be a concern. Based on Atkins' experience related to soil sampling, there has never been any indication of excessive heat buildup at the drive point or any indication of a heat signature from the driving action when conducting temperature logs (part of their geophysical logging suite runs), and soil samples have never come up thermally hot. The only heat buildup occurs at the surface drive head where the force is applied directly from the hammer to the drive pipe. The procedure will consist of driving to target depth, dropping in a screen on tubing, then pulling back the drive tubing; therefore, the water sample collected will not contact the drive pipe.

In addition, due to the small diameter of the probe (about 2.5 inches), any heat buildup would not be expected to extend very far into the formation, especially below the water table. It is anticipated that the flow of water across the screened interval will dissipate any heat that has built up during the installation process. To monitor temperature during sampling, field parameters will be measured regularly during the purging process using a flow cell setup to confirm that the samples collected are representative of groundwater conditions.

The screen will be decontaminated between push probe installations using the procedures described in the Quality Assurance Project Plan (QAPP).

#### 4.4.3 Push Probe Groundwater Sampling and Analysis

Groundwater samples will be collected at each probe location using a portable bladder pump (see examples presented in Appendix G) with a small diameter of 0.75 inches that will be easily accommodated within the temporary screen. EPA (2005, see Table 3.2) recommends using bladder pumps for low flow sampling for all types of analytes. The portable bladder pump will be decontaminated between push probe locations using the procedures described in the QAPP.

Groundwater sampling will be conducted using low flow purging techniques as detailed in SOPs presented in the QAPP (Parametrix 2016b). Field parameters (conductivity, pH, temperature, DO, and ORP) will be measured during sampling.

The groundwater samples will be hand delivered to a local analytical laboratory, Energy Northwest, located in Richland, WA, and tested for VOCs with a 24-hour turnaround so that the results can be used to confirm the location of subsequent push probes. A list of VOCs that will be analyzed and their expected reporting limits are presented in Appendix G. Laboratory procedures and analytical methods are presented in the QAPP (Parametrix 2016b).

In addition, probe groundwater samples will be tested for other parameters, if sample quantities are adequate. These additional parameters will consist of the additional natural attenuation parameters methane, ethane, and ethane (RSK parameters). Specific conductivity, pH, temperature, DO, and ORP will be measured in the field.

Ecology will be informed by email two weeks in advance of the tentative date that the push probe investigation will be initiated. Any subsequent changes to the schedule will be provided to Ecology by email and by phone.

Ecology will be furnished with laboratory results as soon as they become available. Ecology will be contacted in person or by phone, and by email.

#### 4.5 Phase 2 - Groundwater Monitoring Well

One downgradient monitoring well will be installed on City Property southeast of the Horn Rapids Landfill in 2017 unless the push probe technology is unsuccessful during Phase 1. In the event direct push probe installation is not successful, the downgradient well will be installed in 2016, at the approximate location shown on Figure 4.

The proposed location of the monitoring well to be installed if push-probe technology does not work was selected with a data quality objective to confirm the absence of contamination downgradient from the center of the contaminant plume, at a distance from the edge of City Property that is sufficient to allow additional actions to be taken in the event that contaminants are identified. Any contaminants identified at the proposed location (greater than 1,000 ft from the City Property Boundary) would not move beyond the City Property for over 50 years at the calculated flow rate of approximately 20 ft per year.

The location is directly downgradient from well MW-9 along the City Facility Boundary that has shown the highest concentrations of VOCs. This well will be used as a sentinel well to identify potential contamination releases from the existing Landfill.

If push-probe technology does not work, the City will confirm the location with Ecology prior to installation.



The following activities will be conducted:

- One groundwater monitoring well will be installed into uppermost groundwater, to a total depth of approximately 100 ft using the air rotary method.
- The groundwater monitoring well will be 2-in diameter Schedule 80 PVC, with a 15-ft screened interval. The top of the screen will be set at a depth approximately 5 ft above the water table encountered during drilling. Construction of the monitoring well will follow the specification previously developed for well MW-11 (see Appendix H).
- Groundwater samples will be collected and tested for WAC 173-351 Appendix I and II parameters using existing procedures described in the QAPP.

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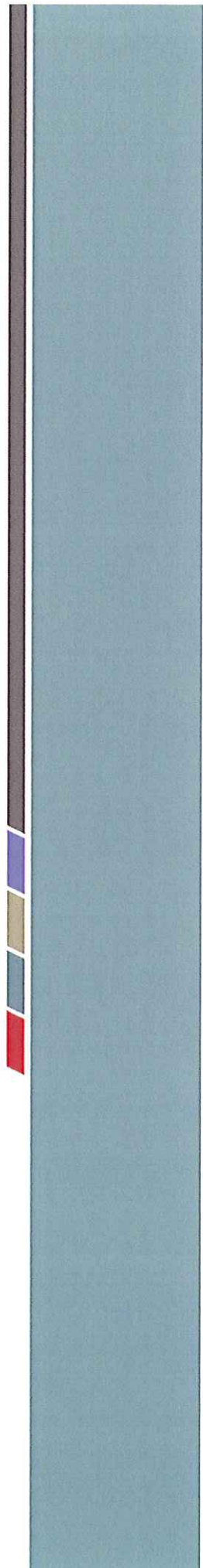
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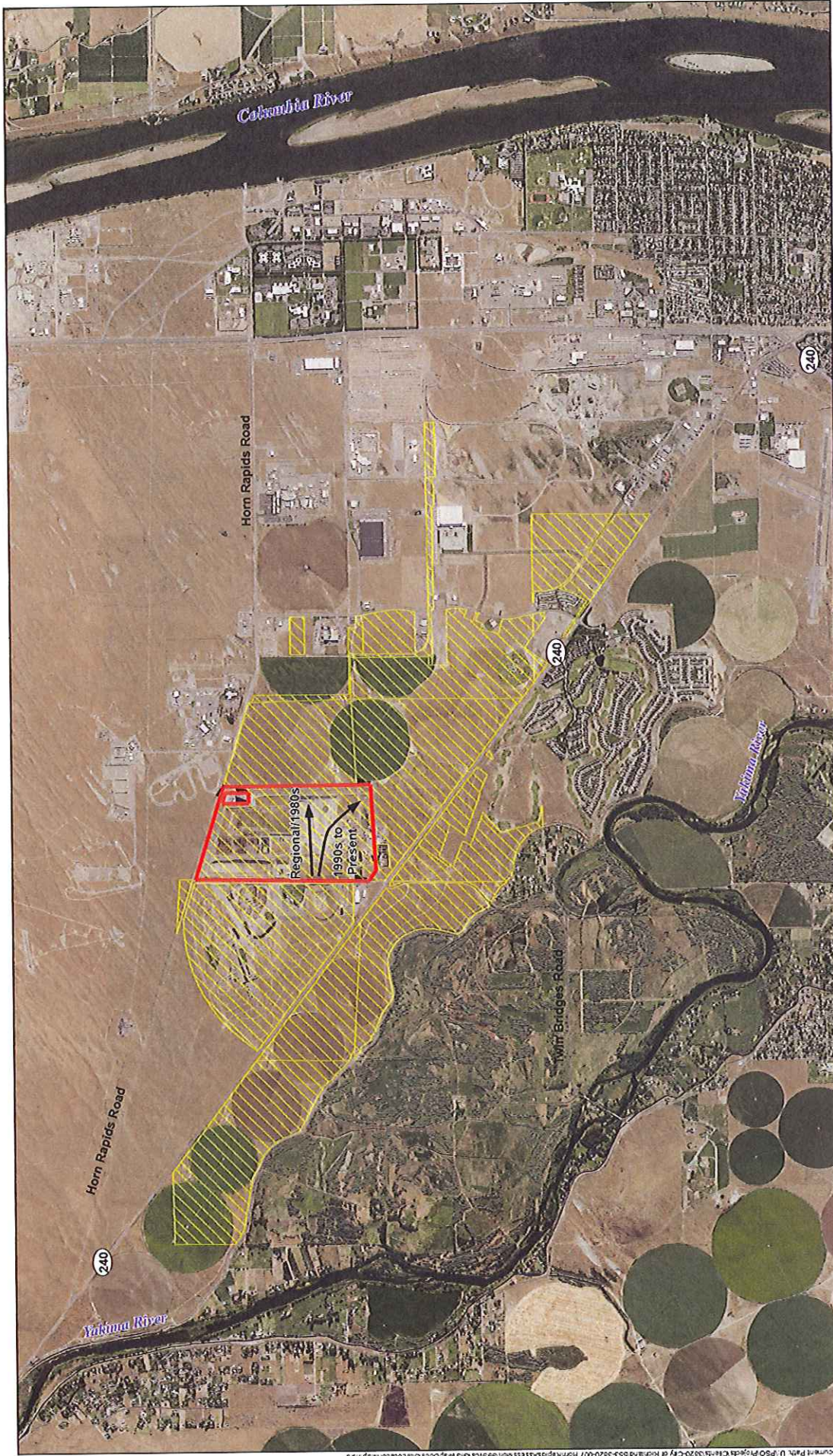
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Figures





**FIGURE 1**  
Horn Rapids Landfill  
Site Location Map

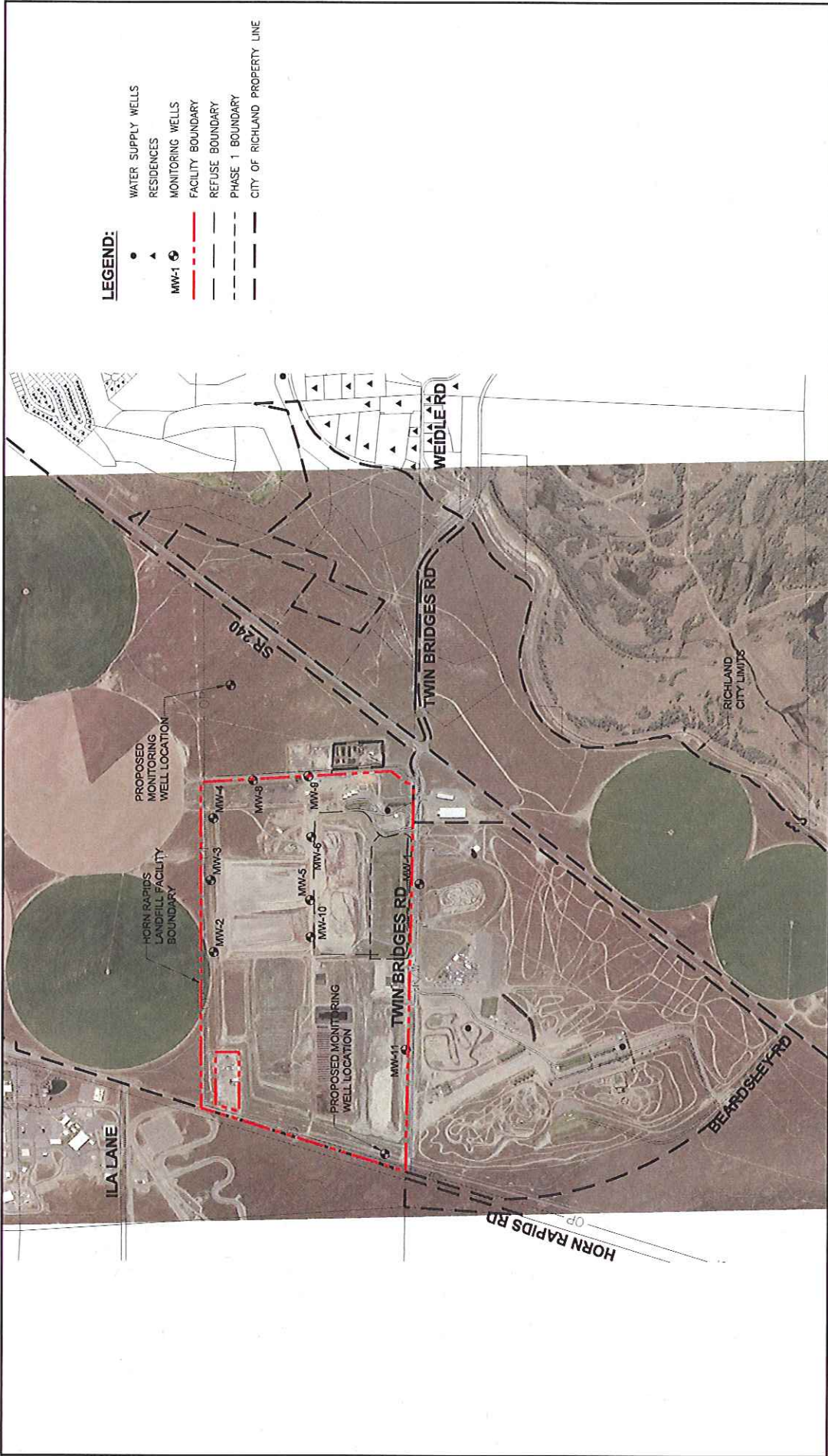
**Legend**

- Facility Boundary
- City Owned Property
- Approximate Groundwater Flow Direction

**Scale:** 0 0.25 0.5 0.75 1 Miles

**North Arrow:** ↑ N

Image Source: MAP 2015 (img07)

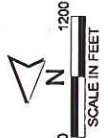


**LEGEND:**

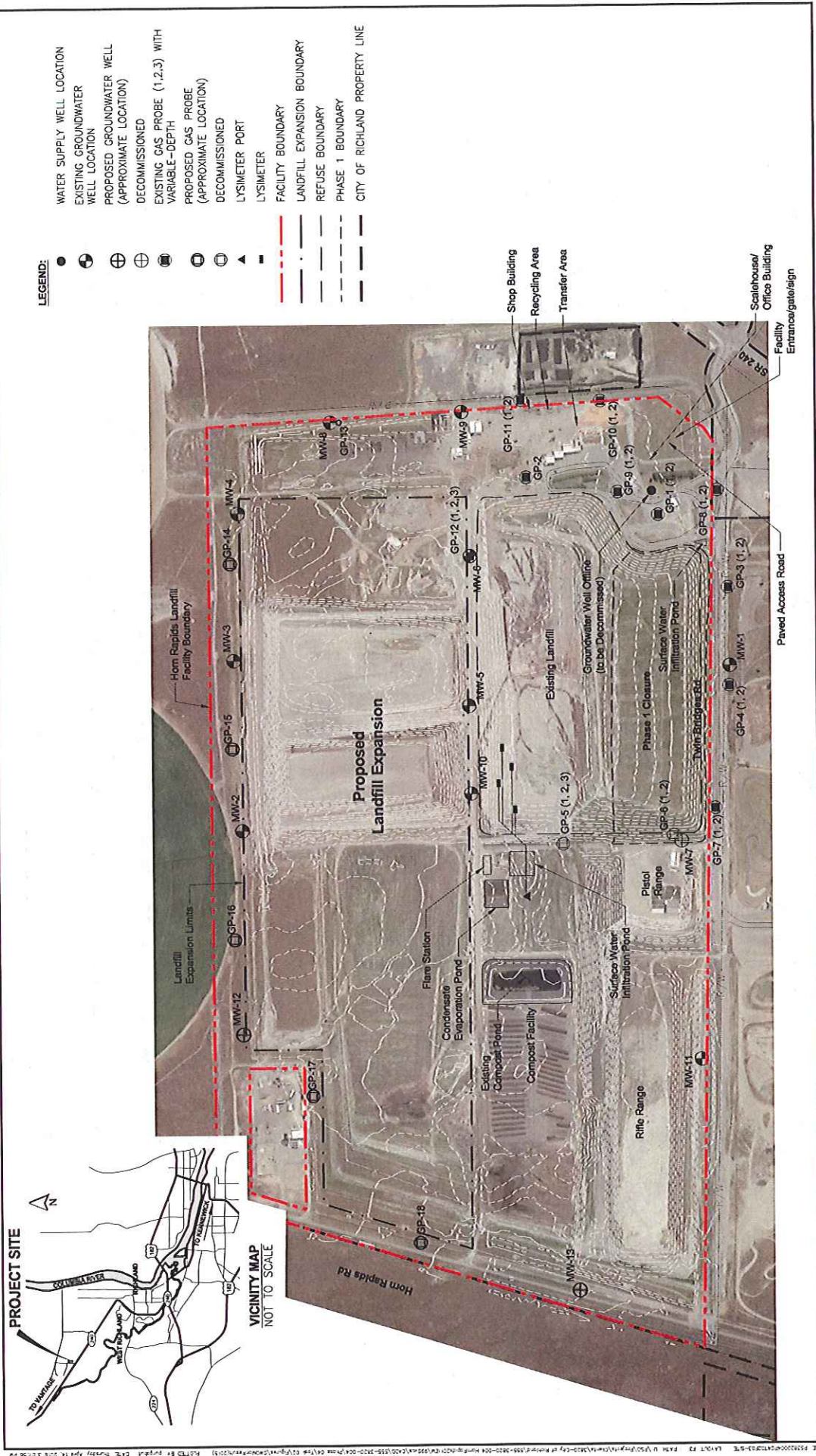
- WATER SUPPLY WELLS
- ▲ RESIDENCES
- ⊕ MW-1 MONITORING WELLS
- FACILITY BOUNDARY
- - - REFUSE BOUNDARY
- - - PHASE 1 BOUNDARY
- CITY OF RICHLAND PROPERTY LINE

**Figure 2**  
**Horn Rapids Landfill**  
**Vicinity Plan**

Parametrix DATE: APR 14, 2016 FILE: BLR2000701012



FILE: BLR2000701012; LAYOUT: P2; PATH: U:\GIS\Projects\GIS\Projects\BLR2000701012\Map\_Series\Map\_Series\_VicinityPlan.aprx; PLOT: 04/14/2016 10:27:25 AM; PLOTED BY: P2; EXT: Dwg; Apr 14, 2016 2:37:25 PM



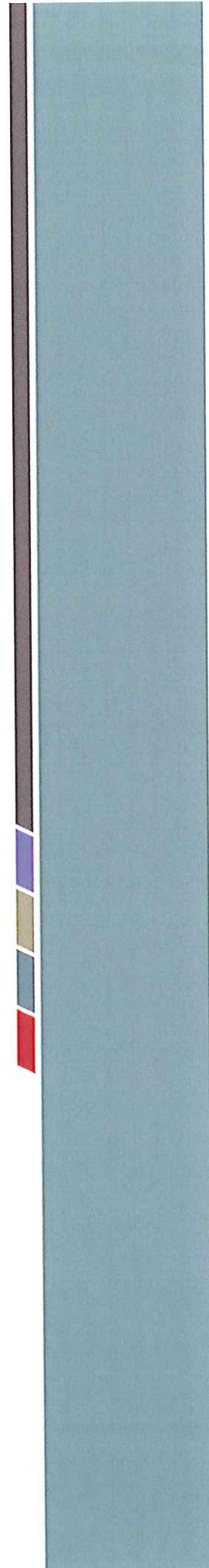
**Figure 3**  
**Horn Rapids Landfill**  
**Site Plan**

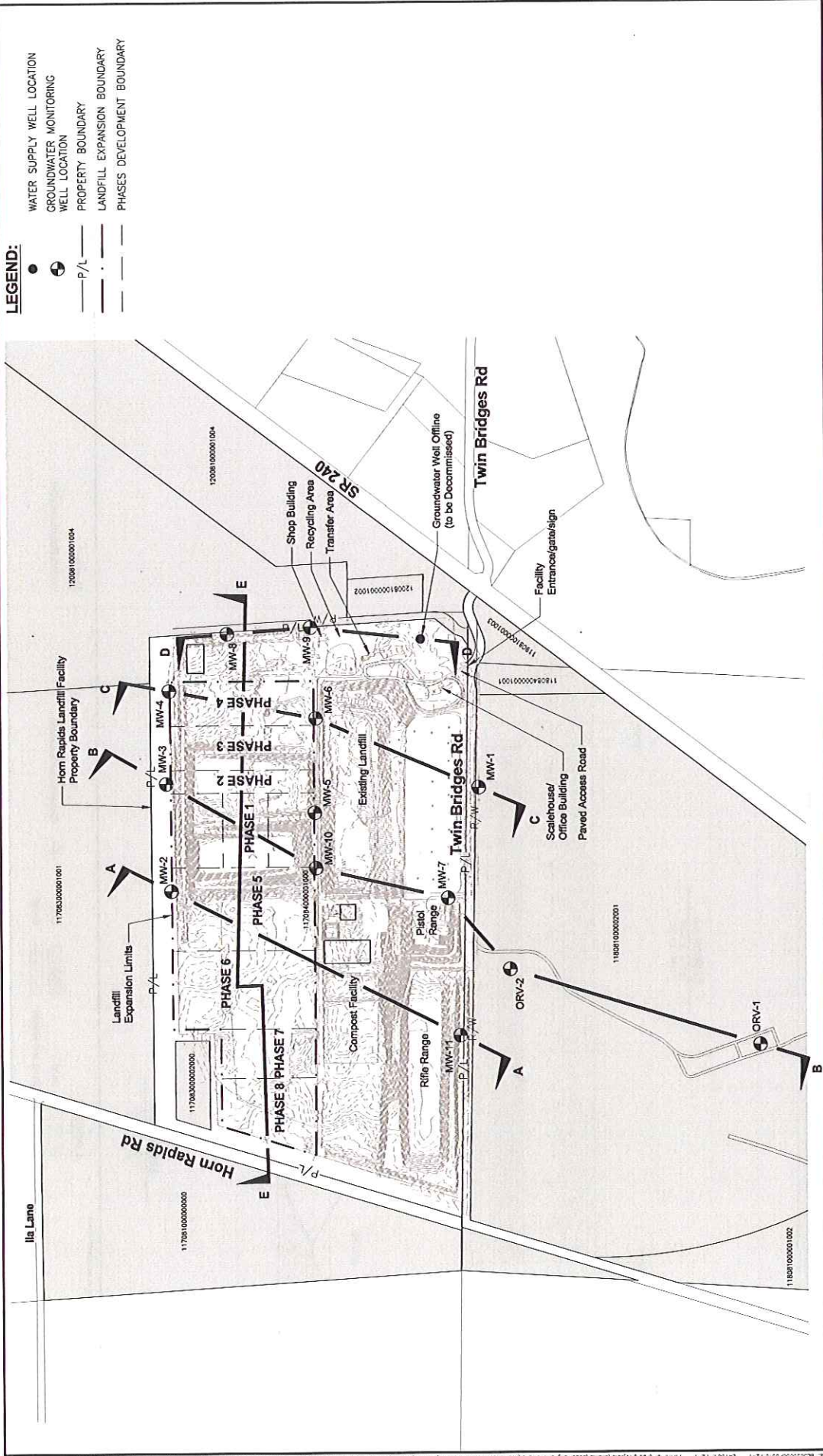




# Appendix A

## Geologic Cross Sections



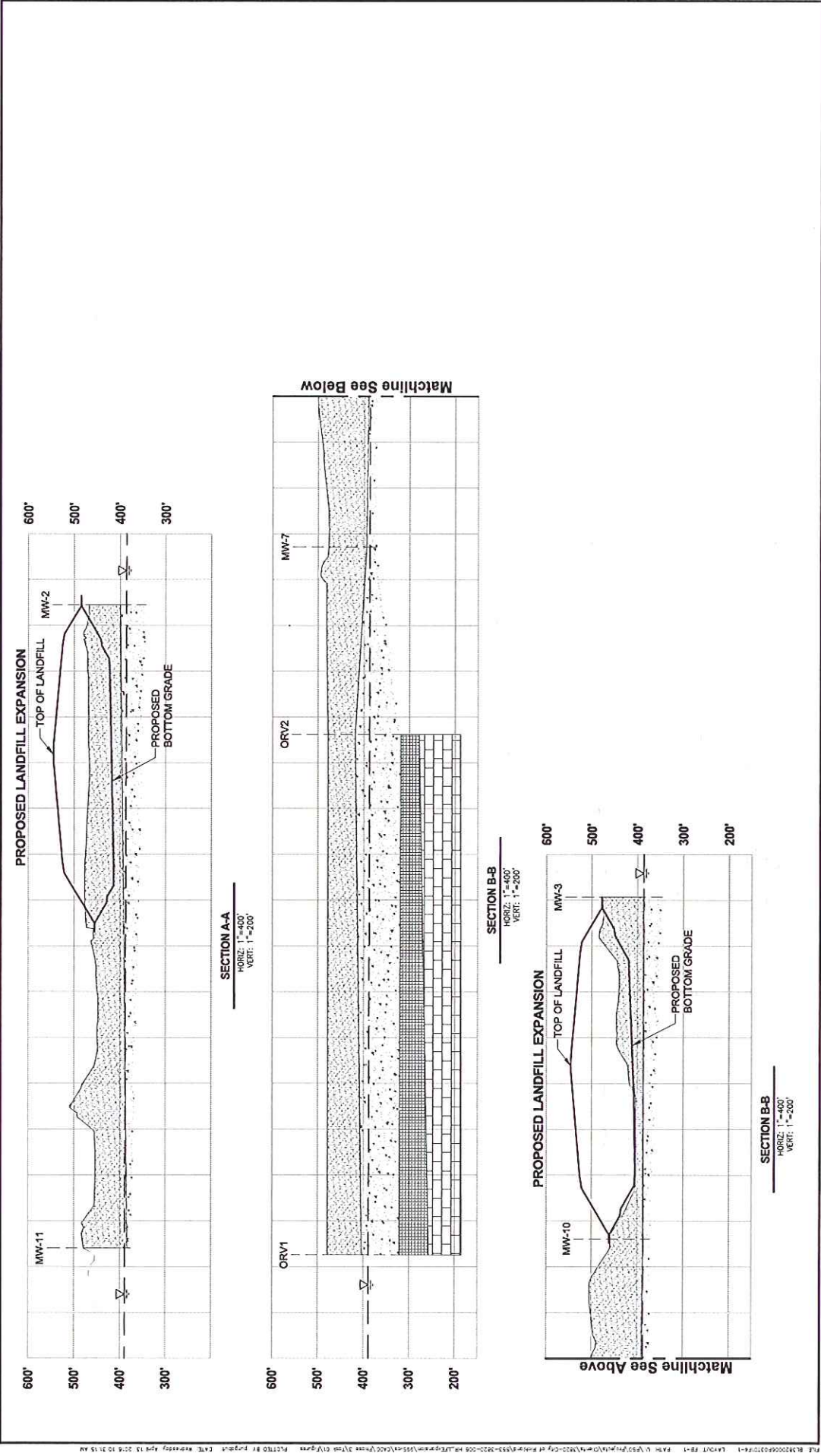


**Figure 2-1**  
**Geologic Cross Sections**  
**Horn Rapids Landfill**

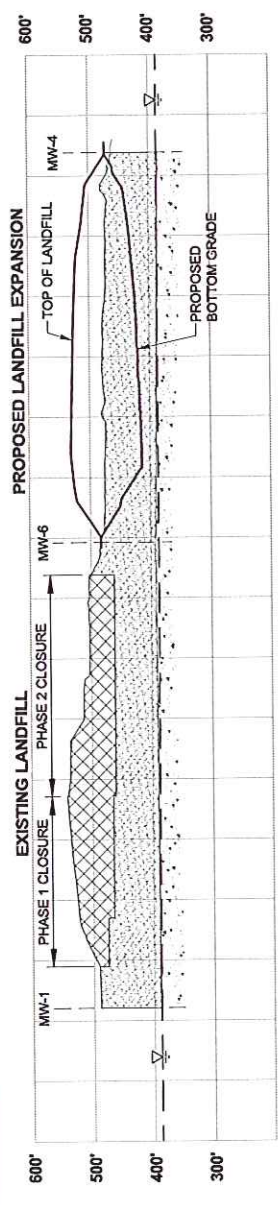
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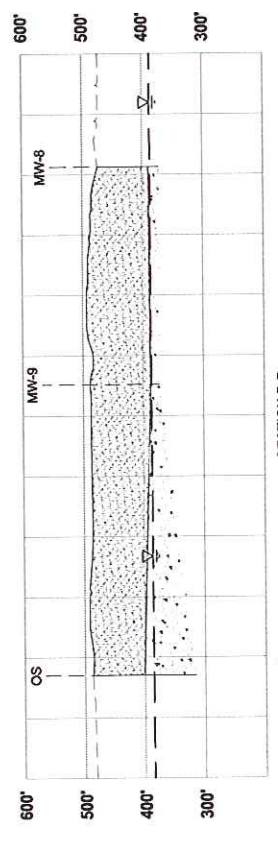
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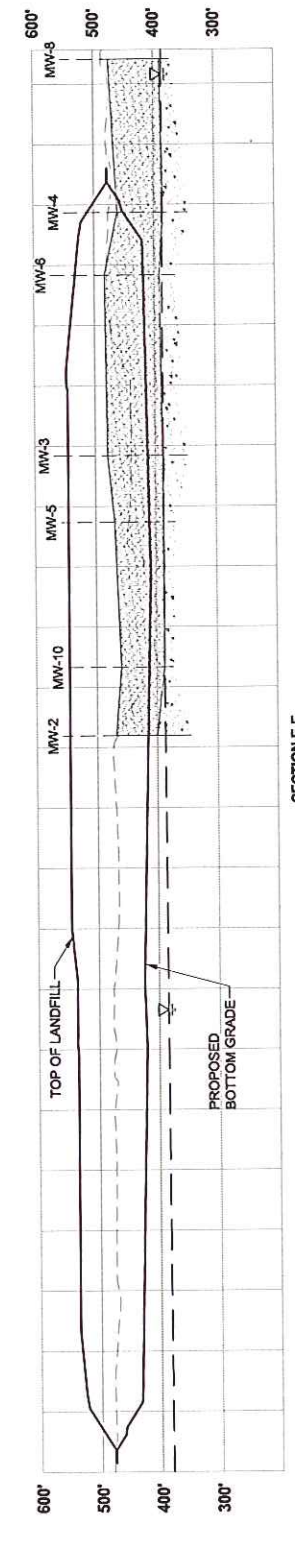
**Figure B-1**  
**Geologic Cross Sections**  
**Horn Rapids Landfill**



**SECTION C-C**  
 HORIZ: 1"=400'  
 VERT: 1"=200'



**SECTION D-D**  
 HORIZ: 1"=400'  
 VERT: 1"=200'



**SECTION E-E**  
 HORIZ: 1"=400'  
 VERT: 1"=200'

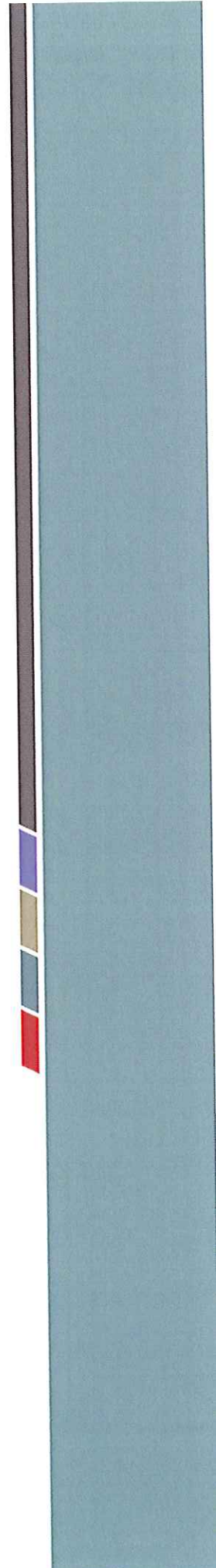
- Legend:**
- Sand
  - Sand and Gravel
  - Refuse
  - Clay
  - Basalt
  - Groundwater Elevation

