STATE OF WASHINGTON
PIERCE COUNTY SUPERIOR COURT

STATE OF WASHINGTON, DEPARTMENT OF ECOLOGY, Plaintiff, v. MURRAY PACIFIC CORPORATION, LOUISIANA PACIFIC CORPORATION, and WASSER & WINTERS INC., Defendants.	NO. CONSENT DECREE WITH MURRAY PACIFIC CORPORATION

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I. INTRODUCTION

A. In entering into this Consent Decree (Decree), the mutual objective of the State of Washington, Department of Ecology (Ecology) and of Murray Pacific Corporation (“Murray Pacific” or “MPC”) is to provide for remedial action at a location where there has been a release of hazardous substances. This Decree requires Murray Pacific to undertake portions of the remedial action specified in the Cleanup Action Plan attached as Exhibit A to this Decree, and to provide funding to be utilized by Ecology in implementing the other portions of the Cleanup Action Plan. Ecology has determined that the actions described in the Cleanup Action Plan are necessary to protect human health and the environment.

B. Ecology and the Defendants have also entered into a settlement agreement with ASARCO LLC, one of the debtors in the U.S. Bankruptcy Court matter styled, In re ASARCO LLC et al., Bankr. S.D. Texas, Case No. 05-21207 (the “Bankruptcy Settlement Agreement”). Under the Bankruptcy Settlement Agreement, the Debtors have agreed that Murray Pacific will have an allowed general unsecured claim in the amount of 20 million dollars in exchange for certain covenants not to sue, and other consideration from Defendants and Ecology as more fully described in the Bankruptcy Settlement Agreement.

C. In entering into this Decree, the parties are addressing and responding to the unique facts presented by the ASARCO bankruptcy proceedings and the history of litigation and similar difficulties that have surrounded this Site for almost 20 years. Because of this unique history, this Consent Decree contains some deviations from other MTCA Consent Decrees that are only appropriate under these unique conditions.

D. The Complaint in this action is being filed simultaneously with this Decree. An Answer has not been filed, and there has not been a trial on any issue of fact or law in this case. However, the Parties wish to resolve the issues raised by Ecology's Complaint. In addition, the Parties agree that settlement of these matters without litigation is reasonable and in the public interest and that entry of this Decree is the most appropriate means of resolving these matters.

E. By signing this Decree, the Parties agree to its entry and agree to be bound by its terms.

F. By entering into this Decree, the Parties do not intend to discharge non-settling parties from any liability they may have with respect to matters alleged in the Complaint other than as provided in the Bankruptcy Settlement Agreement. The Parties retain the right to seek reimbursement, in whole or in part, from any liable persons other than the Debtors for sums expended under this Decree.

G. This Decree shall not be construed as proof of liability or responsibility for any releases of hazardous substances or cost for remedial action nor an admission of any facts; provided, however, MPC shall not challenge the authority of the Attorney General and Ecology to enforce this Decree.

The Court is fully advised of the reasons for entry of this Decree, and good cause having been shown: Now, therefore, it is HEREBY ORDERED, ADJUDGED, AND DECREED as follows:

II. JURISDICTION

A. This Court has jurisdiction over the subject matter and over the Parties pursuant to the Model Toxics Control Act (MTCA), Chapter 70.105D RCW. Authority is conferred upon the Washington State Attorney General by RCW 70.105D.040(4)(a) to agree to a settlement with any potentially liable person (PLP) if, after public notice and any required hearing, Ecology finds the proposed settlement would lead to a more expeditious cleanup of hazardous substances. RCW 70.105D.040(4)(b) requires that such a settlement be entered as a consent decree issued by a court of competent jurisdiction.

B. Ecology has determined that a release or threatened release of hazardous substances has occurred at the Site that is the subject of this Decree.

C. Ecology has given notice to Defendants, as set forth in RCW 70.105D.020(15), of Ecology's determination that each Defendant is a PLP for the Site and that there has been a release or threatened release of hazardous substances at the Site.

D. The actions to be taken pursuant to this Decree are necessary to protect public health and the environment.

E. This Decree has been subject to public notice and comment.

F. Ecology finds that this Decree will lead to a more expeditious cleanup of hazardous substances at the Site in compliance with the cleanup standards established under RCW 70.105D.030(2)(e) and Chapter 173-340 WAC.

G. Defendant Murray Pacific has agreed to undertake the actions specified in this Decree, and to provide the funding required by this Decree, and consents to the entry of this Decree under MTCA.

III. PARTIES BOUND

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

IV. DEFINITIONS

Unless otherwise specified herein, all definitions in RCW 70.105D.020 and WAC 173-340-200 shall control the meanings of the terms used in this Decree.

A. Landfill: The Landfill, as more fully described in the Cleanup Action Plan, consists of an area of approximately 13 acres where landfilled wood waste is present and capped. The Landfill is located on the B&L Property, comprising approximately 18.5 acres in unincorporated Pierce County, Washington.

B. B&L Property: The B&L Property includes the parcels on which the Landfill is located. It is owned by entities who are not parties to this Decree, but who operated and permitted the Landfill.

C. Site: The Site, as more fully described in the Cleanup Action Plan, includes both the Landfill and adjacent areas (B&L Property, wetlands, ditches, etc.) where contamination from the Landfill has come to be located. The Site is part of the Commencement Bay Nearshore/Tideflats Superfund site, which was added in 1983 by the United States Environmental Protection Agency ("EPA") to the National Priorities List established under the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"), 42 U.S.C. § 9601 et seq. The Site constitutes a "facility" under RCW 70.105D.020(4).

D. Parties: Refers to the State of Washington, Department of Ecology, and Murray Pacific Corporation, collectively.

E. Defendants: Refers to Murray Pacific Corporation, Louisiana Pacific Corporation, and Wasser & Winters, Inc.

F. Consent Decree or Decree: Refers to this Decree and each of the exhibits to this Decree. All exhibits are integral and enforceable parts of this Decree. The terms “Consent Decree” or “Decree” shall include all exhibits to this Decree.

G. Day or Days: Refers to a calendar day(s) unless otherwise specified. In computing any period of time under this Decree, if the last day falls on a Saturday, Sunday, or a state or federal holiday, the period shall run until the end of the next day which is not a Saturday, Sunday, or a state or federal holiday. Any time period scheduled to begin on the occurrence of an act or event shall begin on the day after the act or event.

H. Section: Refers to a portion of this Decree identified by a Roman numeral.

I. Debtors: Refers to the several debtors in the bankruptcy case styled *In re ASARCO LLC et al.*, Bankr. S.D. Texas., Case No. 05-21207 including ASARCO LLC (ASARCO). The Debtors are not Parties to this Consent Decree.

V. STATEMENT OF FACTS

Ecology makes the following findings of fact without any express or implied admissions of such facts by Defendants.

A. The Landfill was used for the disposal of wood waste materials, some of which included slag from smelting operations of ASARCO that had been made available to other parties with a representation that the slag was inert and non-toxic. Each of the Defendants arranged for the disposal at the Landfill of wood waste materials containing such ASARCO-generated slag.

B. In 1988, Ecology notified ASARCO, Murray Pacific, Louisiana Pacific Corporation, Wasser & Winters Inc., and others that they were PLPs in regard to the Site.

C. In January 1989, Murray Pacific entered into a consent decree with Ecology to undertake a Remedial Investigation and Feasibility Study for the Site. That consent decree was entered by the Court on February 27, 1989, in an action in this Court styled State of *Washington Department of Ecology v. Murray Pacific Corporation*, No. 89-2-00319-3. Murray Pacific timely and fully completed the work required by that decree.

D. The Remedial Investigation indicated that a number of hazardous substances had been released at the Site, including antimony, arsenic, chromium, copper, lead, nickel, zinc, benzoic acid, and phenol. The respective liabilities of ASARCO, Murray Pacific, Louisiana Pacific, Wasser & Winters, Inc. and other parties for the remediation of the Site was the subject of extensive prior litigation, as part of an action styled *Louisiana-Pacific Corp. et al v. Asarco*, No. C-5259RJB (the "Federal Action"), filed in the United States District Court for the Western District of Washington. Ecology was not a party to that action. Relevant claims of the parties relating to the Site were tried to a jury and to the court, and a judgment was entered. ASARCO appealed from the judgments, and the Ninth Circuit's final opinion was entered on August 30, 1994. 24 F.3d 1565. On January 9, 1995, the Supreme Court denied certiorari.

E. On June 17, 1992, after it was determined in the Federal Action that ASARCO had the majority of the liability for the Site, Ecology issued Enforcement Order No. 92TC-S214 (the Enforcement Order) to ASARCO and Murray Pacific (and to the owner and operator of the Landfill) requiring them to implement a 1991 Final Cleanup Action Plan (1991 FCAP) for the B&L Site. The 1991 FCAP provided for, among other things, the consolidation of materials within the B&L Site, and the construction of a specified cover system over the consolidated materials. ASARCO and Murray Pacific implemented the remedy specified in the 1991 FCAP.

F. Sampling conducted following completion of construction of the remedy set forth in the 1991 FCAP has shown that a plume of contaminated groundwater is emanating from the Landfill, and that a wetland adjacent to the Landfill appears to have been impacted by arsenic and possibly other constituents from the Landfill. On February 25, 2005, Ecology issued an Order to ASARCO and Murray Pacific (and one other party) constituting a Second Amendment to the Enforcement Order No. DE 92TC-S214 (the “Second Amendment”). The Second Amendment required the respondents to implement a “Contingency Plan for the B&L Landfill,” (i) to investigate groundwater contamination in the vicinity of the Landfill and to take appropriate corrective action, and (ii) to study, design and implement measures to remediate the adjacent wetland.

G. On August 5, 2005, ASARCO filed with the United States Bankruptcy Court for the Southern District of Texas voluntary petitions for relief under the United States Bankruptcy Code (the “Bankruptcy Cases”).

H. Following the filing of the Bankruptcy Cases, Murray Pacific undertook and funded the activities required by the Second Amendment, and submitted to Ecology in January 2007 a Draft Groundwater Alternatives Evaluation analyzing potential remedial options.

I. In June 2007, Ecology issued a Draft Cleanup Action Plan (the “draft 2007 CAP”) to address the migration of hazardous substances from the Landfill. The draft 2007 CAP was subject to public notice and comment. A public meeting to present the remedy outlined in the draft 2007 CAP and address public concerns was held on July 18, 2007. Subsequent to the public hearing, the draft 2007 CAP was revised by Ecology to address comments and has been finalized as the 2008 Final Cleanup Action Plan (2008 FCAP). The 2008 FCAP is Exhibit A to this Decree.

J. The Remedial Action selected in the 2008 FCAP includes construction of a containment system around the Landfill, cleanup of groundwater, long-term operation of a groundwater recovery and treatment system, and long-term post-closure operations, maintenance, and monitoring.

K. Consistent with the Bankruptcy Settlement Agreement (see Section I (Introduction)), Murray Pacific has agreed to implement certain elements of the Remedial Action defined in the 2008 FCAP. These elements are described in Section VI (Work to be

Performed) of this Decree. Ecology will be responsible for the portions of the Remedial Action defined in the 2008 FCAP that are not included in Section VI (Work to be Performed) of this Decree.

VI. WORK TO BE PERFORMED

This Decree contains a program designed to protect human health and the environment from the known release, or threatened release, of hazardous substances or contaminants at, on, or from the Site. The responsibility to perform the work described in this section shall be solely that of Murray Pacific. Louisiana Pacific and Wasser & Winters, Inc. shall have no responsibility in this regard.

A. The work to be performed by Murray Pacific is the completion of the work generally described in the 2008 FCAP, and specifically described in the Scope of Work and Schedule. The 2008 FCAP is attached as Exhibit A. The Scope of Work defining the Initial Construction is described in Exhibit B, Scope of Work and Schedule.

B. Murray Pacific shall furnish all personnel, materials and services necessary for, or incidental to, the planning, initiation, completion, and reporting of the work described in Exhibit B, Scope of Work and Schedule.

C. The Initial Construction Phase of the 2008 FCAP and each element thereof are designed and shall be implemented and completed in accordance with MTCA (Chapter 70.105D RCW) and its implementing regulations (Chapter 173-340 WAC) as amended, and all applicable federal, state, and local laws and regulations.

D. As provided in the agreed upon schedule, contained within Exhibit B to this Decree, Murray Pacific shall commence work and thereafter complete all tasks set forth in Exhibit B in the time frames and framework indicated unless Ecology grants an extension in accordance with Section XV (Extension of Schedule) of this Decree.

E. Murray Pacific agrees not to perform any remedial actions at the Site that are outside the scope of this Decree unless the Parties agree to amend the Initial Construction

Phase to cover these actions. All work conducted by Murray Pacific under this Decree shall be done in accordance with Chapter 173-340 WAC unless otherwise provided herein.

F. Because the Site includes a landfill, a deed restriction will need to be placed on the property on which the Landfill is located, and additional deed restriction(s) may be required for at least portions of adjacent properties. Ecology and Murray Pacific acknowledge that Murray Pacific does not own any of the properties that compose the Site. Murray Pacific shall use reasonable efforts, short of litigation, in placing the deed restrictions, and Ecology agrees that these efforts shall be included in MPC Implementation Costs.

VII. DESIGNATED PROJECT COORDINATORS

The project coordinator for Ecology is:

Dom Reale, P.E.
Department of Ecology
Southwest Regional Office
300 Desmond Drive
Lacey, WA 98503
(360) 407-6266

The project coordinator for the Defendant Murray Pacific is:

Teri A. Floyd, Ph.D.
Floyd Snider Inc.
Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101-2341
(206) 292-2078 ext. 2165

Each project coordinator shall be responsible for overseeing the implementation of this Decree. Ecology's project coordinator will be Ecology's designated representative for the Site. To the maximum extent possible, communications between Ecology and Defendant Murray Pacific and all documents, including reports, approvals, and other correspondence concerning the activities performed pursuant to the terms and conditions of this Decree, 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 required by this Decree. The project coordinators may agree to minor modifications to the Work to be

Performed without formal amendments to this Decree. Minor modifications will be documented in writing by Ecology. Substantial changes shall require amendment of this Decree.

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.

VIII. PERFORMANCE

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

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

C. All construction work performed pursuant to this Decree 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 in the State of Washington, except as otherwise provided for by RCW 18.43.130.

D. Any documents submitted containing geologic, hydrologic or engineering work shall be under the seal of an appropriately licensed professional as required by Chapter 18.220 RCW or RCW 18.43.130.

E. Defendant Murray Pacific 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 Decree, in advance of their involvement at the Site.

IX. ACCESS

Ecology or any Ecology authorized representative shall have full authority to enter and freely move about all property at the Site that Defendant Murray Pacific 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 Decree; reviewing Defendant's progress in carrying out the terms of this Decree; 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 Decree; and verifying the data submitted to Ecology by Defendant. Ecology and Murray Pacific acknowledge that Murray Pacific does not own any of the properties that compose the Site. Murray Pacific shall make all reasonable efforts, short of litigation, to secure access rights to the Site, and Ecology agrees that these efforts shall be included in MPC Implementation Costs. Ecology or any Ecology authorized representative shall give reasonable notice, at least two (2) days, if feasible, before entering any Site property controlled by Defendant Murray Pacific unless an emergency prevents such notice. All Parties 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 by Defendant Murray Pacific to sign any liability release or waiver as a condition of Site property access.

X. SAMPLING, DATA SUBMITTAL, AND AVAILABILITY

With respect to the implementation of this Decree, Murray Pacific 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 XI (Progress Reports), 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, Murray Pacific shall allow Ecology and/or its authorized representative to take split or duplicate samples of any samples collected by Murray Pacific pursuant to the implementation of this Decree. Murray Pacific shall notify Ecology seven (7) days in advance of any sample collection or work activity at the Site. Ecology shall, upon request, allow Murray Pacific and/or its authorized representative to take split or duplicate samples of any samples collected by Ecology pursuant to the implementation of this Decree, provided that doing so does not interfere with Ecology's sampling. Without limitation on Ecology's rights under Section IX (Access), Ecology shall notify Murray Pacific 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 Chapter 173-50 WAC for the specific analyses to be conducted, unless otherwise approved by Ecology.

XI. PROGRESS REPORTS

Murray Pacific shall submit to Ecology written Progress Reports as provided in the Scope of Work, Exhibit B of this Decree. Depending on the activities being performed, these progress reports may be required at different frequencies (e.g., weekly, monthly, quarterly) as described in the Scope of Work, and subsequent Work Plans developed to support the Work to be Performed by Murray Pacific as part of this Decree, that describe the actions taken during the previous period to implement the requirements of this Decree. The Progress Reports shall include the following:

A. A list of on-site activities that have taken place during the preceding reporting period;

B. Detailed description of any deviations from required tasks not otherwise documented in project plans or amendment requests;

C. Description of all deviations from the Scope of Work and Schedule (Exhibit B) during the preceding reporting period and any planned deviations in the upcoming reporting period;

D. For any deviations in schedule, a plan for recovering lost time and maintaining compliance with the schedule unless an extension of the schedule is approved by Ecology in accordance with Section XV (Extension of Schedule);

E. All raw data (including laboratory analyses) received by Defendant Murray Pacific during the past reporting period and an identification of the source of the sample; and

F. A list of deliverables for the upcoming reporting period if different from the schedule.

G. All Progress Reports shall be submitted by the tenth (10th) day of the month in which they are due after the effective date of this Decree. Unless otherwise specified, Progress Reports and any other documents submitted pursuant to this Decree shall be sent by certified mail, return receipt requested, to Ecology's project coordinator. At the discretion of the Project Coordinators, progress meetings may be substituted for written progress reports.

XII. RETENTION OF RECORDS

During the pendency of this Decree, and for ten (10) years from the date when the Construction Closeout Report is submitted to Ecology and Ecology assumes full responsibility for the Site as provided in Section XXV (Effect and Duration of Decree), Murray Pacific shall preserve all records, reports, documents, and underlying data in its possession relevant to the implementation of this Decree and shall insert a similar record retention requirement into all contracts with project contractors and subcontractors. Upon request of Ecology, Murray Pacific shall make all records available to Ecology and allow access for review within a reasonable time. Nothing in this Decree is intended to waive any right Murray Pacific may have under applicable law to limit disclosure of records protected by the attorney work-product doctrine, the attorney-client privilege, or any other privilege recognized under Washington law. If Murray Pacific withholds any requested records based on an assertion of privilege, it shall provide Ecology with a privilege log specifying the records withheld and the applicable privilege. No data collected on Site, or required pursuant to the Scope of Work and Schedule shall be considered privileged.

As described in Section XXV (Effect and Duration of Decree) and Exhibit C to this Decree, Murray Pacific will provide Ecology with an Administrative File/Record containing documents pertaining to the Site that Murray Pacific has gathered from Ecology, Pierce County Health Department, Murray Pacific, Floyd Snider, and other public sources. These documents will be provided in electronic format (e.g., CD-ROMs or DVD-ROMs) at the time this Decree is filed in court. The Administrative File is intended to provide the historical, technical and legal support for the Decree and to embody the facts known to the Parties at the time the Decree is entered. The Administrative Record will be comprised of documents selected from the Administrative File, and will be updated throughout the duration of this Decree as additional documents are created by and/or made available to Murray Pacific and its contractors. The information referred to in the first paragraph of this section will be added to the Administrative Record as it becomes available. At the completion of this project, the complete Administrative Record will be transferred to Ecology in electronic format. Details regarding the electronic format of the Administrative File/Record will be determined by the Project Coordinators. Ecology agrees that creating and maintaining the Administrative File/Database shall be included in MPC Implementation Costs.

XIII. RESOLUTION OF DISPUTES

A. In the event a dispute arises as to an approval, disapproval, proposed change, or other decision or action by Ecology's project coordinator, or an itemized billing statement under Section XXI (Remedial Action Costs), the Parties shall utilize the dispute resolution procedure set forth below.

1. Upon receipt of Ecology's project coordinator's written decision, or the itemized billing statement, Defendant Murray Pacific has fourteen (14) days within which to notify Ecology's project coordinator in writing of its objection to the decision or itemized statement.

2. The Parties' project coordinators shall then confer in an effort to resolve the dispute. If the project coordinators cannot resolve the dispute within fourteen (14) days, Ecology's project coordinator shall issue a written decision.

3. Defendant Murray Pacific may then request regional management review of the decision. This request shall be submitted in writing to the Southwest Region Toxics Cleanup Program Section Manager within seven (7) days of receipt of Ecology's project coordinator's written decision.

4. Ecology's Regional Section Manager shall conduct a review of the dispute and shall endeavor to issue a written decision regarding the dispute within thirty (30) days of Defendant's request for review.

5. If Defendant Murray Pacific finds Ecology's Regional Section Manager's decision unacceptable, Defendant may then request final management review of the decision. This request shall be submitted in writing to the Toxics Cleanup Program Manager within seven (7) days of receipt of the Regional Section Manager's decision.

6. Ecology's Toxics Cleanup Program Manager shall conduct a review of the dispute and shall endeavor to issue a written decision regarding the dispute within thirty (30) days of Defendant's request for review of the Regional Section Manager's decision. The Toxics Cleanup Program Manager's decision shall be Ecology's final decision on the disputed matter.

B. If Ecology's final written decision is unacceptable to Defendant Murray Pacific, Defendant has the right to submit the dispute to the Court for resolution. The Parties agree that one judge should retain jurisdiction over this case and shall, as necessary, resolve any dispute arising under this Decree. In the event Defendant presents an issue to the Court for review, the Court shall review any investigative or remedial action or decision of Ecology on the basis of whether such action or decision was arbitrary and capricious and render a decision based on such standard of review.

C. 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.

Where either Party utilizes the dispute resolution process in bad faith or for purposes of delay, the other Party may seek sanctions.

D. Implementation of these dispute resolution procedures shall not provide a basis for delay of any activities required in this Decree, unless Ecology agrees in writing to a schedule extension or the Court so orders.

XIV. AMENDMENT OF DECREE

Except for minor modifications agreed to pursuant to Section VII (Designated Project Coordinators) and extensions that do not constitute a substantial change granted in accordance with Section XV (Extension of Schedule), this Decree may only be amended by a written stipulation among the Parties to this Decree that is entered by the Court or by order of the Court. All amendments shall become effective upon entry by the Court. Agreement to amend shall not be unreasonably withheld by any Party to the Decree.

Any Party may propose an amendment to the Decree. A Party that receives a request for amendment shall indicate its approval or disapproval in a timely manner after the request for amendment is received. If the amendment to the Decree is substantial, Ecology will provide public notice and opportunity for comment. Reasons for the disapproval shall be stated in writing. If any Party does not agree to any proposed amendment, the disagreement may be addressed through the dispute resolution procedures described in Section XIII (Resolution of Disputes) of this Decree.

XV. EXTENSION OF SCHEDULE

A. 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:

1. The deadline that is sought to be extended;
2. The length of the extension sought;

3. The reason(s) for the extension; and

4. Any related deadline or schedule that would be affected if the extension were granted.

B. The burden shall be on Defendant Murray Pacific 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:

1. Circumstances beyond the reasonable control and despite the due diligence of Defendant Murray Pacific 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 Defendant Murray Pacific or delays in obtaining access, after making reasonable efforts short of litigation to obtain access, to properties required to perform the Work required by this Decree; or

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

3. Endangerment as described in Section XVI (Endangerment); or

4. Other circumstances agreed to by Ecology to be exceptional or extraordinary.

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

C. Ecology shall act upon any written request for extension in a timely fashion. Ecology shall give Defendant Murray Pacific written notification of any extensions granted pursuant to this Decree. A requested extension shall not be effective until approved by Ecology or, if required, by the Court. Unless the extension is a substantial change, it shall not be necessary to amend this Decree pursuant to Section XIV (Amendment of Decree) when a schedule extension is granted.

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

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

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

3. Endangerment as described in Section XVI (Endangerment).

XVI. ENDANGERMENT

In the event Ecology determines that any activity being performed at the Site is creating or has the potential to create a danger to human health or the environment, Ecology may direct Murray Pacific to cease such activities for such period of time as needed to abate the danger. Murray Pacific shall immediately comply with such direction.

In the event Murray Pacific determines that any activity being performed for the Site pursuant to this Decree is creating or has the potential to create a danger to human health or the environment, Murray Pacific may cease such activities. Murray Pacific 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, Murray Pacific shall provide Ecology with documentation of the basis for the determination or cessation of such activities. If Ecology disagrees with Murray Pacific's cessation of activities, it may direct Murray Pacific to resume such activities.

If Ecology concurs with or orders a work stoppage pursuant to this Section, Murray Pacific'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 XV (Extension of Schedule), for such period of time as Ecology determines is reasonable under the circumstances.

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

XVII. COVENANT NOT TO SUE

A. Covenant Not to Sue: In consideration of Defendant Murray Pacific's compliance with the terms and conditions of this Decree, Ecology covenants not to institute legal or administrative actions against Murray Pacific regarding the release or threatened release of hazardous substances covered by this Decree at the Site.

This Decree covers only the Site. This Decree does not cover any other hazardous substance or area. Ecology retains all of its authority relative to any substance or area not covered by this Decree.

This Covenant Not to Sue shall have no applicability whatsoever to:

1. Criminal liability;

2. Any Ecology action, including cost recovery, against PLPs not a party to this Decree.

If factors not known at the time of entry of the settlement agreement are discovered and present a previously unknown threat to human health or the environment, the Court shall amend this Covenant Not to Sue pursuant to paragraph B below.

B. Reopeners: Ecology specifically reserves the right to institute legal or administrative action against Defendant Murray Pacific to require it to perform additional remedial actions at the Site and to pursue appropriate cost recovery, pursuant to RCW 70.105D.050 under the following circumstances:

1. Upon Murray Pacific's failure without good cause to perform the work required by this Decree;

2. Upon the availability of new information regarding factors previously unknown to Ecology. Ecology shall make such a determination and issue such notice to Defendant Murray Pacific only if it determines that the previously unknown threat arises from substances sent to the Site by Defendant Murray Pacific. For purposes of this Decree, "factors previously unknown to Ecology," shall mean contamination unknown or undocumented in the B&L Woodwaste Site Administrative File (the outline of which is Exhibit C to this Decree) or in the List of Covered Substances (Exhibit D to this Decree) at the time of entry of this Decree. "Factors previously unknown to Ecology" shall not include any new information related to the presence of, extent of, or impacts from or related to Covered Substances at the Site. "Previously unknown threats to human health or the environment" shall not include: (i) any threat to any beneficial uses of water (including the use of water for agricultural or drinking water purposes) from or related to Covered Substances in or around the Site; (ii) any impediment to development or use of property in or around the Site; (iii) any increase of remedial action costs beyond levels projected by any of the Parties at the time of the entry of this Consent Decree; or (iv) any failure of the remedy set forth in the 2008 FCAP to achieve applicable remedial objectives or other goals. "Covered Substances" shall include those substances listed on Exhibit D. Ecology is specifically aware that wood waste is present at the Site, and does not pose a threat to human health or the environment. Ecology shall not require Murray Pacific to perform investigative or remedial actions for wood waste.

C. Except in the case of an emergency, prior to instituting legal or administrative action against Murray Pacific pursuant to paragraph B above, Ecology shall provide Murray Pacific with fifteen (15) calendar days notice of such action.

XVIII. CONTRIBUTION PROTECTION

With regard to claims against Defendant Murray Pacific for Matters Addressed in this Decree, the Parties agree that Defendant Murray Pacific is entitled to protection against claims for contribution for matters addressed in this Decree as provided by RCW 70.105D.040(4)(d).

The Parties also intend that this Decree has resolved Murray Pacific's liability as defined in CERCLA §113(f)(2). For the purpose of this section, "Matters Addressed" includes all investigative, remedial actions, and other response actions at the Site. "Matters Addressed" also includes all investigative and remedial actions previously undertaken at the Site to characterize the contamination or to enable the selection of a remedial action, and all oversight costs paid to Ecology.

XIX. INDEMNIFICATION

Defendant Murray Pacific 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 for death or injuries to persons or for loss or damage to property to the extent arising from or on account of acts or omissions of Defendant Murray Pacific, its officers, employees, agents, or contractors in entering into and implementing this Decree. However, Defendant Murray Pacific 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 either the State of Washington's or any of its agencies' status as potentially liable persons with respect to contamination at the Site or the intentional, reckless, or negligent acts or omissions of the State of Washington, or the employees or agents of the State, in entering into or implementing this Decree.

XX. COMPLIANCE WITH APPLICABLE LAWS

A. All actions carried out by Defendant Murray Pacific pursuant to this Decree shall be done in accordance with all applicable federal, state, and local requirements, including requirements to obtain necessary permits, except as provided in RCW 70.105D.090. The permits or other federal, state or local requirements that the agency has determined are applicable and that are known at the time of entry of this Decree have been identified in the 2008 FCAP (Exhibit A).

B. Pursuant to RCW 70.105D.090(1), Defendant Murray Pacific is exempt from the procedural requirements of Chapters 70.94, 70.95, 70.105, 77.55, 90.48, and 90.58 RCW and of any laws requiring or authorizing local government permits or approvals. However, Defendant Murray Pacific shall comply with the substantive requirements of such permits or approvals. The exempt permits or approvals and the applicable substantive requirements of those permits or approvals, as they are known at the time of entry of this Decree, have been identified in the 2008 FCAP (Exhibit A).

Defendant Murray Pacific 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 Decree. In the event either Ecology or Defendant Murray Pacific determines that additional permits or approvals addressed in RCW 70.105D.090(1) would otherwise be required for the remedial action under this Decree, it shall promptly notify the other party of this determination. Ecology shall determine whether Ecology or Defendant Murray Pacific shall be responsible to contact the appropriate state and/or local agencies. If Ecology so requires, Defendant Murray Pacific 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 Defendant Murray Pacific and on how Defendant Murray Pacific must meet those requirements. Ecology shall inform Defendant Murray Pacific in writing of these requirements. Once established by Ecology, the additional requirements shall be enforceable requirements of this Decree. Defendant Murray Pacific shall not begin or continue the remedial action potentially subject to the additional requirements until Ecology makes its final determination.

C. 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 Defendant Murray Pacific 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.

XXI. REMEDIAL ACTION COSTS

Defendant Murray Pacific shall pay to Ecology the remedial action costs incurred by Ecology for the Site pursuant to this Decree and consistent with WAC 173-340-550, provided such costs shall be considered MPC Implementation Costs. These costs shall include work performed by Ecology or its contractors for, or on, the Site under Chapter 70.105D RCW, including remedial actions and Decree preparation, negotiation, oversight, and administration. These costs shall include work performed both prior to and subsequent to the entry of this Decree. Ecology's costs shall include costs of direct activities and support costs of direct activities as defined in WAC 173-340-550(2). Defendant Murray Pacific agrees to pay the required amount within ninety (90) 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 with the statement of costs. 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 will result in interest charges at the rate of twelve percent (12%) per annum, compounded monthly.

XXII. PAYMENTS TO THE STATE & ELECTION TO CREATE TRUST

Within 30 days after the State has provided notice to Murray Pacific that the Initial Construction Phase of the Work has been satisfactorily completed, Murray Pacific shall pay the State the sum of $21 million dollars less the MPC Implementation Costs. Payment shall be made payable to the "Washington State Department of Ecology," and payment shall be sent via Federal Express to:

Department of Ecology
ATTN: Gary Zeiler, Fiscal Manager
300 Desmond Drive S.E.
Lacey, WA 98503-1274

The term "MPC Implementation Costs" means the total of all costs reasonably and necessarily incurred by Murray Pacific to implement the Initial Construction Phase of work as required by this Decree. It shall include without limitation: (i) any amounts paid by Murray Pacific to professional advisers or other consultants, third party vendors, suppliers, laboratories, engineers, equipment lessors or other providers of goods and/or services; (ii) any amounts paid by Murray Pacific to obtain access at or near the Site; (iii) any amounts paid by Murray Pacific to obtain insurance with respect to the work required under this Decree; (iv) any taxes paid by Murray Pacific with respect to the work required under this Decree; (v) any amounts reimbursed by Murray Pacific pursuant to Section XXI (Remedial Action Costs) of this Decree; and (vi) permit or license fees paid by Murray Pacific with respect to the work required under this Decree.

Murray Pacific shall provide to Ecology on a semi-annual basis a summary of the MPC Implementation Costs incurred during the prior six month period together with reasonable supporting documentation and an estimate of what amounts will be spent during the following six month period. If Ecology objects to the inclusion of any amount as MPC Implementation Costs, it shall notify Murray Pacific within forty-five (45) days of the receipt of the semi-annual report, and the dispute resolution procedure of Section XIII (Resolution of Disputes) shall be utilized.

Murray Pacific may elect to satisfy certain of its obligations under this Decree by establishing and funding a trust pursuant to the terms and conditions set forth in Exhibit G.

XXIII. IMPLEMENTATION OF REMEDIAL ACTION

If Ecology determines that Defendant Murray Pacific has failed without good cause to do the work required by this Decree, Ecology may, after written notice to Defendant Murray

Pacific and a reasonable opportunity for Murray Pacific to cure the failure, perform any or all portions of the work required by this Decree that remain incomplete. If Ecology performs all or portions of the work required by this Decree because of Defendant’s failure to comply with its obligations under this Decree, Murray Pacific shall pay the State, within fifteen (15) days after the State notifies Murray Pacific of its decision to take over the work, the sum required from Murray Pacific by Section XXII (Payments to the State & Election to Create Trust) less all MPC Implementation Costs incurred through the date such notice is received by Murray Pacific, provided that Murray Pacific is not obligated under this Section to reimburse Ecology for costs incurred for work inconsistent with or beyond the scope of this Decree.

Except where necessary to abate an emergency situation, Murray Pacific shall not perform any remedial actions at the Site outside those remedial actions required by this Decree, unless Ecology concurs, in writing, with such additional remedial actions pursuant to Section XIV (Amendment of Decree).

XXIV. PUBLIC PARTICIPATION

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

A. If agreed to by Ecology, develop appropriate mailing list, prepare drafts of public notices and fact sheets at important stages of the remedial action, such as the submission of work plans, remedial investigation/feasibility study 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.

B. Notify Ecology’s project coordinator prior to the preparation of all press releases and fact sheets, and before major meetings with the interested public and local governments. Likewise, Ecology shall also provide Defendant Murray Pacific with an opportunity to review and comment on all press releases, fact sheets, and other materials that will be distributed to the public and local governments prior to issuance. For all press releases, fact sheets, meetings, and other outreach efforts by Defendant Murray Pacific that do not receive prior Ecology approval, Defendant Murray Pacific shall clearly indicate to its audience that the press release, fact sheet, meeting, or other outreach effort was not sponsored or endorsed by Ecology.

C. 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.

D. When requested by Ecology, arrange and/or continue information repositories at the following locations:

1. Pierce County Library
   1000 Laurel Street
   Milton, WA98354
   (253) 922-2870

2. Tacoma Main Library
   1102 Tacoma Ave. South
   Tacoma, WA 98402
   (253) 591-5666

3. Citizens for a Healthy Bay
   917 Pacific Ave., Suite 100
   Tacoma, WA 98402
   (253) 383-2429

4. WA State Department of Ecology
   Southwest Regional Office
   Toxics Cleanup Program
   300 Desmond Drive
   Lacey, WA 98503
   (360) 407-6365

At a minimum, copies of all public notices, fact sheets, and press releases; all quality assured monitoring data; remedial actions plans and reports, supplemental remedial planning documents; and all other similar documents relating to performance of the remedial action required by this Decree shall be promptly placed in these repositories.

If desired by Ecology, Defendant Murray Pacific will support a project-specific website during the activities covered by this Consent Decree.

XXV. EFFECT AND DURATION OF DECREE

This Decree shall supersede all prior consent decrees and enforcement orders entered with respect to the Site, and those orders and decrees shall, upon the effective date of this Decree, have no further force or effect.

This Decree shall remain in effect until Defendant Murray Pacific has received written notification from Ecology that the requirements of this Decree have been satisfactorily completed. Ecology shall issue such notification within sixty (60) days after the requirements of this Decree have been satisfactorily completed. Thereafter, the Parties within thirty (30) days shall jointly request that the Court vacate this Decree. After the Decree is vacated, Section XVII (Covenant Not to Sue) and XVIII (Contribution Protection) shall survive and continue in full force and effect.

XXVI. CLAIMS AGAINST THE STATE

Murray Pacific hereby agrees that it will not seek to recover any costs accrued in implementing the remedial action required by this Decree, and that it will not seek to recover the sums paid under this Decree, from the State of Washington or any of its agencies. Defendant Murray Pacific will make no claim against the State Toxics Control Account or any Local Toxics Control Account for any costs incurred in implementing this Decree. Except as provided above, however, Defendant Murray Pacific expressly reserves its right to seek to recover any costs incurred in implementing this Decree from any other PLPS, including agencies of the State of Washington, other than the Debtors. This Section does not limit or address funding that may be provided under Chapter 173-322 WAC.

XXVII. EFFECTIVE DATE

This Decree is effective upon the later of (1) the date it is entered by a final order of the Court or (2) the Effective Date of the Bankruptcy Settlement Agreement.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

JAMES PENDOWSKI
Program Manager
Toxics Cleanup Program
(360) 407-7177

Date: ______________________

ROBERT M. MCKENNA
Attorney General

ELLIOTT FURST, WSBA # 12026
Senior Counsel
Attorney for State of Washington
Department of Ecology
(360) 586-3513

Date: ______________________

MURRAY PACIFIC CORPORATION

LT Murray

L.T. MURRAY III
President
Murray Pacific Corporation
(253) 383-4911

Date: 4/29/08

DATED this _____ day of ____________________, 2008.

JUDGE
Pierce County Superior Court

FINAL CLEANUP ACTION PLAN

B&L WOODWASTE SITE

January 2008

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Appendix A
Groundwater Alternatives Evaluation Report, Ecology Comments, & Tech Memos

ACRONYMS AND ABBREVIATIONS

AGI	Applied Geotechnology, Inc.
ARAR	Applicable or relevant and appropriate requirement
Asarco	Asarco Incorporated
CAA	Cleanup Action Area
CAP	Cleanup Action Plan
CB/NT Site	Commencement Bay Nearshore/Tideflats Superfund Site
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Constituents of concern
CUL	Cleanup level
DAHP	Department of Archaeology and Historic Preservation
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
FS	Feasibility Study
GAE	Groundwater Alternatives Evaluation
Gpm	Gallons per minute
I-5	Interstate 5
K/J/C	Kennedy/Jenks/Chilton
LFG	Landfill gas
MSL	Mean sea level
MTCA	Model Toxics Control Act
Murray	Murray Pacific Corporation
ORP	Oxidation-reduction potential
PLP	Potentially liable person
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
Site	B&L Woodwaste Site
SR	State Route
TDS	Total dissolved solids
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compounds
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

FINAL CLEANUP ACTION PLAN
B&L WOODWASTE SITE
PIERCE COUNTY, WASHINGTON

1.0 INTRODUCTION

This Cleanup Action Plan (CAP) has been prepared for the B&L Woodwaste Site, located near Milton, Washington (Figure 1). Contaminants present in the woodwaste have been released to the environment and have migrated to outside areas. For the purposes of this plan, the following definitions have been established to clarify references:

- **B&L Property** is the land owned, operated, and permitted as a woodwaste landfill. This property comprises approximately 18.5 acres and includes the woodwaste landfill.
- **Landfill** is defined as the approximately 13 acre area on the B&L Property where woodwaste is present and over which a landfill cap has been constructed.
- **B&L Woodwaste Site (Site)** is defined as the Landfill and any adjacent areas where contamination from the Landfill has come to be located. The Site is part of the Commencement Bay Nearshore/ Tidelands Superfund site.

The B&L Property (including the Landfill) is located in unincorporated Pierce County. Portions of the Site extend beyond the B&L Property and into the City of Milton. The Site has been subdivided into three Cleanup Action Areas (CAAs) as described in more detail in Section 1.1.

The CAP has been prepared in accordance with the requirements of Enforcement Order No. DE 92TC-S214 (as amended) issued by the Washington State Department of Ecology (Ecology) pursuant to the authority of Chapter 70.105D.050(1) of the Revised Code of Washington (RCW 70.105D.050[1]), and entered into by the potentially liable persons (PLPs) Asarco Incorporated (Asarco), Murray Pacific Corporation (Murray), and Executive Bark Incorporated (Executive Bark), to meet the requirements of the Washington State Model Toxics Control Act (MTCA) cleanup regulation, as established in Chapter 173-340 of the Washington Administrative Code (WAC). The CAP describes the Site, the nature and extent of contamination, the cleanup action alternatives considered, and the proposed cleanup action for soil, groundwater, sediments and surface water with concentrations of arsenic above the applicable MTCA cleanup levels. The CAP will be implemented pursuant to the one of the following: the existing Enforcement Order, a new Consent Decree, or an Agreed Order between the PLPs and Ecology. Other PLPs may be included as appropriate.

Previous work conducted at the Site included a Remedial Investigation (RI), prepared by Kennedy/Jenks/Chilton and Applied Geotechnology, Inc. (K/J/C & AGI 1990a), a Feasibility Study (FS) also prepared by K/J/C & AGI (1990b), and an Engineering Design report prepared by Hydrometrics, Inc. (1992). These documents were used as the basis for a 1991 CAP that was prepared by Ecology (1991) for the Site.

The 1991 CAP recommended a remedy consisting of landfill consolidation, the installation of a multi-media cap, the creation of stormwater retention basins, groundwater pumping and treatment (as needed), ditch remediation, landfill gas controls, surface water controls, and institutional controls (barrier fencing around the Landfill), and groundwater and surface water monitoring. The 1991 CAP recommended remedy did not contain a bottom liner for the Landfill. The recommended remedy was installed in 1993.

In 2001, Ecology determined that arsenic-contaminated groundwater was continuing to migrate from beneath the Landfill toward the Wetlands area located to the north of the Landfill. In 2005, Asarco declared bankruptcy. Since 2005, a substantial effort has been made by Murray to investigate the nature and extent of this migration of arsenic-contaminated groundwater. This effort was recently summarized in the Groundwater Alternatives Evaluation Report (Floyd|Snider 2007a), referred to as the GAE Report. The GAE Report, Ecology's Comments on the Report, and three Technical Memoranda addressing key comments have been included in CD-ROM format as Appendix A to this CAP.

1.1 Purpose

The purpose of this CAP is to implement additional remedial actions to halt the continued migration of arsenic into shallow groundwater and to address the existing off-site contamination.

This CAP has been prepared in accordance with WAC 173-340-380 to present the proposed cleanup action and to specify cleanup standards and other requirements for the cleanup action. The cleanup action will meet the threshold requirements of WAC 173-340-360 to protect human health and the environment, comply with cleanup standards, comply with applicable state and federal laws, and provide for compliance monitoring.

For the purposes of this CAP, the Site has been divided into three CAAs: the Landfill/Ditch CAA, the Wetlands CAA, and the End of Plume CAA. The three CAAs comprise the Site.

The cleanup action proposed by Ecology in this CAP for each area includes:

- **Landfill/Ditch CAA**. Installation of a perimeter slurry wall around the Landfill that is tied into both the existing landfill cap and a low-permeability soil unit located below the Landfill, the diversion of clean surface water and groundwater before it reaches the slurry wall, and the extraction and treatment of leachate from within the slurry wall to maintain hydraulic control by creating an inward hydraulic flow gradient. Once the slurry wall is installed, contaminated sediments in the adjacent agricultural drainage ditches will be excavated and disposed of at a permitted landfill.

- **Wetlands CAA.** A groundwater pump and treat system will be used to remove arsenic from the groundwater plume in the Wetlands CAA. Performance-based criteria will be used to assure compliance with MTCA requirements. It is anticipated that up to 120 million gallons of water may require treatment.

- **End of Plume CAA.** In situ treatment will be used to precipitate out dissolved arsenic followed by monitored natural attenuation of groundwater that reaches 12th Street East. Performance-based criteria will be used to assure compliance with MTCA requirements. Only a thin layer of arsenic-contaminated groundwater remains above the cleanup level in the End-of-Plume CAA; without treatment this area would likely come into compliance as the effect of cleanups in the Landfill and Wetlands CAAs reached the End-of-Plume CAA. Treatment in the End-of-Plume CAA is, therefore, intended to reduce the restoration timeframe by bringing the area into compliance within 2 to 5 years; although treatment will be continued as long as needed based on the performance criteria.

2.0 SITE DESCRIPTION AND BACKGROUND

Much of the content of this section was initially summarized in the GAE Report (Floyd|Snider 2007a). These summaries have been adapted for use in this CAP.

2.1 Site Description

2.1.1 Physical Site Description

B&L Woodwaste Site is located in Pierce County and consists of the B&L Property (which includes the Landfill) and adjacent areas that have been affected by releases from the Landfill. Portions of the Site extend into the city limits of Milton, Washington. The B&L Property, which includes the Landfill, is located on a tax parcel of approximately 18.5 acres in unincorporated Pierce County, approximately 1/4 mile east of Interstate 5 (I-5) and 5 miles east of Tacoma. The Landfill, shown on Figure 2, is situated in a residential and agricultural area in northern Pierce County. Farmland borders the western and southwestern edges of the B&L Property, and an apartment complex adjoins the southeastern corner. Fife Way defines the southeastern boundary, and Puget Power Access Road (also known as Barth Road) delineates the north side. The Puget Power Access Road and adjacent drainage ditches are located in the City of Milton; portions of this road and ditches are within the Site, since Landfill contaminants are present in this area. The pentagonal-shaped Landfill itself occupies approximately 13 acres of the 18.5 acre B&L Property parcel and rises to an elevation of approximately 50 feet above mean sea level (MSL).

To the north of the Landfill and the Puget Power Road is former farmland that has re-established itself as a grassy wetland that stretches north and west to I-5. Portions of this wetland have been affected by releases from the Landfill and are, therefore, within the Site. This wetland area is located in unincorporated Pierce County. The wetland ground surface is flat and lies at approximately 9 to 10 feet above MSL. During winter months, the ground is generally covered with shallow standing water. Several hundred feet north of Puget Power Access Road is another roadway, 12th Street East, a primitive, unused, and now mostly overgrown road grade that cuts through the wetland, marking the boundary between land parcels.

2.1.2 Land Use

Historically, land surrounding the Landfill has been used for agriculture, but in recent years it has become increasingly developed, as has most of the land in northern Pierce and southern King Counties. The population of Pierce County increased nearly 20 percent between 1990 and 2000, and the growth rates in the Site vicinity (the Cities of Fife and Milton) were even greater. Future growth estimates project similar rates for the next two decades. The Landfill, wetlands, and 12th Street East parcels are zoned for moderate density single family development (Pierce County 2006). The Puget Power Access Road is owned by the City of Milton, and is zoned as an open space district as part of the Interurban Trail project (City of Milton 1999).

Land use in the general vicinity is changing from the once agricultural, semi-rural uses, to more suburban residential, commercial, recreational, and environmental restoration project uses. Figure 3 shows the existing and proposed future land use in the larger Hylebos Creek Watershed where the Landfill is located. These types of development increase stormwater flow through the creation of impervious (paved) surfaces. This increased flow is likely to affect groundwater and surface water hydrology in and around the Site.

The B&L Property is currently bordered by vacant and/or agricultural lands immediately to the south (farmed land), west (vacant and farmed lands,) and north (wetlands). East of the B&L Property is Fife Way East, a public road. To the south, is a multi-unit residential complex built in the late 1980s. To the northeast lies a parcel of land currently occupied by a single private residence, which, according to public record, has recently been the subject of permit applications for development of ten single-family homes. The Cities of Fife and Milton both have explored the potential for the commercial and/or recreational development of lands near and/or adjacent to the B&L Property. The City of Fife recently purchased the agricultural fields to the south and west of the B&L Property. Ownership of parcels adjacent the B&L Property is illustrated on Figure 4.

Hylebos Creek and Surprise Lake Drain Restoration

Several parcels to the north and west of the Landfill likely would be impacted by a major proposed Washington State Department of Transportation (WSDOT) highway project, the completion of State Route (SR) 167 between SR 161 in North Puyallup and the SR 509 freeway in Tacoma. The final Environmental Impact Statement (EIS) for this project has recently been issued, and once the Record of Decision (ROD) is prepared, the project will move into the design phase. If the funding for the project becomes available, construction will be done in stages based on available money.

As part of its proposed SR 167 project, WSDOT has proposed major riparian restoration projects to manage stormwater, including relocating the channel of Hylebos Creek from its current path adjacent to I-5 northwest of the Landfill. The proposed relocation is designed to mitigate SR 167 construction impacts, to improve stormwater management, and to enhance and protect aquatic habitat in this stretch of the creek. While the exact location of the new creek channel is subject to change in the final design, the proposed general area of relocation, as shown on Figure 5, indicates that the creek channel will meander several hundred feet closer to the Landfill. The current Surprise Lake Drain ditch will also be restored to a more natural meandering channel. According to public records, in recent years, WSDOT has purchased a number of parcels in the area that will be impacted by the project.

Mitigation efforts planned for the SR 167 project include increasing the floodplain capacity of the area by deepening a section of the Hylebos Creek channel located between the Site and the mouth of the creek at the Hylebos Waterway. This channel deepening would decrease regional flooding by lowering the water surface elevation during recurring flood events, such as the 100-year flood. As shown on Figure 6, the mitigation projects are expected to prevent the 100-year flood waters from inundating the portion of the Site south of the Puget Power Access Road—including the perimeter of the Landfill, the drainage ditch system, and the adjacent agricultural fields.

Several other Hylebos Creek restoration projects have been completed in recent years or are currently underway. Such projects include those identified in the CB/NT Site natural resource damage assessment process, and wetlands and instream habitat enhancement projects by groups such as Friends of the Hylebos and Citizens for a Healthy Bay.

2.1.3 Regional Topographic and Hydrologic Setting

The regional topographic and hydrologic settings exert significant influence on the surface water and the shallow groundwater regime at the Site. More detailed information on Site hydrogeology, groundwater occurrence, and local surface water drainage is presented in the GAE Report.

Regional topography, surface water, and drainage features are shown on Figure 7. The Site is located in the floodplain of the Hylebos Creek Watershed, close to where it merges with the larger Puyallup River valley. To the east of the Site, Fife Way marks the steep transition between the flat floodplain and the rolling hilly relief of the uplands glacial drift plain.

The Hylebos Creek Watershed is a tributary sub-basin that drains 19 square miles of urban and suburban area between Fife and Federal Way (Entranco 2004). The primary surface water body, Hylebos Creek, is a man-made channel in the vicinity of the Site. Hylebos Creek generally flows in a southerly direction until turning west for the last 2 miles prior to its discharge into the Hylebos Waterway. The last 1.6 miles of stream are influenced by tidal backwater (MSG et al. 2004). A historical survey completed in 1870 indicates the floodplain was already cleared, drained, and at least partially diked for agriculture by the time of the survey (MSG et al. 2004).

The Hylebos Creek floodplain is situated on a series of alluvial deposits. The transition between the adjacent glacial drift hills and the floodplain alluvium is marked by a mixed gravel and sand colluvial deposit. Groundwater flowing from the glacial hills recharges the several hundred feet of water-bearing alluvial sand units that are punctuated by low-permeability strata (aquitards). The inputs of groundwater from this higher elevation drive groundwater flow beneath the Landfill in a northwesterly direction toward its eventual discharge into Hylebos Creek. Recent field studies indicated recurring flooding during major storm events is likely the result of a combination of flat topography, high groundwater table, and backwater conditions experienced at high tide during major storm events (Entranco 2004).

2.2 Site History

A detailed history of the Landfill is presented in Section 2 of the GAE Report; the discussion below is a brief summary.

The permitted Landfill was owned and operated by Mr. William Fjetland of Executive Bark and Eagle Trucking. The Landfill contains primarily deck debris from log sort yards operating in the Tacoma Tideflats area. The log sort yards operators had used Asarco slag as roadway and yard ballast believing it to be inert “rock.” This slag was mixed with the bark and dirt that was cleaned periodically from the log sort yards and transported to the Landfill for disposal.

In the early 1980's Ecology discovered that the slag at the yards and at the Landfill was leaching arsenic and other heavy metals at concentrations far in exceedance of their surface water standards.

In September 1983, U.S. Environmental Protection Agency (USEPA) placed the Commencement Bay Nearshore/Tideflats Superfund Site (CB/NT Site) on the National Priorities List (NPL), pursuant to Section 105 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 U.S.C. Sec. 9605). The CB/NT Site included the Hylebos Waterway and sites that were believed to contribute contamination to the waterway. The 1989 ROD for the CB/NT Site lists the Landfill as one of the sources of metals contamination.

2.2.1 The Early Regulatory Years—1988 to 1991

In January 1988, Ecology sent notices to a number of entities advising them of their status as PLPs under MTCA for contamination at the Landfill, and requesting their participation in an investigation and the development of a remedial strategy for the Site. The original PLP letters were sent to Asarco, Mr. Fjetland, Murray, Louisiana-Pacific, Inc., the Weyerhaeuser Corporation, and L-Bar Products, Inc.

Following discussions with the PLPs and additional research into historical landfill operations, Ecology sent additional letters to a revised list of parties. This revised PLP list was comprised of Asarco, Mr. Fjetland, L-Bar Products, Inc., Murray, Louisiana-Pacific, Inc., Portac, Inc., U.S. Gypsum, Inc., Executive Bark, Inc., General Metals, Inc., Wasser Winters, Inc., and West Coast Orient, Inc. With the exception of Murray, the PLPs declined Ecology's request to address environmental problems at the Site. Murray and Ecology negotiated a Consent Decree in March 1989, pursuant to which Murray agreed to conduct a RI/FS and implement a cleanup remedy at the Site. Ecology agreed to join Murray, following completion of the remedy, in pursuing other PLPs for contribution to the cost of the studies and the cleanup (see Section III of the Consent Decree). Murray engaged Kennedy Jenks, Inc. and Applied Geotechnology, Inc. (AGI) to prepare the RI/FS, which was completed in September 1990.

In 1988, the log sort yard owners and the Port of Tacoma sued Asarco for slag-related contamination at the yards and at Landfill. The court found Asarco liable for 79 percent of the costs to cleanup the Site, the Landfill operator for 14 percent (assigned equally to Eagle Trucking, Inc. and William Fjetland), and Murray responsible for the remaining 7 percent. The verdict and decision were affirmed on appeal in 1994.

2.2.2 Asarco Project Lead Years—1991 to 2005

Following the judgment in the federal lawsuit, Ecology issued an Enforcement Order (No. DE 91TC-S267) to Asarco, Murray, and Executive Bark, Inc. (c/o Camille Fjetland, Mr. Fjetland's widow) to develop preliminary designs for the remedial actions identified in the CAP. In June 1992, Ecology issued another Enforcement Order (No. DE-92TC-S214) to Asarco, Murray, and Executive Bark, Inc. for construction, operation, and monitoring of the selected remedial action. Asarco and its consultant, Hydrometrics, Inc. (Hydrometrics), took the lead in implementation of the remedy, which was substantially completed in 1993.

The Landfill remedial action primarily consisted of consolidating and capping landfill materials with a multi-layer, Resource Conservation and Recovery Act (RCRA) equivalent capping system; installing landfill gas collection wells; installing a leachate monitoring system; a stormwater collection pond and infiltration trenches; ditch remediation; institutional controls (site fencing); and routine monitoring of surface water and groundwater. A groundwater remedy (pump and treat) was evaluated, but not implemented, as it was viewed only as a future contingency action. The 1993 capping of the Landfill by Asarco was effective in reducing surface water infiltration into the Landfill and likely ceased the production of leachate generated by surface water infiltration; however, it did not adequately address groundwater under or adjacent to the Landfill.

In a draft report to Ecology in May 2001, "Review of Remedial Activities at the Landfill," Asarco presented monitoring data that indicated a migration of arsenic in groundwater into ditches adjacent to and downstream of the Landfill, and in the wetlands north of the Landfill (Hydrometrics 2001a). In June 2001, Asarco submitted a "Contingency Plan for the Landfill" that proposed several remedies for controlling groundwater at the Landfill (Hydrometrics 2001b). Asarco did not complete the activities scoped in the Plan.

In February 2005, the Second Amendment to the Enforcement Order issued by Ecology required the resumption, completion, and implementation of the activities outlined in the 2001 Contingency Plan.

2.2.3 Recent Activity—2005 to Present

Asarco declared bankruptcy on August 10, 2005, with none of the activities outlined in the Second Amendment to the Enforcement Order completed. Executive Bark, Inc. has not participated in remedial activities at the Site. In the interim, Murray has taken on the investigation of groundwater contamination in the wetlands and the development of remedial alternatives to address groundwater.

The GAE Report summarized all information known about the Landfill starting with the original RI, continuing through the Asarco work, and ending with identification of a series of data gaps investigations performed by Floyd|Snider for Murray in 2006 and 2007. A copy of the GAE Report, Ecology's Comments to the GAE Report, and Tech Memos related to the comments are contained on a CD-ROM in Appendix A.

2.3 The 1993 Remedial Action

This section presents the basis for the remedial approach that was selected by Ecology in 1991 and implemented in 1993.

The 1993 Remedy as Implemented

In the 1991 CAP, Ecology identified a selected remedial alternative for the Site consisting of the following:

- Consolidation of the Landfill to a less than 13 acre footprint.
- Installation of a multimedia (RCRA) cap or equivalent.
- Installation of a stormwater system including a detention basin.
- Excavation of ditch sediments.
- Passive landfill gas controls.
- Placement of institutional controls (including barrier fencing around the Landfill and groundwater and surface water monitoring).
- Surface and groundwater monitoring.
- Contingency for groundwater actions, if needed in the future.

The selected remedy did not include the bottom liner for the Landfill that was a component of the preferred remedy in the FS. In the CAP, Ecology determined that the selected remedy was equivalent to the construction of a raised landfill base or a bottom liner system, but that these latter alternatives were more expensive than the selected remedy, and required more earth moving and truck traffic, resulting in excessive short-term negative impacts on human health and the environment.

The consolidation and capping alternative that was implemented has been successful in eliminating or significantly reducing risks to human health and the environment in a number of critical ways. Capping and perimeter fencing of the B&L Property have eliminated human exposure to landfill waste through accidental ingestion, inhalation, and dermal contact. Excavation of contaminated ditch sediment eliminated existing sediment impacts and associated surface water contamination by the sediments. Capping has eliminated the pathway of runoff to surface water and significantly reduced water transmission through landfill materials by blocking infiltration, thereby greatly reducing the volume of leachate generated. This has decreased the transport of contaminants to surface water and groundwater, and to sediments in perimeter ditches. Since the implementation of the 1993 remedy, conditions in the perimeter ditches have improved to such an extent that metals contamination is no longer reaching Hylebos Creek via the ditches.

However, the 1993 remedy was not completely effective in preventing the formation of arsenic-containing leachate, nor in preventing the leachate from leaving the Landfill and entering the adjacent wetlands and slowly recontaminating the perimeter ditch sediments. The base of the Landfill is continually wet due to groundwater intrusion and the groundwater beneath the Landfill, and in the adjacent wetlands, in the Upper Sand Aquifer is heavily contaminated with arsenic. Therefore Ecology has made the determination that additional remedial action is necessary.

3.0 REMEDIAL INVESTIGATION

The GAE Report presents a longer discussion of Site conditions and is included in Appendix A. The following is a summary.

3.1 Surface Water and Hydrology

3.1.1 Surface Water

Surface water at the Site drains to Hylebos Creek via two small sub-basins, one north of the Puget Power Access Road in the wetlands within the floodplain of Hylebos Creek and the other south of the road, in the agricultural farmlands of the Puyallup River valley. Surface water features close to the Landfill are shown on Figure 7.

Land south of the Puget Power Access Road is drained by the agricultural ditches, including those that run along the perimeter of the Landfill. These ditches discharge into the larger Surprise Lake Drain, which, in turn, discharges into Hylebos Creek via the 70th Avenue culvert under I-5.

Within the fenced area of the Landfill footprint, precipitation infiltrates the multi-layer cap until reaching a drainage layer that directs stormwater into troughs around the Landfill that lead to one of two infiltration ponds. Within the main infiltration pond south of the Puget Power Access Road is an overflow pipe that leads into the adjacent agricultural ditch system, as shown on Figure 2. This ditch system also captures stormwater that overflows from the smaller secondary stormwater pond at the northeast corner of the Landfill, outside the footprint edge of refuse, and the fenced perimeter.

The wetlands located north of Puget Power Access Road are part of a larger system of wetlands along Hylebos Creek (see Section 2.1). The wetlands receive significant surface water input via precipitation, runoff from Fife Way, seasonal expressions of the rising water table, and, during flood stages, overflow from Hylebos Creek.

3.1.2 Geology and Hydrostratigraphy

Cross Sections F-F' (Figure 8) and E-E' (Figure 9) illustrate the relevant geologic and groundwater-bearing (hydrostratigraphic) units underlying the Landfill and Wetlands. Underneath the woodwaste material and forming the surface soils in the Wetlands is an organic silt and peat unit 4 to 7 feet thick that transitions into a plastic silt deposit approximately 6 inches thick at its base. These deposits correspond to the pre-Landfill ground surface. Boring logs indicate the silt unit beneath the Landfill has been compacted and partially reworked into the fill material by grading and filling activities.

Saturated alluvial deposits (primarily sands) underlie the surface soils and comprise the Upper and Lower Sand Aquifer. These alluvial sands were encountered to the depths of the deepest RI borings. At the southeastern edge of the Site, closest to the glacial drift plain, the alluvial deposits grade into the colluvium and Pleistocene glacial silty gravel deposits[1]. Previous subsurface investigations (K/J/C & AGI 1990b; Hydrometrics 2001a) identified the Upper Sand Aquifer and Lower Sand Aquifer as the primary water-bearing units underlying the Landfill. At the Landfill, the water level of Upper Sand Aquifer exists within the lower 4 to 6 feet of landfill materials.

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[1] In general, the uplands areas surrounding Hylebos Creek consist of glacial deposits, while the lowlands consist of flood plain (alluvial) deposits of silts and sands. Colluvium deposits consist coarse materials that have eroded off the bluff and exist at the toe of the slope.

The alluvial deposits are divided into the Upper and Lower Sand Aquifer by the Lower Aquitard, a 3-to 6-foot-thick layer of interbedded silt, peat, and silty sand. This low permeability silt unit was encountered in all borings except those drilled into colluvium at the toe of the bluff.

3.1.3 Groundwater Flow Direction and Gradients

Three potentiometric surfaces as measured in April 2002 (Hydrometrics 2002), August 2006, and October 2006 (Floyd|Snider 2007a) are displayed on Figure 10. These contours indicate a northerly to northwesterly groundwater flow direction in the Upper Sand Aquifer, which is consistent with topography and a flow path toward Hylebos Creek. The groundwater gradient is generally steepest from the bluff to beneath the Landfill, relatively flat through the wetlands, and begins to get steeper again north of MW-15. These gradients also reflect the topography of the area.

Upward vertical groundwater gradients are present beneath the wetlands but tend to flatten toward the bluff. Potentiometric surfaces are approximately one foot higher in the Lower Sand Aquifer than in the Upper Sand Aquifer in the Wetlands area. Such upward gradients indicate a strong component of upward flow of groundwater. The Lower Aquifer beneath the Wetlands exerts hydraulic pressure on the aquitard between the Lower and Upper Aquifers, and thus probably acts as a hydraulic barrier to the downward migration of arsenic-contaminated groundwater that is present in the Upper Aquifer in the Wetlands area. According to Hydrometrics (2001a), data collected during the RI indicate vertical hydraulic gradients between the Lower and Upper Sand Aquifers are flat or slightly upward in the Landfill and show an increasingly upward trend in the Wetlands area north of the Landfill. This finding was confirmed by 2006 and 2007 field measurements (Floyd|Snider 2006; Floyd|Snider 2007b) that showed strong upward gradients beneath the Wetlands, even with several feet of ponded surface water atop the Upper Sand Aquifer. This is characteristic of floodplains that function as regional groundwater discharge areas. Many of the residential wells in the area south (upgradient) of the Landfill are reported to be artesian flowing wells—confirming a general upward vertical gradient trend in the lowland area (Hydrometrics 2001a).

Vertical hydraulic gradients are lower beneath the Landfill and can be as low as zero indicating no net upward or downward gradients. When combined with the aquitard, this acts to prevent downward migration of contamination.

3.1.4 Hydraulic Conductivity and Average Linear Velocity

Pumping tests of the Upper Sand Aquifer (Floyd|Snider 2007a) in the Wetlands area indicate a highly transmissive aquifer with a preferential hydraulic conductivity in the north–south direction. Calculated hydraulic conductivities are in the range of 100 to 250 feet per day parallel to the direction of groundwater flow and 2.7 to 5.7 feet per day perpendicular to the direction of groundwater flow. These findings are generally consistent with Asarco's 1999 slug test results.

The observed anisotropy in hydraulic conductivities, with conductivity an order of magnitude greater in the approximate north-south direction than in the east-west direction, is consistent with the observed presence of coarser sand grain sizes (up to medium to coarse and thin deposits of coarse sand at the base of the Upper Sand Aquifer) along the eastern edge of the wetlands investigation area. This may reflect that the Upper Sand Aquifer is composed of highly elongated sand channels that were deposited by alluvial processes, predominantly in a north-south direction.

Average linear groundwater seepage velocities, calculated based on a wetlands gradient of 0.001 and an assumed effective porosity of 35 percent, indicate representative Wetlands groundwater seepage velocities ranging from approximately 100 to 260 feet/year. At these velocities, it would take approximately 2 to 6 years for groundwater to travel the 600 feet from the edge of the refuse in the Landfill to 12th Street East.

3.1.5 Groundwater Interaction with Surface Water

Groundwater-surface water interactions are important processes in both the Landfill and the Wetlands because the Upper Sand Aquifer beneath the Site maintains a very high water table at, or within a few feet of, land surface throughout the year.

As a consequence, agricultural drainage ditches (illustrated on Figure 2) are deep enough to receive groundwater discharge from the Upper Sand Aquifer based on staff gage and monitoring well measurements (K/J/C & AGI 1990b). These ditches primarily collect groundwater discharge, but locally and seasonally can recharge the shallow groundwater system. The section of ditch along the northern perimeter of the Landfill is higher than the rest of the ditch system and is often dry, and not as prone to receiving groundwater discharge. The ditch system drains to the west where it joins the Surprise Lake Drain; however, drainage of ditch water is limited by the shallow depth of the ditch, its flat gradient, and the generally consistent base flow elevation of water in the Surprise Lake Drain. These factors limit the ability of the ditches to function as an active groundwater drain. They also limit the flow rate along the ditch giving any arsenic that reaches the ditch ample opportunity to precipitate out before it reaches the larger Surprise Lake Drain.

In the Wetlands, during winter months or other wet conditions, the potentiometric surface rises above the ground surface due to both flooding inputs and upward discharge from the aquifer. The majority of groundwater flux through the Upper Sand Aquifer, however, occurs in the sands below the upper 3 to 8 feet of silty surface soils and especially in the coarser sand deposits at the base of the aquifer.

3.2 Nature and Extent of Contamination

Multiple investigations and monitoring activities have been conducted to examine soil, surface water, ditch sediment, and groundwater conditions at the Landfill and in the surrounding vicinity. The results of these investigations and years of monitoring indicate that arsenic is the only COC that still exceeds cleanup levels. Arsenic exceeds cleanup levels in groundwater, surface water, and ditch sediments.

Other slag-related metals (copper, lead, and nickel) and the organic compound phenol (a natural component within wood waste) were occasionally detected in some samples during the RI at concentrations greater than screening levels and, therefore, were identified as Site-wide COCs. Subsequent monitoring indicates that these non-arsenic COCs are still only occasionally detected, and at low concentrations in association with arsenic.

Elevated arsenic concentrations in groundwater generally extend from beneath the Landfill and downgradient into the Upper Sand Aquifer beneath the Wetlands. Arsenic contamination in surface water and sediments in the drainage ditch system extends to the west of the Landfill. The pattern of groundwater contamination at the Landfill perimeter consists of a broad area of elevated concentrations along the northern perimeter where the arsenic plume flows into the Wetlands and a “halo” of slightly elevated concentrations immediately adjacent to the Landfill perimeter. Groundwater monitoring since the 1990s has indicated that the arsenic plume in the Wetlands is generally stable.

3.2.1 Arsenic Release to Groundwater from Landfill Materials

Arsenic speciation and the reduction-oxidation (redox) chemistry that controls it are central to the release, transport, and attenuation mechanisms at the Site. The plume of elevated arsenic concentrations in groundwater beneath the Landfill and Wetlands is primarily comprised of As(III), a form of inorganic arsenic known as trivalent arsenic or arsenite that generally occurs under mildly reducing conditions. Such reducing conditions within the Landfill are generally responsible for releases of arsenic trapped on mineral surfaces in soil or slag via dissolution and desorption. In addition to arsenic and iron, Landfill materials appear to be the source of elevated groundwater concentrations of dissolved organic carbon (DOC) and common groundwater ions present in landfill leachate—including chloride, calcium, magnesium, and sodium. The presence of elevated concentrations of DOC and these ions, and the resulting elevated total dissolved solids (TDS), salinity, and specific conductivity, define a general leachate plume in the Wetlands that overlaps with, but is broader than, the arsenic plume.

The pattern of arsenic concentrations in the Upper Sand Aquifer along the boundary of the Landfill with the Wetlands suggests that arsenic-contaminated groundwater discharges along the whole northern border of the Landfill, and flows beneath the Puget Power Access Road.

3.2.2 Extent of Arsenic Groundwater Plume

The arsenic groundwater plume exists only within the Upper Sand Aquifer. In the wetlands, it forms a broad western lobe that terminates within approximately 300 feet of the Landfill boundary in the upper section of the aquifer, and an elongated deeper plume “finger” that extends approximately 400 feet further downgradient. The extent of the arsenic plume in shallow groundwater is shown on Figure 8, which shows arsenic concentrations along a section parallel to the axis of the entire plume, and Figure 11, which is a plan view of arsenic concentrations at two different depths in the Upper Sand Aquifer.

Figure 11 also shows that a relatively small “halo” of arsenic surrounds the Landfill to the west and south near locations D-8 and D-9. Results from monitoring wells (MW-18 through MW-22, now decommissioned, but shown on Figure 11) confirm that the halo does not extend a significant distance off the B&L Property. A localized area of elevated concentrations exists upgradient to the east of the Landfill as well, around monitoring Well D-10A. This well is completed in an isolated pocket of colluvium that is not hydraulically connected to the Upper Sand Aquifer (based on potentiometric surface data). Arsenic concentrations typically drop an order of magnitude to near background levels in a short distance (from 250 μg/L in D-10A to 25 μg/L in MW-23, lying 100 feet downgradient). The source of this contamination is unknown, but its footprint and concentrations have remained stable since the RI in the late 1980s.

The northern extent of the plume is characterized by a thin seam of elevated concentrations at the more permeable coarse sandy base of the aquifer. A cross section showing arsenic concentrations through the full reach of the northern extent of the plume is illustrated in Figure 9. Dissolved arsenic, at a maximum concentration of 0.056 mg/L, was detected across an area no greater than 200 feet wide by 5 feet thick between depths of 17 and 22 feet. The exact downgradient extent of this plume “finger,” however, is not currently established because of difficult field conditions in 2006. Regardless, given the low concentrations at 12th Street East, it is likely that the plume “finger” extends a limited distance north of 12th Street East, before attenuating to background levels.

Groundwater monitoring in the Lower Sand Aquifer indicates that the Landfill has had little or no impact on the aquifer. The only exceedance of arsenic in the Lower Sand Aquifer potentially related to the Landfill exists at Well D-8B. In this area the aquitard may be discontinuous, but hydraulic gradients are upwards. Arsenic concentrations at this well are generally around 15 to 20 μg/L – higher than the Site cleanup standard of 5 μg/L, but still relatively low; wells downgradient of D-8B are at or below background concentrations.

3.2.3 Non-Toxic Leachate Indicators in Groundwater

Leachate indicators other than arsenic, including DOC, TDS, dissolved iron, and oxidation-reduction potential (ORP) are present in Wetlands area groundwater in patterns similar to but broader than the arsenic plume. These visually apparent similarities are supported by quantitative correlations between these constituents and parameters (Floyd|Snider 2006).

Correlations between arsenic and negative ORP, DOC, TDS, and iron (total and dissolved) support the model of reductive dissolution of arsenic, iron, and other ions. The correlations also support the transport of arsenic in groundwater with DOC, iron, and elevated TDS under the mildly reducing conditions measured (ORP between 0 and –100 mV).

Monitoring of leachate indicators in the Lower Sand Aquifer have shown that they are not present in the aquifer, further supporting the absence of landfill impact on the Lower Sand Aquifer.

3.2.4 Plume Stability and Attenuation Processes

The stable boundaries of the arsenic plume indicate that the plume is largely controlled at its downgradient edges by natural attenuation processes, primarily sorption to the soil and diffusion, which slow the rate of arsenic migration relative to the flow of groundwater. Several lines of evidence support attenuation, including:

- The arsenic plume boundaries have remained stable since the beginning of post-remedy Wetlands groundwater monitoring in 1994.
- Leachate indicators (elevated iron, TDS and DOC) are more widespread than the distribution of the arsenic plume. Individual conservative tracers (i.e., ions that stay in solution) for leachate, such as chloride, are present in relatively uniform concentrations downgradient from the Landfill, while arsenic concentrations in groundwater decrease. This indicates that arsenic in Wetlands groundwater is not as mobile as these other Landfill-related constituents.
- Arsenic concentrations in D-6A, at the heart of the Wetlands plume, have been between 1 and 4 mg/L consistently since the well was installed in 1994. Groundwater travel times indicate that groundwater from D-6A would have reached 12th Street East in approximately 2 to 5 years. Yet, today (13 years after the first measurements at D-6A), concentrations at 12th Street East are 50 times lower than the concentrations at D-6A, indicating that at least 95 percent of the arsenic is attenuating between the two locations.
- The shallow, more oxidized portion of the plume does not extend more than 400 feet from the edge of the Landfill.
- The highest percentages of As(V), a less mobile form of arsenic than As(III), were measured in monitoring wells at the downgradient edge of the plume, a finding that is consistent with a shift in geochemical conditions.

Additionally, as suggested by Cross Section F-F' (see Figure 8), simple recharge of stormwater from the Landfill stormwater pond may be diluting/attenuating arsenic from the upper part of the aquifer.

3.2.5 Wetlands Soil Quality and Groundwater Attenuation

It is possible that the aquifer soils in the Wetlands accumulate arsenic over time due to a cyclical pattern of sequestration and dissolution associated with Wetlands flooding. As water levels drop and oxidizing conditions extend several feet into the aquifer, arsenic is likely to be adsorbed onto and/or co-precipitated with iron oxide mineral coatings. When water levels rise again, and reducing conditions return, arsenic would then be re-dissolved by reductive dissolution processes similar to those that originally released arsenic from the landfill waste.

Although this sequestration/dissolution cycle appears to be occurring in the Wetlands, soil analytical results indicate that the mass of dissolved arsenic in groundwater is not significant enough to cause concentrations of arsenic in soil to become elevated. Soil core samples from throughout the Wetlands, including the area with the highest concentrations in groundwater, resulted in only five detections of arsenic at concentration greater than 10 mg/kg.

3.2.6 Extent of Contamination in Ditch Surface Water and Sediments

Discharge of leachate into the adjacent ditch system to the west of the Landfill has resulted in localized arsenic contamination in agricultural ditch surface water that, when oxidized, precipitates out iron/arsenic solids that settle into ditch sediments. The lateral extent of surface water and sediment contamination, based on 2006 results, is presented on Figures 12 and 13, respectively.

The extent of the arsenic contamination of the ditch system is generally limited to the agricultural ditch along the western Landfill boundary. Significantly lower arsenic concentrations were detected in the ditch segment downgradient of the Landfill. The highest detections of arsenic in ditch sediments were co-located with the highest detections of arsenic in ditch surface water.

In addition to generally decreasing occurrences in ditches downgradient from the Landfill, arsenic concentrations in ditch sediments decrease by orders of magnitude within a few inches of the surface. This depth profile indicates that the likely mechanism for ditch recontamination (the ditches were cleaned out as part of the 1993 remedy) is interaction with oxygen and precipitation of arsenic that is deposited in the upper part of the ditch sediments.

No arsenic impact to the Surprise Lake Drain or surface water downgradient of this input has been observed. Arsenic concentrations (0.011 mg/L) in surface water downgradient of the Surprise Lake Drain are reflective of background levels

3.2.7 Methane

Emission of landfill gas (LFG), including methane, was not identified during the 1990 RI as a pathway by which contamination leaves the Landfill, and was not included in the 1991 CAP as a risk associated with the Landfill Passive gas controls were installed as part of the consolidation and capping remedy implemented in 1993 to control the potential release of LFG. Methane was monitored at the edge of the Landfill mound to ensure it did not exceed the lower explosive limit (LEL) as part of protection monitoring (Hydrometrics 1994). Based on November 2005 air quality measurements of the vents of the gas collection system, the Landfill has apparently ceased emission of measurable quantities of methane (the component of LFG that is associated with generating subsurface pressure and potentially explosive concentrations). The Landfill is also not emitting measurable quantities of hydrogen sulfide, a toxic air pollutant. Because volatile organic compounds (VOCs) are not detected in landfill leachate or Site groundwater, there is no reason to suspect emission of other toxic air pollutants from the Landfill gas collection system or from fugitive emissions.

3.3 Site Conceptual Model

3.3.1 Potential Exposure Pathways and Receptors

The 1993 remedy was effective in eliminating the potential for direct contact to the landfill waste and ditch sediment, in preventing the formation of contaminated surface water discharge, in eliminating most of the discharge of contaminated leachate into the perimeter ditch system, and in reducing leachate by preventing the infiltration of rainwater. The 1993 Remedy was effective in reducing the major risks to human health and the environment from Landfill. Despite this, a number of potential exposure routes remain, all of which stem from the continued discharge of leachate-contaminated groundwater from the base of the Landfill.

While leaching associated with stormwater infiltration is controlled by the consolidation and capping of landfill materials, leachate is still produced when groundwater flowing beneath the Landfill saturates landfill waste. The bottom 4 to 6 feet of the Landfill are believed to remain saturated under current conditions. Specifically, the discharge from adjacent bluff into the Landfill and surrounding lands acts to continually “recharge” the landfill wastes with water that forms arsenic-contaminated leachate. The leachate, in turn, migrates as contaminated groundwater from beneath the landfill into the adjacent wetlands, and seasonally into the perimeter ditch system.

Seasonal groundwater discharge to the perimeter ditches has slowly recontaminated ditch sediments. The groundwater discharge to the wetlands has resulted in a distinct plume of arsenic contaminated groundwater that seasonally discharges to land surface where it impacts “ponded” surface water quality in part of the wetlands.

Exposure to Contaminated Groundwater

Arsenic-contaminated groundwater beneath the Landfill and Wetlands areas is not in an aquifer that is currently used as a drinking water source. There is no completed hydrogeologic pathway for arsenic to reach nearby drinking water wells (i.e., City of Milton wells) based on a number of factors; including well locations upgradient of the Landfill, the depths of well completions below the Upper Sand Aquifer, and the protective aquitard and upward vertical gradients that separate the Upper Sand Aquifer from deeper aquifers. Additionally, Washington State Well Regulations require that no drinking water well be screened at depths less than 20 feet and wells are banned from being drilled within 1,000 feet of an existing landfill. As described in Section 3.2, elevated arsenic concentrations in groundwater are limited to the upper 20 feet of soil and arsenic apparently does not extend more than 700 feet away from the Landfill boundary.

The attenuation mechanisms at work in the Wetlands are limiting migration of arsenic by precipitating the arsenic onto subsurface soils. Although this reduces the concentrations in groundwater, it has not yet raised arsenic soil concentrations above background. Eventually groundwater from the Landfill discharges into Hylebos Creek. The section of the current Hylebos Creek channel located closest to the arsenic plume, near the culvert channeling the creek under I-5, is located approximately 600 feet from the downgradient end of the Wetlands plume. As indicated earlier in this section, the downgradient extent of the arsenic plume is in a relatively thin seam of sand at the base of the aquifer. Although natural attenuation is likely to prevent further movement of the plume and the arsenic has not currently reached the creek, the potential remains for a completed pathway in the future due to the proposed relocation of Hylebos Creek by WSDOT. Preliminary designs by WSDOT (refer to Figure 5) place the relocated channel within 200 feet of the known extent of the plume and could alter the existing shallow groundwater flow regime and potentially affect the stability of the plume.

Exposure to Contaminated Surface Water

The discharge of arsenic-contaminated groundwater into perimeter ditches and the groundwater-surface water interaction in the Wetlands creates the potential for surface water exposure pathways.

Contaminated ditch surface water creates a potential pathway for direct human contact under a trespass scenario. The drainage of ditch surface water to Surprise Lake Drain, which drains to Hylebos Creek, creates a potential pathway for human exposure through fish consumption and for direct contact to aquatic receptors. Available data indicate that only background concentrations of arsenic have been measured downgradient of the ditch. Changes in land use within the basin, however, may result in a complete pathway in the future if the ditches are rerouted.

The seasonally high water table creates a condition for the arsenic in the Wetlands plume to discharge and commingle with the intermittently ponded surface water in the Wetlands. This creates a potential pathway for direct human contact under a recreational or trespass scenario and for terrestrial exposure by Wetlands biota.

Ditch Sediments

Contaminated ditch sediments associated with leachate discharging to surface water in the perimeter ditches creates potential pathways for direct human and animal contact under a trespass scenario. These sediments were excavated in the 1993 Remedy removing this exposure pathway; however, seasonal discharge of leachate into the ditches continues and the sediments are slowly recontaminating; although at no where near their historical concentrations.

Wetland Soils

The concentrations of arsenic detected in shallow Wetlands soils (depths of 0 to 2 feet) are at or less than MTCA Method A CULs for arsenic of 20 mg/kg. In addition, shallow soil arsenic concentrations in Wetlands soils are within the moderate range for the Tacoma Smelter Plume area-wide contamination, and less than the Interim Action Trigger Level of 100 mg/kg (Landau 2006). Shallow Wetland soils, therefore, do not present a potential pathway for exposure. The concentrations of arsenic in deeper Wetlands soils are less than CULs, and there is no potential pathway for exposure from deeper Wetlands soils.

3.4 Cleanup Action Areas

The Site was divided into three cleanup action areas (CAAs) to facilitate the selection of the cleanup action appropriate for the Site. The CAAs are discussed below, and illustrated on Figure 14.

3.4.1 Landfill/Ditch CAA

The Landfill/Ditch CAA consists of the Landfill and the surrounding agricultural ditch system. This represents the original 18.5-acre footprint of Landfill operations. Although the Landfill was consolidated in 1993 to approximately 13 acres, the remaining acreage is used for access roads, maintenance of landfill closure systems, stormwater management, and fencing. No Landfill waste is believed to remain outside of the Landfill/Ditch CAA. The agricultural ditch system that surrounds the Landfill drains to the west, where it joins the Surprise Lake Drain.

3.4.2 Wetlands CAA

The Wetlands CAA consists of that section of wetlands immediately downgradient of the Landfill that contains arsenic-contaminated groundwater released from the Landfill that remains above the cleanup level. This plume has been stable in size since its discovery in 2001. On the south, it is bounded by Puget Power Access Road and then the Landfill/Ditch CAA, on the east and west it is bounded by groundwater that meets the groundwater CUL established for the Site. Near the Landfill, contamination is present throughout the shallow aquifer and has a potential to seasonally discharge to the land surface. As the groundwater moves to the north, (the direction of groundwater flow) the upper reaches of the aquifer comply with the groundwater CUL and no exposure is present in the surface soils or near-surface groundwater; however, contaminated groundwater remains at the base of the shallow aquifer. The northern boundary of the Wetlands CAA is taken as E. 12th St. This unused right-of-way acts as a property line for ownership of the Wetlands CAA, and represents the location where only a narrow seam of contamination at the base of the shallow aquifer remains. Contaminated groundwater remains at the base of the aquifer but can not reach terrestrial receptors in the Wetlands. This contamination at the base of the aquifer is included in the next cleanup area, the End of Plume CAA.

3.4.3 End of Plume CAA

The End of Plume CAA is defined as the extension of the Wetlands CAA’s groundwater plume at E 12th St. Within the End of Plume CAA, soils already comply with CULs, as does the upper section of the Upper Sand Aquifer. The area is defined by a narrow seam of groundwater contamination at the base of the aquifer that is less than or equal to 5 feet thick and less than 200 feet wide. There is no known current exposure to this contamination. However, depending on the rate of naturally occurring attenuation and future plans by WSDOT to relocate Hylebos

Creek as part of the SR 167 project, it may reach Hylebos Creek in the future unless action is taken.

Remedial alternatives implemented in the upgradient Landfill/Ditch CAA and the Wetlands CAA are expected to control the source of contamination in this area. However, additional alternatives are proposed for the End of Plume CAA to speed its recovery and bring it into compliance in a faster time frame.