**Note:**  
 Vertical Datum: NAVD88

**Figure B-2**  
**Geologic Cross Sections**  
**Horn Rapids Landfill**

# Appendix B

## Potentiometric Surface Maps



DRAWING NUMBER 810835\_FIG1

CHECKED BY

APPROVED BY

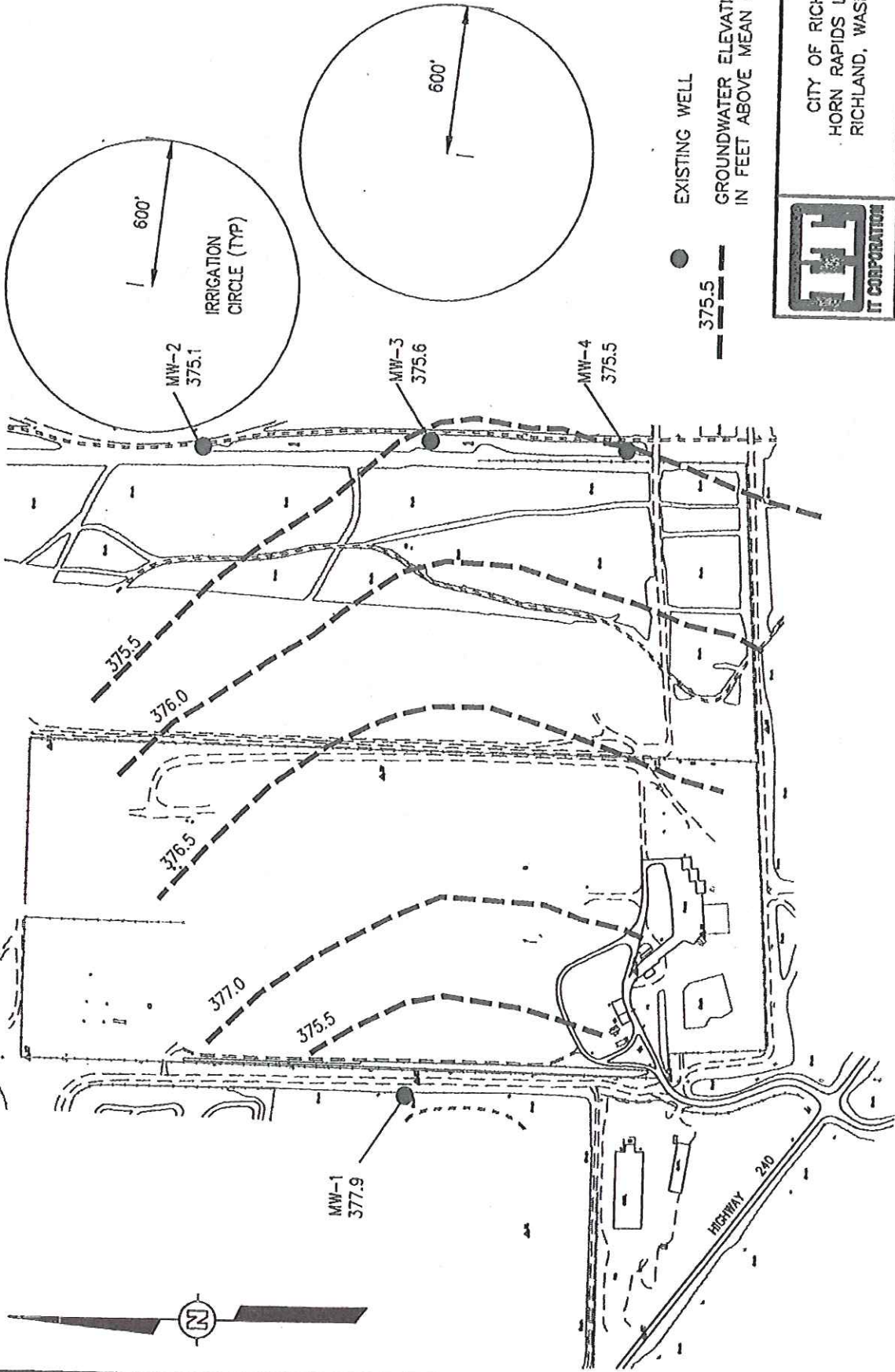
DATE 9/5/00

OFFICE

RICHLAND, WA

J. WILLIAMS

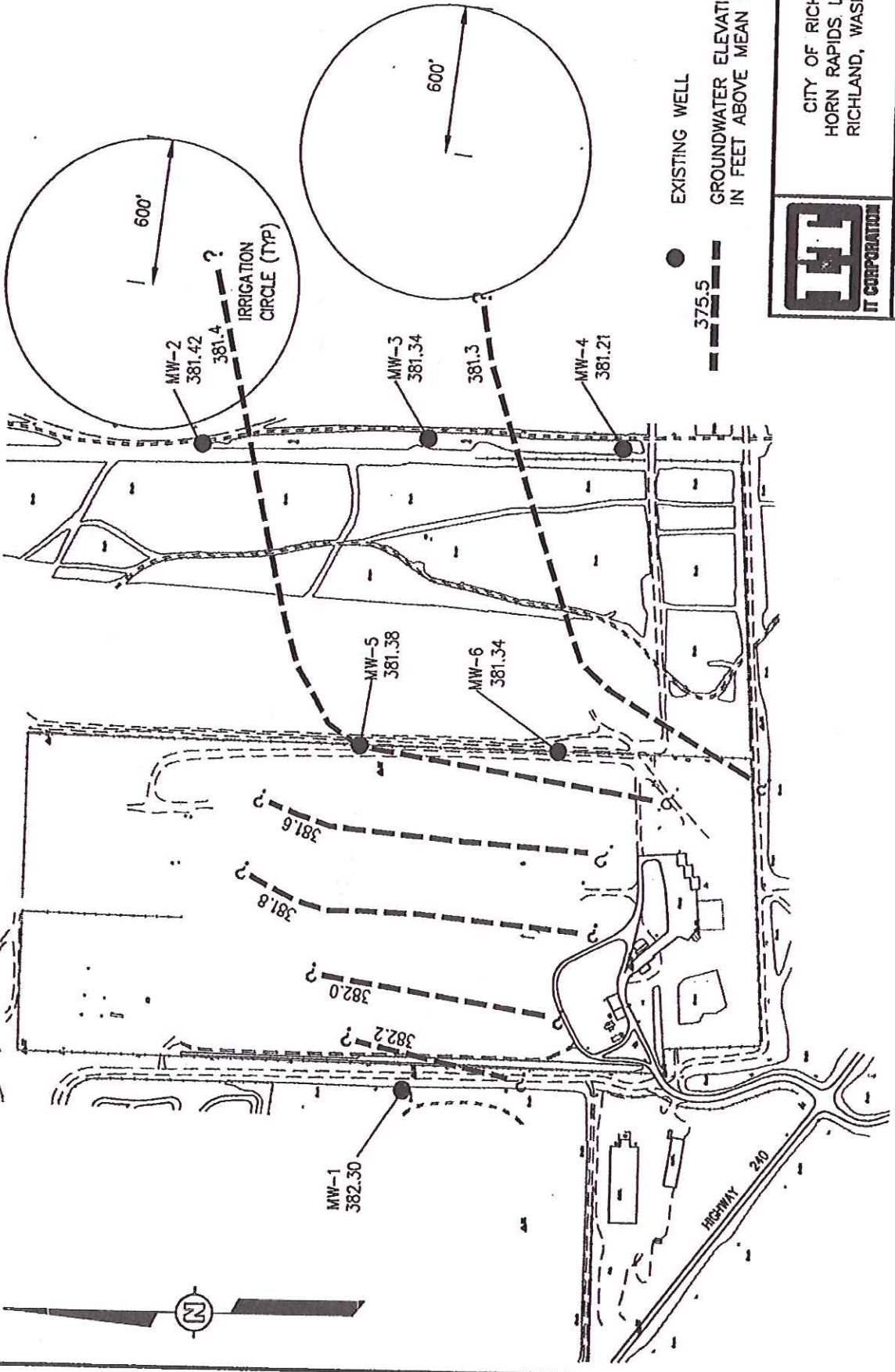
9/5/00



CITY OF RICHLAND  
 HORN RAPIDS LANDFILL  
 RICHLAND, WASHINGTON

FIGURE 5

GROUNDWATER ELEVATIONS 1987  
 RICHLAND LANDFILL  
 RICHLAND, WASHINGTON



CITY OF RICHLAND  
HORN RAPIDS LANDFILL  
RICHLAND, WASHINGTON

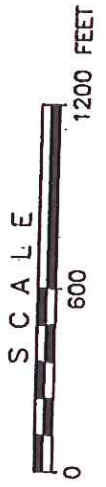


FIGURE 7

GROUNDWATER ELEVATIONS AUGUST 1998  
RICHLAND LANDFILL  
RICHLAND, WASHINGTON

DRAWING NUMBER  
810835-A1

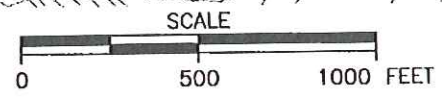
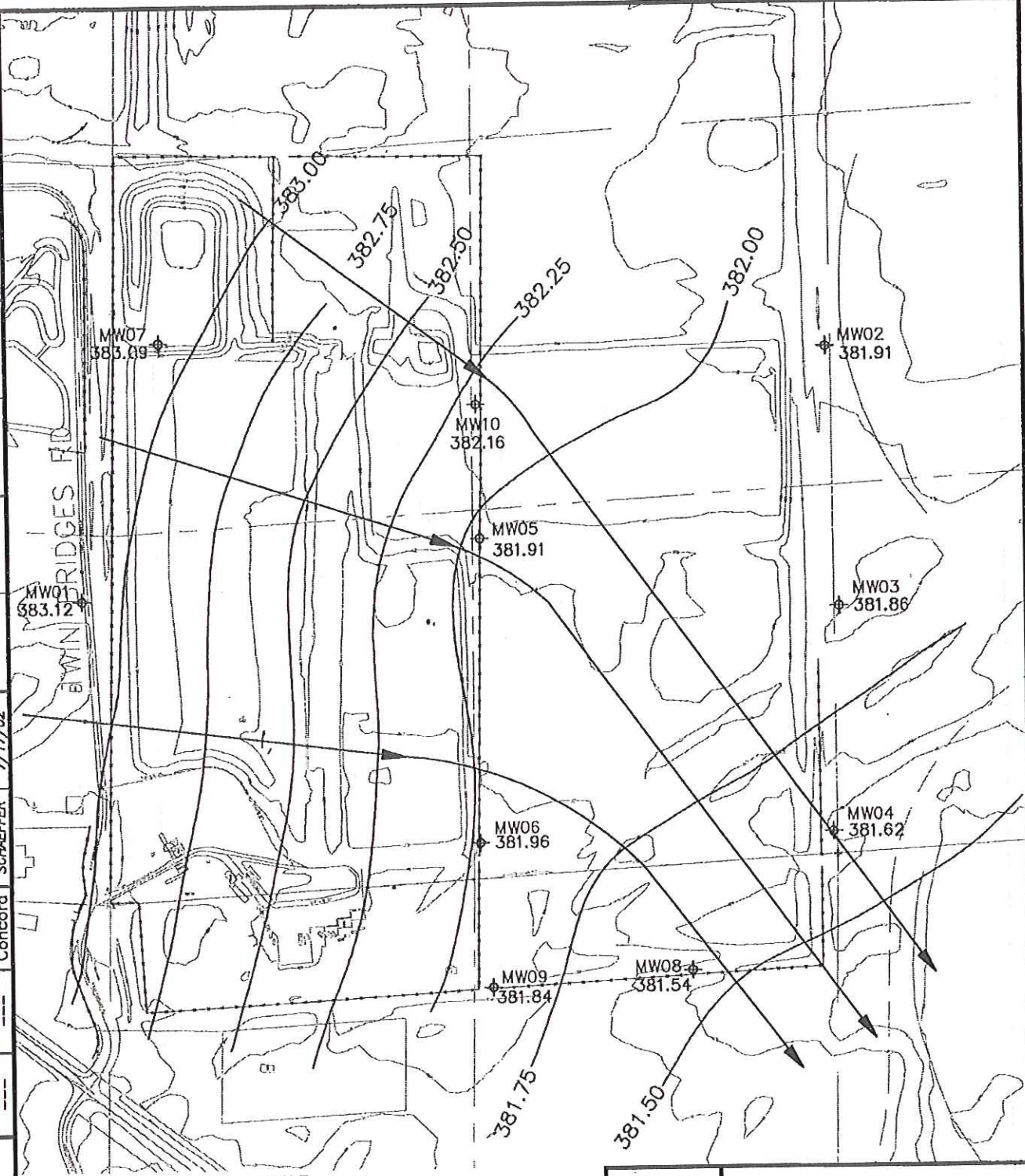
APPROVED BY

CHECKED BY

DRAWN BY  
SCHAEFFER 7/17/02

OFFICE  
Concord

X-REF



- LEGEND
- ⊕ MONITORING WELL LOCATION
  - 381.84 GROUNDWATER ELEVATION (FEET)
  - GROUNDWATER ELEVATION CONTOUR (FEET)
  - GROUNDWATER FLOW LINE

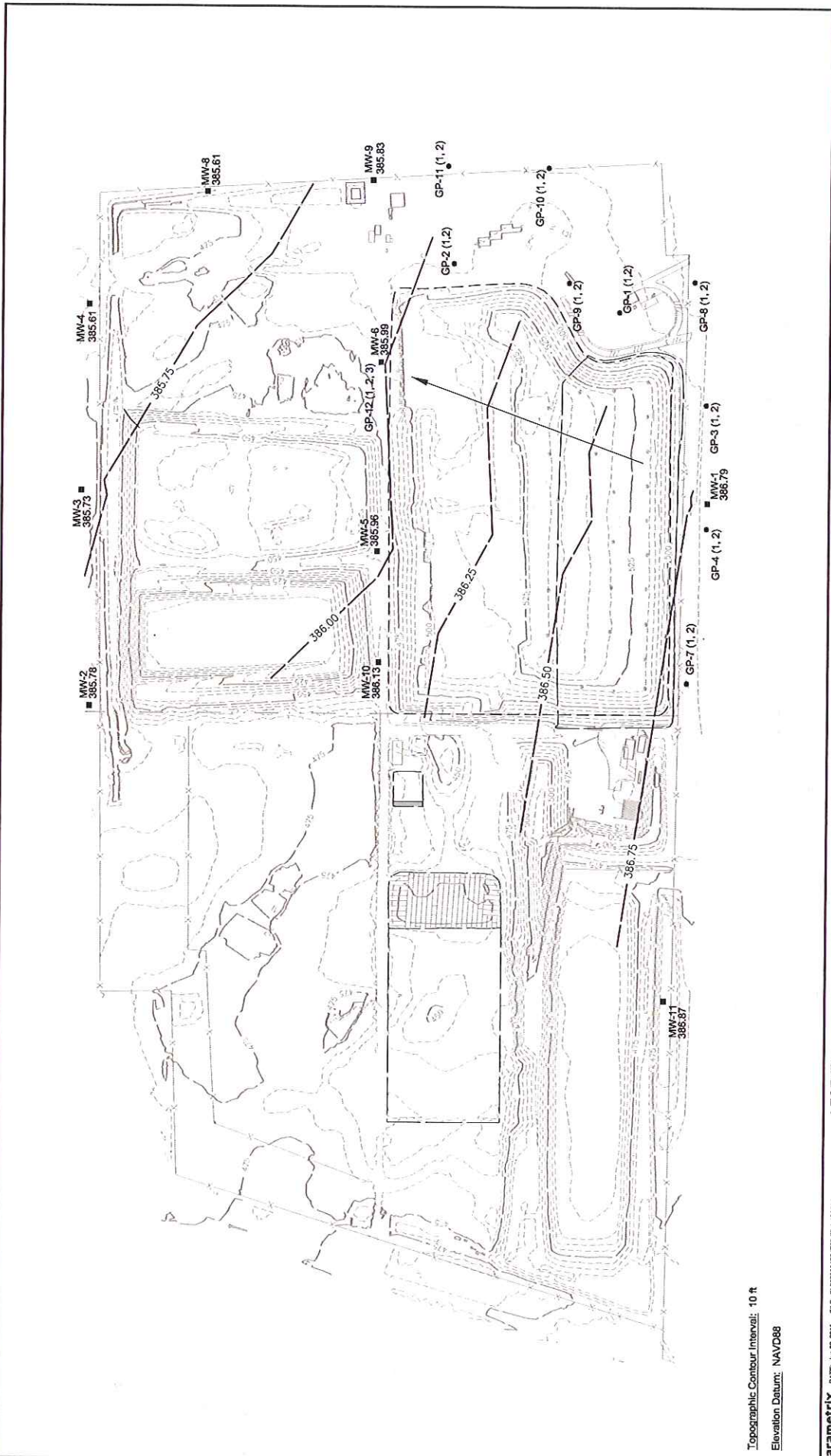


HORN RAPIDS LANDFILL

FIGURE 9

GROUNDWATER ELEVATION MAP  
MARCH 2002





Topographic Contour Interval: 10 ft  
 Elevation Datum: NAVD88

Parametrix DATE: Jan 02, 2015 FILE: B:\300000\PROJECTS\2015\2015\_01\FIG2 - POTENTIAL GROUNDWATER FLOW DIRECTION MAP.dwg



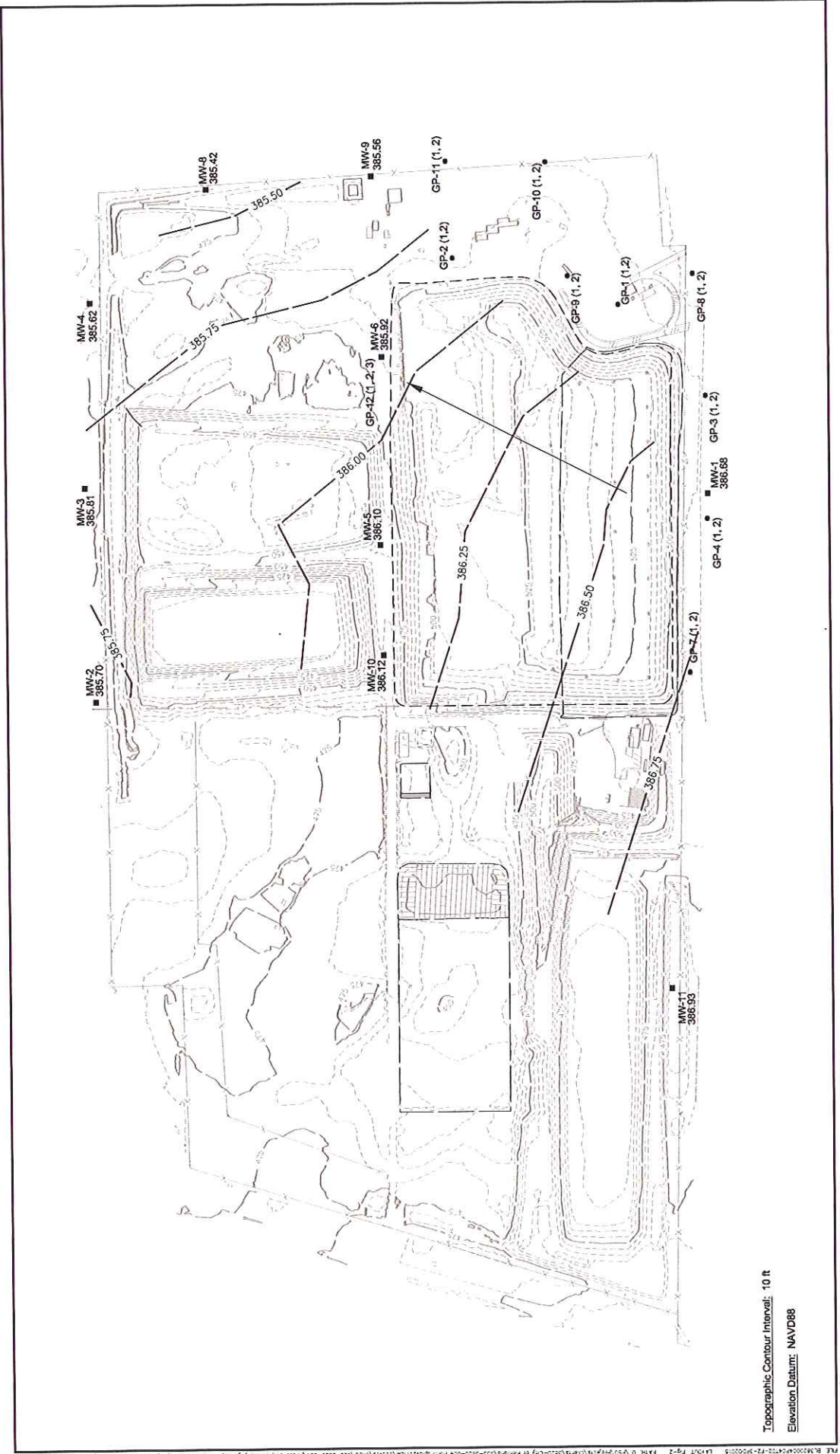
**LEGEND:**

- Approximate extent of refuse
- - - Approximate site boundary
- Groundwater elevation contour
- Approximate groundwater flow direction

**Monitoring Stations**

- Monitoring well, with groundwater elevation in ft NAVD88 measured March 30 and 31, 2015
- Gas Probe (1, 2, 3) with variable-depth screens

**Figure 2**  
**Potentiometric Surface Map**  
**First Quarter 2015**  
**Horn Rapids Landfill**



**Figure 2**  
**Potentiometric Surface Map**  
**Third Quarter 2015**  
**Horn Rapids Landfill**

**Monitoring Stations**

- Monitoring well, with groundwater elevation in ft NAVD88 measured September 16 and 17, 2015
- Gas Probe (1, 2, 3) with variable-depth screens

**LEGEND:**

- - - - - Approximate extent of refuse
- --- --- Approximate site boundary
- --- --- Groundwater elevation contour
- Approximate groundwater flow direction

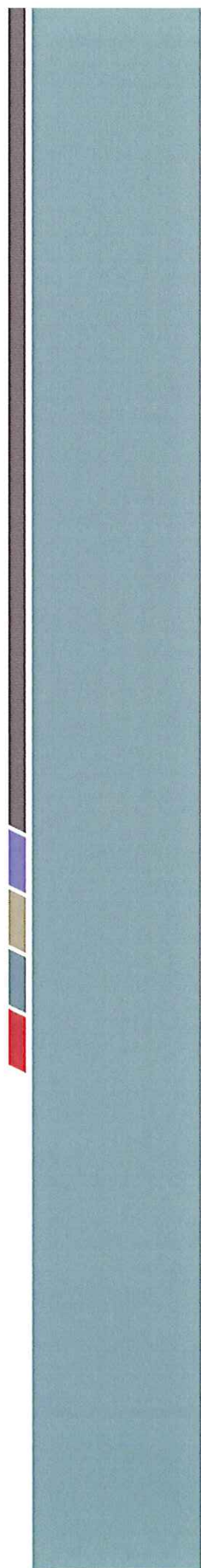
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Topographic Contour Interval: 10 ft  
 Elevation Datum: NAVD88

0 N 400  
 SCALE IN FEET

# Appendix C

## Landfill Gas Data



### Summary of Methane Data in Gas Probes, Horn Rapids Landfill

Probe	Port	Ground Surface Elev	Top of Screen	Bottom of Screen	1/26/2006	10/7/2006	12/29/2006	3/15/2007	6/13/2007	9/27/2007	12/19/2007	3/26/2008	6/28/2008
GP-1	1	485.3	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	485.3	8.5	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-2	1	489.1	36.5	38.0	37.1	14.6	30.5	16.2	31.7	2.8	1.9	41.9	32.1
	2	489.1	18.5	20.0	41.2	42.7	40.5	0.0	21.2	4.7	46.5	44.7	44.4
GP-3	1	477.1	36.5	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	477.1	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-4	1	477.5	36.5	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	477.5	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-5	1	479.4	56.5	58.0	6.4	10.1	12.3	0	2.0	0.8	13.9	12.7	0
	2	479.4	36.5	38.0	4.4	7.0	25.0	3.9	6.8	1.0	13.7	12.4	10.7
	3	479.4	18.5	20.0	0.1	0.0	10.4	0	0.0	0.5	4.1	1.2	0
GP-6	1	479.4	36.5	38.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	479.4	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-7	1	479.4	24.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	479.4	11.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-8	1	478.8	26.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	478.8	11.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-9	1	489.3	26.0	30.0	6.3	0.1	7.8	0.0	0.0	1.2	2.2	17.0	9.0
	2	489.3	11.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
GP-10	1	484.5	11.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	484.5	26.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-11	1	486.0	36.0	39.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	486.0	14.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-12	1	480.3	22.5	32.5	8.6	11.3	0.0	9.7	16.3	1.4	29.0	26.2	16.9
	2	480.3	49.5	59.5	28.7	35.3	7.2	21.2	26.4	4.6	35.3	30.9	30.0
	3	480.3	76.5	86.5	21.3	22.9	0.0	10.4	14.1	1.4	21.2	22.0	22.0

### Summary of Methane Data in Gas Probes, Horn Rapids Landfill

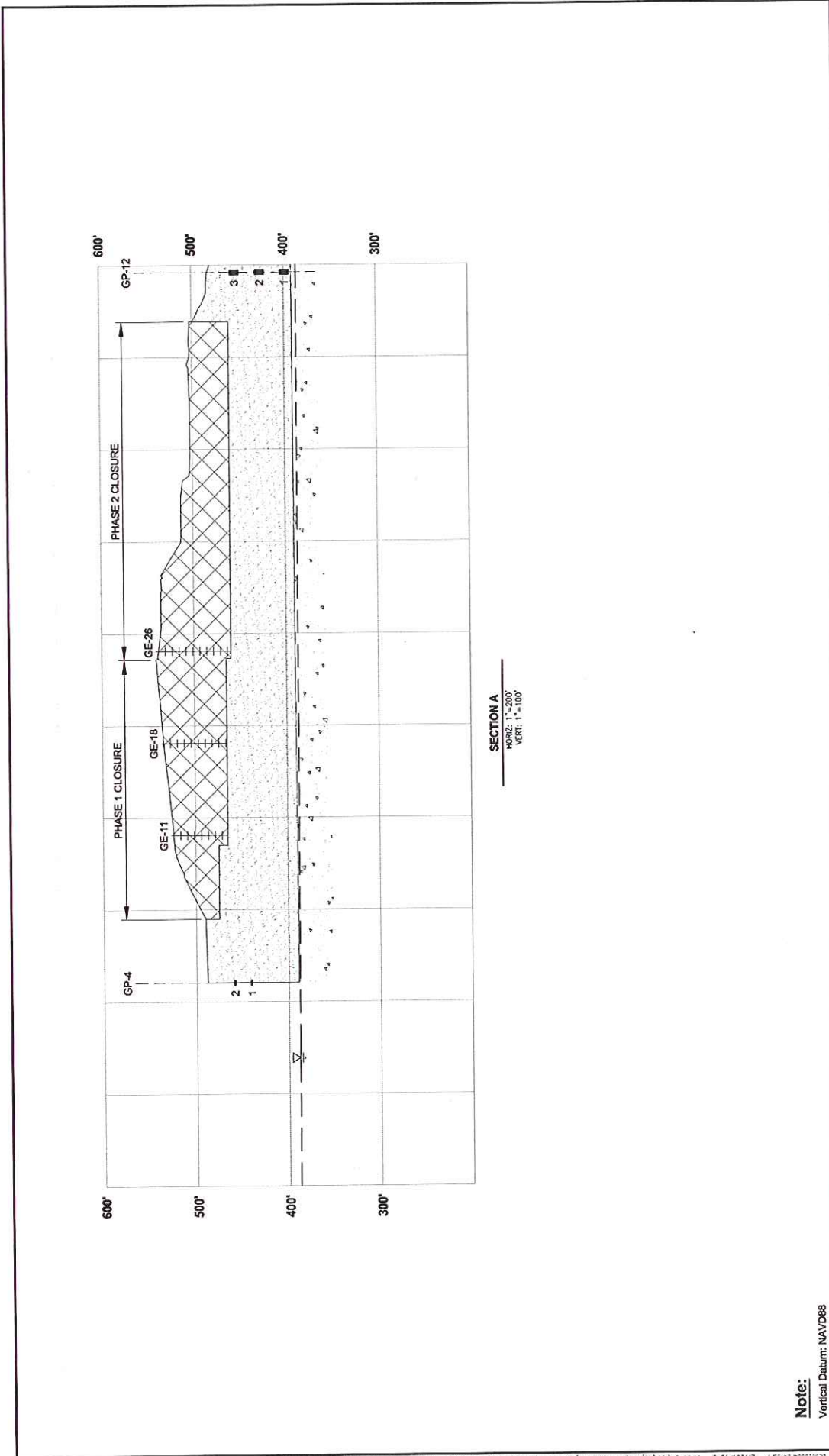
		Ground												
Probe	Port	Surface Elev	Top of Screen	Bottom of Screen	9/26/2008	1/8/2009	3/19/2009	6/17/2009	9/24/2009	12/17/2009	3/11/2010	6/16/2010	9/8/2010	11/18/2010
GP-1	1	485.3	18.5	20.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	2	485.3	8.5	10.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GP-2	1	489.1	36.5	38.0	0.2	34.2	41.4	35.6	36.8	0.1	36.8	27.8	33.6	0.0
	2	489.1	18.5	20.0	0.2	45.2	42.0	1.0	40.8	0.1	40.9	38.3	33.8	0.0
GP-3	1	477.1	36.5	38.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0
	2	477.1	18.5	20.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GP-4	1	477.5	36.5	38.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	2	477.5	18.5	20.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GP-5	1	479.4	56.5	58.0	1.0	15.2	13.7	1.8	0.4	8.7	14.7	NA	NA	NA
	2	479.4	36.5	38.0	11.2	9.7	12.6	13.9	0.2	10.9	13.0	NA	NA	NA
	3	479.4	18.5	20.0	0.3	0.0	2.6	0.5	3.1	8.9	2.0	NA	NA	NA
GP-6	1	479.4	36.5	38.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	NA	NA	NA
	2	479.4	18.5	20.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	NA	NA	NA
GP-7	1	479.4	24.0	28.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	2	479.4	11.0	15.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GP-8	1	478.8	26.0	30.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	2	478.8	11.0	15.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GP-9	1	489.3	26.0	30.0	0.0	16.4	16.4	17.7	18.1	0.1	2.6	0.0	11.3	0.0
	2	489.3	11.0	16.0	0.0	0.5	0.2	0.4	0.7	0.1	0.1	0.0	0.4	0.0
GP-10	1	484.5	11.0	15.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	2	484.5	26.0	30.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
GP-11	1	486.0	36.0	39.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
	2	486.0	14.0	17.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
GP-12	1	480.3	22.5	32.5	21.8	20.4	23.4	21.6	23.5	0.0	18.8	15.5	19.5	26.6
	2	480.3	49.5	59.5	24.7	34.1	32.9	28.8	15.8	2.1	28.0	24.5	24.9	31.5
	3	480.3	76.5	86.5	16.3	27.3	23.5	18.6	19.5	0.1	21.5	19.6	18.0	21.4