4.0 CLEANUP STANDARDS

4.1 Remedial Action Objectives (RAOs)

RAOs are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, including:

- Implement administrative principles for cleanup (WAC 173-340-130);
- Meet requirements, procedures, and expectations for conducting an FS and developing cleanup action alternatives (WAC 173-340-350 through 173-340-370); and
- Develop CULs (WAC 173-340-700 through 173-340-760).

In particular, RAOs must include the following threshold requirements from WAC 173-340-360:

- Protect human health and the environment;
- Comply with CULs;
- Comply with applicable state and federal laws; and
- Provide for compliance monitoring.

In addition to the threshold requirements, the following selection criteria, provided in WAC 173-340-360, allow for selecting among alternatives that meet the threshold requirements. The selection criteria require cleanup actions to:

- Use permanent solutions to the maximum extent practicable;
- Provide for a reasonable restoration time frame; and
- Consider public concerns.

MTCA [WAC 173-340-350(8)] allows for an initial screening of possible alternatives that eliminates those alternatives that do not meet the threshold requirements, are disproportionately costly compared to other alternatives that meet the threshold requirements, or are technically impossible at the Site.

Once the initial screening has been performed and several alternatives remain that meet the threshold requirements, a more detailed analysis to select the alternative that "uses permanent solutions to the maximum extent practicable" is performed. This review makes use of a "disproportionate cost" analysis. If one alternative is clearly preferred by both Ecology and the PLP at this stage, this analysis is not required [WAC 173-340-360(3)(d)]. In the disproportionate cost analysis, the following criteria are evaluated [WAC 173-340- 360(3)(e and f)]:

- Overall protectiveness;
- Permanence;
- Cost;
- Effectiveness over the long term, which includes reductions in toxicity, mobility, and volume;
- Management of short-term risks;
- Technical and administrative implementability; and
- Consideration of public concerns.

In addition to these criteria, the restoration time frame must be considered when choosing between alternatives.

MTCA also sets forth requirements specifically for groundwater cleanups. Cleanup actions for groundwater must be permanent, or, if non-permanent, must contain and either treat or remove the source of any release that cannot be reliably contained.

MTCA also includes the following expectations, paraphrased from WAC 173-340-370, that are potentially appropriate for the Site.

- Treatment technologies will be emphasized at sites with areas contaminated with high concentrations of hazardous substances, highly mobile materials, and/or discrete areas of hazardous substances that lend themselves to treatment.
- Engineering controls, such as containment, are appropriate for sites or portions of sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable.
- Active measures will be taken to prevent/minimize releases to surface water via surface runoff and groundwater discharges in excess of CULs.
- Natural attenuation of hazardous substances may be appropriate at sites where source control has been conducted to the maximum

> extent practicable; leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health or the environment; there is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

The RAOs for the Site are also guided by specific MTCA requirements defined in WAC 173-340-360 for groundwater cleanup actions, institutional controls, releases and migration, and remediation levels.

Soils that are contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) are met:

> *WAC 173-340-740 (6) (f)*
>
> *The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:*
>
> *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
>
> *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
>
> *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
>
> *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
>
> *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*

(vi) The types, levels, and amount of hazardous substances remaining on site and the measures that will be used to prevent migration and contact with those substances are specified in the draft.

4.2 Applicable or Relevant and Appropriate Requirements (ARARs)

The selected groundwater alternative must comply with MTCA cleanup regulations (Chapter 173-340 WAC) and with applicable state and federal laws. Under WAC 173-340-350 and 173-340-710, the term "applicable requirements" refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a COC, remedial action, location, or other circumstance at the facility. The "relevant and appropriate" requirements are regulatory requirements or guidance that do not apply to the facility under law, but have been determined to be appropriate for use by Ecology. ARARs are discussed in more detail in the GAE Report (Appendix A).

Remedial actions conducted under a consent decree with Ecology must comply with the substantive requirements of the ARARs, but are exempt from their procedural requirements, such as permitting and approval requirements [WAC 173-340-710(9)]. This exemption applies to state and local permitting requirements, including; the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Hazardous Waste Management Act, the Clean Air Act, the State Fisheries Code, the Shoreline Management Act, and local laws requiring permitting.

The Washington State Environmental Policy Act (SEPA) (RCW 43.21C) requires, among other things, that state and local governments consider impacts to cultural resources when assessing projects. The CAP will be conducted in a manner that is sensitive to cultural resources and complies with applicable state laws and regulation including a survey or assessment of cultural resources and consultation with the Puyallup Tribe. Background historical research will be conducted with the Department of Archaeology and Historic Preservation (DAHP) and reported as appropriate during implementation of the CAP. An archaeological assessment will also be performed during implementation of the CAP. ARARs for the archaeological assessment and historical research are identified below.

4.2.1 State and Local ARARs

The following state and local ARARs have been considered in selecting the remedy:

- Model Toxics Control Act Cleanup (Chapter 173-340 WAC)
- Sediment Management Standards (Chapter 173-204 WAC)
- Water Quality Standards for Washington Surface Waters (Chapter 173-201A WAC)
- Washington State Shoreline Management Act (RCW 90.58, Chapter 173-18 WAC, Chapter 173-22 WAC, and Chapter 173-27 WAC)
- Pierce County Shoreline Management Use Regulation (Title 20)
- Pierce County Development Regulations—Critical Areas (Title 18E)
- Pierce County Ordinances (Title 13.06 for Publicly Owned Treatment Works), and National Pretreatment Requirements (40 CFR 403)
- Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC)
- Washington State Environmental Policy Act (RCW 43.21C)
- Washington State Hydraulics Projects Approval (RCW 77.55; Chapter 220-110 WAC)
- Washington Dangerous Waste Regulations (Chapter 173-303 WAC)
- Water Quality Standards for Surface Waters of the State of Washington (RCW 90.48 and 90.54; Chapter 173-201A WAC)
- State, and Local Air Quality Protection Programs
- State of Washington Worker Safety Regulations
- Washington's Indian Graves and Records Law (RCW 27.44); Archaeological Site Assessment Requirements (RCW 27.44 and 27.53);

4.2.2 Federal ARARs

The following federal ARARs have also been considered in remedy selection:

- The Clean Water Act (33 USC 1251 et seq.)
- National Toxics Rule (40 CFR 131.36 et seq.)
- Magnuson-Stevens Act (16 USC § 1801 et seq.)
- Comprehensive Environmental Response Compensation, and Liability Act of 1980 (42 USC 9601 et seq. and 40 CFR 300)

- Endangered Species Act (16 USC § 1531 et seq.)
- Native American Graves Protection and Repatriation Act (25 USC 3001 through 3113; 43 CFR Part 10
- Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR Part 7)
- National Historic Preservation Act (16 USC 470 et seq.; 36 CFR Parts 60, 63, and 800)

4.3 Cleanup Standards Established for the B&L Woodwaste Site

4.3.1 Cleanup Levels

The Table below presents the CULs established by Ecology for the Site. The Site has been in compliance for all COCs except arsenic since the implementation of the 1993 remedy. Therefore, Ecology is shortening the COC list for future compliance to include only arsenic. For completeness, arsenic cleanup levels for soil, sediment, groundwater, and surface water are included in this CAP.

B&L Woodwaste Site Cleanup Levels

Parameter	Soil/Fill[(a)] in mg/kg	Groundwater[(b)] in µg/L	Surface Water in µg/L	Sediments[(d)] in mg/kg
1991 CAP COCs				
Arsenic	20 (e)	5.0 (e,j) 10.0 (f)	5.0 (h) 10.0 (f)	20 (e)
Copper	--	--	12.0	390 (g)
Lead	250 (e)	5.0 (e,j) 10.0 (f)	3.0 (h) 1.0 (f)	250 (e)
Nickel	--	320 (i)	--	--
Phenol	--	9,600 (i)	2,560 (c)	--
Current CAP COC				
Arsenic	**20 (e)**	**5.0 (e,j)**	**5.0 (h)**	**20 (e)**

Notes:

a More restrictive soil cleanup levels may be required to maintain compliance with groundwater and surface water cleanup levels.

b Points of compliance are the Upper Aquifer and Lower Aquifer at the Slurry Wall boundary.

c USEPA ambient freshwater quality chronic criterion.

d Cleanup levels have been chosen as the more stringent level between MTCA residential soil cleanup level, Commencement Bay ROD sediment cleanup objectives, and Ecology salt water sediment cleanup level.

e MTCA Method A residential cleanup levels.

f Practical Quantitation Level (PQL). These values serve as the cleanup level where listed. If lower PQLs become achievable during the cleanup an evaluation will be made to determine whether cleanup levels should be lowered by Order/Agreed Order/Consent Decree amendment.

g Sediment Management Standards Minimum Cleanup Levels WAC 173-204-520.

h National Toxics Rule; defaulting to the State of WA background level of 5.0 µg/L used in MTCA Method A Groundwater Standard.

i MTCA Method B Cleanup Levels.

j Natural background may be demonstrated by Ecology to be higher than the cleanup level per WAC 173-340-708(11). In that case, natural background concentration may be substituted by Ecology as cleanup level.

4.3.2 Point of Compliance

Per WAC 173-340-720(8)(c) a Conditional Point of Compliance (CPOC) for soil, sediment, groundwater and surface water is established at the landfill/cap perimeter areally, extending downward through the first aquitard vertically.

4.4 Remedial Action Objectives for Each Cleanup Area

The following section discusses narrative performance standards for each of the cleanup areas.

4.4.1 Landfill/Ditch CAA

Remedial Action Objectives

Since the installation of the 1993 Remedy, the exposure pathways from the Landfill are limited to the migration of arsenic-contaminated groundwater beyond the perimeter of the Landfill and into the surrounding ditches and adjacent Wetlands area.

The drainage ditch system along the perimeter of the Landfill presents potential exposure pathways to terrestrial receptors (animals and birds) and occasional recreational human users. Both groups would come into incidental direct contact with the surface water and sediments. Since water from the ditches eventually drains into Hylebos Creek, there is also the potential for contamination from the perimeter ditches to reach Hylebos Creek, although current data indicate that this has not happened since the 1993 remedy was implemented.

The following RAOs apply to this action area:

- Meet MTCA Threshold Requirements, as defined by WAC 173-340-760(6)(f) for containment remedies;

- Implement closure requirements from Minimum Functional Standards for Solid Waste Landfills (Chapter 173-304 WAC);
- Prevent arsenic-containing groundwater from migrating beyond the Landfill into adjacent wetlands and agricultural drainage ditches;
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent possible; and
- Protect the sediment and surface water quality of Hylebos Creek (and associated restoration projects) from arsenic releases from the Landfill.

Cleanup Levels

The CUL for arsenic in **soil** is 20 mg/kg. The point of compliance for soil, as defined in WAC 173-304-462(2)(e)(i) and WAC 173-304-100, is limited to those soils that are outside the footprint of the Landfill containment area. Since this CAA only includes the Landfill footprint and surrounding ditches, this effectively means that the clean soil layer of the Landfill cap must meet the soil CUL.

The CUL for arsenic in **groundwater** is 5 μg/L or the background level, whichever is higher. The conditional groundwater point of compliance for the Landfill is the edge of waste. A series of groundwater wells (most of which already exist) will be installed (by the remedy selected for the Site) around the perimeter of the Landfill and will act to measure groundwater quality at the edge of waste. Monitoring at this point will be used to assess the successful implementation of source control at the Landfill. As discussed in the next section on the Wetlands CAA, 12th Street East is considered to be the best location to quickly stop the migration of the arsenic plume, as required by WAC 173-340-360(2)(f), because of this former road bed's access to the far end of the plume prior to its potential future discharge to Hylebos Creek.

The CUL for arsenic in **sediment** is 20 mg/kg and includes consideration for the protection of Hylebos Creek. The point of compliance for this area is throughout the ditch system.

The CUL for arsenic in **surface water** is 5 μg/L or the background level, whichever is higher. Because much of the surface water comes from groundwater recharge (these are drainage ditches for flooded agricultural lands), the regional groundwater background concentration has been considered in establishing the surface water standard. The point of compliance for surface water is everywhere within the perimeter ditch system.

4.4.2 Wetlands CAA

Remedial Action Objectives

Because of the discharge of arsenic-contaminated groundwater into the Wetlands CAA, there is a risk of arsenic exposure to human and ecological receptors. This risk of exposure does not necessarily correspond to risks of toxic effects, degradation, bioaccumulation, or other harms to ecological receptors. There is no evidence that such harm has or is currently taking place.

The RAOs for this CAA include the following objectives to prevent or minimize exposure to the Upper Sand Aquifer and surface water, as well as exposure to surface water and sediments in the Wetlands CAA.

The following RAOs apply to this CAA:

- Meet MTCA threshold requirements, including protection of recreational, human and ecological receptors from arsenic contamination that is seasonally present in ponded surface water, soil porewater, and groundwater;
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable;
- Remove or control the potential for the groundwater plume in the Wetlands CAA to continue to migrate downgradient into the End of Plume CAA, within a reasonable restoration timeframe; and
- Ensure remediation activities in Wetlands CAA will be consistent with the potential restoration activities in the area associated with the WSDOT SR 167 Project and potential Hylebos Creek relocation. Coordination with the WSDOT planning process is anticipated to ensure the selected alternative will not negatively impact the planned riparian restoration along Hylebos Creek.

Cleanup Levels

The CUL for Wetlands soils is 20 mg/kg. The point of compliance is the upper 15 feet of the Wetlands soils throughout the cleanup area.

The CUL for groundwater in the Wetlands CAA is 5 µg/L.. This CUL protects potential future drinking water uses (minimum 1,000 feet from the Landfill) and protects surface water quality at Hylebos Creek. The existing groundwater plume extends to the vicinity of 12th Street East; whereas both of these potential future receptors are well downgradient of 12th Street East. Between the Landfill and 12th Street East, the property is owned by a private party who has granted access for investigation tasks only. Beyond 12th Street East the wetlands are owned by the municipal parties. The WSDOT SR 167 project would relocate Hylebos Creek much closer to 12th Street East and, therefore, potentially alter the current groundwater flow regime. 12th Street East is considered to be the best location to quickly stop the migration of the arsenic plume, as required by WAC 173-340-360(2)(f), because of this former road bed's access to the far end of the plume prior to its potential future discharge to Hylebos Creek.

As discussed in Section 5, no feasible alternative was identified that would comply with CULs throughout the Wetlands CAA in a reasonable restoration time frame. Alternatives were identified, however, that would be able to meet CULs relatively quickly at 12th Street East. For this reason, alternatives in the Wetlands CAA were evaluated in their ability to (1) protect human health and the environment throughout the Wetlands, (2) treat Wetlands arsenic to the maximum extent practicable, and (3) support the rapid cleanup action at the End of Plume CAA.

4.4.3 End of Plume CAA

Remedial Action Objectives

The following RAOs apply to this CAA:

- Meet MTCA threshold requirements, including considerations for the long-term potential for the plume to reach Hylebos Creek;
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent possible; and
- Ensure that remediation activities in the End of Plume CAA will be consistent with the potential restoration activities in the area associated with the WSDOT SR 167 project and potential Hylebos Creek relocation. Coordination with the WSDOT planning process is anticipated to ensure the selected alternative will not negatively impact the planned riparian restoration along Hylebos Creek.

Cleanup Levels

Soils in the End of Plume CAA already comply with MTCA. The CUL for arsenic in groundwater is 5 μg/L. Within the End of Plume CAA, there appears to be no current exposure to the thin seam of arsenic-contaminated groundwater at the base of the aquifer. Potential future exposures in this area could be controlled with institutional controls if the owner of the property agrees. Beyond 12th Street East, the PLPs do not have reasonable controls on the use of groundwater, and exposure at Hylebos Creek could conceivably occur at some time in the future, especially if the creek is rerouted by WSDOT. Therefore, groundwater at the far side of 12th Street East must comply with the CUL throughout the Upper Sand Aquifer.

5.0 DESCRIPTION AND EVALUATION OF CLEANUP ALTERNATIVES

The GAE Report (Appendix A) contains a detailed screening and evaluation of technologies for the Landfill, Wetlands, and End-of-Plume CAA. Ecology determined that the screening of technologies was adequate to for Ecology to build specific alternatives to be considered at the Site. The alternatives have a series of "common elements" that appear in all alternatives.

5.1 Identification of Cleanup Alternatives

Ecology identified the following 5 cleanup alternatives for further evaluation:

- Alternative 1:Slurry Wall Containment
- Alternative 1a: Slurry Wall with Hydraulic Control
- Alternative 2: Slurry Wall Containment with Waste Dewatering
- Alternative 3a: Excavation and Disposal of Landfill Waste ("Dig and Haul")
- Alternative 3b: Excavation and Disposal of Landfill Waste and Contaminated Soils Below the Landfill Waste ("Deep Dig and Haul")

A number of remedy elements are common to all of the above alternatives, as listed below:

- Excavation of contaminated sediment in perimeter ditches.
- Installation of an upgradient interceptor trench
- Pumping and treatment of groundwater along the Landfill perimeter outside of the slurry wall
- Pumping and treatment of groundwater in the Wetlands CAA
- In situ sequestration and monitored natural attenuation in the End-of-Plume CAA.
- Long Term Monitoring and Maintenance

5.2 Common Elements to All Cleanup Alternatives

The common elements are briefly described below. Further information on each element is described in the GAE report (Appendix A).

Excavation of Sediment in Ditches

Excavation of ditch sediments was performed during the Landfill consolidation and capping in 1993. Localized recontamination has occurred due to the continued discharge of arsenic-contaminated groundwater and precipitation of arsenic into ditch sediments. The depth of ditch sediment contamination in the perimeter ditches is generally limited to approximately the upper 12 inches and therefore, is easily mucked out by a backhoe. Additional sampling would need to be performed to identify specific sections of the ditch where contaminant concentrations exceed CULs before remediation would begin and also after remediation to confirm compliance. For the purposes of this document, it is assumed that the affected ditch segment starts at the adjoining apartment complex and continues until approximately 400 feet downgradient of the Landfill (sediment Station SW-4). Assuming a 3-foot wide ditch bottom dug 12 inches, on average, this represents approximately 250 tons of sediment. The sediments would be stabilized, as necessary, to reduce their water content and then disposed of at a permitted landfill. The ditches would remain, following excavation, and continue to function to drain the agricultural fields and apartment complex.

Upgradient Interceptor Trench

The natural groundwater flow through the Landfill will be blocked by the installation of a slurry wall, and will instead migrate around the sides of the slurry wall. If the natural rate of migration is thus limited, this may cause groundwater along the upgradient section of the slurry wall to build up, causing uneven hydrostatic pressure on the slurry wall and/or groundwater ponding. This pressure could be alleviated by interceptor drains or other means (e.g., French drains) that would funnel away upgradient groundwater. Upgradient clean water in the upper section of the Shallow Sand Aquifer will be intercepted by the trench system before it reaches the Landfill and will be redirected within the watershed. This will lower the hydraulic gradient in the aquifer between the bluff and the Landfill. This alone is expected to greatly decrease the amount of water entering the Landfill area and forming leachate. Therefore, the interceptor trench is a major component of the proposed slurry wall remedy.

Treatment of Groundwater Outside the Landfill Perimeter

Groundwater containing arsenic at concentrations above CULs was detected in Wells D-8, D-9, and MW-23 at locations (refer to Figure 11) adjacent to but outside of the perimeter of the existing Landfill cover. This area of contamination, present in some areas just outside the landfill's perimeter ditch system, has been referred to as the "halo". Pumping wells will be used to remove the contaminated groundwater and it will be treated to remove the arsenic along with groundwater treatment occurring in other parts of the Site. The quantity of water, and the length of time that groundwater would have to be removed and treated at these locations is not known at this time but will be evaluated during the design stage.

Pumping and Treatment of Groundwater in the Wetlands CAA

The proposed remedy for the Wetlands CAA is pumping of groundwater from the Upper Sand Aquifer beneath the Wetlands, treatment of the groundwater to remove arsenic and iron, and re-infiltration of the treated groundwater into existing stormwater ponds or back into the Wetlands. The intent is to install a number of pumping wells in order to quickly remove dissolved arsenic mass from the system as quickly as possible. The work can only be performed in the dry season due to the surface water ponding and flooding that occurs in the wet season, which would greatly limit the effectiveness of mass removal by pumping. Some rebound of arsenic concentrations from the soil is expected following shutdown of pumping; therefore, it is not known how many years it will take to permanently achieve cleanup levels. However, the intent is to use groundwater pump and treat as a rapid method for mass reduction, to better protect downgradient and surface water receptors.

In situ ***Sequestration and Monitored Natural Attenuation in the End-of-Plume CAA***

This remedy consists of enhancing the natural attenuation that is already occurring by adding specific sequestration agents that will act to quickly and, to the extent possible, irreversibly to precipitate the dissolved arsenic. This will be accomplished along the 12th Street East right of way. This location was selected for the following reasons:

- The 12th Street East right of way is an unused roadway that cuts through the wetlands and allows for easy access to the Wetlands without further disruption to the Wetlands.
- The land between the Landfill and 12th Street East is owned by a single party, which will simplify the process for obtaining access agreements and institutional controls, although it may still be difficult to do so.

- The residual contamination at 12th Street East exists as a thin seam of moderately elevated arsenic at the base of the aquifer in a well defined and accessible sand zone.
- Land beyond 12th Street East is planned for habitat restoration, including the potential relocation of Hylebos Creek, making the control of arsenic at 12th Street East critical.

A series of injection wells or a single trench will be used to inject the sequestering solution into the base of the aquifer where natural conditions are already reducing and favorable. On the downgradient side of 12th Street East, compliance monitoring wells will be installed to monitor the success of the remedy and confirm compliance with Site arsenic cleanup standards.

Long Term Monitoring and Maintenance

This common element consists on continuing the maintenance obligations for the 1993 remedy including inspection and repairs of the cap, fence, stormwater controls, and passive gas system. Additionally, the selected remedy will include new systems for each of the CAA that each involve operation, long term monitoring and maintenance to be successful. A financial mechanism is needed to ensure the availability of funding for operation, maintenance and monitoring of this long term project. A combined operations, maintenance and monitoring plan for the entire Site will be developed during the design and implementation phase.

5.3 Landfill/Ditch CAA Alternatives

The RAOs for the Landfill CAA will be met by preventing arsenic-contaminated leachate from migrating beyond the edge of the waste. Technologies that involve simply pumping or dewatering of the leachate to achieve this were excluded as impractical or ineffective. The retained remedial technologies were those that will contain groundwater within the Landfill/Ditch CAA or alternatively, removal of the landfill waste itself as well as contaminated soils below the landfill waste that would continue to contribute to groundwater contamination following removal of only the landfill waste.

Additionally, sediment in the nearby agricultural drainage ditches has become recontaminated since the 1993 remedy was installed. While the Landfill CAA alternatives would eliminate future recontamination of the ditches, contaminated sediment that is presently in the ditches will need to be remedied.

Alternative 1 - Slurry Wall without Hydraulic Control and Alternative 1a - Slurry Wall with Hydraulic Control

Alternative 1 is a passive (no leachate pumping) slurry wall with an upgradient interceptor trench. Alternative 1a incorporates technical enhancements that augment the effectiveness of the passive slurry wall by including:

- Pumping of groundwater/leachate within the slurry wall to maintain hydraulic control.
- Extraction and treatment of the water removed from within the slurry wall.
- Construction of a permanent facility to treat groundwater.
- Pump and treat of groundwater from contaminated well locations D-8, D-9 and MW-23; located outside the slurry wall.

The reduction in the water level inside the slurry wall will create a hydraulic head that will develop an inward gradient for water outside the wall, and increase the ability of the wall to prevent the horizontal flow of contaminated groundwater. The additional upward flow of 'clean' groundwater from the Lower Aquifer to the Upper Aquifer within the slurry wall may also increase the ability of the wall to contain contaminants in the Upper Aquifer. The rate of upward flow from the Lower Aquifer will be monitored.

The drawdown of leachate within the slurry wall will proceed in an incremental manner to first identify the groundwater level that ensures a small upward gradient from the Lower Aquifer to the Upper Aquifer.

Alternative 2 – Slurry Wall and Landfill Waste Dewatering

Alternative 2 adds one additional treatment element to the remedy proposed by Alternative 1a—the pumping of additional leachate from within the slurry wall to lower the water level to a level below the landfill waste that increases the upflow of groundwater from the Lower Aquifer to the Upper Aquifer.

Alternative 2 would initially remove leachate to lower the water level within the slurry wall (approximately 11 feet MSL when the slurry wall is initially installed) to a level that increases the upflow of groundwater from the Lower Aquifer to the Upper Aquifer with the goal of lowering the groundwater to a level that is lower than the base of the wood waste, slag, and other debris (approximately 6 feet MSL). Continued extraction of leachate would be required permanently to prevent the leachate levels from rising up into the waste materials following cessation of pumping.

This approach provides a level of protection beyond that provided by Baseline Alternatives 1 and by Alternative 1a. Alternative 2 removes and treats additional arsenic by extracting more groundwater that may accumulate within the slurry wall than Baseline Alternative 1 or Alternative 1a. By keeping the waste de-watered, Alternative 2 should result in cleanup over time of the aquifer within the slurry wall, such that the degree of treatment needed may eventually be reduced or eliminated. An added benefit of reducing the arsenic concentration inside the slurry wall would be to reduce any damage which might be done by future short term leaks through the containment wall.

As in Alternative 1 and Alternative 1a, Alternative 2 includes an interceptor drain upgradient of the slurry wall. This drain would redirect water coming off the bluff from the upgradient edge of the slurry wall and prevent it from flowing under the Landfill. The location of the trench is shown in Figure 16. This water will be diverted to the agricultural drainage ditch system at the southern boundary of the Landfill.

It may not be possible to reduce the level of groundwater within the slurry wall to a level that is below the level of the waste in the Landfill without potentially damaging the containment system (i.e., slurry wall and aquitard). Monitoring of groundwater, both inside and outside of the slurry wall, will be used to ensure that this will not occur. Similar to Alternative 1a, this alternative also removes arsenic as the water pumped is extracted and treated each day.

Alternative 3 – Alternative 3(a and b) — Excavation and Disposal of Contaminated Soils within the Landfill

Alternative 3a installs a sheet pile wall to a depth of approximately 15 feet below grade or until a connection to the aquitard is achieved, and installs an upgradient interceptor trench. The sheet pile wall will connect with the aquitard layer, and the existing Landfill cover will be removed. Wood waste and other materials in the Landfill will be removed from the top downward. It is expected that the Landfill mass will not require dewatering until the excavation reaches an elevation of about 13 feet MSL, a level that is 2 feet above the expected level of leachate in the Landfill area (11 feet MSL when the sheet pile wall is initially installed). Wood waste and other materials removed from below an elevation of about 13 feet MSL will require dewatering prior to disposal.

The volume of original Landfill waste is estimated to total approximately 350,000 cubic yards (Floyd|Snider 2007a). This estimate assumes that the bottom of the Landfill lies at an elevation of 8 feet MSL. As discussed in Section 2.3, the top 2 to 3 feet of soil within the B&L Property were mixed into the Landfill waste as it was emplaced. Alternative 3a excavates soil within the slurry wall to a depth of 6 feet MSL. The total volume of soil that would be excavated by Alternative 3a is estimated to be approximately 400,000 cubic yards or a mass of approximately 480,000 tons (assuming a bulk density of 1.2 tons/cy).

Alternative 3b removes both the capped waste as well as contaminated sub-soils existing beneath the waste and down to the aquitard layer. This Alternative will excavate soil to a depth of 4 feet MSL (approximate top of the aquitard). This will require that the sheet pile wall be driven down to about 30 feet below grade. Alternative 3b, also includes the upgradient interceptor trench. Approximately 620,000 cubic yards of waste and soil (or approximately 745,000 tons assuming a bulk density of 1.2 tons/cy) would be excavated as part of Alternative 3b. The sheet pile wall will be removed (optional) once the excavation for Alternative 3b has been backfilled.

Water removed from the Landfill mass is likely to contain arsenic at concentrations that exceed CULs. This water will be treated by the groundwater treatment system proposed in Alternative 1a and 2. For Alternative 3a, it is expected that approximately 5 million gallons of water will result from the dewatering process. This water will be treated at a rate of 15 gpm for a period of approximately 230 days.

For Alternative 3b, it is expected that approximately 18 million gallons of water will be produced during the dewatering process. This water will be treated at a rate of 40 gpm for a period of approximately 320 days over two construction seasons. The sheet pile wall can be removed once the excavation for Alternative 3b has been backfilled. Therefore, groundwater extraction and treatment from within the sheet pile wall under Alternative 3b will be focused on dewatering the Landfill mass, rather than on creating an inward hydraulic gradient across the sheet pile wall.

Wood waste and other materials removed from the Landfill will be stockpiled on Site, prior to transport and disposal at an appropriate landfill. The soils excavated will likely consist of some soils that will require disposal in a RCRA Subtitle C (hazardous) landfill and other soils that can be disposed of at a RCRA Subtitle D disposal facility. For the purposes of this evaluation, it was assumed that 75 percent of the excavated soils could be disposed of at a Subtitle D facility, while 25 percent would require disposal at a RCRA Subtitle C facility.

The segregation of Subtitle C from Subtitle D soils will be difficult; and may not be practicable. Pilot-scale tests will be needed to address this issue. These tests will be conducted during the engineering design phase of the project.

The existing Landfill cover is made up of five layers and consists of a geosynthetic clay liner, a 40 mil polyvinyl chloride (PVC) liner, a geocomposite drainage net, 19 inches of sandy pit run, and 6 inches of topsoil (Hydrometrics 1994).

Since soils below the existing grade at the Site will be excavated, it will be necessary to import fill material. This fill material will be needed to create a surface contour that will effectively drain rainwater from the new cap for Alternative 3a. Approximately 300,000 cubic yards of imported fill will be required to bring the grade within the sheet pile wall from 6 feet MSL to 11 feet MSL for Alternative 3a and approximately 845,000 cubic yards of imported fill will be required to bring the grade within the sheet pile wall from –4 feet MSL to 11 feet MSL for Alternative 3b.

5.4 Comparative Analysis of Landfill Remedial Alternatives

Containment vs. Excavation and Disposal Alternatives

The 1993 Remedy was effective in eliminating the potential for direct contact to the Landfill waste and ditch sediment, and in eliminating leachate production via stormwater, and thus reducing certain risks to human health and the environment. Despite this, a number of potential exposure routes remain, all of which stem from contaminated groundwater. While leaching associated with stormwater infiltration is controlled by the consolidation and capping, leachate is still produced when groundwater flowing beneath the Landfill saturates landfill waste, which has no liner beneath it. Arsenic in this leachate travels away from the Landfill via groundwater. Contaminated groundwater has the potential to contaminate other media that may provide additional transport or exposure pathways. Groundwater discharge to the perimeter ditches or in the Wetlands area has re-contaminated ditch sediments and seasonally may impact Wetlands surface water quality.

The focus of remedial activities at the Site is protecting potential human and ecological receptors from exposure to arsenic. The primary exposure routes are as follows:

- Wetlands biota and human trespasser exposure to contaminated surface water and/or shallow groundwater in the Wetlands CAA.

- Biota and human trespasser exposure to contaminated surface water and/or ditch sediments in the perimeter ditches.
- Potential exposure at Hylebos Creek due to discharge of contaminated groundwater into the Creek.

The decision of whether to use containment or “dig and haul” must be based on an assessment of the reduction in risk that the alternative provides to these receptors. Since each of the alternatives (1, 1a, 2, 3a, and 3b) evaluated remediate the ditch sediments in the same way, only the environmental benefits provided to the potential receptors in the Wetlands CAA by each alternative was assessed as part of this disproportional cost analysis.

Leaching of arsenic from the landfill waste by groundwater flowing below the Landfill toward the Wetlands is the source of the arsenic that is present in Wetlands surface water, groundwater, and soils. Thus cleanup of this groundwater is the driver for this evaluation. The ability of containment alternatives (1, 1a, and 2), and excavation and disposal alternatives (3a and 3b) to effect the cleanup of groundwater in the Wetlands CAA is a key factor in the disproportional cost analysis used to select a remediation approach at the Site.

Alternatives 3a and 3b treat the groundwater in the Wetlands and End of Plume CAAs in the same way and for the same duration as the groundwater treated by Alternatives 1a and 2. This occurs since it is expected that ‘arsenic rebound’ will occur once an initial volume (about 20 million gallons) of groundwater and surface water in the Wetlands is treated (refer to Section 3.2). Ecology expects that up to approximately 120 millions gallons of groundwater and surface water in the Wetlands CAA may require treatment, and that the End of Plume treatment system may have to operate for up to 30 years to achieve CULs, regardless of whether an excavation and disposal or an effective containment alternative is selected for the Site.

Alternative 3a also excavates and disposes of approximately 400,000 cubic yards of landfill waste. Alternative 3b excavates and disposes of all of the landfill waste, plus contaminated sub-soils that are present above the aquitard (approximately 620,000 cubic yards). Both of these alternatives provide a higher degree of protection to the environment as a whole than do any of the containment alternatives that were evaluated.

However, the cleanup of groundwater in the Wetlands does not benefit by Alternatives 3a or 3b if: 1) it is possible to construct a competent slurry wall or sheet pile containment around the landfill waste to stop horizontal groundwater flow; 2) there is a competent aquitard below the Upper

Aquifer at the Site; and 3) the successful operation and maintenance of the barrier and water treatment systems can be maintained over the long term. Ecology's analysis of existing data suggests that these three items are more likely than not to be valid (refer to Section 3). Thus each alternative was presumed capable of stopping the flow of contaminated groundwater from below the Landfill to the Wetlands CAA.

Alternatives 3a and 3b provide more protection to the "environment as a whole" than the containment alternatives since these excavation alternatives directly remove arsenic and other COCs from the Landfill.

Alternatives 3a and 3b would provide much higher short-term risks to human health and the environment than would the containment remedies. Developing detailed work plans and health and safety plans could mitigate these risks.

Both the containment remedies and Alternatives 3a and 3b could potentially comply with cleanup standards and likely exhibit equivalent technical and administrative implementability. Both the containment remedies and Alternatives 3a and 3b are expected to take up to 30 years to bring the Wetlands and End of Plume CAAs into compliance with CULs. The containment alternatives and Alternative 3a are expected to operate for 50 years or longer since these alternatives remove groundwater from within the barrier. This groundwater must be treated for as long as it is produced. Groundwater treatment for Alternative 3b is expected to operate for a shorter time period (up to 30 years) since pumping within a barrier is not required under this excavation option.

This conceptual-level (±25 percent) cost estimate prepared for each alternative uses an interest rate of 2 percent and a duration of 50 years to compute the net present value of most recurring annual costs. The present worth factor associated with this interest rate and duration is 31.424. If the duration was increased to 100 years, the present worth factor would become 43.098.

The estimated cost (±25 percent) of each alternative was developed in Sections 5.1 through 5.4 and is summarized below:

Alternative	Costs for Years 1 & 2	Costs for Years 3 to 5	Total
1	$3.6 million	$3.7 million	$7.3 million
1a	$6 million	$12 million	$18 million
2	$7 million	$13 million	$20 million
3a	$73 million	$13 million	$86 million

3b	$114 million	$8 million	$122 million

Since each alternative is considered to be equally capable of stopping the flow of contaminated groundwater from below the Landfill to the Wetlands CAA and able to treat groundwater in the Wetlands and End of Plume CAAs, each alternative should provide a generally equivalent degree of protection to the receptors of interest in the Wetlands CAA. Because the cost of Alternatives 3a and 3b ($86 to $122 million) are substantially greater than equally protective containment Alternatives 1, 1a, and 2 ($7 to $20 million), the cost of excavation is judged to be disproportional to the benefits provided to the treatment of Site groundwater alone. **Thus the excavation and treatment alternatives were not selected for implementation at the Site.**

Selecting Among the Containment Alternatives

The three containment alternatives were described above and include:

- Baseline Alternative 1—Containment with Groundwater Controls (Sections 5.1 through 5.3);
- Alternative 1a—Alternative 1 with Additional Protections Added (Section 5.4.1); and
- Alternative 2—Reduce Water Level within Containment Wall to Below Level of Waste (Section 5.4.2).

Alternative 1a was developed to address technical uncertainties that were inherent in Alternative 1, and includes additional protections to safeguard human health and the environment by increasing the likelihood that a containment remedy would protect receptors in the Wetlands and End of Plume CAAs. These additional enhancements would only be implemented if needed to meet the performance criteria as discussed in Section 6; they include:

- Installation of an internal drain within the slurry wall to create an inward groundwater flow gradient across the barrier;
- Extraction and treatment of up to 1,000 gallons/day of water removed from within the slurry wall;
- Ten additional treatment passes (about 100 million gallons) for the water within the Wetlands (assumed needed to meet a “process” performance specification);
- 25 additional years of operation of the End of Plume in situ treatment system (assumed needed to meet a “performance” specification);
- Extraction and treatment of groundwater from locations D-8, D-9 and MW-23; and

- Establishment of a trust fund or similar financial mechanism to support the long-term operation and monitoring of the facilities at the Site.

Alternative 2 adds one additional treatment element to the remedy proposed by Alternative 1a; the collection and treatment of additional leachate within the barrier that results from the drawdown of the level of groundwater within the barrier to a level that ensures a controlled upflow of groundwater from the Lower Aquifer to the Upper Aquifer, and potentially to a level (approximately 6 feet MSL) expected to be below the level of the waste in the Landfill. The flow of groundwater from the Lower Aquifer to the Upper Aquifer has the potential to increase the protectiveness of this remedy to human health and the environment compared to Alternative 1a.

Alternatives 1a and 2 may have to operate for a long period of time. The development of a trust fund or other financial assurance would be required to fund annual expenses such as long-term monitoring, groundwater pumping and treatment of water removed from inside the containment wall (Alternatives 1a, 2, and 3a), the potential long-term operation of the Wetlands and End of Plume treatment systems, and the long-term maintenance or replacement of the Landfill cap and slurry wall (except for Alternative 3b in which case the cap will not be necessary).

Aquitard Continuity, Vertical Gradients, and Lower Sand Aquifer Quality

As described in Appendix A, the preponderance of boring log evidence suggests that an aquitard is present beneath the Landfill footprint and below the Upper Aquifer in the Wetlands CAA. In addition, the absence of elevated arsenic or other leachate indicators in Lower Sand Aquifer groundwater, summarized in Section 3, provides additional evidence for the continuity of the aquitard and/or a lack of downward plume migration in areas where the aquitard may not be continuous.

As indicated in Section 3, upward groundwater gradients from the Lower Aquifer to the Upper Aquifer were present in the Wetlands CAA, while flatter gradients were measured in the Landfill CAA. Thus the weight of the available evidence indicates that it is more probable than not that: 1) an aquitard separates the Upper Aquifer from the Lower Aquifer in the Landfill and Wetlands CAAs, and 2) a properly installed slurry wall would prevent the horizontal flow of groundwater in the Upper Aquifer from transporting arsenic downgradient to the Wetlands CAA.

Permanence

Alternative 1a and 2 remove more arsenic from groundwater (in the Wetlands and End of Plume CAAs and from within the slurry wall or sheet pile wall), and provide additional safeguards that will assure that CULs will be met in the Wetlands CAA and at the conditional point of compliance along 12th Avenue East, than Alternative 1. Thus Alternatives 1a and 2 are considered to be more permanent remedies than Alternative 1.

Alternative 2 has the potential to be more protective than Alternative 1a since the additional drawdown of groundwater within the slurry wall is expected to increase upflow of "clean" water from the Lower Aquifer to the Upper Aquifer within the Landfill footprint. This upflow would produce another driving force to contain contaminated groundwater within the footprint of the Landfill.

Thus Alternative 2 provides more protection to the environment as a whole than Alternative 1a.

Effectiveness over the Long Term

Alternatives 1a and 2 are expected to be more effective over the long term than Alternative 1 since these alternatives use process specifications to guide the treatment of groundwater in the Wetlands and End of Plume CAAs and propose to treat this groundwater for a much longer time period than Alternative 1.

Alternatives 1a and 2 extract groundwater from within the slurry wall or sheet pile wall to maintain an inward hydraulic flow gradient across the barrier wall and, in the case of Alternative 2, reduce the groundwater elevation to a level that induces an upflow of groundwater from the Lower Aquifer to the Upper Aquifer, and potentially to a level that is below the base of the most contaminated waste in the Landfill. The extracted groundwater will have to be treated for the life of the remedy (50 years or more). Thus Alternatives 1a and 2 are more likely to encounter long-term operational problems than Alternative 1.

The slurry wall technology used by each containment remedy is well developed and has been successfully demonstrated at other locations.

The most significant technology risk at the Site is the ability of the groundwater treatment systems proposed for the Wetlands and End of Plume CAAs to achieve CULs for arsenic in a reasonable restoration time frame. Bench- and pilot-scale tests would reduce the uncertainty associated with this concern. This risk is associated with each containment alternative.

Management of Short-Term Risks

Short-term risks to human health and the environment would occur if any of the containment alternatives were implemented. These short-term risks will be present during installation and operation of the Wetlands and End of Plume CAAs groundwater treatment systems and the installation of a slurry wall.

Detailed work plans would be developed to identify potential implementation issues and identify procedures that would be used to resolve these installation and operational concerns. Health and Safety Plans would be prepared to address risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a worker monitoring program will provide additional protection to Site workers and the public who may visit the Site.

Alternative 1 provides the least short-term risk since it employs the fewest number of technologies during its implementation. Alternatives 1a and 2 add the additional long-term risk associated with extracting and treating groundwater from within the slurry wall.

Technical and Administrative Implementability

Slurry wall and sheet pile technologies are well developed and have been successfully demonstrated at other locations to stop the horizontal flow of groundwater. Routine monitoring is expected to identify whether leaks occur or are likely to occur. These leaks can be stopped by conventional sealing techniques.

The most significant technology risk at the Site is the ability of the groundwater treatment systems proposed for the Wetlands and End of Plume CAAs to achieve arsenic CULs in a reasonable restoration time frame. Bench and pilot-scale tests will be required to reduce the uncertainty associated with this risk.

Another significant technical risk is the ability of the aquitard below the Landfill to isolate contamination in the Upper Aquifer from the Lower Aquifer. The weight of the available data (refer to Appendix A) indicates that this aquitard is present below the Landfill. The slurry wall or sheet piles installed will be driven down until they reach this aquitard. The inward hydraulic gradients across the slurry wall established by Alternatives 1a and 2 will be monitored.

Alternative 2 reduces the level of groundwater within the slurry wall to a level that will encourage the upflow of “clean” groundwater from the Lower Aquifer to the Upper Aquifer. This upflow would increase the ability of the aquitard to prevent contaminated groundwater in the Upper Aquifer from migrating into the Lower Aquifer. However, current information does not allow the calculation of the maximum upflow rate that could be achieved without creating a “hole” in the aquitard between the Lower Aquifer and the Upper Aquifer.

The additional capability to remove and treat groundwater from within the slurry wall provides Alternative 2 with additional operational flexibility (compared to Alternative 1a) as the alternative is implemented and operated over time.

Restoration Time Frame

The containment remedy is expected to be effective in halting releases of arsenic from the Landfill immediately upon installation. This is true for Alternatives 1, 1a, and 2. The End-of-Plume remedy, a common element in all three alternatives, is designed to bring groundwater concentrations at 12th Street East into compliance as soon as possible, likely within a few treatment cycles. Compliance in the Wetlands CAA is expected to take longer than in the other two areas, but the remedy is expected to result in concentrations that are protective of human health and the environment is a reasonable time frame. Bench-scale studies and actual operations and monitoring data will allow for a better estimate of when the Wetlands CAA will come into compliance. This data will be available for future MTCA reviews.

Current and future land use in the three Cleanup Action Areas are compatible with the proposed remedy. Institutional controls within the Wetland CAA are expected to be implemented throughout the restoration time frame, effectively reducing risks posed by contaminants in this area.

Alternatives 1a and 2 pump and treat an additional 100 million gallons of water in the Wetlands CAA (by pumping for more years) as compared to Alternative 1. This additional removal is expected to result in compliance in the Wetlands CAA is a shorter timeframe.

Conceptual-Level Cost

Conceptual-level (±25 percent) cost estimates and supporting assumptions for Alternatives 1, 1a, and 2 are summarized above.

The estimate of the cost of Alternative 1 (approximately $7 million) is summarized in Table 8. The cost of the compliance monitoring program included in Baseline Alternative 1 is also a part of Alternatives 1a and 2. The cost of additional performance monitoring recommended for each alternative was also included in these cost estimates.

Alternatives 1a and 2 treat an additional 100 million gallons of water in the Wetlands CAA, and operate the End of Plume treatment process for 25 years more than Alternative 1 and extract groundwater from within the slurry wall. The cost (±25 percent) of this additional capability has a net present value (I = 2 percent, n= 50 years) of about $11 to $13 million. The actual length of time that treatment would be needed and the cost of that treatment cannot be known with certainty until appropriate site-specific bench- and pilot-scale tests have been conducted at the Site.

Alternative 2 appears to be more protective than Alternative 1a since Alternative 2 provides additional capability to drawdown groundwater within the slurry wall to a level that is expected to increase the upflow of "clean" water from the Lower Aquifer to the Upper Aquifer within the Landfill footprint. This upflow produces another driving force to contain contaminated groundwater within the footprint of the Landfill. However, current information does not allow the calculation of a maximum upflow rate that could be achieved without creating a "hole" in the aquitard between the Lower Aquifer and the Upper Aquifer. Alternative 2 also provides additional groundwater extraction and treatment capacity than Alternative 1a.

The additional protectiveness provided by Alternative 2 compared to Alternative 1a comes at the cost of about $3 million. This additional cost results from the need to remove and treat a greater volume of groundwater drained from inside the slurry wall, since the upflow from the Lower Aquifer to the Upper Aquifer is expected to be higher for Alternative 2 (refer to Appendix A). This greater volume of groundwater would have to be treated for an extended period of time.

Ecology cannot assume at this time that the redirection of clean groundwater alone will result in sufficient decrease in hydraulic head to maintain upward gradients to protect deeper groundwater; therefore, Ecology has added to the slurry wall alternative in the GAE Report the requirement of active pumping to maintain inward hydraulic gradients within the slurry wall. Two options have been considered as follows:

Hydraulic control (Alternatives 1a and 2). The first option assumes that a groundwater extraction system is installed within the Landfill area that will decrease the water levels inside the slurry wall to levels that are lower than levels outside the wall. This will cause groundwater outside the slurry wall and below the aquitards to flow inward preventing contaminated leachate from leaking out. This situation is more protective than a slurry wall without leachate/groundwater pumping.

Ecology expects that the landfill waste (slag, bark, and soil) could be dewatered and remain dewatered. This would require approximately 6 feet of drawdown within the slurry wall. Since a high volume of water will need to be removed initially to achieve this drawdown, and also due to the fact that the waste sits on the organic-rich silts of the original land surface, this level of drawdown will take time to be established and result in relatively high volumes of water to be pumped and treated, compared with Alternative 1a. Nevertheless, Ecology assumes that if waste can be dewatered, this would better protect the underlying groundwater as it would over time become cleaner as more clean groundwater from outside the slurry wall is works it way into the system. If this system functions as planned, eventually the water pumped from within the slurry wall would be clean enough to discharge with little or no treatment.

Based on the above analysis Ecology has selected Alternative 2 as the proposed Remedial Alternative for the Site.

Consideration of Public Concerns

Ecology has worked extensively with the community, and continues to do so, with the objective of identifying and addressing public concerns. The communities of Milton, Fife and Tacoma, along with Pierce County and local Tribes of Indians and several environmental groups are concerned about delaying the cleanup process, and would like the cleanup to proceed as soon as possible. In addition, they are concerned about disruption caused by cleanup, and would like Ecology to minimize the short-term disruption remediation construction will cause. Ecology will continue to consider public concerns during the cleanup process. The Draft Cleanup Action Plan had been available to the public for review and comment for 30 days. In addition, a public meeting has been held to discuss with stakeholders and citizens the selection of the cleanup remedy.

6.0 PROPOSED CLEANUP ACTION – ALTERNATIVE 2

The cleanup action selected by Ecology is summarized in the following sections and is based heavily on Alternative 2 from Section 5:

- Landfill/Ditch CAA—Section 6.1
- Wetlands CAA—Section 6.2
- End of Plume CAA—Section 6.3
- Satisfying the MTCA Criteria—Section 6.4
- Funding and Planning for Future Contingencies—Section 6.5
- Long Term Operations, Maintenance and Monitoring—Section 6.6
- Additional Requirements—Section 6.7

6.1 Landfill/Ditch CAA

The proposed cleanup action for the Landfill/Ditch CAA includes the following elements:

- A **slurry wall** around the entire perimeter of the Landfill, tied into the existing Landfill cap above and the Silt Aquitard below. The Landfill cap, slurry wall, and silt aquitard will work together to form a robust containment system for landfill materials, leachate, and contaminated groundwater beneath the Landfill. The containment system is supported by the upward gradients between the Upper and Lower Sand Aquifers.
- An **interceptor trench** between the Landfill and the bluff along Fife Way to redirect clean groundwater and surface water that historically would have entered the Landfill. The goal will be to lower the water level in the Upper Sand Aquifer immediately upgradient of the Landfill by several feet to prevent build-up of groundwater pressure and to help prevent seasonal flooding of the area by surface water runoff.
- **Hydraulic control** will be maintained within the slurry wall containment system to ensure that any groundwater leakage is clean groundwater leaking inward and not contaminated groundwater leaking outward. Hydraulic control will be maintained using groundwater extraction, treatment of the extracted groundwater, and discharge.
- The groundwater extraction system within the slurry wall will be designed to **dewater the saturated landfill waste** if this is practicable. The specific amount of groundwater that will be removed will be determined once the slurry wall is constructed. At a minimum, enough groundwater must be removed to create an inward hydraulic gradient; sufficient groundwater to dewater the

refuse will be withdrawn if proven practicable If effective in dewatering the landfill waste and in "flushing" contamination from beneath the Landfill, this component has the potential to allow for eventual downscaling or decommissioning of the treatment system.

- The groundwater extraction system will be designed to include the installation of a system of additional wells outside of the slurry wall to **remove the groundwater "halo."** This halo exists as an area of localized contamination near Wells MW-23/D-10, D-8, and D-9.
- Following installation of the slurry wall, **excavation of contaminated sediments in the agricultural ditches adjacent to the Landfill** will be performed. Eventually, the ditches may be buried and/or rerouted when the agricultural fields are redeveloped by the owner (currently the City of Fife). The removal of contaminated sediments will be performed as part of the Landfill remedy; the eventual modification/removal of agricultural ditches will be performed by the developer as part of the redevelopment of the surrounding lands and is not part of the proposed Landfill remedy.
- Installation of additional **compliance monitoring** wells and probes (As needed to bolster the existing well systems), inside and outside of the Landfill, in the Wetlands and in End of Plume areas, to monitor the effectiveness of the remedy, and the progress of the cleanup.

With the addition of the slurry wall and associated elements to the existing 1993 Landfill remedy, the Landfill/Ditch CAA will meet the following RAOs identified in Section 4.3:

- Meet MTCA threshold requirements, and WAC 173-340-740(6)(f) requirements for containment remedies and implement the closure requirements under Minimum Functional Standards for Solid Waste Landfills (Chapter 173-304 WAC).
- Prevent arsenic-contaminated groundwater from migrating beyond the Landfill perimeter into adjacent wetlands and agricultural drainage ditches.
- Meet MTCA minimum requirements.
- Protect the sediment and surface water quality of Hylebos Creek and associated restoration projects from future arsenic releases from the Landfill.

Landfill CAA Performance Based Criteria

Hydraulic control within the slurry wall must be maintained as a performance standard for the slurry wall. Pumping rates may have to be adjusted throughout the year as the natural gradients undergo seasonal change. Waste dewatering, assuming it proves it to be practicable, is

Ecology's preferred alternative as it halts the production of new leachate, and should over time reduce the concentration in the groundwater within the slurry wall to levels that would require little or no treatment. This in turn could allow for the treatment system to be downscaled or turned off. The extraction system (removing clean groundwater) would continue to operate to maintain the water level below the waste.

In order to assess the practicability of waste dewatering it will be necessary to perform a series of extraction and treatment tests (to be established during the Remedial Design phase) after the slurry wall and interceptor trench have been installed; as well as during long term monitoring of system operation. In order for the technology to be considered practicable, each of the following will need to be evaluated as part of the design process, and again during system operation, when the system is built:

- Depth of Drawdown – it must be physically possible to obtain sufficient drawdown of the water level to fully dewater the waste. That is, if the waste can not be dewatered with practicable pumping rates, then the remedy will not be considered to be practicable.
- Ability to Downscale or Shut Down the Treatment System – the two key goals of the waste dewatering are: 1) to stop the production of leachate; and 2) to flush out the contaminated groundwater beneath the Landfill. The first goal would be accomplished by drawing the water level to beneath the landfill waste and maintaining it at that level over time. This would stop the production of new leachate. The second goal would be to "flush" the existing contamination in the aquifer beneath the Landfill (and contained within the slurry wall) out by removing contaminated groundwater and causing new clean groundwater to leak into the containment. Since arsenic would continue for some time to dissolve from the aquifer soils, and since this "flushing" would likely be a slow process, the likelihood of achieving this goal is unknown at this time. If successful, this system would result in the extracted groundwater being clean enough for direct discharge with little or no treatment allowing for the treatment facility to be either modified into a less rigorous and less costly type of treatment, or to allow the treatment system to be shut down completely. If studies, based on system performance over time, indicate that either or both of these goals are unlikely to be achieved, then Ecology may determine that the waste dewatering component of the remedy is not practicable.
- Overall Remedy Protectiveness – the pumping rate that is sufficient to dewater the waste must not cause adverse effects on the integrity of the slurry wall or the aquitard. For example, if continued pumping to maintain the water level results in a decrease of the

containment integrity, the dewatering system would be modified or stopped to protect the overall containment integrity.

- Protection of Wetlands – the drawdown sufficient to dewater the waste must not cause a loss of water to the watershed that would adversely affect the adjacent wetlands and restoration projects.

6.2 Wetlands CAA

Once the slurry wall containment has been implemented surrounding the Landfill, no further releases from the Landfill are expected to enter the Wetlands CAA. However, the Wetlands CAA already contains groundwater that has arsenic concentrations up to 1,000 times background. This groundwater contamination will need to be remediated in order to bring the Site into compliance with MTCA and landfill closure requirements.

The proposed cleanup action for the Wetlands CAA contains the following elements:

- Pumping of groundwater from the Upper Sand Aquifer beneath the wetlands in the core of the plume.
- Treatment of the pumped groundwater to remove arsenic and iron.
- Re-infiltration of treated groundwater into existing stormwater ponds or back into the wetlands.

The intent of the cleanup alternative in the Wetlands CAA is to install a number of pumping wells to intensely manage the residual mass of dissolved arsenic and remove it from the system as quickly as possible. The extracted groundwater will be piped to the treatment system used to treat groundwater extracted from within the slurry wall.

The preferred remedy for the Wetlands CAA relies on the following observations based on existing data:

- Soil concentrations in the Wetlands CAA are already in compliance with the soil cleanup level, that is, groundwater and ponded surface water are the only media of concern in this area.
- Groundwater in the Wetlands CAA exists in a relatively homogeneous and transmissive aquifer with a demonstrated capacity for sustained groundwater pumping.
- Arsenic is present in groundwater as a dissolved phase that will migrate readily to nearby pumping wells.

- Historical data shows that 95 percent of the arsenic is already attenuating in the wetlands as groundwater migrates from the Landfill to 12th Street East; therefore, the area that needs remedial action is limited and well defined

The preferred remedy for the Wetlands CAA also relies on the following assumptions:

- Future releases from the Landfill will be eliminated by the slurry wall remedy for the Landfill CAA, and the Wetlands CAA remedy will not be installed until after the slurry wall is completed.
- Restoration areas along Hylebos Creek are being developed and will potentially move Hylebos Creek closer to the Landfill. For this reason, risk of migration of arsenic from Landfill releases beyond 12th Street East is unacceptable.

The pump and treat remedy would meet the RAOs for the Wetlands CAA by:

- Lowering groundwater arsenic concentrations to levels that comply with Site cleanup standards, and are protective of human health and the environment within the wetlands;
- Decreasing the mobility and volume of arsenic in the wetlands plume through treatment; and
- Increasing the overall permanence and effectiveness and decreasing the restoration time frame of the overall remedy by removing as much residual mass of dissolved arsenic from the wetlands as is practical.

It is considered likely that the Wetlands CAA remedy would meet the groundwater CUL within the Wetlands CAA only after many years, but the remedy would support the End of Plume remedy in meeting the CUL at the 12th Street East End of Plume CAA by removing arsenic and limiting further migration to toward Hylebos Creek.

The land between the Landfill and the 12th Street East End of Plume CAA is currently owned by a single party, and land owner permission will be required to proceed with this element of the cleanup.

Wetland CAA Performance-based Criteria

The goal for cleanup of the Wetlands CAA is to protect the wetlands, by meeting the groundwater CUL of 5 μg/L. Pump and treat, however, may be unable to obtain this CUL, or may require an extremely long restoration timeframe. If the pump and treat Wetlands CAA remedy is shown to be unable to achieve CULs or to be slower than other options, then Ecology and the PLPs may consider development of an alternative treatment technology for the Wetland CAA. An example would be if End-of-Plume sequestration is highly successful, the sequestration remedy could be extended into the Wetlands CAA to reduce or eliminate the need for groundwater pumping and treatment, or to decrease the overall restoration timeframe. Additional details on performance-based monitoring will be provided in the Long Term Operations, Maintenance and Monitoring Plan that will be prepared during implementation of this CAP.

6.3 End of Plume CAA

The proposed cleanup action for the Wetlands CAA contains the following element:

- Enhancement of the natural attenuation that is already occurring by adding specific sequestration agents that will act more quickly and irreversibly to precipitate the dissolved arsenic. This will be accomplished along the 12th Street East right of way.

The 12th Street right-of-way was selected as the location for implementation of the End of Plume CAA for the following reasons:

- The 12th Street East right of way is an unused roadway that cuts through the wetlands and allows for easy access to the wetlands without further disruption to the wetlands.
- The land between the Landfill and 12th Street East is owned by a single party, which will simplify getting access agreements and institutional controls, although it may still be difficult to do so.
- The residual contamination at 12th Street East exists as a thin seam of moderately elevated arsenic at the base of the aquifer in a well-defined and accessible sand zone.
- Land beyond 12th Street East is planned for habitat restoration, including the potential relocation of Hylebos Creek, making the control of arsenic at 12th Street East critical.

A series of injection wells or a single trench will be used to inject the sequestering solution into the base of the aquifer where natural conditions are already reducing and favorable. On the downgradient (North) side of 12th Street East, compliance monitoring wells will be installed to monitor the success of the remedy and confirm compliance with Site arsenic cleanup standards.

Bench- and pilot-scale treatability tests will be needed to determine the means of treatment and length of time that this remedy will have to operate to achieve the CULs for arsenic at the point of compliance.

This remedy meets the RAOs for this area by:

- Reducing the mobility and volume of arsenic in groundwater by sequestering it onto the soil matrix at the base of the aquifer;
- Protecting human health and the environment, including potential future receptors at Hylebos Creek; and
- Attaining CULs and meeting ARARs at 12th Street East.

End of Plume Performance-based Criteria

Performance-based criteria will be used to assess compliance and determine the frequency and duration of the in situ treatment applications that will accompany monitoring. Performance-based criteria will be protection of the wetlands by attainment of the groundwater arsenic cleanup level of 5 μg/L in monitoring wells downgradient of 12th Street E.

Additional details on performance-based monitoring will be provided in the Long Term Operations, Maintenance and Monitoring Plan.

6.4 Satisfying the MTCA Selection Criteria

6.4.1 Compliance with Threshold Criteria

The selected cleanup action alternative must be able to meet the threshold criteria established by MTCA. These threshold criteria are:

- Protect Human Health and the Environment;
- Comply with Cleanup Standards (WAC 173-340-700 through 173-340-760);
- Comply with Applicable State and Federal Laws (WAC 173-340-710);
- Provide for Compliance Monitoring (WAC 173-340-410 and 173-340-720 through 173-340-760); and
- Provide for a Reasonable Restoration Timeframe (WAC 173-340-360(4).

Overall Protection of Human Health and the Environment

The cleanup of groundwater at the Site by implementation of a containment remedy with groundwater extraction and in-situ treatment of historical releases will be protective of human health and the environment by stopping the release of arsenic from the Landfill and by bringing the adjacent wetlands into compliance with cleanup standards in a reasonable restoration timeframe.

Comply with Cleanup Standards

Ecology has established cleanup standards have been established consistent with the MTCA regulations, including consideration of ARARs. These cleanup standards are expected to be meet by this remedial action is a reasonable restoration timeframe.

Comply with Applicable State and Federal Laws

The ARARs applicable to remedial action at this Site were identified in Section 4. Chemical-specific ARARs were considered in the development of cleanup levels. Action- and location-specific ARARs were used during the screening and selection of alternatives in Section 5. ARARs will also be considered during the design, permitting, and implementation of the remedy.

Compliance Monitoring

Long term compliance monitoring is a component of existing 1993 Remedy, landfill closure requirements, and as part of the currently selected groundwater remedial action. Monitoring requirements are discussed further in the next section.

Reasonable Restoration Timeframe

The individual components of the proposed remedy are expected to provide for a reasonable restoration time frame, considering the potential risks posed by the Site, the practicability of achieving a shorter timeframe, the current and proposed future uses of the Site and surrounding areas, the likely effectiveness of institutional controls, the ability to control and monitor migration of contaminants from the Site, the toxicity of the hazardous substance (arsenic) and the natural attenuation processes that have been observed at the Site.

The containment remedy component is expected to be effective in halting releases of arsenic from the Landfill immediately upon installation. The

End-of-Plume remedy is designed to bring groundwater concentrations at the 12th Street East End of Plume CAA into compliance as soon as possible, likely within a few treatment cycles. Compliance in the Wetlands CAA is expected to take longer than in the other two areas, but the remedy is expected to result in concentrations that are protective of human health and the environment is a reasonable time frame. Current and future land uses in the three Cleanup Action Areas are compatible with the proposed remedy. Institutional controls within the Wetland CAA are expected to be implemented throughout the restoration time frame, effectively reducing risks posed by contaminants in this area.

6.5 Long Term Operations, Maintenance and Monitoring

6.5.1 Long Term Operations and Compliance Monitoring

Monitoring of the cleanup action will be performed in accordance with the requirements of WAC 173-340-410, and will include protection, performance, and confirmation monitoring. The monitoring requirements for the cleanup action are presented in the following sections. Specific requirements for monitoring the cleanup action will be provided in an Operations, Maintenance, and Monitoring Plan (OM&MP) as part of the Engineering Design Report package.

6.5.2 Protection Monitoring

Protection monitoring, which will include monitoring wetlands soil, groundwater, and surface water quality, will be conducted during the cleanup action to confirm that receptors in the Wetlands CAA and at the End of Plume CAA, and workers at the Site are protected during the cleanup action.

6.5.3 Performance Monitoring

Groundwater and surface water monitoring and sampling and analysis will be conducted to assure that the proposed pump and treatment system, which will remove arsenic from groundwater and leachate extracted from within the slurry wall, and from water removed from the Wetlands CAA, will meet appropriate discharge requirements. Performance groundwater and surface water monitoring and sampling and analysis will also be conducted to ensure that the End of Plume treatment system achieves MTCA CULs for arsenic. The frequency, scope, and duration of the monitoring and sampling and analysis will be detailed in the OM&MP.

6.5.4 Confirmation Monitoring

Following completion of the remedial action, confirmation soil, groundwater, ditch sediment and surface water monitoring and sampling and analysis will be performed to evaluate the effectiveness of the cleanup action and to assess when the cleanup levels have been met at the defined points of compliance. The frequency, scope, and duration of the monitoring and sampling and analysis will be detailed in the OM&MP.

6.6 Special Requirements for Containment Remedies

6.6.1 Type, Level, and Amount of Hazardous Substances Remaining on the Site

The remedy for the Site contains, rather than removes, the arsenic and other contamination contained in the Landfill. MTCA [WAC 193-340-380 (a)(ix)] requires that “the type, level, and amount of hazardous substances remaining on site and the measures that will be taken to prevent the migration of those substances” be specified.

Information about the concentration of contaminants in the landfill refuse is summarized in the focused Remedial Investigation prepared by K/J/C and AGI (1990b). This information suggests that the landfill refuse may contain up to approximately 250,000 pounds of arsenic. This arsenic will be contained by the slurry wall, which connects to the aquitard and the existing multi-layer cap. Some amount of arsenic in the refuse will be eliminated over time as groundwater and leachate are extracted from within the slurry wall, and treated, but this amount is not expected to significantly reduce the mass of arsenic currently contained in the Landfill.

6.6.2 Institutional Controls

The selected remedial action is a containment remedy and includes institutional controls. The Wetlands and Landfill CAA includes land owned by third parties. Implementation of the remedy will require access to the Landfill as well, the adjacent Wetlands to 12th Street East, the adjacent agricultural drainage ditches, the 12th Street East and Puget Power right of ways, and the small section of the Wetlands beyond 12th Street East (for monitoring well installation and access). The remedy for the Site includes the continued payment for the rights to access this land.

Additionally, the interceptor drain associated with the slurry wall will likely require interactions with the adjoining apartment complex and with the City of Fife.

The parties likely to implement this remedy do not own any of these properties. Therefore, implementation of the remedy may require significant negotiations of both short-term and long-term access agreements. Figure 4 shows current property ownership in the vicinity of the Site.

Institutional controls will include on-site features such as signs and fences to protect the integrity of the Landfill cap and remedy, and legal mechanisms, such as lease restrictions, deed restrictions, land use and zoning designations, and building permit requirements. Institutional controls for the Wetlands and the Landfill may be different. Specific institutional controls will be presented in the Engineering Design Report.

6.6.3 Financial Assurance

The arsenic in the Landfill will not “decompose” over time, and will require containment in perpetuity, and the containment remedy will require operations, maintenance, and monitoring in perpetuity. Accordingly, Ecology has decided that a critical component of the remedy is the establishment of a trust fund or equivalent financial mechanism to support the long-term operations, maintenance, and monitoring at the Site associated with both the 1993 remedy and the current groundwater remedy. The financial mechanism must include sufficient funds to cover the following:

- Operations and maintenance of all components of the 1993 remedial action and the current groundwater remedial action.
- Long term compliance monitoring, including reporting and the MTCA 5-year Review Process.
- Replacement costs for all landfill components that have the potential to fail within the first 100 years of the life of the Landfill.
- Payment of Ecology project oversight cost billings.

Ecology has estimated that the trust fund or equivalent financial mechanism would likely need to contain between $12 and $15 million dollars.

6.7 Permitting, Design, and Planning Requirements

This section discusses additional requirements that apply to the permitting, design, and planning for the remedial action.

6.7.1 Permits/Other Requirements

The Cleanup Action will be conducted under an Ecology Agreed Order, Enforcement Order, or Consent Decree; therefore, the Cleanup Action is exempt from the procedural requirements of certain laws and all local permits [WAC 173-340-710(9)(a)] but must comply with the substantive requirements of these laws and permits. The exemption from procedural requirements applies to the following:

- Washington Clean Air Act (RCW 70.94)
- Solid Waste Management Act (RCW 70.95)
- Hazardous Waste Management Act (RCW 70.105)
- Construction Projects in State Waters (RCW 77.55)
- Water Pollution Control Act (RCW 90.48)
- Shoreline Management Act (RCW 90.58)
- Any laws requiring or authorizing local government permits or approvals.

The exemption is not applicable if Ecology determines that the exemption would result in the loss of approval from a federal agency that may be necessary for the state to administer any federal law.

The Cleanup Action for the Site is expected to fully comply with all action-, chemical- and location-specific ARARs as described in Section 4.2. The Cleanup Action also includes all of the elements of landfill closure as specified in Minimum Functional Standards for Solid Waste Landfills (Chapter 173-304 WAC), including the use of a slurry wall to halt migration of leachate and contaminated groundwater from beneath the Landfill.

6.7.2 Engineering Design Report

An Engineering Design Report will include sufficient information for the development and review of construction plans and specifications to document engineering concepts and design criteria used for the design of the cleanup action. The information required under WAC 173-340-

400(4)(a)(i) through 173-340-400(4)(a)(xx) will be included in the Engineering Design Report including the specific criteria that govern the design of each of the components listed in Section 6.1.

The Engineering Design Report will also include an Operations Maintenance and Montoring Program describing long-term operations, maintenance, and monitoring for the remedy.

The Enforcement Order, Agreed Order or Consent Decree which requires the current remedial action to be implemented, and/or the Engineering Design Report will also include the proposed Deed Restriction for the B&L Property and the Wetlands properties.

6.7.3 Construction Plans and Specifications

The Construction Plans and Specifications will detail the construction of the cleanup action to be performed. As required by WAC 173-340-400(4)(b), the documents will include the following information, as applicable:

- A description of the work to be performed, and a summary of the engineering design criteria from the Engineering Design Report;
- A Site location map and a map of existing conditions;
- A copy of applicable permit applications and approvals;
- Detailed plans, procedures, and specifications necessary for the cleanup action;
- Specific quality control tests to be performed to document the construction, including specifications for testing or reference to specific testing methods, frequency of testing, acceptable results, and other documentation methods; and
- Provisions to ensure that the health and safety requirements of WAC 173-340-810 are met.

All aspects of construction will be performed and documented in accordance with WAC 173-340-400(6). These aspects include approval of all of the plans listed above prior to commencement of work, oversight of construction by a Professional Engineer licensed in the State of Washington, and submittal of a Construction Completion Report that documents all aspects of the cleanup and includes an opinion of the engineer as to whether the cleanup was conducted in substantial compliance with the CAP, the Engineering Design Report, and the Construction Plans and Specifications.

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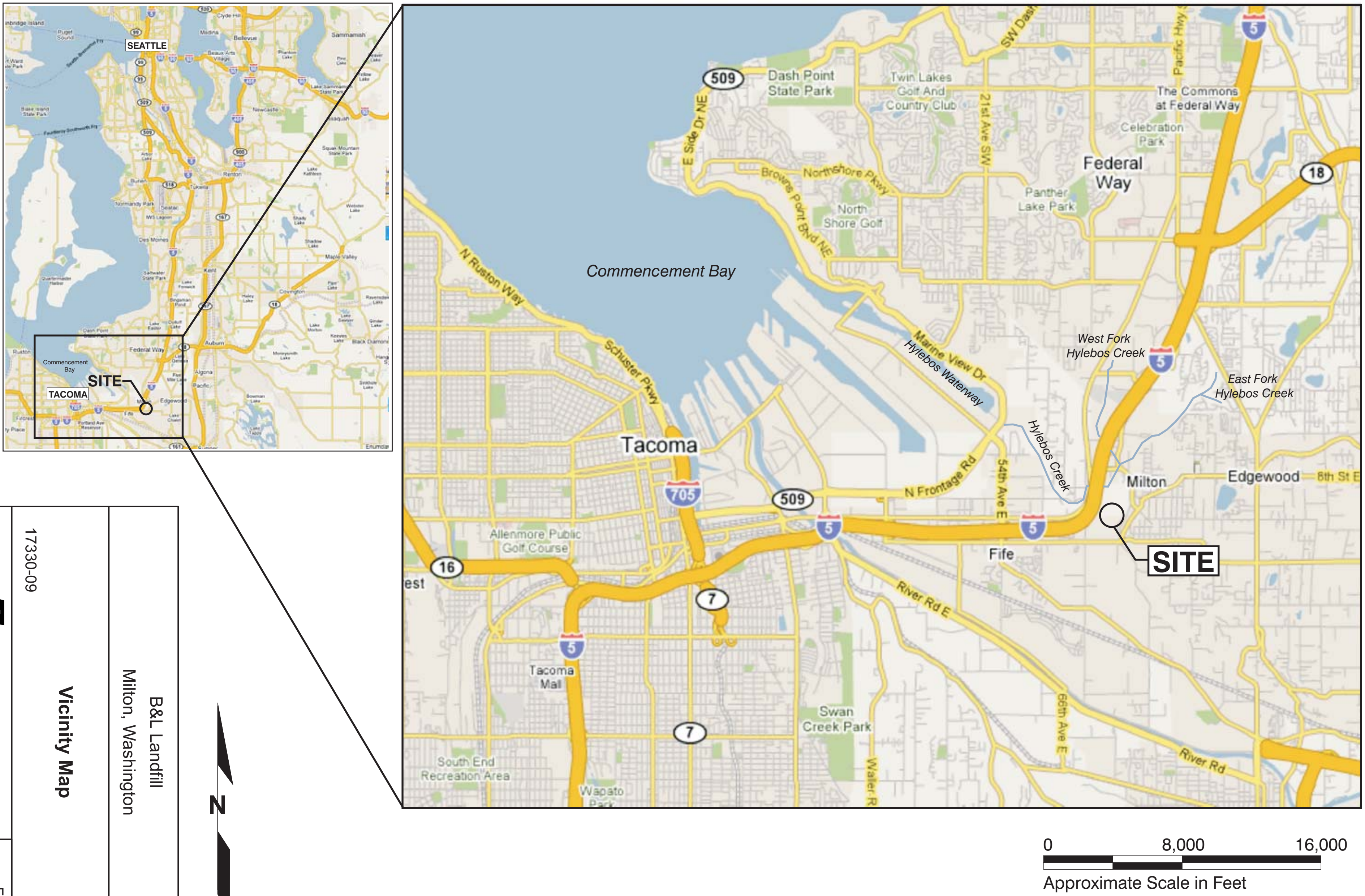

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

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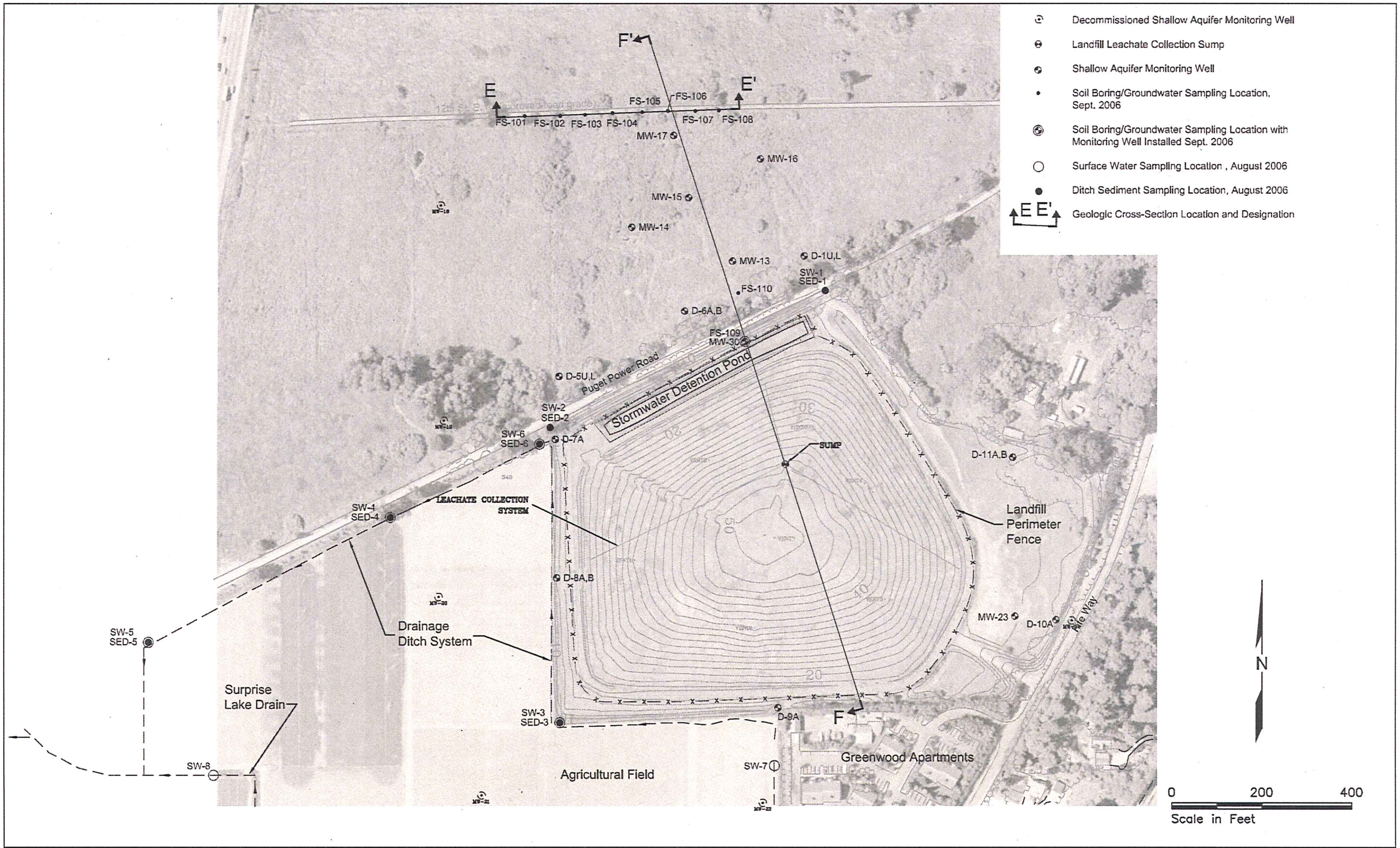
Vicinity Map

B&L Landfill
Milton, Washington

Figure
1



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strategy ▪ science ▪ engineering

Cleanup Action Plan
B&L Landfill
Milton, WA

Figure 2
Site Map and Cross Section Locations

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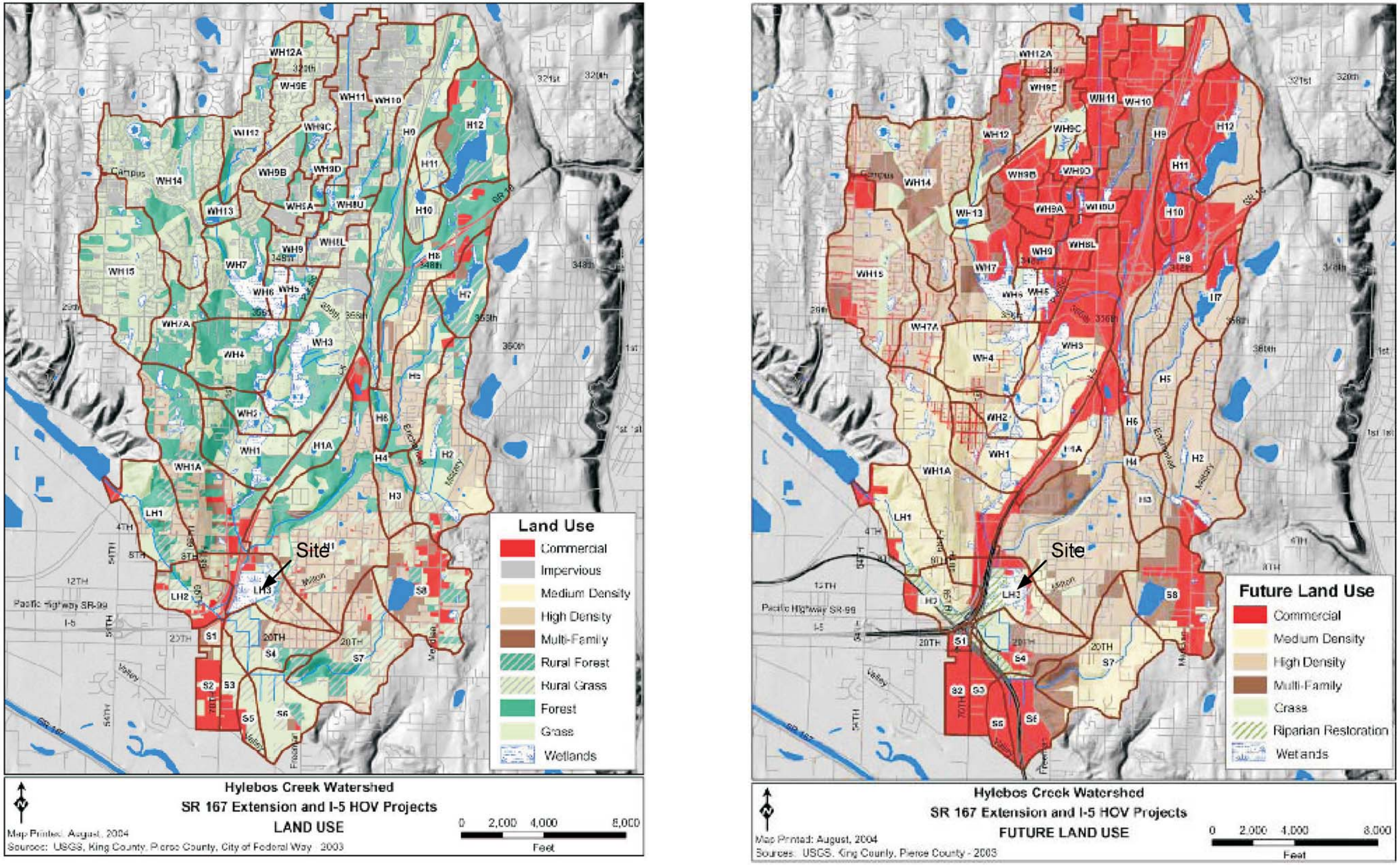

Source: Analysis of the SR 167 Extension and Riparian Restoration Proposal in the Hylebos Watershed Hydrology, Hydraulics and Geomorphology. MGS Engineering Consultants, Inc., Montgomery Water Group, Inc., GeoEngineers, and Kirsty Burt Geographic Information Services. November 2004.

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

B&L Landfill
Milton, Washington

Current and Projected Changes in Land Use in Site Vicinity

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Figure
3

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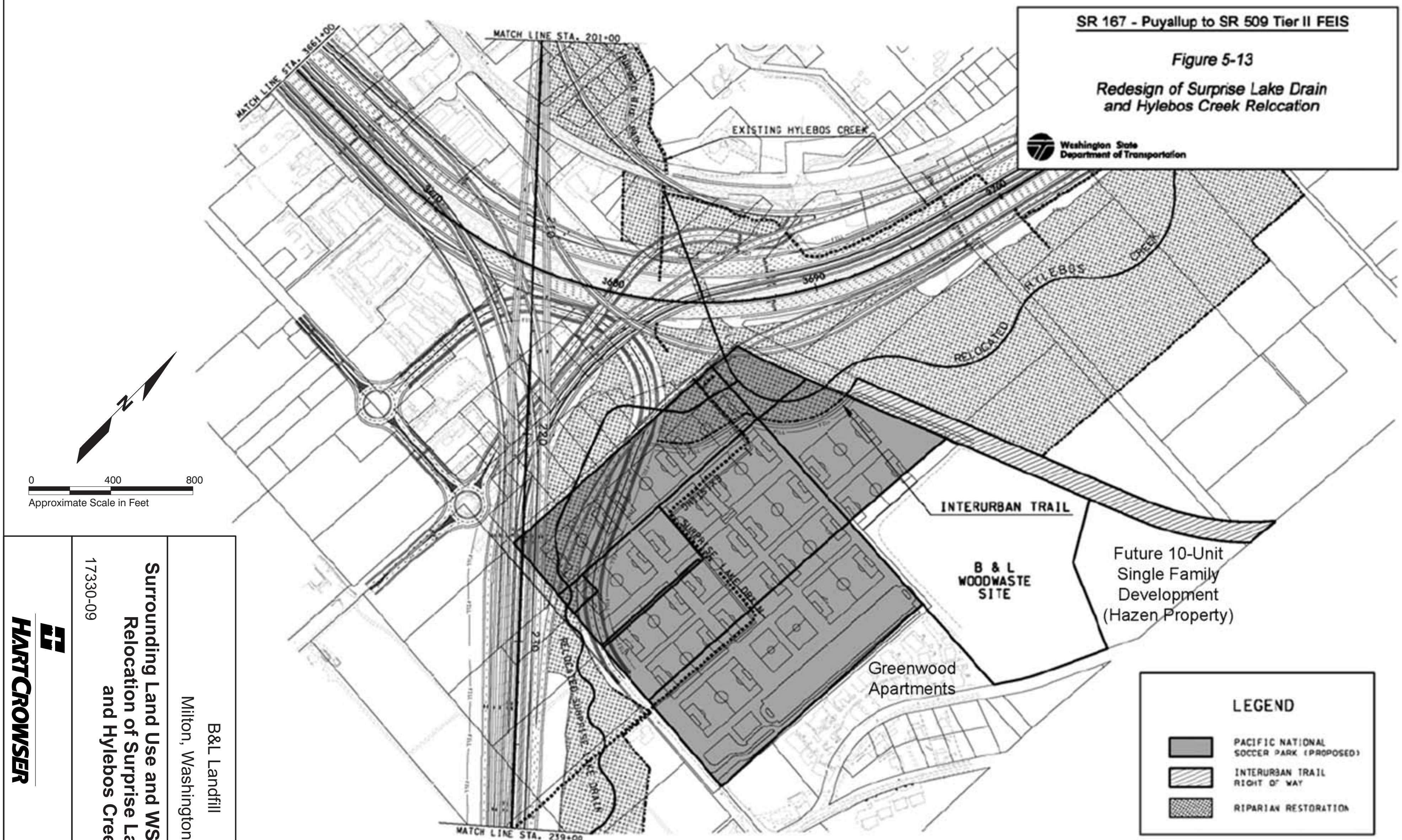

Source: Tier II Final Environmental Impact Statement and Section 4(f) Evaluation SR 167 Puyallup to SR 509. U.S. Department of Transportation Federal Highway Administration,Washington State Department of Transportation, Army Corps of Engineers, and City of Fife. November 2006.

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

B&L Landfill
Milton, Washington

Surrounding Land Use and WSDOT Proposed Relocation of Surprise Lake Drain and Hylebos Creek

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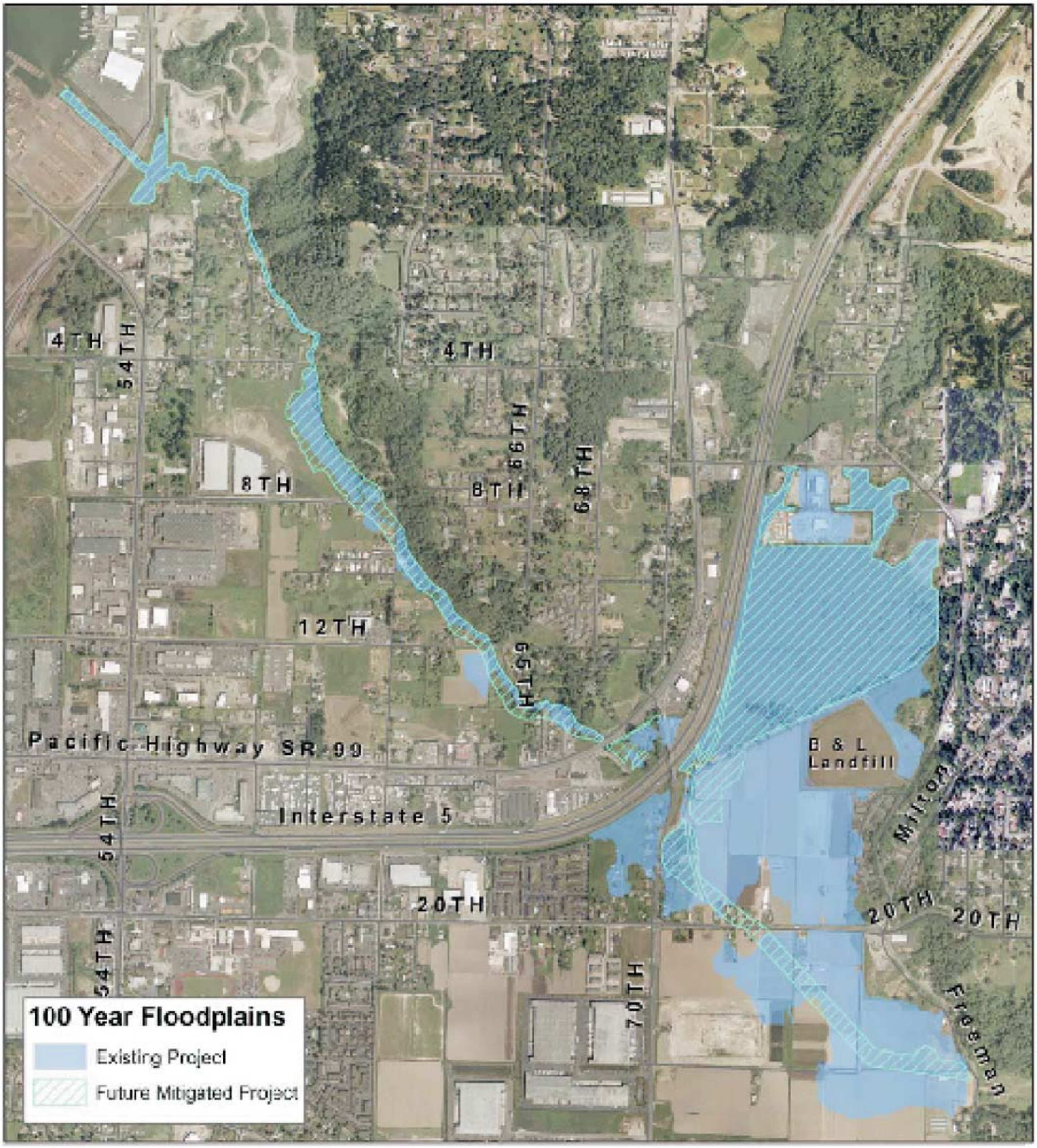
Figure
5



Source: Analysis of the SR 167 Extension and Riparian Restoration Proposal in the Hylebos Watershed Hydrology, Hydraulics and Geomorphology. MSG Engineering Consultants, Inc., Montgomery Water Group, Inc., GeoEngineers, and Kirsty Burt Geographic Information Services. November 2004.

0 700 1400

Approximate Scale in Feet

N

B&L Landfill

Milton, Washington

WSDOT Existing and Future Mitigated Project for Hylebos Creek 100-Year Floodplain

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Figure

6

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

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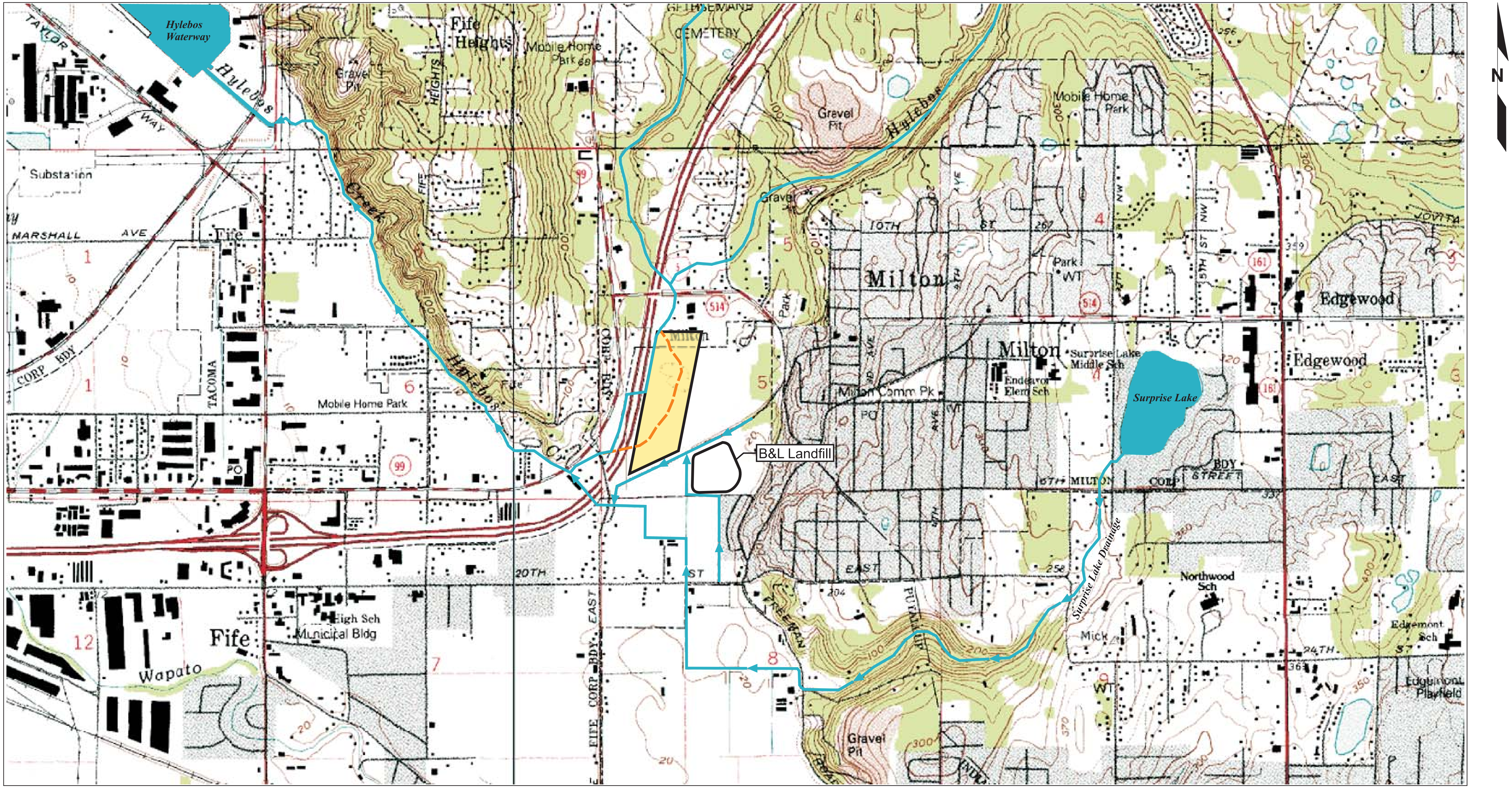

← Existing Stream or Surface Water Conveyance

- - - Approximate Location of Proposed Hylebos Creek Relocation Channel

🟨 Approximate Location of Proposed Riparian Restoration Area

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

0 1/4 1/2

Approximate Scale in Feet

B&L Landfill
Milton, Washington

Topography and Drainage Features in Site Vicinity

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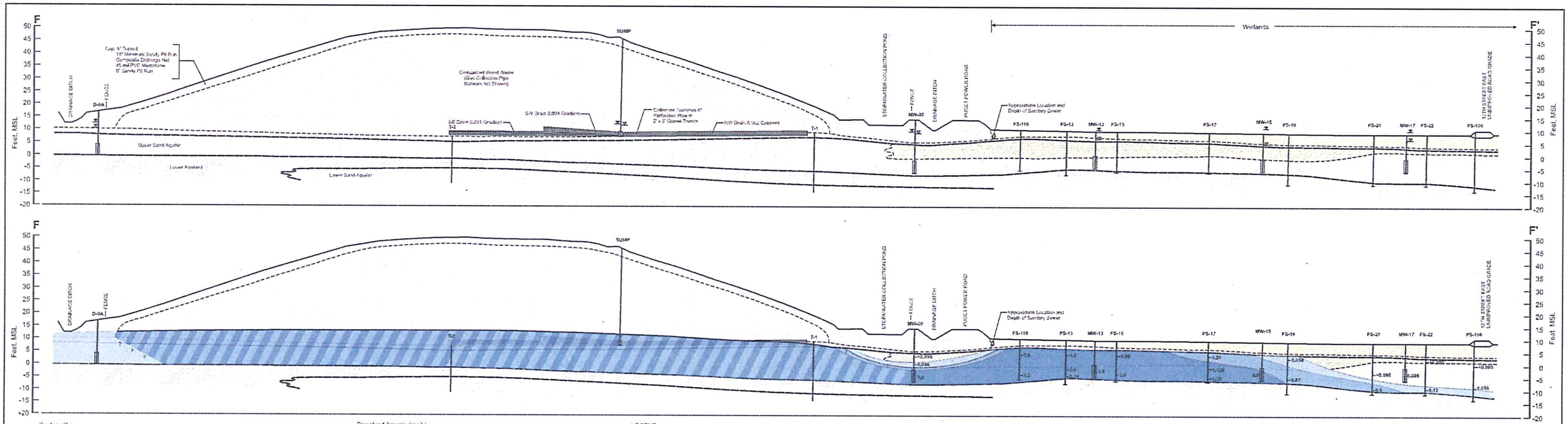
Figure
7

EAL 05/25/07 1733009-AD.cdr



Geology Key

- ☐ Imported Cap/ Road material
- ☐ Compacted Wood Waste
- ☐ Silt
- ☐ Organic Silt and Peat
- ☐ Silty Sand
- ☐ Sand
- ☐ Silt Interbedded with Peat
- ▨ Drainage Gravel

Dissolved Arsenic (mg/L)

- ☐ <0.005 - 0.020
- ▨ 0.020 - 0.200
- ▨ 0.200 - 2.000
- ■ >2.0
- ▨ Unknown Concentration
- 0.054 Actual Concentration

LEGEND

- Known High Water Elevation
- Known Low Water Elevation
- Monitoring Well
- Soil Boring
- 0.046 Monitoring Well Screened Interval and Dissolved Arsenic Concentration (2006 Results)
- 3.3 Discrete Depth Groundwater Sampling Interval and Dissolved Arsenic Concentration (2005 and 2006 Results)

NOTES

(1) Refer to Figure 2.1 for Cross Section Location
(2) Arsenic concentration contours are interpreted from a combination of 2005 and 2006 discrete-depth sampling and 2006 monitoring well sampling results.

SOURCES

September 2006 Borings (Appendix A)
Floyd & Snider, 2006
Hydrometrics, 1994
AGI/KJC 1990

Horizontal Scale in Feet
0 50 100
0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 2.5

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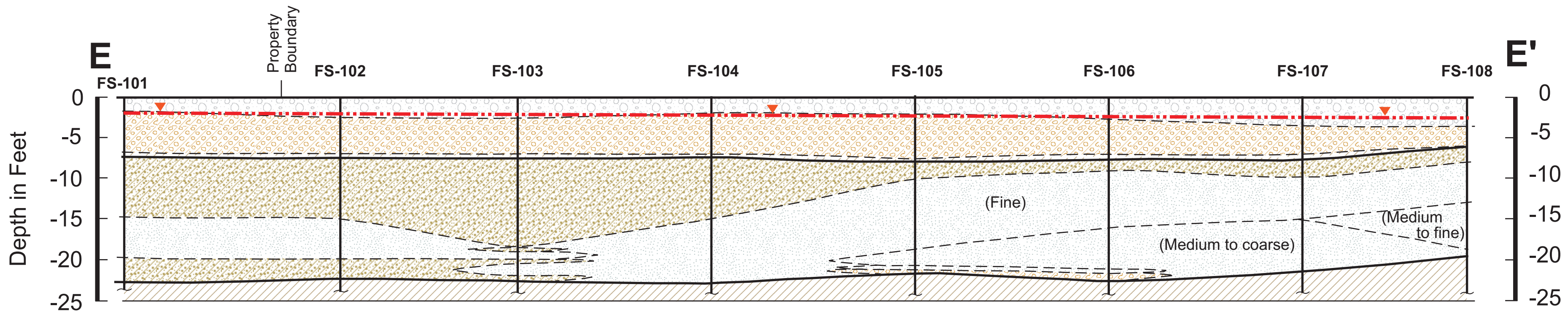
strategy • science • engineering

Cleanup Action Plan
B&L Landfill
Milton, WA

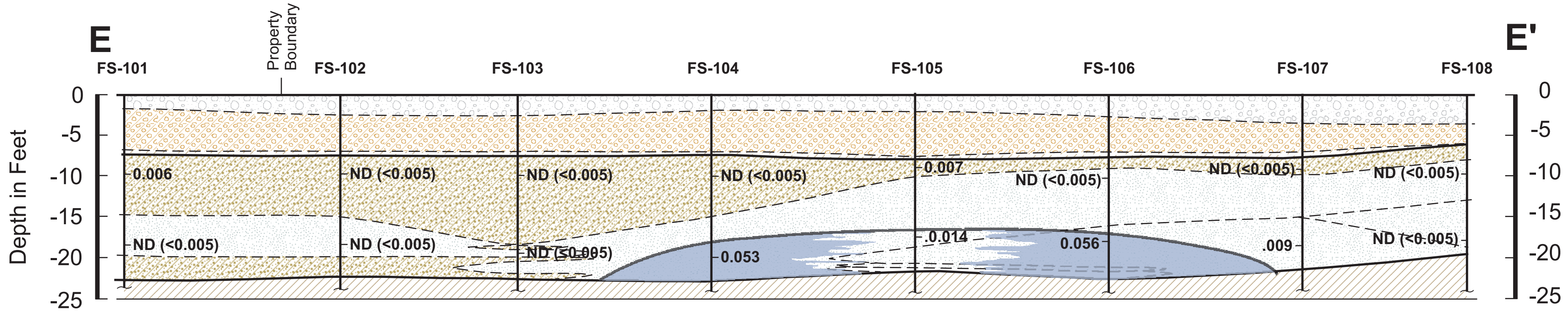
Figure 8
Cross Section F-F'
Site Hydrostratigraphy and Dissolved Arsenic Concentrations in Groundwater

g:projects/clients/floydsnider/B&L/groundwater alternatives/Figure 3.1.ccrC

01/10/2007 Ecology Preliminary Review Draft



Approximate Ground Surface Along Transect = 11 Ft. MSL.



Geology Key

▨	Imported Road Material	▨	Silty Sand
▨	Silt	☐	Sand (Grain size)
▨	Organic Silt and Peat	▨	Silt Interbedded with Peat

Dissolved Arsenic in mg/L

☐	<0.005 to 0.020	🟦	0.200 to 2.000
🟦	0.020 to 0.200	🟦	>2.0

0.054 Actual Concentration

—·▼·· Approximate Potentiometric Surface Elevation

Notes:
1. Refer to Figure 2 for cross section location.
2. Arsenic concentration contours are interpreted from 2006 discrete-depth sampling results.
3. Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

Horizontal Scale in Feet
0 50 100
0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 2.5

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Milton, Washington

Cross Section E-E'
Site Hydrostratigraphy and Dissolved
Arsenic Concentrations in Groundwater
17330-09 5/07

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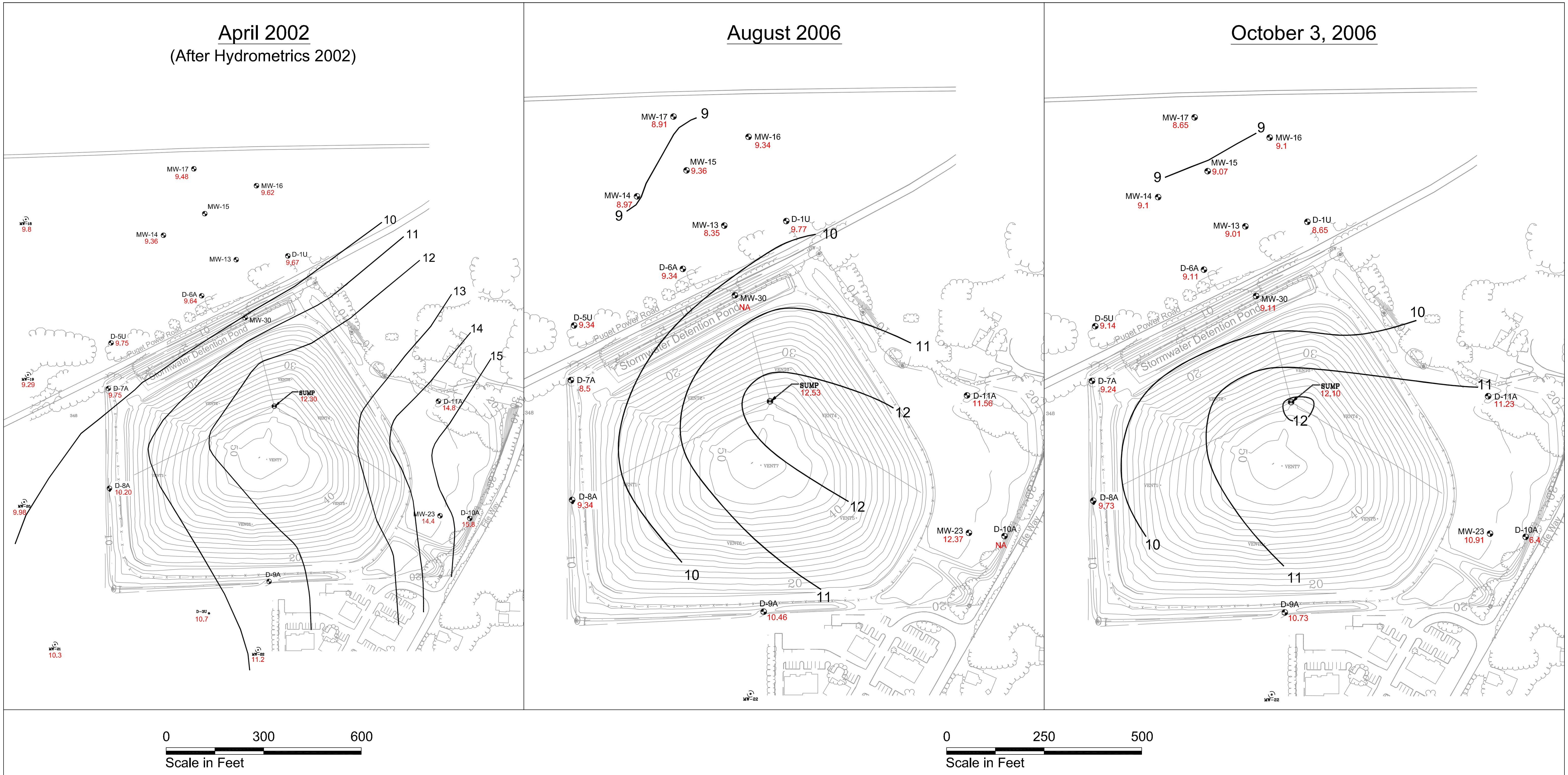
Figure
9

EAL 05/25/07 1733009-AG.cdr



● D-8A 9.34 Upper Sand Aquifer Monitoring Well and Groundwater Elevation in Feet (MSL)

⊙ 10.3 Decommissioned Upper Sand Aquifer Monitoring Well and Groundwater Elevation in Feet (MSL)

— 10 — Potentiometric Elevation Contour in Feet (MSL)

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

N

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Potentiometric Surfaces in Upper Sand Aquifer

17330-09

5/07

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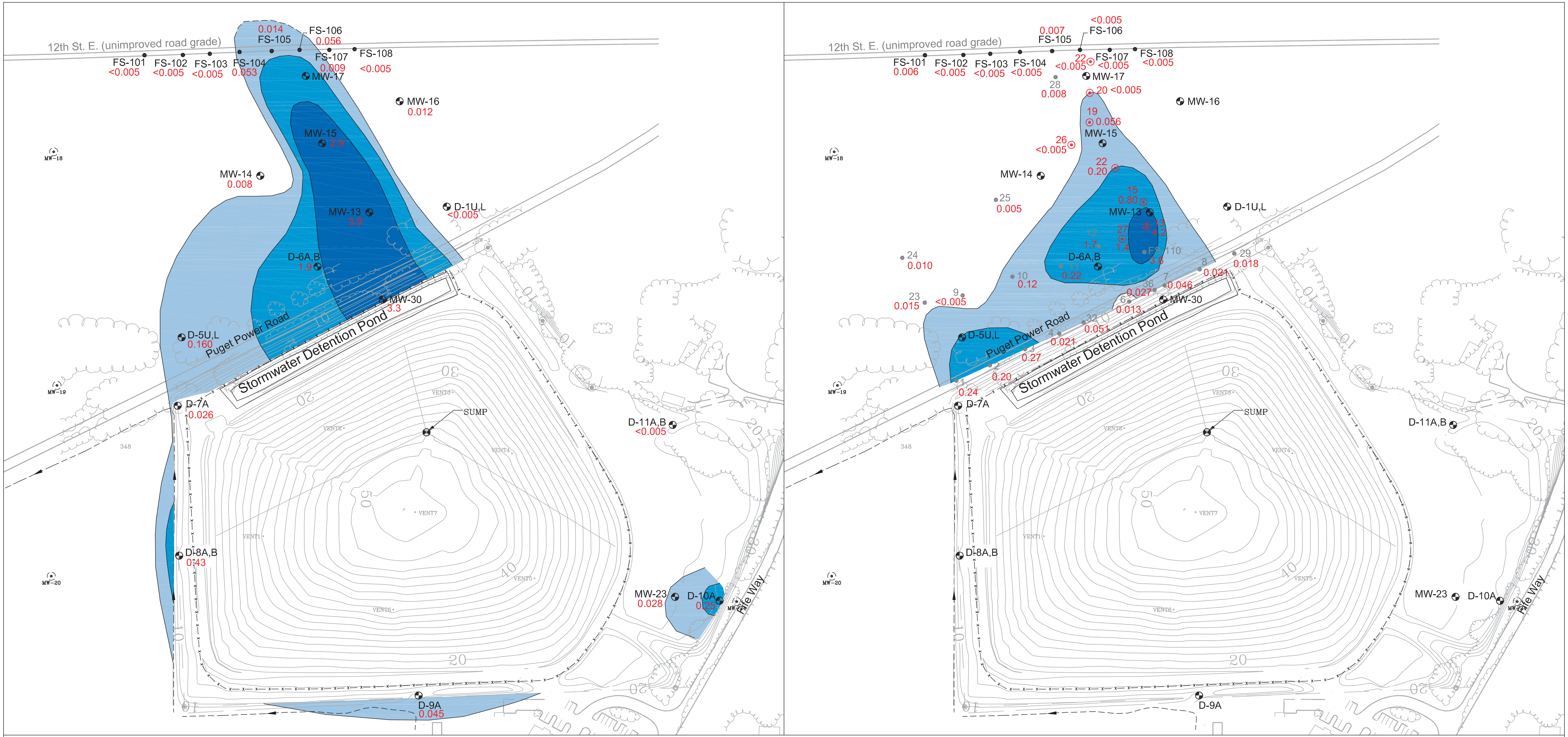
Figure
10

EAL 05/25/07 1733009-006.dwg



- ● FS-102 Geoprobe Groundwater Sampling Location, Sept. 2006
- MW-15 Shallow Aquifer Monitoring Well
- Decommissioned Shallow Aquifer Monitoring Well
- Sump Monitoring Well
- • 1 Geoprobe Groundwater Sampling Location, Aug-Oct. 2005 ("FS" prefix omitted for clarity)
- ⊙ 15 Geoprobe Groundwater Sampling and Temporary Piezometer Location
- ○ 14 Temporary Piezometer Location

Dissolved Arsenic in mg/L

☐	<0.005 to 0.020
🟦	0.020 to 0.200
🟦	0.200 to 2.000
🟦	> 2.0
0.023	Actual Concentration in mg/L

Notes:

1. Contours based on August 2006 sampling of monitoring wells with screened intervals in the bottom 5' of the Shallow Aquifer.
2. Results from MW-17 were excluded because MW-17 is screened above this interval.
3. Only Sept. 2006 discrete-depth probe groundwater samples from the deeper interval (16-20' to 19-23') at the base of the Upper Sand Aquifer are shown.

0 200 400
Scale in Feet

N

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Extent of Dissolved Arsenic in the Upper Sand Aquifer

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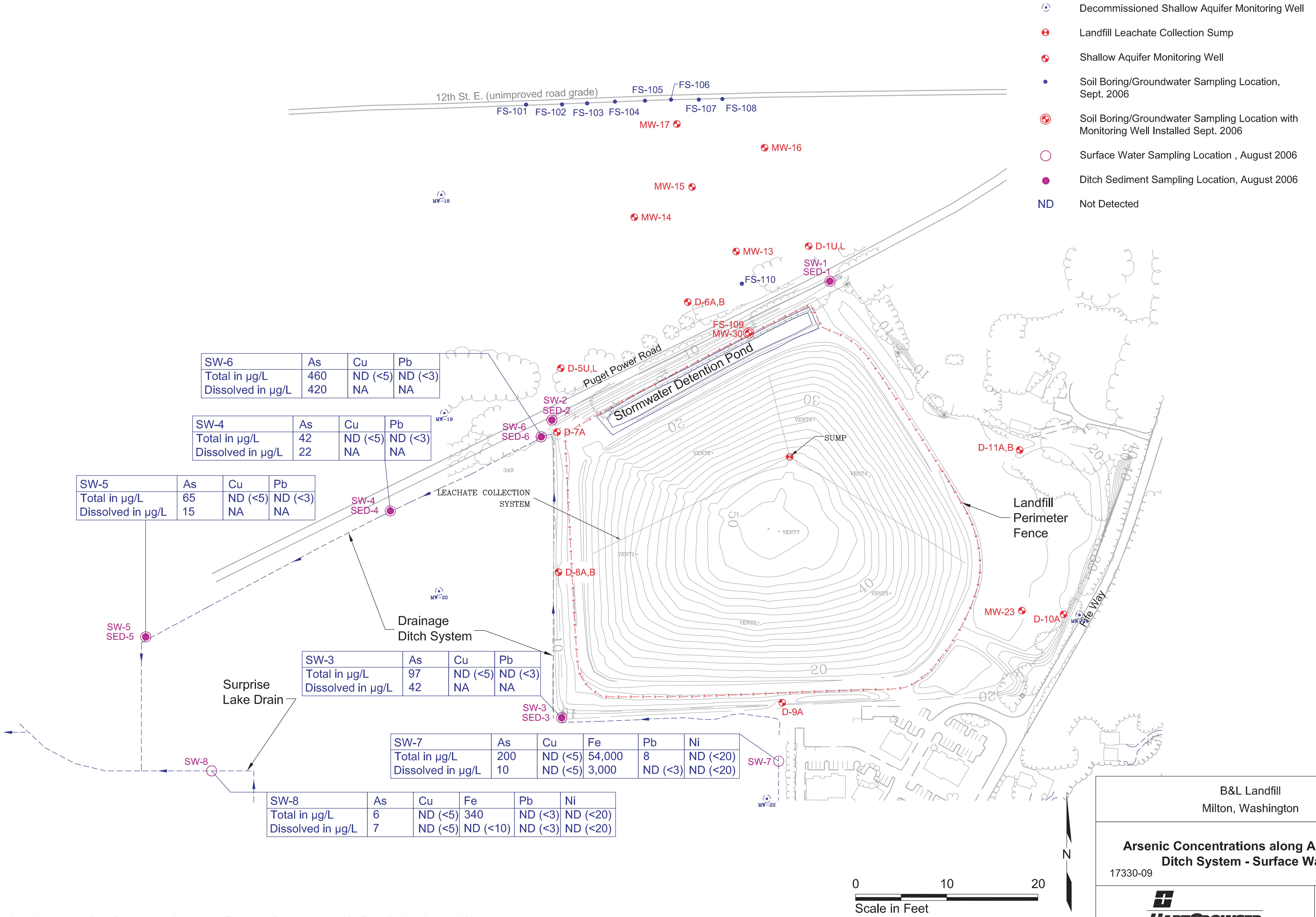
Figure
11

EAL 05/25/07 1733009-007.dwg

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.



SW-6	As	Cu	Pb
Total in µg/L	460	ND (<5)	ND (<3)
Dissolved in µg/L	420	NA	NA

SW-4	As	Cu	Pb
Total in µg/L	42	ND (<5)	ND (<3)
Dissolved in µg/L	22	NA	NA

SW-5	As	Cu	Pb
Total in µg/L	65	ND (<5)	ND (<3)
Dissolved in µg/L	15	NA	NA

SW-3	As	Cu	Pb
Total in µg/L	97	ND (<5)	ND (<3)
Dissolved in µg/L	42	NA	NA

SW-7	As	Cu	Fe	Pb	Ni
Total in µg/L	200	ND (<5)	54,000	8	ND (<20)
Dissolved in µg/L	10	ND (<5)	3,000	ND (<3)	ND (<20)

SW-8	As	Cu	Fe	Pb	Ni
Total in µg/L	6	ND (<5)	340	ND (<3)	ND (<20)
Dissolved in µg/L	7	ND (<5)	ND (<10)	ND (<3)	ND (<20)

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

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Arsenic Concentrations along Agricultural Ditch System - Surface Water

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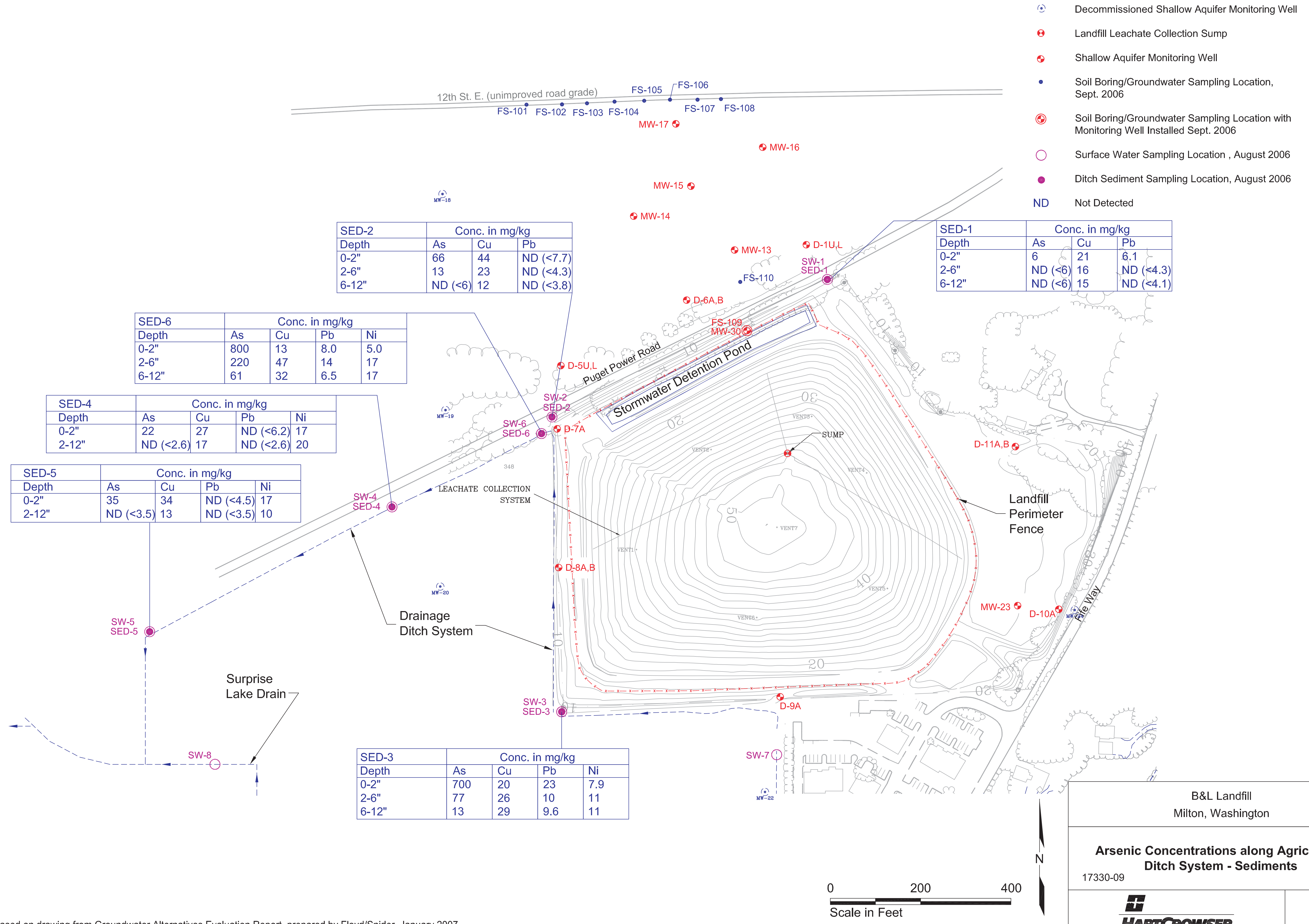
Figure 12

EAL 05/25/07 1733009-004.dwg



SED-1	Conc. in mg/kg		
Depth	As	Cu	Pb
0-2"	6	21	6.1
2-6"	ND (<6)	16	ND (<4.3)
6-12"	ND (<6)	15	ND (<4.1)

SED-2	Conc. in mg/kg		
Depth	As	Cu	Pb
0-2"	66	44	ND (<7.7)
2-6"	13	23	ND (<4.3)
6-12"	ND (<6)	12	ND (<3.8)

SED-3	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	700	20	23	7.9
2-6"	77	26	10	11
6-12"	13	29	9.6	11

SED-4	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	22	27	ND (<6.2)	17
2-12"	ND (<2.6)	17	ND (<2.6)	20

SED-5	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	35	34	ND (<4.5)	17
2-12"	ND (<3.5)	13	ND (<3.5)	10

SED-6	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	800	13	8.0	5.0
2-6"	220	47	14	17
6-12"	61	32	6.5	17

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

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Arsenic Concentrations along Agricultural Ditch System - Sediments

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Figure
13

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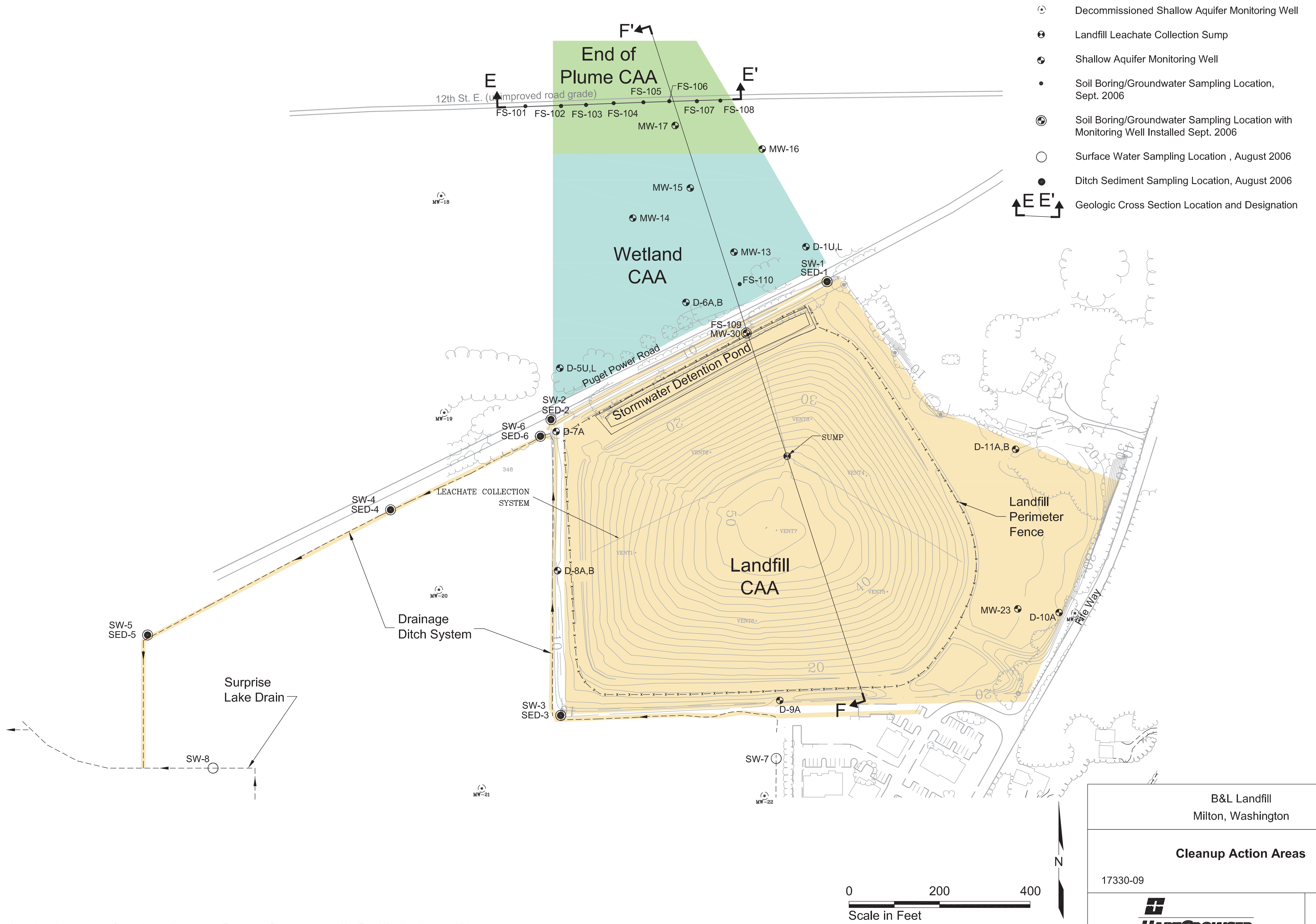

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

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Cleanup Action Areas

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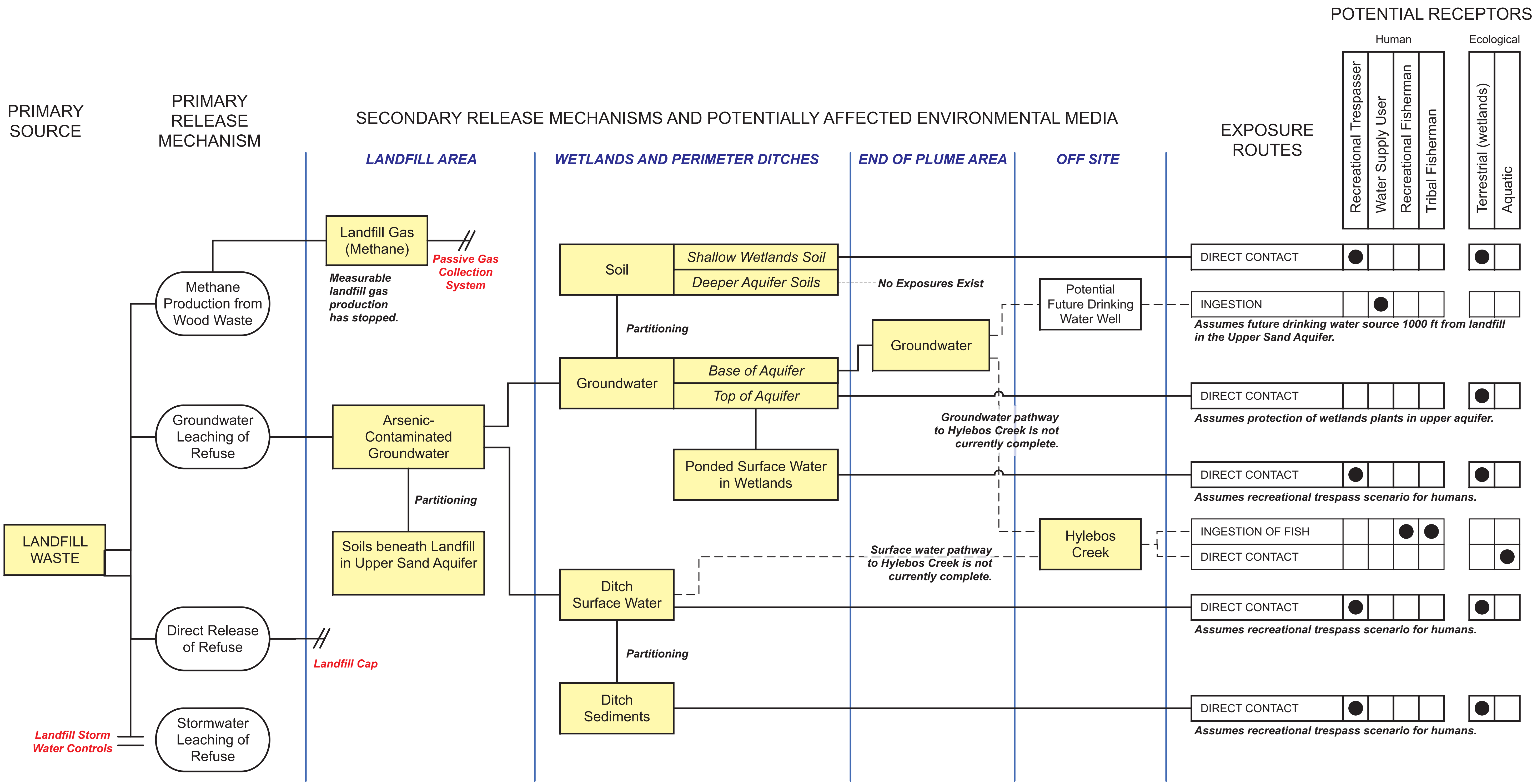
Figure
14

EAL 05/25/07 1733009-005.dwg



EXPOSURE ROUTES	POTENTIAL RECEPTORS					
	Human				Ecological	
	Recreational Trespasser	Water Supply User	Recreational Fisherman	Tribal Fisherman	Terrestrial (wetlands)	Aquatic
DIRECT CONTACT	●				●	
INGESTION		●				
DIRECT CONTACT					●	
DIRECT CONTACT	●				●	
INGESTION OF FISH			●	●		
DIRECT CONTACT						●
DIRECT CONTACT	●				●	
DIRECT CONTACT	●				●	

Assumes future drinking water source 1000 ft from landfill in the Upper Sand Aquifer.

Assumes protection of wetlands plants in upper aquifer.

Assumes recreational trespass scenario for humans.

Assumes recreational trespass scenario for humans.

Assumes recreational trespass scenario for humans.

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

B&L Landfill
Milton, Washington

Conceptual Model of Potential Exposure Pathways and Receptors

17300-09
5/07

Figure
15

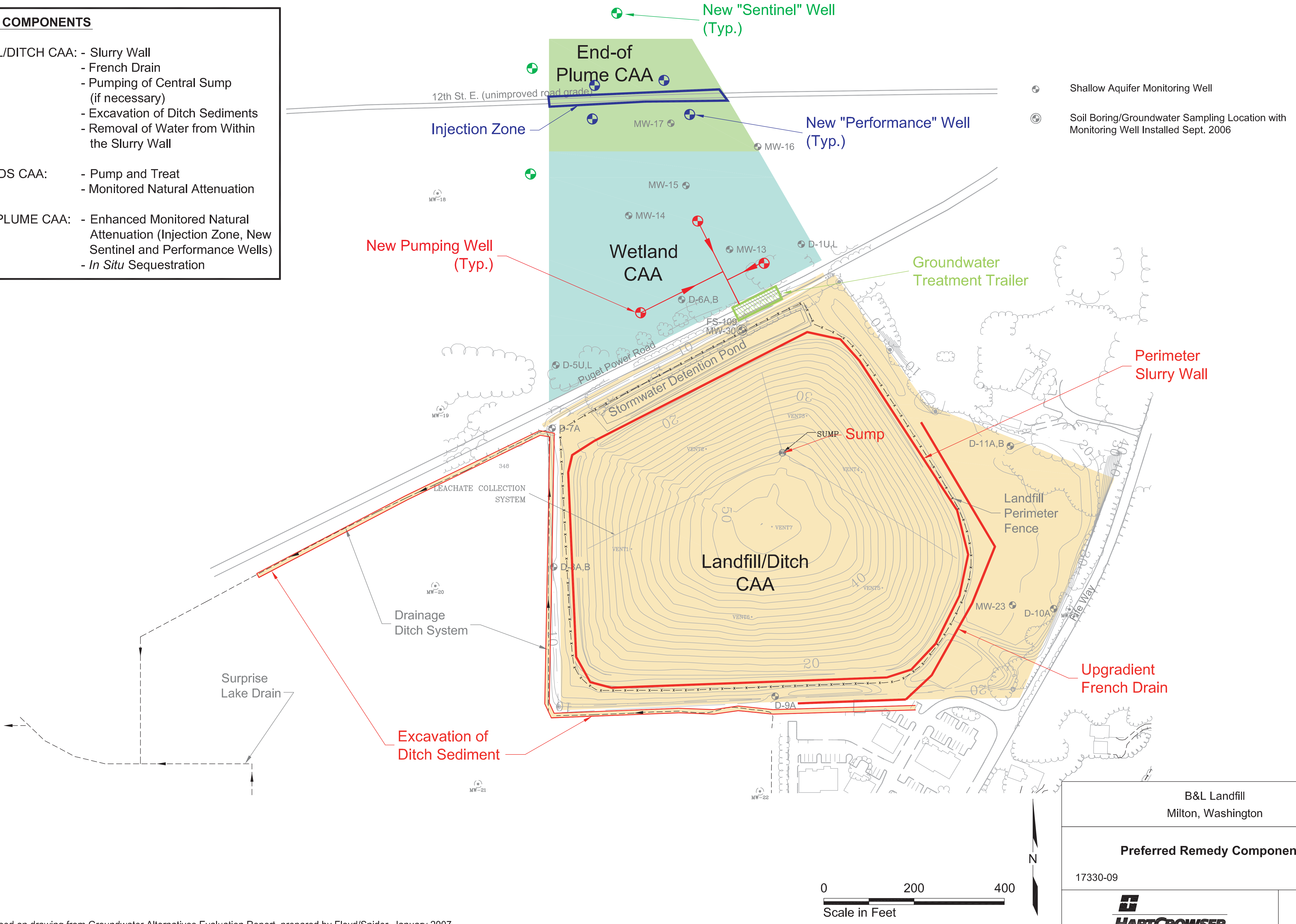
EAL 05/25/07 1733009-AH.cdr

REMEDY COMPONENTS

LANDFILL/DITCH CAA:
- Slurry Wall
- French Drain
- Pumping of Central Sump (if necessary)
- Excavation of Ditch Sediments
- Removal of Water from Within the Slurry Wall

WETLANDS CAA:
- Pump and Treat
- Monitored Natural Attenuation

END OF PLUME CAA:
- Enhanced Monitored Natural Attenuation (Injection Zone, New Sentinel and Performance Wells)
- *In Situ* Sequestration



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Preferred Remedy Components

17330-09 5/07

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Figure
16

Note: Figure based on drawing from Groundwater Alternatives Evaluation Report, prepared by Floyd/Snider, January 2007.

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B&L Landfill

Groundwater Alternatives Evaluation

Prepared for

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1201 Pacific Avenue, Suite 1750
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Prepared by

FLOYD | SNIDER
Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101

January 2007

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List of Abbreviations and Acronyms

Acronym/Abbreviation	**Definition**
AOC	Area of Contamination
ARARs	Applicable or relevant and appropriate requirements
ASARCO	ASARCO, LLC
BOF	Basic oxygen furnace material
bgs	Below ground surface
CAAs	Cleanup Action Areas
CAMU	Corrective Action Management Unit
CAP	Cleanup Action Plan
CBN/T Site	Commencement Bay Nearshore/Tideflats Superfund Site
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic feet per second
COCs	Contaminants of concern
COD	Chemical oxygen demand
Corps	U.S. Army Corps of Engineers
CSM	Conceptual Site Model
CULs	Cleanup levels
CWA	Clean Water Act
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EMNA	Enhanced Monitored Natural Attenuation
EEI	Ecology and Environment, Inc.
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FWS	Free water surface
GAE	Groundwater Alternatives Evaluation
gpd	Gallons per day
gpm	Gallons per minute
HAZWOPER	Hazardous Waste Operations and Emergency Management
I-5	Interstate 5

Acronym/Abbreviation	**Definition**
LDRs	Land disposal restrictions
LEL	Lower explosive limit
LFG	Landfill gas
MNA	Monitored Natural Attenuation
MSA	Magnuson-Stevens Act
MSL	Mean sea level
MTCA	Washington State Model Toxics Control Act
Murray	Murray Pacific Corporation
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	Net present value
O&M	Operations and maintenance
ORP	Oxidation-reduction potential
OSHA	Occupational Safety and Health Act
PLPs	Potentially liable parties
POTW	Publicly Owned Treatment Works
PRB	Permeable Reactive Barrier
PSCAA	Puget Sound Clean Air Authority
QA/QC	Quality assurance/quality control
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
Redox	Reduction-oxidation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SEPA	State Environmental Policy Act
SMS	Sediment Management Standards
SR	State route
SRB	Sulfate-reducing bacteria
SSF	Sub-surface flow
SVOCs	Semivolatile organic compounds
TDS	Total dissolved solids

Acronym/Abbreviation	Definition
TPCHD	Tacoma-Pierce County Health Department
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOCs	Volatile organic compounds
WDFW	Washington State Department of Fish and Wildlife
WISHA	Washington Industrial Safety and Health Act
WSDOT	Washington State Department of Transportation

Executive Summary

EXECUTIVE SUMMARY

This Groundwater Alternatives Evaluation (GAE) explores alternatives for addressing groundwater contamination at the B&L Landfill (the Landfill) in Milton, Washington. The Landfill is the subject of a 1989 Consent Decree between the Washington State Department of Ecology (Ecology) and Murray Pacific Corporation (Murray), which resulted in a 1991 Cleanup Action Plan (CAP). The Remedial Action identified in the CAP was substantially completed in 1993, pursuant to a 1991 Enforcement Order directed by Ecology to ASARCO, Inc. (ASARCO), Murray, and Executive Bark Corporation—the Landfill operator. Remediation of groundwater contamination was reserved as a contingency action and was not a component of the 1993 construction. This document presents a comparative evaluation of potential alternatives to address groundwater contamination that is now known to exist in a wetlands area north of the Landfill. The selected alternatives will be added to the existing remedy for the site.

BACKGROUND AND PROBLEM STATEMENT

The B&L Landfill primarily received wood waste generated from the sweeping of log sort yards in Tacoma, Washington in the late 1970s and early 1980s. Much of this wood waste contained slag byproduct from the ASARCO copper smelter in Ruston, Washington. The slag was sold to the log yard operators (including Murray) by ASARCO for use as ballast to provide a durable rolling surface for heavy equipment in the yards. ASARCO misrepresented the slag to be a safe, inert substitute for the gravel that had been used traditionally as ballast material. In fact, the slag contained significant amounts of metals, including arsenic. When runoff, infiltrating rainwater or groundwater came into contact with the slag, arsenic leached from the slag and dissolved into the water. In the early to mid-1980s, environmental regulators and public health officials became aware that arsenic in runoff from the log yards and the Landfill was a source of contamination to surface water, including Hylebos Creek.

In 1990, a remedial investigation and focused feasibility study (RI/FS) performed by Murray defined the nature and extent of contamination at the Landfill and recommended a remedial approach. This approach included the consolidation and capping of Landfill materials with installation of a bottom liner; ditch remediation; installation of landfill gas collection wells and a leachate monitoring system; installation of a stormwater collection pond and infiltration trenches; institutional controls (site fencing); and routine monitoring of surface water and groundwater. The remedy embodied in the 1991 CAP substantially met the elements of the U.S. Environmental Protection Agency's (USEPA) Presumptive Remedy for a municipal landfill cleanup and was very similar to the preferred alternative listed in the RI/FS. Its major difference was that it omitted a liner, assuming that Landfill consolidation and capping alone would be sufficiently protective of groundwater at the site.

Both the RI/FS and the CAP rejected the “dig and haul” remedial alternative, by which the Landfill material would have been excavated and removed to a hazardous waste disposal facility, as being disproportionately expensive, compared to other alternatives. A reevaluation of the cost of this alternative confirms that it remains disproportionately expensive nor would it address the underlying groundwater plume.

In 1991, a judgment in a federal lawsuit found that ASARCO had failed to inform the log yard operators of the dangers presented by the slag. ASARCO was held liable for 79 percent of the costs to clean up the Landfill and the Landfill operator was assigned 14 percent. The remaining responsibility was assigned to Murray (7 percent). When the operator later became insolvent, ASARCO and Murray agreed to split its residual responsibility, which made ASARCO liable for approximately 92 percent and Murray for 8 percent of the cleanup. ASARCO and its consultant agreed to take the lead role in the implementation of the selected remedy and the long-term monitoring.

In 2001, ASARCO presented monitoring data to Ecology that indicated arsenic-contaminated groundwater was continuing to migrate into agricultural drainage ditches adjacent to the Landfill, and new wells identified a much larger groundwater plume (than previously realized) existed in the wetlands north of the Landfill. ASARCO submitted a Contingency Plan that proposed a study of potential remediation alternatives for groundwater. ASARCO did not complete implementation of the plan. In February 2005, a Second Amendment to the 1991 Enforcement Order required the implementation of activities outlined in the 2001 Contingency Plan. ASARCO declared bankruptcy in August 2005, and Murray stepped forward and assumed responsibility for the development of a remedial strategy to address the groundwater contamination—including a substantial investigative effort to understand current conditions at the Landfill and adjacent wetlands.

EVALUATION OF ALTERNATIVES FOR GROUNDWATER

This report is based on data collected pursuant to the monitoring program outlined in the Contingency Plan and on additional information developed by Murray and Floyd|Snider during the 2006 field season. The report defines three distinct but interrelated Cleanup Action Areas (CAAs) for implementation of a groundwater remedy: (1) the Landfill and perimeter ditches, (2) the wetlands area north of the Landfill, and (3) the End-of-Plume area along 12th St. E. (an abandoned right-of-way that allows access into the wetlands).

A broad range of potentially available technologies are identified in the report for each of the three action areas. These alternatives are screened on the bases outlined in WAC 173-340-360, including effectiveness in meeting remedial objectives; implementability (either technical or administrative), and cost compared to other feasible alternatives. Retained alternatives are evaluated in detail with respect to their overall protectiveness of human health and the environment; regulatory compliance; long and short-term effectiveness; permanence; reductions in contaminant toxicity volume and mobility; implementability; and cost. Based on this analysis, the evaluation report presents three preferred remedies for addressing groundwater contamination associated with the three CAAs. These remedies, in combination, will form a comprehensive remedy for groundwater at the site.

THE PREFERRED REMEDY

For the B&L Landfill itself, the remedy will consist of source control to eliminate leachate discharge and contain groundwater beneath the landfill that is already contaminated with arsenic. This will be achieved by the installation of a perimeter slurry wall around the refuse that is tied into both the existing landfill cap and a low-permeability unit (the Upper Silt Aquitard) located 15 to 20 feet below the base of the Landfill. Following installation of the slurry wall, contaminated sediments in the adjacent agricultural drainage ditches will be excavated. It is assumed that these ditches eventually will be buried or rerouted as part of development of adjacent parcels by others.

Within the wetlands area, a short-term groundwater pump-and-treat approach will be used to remove a mass of dissolved arsenic from the groundwater plume beneath the wetlands. Arsenic in this area is slowly partitioning onto soils, but much still remains in groundwater, which seasonally discharges to land surface and which migrates to the End-of-Plume area. The goal of this effort is to decrease concentrations of arsenic discharging to land surface and to limit downgradient migration of the arsenic.

At the End-of-Plume area along the unused 12th St. E. right-of-way, the preferred remedy will be in-situ treatment to precipitate out dissolved arsenic followed by monitored natural attenuation. In-situ treatment will accelerate the natural restoration time frame and increase the permanence of the remedy. New monitoring wells located in the downgradient reaches of the plume and sentinel wells (beyond the limits of the plume) will ensure the effectiveness of this remedy component.

The preferred remedy in each Action Area will include the establishment and/or continuation of institutional controls (i.e., signs, fencing, and land use restrictions) to limit public access to potentially contaminated media. Implementation of the remedies will require the cooperation of impacted landowners and stakeholders to allow for the construction, operation, and long-term maintenance of the various remedial components.

The combination of aggressive source control at the Landfill, reducing the mass of the wetlands plume, and in situ treatment at the downgradient edge to prevent further migration of the plume will all serve to meet the Washington State Model Toxics Control Act (MTCA) requirements for cleanup and to protect current and future potential downgradient receptors from arsenic releases from the B&L Landfill.

1.0 Introduction

1.1 PURPOSE OF THE GROUNDWATER ALTERNATIVE EVALUATION

This report evaluates the alternatives for addressing groundwater contamination at the B&L Landfill (the Landfill) in Pierce County, Washington. The Landfill is the subject of a 1989 Consent Decree that resulted in a 1991 Cleanup Action Plan (CAP) followed by remedial action construction in 1993. Remediation to address groundwater contamination was envisioned in the 1991 CAP only as a potential future contingency action. This document compares alternative remedial measures and identifies a preferred alternative that supplements the existing remedial action in order to address groundwater contamination.

1.2 REGULATORY CONTEXT

The regulatory and enforcement history at the Landfill is complex and was directly impacted by a federal lawsuit regarding responsibility for the Landfill cleanup. The following section describes the regulatory context and history of the Landfill from the late 1970s through today.[1]

The B&L Landfill investigation and cleanup is the subject of a Consent Decree entered into in March 1989 between Murray Pacific Corporation (Murray) and the Washington State Department of Ecology (Ecology), pursuant to the Washington State Model Toxics Control Act (MTCA). The Landfill cleanup is also the subject of an Ecology Enforcement Order (No. DE 92TC-S214, June 1992, amended in July 1992 and February 2005) directing ASARCO, LLC (ASARCO), Executive Bark, Inc. (refer to the Site History discussion below), and Murray to implement the remedy. Ecology's Enforcement Order (Second Amendment) requires implementation of a contingency plan to evaluate and potentially remedy a groundwater plume of arsenic occurring in the wetlands north of the Landfill. The Second Amended Order at paragraph 2 states, "The scope of the Contingency Plan shall be expanded to also include an additional work phase, consisting of the study, design and implementation, with Ecology approval, of measures needed to remediate the wetland area adjacent to the Site."

The scope of work for this Groundwater Alternatives Evaluation (GAE) was designed to satisfy the study element of paragraph 2 in the Amended Order. ASARCO, as the primary potentially liable party (PLP) for the Landfill, was originally directed by Ecology to complete this work. However, the failure of ASARCO to perform its obligations under the Order led Murray in good faith to step in and complete the study aspect of the order.

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[1] Much of the factual history presented herein is derived from documents, testimony, and pleadings generated in the federal lawsuit, which is described in Section 1.3.3.

1.3 SITE HISTORY

1.3.1 The Years of Landfill Operation—1978 to 1984

Throughout its operation from the late 1800s to 1985, the ASARCO copper smelter in Ruston, Washington produced significant amounts of reverberatory slag, a waste product from the smelting operation. This molten slag by-product hardened into rock-like pieces containing up to 2 percent arsenic. Much of it (approximately 15 million tons) was deposited on ASARCO's Ruston property and/or directly into Commencement Bay. In the mid-1970s, faced with pressures from environmental regulators to curtail the dumping of slag into the bay, ASARCO arranged with an intermediate broker, Black Knight, Inc. (later Industrial Mineral Products, Inc., and L-Bar Construction) to provide slag to log sort yards in Tacoma. This slag was to be used as a ballast material, in lieu of gravel, as a durable surface for the heavy rolling stock used at the yards. Black Knight, Inc. and its successors arranged with a Tacoma trucking company called B&L Trucking, Inc. (and later a related entity called Eagle Trucking, Inc.) to purchase the slag at the ASARCO facility and haul it to the log yards for resale to the log yard operators. The slag was misrepresented by ASARCO and the brokers to be chemically inert, and an acceptable and safe material to use at the log yards.

B&L Trucking, Eagle Trucking Inc., and an associated company, Executive Bark, Inc., were owned and operated by Mr. William Fjetland. Along with transporting the ASARCO slag to the log yards, Mr. Fjetland independently contracted with the same log yard operators for cleanup of their yards, which would become cluttered with bark, dirt, rock, and wood debris in the course of normal operations. The material that was removed from the log yards during these cleanup operations contained significant amounts of slag. Mr. Fjetland required a disposal location for this material. He contacted the Tacoma-Pierce County Health Department (TPCHD) in January 1977 to request a permit allowing the disposal of the wood debris/slag/dirt mixture in an agricultural lowland area of approximately 18.5 acres located in unincorporated Pierce County near the cities of Fife and Milton (refer to Figure 1.1). This permit was granted in January 1978 and the disposal area became known as the B&L Landfill.

The TPCHD wood waste landfill permit for the B&L Landfill has not been located. According to sworn testimony, however, in the federal lawsuit (see discussion below) by both Mr. Fjetland and a representative of the TPCHD, the Landfill did operate pursuant to such a permit, with regulatory oversight from both the TPCHD and Ecology, from its inception in 1978 until the permit was revoked in January 1981 (due to changes in federal regulations that prohibited filling of wetlands). Following the permit revocation, individual shipments of wood waste continued to occur, with TPCHD approval, through 1983 or 1984.

The wood debris, dirt, and ASARCO slag mixture constituted the majority (by far) of the material deposited at the B&L Landfill. Mr. Fjetland's log yard customers included Murray, the Louisiana Pacific Corporation, Wasser Winters, Inc., Portac Inc., Cascade Timber Company, and others—all of which used ASARCO slag at their yards and contracted with Mr. Fjetland for its removal and disposal at the Landfill. Lesser amounts of other nonputrescible wastes were occasionally disposed at the Landfill, including "auto fluff" from a General Metals, Inc. metal reclamation facility, and waste shot from U.S. Gypsum Inc. Between 1978 and 1984 approximately 400,000 cubic yards of debris was deposited at the Landfill. Over 95 percent of this material is believed to have been log yard debris consisting of dirt, bark, rock, and ASARCO slag.

1.3.2 Discovery of B&L Landfill-Related Problems—1981 to 1987

Beginning in the early 1980s, Ecology and the U.S. Environmental Protection Agency (USEPA) gradually became aware of elevated levels of arsenic in the Blair and Hylebos waterways and adjoining properties—particularly those that were using the ASARCO slag as log yard ballast. Ecology convened a meeting of log yard owners in 1981 to discuss the possible relationship between arsenic contamination and leachate from log yard slag, and to recommend alternative materials as ballast at the yards. ASARCO attended this meeting, and vigorously refuted the notion that the log yard slag could be a contributing factor to elevated arsenic in surface or groundwater, contending again that the slag was chemically inert. Ecology and USEPA continued to study the arsenic problem.

Table 1.1 identifies key studies and documents related to Ecology's and USEPA's evolving understanding in the 1980s of the role of ASARCO slag as a source of metals (particularly arsenic) contamination to surface and groundwater and sediment in the Hylebos (and Blair) Waterways and at the Landfill. These studies began to focus on the Landfill as a contaminant source in the mid-1980s, after its closure.

In September 1983, USEPA placed the Commencement Bay Nearshore/Tideflats Superfund Site (CBN/T Site) on the National Priorities List (NPL), pursuant to Section 105 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 U.S.C. Sec. 9605). The CBN/T site included the Hylebos Waterway and sites that were believed to contribute contamination to the waterway. The 1989 Record of Decision for the CBN/T Site lists the B&L Landfill as one of the sources of contamination.

1.3.3 The Early Regulatory Years—1988 to 1991

In January 1988, Ecology sent notices to a number of entities advising them of their status as PLPs under MTCA for contamination at the B&L Landfill, and requesting their participation in an investigation and the development of a remedial strategy for the Site. The original PLP letters were sent to ASARCO, Mr. Fjetland, Murray, Louisiana-Pacific, Inc., the Weyerhaeuser Corporation, and L-Bar Products, Inc. Following discussions with the PLPs and additional research into historical landfill operations, Ecology sent additional letters to a revised list of parties. This revised PLP list was comprised of ASARCO, Mr. Fjetland, L-Bar Products, Inc., Murray, Louisiana-Pacific, Inc., Portac, Inc., U.S. Gypsum, Inc., Executive Bark., Inc., General Metals, Inc., Wasser Winters, Inc., and West Coast Orient., Inc. With the exception of Murray, the PLPs declined Ecology's request to address environmental problems at the Site. Murray and Ecology negotiated a Consent Decree in March 1989, pursuant to which Murray agreed to conduct a remedial investigation/feasibility study (RI/FS) and implement a cleanup remedy at the Site. Ecology agreed to join Murray, following completion of the remedy, in pursuing other PLPs for contribution to the cost of the studies and the cleanup (see Section III of the Consent Decree). Murray engaged Kennedy Jenks, Inc. and Applied Geotechnology, Inc. to prepare the RI/FS, which was completed in September 1990. The RI/FS recommended a remedy for the Landfill cleanup (refer to Section 1.4 for details). Ecology selected the recommended remedy with modifications and incorporated it into the CAP in October, 1991.

In 1988, Louisiana-Pacific, Inc. instituted an action in the United States Federal Court (Western District of Washington) against ASARCO for damages associated with releases of arsenic to the

Hylebos Waterway from slag used as ballast at its log sort yard. ASARCO then sued a number of third-party defendants, including Murray. Following the filing of counterclaims by the defendants, the court eventually realigned Murray and others as plaintiffs versus ASARCO. Along with issues related to releases at the log yards themselves, the lawsuit also addressed liability with respect to the B&L Landfill. After approximately three years of discovery, which included nearly 100 depositions of factual and expert witnesses, the case was tried in early 1991. It was in part, a jury trial (with respect to state claims and product liability claims) and in part, a bench trial (with respect to claims under CERCLA). The jury found that ASARCO had violated the Washington State Hazardous Waste Management Act, and that it had failed to provide adequate warnings to the log yard owners regarding the risks posed by its slag by-product. The court apportioned liability for damages related to the Landfill pursuant to a number of factors, including volumetric contribution of wood debris. The court found ASARCO liable for 79 percent of the costs to clean up the Site, the Landfill operator for 14 percent (assigned equally to Eagle Trucking, Inc. and William Fjetland), and Murray responsible for the remaining 7 percent. The verdict and decision were affirmed on appeal in 1994.

1.3.4 The ASARCO Years—1991 to 2005

Following the judgment in the federal lawsuit, Ecology issued an Enforcement Order (No. DE 91TC-S267) to ASARCO, Murray, and Executive Bark, Inc. (c/o Camille Fjetland, Mr. Fjetland's widow) to develop preliminary designs for the remedial actions identified in the CAP. In June 1992, Ecology issued another Enforcement Order (No.DE-92TC-S21492) to ASARCO, Murray, and Executive Bark, Inc. for construction, operation, and monitoring of the selected remedial action. ASARCO and its consultant, Hydrometrics, Inc. (Hydrometrics), took the lead in implementation of the remedy, which was substantially completed in 1993. In September 1995, following affirmation of the federal judgment on appeal, Murray and ASARCO signed a Settlement Agreement based on the percentages of liability set forth in the 1991 federal judgment. Because the Landfill owner was no longer viable, the settlement reallocated percentages and fixed ASARCO's liability at 91.86 percent and Murray's at 8.14 percent for clean-up of the Landfill. Murray and ASARCO agreed that ASARCO would continue to control and direct activities at the Landfill.

As described in Section 1.4, the B&L remedial action primarily consisted of consolidating and capping landfill materials; installing landfill gas collection wells; installing a leachate monitoring system; a stormwater collection pond and infiltration trenches; ditch remediation; institutional controls (site fencing); and routine monitoring of surface water and groundwater. A groundwater remedy (pump-and-treat) was evaluated, but not implemented, as it was viewed only as a future contingency action. The 1993 capping of the Landfill by ASARCO was effective in reducing surface water infiltration into the Landfill and likely ceased the production of leachate generated by surface water infiltration; however, it did not address groundwater under or adjacent to the Landfill.

In a draft report to Ecology in May 2001, "Review of Remedial Activities at the B&L Landfill," ASARCO presented monitoring data that indicated a migration of arsenic in groundwater into ditches adjacent to and downstream of the Landfill, and in the wetlands north of the Landfill (Hydrometrics 2001a). In June 2001, ASARCO submitted a "Contingency Plan for the B&L Landfill" that proposed several remedies for controlling groundwater at the Landfill (Hydrometrics 2001b). ASARCO did not complete the activities scoped out in the Plan.

In February 2005, the Second Amendment to the Enforcement Order required the resumption, completion, and implementation of the activities outlined in the 2001 Contingency Plan.

1.3.5 Recent Activity—2005 to Present

ASARCO declared bankruptcy on August 10, 2005, with none of the activities outlined in the Second Amendment to the Enforcement Order completed. Executive Bark, Inc. has not participated in remedial activities at the Site. In the interim, Murray has taken on the investigation of groundwater contamination in the wetlands and the development of remedial alternatives to address groundwater. As part of this effort, Floyd|Snider, on Murray's behalf, has investigated the hydrogeology and geochemistry of the groundwater and surface water contamination in the vicinity of the Landfill, undertaken a study of surface and ditch drainage in the Site area, and identified data gaps relevant to the design and implementation of a remedy. The GAE is intended to meet the continuing requirements of the Murray/Ecology Consent Decree and the Second Amendment to the Enforcement Order.

1.4 BASIS FOR THE 1993 SELECTED REMEDY

This section presents the basis for the remedial approach that was selected by Ecology in 1991 and implemented in 1993.

1.4.1 Selection of Remedial Alternative

The 1990 FS established Remedial Action Objectives (RAOs) for ditch sediments, landfill materials, groundwater, and surface water based on exposure pathways and risk to receptors (K/J/C & AGI 1990a). The media of concern, contaminants of concern (COCs), and cleanup levels (CULs) established in the FS were adopted in the 1991 CAP and included arsenic, copper, lead, nickel, and phenol in soil, groundwater, surface water, and ditch sediments. These are presented in Table 1.2, which has been reproduced from the CAP. In its screening of remediation technologies, the FS examined technologies to address a range of general response actions for soil, groundwater, surface water, sediments, and air. Preliminary alternatives assembled from the technologies and process options that survived the initial screening ranged from "no action" to treatment of landfill materials, ditch sediments, and Site groundwater and surface water. Nine of twelve preliminary alternatives were distinct enough to preserve the range of alternatives and were subjected to a detailed analysis. These are listed in Table 1.3. Estimated costs are given in 1990 dollars, and thus are presented here only for comparison.

The alternative that was ultimately implemented most closely resembles the preferred alternative, 7C. Alternative 6 would have removed landfill wastes from the Site and disposed of them at another facility (dig and haul).

1.4.2 Dig and Haul Reconsideration

Dig and haul with off-site disposal was addressed by Ecology in the 1991 CAP. Ecology concluded that the cost of off-site disposal, compared to other lower cost alternatives, was disproportionately high. However, the CAP recommended reconsideration of the dig and haul alternative “if a lower cost disposal option becomes available in the future it should be considered” (Ecology 1991). To meet this request, the possibility of removal and off-site disposal is revisited here to reflect 2007 conditions.

Originally, the dig and haul costs, as presented in the FS, estimated that excavation of the Landfill and disposal in an off-site RCRA Subtitle C hazardous waste facility would cost approximately $106 million (assuming 100 percent of the waste designates as hazardous[2]).

The 2002 Corrective Action Management Unit (CAMU) amendments to the 1993 Resource Conservation and Recovery Act (RCRA) Rule offer an opportunity for lower disposal costs. The CAMU amendments, intended to remove disincentives to remediation waste handling during cleanups, generally allow off-site disposal of CAMU-eligible waste in a permitted RCRA Subtitle C facility without expensive pretreatment. Ecology adopted the federal amendments in WAC 173-303-646, and set forth the requirements for disposal of CAMU-eligible wastes into permitted dangerous waste landfills in WAC 173-303-646.910.

Waste Management, the operator of the regional RCRA Subtitle C facilities, was asked by Murray to update costs for a dig and haul alternative, including consideration of the CAMU amendments to RCRA (that is, without pretreatment). The results of this estimate indicate that excavation and disposal of 100 percent of the Landfill waste (approximately 350,000 cubic yards) in a RCRA Subtitle C landfill would cost approximately $41 million. Excavation and disposal of the estimated ratio of 25 percent RCRA waste and 75 percent non-RCRA waste would cost approximately $32 million. These costs cover only excavation and disposal of the Landfill materials and do not include costs for dewatering of the refuse prior to transport, disposal or reuse of the existing clean landfill cap soil, treatment of the groundwater plume that would remain beneath the Landfill footprint, and possible removal or other treatment of contaminated soil directly beneath the Landfill. These additional activities would add tens of millions of dollars to the Waste Management estimate of the costs of the dig and haul alternative.

In conclusion, the dig and haul alternative, while lower in unit cost than originally projected, still remains substantially and disproportionately more costly than other feasible options, and it would not address groundwater contamination beneath and adjacent to the Site.

1.4.3 The 1993 Remedy as Implemented

In the 1991 CAP, Ecology identified a selected remedial alternative for the Site consisting of landfill consolidation, multimedia (RCRA) cap or equivalent, stormwater detention basin, groundwater pumping/treatment (as needed), ditch remediation, landfill gas controls, surface water controls, and institutional controls (including barrier fencing around the Landfill and groundwater and surface water monitoring).

The selected remedy did not include the bottom liner for the Landfill that was a component of the preferred remedy in the FS. In the CAP, Ecology determined that the selected remedy was equivalent to the construction of a raised landfill base or a bottom liner system, but that these

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[2] Testing of a very small number of landfill waste samples indicated that approximately 25 percent of the samples designated as hazardous waste (AGI/KJC 1990).

latter alternatives were more expensive than the selected remedy, and required more earth moving and truck traffic, resulting in excessive short term negative impacts on human health and the environment. Landfill consolidation and capping along with site monitoring and institutional controls, without a liner, was expected to achieve the objectives of protection of human health and the environment, compliance with cleanup objectives, compliance with applicable laws, and compliance monitoring.

ASARCO provided a report to Ecology in August 1991 that argued that only limited groundwater contamination had occurred at the Site at that time (Hydrometrics 1991). The report contended that metals in groundwater at the Landfill, including arsenic, were subject to natural attenuation processes “that prevent these contaminants from being transported from the Landfill in groundwater,” and that “groundwater (could) not be an important pathway for arsenic transport.” The report recommended an integrated monitoring plan for surface and groundwater, including a contingency plan, if excessive metals and arsenic concentrations were detected.

The consolidation and capping alternative that was implemented has been successful in eliminating or significantly reducing risks to human health and the environment in a number of critical ways. Capping and perimeter fencing of the Site have eliminated human exposure to landfill waste through accidental ingestion, inhalation, and dermal contact. Excavation of contaminated ditch sediment eliminated existing sediment impacts and associated surface water contamination by the sediments. Capping has eliminated the pathway of runoff to surface water and significantly reduced water transmission through landfill materials by blocking infiltration, thereby reducing the volume of leachate generated. This has decreased the transport of contaminants to surface water and groundwater, and to sediments in perimeter ditches.

1.4.4 Presumptive Remedies

Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and scientific and engineering evaluation of performance data on technology implementation. Presumptive remedies are intended to streamline site investigations, speed up selection of cleanup actions, ensure consistency in remedy selection, and reduce the cost and time required to clean up similar types of sites.

According to USEPA, the presumptive CERCLA remedy for municipal landfill sites is containment—primarily containment of the landfill mass and collection and/or treatment of landfill gas. The presumptive remedy for such sites includes measures to control landfill leachate, affected groundwater at the perimeter of the landfill, and/or upgradient groundwater that is causing saturation of the landfill mass (USEPA 1993). USEPA’s position, supported by pilot studies, is that containment technologies are generally most appropriate for landfill waste because the volume and heterogeneity of the waste generally make treatment impracticable. Presumptive remedies do not address exposure pathways outside the source area (landfill), nor do they include long-term groundwater response actions.

Components of the presumptive remedy for landfill sites include:

- A landfill cap
- Source area groundwater control to contain plume(s)

- Leachate collection and treatment
    - Landfill gas collection and treatment; and/or institutional controls to supplement engineering controls

These components were largely included in the 1993 remedy specified in the CAP, as discussed in Section 1.4.3.

1.5 REPORT ORGANIZATION

Section 2.0 of this Report presents the current status of the Landfill site and environs, including land use and demographics, regional topography, and a summary of prior investigations.

Section 3.0 presents a Conceptual Site Model (CSM) of the Landfill site, describing its hydrogeology and the current nature and extent of contamination, as well as identifying both contaminant transport and exposure pathways, and potential human and environmental receptors for landfill-related contaminants.

Section 4.0 identifies RAOs and CULs for the groundwater remediation, and evaluates applicable or relevant and appropriate requirements (ARARs). It also identifies three distinct, but interrelated, CAAs: the Landfill and perimeter ditches, the wetlands area north of the Landfill and the End-of-Plume Area north of the wetlands area.

Section 5.0 presents a screening process for a broad range of potential remedial technologies for each CAA. Alternatives are evaluated with respect to implementability (either technical or administrative) and disproportionate cost compared to other feasible alternatives.

Section 6.0 evaluates retained alternatives in detail and ranks them in terms of their overall protectiveness of human health and the environment; regulatory compliance; long and short-term effectiveness; permanence; reductions in contaminant toxicity, volume and mobility; implementability; and cost.

Section 7.0 presents and justifies the recommended alternatives for addressing the groundwater plume in each of the identified CAAs.

2.0 Site Setting and Summary of Past Investigations

2.1 PHYSICAL SITE DESCRIPTION

The B&L Landfill is located on a tax parcel of approximately 18.5 acres in unincorporated Pierce County, Washington, approximately one-quarter mile east of Interstate 5 (I-5) and five miles east of Tacoma. The Landfill, shown in Figure 2.1, is situated in a residential and agricultural area in northern Pierce County. Farmland borders the western and southwestern edges of the Landfill, and an apartment complex adjoins the southeastern corner. Fife Way defines the southeastern boundary, and Puget Power Access Road (also known as Barth Road) delineates the north side. The pentagonal landfill occupies approximately 13 acres and rises to an elevation of approximately 50 feet above mean sea level (MSL).

To the north of the Landfill is former farmland that has re-established itself as a grassy wetland that stretches north and west to I-5. The wetland ground surface is flat and lies at approximately 9 to 10 feet above MSL. During winter months, the ground is generally covered with shallow standing water. Several hundred feet north of Puget Power Access Road is another roadway, 12th St. E., a primitive, unused and now mostly overgrown road grade that cuts through the wetland, marking the boundary between parcels.

2.2 LAND USE

Historically, land surrounding the Landfill has been used for agriculture, but in recent years it has become increasingly developed, as has most of the land in northern Pierce and Southern King Counties. The population of Pierce County increased nearly 20 percent between 1990 and 2000, and the growth rates in the Site vicinity (the Cities of Fife and Milton) were even greater. Future growth estimates project similar rates for the next two decades. The Landfill, wetlands, and 12th St. E. parcels are zoned for moderate density single family development (Pierce County 2006). The Puget Power Access Road is owned by the City of Milton, and is zoned as an open space district as part of the Interurban Trail project (City of Milton 1999).

Land use in the general vicinity is changing from the once agricultural, semi-rural uses, to more suburban residential, commercial, recreational, and environmental restoration project uses. Figure 2.2 shows the existing and proposed future land use in the larger Hylebos Creek watershed where the Landfill is located. These types of development increase stormwater flow through the creation of impervious (paved) surfaces. This increased flow is likely to affect groundwater and surface water hydrology in and around the Site.

As shown on Figure 2.3, the Landfill is currently bordered by vacant and/or agricultural lands immediately to the south (farmed land), west (vacant and farmed lands,) and north (wetlands). East of the Landfill is Fife Way East, a public road. To the south, is a multi-unite residential complex built in the late 1980s. To the northeast lies a parcel of land currently occupied by a single private residence, which, according to public record has recently been the subject of permit applications for development of 10 single-family homes. The cities of Fife and Milton both have explored the potential for the commercial and/or recreational development of lands near and/or adjacent to the Landfill. The City of Fife recently purchased the agricultural fields to the south and west of the site.

2.2.1 Hylebos Creek and Surprise Lake Drain Restoration

Several parcels to the north and west of the Landfill are likely to be directly impacted by a major Washington State Department of Transportation (WSDOT) highway project, the completion of State Route (SR) 167 between SR 161 in North Puyallup and the SR 509 freeway in Tacoma (refer to Figure 2.4). The final Environmental Impact Statement (EIS) for this project has recently been issued, and once the Record of Decision is prepared, the project will move into the design phase.

As part of its proposed SR 167 project, WSDOT has proposed major riparian restoration projects to manage stormwater, including relocating the channel of Hylebos Creek from its current path adjacent to I-5 northwest of the Landfill. The proposed relocation is designed to mitigate SR 167 construction impacts, to improve stormwater management, and to enhance and protect aquatic habitat in this stretch of the creek. While the exact location of the new creek channel is subject to change in the final design, the proposed general area of relocation, as shown on Figure 2.3, indicates that the creek channel will meander several hundred feet closer to the Landfill. The current Surprise Lake Drain ditch will also be restored to a more natural meandering channel. According to public records, in recent years, WSDOT has purchased a number of parcels in the area that will be impacted by the project.

Mitigation efforts planned for the SR 167 project include increasing the floodplain capacity of the area by deepening a section of the Hylebos Creek channel located between the Site and the mouth of the creek at Hylebos Waterway. This channel deepening would decrease regional flooding by lowering the water surface elevation during recurring flood events, such as the 100-year flood. As shown in Figure 2.5, the mitigation projects are expected to prevent the 100-year floodwaters from inundating the portion of the Site south of the Puget Power Access Road—including the perimeter of the Landfill, the drainage ditch system, and the adjacent agricultural fields.

Several other Hylebos Creek restoration projects have been completed in recent years or are currently underway. Such projects include those identified in the CBN/T site natural resource damage assessment process, and wetlands and instream habitat enhancement projects by groups such as Friends of the Hylebos and Citizens for a Healthy Bay.

2.3 REGIONAL TOPOGRAPHIC AND HYDROLOGIC SETTING

The regional topographic and hydrologic setting exerts significant influence upon the surface water and the shallow groundwater regime at the Site. More detailed information on Site hydrogeology, groundwater occurrence, and local surface water drainage is presented in Section 3.0.

Regional topography, surface water, and drainage features are shown in Figure 2.6. The Site is located in the floodplain of the Hylebos Creek watershed, close to where it merges with the larger Puyallup River valley. To the east of the Site, Fife Way marks the steep transition between the flat floodplain and the rolling hilly relief of the uplands glacial drift plain.

The Hylebos Creek watershed is a tributary sub-basin that drains 19 square miles of urban and suburban area between Fife and Federal Way (Entranco 2004). The primary surface water body, Hylebos Creek, is primarily a man-made channel in the vicinity of the Landfill. Hylebos

Creek generally flows in a southerly direction until turning west for the last 2 miles prior to its discharge into the Hylebos Waterway. The last 1.6 miles of stream is influenced by tidal backwater (MSG et al. 2004). A historic survey completed in 1870 indicates the floodplain was already cleared, drained, and at least partially diked for agriculture by the time of the survey (MSG et al. 2004).