### Summary of Methane Data in Gas Probes, Horn Rapids Landfill

Probe	Port	Ground		Top of Screen	Bottom of Screen	3/16/2011	6/21/2011	9/15/2011	12/16/2011	3/22/2012	6/20/2012	9/19/2012	10/16/2012	3/13/13	6/11/13
		Surface Elev	Screen												
GP-1	1	485.3	18.5	20.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	485.3	8.5	10.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-2	1	489.1	36.5	38.0	0.2	35	0	0	0	3.0	0.0	0.0	0.0	0.0	0.0
	2	489.1	18.5	20.0	0.0	40	0	0	0	2.9	0.0	0.0	0.0	0.0	0.0
GP-3	1	477.1	36.5	38.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	477.1	18.5	20.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-4	1	477.5	36.5	38.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	477.5	18.5	20.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-5	1	479.4	56.5	58.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	479.4	36.5	38.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	3	479.4	18.5	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GP-6	1	479.4	36.5	38.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	479.4	18.5	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GP-7	1	479.4	24.0	28.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	479.4	11.0	15.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-8	1	478.8	26.0	30.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	478.8	11.0	15.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-9	1	489.3	26.0	30.0	0.0	0	0	2	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	489.3	11.0	16.0	0.5	16	3	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-10	1	484.5	11.0	15.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	484.5	26.0	30.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-11	1	486.0	36.0	39.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	2	486.0	14.0	17.0	0.0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
GP-12	1	480.3	22.5	32.5	15.0	11	16	10	10	7.0	8.0	8.0	8.0	5.0	4.0
	2	480.3	49.5	59.5	19.5	20	23	26	26	17.0	20.0	18.0	18.0	12.0	10.0
	3	480.3	76.5	86.5	17.2	16	17	17	17	16.0	17.0	20.0	15.0	14.0	11.0

### Summary of Methane Data in Gas Probes, Horn Rapids Landfill

Ground			Methane Data (ppm)											
Probe	Port	Surface Elev	Top of Screen	Bottom of Screen	9/20/13	1/8/14	3/13/14	6/18/14	9/29/14	12/12/14	3/19/2015	7/14/2015	10/7/2015	1/7/2016
GP-1	1	485.3	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	485.3	8.5	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP-2	1	489.1	36.5	38.0	0.0	0.0	0.0	18.0	0.0	0.0	19.0	4.0	4.0	0
	2	489.1	18.5	20.0	0.0	0.0	0.0	2.0	0.0	0.0	28.0	0.0	2.7	0
GP-3	1	477.1	36.5	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	477.1	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GP-4	1	477.5	36.5	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	477.5	18.5	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GP-5	1	479.4	56.5	58.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	479.4	36.5	38.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	3	479.4	18.5	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GP-6	1	479.4	36.5	38.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2	479.4	18.5	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GP-7	1	479.4	24.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	479.4	11.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GP-8	1	478.8	26.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	478.8	11.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GP-9	1	489.3	26.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0
	2	489.3	11.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0
GP-10	1	484.5	11.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	484.5	26.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GP-11	1	486.0	36.0	39.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	486.0	14.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GP-12	1	480.3	22.5	32.5	0.0	0.0	5.0	1.0	0.0	0.0	5.0	0.0	0.0	0
	2	480.3	49.5	59.5	0.0	4.0	12.0	2.0	0.0	0.0	0.0	0.0	0.8	1
	3	480.3	76.5	86.5	0.0	5.0	14.0	0.0	1.0	0.0	1.0	0.0	0.0	1



**Geologic Cross Section  
Showing Gas Probes  
Horn Rapids Landfill**

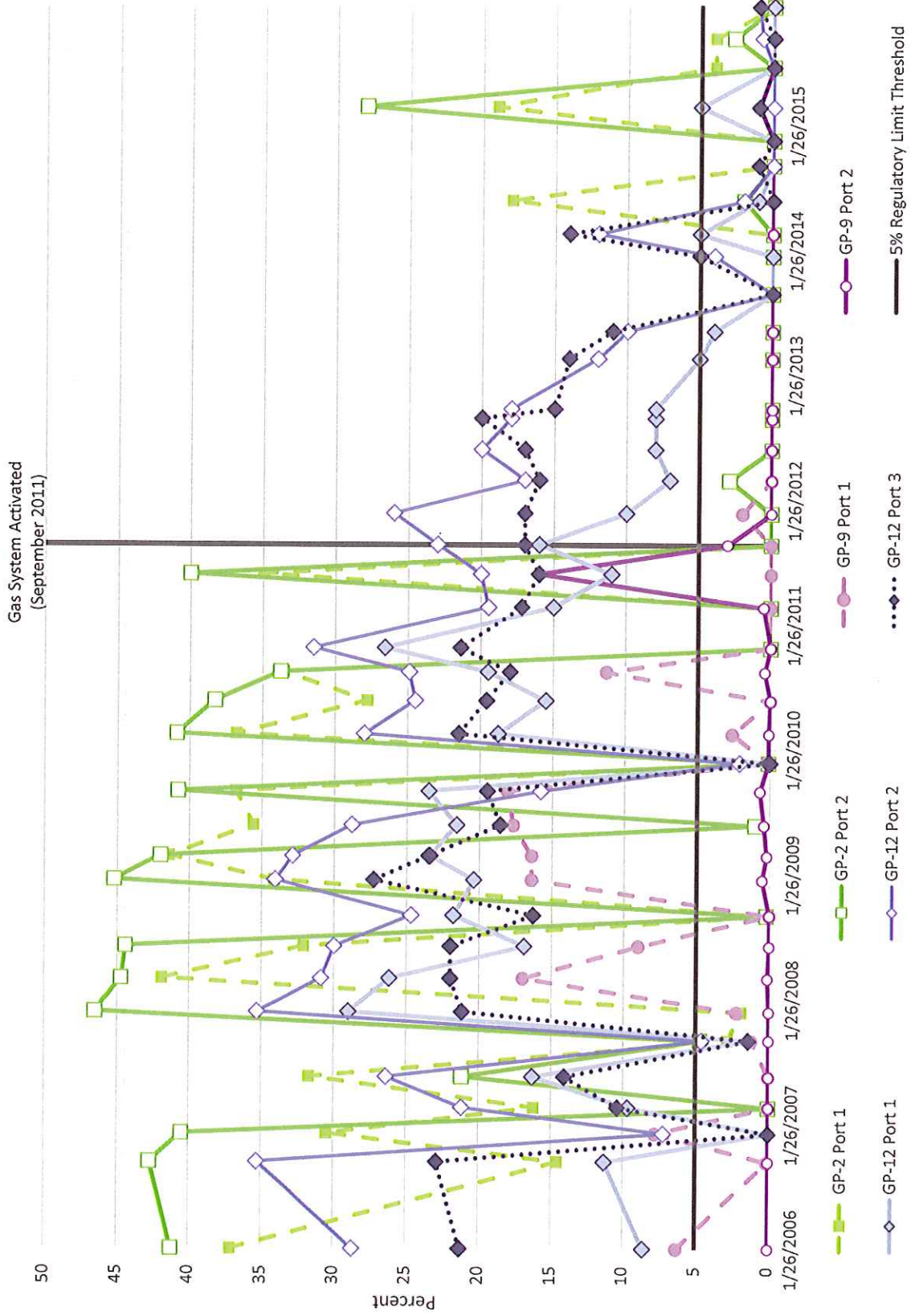
**SECTION A**  
HORIZ: 1" = 200'  
VERT: 1" = 100'

- Legend:**
- Sand
  - Sand and Gravel
  - Clay
  - Basalt
  - Gas Probe, Showing Screened Intervals
  - Gas Extraction Well

**Note:**  
Vertical Datum: NAVD88

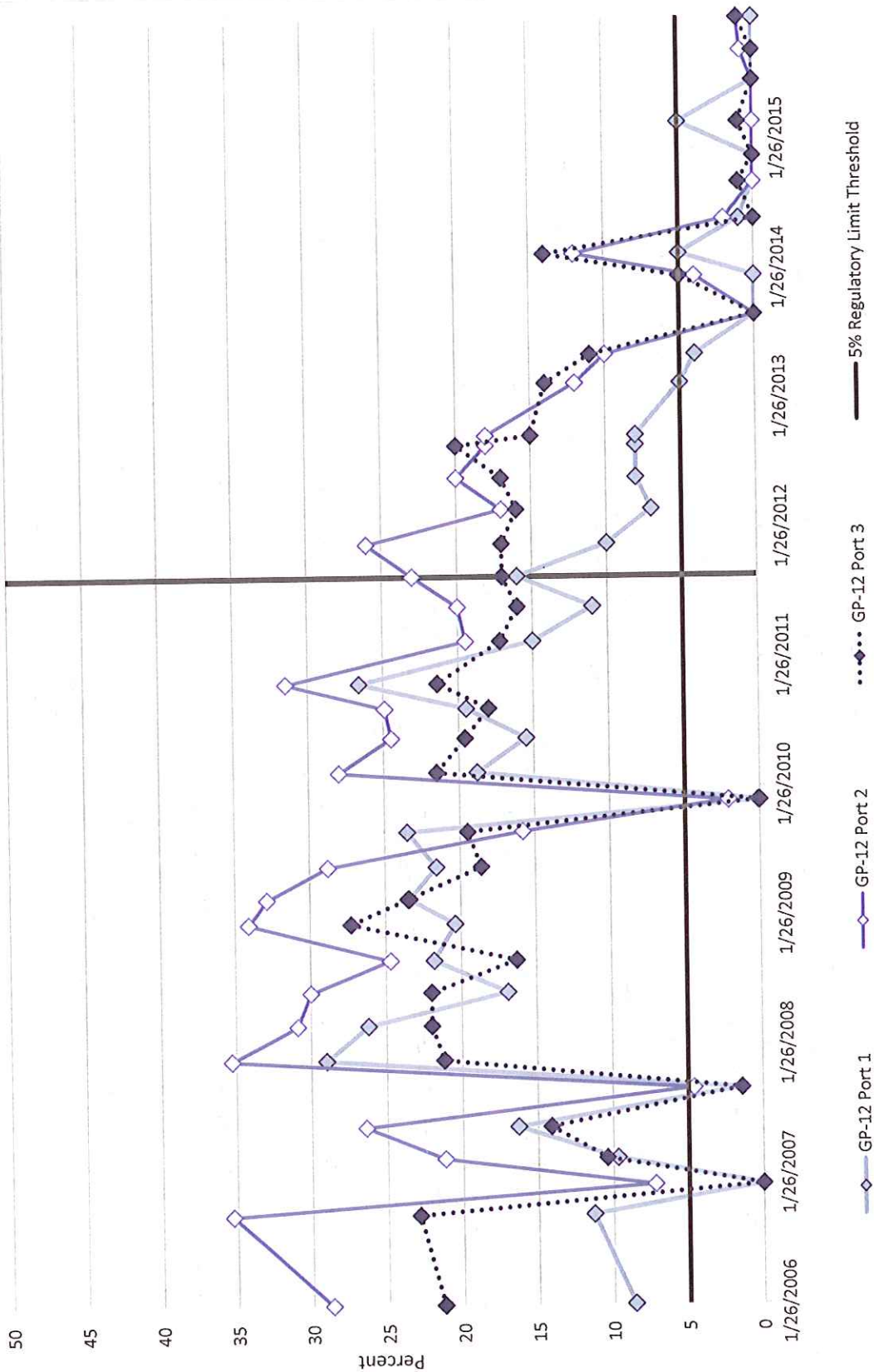
**Parametrix** DATE: APR 14, 2016  
FILE: BLR0000PART03.DWG





**Figure 2**  
**Methane in Landfill Gas Probes,**  
**Horn Rapids Landfill**

Gas System Activated  
(September 2011)



**Methane in Landfill Gas Probe 12,  
Horn Rapids Landfill**

Yielded to Area 59.7 acres

Q/R 7887



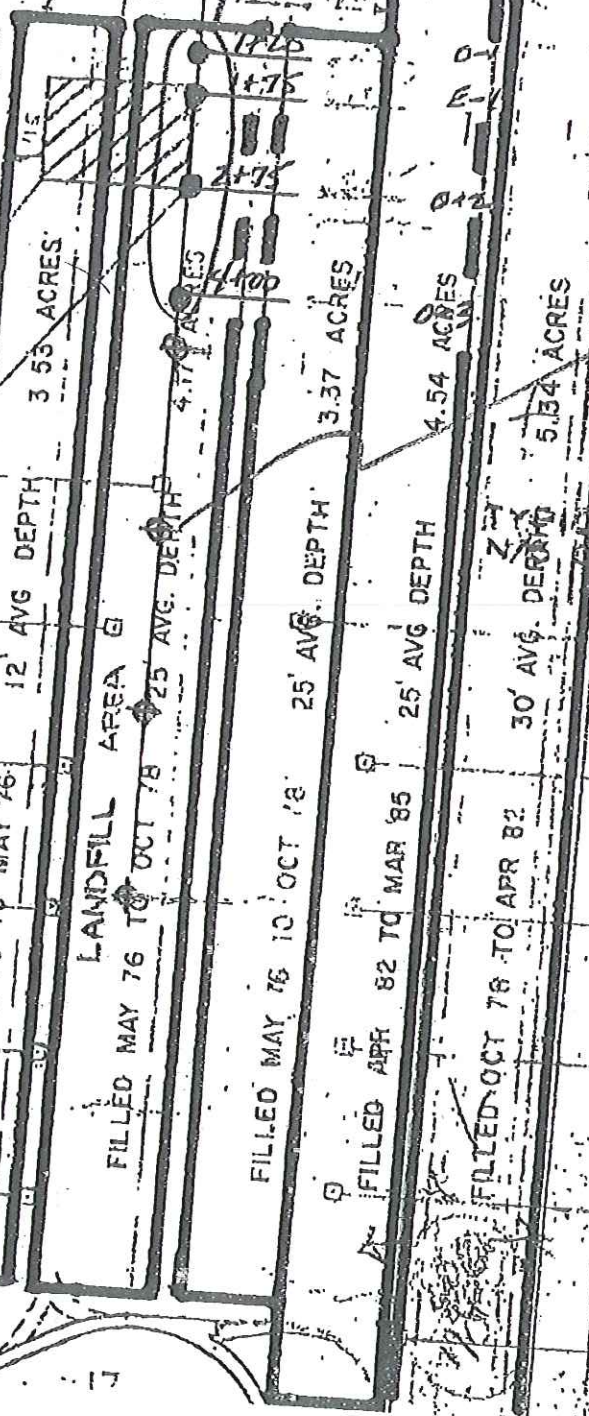
1" = 200'

300'

MW-07

Well's not installed  
Proposed location

125' 125' 425'



UNFILLED AREA

Use this for ext. well

TRENCH ORIENTATION

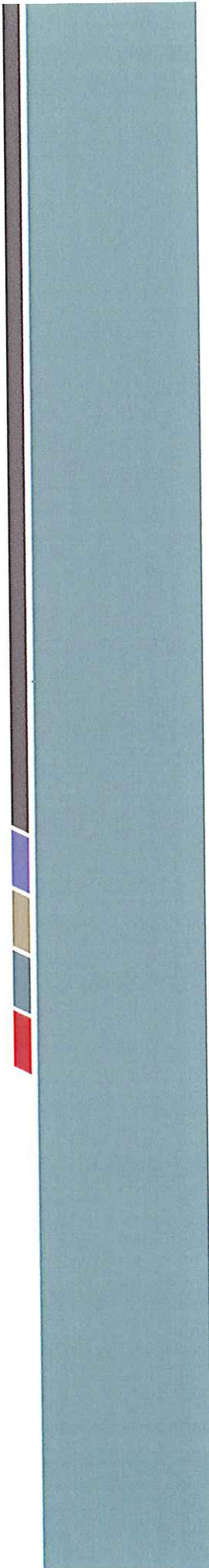
6" Aluminum Pipe, Type 78  
40' Joints

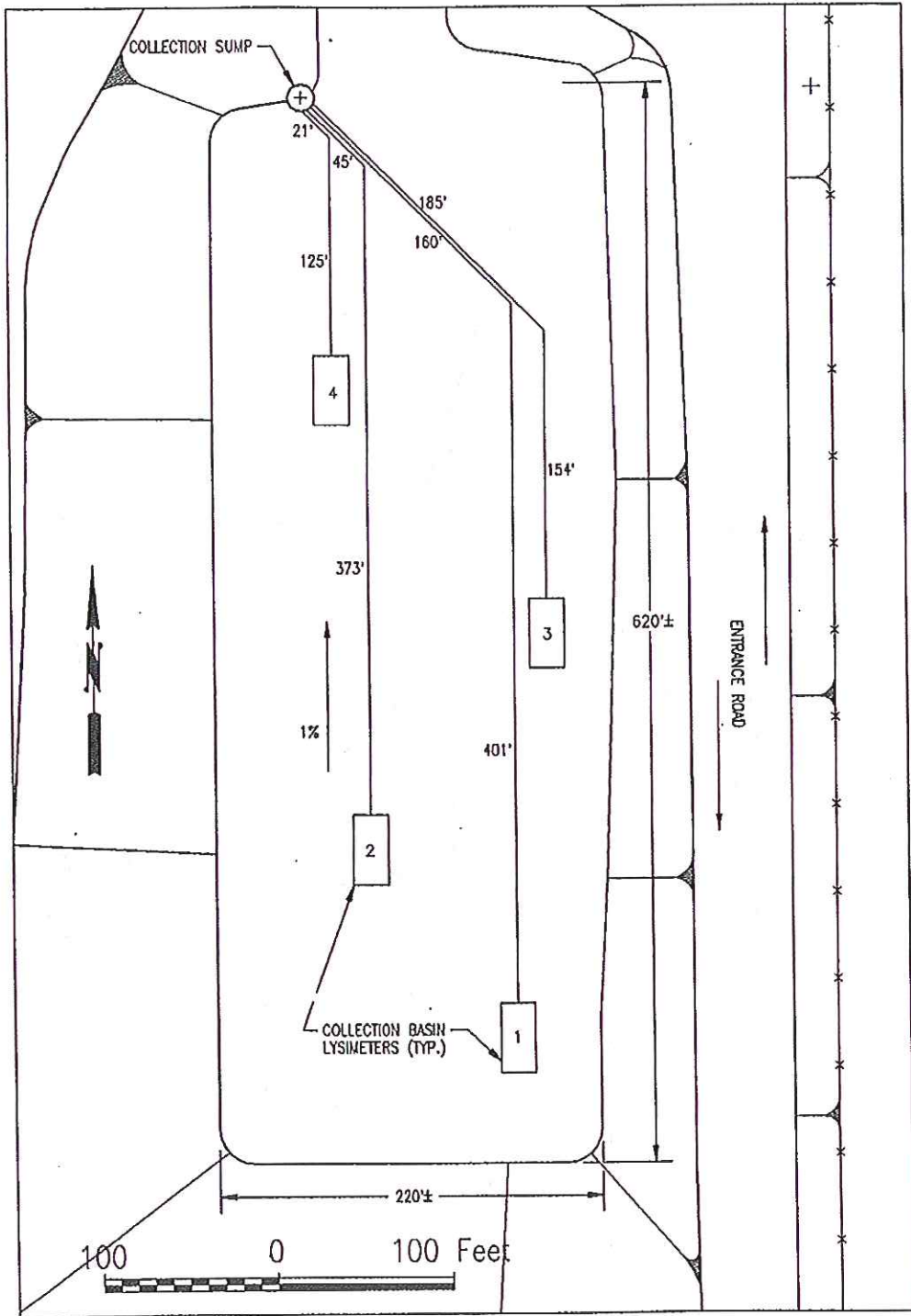
117  
SIT

114.1

# Appendix D

Leachate Data





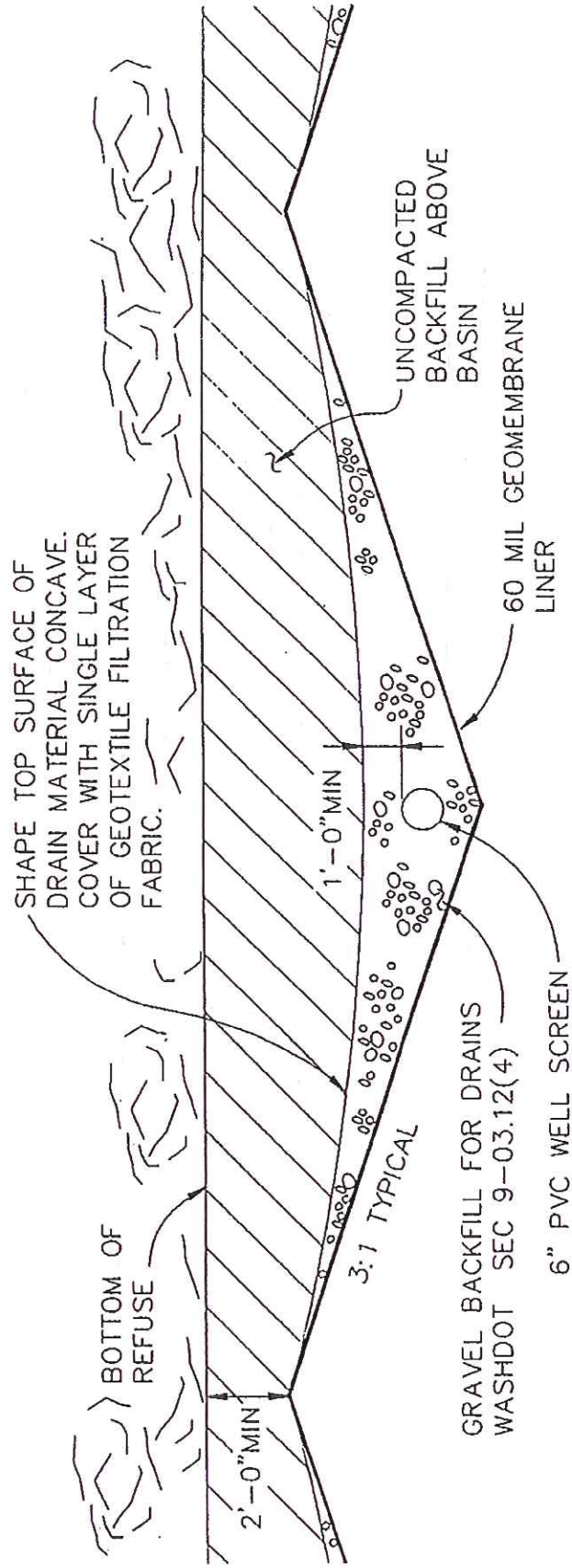
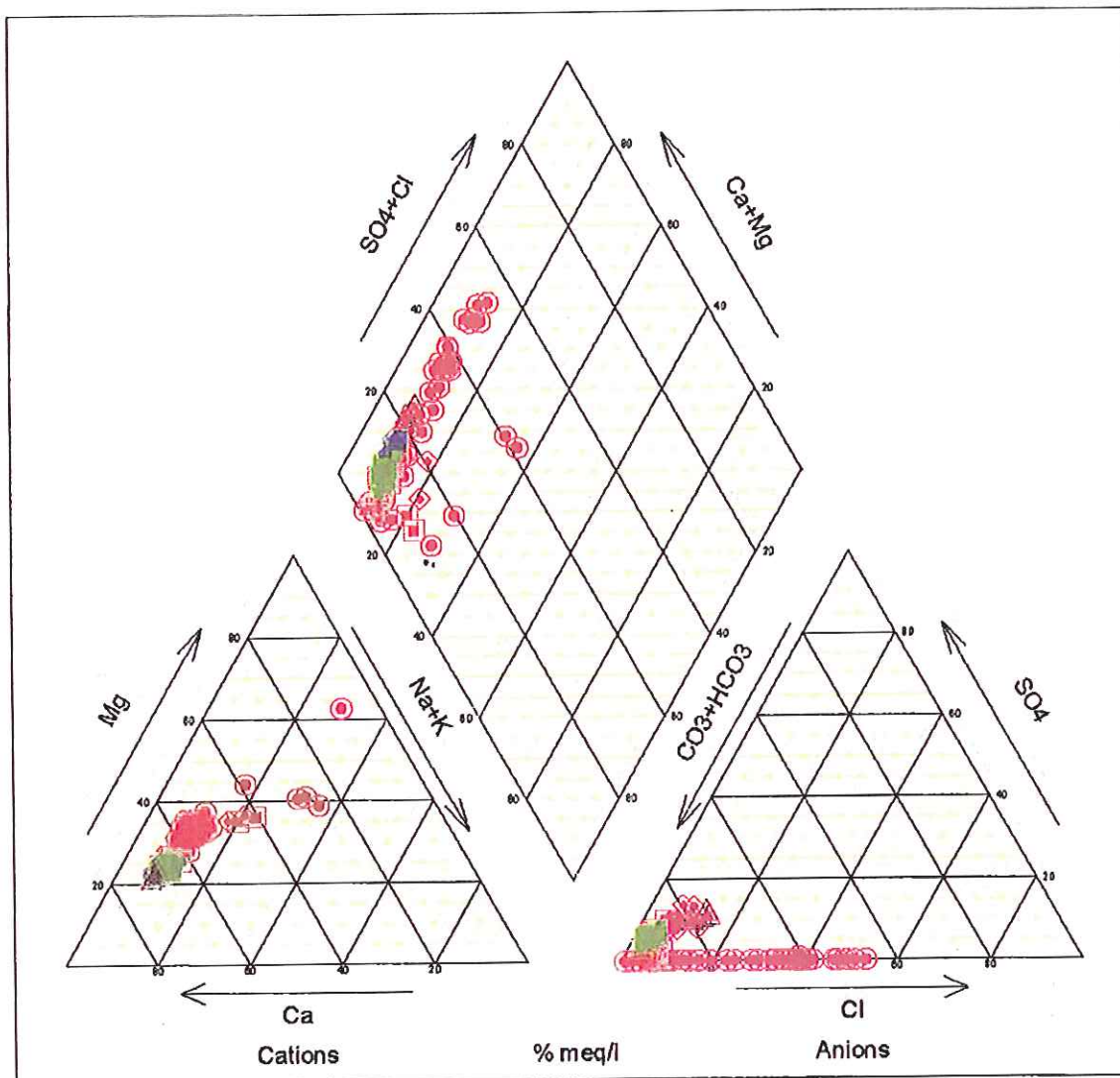


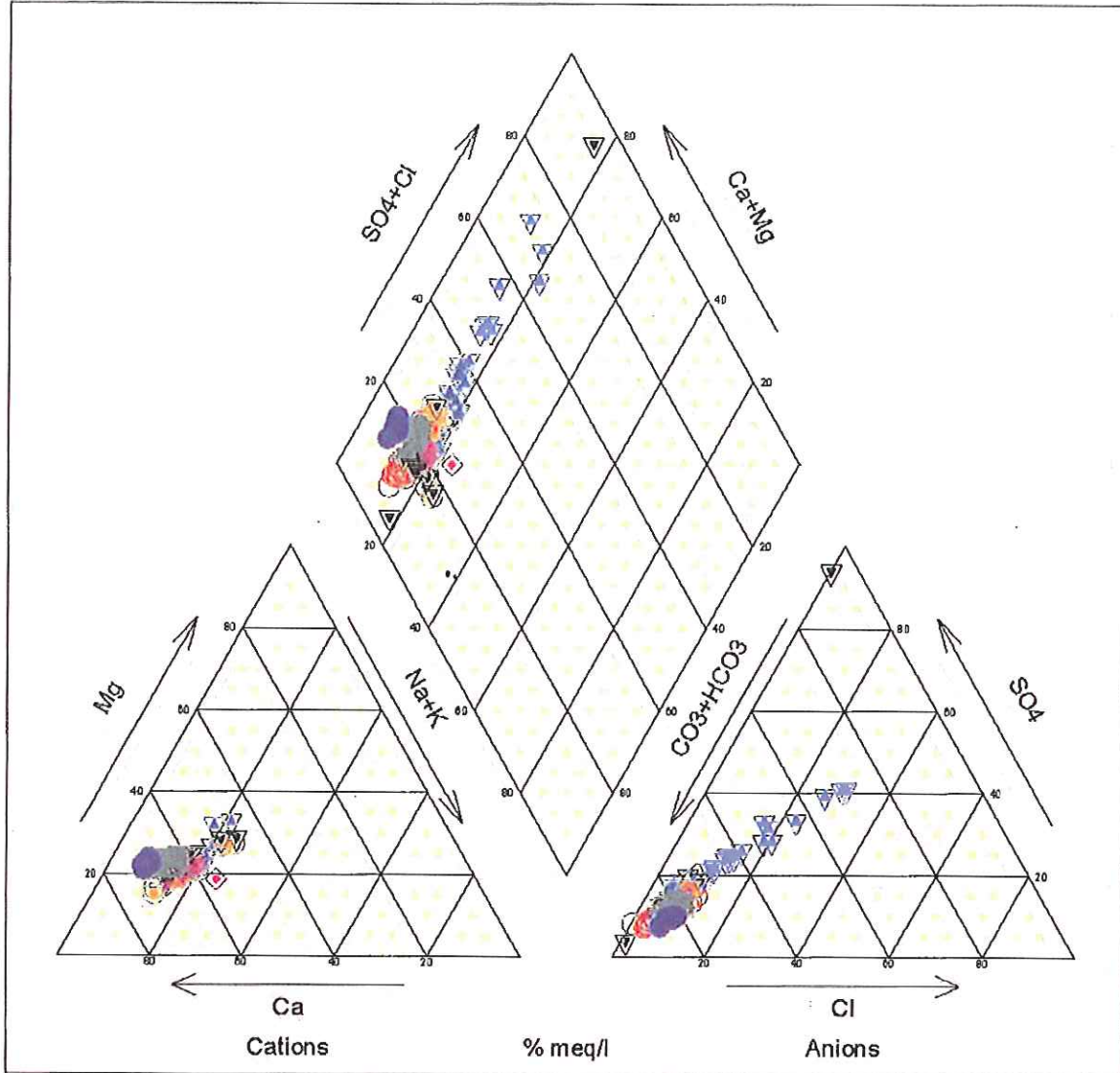
Figure III-3  
Richland Landfill Closure  
Cross-Section  
Collection Basin Lysimeter

Figure 3-1  
 Piper (Trilinear) Diagram Showing Ionic Chemistry of MW05, MW06  
 and MW07 Groundwater Samples and Lysimeter Liquid Samples  
 Horn Rapids Landfill