The Hylebos Creek floodplain is situated on a series of alluvial deposits. The transition between the adjacent glacial drift hills and the floodplain alluvium is marked by a mixed gravel and sand colluvial deposit. Groundwater flowing from the glacial hills recharges the several hundred feet of water-bearing alluvial sand units that are punctuated by low-permeability strata (aquitards). The inputs of groundwater from this higher elevation drive groundwater flow beneath the Landfill in a northwesterly direction toward its eventual discharge into Hylebos Creek. Recent field studies found that recurring flooding during major storm events is likely due to a combination of flat topography, high groundwater table, and backwater conditions experienced at high tide during major storm events (Entranco 2004).

2.4 INVESTIGATIONS PRIOR TO LANDFILL REMEDY

Since the 1980s, many investigations and monitoring activities have been conducted to examine soil, surface water, ditch sediment, and groundwater conditions at the Site. Relevant findings from earlier investigations are discussed below and all previous investigations are summarized in Table 2.1.

Investigative activities at the Landfill began in 1985 when Ecology inspectors collected four samples of mixed soil and wood waste. Two of these samples were found to have leachable concentrations of arsenic that exceeded the Dangerous Waste thresholds (K/J/C & AGI 1990b). The USEPA then conducted a study of the Site in 1987 (EEI 1987). An USEPA contractor, Ecology and Environment, Inc. (EEI) installed five monitoring wells (EE-19 through EE-23) in the vicinity of the Landfill. EEI also inventoried and sampled residential wells and municipal wells in the area. Results indicated arsenic concentrations in landfill waste of up to 795 mg/kg and in unfiltered water from saturated waste-bearing zones of up to 38 mg/L. Elevated arsenic concentrations were not detected in residential and municipal wells.

In September 1990, a Focused RI was completed by Kennedy/Jenks/Chilton and Applied Geotechnology Inc. for Murray (K/J/C & AGI 1990b). The RI established the Site history, Site geology, hydrogeology, leachability of fill slag, extent and type of contamination, and other physical and chemical properties of soil, groundwater, surface water, and sediments. The samples collected during the RI were analyzed for a comprehensive suite of analyses. Site soils and sediments were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and priority pollutant metals. Groundwater samples were analyzed for VOCs, SVOCs, total and dissolved priority pollutant metals, and chemical oxygen demand (COD), in addition to standard groundwater quality parameters. Surface water samples were analyzed for VOCs, SVOCs, and priority pollutant metals.

The investigation concluded that heavy metals were the COCs, primarily arsenic leached from ASARCO slag into the saturated landfill waste and Upper Sand Aquifer. The leaching of arsenic and iron from slag was thought to result from anoxic (low dissolved oxygen), reducing geochemical conditions. Soil and groundwater were investigated through advancement of soil borings and installation of 20 monitoring wells (T-1 through T-4 and shallow/deep couplets D-1 through D-5), some of which were placed in the wetlands. However, the arsenic plume beneath the wetlands was not adequately identified as it passed between the downgradient wells D-1 and D-5, which are located approximately 600 ft apart. Arsenic was either not detected or was present at background levels in nearby domestic and irrigation wells (refer to Appendix B for private well locations).

2.5 INVESTIGATIONS FOLLOWING LANDFILL REMEDY

After the completion of landfill consolidation/capping activities in November 1993, Hydrometrics conducted further soil and groundwater monitoring. Soil samples confirmed the successful consolidation of landfill materials. Ten additional monitoring wells (shallow/deep couplets D-6 through D-11) were installed in the area surrounding the Landfill for the purpose of post-remedy confirmation monitoring. Quarterly monitoring was conducted by Hydrometrics between 1994 and 1998 of 18 landfill monitoring wells and the City of Milton municipal water well. Water samples were also collected from a leachate collection sump in the Landfill, from adjacent ditches, and from nearby private wells. In January 1994, arsenic was detected at 2.5 mg/L in a new wetlands Well (D-6A), indicating the arsenic contamination in wetlands groundwater was more significant than previously realized. This detection directly after the 1993 remedial action indicates that the plume was already present in the wetlands prior to the remedial action.

Nearby drinking water wells were retested following discovery of the more significantly elevated arsenic concentrations. Arsenic concentrations in municipal and private wells were consistently found to be less than 0.002 to 0.005 mg/L, with two exceptions. Arsenic was detected in the City of Fife municipal Well #3 at 0.021 mg/L in 1992 and 0.02 mg/L in 2000. This municipal well is located approximately 1 mile northwest of the Site in a deeper aquifer that is not hydraulically connected to the local groundwater system at the Landfill. Arsenic was detected at 0.021 mg/L in both 1992 and 2000 in a well located approximately one-quarter mile south and hydraulically upgradient of the Landfill. A map showing locations of nearby wells and a detailed discussion of the potential pathway to drinking water is provided in Appendix B.

Between July 1995 and September 1996, Hydrometrics undertook a direct-push investigation to further define arsenic concentrations in groundwater around the Landfill perimeter and in the wetlands. Arsenic was detected in wetlands groundwater at concentrations up to 6 mg/L, and arsenic was detected at concentrations greater than 2 mg/L at three other wetland sample locations in the southern end of the wetland.

In September 1998 additional monitoring wells (MW-13 through MW-17) were installed in the wetlands for ongoing monitoring. Hydrometrics sampled these new wetland wells quarterly along with 18 others, as part of Expanded Performance Monitoring between 1998 and 2001. In addition, slug tests were conducted in 1999 on the wetland monitoring wells to evaluate the hydraulic conductivity of the shallow groundwater system in the wetlands area.

In June 2001, Hydrometrics prepared a Contingency Plan for the B&L Landfill (Hydrometrics 2001b) to address groundwater contingency actions. Additional soil and groundwater data were collected by Hydrometrics between 2001 and 2003. Hydrometrics established that arsenic concentrations in soil throughout the arsenic plume were generally low (less than 10 mg/kg), with slightly elevated soil concentrations (up to 24 mg/kg) in surface soils adjacent to the

Landfill. Additional perimeter temporary monitoring wells were installed in the agricultural fields west, south, and east of the Landfill, and arsenic in groundwater from these wells was generally found to be at or less than the MTCA Method A CUL of 0.005 mg/L. Groundwater monitoring throughout this time indicated that the arsenic plume remained stable in size and concentration.

In 2002, Ecology studied the impacts of arsenic species and selected metals on the wetland adjacent to the Landfill (Ecology 2002). The report was based on surface soil (0 to 2 feet below ground surface [bgs]), soil pore water, wetland plants, and surface water samples. Elevated arsenic concentrations were detected in one unfiltered sample of ponded water (up to 0.556 mg/L) in the southern area of the wetland. The primary oxidation state of the arsenic species detected in surface water was the less-oxidized As (III) form of arsenic. The concentrations detected were thought to be associated with colloidal particles, instead of dissolved arsenic.

Similar to previous findings, surface soil arsenic concentrations in the wetlands were found at or slightly greater than background. Plant root tissue was found to be elevated in arsenic concentrations compared with background plant tissues; however, arsenic was not elevated in shoot tissue.

In February, 2006 Floyd|Snider, on behalf of Murray, submitted a Wetlands Investigation Data Report to Ecology summarizing field activities during the summer of 2005 (Floyd|Snider 2006). The 2005 investigation was intended to fill several interrelated groundwater data needs. The findings form the basis of the detailed site information presented in Section 3.0. Floyd|Snider delineated the wetlands plume at two aquifer depths and found significantly different conditions in the upper versus lower parts of the Upper Sand Aquifer. Floyd|Snider also tested the hydraulic conductivity and groundwater geochemical conditions of the Upper Sand Aquifer.

To fill in several remaining data gaps, Floyd|Snider continued investigative activities in 2006. They explored the downgradient plume boundary; tested the feasibility of dewatering the Landfill by pumping the central sump; installed a monitoring well where high arsenic concentrations exit the Landfill; resurveyed wetland wells; and conducted groundwater, surface water, and sediment sampling. The 2006 investigation results are presented in Appendix A and its findings are incorporated into the CSM presented in Section 3.0.

3.0 Conceptual Site Model

The current nature of the contamination associated with the Landfill, but not fully addressed by the 1993 remedy, centers on groundwater. This section describes site specific conditions that indicate groundwater beneath the Landfill continues to saturate landfill waste and generate leachate-impacted groundwater that contributes to two areas of contamination north and west of the landfill. Leachate-impacted groundwater is transported in the direction of groundwater flow to the north-northwest, adding arsenic to the relatively stable groundwater plume beneath the wetlands. Arsenic in the wetlands is generally limited to groundwater, though seasonal discharges may affect ponded wetlands surface water. In addition, leachate-impacted groundwater discharges to the drainage ditch system west of the Landfill, causing localized surface water and ditch sediment contamination. These issues are examined more fully in this section. This CSM draws largely on the information obtained from the Wetlands Investigation Data Report (Floyd|Snider 2006) supplemented with the findings of the 2006 Wetlands Investigation work (Appendix A).

3.1 SURFACE WATER AND HYDROGEOLOGY

3.1.1 Surface Water

Surface water at the Site drains to Hylebos Creek via two small sub basins, one north of the Puget Power Access Road in the wetlands within the floodplain of Hylebos Creek and the other south of the road, in the agricultural farmlands of the Puyallup River valley (refer to Figure 2.2). Surface water features close to the Landfill are shown on Figure 2.6.

The wetlands receive significant surface water input via precipitation, runoff from Fife Way and, during flood stages, overflow from Hylebos Creek. The greatest floods of Hylebos Creek are caused by precipitation events occurring between October and March, with melting snow occasionally contributing to flooding. Hylebos Creek rises quickly because of the relatively steep terrain and extent of development in the upper watershed. As a rule, the creek rises to flood stage within a day of peak rainfall and the duration of the flooding is only a few days (FEMA 1987). Flood waters in the wetlands slowly drain to the west to Hylebos Creek but the low areas of the wetlands remain seasonally ponded well into summer, depending on dry season rainfall intensity.

Land south of the Puget Power Access Road is drained by the agricultural ditches that run along the perimeter of the Landfill and further south, the larger Surprise Lake Drain. These ditches are within Pierce County Drainage District #23. The headwaters for the Surprise Lake Drain are located on the north hill plateau in the City of Milton—east of the project area. The outlet from Surprise Lake flows through a ravine, then along the Puyallup valley, and finally into a ditch system that receives runoff from mostly agricultural land, including land immediately surrounding the project area to the south and southeast. The drain discharges to Hylebos Creek via the 70th Ave culvert under I-5.

The ditch adjacent to the south and west perimeter of the Landfill drains surface water from the agricultural fields and the apartment complex south of the Landfill. Water is conveyed along a ditch running parallel to the Puget Power Access Road and then south to where it joins the

Surprise Lake Drain. The agricultural fields west of the Landfill drain overland flow into this ditch system as well. Portions of the fields near the Landfill are observed to be slightly lower, and they flood more easily. These ponded waters drain slowly due to saturated soil conditions and backwater caused by the normally higher water level in the Surprise Lake drainage channel.

A plan obtained from the Drainage District #23 from 1937 shows the agricultural and Surprise Lake Drain ditches in approximately the same location and alignment as currently observed (MSG et al. 2004).

Within the fenced area of the Landfill footprint, precipitation infiltrates the multi-layer cap until reaching a drainage layer that directs stormwater into troughs around the Landfill that lead to one of two infiltration ponds. Within the main infiltration pond south of the Puget Power Access Road is an overflow pipe that leads into the adjacent agricultural ditch system, as shown on Figure 2.1. This ditch system also captures stormwater that overflows from the smaller secondary stormwater pond at the northeast corner of the Landfill, outside the footprint edge of refuse, and the fenced perimeter.

3.1.2 Geology and Hydrostratigraphy

Cross-section F-F' (Figure 3.1) illustrates the relevant geologic and groundwater-bearing (hydrostratigraphic) units underlying the Landfill and wetlands. Underneath the Landfill material and forming the surface soils in the wetlands is an organic silt and peat unit 4 to 7 feet thick that transitions into a plastic silt deposit approximately six inches thick at its base. These deposits correspond to the pre-landfill ground surface.[3] Boring logs indicate the silt unit beneath the Landfill has been compacted and partially reworked into the fill material by grading and filling activities.

Saturated alluvial deposits (primarily sands) underlie the surface soils and comprise the Upper and Lower Sand Aquifer. These alluvial sands were encountered to the depths of the deepest RI borings. At the southeastern edge of the Site, closest to the glacial drift plain, the alluvial deposits grade into the colluvium and Pleistocene glacial silty gravel deposits. Previous subsurface investigations (K/J/C & AGI 1990b; Hydrometrics 2001a) identified the Upper Sand Aquifer and Lower Sand Aquifer as the primary water-bearing units underlying the Landfill. At the Landfill, the Upper Sand Aquifer extends into the lowest several feet of consolidated wood waste within the cap[4]. The alluvial deposits are divided into the Upper and Lower Sand Aquifer by the Lower Aquitard, a three-to-six-foot thick layer of interbedded silt, peat, and silty sand. This low permeability silt unit was encountered in all Site borings except those drilled into colluvium[5].

Soil borings from 2005 and 2006 investigation activities in the wetlands demonstrate that the same native geologic units identified during the RI extend throughout the wetland area. Detailed subsurface soils at the far end of the wetland along 12th St. E. (an unimproved road grade) are shown in geologic cross-section E-E' in Figure 3.2. Subsurface soils are generally

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[3] This near-surface low permeability unit was referred to as the "Upper Silt Aquitard" in the RI (K/J/C & AGI 1990b).

[4] Saturated refuse was referred to as the "Fill Aquifer" in the RI (K/J/C & AGI 1990b).

[5] Boring logs indicate the Lower Aquitard may be sandier in the southwest corner of the Landfill, where this unit was characterized as silty sand and peat with interbedded silt.(K/J/C & AGI 1990b).

uniform throughout the Upper Sand Aquifer in the wetland area; with fine silty sands coarsening downward and becoming increasingly silt-free, until the Lower Aquitard is encountered.[6] As indicated in Cross-section F-F'' (Figure 3.1), the Lower Aquitard is approximately 3 feet deeper at the northern end of the wetlands investigation area than at the southern end.

3.1.3 Groundwater Flow Direction and Gradients

Three potentiometric surfaces as measured in April 2002 (Hydrometrics 2002), August 2006, and October 2006 are displayed in Figure 3.3. These contours indicate a northerly to northwesterly groundwater flow direction in the Upper Sand Aquifer, which is consistent with topography and a flow path towards Hylebos Creek.

Also reflecting topography is the groundwater gradient that is generally steeper beneath the Landfill than in the wetlands, which is comparatively flat. Local groundwater depressions are occasionally observed in wetlands wells and may be related to measurement error or transient disequilibrium between that well and the rest of the Upper Sand Aquifer. Potentiometric contours also indicate that the flat wetlands gradient becomes slightly steeper and more consistent to the north of MW-15.

Potentiometric surfaces are approximately one foot higher in the Lower Sand Aquifer than in the Upper Sand Aquifer in the wetland area. Such upward gradients indicate a strong component of upward flow of groundwater. According to Hydrometrics (Hydrometrics 2001a), data collected during the RI indicates vertical hydraulic gradients between the Lower and Upper Sand Aquifers are flat or slightly upward in the Landfill and show an increasingly upward trend in the wetland area north of the Landfill. This finding was confirmed by 2006 field measurements that showed strong upward gradients, even with several feet of ponded surface water atop the Upper Sand Aquifer. This is characteristic of floodplains that function as regional groundwater discharge areas. Many of the residential wells in the area south of the Landfill are reported to be artesian flowing wells—confirming a general upward vertical gradient trend in the lowland area (Hydrometrics 2001a).

3.1.4 Hydraulic Conductivity and Average Linear Velocity

Pump testing of the Upper Sand Aquifer in the wetlands indicates a highly transmissive aquifer with a preferential direction of hydraulic conductivity in the north–south direction. Calculated hydraulic conductivities are in the range of 100 to 250 feet per day parallel to the direction of groundwater flow[7] and 2.7 to 5.7 feet per day perpendicular to the direction of groundwater flow. These findings are generally consistent with ASARCO's 1999 slug test results.

The observed anisotropy in hydraulic conductivities, with conductivity an order of magnitude greater in the approximate north-south direction than in the east-west direction, is consistent with the observed presence of coarser sand grain sizes (up to medium-to-coarse and thin deposits of coarse sand at the base of the Upper Sand Aquifer) along the eastern edge of the wetlands investigation area. This may reflect that the Upper Sand Aquifer is composed of highly

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[6] The Upper Sand Aquifer was referred to as the "Shallow Aquifer" in the 2005 Data Report (Floyd|Snider 2006).

[7] A hydraulic conductivity result of 33 feet per day between MW-15 and MW-17 was deemed anomalous and not included in these calculations. Slug test results from MW-13 (Hydrometrics 2000) are not included due to anomalous results from this monitoring well compared with observed subsurface hydrogeology.

elongated sand channels that were deposited by alluvial processes, predominantly in a north-south direction.

Average linear groundwater seepage velocities, calculated based on a wetlands gradient of 0.001 and an assumed effective porosity of 35 percent, indicate representative wetland groundwater seepage velocities ranging from approximately 100 to 260 feet/year.[8] At these velocities, groundwater would take approximately two to six years to travel the 600 feet from the edge of the refuse to 12th St. E.

3.1.5 Groundwater Interaction with Surface Water

Groundwater-surface water interactions are important processes in both the Landfill and the wetlands because the Upper Sand Aquifer beneath the Site maintains a very high water table that is at, or within a few feet of, land surface throughout the year.

As a consequence, agricultural drainage ditches (illustrated in Figure 2.1) are deep enough to receive groundwater discharge from the Upper Sand Aquifer based on staff gauge and monitoring well measurements (K/J/C & AGI 1990b). These ditches primarily collect groundwater discharge, but locally and seasonally can recharge the shallow groundwater system. The section of ditch along the northern perimeter of the Landfill is higher than the rest of the ditch system and is often dry, and not as prone to receiving groundwater discharge. The ditch system drains to the west where it joins the Surprise Lake Drain; however, drainage of ditch water is limited by the shallow depth of the ditch, its flat gradient, and the generally consistent base flow elevation of water in the Surprise Lake Drain. These factors limit the ability of the ditches to function as an active groundwater drain.

In the wetlands, during winter months or other wet conditions, the potentiometric surface rises above the ground surface due to both flooding inputs and upward discharge from the aquifer. The majority of groundwater flux through the Upper Sand Aquifer, however, occurs in the sands below the upper 3 to 8 feet of silty surface soils and especially in the coarser sand deposits found at the base of the Aquifer.

3.2 NATURE AND EXTENT OF CONTAMINATION

Multiple investigations and monitoring activities have been conducted to examine soil, surface water, ditch sediment, and groundwater conditions at the Landfill and in the surrounding vicinity. Relevant findings from these investigations are discussed briefly in Section 2.0 and respective tables. The results of these investigations and years of monitoring indicate that arsenic remains the dominant COC associated with the Landfill, and that the arsenic-affected media are groundwater, surface water, and ditch sediments. Other slag-related metals (copper, lead, and nickel) and the organic compound phenol (a natural component within wood waste) were occasionally detected in some samples during the RI at concentrations greater than screening levels and so therefore identified as Site-wide COCs. Subsequent monitoring indicates that

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[8] These calculations are based on a generalized gradient for the wetlands area. Calculated seepage velocities between monitoring wells based on actual gradient measurements are presented in Appendix A.

these non-arsenic COCs are still only occasionally detected, and at low concentrations in association with arsenic.

Elevated arsenic concentrations in groundwater generally extend from beneath the Landfill and downgradient into the Upper Sand Aquifer beneath the wetlands. Arsenic-contaminated surface water and ditch sediment impacted from the discharge of contaminated groundwater into the drainage ditch system extends to the west of the Landfill. The pattern of groundwater contamination at the Landfill perimeter consists of a broad area of elevated concentrations along the northern perimeter where the arsenic plume flows into the wetlands and a “halo” of slightly elevated concentrations immediately adjacent to the Landfill perimeter. Groundwater monitoring since the 1990s has indicated that the arsenic plume in the wetlands is generally stable, with its lateral extent apparently controlled by naturally occurring attenuation processes, as discussed in detail below.

3.2.1 Arsenic Release to Groundwater from Landfill Materials

The plume of elevated arsenic concentrations in groundwater beneath the Landfill and wetlands is primarily comprised of As(III), a form of inorganic arsenic known as trivalent arsenic or arsenite that generally occurs under mildly reducing conditions. As(III) is more mobile and toxic than its other primary inorganic species, the more oxidized form, As(V), known as pentavalent arsenic or arsenate. As(III), as a percentage of inorganic dissolved arsenic, ranged from 72 percent to 100 percent of total dissolved arsenic in groundwater based on 2005 sampling of monitoring wells. The remainder of the arsenic was present as As(V).

Arsenic speciation and the reduction-oxidation (redox) chemistry that controls it are central to the release, transport, and attenuation mechanisms at the Site. The As(III) form is consistent with release of arsenic from landfill wastes through a process called reductive dissolution, and the dominance of As(III) confirms reducing, anoxic conditions in the groundwater plume. Microbes in landfill settings commonly use up dissolved oxygen, and generate anoxic, reducing conditions in groundwater (e.g., Delemos et al. 2006; Keimowitz 2005). Iron and arsenic are considerably more soluble in their less-oxidized states, and reducing conditions are generally responsible for releases of arsenic trapped on mineral surfaces in soil or slag via dissolution and desorption. Reducing conditions from landfill organics are also capable of releasing significant concentrations of arsenic to groundwater from uncontaminated, native soils as well (Welch and Stollenwerk 2003).

In addition to arsenic and iron, landfill materials appear to be the source of elevated groundwater concentrations of dissolved organic carbon (DOC) and common groundwater ions found in landfill leachate—including chloride, calcium, magnesium, and sodium. The presence of elevated concentrations of DOC and these ions, and the resulting elevated total dissolved solids (TDS), salinity, and specific conductivity, define a general leachate plume in the wetlands that overlaps with, but is broader than, the arsenic plume.

3.2.2 Arsenic in Groundwater at the B&L Landfill Boundary

Arsenic concentrations in groundwater at the northern landfill boundary indicate that the arsenic migrating from the Landfill via groundwater is source of the existing wetlands arsenic plume. The pattern of arsenic concentrations in groundwater along this transect suggests that arsenic originating from Landfill wastes migrates downgradient across the entire width of the landfill boundary in two general patterns: (1) in deeper groundwater in the east and (2) in shallower groundwater in the west. This pattern is illustrated in Figure 3.4 by Cross-section A-A' modified from the Wetlands Investigation Data Report (Floyd|Snider 2006).

Arsenic was found to be the most concentrated and most extensive at the base of the Upper Sand Aquifer across an approximately 400 foot long section of the northern landfill boundary. Arsenic migrating from the Landfill in this area appears to account for the majority of the mass of arsenic in the plume. Aquifer materials in this area at this depth are medium to coarse sands that are noticeably coarser and more permeable than the fine to medium sands further west.

Arsenic in the upper part of the Upper Sand Aquifer at the Landfill boundary was detected across the full extent of the northern Landfill boundary, with higher concentrations to the west. The off-site migration of arsenic from the Landfill via shallow groundwater appears to be the source of the broad, moderately elevated, western lobe of the wetlands plume.

Significant temporal variability in the concentration of arsenic has been observed in groundwater at the northern boundary of the Landfill, suggesting rapidly changing rates of dissolution from landfill materials or varying rates of dilution/attenuation—possibly due to recharge from the stormwater pond that lies directly upgradient of where the samples were collected.

3.2.3 Extent of Arsenic Plume

The arsenic plume in the wetlands, shown on Figure 3.5, is entirely within the Upper Sand Aquifer. It forms a broad western lobe that terminates within approximately 300 feet of the Landfill boundary in the upper section of the aquifer, and an elongated deeper plume "finger" that extends approximately 400 feet further downgradient. The extent of the arsenic plume in shallow groundwater is shown in Figure 3.1, which shows arsenic concentrations along a section parallel to the axis of the entire plume and Figure 3.5, which is a plan view of arsenic concentrations at two different depths in the Upper Sand Aquifer.

Figure 3.5 also shows a slight "halo" of arsenic surrounds the Landfill to the west and south. Results from off-site monitoring wells (MW-18 through MW-22, now decommissioned, but shown on Figure 3.5) confirm that the halo does not extend a significant distance off-site. A localized area of elevated concentrations exists upgradient to the east of the Landfill as well, around Monitoring Well D-10A. This well is completed in an isolated pocket of colluvium that is not hydraulically connected to the Sand Aquifer (based on potentiometric surface data). Arsenic concentrations typically drop an order of magnitude to near background levels in a short distance (from 250 µg/L in D-10A to 25 µg/L in MW-23, lying 100 feet downgradient). This contamination is thought to be residual from wood waste landfilling in this area prior to consolidation and capping in 1993.

The northern extent of the plume is characterized by a thin seam of elevated concentrations at the more permeable coarse sandy base of the aquifer. A cross-section showing arsenic concentrations through the full reach of the northern extent of the plume is illustrated in Figure 3.2. Dissolved arsenic, at a maximum concentration of 0.056 mg/L, was detected across an area no greater than 200 feet wide by 5 feet thick between 17 and 22 feet bgs. The exact downgradient extent of this plume "finger", however, is not currently established due to difficult field conditions in 2006. Regardless, given the low concentrations at 12th Ave E, it is likely that the plume “finger” extends a limited distance north of 12th St. E., before attenuating to background concentrations.

It is possible that the aquifer soils in the wetlands accumulate arsenic over time, perhaps related to a cyclical pattern of sequestration and dissolution associated with wetland flooding. As water levels drop and oxidizing conditions extend several feet into the aquifer, arsenic is likely to be adsorbed onto and/or co-precipitated with iron oxide mineral coatings. When water levels rise again, and reducing conditions return, arsenic would then be re-dissolved by reductive dissolution processes similar to those that originally released arsenic from landfill waste. This process would explain the recent increase in groundwater arsenic concentrations in the wetlands in 2006 results, as described in Appendix A.

Soil analytical results indicate that the mass of dissolved arsenic in groundwater is not significant enough to cause concentrations of arsenic in soil to become elevated by sequestration. Soil core samples from throughout the wetlands, including the area with the highest concentrations in groundwater, resulted in only five detections of arsenic in concentration greater than 10 mg/kg. The highest concentration was 24 mg/kg in the 0 to 2 feet interval near MW-13 (Hydrometrics 2001a). These concentrations are generally consistent with findings from a more limited study of shallow soils, in which arsenic was detected at 23.3 to 27.5 mg/kg from a depth interval of 0 to six inches and 7 to 16.3 mg/kg from a depth interval of 18 to 24 inches in an area of shallow ponded surface water (Ecology 2002).

3.2.4 Nontoxic Leachate Indicators in Groundwater

Leachate indicators other than arsenic, including DOC, TDS, dissolved iron, and oxidation-reduction potential (ORP) are present in wetlands area groundwater in patterns similar to but broader than the arsenic plume. These visually-apparent similarities are supported by quantitative correlations between these constituents and parameters, which are discussed in greater detail in Appendix A.

Correlations between arsenic and negative ORP, DOC, TDS, and iron (total and dissolved) supports the model of wood waste-generated DOC causes reductive dissolution of arsenic, iron, and other ions. The correlations also support the transport of arsenic in groundwater with DOC, iron, and elevated TDS under the mildly reducing conditions measured (ORP between 0 and -100 mV).

3.2.5 Plume Stability and Attenuation Processes

The stable boundaries of the arsenic plume indicate that the plume is largely controlled at its downgradient edges by natural attenuation processes that slow the rate of arsenic migration relative to the flow of groundwater. Several lines of evidence support attenuation, including:

- The known plume boundaries have remained stable since the beginning of post-remedy wetlands groundwater monitoring in 1994. The thin “finger” of deeper arsenic discovered in 2005 at the northern part of the wetlands does not indicate active migration of the plume, as it is a recent discovery found below the screen depth of MW-17, which had until then been considered to be in a location well suited for monitoring plume migration.

- Leachate indicators are more widespread than the distribution of the arsenic plume. Elevated iron, TDS, and DOC are detected in groundwater at the downgradient edges of the arsenic plume, and in some cases in monitoring wells where arsenic is less than the detection. Individual conservative tracers (i.e., ions that stay in solution) for leachate, such as chloride, are present in relatively uniform concentrations downgradient from the Landfill, while arsenic concentrations in groundwater decrease. This indicates that arsenic in wetlands groundwater is not as mobile as these other constituents.
- Arsenic concentrations in D-6A have been between 1 and 4 mg/L consistently since the well was installed in 1994. Groundwater travel times indicate that groundwater from D-6A would have reached 12th St. E. in approximately two to five years. Yet, today (13 years after the first measurements at D-6A), concentrations at 12th St. E. are 50 times lower than the concentrations at D-6A, indicating that at least 95% of the arsenic is attenuating between the two locations.
- The shallow, more oxidized portion of the plume does not extend more than 400 feet from the edge of the Landfill.
- The highest percentages of As(V) compared with As(III) were measured in monitoring wells at the downgradient edge of the plume, a finding that is consistent with a shift in geochemical conditions resulting in a less mobile form of arsenic, As(V).

The evidence strongly suggests that oxidation and then adsorption/co-precipitation of arsenic onto soil mineral surfaces (most likely iron oxide coatings) is the process controlling shallow attenuation. As(III) rapidly oxidizes in aerated water to the less mobile and less toxic form As(V) that is scavenged by precipitating iron oxides through adsorption or co-precipitation. As(V) is less mobile because it has a higher tendency to be adsorbed by or to co-precipitate with iron and manganese oxides than does As(III) at the neutral to mildly acidic pH ranges present in groundwater at the Site. This partitioning into the solid phase (as arsenic enters a zone of oxidation) immobilizes arsenic in the subsurface, preventing further migration (Reisinger et al. 2005). The finer-grained aquifer materials in the shallowest part of the aquifer (and generally in the western part of the wetlands study area) may assist in this process by providing more mineral surface area and adsorption sites.

Additionally, as suggested by Cross Section F-F' (see Figure 3.1), simple recharge of stormwater from the Landfill stormwater pond may be diluting/attenuating arsenic from the upper part of the aquifer.

3.2.6 Extent of Contamination in Ditch Surface Water and Sediments

Discharge of leachate into the adjacent ditch system to the west of the Landfill has resulted in localized arsenic contamination in agricultural ditch surface water that when oxidized, precipitates out iron/arsenic solids that settle into ditch sediments. The elevated concentrations in ditch surface water along the western boundary ditch are consistent with concentrations measured in the monitoring well adjacent to the western Ditch, D-8A. This strongly suggests that Upper Sand Aquifer groundwater from beneath the Landfill is the source of the arsenic in ditch surface water. The lateral extent of surface water and sediment contamination, based on 2006 results, is presented in Figures 3.6 and 3.7.

The extent of the arsenic contamination of the ditch system is generally limited to the agricultural ditch along the western Landfill boundary. Significantly lower arsenic concentrations were detected in the ditch segment downgradient of the Landfill. The highest detections of arsenic in ditch sediments were co-located with the highest detections of arsenic in ditch surface water.

In addition to generally decreasing in ditches downgradient from the Landfill, arsenic concentrations in ditch sediments decrease by orders of magnitude within a few inches of the surface. Copper and lead concentrations also decrease with depth. This suggests that the impacted zone is limited approximately to the upper 6 inches to 1-foot of ditch sediments. This depth profile reinforces that the mechanism for ditch recontamination (the ditches were cleaned out as part of the 1993 remedy) is interaction with oxygen and precipitation of arsenic that is deposited in the upper part of the ditch sediments.

No arsenic impact to the Surprise Lake Drain or surface water downgradient of this input has been observed. This is because the discharge of arsenic to the ditch system has been intermittent, the ditch system drainage is extremely slow, arsenic attenuates readily in aerated water, and some fraction of arsenic is apparently transferred to ditch sediments. As a result, the actual loading of arsenic to surface water beyond the Surprise Lake Drain is considered minimal or non-existent. Arsenic concentrations in surface water downgradient of the Surprise Lake Drain have been measured at levels reflective of background (0.011 mg/L), while concentrations in ditch surface water adjacent to the Landfill were concurrently measured at concentrations up to 0.45 mg/L (Hydrometrics 2001a).

3.2.7 Methane

Emission of landfill gas (LFG), including methane, was not identified during the 1990 RI as a pathway by which contamination leaves the Site, and was not included in the 1991 CAP as a risk associated with the Site. Active and passive LFG controls were evaluated as part of the 1990 Focused Feasibility Study, which noted that existing information regarding the type and quantity of gas production at the Landfill was inadequate for determining which approach was more appropriate. In the 1992 Engineering Design Report (EDR), passive gas controls were selected based on calculations of the maximum potential emissions of methane and carbon dioxide from decomposition of wood waste (Hydrometrics 1992). Passive gas controls were installed as part of the consolidation and capping remedy implemented in 1993 to control the potential release of LFG. Methane was monitored at the edge of the Landfill mound to ensure it did not exceed the lower explosive limit (LEL) as part of protection monitoring (Hydrometrics 1994). Air monitoring was not included in post-remediation monitoring.

Based on November 2005 air quality measurements of the vents of the gas collection system, the Landfill has apparently ceased emission of measurable quantities of methane (the component of LFG that is associated with generating subsurface pressure and potentially explosive concentrations). The Landfill is also not emitting measurable quantities of hydrogen sulfide, a toxic air pollutant. Because VOCs are not detected in landfill leachate or Site groundwater, there is no reason to suspect emission of other toxic air pollutants from the Landfill gas collection system or from fugitive emissions.

3.3 POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS

The 1993 remedy was effective in eliminating the potential for direct contact to the Landfill waste and ditch sediment, and in eliminating leachate production via stormwater, and thus reducing certain risks to human health and the environment. Despite this, a number of potential exposure routes remain, all of which stem from contaminated groundwater. While leaching associated with stormwater infiltration is controlled by the consolidation and capping, leachate is still produced when groundwater flowing beneath the Landfill saturates landfill waste, which has no liner beneath it. Arsenic in this leachate travels away from the Landfill via groundwater. Contaminated groundwater has the potential to contaminate other media that may provide additional transport or exposure pathways. Groundwater discharge to the perimeter ditches or in the wetland area has recontaminated ditch sediments and seasonally may impact wetland surface water quality. These pathways and potential receptors are discussed below by media. Emission of LFG or methane to ambient air is not considered a potential exposure pathway due to the effectiveness of passive gas controls. A summary of the potential exposure pathways and receptors is presented in Figure 3.8.

3.3.1 Groundwater

Arsenic-contaminated groundwater beneath the Landfill and wetlands areas is not in an aquifer that is used as a drinking water source. There is no completed hydrogeologic pathway for arsenic to reach nearby drinking water wells (i.e., City of Milton wells) due to a number of factors including: well locations upgradient of the Landfill, the depths of well completions below the Upper Sand Aquifer, and the protective aquitards and upward vertical gradients that separate the Upper Sand Aquifer from deeper aquifers. Refer to Appendix B for a full discussion of this pathway.

Additionally, Washington State Well Regulations requires that no drinking water well be screened at depths less than 20 feet and wells are banned from being drilled within 1,000 feet of an existing landfill. As described in the previous section, elevated arsenic concentrations in groundwater are limited to the upper 20 feet of soil and arsenic apparently does not extend more than 700 feet away from the Landfill boundary.

The attenuation mechanisms at work in the wetlands are limiting migration of arsenic via groundwater, which eventually discharges into Hylebos Creek. The section of the current Hylebos Creek channel located closest to the arsenic plume, near the culvert channeling the creek under I-5, is located approximately 600 feet from the downgradient end of the wetlands plume. As indicated earlier in this section, the downgradient extent of the arsenic plume is in a relatively minor, thin seam of sand at the base of the aquifer. Although natural attenuation is likely to prevent further movement of the plume, the potential remains for a completed pathway in the future due to the proposed relocation of Hylebos Creek by WSDOT. Preliminary designs by WSDOT (refer to Figure 2.3) place the relocated channel within 200 feet of the plume and would likely alter the existing shallow groundwater flow regime and potentially the stability of the plume.

3.3.2 Surface Water

The discharge of arsenic-contaminated groundwater into perimeter ditches and the groundwater-surface water interaction in the wetlands creates the potential for surface water exposure pathways.

Contaminated ditch surface water creates a potential pathway for direct human contact under a trespass scenario. The drainage of ditch surface water to Surprise Lake Drain, which drains to Hylebos Creek, creates a potential pathway to human exposure through fish consumption and for direct contact to aquatic receptors. Available data indicate that only background concentrations of arsenic have been measured downgradient of the ditch. Changes in land use within the basin, however, may result in a complete pathway in the future if the ditches are rerouted.

The seasonally high water table creates a condition for the arsenic in the wetlands plume to discharge and commingle with the intermittently, ponded surface water in the wetlands. This creates a potential pathway for direct human contact under a recreational or trespass scenario and for terrestrial exposure by wetlands biota.

3.3.3 Ditch Sediments

Contaminated ditch sediments associated with leachate discharging to surface water in the perimeter ditches creates potential pathways for direct human contact under a trespass scenario.

3.3.4 Wetland Soils

The concentrations of arsenic detected in shallow wetlands soils (depths of 0 to 2 feet) are at or less than MTCA Method A CULs for arsenic of 20 mg/kg. In addition, shallow soil arsenic concentrations in wetlands soils are within the moderate range for the Tacoma Smelter Plume area-wide contaminated site, and less than the Interim Action Trigger Level of 100 mg/kg (Landau 2006). Shallow wetland soils, therefore, do not present a potential pathway for exposure. The concentrations of arsenic in deeper wetlands soils are less than CULs and there is no potential pathway for exposure from deeper wetlands soils.

3.3.5 Methane

Emission of methane to ambient air is not considered a potential future risk because the landfill is no longer emitting measurable amounts of methane.

4.0 Remedial Action Objectives and Cleanup Levels

4.1 REMEDIAL ACTION OBJECTIVES

RAOs are broad, administrative goals for a cleanup action that address the overall MTCA cleanup process, including:

- Implement administrative principles for cleanup (WAC 173-340-130)
- Meet requirements, procedures, and expectations for conducting an FS and developing cleanup action alternatives (WAC 173-340-350 through 173-340-370)
- Develop CULs (WAC 173-340-700 through 173-340-760)

In particular, RAOs must include the following threshold requirements from WAC 173-340-360:

- Protect human health and the environment
- Comply with CULs
- Comply with applicable state and federal laws
- Provide for compliance monitoring

In addition to the threshold requirements, the following selection criteria, provided in WAC 173-340-360, allow one to select among alternatives that meet the threshold requirements. The selection criteria require cleanup actions to:

- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration time frame
- Consider public concerns

MTCA (WAC 173-340-350(8)) allows for an initial screening of possible alternatives that eliminates those alternatives that do not meet the threshold requirements, are disproportionately costly compared to other alternatives that meet the threshold requirements, or are technically impossible at the site.

Once the initial screening has been performed and several alternatives remain that meet the threshold requirements, a more detailed analysis to select the alternative that "uses permanent solutions to the maximum extent practicable" is performed. This review makes use of a "disproportionate cost" analysis. If one alternative is clearly preferred by both Ecology and the PLP at this stage, this analysis is not required (WAC 173-340-360(3)(d)). In the disproportionate cost analysis, the following criteria are evaluated (WAC 173-340- 360(3)(e through f)):

- Overall protectiveness
- Permanence
- Cost
- Effectiveness over the long term, which includes reductions in toxicity, mobility, and volume

- Management of short term risks
- Technical and administrative implementability
- Consideration of public concerns

In addition to these criteria, the restoration time frame must be considered when choosing between alternatives.

Federal cleanups under the CERCLA have a very similar set of criteria that must be used to evaluate remedial action alternatives at Superfund Sites. Because the B&L Landfill is part of the CBN/T Site, these criteria are also relevant to the selection of alternatives. This report considers all of these criteria in order to comply with both processes. The CERCLA criteria are as follows (USEPA 1988):

- Overall protection of human health and the environment
- Compliance with ARARs, CULs
- Long-term effectiveness and permanence, including compliance monitoring
- Reductions in toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State and community acceptance (following comments on the Draft GAE)

MTCA also sets forth requirements specifically for groundwater cleanups. Cleanup actions for groundwater must be permanent, or, if non-permanent, must contain and either treat or remove the source of any release that cannot be reliably contained.

MTCA also includes the following expectations, paraphrased from WAC 173-340-370, that are potentially appropriate for the Site.

- Treatment technologies will be emphasized at sites with areas contaminated with high concentrations of hazardous substances, highly mobile materials, and/or discrete areas of hazardous substances that lend themselves to treatment.
- Engineering controls, such as containment, are appropriate for sites or portions of sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable.
- Active measures will be taken to prevent/minimize releases to surface water via surface runoff and groundwater discharges in excess of CULs.
- Natural attenuation of hazardous substances may be appropriate at sites where source control has been conducted to the maximum extent practicable; leaving contaminants on-site during the restoration time frame does not pose an unacceptable threat to human health or the environment; there is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and appropriate monitoring requirements are

conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

The RAOs are also guided by specific MTCA requirements defined in WAC 173-340-360 for groundwater cleanup actions, institutional controls, releases and migration, and remediation levels.

Soils that are contained as a part of the remedy will be deemed to meet CULs if certain requirements set out in WAC 173-340-740(6)(f) are met:

WAC 173-340-740 (6) (f)

> *The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:*
>
> > *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
> >
> > *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
> >
> > *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
> >
> > *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
> >
> > *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*
> >
> > *(vi) The types, levels and amount of hazardous substances remaining on-site and the measures that will be used to prevent migration and contact with those substances are specified in the draft.*

4.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The selected groundwater alternative must comply with MTCA cleanup regulations (WAC 173-340) and with applicable state and federal laws. Under WAC 173-340-350 and WAC 173-340-710, the term “applicable requirements” refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a COC, remedial action, location, or other circumstance at the facility. The “relevant and appropriate” requirements are regulatory requirements or guidance that do not apply to the facility under law, but have been determined to be appropriate for use by Ecology.

ARARs are often categorized as chemical-specific, location-specific, or action-specific. Chemical-specific ARARs include regulatory CULs for the relevant COCs. As discussed previously, the only COC for the groundwater at the Site is arsenic. Location-specific ARARs include any regulations or guidance relevant to the specific location of the facility. For instance, the wetlands adjacent to the Landfill will require special consideration for ecological receptors. Action-specific ARARs include regulations or guidance governing any activities proposed to remediate the Site. Any construction activities or excavations will require compliance with stormwater and water quality regulations.

Remedial actions conducted under a consent decree with Ecology must comply with the substantive requirements of the ARARs, but are exempt from their procedural requirements, such as permitting and approval requirements (WAC 173-340-710(9)). This exemption applies to permitting requirements under the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Hazardous Waste Management Act, the Clean Air Act, the State Fisheries Code, the Shoreline Management Act, and local laws requiring permitting.

4.2.1 Chemical Specific ARARs

The remediation of contaminated Site media must meet the CULs developed under MTCA, which include chemical-specific ARARs. Chemical-specific ARARs include those requirements that regulate the acceptable amount or concentration of a constituent that may be found in or released to the environment.

4.2.1.1 Model Toxics Control Act Cleanup (WAC 173-340)

MTCA requires that cleanup actions meet cleanup standards at least as stringent as those under CERCLA and the Superfund Amendments and Reauthorization Act of 1986 (SARA), and WAC 173-340-710 requires that all cleanup actions be in compliance with applicable state and federal laws.

4.2.1.2 Sediment Management Standards (WAC 173-204)

These standards provide chemical concentration criteria and biological effects criteria for the quality of surface sediment (without adverse effects), including no acute or chronic adverse effects on biological resources and no significant health risk to humans.

Sediment Management Standards (SMS) were considered applicable in the 1990 RI/FS because of the Site's inclusion in the CBN/T NPL site and concerns for contaminated sediments impacting Hylebos Creek. Upon review of exposure pathways for this groundwater alternatives evaluation, the ditch sediments do not present a threat to ecological receptors in Hylebos Creek. Therefore, the SMS criteria may not be applicable to this site.

4.2.1.3 *Water Quality Standards for Washington Surface Waters (WAC 173-201A)*

Water quality standards under WAC 173-201A are intended to establish water quality standards for surface waters of the state of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife. Surface waters of the state include lakes, rivers, ponds, streams, inland waters, salt waters, wetlands, and all other surface waters and water courses within the jurisdiction of the state of Washington. Compliance with the surface water quality standards of the state of Washington requires compliance with WAC 173-201A, as well as WAC 173-204, SMS, and applicable federal rules.

The Washington State Surface Water Standards apply to the following Site-related surface waters:

- Wetland area surface waters
- Groundwater discharges to Hylebos Creek
- Surface water in the drainage ditches
- Stormwater discharges during construction

4.2.1.4 *The Clean Water Act (33 USC 1251 et seq.)*

Sections 401 and 404 of the Clean Water Act (CWA) require the establishment of guidelines and standards to control the direct or indirect discharge of pollutants to the waters of the United States. Compliance with the CWA Standards is required for discharge into the wetlands area or Hylebos Creek.

4.2.1.5 *National Toxics Rule*

This rule sets numeric criteria for several priority toxic pollutants in surface waters..

4.2.1.6 *Cleanup Levels and Chemical-specific ARARs*

Table 4.1 summarizes the chemical-specific ARARs that were considered for each of the media. In general, they are the same ARARs that were considered in the 1991 CAP, although a few have changed in the intervening decade.

Table 4.2 presents changes that are recommended to address additional information and/or regulatory standards since the 1991 CAP. All COCs, except for arsenic, are in compliance and have been for at least five years. The COC list, therefore, should be shortened to reflect this improvement. This will leave arsenic as the only COC for the site.

No change is proposed for soil, groundwater, or sediment CULs. Currently all three are driven by background considerations and assume unrestricted land use, even in the agricultural drainage ditches.

A minor, but important change is proposed for surface water. With the 2001 revisions to MTCA, the surface water CUL would now be applied to groundwater in order to protect surface water uses. The point of compliance for this would be where groundwater discharges into surface water, unless there is an intervening property. In the case of sites that do not abut surface water, the surface water CUL must be met in groundwater at a conditional point of compliance closer to the source. Currently, the surface water CUL is 5 µg /L, however, this concentration is at or less than the background arsenic concentration in groundwater. Therefore, the proposed change would be to add the same "background consideration" to the surface water CUL that has already been applied to the groundwater CUL. Specifically, the following footnote from the 1991 CAP would be applied to both groundwater and surface water and would refer to the groundwater background concentration:

> "Natural background may be demonstrated by Ecology to be higher than the cleanup level per WAC 173-340-709. In that case, natural background may be substituted by Ecology as the cleanup level."
>
> Please note that the citation to MTCA has also been changed from WAC 173-340-708(11) to WAC 173-340-709 to conform with MTCA section headings, as they appear in 2007.

4.2.2 Location Specific ARARs

Location-specific ARARs are those requirements that restrict the concentration of hazardous substances or the performance of activities solely because they occur in specific locations.

4.2.2.1 The Clean Water Act (33 USC § 1251 et seq.)

Under § 404 of the CWA, the U.S. Army Corps of Engineers (Corps) regulates the discharge of dredged or fill material in the waters of the United States, including wetlands. Any discharge of dredged or fill material into waters of the United States must be authorized by the Corps. All appropriate and practicable measures must be taken to minimize the adverse impacts to the wetlands and ensure those impacts are not contrary to public opinion (Ecology 2004). The Corps makes the determination regarding applicability of the CWA, not the applicant or Ecology.

Section 401 of the CWA requires the establishment of guidelines and standards to control direct or indirect, discharge of pollutants to the waters of the United States. Section 402 establishes the National Pollutant Discharge Elimination System (NPDES), which provides for the issuance of permits to regulate discharges into navigable waters. Washington State has been delegated authority to issue NPDES permits. The Washington Water Pollution Control Law and its regulations address the requirement under Sections 301, 302, and 303 of the CWA, which requires states to adopt water quality standards.

4.2.2.2 Magnuson-Stevens Act (16 USC § 1801 et seq.)

The Magnuson-Stevens Act (MSA) governs marine fisheries management in the United States. The MSA mandates the identification of essential fish habitat for federally managed species and development of measures to conserve and enhance the habitat necessary for the fish life cycles. Because of anadromous fish runs in Hylebos Creek, MSA requirements may be applicable.

4.2.2.3 Washington State Shoreline Management Act (RCW 90.58, WAC 173-18, WAC 173-22, and WAC 173-27)

The substantive requirements of this statute and its implementing regulations apply to activities within 200 feet of shorelines in the state, which includes the shoreline of Hylebos Creek and associated wetlands. Proposed remedial actions must be consistent with the policies and goals of the approved Washington State coastal zone management program and with the policies and shorelands use designations of the local jurisdiction's shoreline master plan (Pierce County 2006; WAC 173-22-0636).

4.2.2.4 Pierce County Shoreline Management Use Regulation (Title 20)

Shorelines within Pierce County include all shorelines and associated wetlands of streams with a mean annual flow of at least 20 cubic feet per second (cfs). These regulations provide constraints on use activities such as dredging and shoreline disposal of fill.

Simulated data provided in the WSDOT studies of Hylebos Creek under current conditions estimate mean annual flow at approximately 18 cfs (MSG et al. 2004). However, the U.S. Geological Survey (USGS) calculates mean annual flow on Hylebos Creek as over 30 cfs, based on approximately five years of flow data collected in the 1990s. These regulations will be revisited upon selection of an alternative. Any dredge and fill activities associated with the selected alternative will meet Title 20 of the Pierce County Regulations.

4.2.2.5 Pierce County Development Regulations—Critical Areas (Title 18E)

These regulations protect critical areas by limiting any actions that are planned within 150 feet of a wetland or 35 feet of a stream, or near a geologic hazard area, or a fish and wildlife habitat area. Pierce County has mapped critical areas such as wetlands, flood zones, and liquefaction areas near or within the Site (Pierce County 2006).

4.2.3 Action-specific ARARs

Action-specific ARARs are requirements that define acceptable management practices and are usually specific to certain kinds of activities that occur or technologies that are used during the implementation of cleanup actions.

4.2.3.1 Comprehensive Environmental Response Compensation, and Liability Act of 1980 (42 USC 9601 et seq. and 40 CFR 300)

The B&L Landfill was originally identified by USEPA as a potential upland source for arsenic contamination in the CBN/T Site (K/J/C & AGI 1990a). Because authority for the cleanup of uplands sites was transferred from USEPA to Ecology, this cleanup action is conducted under MTCA. However, MTCA requirements are at least as restrictive if not more restrictive than those under CERCLA. This alternatives analysis is intended to meet the requirements of both MTCA and CERCLA.

4.2.3.2 The Clean Water Act (33 USC 1251 et seq.), Pierce County Ordinances (Title 13.06 for Publicly Owned Treatment Works), and National Pretreatment Requirements (40 CFR 403)

Sections 401 and 404 of the CWA require the establishment of guidelines and standards to control the discharge of pollutants to the waters of the United States. Compliance with the CWA Standards is required for discharges of groundwater or surface water from the Site into the wetlands area or Hylebos Creek.

The Pierce County Ordinance for Publicly Owned Treatment Works (POTW) sets forth uniform requirements for all users of the POTW for Pierce County and enables the County to comply with all applicable state and federal laws, including the CWA (33 USC 1251 et seq.) and the National Pretreatment Regulations (40 CFR Part 403). These Regulations prevent the introduction of pollutants into the POTW, prevent inadequately treated pollutants from passing through the POTW into receiving waters, and protect the general public and POTW personnel who may be affected by pollutants entering or passing though the system.

The Industrial Pretreatment Regulations (Pierce County Ordinance 13.06) authorize the issuance of wastewater discharge permits and authorize monitoring, compliance, and enforcement activities. Any discharges into POTW from the Site are required to meet these pre-treatment and permitting requirements.

4.2.3.3 Minimum Functional Standards for Solid Waste Handling (WAC-173-304)

MTCA specifies that for solid waste landfills, the landfill closure requirements in WAC 173-304, Minimum Functional Standards for Solid Waste Landfills, shall be a minimum requirement for cleanup.

These regulations are promulgated specifically for wood waste landfilling facilities under WAC 173-304-462. Among the requirements for wood waste landfills of greater than 10,000 cubic yards are a leachate collection and treatment system or a groundwater monitoring system and compliance with the general landfill performance standards of WAC 173-304-460(2). To meet these standards, the landfill owner or operator may not contaminate the underlying groundwater beyond the point of compliance, as defined in WAC 173-304-100. The point of compliance for the Site is discussed further in Section 4.3.

The minimum functional standards for landfills also require that an owner or operator of a landfill not cause a violation of any receiving water quality standard or violate chapter 90.48 RCW from discharges of surface run-off, leachate, or any other liquid associated with a landfill.

The minimal functional standards also include requirements for air quality and toxic emissions, which are not relevant because the Landfill no longer releases measurable methane, other explosive gases, or any other compounds that would cause a violation of ambient air quality standards or emission standard.

4.2.3.4 State Environmental Policy Act (RCW 43.21C)

This statute requires state agencies to analyze the impacts of proposals for legislation and other actions that might significantly affect the quality of the environment.

4.2.3.5 Washington State Hydraulics Projects Approval (RCW 75.20.10 through 75.20.160, WAC 220-110)

This statute and its implementing regulations apply to any work conducted within the designated shoreline that changes the natural flow or bed of the water body (and therefore, has the potential to affect fish habitat). The requirements include bank protections and prohibited work times based on life stages of endangered or threatened fish species. Any work along Hylebos Creek or adjustments to its drainage sources will involve consultation with the Washington State Department of Fish and Wildlife (WDFW) to determine appropriate mitigation measures.

4.2.3.6 Endangered Species Act (16 USC § 1531 et seq.)

The ESA ensures that the actions that federal agencies authorize, fund, or carry out do not jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse impact of designated critical habitat. Section 9 of the ESA prohibits all individuals, governments, and other entities from “taking” listed species of fish and wildlife, except as exempted under the ESA. It also establishes a federal program to protect threatened and endangered species and to conserve the ecosystems upon which these species depend. Section 7 of the ESA requires federal departments and agencies to consult with the National Oceanic and Atmospheric Administration (NOAA) Fisheries and/or the U. S. Fish and Wildlife Service (Ecology 2004).

Hylebos Creek is a salmon-bearing stream for species including Chinook, and provides habitat for bull trout, both of which are threatened species under the ESA. Bald eagles, currently listed as threatened under the ESA, may use the Site and adjacent areas for hunting and foraging. Cleanup actions will be required to address impacts to Hylebos Creek and associated critical habitat.

4.2.3.7 Native American Graves Protection and Repatriation Act (25 USC 3001 through 3113; 43 CFR Part 10) and Washington’s Indian Graves and Records Law (RCW 27.44)

These statutes prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribe. Because the Site has been occupied, or otherwise used, by Native American tribes, remediation activities could uncover graves or other protected items. Therefore, these programs are applicable to the remedial action alternatives, but only if cultural items are found. The activities must cease in the area of the discovery; a reasonable effort must be made to protect the items discovered; and notice must be provided.

4.2.3.8 Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR part 7)

This program sets forth requirements that are triggered when archaeological resources are discovered. These requirements only apply if archaeological items are discovered during implementation of the selected remedy.

4.2.3.9 National Historic Preservation Act (16 USC 470 et seq.; 36 CFR parts 60, 63, and 800)

The National Historic Preservation Act (NHPA) program sets forth a national policy of historic preservation and provides a process that must be followed to ensure that archaeological, historic, and other cultural resources are protected.

4.2.3.10 Washington Dangerous Waste Regulations (WAC 173-303)

These requirements potentially apply to the identification, generation, accumulation, and transport of hazardous/dangerous wastes at the Site. Under Ecology's Area of Contamination (AOC) policy, if contaminated soil is managed within an AOC, it is not considered to be "generated" as a hazardous waste, even if constituent concentrations would cause it to exceed regulatory levels and ordinarily be considered a hazardous waste. Ecology may set an AOC or AOCs for a site undergoing cleanup under a MTCA Consent Decree. Hazardous waste requirements would, therefore, not apply unless the wastes resulting from the Site cleanup were moved outside the boundary of the AOC.

Federal land disposal restrictions (LDRs) under 40 CFR Part 268 require that hazardous wastes be treated prior to being disposed of in a land-based disposal unit. USEPA has developed special LDRs for contaminated soil and debris. The treatment standards for these substances are expressed as numerical limits and treatment methods, respectively. These standards would generally not apply to contaminated media disposed of within an AOC.

4.2.3.11 Water Quality Standards for Surface Waters of the State of Washington (RCW 90.48 and 90.54; WAC 173-201A)

Remedial actions at the Site may require soil removal or movement and discharge of treated water or stormwater. These actions must not result in exceedances of surface water quality standards unless a short-term modification of water quality has been approved by Ecology prior to the activity (WAC 173-201A-110). Surface water quality standards such as turbidity, temperature, and metals limits (specifically arsenic) would likely apply to the remedial actions.

4.2.3.12 Federal, State, and Local Air Quality Protection Programs

Regulations promulgated under the federal Clean Air Act (42 USC 7401) and the Washington State Clean Air Act (RCW 70.94) govern the release of airborne contaminants from point and non-point sources. Local air pollution control authorities such as the Puget Sound Clean Air Authority (PSCAA) have also set forth regulations for implementing these air quality requirements. These requirements may be applicable to the Site for the purposes of dust control should the selected remedial alternatives require excavation activities. Both PSCAA (under Regulation III) and WAC 173-460 establish ambient source impact levels for arsenic. Any construction activities associated with the selected alternatives will need to meet all Federal, State, and local air quality requirements to control fugitive dust and other emissions.

4.2.3.13 Federal and State of Washington Worker Safety Regulations

- Health and Safety for Hazardous Waste Operations and Emergency Response (HAZWOPER) WAC 296-62 and Health and Safety 29 CAR 1901.120;
- Occupational Safety and Health Act (OSHA)
- Washington Industrial Safety and Health Act (WISHA), WAC 296-62; WAC 296-155, RCW 49.1

The Health and Safety for Hazardous Waste Operations and Emergency Management (HAZWOPER) regulate health and safety operations for hazardous waste sites. The health and safety regulations describe federal requirements for health and safety training for workers at hazardous waste sites.

OSHA provides employee health and safety regulations for construction activities and general construction standards, as well as regulations for fire protection, materials handling, hazardous materials, personal protective equipment, and general environmental controls. Hazardous waste site work requires employees to be trained prior to participation in site activities, medical monitoring, monitoring to protect employees from excessive exposure to hazardous substances, and decontamination of personnel and equipment.

Washington adopted the standards that govern the conditions of employment in all work places under its WISHA regulations. The regulations encourage efforts to reduce safety and health hazards in the work place and sets standards for safe work practices for dangerous areas such as trenches, excavations, and hazardous waste sites.

4.3 CLEANUP ACTION AREAS

Arsenic contamination at the Site emanates from the Landfill waste and is transported beyond the Landfill boundaries via groundwater into the agricultural ditches and wetlands. To address the source of this contamination and cleanup of the affected pathways, the Site has been divided into three CAAs based on distinct considerations due to affected media, exposure pathways, or uniqueness of remedial alternatives. These CAAs are defined below and illustrated on Figure 4.1.

4.3.1 Landfill/Ditch Cleanup Action Area

The Landfill/Ditch CAA consists of the B&L Landfill as shown in Figure 4.1 and the surrounding agricultural ditch system. This represents the original 18.5 acre footprint of landfill operations. Although the Landfill was consolidated in 1993 to approximately 14 acres, the remaining acreage is used for access roads, maintenance of landfill closure systems, stormwater management, and fencing. The agricultural ditch system that surrounds the Landfill drains to the west, where it joins the Surprise Lake Drain; the ditch system is also shown on Figure 4.1.

4.3.1.1 Remedial Action Objectives

The exposure pathways from the Landfill are limited to the migration of arsenic contaminated groundwater beyond the perimeter of the Landfill and into the wetlands area.

The drainage ditch system along the perimeter of the Landfill presents potential exposure pathways to terrestrial receptors (animals and birds) and occasional recreational human users. Both groups would come into incidental direct contact with the surface water and sediments. Since water from the ditches eventually drains into Hylebos Creek, there is also the potential for contamination from the perimeter ditches to reach Hylebos Creek, although current data indicate that this has not happened since the 1993 remedy was implemented.

The following RAOs apply to this action area:

- Meet MTCA Threshold Requirements, as defined by WAC 173-340-760(6)(f) for containment remedies.
- Implement closure requirements from Minimum Functional Standards for Solid Waste Landfills (WAC 173-304).
- Prevent arsenic-containing groundwater from migrating beyond the Landfill into adjacent wetlands and agricultural drainage ditches.
- Meet MTCA Minimum Requirements, including the use of a permanent solution to the maximum extent possible.
- Protect the sediment and surface water quality of Hylebos Creek (and associated restoration projects) from arsenic releases from the B&L Landfill.

4.3.1.2 Cleanup Levels

The CUL for **soil** is given in Table 4.2. Because this is a landfill, the point of compliance for soil, as defined in WAC 173-304-462(2)(e)(i) and WAC 173-304-100, is limited to those soils that are outside the footprint of the Landfill containment area. Since this CAA only includes the Landfill footprint and surrounding ditches, this effectively means that the clean soil layer of the Landfill cap must meet the soil CUL.

The CUL for **groundwater** is given in Table 4.2. Because this site is a landfill, the default groundwater point of compliance for the landfill is the edge of refuse. A series of groundwater wells (most of which already exist) will be installed around the perimeter of the Landfill and will act to measure groundwater quality at the edge of refuse. Monitoring at this point will be used to assess the successful implementation of source control at the landfill. As discussed in the next section on the Wetlands CAA, a conditional point of compliance may be established at 12th St. E. due to the plume of arsenic that has already left the landfill and exists in the wetlands.

The CUL for **sediment** is provided in Table 4.2 and includes consideration for the protection of Hylebos Creek. The point of compliance for this area is throughout the ditch system.

The CUL for **surface water** is provided in Table 4.2. Because much of the surface water comes from groundwater recharge (these are drainage ditches for flooded agricultural lands), the regional background concentration has been considered in establishing the surface water standard. The point of compliance for surface water is everywhere within the perimeter ditch system.

4.3.1.3 Restoration Timeframe

Soils in the Landfill/Ditch CAA already comply with the CUL and associated ARARs.

Groundwater in the Landfill/Ditch CAA at the monitoring locations for the CAA is expected to comply with CULs within a few years, if new upgrades to the existing landfill remedy are implemented, with the exception of the area along the downgradient edge of the Landfill. A substantial off-site groundwater plume of arsenic exists in this area and is included in the following description of the wetlands CAA.

Remedies that may be considered for sediment and surface water in the drainage ditches are expected to result in fairly rapid compliance with CULs, as discussed further in Section 6.0.

4.3.2 The Wetlands Cleanup Action Area

The Wetlands CAA consists of a section of wetlands immediately downgradient of B&L Landfill, as shown on Figure 4.1. The presence of an arsenic-contaminated groundwater plume in the Upper Sand Aquifer that has a potential to seasonally discharge to the land surface is used to define the extent of the Wetlands CAA. This plume is stable, allowing for the footprint of this area to be defined. On the south, it is bounded by Puget Power Access Road and then the Landfill/Ditch CAA, on the east and west it is bounded by groundwater that meets the groundwater CUL in Table 4.2. The Wetlands CAA is bounded on the north, where the upper reaches of the Upper Sand Aquifer are now clean. Contaminated groundwater remains at the base of the aquifer but can not reach terrestrial receptors. This contamination at the base of the aquifer is included in the next cleanup area, the End-of-Plume Area.

4.3.2.1 Remedial Action Objectives

Due to discharge of arsenic-contaminated groundwater into the wetlands, there is a risk of arsenic exposure to human and ecological receptors. This risk of exposure does not necessarily correspond to risks of toxic effects, degradation, bioaccumulation, or other harms to ecological receptors. There is no evidence that such harm has or is currently taking place.

The RAOs for this area include the following objectives to prevent or minimize exposure to the Upper Sand Aquifer and surface water, as well as exposure to surface water and sediments in the drainage ditches.

The following RAOs apply to this area:

- Meet MTCA threshold requirements, including protection of recreational human and ecological receptors from arsenic contamination that is seasonally present in ponded surface water and shallow groundwater.
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable.

- Remove or control the potential for the groundwater plume in the Wetlands CAA to continue to migrate downgradient into the End-of-Plume area, within a reasonable restoration timeframe.
- Ensure remediation activities in Wetlands CAA will be consistent with the potential restoration activities in the area associated with the WSDOT SR 167 Project and potential Hylebos Creek relocation. Coordination with the WSDOT planning process is anticipated to ensure the selected alternative will not negatively impact the planned riparian restoration along Hylebos Creek.

4.3.2.2 Cleanup Levels

The CUL for wetlands soils is 20 mg/kg, as shown in Table 4.2. The point of compliance is the upper 15 feet of the wetlands soils throughout the cleanup area.

The CUL for groundwater is 5 μg/L as shown in Table 4.2. The CUL is based on the background concentration of arsenic in groundwater in the aquifer. Ecology reserved the ability in the 1991 CAP to increase the numeric value based on assessment of regional background concentrations.

This CUL protects potential future drinking water uses (minimum 1,000 feet from the Landfill) and protects surface water quality at Hylebos Creek. The existing groundwater plume extends to 12th St. E.; whereas both of these potential future receptors are well downgradient of 12th St. E. Between the Landfill and 12th St.E., the property is owned by a private party who has granted access for investigation tasks only. Beyond 12th St. E. the wetlands are owned by the municipal parties. The WSDOT SR 167 project would relocate Hylebos Creek much closer to 12th St. E. and therefore potentially alter the current groundwater flow regime.

As discussed later in Section 6, no feasible alternative was identified that would obtain CULs throughout the Wetlands CAA in a reasonable restoration time frame. Alternatives were identified, however, that would be able to meet CULs at a conditional point of compliance (CPOC) located at 12th St. E. For this reason, alternatives in the Wetlands CAA were evaluated in their ability to (1) protect human health and the environment throughout the wetlands, (2) treat arsenic prior to the CPOC to the maximum extent practicable, and (3) support the cleanup action at the End-of-Plume CAA.

4.3.2.3 Restoration Timeframe

Potential remedies for groundwater contamination in Wetlands CAA have highly variable restoration timeframes. For this reason, the restoration time frames are discussed with the alternatives in Section 6.

4.3.3 End-of-Plume Cleanup Action Area

The End-of-Plume CAA, as shown in Figure 4.1, is defined as the extension of the Wetlands CAA's groundwater plume beyond the Wetlands CAA. Within the End-of-Plume CAA, soils already comply with CULs, as does the upper section of the Upper Sand Aquifer. The area is defined by a narrow seam of groundwater contamination at the base of the aquifer that is less than or equal to 5 feet thick and less than 200 feet wide. There is no current exposure to this contamination. However, depending on the rate of naturally occurring attenuation and future plans by WSDOT to relocate Hylebos Creek as part of the SR 167 project, it may reach Hylebos Creek in the future unless action is taken.

Any remedial alternatives implemented in the upgradient Landfill/Ditch CAA and the Wetlands CAA are expected to control the source of contamination in this area. However, additional alternatives are being considered for the End-of-Plume CAA to speed its recovery and bring it into compliance in a faster time frame.

The following RAOs apply to this area:

- Meet MTCA threshold requirements, including considerations for the long-term potential for the plume to reach Hylebos Creek.
- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent possible.
- Ensure that remediation activities in the End-of-Plume CAA will be consistent with the potential restoration activities in the area associated with the WSDOT SR 167 project and potential Hylebos Creek relocation. Coordination with the WSDOT planning process is anticipated to ensure the selected alternative will not negatively impact the planned riparian restoration along Hylebos Creek.

4.3.3.1 Cleanup Levels

Soils in the End-of-Plume area already comply with MTCA. The CUL for groundwater is listed in Table 4.2. Within the End-of-Plume CAA there is no current exposure to the thin seam of arsenic-contaminated groundwater at the base of the aquifer. Potential future exposures in this area could be controlled with institutional controls if the owner of the property agrees. Beyond 12th St. E., the PLPs do not have reasonable controls on the use of groundwater, and exposure at Hylebos Creek could conceivably occur at some time in the future, especially if the creek is rerouted by WSDOT. Therefore, groundwater at the far side of 12th St. E. must comply with the CUL throughout the Upper Sand Aquifer.

4.3.3.2 Restoration Timeframe

Natural attenuation is already occurring throughout the Upper Sand Aquifer. However source control at the Landfill and actions that reduce migration from the Wetlands CAA will decrease the amount of arsenic reaching the End-of-Plume CAA, which will, in turn, decrease the restoration time frame in the End-of-Plume CAA.

4.3.4 Point of Compliance

A conditional point of compliance (CPOC) for groundwater is being requested at 12th St. E. The property between the Landfill and the proposed CPOC is owned by a single party, whose permission will be required in order to obtain the CPOC. This GAE proposes actions between the Landfill and the proposed CPOC that would treat or control arsenic concentrations to the maximum extent practicable and that will bring groundwater into compliance at the CPOC.

This location meets the requirements for an off-property CPOC according to WAC 173-340-720(8)(d)(ii). As the analysis contained in this report indicates (refer to Sections 6.0 and 7.0), it is not practicable to meet the cleanup level throughout the Site within a reasonable restoration timeframe, and the preferred alternative includes the use of all practicable methods of treatment. The groundwater cleanup is based on protection of beneficial uses of surface water (Hylebos Creek). The source of the contamination is located near, but does not directly abut, Hylebos Creek. The 12th St. E. boundary is located as close to the Landfill source as is practicable to remediate to CULs. The CPOC does not extend beyond the extent of groundwater contamination.

Groundwater in the Upper Sand Aquifer between the Landfill and 12th St. E. is not currently and cannot be used in the future as a source of drinking water. There are no private or municipal drinking water sources located in the vicinity of this boundary (refer to Appendix B), which is situated approximately 400 to 600 feet from the Landfill. This groundwater may meet the standards for potable water according to WAC 173-340-720(2), however, new water wells may not be located within 1,000 feet of an existing solid waste landfill and new water wells must be located outside of known or potential sources of contamination according to WAC173-160(Regulations Governing Well Contractors and Operators). Additionally, the Department of Health must approve of all new municipal well locations.

5.0 Preliminary Screening of Remedial Technologies

This section identifies a broad range of potentially applicable technologies and screens out those whose costs exceed their benefits compared to other alternatives, those that are not technically possible, and any that otherwise clearly fail to meet minimum requirements. Selected technologies that pass the screening undergo a detailed evaluation in Section 6.0. Preliminary technologies were identified for the affected media within each of the three CAAs. In all cases, the No Action Alternative (or the No Additional Action Alternative in the case of the Landfill where O&M is already underway), was retained for detailed evaluation as the baseline case.

- Landfill/Ditch CAA
- Wetlands CAA
- End-of-Plume CAA

Table 5.1 presents a list of the preliminary technologies identified for each CAA in further detail and explains the rationale for rejecting or retaining each technology.

In the **Landfill/Ditch CAA**, the potential technologies considered include those that would control, contain, or eliminate the production of leachate, and/or treat contaminated groundwater as it leaves the Landfill. These alternatives include:

- A slurry wall and trenches that would passively contain leachate-contaminated groundwater and divert clean groundwater away from the Landfill.
- A permeable reactive barrier that would treat groundwater as it leaves the Landfill.
- Pump-and-treat wells to dewater the Landfill and/or contain the plume.
- Installation of a landfill liner.

For the ditches, technologies were considered that control the contaminated groundwater that enters the ditches, collect and treat ditch waters, eliminate the ditch pathway entirely, or prevent exposure by physically blocking the pathway.

The technologies that were considered for the **Wetlands CAA** would remove arsenic from surface/shallow groundwater by:

- Creating ponds that would filter or aerate the water.
- Implementing phytoremediation or plantings that would sequester the arsenic.
- Pumping and ex-situ treatment of the groundwater.
- Treating groundwater with in situ applications.
- Monitored natural attenuation.
- Excavating the plume soil and water and capping.
- Installing a permeable soil cover to prevent surface water exposure.

- Implementing containment and capping of the wetlands plume to prevent surface water exposure and prevent downgradient migration.

Phytoremedation in the wetlands, when considered as the sole remedy, was rejected due to its unproven ability to sequester significant concentrations of arsenic and the difficulty of implementation in an area that is flooded for a significant portion of the year. However, phytoremediation and other rejected stand-alone remedies may be considered as components of a broader remedy in the Wetlands CAA.

Impractical and costly remedies such as excavation of the wetlands plume were also rejected due to the difficulty of excavating unstable, loose, and saturated sands to a depth of 20 feet across a large geographic and environmentally sensitive area.

The **End-of-Plume CAA** technologies considered would contain or chemically treat arsenic at the base of the Upper Sand Aquifer to prevent further migration of the arsenic plume. Technologies that would monitor or enhance the natural attenuation processes that are currently underway were also considered.

Remedies that involve construction of a permanent pump-and-treat system as the primary remedial technology (i.e., groundwater pumping and ex-situ treatment and discharge) were rejected due to the lengthy time frame for restoration, given the non-degradable nature of arsenic, the large volumes of waste water that would be generated, the difficulty of maintaining hydraulic control of a seasonally flooded wetlands, the anticipated volume of iron solids that would foul the treatment system, and the high cost and difficulty in treating the water. These factors cause permanent pump-and-treat alternatives to be technically challenging and extremely costly to meet discharge standards. Also, pump-and-treat technologies are viewed widely as ineffective long-term solutions to groundwater contamination. A short-term pump-and-treat approach was retained for the Wetlands CAA because it is a potentially effective method of reducing the mass of arsenic in groundwater in this location, where an area of primarily dissolved arsenic in higher concentrations suggests short-term pumping may significantly aid in meeting Wetlands CAA RAOs.

Permanently pumping the Landfill sump was also rejected not only because of the very high cost of treatment (as noted above) but also on the basis of technical infeasibility. The design of the sump and leachate collection trenches is inadequate to fully dewater the Landfill waste that was found to be significantly saturated year-round due to upgradient groundwater flow (refer to the discussion in Appendix A). Because leachate would continue to be produced, a permanent pump-and-treat system would not meet the key Landfill/Ditch System CAA RAO of preventing leachate-contaminated groundwater from migrating beyond the edge of refuse. However, temporary pumping may be necessary under certain situations, such as maintaining containment.

Table 5.1 provides details of all of the above considerations. For the Landfill/Ditch CAA, relatively few alternatives passed the screening. These remedies generally include containment and treatment of leachate-contaminated groundwater. For the Wetlands and End-of-Plume CAA, a much larger number passed the screening because of the greater need for a detailed analysis to judge the merits of the technologies identified, given the unique challenges that the wetlands present.

6.0 Detailed Analysis of Alternatives

In this section the alternatives based on technologies that were retained from the preliminary screening are further defined and scrutinized using the standard MTCA evaluation criteria. This section provides a thorough evaluation of each technology and allows selection of preferred cleanup actions for each of the three CAAs: (1) the Landfill/Ditch CAA, (2) the Wetlands CAA, and (3) the End-of-Plume Area. Together with the cleanup actions already undertaken, these preferred cleanup actions will constitute the preferred comprehensive Site remedy.

The remedial technologies and process options retained for further evaluation are discussed by CAA below.

6.1 LANDFILL/DITCH CLEANUP ACTION AREA ALTERNATIVES

The RAOs for the Landfill/Ditch CAA will be met by preventing arsenic-contaminated leachate from migrating beyond the edge of refuse. Alternatives that involve pumping or dewatering of the leachate to achieve this were rejected in Section 5.0 as impractical or ineffective. The retained remedial alternatives are those that will contain groundwater within the Landfill/Ditch CAA or treat contaminated groundwater as it migrates beyond the Landfill perimeter including:

- Alternative 1—No Additional Action (baseline case)
- Alternative 2—Slurry Wall Containment
- Alternative 3—Permeable Reactive Barrier (PRB)
- Alternative 4—Funnel with PRB Gate

Additionally, sediment in the nearby agricultural drainage ditches has become recontaminated since the 1993 remedy was installed. While the above alternatives would eliminate future recontamination of the ditches, contaminated sediment that is presently in the ditches will need to be remedied. Remedial alternatives retained from the preliminary screening that will address contamination in the ditches include:

- Alternative 5—Excavation of Sediment in Ditches
- Alternative 6—Burial of Current Ditch
- Alternative 7—Tight-lining or Concrete Lining of Ditch

A conceptual figure showing each of these proposed remedial alternatives is shown in Figure 6.1. These alternatives are described and considered individually, with respect to evaluation criteria in the following sections. This is followed by a comparative analysis of the relative strengths and weaknesses of each alternative. Table 6.1 presents a summary of this comparative analysis.

6.1.1 Alternative 1—No Additional Action

This alternative is retained as the baseline case. It maintains the current action—a landfill cap with stormwater controls, passive landfill gas venting, maintenance of the Landfill cap, and groundwater compliance monitoring. Additional wells would be installed to monitor the end of the plume and other areas of the site as deemed necessary by Ecology. This remedy, implemented in 1993, prevents generation of leachate from infiltrating rainwater via an impermeable cap liner that prevents stormwater infiltration, controls the potential accumulation of methane, and prevents human contact with the slag in the refuse with a soil cover and fencing. However, this alternative allows seasonal intrusion of groundwater into the refuse, followed by the production of leachate, and discharge of the contaminated leachate from the Landfill into the Upper Sand Aquifer and the adjacent agricultural drainage ditches. Alternative 1 fails to meet MTCA's threshold requirements because of the on-going production and release of leachate and its discharge beyond the Landfill.

6.1.2 Alternative 2—Slurry Wall Containment

This alternative involves containment of the contaminated leachate within the Landfill perimeter by a slurry wall, also known as a "cutoff wall." Slurry walls physically block the flow of groundwater and prevent migration of arsenic-contaminated leachate or groundwater beyond the confines of the slurry wall. The slurry wall would be tied into the aquitard that fully underlies the refuse (refer to Appendix A) and would extend along the entire perimeter of the Landfill. The top of the slurry wall would be tied into the existing cap to prevent stormwater from entering into the contained area.

Well-constructed slurry walls have a low permeability and are intended to resist groundwater migration, especially when a shallow (generally less than 20 feet bgs) low permeability aquitard is present, as it is at B&L Landfill. The permeability of cement-bentonite or soil-bentonite slurry walls range from $1X10^{-6}$ cm/sec to $1X10^{-8}$ cm/sec, similar to a natural clay (Opdyke and Evans 2001).

The absence of physical barriers at the site and the shallowness of the aquitard make it feasible to construct the slurry wall with no physical gap during placement. This, in combination with the natural flexibility to slow earth deformations, leads to long-term stability, effectiveness, and permanence. Testing would be required to ensure chemical compatibility with Site conditions before the specific design and composition of the wall could be completed; however, the contaminated groundwater at the Landfill is similar to municipal landfill leachate (high iron and DOC, neutral to slightly acid pH), so no problem is expected. A rare, large magnitude earthquake that results in lateral displacement faults and other earth movements could breach a slurry wall, but such breaches are repaired by replacing the damaged section of the wall.

The slurry wall does not change or modify the underlying aquitard. In most areas, it consists of interbeded silts, clay, and peats that are often dry—indicating very little leakage of groundwater across the aquitard. Nevertheless, there is always some risk that upward gradients from the Lower Sand Aquifer into the Upper Sand Aquifer would eventually saturate the contained area, potentially causing hydraulic spill over. The possibility of accumulations of water within the containment wall, and the potential design features to mitigate them, are suitable for evaluation during the design stage. If necessary, spill over contingencies (including drain wells), overflow portals, or the temporary pumping of the central sump, could be developed.

The natural groundwater flow through the Landfill will be blocked, and will instead migrate around the sides of the slurry wall. If the natural rate of migration is limited, this may cause groundwater along the upgradient section of the slurry wall to build up, causing uneven hydrostatic pressure on the slurry wall and/or groundwater ponding. This pressure could be alleviated by interceptor drains or other means (e.g., French drains) that would funnel away upgradient groundwater. The goal of these systems is not to prevent groundwater from reaching the slurry wall, but to prevent an undesired increase in potentiometric head by giving the groundwater coming off the nearby uplands an “easy” route around the Landfill. Such considerations would be evaluated during the design stage. Regardless, the remedy would alter groundwater gradients to accommodate the blockage and increased flow around the slurry wall. A zone of groundwater stagnation may form directly downgradient of a large subsurface barrier such as a slurry wall. The effects of such a zone would be evaluated during the design stage as well. Currently, the Landfill’s stormwater pond (which accepts only clean stormwater falling on the Landfill cap) discharges into the potential stagnation point for the slurry wall and may prevent the stagnation from occurring.

Construction of slurry walls in homogenous, sandy materials (such as those at the Site) is not technically challenging. These conditions, and the anticipated depths of the barrier, may allow installation through the relatively efficient technology of one-pass trenching, where the soil is dug out, and the slurry wall emplaced at the same time with a continuous trenching machine. Containment barriers like slurry walls are a proven, effective method for achieving groundwater control. They have a high degree of permanence, and in many cases, require virtually no maintenance. Performance monitoring would be designed to identify potential maintenance needs such as breaks, dislocations, or voids, which are readily reparable by reintroduction of the slurry in the affected section.

6.1.3 Alternative 3—Permeable Reactive Barrier

This alternative involves the digging of a subsurface trench and filling the trench with one of several potential permeable reactive materials that have been demonstrated to precipitate dissolved arsenic in groundwater onto mineral surfaces. Treatment occurs passively as groundwater flows through the barrier wall under natural gradients. The trench would be placed immediately downgradient of the entire extent of the refuse perimeter where the groundwater plume exits the Landfill, a distance of approximately 600 feet. The vertical extent of the barrier wall would extend to a depth of approximately 20 feet and be tied into the aquitard at the base of the shallow aquifer.

Laboratory bench-scale testing would be necessary to identify the most effective and long-lasting reactive media for site conditions. Reactive materials that would potentially be evaluated in the bench or pilot study are primarily based on the removal mechanism of reductive precipitation, which is compatible with the saturated, anoxic conditions at the targeted treatment depth[9] (Blowes et al. 1999abc). These reagents generally sequester arsenic by lowering the redox potential of the groundwater through corrosion of zerovalent iron (ZVI) and/or by introducing organic compounds; arsenic is trapped in the crystal lattice of iron sulfide minerals such as arsenopyrite. The approach is compatible with the addition of sulfide into the system to allow the precipitation of iron sulfide minerals.

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[9] ZVI is capable of functioning in shallow aerated groundwater, but a portion of the reactivity of the media will be consumed in reactions to remove oxygen from the water (Blowes et al. 1999abc).

In addition to developing the appropriate mixture for site groundwater and aquifer geochemistry, the physical parameters of the PRB must be designed based on site-specific hydrogeologic conditions. The hydraulic conductivity of the trench must be greater than or equivalent to the surrounding aquifer and the residence time for the groundwater as it flows through the trench must be long enough for the desired reactions to occur. This is a critical design parameter to ensure effectiveness.

A variation on the ZVI media would be to use newly emerging alternatives, including the less-expensive basic oxygen furnace material (BOF), a non-metallic waste by-product of steel production containing various oxides and silicates of iron, calcium, magnesium, and aluminum. BOF initially removes contaminants such as arsenic by sorption, but subsequent reactions commonly result in the conversion of sorbed to stable mineral phases. Reductive precipitation is considered the predominant removal mechanism (Blowes et al. 1999abc, Baker et al. 1997, 1998; McRae et al. 1999**)**. BOF can function in aerated groundwater, but drying cycles associated with fluctuations of the water table may result in cementation reactions. Additionally, the interaction of BOF and water causes elevated pH (10 to 12) conditions to develop. This effect may have unintended consequences downgradient of the treatment zone, especially where groundwater discharges to surface water (Blowes et al. 1999abc). BOF may also contain impurities that could potentially release unintended constituents into groundwater.

Review of the literature indicates a relatively short life for PRBs before a gradual and irreversible decline in effectiveness is observed, typically due to clogging of pores by mineral co-precipitation on the reactive media surfaces (FRTR 2002). Replacement of the treatment media is estimated to be necessary once every 20 years, based on treatment for chlorinated solvents. Relatively few PRBs have been installed expressly for treatment of arsenic, so field data are lacking to assess a realistic replacement life. The periodic replacement of the reactive media in the PRB would have to occur indefinitely, as no decline in concentrations of arsenic in the leachate have been observed since the capping remedy was performed and no decline is expected in the foreseeable future.

6.1.4 Alternative 4—Funnel and Gate Permeable Reactive Barrier

A variation of the full length PRB alternative is to divert groundwater leaving the Landfill perimeter to a PRB treatment “gate.” This would be done with inward angled impermeable “wing walls” composed of either sheetpiles or a slurry wall (and potentially groundwater extraction wells to better control gradient as a contingency). The gate would be a treatment trench of reduced size, typically a third to a quarter of what otherwise would be necessary (e.g., 150 feet long instead of 600 feet). The advantage of this approach is that the volume of reactive material required is greatly reduced, which lowers operation and maintenance (O&M) costs. More importantly, the limited length of the treatment trench makes the system’s effectiveness more easily monitored and also insures that the entire breadth of the plume is diverted through the gate. The thickness of the PRB at the gate would need to be increased to account for the increased seepage velocity of groundwater as it passes through the gate. A much more detailed study of the groundwater flow regime would have to be undertaken to ensure effectiveness of the alternative, but if feasible, this alternative would be much more cost effective over a long time period due to the stability of the wing walls and the lower cost of the treatment media.

6.1.5 Alternative 5—Excavation of Sediment in Ditches

Excavation of ditch sediments was performed during the Landfill consolidation and capping in 1993. Localized recontamination has occurred due to the continued discharge of arsenic-contaminated groundwater and precipitation of arsenic into ditch sediments. The depth of ditch sediment contamination in the perimeter ditches is generally limited to approximately the upper 12 inches and therefore, is easily mucked out by a backhoe. Additional sampling would need to be performed to identify specific sections of the ditch where contaminant concentrations exceed CULs before remediation would begin and also after remediation to confirm compliance. For the purposes of this document, it is assumed that the affected ditch segment starts at the adjoining apartment complex and continues until approximately 400 feet downgradient of the Landfill (sediment Station SW-4). Assuming a 3-foot wide ditch bottom dug 12 inches, on average, this represents approximately 250 tons of sediment. The sediments would be stabilized, as necessary, to reduce their water content and then disposed of at a permitted landfill. The ditches would remain, following excavation, and continue to function to drain the agricultural fields and apartment complex. Selection of either PRB alternative for landfill source control may result in ditch recontamination and the need for repeated ditch excavation.

6.1.6 Alternative 6—Burial of Current Ditch

This alternative involves removal of the arsenic-contaminated sediment from the existing ditches and then permanently burying the ditches to grade. Elimination of the perimeter ditches would completely eliminate this pathway by preventing groundwater from discharging to surface water. This "remedy" is included because it is an expected component of future plans to redevelop the agricultural fields for recreational or commercial use. This redevelopment would eliminate the need for the ditches. The burial of the existing ditch would need to be done concurrent with redevelopment and coordinated with the City of Fife, as owners of the agricultural fields, as well as the Drainage Ditch District #23, which controls the ditch system in this area of Pierce County. This remedy would also need to be coordinated closely with WSDOT, who will be removing a section of the ditch segment downstream from the Landfill as part of the riparian restoration zone for the SR167 project (refer to Figure 2.4). According to the EIS for SR-167, stormwater from the redeveloped agricultural fields and the adjoining apartment complex would be diverted to the riparian restoration area.

From the standpoint of the B&L Landfill remedy, Alternatives 5 and 6 would be equivalent and would remove contaminated sediment as part of the remedy. Subsequent burial of the ditches would be done by the developer of the agricultural lands.

6.1.7 Alternative 7—Tightlining or Concrete Lining of Ditch

This alternative involves removal of the arsenic-contaminated sediment from the existing ditches and re-engineering the current Landfill perimeter sections of ditch to prevent the discharge of contaminated groundwater—either by installing a closed pipe (tightline) along the ditch segments that pass by the Landfill or alternatively, lining the trench with concrete. Such actions would prevent groundwater from entering into the ditch, thereby eliminating this pathway. Tightlined sections would be buried to block direct exposure. Upstream uncontaminated surface water would pass through the pipe/lined trench and discharge into the Surprise Lake ditch without any arsenic input from the zone of contaminated groundwater.

For the tightline remedy, the functionality of the ditch system would be impaired as rainwater would not be able to drain into the tightlined sections, which may lead to longer periods of flooding of the fields. The concrete-lined ditch would function better in this regard, as it would still allow accumulated surface waters from the agricultural field to drain directly into the trench.

This remedy would only be considered if the PRB is selected for the Landfill, but would not be necessary if the slurry wall was installed, as one of the functions of the slurry wall would be to keep leachate-contaminated groundwater from exiting the entire perimeter of the Landfill. In contrast, the PRB would be downgradient of the ditches and so would not be able to control discharge, making a separate control action for the perimeter ditches necessary.

6.1.8 Comparative Analysis of Landfill/Ditch Cleanup Action Areas Alternatives

Overall protection of human health and the environment

Alternatives that meet the RAO for the Landfill/Ditch CAA of preventing arsenic-contaminated groundwater from migrating beyond the edge of refuse are protective of human health and the environment (with the exception of Alternative #1—the No Additional Action alternative, which is only considered further to provide a baseline). The other three alternatives each meet this RAO by providing source control through either containment or treatment. While each provides a high degree of protectiveness, containment provides a higher degree of protectiveness than the two PRB alternatives. This is due in part to the differences between physical and chemical controls. Containment prevents the generation of additional leachate, and will eliminate the groundwater discharge to ditch water pathway. Containment does not require as sophisticated a treatability testing process as does a PRB, and is not prone to potential unexpected consequences resulting from changing groundwater chemistry. A PRB may not consistently prevent all of the groundwater with elevated arsenic concentrations from migrating beyond the edge of refuse. Additionally, a PRB will not be able to prevent leachate-impacted groundwater from migrating to the ditches along the sides of the Landfill and so is not as protective. To be as protective as the slurry wall, a PRB remedy must be combined with a remedy specific to the ditches. In addition, slurry wall containment has a longer track record as a proven groundwater remedy.

Compliance with ARARs

With the exception of the No Additional Action alternative, all of these alternatives would comply with the ARARs specific to the Landfill/Ditch CAA, specifically, controlling leachate beyond the edge of refuse (minimum functional standards) and meeting federal and state surface water standards by eliminating the discharge of arsenic-contaminated groundwater into the ditch. Attainment of groundwater standards beyond the edge of refuse is addressed in the wetlands area discussion.

Long-term effectiveness and permanence

Alternative 2—Slurry Wall

The long-term reliability of the slurry wall containment depends on a post-construction program of performance monitoring, inspection and maintenance, and contingency measures (e.g., to address overflow, if necessary). Literature review indicates that properly constructed slurry walls last many decades and are used extensively for this reason in civil construction projects. (Rumer and Ryan 1995).

A major factor affecting the long-term effectiveness and permanence of the proposed slurry wall is the wall's integrity and overall performance as a low permeability barrier. For example, defects during its construction could cause localized areas of higher permeability. Construction quality assurance/quality control (QA/QC) measures are, therefore, particularly important during implementation of this remedial action. Potential long-term changes in the permeability of the slurry wall could also result from (1) wetting and drying of the section of the wall that is exposed to the fluctuating groundwater table, (2) freezing and thawing cycles, and (3) chemical incompatibility.

Wetting and drying and/or desiccation are not major concerns for the proposed design because the very shallow depth to groundwater would generally be maintained across the slurry wall. The exception to this would be the top few feet of the slurry wall. Freezing and thawing is not a concern because of the soil freezing depth (12-16" below grade) does not extend beyond the top of the expected tie in depth of the slurry wall to the existing soil cover. Chemical incompatibility of the slurry wall backfill mix with hazardous substances that are being contained could also potentially cause an increase in the permeability of the slurry wall over the long term. However, this concern is more relevant when containing highly concentrated organic compounds that can result in increased hydraulic conductivity within the slurry wall (Rumer. and Ryan 1995). Therefore, chemical compatibility is not anticipated to be a significant problem at B&L, but will be confirmed with a bench scale compatibility test during design.

Effectiveness of the slurry wall containment system will not depend on implementation of hydraulic control measures to control groundwater flow. The O&M plans (and costs) will include repair and replacement actions that may be implemented based on the performance monitoring data, as well as contingent inspection and repairs following severe earthquakes.

Alternatives 3 and 4—Permeable Reactive Barrier

The long term effectiveness of the two PRB alternatives is less certain than containment by means of a slurry wall. This uncertainty stems in large part from relatively few examples of PRBs in operation to treat arsenic. Although the number is growing, in 2002 there were fewer than five PRBs nationwide installed to treat arsenic (USEPA 2002).

Challenges to long term effectiveness include the need to thoroughly understand system hydrogeology prior to implementing a PRB, due to the need for the plume to passively flow through the reactive zone with enough residence time to achieve the necessary chemical reactions. The hydrogeologic characterization must yield this information before the thickness of the PRB can be designed. Once installed, however, groundwater monitoring would allow accurate assessment of whether or not the performance objectives are being met.

Achieving and maintaining the proper in situ chemistry is another problem that must be overcome to effectively implement a PRB over the long term. One of the main factors affecting long term effectiveness of either the full length PRB or the funnel and gate PRB is the limited longevity of iron barriers due to formation of precipitates in the iron upon contact with groundwater. Common mineral precipitates include iron (oxy)hydroxides, iron sulfides, iron and calcium carbonates. Understanding the processes that control the rate and type of precipitates is important in barrier planning and design. Other geochemical considerations may limit the long-term effectiveness of PRBs. For example, the elevated total dissolved solids and dissolved organic carbon in the landfill leachate may shorten the life of the treatment media by generating precipitates that cause a decline in permeability (USEPA 1998). These factors contribute to the need for a complex treatability testing regime, and rigorous performance monitoring of installed barriers.

The slurry wall has a much higher degree of certainty associated with its long term protectiveness then the two PRB alternatives, and is significantly more permanent. PRBs may provide similar long-term protectiveness, if a number of factors are able to be resolved and proper maintenance is implemented. PRB impermanence can be addressed by periodic replacement of reactive media, estimated to be once every 10-20 years.

Alternatives 5 through 7—Ditches

The long term effectiveness of the ditch remedy, should the ditches remain in use for an extended period of time, depends on whether the Landfill groundwater is controlled from migrating just beyond the Landfill perimeter to the ditches. If containment of the Landfill groundwater at the Landfill perimeter is first established via a slurry wall, then recontamination of the ditches, following implementation of the excavation remedy, should not occur, as contaminated groundwater can no longer migrate away from the refuse. Long term effectiveness can be easily assessed by sampling the ditch sediment following implementation of the remedy.

However, if landfill control is established via a downgradient PRB, then recontamination of the ditch waters and sediment would be expected to occur, as the PRB will not affect the groundwater conditions along the west side and south sides of the Landfill, where the ditches currently intersect contaminated groundwater. In this case, ditch sediments would require repeated excavation to maintain compliance.

Burial of the ditches would address the long term effectiveness concern, regardless of whether the slurry wall or PRB is implemented—as the pathway for exposure would no longer exist.

In summary, excavation of the ditch sediment (as a remedy by itself), without either burial of the ditches or implementation of the slurry wall to prevent continued seepage, is a temporary measure. It is likely that the ditches will be buried anyway, as part of the redevelopment of the agricultural fields/SR 167 project.

Reductions in Toxicity, Mobility, and Volume through Treatment

The slurry wall would physically isolate the contamination, thereby reducing its mobility. No treatment would be performed, however. Containment will result in a reduction in the volume of arsenic in groundwater beyond the Landfill perimeter by eliminating the continued production of leachate from fresh groundwater contacting landfill wood waste. In contrast, the PRB would use in situ treatment to reduce the volume of existing arsenic in groundwater, its mobility and its toxicity by converting it to a solid phase that would be unable to migrate further downgradient via groundwater. The PRB alternatives would not reduce the future production of leachate nor its discharge, but would treat the leachate contaminated groundwater as it exits the Landfill perimeter. Excavation of the ditch sediment would reduce toxicity in the ditch itself.

Short-term Effectiveness

The risks to human health and the environment during the construction of the Landfill alternatives are low. All of the alternatives involve the normal worker safety concerns associated with implementing cleanup alternatives, which are slightly higher in the larger-scale construction project of a containment barrier wall. The public would not be allowed to enter the work zone. All remedies involve subsurface work, and hence risk of personal injury. All work will be conducted beyond the edge of refuse, where past data suggest soil concentrations are not elevated greater than either natural background or industrial worker standards. For installation of the slurry wall, the edge of the cap would need to be rolled back, potentially exposing landfill waste, which would be scraped off and placed back inside the cap following construction. For the ditch soil that is excavated, it may be possible to place this soil under the Landfill cap or if this is not possible, characterize and transport off-site. Finally, standard construction controls to prevent release of soil and sediments to the Surprise Lake Drain (downgradient of the agricultural ditches) will prevent impacts to sensitive habitat or species in the downgradient restoration areas.

The installation of either of the PRB alternatives pose similarly insignificant risks. All Landfill/Ditch CAA alternatives could be field constructed within a six-month time frame. Cleanup of the ditches should follow slurry wall construction. Pre-construction design and planning would take approximately one year for the slurry wall and up to two years for the PRB, due to the need to conduct extensive bench scale tests and more hydrogeologic characterization and modeling.

There is a slight difference in the short-term effectiveness of the three alternatives in achieving the RAO for surface water, based on the timing of implementation, and the selected alternative for the Landfill/Ditch CAA.

Ditch burial or tightlining/concrete lining would immediately eliminate the infiltration of contaminated groundwater once implemented. In contrast, the timing of when ditch excavation is implemented affects its short-term effectiveness (assuming that containment is selected for the Landfill). If ditch excavation is implemented well before the slurry wall is in place, then continued discharge of contaminated groundwater into the ditch would occur until the slurry wall is completed. If the ditch excavation is implemented after the slurry wall, recontamination would be limited to the residual groundwater contamination “halo” outside the slurry wall, which may be insignificant.

Other short-term effectiveness concerns due to worker safety are not significant for any of the ditch alternatives due to the limited volume of ditch sediment, its relatively low contaminant concentrations, and quick timeframe for implementation (one month or less).

Implementability

All landfill remedies are about equally implementable. The design of both the slurry wall and the PRB would involve bench scale testing and further hydrogeologic and geotechnical investigation before a final design could be developed. A QA/QC program would need to be implemented during construction to ensure that no construction defect occurs that would impair the functionality of either remedy. The permission of the current land owners would also need to be obtained. In addition, the substantive grading/land use requirements of the City of Fife and/or Pierce County would have to be met, including a state environmental policy act (SEPA) review.

Cost

The estimated costs for the Landfill perimeter and ditch alternatives are summarized in the table below. Appendix C contains a detailed spreadsheet from which these cost estimates are derived. The No Additional Action alternative continues the current OM&M of the entire Site, which consists of cap inspection and mowing, repairs and maintenance, and semi-annual groundwater and surface water monitoring around the Landfill and wetlands. Additional wells would be installed to monitor the end of the plume area and the effect of future restoration areas. O&M costs include monitoring of approximately 14 locations, Ecology reviews and a yearly access fee for the wetlands. For the slurry wall and PRB, the capital cost includes treatability tests and design costs, and a 30 percent construction contingency. The major post-construction contingencies (such as unforeseen slurry wall repairs and replacement of the PRB once every 20 years), are accounted for in the 50-year O&M cost column. The total cost is presented as the sum of the capital cost, the capital contingency costs, and net present value of the 50-year O&M cost.

The slurry wall alternative is clearly more cost effective than the PRB for both capital cost, (mainly due to the high cost of iron for the PRB) and also long term contingency costs, as the slurry wall does not need to be replaced every 20 years as the PRB does, which drives up the cost significantly. In comparison, the costs for the ditch remedies are all fairly low and cost should not be a deciding factor.

Comparative Costs for Landfill/Ditch CAA Alternatives

Alternative	**Capital Cost** with Contingency[1]	**Yearly O&M Cost[2]**	**50-year O&M (Net Present Value[3])**	**Total Cost[4]**
No Additional Action	$109,000	$91,000	$3.1 million	$3.3 million
Slurry Wall	$1.9 million	$20,000	$630,000	$2.6 million
Full length PRB	$3.0 million	$133,000	$4.2 million	$7.3 million
Funnel and Gate PRB	$2.4 million	$72,000	$2.3 million	$4.8 million
Excavation of Ditch Sediment	$46,000	--	--	$46,000
Excavation of Ditch Sediment and Burial of Ditches (following excavation)	$52,000	-	-	$52,000
Excavation of Ditch Sediment and Tight-lining of Ditches	$59,000	-	-	$59,000

Notes:

1 Capital cost includes contingency; see Appendix C for details.
2 Annual monitoring and maintenance and annualized repairs.
3 Net present value assumes uses a 2 % effective discount that assumes a risk free rate of approximately 5%, net of inflation of approximately 2%..
4 The sum of capital cost (including contingency) and NPV of the O&M costs.

6.2 WETLANDS AREA ALTERNATIVES

The RAOs for the Wetlands CAA will be met by preventing arsenic-contaminated groundwater from reaching potential receptors in shallow groundwater and ponded surface water and preventing further migration of arsenic-contaminated groundwater to downgradient receptors. The remedial alternatives retained for further consideration include the following alternatives that appear suitable based on undeveloped wetlands land use:

- Alternative 1—No Further Action
- Alternative 2—Monitored Natural Attenuation (MNA)
- Alternative 3—In situ Sequestration
- Alternative 4—Short-term Pump-and-Treat Removal
- Alternative 5—Surface Water Treatment Cells

In addition, two alternatives are retained that are only considered feasible if the land use for the wetlands parcel is changed to allow for commercial, residential, or mixed use development. Remedial actions that eliminate the wetlands functions may be considered unacceptable to regulatory agencies or to stakeholders supporting restoration of the watershed:

- Alternative 6—Soil Cover

- Alternative 7—Containment and Capping

A conceptual figure showing each of these proposed remedial alternatives is shown in Figure 6.2. These alternatives are described and considered individually with respect to evaluation criteria in the following sections. This is followed by a comparative analysis of the relative strengths and weaknesses of each alternative. Table 6.2 presents a summary of this comparative analysis.

6.2.1 Alternative 1—No Further Action

This alternative assumes that source control is implemented in the Landfill/Ditch CAA that results in no new release of arsenic from the Landfill. It does not address contamination that already lies in the wetlands due to past releases at the Landfill.

Over the last 10 years, groundwater monitoring of the plume has indicated that it is relatively stable in size with peak concentrations declining, but as shown in 2006, concentrations can vary significantly over the short term possibly related to seasonal hydrology —indicating that the plume may not be stable under all reasonably anticipated conditions.

Although source control in the Landfill/Ditch CAA will result in no new release to the wetlands, the arsenic in groundwater beneath the wetlands presents a potential exposure risk through the following pathways:

- Long-term migration to Hylebos Creek.
- Long-term migration to a potential future drinking water well located 1,000 feet from the Landfill.
- Short-term, seasonal exposures to human and terrestrial receptors that contact contaminated groundwater discharging to the shallow ponded surface water in the wetlands.

Because of the seasonal discharge of contaminated groundwater to wetlands surface water and the uncertainty regarding the stability of the plume of dissolved arsenic, the No Further Action alternative does not comply with MTCA threshold requirements.

6.2.2 Alternative 2—Monitored Natural Attenuation

This alternative would involve installation of monitoring wells in the Wetlands CAA for more precise monitoring of plume boundaries and ongoing monitoring of the groundwater and surface water quality (including relevant physical and chemical parameters and constituents) and hydrology (including groundwater-surface water interactions). This alternative assumes source control in the Landfill/Ditch CAA, so that no new release of arsenic occurs from the Landfill.

MNA would increase the degree of protection of human health and the environment as compared to the No Action Alternative by more clearly establishing the groundwater-surface water interactions and associated risk of potential exposures, and by providing data to allow continued evaluation of the attenuation processes in the area of highest arsenic concentrations. When combined with landfill controls, the overall degree of protection is considered moderate because naturally-occurring processes are likely to occur over a lengthy restoration timeframe.

In the meantime, the potential for human and ecological exposures would continue to occur. MNA would only potentially comply with ARARs if the following conditions were met:

- Risk assessment showed that elevated arsenic concentrations in ponded surface water were insufficient to cause ecological and human health harm.
- MNA monitoring indicated that the plume continued to remain stable or shrink over time.
- Ecology approved a conditional point of compliance near 12th St. E. (but no further than 1,000 feet from the Landfill) where the current arsenic concentrations decrease to background levels.

Due to the redox-sensitive reversibility of the natural attenuation processes, MNA in the Wetlands CAA would require long-term monitoring to confirm that the remedy is permanent. Because of the slow rate at which natural attenuation occurs, the short-term effectiveness of this alternative is considered low. Reductions in arsenic mobility and volume in groundwater are likely to occur, over time, by natural adsorption and precipitation processes.

This alternative carries negligible short-term effectiveness considerations related to standard worker safety risks during well installation and monitoring activities. It is readily implementable, with minor physical obstacles related to working conditions in the wetlands.

Costs are low beyond the costs of ongoing monitoring. Costs would include a small one-time capital expenditure to install additional monitoring wells, and ongoing monitoring costs in perpetuity.

6.2.3 Alternative 3—In situ Sequestration

The In situ Sequestration alternative for the Wetlands CAA would utilize one of several possible combinations of chemical reactants and in situ delivery systems that can permanently sequester dissolved arsenic into the solid phase. The purpose of adding the chemicals is to enhance the sorption/precipitation process that is naturally occurring, and to ensure that there is sufficient sulfide present to form arsenopyrites as the sequestering phase.

In situ Sequestration is being proposed as the remedy of choice in the End-of-Plume CAA (refer to Section 7.0). If it were to be used in the wetlands also, this alternative would most likely be implemented as an upgradient extension of In situ Sequestration in the End-of-Plume CAA. The End-of-Plume system would be installed first due to the ease of access for equipment along 12th St. E. and ease of access to dissolved arsenic (thin band of arsenic at the base of the aquifer). Once the End-of-Plume system is optimized, work would begin on the upgradient extensions into the wetlands.

Successful in situ treatment further downgradient could demonstrate the most cost-effective product and delivery system for permanent sequestration. Additional pilot study data would be collected to support expansion of the End-of-Plume treatment into the area where arsenic concentrations are more elevated and present at both the top and base of the aquifer. The alternative would include construction of a permanent in situ delivery system and/or access roads in the wetlands for repeated treatments; delivery of the reactive media to the targeted treatment zone; installation of additional monitoring wells suitable for performance monitoring;

performance monitoring of groundwater quality (including relevant physical and chemical parameters and constituents) and hydrology; and operations and maintenance of the treatment system. It is expected that ongoing treatment would last approximately three years, with approximately 10 years of performance monitoring, during which additional treatment could be applied as necessary.

Treatment products and delivery systems that would potentially be evaluated in the pilot study are the same as those considered for the End-of-Plume CAA. Chemical reactants are based on the removal mechanism of reductive precipitation. Refer to Section 6.3 for a description of these technologies and delivery systems.

This alternative offers a moderate to high degree of protectiveness for human health and the environment. It carries a high likelihood of effectiveness in halting the migration of arsenic in groundwater near the base of the aquifer. The high concentrations of arsenic in the shallow portion of the Upper Sand Aquifer in the Wetlands CAA, however, present a technical problem for complete protectiveness. Water level fluctuations in this part of the aquifer would prevent the establishment of reducing conditions in this part of the Aquifer. In addition, the natural processes that are apparently attenuating arsenic in the upper few feet of the Upper Sand Aquifer (oxidation and adsorption/co-precipitation) are incompatible with an in situ remedy that relies on producing a reducing environment. For these reasons, in situ reductive precipitation is unlikely to sequester arsenic in the upper part of the Upper Sand Aquifer, and may contribute to the mobilization of additional arsenic from the upper part of the Upper Sand Aquifer. In situ methods that rely on oxidation and adsorption/precipitation are unlikely to be sustainable in the deeper portions of the aquifer that are naturally anoxic and reducing.

Because this alternative would not remediate the uppermost part of the plume, the potential would remain for exceedances of CULs in seasonally ponded surface water. In addition, construction of delivery systems in the wetlands, particularly road-building, may be difficult to permit.

In situ Sequestration is expected to provide a high degree of long-term effectiveness and permanence for groundwater below approximately 8 feet bgs, where reducing conditions remain stable. It is expected to provide a low degree of long-term effectiveness and permanence in the shallower part of the aquifer, where redox potential fluctuates. Natural attenuation processes in shallow groundwater may be sufficient to allow In situ Sequestration to be an effective permanent solution for deeper groundwater. Once properly immobilized within sulfide minerals, the risk of large-scale remobilization would be low in groundwater at the base of the aquifer, where anoxic conditions are expected to persist. This alternative also offers the possibility of a permanent solution without source control in the Landfill/Ditch CAA; in such a case, ongoing treatment may be necessary to sequester continued arsenic inputs.

The use of In situ Sequestration is expected to result in major reductions in the mobility of arsenic and the volume of arsenic in deeper groundwater by sequestering arsenic into aquifer minerals. The toxicity of arsenic would also be significantly decreased, because arsenic would be bound in mineral crystal lattices instead of moving as a dissolved ion or in association with colloids. The scale of these reductions would be unaffected by the implementation of upgradient source control; greater treatment would be applied to sequester a greater mass of arsenic inputs. However, the reductions in mobility, volume, and toxicity of arsenic in shallow groundwater (within 6 feet bgs; where the water table seasonally drops below land surface) are expected to be low.

This alternative carries minor short-term effectiveness considerations related to standard worker safety risks during delivery system construction, treatment, well installation, and monitoring activities. It may also result in some short-term damage to the existing wetlands.

In situ Sequestration has some obstacles to implementation. Construction of a delivery system may require some filling of the wetlands in order to construct access roads. This is in addition to the physical obstacles related to working conditions in the wetlands.

Costs are high relative to other Wetlands CAA alternatives. Costs would include capital expenditures to install a delivery system likely to consist of multiple transects and some permanent above-ground components, well installation, treatment reagent, and labor. Long-term costs would include O&M of the treatment system in addition to ongoing monitoring costs. If a PRB delivery system is selected, O&M costs may be reduced unless the PRB requires periodic replacement. Contingency costs would be used for additional engineering of modifications to the in situ system, if needed.

6.2.4 Alternative 4—Short-term Pump-and-Treat Removal

As indicated in Section 5.0, although long-term ex-situ pump and treat systems did not pass the preliminary screening due to inability to achieve cleanup levels and disproportionately high costs (treatment plant construction costs, high O&M costs due to iron fouling, etc.) a short-term pump-and-treat approach was deemed potentially suitable for meeting RAOs. Short-term pump and treat is favored by the following conditions in the wetlands:

- The size of the plume is limited and can be “captured” by relatively few wells.
- Most of the mass of arsenic in the plume is within a 2-acre core containing elevated concentrations above 2 mg/L.
- The source for the high concentrations in the plume is landfill leachate that will no longer be able to migrate to the wetlands following implementation of the Landfill/Ditch CAA remedy.
- Arsenic is present in the plume as dissolved phase that will migrate readily with the groundwater to nearby pumping wells.
- Aquifer materials are relatively homogenous and transmissive and have a demonstrated capacity for sustained groundwater pumping.
    - Soil arsenic concentrations in the wetlands are near background levels, so this soil is not expected to contribute to significant post-pumping rebound.

These factors suggest that the residual mass of arsenic in the wetlands plume following implementation of the Landfill remedy could be readily removed by pumping. This alternative would meet RAOs by permanently lowering the elevated concentrations now observed in the plume, shrinking its footprint, and decreasing the mass of arsenic available for transport by groundwater.

This alternative would conceptually consist of the installation of several new pumping wells and/or re-fitting of existing monitoring wells; installation of associated pumps, plumbing and electrical connections; site preparations to allow the temporary installation of an ex-situ treatment system trailer, water storage tanks, and a waffle press to dewater iron solids; discharge of treated water to the existing stormwater infiltration ponds[10]; periodic removal of iron solids; performance monitoring; and operations and maintenance.

A small number of pumping wells in the central area of the 2-acre wetlands plume, and a temporary ex-situ treatment system that treats 15,000 gallons per day (equivalent to 10 gpm) would treat 5 million gallons (a volume equivalent to the amount of pore water in the approximately 3.2-acre area of the aquifer with concentrations exceeding 0.200 mg/L) in about one year. The mass of arsenic in this volume of water is approximately 53 lbs, over 90% of which is located in the 2-acre area with groundwater arsenic concentrations greater than 2 mg/L. Location of the pumping wells in this core area of the plume would optimize the removal of arsenic mass. Higher pumping rates may be applied to treat this volume of water during a single dry season. Lower rates of pumping, however, may more efficiently remove the most contaminated groundwater because lower rates would limit the mixing of the plume with clean water pulled in from outside the plume.

Several ex-situ treatment technologies that use iron precipitation to co-precipitate arsenic are available and relatively inexpensive to operate. For example, pumped water can be super-saturated with oxygen and/or treated with hydrogen peroxide to precipitate iron and remove arsenic. Additional polishing steps could be added to the process; one or more of these technologies may need to be applied to reach CULs prior to discharge of treated water.

Based on observed iron concentrations (up to 100 mg/L), the estimated volume of iron solid that would be produced from 5 million gallons is approximately two tons. This material could be collected on-site and transported to the appropriate disposal facility, as needed. Water would be pumped under pressure prior to treatment to prevent atmospheric oxygen from causing rapid iron fouling of plumbing.

The alternative may also be preceded by a pilot study to determine the effectiveness of the treatment technology and the likelihood of rebound of dissolved concentrations from the solid phase. There is a potential for arsenic that is currently adsorbed and co-precipitated onto mineral surfaces to desorb or dissolve into groundwater as the arsenic concentration in groundwater is decreased. While soil arsenic concentrations are generally not elevated, dissolution of even small amounts of arsenic from soil have been shown to produce elevated groundwater concentrations under certain geochemical conditions. The low soil arsenic concentrations, the reducing nature of the system, and the arsenic speciation of As(III), however, together suggest a low degree of partitioning into the solid phase and suggest that a limited ex-situ treatment regime would have success in permanently reducing the most elevated concentrations.

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[10] Discharge of treated water to POTW through the sanitary sewer along the Puget Power Road was considered and rejected because wastewater discharge is not allowed on a temporary basis by Pierce County. The estimated cost for a permanent connection and capacity to discharge up to 150,000 gallons per day was approximately $1,000,000 in 2006 dollars.

The pilot study may also be able to determine whether anisotropic aquifer conditions (including horizontal hydraulic conductivities that vary with direction) would prevent removal of dissolved arsenic from less transmissive parts of the aquifer. Generally, this is of most concern in the shallowest, most fine-grained portion of the Upper Sand Aquifer, where less-permeable, fine-grained materials may have contributed to increased absorption. The majority of the aquifer, however, is sandy and transmissive, and should allow a suitable capture zone to develop during pumping.

In addition to potential rebound of arsenic through desorption and dissolution from mineral surfaces, a second complicating factor is the seasonal limitation to pump and treat. Pumping during the flooded winter months may capture a large volume of ponded surface water that could overwhelm efforts to maintain hydraulic capture of the plume and result in costly increased treatment volumes of water with relatively low arsenic concentrations. Therefore, one or more dry seasons of operation will be necessary, depending on rainfall. The system would be run until the mass removed by the daily pumping is insignificantly small and/or arsenic concentrations become asymptotic.

The short-term pump-and-treat alternative would provide a high degree of overall protectiveness of human health and the environment. It would significantly decrease the mass of arsenic migrating downgradient toward potential receptors, thereby helping to limit further migration of the plume. In addition, it would decrease the concentrations in groundwater throughout the thickness of the Upper Sand Aquifer, including the shallowest groundwater that currently discharges to the surface above CULs. This alternative alone, however, is unlikely to completely achieve CULs because the residual mass of arsenic is unlikely to be fully removed by pumping and sufficient arsenic will remain attached to aquifer soils to result in rebound to concentrations above groundwater CULs.

Following one to two years of pumping, naturally-occurring attenuation processes in concert with source control at the Landfill are expected to decrease residual concentrations to levels protective of receptors. By removing a significant mass of arsenic, the short-term pump-and-treat alternative, barring significant rebound, would greatly reduce the restoration timeframe for post-pumping natural attenuation processes.

Because it would permanently remove and treat arsenic contamination, this alternative would result in high long-term effectiveness for preventing a significant volume of arsenic from further migration and for lowering concentrations at the surface exposure pathway. Ultimately, the long-term effectiveness will depend on the potential for rebound by dissolution of solid state arsenic, which is thought to be low because existing soils are not elevated in arsenic. This alternative has the potential to be highly permanent especially if combined with effective source control at the Landfill/Ditch CAA.

This alternative ranks high for significantly reducing the volume of arsenic in groundwater through treatment. While the pumping wells are not designed to maintain hydraulic control over the long term, the overall mobility of the plume would be decreased following pumping because of the decreased mass of arsenic left in the plume.

This alternative carries minor short-term worker safety risks during installation of system components, as well as low worker safety risks during treatment, iron sludge handling, and well installation and monitoring. Short-term pump-and-treat to remove the groundwater is readily implementable, with limited pilot studies needed only to fine-tune the treatment method.

Costs for this alternative are moderate to high compared with the costs for other alternatives under consideration. The costs were considered to be entirely of a capital nature, and the O&M for the duration of treatment is included in the capital cost.

6.2.5 Alternative 5—Wetlands Surface Treatment Cells

The wetlands surface treatment cells alternative would utilize one or more technologies designed to treat flowing surface water in engineered wetlands treatment cells. These technologies would be modified for the conditions of the Wetlands CAA, in which there is little or no surface water flow and discharging groundwater associated with a seasonally-fluctuating groundwater table is a potentially more significant arsenic transport mechanism. Such a system would generally be limited to treating the upper two feet of shallow groundwater and surface water. The design would require coordination with planned Hylebos Creek riparian restoration activities.

This alternative would consist of one or more treatment cells in the Wetlands CAA to be constructed using raised berms to contain surface water. The cells would be designed to remove arsenic from discharging groundwater and surface water through a treatment train—primarily using aeration and/or anaerobic bioreactor technologies. In addition, the treatment train may include one or more polishing cells that treat the remaining arsenic through adsorption/precipitation and phytoremediation. The system may also integrate a liner to prevent discharge of groundwater to the surface, and/or a stormwater infiltration system through which clean stormwater is introduced into a cell to oxygenate or otherwise attenuate the shallow part of the plume. Additional controls beyond berms may be needed to address flooding of the treatment system during extreme storm events.

Implementation of the surface treatment cells alternative would require pilot testing; roadbuilding; construction of berms; placement of reactive material, aerators, and/or other engineered components; replanting/restoration; and institutional controls. Operations and maintenance would include periodic excavation of contaminated media (reactive media, surface sediments, and plants) in addition to performance monitoring.

Three types of cells are commonly used in constructed wetland treatment systems: pond, free water surface (FWS), and sub-surface flow (SSF) cells:

- Pond wetland cells are shallow pools vegetated around the peripheries (10–30 percent coverage) and having major portions of their surfaces consisting of open water, in which floating or submergent vegetation is found.
- FWS wetland cells are marsh ecosystems with water free-flowing on the surface in a basin through emergent wetland vegetation. In them, the submerged portions of wetland plants, as well as soil and detritus, act as attachment surfaces for biofilms of micro-organisms. These micro-organisms and physical filtration are responsible for much of the pollutant removal.
    - In SSF constructed wetland cells, water flows just below the surface of a porous material (substrate). Pollutant removal occurs via the substrate (and

often in vegetation root systems growing in it). Wetland vegetation is normally present growing on predominantly dry surface soil. Generally, a SSF wetland cell consists of one or more beds of rock, gravel, aggregate, or sand. SSF wetland cells are usually smaller in area than FWS ones for the same levels of pollutant removal, and can tolerate higher loadings. Compared to the pond and FWS cells, SSF wetlands cells are more complex to design, engineer and build correctly so that proper hydraulic control is maintained and desired performance is achieved.

Characteristics of each type of cell are desirable for the surface treatment cells alternative. Combining the useful components of each (and in particular, maintaining redox conditions suitable for both aerobic and anaerobic treatment cells during both dry and flooding conditions) is likely to be a central engineering obstacle. SSF cells offer the potential to treat arsenic-contaminated groundwater before it discharges to the surface, and are likely to be most compatible with anaerobic bioreactors. Pond wetland and FWS cells provide aerobic environments with shallow water depths that will provide residence time and aeration for oxidation so that arsenic can be precipitated out and retained in situ.

Anaerobic bioreactors generally utilize the process of reductive precipitation of arsenic using sulfate-reducing bacteria (SRB) that facilitate the conversion of sulfate to sulfide. The sulfides generally react with metals to precipitate them as metal sulfides, many of which are stable in the anaerobic conditions of an anaerobic digester treatment system (Cohen 2006). This process is similar in nature to the technologies evaluated for In situ Sequestration of groundwater as part of other alternatives for the Wetlands and End-of-Plume CAAs. As an example, anaerobic solid-substrate reactors tested in a 23-month laboratory study of acid mine drainage treatment, resulted in arsenic removal rates of 84 percent to 89 percent. The substrates were composed of cow manure and sawdust, and amended with cheese whey (Drury et al 1999).

The addition of high intensity aeration technology to the treatment train can improve treatment efficiency and reduce chemical consumption. Such a treatment cell would rely upon oxidation of arsenic and iron and precipitation/adsorption with iron oxides. While this oxidative approach is generally incompatible with the reductive approach described above, it could potentially be applied in one or more cells that are separate from anaerobic bioreactor treatment.

A potential additional step to the treatment train could be the construction of one or more polishing cells designed to remove any remaining arsenic by precipitation/adsorption onto soil mineral surfaces and iron plaques that form on plant roots, and to a lesser extent, through phytoremediation. Both natural and constructed wetlands have been shown to act as natural filters for arsenic-contaminated water as a result of the high metal-binding affinity of some wetlands soils (Beining and Otte 1996; Ye et al. 2003; Donbeck et al. 1998). Typical wetlands plants apparently account for only a small percentage (2–5 percent in the studies cited above) of arsenic removal in wetland treatment systems, although arsenic hyperaccumulating plants (i.e., *Pteris vittata*, Chinese brake fern) remain an option if plant uptake is deemed more desirable than accumulation in wetlands cell sediments.

The wetlands treatment cells alternative would result in a moderate degree of overall protectiveness of human health and the environment for ponded surface water, but a low degree of protectiveness with regard to stopping further migration of arsenic in groundwater from the Wetlands CAA. It would not necessarily result in meeting CULs in all ponded wetlands surface water, since several treatment cells may be needed, and furthermore, would intentionally accumulate arsenic into reactive media, sediments, and potentially plant tissue. The treatment cells alternative is likely to rely on institutional controls to keep out potential human and some ecological receptors (e.g., use of netting to keep out birds). This would not eliminate potential ecological exposures, however. Constructed wetland treatment systems may attract wildlife to wetland treatment cells that would be exposed to contaminants accumulating in these ponds. It has been found that wetland treatment systems do not offer clean ecosystems for wildlife and the monitoring of contamination and its effects is necessary (Bishop et al. 2000).

The treatment cells alternative would not necessarily satisfy ARARs. Assuming effective treatment, this alternative would meet CULs at end of the treatment train. It would not meet CULs for groundwater below 2 feet bgs, where the remedy is not effective. In addition it would require construction in wetlands that may be difficult to permit.

While wetlands treatment cells may be an effective part of a long-term solution for the surface expression of arsenic in the wetlands, they are ranked low for overall long-term effectiveness because they would not address the continued migration of arsenic in groundwater. The effectiveness of using redox-based technologies at the wetlands surface remains uncertain. Fluctuating redox conditions associated with varying water levels are thought to cause alternating precipitation/adsorption and dissolution of arsenic under current conditions. The surface water system also may not withstand seasonal flooding. Berms would need to be greater than 3 feet tall to prevent the accumulated arsenic in impacted sediments from potentially spreading contamination throughout the wetlands. In addition, the need for continued excavation as part of O&M suggests that this remedy is not highly permanent.

This alternative would result in a moderate reduction in the volume and mobility of arsenic in surface water, but cause little or no reduction in the volume or mobility of arsenic in groundwater.

There are minor short-term effectiveness considerations related to standard worker safety risks during construction, repeated excavations, and monitoring activities. It will also result in significant short-term to medium-term damage to the existing wetlands.

Significant obstacles to implementation include obtaining landowner permission, and pilot demonstrations validating that one or more of these technologies can be successfully modified to treat groundwater in vertical flux rather than as surface water flow, and can overcome fluctuating water levels and redox conditions.

While capital costs are low relative to other Wetlands CAA alternatives, O&M costs are significantly higher. Costs would include capital expenditures to install the treatment cells (including purchase and placement of aerators and/or reactive digester substrate), excavation and disposal of a limited volume of wetlands soils, construction of access roads, and bird netting. Long-term costs would include O&M of the treatment cells, including annual dredging of the ponds, disposal of contaminated materials, and replacement of reactive substrate.

6.2.6 Alternative 6—Soil Cover

As described in the introduction to section 6.2, the soil cover alternative for the Wetlands CAA is one of two alternatives under consideration that are retained primarily in case the land use of the wetlands changes. Should the owner of the wetlands property decide to redevelop the wetlands into residential or commercial properties, with appropriate mitigation for the wetlands loss, then alternatives that do not preserve the function of the wetlands become feasible.

This remedy would consist of placement of a soil cover over the portion of the Wetlands CAA where discharge to surface water results in a complete exposure pathway or exceedance of CULs. The soil cover would be permeable imported fill material that allows infiltration. It would be placed to an elevation designed to prevent discharge to surface water—even in extreme flooding events. The soil cover would be placed in a manner that is consistent with planned construction activities in the wetlands area. The filling of wetlands would be mitigated as appropriate.

The soil cover alternative would provide a moderate degree of overall protectiveness of human health and the environment by blocking the key exposure pathway at the surface. It would only provide a low degree of overall protectiveness with regard to the other RAO for the Wetlands CAA—the continued migration of arsenic-contaminated groundwater. The soil cover alternative would be highly compliant with CULs for groundwater discharging to the land surface, because it would block this pathway. It would not be compliant with groundwater CULs *within* the aquifer, because the remedy would not decrease arsenic concentrations in groundwater. Filling of wetlands would require permitting and mitigation and may not be acceptable due to either habitat or flood plain considerations.

The soil cover would be highly permanent because it would permanently block the surface water and shallow groundwater pathway in the Wetlands CAA. However, it may not be an effective long-term solution because it does not address the continued migration of arsenic in groundwater. Only naturally-occurring processes would act to attenuate continued migration of arsenic in groundwater.

The soil cover alternative would not reduce the volume, mobility, or toxicity of arsenic in groundwater through treatment. This alternative would result in a significant reduction in the mobility of arsenic with respect to the discharge of groundwater arsenic to surface water.

There are minor short-term effectiveness considerations related to standard worker safety risks during soil cover placement. It would also result in short-term damage to the existing wetlands.

There are significant implementability obstacles for placement of a soil cover in the Wetlands CAA, in addition to the physical obstacles related to working conditions in the wetlands. This remedy would require regulatory approval for filling a wetlands area, which may be difficult to obtain.

The costs of the soil cover remedy are moderate to high compared to other alternatives under consideration for the Wetlands CAA. A major component of the cost is wetlands mitigation.

6.2.7 Alternative 7—Containment and Capping

The containment and capping alternative for the Wetlands CAA, like the soil cover alternative, is one of two alternatives under consideration—should the owner of the wetlands decide to redevelop the wetlands.

This alternative would involve construction of a subsurface slurry wall or sheetpile barrier around the wetlands plume, placement of an impermeable liner atop the plume and tied into the barrier and filling a portion of the wetlands to cap the contained area. This alternative would prevent both infiltration of surface water into the contained area and discharge of contaminated groundwater to wetlands surface water. The alternative would also include construction of stormwater controls and installation of monitoring wells suitable for performance monitoring. The cap would be placed in a manner consistent with construction activities planned for the development of the wetlands area. The filling of wetlands would be mitigated as appropriate and maintenance would be required of plantings in the mitigation area.

Depending on the selected alternative for the End-of-Plume area, this alternative could be extended from encircling the Wetlands CAA to contain the entire arsenic plume. The containment/capping alternative in the Wetlands CAA is highly dependent on future land use considerations, including the acceptability of filling the wetlands and the uncertain potential for development in this location.

The use of a containment barrier and cap would provide a high degree of protectiveness of human health and the environment by blocking the surface water exposure pathway and ensuring no further migration of arsenic beyond the limits of the barrier.

The barrier and cap would not necessarily meet ARARs for wetlands because several acres would ultimately be filled under this alternative.

This alternative would be highly effective over the long term, due to its permanent nature. In particular, it would be highly effective in reducing the mobility of arsenic both from reaching surface water and from migrating beyond the limits of the barrier. Slurry walls and caps are known remedies with long lives. The toxicity and volume of arsenic in groundwater would remain unchanged within the contained area.

There are minor short-term effectiveness considerations related to standard worker safety risks during barrier construction, cap placement, well installation, and monitoring activities. It would also result in short-term damage to the existing wetlands.

There are significant implementability obstacles for construction of a barrier wall and cap in the Wetlands CAA—in addition to the physical obstacles related to working conditions in the wetlands. This remedy would require regulatory approval of excavation work and filling of a wetlands area. It would require permitting and mitigation and may not be acceptable due to either habitat or flood plain considerations. It would effectively result in the destruction of the wetlands, which may result in this alternative being administratively infeasible unless combined with a commercial development and wetlands mitigation elsewhere in the basin. Landowner approval would be necessary and would only be possible if planned future land use was compatible with the cap.

The costs of the containment and cap remedy are high relative to other Wetlands CAA alternatives. The primary costs are capital expenditures associated with construction of the barrier and placement of the cap and wetlands mitigation. Ongoing costs would primarily be limited to monitoring.

6.2.8 Comparative Analysis of Wetlands Cleanup Action Area Alternatives

Containment and Capping would provide the highest degree of overall protectiveness of human health and the environment because it would block the pathway to surface water and address the continued migration of arsenic in groundwater. However, it would completely change the use of the wetlands, and require wetlands mitigation elsewhere. Because the capping would require a change in future land use and expensive redevelopment of the parcel, landowner approval and/or developer backing may be difficult to obtain.

Short-term pump-and-treat would be highly protective by addressing both the surface water pathway and further groundwater migration, but would not necessarily completely solve either problem because the alternative is unlikely to decrease concentrations to background levels throughout the wetlands. In situ Sequestration would be moderately to highly protective by stopping the migration of arsenic in deeper groundwater, but has a low potential for success in removing arsenic from shallow groundwater. A soil cap would block the surface water pathway, but not address migration of contaminated groundwater. Surface treatment cells would be moderately protective in addressing surface contamination, but would not address migration of contaminated groundwater. The MNA and No Further Action alternatives have a moderate degree of protectiveness due to natural attenuation processes that are already occurring, but are also not expected to decrease concentrations to background levels over time, and have very long restoration time frames.

None of the Wetlands CAA alternatives are likely to result in compliance with groundwater CULs within the Wetlands CAA in a short timeframe. Short-term pump-and-treat would quickly reduce arsenic concentrations in groundwater and surface water, but may not reach CULs within the Wetlands CAA. In situ Sequestration would reach groundwater CULs below approximately 8 feet bgs, but may not meet CULs in shallow groundwater and so leaves the potential for noncompliance in the ponded surface water. Surface water treatment cells would reduce arsenic concentrations to CULs in shallow groundwater and seasonally discharging groundwater (at the end of the treatment train, if applicable), but would not have much impact deeper in the aquifer. No Further Action and MNA would reduce arsenic concentrations in groundwater and surface water very slowly.

In addition, surface water treatment cells, In situ Sequestration, soil cover, and containment and capping may each be difficult to permit and otherwise comply with wetlands ARARs. The degree of disruption varies from installing access roads for In situ Sequestration to filling in the wetlands area.

Containment and Capping would provide the highest degree of long-term effectiveness and permanence; the soil cover alternative would be similarly permanent but would not address the continued migration of arsenic in groundwater. In situ Sequestration and short-term pump-and-treat rank lower for long-term effectiveness because they are likely to leave some contaminated groundwater. In situ Sequestration would leave elevated concentrations in shallow groundwater, while short-term pump-and-treat may leave elevated concentrations throughout the aquifer in the interim timeframe before source control and natural attenuation can eliminate the elevated concentrations. Surface water treatment cells rank lower for relative permanence because of the need for continued excavation of treatment pond solids, and lower for long-term effectiveness because this remedy would not address continued migration of contaminated groundwater. Neither No Further Action nor MNA would be effective or permanent over the long-term due to the reversibility of the redox-sensitive attenuation processes.

Containment and Capping, though it involves no treatment, would result in the greatest reduction in arsenic mobility by stopping both discharge to surface water and continued migration of arsenic in groundwater. Short-term pump-and-treat would likely result in the greatest reduction in arsenic volume through removal and treatment. In situ Sequestration would result in similarly large reductions in arsenic mobility, volume, and toxicity through treatment, but would leave a significant volume of arsenic in shallow groundwater and in shallow aquifer solids that could later be remobilized. Surface water treatment cells would remove a limited mass of arsenic from shallow groundwater and surface water through treatment, though the mobility of the plume beneath the surface treatment cells would not be decreased. MNA and No Further Action would reduce mobility, toxicity, and volume of arsenic through natural attenuation processes only.

The longer restoration timeframes associated with No Further Action and MNA cause both of these alternatives to be ineffective in the short-term. None of the other alternatives under consideration provide substantial reasons to prefer one or the other based on short-term effectiveness concerns. All of these alternatives involve the normal worker safety concerns associated with implementing cleanup alternatives, which generally increase with the complexity of the work. The soil cover, containment and capping, In situ Sequestration, and surface water treatment cell alternatives would each involve short-term damage to the existing wetlands. The soil cover and containment/capping alternatives would cause the most destruction of the wetlands, though this consideration must be assessed in the context of a hypothetical development project in the wetlands. In situ Sequestration and surface water treatment cells would cause considerably less damage than these alternatives. Surface water treatment cells, however, may be part of a wetlands restoration effort that ultimately improves the quality of the wetlands. Short-term pump-and-treat would not result in significant damage to the wetlands.

Surface water treatment cells, In situ Sequestration, soil cover, and containment and capping each have potential problems with implementability associated with wetlands disruptions. Soil cover and containment/capping implementability are assessed in the context of a hypothetical development project in the wetlands. In situ Sequestration may not require substantial or permanent road building, and therefore may be readily implementable without need for filling of wetlands. Short-term pump-and-treat is readily implementable with no anticipated disruption of the wetlands. Following the initial disruption from construction activities and depending on the ultimate design, surface water treatment cells may ultimately improve the quality of the wetlands. However, surface water treatment cells have not yet been shown to be implementable in the context of wetlands site conditions (i.e., discharging groundwater from below and fluctuating water levels and redox boundary). No Further Action and MNA are readily implementable.

Regarding costs, Wetland Treatment Cells and In situ Sequestration are the most expensive alternatives in the Wetlands CAA. Surface treatment cells are among the lowest cost alternatives for capital expenditures, but are by far the most expensive with respect to O&M costs which would continue for 50 years. Containment and Capping is also a high-cost alternative relative to the other alternatives, particularly with regard to capital costs. Short-term Pump-and-Treat, Soil Cover and MNA are moderate cost alternatives. Most of the MNA cost is for long term monitoring for 50 years. Containment and Capping, soil cover, and short-term pump-and-treat costs are primarily capital costs, while In situ Sequestration involves higher operations and maintenance over the first decade following implementation. The pump-and-treat cost includes a significant contingency to allow for a second season of treatment but no O&M costs.

Comparative Costs for Wetlands CAA Alternatives

Alternative	**Capital Cost With Contingency[1]**	**Yearly O&M Cost[2]**	**O&M (Net Present Value[3])**	**Total Cost[4]**
MNA	$60,000	$17,000 (50 years)	$534,000	$594,000
Wetlands Treatment Cells	$387,000	$65,000 to $80,000 (50 years)	$2.0 to $2.5 million	$2.4 to $2.9 million
In situ Sequestration	$1.9 million	$40,000 (yrs 1-5) $10,000 (yrs 6-10)	$330,000	$2.2 million
Short-term Pump-and-treat Removal	$926,000	--	--	$926,000
Soil Cover	$800,000	--$20,000 (years 1-5) _	$100,000	$900,000
Containment and Capping	$1.5 million	$25,000 (5 years)	-$118,000-	$1.6 million

Notes:

1 Capital cost includes contingency; see Appendix C for details.
2 Annual monitoring and maintenance and annualized repairs.
3 Net present value assumes uses a 2% effective discount that assumes a risk free rate of approximately 5%, net of inflation of approximately 2%.
4 The sum of capital cost (including contingency) and NPV of the O&M costs.

6.3 END-OF-PLUME AREA ALTERNATIVES

The RAOs for the End-of-Plume CAA will be met by preventing arsenic-contaminated groundwater from migrating beyond the End-of-Plume area at 12th St. E. This location was selected for the following reasons:

- The un-used 12th St. E. right-of-way allows for easy access for equipment and limits disruptions to the wetlands.
- The wetlands between the Landfill and the 12th St. E. are owned by a single party with whom an Access Agreement already exists.
- MW-17 (the original compliance well nearest 12th St. E.) is in compliance with the groundwater CUL. However, the well screen does not reach to the bottom of the

aquifer, and a thin seam of contaminated groundwater is passing below the bottom of the screen.

The End-of-Plume alternatives have been designed to address this thin seam of contamination at the base of the aquifer.

Preliminary alternatives that include ex-situ treatment of groundwater were rejected due to the impracticality of maintaining hydraulic control over the fluctuating wetlands water levels and the anticipated fouling of the treatment system from elevated iron concentrations in groundwater. The remaining remedial alternatives retained for further consideration include the following alternatives intended for continued undeveloped wetlands land use:

- Alternative 1—No Further Action
- Alternative 2—Monitored Natural Attenuation
- Alternative 3—Enhanced Monitored Natural Attenuation
- Alternative 4—In situ Sequestration

In addition, one alternative is retained for possible future wetlands land use involving significant commercial or other development:

- Alternative 5—Containment and Capping

Containment and Capping is an extension of the same alternative for the Wetlands CAA, and would only be implemented if the Wetlands CAA is contained and capped.

A conceptual figure showing each of these proposed remedial alternatives is shown in Figure 6.3. These alternatives are described and considered individually with respect to evaluation criteria in the following sections. This is followed by a comparative analysis of the relative strengths and weaknesses of each alternative. Table 6.3 presents a summary of this comparative analysis.

6.3.1 Alternative 1—No Further Action.

This alternative would be to take No Further Action at the End-of-Plume area. The Landfill source control remedy would still be implemented. When combined with Landfill source control, No Further Action would provide a moderate overall degree of protection of human health and the environment because natural attenuation processes, combined with upgradient source control, would likely result in control of arsenic concentrations in groundwater over a long restoration timeframe. However, the remedy would not address arsenic contamination that has already left the Landfill and is currently contained in the aquifer beneath the wetlands; this contamination would still migrate slowly towards Hylebos Creek. Natural attenuation would continue to decrease the arsenic concentrations in the plume, and concentrations at Hylebos Creek may never exceed CULs.

In the short-term, the average concentration of arsenic in the End-of-Plume area along 12th St. E. already meets the CUL and ARARs. However, arsenic concentrations in the thin seam at the base of the aquifer are up to 10 times the CUL. There are not any current human or ecological receptors with access to this groundwater (at the base of the aquifer) between the

Landfill and Hylebos Creek, so the remedy would be protective of human health and the environment between the End-of-Plume area and Hylebos Creek.

WSDOT has plans to relocate Hylebos Creek closer to 12th St. E., as part of the construction of SR-167. Depending on the timing of this action, arsenic contamination that is currently in the aquifer beneath the wetlands may have migrated at the base of the aquifer beyond 12th St. E. to the location of the relocated creek. This could result in exceedances of the CUL (designed to be protective of surface water uses) at the relocated Hylebos Creek for a number of years, until the effect of the Landfill source control remedy allows the arsenic concentrations in the system to return to background. Since the specific location of the creek and the timing of its relocation are still unknown, the potential for this short-term impact at the creek is hypothetical.

This alternative does not entail any implementability considerations or additional costs.

6.3.2 Alternative 2—Monitored Natural Attenuation

This alternative would involve complete delineation of the downgradient extent of the arsenic plume, installation of monitoring wells in the downgradient reaches of the plume and beyond the limits of the plume, and ongoing monitoring of the groundwater quality (including relevant physical and chemical parameters and constituents), and hydrology in the End-of-Plume CAA. This alternative would be designed to accompany alternatives in one or both of the other CAAs that control the source of arsenic.

When combined with landfill source control, MNA would provide the same level of protection and compliance with cleanup standards and ARARs as the No Further Action alternative discussed above. However, MNA would provide early warning of any further migration of the plume front, and allow continued evaluation of the attenuation processes within the plume. It would also provide critical data on how the plume would likely interact with the WSDOT creek relocation plans, and could be used to guide and influence that design.

Costs are relatively low beyond the costs of ongoing monitoring. Costs would include modest capital expenditure to complete plume delineation, installation of a monitoring well network, and ongoing monitoring costs (until the Landfill source control allows the system to return to background conditions).

6.3.3 Alternative 3—Enhanced Monitored Natural Attenuation (EMNA)

This alternative includes all of the components of MNA, combined with limited use of one or more in situ groundwater treatment options as a targeted, short-term supplement to the naturally-occurring attenuation processes in groundwater. A small-scale pilot study would be implemented to evaluate the most effective technology to accompany natural attenuation processes. The presumed technology would be reductive precipitation, and the presumed delivery system would be a transect of injection well points or repeated injections with removable direct-push equipment along 12th St. E. Equipment access would be provided along the roadway. Multiple iterations of treatment and performance monitoring would be conducted over a period of several years. For example, the alternative could consist of three years of quarterly treatments, followed by three years of performance monitoring with a contingency for additional treatments.

Treatment products that would be evaluated in the pilot study are based on the removal mechanism of reductive precipitation. These reagents generally sequester arsenic by lowering the redox potential of the groundwater through corrosion of zerovalent iron and/or by introducing organic compounds; arsenic is trapped in the crystal lattice of iron sulfide minerals such as arsenopyrite. The approach is compatible with the addition of sulfide into the system to allow the precipitation of iron sulfide minerals. Examples include:

- Adventus: EHC-M (integrated carbon and zerovalent iron)
- Green World Science Process (soluble organics, controlled iron and sulfide)
- ReSolution Partners (sulfate salts, polysulfides, or in situ polysulfide generation)
- University of Waterloo/Environmental Technologies: BOF slag (non-metallic waste by-product of steel production containing various oxides and silicates of iron, calcium, magnesium, and aluminum; reductive precipitation is the predominant removal mechanism)

EMNA, when combined with landfill source control, would result in a high degree of overall protection of human health and the environment. Landfill source control would eliminate future releases of arsenic from the Landfill, while the EMNA would reduce arsenic concentrations at 12th St. E. by reductive precipitation of the arsenic at the base of the aquifer. This alternative would work whether or not additional source control was performed in the Wetlands CAA. The advantage of additional source control in the Wetlands CAA (especially removal of dissolved phase arsenic) would be that EMNA at the End-of-Plume would be needed for a much shorter period of time.

As with MNA, EMNA would provide early warning of any further migration of the plume front, and would provide data to allow continued evaluation of attenuation.

EMNA would be highly compliant with ARARs. When combined with upgradient source control, this alternative is expected to bring the residual contamination at the base of the aquifer into compliance.

EMNA would be a permanent solution that is effective in preventing exposures over the long term, if this alternative were to be selected in combination with source controls. If source control is not implemented, EMNA is unlikely to be a permanent solution. Available research indicates that reductive precipitation is generally a non-reversible immobilization, and that iron sulfide minerals, once precipitated, remain stable even if the redox potential rises above the range at which these minerals form. Groundwater beneath the wetlands (at the depths that would be treated; approximately 12 to 22 feet bgs) is naturally a mildly reducing environment that is highly compatible with the process of reductive precipitation, and these redox conditions are expected to remain stable. Based on these factors, periodic injections and monitoring over a period of several years can reasonably be expected to sequester the mass of arsenic currently transported by groundwater in the End-of-Plume CAA, provided additional arsenic is not continuously introduced into the system.

The use of limited in situ treatments is expected to result in significant reductions in the mobility and the volume of arsenic in groundwater by sequestering arsenic into aquifer minerals. The toxicity of arsenic would also be significantly decreased, because it would be bound in a mineral crystal lattice instead of moving as a dissolved ion or in association with colloids. The scale of these reductions would depend on the success of the limited treatments and the implementation of upgradient source control.

This alternative would be highly effective in the short term, and its restoration time frame should be acceptable for adjacent restoration projects. There are negligible short-term effectiveness considerations related to standard worker safety risks during plume delineation, well installation, and treatment and monitoring activities. It is moderately to highly implementable, with only minor physical obstacles related to working conditions in the wetlands.

Costs are low to moderate. Costs would include capital expenditures to complete plume delineation and install a monitoring well network, install semi-permanent injection well points, and repeated purchase/transport/injection of treatment reagent. Long-term operations and maintenance costs would generally be limited to ongoing monitoring costs. The cost of this alternative would increase significantly if performance monitoring indicated a need to upgrade to a more robust in situ treatment system, such as that described in Alternative 4.

6.3.4 Alternative 4—In situ Sequestration

This alternative is a larger-scale application of the in situ technologies described as part of the EMNA alternative. The primary differences in approach in this alternative from EMNA are that the In situ Sequestration technologies would be more carefully evaluated, applied at a greater scale and for sufficient time to ensure compliance with groundwater CULs at 12th St. E. Rather than simply supplementing the natural attenuation processes, this approach would involve engineering a permanent solution.

The In situ Sequestration alternative would involve complete delineation of the downgradient extent of the arsenic plume; a pilot study to determine the most cost-effective reactive media solution and delivery system for permanently sequestering arsenic at the base of the aquifer; construction of a permanent plumbing to inject the solution;, building of access roads in the wetlands suitable for repeated treatments; installation of monitoring wells in the downgradient reaches of the plume and beyond the limits of the plume including monitoring wells suitable for performance monitoring; delivery of the reactive media solution to the targeted treatment zone, ongoing performance monitoring of groundwater quality (including relevant physical and chemical parameters and constituents) and hydrology; continued treatment as needed based on performance monitoring; and operations and maintenance.

Treatment products based on the removal mechanism of reductive precipitation and described in the previous section would be evaluated in the pilot study for the in situ alternative. The delivery system layout is expected to include two transects, including one at the 12th St. E. proposed point of compliance and one further south to begin treating groundwater before it reaches this property boundary. Delivery system components that may be evaluated in the pilot study include:

- Removable vehicle-mounted direct-push injections
- Permanent injection wells
- Infiltration or recirculation trenches
- PRBs

- Funnel and gate PRBs with slurry wall barriers

This alternative offers a high degree of protectiveness for human health and the environment. When combined with upgradient source control, this alternative would treat the elevated arsenic concentrations at the base of the aquifer. If needed to ensure success, the system could be expanded southward into the wetlands with additional transects, for example. This expansion could be coordinated with a decision to implement full-scale In situ Sequestration in the Wetlands CAA, as described in Section 6.2. It would be highly compliant with ARARs and if combined with source control would eliminate all potential exposure pathways from the End-of-Plume area by lowering arsenic concentrations in groundwater to below CULs at the 12th St. E.

In situ Sequestration is expected to be effective over the long term and could be an important component of a permanent solution. If source control were to be implemented upgradient of the End-of-Plume CAA, this alternative would have a high potential for permanence without continued treatment over the long term. Sufficient iron, sulfide, and lowered redox potential could be controlled to remove the entire mass of arsenic expected to reach the End-of-Plume CAA. Once properly immobilized within sulfide minerals, the risk of large-scale remobilization would be low provided there are no local geochemical changes resulting from land-use changes in the drainage basin.

The use of In situ Sequestration is expected to result in large-scale reductions in the mobility and the volume of arsenic in groundwater by sequestering arsenic into aquifer minerals. The toxicity of arsenic would also be significantly reduced, because it would be bound in mineral crystal lattices. The scale of these reductions would be determined by the implementation of upgradient source control; greater treatment would be applied to sequester a greater mass of arsenic inputs.

This alternative would be highly effective in the short term, and its restoration time frame should be acceptable for adjacent restoration projects. There are minor short-term effectiveness considerations related to standard worker safety risks during plume delineation, well installation, treatment and monitoring activities. It may also result in some short-term damage to the existing wetlands. It is moderately implementable, with physical obstacles related to working conditions in the wetlands.

Costs are moderate to high relative to other End-of-Plume alternatives. Costs would include capital expenditures to complete plume delineation and install a monitoring well network, install a permanent delivery system likely to consist of two or more transects and potentially some permanent above-ground components in addition to access roads, and treatment reagent and labor. Long-term costs would include O&M of the treatment system in addition to ongoing monitoring costs. If a PRB delivery system is selected, O&M costs may be reduced unless the PRB requires periodic replacement. Contingency costs would be used for additional engineering of modifications to the in situ system if needed.

6.3.5 Alternative 5—Containment and Capping

The containment and capping alternative for the End-of-Plume CAA is only considered in conjunction with re-development of the wetlands into residential or commercial property by the owner. Wetlands mitigation would be included as part of the re-development. This alternative would be designed to accompany the selection of a containment and capping alternative in the Wetlands CAA. Under this alternative in the End-of-Plume CAA, the containment barrier would be extended from encircling the Wetlands CAA to contain the arsenic plume at least as far as 12th St. E.

This alternative would involve complete delineation of the downgradient extent of the arsenic plume, construction of a subsurface barrier around the downgradient edge of the plume or at the proposed 12th St. E. parcel boundary if applicable; installation of monitoring wells suitable for performance monitoring; placement of an impermeable liner and introduction of sufficient fill material into the End-of-Plume CAA to cap the contained area and ensure the effectiveness of the subsurface barrier wall. This would be designed to prevent both infiltration of surface water into the contained area and discharge of contaminated groundwater to wetlands surface water.

The use of a containment barrier and cap would provide a high degree of protectiveness of human health and the environment by ensuring no further migration of arsenic beyond the limits of the barrier.

The barrier would not immediately meet groundwater CULs at the proposed 12th St. E. point of compliance. If located at the downgradient edge of the plume, the barrier would contain an area of contaminated groundwater beyond the point of compliance. If located at 12th St. E., the barrier would leave a relatively small area of groundwater with elevated arsenic concentrations. This residual arsenic contamination would be expected to attenuate well before any risk of exposure through any of the identified exposure pathways. The barrier and cap would be difficult to permit because several acres of wetlands would ultimately be filled under this alternative.

This alternative would be highly effective over the long term due to its permanent nature. As discussed in previous sections, slurry walls and caps have long lives. In particular, it would be highly effective in reducing the mobility of arsenic, though not through treatment. Toxicity and volume in groundwater would remain unchanged within the contained area.

Containment and Capping would be highly effective in the short term and the restoration timeframe would be acceptable for adjacent restoration projects. This alternative carries minor short-term effectiveness considerations related to standard worker safety risks during barrier construction, cap placement, plume delineation, well installation and monitoring activities. It would also result in significant damage to the existing wetlands.

There are significant implementability obstacles for construction of a barrier wall and cap in the End-of-Plume CAA in addition to the physical obstacles related to working conditions in the wetlands. This remedy would not only require the selection of the containment and capping alternative in the Wetlands CAA, but would also require regulatory approval of excavation work and permitting for filling of wetlands.

The costs of the containment and cap remedy are high relative to other End-of-Plume alternatives. The primary costs are capital expenditures associated with construction of the barrier and placement of the cap. Ongoing costs would primarily be limited to monitoring.

6.3.6 Comparative Analysis of End-of-Plume Alternatives

Groundwater at the proposed CPOC currently exceeds the cleanup level for arsenic, and the properties beyond the proposed CPOC are undergoing a number of restoration projects that include moving Hylebos Creek closer to the proposed CPOC. It is critical that remedies for the End-of-Plume area be protective of human health and the environment, meet cleanup levels at the proposed CPOC at 12th St. E., and are compatible with the changing land uses within the basin, including planned restoration projects.

Because of the natural attenuation that is already occurring within the system, all of the alternatives are protective of current receptors, but may not be protective of future receptors if planned changes are made in the basin beyond 12th St. E. In the future, in-situ sequestration and containment/capping provide the highest degree of protectiveness of human health and the environment. The same high degree of protectiveness is also possible under EMNA, especially if it occurs in conjunction with the removal of the bulk of dissolved arsenic from the Wetlands CAA. No action provides the lowest degree of protectiveness, while MNA provides a slightly higher degree of protectiveness than no action because monitoring would provide a warning prior to any potential exposure due to unexpected plume migration. This comparison is summarized in Table 6.3.

The following alternatives would comply with CULs: containment/capping, In situ Sequestration, and EMNA. The first would contain the arsenic, thereby preventing migration, while the other two would treat the arsenic in situ to obtain CULs. The long term effectiveness of the EMNA is greatly enhanced by a successful implementation of Short Term Pump and Treat to remove dissolved arsenic in the Wetlands CAA. No-action and MNA alternatives may not meet CULs through the thickness of the aquifer in the End-of-Plume area in a reasonable timeframe.

Compliance with ARARs would require the containment/capping remedy to mitigate for wetlands loss and would require additional permitting.

Containment and Capping ranks slightly higher than In situ Sequestration and EMNA for long-term effectiveness and permanence because of the permanent nature of a physical barrier vs. the uncertainties of the permanence of in situ modifications to a natural geochemical system. The long-term effectiveness and permanence of EMNA is enhanced by removal of the bulk of the dissolved arsenic in the Wetlands CAA and is based on an assumption that the wetlands remains undeveloped (a situation that is completely compatible with future plans for the watershed). MNA and No Further Action are ranked lower for long-term effectiveness and permanence because without the addition of specific additives the arsenic may precipitate or adsorb only later to re-dissolve under natural conditions.

In situ Sequestration, EMNA, and Containment and Capping would each almost entirely eliminate arsenic mobility. In situ Sequestration and EMNA would also reduce the volume of arsenic in groundwater and the toxicity of arsenic by transferring it to an encapsulated solid phase, rather than just containing it. EMNA would potentially reduce the mobility, volume in groundwater, and toxicity of arsenic to a lesser degree than In situ Sequestration. Both No Further Action and MNA would rely on the natural processes that reduce arsenic mobility and volume in groundwater.

EMNA, In situ Sequestration, and Containment and Capping are each considered highly effective in the short term, and these alternatives are likely to meet CULs in a timeframe that places no constraint on the relocation of Hylebos Creek. The No Further Action and MNA alternatives are expected to meet groundwater CULs over a significantly longer timeframe. All of the alternatives involve the normal worker safety concerns associated with implementing cleanup alternatives, which generally increase with the complexity of the work. Containment and Capping would result in significantly greater damage to existing wetlands than In situ Sequestration, which would require some limited road-building and potentially trenching.

With the exception of Containment and Capping, none of the alternatives under consideration provide substantial reasons to prefer one or the other based on implementability. All would require landowner permission but as previously described, Containment and Capping has significant obstacles to implementation because it requires a significant change in wetlands land use, permitting for excavation and filling of wetlands, and the selection of the Containment and Capping alternative in the Wetlands CAA.

As expected, costs increase from the baseline MNA cost. The costs of In situ Sequestration, the most expensive alternative, include both significant capital costs and O&M costs for treatment and performance monitoring during the first decade after implementation. Containment and Capping, is primarily a capital cost that would only occur if the wetlands were developed. The costs for EMNA is relatively inexpensive compared to the other two active alternatives and has moderately low O&M costs for the 10 years of implementation.

Comparative Costs for End-of-Plume CAA Alternatives

Alternative	Capital Cost with Contingency[1]	Yearly O&M Cost[2]	O&M (Net Present Value[3])	Total Cost[4]
MNA	$60,000	$12,000 (50 years-	$377,000	$437,000
EMNA	$605,000	$18,000 (10 years)	$162,000	$767,000
In situ Sequestration	$927,000	$42,000 (years 1 to 5); $22,000 (years 6-10)	$357,000	$1.3 million
Containment and Capping	$892,000	$15,000 (5 years)	$71,000	$963,000

Notes:

1 Capital cost includes contingency; see Appendix C for details.
2 Annual monitoring and maintenance and annualized repairs.
3 Net present value assumes uses a 2 % effective discount that assumes a risk free rate of approximately 5%, net of inflation of approximately 2%.
4 The sum of capital cost (including contingency) and NPV of the O&M costs.

6.4 COMPATIBILITY OF ALTERNATIVES

Beyond the individual and comparative analysis of alternatives for each CAA, an additional matrix is needed to evaluate how alternatives for each CAA would work in combination with each other. In Table 6.4, the alternatives are assembled into various combinations that are considered with respect to overall compliance with RAOs. By integrating and comparing the net effects of potential comprehensive remedies, a logical framework is provided for the selection of a preferred comprehensive groundwater remedy in Section 7.0.

7.0 Preferred Remedy

7.1 DESCRIPTION OF THE PREFERRED REMEDY

The preferred remedy for groundwater is comprised of individual remedies for each of the three groundwater CAAs that, along with continued O&M for the Landfill cap, will form a comprehensive site remedy for the B&L Landfill.

The first component of that remedy is actually part of the existing 1993 Remedy:

- Operations and maintenance of the existing 1993 Remedy, including inspection and repairs of the cap, fence, storm water controls, and passive gas system

- Compliance monitoring for the MTCA remedy and for landfill closure.

Included in the current remedy description and cost estimates are revisions of the existing Compliance Monitoring Plan to incorporate additional monitoring wells. This revised plan, which will be an Operations, Maintenance, and Monitoring Plan for the site, will be written as part of the proposed remedy described below. The costs to review the plan and perform its functions annually for the next 50 years are shown in Table 7.1.

7.1.1 The Landfill/Ditch Cleanup Action Area

For the Landfill/Ditch CAA, the remedy will consist of installation of a slurry wall around the entire perimeter of the Landfill that will be tied into the existing Landfill cap above and the Lower Silt Aquitard below. The Landfill cap, slurry wall, and silt aquitard will work together to form a robust containment system for leachate and contaminated groundwater beneath the Landfill. An interceptor drain may be installed as part of this remedy to redirect water coming off the bluff from the upgradient edge of the slurry wall. The goal will be to lower the potentiometric head by several feet to prevent buildup of groundwater pressure. As part of the design of the trench, water quality will be addressed around the MW-23 area.

Following installation of the slurry wall, the sediments at the base of the agricultural ditches will be excavated. Eventually, the ditches will be buried and/or rerouted when the agricultural fields are redeveloped by the owner (currently the City of Fife). The removal of contaminated sediments will be performed as part of the B&L Landfill remedy; the eventual modification/removal of agricultural ditches will be performed by the developer as part of the redevelopment of the surrounding lands and is not part of the proposed landfill remedy.

With the addition of the slurry wall to the existing 1993 landfill remedy, the Landfill/Ditch CAA will meet the following RAOs identified in Section 4.3:

- Meet MTCA threshold requirements, and WAC 173-340-740(6)(f) requirements for containment remedies and implement the closure requirements under Minimum Functional Standards for Solid Waste Landfills (WAC 173-304).

- Prevent arsenic-contaminated groundwater from migrating beyond the Landfill perimeter into adjacent wetlands and agricultural drainage ditches.

- Meet MTCA minimum requirements, including the use of a permanent solution to the maximum extent practicable.
- Protect the sediment and surface water quality of Hylebos Creek and associated restoration projects from arsenic releases from B&L Landfill.

7.1.2 The Wetlands Cleanup Action Area

Once the slurry wall containment has been implemented surrounding the Landfill, no further releases from the Landfill will enter the Wetlands CAA. However, the Wetlands CAA already contains groundwater that has concentrations up to 1,000 times the background concentrations. This residual mass of groundwater contamination will need to be remediated in order to bring the site into compliance with MTCA and landfill closure requirements.

The preferred remedy for the Wetlands CAA relies on the following observations and assumptions:

- Future releases from the Landfill will be eliminated by the slurry wall remedy for the Landfill CAA, and the Wetlands CAA remedy will not be installed until after the slurry wall is completed.
- Soil concentrations in the Wetlands CAA comply with the soil CUL; groundwater is the only medium of concern.
- Groundwater in the Wetlands CAA exists in a relatively homogenous and transmissive aquifer with a demonstrated capacity for sustained groundwater pumping.
- Arsenic is present in groundwater as a dissolved phase that will migrate readily to nearby pumping wells.
- Historical data shows that 95% of the arsenic is already attenuating in the wetlands as groundwater migrates from the landfill to 12th St. E.; therefore the area that needs remedial action is limited and well-defined.
- Restoration areas along Hylebos Creek are being developed and will potentially move Hylebos Creek closer to the Landfill. For this reason, migration of arsenic from Landfill releases beyond 12th St. E. is unacceptable.

The proposed remedy for the Wetlands CAA is short-term pumping of groundwater from the Upper Sand Aquifer beneath the wetlands, treatment of the groundwater to remove arsenic and iron, and re-infiltration of the treated groundwater into existing stormwater ponds or back into the wetlands. The intent is to install a number of pumping wells in order to intensely manage the residual mass of dissolved arsenic and remove it from the system as quickly as possible. The work will be performed in the dry season to reduce the amount of infiltrating rainwater that is treated. Some rebound of arsenic concentrations from the soil is expected; therefore, the remedy includes contingency for more than a single dry season. However, the intent is to use groundwater pump and treat as a rapid method for mass reduction, while using the End-of-Plume remedy to obtain the low cleanup levels for arsenic (set at background for the aquifer).

The short-term pump-and-treat remedy would meet the following RAOs for the Wetlands CAA by:

- Lowering groundwater arsenic concentrations to levels that are protective of human health and the environment within the wetlands.
- Decreasing the mobility and volume of arsenic in the wetlands plume through treatment.
- Increase the overall permanence and effectiveness and decrease the restoration time frame of the overall remedy by removing as much residual mass of dissolved arsenic from the wetlands as is practical.

It is considered likely that the Wetlands CAA remedy would meet the groundwater CUL within the Wetlands CAA only after many years, but the remedy would support the End-of-Plume Remedy in meeting the CUL at a CPOC at 12th St. E within a few years of remedy implementation.

The land between the Landfill and the CPOC at 12th St. E. is currently owned by a single party, whose permission will be needed to obtain the CPOC.

7.1.3 The End-of-Plume Cleanup Action Areas

For the End-of-Plume area, the remedy will consist of enhancing the natural attenuation that is already occurring by adding specific sequestration agents that will act more quickly and more irreversibly to precipitate the dissolved arsenic. This will be accomplished along the 12th St. E. right-of-way. This location was selected for the following reasons:

- The 12th St. E. right-of-way is an unused roadway that cuts through the wetlands and allows for easy access to the wetlands without further disruption to the wetlands.
- The land between the Landfill and 12th St. E. is owned by a single party, which will simplify getting access agreements and institutional controls, although it may still be difficult to do so.
- The residual contamination at 12th St. E. exists as a thin seam of moderately elevated arsenic at the base of the aquifer in a well-defined and accessible sand zone.
    - Land beyond 12th St. E. is planned for habitat restoration, including the potential relocation of Hylebos Creek, making the control of arsenic at 12th St. E. critical.

A series of injection wells or a single trench will be used to inject the sequestering solution into the base of the aquifer where natural conditions are already reducing and favorable. On the downgradient side of 12th St. E., compliance monitoring wells will be installed to monitor the success of the remedy and confirm compliance with background arsenic concentrations.

This remedy meets the RAOs for this area by:

- Reducing the mobility and volume of arsenic in groundwater by sequestering it onto the soil matrix at the base of the aquifer.
- Protecting human health and the environment, including potential future receptors at Hylebos Creek.

- Attaining CULs and meeting ARARs at 12th St. E.

Table 7.1 presents the remedy in tabular form and Figure 7.1 shows the conceptual locations of the various remedial components.

7.2 COMPLIANCE WITH MODEL TOXICS CONTROL ACT

The preferred remedy meets MTCA requirements for a remedial action, as specified under the Selection of Cleanup Actions (Chapter 173-340-360 WAC) as follows.

The proposed remedy meets the threshold requirements:

1. **Protect Human Health and the Environment.** The preferred remedy will protect human health and the environment in both the short and long term. The remedy will permanently reduce the risks presently posed to receptors through a combination of continued maintenance of the Landfill cap, source control of groundwater via a slurry wall, removal and treatment of dissolved arsenic in the wetlands via pumping, in situ treatment of the downgradient edge of plume, and implementation of a long-term groundwater monitoring program to ensure the remedy is protective. Existing state laws on landfill closure (WAC 173-304) and siting of drinking water wells, when combined with MCTA, supply the necessary long-term land use restrictions to protect the Landfill remedy and prevent the installation of a drinking water well at the Landfill or within the adjacent wetlands.
2. **Comply with Cleanup Levels.** The preferred remedy will comply with CULs set forth in Section 4.3 for groundwater, soil, surface water, and sediment. The proposed point of compliance for groundwater is a conditional point of compliance at 12th St. E.
3. **Comply with ARARs.** The preferred remedy is expected to fully comply with all action-, chemical-, and location-specific ARARs, as described in Section 4.2 and summarized in Table 7.2. The preferred remedy also includes all the elements of landfill closure as specified in Minimum Functional Standards for Solid Waste Landfills (WAC 173-304), including the use of the slurry wall to halt migration of leachate and contaminated groundwater beneath the landfill. Finally, the Landfill closure activities meet MTCA requirements for containment remedies to meet CULs.
4. **Provide Compliance Monitoring.** The preferred remedy will continue to provide for compliance monitoring. The long-term O&M plan will be revised for the Site to add a more comprehensive monitoring program for groundwater and surface water to judge effectiveness and permanence of the remedy. The monitoring is expected to be more intensive for the initial 5 to 10 years following remedy implementation, with less frequent monitoring in the future.

The preferred remedy also meets the selection criteria of the MTCA which are:

1. **Providing for reasonable restoration time frame.** The preferred remedy for the slurry wall can be designed, permitted, and installed in as little as two years after the CAP for this Site is adopted. The preferred remedy for the Wetlands CAA and the End-of-Plume CAA can be implemented within one year after the slurry wall is

completed. The restoration time frame for these actions to achieve CULs at 12th St. E. is expected to be within one to three years following implementation.

2. **Using Permanent Solutions to the Maximum Extent Practicable.** The preferred remedy utilizes permanent solutions to the degree practical. Excavation of the Landfill waste and transport and disposal of this waste to a lined landfill was considered (both during the original FS and then reconsidered in 2006) but deemed impractical due to the disproportionate cost and effort involved. Excavation of the wetlands plume was considered in Section 5.0 of this report and rejected as an impractical solution as well. Source material will be left in place under the Landfill cover, but contained within a slurry wall, the most permanent of the alternatives considered. Arsenic in the wetlands plume will be removed, treated, and landfilled as part of iron sludge; residual arsenic at the End-of-Plume will be reductively sorbed/precipitated onto aquifer soils to produce a stable media.
3. **Considering Public Concerns.** This document will be presented to the public and stakeholders through a public comment process. A public meeting will be held if sufficient requests are received. Ecology will prepare a responsiveness summary as part of the CAP that documents how each of the public comments were considered and addressed. The remedies presented in this document already considered increasing development in the area—including adjacent residential units, major new and planned restoration projects in the area, and hydraulic changes planned by the WSDOT and others for the watershed.

Finally, the remedy meets MTCA requirements for groundwater actions specified in Chapter 173-340-360 (2)(c). The groundwater pump-and-treat remedy in the Wetlands and the End-of-Plume sequestering remedy are both intended to permanently remove existing contamination from groundwater. The slurry wall around the Landfill, including existing underlying groundwater contamination, is designed to tie into the Lower Silt Aquitard and the existing Landfill cap. This will result in groundwater containment at the Landfill designed to prevent lateral and vertical migration. The slurry wall also controls the source of future contamination to the wetlands, increasing the permanence of the Wetlands and End-of-Plume remedies by preventing recontamination of the groundwater.

7.3 OWNERSHIP AND ACCESS

Implementation of the remedy will require access to the Landfill, the adjacent wetlands to 12th St. E., the adjacent agricultural drainage ditches, the 12th St. E. and Puget Power right-of-ways, and the small section of the wetlands beyond 12th St. E. (for monitoring well installation and access). Additionally, the interceptor drain associated with the slurry wall will likely require interactions with the adjoining apartment complex and with the City of Fife. The parties likely to implement this remedy do not own any of these properties. Therefore, implementation of the remedy will require significant negotiations of both short term and long term access agreements including agreement on an off-property conditional point of compliance. Institutional controls, including fencing and deed restrictions, will also need to be placed on various properties as part of the remedy. Ecology's assistance, in accordance with the 1989 Consent Decree, will be critical in this process. Figure 7.2 shows current property ownership.