● port 1 6/18/1994 - 8/08/1994	● port 3 4/15/1997	● port 4 12/21/1999 - 1/11/2000	◆ MW05 10/18/2001	■ MW06 11/08/2000 - 12/05/2000
● port 1 10/13/1994	● port 3 9/23/1997	● port 4 1/11/2000 - 2/08/2000	◆ MW05 12/05/2001 - 12/18/2001	■ MW06 3/20/2001 - 4/10/2001
● port 1 2/22/1995 - 3/01/1995	● port 3 4/08/1999	● port 4 11/08/2000 - 12/05/2000	◆ MW05 3/20/2002	■ MW06 7/25/2001
● port 1 8/15/1995 - 9/12/1995	● port 3 10/21/1999 - 11/18/1999	● port 4 8/18/2001	◆ MW05 7/03/2002	■ MW06 10/16/2001
● port 1 4/15/1997	● port 3 8/29/1999	● port 4 12/05/2001 - 12/18/2001	◆ MW05 10/15/2002	■ MW06 12/05/2001 - 12/18/2001
● port 1 9/23/1997	● port 3 12/21/1999 - 1/11/2000	◆ MW05 5/18/1999	◆ MW05 12/17/2002 - 12/31/2002	■ MW06 3/20/2002
● port 1 4/08/1999	● port 3 1/11/2000 - 2/08/2000	◆ MW05 8/30/1999 - 7/07/1999	◆ MW05 3/20/2003	■ MW06 7/03/2002
● port 1 10/21/1999 - 11/18/1999	● port 3 11/08/2000 - 12/05/2000	◆ MW05 8/10/1999	◆ MW05 8/11/2003	■ MW06 10/15/2002
● port 1 12/21/1999 - 1/11/2000	● port 3 8/18/2001	◆ MW05 10/21/1999 - 11/18/1999	◆ MW05 5/18/1999	■ MW06 12/17/2002 - 12/31/2002
● port 1 1/11/2000 - 2/08/2000	● port 3 12/05/2001 - 12/18/2001	◆ MW05 1/2/1999	◆ MW05 8/30/1998 - 7/07/1998	■ MW06 3/20/2003
● port 1 11/08/2000 - 12/05/2000	● port 4 6/18/1994 - 8/08/1994	◆ MW05 5/12/1999	◆ MW05 8/10/1998	■ MW06 8/11/2003
● port 1 8/18/2001	● port 4 10/13/1994	◆ MW05 10/05/1999	◆ MW05 10/21/1999 - 11/18/1999	▲ MW07 3/20/2001 - 4/10/2001
● port 1 12/05/2001 - 12/18/2001	● port 4 2/22/1995 - 3/01/1995	◆ MW05 1/28/1999	◆ MW05 1/28/1999	▲ MW07 7/25/2001
● port 2 2/22/1995 - 3/01/1995	● port 4 7/10/1995 - 7/21/1995	◆ MW05 8/12/1999	◆ MW05 5/12/1999	▲ MW07 10/16/2001
● port 2 7/19/1995 - 7/21/1995	● port 4 8/15/1995 - 9/12/1995	◆ MW05 1/11/2000 - 2/08/2000	◆ MW05 10/05/1999	▲ MW07 12/05/2001 - 12/18/2001
● port 2 8/15/1995 - 9/12/1995	● port 4 4/15/1997	◆ MW05 8/30/2000	◆ MW05 12/21/1999 - 1/11/2000	▲ MW07 7/03/2002
● port 2 4/15/1997	● port 4 9/23/1997	◆ MW05 11/08/2000 - 12/05/2000	◆ MW05 1/11/2000 - 2/08/2000	▲ MW07 3/20/2003
● port 2 8/23/1997	● port 4 4/08/1999	◆ MW05 3/20/2001 - 4/10/2001	◆ MW05 5/18/2000	▲ MW07 8/11/2003
● port 3 8/15/1995 - 9/12/1995	● port 4 8/29/1999	◆ MW05 7/25/2001	◆ MW05 8/30/2000	

Figure 3-2  
Trilinear (Piper) Diagram Showing  
Ionic Chemistry of MW01, MW02, MW03, MW04, MW08,  
MW09 and MW10 Groundwater Samples  
Horn Rapids Landfill



MW01	2/27/95 - 3/17/95	MW01	1/10/2001 - 12/6/2001	MW02	2/27/95	MW03	12/27/95	MW04	12/6/2001 - 12/6/2001	MW08	3/25/2001
MW01	4/7/95	MW01	3/25/2001 - 1/16/2001	MW02	5/18/95	MW03	2/29/95 - 3/13/95	MW04	6/19/95	MW08	6/1/2001
MW01	1/29/95 - 1/21/95	MW01	1/6/2001	MW02	6/12/95	MW03	1/27/95 - 2/10/95	MW04	12/29/95	MW08	3/25/2001 - 4/25/2001
MW01	10/27/95	MW01	5/16/2001 - 10/16/2001	MW02	10/21/95 - 11/15/95	MW03	5/27/95 - 6/27/95	MW04	12/21/95 - 1/12/2001	MW08	1/25/2001
MW01	1/27/95	MW01	12/6/2001 - 12/15/2001	MW02	1/15/95 - 1/29/95	MW03	1/9/95 - 5/5/95	MW04	12/17/2001 - 12/31/2001	MW08	5/5/2001 - 13/15/2001
MW01	2/22/95 - 3/13/95	MW01	3/25/2001	MW02	6/12/95	MW03	5/5/95 - 5/27/95	MW04	5/16/2001	MW08	12/25/2001 - 12/15/2001
MW01	4/30/95 - 5/30/95	MW01	10/30/2001	MW02	10/30/95	MW03	11/21/95	MW04	6/1/2001	MW08	3/25/2001
MW01	5/30/95 - 6/21/95	MW01	10/15/2001	MW02	12/21/95 - 1/11/2001	MW03	2/27/95	MW04	2/29/95 - 3/11/95	MW08	1/25/2001
MW01	1/11/95 - 5/15/95	MW01	1/11/2001 - 12/11/2001	MW02	1/11/2001 - 2/18/2001	MW03	5/27/95	MW04	3/25/2001 - 4/25/2001	MW08	12/11/2001 - 12/11/2001
MW01	5/15/95 - 5/12/95	MW01	5/1/2001	MW02	5/1/2001	MW03	5/1/2001	MW04	1/6/2001	MW08	1/6/2001
MW01	1/21/95	MW01	5/1/2001	MW02	8/20/2001	MW03	12/27/95	MW04	10/12/95	MW08	3/25/2001
MW01	2/27/95	MW01	2/27/95 - 3/17/95	MW02	2/27/95 - 12/25/2001	MW03	12/27/95	MW04	12/6/2001 - 12/6/2001	MW08	10/15/2001
MW01	5/20/95	MW01	12/17/95	MW02	12/17/95	MW03	1/15/2001 - 12/15/2001	MW04	12/17/2001 - 12/17/2001	MW08	12/17/2001 - 12/15/2001
MW01	6/20/95	MW01	1/1/2001	MW02	1/1/2001	MW03	1/1/2001	MW04	1/1/2001	MW08	1/1/2001
MW01	8/11/95	MW01	5/1/2001	MW02	5/1/2001	MW03	5/1/2001	MW04	5/1/2001	MW08	5/1/2001
MW01	12/10/95	MW01	12/10/95	MW02	12/10/95	MW03	12/10/95	MW04	12/10/95	MW08	12/10/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/18/95	MW01	5/18/95	MW02	5/18/95	MW03	5/18/95	MW04	5/18/95	MW08	5/18/95
MW01	10/21/95 - 11/15/95	MW01	10/21/95 - 11/15/95	MW02	10/21/95 - 11/15/95	MW03	10/21/95 - 11/15/95	MW04	10/21/95 - 11/15/95	MW08	10/21/95 - 11/15/95
MW01	1/9/95 - 5/5/95	MW01	1/9/95 - 5/5/95	MW02	1/9/95 - 5/5/95	MW03	1/9/95 - 5/5/95	MW04	1/9/95 - 5/5/95	MW08	1/9/95 - 5/5/95
MW01	5/5/95 - 5/27/95	MW01	5/5/95 - 5/27/95	MW02	5/5/95 - 5/27/95	MW03	5/5/95 - 5/27/95	MW04	5/5/95 - 5/27/95	MW08	5/5/95 - 5/27/95
MW01	1/9/95 - 1/29/95	MW01	1/9/95 - 1/29/95	MW02	1/9/95 - 1/29/95	MW03	1/9/95 - 1/29/95	MW04	1/9/95 - 1/29/95	MW08	1/9/95 - 1/29/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/30/95 - 6/21/95	MW01	5/30/95 - 6/21/95	MW02	5/30/95 - 6/21/95	MW03	5/30/95 - 6/21/95	MW04	5/30/95 - 6/21/95	MW08	5/30/95 - 6/21/95
MW01	1/11/95 - 5/15/95	MW01	1/11/95 - 5/15/95	MW02	1/11/95 - 5/15/95	MW03	1/11/95 - 5/15/95	MW04	1/11/95 - 5/15/95	MW08	1/11/95 - 5/15/95
MW01	5/15/95 - 5/12/95	MW01	5/15/95 - 5/12/95	MW02	5/15/95 - 5/12/95	MW03	5/15/95 - 5/12/95	MW04	5/15/95 - 5/12/95	MW08	5/15/95 - 5/12/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/18/95	MW01	5/18/95	MW02	5/18/95	MW03	5/18/95	MW04	5/18/95	MW08	5/18/95
MW01	10/21/95 - 11/15/95	MW01	10/21/95 - 11/15/95	MW02	10/21/95 - 11/15/95	MW03	10/21/95 - 11/15/95	MW04	10/21/95 - 11/15/95	MW08	10/21/95 - 11/15/95
MW01	1/9/95 - 5/5/95	MW01	1/9/95 - 5/5/95	MW02	1/9/95 - 5/5/95	MW03	1/9/95 - 5/5/95	MW04	1/9/95 - 5/5/95	MW08	1/9/95 - 5/5/95
MW01	5/5/95 - 5/27/95	MW01	5/5/95 - 5/27/95	MW02	5/5/95 - 5/27/95	MW03	5/5/95 - 5/27/95	MW04	5/5/95 - 5/27/95	MW08	5/5/95 - 5/27/95
MW01	1/9/95 - 1/29/95	MW01	1/9/95 - 1/29/95	MW02	1/9/95 - 1/29/95	MW03	1/9/95 - 1/29/95	MW04	1/9/95 - 1/29/95	MW08	1/9/95 - 1/29/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/30/95 - 6/21/95	MW01	5/30/95 - 6/21/95	MW02	5/30/95 - 6/21/95	MW03	5/30/95 - 6/21/95	MW04	5/30/95 - 6/21/95	MW08	5/30/95 - 6/21/95
MW01	1/11/95 - 5/15/95	MW01	1/11/95 - 5/15/95	MW02	1/11/95 - 5/15/95	MW03	1/11/95 - 5/15/95	MW04	1/11/95 - 5/15/95	MW08	1/11/95 - 5/15/95
MW01	5/15/95 - 5/12/95	MW01	5/15/95 - 5/12/95	MW02	5/15/95 - 5/12/95	MW03	5/15/95 - 5/12/95	MW04	5/15/95 - 5/12/95	MW08	5/15/95 - 5/12/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/18/95	MW01	5/18/95	MW02	5/18/95	MW03	5/18/95	MW04	5/18/95	MW08	5/18/95
MW01	10/21/95 - 11/15/95	MW01	10/21/95 - 11/15/95	MW02	10/21/95 - 11/15/95	MW03	10/21/95 - 11/15/95	MW04	10/21/95 - 11/15/95	MW08	10/21/95 - 11/15/95
MW01	1/9/95 - 5/5/95	MW01	1/9/95 - 5/5/95	MW02	1/9/95 - 5/5/95	MW03	1/9/95 - 5/5/95	MW04	1/9/95 - 5/5/95	MW08	1/9/95 - 5/5/95
MW01	5/5/95 - 5/27/95	MW01	5/5/95 - 5/27/95	MW02	5/5/95 - 5/27/95	MW03	5/5/95 - 5/27/95	MW04	5/5/95 - 5/27/95	MW08	5/5/95 - 5/27/95
MW01	1/9/95 - 1/29/95	MW01	1/9/95 - 1/29/95	MW02	1/9/95 - 1/29/95	MW03	1/9/95 - 1/29/95	MW04	1/9/95 - 1/29/95	MW08	1/9/95 - 1/29/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/30/95 - 6/21/95	MW01	5/30/95 - 6/21/95	MW02	5/30/95 - 6/21/95	MW03	5/30/95 - 6/21/95	MW04	5/30/95 - 6/21/95	MW08	5/30/95 - 6/21/95
MW01	1/11/95 - 5/15/95	MW01	1/11/95 - 5/15/95	MW02	1/11/95 - 5/15/95	MW03	1/11/95 - 5/15/95	MW04	1/11/95 - 5/15/95	MW08	1/11/95 - 5/15/95
MW01	5/15/95 - 5/12/95	MW01	5/15/95 - 5/12/95	MW02	5/15/95 - 5/12/95	MW03	5/15/95 - 5/12/95	MW04	5/15/95 - 5/12/95	MW08	5/15/95 - 5/12/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/18/95	MW01	5/18/95	MW02	5/18/95	MW03	5/18/95	MW04	5/18/95	MW08	5/18/95
MW01	10/21/95 - 11/15/95	MW01	10/21/95 - 11/15/95	MW02	10/21/95 - 11/15/95	MW03	10/21/95 - 11/15/95	MW04	10/21/95 - 11/15/95	MW08	10/21/95 - 11/15/95
MW01	1/9/95 - 5/5/95	MW01	1/9/95 - 5/5/95	MW02	1/9/95 - 5/5/95	MW03	1/9/95 - 5/5/95	MW04	1/9/95 - 5/5/95	MW08	1/9/95 - 5/5/95
MW01	5/5/95 - 5/27/95	MW01	5/5/95 - 5/27/95	MW02	5/5/95 - 5/27/95	MW03	5/5/95 - 5/27/95	MW04	5/5/95 - 5/27/95	MW08	5/5/95 - 5/27/95
MW01	1/9/95 - 1/29/95	MW01	1/9/95 - 1/29/95	MW02	1/9/95 - 1/29/95	MW03	1/9/95 - 1/29/95	MW04	1/9/95 - 1/29/95	MW08	1/9/95 - 1/29/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/30/95 - 6/21/95	MW01	5/30/95 - 6/21/95	MW02	5/30/95 - 6/21/95	MW03	5/30/95 - 6/21/95	MW04	5/30/95 - 6/21/95	MW08	5/30/95 - 6/21/95
MW01	1/11/95 - 5/15/95	MW01	1/11/95 - 5/15/95	MW02	1/11/95 - 5/15/95	MW03	1/11/95 - 5/15/95	MW04	1/11/95 - 5/15/95	MW08	1/11/95 - 5/15/95
MW01	5/15/95 - 5/12/95	MW01	5/15/95 - 5/12/95	MW02	5/15/95 - 5/12/95	MW03	5/15/95 - 5/12/95	MW04	5/15/95 - 5/12/95	MW08	5/15/95 - 5/12/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/18/95	MW01	5/18/95	MW02	5/18/95	MW03	5/18/95	MW04	5/18/95	MW08	5/18/95
MW01	10/21/95 - 11/15/95	MW01	10/21/95 - 11/15/95	MW02	10/21/95 - 11/15/95	MW03	10/21/95 - 11/15/95	MW04	10/21/95 - 11/15/95	MW08	10/21/95 - 11/15/95
MW01	1/9/95 - 5/5/95	MW01	1/9/95 - 5/5/95	MW02	1/9/95 - 5/5/95	MW03	1/9/95 - 5/5/95	MW04	1/9/95 - 5/5/95	MW08	1/9/95 - 5/5/95
MW01	5/5/95 - 5/27/95	MW01	5/5/95 - 5/27/95	MW02	5/5/95 - 5/27/95	MW03	5/5/95 - 5/27/95	MW04	5/5/95 - 5/27/95	MW08	5/5/95 - 5/27/95
MW01	1/9/95 - 1/29/95	MW01	1/9/95 - 1/29/95	MW02	1/9/95 - 1/29/95	MW03	1/9/95 - 1/29/95	MW04	1/9/95 - 1/29/95	MW08	1/9/95 - 1/29/95
MW01	1/21/95	MW01	1/21/95	MW02	1/21/95	MW03	1/21/95	MW04	1/21/95	MW08	1/21/95
MW01	2/27/95	MW01	2/27/95	MW02	2/27/95	MW03	2/27/95	MW04	2/27/95	MW08	2/27/95
MW01	5/30/95 - 6/21/95	MW01	5/30/95 - 6/21/95	MW02	5/30/95 - 6/21/95	MW03	5/30/95 - 6/21/95	MW04	5/30/95 - 6/21/95	MW08	5/30/95 - 6/21/95
MW01	1/11/95 - 5/15/95	MW01	1/11/95 - 5/15/95	MW02	1/11/95 - 5/15/95	MW03	1/11/95 - 5/15/95	MW04	1/11/95 - 5/15/95	MW08	1/11/95 - 5/15/95
MW01	5/15/95 - 5/12/95	MW01	5/15/95 - 5/12/95	MW02	5/15/95 - 5/12/95	MW03	5/15/95 - 5/12/95	MW04	5/15/95 - 5/12/95	MW08	5/15/95 - 5/12/95
MW01											

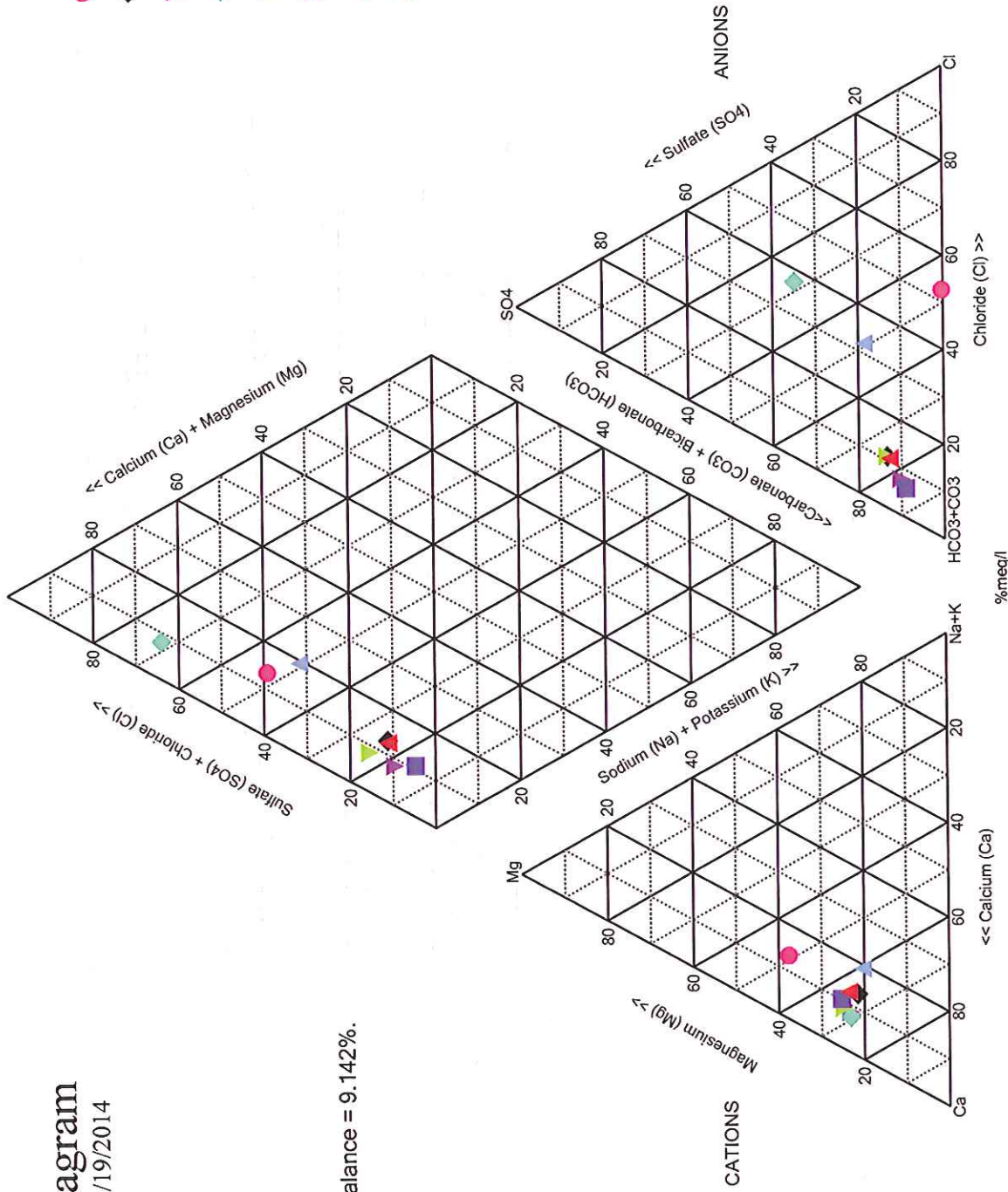


# Piper Diagram

11/20/2014, 11/19/2014

Cation-Anion Balance = 9.142%.

- LeachatePort#3
- ◆ MWWell#1 (bg)
- ▼ MWWell#10
- ◆ MWWell#11 (bg)
- ▼ MWWell#5
- MWWell#6
- ▲ MWWell#8
- ▲ MWWell#9



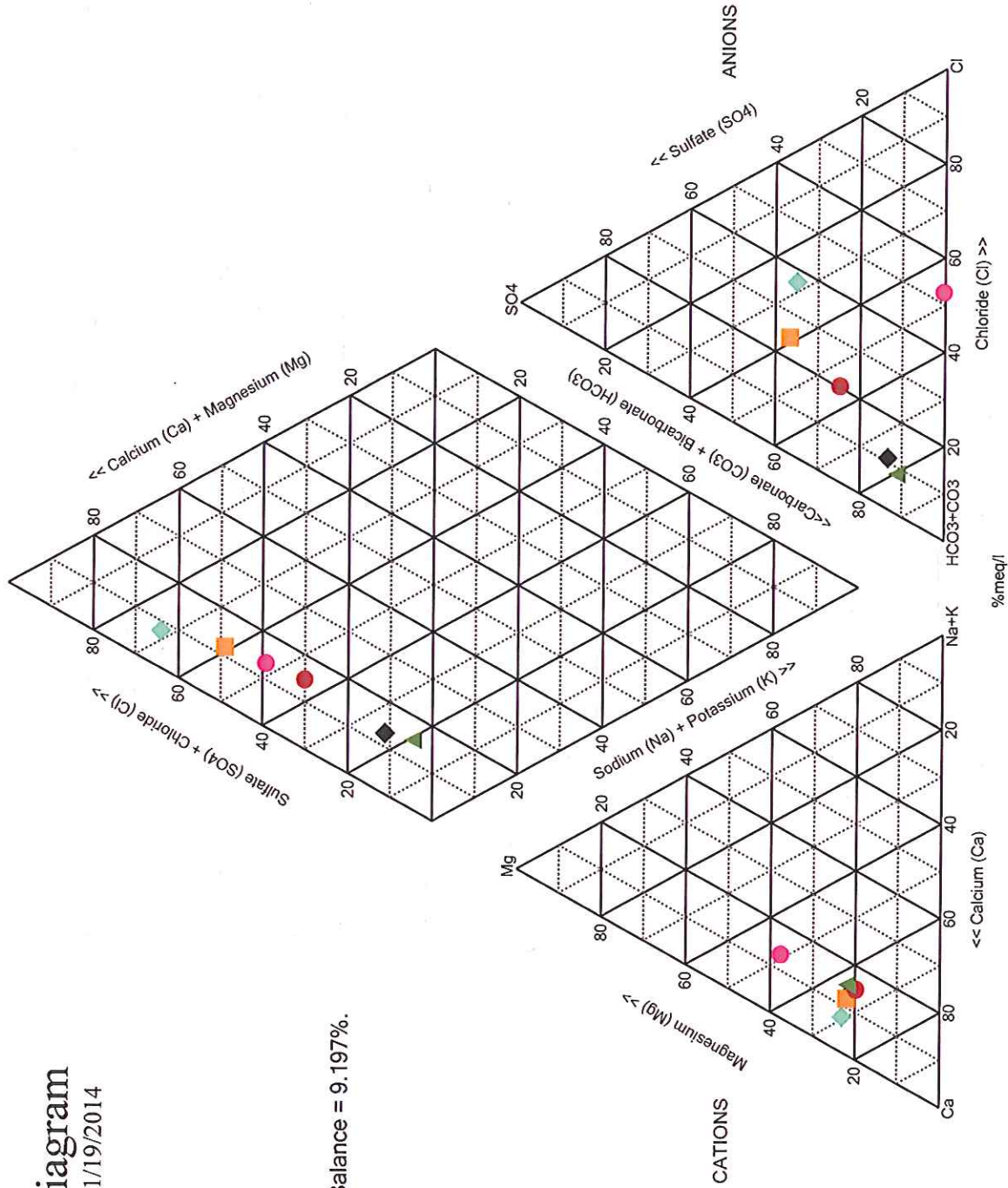
Analysis Run 2/19/2015 4:36 PM

# Piper Diagram

11/20/2014, 11/19/2014

Cation-Anion Balance = 9.197%.

- LeachatePort#3
- ◆ MWWell#1 (bg)
- ◆ MWWell#11 (bg)
- MWWell#2
- MWWell#3
- ▲ MWWell#4



Analysis Run 2/19/2015 4:35 PM

Facility: Horn Rapids LF Client: City of Richland Data File: 4Q\_14\_PIPER2

# Appendix E

## Groundwater Data and Isoconcentration Maps

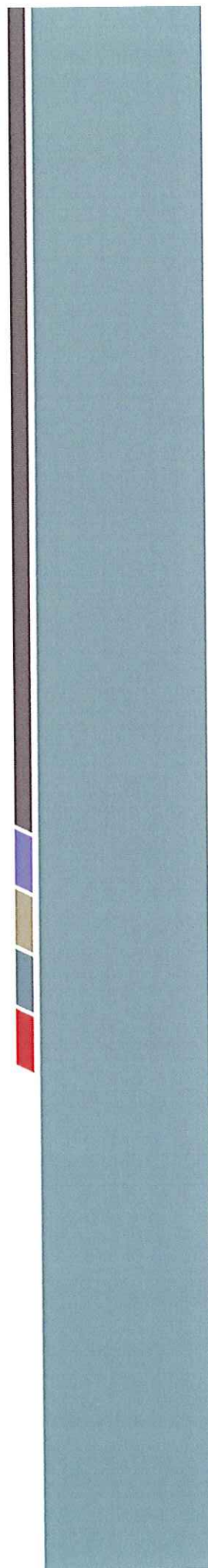




Table E-1. Groundwater Quality Results, Appendix I and II\*, Horn Rapids Landfill, 2015

Analyte	Units	OWQS	MCL	MW-6 8/25/2015	MW-6 9/16/2015	MW-6 (MW-6 Dup) 3/5/2015	MW-8 6/24/2015	MW-8 9/17/2015	MW-8 12/3/2015	MW-9 3/30/2015	MW-9 (MW-9 Dup) 3/30/2015	MW-9 6/24/2015	MW-9 9/17/2015	MW-9 12/3/2015	MW-10 3/30/2015	MW-10 6/24/2015	MW-10 9/16/2015	MW-10 (MW-10 Dup) 9/16/2015	MW-11 12/2/2015	MW-11 3/30/2015	MW-11 6/24/2015	MW-11 9/16/2015	MW-11 12/2/2015	
<b>FIELD DATA</b>																								
Conductivity	µmhos/cm	6.5-8.5	700	7.77	7.64	7.90	7.59	7.72	7.82	7.92	7.92	7.82	7.72	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82
pH	units			7.77	7.64	7.90	7.59	7.72	7.82	7.92	7.92	7.82	7.72	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82
Temperature	°C			23.45	26.04	22.52	18.90	24.37	21.53	20.65	21.41	22.39	22.50	21.21	23.92	24.52	24.52	24.52	24.52	24.52	24.52	24.52	24.52	24.52
Oxidation-Reduction Potential	mV			97.1	-215.0	-216.3	75	-110.0	-84.7	-65.3	31	96.9	-130.3	-87.0	70	88.6	-224.7	NA	-224.0	28	103.1	26	103.1	26
Dissolved Oxygen	mg/L			1.7	0.4	0.47	8.96	8.07	7.79	7.53	3.23	2.84	2.98	2.73	0.81	0.63	0.40	NA	0.35	7.97	7.18	7.97	7.18	
Nitrate-Nitrogen	mg/L as N	10	10	1.8	2.0	2.2	14	8.2	17.7	8.4	3.4	3.2	3.5	3.9	3.2	4.1	NA	4.3	3.6	3.7	3.6	3.7	3.6	
Calcium	mg/L			160	160	160	98	67	120	67	130	140	150	130	220	200	210	210	220	220	220	220	220	
Sodium	mg/L			160	160	160	98	68	NA	NA	130	140	140	140	200	200	210	210	210	210	210	210		
Total Alkalinity	mg/L as CaCO3	250	250	22	22	24	24	19	28	19	24	25	26	23	22	22	22	22	23	20	19	20	19	
Bicarbonate Alkalinity	mg/L as CaCO3			500	500	490	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
Chloride	mg/L	250	250	10	10	10	120	110	130	120	120	120	120	120	120	120	120	120	120	120	120	120		
Magnesium	mg/L			38	38	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	39		
Potassium	mg/L			38	38	38	20	14	NA	NA	29	30	31	30	30	30	30	30	30	30	30	30		
Sulfate	mg/L			12	11	12	8.9	6.9	10	9.5	9.4	9.4	9.4	9.4	13	12	12	12	12	12	12	12		
Total Alkalinity	mg/L as CaCO3	250	250	45	42	50	54	37	63	43	53	52	55	58	60	61	57	57	62	200	230	200		
Iron	mg/L	0.3	0.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
Manganese	mg/L	0.05	0.05	<0.034	0.029	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038		
Ammonia-Nitrogen	mg/L as N	0.05	0.05	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034		
Total Organic Carbon	mg/L			2.6	1.8	1.7	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1		
Total Dissolved Solids	mg/L	500	500	660	660	660	510	371	620	380	590	590	650	550	640	620	610	620	620	620	620	620		
Total Suspended Solids	mg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0		
<b>METALS</b>																								
Antimony	mg/L		6	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	
Arsenic	mg/L	0.0005	0.01	0.0017	<0.0004	<0.0004	0.0011	<0.0004	<0.0004	<0.0004	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	
Barium	mg/L		1	0.059	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044		
Beryllium	mg/L		0.004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		
Cadmium	mg/L	0.01	0.005	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		
Cerium	mg/L		0.005	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		
Chromium	mg/L	0.05	0.1	0.0081	NA	NA	0.0026	0.019	0.0074	0.0051	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221	0.0221		
Cobalt	mg/L		0.05	0.00952	0.0042	0.0080	0.0053	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074		
Copper	mg/L		1	0.063	NA	NA	0.0026	0.0014	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		
Lead	mg/L		1	0.052	NA	NA	0.0026	<0.002	<0.002	<0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		
Nickel	mg/L		0.1	<0.003	NA	NA	0.004	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003		
Selenium	mg/L	0.01	0.05	<0.001	NA	NA	0.0026	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014		
Silver	mg/L	0.01	0.05	<0.0004	NA	NA	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		
Thallium	mg/L	0.002	0.02	<0.001	NA	NA	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Vanadium	mg/L		5	0.065	NA	NA	0.014	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017		
Zinc	mg/L	5	5	0.062	0.063	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073		
Zinc	mg/L	5	5	0.018	0.018	0.018	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007		
Chloroethane	µg/L		2	2.9	3.5	3.3	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020		
Bromoethane	µg/L		2	2.9	3.5	3.2	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020		
Trichloroethane	µg/L		7	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50		
1,1-Dichloroethane	µg/L		7	0.27	0.27	0.32	0.25	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		
Iodoethane	µg/L		7	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50		