7.4 SUMMARY OF THE ESTIMATED REMEDY COSTS

The estimated costs for this remedy are shown in Table 7.1. Cost documentation backup worksheets are presented in Appendix C. Capital costs are shown in 2006 dollars. At Ecology's request the O&M and Monitoring (OM&M) costs are based on a 50-year timeframe when applicable, rather than the more traditional 30-year timeframe for landfills. The OM&M costs were also calculated as net present value (NPV), assuming a real discount rate of 2 percent for the applicable time period.

The preferred remedy has an estimated capital cost of approximately $2.5 million minimum cost with a contingency cost of $1.1 million. The expected OM&M costs for the preferred remedy at the Site are estimated at $130,000 per year for the first 10 years then drop to $112,000 as the more intensive initial monitoring at the End-Of-Plume area is no longer needed.

The total project cost, as defined as the sum of the capital costs, the contingency capital costs, and the NPV of 50 years of O&M, is approximately $7.2 million. This cost includes customary design and permitting costs, but does not include additional costs for coordination with multiple stakeholders, compensatory costs for municipal infrastructure upgrades and interactions with multiple adjacent restoration projects, or for access agreements or land purchase.

8.0 References

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B&L Landfill

Groundwater Alternatives Evaluation

Tables

Table 1.1
Previous Investigations and Key Documents

Date	Author	Title	Scope	Key Findings
September 1980	USEPA	USEPA Surveillance Sampling	Discharges to Blair Waterway	High levels of arsenic originating at log sort yards.
February 1981	Richard Pierce, Ecology	Log Sort Yard Survey Results	Log Sort Yard storm water run-off	Acutely high levels of metals in sort-yard run-off using ASARCO slag.
December 1982	Richard Pierce, Ecology	Investigation Report: ASARCO Slag in Log Sort Yards, Commencement Bay	B&L leachate; metals concentrations	Implicated ASARCO slag as source of leachate metals including arsenic.
November 1983	Dale Norton, Ecology	Data on Leachate from the B&L Woodwaste Landfill	Data summary of 1982 and 1983 leachate samples	High concentrations of arsenic (up to 26.9 ppm) detected in Landfill leachate
August 1985	Tetra Tech	CBN/T RI	Hylebos Waterway	Arsenic in surface water above USEPA marine acute and chronic criteria
January 1985	Dale Norton and Art Johnson, Ecology	Metals Concentrations in Water, Sediment and Fish Tissue from Hylebos Creek Drainage	Hylebos Creek	Elevated metals (arsenic) concentrations from B&L Landfill ditches to Hylebos
February 1985	Dale Norton and Art Johnson, Ecology	Assessment of Log Sort Yards as Metal Sources to Commencement Bay	Run-off from log sort yards adjacent to Blair and Hylebos Waterways	ASARCO slag is probable source of elevated metals concentrations in sort yard run-off, nearshore surface waters and sediments.
1987	Ecology and Environment (under USEPA contract)	Site Inspection Report for CBN/T		Elevated metals including arsenic in groundwater within and beneath the Landfill.

Table 1.2
B&L Wood Waste Site Cleanup Levels[(g)] from Cleanup Action Plan

Parameter	Soil/Fill[(a)] (mg/kg)	Groundwater[(b)] (mg/kg)	Surface Water[(c)] (mg/L)	Sediments[(d)] (mg/kg)
Arsenic	20 [(e)]	0.005 [(e,j)] 0.01 [(f)]	0.005 [(h)] 0.01 [(f)]	20 [(e)]
Copper	--	--	0.012	390 [(g)]
Lead	250 [(e)]	0.005 [(e,j)] 0.01 [(f)]	0.003 [(h)] 0.01 [(f)]	250 [(e)]
Nickel	--	0.32 [(i)]	--	--
Phenol	--	9.60 [(i)]	2.56	--

Notes:

a More restrictive soil cleanup levels may be required to maintain compliance with groundwater and surface water cleanup levels.

b Points of compliance are the upper and lower sand aquifer at the Site boundary.

c USEPA ambient freshwater quality chronic criteria.

d Cleanup levels have been chosen as the more stringent level between MTCA residential soil cleanup level, Commencement Bay ROD sediment cleanup objectives, and Ecology salt water sediment cleanup level.

e MTCA Method A residential cleanup levels.

f Practical Quantitation Level (PQL). These values serve as the cleanup level where listed. If lower PQLs become achievable during the cleanup an evaluation will be made to determine whether cleanup levels should be lowered by Consent Decree amendment.

g Sediment Management Standards Minimum Cleanup Levels WAC 173-204-520.

h Ambient Water Quality Criteria – Level protective of human health based on fish ingestion alone at a risk of 10^{-6}.

i MTCA Method B Cleanup Levels.

j Natural background may be demonstrated by ecology to be higher than the cleanup level per WAC 173-340-708(11). In that case, natural background concentration may be substituted by Ecology as cleanup level.

Table 1.3
Summary of Detailed Analysis of Alternatives from 1990 FS[1]

Alternative	Summary of Detailed Analysis Result
3. Ditch remediation, sedimentation basin, surface water controls, and institutional controls.	Marginal improvement in overall protection of human health and the environment. Risks would have remained from landfill waste, contaminated groundwater and surface water. Would not have satisfied several key ARARs including site cleanup levels, solid waste functional standards, and dangerous waste regulations. Relatively low cost ($6 M).
4. Interceptor trench, surface water controls, water treatment, ditch remediation, institutional controls	Groundwater treatment would have provided protection for downstream areas. Risks would have remained from landfill waste. Would not have satisfied several key ARARs including site cleanup standards, solid waste functional standards, and dangerous waste regulations. Moderate cost ($11 M).
6. Separation, offsite disposal, subsurface drains, water treatment, surface water controls, ditch remediation, institutional controls	Very high cost ($106 M). Source removal and water treatment would have given a high level of protection of human health and environment. Would not have reduced contaminant volume or toxicity. Would not have met CERCLA or MTCA preferences for avoiding landfilling without treatment.
7A. Asphalt cap, subsurface drains, water treatment, ditch remediation, surface water/ landfill gas/ institutional controls	Water treatment, removing ditch sediments, and landfill cap would have provided adequate protection for human health and the environment, 7C preferred because of impermeable liner and clean fill pad. Moderate cost ($17 M).
7C. New landfill base, landfill consolidation, cap, subsurface drains, water treatment, ditch remediation, landfill gas/ institutional controls	**#1 Preferred alternative. Deemed cost effective ($17 – $20 M) because cap, liner, and clean fill base eliminate exposure routes of inhalation, inadvertent ingestion, dermal contact, downstream migration. Containment of wastes thought to virtually eliminate further leaching into groundwater/surface water.**
8. Bioremediation, offsite disposal, ditch remediation, subsurface drains, surface water/institutional controls	#2 Preferred alternative. Treatment of hazardous materials a regulatory preference. Protectiveness, ability to meet ARARs, and implementability were dependent on success of treatment. Offsite waste disposal would have given high level of protection of human health and environment. Costs high ($50 M).
9. Solidification, onsite disposal, ditch remediation, surface water/institutional controls	#3 Preferred alternative. Would have reduced contaminant mobility and toxicity while allowing onsite disposal. Would not have met MTCA standards, a key cleanup ARAR. Would have increased waste volume despite reducing mobility and left residual longterm risks. Costs high ($38 M).

Notes:
1 K/J/C & AGI 1990b

Table 2.1
Summary of Relevant Findings from Previous Investigations

Investigation	Relevant Data Collection	Relevant Findings
1987 USEPA Field Investigation Team study (E & E 1987)	Installed five monitoring wells (EE 19 to EE 23); sampled monitoring, residential and municipal well water.	Arsenic detected in landfill waste up to 795 mg/kg and in unfiltered groundwater up to 38 mg/L from groundwater wells in the landfill. No elevated arsenic concentrations above regional background levels detected in residential or municipal wells.
1990 Focused Remedial Investigation (AGI & K/J/C 1990)	Soil: 35 samples collected at nine locations. Groundwater: installed 21 monitoring wells (T-1 to T-4, D-1 to D-5).	Established site history and conditions, including nature and extent of contamination around landfill, established physical and chemical properties of soil and groundwater, identified arsenic in surface water and ditch sediments, and established leachability of slag. Magnitude of wetlands plume was not identified due to side gradient location of well couplets D-1 and D-5. Abandoned earlier E & E wells. Nearby private wells within regional background levels for arsenic.
1992–1994 Hydrometrics Cleanup Performance Monitoring	Installed ten monitoring wells (D-6 to D-11).	Wetlands wells installed after landfill was successfully consolidated and capped.
1994–1998 Hydrometrics Confirmational Monitoring	Quarterly groundwater sampling of 18 wells, City of Milton municipal well.	Arsenic detected at 2.5 mg/L in wetlands Monitoring Well D-6A in January 1994. Municipal and private wells within regional background levels for arsenic.
1995–1996 Hydrometrics Phase I and II Hydropunch Investigations	Groundwater: 47 direct-push probe shallow groundwater samples.	Phase I: landfill perimeter; Phase II: wetland locations. Arsenic detected in wetlands groundwater up to 6 mg/L (HP-117). General extent of present-day wetlands plume established and "hotspot" near MW-13 identified.
1998–2001 Hydrometrics Expanded Performance Monitoring	Installed well points along 12th Street road grade (ASWP1 to ASWP4). Installed five monitoring wells in wetland (MW-13 to MW-17). Quarterly groundwater sampling of 23 monitoring wells.	Arsenic plume in wetlands delineated and monitored. Temporary well points indicate background arsenic concentrations at 0.008 mg/L at northern edge of wetlands. Re-sampling of eight residential wells and three municipal wells indicates no impact from B&L.
2001–2003 Contingency Plan and Monitoring Activities	Soil: subsurface direct-push borings SB-101 to SB-113 and well borings. Groundwater: installed wetlands and landfill perimeter MW-18 through MW-25.	Background arsenic concentrations were found in wetlands soils. Arsenic plume boundaries in wetlands groundwater remain unchanged. Arsenic concentrations in groundwater samples from new perimeter monitoring wells south and west of landfill were not greater than background concentrations.

Investigation	**Relevant Data Collection**	**Relevant Findings**
2002 Ecology study on impacts to wetlands (Ecology 2002)	Soil: surface samples to 2 feet bgs; pore waters by centrifuge (unfiltered). Biota: wetland plant samples. Surface water samples. Microtox bioassays.	Elevated arsenic detected in wetlands surface water (0.556 mg/L) associated with colloidal particles; surface water arsenic speciation measured. Porewater arsenic found to be mostly colloidal. Arsenic in wetlands soil found to be near background levels. Concentrations of arsenic in plant root tissue were greater than background concentrations of arsenic; shoot tissue concentrations were not elevated. Apparent decrease in bacterial functions closer to the landfill may be associated with elevated specific conductivity.
2005 Floyd|Snider Wetlands Investigation Data Report (Floyd|Snider 2006a)	Groundwater: 37 soil borings with multiple discrete depth groundwater samples. Site-wide monitoring well sampling with arsenic speciation and complete groundwater quality indicators suite. Shallow aquifer wetland pump tests.	(*See Conceptual Site Mode, Section 3.0*). Consistent geology of sandy shallow aquifer observed with low-permeability silt unit beneath. Arsenic exits landfill across a wide area and diminishes to a thin seam at the base of the aquifer. Arsenic plume is dominantly dissolved As(III) that may be controlled by adsorption. High TDS and low ORP characterize landfill leachate “plume”. Arsenic concentrations show declining trend over time. Upper Sand Aquifer highly conductive.
2006 Floyd|Snider Data Report (GAE Appendix A; Floyd|Snider 2006b)	Groundwater: 10 soil borings with multiple discrete depth groundwater samples. Site-wide monitoring well sampling, surface water, and ditch sediment sampling with complete COC suite. Landfill sump pumping. Installation of MW-30.	(*See Appendix A and Conceptual Site Mode, Section 2.3*) Aquitard extends throughout investigation area in wetlands. Downgradient edge of plume is constrained to thin, narrow seam at base of aquifer at concentrations of 0.056 mg/L. Arsenic concentrations in groundwater spiked upward slightly due to 2006 flooding. Arsenic concentrations highly variable at downgradient landfill perimeter. Landfill leachate has discharged arsenic to ditch surface water and sediments at western perimeter. No exceedances for copper, lead, nickel or zinc in any media. High pumping rates needed to dewater wood waste materials through landfill Sump.

Table 4.1
ARARs Considered for Establishment of Cleanup Levels

Media	ARARs and To-be-considered Criteria
Soil (including wetlands soils)	• MTCA Method A for unrestricted land use; value based on Ecology-established regional background. • MTCA Method B for unrestricted land use, corrected for Ecology-established regional background. • MTCA Ecological Protection (Ch. 173-340-749 ….) for protection of terrestrial biota. • MTCA Methods are sufficiently similar to EPA's Risk Assessment Guidance under Superfund (RAGS) procedures that the MTCA values are also protective and consistent with federal risk-based methods under Superfund.
Groundwater	• MTCA Methods A and B for drinking water use. • State Safe Drinking Water Act (Chapter 70.119A RCW) • Federal Safe Drinking Water Act (40 CFR 141.154) • MTCA requirement for protection of surface water where groundwater discharges into surface water; groundwater at the discharge point must meet the surface water cleanup level.
Sediments (perimeter agricultural ditches)	• MTCA Method A for unrestricted land use; value based on Ecology-established regional background. • MTCA Method B for unrestricted land use, corrected for Ecology-established regional background. • MTCA Ecological Protection (Ch. 173-340-749 ….) for protection of terrestrial biota. • MTCA Methods are sufficiently similar to EPA's Risk Assessment Guidance under Superfund (RAGS) procedures that the MTCA values are also protective and consistent with federal risk-based methods under Superfund. • SMS SQS for marine sediments (treated as a TBC for the protection of sediments in lower Hylebos Creek).
Surface Water	• Surface Water Quality Criteria (WAC 173-201a, revised Dec. 2006) • Clean Water Act Water Quality Standards (40 CFR 13) • National Toxics Rule (40 CFR 131.36) • MTCA/Risk Assessment Guidelines for Superfund Human Health Incidental Risk Calculations for Recreation and Trespass Scenarios

Table 4.2
Proposed Revisions or Clarifications to Cleanup Levels

Changes to COCs

Eliminate copper, lead, nickel, and phenol as COCs because there are no exceedances in site media. Arsenic is the only remaining COC. It is a COC for soil, groundwater, surface water, and ditch sediments.

Clarification of Cleanup Levels

Media	Current	Proposed	Rationale
Soil	20 mg/kg	No change	Based on regional background established by Ecology and used as MTCA Method A for unrestricted land use.
Groundwater	5 µg/L or background	No change	Based on protection of Hylebos Creek and drinking water. If regional background is found to be greater than 5 µg/L, the cleanup level will be raised to background.
Sediments	20 mg/kg	No change	Based on regional background established by Ecology and used as MTCA Method A for unrestricted land use. Also protective of aquatic and terrestrial biota.
Surface Water	5 µg/L	5 µg/L or groundwater background	The existing landfill cap blocks the potential pathway from the landfill refuse to surface water. The existing pathway for surface water impacts is from discharging groundwater; therefore the background consideration applies to surface water also.

Table 5.1
Preliminary Screening of Remedial Technologies

Landfill Cleanup Action Area

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Prevent arsenic-contaminated groundwater from migrating beyond edge of refuse	Groundwater containment at edge-of-refuse	Slurry wall around landfill perimeter	Slurry wall tied into existing landfill cap and Lower Aquitard implies full containment of leachate and isolation of groundwater under refuse; this prevents the migration of contaminated groundwater beyond the landfill perimeter.	**Retained**. Slurry walls are proven technology to isolate groundwater and prevent migration. Sheet piles rejected due to similar effectiveness but much higher cost, leakage, and shorter life span.
	Groundwater treatment at edge-of-refuse	Permeable reactive barrier (PRB) using zero-valent iron (ZVI) or basic oxygen furnace material (BOF)	Reactive media (e.g. zero-valent iron) removes arsenic from groundwater in situ as it travels beyond edge of refuse.	**Retained**. Developing technology for arsenic. More developed for treatment of VOCs. Has low O&M costs, and is a passive process. May require expensive periodic replacement.
	Groundwater controls/treatment at edge-of-refuse	Funnel and Gate with treatment at Gate	Funnels groundwater to central gate, using wing walls and in situ treatment at gate to remove arsenic	**Retained in combination with PRB-** proven technology to capture contaminated groundwater. Gate treatment area more easily replaced.
	Prevention of leachate generation and/or discharge to groundwater	Leachate collection using existing sump as sole dewatering well with ex-situ treatment	Add pump to existing landfill sump, pump and treat, and discharge water. Must be done year round due to fully saturated condition of leachate from upgradient groundwater flow.	**Rejected.** Existing sump is inadequately designed to dewater refuse which is partially saturated year round. The existing leachate collection system drains are incapable of dewatering all of the refuse. Also, very high cost to treat the large quantity of water that would be generated by sump pumping. **Retained as a contingency** component of the slurry wall technology to control hydraulic head within the slurry wall if leakage occurs.
		Leachate collection using existing sump and new dewatering wells around landfill with ex-situ treatment	Large scale drawdown would prevent saturation of wood waste, large scale treatment plant to treat and discharge water.	**Rejected**. Technically possible but impractical to implement due to huge volume of water that must be pumped and treated, the high iron content, and the long time period for restoration (decades).
		Upgradient and perimeter groundwater diversion with interceptor trenches	Collect and transport groundwater with drain trenches around landfill.	**Rejected as stand-alone technology**. Natural gradients are very low. Trenches without pumping would not dewater refuse, and limitations on where diverted water can be routed. **Retained as a component** of slurry wall technology to reduce hydraulic gradients between the uplands bluff and slurry wall.
		Install landfill liner beneath existing refuse and re-install existing sump, leachate collection lines, and engineered cap.	Involves temporary removal of the wood waste, import of low permeability clay and PVC liner and leachate collection trenches and above ground treatment system	**Rejected**. Site is too small to temporarily relocate refuse and technically impractical and extremely expensive to move wood waste and construct liner ($20+M). This option was considered and rejected during the RI/FS process in 1993. It would be even more costly now as the existing engineered cap and leachate collection system would have to be removed.

Drainage Ditches

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Prevent groundwater discharge to perimeter agricultural ditches that discharge to Hylebos Creek	Control of contaminated groundwater discharge to ditches	Pump and treat ditch waters	Ditch sump system collects ditch waters and pumps to ex-situ treatment unit	**Rejected**. Difficult to implement and unable to treat high flows during storm events. Not needed if groundwater is intercepted before it reaches ditches.
		Burial of existing ditches and rerouting of drainage to location away from contaminated groundwater.	Bury existing ditches and reroute ditches away from landfill.	**Retained**. Burial of existing ditches eliminates pathway for contaminated groundwater discharge. Ditches will be eliminated in future by WSDOT and Fife as part of area development. Not needed if groundwater is intercepted before it reaches ditches.
		Tight-line ditches around perimeter of landfill.	Line ditches with culvert pipe that prevents contaminated groundwater along landfill perimeter from entering into pipe. Pipe allows uncontaminated upgradient ditch waters to pass through unaffected into Hylebos Creek.	**Retained**. Tight-lining eliminates groundwater infiltration into ditch. Not needed if groundwater is intercepted before it reaches ditches.
Prevent exposure to contaminated ditch sediment by human users and trespassers and by terrestrial biota. *Note: contaminated surface water will be remedied by controlling groundwater and removing contaminated sediments and does not need to be considered independently.*	Elimination of pathway	Burial of existing ditches and rerouting of drainage to location away from contaminated groundwater.	Bury existing ditches and reroute new agricultural drainage ditches away from landfill.	**Retained**. Easy to implement, must be combined with ditch rerouting to restore functionality of agricultural drainage
	Removal of contaminated sediment	Excavation of sediment in perimeter agricultural ditches	Excavate upper foot of sediment by backhoe.	**Retained**. Easy to implement but must be implemented with landfill groundwater controls to prevent recontamination
	Institutional restrictions or controls	Fencing	Fencing around ditches and place use restrictions and signage.	**Rejected**. Fencing does not control potential erosion and transport of contaminated sediments to downstream locations.
		Hard cover over ditches	Install planking across ditches, allows uncontaminated runoff from adjacent field to enter ditches and drain.	**Rejected**. Hard cover does not control potential erosion and transport of contaminated sediments to downstream locations.

Wetlands Cleanup Action Area

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Prevent migration of the groundwater plume from beneath the Wetlands CAA toward the End-of-Plume CAA , the anticipated point of compliance at 12th St. E, and therefore from eventually reaching downgradient receptors at Hylebos Creek or at a potential future downgradient drinking water well (> 1000 feet from landfill).	Natural Attenuation	Monitored Natural Attenuation (MNA)	Monitoring and demonstrating natural processes including sequestration by natural reactions on aquifer mineral surfaces. Requires new wells and intensive monitoring program to demonstrate effectiveness of natural processes in preventing further plume migration.	**Retained**. Natural processes are effectively removing arsenic from solution beneath the wetlands. The long term permanence and restoration time frame may not be adequate given the number of restoration projects planned for the downgradient area.
		Enhanced MNA	Use any of the in situ groundwater treatment options as targeted, short-term boosts to the natural system; followed by long-term monitoring of COCs and redox conditions.	**Rejected** in favor of in situ treatment by reductive precipitation; reductive precipitation was the only enhancement that was consistent with long term permanence due to redox conditions in the base of the aquifer.
	Excavation	Excavation of the aquifer plume and soils	Excavation of wetlands plume to 10 feet bgs to remove the highest concentrations that can seasonally rise and discharge to surface waters	**Rejected.** Would remove un-impacted soil and do nothing to treat the impacted media, groundwater, which would continue to migrate toward the End-of-Plume CAA and would recontaminate the excavated area. Also, existing wetlands would be destroyed as part of the process and would need to be restored. Finally, excavation technically impractical to operate heavy equipment in wetlands and excavate to depth loose wet soils
	Containment/Capping	Slurry wall and impermeable liner and soil cover	Install slurry wall around Wetlands CAA above cleanup levels and cover Wetlands CAA with impermeable liner, soil cover, and potentially a paved surface or building to divert rainwater	**Retained.** Only if future land use in the wetlands allows for commercial development. Destruction of wetlands functionality and floodplain capacity may be mitigated. Option not feasible for existing conditions as wetlands makes it administratively impractical to install slurry wall and cap wetlands with impermeable liner and cover.
	Reduction of groundwater arsenic concentrations beneath wetlands to limit further migration of arsenic	Groundwater pumping and ex-situ treatment	Temporary pumping of wells across wetlands plume to remove dissolved arsenic from groundwater. Treat water and discharge to existing stormwater infiltration ponds.	**Retaine**d as a temporary measure to remove what may be a significant fraction of the dissolved arsenic in the wetlands plume, making the follow on more permanent remedy more implementable.
		Air sparging	Inject air to oxidize and sequester arsenic with iron oxides.	**Rejected**. Air sparging is an ineffective system to oxygenate the base of the aquifer, especially in the presence of high reduced iron concentrations.
		Chemical oxidant injection in hot spot area	Inject chemical oxidant to oxidize and sequester arsenic with iron oxides.	**Rejected**. Case studies indicate that this technology is not sufficiently permanent as the arsenic that is sequestered re-dissolves with relatively minor decreases in redox potential. Also, the very high iron content of the aquifer would result in significant clogging problems.
		Passive aeration system	Construction and operation of a pond with aeration features in the wetlands to remove arsenic by infiltration of oxygenated surface waters.	**Rejected**. Surface feature unlikely to reach base of aquifer where the arsenic occurs. Oxygenation incompatible with negative redox potentials naturally occurring in wetlands.
		Chemical reductant injection or reductive PRB.	Inject chemical reductant or install PRB delivery system to sequester arsenic in situ with sulfide minerals.	**Retained**. Case studies indicate that reductive precipitation is successful in permanently treating arsenic in situ and is compatible with naturally occurring redox conditions in the wetlands and at the base of the aquifer.

Wetlands Cleanup Action Area

Remedial Action Objective	Implemented By	Technology Options	Description	Retained or Rejected
Prevent exposure to arsenic in biologically-active zone of wetlands soils (upper 6 feet bgs) and in seasonally ponded surface water caused by contaminated groundwater discharge to the wetlands surface.	Natural Attenuation	Monitored Natural Attenuation	Monitoring and demonstrating natural processes. Requires new wells and intensive monitoring program to demonstrate effectiveness of natural processes	**Rejected**. No natural process identified that would prevent exposure at wetlands surface under reasonable restoration timeframe.
	Phytoremediation	Arsenic hyper-accumulator plants, e.g. *Pteris vittata* (Chinese brake fern)	Plant arsenic hyper-accumulator vegetation in wetlands to sequester arsenic in plant tissue.	**Rejected, as stand-alone alternative**. Unproven technology for arsenic in surface water. Would transfer contamination from one media to another, creating new exposure pathway. Planting would also have difficulty surviving flooded conditions. **Retained** as potential component of surface treatment cells.
	Soil covers and caps	Cover plume area with permeable soil above high groundwater mark	Cover wetlands with permeable soil and develop, preventing ponding and blocking pathway to surface water. Potential variation includes a subsurface liner and wetlands restoration.	**Retained**. Would effectively block exposure pathway to surface water in wetlands. Destruction of wetlands functionality and floodplain capacity may require mitigated. Also retained because it is compatible with potential future development of the wetlands area as commercial property which is still be considered by other parties.
	Removal of arsenic from surface water	Surface water treatment cells	Construct surface water treatment cells in wetlands to lower arsenic concentrations by adsorption/precipitation and filtration prior to discharge.	**Retained**. Surface water treatment has potential to rapidly precipitate and/or filter arsenic to treatment standards for surface water
	Reduction of groundwater arsenic concentrations so that groundwater that discharges seasonally to the wetlands surface is protective of ecological exposures.	Groundwater pump and treat	Temporary pumping of wells across wetlands plume to remove dissolved arsenic from groundwater. Treat water and discharge to wetlands or to nearby POTW manhole	**Retained**, but as a temporary measure to remove what may be a significant fraction of the dissolved arsenic in the wetlands plume, making the follow on more permanent remedy more implementable.
		Air sparging	Inject air to oxidize and sequester arsenic with iron oxides.	**Rejected**. The high vegetation load in the biologically active zone of the wetlands results in naturally reducing redox conditions that will negate the effect of aeration system and allow the arsenic to re-dissolve over time.
		Chemical oxidant injection in hot spot areas to meet surface water standards	Inject chemical oxidant to oxidize and sequester arsenic with iron oxides.	**Rejected**. The high vegetation load in the biologically active zone of the wetlands results in naturally reducing redox conditions that will negate the effect of aeration system and allow the arsenic to re-dissolve over time.
		Chemical reductant injection in hot spot areas to meet surface water standards	Inject chemical reductant to sequester arsenic with sulfide minerals. Must be done throughout the upper 10 foot zone of the aquifer that has the potential to rise up and discharge to surface waters	**Retained**. Case studies indicate that reductive precipitation is successful in permanently treating arsenic in situ and may be done without destruction of the wetlands.

End of Plume Cleanup Action Area

Remedial Action Objectives	Implemented By	Technology Options	Description	Retained or Rejected
Prevent further migration of the plume by attaining cleanup level in base of aquifer at a conditional point of compliance along 12th St. E. *Note: 12th St. E is treated as the End-of-Plume area. Contamination at this location is contained within a well-defined thin, high-permeability sand zone at base of aquifer. Access is available via the abandoned 12th St. E roadway.*	Natural Attenuation	Monitored Natural Attenuation (MNA)	Monitoring and demonstrating natural processes including sequestration by natural reactions on aquifer mineral surfaces. Requires new wells and intensive monitoring program to demonstrate effectiveness of natural processes in attenuating historically released arsenic beyond the 12th St. E boundary. Only applicable if source of arsenic upgradient is controlled.	**Retained**. Available data indicates natural attenuation processes maintaining stable plume without rebound. Source control actions at landfill and in wetlands are expected to result in reduction in concentration reaching end-of-plume area. Natural processes are expected to further reduce conditions to obtain cleanup level.
		Enhanced MNA.	Use any of the in situ groundwater treatment options as targeted, short-term boosts to the natural attenuation of historically released arsenic beyond the 12th St. E boundary; followed by long-term monitoring of COCs and redox conditions.	**Retained**. Limited in situ treatments to reduce the restoration timeframe at the End-of-Plume area.
	Groundwater pumping and ex-situ treatment	Extraction wells at downgradient edge of wetland with ex-situ treatment	Install extraction wells at end-of-plume, extract and treat groundwater, discharge treated groundwater to subsurface, wetlands, or POTW.	**Rejected.** High cost for maintaining permanent treatment system due to iron content, and not effective long term remedy. Source control in wetlands and at landfill are significantly more effective than end-of-plume pump and treat.
	Containment/capping	Slurry wall and impermeable liner and soil cover	Extend slurry wall from Wetlands CAA to include End-of-Plume CAA and cover with impermeable liner, soil cover, and potentially a paved surface or building to divert rainwater	**Retained** only if future land use in the wetlands allows for commercial development, and only if containment /capping remedy selected for Wetlands CAA as well. Destruction of wetlands functionality and floodplain capacity may be mitigated. Option not feasible for existing conditions as wetlands makes it administratively impractical to install slurry wall and cap wetlands with impermeable liner and cover.
	In situ treatment to prevent arsenic already released from landfill from crossing 12th St. E.	Passive aeration system. Infiltration of oxygenated surface waters	Construction and operation of a pond with aeration features at the downgradient edge of plume.	**Rejected**. Surface feature unlikely to reach base of aquifer where the arsenic occurs. Oxygenation incompatible with reducing wetlands conditions.
		Permeable reactive barrier (PRB) using zerovalent iron (ZVI) or basic oxygen furnace material (BOF) at downgradient edge of plume	Reactive barrier along entire downgradient plume edge with barrier walls to channel flow.	**Retained** as potential delivery system option for treatment thorough reductive precipitation. Developing technology for arsenic, but has ability to be effective in removing arsenic from groundwater.
		Funnel and gate PRB with zerovalent iron (ZVI) or basic oxygen furnace material (BOF)	Channel groundwater flow through limited PRB treatment zone using slurry wall.	**Retained** as potential delivery system option for treatment thorough reductive precipitation. Developing technology for arsenic, but has ability to be effective in removing arsenic from groundwater.
		Air sparging	Inject air to oxidize and sequester arsenic with iron oxides.	**Rejected**. Oxidation incompatible with reducing wetlands conditions and not permanent.
		Chemical oxidant injection	Inject chemical oxidant to oxidize and sequester arsenic with iron oxides.	**Rejected**. Oxidation incompatible with reducing wetlands conditions and not permanent, rebound may occur.
		Chemical reductant injection	Inject chemical reductant to sequester arsenic with sulfide minerals.	**Retained**. Promising technology compatible with reducing wetlands conditions.

Table 6.1
Comparative Analysis of Alternatives: Landfill/Ditch Area

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reductions in Toxicity, Mobility, and Volume though Treatment	Short-term Effectiveness	Implementability	Cost
Control of Landfill Leachate							
No additional action	Low	No - Groundwater standards exceeded, leachate migration beyond edge of refuse	None - leachate will continue to migrate into ditch and wetlands	None	NA	NA	$25K per year (2006 dollars) for baseline semi-annual groundwater monitoring and landfill cap mowing and inspection and minor repairs
Slurry wall around landfill	High through containment	Yes - will fulfill MFS for containment of leachate at edge of refuse	Very High - Slurry wall has very long lifetime (+100 years)	Moderate - No treatment, but groundwater will be physically contained, thereby reducing mobility	High	High - slurry wall is the most straightforward remedy to design and implement, uses conventional technology and design principles	Moderate - $2MM Capital and low O&M
Permeable Reactive Barrier (PRB)	High through treatment	Yes - groundwater will attain standards after passing through PRB	Moderate - reactive media does not last >20 years and may not be fully effective for arsenic	High - reduces toxicity by treatment	High	Moderate - need to perform bench scale testing to demonstrate long term effectiveness of PRB media for arsenic	High due to unit cost of PRB, extent of barrier, and need for replacement and performance monitoring.
Funnel and treatment gate with PRB	High through containment and treatment.	Yes - groundwater will attain standards after passing through PRB	Moderate - reactive media does not last >20 years and may not be fully effective for arsenic	High - reduces toxicity by treatment	High	Low - need to perform extensive hydrologic modeling to ensure capture and funneling of plume and prove effectiveness of PRB media for arsenic	Moderately high due to unit cost of PRB, need for replacement of PRB, need for maintenance of funnel and gate system, and performance monitoring. Use of funnel and gate decreases extent of PRB.
Agricultural Drainage Ditches							
Excavation of sediment in Ditches	High through removal of contaminated media.	Yes	High but not permanent unless slurry wall is installed to prevent recontamination	High - contaminated sediments will be removed and disposed of in landfill	High - limited, but controllable, risk of worker exposure during excavation	Implementable	Low ($50,000)
Excavation and ditch burial	High - contaminated media will be removed and pathway eliminated	Yes	High - permanently eliminates pathway	High - contaminated sediments will be removed and disposed of in landfill	High - limited, but controllable, risk of worker exposure during excavation	Implementable if done concurrent with WSDOT project	Low ($55,000)
Tight lining or concrete lining of ditch	High - contaminated media will be removed and pathway blocked	Yes	Moderate - engineering remedy that needs monitoring and repairs over time	High - Reduces mobility by eliminating groundwater pathway to surface water	High - limited, but controllable, risk of worker exposure during excavation	Implementable, if agreed to by the City of Fife and Drainage District #23	Moderately low ($75,000)

Table 6.2
Comparative Analysis of Alternatives: Wetlands Area

Wetlands Area							
Alternative	**Overall Protection of Human Health and the Environment**	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reductions in Toxicity, Mobility, and Volume though Treatment**	**Short-term Effectiveness**	**Implementability**	**Cost**
No action in the wetlands *Note: Upgrades to the landfill are assumed to occur (see Table 6.1)*	Moderate – When combined with landfill controls, natural processes will likely result in eventual control of arsenic concentrations in groundwater and its subsequent discharge to surface and migration towards Hylebos Creek. Restoration timeframe may be excessive.	Low – standards for groundwater and ponded surface water are not currently met. Standards may be met in the future due to a combination of landfill upgrades (Table 6.1) and natural attenuation. Restoration timeframe may be excessive.	Low - not an effective long-term or permanent solution because naturally occurring sorption process are prone to re-dissolution with minor fluctuations in redox potential.	Moderate - does not involve active treatment, but uses naturally occurring processes to reduce mobility, toxicity and volume through adsorption.	Low – groundwater and seasonally ponded surface water expected to continue to exceed cleanup levels for years.	High - No implementation required.	No additional costs.
Monitored Natural Attenuation (MNA)	Moderate – When combined with landfill controls, MNA will likely result in eventual control of arsenic concentrations in groundwater and its subsequent discharge to surface and migration towards Hylebos Creek. Restoration timeframe may be excessive.	Low – standards for groundwater and ponded surface water are not currently met. Standards may be met in the future due to a combination of landfill upgrades (Table 6.1) and natural attenuation. Restoration timeframe may be excessive.	Low - not an effective long-term or permanent solution because naturally occurring sorption process are prone to re-dissolution with minor fluctuations in redox potential.	Moderate - does not involve active treatment, but uses naturally occurring processes to reduce mobility, toxicity and volume through adsorption.	Low – groundwater and seasonally ponded surface water expected to continue to exceed cleanup levels for years.	High - Readily implementable.	Moderate costs for plume definition and tracking and continued monitoring.
In situ sequestration	Moderate to High - Stops migration of arsenic in groundwater at base of aquifer. Seasonally ponded surface pathway may be insufficiently protected due potential for oxidative dissolution of arsenic from shallow soils during drought conditions.	Moderate - Potential for surface water to be out of compliance. Requires construction in wetlands that may be difficult to permit.	High for groundwater > 8 ft bgs where reducing conditions are stable. Low for shallow groundwater < 6 ft bgs where intermittent dry conditions may result in remobilization of arsenic.	High for groundwater > 8 ft bgs where reducing conditions are stable. Low for shallow groundwater < 6 ft bgs where intermittent dry conditions may result in remobilization of arsenic.	High - Minor worker safety risks during construction of delivery system. Negligible worker safety risks during treatment, well installation and monitoring.	Moderate - Delivery system construction may require filling wetlands for roads and treatment system pads; and for other excavation. Nees landowner permission.	High costs, primarily capital costs.
Short-term pump-and-treat removal	High - permanently decreases arsenic in groundwater, thus limiting its migration and discharge.	Moderate - it may not be possible for groundwater pump and treat to obtain background arsenic concentrations (the cleanup level for the site).	High – permanently removes and treats arsenic contamination. Because existing soils are not elevated in arsenic; groundwater concentrations are not expected to "rebound."	High - Major reductions in volume of arsenic in groundwater through treatment. Mobility of plume decreased because lowered potential for migration of significant mass of arsenic.	High - Minor worker safety risks during installation. Negligible worker safety risks during treatment, well installation and monitoring.	High – Readily implementable but need Lnadowner permission	Moderate costs.

Wetlands Area

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reductions in Toxicity, Mobility, and Volume though Treatment	Short-term Effectiveness	Implementability	Cost
Surface water treatment cells	Moderate for ponded surface water – remedy is able to treat groundwater that discharges to the surface. Low for groundwater migration towards Hylebos Creek. This remedy does not address arsenic contamination below 6 ft bgs.	High for ponded surface water where cleanup levels are met. Low for groundwater in aquifer where remedy is not effective.	Low - does not address migration of arsenic in groundwater. May not withstand flooding. Accumulation of arsenic in sediments, plants, and reactive media will require repeated excavation for O & M.	Moderate reduction in volume in surface water. No reduction of volume or mobility in groundwater.	High - Minor worker safety risks during treatment zone construction.	Moderate to Low – Remedy is relatively easy to implement, but may be difficult to permit due to need to modify wetlands conditions and must obtain landowner permission.	High costs composed of low capital costs, high O&M costs.
Permeable soil cover	Moderate for ponded surface water – remedy blocks exposure. Low for groundwater migration towards Hylebos Creek, which remedy does not address.	High for ponded surface water where blocked pathway should bring surface water into compliance; however it fills the wetlands decreasing its value as a wetlands. Low for groundwater in aquifer where remedy is not effective.	High - high degree of permanence for blocking surface pathway. Low - ineffective against groundwater arsenic migration.	Moderately Low - does not involve treatment. Significant reduction in mobility of arsenic to discharge to surface water. No reduction in volume or mobility in groundwater.	High - Minor worker safety risks during cap placement.	Moderate to Low – Remedy is easy to implement, but may be difficult to permit due to need to modify wetlands conditions.and must obtain landowner permission.	Moderate costs.
Containment and capping	High - blocks surface pathway and migration of arsenic in groundwater.	Moderately Low - requires filling wetlands; may only be acceptable if combined with mitigation.	High – slurry walls and caps are known remedies with long lives.	Moderate - does not involve treatment. Major reduction in mobility of arsenic to migrate in groundwater and discharge to surface.	High - Minor worker safety risks during construction of barrier and cap placement.	Low – installation of slurry wall and impermeable cap will effectively destroy the wetlands. This remedy is potentially administratively infeasible unless combined with a commercial development that performs wetlands mitigation elsewhere in the basin.	High costs, chiefly capital costs.

Table 6.3
Comparative Analysis of Alternatives: End-of-Plume Area

End-of-Plume Area							
Alternative	**Overall Protection of Human Health and the Environment**	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reductions in Toxicity, Mobility, and Volume though Treatment**	**Short-term Effectiveness**	**Implementability**	**Cost**
No action *Note: Upgrades to landfill are assumed to occur (see Table 6.1)*	Moderate – When combined with landfill controls, natural processes will likely result in eventual control of arsenic concentrations in groundwater and its subsequent discharge to surface and migration towards Hylebos Creek. Restoration timeframe may not meet the needs of adjacent restoration projects.	Moderate – standards for groundwater are not currently met but there are no current receptors. Standards may be met in the future due to a combination of landfill upgrades and natural attenuation. Restoration timeframe may not meet the needs of adjacent restoration projects.	Moderately High – landfill and wetlands actions are expected to bring groundwater at 12th St. E into compliance over time.	High – natural processes are expected to remove the residual contamination by sorption at the base of the aquifer where redox conditions are stable.	Moderate – No implementation required. Restoration timeframe may not meet the needs of adjacent restoration projects.	High - No implementation required.	No additional costs.
Monitored Natural Attenuation (MNA)	Moderate – When combined with landfill controls, MNA likely result in eventual control of arsenic concentrations in groundwater and its subsequent discharge to surface and migration towards Hylebos Creek. Restoration timeframe may not meet the needs of adjacent restoration projects.	Moderate – standards for groundwater are not currently met but there are no current receptors. Standards may be met in the future due to a combination of landfill upgrades and natural attenuation. Restoration timeframe may not meet the needs of adjacent restoration projects.	Moderately High – landfill and wetlands actions are expected to bring groundwater at 12th St. E into compliance over time.	High – natural processes are expected to remove the residual contamination by sorption at the base of the aquifer where redox conditions are stable.	Moderate – Negligible worker safety risks during delineation, well installation and monitoring. Restoration timeframe may not meet the needs of adjacent restoration projects.	High - Soft and/or flooded wetlands present minor obstacles to delineation and well installation. Must obtain landowner permission to establish a conditional Point of Compliance.	Low to moderate costs.
Enhanced MNA	High – when combined with landfill and wetlands controls, Enhanced MNA will address the residual contamination at the base of aquifer and eliminate further migration to Hylebos Creek.	High – when combined with landfill and wetlands controls, Enhanced MNA will bring the residual contamination at the base of aquifer into compliance.	High – when combined with landfill and wetlands controls, Enhanced MNA will treat the residual contamination at the base of the aquifer where redox conditions are stable.	High – enhanced natural processes are expected to remove the residual contamination by sorption at the base of the aquifer where redox conditions are stable.	High – Negligible worker safety risks during treatment, delineation, well installation and monitoring. Restoration time frame should be acceptable for adjacent restoration projects.	Moderately High – Soft and/or flooded wetlands present obstacles to injection well point installation and minor obstacles to delineation, and monitoring well installation. Must obtain landowner permission to establish a conditional Point of Compliance.	Moderate costs. Need for repeated treatments could increase overall costs.
In situ sequestration	High – when combined with landfill and wetlands controls, in situ sequestration will address the residual contamination at the base of aquifer and eliminate further migration to Hylebos Creek.	High – when combined with landfill and wetlands controls, this will bring the residual contamination at the base of aquifer into compliance.	High – when combined with landfill and wetlands controls, this will treat the residual contamination at the base of the aquifer where redox conditions are stable.	High – reductive process (which are compatible with naturally occurring processes) are expected to remove the residual contamination by sorption at the base of the aquifer where redox conditions are stable.	High – Negligible worker safety risks during treatment, delineation, well installation and monitoring. Restoration time frame should be acceptable for adjacent restoration projects.	Moderate - Soft and/or flooded wetlands present obstacles to construction of delivery system, treatment, and minor obstacles to delineation, well installation, and monitoring. Must obtain landowner permission to establish a conditional Point of Compliance.	High costs. Costs depend on effectiveness of wetlands remedies.

End-of-Plume Area							
Alternative	**Overall Protection of Human Health and the Environment**	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reductions in Toxicity, Mobility, and Volume though Treatment**	**Short-term Effectiveness**	**Implementability**	**Cost**
Containment and capping	High degree of protectiveness.	Moderate. Does not immediately meet groundwater CULs at 12th Street E. May be difficult to permit.	High long-term effectiveness and permanence.	Moderate. Does not involve treatment. Wholesale reduction of arsenic mobility beyond barrier. No reduction of arsenic volume in groundwater.	High. Short restoration timeframe acceptable for adjacent restoration projects. Minor worker safety risks during construction of barrier and cap placement. Negligible worker safety risks during, delineation, well installation and monitoring. Significant damage to wetlands.	Low. Significant obstacles to implementation. Land use of filling wetlands and Wetlands CCA containment required. Soft and/or flooded wetlands present physical obstacles to construction. Must obtain landowner permission to establish a conditional Point of Compliance.	Moderate to high costs.

Table 6.4
Compatibility of Alternatives

Combination	1993 Actions	Landfill CAA				Wetlands CAA							End-of-Plume CAA					Overall Compliance with RAOs
	Existing Landfill Remedy & Compliance Monitoring	No Further Action	Slurry Wall	PRB or Funnel & Gate PRB	Ditch Excavation and Cleanout	No Further Action	MNA	In Situ Sequestration	Short-term Pump & Treat	Surface Treatment Cells	Soil Cover	Containment and Capping	No Further Action	MNA	Enhanced MNA	In Situ Sequestration	Containment and Capping	
No Further Action	**X**	**X**				**X**							**X**					Does not meet MTCA Remedy requirements; does not comply with cleanup levels; does not control leachate formation and discharge.
Landfill Source Control Only	**X**		**X**		**X**	**X**							**X**					Meets requirements for source control at landfill; requires long restoration timeframe to bring downgradient groundwater into compliance; compliance monitoring of historical groundwater releases is limited; future impacts to downgradient receptors from historical releases may not be adequately controlled by natural processes.
Landfill Source Control plus MNA	**X**		**X**		**X**		**X**							**X**				Meets requirements for source control at landfill; requires long restoration timeframe to bring downgradient groundwater into compliance; compliance monitoring of historical groundwater releases is thorough and would allow for early warning before contamination reaches downgradient receptors.
Landfill Source Control plus Wetlands Plume Migration Controls plus MNA	**X**		**X**		**X**			**X**						**X**				Meets requirements for source control at landfill; decreases restoration timeframe by in situ treatment; compliance monitoring of historical groundwater releases is thorough and would allow for early warning before contamination reaches downgradient receptors, which is now highly unlikely due to the treatment of arsenic in the wetlands; may not adequately control seasonal exposures to wetlands biota.
Landfill Source Control plus Arsenic Removal in Wetlands plus MNA	**X**		**X**		**X**		**X**		**X**					**X**				Meets requirements for source control at landfill; decreases restoration timeframe by removing the mass of dissolved arsenic beneath the wetlands followed by NMA to reach cleanup levels; compliance monitoring of historical groundwater releases is thorough and would allow for early warning before contamination reaches downgradient receptors, which is now highly unlikely due to the treatment of arsenic in the wetlands. ***Would likely meet RAOs although may require 10 year restoration timeframe and assumes Hylebos Creek is not moved closer to 12th St. E. during that timeframe.***
Landfill Source Control plus Wetlands Surface Controls plus MNA	**X**		**X**		**X**					**Choose One**				**X**				Meets requirements for source control at landfill; requires long restoration timeframe to bring downgradient groundwater into compliance; compliance monitoring of historical groundwater releases is thorough and would allow for early warning before contamination reaches downgradient receptors; blocks or protects shallow soils pathway to wetlands biota.

Table 6.4
Compatibility of Alternatives, Continued

Combination	1993 Actions	Landfill CAA				Wetlands CAA							End-of-Plume CAA					Overall Compliance with RAOs
	Existing Landfill Remedy & Compliance Monitoring	No Further Action	Slurry Wall	PRB or Funnel & Gate PRB	Ditch Excavation and Cleanout	No Further Action	MNA	In Situ Sequestration	Short-term Pump & Treat	Surface Treatment Cells	Soil Cover	Containment and Capping	No Further Action	MNA	EMNA	In Situ Sequestration	Containment and Capping	
Landfill Source Control plus containment and capping of Wetlands Plume	**X**		**X**		**X**							**X**					**X**	Complies with RAOs, but assumes redevelopment of wetlands property into commercial or residential property and mitigation of lost wetlands and flood control plain. Redevelopment may not be economically or politically viable; without redevelopment, loss of wetlands and flood plain is unlikely to meet permit requirements.
Landfill Source Control plus End-of-Plume Treatment	**X**		**X**		**X**	**X**										**X**		Meets requirements for source control at landfill and protects Hylebos Creek and other possible receptors down-gradient of 12th St. E. Does not meet groundwater cleanup levels within wetlands, and does not prevent seasonal exposures to wetlands biota. Requires longer term operation of End-of-Plume remedy.
Landfill Source Control, plus Wetlands Surface Controls and End-of-Plume Treatment	**X**		**X**		**X**					**Choose One**						**X**		Meets requirements for source control at landfill and protects Hylebos Creek and other possible receptors down-gradient of 12th St. E. Does not meet groundwater cleanup levels within wetlands, but blocks seasonal exposures to wetlands biota. Requires longer term operation of End-of-Plume remedy.
Landfill Source Control plus Arsenic treatment throughout plume	**X**		**X**		**X**			**X**							**X**			Meets requirements for source control at landfill and protects Hylebos Creek and other possible receptors down-gradient of 12th St. E. Treats a significant quantity of arsenic in the wetlands reducing restoration timeframe, simplifying the End-of-Plume system and decreasing the timeframe of its operation. May not completely prevent seasonal exposures to wetlands biota.
Landfill Source Control plus Arsenic treatment plus Wetlands Surface Controls	**X**		**X**		**X**			**X**		**Choose One**					**X**			Identical to previous combination, but adds surface water treatment cells or a permeable soil cap to prevent seasonal exposures to wetlands biota.
Landfill Source Control plus Arsenic Removal in Wetlands plus End-of-Plume Enhancements	**X**		**X**		**X**				**X**						**X**			Complies with RAOs while maintaining functions of the wetlands. Uses slurry wall around landfill to control leachate and prevent future releases to groundwater; uses short-term pump and treat to remove the mass of dissolved arsenic present beneath the wetlands followed by MNA to bring groundwater into compliance; uses EMNA at 12th St. E. to treat the end of the historical groundwater plume allowing WSDOT to relocate Hylebos Creek earlier.

Table 7.1
Summary of Remedial Action Comparative Costs for "Groundwater Upgrades" to the 1993 Remedy

These costs represent most probable estimates based on conceptual remedies as described in Section 6. Actual costs for implementation may vary based on field conditions. Details are presented in Appendix C.

	Remedial Strategy	Capital Cost[1]		Capital Contingency[2]		Annual O & M Cost		50-year O & M Cost	Present Value of 50-year O & M Cost[3]	Sum of Capital and Contingency Costs and present value of O&M Costs[4]
	Landfill Closure Actions (Current Activities)									
1a	Wetlands Lease and Property Taxes on Landfill and wetlands parcel	$ -	none	$ -	none	$ 38,000	Lease payment on wetlands parcel and taxes on landfill property	$ 1,900,000	$ 1,190,000	$ 1,190,000
1b	Landfill Cap & Storm Water Controls	$ -	Installed in 1993	$ -		$ 21,000	Cap Inspections & vegetative cover mowing; fence repairs; periodic clean out of pond	$ 1,050,000	$ 660,000	$ 660,000
1c	Landfill Gas Collection System	$ -	Installed in 1993	$ -		$ -	No measurable gas production remains	$ -		$ -
1d	Landfill Leachate Collection System	$ -	Installed in 1993; not used; superseded by slurry wall upgrade	$ -		$ -	Not used in revised remedy.	$ -		$ -
1e	Groundwater Monitoring Network	$ 29,000	Installation of 3 additional monitoring wells and revisions to the Compliance Monitoring Plan.	$ 80,000	Additional Agency discussions, extra wells and hydrologic analysis due to adjacent restoration projects.	$ 27,000	Semi-annual monitoring and reporting for compliance with remedy.	$ 1,350,000	$ 850,000	$ 959,000
1f	MTCA 5-Year Review Process	$ -		$ -		$ 5,000	$25K regulatory process every 5 years	$ 250,000	$ 160,000	$ 160,000
	Landfill Containment Upgrades									
2a	Slurry Wall Enclosure of Landfill	$ 1,169,000	Slurry wall surrounds landfill refuse and is keyed into both the underlying Lower Aquitard and the existing landfill cap.	$ 308,000	50% contingency on construction tasks; primarily to address installation under soft, wet soil conditions	$ 10,000	Repairs & upgrades every 10 years	$ 500,000	$ 310,000	$ 1,787,000
2b	Upgradient Diversion of Clean Water	$ 334,000	1,100 foot interceptor drain to reroute groundwater discharge from glacial uplands. Done only for the slurry wall remedy. Assumes lift station and pumped water discharged to wetlands or stormwater pond.	$ 80,000	30% contingency due to potential need to reroute water to coordinate with other porjects in basin.	$ 10,000	Maintenance of lift station for interceptor drain	$ 500,000	$ 310,000	$ 724,000
2c	Perimeter Ditch Cleanup	$ 35,000	One time cleanup of ditch sediment combined with implementation of slurry wall. Sediments placed under landfill liner.	$ 11,000	Disposal of sediments at an off-site landfill rather than at B&L.	$ -	Ditches will be replaced as part of storm water upgradients when the adjacent parcels are developed for other uses.	$ -		$ 46,000
2d	*Optional Upgrades to Fife Way*			*$ 50,000*	*Placeholder for possible needs to upgrade drainage on Fife Way.*	*$ -*	*This is a one-time upgrade to County's drainage system along Fife Way*	*$ -*		*$ 50,000*
2e	*Optional Upgrades to Greenwood Apartment Storm water Management*			*$ 25,000*	*Apt. drainage will need to be rerouted; may be part of remedy or part of redeleopment in area*	*$ -*	*This is a one-time upgrade to a privately owned system.*	*$ -*		*$ 25,000*
	Wetlands Controls and Enhancements									
4	Short-term groundwater pump and treat to remove mass of mobile dissolved arsenic.	$ 529,000	Assumes 3- 4 new wells, and 6 month pumping time, with onsite treatment and discharge clean enough to go to existing stormwater pond.	$ 397,000	Contingency assumes a second season of operations.	$ -	Monitoring is included in end-of-plume discussion below	$ -	$ -	$ 926,000
	End-of-Plume Controls									
3b	End-of-plume Enhanced Monitored Natural Attenuation and Treatment System	$ 364,000	Pilot study; engineering design; additional wells and characterization & optimization. This includes multiple treatment phases over a 3 to 5 year period.	$ 241,000	Contingency for longer treatment times.	$ 18,000	Additional monitoring for 10 years to confirm gradients, redox conditions, and water quality. No monitoring beyond 10 years, excepts for semi-annual compliance monitoring costed above.	$ 180,000	$ 162,000	$ 767,000
	TOTAL COSTS									
	Total without Optional Costs	**$ 2,460,000**		**$ 1,117,000**		**$ 129,000**		**$ 5,730,000**	**$ 3,642,000**	**$ 7,219,000**
	Total including Optional Costs	***$ 2,460,000***		***$ 1,192,000***		***$ 129,000***		***$ 5,730,000***	***$ 3,642,000***	***$ 7,294,000***

Notes
1 Capital Costs include engineering design, permitting, construction management and construction.
2 Contingency Costs are set at a minimum of 30%, and increased as appropriate for remedial actions with specific risks of unknowns; see appendices for examples.
3 Assumes a real discount rate of 2% or 50 years based on inflation @3% and nominal investment rate @5%. Investment income is based on risk-free, secure investments.
4 The sum of capital costs, contingency, and present value of O&M Costs.
5 No Ecology Costs are included

Table 7.2
Action-Specific ARARs and the Preferred Remedy

Remedy Component	Potential Action-Specific ARARs
General Activities	• General Construction ARARs such as Grade and Fill Permits, NPDES Storm Water Discharge, Air Quality Standards, and worker safety requirements will be followed. • Because the Site is located on former Tribal Lands, any excavation activities will consider potential for disturbing or discovering cultural artifacts. • Because the Site is located near a stream with ESA listed species, any construction and land disturbance will consider storm water and surface water impacts to the stream and associated wetlands.
Landfill/Ditch CAA	
Slurry Wall with Interceptor Drain	• Closure requirements under Minimum Functional Standards for Solid Waste Handling. • Dangerous Waste Regulations for excavated materials that are disposed off-site. • Clean Water Act permitting for discharge of clean water from upgradient interceptor.
Excavation of Ditch Sediments	• Washington State Hydraulics Project Approval.
Wetlands CAA	
Short-term Groundwater Pump and Treat	• Washington State Hydraulics Projects Approval for work within wetlands. • NPDES Discharge and/or POTW Permitting.
End-of-Plume CAA	
Enhanced Monitored Natural Attenuation (Injection Zone, New Sentinel and Performance Wells	• Washington State Hydraulics Project Approval. • Clean Water Act. • Washington State Well Installation Standards.

B&L Landfill

Groundwater Alternatives Evaluation

Appendix A
2006 Data Report

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GEOLOGIST CERTIFICATION

The geological and hydrogeological facts and conclusions within this document were prepared by or under my responsible charge and that to my knowledge and belief this document was prepared in accordance with the requirements of Chapter 18.220 RCW.

Tom Colligan, LHG	Brett Beaulieu, LG
Hydrogeologist	Hydrogeologist

1.0 Introduction

The purpose of this appendix is to document the results of 2006 investigative efforts at the B&L Landfill (the Landfill). In 2005, Murray Pacific Corporation engaged Floyd|Snider to perform an investigation of the wetlands northwest of the B&L Landfill in Milton, Washington, as shown in Figure A.1. The investigation was performed in response to an amended enforcement order (Order No. DE 92TC-S214, as amended Feb 14, 2005) issued by the Washington State Department of Ecology (Ecology) to Asarco Inc, Murray Pacific, and Executive Bark. The amendment specified implementation of a contingency plan to address the groundwater plume of arsenic occurring in the wetlands to the north of the Landfill. Per paragraph 2 of the amended order, "The scope of the Contingency Plan shall be expanded to also include an additional work phase, consisting of the study, design and implementation, with Ecology approval, of measures needed to remediate the wetland area adjacent to the Site."

The scope of work (SOW) of this investigation was designed to satisfy the "study" element of paragraph 2 in the amended order. Asarco, as the primary potentially liable party (PLP) for the Landfill, was originally directed by Ecology to complete this work. However, the failure of Asarco to perform its obligations under the Order following its bankruptcy in 2005 led Murray Pacific, in good faith, to step in and complete the study aspect of the order.

The scope of the 2006 investigation was developed based, in part, on remaining data gaps that were not filled during the 2005 Wetlands Investigation and, in part, on Ecology comments on the 2005 Wetlands Investigation Data Report (Floyd|Snider 2006). Details of the 2006 investigative effort were presented to Ecology in a SOW document dated May 2006, and in the SOW for the Groundwater Alternatives Evaluation, dated June 12, 2006. Following conversations with Ecology, a letter dated June 9, 2006 was sent to Ecology that documented verbal approval of the 2006 investigation SOW and provided several clarifications and modifications in response to Ecology requests.

The results presented in this appendix were used to improve the previous understanding of the wetlands plume and, primarily, to assess the feasibility of various remedial options for the groundwater plume in the wetlands north of the Landfill.

1.1 BACKGROUND

Relevant background information on the Landfill, including the site history, is presented in the body of the Groundwater Alternatives Evaluation (GAE) and in the 2005 Wetlands Investigation Data Report (Floyd|Snider 2006). Review and understanding of these documents is essential to a full understanding of the supplemental information presented in this appendix.

1.2 PREVIOUS INVESTIGATIONS

Multiple investigations and monitoring activities have been conducted to examine soil, surface water, ditch sediment, and groundwater conditions at the Landfill and in the surrounding vicinity. Relevant findings from these investigations are presented in the GAE. Additional discussion of pre-2005 investigations is provided in the Wetlands Investigation Data Report (Floyd|Snider 2006).

In February 2006 Floyd|Snider submitted a Data Report to Ecology based on field investigation activities during the summer of 2005 (Floyd|Snider 2006). The investigation was intended to fill several interrelated data needs to satisfy the current amended order, which calls for the evaluation and implementation of measures needed to remediate the wetland area. The findings of the Data Report form the basis of the conceptual site model presented in the GAE. They include a more precise lateral and vertical delineation of the arsenic plume, the association of groundwater arsenic with various geologic units, and the hydraulic conductivity and groundwater geochemical conditions of the Upper Sand Aquifer.

1.3 2006 INVESTIGATION GOALS

The scope of the 2006 investigation was driven by data gaps identified following the 2005 Wetlands Data Report and by Ecology requests. Specifically, the investigative activities were designed to:

- Delineate the full downgradient extent of the arsenic plume.
- Map the distribution of leachate indicators (dissolved iron, total dissolved solids, and dissolved organic carbon).
- Re-survey wetland monitoring wells that were suspected to have settled to support accurate potentiometric measurements.
- Assess the Landfill sump as a possible extraction well by pumping it to determine the sustainable pumping rate and feasibility of dewatering the consolidated wood waste.
- Measure groundwater quality in the Upper Sand Aquifer from existing monitoring wells (as part of long-term monitoring).
- Measure surface water quality in the ditches adjacent to the Landfill (as part of long-term monitoring).
- Measure sediment quality in the ditches adjacent to the Landfill.
- Install a small-diameter monitoring well to measure the variability in arsenic concentrations over time at the downgradient edge of the Landfill.
- Further establish the continuity and thickness of the silt aquitard unit in the wetlands.

2.0 Field Methods

Floyd|Snider conducted the following field investigation activities between June and October 2006. Working conditions in the wetlands were greatly hampered by the persistent flooded condition of the wetlands in combination with the normally very soft soils that made machine work in the wetlands very difficult. Results of the work described in this section are presented in Section 3.0.

2.1 SOIL BORINGS WITH DISCRETE-DEPTH GROUNDWATER SAMPLES

In September 2006, ten soil borings with groundwater samples from discrete depths were collected using a direct-push probe rig. Soil boring locations are shown on Figure A.1. Eight borings (FS-101 through FS-108) were located along the 12th Street East unimproved road grade to further define the downgradient extent and depth of the arsenic plume. As mentioned above, flooded conditions limited probe rig access to areas immediately adjacent to the raised road grade. Two borings (FS-109 and FS-110) were located on either side of the Puget Power road to define arsenic and leachate concentrations at the Landfill perimeter and in the area of high concentrations in the wetlands immediately north of the Puget Power road. Boring FS-109 was also advanced for the purpose of installing a small-diameter monitoring well, as described in Section 2.2.

Borings along 12th Street East were advanced until the silt low-permeability unit was reached, at depths ranging from approximately 20 to 23 feet below ground surface (bgs). Continuous 4-foot soil cores from each boring were logged by a geologist. Groundwater samples were collected from a retractable well screen driven to selected depths in a second boring within 5 feet of each soil boring. The screened interval was based on the geology encountered in the initial soil boring at each location. The groundwater sampling depths were selected to represent groundwater quality near the top of the Upper Sand Aquifer and at the base of the Upper Sand Aquifer—except at boring FS-109, where only one groundwater sample was collected, from the base of the Upper Sand Aquifer.

Field-filtered groundwater samples were submitted for arsenic, iron, and total organic carbon analyses with the goal of measuring the dissolved fraction of these constituents, given the high turbidity often associated with the temporary well screen sampling methodology.

2.2 WELL INSTALLATION AND SAMPLING

On September 14, 2006, a small-diameter monitoring well, MW-30 was installed at boring FS-109 at the northwest Landfill perimeter according to standard practices during direct-push soil boring activities. The location of MW-30 is shown on Figure A.1. MW-30 was developed according to standard practices. On October 3, 2006 groundwater from MW-30 was sampled and submitted for dissolved arsenic and iron.

2.3 SURVEYING

The measuring points of the sump and wetland wells were surveyed to verify elevation according to standard practices. The sump was surveyed by Floyd|Snider field crew in response to conflicting survey information presented in post-remediation site configuration maps prepared by Asarco (Hydrometrics 1994). The survey of the sump was made using the known elevations of landfill gas vents as control points. Wetland wells were surveyed by a professional surveyor (Duane Hartman and Associates), and used control points and site features that were originally used to survey site features following implementation of the 1993 landfill remedy (Hydrometrics 1994).

2.4 GROUNDWATER SAMPLING OF EXISTING WELLS

In August 2006, groundwater samples were collected according to standard practices from the existing Upper Sand Aquifer wells and submitted for total arsenic, nickel, copper, iron, and total dissolved solids (TDS). Field-filtered samples were also collected and submitted for dissolved arsenic, lead, nickel, copper, iron, and organic carbon.

In the landfill area, Monitoring Wells sampled included: the central SUMP, D-10A, MW-23, D 9A, D-8A, D-7A, and D-11A; in the wetland, this includes: D-5U, D-6A, D-1U, MW-13, MW-14, MW 15, MW-16, and MW-17 (refer to Figure A.1). Water level measurements were collected with a water level indicator prior to sampling. A water quality instrument was used to collect groundwater parameters at the time of sampling including: dissolved oxygen, pH, temperature, oxidation reduction potential (ORP), specific conductivity/salinity/TDS, and turbidity.

2.5 SURFACE WATER SAMPLING

In July 2006, surface water samples were collected according to standard practices and submitted for dissolved and total arsenic, total copper and total lead. In August 2006, additional surface water samples were collected according to standard practices and submitted for dissolved and total arsenic, copper, iron and lead. Samples were collected from standard sample collection points in the outer ditches at the corners of the Landfill (SW-3, SW-6; as shown in Figure A.1), from downgradient ditch locations west of the Landfill (SW-4, SW-5), from an agricultural ditch upgradient of the Landfill (SW-7), and from the Surprise Lake Drain upgradient of the agricultural ditch system (SW-8). No sample collection was possible from the dry stretch of ditch along the northern perimeter of the Landfill, where samples were collected by previous consultants from locations SW-1 and SW-2. (For comparison purposes, SW-2 is located within approximately 20 feet of SW-6).

2.6 DITCH SEDIMENT SAMPLING

Sediment samples were collected along the perimeter ditches according to standard practices and submitted for arsenic, copper, lead, and nickel. As shown on Figure A.1, sediment samples were collected from locations corresponding to surface water sampling locations described above. Three depth intervals were sampled: 0 to 2 inches, 2 to 6 inches, and 6 to 12 inches. Where ditch sediments were submerged beneath surface water, this procedure was modified to depth intervals of 0 to 2 inches and 2 to 12 inches.

2.7 SUMP PUMPING EVALUATION

On July 6, 2006, the 12-inch diameter sump well was pumped at rates up to approximately 10 gallons per minute (gpm) using a variable-speed electric submersible pump. Approximately 500 gallons of water were pumped during the evaluation. Water levels in the sump well were continuously monitored using a water level meter to measure drawdown and assess productive capacity. Water levels in landfill perimeter Upper Sand Aquifer Monitoring Wells D-7A, D-8A, and D-9A were also measured. Effluent water was stored in an on-site tank for later analysis and disposal.

3.0 Results

The results of the 2006 investigation are presented in this section. Key findings are also incorporated into the GAE conceptual site model presented in the main body text.

3.1 SOIL BORINGS WITH DISCRETE-DEPTH GROUNDWATER SAMPLES

3.1.1 Geology

Subsurface geology logged in Soil Borings FS-101 through FS-108 is presented in Figure A.2 (Cross-section E-E'). As illustrated in this cross-section, the subsurface geology along the 12th Street East alignment is consistent with what was found in previous borings in the wetlands (Floyd|Snider 2006). Peat with organic silt was encountered to approximately 7 feet, and is underlain by a thin, approximately 6-inch-thick, silt unit. Beneath this silt unit, fine silty sand was encountered, with a silt content that decreases with depth grading to a fine sand. In borings along the eastern side of the transect (FS-104 through FS-108), the sand is coarser than in borings to the west, and coarsens considerably towards the base of the upper aquifer. In contrast, fine sand was encountered at the base of the aquifer in Borings FS-101 through FS-103 to the west.

A low-permeability (aquitard) unit consisting of plastic silt with interbedded peat was encountered at depths of approximately 20 to 23 feet bgs. This deposit was found to be at least 4 feet thick in FS-108. The depth of the aquitard unit was found to be several feet deeper than its depth closer to the Landfill.

Cross-section F-F', presented in Figure A.3, correlates the subsurface geology identified along 12th Street East with that encountered in previous borings in the wetlands (Floyd|Snider 2006) and beneath the landfill area during the RI phase (KJC and AGI 1990). As shown in this cross-section, the hydrogeologic units identified in the original remedial investigation including the Upper Aquitard, the Upper Sand Aquifer, and the Lower Aquitard, are continuous throughout the investigation area.

3.1.2 Discrete-depth Groundwater Results

Direct-push probe retractable-screen groundwater results from the 12th Street borings, are presented in Table A.1, and in cross-section in Figures A.2, and A.3. Figures A.4 and A.5 show probe groundwater results from the top and base of the Upper Sand Aquifer, respectively, and also include 2005 probe groundwater results. The results indicate that the distal end of the plume in the wetlands has been identified to extend to at least 12th Street, where the plume is limited in concentration and in occurrence to a seam of groundwater at the more permeable base of the Upper Sand Aquifer. This seam of elevated arsenic in groundwater was constrained to a maximum thickness of 5 feet and maximum width of 200 feet. Dissolved arsenic was detected at a maximum concentration of 0.056 mg/L in this zone. One sample in the middle of this zone did not contain arsenic greater than background levels, indicating an uneven distribution of arsenic across this zone. This finding may be a result of localized heterogeneities in aquifer permeability, such as a deposit of greater silt content.

In contrast, arsenic was not detected greater than background levels in the upper part of the Upper Sand Aquifer at the distal end of the plume. Leachate plume indicators are discussed in the context of monitoring well results in Section 3.4.

In Boring FS-110, dissolved arsenic was also detected at elevated concentrations (3.2 to 3.6 mg/L) in samples from both the upper and deeper sections of the Upper Sand Aquifer. This finding is consistent with previous borings in the area, which showed that in the most concentrated area of the arsenic plume in the wetlands, highly elevated concentrations are present throughout the Upper Sand Aquifer in this area. Boring FS-110 is located approximately midway between the edge of the Landfill and MW-13 and indicates that the elevated core of the plume in the wetlands can be traced back to the edge of the Landfill.

At the Landfill boundary, where Boring FS-109 was located, the discrete-depth groundwater sample from the base of the Upper Sand Aquifer resulted in a concentration of dissolved arsenic of 1.9 mg/L. This result is consistent with results from this location based on prior Geoprobe samples collected in October 2005 (e.g., FS-36 and FS-37; Floyd|Snider 2006). Significant variability, however, was observed in the 2005 samples collected over a one month interval (between September and October 2005) at the same location. During this time, dissolved arsenic concentrations increased from approximately 0.4 mg/L to approximately 1.9 mg/L. This variability was confirmed by 2006 results discussed below.

3.2 MONITORING WELL MW-30 INSTALLATION AND SAMPLING

Well construction details for MW-30 are presented in Figure A.6. The screened interval is located in the sand unit at the base of the Upper Sand Aquifer (16 to 21 feet bgs), in which high arsenic concentrations have been detected previously. As shown on Figure A.5, the FS-109/MW-30 boring is located in the vicinity of 2005 Borings FS-7 and FS-36.

The screened interval of MW-30 corresponds approximately to the retractable-screen sampling interval of 17 to 21 feet in Soil Boring FS-109 from which groundwater was sampled at this location on September 14, 2006. The results of sampling of MW-30 on October 3, 2006, however, indicate significantly higher dissolved arsenic in groundwater at the Landfill perimeter three weeks later.

While groundwater samples from differing methods (retractable screen versus permanent well) present obstacles to exact comparisons, this increase in arsenic concentrations never-the-less suggests that dynamic geochemical conditions or dilution causes fluctuating concentrations of dissolved arsenic in groundwater leaving the Landfill boundary.

3.3 SURVEYING

Surveying results for the coordinates of wetland monitoring wells and elevation of measuring points are incorporated into site figures and tables. The re-survey indicated that many of the wetland wells had, in fact, settled, some up to 3 inches. The re-survey was important, in that it allowed a more precise definition of the groundwater surface in the wetlands, as discussed below.

3.4 GROUNDWATER SAMPLING OF MONITORING WELLS

3.4.1 Potentiometric Surface Contours

Using depth to water measurements from two data-gathering events in 2006 and the newly surveyed measuring points for wetland monitoring wells, potentiometric surface contours based on these data and one round of 2002 water level data collected by a previous consultant (Hydrometrics 2002) were plotted and are presented in Figure A.7. Hydraulic gradients based on 2006 measurements are presented in Table A.3.

The results are generally consistent with previous findings that show a generally northwesterly direction of groundwater flow with some variation (Floyd|Snider 2006; Hydrometrics 2001; Hydrometrics 2002). The hydraulic gradient in the area of the wetlands between the Puget Power Road and MW-15 is flatter than in other areas of the site, including the wetlands north of MW-15. The observed depressions in the potentiometric surface in this area (D-6A, MW-13, and D-1U at various times) are interpreted to be a function of local hydraulic disequilibrium commonly observed in unconfined aquifers with flat gradients in fine grained aquifer material, and do not represent actual reversals of gradient.

3.4.2 Analytical Results—Arsenic

Analytical results from groundwater sampling of monitoring wells are presented in Table A.2 and Figure A.8. A summary of dissolved arsenic data dating back to 1989 is presented in Table A.4.

Total and dissolved arsenic results in monitoring well samples were generally similar, which is consistent with the 2005 finding that the majority of the arsenic in the plume is dissolved As(III). Monitoring well results for dissolved arsenic, shown in Figure A.8, indicate a general increase in dissolved arsenic in monitoring wells at the site in 2006. This increase is most notable in two areas: the center of the plume in the wetlands and the western perimeter of the Landfill. In the center of the wetlands, dissolved arsenic in MW-15 increased from 0.87 mg/L in 2005 to 2.9 mg/L in 2006. At the western edge of the Landfill, dissolved arsenic in D-8A increased from 0.075 mg/L to 0.46 between 2005 and 2006.

The increased arsenic concentrations in 2006 are potentially attributable to higher water levels and the associated effects on the redox boundary and the solubility of arsenic and iron. The elevated water level elevations may have subjected additional slag in the landfill and adsorbed arsenic and iron oxides in wetland aquifer solids to mildly reducing conditions (ORP ranging from approximately 0 to -100 mV). This change would explain the increase in arsenic in D-8A. Additional dissolution of adsorbed and co-precipitated arsenic from wetland Upper Sand Aquifer solids would explain the increase in arsenic in MW-15. Decreased arsenic concentrations in the Sump are consistent with dilution with clean recharge water.

Trends in arsenic concentrations of selected wells are presented in Figures A.9 and A.10.

3.4.3 Analytical Results—Leachate Indicators and Geochemical Correlations

Analytical results presented in Table A.2 also include several leachate indicators, including dissolved organic carbon (DOC), total dissolved solids (TDS), and dissolved iron.

Concentration contours for these leachate indicators are presented in Figures A.11, A.12, and A.13. The field parameters ORP, dissolved oxygen (DO), and specific conductivity may also indicate the presence of landfill leachate. ORP contours are shown in Figure A.14.

All these figures illustrate that leachate indicators are present in distributions similar to the arsenic plume. Quantitative correlations between the various leachate indicators, generated using a correlation formula in Excel's data analysis package, are presented in Table A.5. Two important observations are apparent based on these correlations for the entire data set:

- Leachate indicators are well-correlated with each other. For example, DOC is strongly correlated with iron (total and dissolved), and both DOC and iron are correlated with specific conductivity and TDS. This indicates the release of both organic carbon and various ions, including iron species, from landfill wood waste.
- Arsenic correlations with leachate indicators, however, are generally less strong than leachate indicator correlations with other leachate indicators. For example, DOC is more strongly correlated with dissolved iron, ORP, and TDS than with arsenic. Negative ORP is more strongly correlated with iron (total and dissolved), DOC, and TDS than with arsenic. Correlations between arsenic and iron were not as strong as expected.

Correlations based on all the monitoring well data, however, may not be the most useful tool to assess geochemical conditions as they relate to the processes controlling the arsenic and leachate plumes. The monitoring well geochemical data suggest three separate populations: upgradient conditions, the western lobe and downgradient edge of the arsenic plume, and the main arsenic plume. Separate correlations within each of these groups, presented in Table A.6, establish patterns within similar geochemical conditions, and may, therefore, be useful in interpreting processes at work. Although based on small data sets, the following observations may be relevant.

In monitoring wells representing the main plume (Sump, D-6A, MW-13, MW-15):

- The influence of reducing conditions on increased arsenic concentration is apparent. Negative ORP is strongly correlated with arsenic (total and dissolved). Negative ORP is also strongly correlated with DOC, as would be expected.
- Arsenic and iron (total and dissolved) are strongly correlated. This is consistent with the co-release and co-transport of arsenic and iron species in the main plume.

In the western lobe of the plume and the downgradient edge of the main plume (D-5U, D-7A, MW-14, MW-17, D-8A):

- Reducing conditions are not associated with arsenic, but are associated with other leachate plume indicators. Negative ORP measurements are negatively correlated with arsenic (total and dissolved) concentrations. Negative ORP shows moderate correlation with DOC, TDS, and iron (total and dissolved).
- Organics are tied to iron, but not to arsenic. DOC is strongly negatively correlated with total and dissolved arsenic, but strongly positively correlated with total and dissolved iron.

- Arsenic and iron (total and dissolved) are strongly *negatively* correlated. This could support a proposed attenuation process of adsorption onto-, or co-precipitation of arsenic with, iron oxides.

In the monitoring wells that represent generally upgradient conditions (D-1U, D-9A, D-10A, D-11A, MW-16, and MW-23):

- Redox, as measured by ORP, does not demonstrate a strong or consistent relationship with arsenic or other leachate indicators. Negative ORP is weakly negatively correlated with arsenic.
- DOC is correlated with iron, particularly dissolved iron, but only very weakly correlated with arsenic.
- Arsenic and iron (total and dissolved) are weakly negatively correlated.

These observations of the three general groundwater populations and their apparently distinct geochemical signatures provide a basis for further examination of attenuation and other processes that affect the nature of the arsenic and leachate plumes.

3.5 SURFACE WATER SAMPLING

Surface water results are presented in Table A.7 and Figure A.15. Arsenic was detected in several ditch surface water sampling locations, particularly in the ditches adjacent to the Landfill on the western perimeter. The highest detection was 0.460 mg/L total arsenic and 0.420 mg/L dissolved arsenic at SW-6 (located slightly downgradient of the previous surface water location, SW-2, which was dry at the time of sampling). Elevated concentrations were also detected at the southwest corner of the Landfill at SW-3, where total arsenic was detected at 0.097 mg/L and dissolved arsenic was detected at 0.042 mg/L. Arsenic concentrations in the ditch surface water decrease steadily downgradient from the Landfill.

Total copper and dissolved copper were not detected in ditch surface water greater than a detection limit of 0.005 mg/L. Total lead was not detected in site surface water greater than a detection limit of 0.003 mg/L. Total lead was detected at .008 mg/L in sample SW-7, which was collected from a ditch upgradient of the Landfill.

3.6 DITCH SEDIMENT SAMPLING

Ditch sediment results are presented in Table A.8 and Figure A.16. Arsenic was detected in concentrations greater than the cleanup level of 20 mg/kg in several ditch sediment sampling locations. These locations generally correspond to surface water sampling locations adjacent to the Landfill on the western perimeter. The highest detection was 800 mg/kg arsenic in the surficial 2 inches at SED-6 (co-located with SW-6), followed by 700 mg/kg arsenic in the top 2 inches at SED-3 at the southwest corner of the Landfill. Concentrations decrease by orders of magnitude within a few inches of the surface. This suggests that exceedances of the soil cleanup level are limited approximately to the upper 6 to 12 inches of ditch sediments. In addition, these results support the model that the arsenic in the ditch sediment is due to precipitation from ditch surface water. The anoxic conditions that keep arsenic and iron dissolved in groundwater are replaced with exposure to oxygen in the shallow ditches when groundwater discharges into the ditch system along the perimeter of the Landfill. As a result, arsenic and iron collect in the solid phase on the surfaces of ditch sediment minerals.

Copper and lead, the other previously-established contaminants of concern in sediments, were not detected in ditch sediments at concentrations greater than cleanup levels. Copper was detected at concentrations ranging from 12 to 47 mg/kg. Lead was detected at concentrations ranging from 6.5 mg/kg to 23 mg/kg.

3.7 LANDFILL SUMP PUMPING EVALUATION

During the course of the pumping evaluation, the drawdown of the water level in the Sump was negligible (maximum of approximately one-half inch). Consequently, no drawdown effect was measured in Landfill perimeter Wells D-7A, D-8A, and D-9A.

These results indicate that the sump is capable of maintaining a pumping rate of greater than 10 gpm. The leachate collection system includes three drain lines of approximately 200 to 300 feet long, composed of wrapped perforated pipe in a 2-foot by 3-foot trench filled with gravel and constructed to drain toward the sump at gradients ranging from 0.001 to 0.004. The test results do not allow evaluation of a sustained sump pumping rate. In order to do so, the leachate collection system (estimated capacity approximately 20,000 gallons) must first be fully dewatered. The pumping evaluation results, therefore, cannot definitively determine whether dewatering compacted wood waste is a feasible cleanup action alternative to reduce or prevent further release of arsenic-contaminated leachate from the Landfill.

The leachate collection system, however, was not designed to dewater the consolidated wood waste, and would not support this approach as currently constructed even at significantly higher pumping rates. The elevation of the Sump bottom (approximately 7.5 feet mean sea level [MSL]) in the Upper Silt Aquitard at the approximate former ground surface is far too high to support a sufficient cone of influence (refer to Figure A.3). The Sump well has approximately 2 feet of screened interval and intersects a maximum of 5 feet of the saturated zone. The three leachate collection drainage lines cannot extend the cone of influence enough to allow dewatering of wood waste through the single Landfill Sump. In particular, these drainage lines do not extend into several acres of consolidated wood waste at the southern end of the Landfill.

4.0 References

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Appendix A
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Tables

Table A.1
September 2006 Direct-push Probe Groundwater Results

Sample Location	Depth	Arsenic (mg/L)	Iron (mg/L)	Total Organic Carbon (mg/L)
FS-101	8-12’	0.006	61	21
FS-101	18-22’	0.005 U	45	20
FS-102	8-12’	0.005 U	51	19
FS-102’	18-22’	0.005 U	51	18
FS-103	8-12’	0.005 U	45	20
FS-103	18-22’	0.005 U	68	37
FS-104	8-12’	0.005 U	75	96
FS-104	19-23’	0.053	84	55
FS-104 Blind Duplicate	19-23’	0.054	85	55
FS-105	8-12’	0.007	83	78
FS-105	7-21’	0.014	160	63
FS-106	8-12’	0.005 U	58	76
FS-106	17-21’	0.056	180	61
FS-107	8-12’	0.005 U	55	62
FS-107	17-21’	0.009	160	52
FS-107 Blind Duplicate	17-21’	0.009	150	57
FS-108	8-12’	0.005 U	66	45
FS-108	16-20’	0.006	77	33
FS-109	17-21’	1.9	85	45
FS-109 Blind Duplicate	17-21’	1.9	0.086	49
FS-110	4-8’	3.6	150	50
FS-110	12-16’	3.2	180	49

Note:

U Analyte analyzed for but not detected at level above reporting limit. Value given is the reporting limit.

Table A.2
Summary of Groundwater Quality from 2006 Monitoring Well Sampling

		Field Parameters[1]					Conventionals			Metals									
Well ID	**Sample Date**	**T (°C)**	**pH**	**DO (mg/L)**	**Specific Conductivity (mS/cm)**	**ORP (mV)**	**DOC (mg/L)**	**TDS (mg/L)**	**Total Arsenic (mg/L)**	**Dissolved Arsenic (mg/L)**	**Total Copper (mg/L)**	**Dissolved Copper (mg/L)**	**Total Iron (mg/L)**	**Dissolved Iron (mg/L)**	**Total Lead (mg/L)**	**Dissolved Lead (mg/L)**	**Total Nickel (mg/L)**	**Dissolved Nickel (mg/L)**
D-1U	8/14/2006	12.61	6.24	1.2	0.834	-82.6	19	470	ND	ND	ND	ND	42	41	ND	ND	ND	ND
D-5U	8/14/2006	12.31	6.16	1.3	1.246	-100.2	55	1900	0.089	0.16	ND	ND	110	120	ND	ND	ND	ND
D-6A	8/15/2006	12.02	6.26	0.9	1.383	-102.7	46	1900	1.9	1.9	0.023	ND	91	89	ND	ND	0.025	ND
D-7A	8/14/2006	14.27	6.11	0.6	1.402	-106.7	84	880	0.026	0.026	ND	ND	140	140	ND	ND	ND	ND
D-8A	8/14/2006	14.78	6.39	0.4	0.328	-75.4	8.9	270	0.45	0.463	ND	ND	17	17	ND	ND	ND	ND
D-9A	8/14/2006	12.47	7.27	0.4	0.233	-95.6	2.5	180	0.038	0.045	ND	ND	0.16	0.15	ND	ND	ND	ND
D-10A	8/15/2006	12.74	6.02	0.8	0.259	26.0	15	200	0.2	0.25	ND	ND	14	14	ND	ND	ND	ND
D-11A	8/15/2006	14.07	6.3	0.6	0.429	23.8	2.4	270	ND	ND	ND	ND	27	0.21	ND	ND	ND	ND
D-11A Duplicate	8/15/2006						2	280	ND	ND	ND	ND	0.2	0.11	ND	ND	ND	ND
MW-13	8/15/2006	10.96	6.24	0.8	1.398	-109.9	59	780	3.8	3.4	0.059	0.01	110	110	ND	ND	0.054	ND
MW-14	8/15/2006	12.11	6.31	1.1	1.429	-92.7	48	740	0.009	0.008	ND	ND	140	170	ND	ND	ND	ND
MW-15	8/15/2006	10.68	6.25	2.0	1.784	-95.6	63	980	3.7	2.9	ND	ND	160	160	ND	ND	ND	ND
MW-16	8/15/2006	11.45	6.32	1.2	0.562	-30.0	12	340	0.011	0.012	ND	ND	20	20	ND	ND	ND	ND
MW-17	8/15/2006	11.57	6.19	1.8	1.344	-69.0	63	770	0.015	0.008	ND	ND	76	130	ND	ND	ND	ND
MW-23	8/15/2006	17.39	6.11	1.6	0.745	-57.4	20	440	0.032	0.028	ND	ND	25	23	ND	ND	ND	ND
MW-24																		
SUMP	8/15/2006	12.73	6.17	0.8	1.236	-68.6	22	540	1.7	1.7	ND	ND	30	55	ND	ND	ND	ND

Notes:

1 Field parameters collected with a YSI probe, model 556 #92F4.

ND Not detected.

Table A.3
Gradients, Seepage Velocities and Travel Times over Cross-section F-F'

Well Pair		Gradient	Approximate Hydraulic Conductivity (ft/day)[1]	Assumed Effective Porosity	Average Linear Velocity (ft/day)	Average linear Velocity (ft/year)	Distance (ft)	Time to Travel (days)	Time to Travel (years)	Total Travel Time to MW-17 (years)
October 3, 2006										
SUMP	MW-30	0.0104	50	0.35	1.5	539.7	289	195	0.5	12
MW-30	MW-13	0.0005	50	0.35	0.1	28.1	186	2416	6.6	
MW-13	MW-15	0.0003	100	0.35	0.1	35.2	178	1846	5.1	
MW-15	MW-17	0.0029	200	0.35	1.7	606.5	144	87	0.2	
October 3, 2006 (Without Sump[2])										
MW-30	MW-13	0.0005	50	0.35	0.1	28.1	186	2416	6.6	12
MW-13	MW-15	0.0003	100	0.35	0.1	35.2	178	1846	5.1	
MW-15	MW-17	0.0029	200	0.35	1.7	606.5	144	87	0.2	
August 6, 2006										
SUMP	MW-13	0.0087	50	0.35	1.2	456.2	478	382	1.0	2
MW-13	MW-15	0.0057	100	0.35	1.6	592.5	178	110	0.3	
MW-15	MW-17	0.0031	200	0.35	1.8	649.8	144	81	0.2	
September 2005										
SUMP	MW-13	0.0090	50	0.35	1.3	471.5	478	370	1.0	2
MW-13	MW-15	0.0019	100	0.35	0.5	199.5	178	326	0.9	
MW-15	MW-17	0.0028	200	0.35	1.6	592.1	144	89	0.2	

Notes:

1 Hydraulic conductivities based on 2005 pump test results (Floyd|Snider 2006) and 1999 slug tests (Hydrometrics 2001). Hydrometrics result of 3.3 ft/day for MW-13 rejected based on nearby observed geology in 2005 direct-push probe soil cores.

2 Hydraulic conductivity between SUMP and other wells unknown; gradients may reflect perched water.

Table A.4
Dissolved Arsenic (mg/L) Data from Historic Monitoring Well Sampling

	Wells													
Date	**D-1U**	**D-5U**	**D-6A**	**D-7A**	**D-8A**	**D-9A**	**D-10A**	**MW-13**	**MW-14**	**MW-15**	**MW-16**	**MW-17**	**MW-23**	**SUMP**
Sep-89	0.008	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Dec-89	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
May-93	< .02	0.17	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Jan-94	< 0.005	0.27	2.543	< 0.005	0.144	0.038	0.371	NT	NT	NT	NT	NT	NT	NT
May-94	< 0.005	0.306	2.794	< 0.005	0.133	0.045	0.347	NT	NT	NT	NT	NT	NT	NT
Aug-94	< 0.005	0.286	3.901	< 0.005	0.122	0.055	0.564	NT	NT	NT	NT	NT	NT	NT
Dec-94	< 0.005	0.307	2.914	< 0.005	0.112	0.041	0.525	NT	NT	NT	NT	NT	NT	NT
Mar-95	< 0.005	0.41	2.9	< 0.005	0.21	0.035	0.34	NT	NT	NT	NT	NT	NT	NT
Jun-95	< 0.005	0.25	0.01A	< 0.005	0.18	0.043	0.52	NT	NT	NT	NT	NT	NT	NT
Dec-95	NT	NT	NT	< 0.005	0.2	0.043	0.47	NT	NT	NT	NT	NT	NT	NT
Mar-96	NT	NT	NT	0.006	0.16	0.042	0.4	NT	NT	NT	NT	NT	NT	NT
Jun-96	NT	NT	NT	< 0.005	0.13	0.053	0.43	NT	NT	NT	NT	NT	NT	NT
Sep-96	0.005	0.33	1.9	0.005	0.26	0.087	0.49	NT	NT	NT	NT	NT	NT	NT
Jan-97	< 0.005	0.36	2.1	< 0.005	0.14	0.04	0.36	NT	NT	NT	NT	NT	NT	NT
Mar-97	< 0.005	0.34	1.9	0.005	0.12	0.041	0.36	NT	NT	NT	NT	NT	NT	NT
Jun-97	< 0.005	0.38	2.1	< 0.005	0.2	0.054	0.36	NT	NT	NT	NT	NT	NT	NT
Sep-97	< 0.005	0.4	2.6	< 0.005	0.23	0.062	0.42	NT	NT	NT	NT	NT	NT	NT
Dec-97	< 0.005	0.46	2.5	< 0.005	0.13	0.043	0.41	NT	NT	NT	NT	NT	NT	NT
Mar-98	< 0.005	0.37	2.4	< 0.005	0.1	0.038	0.32	NT	NT	NT	NT	NT	NT	NT
Jun-98	< 0.005	0.27	1.9	< 0.005	0.061	0.04	0.34	NT	NT	NT	NT	NT	NT	NT
Sep-98	< 0.005	0.32	1.8	< 0.005	0.15	0.059	0.34	NT	NT	NT	NT	NT	NT	NT
Dec-98	< 0.005	0.33	1.1	0.007	0.11	0.039	0.28	5.4	0.008	2.8	0.005	0.005	NT	NT
Mar-99	< 0.005	0.34	1.9	< 0.005	0.19	0.041	0.2	4.6	< 0.005	3.1	< 0.005	< 0.005	NT	NT
Jun-99	< 0.005	0.33	1.8	< 0.005	0.18	0.041	0.26	5.0	< 0.005	2.7	0.007	< 0.005	NT	NT
Sep-99	< 0.005	0.35	1.9	< 0.005	0.14	0.046	0.32	5.6	0.006	2.9	< 0.005	< 0.005	NT	NT
Jan-00	< 0.005	0.21	1.2	< 0.005	0.13	0.041	0.24	4.2	< 0.005	1.8	< 0.005	< 0.005	NT	NT
Mar-00	< 0.005	0.3	1.7	< 0.005	0.14	0.037	0.19	5.0	NT	2.5	0.006	< 0.005	NT	NT
Jun-00	< 0.005	0.26	1.6	< 0.005	0.089	0.038	0.25	3.8	< 0.005	2.5	< 0.005	< 0.005	NT	NT

	Wells													
Date	**D-1U**	**D-5U**	**D-6A**	**D-7A**	**D-8A**	**D-9A**	**D-10A**	**MW-13**	**MW-14**	**MW-15**	**MW-16**	**MW-17**	**MW-23**	**SUMP**
Sep-00	0.003	0.26	1.8	< 0.002	0.063	0.05	0.33	4.7	0.004	2.7	0.004	< 0.002	NT	NT
Dec-00	0.004	0.3	2.1	0.004	0.065	0.044	0.29	5.5	0.006	3.1	0.005	0.004	NT	NT
Mar-01	0.002	0.23	1.9	< 0.002	0.12	0.035	0.21	4.8	0.003	2.8	0.004	0.005	NT	NT
Apr-02	< 0.005	0.23	1.5	< 0.005	0.36	0.036	0.24	3.8	< 0.005	2.2	< 0.005	< 0.005	0.011	1.6
Jun-02	< 0.005	0.25	1.7	< 0.005	0.29	0.037	0.25	4.6	0.007	2.6	< 0.005	0.005	0.014	1.4
Sep-02	< 0.005	0.23	1.6	< 0.005	0.097	NT	0.28	4.3	< 0.005	2.3	0.005	< 0.005	0.018	1.6
Oct-02	NT	NT	NT	NT	NT	0.036	NT	NT	NT	NT	NT	NT	NT	NT
Dec-02	< 0.005	0.23	1.7	< 0.005	0.057	0.043	0.29	4.1	< 0.005	2.5	< 0.005	< 0.005	0.013	4.6
Mar-03	0.006	0.23	1.7	< 0.005	0.33	0.037	0.22	4.3	0.009	2.5	0.017	< 0.005	0.014	1.8
Jun-03	< 0.005	0.23	1.8	< 0.005	0.37	0.038	0.26	4.4	0.005	2.7	< 0.005	0.008	0.02	2.2
Sep-03	< 0.005	0.19	1.9	< 0.005	0.11	0.038	0.29	4.2	0.007	2.8	< 0.005	0.008	0.019	5.8
Sep-05	NT	0.0628	1.54	NT	0.0757	0.035	0.222	2.28	0.0023	0.874	NT	0.0118	NT	5.66
Aug-06	ND	0.16	1.9	0.026	0.463	0.045	0.25	3.4	0.008	2.9	0.012	0.008	0.028	1.7

Notes:

A	Value qualified as “anomalous” (Hydrometrics 2001b).
ND	Not detected.
NT	Not tested.

Table A.5
Correlations between Selected Geochemical Parameters in Monitoring Wells

	T (°C)	pH	DO (mg/L)	Specific Conductivity	ORP (mV)	DOC	TDS	Total Arsenic	Dissolved Arsenic	Total Iron	Dissolved Iron
T (°C)	1.00										
pH	-0.12	1.00									
DO (%)	-0.09	-0.41									
DO (mg/L)	-0.20	-0.39	1.00								
Specific Conductivity	-0.43	-0.39	0.54	1.00							
ORP (mV)	0.23	-0.21	-0.15	-0.64	1.00						
DOC	-0.33	-0.39	0.41	0.88	-0.60	1.00					
TDS	-0.30	-0.27	0.30	0.68	-0.54	0.64	1.00				
Total Arsenic	-0.48	-0.11	0.22	0.56	-0.37	0.37	0.29	1.00			
Dissolved Arsenic	-0.47	-0.12	0.16	0.55	-0.37	0.35	0.32	0.99	1.00		
Total Iron	-0.40	-0.32	0.41	0.89	-0.59	0.91	0.64	0.45	0.42	1.00	
Dissolved Iron	-0.43	-0.32	0.46	0.92	-0.61	0.93	0.61	0.36	0.34	0.96	1.00

Notes:

DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
ORP	Oxidation-reduction Potential
T	Temperature
TDS	Total Dissolved Solids

Table A.6
Correlations between Selected Geochemical Parameters in Three Monitoring Well Groupings

	T (°C)	pH	DO (%)	DO (mg/L)	Specific Conductivity	ORP (mV)	DOC	TDS	Total Arsenic	Dissolved Arsenic	Total Iron	Dissolved Iron
Main plume (Sump, D-6A, MW-13, MW-15)												
T (°C)	1.00											
pH	-0.69	1.00										
DO (%)	-0.63	0.38	1.00									
DO (mg/L)	-0.65	0.39	1.00	1.00								
Specific Conductivity	-0.81	0.59	0.96	0.96	1.00							
ORP (mV)	0.71	-0.89	-0.08	-0.10	-0.36	1.00						
DOC	-0.97	0.84	0.57	0.59	0.78	-0.84	1.00					
TDS	0.01	0.71	0.01	0.01	0.10	-0.50	0.23	1.00				
Total Arsenic	-0.96	0.48	0.51	0.53	0.69	-0.61	0.88	-0.27	1.00			
Dissolved Arsenic	-0.91	0.47	0.31	0.34	0.52	-0.69	0.84	-0.26	0.98	1.00		
Total Iron	-0.94	0.79	0.79	0.80	0.93	-0.67	0.95	0.22	0.82	0.72	1.00	
Dissolved Iron	-0.93	0.68	0.86	0.87	0.97	-0.55	0.91	0.09	0.83	0.71	0.99	1.00
Western lobe/edge of plume (D-5U, D-7A, MW-14, MW-17, D-8A)												
T (°C)	1.00											
pH	0.25	1.00										
DO (%)	-0.94	-0.38	1.00									
DO (mg/L)	-0.94	-0.37	1.00	1.00								
Specific Conductivity	-0.66	-0.72	0.58	0.58	1.00							
ORP (mV)	-0.17	0.54	0.31	0.32	-0.46	1.00						
DOC	-0.32	-0.93	0.37	0.37	0.88	-0.54	1.00					
TDS	-0.44	-0.64	0.43	0.41	0.48	-0.55	0.44	1.00				
Total Arsenic	0.69	0.71	-0.63	-0.62	-1.00	0.40	-0.87	-0.45	1.00			
Dissolved Arsenic	0.65	0.65	-0.59	-0.59	-0.98	0.32	-0.86	-0.30	0.99	1.00		
Total Iron	-0.36	-0.61	0.19	0.19	0.89	-0.77	0.78	0.47	-0.86	-0.83	1.00	
Dissolved Iron	-0.60	-0.60	0.47	0.47	0.98	-0.50	0.81	0.39	-0.97	-0.97	0.93	1.00
Upgradient (D-1U, D-9A, D-10A, D-11A, MW-16, MW-23)												
T (°C)	1.00											
pH	-0.39	1.00										
DO (%)	0.78	-0.59	1.00									
DO (mg/L)	0.72	-0.61	1.00	1.00								
Specific Conductivity	0.47	-0.46	0.80	0.83	1.00							
ORP (mV)	0.02	-0.58	-0.21	-0.22	-0.37	1.00						
DOC	0.38	-0.68	0.86	0.89	0.70	-0.16	1.00					
TDS	0.49	-0.48	0.83	0.86	1.00	-0.37	0.73	1.00				
Total Arsenic	-0.25	-0.30	-0.14	-0.13	-0.54	0.52	0.19	-0.51	1.00			
Dissolved Arsenic	-0.29	-0.29	-0.18	-0.16	-0.56	0.52	0.17	-0.53	1.00	1.00		
Total Iron	0.20	-0.65	0.53	0.58	0.86	0.03	0.55	0.84	-0.41	-0.41	1.00	
Dissolved Iron	0.10	-0.50	0.69	0.75	0.84	-0.36	0.88	0.84	-0.11	-0.12	0.75	1.00

Notes:

DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
ORP	Oxidation-reduction Potential
T	Temperature
TDS	Total Dissolved Solids

Table A.7
2006 Surface Water Results

Sample ID	Sample Date	Total Arsenic (µg/L)	Dissolved Arsenic (µg/L)	Total Copper (µg/L)	Dissolved Copper (µg/L)	Total Iron (µg/L)	Dissolved Iron (µg/L)	Total Lead (µg/L)	Dissolved Lead (µg/L)	Total Nickel (µg/L)	Dissolved Nickel (µg/L)
SW-1	NA	-	-	-	-	-	-	-	-	-	-
SW-2	NA	-	-	-	-	-	-	-	-	-	-
SW-3	7/7/2006	97	42	ND (<5)	-	-	-	ND (<3)	-	-	-
SW-4	7/7/2006	42	22	ND (<5)	-	-	-	ND (<3)	-	-	-
SW-5	7/7/2006	65	15	ND (<5)	-	-	-	ND (<3)	-	-	-
SW-6	7/7/2006	460	420	ND (<5)	-	-	-	ND (<3)	-	-	-
SW-7	8/14/2006	200	10	ND (<5)	ND (<5)	54,000	3,000	8	ND (<3)	ND (<20)	ND (<20)
SW-8	8/14/2006	6	7	ND (<5)	ND (<5)	340	ND (<10)	ND (<3)	ND (<3)	ND (<20)	ND (<20)

Notes:

-	Indicates sample was not analyzed for this constituent.
NA	Not applicable. The area of the ditch where SW-1 and SW-2 are located was dry at the time of sampling and no surface water samples were collected.
ND	Not detected.
	SW-6 is located approximately 20 feet downgradient of SW-2, which does not receive drainage from the agricultural ditch along the western landfill boundary and which was dry at the time of sampling.

Table A.8
Ditch Sediment Results

Sample Location/Depth	Sample Date	Arsenic (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)
SED-1 0-2"	7/7/2006	6	21	6.1	-
SED-1 2-6"	7/7/2006	ND (<6)	16	ND (<4.3)	-
SED-1 6-12"	7/7/2006	ND (<6)	15	ND (<4.1)	-
SED-2 0-2"	7/7/2006	66	44	ND (<7.7)	-
SED-2 2-6"	7/7/2006	13	23	ND (<4.3)	-
SED-2 6-12"	7/7/2006	ND (<6)	12	ND (<3.8)	-
SED-3 0-2"	8/14/2006	700	20	23	7.9
SED-3 2-6"	8/14/2006	77	26	10	11
SED-3 6-12"	8/14/2006	13	29	9.6	11
SED-4 0-2"	8/15/2006	22	27	ND (<6.2)	17
SED-4 2-12"	8/15/2006	ND (<2.6)	17	ND (<2.6)	20
SED-5 0-2"	8/15/2006	35	34	ND (<4.5)	17
SED-5 2-12"	8/15/2006	ND (<3.5)	13	ND (<3.5)	10
SED-6 0-2"	8/15/2006	800	13	8	5
SED-6 2-6"	8/15/2006	220	47	14	17
SED-6 6-12"	8/15/2006	61	32	6.5	17

Notes:

-	Sample was not analyzed for this constituent.
ND	Not detected.

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Appendix A
2006 Data Report

Figures

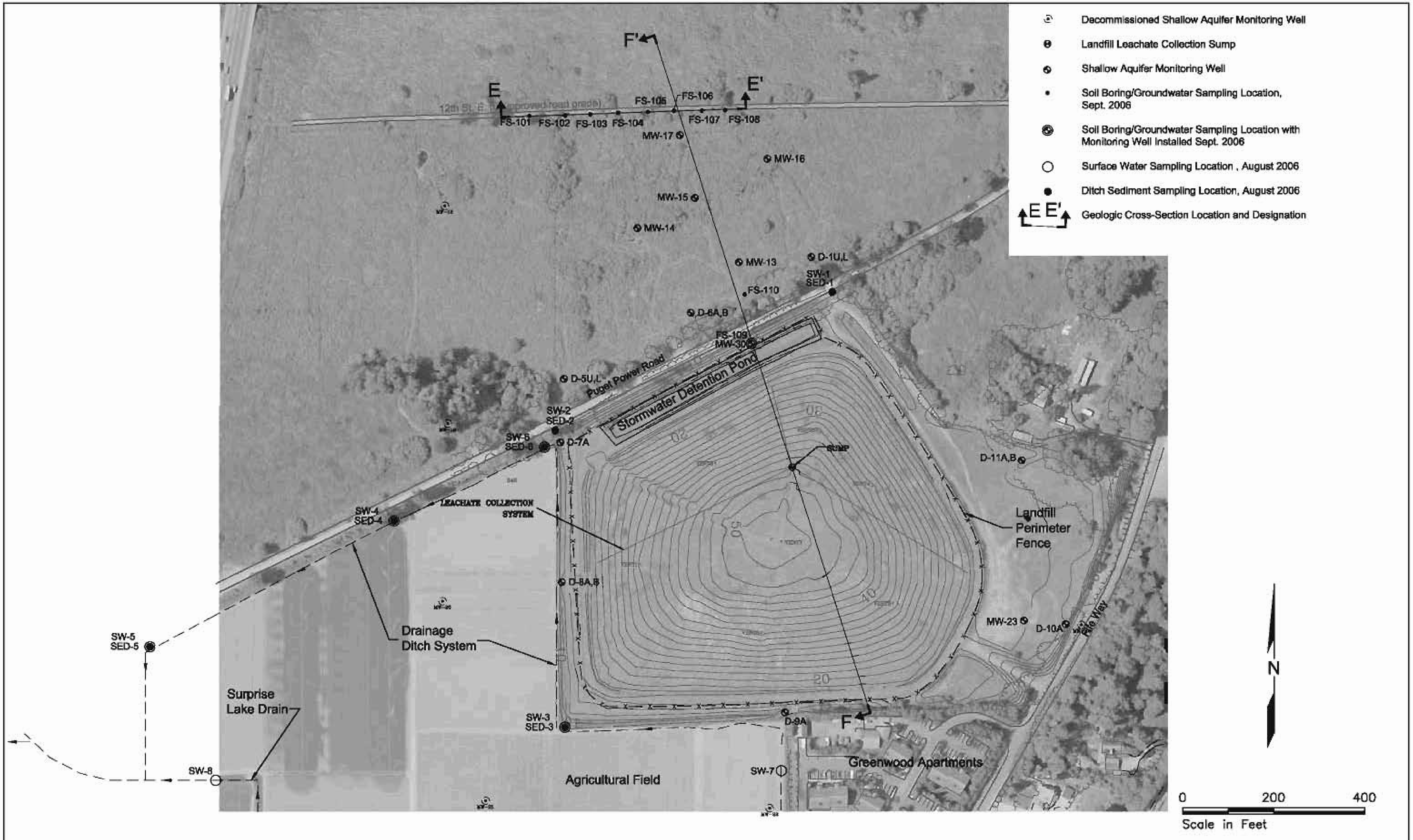

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Figure A.1
Site Map and Cross Section Locations

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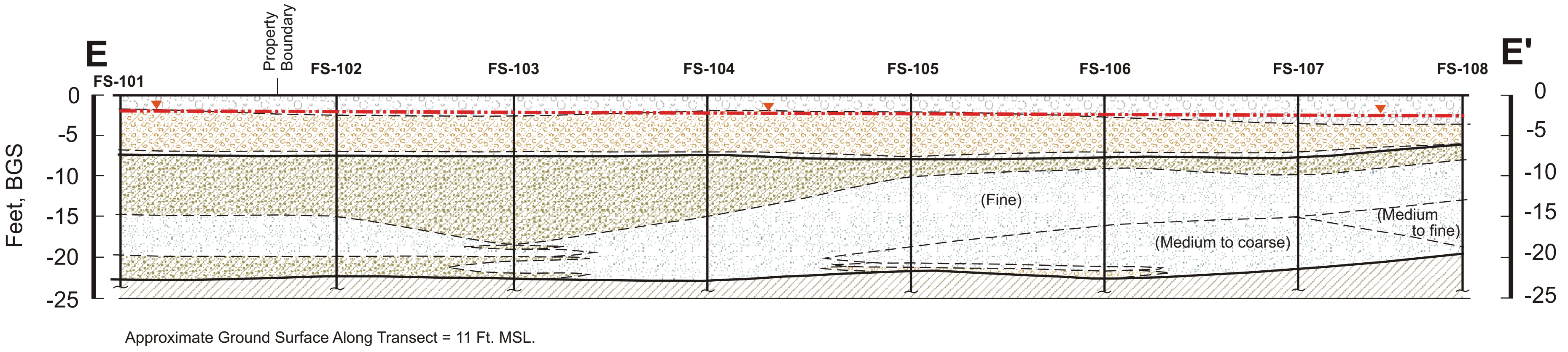
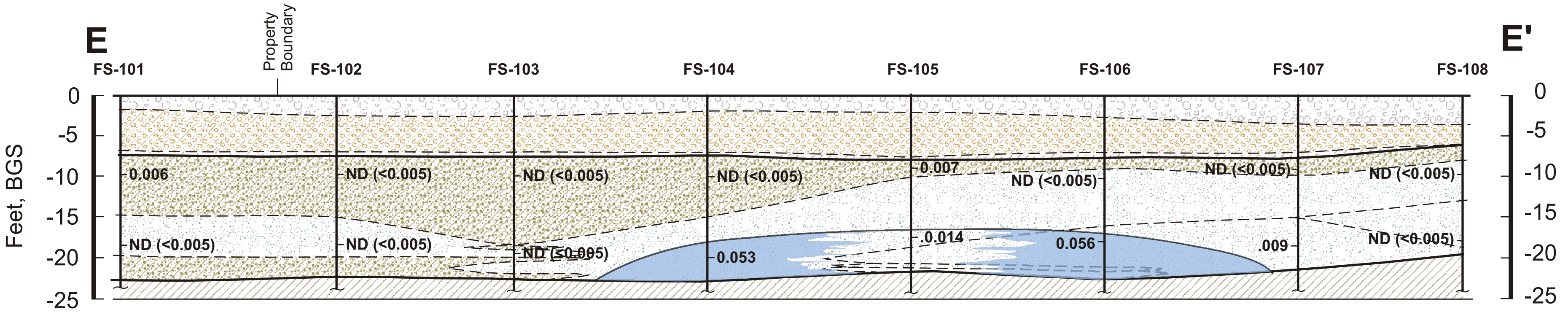
01/10 2007 Ecology Preliminary Review Draft



Approximate Ground Surface Along Transect = 11 Ft. MSL.



Geology Key

- ▨ Imported Road Material
- ▨ Silt
- ▨ Organic Silt and Peat
- ▨ Silty Sand
- ▨ Sand (Grain size)
- ▨ Silt Interbedded with Peat

Dissolved Arsenic (mg/L)

- ☐ <0.005 - 0.020
- 🟦 0.020 - 0.200
- 🟦 0.200 - 2.000
- 🟦 >2.0

0.054 Actual Concentration

-·-▼·-·- Approximate Potentiometric Surface Elevation

Notes: Refer to Figure 2.1 for cross section location.

Arsenic concentration contours are interpreted from 2006 discrete-depth sampling results.

BGS = Below Ground Surface

Horizontal Scale in Feet

0 50 100

0 20 40

Vertical Scale in Feet

Vertical Exaggeration x2.5

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Figure A.2
Cross Section E-E'
Site Hydrostratigraphy and Dissolved Arsenic Concentrations in Groundwater

g:projects/clients/floydsnider/B&L/groundwater alternatives/Figure A.2.cdr

01/10/2007 Ecology Preliminary Review Draft

Geology Key

▨ Imported Cap/ Road material	▨ Silt	▨ Silty Sand	▨ Silt Interbedded with Peat
▨ Compacted Wood Waste	▨ Organic Silt and Peat	▨ Sand	▨ Drainage Gravel

Dissolved Arsenic (mg/L)

☐ <0.005 - 0.020	🟦 0.200 - 2.000	▨ Unknown Concentration
🟦 0.020 - 0.200	🟦 >2.0	0.054 Actual Concentration

LEGEND

- ▼ Known High Water Elevation
- ▽ Known Low Water Elevation
- Monitoring Well
- Soil Boring
- 0.046 Monitoring Well Screened Interval and Dissolved Arsenic Concentration (2006 Results)
- 3.3 Discrete Depth Groundwater Sampling Interval and Dissolved Arsenic Concentration (2005 and 2006 Results)

NOTES

(1) Refer to Figure 2.1 for Cross Section Location
(2) Arsenic concentration contours are interpreted from a combination of 2005 and 2006 discrete-depth sampling and 2006 monitoring well sampling results.

SOURCES

September 2006 Borings (Appendix A)
Floyd & Snider, 2006
Hydrometrics, 1994
AGI/KJC 1990

Horizontal Scale in Feet
0 50 100

0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 2.5

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Figure A.3
Cross Section F-F'
Site Hydrostratigraphy and Dissolved Arsenic Concentrations in Groundwater

g:projects/clients/foydsnider/B&L/groundwater alternatives/Figure A.3.cdr

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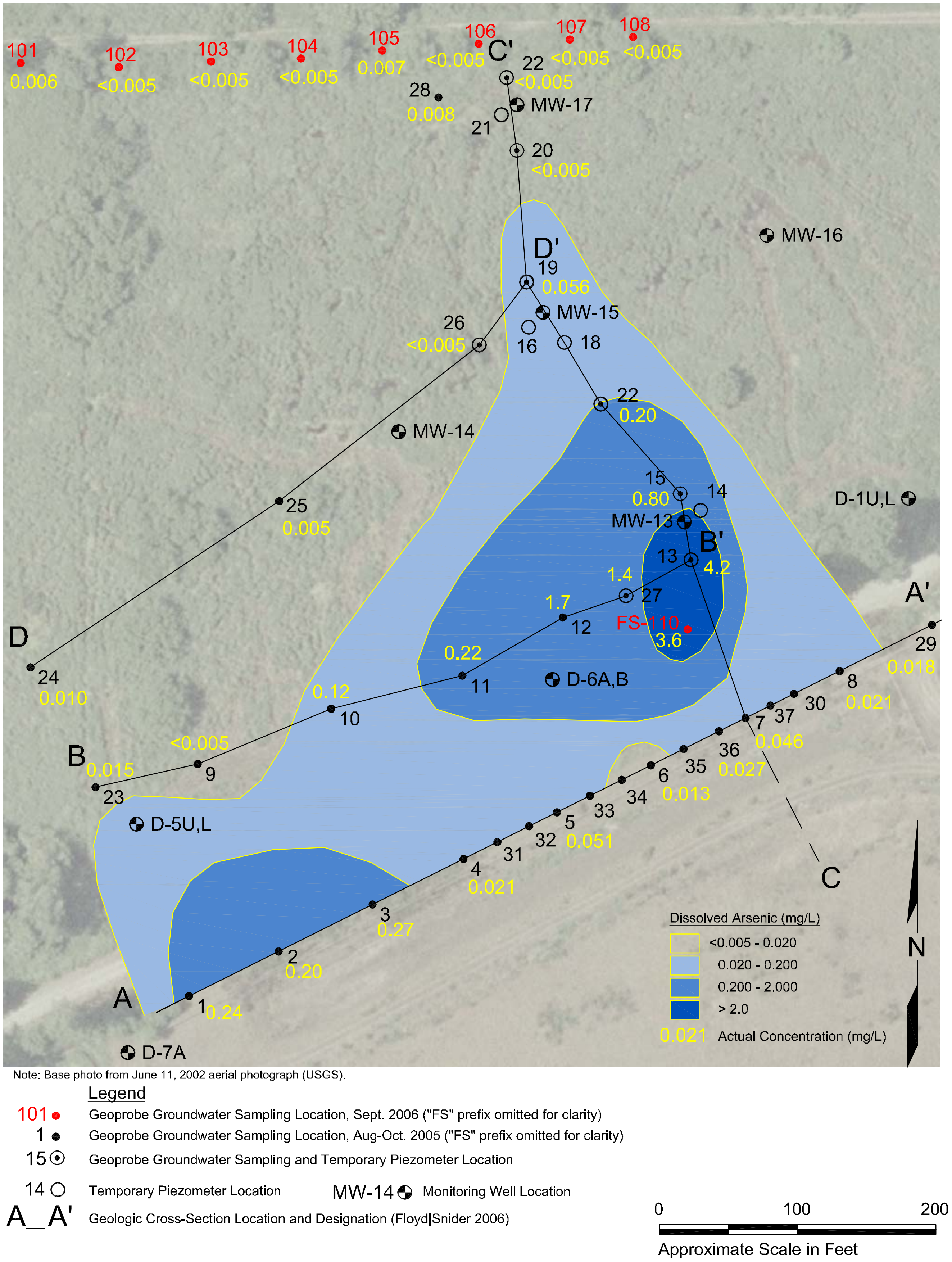

Note: Base photo from June 11, 2002 aerial photograph (USGS).

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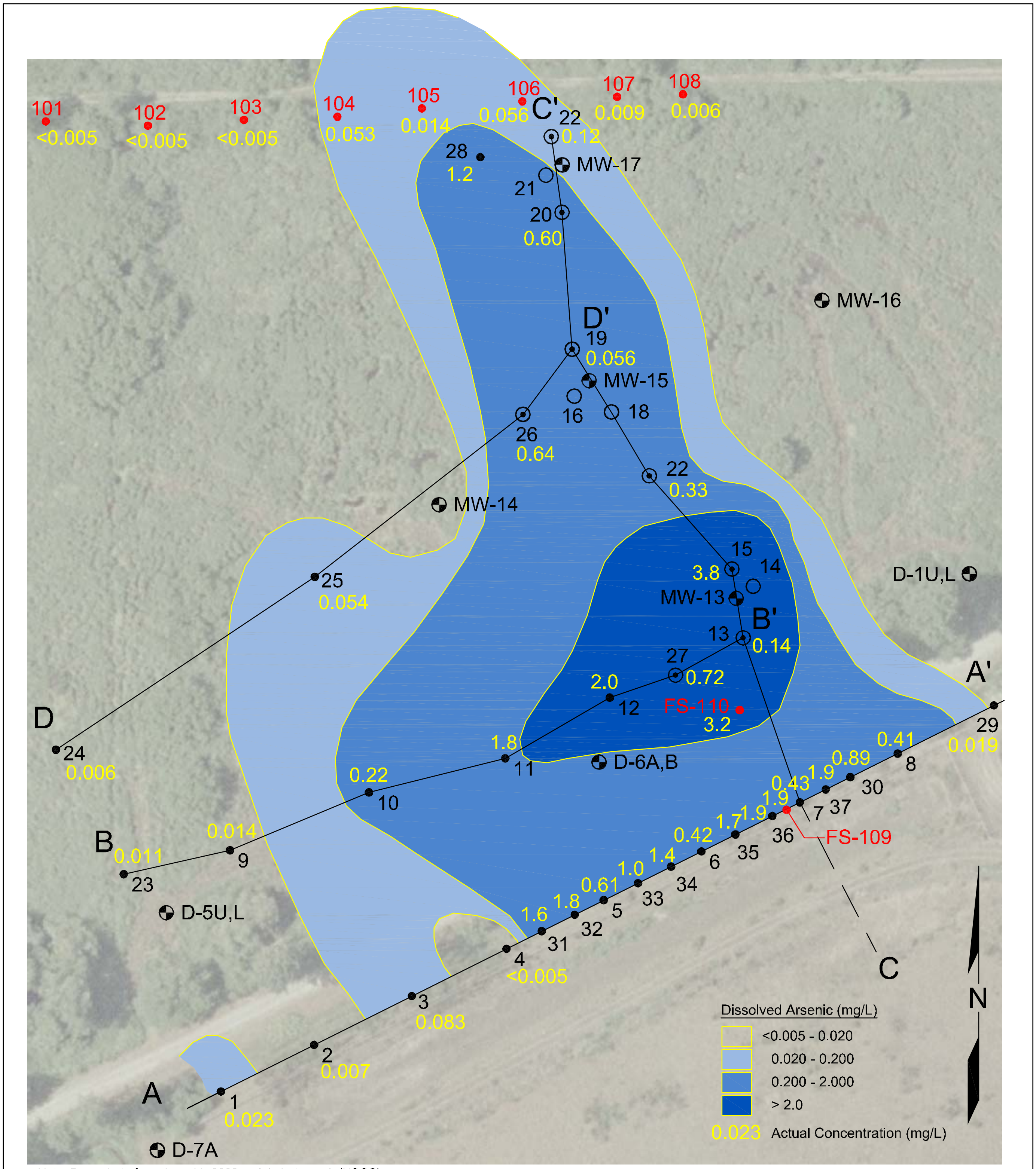
Figure A.4
Dissolved Arsenic at Top of
Upper Sand Aquifer



Note: Base photo from June 11, 2002 aerial photograph (USGS).

Legend

101 ● Geoprobe Groundwater Sampling Location, Sept. 2006 ("FS" prefix omitted for clarity)

1 ● Geoprobe Groundwater Sampling Location, Aug-Oct. 2005 ("FS" prefix omitted for clarity)

15 ⊙ Geoprobe Groundwater Sampling and Temporary Piezometer Location

14 ○ Temporary Piezometer Location MW-14 ⊕ Monitoring Well Location

A_A' Geologic Cross-Section Location and Designation (Floyd|Snider 2006)

0 100 200

Approximate Scale in Feet

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DATE: 01/08/07 10:06am

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Figure A.5
Dissolved Arsenic at Base
of Upper Sand Aquifer

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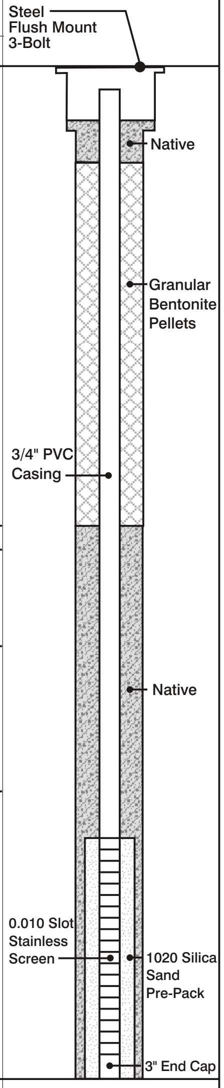
Floyd Snider
Boring FS-109/MW-30 Date 9/14/06 Sheet 1 of 1
Job B&L Landfill Job No. MPC B&L
Logged By Brett Beaulieu Weather Cloudy, High 50s
Drilled By Cascade Drilling
Drill Type/Method Track-Mounted LAR GeoProbe
Sampling Method Continuous Soil Core Sleeves, 4'
Bottom of Boring 21 Ft BGS (-7 Ft) ATD Water Level Depth 5 Ft BGS (9 Ft)
Ground Surface Elevation 14 Ft

Obs. Well Install. ☒ Yes ☐ No

SAMPLE ID	Blow Count N/12"	RECOVERY From	RECOVERY To	GRAPHIC RECOVERY	Depth	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
					0–9.5	SW-SM ∇	Brown, fine to medium, well-graded SAND with silt and gravel (Fill). Dry. Grey and wet below 5 Ft.
					9.5–10	ML	Grey SILT. Moist.
					10–12	ML	Dark grey, sandy SILT. Wet.
					12–15	SP-SM	Dark grey, fine, poorly-graded SAND with SILT. Coarsens with depth. Wet.
					15–21	SW	Drak grey, fine to medium, well-graded SAND. Coarsens with depth. Wet.
					21–25		Bottom of boring at 21 feet. Note: Ecology Well # ALN 117. Subsurface geology based on FS-7 (Floyd Snider 2006.

WELL CONSTRUCTION



∇ Groundwater Observed At Time of Drilling

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Figure A.6
Well Construction Details
MW-30

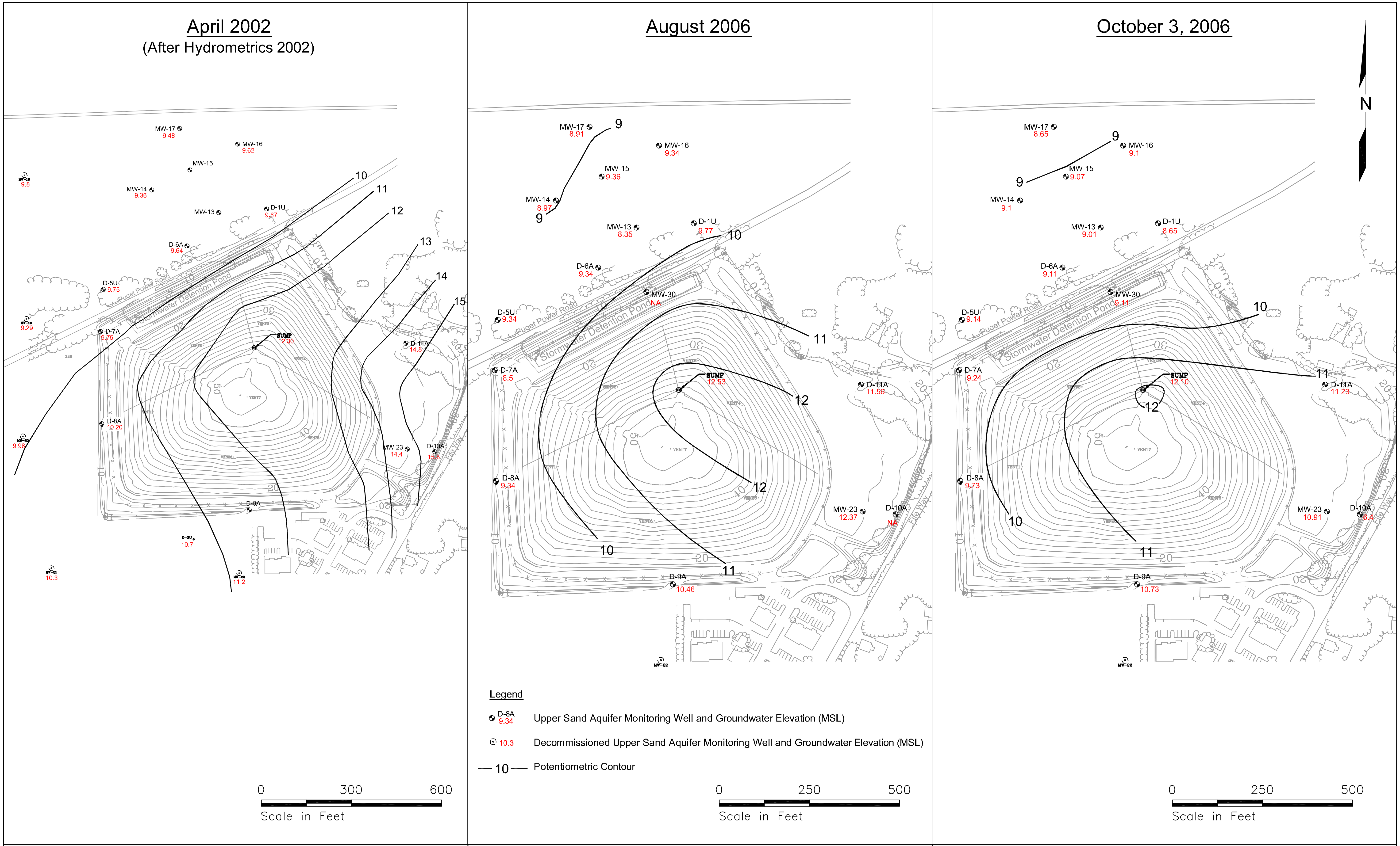

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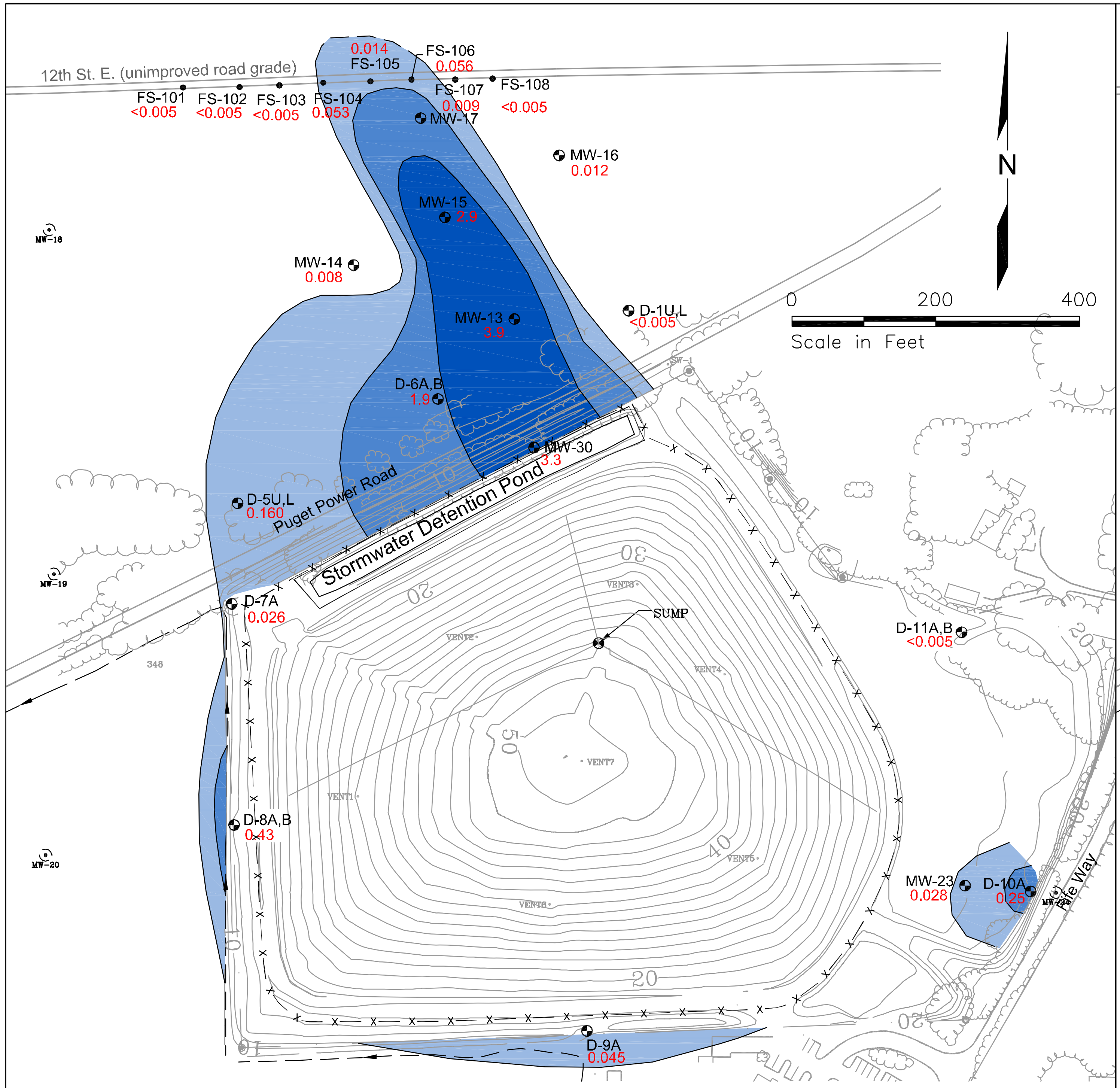
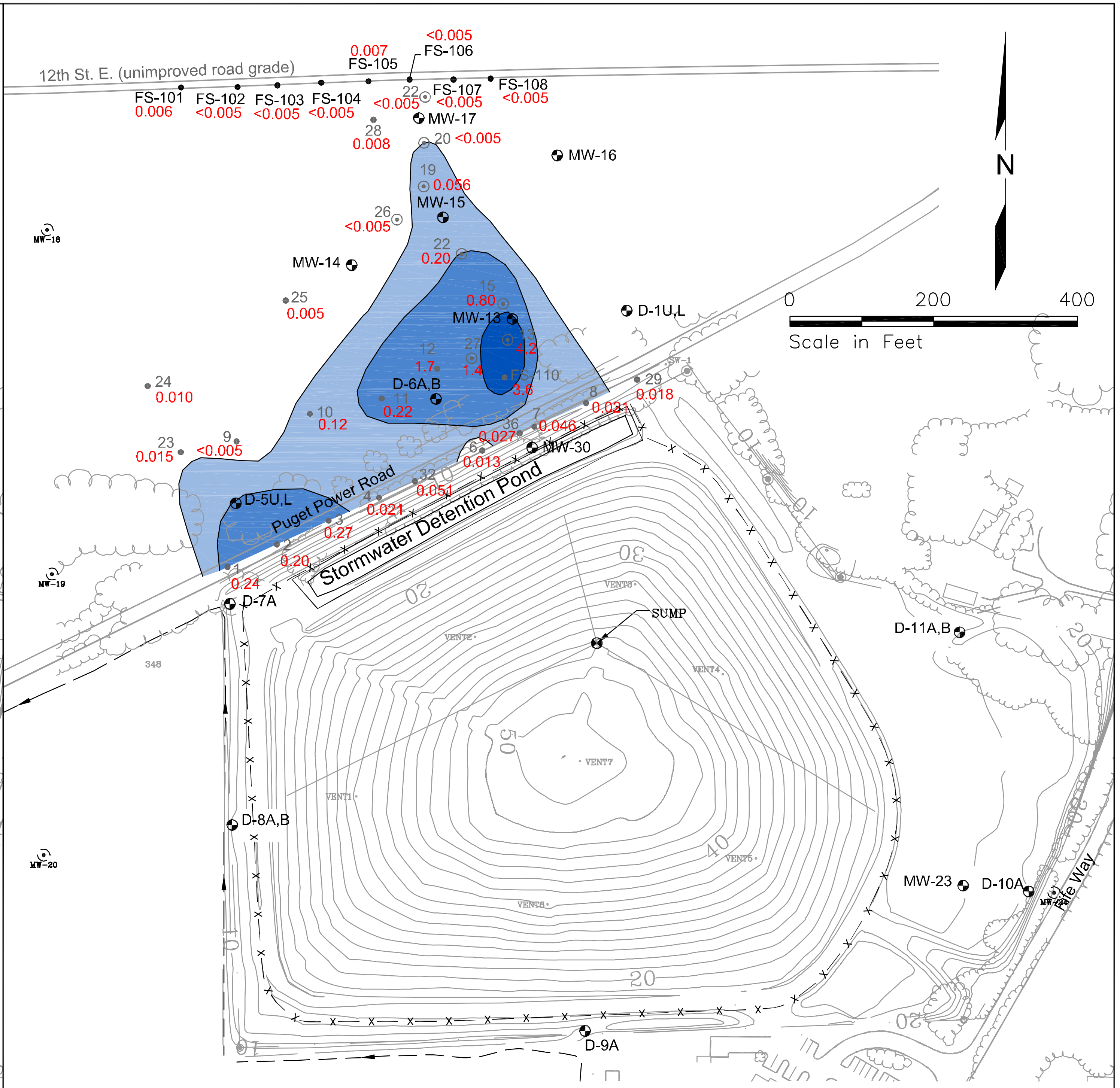
Figure A.7
Potentiometric Surfaces
Upper Sand Aquifer





Legend

- FS-102 Geoprobe Groundwater Sampling Location, Sept. 2006
- MW-15 Shallow Aquifer Monitoring Well
- Decommissioned Upper Sand Aquifer Monitoring Well
- Sump Monitoring Well

Dissolved Arsenic (mg/L)

☐ <0.005 - 0.020
▨ 0.020 - 0.200
▨ 0.200 - 2.000
■ > 2.0
0.023 Actual Concentration (mg/L)

Notes:

1. Contours based on August 2006 sampling of monitoring wells with screened intervals in the bottom 5' of the Shallow Aquifer.
2. Results from MW-17 were excluded because MW-17 is screened above this interval.
3. Only Sept. 2006 discrete-depth probe groundwater samples from the deeper interval (16-20' to 19-23' bgs) at the base of the Upper Sand Aquifer are shown.

Legend

- FS-102 Geoprobe Groundwater Sampling Location, Sept. 2006
- MW-15 Shallow Aquifer Monitoring Well
- Decommissioned Shallow Aquifer Monitoring Well
- Sump Monitoring Well
- 1 Geoprobe Groundwater Sampling Location, Aug-Oct. 2005 ("FS" prefix omitted for clarity)
- 15 Geoprobe Groundwater Sampling and Temporary Piezometer Location
- 14 Temporary Piezometer Location

Dissolved Arsenic (mg/L)

☐ <0.005 - 0.020
▨ 0.020 - 0.200
▨ 0.200 - 2.000
■ > 2.0
0.021 Actual Concentration (mg/L)

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Figure A.8
Extent of Dissolved Arsenic in the Upper Sand Aquifer

DWG NAME: G:\project\Clients\Floyd and Snider\BandL\BandL021.dwg
DATE: 01/05/07 11:56am

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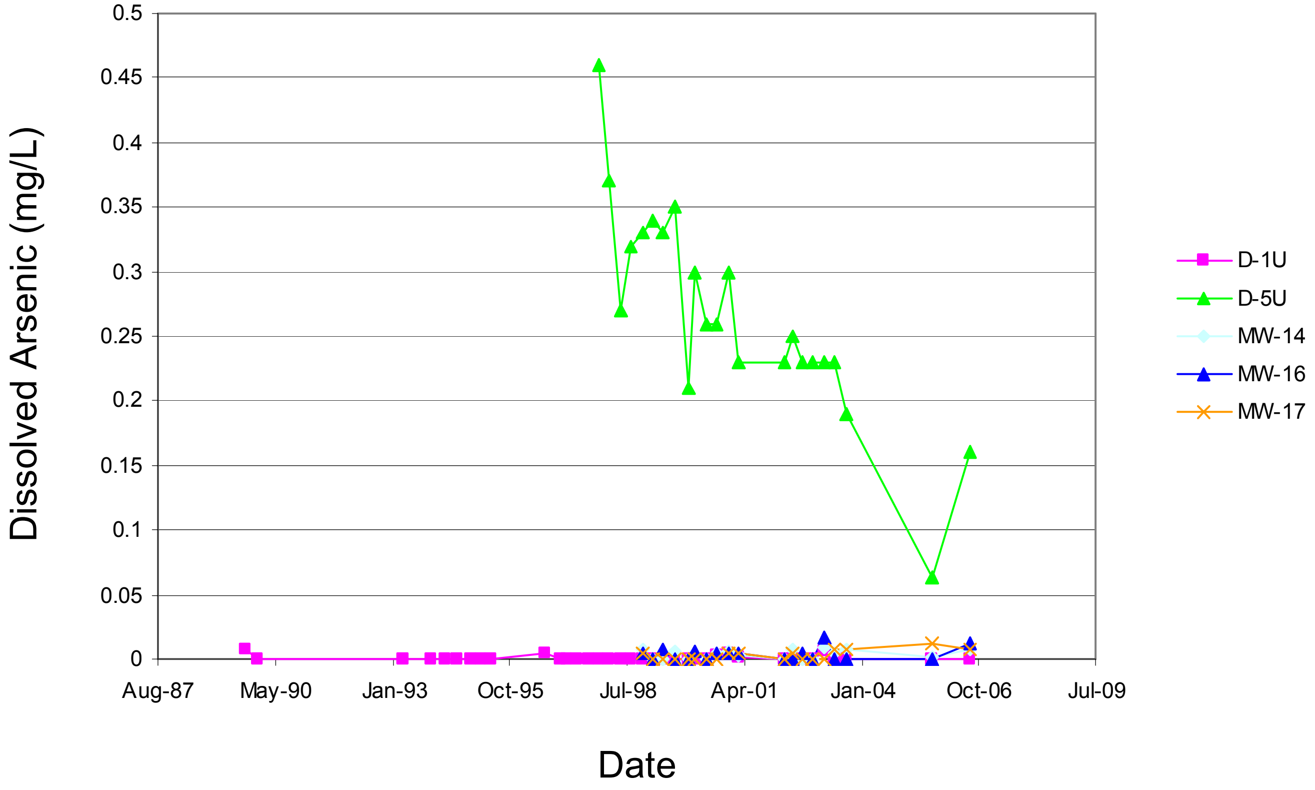

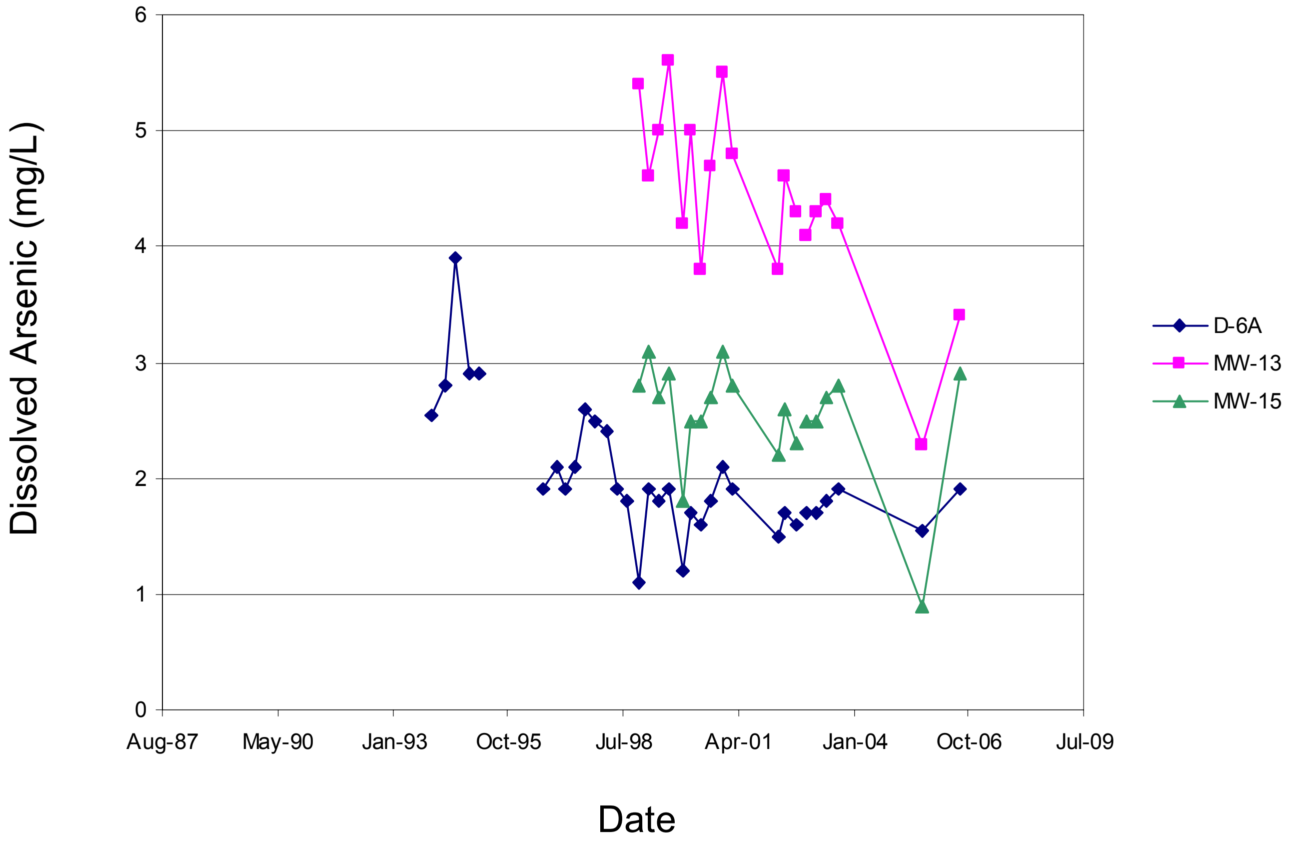

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Figure A.9
Dissolved Arsenic Concentrations in Wetland Wells Over Time

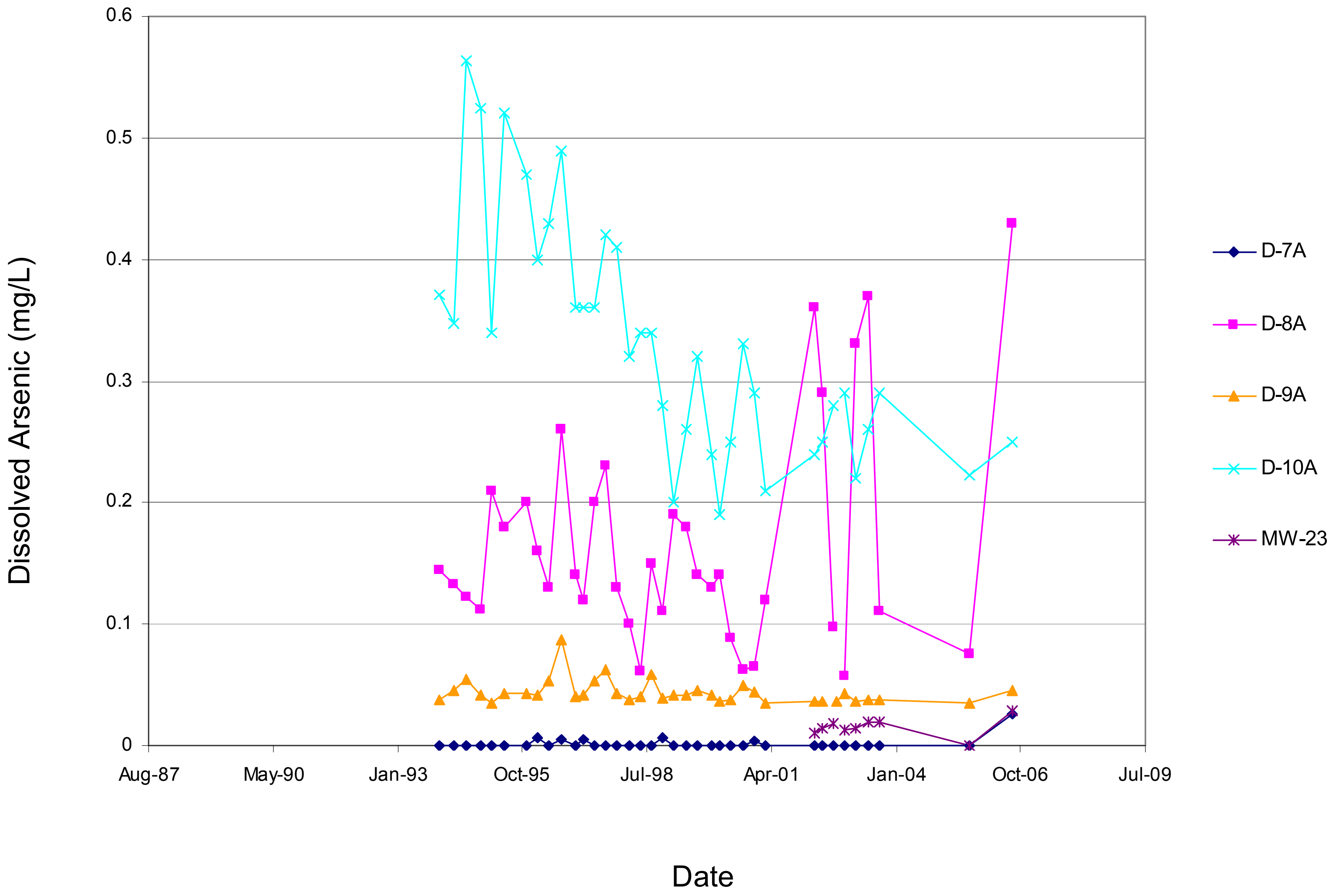

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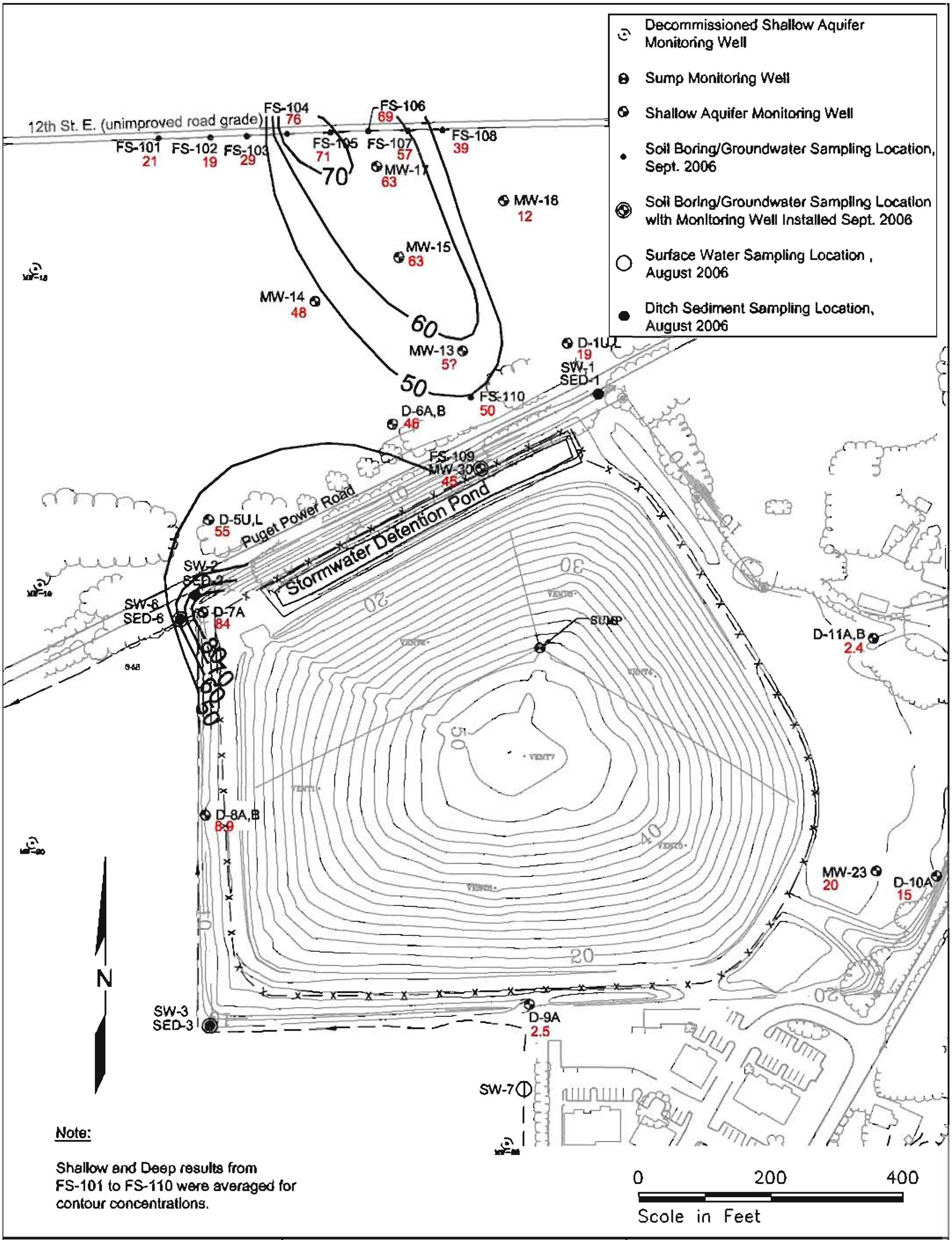
Figure A.10
Dissolved Arsenic Concentrations
In Landfill Wells Over Time



Note:

Shallow and Deep results from FS-101 to FS-110 were averaged for contour concentrations.

DWG NAME: G:\project\Clients\Floyd and Snider\BandL\BandL023.dwg
DATE: 01/05/07 12:05pm

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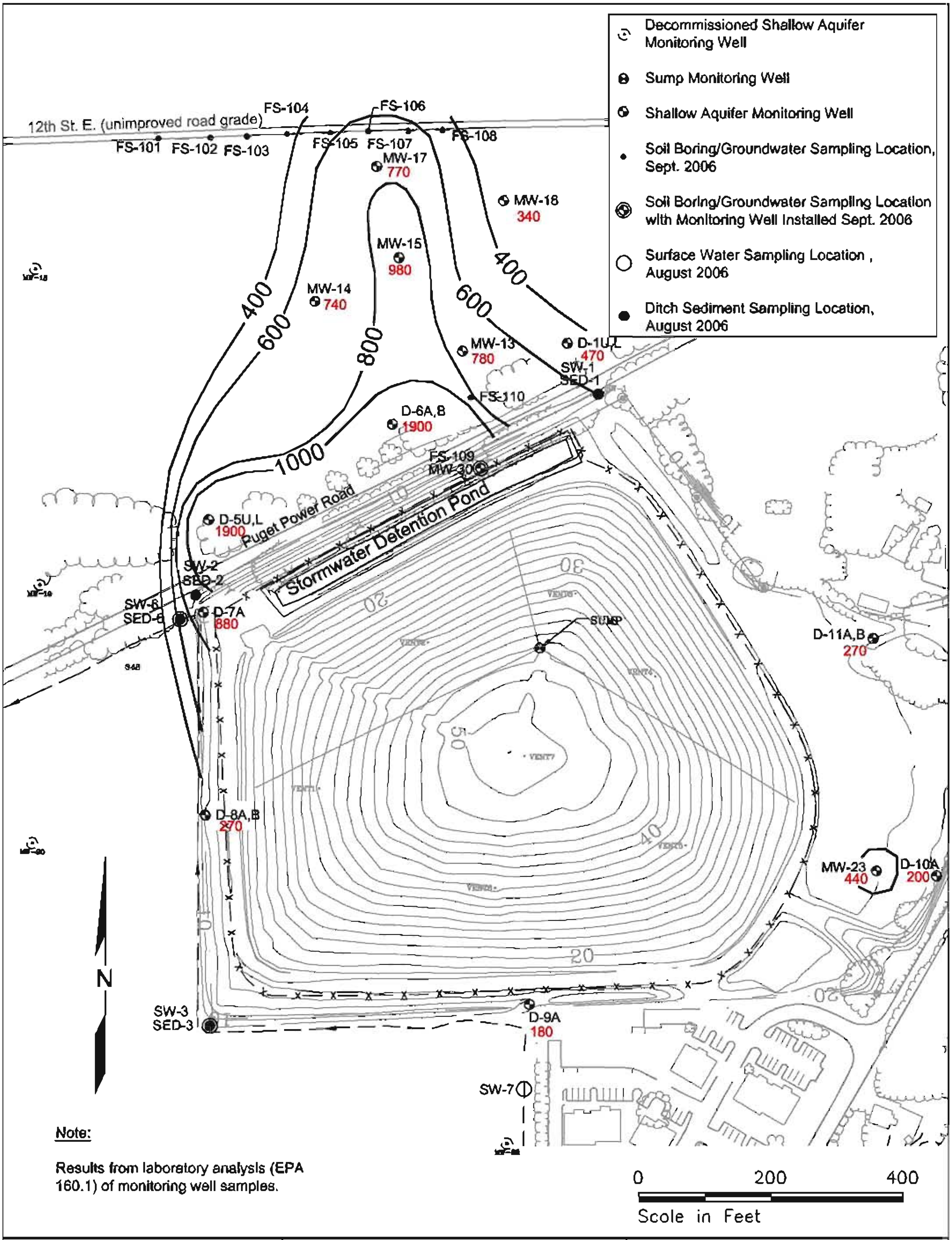
Figure A.11
Dissolved Organic Carbon
(DOC; mg/L)



Note:

Results from laboratory analysis (EPA 160.1) of monitoring well samples.

DWG NAME: G:\project\Clients\Floyd and Snider\BandL\BandL024.dwg
DATE: 01/05/07 12:05pm

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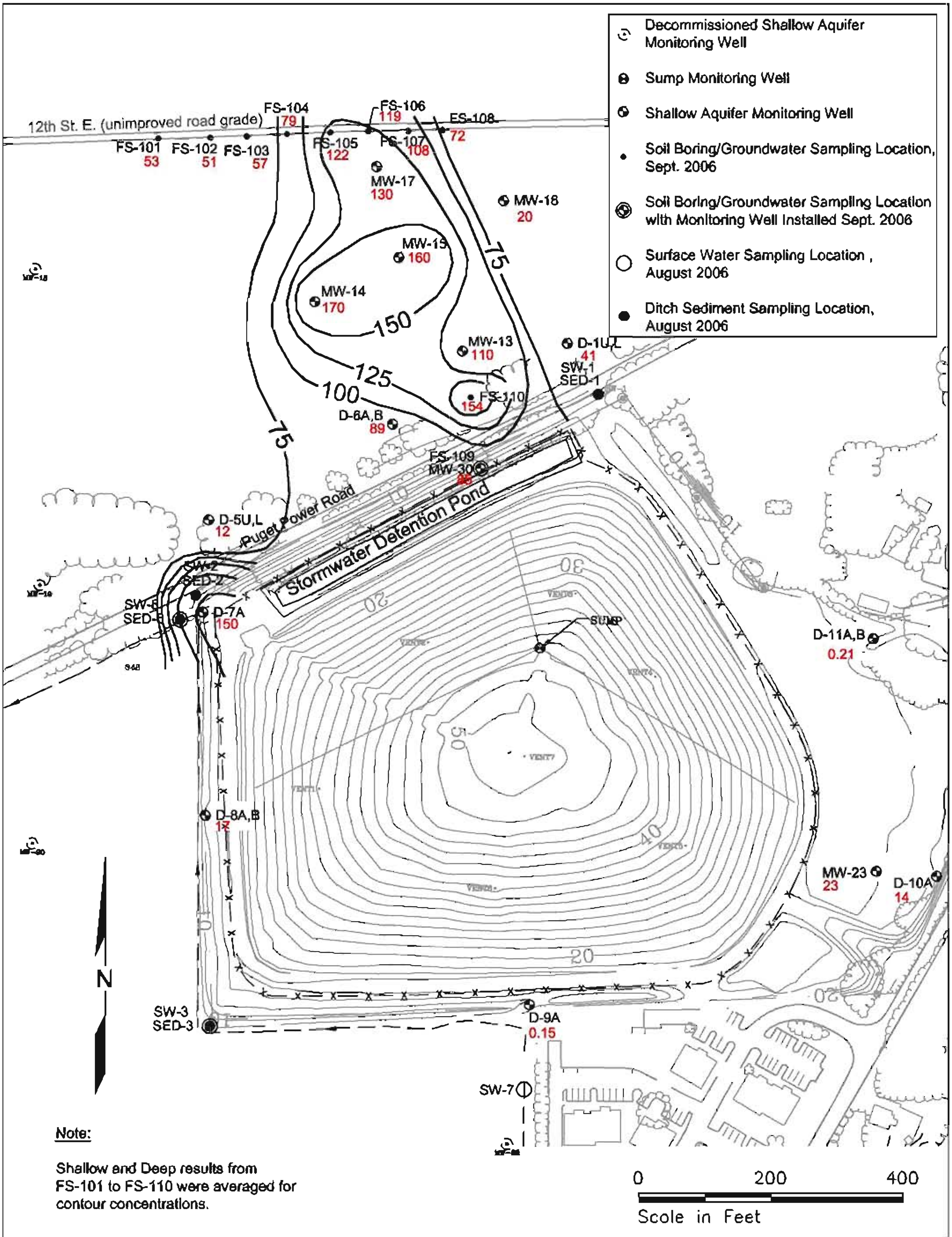
Figure A.12
Total Dissolved Solids;
(TDS, mg/L)



Note:

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DATE: 01/05/07 12:08pm

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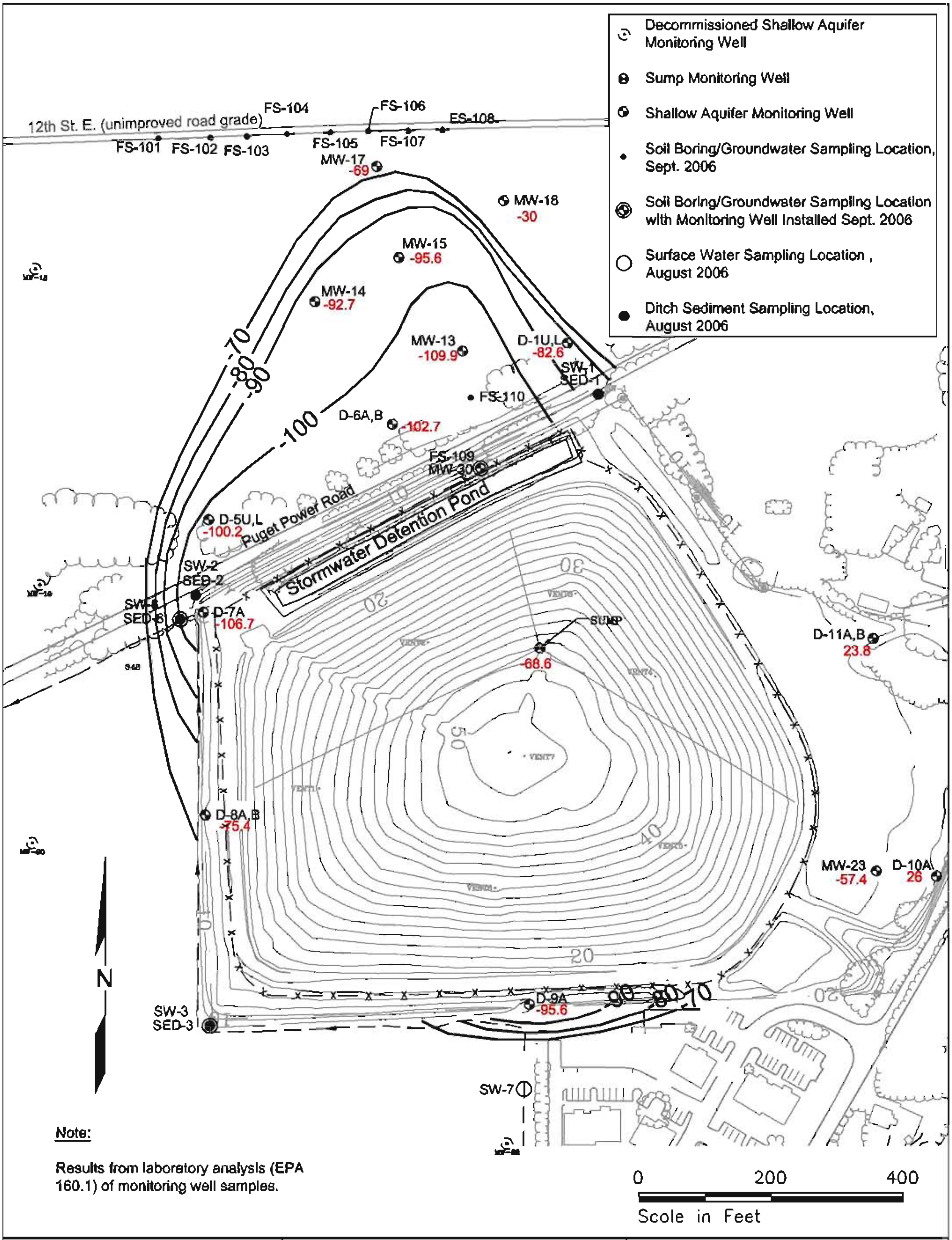
Figure A.13
Dissolved Iron;
(Fe, mg/L)



Note:

Results from laboratory analysis (EPA 160.1) of monitoring well samples.

DWG NAME: 01/05/07 12:07pm
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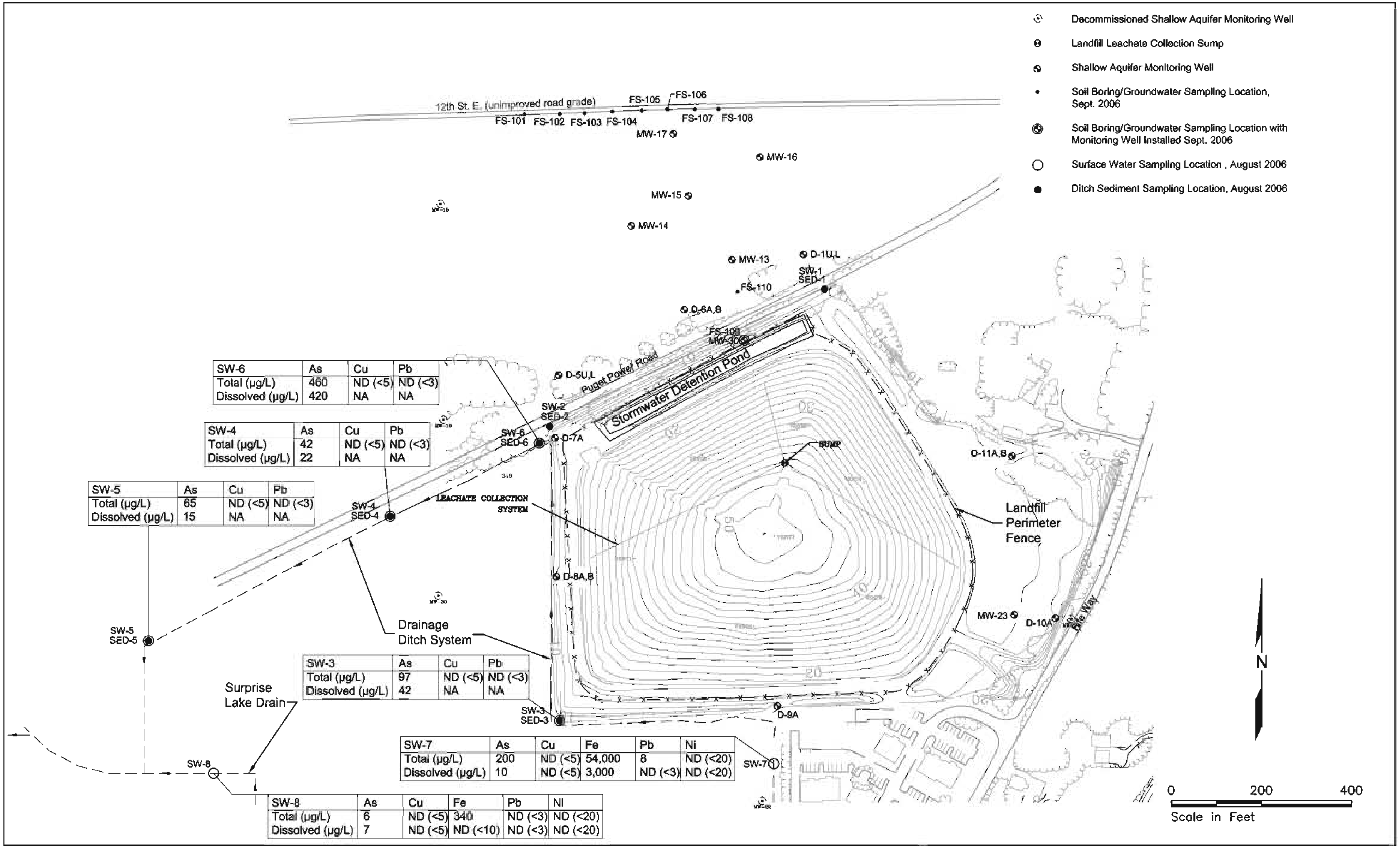
Figure A.14
Oxidation-Reduction Potential;
(ORP, mV)



SW-6	As	Cu	Pb
Total (µg/L)	460	ND (<5)	ND (<3)
Dissolved (µg/L)	420	NA	NA

SW-4	As	Cu	Pb
Total (µg/L)	42	ND (<5)	ND (<3)
Dissolved (µg/L)	22	NA	NA

SW-5	As	Cu	Pb
Total (µg/L)	65	ND (<5)	ND (<3)
Dissolved (µg/L)	15	NA	NA

SW-3	As	Cu	Pb
Total (µg/L)	97	ND (<5)	ND (<3)
Dissolved (µg/L)	42	NA	NA

SW-7	As	Cu	Fe	Pb	Ni
Total (µg/L)	200	ND (<5)	54,000	8	ND (<20)
Dissolved (µg/L)	10	ND (<5)	3,000	ND (<3)	ND (<20)

SW-8	As	Cu	Fe	Pb	Ni
Total (µg/L)	6	ND (<5)	340	ND (<3)	ND (<20)
Dissolved (µg/L)	7	ND (<5)	ND (<10)	ND (<3)	ND (<20)

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Figure A.15
Arsenic Concentrations along Agricultural Ditch System - Surface Water

DWG NAME: G:\project\Clients\Floyd and Snider\BondL\BondL010.dwg
DATE: 01/08/07 10:13am

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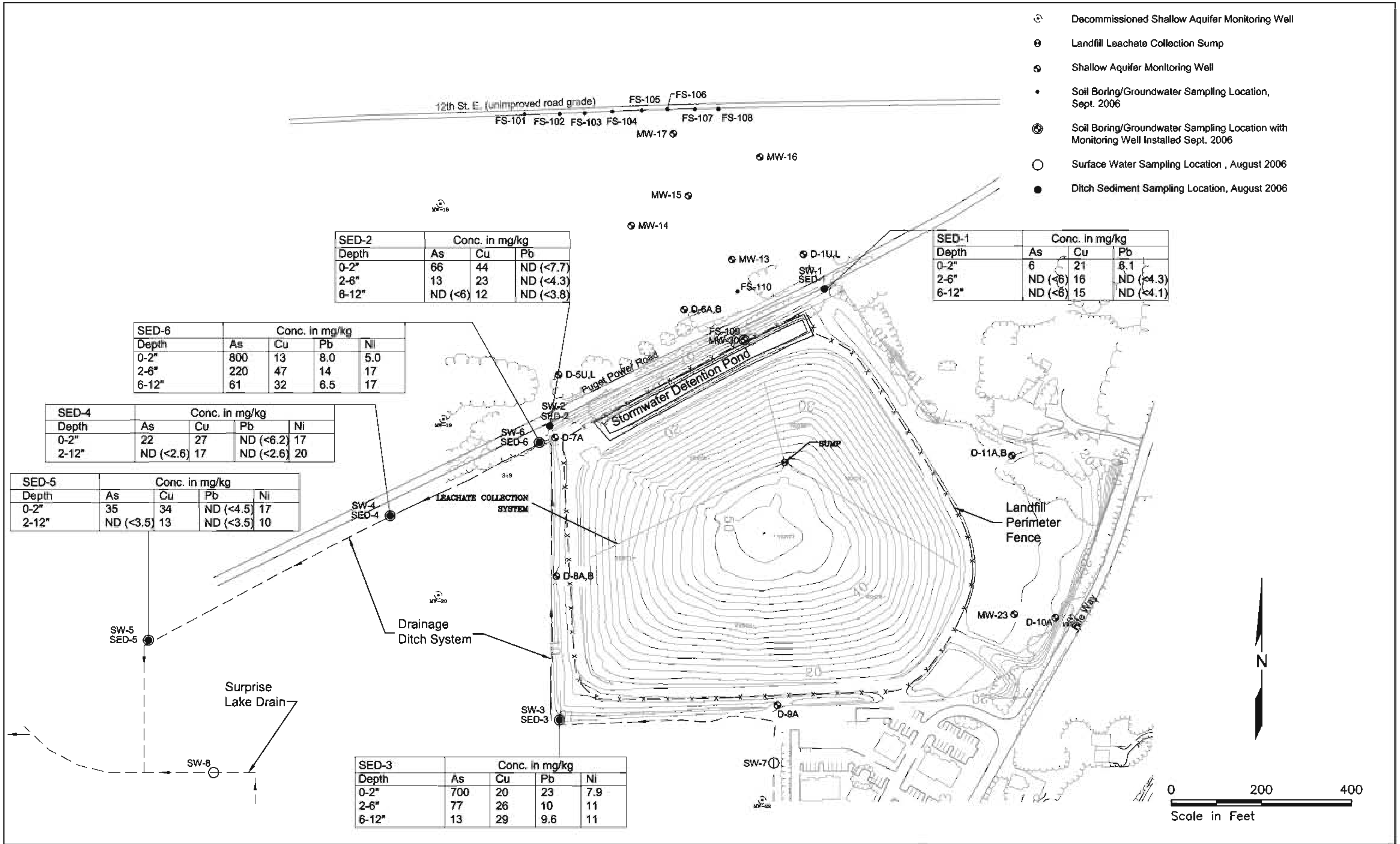

SED-2	Conc. in mg/kg		
Depth	As	Cu	Pb
0-2"	66	44	ND (<7.7)
2-6"	13	23	ND (<4.3)
6-12"	ND (<6)	12	ND (<3.8)

SED-1	Conc. in mg/kg		
Depth	As	Cu	Pb
0-2"	6	21	6.1
2-6"	ND (<6)	16	ND (<4.3)
6-12"	ND (<6)	15	ND (<4.1)

SED-6	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	800	13	8.0	5.0
2-6"	220	47	14	17
6-12"	61	32	6.5	17

SED-4	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	22	27	ND (<6.2)	17
2-12"	ND (<2.6)	17	ND (<2.6)	20

SED-5	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	35	34	ND (<4.5)	17
2-12"	ND (<3.5)	13	ND (<3.5)	10

SED-3	Conc. in mg/kg			
Depth	As	Cu	Pb	Ni
0-2"	700	20	23	7.9
2-6"	77	26	10	11
6-12"	13	29	9.6	11

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Figure A.16
Arsenic Concentrations along
Agricultural Ditch system - Sediments

DWG NAME: G:\project\Clients\Floyd and Snider\BandL\BandL011.dwg
DATE: 01/08/07 10:17am

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Appendix B
Drinking Water Exposure Pathway Factors

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1.0 Introduction

This appendix is designed to address concerns related to potential exposure to arsenic through drinking water that were expressed by the Washington State Department of Ecology (Ecology) in response to the Wetlands Investigation Data Report (Floyd|Snider 2006). Specifically, Ecology expressed concern related to the depth, continuity, and permeability of the low permeability unit (Lower Aquitard) beneath the Upper Sand Aquifer and its effectiveness in preventing migration of contaminants from reaching municipal and private drinking wells nearby.