Table E-1. Groundwater Quality Results, Appendix I and II, Horn Rapids Landfill, 2015

Analyte	Units	GWQS	MCL	MW-21 (MW-11 Dup)		MW-11		Trip Blank		Trip Blank		Port 3	
				8/24/2015	9/16/2015	12/22/2015	12/22/2015	3/30/2015	6/24/2015	9/16/2015	12/22/2015	6/25/2015	12/22/2015
<b>FIELD DATA</b>													
Conductivity	µmhos/cm		700 **	NA	1643	1680	NA	NA	NA	NA	NA	NA	NA
pH	units	6.5-8.5		NA	7.43	7.28	NA	NA	NA	NA	NA	NA	NA
Temperature	°C			NA	22.22	19.15	NA	NA	NA	NA	NA	NA	NA
Oxidation-Reduction Potential	V			NA	-55.5	-11.5	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	mg/L			NA	7.24	8.65	NA	NA	NA	NA	NA	NA	NA
<b>WATER QUALITY PARAMETERS</b>													
Nitrate-Nitrogen	mg/L as N	10 *	10 *	39 H	38	36	NA	NA	NA	NA	NA	NA	NA
Calcium	mg/L			230	240	240	NA	NA	NA	NA	NA	NA	NA
Sodium	mg/L			210	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	mg/L		250 **	230	270	270	NA	NA	NA	NA	NA	NA	NA
Total Alkalinity	mg/L as CaCO3			180	180	170	NA	NA	NA	NA	NA	NA	NA
Iron	mg/L	0.3 **	0.3 **	<0.5	<0.5	<0.5	NA	NA	NA	NA	NA	NA	NA
Manganese	mg/L	0.05 **	0.05 **	<0.02	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA
Ammonia-Nitrogen	mg/L as N			<0.20	<0.20	<0.20	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	mg/L			2.2	2.4	2.4	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	mg/L		500 **	1100	1200	1300	NA	NA	NA	NA	NA	NA	NA
Total Suspended Solids	mg/L			<2.0	<2.0	<2.0	NA	NA	NA	NA	NA	NA	NA
<b>METALS</b>													
Antimony	mg/L	6 *		<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Arsenic	mg/L	0.00005 ***	0.01 *	0.0043	0.0043	0.0045	NA	NA	NA	NA	NA	NA	NA
Barium	mg/L	1 *	2 *	0.110	0.110	0.130	NA	NA	NA	NA	NA	NA	NA
Beryllium	mg/L	0.004 *	0.004 *	<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Bismuth	mg/L	0.01 *	0.005 *	<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Cadmium	mg/L	0.01 *	0.005 *	<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Chromium	mg/L	0.05 *	0.1 *	0.0032	0.0048	0.0031	NA	NA	NA	NA	NA	NA	NA
Chromium	mg/L	0.05 *	0.1 *	0.0032	0.0048	0.0031	NA	NA	NA	NA	NA	NA	NA
Cobalt	mg/L			<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Copper	mg/L	1 **		0.0045	0.0045	0.0045	NA	NA	NA	NA	NA	NA	NA
Copper	mg/L	1 **		0.0037	0.0053	<0.002	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	0.05 *		<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Lead	mg/L	0.05 *		<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	0.1 *		0.005	0.005	<0.003	NA	NA	NA	NA	NA	NA	NA
Nickel	mg/L	0.1 *		0.012	<0.003	<0.003	NA	NA	NA	NA	NA	NA	NA
Selenium	mg/L	0.01 *	0.05 *	0.011	0.011	0.011	NA	NA	NA	NA	NA	NA	NA
Selenium	mg/L	0.01 *	0.05 *	<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	0.05 *	0.1 **	<0.0004	<0.0004	<0.0004	NA	NA	NA	NA	NA	NA	NA
Silver	mg/L	0.05 *	0.1 **	<0.001	<0.001	<0.001	NA	NA	NA	NA	NA	NA	NA
Thallium	mg/L	0.002 *		0.0092	0.0092	0.0092	NA	NA	NA	NA	NA	NA	NA
Thallium	mg/L	0.002 *		<0.007	<0.007	<0.007	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	5 **	5 **	0.0063	0.0063	0.0063	NA	NA	NA	NA	NA	NA	NA
Vanadium	mg/L	5 **	5 **	<0.020	<0.020	<0.020	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	0.02 ***	2 *	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA
Zinc	mg/L	0.02 ***	2 *	<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA
<b>VOLATILE ORGANIC COMPOUNDS</b>													
Chloroethane	µg/L			<0.30	<0.30	<0.30	NA	NA	NA	NA	NA	NA	NA
Vinyl Chloride	µg/L			<0.30	<0.30	<0.30	NA	NA	NA	NA	NA	NA	NA
Bromoethane	µg/L			<1.0	<1.0	<1.0	NA	NA	NA	NA	NA	NA	NA
Chloroethane	µg/L			<0.50	<0.50	<0.50	NA	NA	NA	NA	NA	NA	NA
Trichlorofluoromethane	µg/L			<0.50	<0.50	<0.50	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethane	µg/L			<0.10	<0.10	<0.10	NA	NA	NA	NA	NA	NA	NA
Iodomethane	µg/L			<0.50	<0.50	<0.50	NA	NA	NA	NA	NA	NA	NA



Table E-1. Groundwater Quality Results, Appendix I and II<sup>1</sup>, Horn Rapids Landfill, 2015

Analyte	Units	GWQS	MCL	MW-6 6/25/2015	MW-8 9/16/2015	MW-4 12/2/2015	MW-8 3/31/2015	MW-8 6/24/2015	MW-4 9/17/2015	MW-4 12/3/2015	MW-9 3/30/2015	MW-21 (MW-9 Dup) 3/30/2015	MW-9 6/24/2015	MW-9 9/17/2015	MW-9 12/3/2015	MW-10 3/30/2015	MW-10 6/24/2015	MW-10 9/16/2015	MW-21 (MW-10 Dup) 9/16/2015	MW-10 12/2/2015	MW-10 3/30/2015	MW-11 6/24/2015
<b>VOLATILE ORGANIC COMPOUNDS (Cont.)</b>																						
Carbon Disulfide	µg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Acetone	µg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Methylene Chloride	µg/L	5 ***		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,2-Dichloroethane	µg/L			1.9	2.0	2.0	1.7				0.25	0.24	0.26	0.40	0.27	0.24	3.7	4.2	0.21	0.21	0.27	0.27
Acrylonitrile	µg/L	0.07 ***		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,1-Dichloroethane	µg/L			5.4	6.0	5.7	4.7				3.2	3.3	2.7	4.6	9.6	8.0	9.2	9.0	7.5	9.0	7.5	
Vinyl Acetate	µg/L			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
cis-1,2-Dichloroethane	µg/L	70 *		53	56	58	49				8.7	9.2	6.3	7.3	14	16	15	15	14	16	15	
2-Butanone	µg/L			<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	
Bromochloromethane	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Chloroform	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
1,1,1-Trichloroethane	µg/L	200 *		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Carbon Tetrachloride	µg/L	0.3 *		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Benzene	µg/L	0.5 ***		0.36	0.36	0.36	0.36				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
1,2-Dichloroethane	µg/L	0.5 ***		0.36	0.36	0.36	0.36				0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
2-Hexanone	µg/L	3 *		18	17	18	15				4.5	4.8	3.4	3.6	6.6	4.0	3.7	3.5	3.4	3.2	3.2	
1,2-Dichloropropane	µg/L	0.6 ***		0.34	0.41	0.45	<20				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Dibromochloromethane	µg/L	0.3 ***		<20	<20	<20	<20	0.44	0.73	0.41	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
cis-1,3-Dichloropropene	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	
4-Methyl-2-pentanone	µg/L			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
Toluene	µg/L	1000 *		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
trans-1,3-Dichloropropene	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
1,1,2-Trichloroethane	µg/L	5 *		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Tetrachloroethane	µg/L	0.8 ***		38	37	40	41				11	11	11	13	13	7.5	7.1	6.6	6.4	7.6	7.6	
Dibromochloromethane	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
1,2-Dibromomethane	µg/L	0.001 ***		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
Chlorobenzene	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
1,1,1,2-Tetrachloroethane	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Ethylbenzene	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
n-Propylbenzene	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Styrene	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Bromoform	µg/L	5 ***		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	
1,1,2,2-Tetrachloroethane	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	
1,2,3-Trichloropropane	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
trans-1,4-Dichloro-2-butene	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
1,4-Dichlorobenzene	µg/L	4 ***		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	
1,2-Dichlorobenzene	µg/L	600 *		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	
1,2-Dibromo-3-Chloropropane	µg/L	0.2 *		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
Total Xylenes	µg/L	10000 * XYL		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	
Methane	µg/L			2300	5100	3500	3600	5.4	<5-H	<5-H	<5	<5	<5	<5	<5	1100	820 H	1600	1700	1900	5.4	
Ethane	µg/L			<5	<5	<5	<5	<5	<5-H	<5-H	<5	<5	<5	<5	<5	<5	<5-H	<5	<5	<5	<5	
Ethene	µg/L			<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	

Notes:  
<sup>1</sup> = Chapter 173-351 VAC  
 GWQS = Water Quality Standards for Ground Waters of the State of Washington (WAC 173-200)  
 MCL = Maximum Contaminant Level, State Drinking Water Regulations (WAC 246-230)  
 \* = Primary  
 \*\* = Secondary  
 \*\*\* = Carcinogen  
 \*THM = Primary MCL for the sum of all trihalomethanes  
 \*XYL = Primary MCL for the sum of all xylenes  
 H = Estimated value, analyzed beyond specified holding time  
**Bold** = Does not meet GWQS or MCL  
 -,-,- = Not analyzed

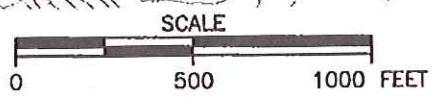
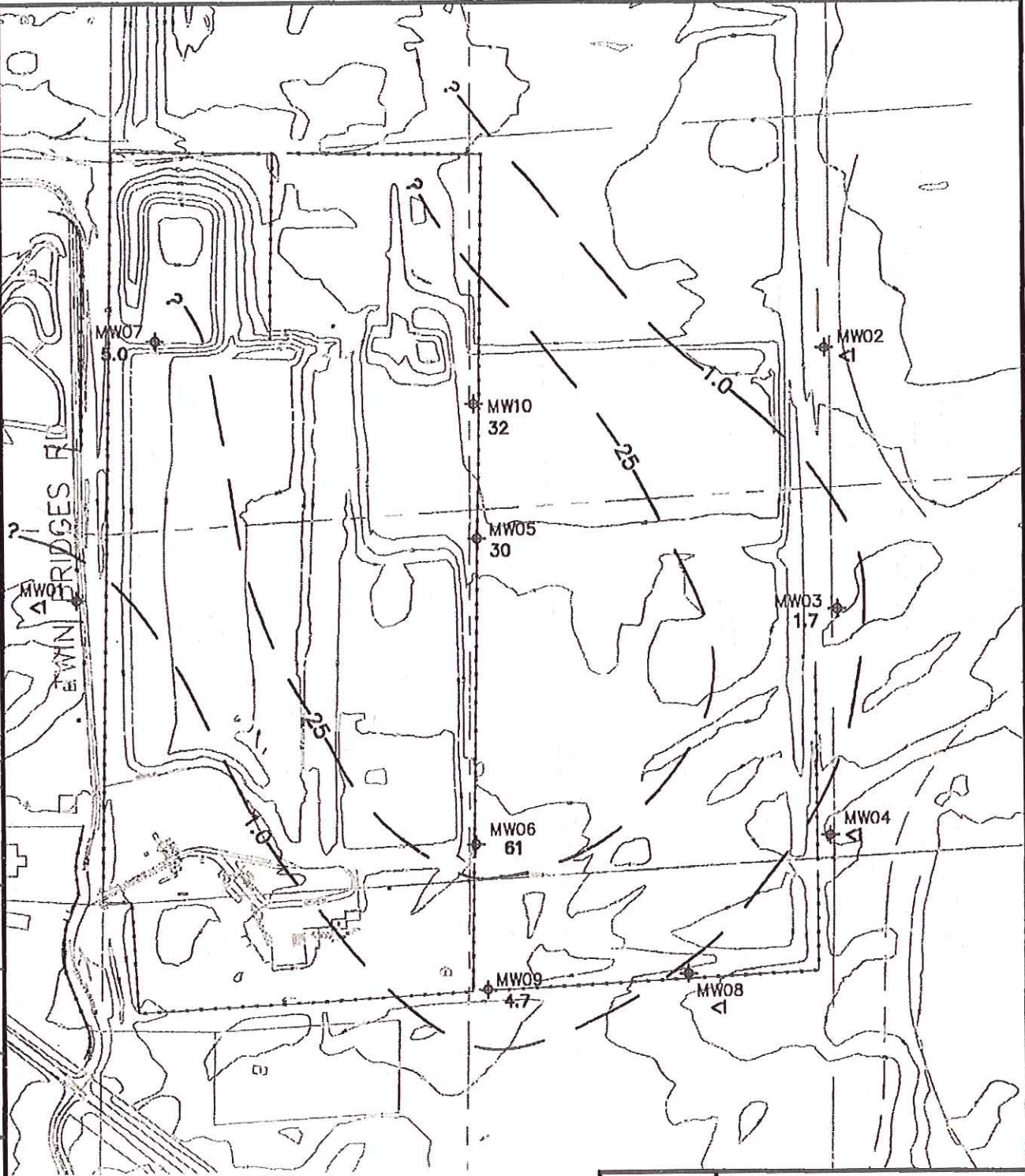


Table E-1. Groundwater Quality Results, Appendix I and II<sup>1</sup>, Horn Rapids Landfill, 2015

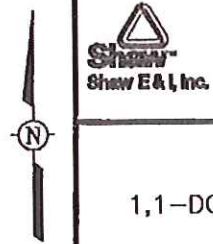
Analyte	Units	GWQS	MCL	MW-21 (MW-11 Dup)		MW-11		Trip Blank		Trip Blank		Trip Blank		Port 3	
				6/24/2015	9/16/2015	12/22/2015	3/30/2015	6/24/2015	9/16/2015	12/22/2015	6/25/2015	9/16/2015	12/22/2015		
<b>VOLATILE ORGANIC COMPOUNDS (cont.)</b>															
Carbon Disulfide	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	5.7
Acetone	µg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	4.7
Methylene Chloride	µg/L			<0.50	<0.50	<0.50	<0.50	0.66	1.4	<0.50	<0.50	<0.50	<0.50	<0.50	2.3
trans-1,2-Dichloroethene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Acetone	µg/L			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	12
1,1-Dichloroethane	µg/L			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.3
cis-1,2-Dichloroethene	µg/L			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.0
2-Butanone	µg/L			<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15
Bromochloromethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Chloroform	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,1,1-Trichloroethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Carbon Tetrachloride	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Benzene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	1.0
1,2-Dichloroethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.71
Trichloroethene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.29
1,2-Dichloropropane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dibromomethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Bromochloromethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
cis-1,3-Dichloropropane	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,3-Dichloropropane	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Toluene	µg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.8
trans-1,2-Dichloroethene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,1,2-Trichloroethane	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.20
Tetrachloroethene	µg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.6
2-Hexanone	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dibromochloromethane	µg/L			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
1,2-Dibromoethane	µg/L			<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chlorobenzene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,1,1,2-Tetrachloroethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Ethylbenzene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	2.6
m,p-Xylene	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	16
o-Xylene	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	15
Styrene	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodorm	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2,2-Tetrachloroethane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,2,3-Trichloropropane	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
trans-1,4-Dichloro-2-butene	µg/L			<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,4-Dichlorobenzene	µg/L			<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
1,2-Dichlorobenzene	µg/L			<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
1,2-Dibromo-3-Chloropropane	µg/L			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Xylenes	µg/L			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	31
<b>ATTENUATION PARAMETERS</b>															
Methane	µg/L			<5-H	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5-H
Ethane	µg/L			<5-H	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5-H
Ethene	µg/L			<5-H	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5-H


Notes:  
<sup>1</sup> = Chapter 173-351 WAC  
 GWQS = Water Quality Standards for Ground Waters of the State of Washington (WAC 173-200)  
 MCL = Maximum Contaminant Level, State Drinking Water Regulations (WAC 246-280)  
 \* = Primary  
 \*\* = Secondary  
 \*\*\* = Estimated MCL for the sum of all trihalomethanes  
 \*THM = Primary MCL for the sum of all trihalomethanes  
 \*XYL = Primary MCL for the sum of all xylenes  
 H = Estimated value; analyzed beyond specified holding time  
**Bold** = Does not meet GWQS or MCL  
 N/A = Not analyzed

DRAWING NUMBER 810835-A2  
 APPROVED BY  
 CHECKED BY  
 DRAWN BY SCHAEFFER 7/17/02  
 OFFICE Concord  
 X-REF  
 IMAGE



**LEGEND**  
 ◆ MONITORING WELL LOCATION  
 30 1,1-DCA CONCENTRATION IN µg/L  
 — 1,1-DCA ISOCONCENTRATION CONTOUR



	HORN RAPIDS LANDFILL
	<b>FIGURE 18</b> 1,1-DCA ISOCONCENTRATION MAP MARCH 2002

DRAWING NUMBER 810835-A3

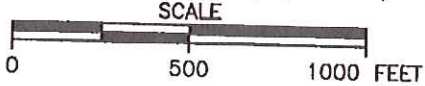
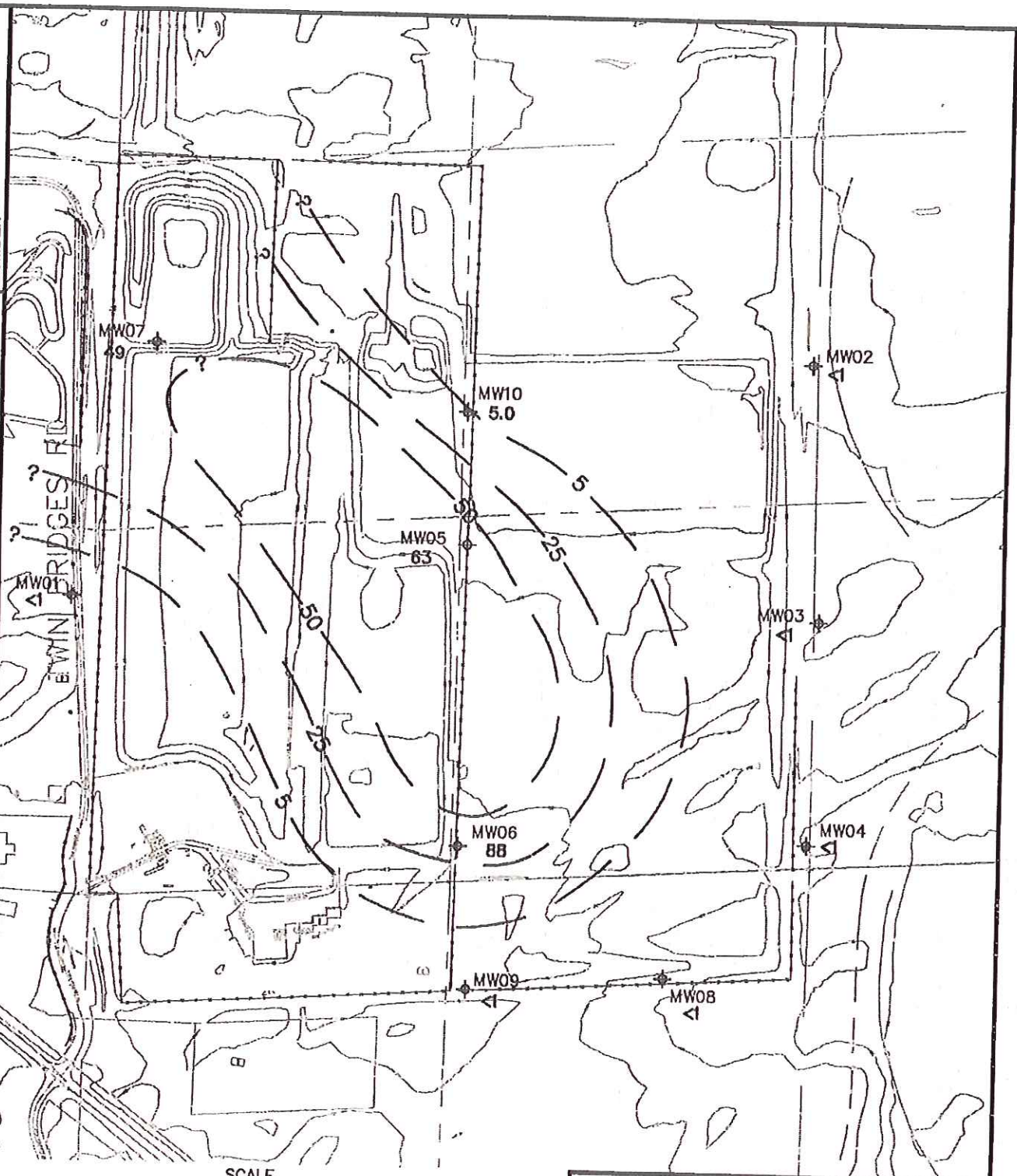
APPROVED BY



CHECKED BY

DRAWN BY SCHAEFFER 7/17/02

OFFICE Concord

X-REF



- LEGEND
-  MONITORING WELL LOCATION
  - 63** CIS-1,2-DCE CONCENTRATION IN  $\mu\text{g/L}$
  -  CIS-1,2-DCE ISOCONCENTRATION CONTOUR



HORN RAPIDS LANDFILL

FIGURE 19

CIS-1,2-DCE ISOCONCENTRATION MAP  
MARCH 2002

DRAWING NUMBER 810835-A4

APPROVED BY

CHECKED BY

DRAWN BY

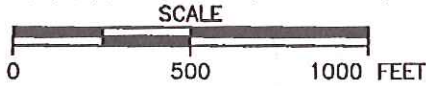
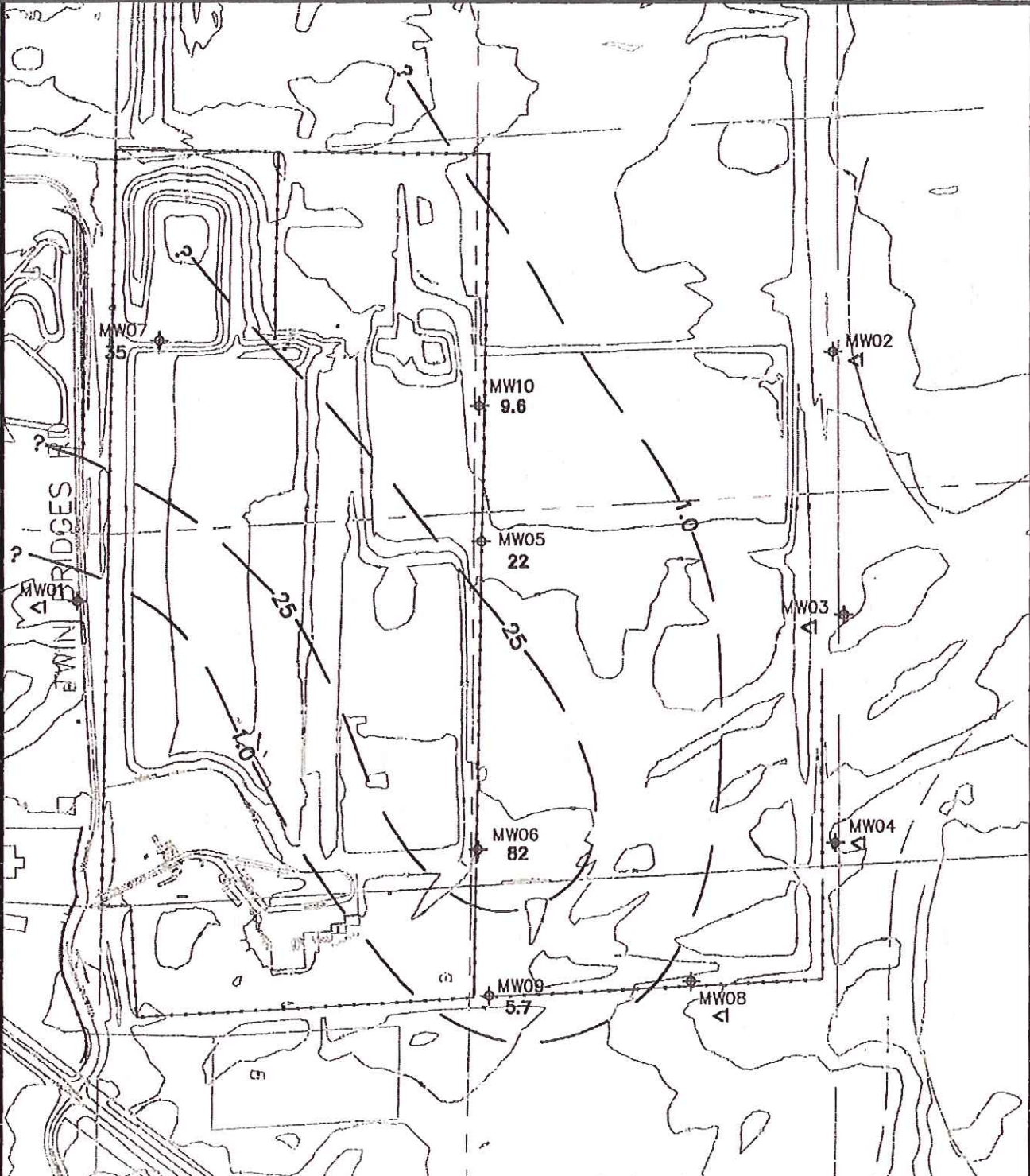
OFFICE

IMAGE X-REF

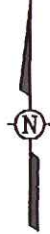
7/17/02

SCHAEFFER

Concord



- LEGEND
- ◆ MONITORING WELL LOCATION
  - 22 PCE CONCENTRATION IN  $\mu\text{g/L}$
  - PCE ISOCONCENTRATION CONTOUR



HORN RAPIDS LANDFILL

FIGURE 20  
PCE ISOCONCENTRATION MAP  
MARCH 2002

DRAWING NUMBER 810835-A5

APPROVED BY

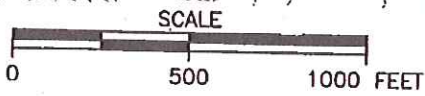
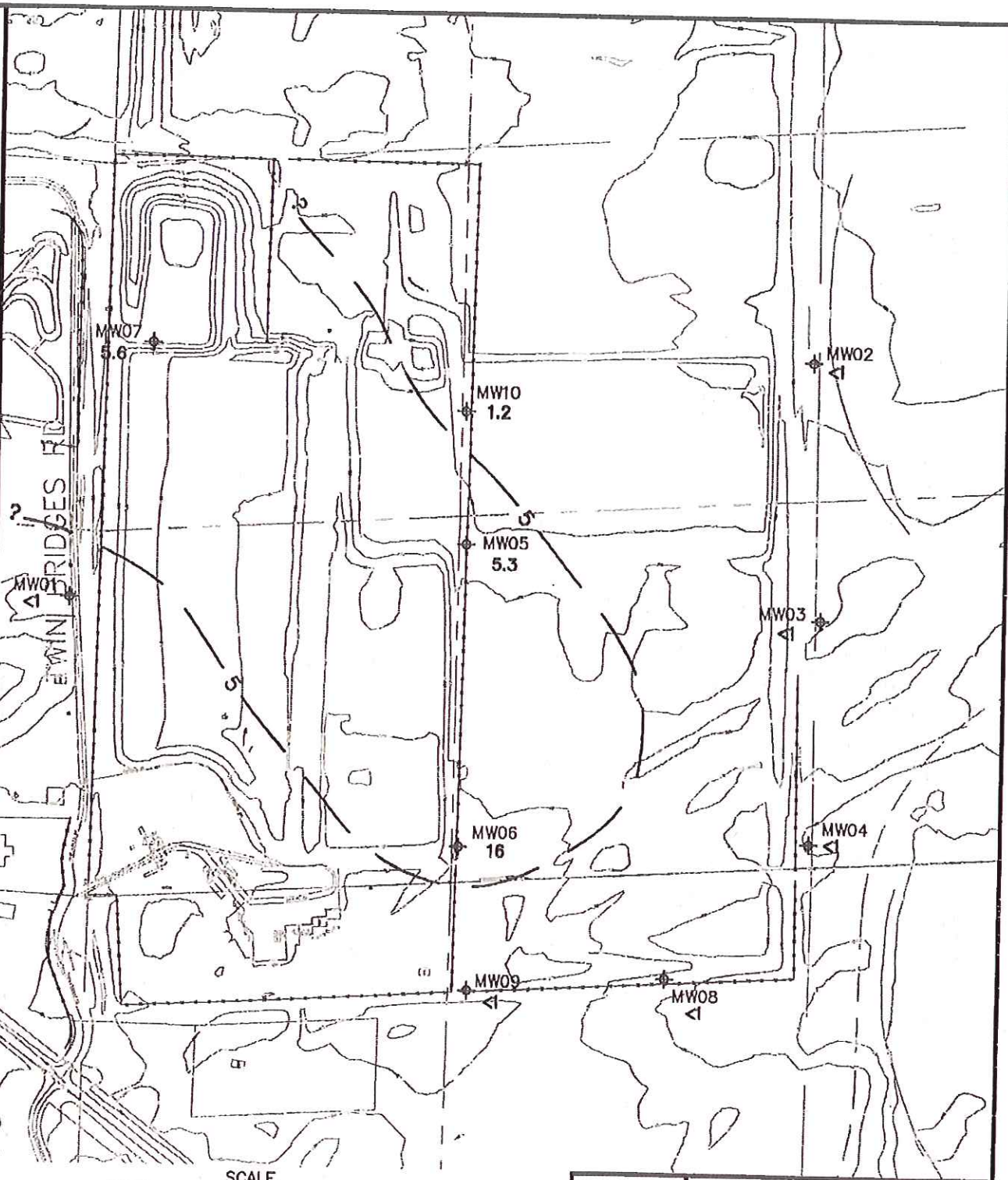
CHECKED BY



DRAWN BY SCHAEFFER 7/17/02

OFFICE Concord

X-REF

IMAGE



- LEGEND
-  MONITORING WELL LOCATION
  - 5.3** TCE CONCENTRATION IN µg/L
  -  TCE ISOCONCENTRATION CONTOUR



HORN RAPIDS LANDFILL

FIGURE 21

TCE ISOCONCENTRATION MAP  
MARCH 2002

DRAWING NUMBER  
810835-A6

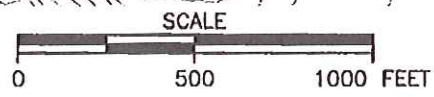
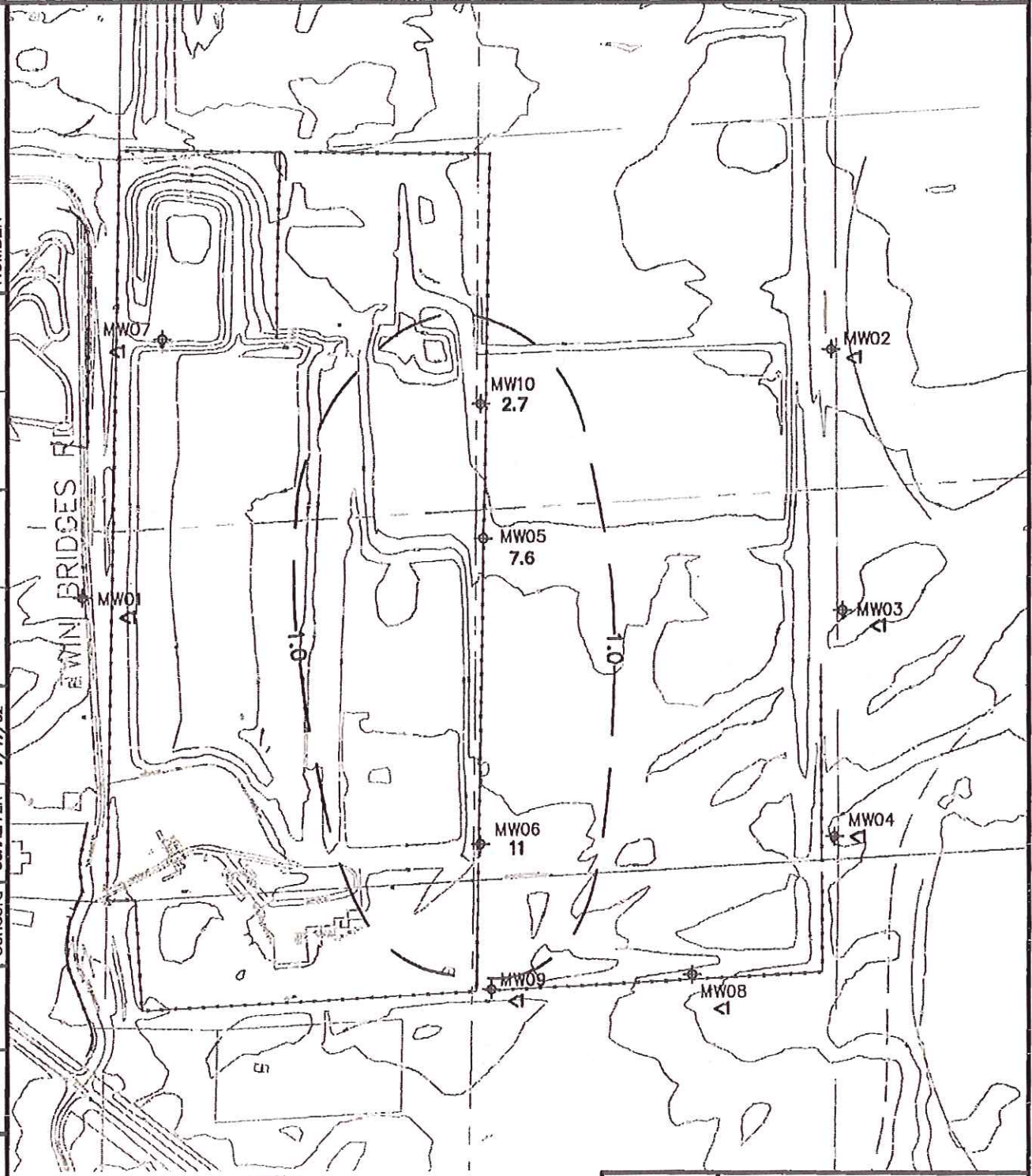
APPROVED BY

CHECKED BY

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SCHAEFFER 7/17/02

OFFICE  
Concord

IMAGE X-REF



- LEGEND
- ◆ MONITORING WELL LOCATION
  - 2.7 VINYL CHLORIDE CONCENTRATION IN  $\mu\text{g/L}$
  - VINYL CHLORIDE ISOCONCENTRATION CONTOUR

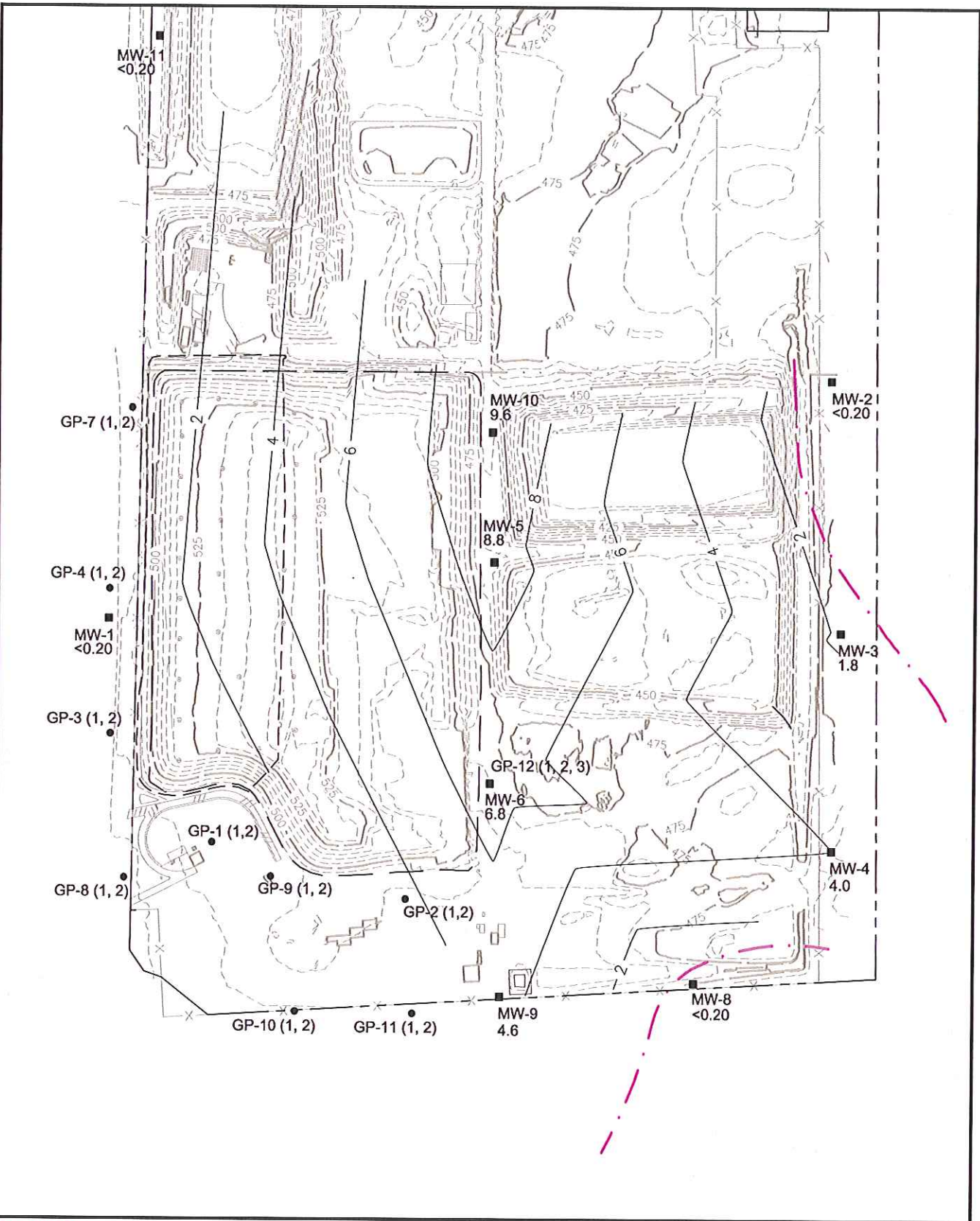


HORN RAPIDS LANDFILL

FIGURE 22

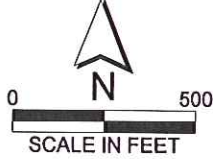
VINYL CHLORIDE ISOCONCENTRATION MAP  
MARCH 2002

FILE: PS3820004P04T02-F1 LAYOUT: F1 PATH: U:\P20\Projects\Clean03\_2012-CM\_HornRapid2011\DWG\PS3820004P04T02-F1.dwg PLOTTO BY: pparametrix DATE: Wednesday, March 16, 2016 2:55:35 PM



Parametrix

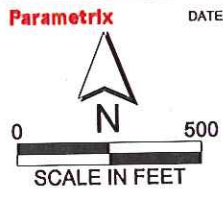
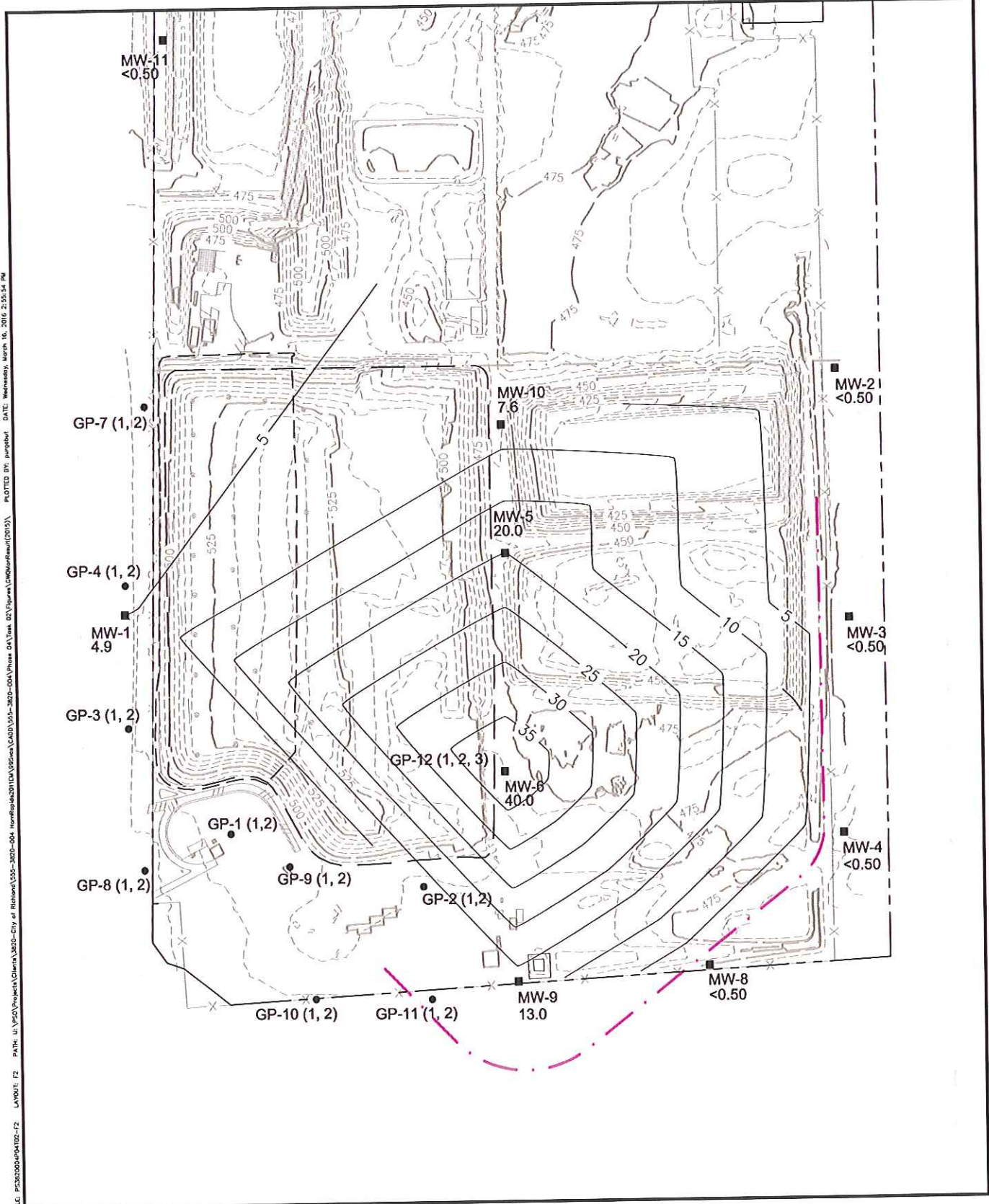
DATE: March 16, 2016 FILE: PS3820004P04T02-F1



- Legend:**
- Facility Boundary
  - Refuse Limit
  - - - Closure Limit
  - 2- Isoconcentration Contour
  - 1,1-Dichloroethane GWQS = 1 µg/L

**Figure 1**  
**Maximum 2015 Concentrations of 1,1-Dichloroethane (µg/L) in Groundwater Horn Rapids Landfill**

FILE: PS3820004P04T02-F2 LAYOUT: F2 DATE: March 16, 2018 2:35:34 PM  
 PATH: U:\PS3\Projects\Objects\3820-004\HorizMap2015M\GP500\505-3820-004\Press 04\Title 02\Figures\Groundwater\02193



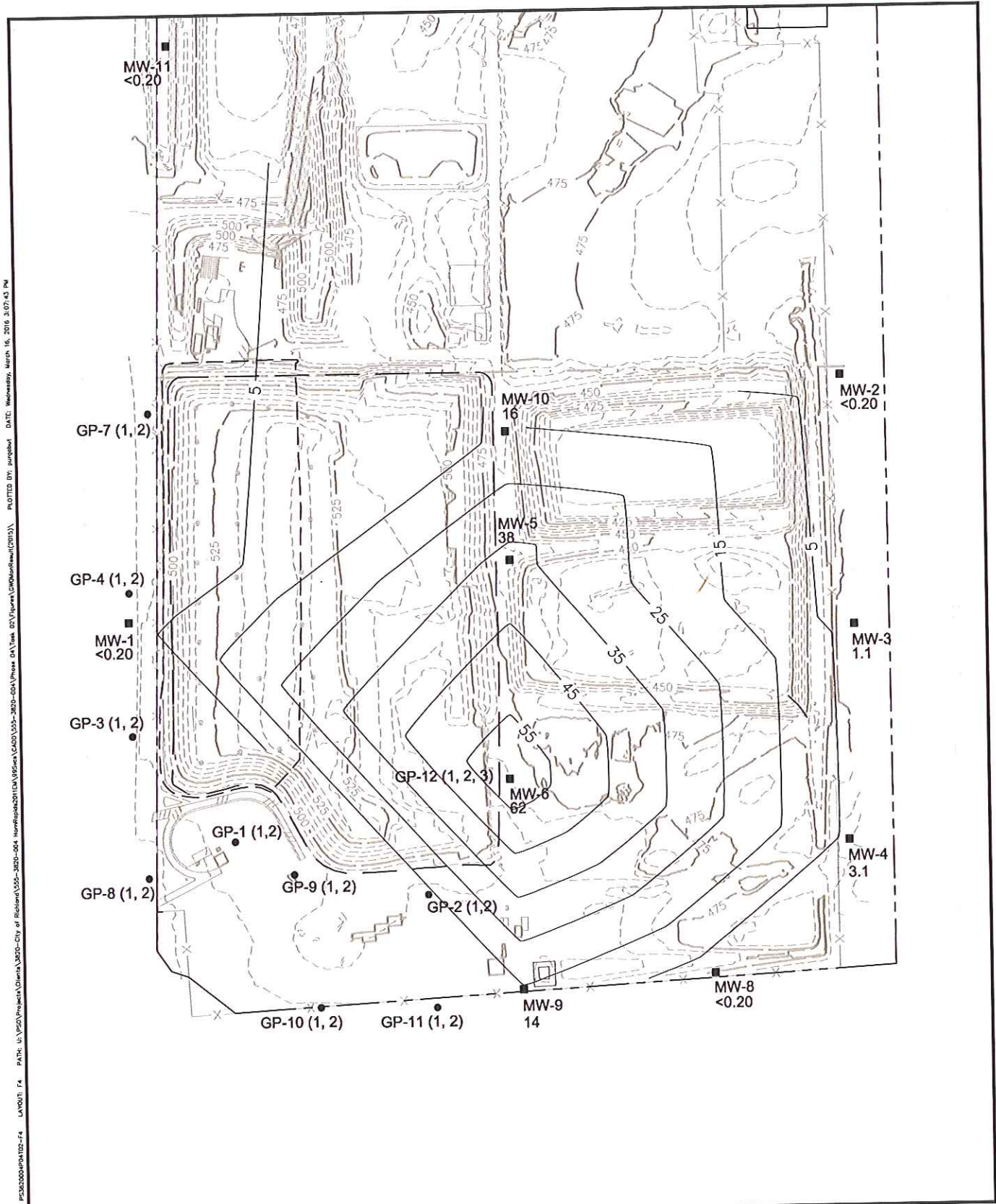
- Legend:**
- Facility Boundary
  - - - - Refuse Limit
  - - - - Closure Limit
  - 2 — Isoconcentration Contour
  - · — Tetrachloroethene GWQS = 0.8 µg/L

**Figure 2**  
**Maximum 2015 Concentrations of Tetrachloroethene (µg/L) in Groundwater Horn Rapids Landfill**



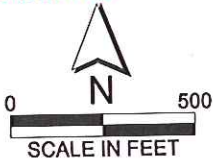


FILE: PS3820004P04T02-F4 LAYOUT: F4 PATH: U:\PS3820004\Projects\04\2\3820004\City of Richmond\3820-004\3820-004\North\Map2011\DWG\3820-004\Phase 04\T02-F4\Figures\GP\MapInfo\MapInfo(2011). PLOTTED BY: jperdue DATE: Wednesday, March 16, 2016 3:07:43 PM



Parametrix

DATE: March 16, 2016 FILE: PS3820004P04T02-F4

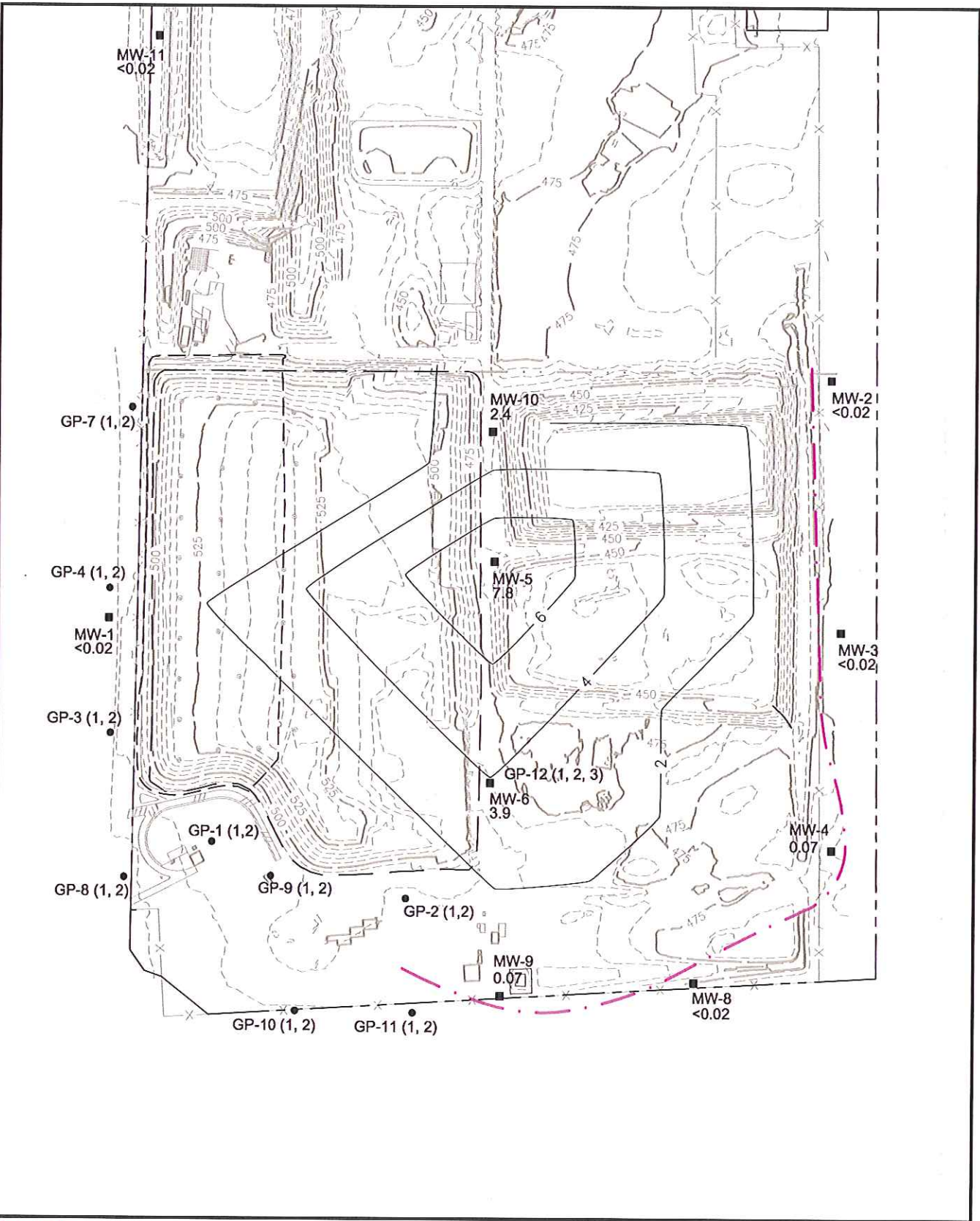


**Legend:**

- Facility Boundary
- - - Refuse Limit
- - - Closure Limit
- Isoconcentration Contour
- cis-1, 2-Dichloroethene  
MCL = 70 µg/L

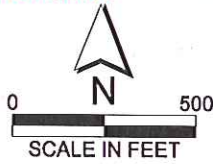
**Figure 4**  
**Maximum 2015 Concentrations of**  
**cis-1, 2-Dichloroethene (µg/L) in Groundwater**  
**Horn Rapids Landfill**

FILE: P:\3820004\04T02-F5 LAYOUT: F5 PATH: U:\P50\Projects\Gis\2015-City of Richmond\555-3000-04 Newport\2015\CA00\555-3000-04\Phase 5A\Task\_03\Figures\Concentration\2015\ PLOTTED BY: jperout DATE: Wednesday, March 16, 2016 3:38:26 PM



Parametrix

DATE: March 16, 2016 FILE: PS3820004P04T02-F5

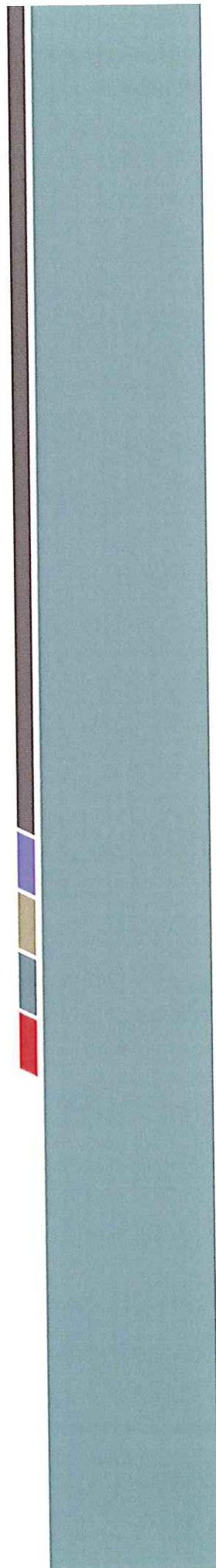


- Legend:**
- Facility Boundary
  - - - Refuse Limit
  - - - Closure Limit
  - 2 — Isoconcentration Contour
  - 0.02 — Vinyl Chloride GWQS = 0.02 µg/L

**Figure 5**  
**Maximum 2015 Concentrations of Vinyl Chloride (µg/L) in Groundwater Horn Rapids Landfill**

# Appendix F

## Push Probe Equipment Information



**Energy***Solutions*  
**Three Rivers Scientific**

October-2011

Hydraulic Hammer  
Direct Push

Kent Reynolds-ES  
Dr. R. Randall- TRS

# SYSTEM DESIGN

- Intended as an exploration and sampling system
- Utilizes 2 ½ In closed end probe for exploring, log data collection and placement of specialty constructions.
- Utilizes 2 5/8 In removable tip design for multi-point sampling.
- Hammer system has high energy impact (450-650 ft/lbs per cycle @ 2000 cycles per minute) and rotates the pipe while driving.

# WRPS/ES

- Four direct push units are available
- Three rubber tire-4 wheel drive back hoe units
- One crawler mounted heavy duty unit
- Since 2005 over 32,000 feet of 2 ½" and 2 5/8" of pipe have been driven in and around Hanford tank farms-additional footage (approx. 6,000 ft) has been placed for Fluor and CHPRC
- 390+ individual probe holes
- Logging of the exploration holes (2 ½") vastly improves worker safety by identifying radioactive contamination intervals.

## Vadose Characterization

- Since 2005 over 17,000 feet of logging data (gross, spectral gamma and neutron-neutron moisture) and 370+ soil samples have been collected in tank farms using hydraulic hammer direct push technology.
- This methodology was awarded DOE Best In Class (Vadose Characterization) in 2007.



# Unit #1



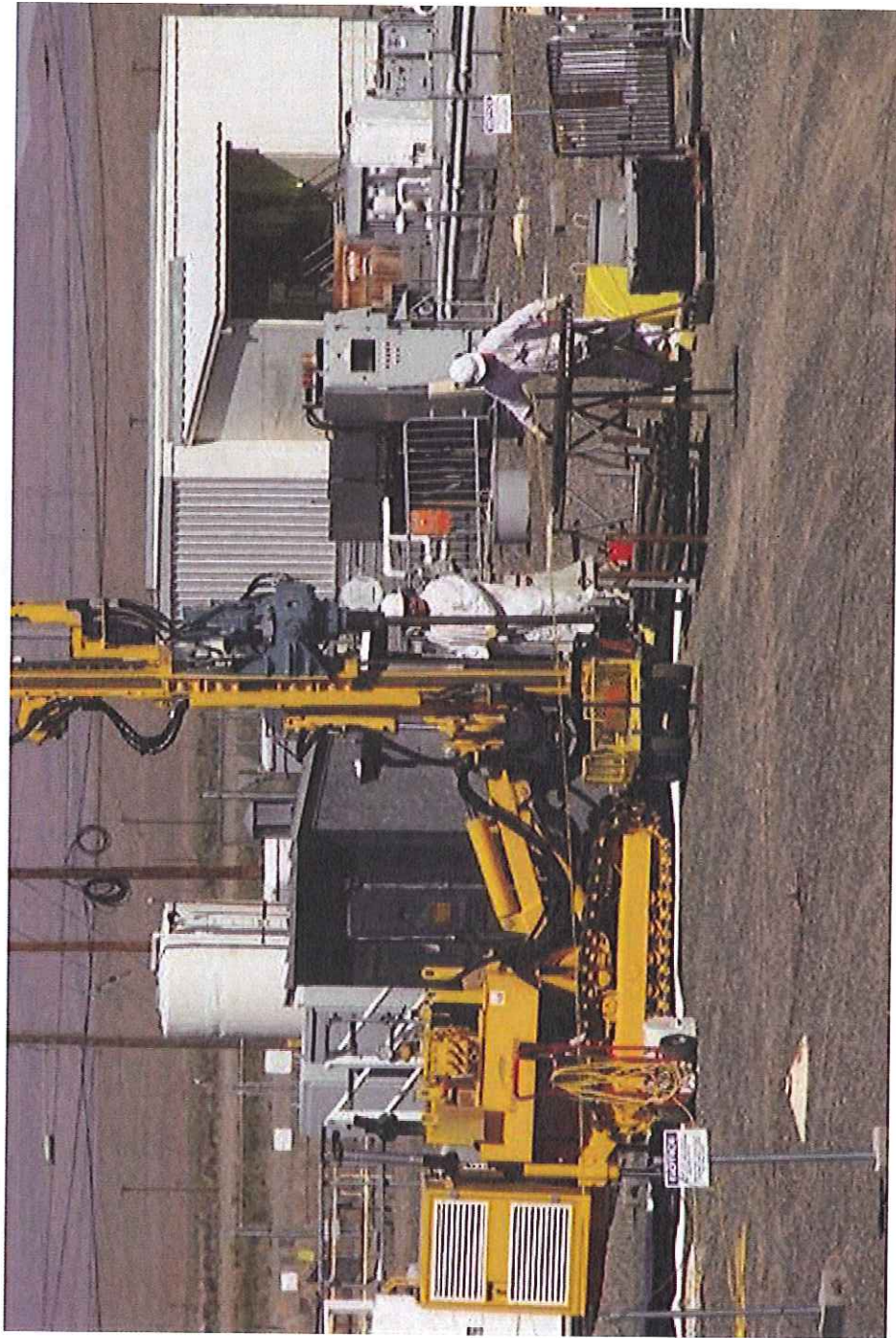
# Unit # 2



# Unit # 3



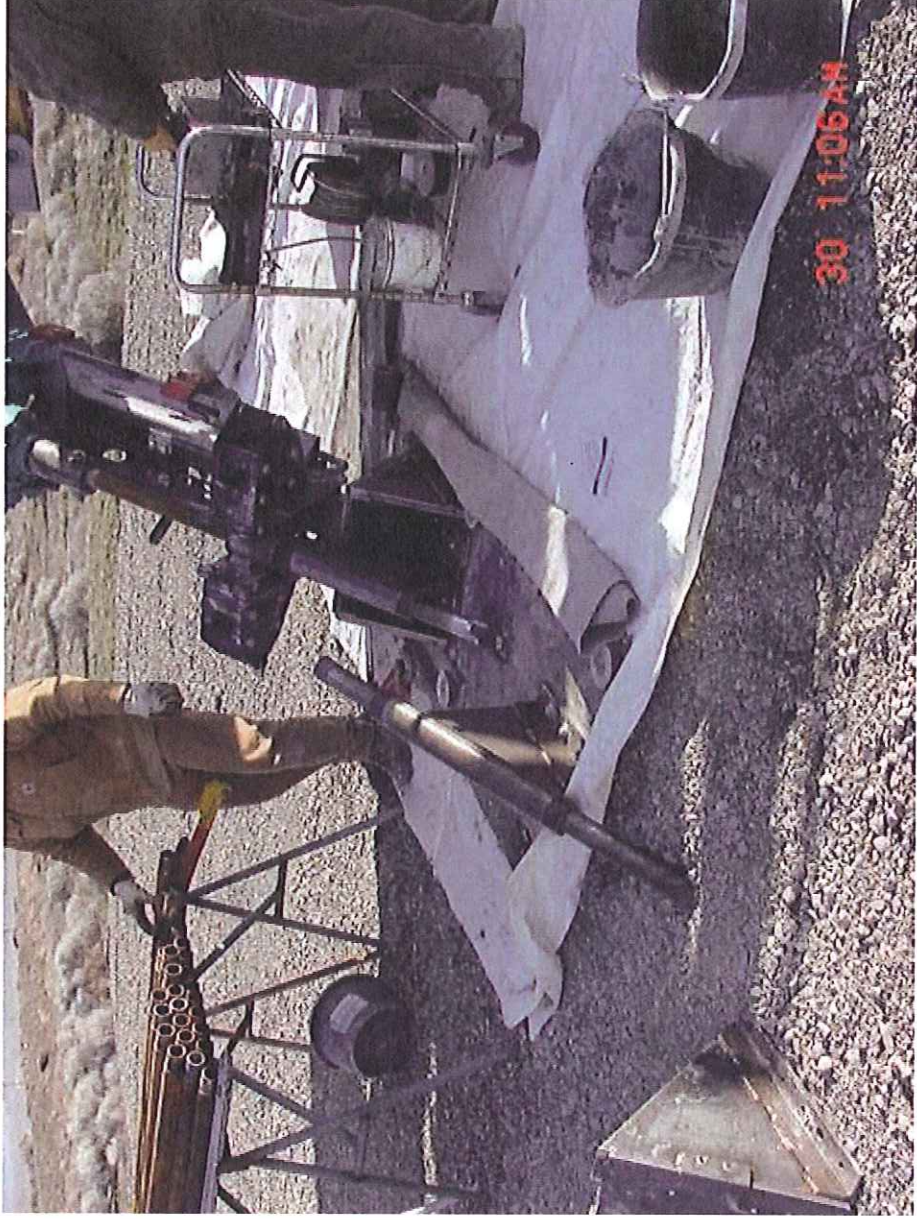
# Unit # 4 XL



# Angle Capabilities



# Base Plate and Angle Guides for Angle and Azimuth Control

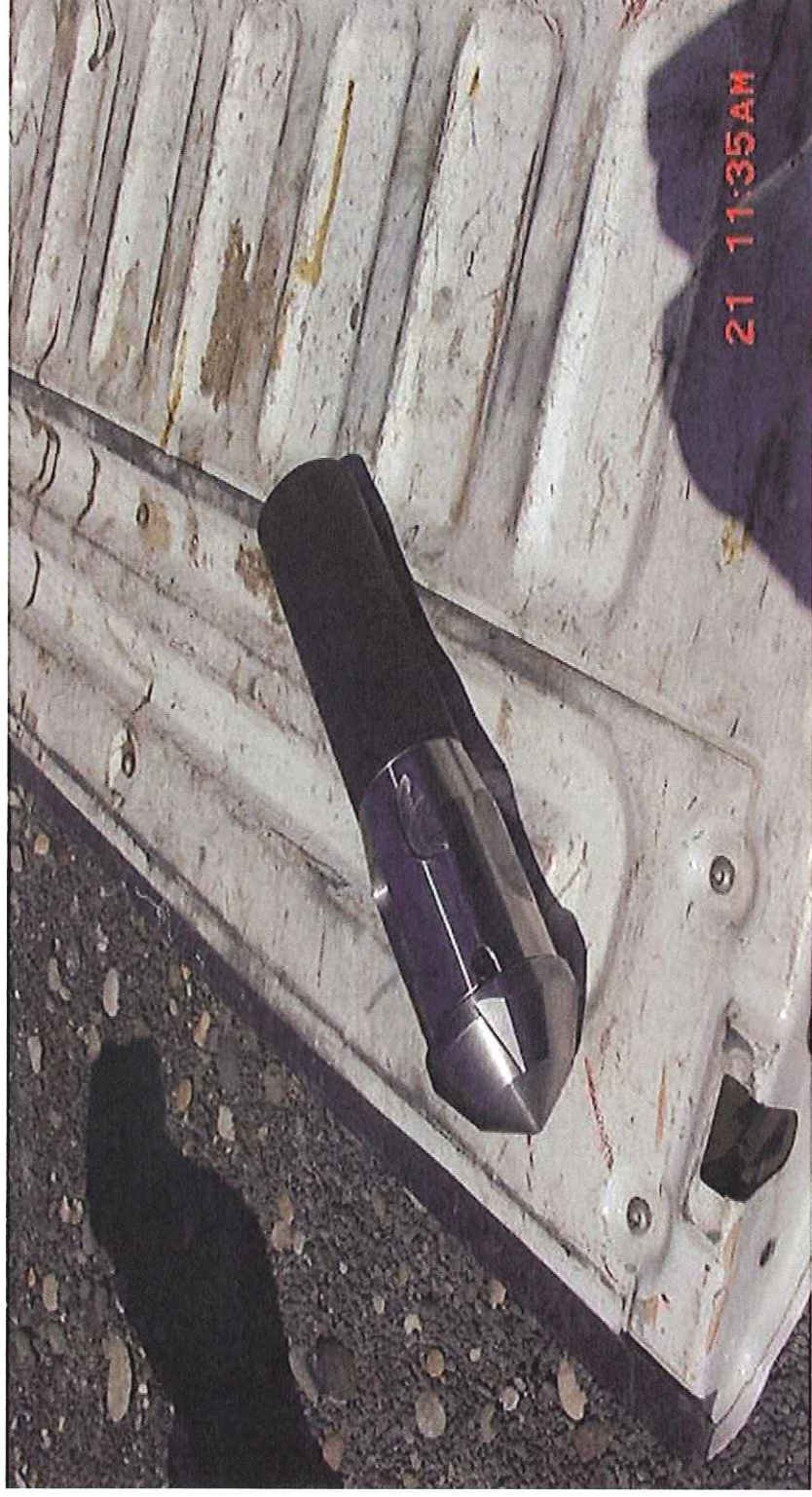


# Depth Capabilities

- In 200 E (C Farm) vertical pushes have reached 220+ feet on 95+% attempts for that depth
- Angle pushes in 200 E have achieved over 260+ feet of pipe run at 30 degrees from vertical (95+% success results) and 200+ ft at 28 degrees from horizontal
- In 200 West able to push to top of Lower Cold Creek (caliche unit- 130 to 150+ feet) in most areas T-TX-TY, U, and S- SX

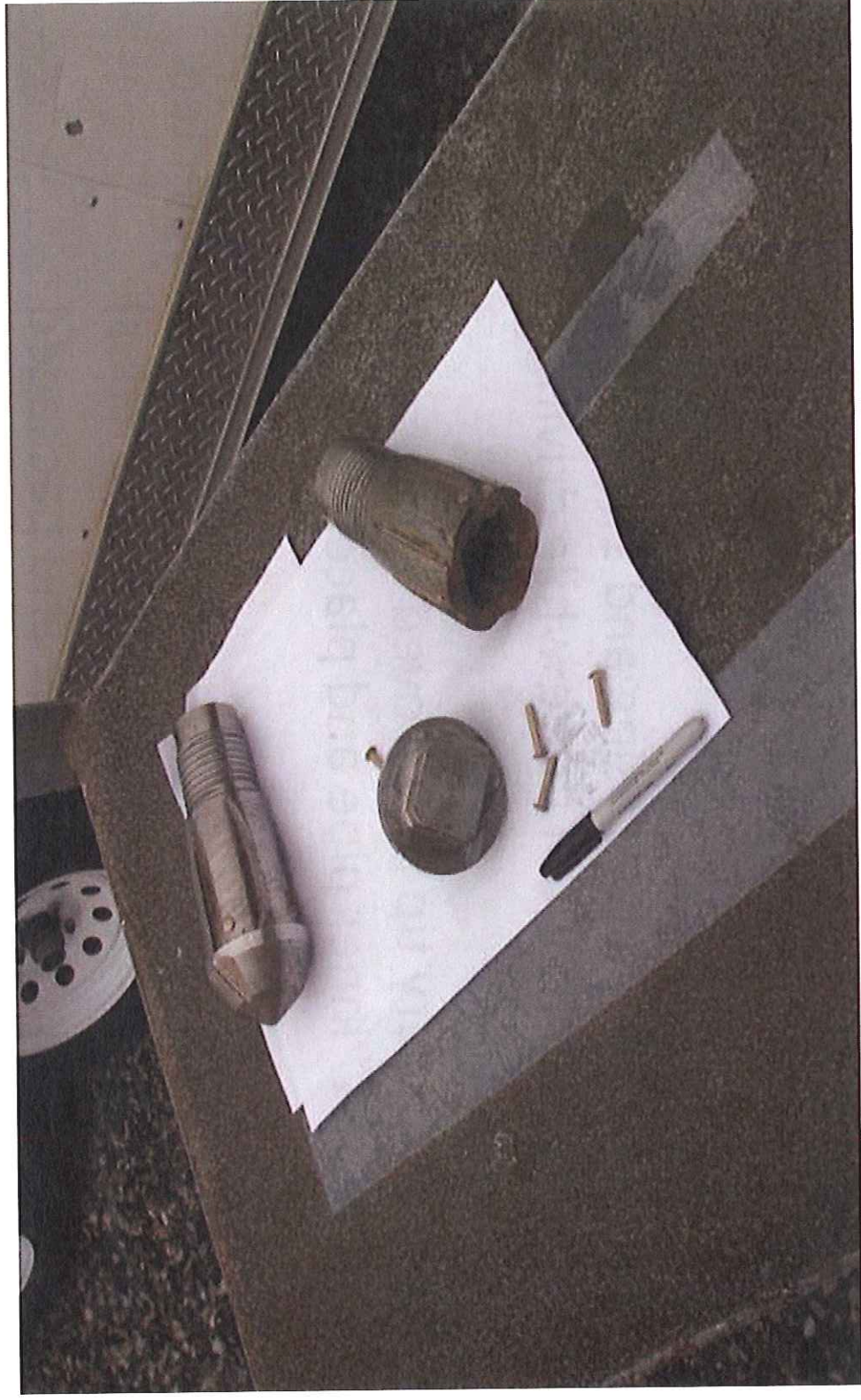
# Unique tooling designs and hammer properties allow for deep vadose direct push exploration

2.5 in. disposable tip and holder





# Exploration 2 1/2" Drive Pipe Tip Holder & tip



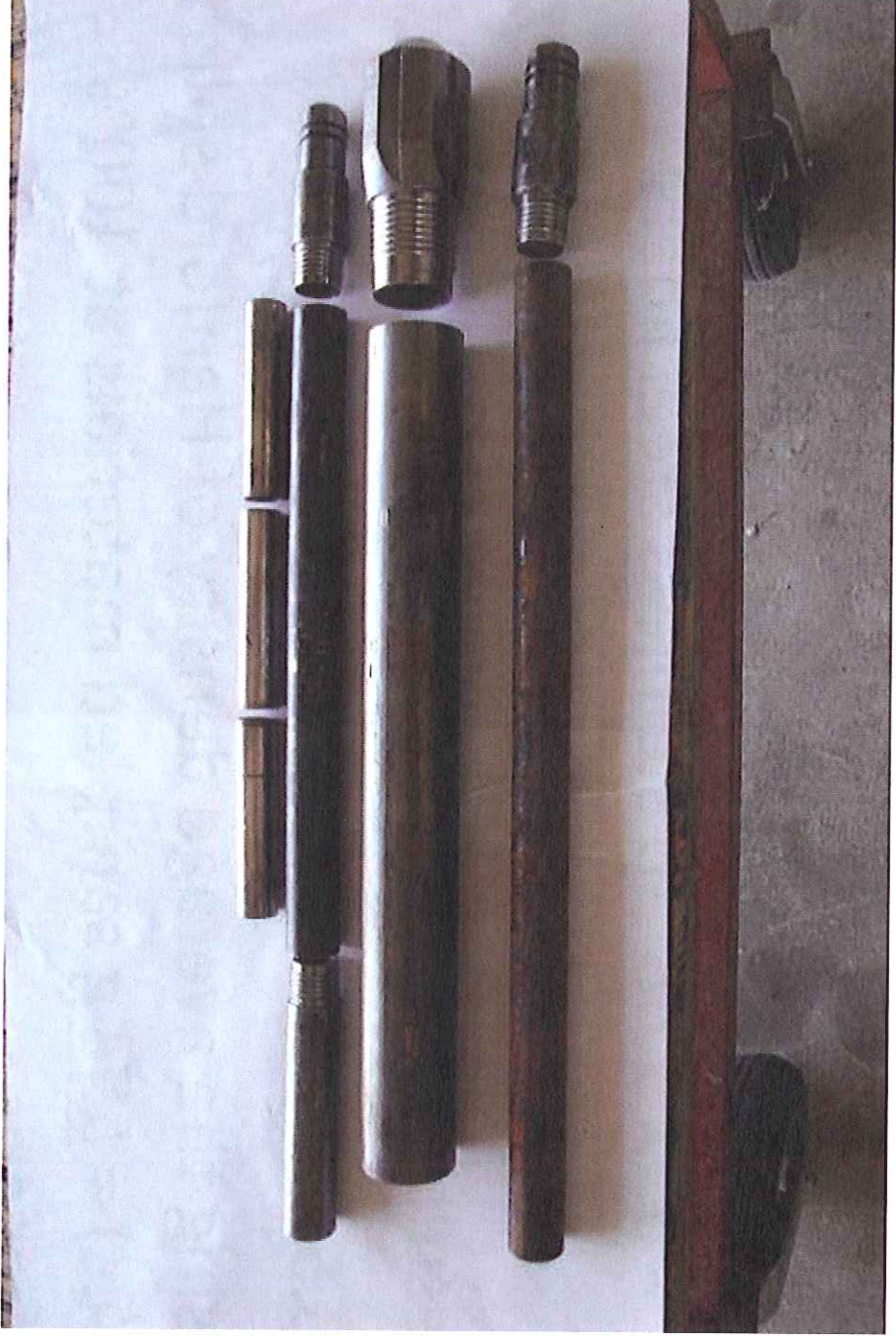
## 2 5/8" Multi-point Sampling

- Uses a 2 5/8" outer casing and 1 1/2" inner string to hold a temporary point in place while driving to sample depth
- The temporary tip is removed and a sampler is placed on the 1 1/2" inner pipe and placed into the outer casing.
- The dual casings are advanced through the selected sample zone (approximately 22-24 inches)
- Sampler is pulled to surface and packaged
- Inner string with temporary tip placed into the casing and entire system is advanced to next sample zone.

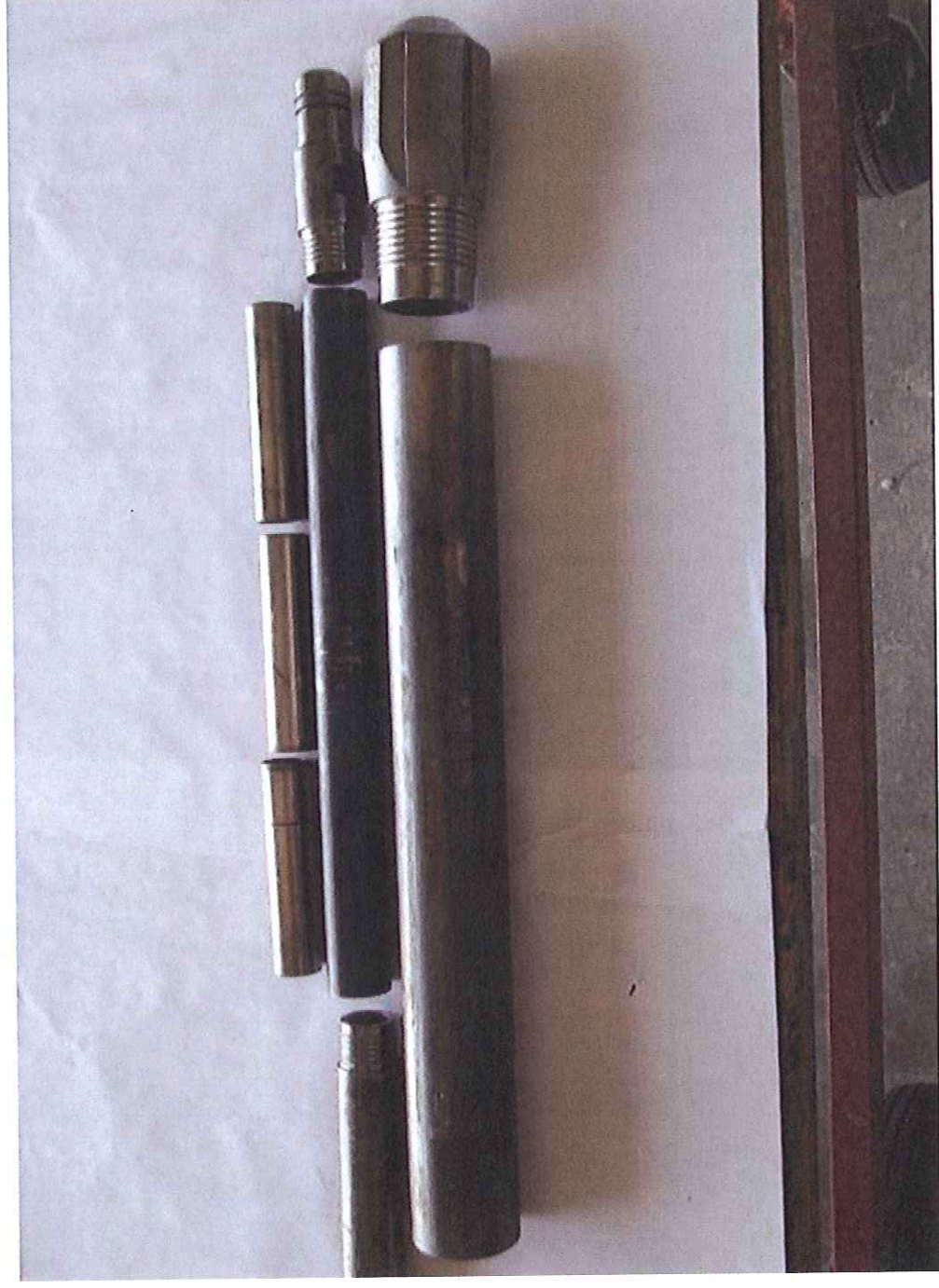
# Sampling System

- 3 - 6" X 1.08" ID stainless steel liners
- 1 - 4" X 1.08" ID sampler shoe
- Results in 330 cc/ 20.15 cu. in. of material
- 16.5 cu. in. in liners 3.65 cu. in. in shoe
- Using the average density of Hanford soils (1.8 g/cc) = 594 g sampled materials at 100% recovery

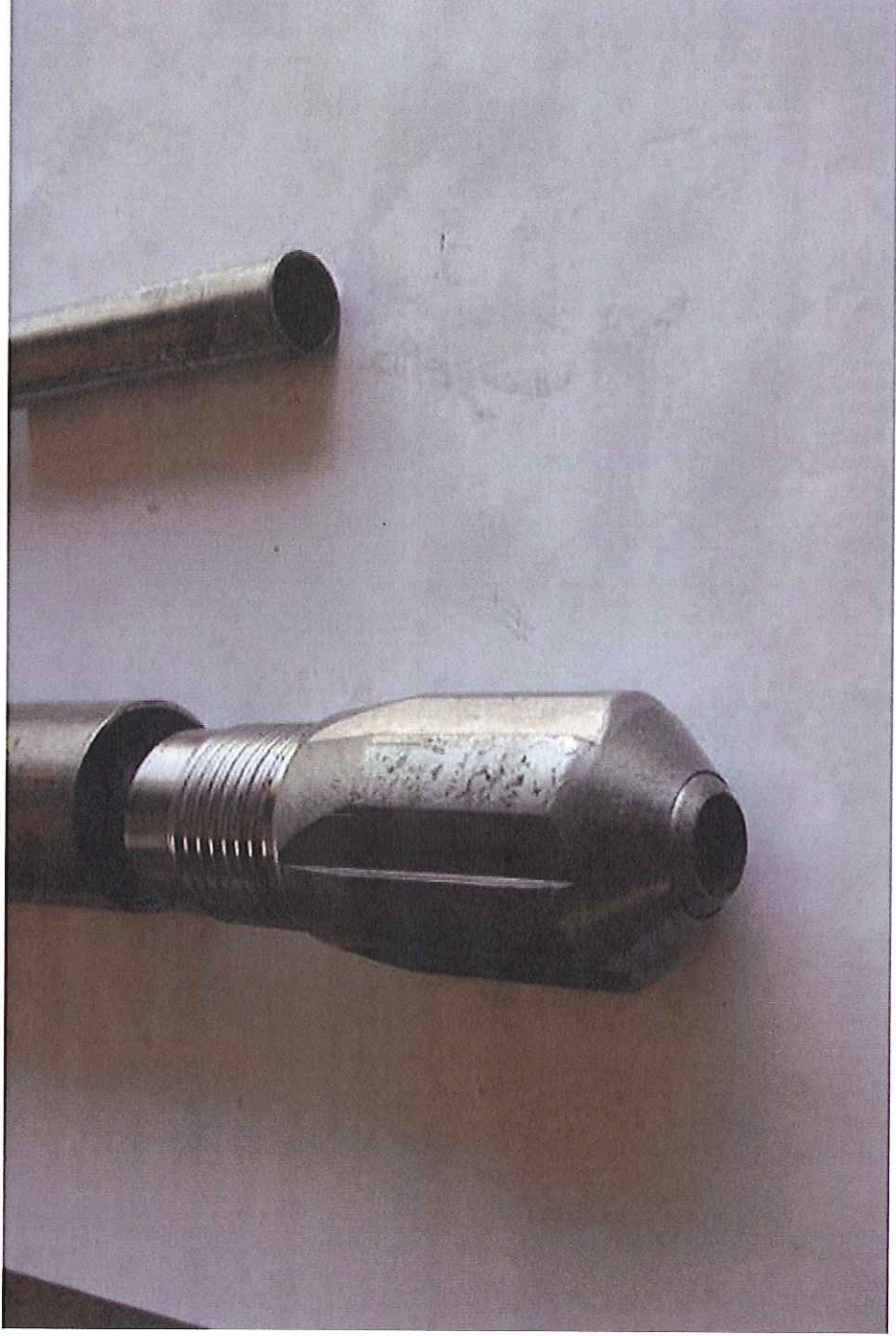
# 2 5/8" Driving and Sampling System



# Multi-point 2 5/8" Sampling System



# Dual Wall Sampler Shoe

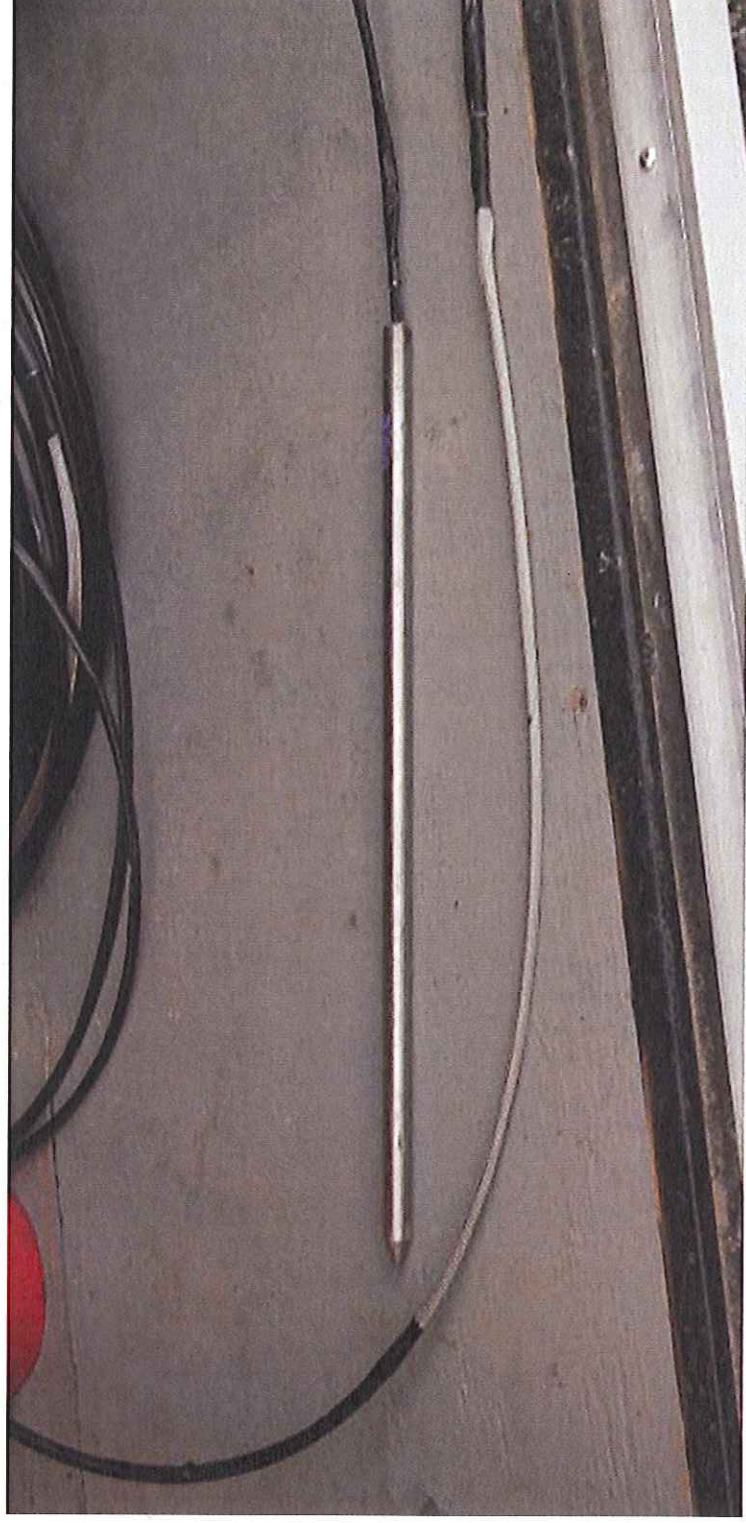


## Other Capabilities

- Mini-piezometers-Placed 8 piezometers to 20 and 30 ft bgs depths in 100 N Area in 5 working days using pre-built 2" constructions.
- At 3 locations on the US Ecology Site placed 9 vapor sampling installations- clusters of three (1-shallow 5-8 feet, 1 mid-range 30-35 feet, 1 deep 75-80 feet)
- System used to build moisture monitoring stations by placing HDU and capacitance sensors to various depths and building moisture logging placements in TY and T Farms

## Other Capabilities Continued

- Routinely place resistivity tooling in exploration probe holes in the tank farm (two styles- single point and multi-depth)



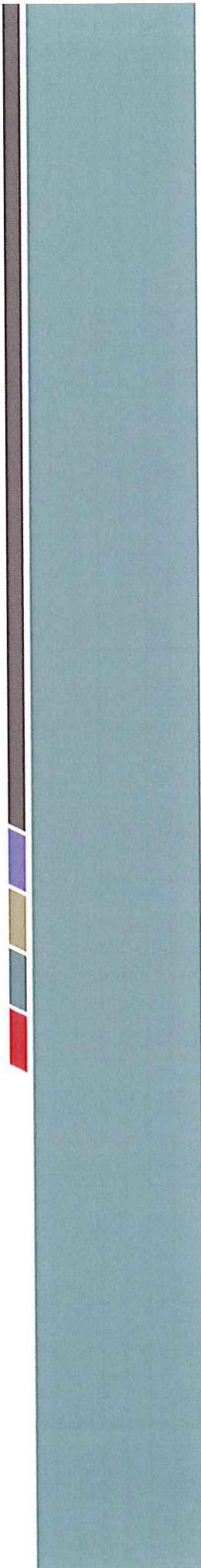


## Direct Push Support Services

- Safety field oversight- Trained and certified safety personnel familiar with the technology.
- All crew members have received 30 Hour OSHA Industry safety training as well as current with all entry and site requirements for Hanford.
- Logging support
- Specialty project designs

# Appendix G

## Push Probe Groundwater Sampling Information



**Methods and Quantitation Limits for Analysis of Groundwater Push-Probe Samples, Horn Rapids Landfill**

Parameters	Units	Groundwater Regulatory Standard		Laboratory	PQL (mg/L)	Analytical Method
		MCL	GWQS			
<b>Volatile Organics</b>						
1,1,1,2-Tetrachloroethane	µg/L			ENW	0.5	8260B
1,1,1-Trichloroethane	µg/L	200 *	200 *	ENW	0.5	8260B
1,1,2,2-Tetrachloroethane	µg/L			ENW	0.5	8260B
1,1,2-Trichloroethane	µg/L	5 *		ENW	0.5	8260B
1,1-Dichloroethane	µg/L		1 ***	ENW	0.5	8260B
1,1-Dichloroethene	µg/L	7 *		ENW	0.5	8260B
1,2,3-Trichloropropane	µg/L			ENW	0.5	8260B
1,2-Dibromo-3-chloropropane	µg/L	0.2 *		ENW	0.5	8260B
1,2-Dibromoethane	µg/L	0.05 *	0.001 ***	ENW	0.001	8260 SIM
1,2-Dichlorobenzene	µg/L	600 *		ENW	0.5	8260B
1,2-Dichloroethane (total)	µg/L	5 *	0.5 ***	ENW	0.5	8260B
1,2-Dichloropropane	µg/L	5 *	0.6 ***	ENW	0.5	8260B
1,4-Dichlorobenzene	µg/L	75 *	4 ***	ENW	0.5	8260B
2-Butanone	µg/L			ENW	4	8260B
2-Hexanone	µg/L			ENW	4	8260B
4-Methyl-2-pentanone	µg/L			ENW	4	8260B
Acetone	µg/L			ENW	4	8260B
Acrylonitrile	µg/L		0.07 ***	ENW	0.07	8260 SIM
Benzene	µg/L	5 *	1 ***	ENW	0.5	8260B
Bromochloromethane	µg/L			ENW	0.5	8260B
Bromodichloromethane	µg/L	80 *THM	0.3 ***	ENW	0.3	8260B
Bromoform	µg/L	80 *THM	5 ***	ENW	0.5	8260B
Bromomethane	µg/L			ENW	0.5	8260B
Carbon disulfide	µg/L			ENW	0.5	8260B
Carbon tetrachloride	µg/L	5 *	0.3 ***	ENW	0.3	8260B
Chlorobenzene	µg/L	100 *		ENW	0.5	8260B
Chloroethane	µg/L			ENW	0.5	8260B
Chloroform	µg/L	80 *THM	7 ***	ENW	0.5	8260B
Chloromethane	µg/L			ENW	0.5	8260B
cis-1,2-Dichloroethene	µg/L	70 *		ENW	0.5	8260B
cis-1,3-Dichloropropene	µg/L			ENW	0.5	8260B
Dibromochloromethane	µg/L	80 *THM		ENW	0.5	8260B
Dibromomethane	µg/L			ENW	0.5	8260B
Ethylbenzene	µg/L	700 *		ENW	0.5	8260B
m,p-xylene	µg/L	10000 *XYL		ENW	1	8260B
Methyl iodide	µg/L			ENW	NA	NA
Methylene chloride	µg/L	5 *	5 ***	ENW	0.5	8260B
o-xylene	µg/L	10000 *XYL		ENW	0.5	8260B
Styrene	µg/L	100 *		ENW	0.5	8260B
Tetrachloroethene	µg/L	5 *	0.8 ***	ENW	0.5	8260B
Toluene	µg/L	1000 *		ENW	0.5	8260B
trans-1,2-Dichloroethene	µg/L	100 *		ENW	0.5	8260B
trans-1,3-Dichloropropene	µg/L			ENW	0.5	8260B

**Methods and Quantitation Limits for Analysis of Groundwater Push-Probe Samples, Horn Rapids Landfill**

Parameters	Units	Groundwater Regulatory Standard		Laboratory	PQL (mg/L)	Analytical Method
		MCL	GWQS			
trans-1,4-Dichloro-2-butene	µg/L			ENW	NA	NA
Trichloroethene	µg/L	5 *	3 ***	ENW	0.5	8260B
Trichlorofluoromethane	µg/L			ENW	0.5	8260B
Vinyl Acetate	µg/L			ENW	NA	NA
Vinyl Chloride	µg/L	2 *	0.02 ***	ENW	0.02	8260 SIM
<b>Dissolved Gases (RSK-175)</b>						
Ethane	µg/L			TA	10	RSK-175
Ethylene	µg/L			TA	10	RSK-175
Methane	µg/L			TA	1.2	RSK-175

ENW = Energy Northwest

TA - TestAmerica

NA = ENW is not accredited to analyze these parameters

# Bladder Pumps, Groundwater Sampling

## Geotech Bladder Pumps

Together with the USGS, Geotech designed the original bladder pump for groundwater quality and pollution monitoring. They can pump to the surface from as deep as 1000 feet (305 meters) with minimal agitation for the best representative samples.

### FEATURES

- True low flow capability for less agitation
- Proprietary resin grade virgin PTFE bladder for long life
- Constructed of #316 SS for durability
- Dedicated or portable turnkey systems
- Screened intake extends bladder life
- Optional Drop-Tube assembly available for sampling from greater depths
- Limited lifetime warranty on dedicated stainless steel systems
- Compatible with the Geocontrol PRO and BP Controller units

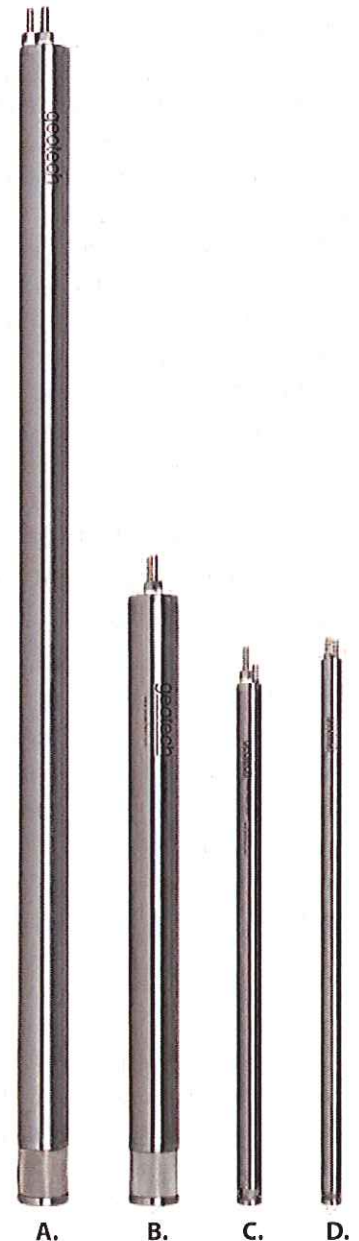
### BLADDER PUMP MODELS

- A. 1.66, 36" (4 cm, 91 cm)**  
Made from SS for maximum durability. Highest volume rate for a low flow pump. For 2" (5 cm) wells or larger.
- B. 1.66, 18" (4 cm, 46 cm)**  
The same as above but for lower pump volume requirements.
- C. .850, 18" (2.2 cm, 46 cm)**  
Made from high-grade SS for maximum durability.  
Extra slim design provides excellent performance for its size.
- D. .675, 18" (1.7 cm, 46 cm)**  
Our smallest bladder pump, fits in any well .75" (1.9 cm) or larger. Made with the same polished stainless steel as our other top-of-the-line pumps.

### SPECIFICATIONS

	1.66, 36"	1.66, 18"	.850, 18"	.675, 18"
Pump Housing	316SS	316SS	316SS	316SS
Bladder Material	Virgin PTFE	Virgin PTFE	Virgin PTFE	Virgin PTFE
O.D.	1.66" (4.2 cm)	1.66" (4.2 cm)	.850" (2.2 cm)	.675" (1.7 cm)
Length w/Screen	38" (96.5 cm)	20" (51 cm)	18 5/8" (47.3 cm)	18 3/4" (47.6 cm)
Weight	5 lbs. (1.9 kg)	2.5 lbs. (0.93 kg)	1.1 lbs. (.5 kg)	.83 lbs. (.4 kg)
Volume /Cycle	21.1 oz. (625 ml)	10.5 oz. (313 ml)	.9 oz. (29 ml)	.5 oz. (15 ml)
Min. Well I.D.	2" (50 mm)	2" (50 mm)	1.00" (2.5 mm)	.75" (1.9 mm)
Operating Pressure	10-450 psi (.7-31 bar)	10-450 psi (.7-31 bar)	100 psi (6.9 bar)	100 psi (6.9 bar)
Min. Operating Pressure	5 psi (.34 bar) ash*	5 psi (.34 bar) ash*	5 psi (.3 bar) ash*	5 psi (.3 bar) ash*
Maximum Depth	1000' (305 m)	1000' (305 m)	200' (61 m)	200' (61 m)
Air Line (ID x OD)	.17" x .25" (4 mm x 6 mm)	.17" x .25" (4 mm x 6 mm)	.17" x .25" (4 mm x 6 mm)	.17" x .25" (4 mm x 6 mm)
Discharge Line (ID x OD)	.25" x .375" (6 mm x 10 mm)	.25" x .375" (6 mm x 10 mm)	.25" x .375" (6 mm x 10 mm)	.25" x .375" (6 mm x 10 mm)

\*ash = above static head



**CALL GEOTECH TODAY (800) 833-7958**

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 2650 East 40th Avenue • Denver, Colorado 80205  
 (303) 320-4764 • (800) 833-7958 • FAX (303) 322-7242  
 email: sales@geotechenv.com website: www.geotechenv.com

# Sampling Pumps

## Geotech Portable Bladder Pumps

Geotech's portable bladder pumps are designed with input from field technicians who actually do the sampling! Single turn release head and quick change bladders allow for quick, in-the-field bladder changes and easy decontamination. Custom hose barbs allow the pump to be secured to tubing without the need for tubing clamps.

### FEATURES

- **Constructed of 316 stainless steel**  
For unsurpassed durability and truly representative samples
- **Portable turnkey systems available**  
Everything you need to quickly and efficiently sample your site
- **Easy-to-open housings**  
No special tools or training required to service the pump
- **Quick-change bladder configuration**  
Bladders are easily changed without tools by sliding back the PTFE collars
- **Drop tube intake option**  
Allows for deeper sampling
- **Extra bladders are readily available**  
Available in PTFE and Polyethylene for all models
- **Bonded tubing**  
In Polyethylene and FEP lined Polyethylene by the foot or by the roll
- **Compatible with the Geocontrol PRO & BP Controller units**
- **CE rated for quality**

### SPECIFICATIONS

	1.66 Portable	.850 Portable	.675 Portable
Pump Housing	316 SS	316 SS	316 SS
Pump Ends	316 SS	316 SS	316 SS
Bladder Material	Virgin PTFE	Virgin PTFE	Virgin PTFE
Outer Diameter	1.66" (4.2 cm)	.850" (2.2 cm)	.675" (1.7 cm)
Length w/Screen	19" (48.3 cm)	18 5/8" (47.3 cm)	18 3/4" (47.6 cm)
Weight	3.0 lbs. (1.4 kg)	1.1 lbs. (.5 kg)	.83 lbs. (.4 kg)
Volume /Cycle	5 oz. (150 ml)	0.9 oz. (29 ml)	0.5 oz. (15 ml)
Min. Well I.D.	2" (5 cm)	1" (2.5 cm)	.75" (1.9 cm)
Max. Operating Pressure	100 psi (6.9 bar)	100 psi (6.9 bar)	100 psi (6.9 bar)
Min. Operating Pressure	5 psi (.3 bar) ash*	5 psi (.3 bar) ash*	5 psi (.3 bar) ash*
Max. Sampling Depth	200' (61 m)	200' (61 m)	200' (61 m)
Tubing Size	Air .17" ID x .25" OD Discharge .25" ID x .375" OD	.17" ID x .25" OD .17" ID x .25" OD	.17" ID x .25" OD .17" ID x .25" OD

\*ash = above static head



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# Sampling Pumps

## Geotech Portable Bladder Pump Optional Accessories

### PORTABLE BLADDER PUMP DROP TUBE ASSEMBLY

Geotech's optional drop tube intake system allows you to easily relocate the bladder pump intake way beyond the depth limitations of the pump. As long as the pump remains submerged, you can effectively and economically low flow sample from the well's screened section.

- Relocate pump intake to deeper well screen interval
- Keeps pump at optimum depth to maximize performance
- Drop tube length custom sized to each well
- Easily adaptable in the field
- Available for all three pump sizes



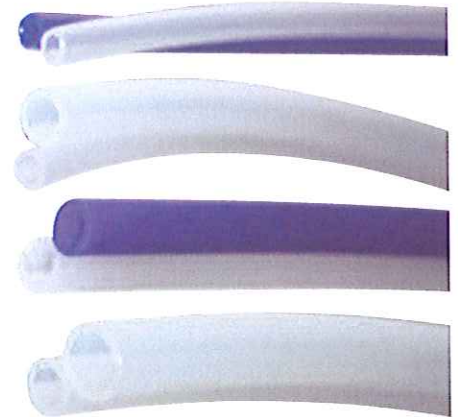
### PORTABLE BLADDER PUMP REEL

- Caddy stores pump when not in use
- Depth ranges to 175 feet (53 m)
- Quick-connect fittings at pump and reel



Portable Bladder Pump Reel System  
(shown with 1.66 Pump)

### BONDED TUBING



#### Bonded Polyethylene x Polyethylene

[.170" x .25", .170 x .25"]



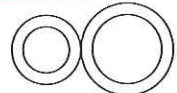
[.170" x .25", .25" x .375"]



[.25" x .375", .25" x .375"]

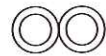


[.25" x .375", .375" x .50"]



#### Bonded FEP Lined Polyethylene x Polyethylene

[.170" x .25", .170 x .25"]



[.170" x .25", .25" x .375"]



[.25" x .375", .25" x .375"]

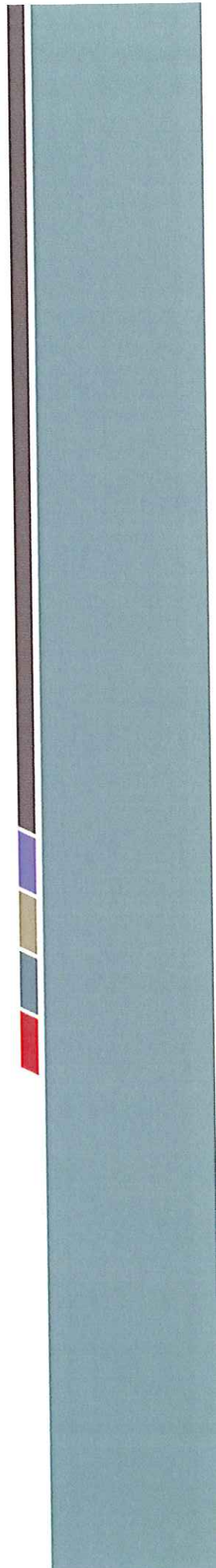


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# Appendix H

## Monitoring Well Specification





## 7-10 Groundwater Monitoring Well

(New Section)

### 7-10.1 Drilling

The appropriate safety precautions apply and shall be addressed in the CONTRACTOR'S Health and Safety Plan, Section 1-07.28. Health and safety training in compliance with 29CRF 1919.120 and Chapter 296-62-300 WAC is required of the CONTRACTOR for this job. In response to this bid, the CONTRACTOR acknowledges that he/she is familiar with conditions at the project site and has ascertained any Health and Safety Plan requirements of applicable laws and regulations pertinent to the specific project site conditions.

The CONTRACTOR shall be required to have a well driller licensed to drill and install monitoring wells in Washington State and a competent driller's assistant on-site during all drilling and well construction activities. The drilling CONTRACTOR shall have successfully completed a minimum of 10,000 linear feet using the same procedures described above. The CONTRACTOR shall provide a rig large enough and capable of reaching the desired depths. The driller's assistant may perform well development alone.

Prior to the commencement of field operations, the CONTRACTOR shall designate the representative who will be the only individual authorized to discuss performance of the work and related matters with the County. The CONTRACTOR shall procure all permits, licenses, and certificates that may be required by law for the execution of the work described in this document. The CONTRACTOR shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work described in this document.

The CONTRACTOR shall submit start cards to Ecology prior to mobilization as specified in Chapter 173-160-055 WAC, Well Construction Notification (Start Card). At the completion of the project, the CONTRACTOR shall be required to complete and submit to Ecology all necessary reports and forms relating to the completion of the each boring (Chapter 173-160-050 WAC, Records).

The CONTRACTOR shall be required to have at least two qualified persons on-site through the duration of drilling and well installation, and at least one qualified person on-site during well development. In addition, the CONTRACTOR shall:

1. Provide electric power at each drill site (if needed to complete the drilling and well installation).
2. Restore site to pre-drilling condition.
3. Provide water and sanitary facilities at each drill site.
4. Review and sign the County daily log of construction activities.

All work, materials, and construction shall conform to the requirements of Chapter 173-160 WAC, Minimum Standards for the Construction of Wells. In the event of a conflict between these specifications and Chapter 173-160 WAC, and in the absence of a variance from Chapter 173-160 WAC, Chapter 173-160 WAC shall govern.

The work will be performed using air rotary drilling methods. All the drilling locations are outside the limits of refuse. No refuse material will be encountered during well installation. The well will be completed with a protective steel casing, locking lid, and guard posts.

No bit lubrication other than filtered air and potable water shall be allowed. Compressed air shall be filtered to eliminate contamination of the air by oil from the compressor. The CONTRACTOR shall prevent contamination of soil or groundwater at the drilling site from hydrocarbons or other chemicals used by the CONTRACTOR on or around the drilling equipment. Drilling muds, foams, and petroleum- or soap-based products shall not be allowed. The use of petroleum-based joint compounds, which are normally used to prevent binding, shall not be allowed.

During air rotary drilling, drill cuttings from the cyclone will be collected at 5-foot intervals using a 5-gallon bucket.

The CONTRACTOR shall conduct all operations in such a way as to prevent any destruction, scarring, or defacing of the work site. Every effort shall be made to present an orderly appearance at the work site while drilling operations take place. At the completion of the field activities, the CONTRACTOR shall restore each drilling site to its pre-drilling condition.

In the event that any damages to the site property occur because of the CONTRACTOR'S activities, the CONTRACTOR shall, at his own expense, repair the damages or reclaim the land to the extent deemed suitable by the ENGINEER.

#### **7-10.2 Decontamination Procedures**

All large drilling equipment (rods, bits, drill rig, etc.) will be steam cleaned with a high-pressure washer prior to drilling the groundwater monitoring well. The area designated for steam cleaning activities will be located at least 50 feet south from the well or as designated by the ENGINEER.

#### **7-10.3 Borehole Logging**

Borehole logging shall be conducted by the ENGINEER for the purpose of this project and must also be done by the CONTRACTOR for fulfillment of state requirements. The CONTRACTOR shall endeavor to provide information on drilling conditions that will assist the ENGINEER in making determinations of subsurface material character.

#### **7-10.4 Alignment**

Alignment requirements during drilling are that any casing, liner, or drill tools can be run freely through the boring. At a minimum, the alignment shall conform to Chapter 173-160-215(4) WAC, Design and Construction—Well Completion—General (Alignment).

#### **7-10.5 Abandonment**

##### **7-10.5(1) New Wells Installation**

If the groundwater monitoring well does not meet the alignment or other requirements, or which is contaminated by the CONTRACTOR, or the well on which the CONTRACTOR stops work will be considered abandoned. Once a well installed by the CONTRACTOR has been designated as abandoned, the CONTRACTOR shall initiate installation of a new well in the immediate vicinity at a location designated by the ENGINEER. The CONTRACTOR may, at his own expense, remove any ungrouted casing. At a minimum, all borings and well shall be abandoned in accordance with Chapter 173-160-560 WAC, Abandonment of Resource Protection Wells.

#### **7-10.5(2) Existing Well Abandonment**

The existing groundwater monitoring well (MW-7) is 105 feet deep and screened between depths of 87.5 feet and 102.5 feet below ground surface. It is installed in a 6-inch diameter borehole and is constructed with 2-inch Schedule 40 PVC pipe with an 8-inch diameter steel monument at the surface.

No well log is available for existing gas probe (GP-6), but the probe has two ½ inch PVC completions within one borehole and an 8-inch diameter PVC monument at the surface. The borehole is approximately 6 to 8 inches in diameter

The well and probe shall be abandoned in accordance with Chapter 173-160-560 WAC, Abandonment of Resource Protection Wells.

The existing gas probe shall be decommissioned by withdrawing the casings and filling the borehole with neat cement grout, neat cement, bentonite, or bentonite slurry as the casing is being withdrawn or by overdrilling and filling the bore hole with neat cement grout, neat cement, bentonite, or bentonite slurry.

The existing monitoring well shall be decommissioned by filling the casing from bottom to land surface with bentonite, bentonite slurry, neat cement grout, or neat cement.

Existing steel casing and locks shall be stockpiled as directed by the Owner. The Owner shall remove existing fence.

#### **7-10.6 Well Installation**

All well casing pipes shall be PVC in accordance with Section 9-05.21(2), and as shown on the Plans. The top of the screen shall be set approximately 5 feet above the top of the groundwater table. Centralizers will be placed at several positions along the upper portion of the solid riser pipe, and above and below the screen.

The well casing will then be lowered into the boring and shall be suspended at the required depth for the remainder of the installation. The casing shall be pulled back a few inches prior to pack material installation to insure that the completion is not caught in the drill casing.

The design dimensions for the monitoring well completion is shown on the Plans. The monitoring well shall be constructed in accordance with Chapter 173-160 WAC, Minimum Standards for Construction and Maintenance of Wells. Specific construction procedures are described in the following sections.

The annular space between the borehole wall and well screen shall be filled with a 20 to 40 mesh silica sand filter pack to approximately 2 feet above the top of the screen. The depth to the top of the filter pack shall be probed using the tremie pipe, verifying the thickness of the sand pack. A 2-foot layer of finer silica sand (100 mesh) shall be placed on top of the sand pack material.

A five-foot seal of bentonite pellets shall be placed above the sand pack and hydrated by pouring clean potable water through a separate tremie pipe placed in the annular space of the well. The completed annular seal shall fully surround the permanent casing, be evenly distributed, free of voids, and extend from the permanent casing to undisturbed or recompacted soil.

The remaining annular space shall be filled to two feet below land surface in a continuous operation with Portland Type I cement/bentonite slurry with a tremie tube. Potable water shall be used to hydrate the mixture.

Well-site safeguards should include keeping all materials covered with plastic sheeting, off the ground, and ensuring that they are touched only with clean tools and gloves. Equipment or materials to be inserted into the bore hole must not be allowed to touch the ground.

#### **7-10.7 Completion**

The monitoring well shall be completed at the surface with an above grade locking steel stovepipe monument to protect the well casing. The steel monument shall be 6 feet in length, extend at least six inches above the top of the well casing, and be cemented at least two feet into the ground. Three protective posts at least three inches in diameter will be installed in a triangular array around the casing and at least two feet from it with at three feet above and below the land surface. The top of the well casing shall be fitted with an expandable-gasket lockable cap, and the well will be locked.

The monitoring well steel casing and the protective posts shall be painted with a highly visible paint as indicated on the Plans and in accordance with Section 9-05.21(2)C.

#### **7.10.8 Well Development**

The objective of monitoring well development shall be to remove sediment that may have accumulated in the well during well installation, to consolidate the filter pack around the well screen, and to enhance the hydraulic connection between the formation and the filter pack. Monitoring well development shall be performed after well installation but not sooner than 48 hours following placement of the grout seal. Prior to development, the water level and total depth of the well shall be measured. The monitoring well shall initially be surged with a surge block in five-foot intervals, beginning at the bottom of the well and working upward. After surging, the monitoring well shall be bailed of coarse sediment using a stainless steel bailer or similar type.

#### **7-10.9 Site Restoration**

At the conclusion of all work activity at a boring, all drilling work, extra casing, trash, disposal of materials used for decontamination, and other materials shall be removed from the site. No work shall begin on subsequent borings until the previous boring site has been cleaned up and approved by the ENGINEER. All boring and miscellaneous trash materials such as bentonite bags will be properly disposed of in the landfill as directed by the ENGINEER. These costs shall be included with unit price.

#### **7-10.10 Well Construction Records**

The CONTRACTOR shall keep a daily written log of operations, including size and length of the casing placed, character, depth and thickness of all formations penetrated, causes of delays, and screen locations. Duplicate copies of this log shall be furnished to the ENGINEER at the end of each work day.

#### **7-10.11 Waste Soil**

The investigation-derived waste soil will be disposed of on the ground surface.

#### **7-10.12 Measurement**

Measurement shall be as follows:

1. "Groundwater Monitoring Well," by the unit price per linear vertical foot. The well shall be measured by vertical measure over the length of the installed from existing grade to bottom of boring as shown on the Plans.
2. "Existing Well Abandonment," by the unit price per linear vertical foot. The well shall be measured by vertical measure over the length of the existing well depth from existing grade to bottom of boring.

#### **7-10.13 Payment**

Payment shall be as follows:

1. "Groundwater Monitoring Well," per vertical linear foot:

The unit price bid per vertical linear foot shall be full compensation for all labor, tools, equipment, and materials necessary to drill, furnish materials and install the wells, complete in place. Work will include but not limited to, drilling, installation of well casing and screened intervals and installation of all well backfill materials as described in the specifications and on the Plans.

Costs for mobilization to and from the well location including all costs for temporary access (e.g., crushed rock, wood timber supports, etc.), if required, are to be incidental with the unit price bid for this item.

Cost for all well materials (e.g., PVC pipe, bentonite, sand backfill, etc.) are to be included in the unit price bid for this item. No payment for materials used in well installation will be made under any other bid item.

In the event abandonment of an incomplete well is necessary due to unforeseen conditions and not the result of poor CONTRACTOR workmanship or materials, the cost of abandonment will be paid at the unit price bid for this item. Prior approval by the ENGINEER will be required.

2. "Existing Well Abandonment," per vertical linear foot.

The unit price bid per vertical linear foot shall be full compensation for all labor, tools, equipment, and materials necessary to abandon wells in place. Work will include but not limited to, removal of surface monument, casing removal or overdrilling, and installation of grout as described in the specifications.

Costs for mobilization to and from the well location including all costs for temporary access, if required, are to be incidental with the unit price bid for this item.

Cost for all well abandonment materials are to be included in the unit price bid for this item. No payment for materials used in well abandonment will be made under any other bid item.

**END OF DIVISION 7**

## DIVISION 9

### MATERIALS

#### 9-05 DRAINAGE STRUCTURES, CULVERTS, AND CONDUITS

##### 9-05.21 HDPE Pipe and Fittings (New Section)

##### 9-05.21(1) HDPE Material

High-density polyethylene pipe and fittings shall be made from polyethylene resin compound qualified as Type III, Category 5, Class C, Grade P34 in ASTM D1248. The HDPE pipe and fittings shall conform to Cell Classification 345464C or 355434C (ASTM D3350). Diameter shall be as shown on the Plans. This material shall have compressive yield strength of 1,600 psi when tested and analyzed by ASTM D695. This material shall have a Tensile Yield Strength of 3,200 psi when tested and analyzed by ASTM D638.

The polyethylene compound shall be suitably protected against degradation by ultraviolet light by means of carbon black, well dispersed by precompounding in a concentration of not less than 2 percent.

The manufacturer shall be listed with the Plastic Pipe Institute as meeting the recipe and mixing requirements of the resin manufacturer for the resin used to manufacture the pipe and fittings for this project.

The HDPE products shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specifications from the same raw material supplier.

The CONTRACTOR shall submit, at the preconstruction meeting, a description of the pipe to be used which includes materials specifications provided by the manufacturer. The CONTRACTOR shall supply the manufacturer's certificate of compliance in accordance with Section 1-06.3 of the Standard Specifications prior to installing any HDPE piping.

##### 9-05.21(1)A High Density Polyethylene (HDPE) Pipe

HDPE pipe meeting the requirements of this section shall be used for the landfill gas and condensate systems, and all other piping unless specified or otherwise shown on the Plans.

The same manufacturer shall supply polyethylene pipe and fittings. Pipe and fittings from different manufacturer's shall not be interchanged.

Pipe and fittings shall be of the nominal diameter shown on the Plans. All pipe sizes, either solid or perforated, shall conform to ASTM F 714.

The maximum allowable hoop stress shall be 1000 psi at 140 degrees F.

The polyethylene pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or their injurious defects. Any pipe with nicks, scrapes, or gouges deeper than 5 percent of the nominal wall thickness shall be rejected. The pipe shall be uniform in color, opacity, density, and other physical properties.

The pipe and fittings used for the landfill gas system, unless otherwise designated on the Plans, shall conform to the following:

1. All vertical gas well pipe shall (solid and slotted) shall have a minimum SDR 11. The slotted pipe sections shall be shop fabricated and supplied in nominal diameter as shown in the Plans. The slots shall be uniformly placed perpendicular to the axis of the pipe in straight rows. The slots shall be 0.25-inch wide, 1-inch long inside length and 2 3/4 inches long outside length, and shall be 1-inch apart on-center in four places equidistant around the pipe. Slotted pipe shall be free of cutting debris, and other physical properties.

The following information shall be continuously marked on the pipe or spaced at intervals not exceeding 5 feet:

1. Name and/or trademark of the pipe manufacturer
2. Nominal pipe size
3. Standard Dimensional Ratio (SDR)
4. PE 3408
5. Manufacturing Standard Reference
6. A production code from which the date and place of manufacture can be determined

Joints and pipe connections shall be thermal butt-fusion. No mechanical couplings shall be used unless shown on the Plans or approved by the ENGINEER.

#### **9-05.21(1)B HDPE Fittings**

Fittings shall be manufactured in accordance with ASTM D3261, and shall be manufactured by injection molding, a combination of extrusion and machining, or fabrication from HDPE pipe conforming to these specifications. Fittings shall be from the same manufacturer as the pipe and shall have the same or numerically smaller SDR than pipe connecting to the fitting. Fittings shall be molded, for sizes 6-inch and smaller.

All reducing tees shall be factory-molded if available as a standard item by any manufacturer having pipe and meeting these specifications. If not available as a standard item, branch saddle reducing tees shall be used. Reducers shall be shop-fabricated. Field fabricated branch saddle connections will not be allowed.

All molded fittings shall have the same or higher pressure rating as the pipe when installed in accordance with the latest technical specifications. All fabricated fittings shall have the same or higher pressure rating as the adjoining pipe when installed in accordance with the manufacturer's recommendations.

#### **9-05.21(1)C Pipe Connections**

Joints and pipe connections shall be thermal butt-fusion. No mechanical couplings shall be used unless shown on the Plans or approved by the ENGINEER.

**9-05.21(1)D Seal Material**

The bentonite seal shall be Volclay Chip medium, Enviroplug medium, CETCO medium bentonite chips, or approved equal. A high-solid content non-shrink cement slurry shall be used to seal the remaining annular space to the ground surface.

**9-05.21(2) Groundwater Monitoring Well Materials**

Groundwater monitoring well shall be constructed using new, commercially manufactured materials.

**9-05.21(2)A PVC Pipe**

The riser pipe and fittings shall be 2-inch Schedule 40 PVC pipe that is flushed threaded. A flush thread end plug shall be fitted to the bottom of the well. The well screens shall have 0.010-inch factory machine-cut horizontal slots and shall be spaced approximately 0.375 inches apart. All joints shall be flush threaded.

**9-05.21(2)B Seal Material**

All bentonite used for the well shall be certified by NSF/ANSI approval standards for use in potable water supply wells, or equivalent standards as approved by the department. The product shall be clearly labeled as meeting these standards. A high-solid content non-shrink cement slurry shall be used to seal the remaining annular space to the ground surface. The neat concrete shall be Class 3000, and shall consist of either Portland cement types I, II, III, or high-alumina cement mixed with not more than six gallons of potable water pre sack of cement (ninety-four pounds per sack).

Unhydrated bentonite--pelletized, granulated, powder, or chip bentonite may be used in the construction of seals or in decommissioning of wells. The bentonite material shall be specifically designed for sealing or decommissioning and be within the industry tolerances for dry western sodium bentonite. Placement of bentonite shall conform to the manufacturer's specifications and result in a seal free of voids or bridges.

**9-05.21(2)C Protective Casing**

The protective casing shall be a new Schedule 40 Grade B, seamless, rust-free, carbon steel pipe per ASTM A53 standard, and shall complete with a lockable steel cap and casing, which should be approved by the Engineer. The protective casing shall be painted with a high visible paint, in accordance with the manufacturer's recommendations, which matches the existing casing as the site or recommended by the Owner. The top of the well casing will be fitted with an expandable-gasket lockable cap, and the well will be locked.

**9-36 SOILS (NEW SECTION)**

**9-36.1 Gas Well Pack Material**

The pack material for the landfill gas wells shall be clean, 1 1/4"- or 1 1/2"-diameter round well-graded drain rock, or as approved by the Engineer.



**9.36.2 Groundwater Monitoring Well Pack Material**

The pack material for the groundwater monitoring well shall be clean, round drain rock, or as approved by the Engineer.

Artificial filter pack will be of 20-40 Colorado silica sand or equivalent. Finer grained sand (100 mesh Colorado silica sand) will be placed above the filter pack to prevent slurry infiltration.

**END OF DIVISION 9**