The goal of this appendix is to address this important potential exposure pathway by integrating relevant available information on site hydrogeology and nearby drinking water wells.

2.0 Drinking Water Wells in the Vicinity of the B&L Landfill

2.1 MUNICIPAL WATER WELL LOCATIONS AND DEPTHS

The risk of contamination of municipal drinking water supply wells has been considered as part of the remedial investigation (RI) of the B&L Landfill (the Landfill; KJC and AGI 1990), as part of post-RI contingency plan activities (Hydrometrics 2001), and again as part of an Agency for Toxic Substances and Disease Registry health consultation (Washington Department of Health 2001). These reports identify several municipal wells within 1 mile of the Landfill. A search of the Washington Department of Ecology (Ecology) Well Log database was performed to identify if any new wells have been drilled in the area since the time of the above reports. The search resulted in updated information on the existing wells, and revealed that the only new municipal well installed in the area was a replacement well installed by the City of Milton, as described below. The following wells, the locations of which are shown on Figures B.1 and B.2, have been identified:

- City of Milton municipal supply Wells No. 3 and No. 9 are located in a well field 750 feet northeast (hydraulically upgradient) of the Landfill. These wells are completed in deltaic outwash deposits at depths of 78 to 200 feet below ground surface (bgs). According to the City of Milton, Well No. 3 draws from the "Redondo/Milton Aquifer." Groundwater occurs here under confined conditions (KJC and AGI 1990).
- City of Milton municipal Wells No. 6, No. 7, No. 10, and No. 12 are located 1/2 mile north-northeast of the Landfill (hydraulically upgradient) at 714 Kent Street and are completed in glacial outwash deposits at depths of 83 to 166 feet bgs in the "Redondo/Milton Aquifer." Well No. 7 is no longer in use. Available well logs for No. 10 indicate a screened interval of 102 to 153 feet bgs. In 2002, the City of Milton installed the new municipal supply well No. 12 in the same well field to replace No. 6 and No. 7. There is no indication that well No. 6 is still in use. Well No. 12 (Ecology Well ID AGP 498) was completed in the same formation to a depth of 180 feet.
- City of Fife Wells No. 1, No. 3, No. 4, No. 5, and No. 6 are located approximately 1 mile northwest of the Landfill. Of these, only No. 5 and No. 6 are active City of Fife supply Wells and No. 3 is used only as an emergency supply source. Well No. 3 is completed in a confined water-bearing zone within Vashon glacial sediments at 154 feet and No. 5 is completed in a confined water-bearing zone within pre-Vashon glacial and/or non-glacial sediments at 687 feet.

2.2 MUNICIPAL WELL WATER QUALITY

Arsenic has not been detected in any public wells maintained by the City of Milton (Washington Department of Health 2001; City of Milton 2005).

Scattered low-level detections of arsenic have been reported in several of the Fife municipal wells in recent years, although there are not any indications that these detections are associated with the B&L Landfill. City of Fife Well No. 3 reported an arsenic detection of 0.021 mg/L in May 1992 and reported a level of 0.020 mg/L arsenic in May 2000. Arsenic was detected in Fife Well No. 6 at 0.013 mg/L in June 1997 and at 0.010 mg/L in Fife Wells No. 5 and No. 6 in May 2000.

These concentrations are within the range of naturally-occurring arsenic in groundwater, which can exhibit a high degree of variability due to natural fluctuations in the quantity of arsenic dissolving into groundwater from mineral sources. In addition, these City of Fife wells are located in an industrial area, in which surficial soils may have been impacted by deposition of airborne arsenic from the Asarco Tacoma smelter. All of these wells are located outside of the zone of impacted groundwater in the wetlands north of the Landfill, as discussed below.

2.3 PRIVATE WATER WELL LOCATIONS AND DEPTHS

The residential well inventory completed as part of the RI (KJC and AGI 1990) identified 48 wells within a 1-mile radius of the Landfill, including eight within 1,500 feet of the Landfill. The inventory was based on Washington State Well Logs, the 1968 Washington State Department of Water Resources Water Supply Bulletin No. 22, and well records and construction reports from the City of Milton and the City of Fife. The closest well is the Hazen well, located 30 feet northeast of the Landfill boundary and is no longer in active use. This residence is abandoned and will soon be demolished to make way for a residential development of 10 single family homes. The Hazen well is believed to be screened in recent alluvium deposits with a total depth of approximately 55 feet. The other private wells identified within 1,500 feet of the Landfill (as part of the RI) were located to the south and include domestic and irrigation wells. These wells are completed in alluvial and deltaic sediments at depths ranging from 60 to 387 feet. An unknown number of wells are not documented in the public record (Hydrometrics 2001; KJC and AGI 1990).

This well inventory has been updated with searches of the Washington Department of Ecology Well Log database. Reliance on this database in the absence of a field survey may risk missing one or more private wells that were potentially installed without proper documentation. For this reason, in 1987 the U.S. Environmental Protection Agency (USEPA) commissioned a door-to-door inventory of the area. In recent years, well drillers must report all well installations to Ecology. Between the door-to-door survey and the well cards, the likelihood of missing a private well in the area is considered low. The locations of known private wells in the vicinity are shown in Figures B.1 and B.2. The Ecology database identified the following potentially active water wells—in addition to the list from the 1990 RI:

Name	Address	Depth	Date	Status
Darth Castan	7014 Pacific Highway E	Screened from 140 to 145 feet	Installed 1987	Unknown
Perry Reiter	6324 16th Street E	70 feet	Unknown	Unknown

2.4 PRIVATE WELL WATER QUALITY

In March 1987, 37 private wells in the vicinity of the B&L Landfill were sampled by USEPA for cyanide and inorganic chemicals on the USEPA target compound list. None of the contaminants detected in private wells during the 1987 sampling event exceeded primary drinking water standards. Arsenic was detected in one private well located northwest of the Landfill at a concentration of 0.024 mg/L (Washington Department of Health 2001).

In May 1992 and May 2000, seven private residential wells were sampled by Hydrometrics and analyzed for arsenic, lead, and nickel. The highest concentration of arsenic, 0.021 mg/L, was detected in the Gustavson well, located south (hydraulically upgradient) of the Landfill. This concentration was detected in 1992 and 2000, and was the highest concentration detected in both sampling events. A single sample result analyzed in March 2000 from a private well owner with a well located south of the site indicated a concentration of 0.031 mg/L (Washington Department of Health 2001; Hydrometrics 2001).

2.5 REGULATIONS GOVERNING FUTURE WELLS

According to Chapter 173-160 WAC (Regulations Governing Well Contractors and Operators), new water wells may not be located within 1,000 feet of an existing solid waste landfill and new water wells must be located outside of known or potential sources of contamination. Additionally, the Department of Health must approve of all new municipal well locations. Therefore, it is not administratively possible to install a new drinking water well close to the Landfill.

3.0 Relevant Hydrogeologic Conditions

3.1 LOWER AQUITARD CONTINUITY, THICKNESS, AND HYDRAULIC CONDUCTIVITY

As described in Appendix A, the arsenic plume is limited in its extent to the Upper Sand Aquifer, a sandy water-bearing unit that extends to approximately 15 to 25 feet bgs in the vicinity of the B&L Landfill. The Upper Sand Aquifer is locally separated from the next deepest water-bearing unit below by the Lower Aquitard, a low-permeability silt unit with interbedded peat layers. “Lower” distinguishes this unit from the thin Upper Silt Aquitard—a term applied during the RI to describe the ground surface prior to landfill consolidation and capping (KJC and AGI 1990). The Lower Aquitard (in combination with upward groundwater gradients) forms a critical protective barrier that limits the extent of groundwater contamination.

The extent of the Lower Aquitard beneath the Landfill was established by RI boring logs to exist across the entire landfill area, with the exception of the southwest corner, where the silt becomes sandier. The unit was observed to be between 3 and 6 feet thick. Figure B.3 illustrates the known extent and thickness of the Lower Aquitard, based both on RI well logs and recent borings. As indicated by this figure, wetlands borings indicate the presence of the silt unit across the entire area of the wetlands plume. The aquitard was observed to be up to 4 feet thick (and may be thicker) as it was never fully penetrated.

Laboratory permeability testing indicates a vertical hydraulic conductivity for the Lower Aquitard of approximately 0.004 feet/day or 10^{-6} cm/sec (Hydrometrics 2001). This vertical hydraulic conductivity agrees with the observed density, moisture content, and grain size of the Lower Aquitard, and is consistent with the expected conductivity of a confining unit. Additionally, observations during logging indicate that the unit is often “dry.”

3.2 DEEPER AQUITARD UNIT

In addition to this protective unit beneath the Upper Sand Aquifer, there are indications of one or more deeper aquitard units below the Lower Aquifer. Irrigation Well 8D3, located in the field southwest of the Landfill, was drilled to over 320 feet. No appreciable quantity of water was found in the fine grained sediments below a depth of approximately 120 feet.

3.3 UPPER SAND AQUIFER GROUNDWATER UPWARD GRADIENTS AND FLOW DIRECTION

The protectiveness of deeper groundwater by the low-permeability confining layers beneath the Upper Sand Aquifer is further supported by upward gradients. Not only does groundwater flow extremely slowly through the aquitards, but indications are that aquifer differential pressures force groundwater to discharge upward from the Lower Aquifer to the Upper Sand Aquifer, or not to flow at all.

Based on data collected in the RI, vertical hydraulic gradients between the lower and upper sand units are flat or slightly upward in the Landfill and show an increasingly upward trend in the wetland area immediately north of the Landfill (Hydrometrics 2001). Water levels are approximately one foot higher in the lower sand unit than in the upper sand unit in the wetland area. Many of the residential wells in the area south of the Landfill are reported to be flowing (artesian) wells; indicating a general upward vertical gradient in the lowland area. The extent of the upward vertical gradient is unknown, but is expected given that the wetlands lie in a regional groundwater discharge area.

In addition, the north-northwesterly flow direction of groundwater in the Upper Sand Aquifer conveys groundwater potentially contaminated with arsenic away from nearby municipal and private wells. City of Fife municipal wells, although downgradient of the plume, are located approximately one mile away. The Lower Aquifer groundwater flow direction is also generally to the northwest, so in the event that arsenic contaminated this unit, it would continue to be transported away from nearby wells.

In summary, a number of factors combine to eliminate the risk of drinking water contamination due to arsenic-contaminated groundwater from the B&L Landfill. These include:

- The existing groundwater plume is well defined and exists solely in the Upper Sand Aquifer, which is not utilized by drinking water wells.
- Several aquitards exist between the Upper Sand Aquifer and the deeper drinking water aquifers.
- Upward gradients prevent downward migration of arsenic to deeper aquifers.
- Nearby City of Milton wells have never had detectable amounts of arsenic.
- All other wells are located either upgradient of the Landfill or approximately one mile away.
- Current regulations forbid the installation of new drinking water wells within 1,000 feet of the Landfill.

4.0 References

City of Milton. 2005. *About Our Water. Consumer Confidence Report 2005*. Milton, Washington.

Floyd|Snider. 2006. *Wetlands Investigation Data Report.*

Hydrometrics, Inc. 2001. *Review of Remedial Activities at the B&L Landfill.* Prepared for Mr. Thomas E. Martin, Site Manager ASARCO Incorporated. May.

Kenndy/Jenks/Chilton (KJC) and AGI. 1990. *Focused RI/FS B&L Woodwaste Site*. Prepared for Murray Pacific.

Washington State Department of Health, 2001. Health Consultation, B&L Woodwaste Landfill, Tacoma, Pierce County, Washington. August.

B&L Landfill

Groundwater Alternatives Evaluation

Appendix C
Cost Calculations

Table C.1
Cost Estimate Summary Sheet of Landfill CAA

Remedial Strategy		Capital Costs			Annual Costs for Operations, Maintenance, & Monitoring				Total
		Assumptions	Base Capital Cost[1]	Capital Costs Plus Contingency[2]	Assumptions	Annual OM&M Cost	50-year OM&M Cost[3]	Present Value 50-year OM&M Cost[4]	Total of Capital, Contigency, & Present Value of OM&M[5]
No Further Action	Includes OM&M costs for existing-1993 Remedy. Does not assume compliance with MTCA.	Installation of additional Site-wide groundwater monitoring wells and revision(s) to existing Compliance Monitoring Plan.	$29,000	$109,000	Site wide semi-annual groundwater monitoring with annual reporting; 5-year Ecology Review Process, no changes in remedy; maintenance of existing cap and fence, access fee for wetlands.	$91,000	$4,550,000	$2,860,000	**$2,970,000**
Slurry Wall with Interceptor Drain	Isolate landfill and groundwater behind perimeter slurry wall barrier keyed into underlying silt aquitard and tied into existing liner; include upgradient interceptor drain to relieve groundwater pressure on slurry wall.	Install to 20-25' below ground surface using one-pass trencher. 1,100 LF of Interceptor drain 5' deep with lift station to infiltration pond (Sheetpile barrier cost would be approximately $3.6 million).	$1,503,000	$1,891,000	Operations and maintenance on slurry wall and lift station for interceptor drain; additional performance monitoring on containment system.	$20,000	$1,000,000	$628,000	**$2,520,000**
In-situ Treatment of Groundwater using a PRB.	Treat groundwater as it exits landfill using a permeable reactive barrier (PRB).	Option 1: No Funnel 600' zerovalent iron PRB. Includes 15% proprietary cost to U. Waterloo.	$2,363,000	$2,950,000	PRB replacement and disposal every 20 years and quarterly performance monitoring.	$133,000	$6,650,000	$4,179,000	**$7,130,000**
		Option 2: With Funnel Funnel and gate with partial (200') zerovalent iron PRB. Includes 15% proprietary cost to U. Waterloo.	$1,692,000	$2,329,000	PRB replacement and disposal every 10 years, quarterly performance monitoring and semiannual groundwater monitoring. Reinjection system O & M.	$72,000	$3,600,000	$2,262,000	**$4,590,000**
Excavation of Ditch Sediment	Excavation of Impacted Sediment at Base of Ditches.	Assumes 600 lf of contamination, 2 ft deep and another 600 lf of contamination that is > 1 ft deep; Subtitle D disposal.	$35,000	$71,000	No O&M requirement	$0	$0	$0	**$71,000**
	Excavation followed by Ditch Burial.	Excavates perimeter ditch where contaminated and backfills perimeter area with clean soil	$41,000	$73,000	No O&M requirement	$0	$0	$0	**$73,000**
	Excavation followed by Tightlining of Ditch with 12" diameter PVC pipe.	Assumes 1000 LF of 12" PVC pipe, and backfill w native, followed by ditch burial	$48,000	$75,000	No O&M requirement	$0	$0	$0	**$75,000**

Notes

1 Capital Costs include engineering design, permitting, construction management and construction.

2 Unless otherwise noted, contingency costs are set at a minimum of 30% of construction cost, and increased as appropriate for remedial actions with specific risks of unknowns; see appendices for examples.

3 50 years, rather than the standard 30 years for solid waste landfill, has been assumed at Ecology's request.

4 The 2% discount rate used in the PV calculation is a real rate that assumes a risk free rate of approximately 5%, net of inflation of approximately 3%.

5 The sum of capital costs, contingency, and present value of O&M Costs.

Table C.1a
No Further Action Costs (includes OM&M for 1993 Remedy)

Includes the following elements:

This alternative includes the costs for Operations, Maintenance, and Monitoring for the 1993 Remedy and basic landfill closure requirements.

This alternative also includes the on-going cost for access in the Wetlands and for Taxes on the Wetlands and Landfill Parcels; since these would be required even if no further remedial action were implemented.

Installation of additional downgradient monitoring wells to monitor plume stability.
Semiannual groundwater sampling of 14 wells for field parameters and arsenic.
Landfil cap inspections and minor repairs to cap and fence.
Annual Reporting to Ecology.
Five-year Annual Review under MTCA: meetings and minor additional reporting.

CAPITAL COSTS

Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Well installation and development	each	$3,000	3	$9,000	12" auger to 20', 2" PVC shallow wells plus oversight.
GW Monitoring Plan Update & Negotiations				$20,000	
Capital Cost Total:				**$29,000**	

Contingency	**Units**		**Quantity**	**Estimated Cost**	**Comments**
Additional agency negotiations and report drafts due to adjacent restoration projects	LS	$50,000	1	$50,000	
Additional monitoring wells due to adjacent restoration projects	each	$3,000	10	$30,000	12" auger to 20', 2" PVC shallow wells plus oversight.
Capital Cost Contingency				**$80,000**	
Capital Cost with Contingency				**$109,000**	

ANNUAL O&M COSTS (Includes monitoring)

Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Semi-Annual Monitoring				$27,000	
Staff Time	*hrs*	*$90*	*90*	*$8,000*	
Analytical	*sample*	*$125*	*30*	*$4,000*	*Assumes 14 wells (sump, MW-23, D-11A, D-9A, D-8A, D-7A, D-5U, MW-13, MW-30, MW-14, MW-17, 3 new wells (one west, two beyond 12th), 1 duplicate, t&d As, field parameters*
Field Equipment	*each*	*$3,000*	*2*	*$6,000*	
Annual Reporting	*hrs*	*$90*	*100*	*$9,000*	
5-Year MTCA Review Reporting & Negotiation	hrs	$100	250	$5,000	Or $25K every 5 years.
Inspections and maintenance of cap and fence	annual	$20,000	1	$21,000	Assumes monthly inspection of cap and fencing, repairs, lawn mowing and related upkeep activities.
Wetlands Access Agreement	month	$3,000	12	$36,000	Lease payment or mortgage&taxes on 8.8 acre wetlands parcel.
Landfill Taxes	annual	$2,000	1	$2,000	
Annual O & M Total				**$91,000**	

Table C.1b
Slurry Wall Costs

Includes the following elements:

Estimated costs for containing and isolating B & L landfill materials from groundwater outside the existing perimeter include costs for site preparation, barrier installation, sealing cap materials to barrier, and O & M. The estimate is based on the following assumptions:
- Containment wall is installed around the 2700 linear feet of landfill perimeter at woodwaste and cap limit. (Fenceline perimeter is 3000 linear feet).
- Containment wall is installed to 20' below ground surface (bgs) and keyed into silt aquitard unit where available.
- Cap materials will be sealed to containment wall perimeter or otherwise seal out infiltration.
- O & M will include continued groundwater monitoring

CAPITAL COSTS					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Costs**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	$100,000	1	$100,000	Assumed. Reflects mob/demob cost estimate by Dewind of $50K, plus additional site preparation costs.
Slurry wall installation	LF	$125	2700	$338,000	Assumes installation of 20-25-ft deep by 2-ft wide by 2,700 feet long Soil-Bentonite Slurry Wall using Dewind one-pass trenching technology.
Cap extension	LF	$60	2700	$162,000	Assumes 10 square feet 80 mil liner ($65/SF) and 7 CY of imported pit run ($6.67/CY) for per LF of barrier, plus labor to install ($6.50/LF).
Performance monitoring well installation	EA	$3,000	5	$15,000	Installation of additional wells to monitor groundwater gradients and performance of slurry wall
Subtotal				**$615,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Costs**	**Comments**
Overall Project Management, Design and permitting	%	$615,000	0.8	$492,000	Project Managment, pre-design treatibility studies, engineering design and permitting, MTCA construction close-out reporting at 80% of construction costs
Construction Management	%	$615,000	0.1	$62,000	Set at 10%; roughly corresponds to 50 workdays for one FTE at $1250/day; assumes efficiency of Dewind technology
Subtotal				**$554,000**	
Capital Cost Total				**$1,169,000**	
Construction Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Costs**	**Comments**
Contingency at 50%	%	$615,000	0.5	$308,000	50% contingency on construction costs, primarily if use of cost effective one-pass Dewind trenching is not possible and standard trenching methods must be used instead.
Capital Cost Contingency				**$308,000**	
Capital Cost with Contingency				**$1,477,000**	
ANNUAL O & M COSTS					
Action	**Units**		**Quantity**	**Estimated Costs**	**Comments**
Groundwater Monitoring	Semi-annual	$0	2	$0	Costs captured in the annual OM&M Cost sheet.
Repairs and upgrades	Annual	$10,000	1	$10,000	Assumes $100,000 in repairs and upgrades every 10 years.
Annual O & M Total				**$10,000**	

Table C.1c
Interceptor Drain for Slurry Wall

Includes the following elements:
Assumes that the interceptor drainis 1100 linear feet, 4 ft wide, and 5 ft deep, and contains a 18-in perforated pipe in pea gravel.
Assumes a small pump station that discharges the clean water into the existing infiltration pond.
Assumes that this trench is only installed in conjunction with the slurry wall remedial aciton.

CAPITAL COSTS					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Costs**	**Comments**
Mobilization, Demobilization, Site Preparation	EA	$23,800	1	$24,000	Assumes 10% mobilization costs beyond the slurry wall mobilization.
Filter Fabric	SY	$5	580	$3,000	Engineer's Estimate
18" PVC Perforated Pipe	LF	$35	1,100	$39,000	Material and labor to install, Familian NW, Kent
Pea Gravel	TON	$13	122	$2,000	2006 The Guide DIV 2-5, 2236.16
Dewatering	LF	$15	1,100	$17,000	Engineer's Estimate
Excavation	CY	$10	815	$8,000	2001 RSMeans 02315-0610-0050, page 023-7. Adjusted for inflation, does not include dewatering
Compaction	CY	$51	815	$42,000	2004 RSMeans 02315-0015+0600-110, page 023-1. Adjusted for inflation, includes backfill
Trench Subtotal				**$135,000**	
Manhole	EA	$5,000	4	$20,000	Engineer's Estimate 3 Manhole are for cleanouts
Pumps	EA	$5,000	2	$10,000	Engineer's Estimate, double pump contingency
Controls	LS	$10,000	1	$10,000	Engineer's Estimate
Mechanical	LS	$15,000	1	$15,000	Engineer's Estimate
6" PVC Force Main	LF	$4	1,187	$5,000	Material and labor to install, 2006 The Guide DIV 2-9, 2625.15
Pea Gravel	TON	$13	1,319	$17,000	2006 The Guide DIV 2-5, 2236.16
Dewatering	LF	$15	1,187	$18,000	Engineer's Estimate
Excavation	CY	$10	528	$5,000	2004 RSMeans 02315-0610-0050, page 023-7. Adjusted for inflation, does not include dewatering
Compaction	CY	$51	528	$27,000	2004 RSMeans 02315-0015+0600-110, page 023-1. Adjusted for inflation, includes backfill
Pump Station Subtotal				**$127,000**	
Construction Subtototal				**$262,000**	
Optional Fife Way Upgrades	*LS*	*$50,000*	*1*		*Guestimate used as a place holder.*
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Costs**	**Comments**
Design and permitting				$66,000	Specific design and permitting associated with discharge of clean water into infiltration pond; other permitting and reporting included in Slurry wall reporting.
Construction Management				$6,000	Added 5 additional days to slurry wall construction oversight.
Subtotal				**$72,000**	
Capital Cost Total				**$334,000**	
Construction Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Costs**	**Comments**
Interceptor Drain				$80,000	30% contingency on construction (and construction oversight) primarily due to need to reroute to coordinate with other projects in watershed.
Capital Cost Contingency				**$80,000**	
Capital Cost with Contingency				**$414,000**	
ANNUAL O & M COSTS					
Action	**Units**		**Quantity**	**Estimated Costs**	**Comments**
Interceptor drain pump station maintenance.	Annual	$10,000	1	$10,000	Engineer's estimate includes 100 hours operator time for PS only (~2hours per week @ $100/hour). No annual cost expected for infiltration trench.
Annual O & M Total				**$10,000**	

Table C.1d
Permeable Reactive Barrier With Wing Walls

Includes the following elements:

This alternative installs a PRB across the 600 ft landfill boundary with the wetlands. The estimated costs include the following:

Costs are based on the following assumptions:the cross-sectional area of groundwater flow to be treated is approximately 600 feet long by 20 feet deep (15 feet saturated); the hydraulic gradient is approximately 0.003; the hydraulic conductivity the upper sand aquifer is approximately 100 to 200 feet/day. Conservative estimated maximum discharge at northwest exit is 100 gpm for the entire 600 foot length.

Costs are based on use of zerovalent iron (ZVI) media, which is the most proven technology for arsenic, and costs approximately $700/ton, plus a proprietary cost of 15% of construction and materials to U. Waterloo/EnviroMetal Technology. Alternative PRB media include EHC-M, an organic/iron mix that further reduces As and permanantly precipitates Fe sulfides (AdventusRemediation, parent company of EnviroMetal Technology or ETI). This media costs $4000/ton, requires less material than ZVI, but requires sulfates, which are non-detect at the site. A third media is oxygen furnace slag from ETI, which costs $30-40/ton but may increase groundwater pH significantly due to lime.

CAPITAL COSTS		**Unit Cost**			
Construction costs	**Units**		**Quantity**	**Estimated Cost**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	$100,000	1	$100,000	Fence removal, access, grading, erosion controls, etc. Cost assumed.
Barrier installation	LF	$300	200	$60,000	Assumes 100-ft long wing wall on each side of PRB wall using conventional methods.
PRB treatibility testing	LS	$40,000	1	$40,000	Laboratory column flow-through testing including analytical costs.
PRB installation	LF	$2,520	600	$1,512,000	Assumes zerovalent iron PRB is 15' deep and 3' thick, 67% zerovalent iron/33% sand, 3 tons ZVI/LF, 1 ton sand/LF, iron at $700/ton, sand at $20/ton. Installation $400/LF. Costs less for furnace slag instead of iron. 600 foot length based on full treatment zone. Total ZVI is 1800 tons.
U. Waterloo proprietary cost	%	$1,552,000	15%	$233,000	Maximum 15% of material and construction cost.
Performance monitoring well installation	EA	$3,000	4	$12,000	To monitor treatment performance downgradient and ensure complete capture by barrier with wing walls.
Subtotal				**$1,957,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Overall Project Management, Design and permitting	%	$1,957,000	0.8	$356,000	Project Management,Pre-design studies, engineering design and permitting, MTCA construction close-out reporting at 80% of contruction costs (excluding the PRB material cost)
Construction Management	%	$1,957,000	0.1	$50,000	Corresponds to 40 workdays for one FTE at $1250/day.
Subtotal				**$406,000**	
Pre-Contingency Total				**$2,363,000**	
Construction Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Contingency at 30%	%	$1,957,000	0.3	**$587,100**	Contingency set at 30% of Construction. Most likely cause would be requirement for an additional 3 to 5 feef of height to the PRB or relocation of the existing stormwater pond (to the wetlands)
Project Total w Contingency				**$2,950,000**	
O & M COSTS					
Item	**Units**		**Quantity**	**Estimated Cost**	**Comments**
Maintenance - PRB replacement	annualized	$97,000	1	$97,000	Cost based on replacement of PRB every 20 years; annual cost is 1/20th of replacement cost.
Maintenance - PRB disposal	LF	$27	600	$16,000	Cost based on disposal of PRB in Subtitle C landfill every 20 years; annual cost is 1/20th of disposal cost. Material should be <1% As by weight. Weight is 4.5 tons/LF. Unit cost for disposal is $120/ton to cover handling, dewatering, shipping, and disposal.
Groundwater monitoring	Annual	$0	1	$0	Costs captured in annual OM&M costs for the 1993 Remedy.
Performance monitoring	Annual	$20,000	1	$20,000	Cost based on quarterly sampling of 4 performance monitoring wells in conjunction with other monitoring and annual reporting.
Annual O & M Total				**$133,000**	

Table C.1e
Permeable Reactive Barrier with Funnel and Gate

Inlcudes the following elements:

This alternative uses funnel and gate technology to control groundwater movement from the landfill to a narrow gate (200 lf) on the downgradient side, and then using a PRB across the gate to accomplish in situ treatment of the arsenic in the groundwater.

Costs are based on the following assumptions:the cross-sectional area of groundwater flow to be treated is approximately 200 feet long by 20 feet deep (15 feet saturated); the hydraulic gradient is approximately 0.003; the hydraulic conductivity the upper sand aquifer is approximately 100 to 200 feet/day. Conservative estimated maximum discharge at northwest exit is 100 gpm for the entire 200 foot length.

Costs are based on use of zerovalent iron (ZVI) media, which is the most proven technology for arsenic, and costs approximately $700/ton, plus a proprietary cost of 15% of construction and materials to U. Waterloo/EnviroMetal Technology. Alternative PRB media include EHC-M, an organic/iron mix that further reduces As and permanantly precipitates Fe sulfides (AdventusRemediation, parent company of EnviroMetal Technology or ETI). This media costs $4000/ton, requires less material than ZVI, but requires sulfates, which are non-detect at the site. A third media is oxygen furnace slag from ETI, which costs $30-40/ton but may increase groundwater pH significantly due to lime.

CAPITAL COSTS	Unit Cost				
Construction costs	**Units**		**Quantity**	**Estimated Cost**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	$100,000	1	$100,000	Fence removal, access, grading, erosion controls, etc. Cost assumed.
Barrier installation	LF	$300	600	$180,000	Uses a 300 lf slurry wall on either side of the gate to act as the funnel, installed using conventional methods.
PRB treatibility testing	LS	$40,000	1	$40,000	Laboratory column flow-through testing including analytical costs.
PRB installation	LF	$4,070	200	$814,000	Assumes zerovalent iron PRB is 15' deep and 5' thick, 67% ZVI, 33% sand, 5.2 tons ZVI/LF, 1.5 tons sand, ZVI at $700/ton, sand at $20/ton. Installation $400/LF. Costs less for furnace slag instead of iron. 200 foot length based on gate treatment zone with greater thickess to address higher flow rates, Total ZVI is 1,040 tons.
U. Waterloo proprietary cost	LS	$128,100	1	$128,000	Maximum 15% of PRB material and construction cost.
Performance monitoring well installation	EA	$3,000	4	$12,000	To monitor treatment performance downgradient and ensure complete capture by barrier/funnel and gate.
Pumping well installation	EA	$6,000	0	$0	Hydraulic gradient is assumed to control funnel and gate.
Upgradient reinjection system installation and startup	LS	$50,000	0	$0	Treated groundwater is allowed to continue to flow into downgradient wetlands.
Subtotal				**$1,274,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Overall Project Management, Design and permitting	%	$1,274,000	0.8	$368,000	Overall Project Management,Pre-design studies, engineering design and permitting, MTCA construction close-out reporting at 80% of contruction costs (excluding the PRB material cost)
Construction Management	%	$1,274,000	0.1	$50,000	Corresponds to 40 workdays for one FTE at $1250/day.
Subtotal				**$418,000**	
Pre-Contingency Total				**$1,692,000**	
Construction Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Contingency at 50%	%	$1,274,000	0.5	$637,000	Contingency set at 50% of Consturction rather than standard 30% to cover issues such as the needed to add pumping wells and re-injection to control flow through the gate, the need for an additional 3 to 5 feef of height to the PRB or relocation of the existing stormwater pond (to the wetlands).
Project Total w Contingency				**$2,329,000**	
O & M COSTS					
Item	**Units**		**Quantity**	**Estimated Cost**	**Comments**
Maintenance - PRB replacement	annualized	$47,000	1	$47,000	Cost based on replacement of PRB every 20 years; annual cost is 1/20th of replacement cost.
Maintenance - PRB disposal	per Lf per 20-year event	$27	200	$5,000	Cost based on disposal of PRB in Subtitle C landfill every 10 years; annual cost is 1/10th of disposal cost. Material should be <1% As by weight. Weight is 4.5 tons/LF. Unit cost for disposal is $120/ton to cover handling, dewatering, shipping, and disposal.
Groundwater monitoring	Annual	$0	1	$0	Costs captured in annual OM&M costs for the 1993 Remedy.
Performance monitoring	Annual	$20,000	1	$20,000	Cost based on quarterly sampling of 4 performance monitoring wells in conjunction with other monitoring and annual reporting.
Annual O & M Total				**$72,000**	

Table C.1f
Ditch Excavation

Includes the following elements:

Assumes 600 lf of ditch along western boundary contains contamination to 2 ft; and another 600 lf upgradient and downgradient contain contamination of less that 1 ft in depth. Assumes ditch is 3 ft wide.

CAPITAL COSTS					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Excavation of ditch contamination	lf	$14	1,200	$17,000	Assumes cleanout by backhoe, field overight, and confirmational sampling.
Load, Transport and Disposal of ditch sediments	ton	$60	300	$18,000	Assumes disposal at Class D landfill as wet sediment.
Capital Cost Total:				**$35,000**	
Contingency	**Units**		**Quantity**	**Estimated Cost**	**Comments**
30% contingency	ton	$37	300	$11,000	For Off Site landfill disposal costs
Revisions to ditch alignment at Greenwood Apts.	*LS*	*$25,000*	*1*	*$25,000*	*May be optional and left to future development.*
Capital Cost Contingency				**$36,000**	
Capital Cost with Contingency				**$71,000**	
ANNUAL O&M COSTS (Includes monitoring)					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Installed with slurry wall		$0	1	$0	No O&M costs are needed.
Annual O & M Total				**$0**	

Table C.2
Cost Estimate Summary Sheet for Wetlands CAA and End-of-Plume CAA

Remedial Strategy		Capital Costs			Annual Costs for Operations, Maintenance, & Monitoring				Total
		Assumptions	Base Capital Cost[1]	Capital Costs Plus Contingency[2]	Assumptions	Annual OM&M Cost	50-year OM&M Cost[3]	Present Value 50-year OM&M Cost[4]	Total of Capital, Contigency, & Present Value of OM&M[5]
MNA	Assumes OM&M for existing-1993 Remedy will also be conducted; but costs are not included here. Does not assume compliance with MTCA.	Uses the same well network as used for Compliance Monitoring, but expands sampling, analysis, data evaluation, and reporting.	$30,000	$60,000	End-of-Plume CAA MNA only: Add-on to existing compliance monitoring and reporting for 50 years.	$12,000	$600,000	$377,000	**$437,000**
					Wetlands CAA MNA only: Add-on to existing compliance monitoring and reporting for 50 years	$17,000	$850,000	$534,000	**$594,000**
					End-of-Plume CAA and Wetlands MNA: Add-on to existing compliance monitoring and reporting for 50 years. Assumes no active remedy beyond landfill boundary.	$42,000	$2,100,000	$1,320,000	**$1,380,000**
Enhanced MNA	Supplement to naturally-occurring attenuation processes through limited in situ treatment in End-of-Plume CAA.	Uses in situ treatment for 150 to 200 ft along 12th St. E. Chemical reductant is added quarterly for 3 years. Costs and duration assume that the mass of dissolved arsenic in wetlands is partially removed through wetlands remedy.	$364,000	$605,000	End-of-Plume CAA only: Add-on to existing compliance monitoring and reporting for 10 years only if implemented with Wetlands Remedy.	$18,000	$180,000	$162,000	**$767,000**
In Situ Sequestration	In situ treatment to permanently sequester groundwater arsenic into the solid phase.	End-of-Plume CAA: Limited roadbuilding, three treatment transects, permanent in situ reagent delivery system or truck-mounted injections, and performance monitoring wells.	$618,000	$927,000	Years 1-5 System O&M & Add-on to compliance monitoring and MTCA reporting	$42,000	$400,000	$357,000	**$1,280,000**
					Years 6-10 Add-on to compliance monitoring and MTCA reporting	$22,000			
					Years 11 - 50 Add-on to compliance monitoring and MTCA reporting	$2,000			
		Wetlands CAA: Assumes implemented following implementation in End-of-Plume CAA. Roadbuilding in wetlands, four treatment transects, and permanent in-situ delivery system or truck-mounted injections. Assumes performance monitoring wells installed as part of End-of-Plume in situ sequestration.	$1,280,000	$1,920,000	Years 1-5 System O&M & Add-on to compliance monitoring and MTCA reporting	$40,000	$330,000	$291,000	**$2,210,000**
					Years 6-10 Add-on to compliance monitoring and MTCA reporting	$10,000			
					Years 11 - 50 Add-on to compliance monitoring and MTCA reporting	$2,000			

Remedial Strategy		Capital Costs			Annual Costs for Operations, Maintenance, & Monitoring				Total
		Assumptions	**Base Capital Cost[1]**	**Capital Costs Plus Contingency[2]**	**Assumptions**	**Annual OM&M Cost**	**50-year OM&M Cost[3]**	**Present Value 50-year OM&M Cost[4]**	**Total of Capital, Contigency, & Present Value of OM&M[5]**
Soil Cover	Permeable, vegetated (or developed) soil cover over portion of the Wetlands CAA where discharge to surface water results in complete exposure pathway or exceedances of CULs. Wetlands mitigation as appropriate.	Assumes 5-foot thick cap, hydroseeded vegetation, wetlands mitigation.	$674,000	$799,000	Mitigation area monitoring & maintenance for 5 years.	$20,000	$100,000	$94,000	**$893,000**
Containment and Capping	Contain and cap the Wetlands CAA and/or End-of-Plume CAA using a slurry wall, impermeable liner, and fill material. Assumes that the 7 acre Redford property is being redeveloped into a residential or commercial development. Several costs are assumed to be covered by the Developer of the property.	Wetlands CAA: 20 foot deep slurry wall, 2 acres contained and capped, 2 acres of wetlands mitigated.	$1,150,400	$1,495,520	Mitigation area monitoring & maintenance for 5 years, performance monitoring of containment for five years.	$25,000	$125,000	$118,000	**$1,610,000**
		End-of-Plume CAA: Assumes that containment and capping in the End-of-Plume is implemented as an add-on to containment and capping in the Wetlands CAA. 25-foot deep slurry wall, additional 1 acre wetlands contained and mitigated.	$686,400	$892,320	Mitigation area monitoring & maintenance for 5 years, performance monitoring of containment for five years.	$15,000	$75,000	$71,000	**$963,000**
Short-term Pump and Treat Removal	Remove mass of dissolved arsenic from concentrated area of plume through a one- to two-year pump and treat measure, using new pumping wells.	Installation of pumping wells and connections, lease, startup, operation, maintenance of ex situ treatment system, disposal of iron solids. Contingency allows for second season of treatment.	$529,000	$926,000	There are no anticipated O&M costs associated with this alternative beyond the baseline compliance monitoring costs.	$0	$0	$0	**$926,000**
Surface Treatment Cells	Use of engineered wetlands treatment cells modified to treat discharging groundwater.	Use of aerators to remove arsenic from surface water. Berms to contain surface water into one or more cells for aeration.	$298,000	$387,000	Includes annual dredging and disposal of treatment cell sediments, performance monitoring of surface water and sediments.	$65,000	$3,250,000	$2,043,000	**$2,430,000**
		Use of aerators and anaerobic bioreactors to remove arsenic from surface water. Berms to contain surface water into one or more cells, with both aerators and digester substrate.	$292,000	$380,000	Includes annual dredging and disposal of treatment cell sediments, performance monitoring of surface water and sediments, and removal, disposal, and replacement of digestor substrate.	$80,000	$4,000,000	$2,514,000	**$2,890,000**

Notes

1 Capital Costs include engineering design, permitting, construction management and construction.

2 Unless otherwise noted, contingency costs are set at a minimum of 30% of construction cost, and increased as appropriate for remedial actions with specific risks of unknowns; see appendices for examples.

3 50 years, rather than the standard 30 years for solid waste landfill, has been assumed at Ecology's request.

4 The 2% discount rate used in the PV calculation is a real rate that assumes a risk free rate of approximately 5%, net of inflation of approximately 3%.

5 The sum of capital costs, contingency, and present value of O&M Costs.

Table C.2a
Monitored Natural Attenuation

Includes the following elements:

Uses the same well network as used for Compliance Monitoring, but expands sampling, analysis, data evaluation, and reporting.

CAPITAL COSTS					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
No additional construction	ls	$0	1	$0	
Subtotal:				**$0**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
MNA Work Plan Development & Approval	ls	$30,000	1	$30,000	
				$30,000	
Capital Cost Total:				**$30,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
100% for additional drafts and/or monitoring wells		$30,000	1	$30,000	
Capital Cost Contingency:				**$30,000**	
Capital Cost with Contingency:				**$60,000**	
ANNUAL O & M COSTS: Option 1: MNA Beyond 12th St. E. Only					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Performance Monitoring (semi-annual measurements and annual reporting)	well	$2,000	5	$10,000	Normalized per well; includes analysis of MNA parameters in the existing compliance monitoring wells, sampled semi-annually and annual reporting as part of compliance monitoring. Monitors only 5.
Add-on to MTCA 5-year Review Process	ls	$2,000	1	$2,000	Equivalent to additional $10K every 5 years for MTCA 5-year Review process
Annual O & M Total				**$12,000**	
ANNUAL O & M COSTS: Option 2: MNA Within Wetlands Only (assumes EMNA at 12th St. E.)					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Performance Monitoring (semi-annual measurements and annual reporting)	well	$2,000	7	$14,000	Normalized per well; includes analysis of MNA parameters semi-annually with compliance monitoring and annual reporting as part of compliance monitoring. Monitors 7 downgradient wells and two background or upgradient wells.
Add-on to MTCA 5-year Review Process	ls	$3,000	1	$3,000	Equivalent to additional $15K every 5 years for MTCA 5-year Review process
Annual O & M Total				**$17,000**	
ANNUAL O & M COSTS: Option 3: MNA in both Wetlands and End-of-Plume CAAs					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Performance Monitoring (semi-annual measurements and annual reporting)	well	$2,000	19	$38,000	Normalized per well; includes analysis of MNA parameters in the existing compliance monitoring wells, sampled semi-annually and annual reporting as part of compliance monitoring. Monitors 14 compliance wells, 4 performance wells, plus 1 duplicate.
Add-on to MTCA 5-year Review Process	ls	$4,000	1	$4,000	Equivalent to additional $20K every 5 years for MTCA 5-year Review process
Annual O & M Total				**$42,000**	

Table C.2b
Enhanced Monitored Natural Attenuation (End-of-Plume CAA)

Includes the following elements and assumptions:

Supplement to naturally-occurring attenuation processes by limited in situ treatment. This alternative assumes that 2 new monitoring wells downgradient of 12th St. E. have already been installed and developed.

CAPITAL COSTS					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Installation of performance monitoring wells	well	$3,000	4	$12,000	Immediately downgradient of 12th St. E.
Injection wells: first row	well	$1,000	20	$20,000	Assumes a 400' row of injection wells upgradient of 12th Ave. E on approximately 20-ft centers.
Pipe connections from wells to system.	LS	$5,000	1	$5,000	Assumes 600 feet main 4" PVC/HDPE and/or 2" PVC, miscellaneous fittings/valves, labor to install.
Truck-mounted reagent delivery system to wells	event	$15,000	12	$180,000	Reagents delivered in 1-day events every quarter for three years. Based on vendor-provided (Adventus) typical treatment ratio of 0.2% of aquifer mass for volume in one acre of targeted depth at End-of-Plume (22,500 tons) and reagent cost of $2/lb., plus labor and equipment for injection events.
Subtotal:				**$217,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Design and permitting	%	$217,000	0.15	$33,000	15% of construction costs.
eMNA Work Plan Development & Approval	LS	$30,000	1	$30,000	
Pilot test/limited injections	LS	$30,000	1	$30,000	To test one or more reagents and the residence time of the reagents in solution.
Construction Oversight	man-day	$1,020	12	$12,000	Oversight during injection process.
Well abandonment at remedy completion	well	$500	24	$12,000	Abandonment of injection and performance monitoring wells; compliance wells would remain.
Final Reporting	LS	$30,000	1	$30,000	
				$147,000	
Capital Cost Total:				**$364,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
100% of Construction, Construction Oversight and Well Abandonment	%	$241,000	1	$241,000	Allows for either a complete second row of injection wells (and their abandonment) or twice the length of time for operations of system.
Capital Cost Contingency:				**$241,000**	
Capital Cost with Contingency:				**$605,000**	
ANNUAL O & M COSTS (FOR 5 YEARS ONLY)					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Performance Monitoring (semi-annual measurements and annual reporting)	well	$2,000	8	$16,000	Normalized per well; includes analysis of MNA parameters in the existing compliance monitoring wells, sampled semi-annually and annual reporting as part of compliance monitoring. Monitors 2 compliance wells, 4 performance wells, plus 2 upgradient.
Add-on to MTCA 5-year Review Process	ls	$2,000	1	$2,000	Equivalent to additional $10K every 5 years for MTCA 5-year Review process
Annual O & M Total				**$18,000**	

Table C.2c
In Situ Sequestration (End-of-Plume CAA and Wetlands CAA)

Includes the following elements and assumptions:

Assumes that in situ sequestration implemented first in End-of-Plume CAA and then expanded to Wetlands CAA. Access agreement, 5-year MTCA review process, and majority of compliance monitoring costs contained in End-of-Plume CAA O&M costs. For both CAAs, assumes operation for five years, compliance monitoring for 10 years. These alternatives assume that 2 new monitoring wells downgradient of 12th St. E. have already been installed and developed.

CAPITAL COSTS: End-of-Plume CAA

Construction Costs	Units	Unit Cost	Quantity	Estimated Cost	Comments
Roadbuilding and well platforms	LF	$80	300	$24,000	Assumes 3' deep by 12' wide temp road, crushed rock at $10/ton including delivery, includes roadbuilding labor.
Installation of performance monitoring wells	well	$3,000	4	$12,000	Immediately downgradient of 12th St. E.
Injection wells: three rows	well	$1,000	36	$36,000	Assumes three 300' rows of injection wells upgradient of 12th Ave. E on approximately 25-ft centers.
Pipe connections from wells to system.	LS	$7,500	1	$8,000	Assumes 4" PVC/HDPE and/or 2" PVC, miscellaneous fittings/valves, labor to install.
Reagent	lbs	$2	135,000	$270,000	Based on vendor-provided (Adventus) typical treatment ratios of 0.2% of aquifer mass for volume in 1.5 acres of targeted depth at End-of-Plume (33,750 tons) and reagent cost of $2/lb.
Reagent injection	LS	$60,000	1	$60,000	Cost assumes either installation, startup, and optimization of injection system with storage tank and pump, or 12 injection events using truck-mounted system.
Subtotal:				**$386,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Design, permitting, reporting, and closeout	%	$386,000	0.60	$232,000	See eMNA for items covered; includes proof of concept.
				$232,000	
Capital Cost Total:				**$618,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
50% of capital costs	%	$618,000	0.50	$309,000	Allows for either closer-spaced injection wells (and their abandonment) or additional reagent/operation of system.
Capital Cost Contingency:				**$309,000**	
Capital Cost with Contingency:				**$927,000**	

CAPITAL COSTS: Wetlands CAA

Construction Costs	Units	Unit Cost	Quantity	Estimated Cost	Comments
Roadbuilding and well platforms	LF	$80	800	$64,000	Assumes 3' deep by 12' wide temp road, crushed rock at $10/ton including delivery, includes roadbuilding labor.
Installation of performance monitoring wells	well	$3,000	0	$0	Assumes performance monitoring wells installed as part of End-of-Plume in situ sequestration.
Injection wells: four rows	well	$1,000	68	$68,000	Assumes four 400' rows of injection wells on approximately 25-ft centers.
Pipe connections from wells to system.	LS	$12,000	1	$12,000	Assumes 1600 feet 2" PVC branch lines (4 transects x 400 feet each), 400 feet main 4" PVC/HDPE to system, miscellaneous fittings/valves, labor to install.
Reagent	lbs	$2	310,000	$620,000	Based on vendor-provided (Adventus) typical treatment ratios of 0.2% of aquifer mass for volume in 2 acres of entire depth in Wetlands CAA (77,440 tons) and reagent cost of $2/lb.
Reagent injection	LS	$100,000	1	$100,000	Cost assumes upgrades and optimization of End-of-Plume injection system for larger scale application, construction of a second injection system at Puget Power Road, or 20 injection events using truck-mounted system.
Subtotal:				**$800,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Design, permitting, reporting, and closeout	%	$800,000	0.60	$480,000	See eMNA for items covered; includes proof of concept.
				$480,000	
Capital Cost Total:				**$1,280,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
50% of capital costs	%	$1,280,000	0.50	$640,000	Allows for either closer-spaced injection wells (and their abandonment) or additional reagent/operation of system.
Capital Cost Contingency:				**$640,000**	
Capital Cost with Contingency:				**$1,920,000**	

ANNUAL O & M COSTS: End-of-Plume CAA, Years 1-5

Action	Units	Unit Cost	Quantity	Estimated Cost	Comments
Performance Monitoring (semi-annual measurements and annual reporting)	well	$2,000	10	$20,000	Normalized per well; includes analysis of MNA parameters in the existing compliance monitoring wells, sampled semi-annually and annual reporting as part of compliance monitoring. Monitors 5 compliance wells, 4 performance wells, plus 1 duplicate.
Maintenance and Repairs	annual	$20,000	1	$20,000	Assumes monthly maintenance visits at $1020/each, $7,500 for miscellaneous repairs.
Add-on to MTCA 5-year Review Process	ls	$2,000	1	$2,000	Equivalent to additional $10K every 5 years for MTCA 5-year Review process
Annual O & M Total				**$42,000**	

Table C.2d
Permeable Soil Cap (Wetlands CAA)

Includes the following elements:
Assumes 75,000 SF area and five-foot thick cap; total volume 15,000 CY.

CAPITAL COSTS					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	10000	1	$10,000	Temporary facilities, erosion controls, roadbuilding
Purchase, Place, and Compact Clean Fill	CY	20	15000	$300,000	Assumes 5 foot thick cap.
Hydroseed soil cover	SF	0.15	75000	$11,250	Assumes high-volume hydroseeding (75,000 SF).
Wetlands mitigation	Acre	50000	2	$100,000	Based on poor quality of habitat; does not include purchase
Subtotal:				**$421,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Design and permitting at 30%	%	$421,000	0.30	$126,300	Additional Site Characterization, Engineering Design, Support and Project Closeout for both soil cover and mitigation acres; includes short-term monitoring of mitigation area
Construction management 15%	%	$421,000	0.15	$63,150	
Analytical Testing at 15%	%	$421,000	0.15	$63,150	Fill testing; testing at mitigation site
Subtotal:				**$253,000**	
Capital Cost Total:				**$674,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
30 % Contingency	%	$421,000	0.30	$126,300	Contingency on construction costs only.
Capital Cost Contingency:				**$126,300**	
Capital Cost with Contingency:				**$799,000**	
ANNUAL O & M COSTS					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Mitigation Area Monitoring & Maintenance for 5 years only	annual	$20,000	1	$20,000	For 5 years only
Annual O & M Total				**$20,000**	

Table C.2e
Containment and Capping (Wetlands CAA and End-of-Plume CAA)

Includes the following elements and assumptions:

These alternatives assume that the 7 acre Redford property is being redeveloped into a residential or commercial development. Assumes that containment and capping in the End-of-Plume is implemented as an add-on to containment and capping in the Wetlands CAA. Several costs are assumed to be covered by the Developer of the property.

CAPITAL COSTS: Wetlands CAA					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	$100,000	1	$100,000	Cost assumed. Driven by site prep in wetlands.
Slurry wall installation	LF	$300	1,200	$360,000	Assumes 2-3 foot thick wall, 20 feet deep by1200 feet long at $15 per square foot ($300/linear foot), installed by conventional methods to allow for wetlands conditions. Conventional slurry wall installation costs range from $10/square foot ($200/linear foot) to $20/SF ($400/LF). 1200 foot perimeter/75,000 SF area assumes containment of high concentration area in Wetlands CAA.
Purchase, Place, and Compact Clean Fill	CY	$20	0	$0	Assumes that all soil needed to bring the site to grade is part of development
Purchase and Install Liner	SF	$2	75,000	$150,000	Assumes 40 mil liner or greater ($0.65/SF), sealed to slurry wall top.
Wetlands mitigation	Acre	$50,000	2	$100,000	Based on poor quality of habitat; note that the additional acres of mitigation would be included in Developer's costs.
Performance monitoring well installation	EA	$3,000	3	$9,000	To ensure containment of plume/monitor performance.
Subtotal:				**$719,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Design & permitting at 50%	%	$719,000	0.50	$359,500	Includes characterization of mitigation site; design, and permitting.
Construction Management 10%	%	$719,000	0.10	$71,900	Slurry wall, liner, and mitigation area
				$431,400	
Capital Cost Total:				**$1,150,400**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Contingency at 30%	%	$1,150,400	0.30	$345,120	Contingency based on wet conditions, additional trenching, and unforeseen disposal costs.
Capital Cost Contingency:				**$345,120**	
Capital Cost with Contingency:				**$1,495,520**	
ANNUAL O & M COSTS: Years 1-5					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Co**	**Comments**
Mitigation Area Monitoring & Maintenance for 5 years only	annual	$20,000	1	$20,000	For 5 years only
Performance monitoring of containment	annual	$5,000	1	$5,000	Additional measurements to monitor containment in Wetlands CAA as add-on to Compliance Monitoring, for 5 years only.
Annual O & M Total				**$25,000**	

Table C.2f
Containment and Capping Add-on to the Wetlands to Include End-of-Plume

CAPITAL COSTS		Unit Cost			
Construction Costs	**Units**		**Quantity**	**Estimated C**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	$50,000	0	$0	No mob required - mob covered by Wetlands CAA containment and capping alternative.
Slurry wall installation	LF	$375	600	$225,000	Assumes 2-3 foot thick wall, 25 feet deep by 600 feet long (length of additional barrier to contain End-of-Plume) at $15 per square foot ($300/linear foot), installed by conventional methods to allow for wetlands conditions. Conventional slurry wall installation costs range from $10/square foot ($250/linear foot) to $20/SF ($500/LF).
Purchase, Place, and Compact Clean Fill	CY	$20	0	$0	Assumes that all soil needed to bring the site to grade is part of development
Purchase and Install Liner	SF	$2	40,000	$80,000	Assumes 40 mil liner or greater ($0.65/SF), sealed to slurry wall top.
Hydroseed soil cover	SF	0.15	40,000	$6,000	Assumes high-volume hydroseeding (40,000 SF).
Additional Wetlands Mitigation	Acre	$100,000	1	$100,000	Based on poor quality of habitat; note that the additional acres of mitigation would be included in Developer's costs.
Performance monitoring well installation	EA	$3,000	3	$9,000	To ensure containment of plume/monitor performance.
Sentinel well installation	EA	$3,000	3	$9,000	3 downgradient sentinel wells for long-term monitoring.
Subtotal				**$429,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated C**	**Comments**
Design & permitting at 50%	%	$429,000	0.50	$214,500	Includes characterization of mitigation site; design, and permitting.
Construction Management 10%	%	$429,000	0.10	$42,900	Slurry wall, liner, and mitigation area
				$257,400	
Capital Cost Total				**$686,400**	

Contingency	Units	Unit Cost	Quantity	Estimated C	Comments
Contingency at 30%	%	$686,400	$0.30	**$205,920**	Contingency based on wet conditions, additional trenching, and unforeseen disposal costs.
Capital Cost Contingency:				**$205,920**	
Capital Cost with Contingency:				**$892,320**	

ANNUAL O & M COSTS: Years 1-5					
Item	**Units**		**Quantity**	**Estimated C**	**Comments**
Mitigation Area Monitoring & Maintenance for 5 years only	annual	$10,000	1	$10,000	For 5 years only
Performance monitoring of containment	annual	$5,000	1	$5,000	Additional measurements to monitor containment in End-of-Plume CAA as add-on to Compliance Monitoring, for 5 years only.
Annual O & M Total				**$15,000**	

Table C.2g
Short-term Pump and Treat Removal (Wetlands CAA)

Includes the following elements and assumptions:
Costs for treating the arsenic plume in the wetlands through ex situ methods include mobilization, pumping well installation, plumbing and electrical from wetland wells to landfill, treatment system lease/ startup/O&M, treatment costs, and solids disposal costs. Assumes discharge to the existing stormwater infiltration ponds.

CAPITAL COSTS					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Mobilization/Demobilization, Site Preparation	LS	$10,000	1	$10,000	Cost assumed.
Pumping well installation	Each	$6,000	3	$18,000	Costs based on 4" wells, 20 feet deep, installed with limited-access track drilling rig, with up to 30 gpm pumps, control boxes, transducers, etc.
Pipe and electrical from pumping wells	LS	$15,000	1	$15,000	Assumes main 8-12" HDPE or PVC, 2"-4" branches, electrical conduit pipe, electrical supplies, labor to install pipes/electrical labor, miscellaneous pipes and fittings.
Treatment system installation and startup	LS	$300,000	1	$300,000	Assumes treatment of up to 50000 gallons/day. Assumes shed, electrical panel, tanks), plumbing, treatment technology, solids collection system. Includes weekly O&M by vender (e.g. Water Tectonics), monthly analytical testing, repairs, electricity.
Treatment cost	per	$0.003	10,000,000	$30,000	Assumes system operation chemical costs at $2/thousand gallons
Transport and disposal of iron solids	cost per	$5,000	1	$5,000	Assumes one truckload to Subtitle C Landfill. Calculated irons solids volume based on groundwater iron concentrations (100 ppm) and estimated
Subtotal:				**$378,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Design & permitting at 25%	%	$378,000	0.25	$94,500	Includes capture zone analysis/design, and permitting.
Construction Management 15%	%	$378,000	0.15	$56,700	Assumes approximately one FTE at $1250/day for 45 days to oversee pumping well installation, system installation and startup, solids transfer, project closeout.
				$151,000	
Capital Cost Total:				**$529,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Contingency at 75%	%	$529,000	0.75	$396,750	Contingency allows for second season of temporary ex situ treatment, limited road-building ($80/LF) if needed.
Capital Cost Contingency:				**$397,000**	
Capital Cost with Contingency:				**$926,000**	
ANNUAL O & M COSTS					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
				$0	*There are no anticipated O&M costs associated with this alternative beyond the baseline compliance monitoring costs; the treatment system is maintained by the vendor.*
Annual O & M Total				**$0**	

Table C.2h
Surface Treatment Cells (Wetlands CAA)

Includes the following elements and assumptions:

CAPITAL COSTS: Aeration

Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Mobilization	EA	$177,000	0.10	$17,700	Cost assumed at 10% of construction costs; driven by wetlands site prep.
Aerator	EA	$8,000	4	$32,000	USFilter estimate, 3HP units, material cost = $5500 per unit. $2,500 added for installation
Temporary access road surfacing	SY	$17	183	$3,163	Assume 8-inch bedding depth, 15-feet wide, 2004 RS Means 01550-700-0010, page 015-5
Temporary access road fill	CY	$15	183	$3,000	Assume native excavated material suitable for road fill, 15-feet wide, 2004 RSMeans 02315-0015-0600-110, page 023-1. Adjusted for inflation, includes backfill
Netting	SF	$0.41	43,560	$18,034	Bird netting, 2004 RS Means 06620-600-0120, page 066-1
Excavation	CY	$12	4,840	$55,660	Assume 300 ft dozer haul 2004 RS Means 02315-432-2420, page 023-3
Loading disposal	CY	$3	4,840	$12,134	Assume 1cy backhoe, 2004 RS Means 02315-424-0200, page 023-3
Disposal and haul	CY	$5.75	4,840	$27,830	2004 RS Means 02315-490-0020, page 023-6
Additional Wetlands Mitigation	Acre	$100,000	0	$0	Assumes no mitigation necessary.
Subtotal:				**$170,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Design and Permitting 60%	%	$170,000	0.60	$102,000	Includes additional surface water characterization, pilot study, engineering design, permitting.
Construction Management 15%	%	$170,000	0.15	$25,500	Approximately 20 days for one FTE at $1250/day.
				$128,000	
Capital Cost Total:				**$298,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Contingency at 30%	%	$298,000	0.30	$89,000	Contingency based on potential wet conditions and unforeseen disposal costs.
Capital Cost Contingency:				**$89,000**	
Capital Cost with Contingency:				**$387,000**	

ANNUAL O & M COSTS: Aeration

Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Annual dredge	CY	$12	2,420	$29,000	Assume clamshell, hopper dumped, 18" deep sediment, 2004 RS Means 02325-250-0500, page 023-8
O&M mobilization	LS	$5,800	1	$6,000	Assumed value, 2004 RS Means 02325-250-0020, page 023-8. Use 20% of O&M total
Performance monitoring	Annual	$30,000	1	$30,000	Cost based on quarterly sampling of surface water and sediment in conjunction with other monitoring and annual reporting.
Annual O & M Total				**$65,000**	

CAPITAL COSTS: Aeration and Anaerobic Digestors					
Construction Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Mobilization	EA	$15,200	1	$15,000	Assume 10%
Aerator	EA	$8,000	2	$16,000	USFilter estimate, 3HP units, material cost = $5500 per unit. $2,500 added for installation
Temporary access road surfacing	SY	$17	183	$3,000	Assume 8-inch bedding depth, 2004 RS Means 01550-700-0010, page 015-5
Temporary access road fill	CY	$15	183	$3,000	Assume native excavated material suitable for road fill. 2004 RSMeans 02315-0015+0600-110, page 023-1. Adjusted for inflation, includes backfill
Netting	SF	$0.41	43,560	$18,000	Bird netting, 2004 RS Means 06620-600-0120, page 066-1
Excavation	CY	$12	4,840	$56,000	Assume 300 ft dozer haul 2004 RS Means 02315-432-2420, page 023-3
Loading disposal	CY	$3	4,840	$12,000	Assume 1cy backhoe, 2004 RS Means 02315-424-0200, page 023-3
Disposal and haul	CY	$6	4,840	$28,000	2004 RS Means 02315-490-0020, page 023-6
Digester substrate	CY	$5	3,227	$16,000	Assumed value of substrate, digester area assumed to be 2/3 of pond area, 3-feet deep.
Additional Wetlands Mitigation	Acre	25,000.00		$0	Assumes no mitigation necessary.
Subtotal:				**$167,000**	
Engineering and Support Costs	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Design and Permitting @ 60%	%	$167,000	0.60	$100,200	Includes additional surface water characterization, pilot study, engineering design, permitting.
Construction Management	EA	$1,250	20.00	$25,000	Approximately 20 days for one FTE at $1250/day.
				$125,000	
Capital Cost Total:				**$292,000**	
Contingency	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Contingency at 30%	%	$292,000	0.30	$88,000	Contingency based on potential wet conditions and unforeseen disposal costs.
Capital Cost Contingency:				**$88,000**	
Capital Cost with Contingency:				**$380,000**	

ANNUAL O & M COSTS: Aeration and Anaerobic Digestors					
Action	**Units**	**Unit Cost**	**Quantity**	**Estimated Cost**	**Comments**
Annual dredge	CY	$12	807	$10,000	Assume only aeration pond dredged (~1/3 of pond volume), clamshell, hopper dumped, 18" deep sediment, 2004 RS Means 02325-250-0500, page 023-8
Digester substrate	CY	$10	3,227	$32,000	Assumed value of substrate, digester area assumed to be 2/3 of pond area, 3-feet deep. Includes new substrate and haul and disposal
O&M mobilization	LS	$8,400	1	$8,000	Assumed value, 2004 RS Means 02325-250-0020, page 023-8. Use 20% of O&M total
Performance monitoring	Annual	$30,000	1	$30,000	Cost based on quarterly sampling of surface water and sediment in conjunction with other monitoring and annual reporting.
Annual O & M Total				**$80,000**	

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CERTIFIED MAIL

March 26, 2007

Mr. Tom Colligan
Floyd Snyder
Two Union Square
610 Union Street, Suite 600
Seattle, WA 98101

Dear Mr. Colligan:

Re: Ecology Comments to Groundwater Alternatives Evaluation, B & L Woodwaste Site

Ecology has reviewed your document entitled "B & L Landfill, Draft Groundwater Alternatives Evaluation (GAE)", dated January 2007. We thank you for this thorough and well prepared document. Ecology does have a number of comments pursuant to our review of the GAE, and to our meeting of March 14, 2007, as follows:

1. Section 3.1.2 references the presence of sandy colluvium encountered in soil borings in the southeast corner of the landfill. Section 3.1 of Appendix B states that sandier soils are found in the southwest corner of the landfill. These areas of the landfill would not then be considered as being underlain by a low permeability confining layer. This raises doubts as to whether groundwater containment could be achieved by the installation of a slurry wall without the inclusion of the pumping of groundwater from within the containment area.

2. Section 3.2.3, (also shown graphically in Figure 3.5 and Figure A.8) at the end of the third paragraph, states that a plume "finger" extends for what is likely a short distance northward of 12th St. E., as judged by the relatively low arsenic concentrations measured at 12th St. E. As shown in Figure 3.5, no wells have been placed northward of 12th St. E., therefore the actual extent of the arsenic plume northward of 12th St. E. is still unknown.

3. Figures 3.2 and 3.4 show the arsenic concentrations in the wetlands to be greatest near the bottom of the upper sand aquifer. The reason for this suggested in the report is that the lower part of the aquifer is of higher permeability (is sandier) than the upper soil layers. This explanation has merit. An additional mechanism for the presence of the arsenic low in the aquifer may have to do with the seasonal recharge from precipitation, which may drive the arsenic laden waters downward. The plume could also be driven downward by dropping water levels during each dry season. This could be important if such downward flow is causing the sorption of arsenic onto the fine grained soils at the top of the low permeability confining layer.

4. Section 3.2.6 last paragraph references data showing surface water arsenic concentrations as high as 450 ug/l in the ditch adjacent to the landfill, but approaching a background value of 11 ug/l below Surprise Lake Drain. This Section states that in the oxygen-rich ditch waters, the arsenic is very likely precipitating out into ditch sediments. Such precipitation is corroborated by the elevated arsenic concentrations found in the upper-most layers of ditch sediments.

5. Section 3.3.1 and General: A definitive demonstration needs to be made to show: the continuity, thickness and permeability of the low permeability confining layer beneath the landfill. This is alluded to in Appendix B, but the actual data are not presented there. A plan view map of the site showing the locations of points of known confining layer thickness and permeability is needed. Any areas where the confining layer seems to be thin, absent, or of higher permeability should also be shown.

6. Section 3.3.1 and General: A definitive demonstration needs to be made of the existence of an upward groundwater gradient between the upper and lower aquifer systems, for the site and wetland areas. This demonstration should include the mapping of shallow/deep well pairs where the deeper well has a higher head and locations of flowing wells. These wells and data need to be evaluated as to whether there is sufficient coverage by deeper wells to conclude the lower aquifer has higher hydraulic head than the upper aquifer. Here again, this existence of this information is alluded to in Appendix B, but is not presented in the report. Any well pairs which show a neutral or downward hydraulic gradient should also be shown. Seasonal effects of hydraulic gradient between these aquifers should also be considered.

7. Section 3.3.1 and General: Lower aquifer arsenic concentrations in both the landfill and wetlands areas should be brought forth into a section demonstrating whether arsenic has been found beneath the first confining layer. A mapping of these wells and data need to be made so that we can determine whether there is sufficient coverage by deeper wells to conclude the lower aquifer is clean. Any wells showing arsenic contamination in the lower aquifer should also be shown.

8. Section 3.3.4 concludes that deeper wetland soils do not exceed cleanup limits. As referenced in Comment 3 above, there may be a deposition of arsenic onto the top of the first confining layer. This would serve as an ongoing source of arsenic to the environment which may reach a receptor. The area of the wetland with the highest arsenic concentrations in groundwater should serve as an area for testing of upper confining layer soils.

9. Page 4-2 includes, in what is presented as a paraphrasing of MTCA, a "bullet" which reads, "Engineering controls, such as containment, are appropriate for sites or portions of sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable". While site wastes have proven to not be subject to effective treatment, these wastes do not have low concentrations of

contaminants. Much of the waste designates as a Dangerous Waste per Ch. 173-303 WAC.

10. Section 4.2.3.3 concludes, due to the presence of contaminated groundwater beyond the landfill boundary points of compliance, that the site has violated state Minimum Functional Standards (Ch. 173-304 WAC).

11. Sections 4.3.2 and 4.3.3 imply that the boundary of the plume of arsenic in the wetlands, including 12th St. E. at the north end of the plume, now qualifies as a conditional point of compliance. Please review Ch. 173-340-720(8) WAC regarding establishment of a conditional point of compliance. Among the many requirements for establishment of a conditional point of compliance are: All practicable means of treatment have been used; Comments must be solicited from local water purveyors, property owners, tribes and local governments; Other conditions as determined by Ecology on a case-by-case basis.

12. What soils data do we have for the 4.5 acres of land outside of the capped area, but inside of the original 18.5 acre site boundary? Please provide this data.

13. Does the water table in the wetlands remain above the confining layer in the dry season?

14. The Remedial Action Objectives (RAOs) for the wetlands should ideally include bringing both soils and groundwater into compliance with cleanup standards. The issue of whether deeper soils cannot be remediated, and whether arsenic must remain there, has not been settled.

15. Please determine the direct horizontal distances of all of the closest private and municipal well systems from the on and off-site arsenic plume. Please provide well logs for each of these private and municipal wells.

16. Section 5, "Preliminary Screening of Remedial Technologies" does not include or evaluate off-site removal of site wastes or contaminated sub-soils. These evaluations were made in an earlier draft report, and must be included in the GAE. It should be assumed in these evaluations that the site wastes and subsoils would remain capped until they have complied with site cleanup standards.

17. Section 5 also does not fully evaluate the use of short or long term pumping and treatment of groundwater, in the landfill, or end of plume areas. This too had been included in an earlier report, and must be included in the GAE.

18. Section 6.1.2 should also evaluate an alternative including construction of a capped slurry wall, and including groundwater pumping inside of the slurry wall. This alternative is very likely superior to a slurry wall without pumping, because: A. We would thus be able to determine the amount of leakance through the slurry wall and confining layer, and to assess the actual degree of containment achieved by the slurry wall, B. Depressing the groundwater table within the slurry wall would create an inward groundwater gradient to

seal in contaminants, C. Depress the water table below ALL of the waste all year, and D. It is likely, with the waste thus cut off from contact with groundwater, that arsenic in the largely inorganic aquifer beneath the landfill would become clean with pumping. Also, a large volume of water would need to be pumped initially to bring the water level below that of all the waste. However, once the water level has been drawn down, the volume of pumping needed to maintain that water level inside of the slurry wall should be minimal, if the confining layer and slurry wall are indeed of low permeability. The existence of a pumping system within the slurry wall also provides a emergency containment system, should the slurry wall fail.

19. An alternative should be evaluated wherein a slurry wall is constructed first, then the waste pile is removed at a later date, or gradually "mined" of its contents. Here again, it should be assumed in these evaluations that the site wastes and subsoils would remain capped until they have complied with site cleanup standards.

20. Section 6.3.3 (Alternative 3 – Enhanced Monitored Natural Attenuation" includes "limited use of one or more in situ groundwater treatment options" followed by "natural attenuation". In this option it is important that the treatment options you may be considering are listed for review. Please include in the presentation of proposed arsenic de-solublization chemical technologies the degree to which the low solubility arsenic reaction products would be permanently sorbed to soils, versus their propensity to re-dissolve over time.

21. Another issue regarding Section 6.3.3 is that Ecology considers natural attenuation to be the chemical or biological destruction of toxic compounds to form less toxic compounds. It appears that the process you refer to is chemical reaction of arsenic to form less soluble arsenic compounds which would sorb the arsenic into the wetland soils. As you are probably aware, sorption of the wetland groundwater arsenic into wetland soil has not as yet been approved as a remedy for the wetland. This remedy will be much more readily approved if it can be demonstrated that both soils and groundwater will continuously remain in compliance with site cleanup standards after treatment.

22. At our March 14, 2007 meeting you had stated that although wetland groundwater arsenic concentrations are elevated in places, that wetland soils concentrations remain low with respect to MTCA limits and area background concentrations. Please map the locations and depths of wetland soils arsenic data. Please include this mapping in an analysis of what the expected arsenic concentrations would be in both wetland soils and groundwater for each proposed treatment option. Please compare these soils arsenic concentrations with site cleanup limits and also with background soil arsenic concentrations.

23. Regarding your proposed remedy; Ecology must stress that the installation of a slurry wall, without pumping of the groundwater within it, does not guarantee containment of contaminated groundwater, since the amount of leakance which would occur through the underlying low permeability layer is as yet unknown.

24. The evaluation of cleanups of the wetlands area and ditches should include a Terrestrial Ecological Evaluation per WAC 173-340-7490.

25. Table 5.1 (Preliminary Screening of Remedial Technologies) must include analysis of waste, waste pile subsoil, and wetland soil off-site removal. This option should be explored for one-time removal of all of the waste, plus incremental removal of smaller portions of the waste over various time periods.

26. Table 5.1 rejects the use of leachate pumping because the installed collection system is too small to handle the anticipated water volume. During our March 14, 2007 meeting, you presented the fact that the existing drain system within the landfill is at a higher elevation than the bottom of the waste. Therefore the landfill drain system cannot fully de-water the waste. However, as stated above, with the addition of a slurry wall, one would expect the volume of water needing to be pumped would be fairly low, once the initial volume of water was removed to lower the water table below the waste. Also, it should be straightforward to design and install a system of horizontal pumping wells within the slurry wall capable of maintaining the proper water level within it.

27. Table 5.1 rejects pumping of groundwater in the wetland and end of plume areas because it would be long term and costly. Testing of the wetland soils has shown that the arsenic concentrations in these sandy wetland aquifer soils are relatively low. Most of the wetland arsenic is in solution in the groundwater, and would seem to be amenable to fairly rapid extraction by pumping. This should be included in the remedy evaluation.

28. Figure 3.5 shows two different arsenic concentration plumes in the same wetlands area maps. As you pointed out during our March 14, 2007 meeting, the difference between these two maps is the depth at which the samples were taken. Please revise this figure to show this distinction.

29. Appendix A Section 3.4.2 shows that arsenic concentrations have increased in well 8A along the western site boundary. Well 9A on the southern site boundary, and wells D10A and MW 23 up the slope to the southeast, also show elevated arsenic. These data imply the presence of a plume of slightly elevated arsenic in groundwater in some perimeter areas of the site. Your preferred remedy includes short term pumping and treatment of groundwater from the wetland hot spot. That system could readily be expanded to include short term pumping and treatment of the groundwater in site perimeter areas where contamination exceeding cleanup standards exists after installation of a slurry wall. Please include an analysis of such a perimeter treatment system in the GAE.

30. Appendix A Section 3.7 evaluates pumping of the landfill sump. The test was not run long enough to dewater the 20,000 gallon sump drain system, such that the test could not determine the long term pumping rate, nor the effect of long term pumping/dewatering on the landfill, as Ecology had intended in asking that the sump be pumped out.

31. Table A.6; The pH units in this table are incorrect.

32. Appendix B, Section 2.2 "Municipal Well Water Quality" states that "scattered low levels of arsenic have been reported in several Fife municipal wells in recent years. In truth, Fife wells are regularly out of compliance with the new 10 ug/l federal drinking water standard for arsenic. This may or may not relate to the B & L Woodwaste site, but it should be noted. The hydrogeologic analysis of the proximity of the site-related arsenic plume to drinking water wells should include "plain talk" text describing the extent of the threat of site-related arsenic to these drinking water systems.

33. Please revise Figure 2.6 to include the known arsenic plume.

34. During our March 14, 2007 meeting you stated that you will try to install a shallow/deep monitoring well pair on 12th Street E. to detect upward hydraulic gradient at the north end of the plume, as well as to establish lower aquifer groundwater quality at that point. Please install such a well system, after approval of its design by Ecology.

35. The MTCA defines a site as, "...area where a hazardous substance, other than a consumer product in consumer use, has been deposited, stored, disposed, or placed, or otherwise come to be located". So therefore the B & L Woodwaste site now includes, in addition to the original Fjetland property, the wetlands and other areas surrounding that property, where contaminants exceeding site cleanup standards have come to be located. That said; Ecology is called upon to remediate any contamination in excess of site cleanup standards which exists outside of the site containment cell.

Sorry for the long list of comments, but the B & L Woodwaste site is complex, and the list of available contingency remedies vary much in their effectiveness and cost. Thank you and Murray Pacific yet again for this pro-active work.

Sincerely,

Dom Reale

Dom Reale, P.E.,
Site Manager

DM/ksc:BL GAE Comments

Cc: Elliott Furst, Esq., AAG
Bob Warren, Ecology
Rebecca Lawson, Ecology

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Memorandum

To: Dom Reale and Bob Warren, Department of Ecology

Copies: Murray Pacific Corporation

From: Teri Floyd, Tom Colligan, LHG, and Brett Beaulieu, LG, Floyd|Snider

Date: April 12, 2007

Project No: MPC – B&L

Re: **Aquitard Continuity and Remedy Analysis at the B&L Landfill**

INTRODUCTION

This memorandum was prepared on behalf of Murray Pacific Corporation at the request of the Washington State Department of Ecology (Ecology) to support decision making on remedial alternatives at the B&L Landfill. This is the third memo in a series begun in early April. Each memo presents new field data that were mutually identified in our meeting in late March as critical to selecting between the alternative proposed in the Groundwater Alternatives Evaluation (GAE) and those being evaluated by Ecology (the Hybrid alternatives).

KEY ISSUES

There are several key questions that need to be answered before a decision can be made between the GAE and Hybrid alternatives. These include the following:

- The landfill is leaching arsenic into shallow groundwater that moves offsite into adjacent wetlands and may eventually reach Hylebos Creek. Which remedy will be more protective of the wetlands and creek in a reasonable restoration timeframe (one that supports planned restoration projects)?
- What is the status of the Lower Sand Aquifer? Is it clean? How do considerations of the Lower Sand Aquifer need to be incorporated into the new remedy? What could change?
- Disproportionate cost between the alternatives. The Hybrid remedies are expected to cost up to tens of millions more that the GAE. Is the increase in protectiveness proportional to the increase in cost?
- Risk of remedy failure. One of the largest differences that may remain is how we evaluate remedy failure. This topic has yet to be addressed between us.

MEMORANDUM OBJECTIVES

This memo is based on a compilation of new and existing data on the Lower Aquitard, a low permeability unit between the Upper and Lower Sand Aquifers. The memo includes descriptions of the Lower Aquitard and a discussion of how this unit functions in combination with other hydrogeologic features at the site to affect historical, current, and future groundwater conditions.

This memorandum addresses the key issues related to protection of the Lower Sand Aquifer. It also addresses related issues associated with potential remedy failure.

Vertical gradients and flow: Our first memo addressed the vertical gradients in the study area and our finding that they are flat at the landfill (groundwater moves from the adjacent bluff recharge area horizontally through the landfill fill and Upper Sand Aquifer) and increasingly upward in the wetlands area as groundwater approaches the Hylebos Creek floodplain discharge area. The primary flow direction in the Upper Sand Aquifer is horizontal, which is expected in an alluvial valley aquifer system and is consistent with previous studies in the area.

Lower Sand Aquifer groundwater quality: Because previous studies had indicated that the Lower Sand Aquifer was not impacted, recent sampling had not included monitoring wells in this zone. Over the last few weeks, we installed a new Lower Sand Aquifer monitoring well in the wetlands and sampled all the wells again for total and dissolved arsenic, dissolved iron, total dissolved solids (TDS), and dissolved organic carbon (DOC). Consistent with previous sampling a decade earlier, the Lower Sand Aquifer is unimpacted by any of these indicators of leachate.

Conceptual Site Model: The simplified conceptual site model (CSM) for B&L Landfill has remained largely unchanged since the early remedial investigation (RI). The site sits in a historical wetlands area of an alluvial plain tied to the Puyallup River system. The area was farmed for many years, but is now being allowed to return to wetlands. The alluvial system consists of interbedded layers of sand, silts, and peats representing the deposition and erosion of the alluvial area over tens of thousands of years. These deposits form a larger system of interconnected aquifers that are locally split into two water-bearing units at the B & L Landfill site.

Groundwater from the uplands discharges into the alluvial deposits and flows horizontally across the floodplain on its way to Commencement Bay. Once in the floodplain, the groundwater moves more slowly due to the flatter topography and very low horizontal gradients, and eventually discharges into Hylebos Creek. Deeper water from the Lower Sand Aquifer trying to discharge into the Upper Sand Aquifer is limited by the Lower Aquitard.

This natural system, which limits downward movement of groundwater in the floodplain, has kept the Lower Sand Aquifer in the study area clean, in spite of the thousandfold higher concentrations in the Upper Sand Aquifer above the aquitard. In places where it is a thick (greater than 5 feet) deposit of clay, plastic silt, and/or peat,, the aquitard effectively blocks groundwater transport between the zones. Several borings in the study area have identified this thickened aquitard condition.

In areas where it is thinner or sandier, the aquitard acts to “direct” rather than stop its movement. The majority of flow is directed horizontally through the more permeable materials. This condition is often seen (and will be discussed below) at the base of the Upper Sand Aquifer where permeable medium sands lie directly above the tight silts and silty sands of the Aquitard.

The low permeability of the aquitard also decreases the ability of arsenic to disperse and diffuse into deeper water as it is transported laterally with groundwater flow.

Our findings, presented in this memo, expand the discussion of the Lower Aquitard. An attempt is made to distinguish between those areas where the aquitard is effectively blocking or significantly slowing groundwater flow, and a limited area where it is apparently absent or thin enough that it is primarily acting to limit the downward spreading of the plume by diffusion and dispersion.

Review of Available Boring Logs

Available boring logs were reviewed for the presence of the aquitard unit. These include logs from the initial investigation by Ecology and Environment, Inc. (EEI 1987) and the subsequent RI (AGI/KJC 1990), post-remedy investigation and monitoring (Hydrometrics 2001), and recent investigation activities in support of a new groundwater alternative (Floyd|Snider 2006; Floyd|Snider 2007). A summary of the relevant information from these logs is presented in the attached table and map figure showing exploration locations.

As this table indicates, of the borings advanced below a depth of 15–20 feet or so, below which the aquitard would be expected, the vast majority (46 of 49) contain descriptions that indicate low permeability materials. Deeper borings located far outside of the landfill area are included in the table as well. As indicated in the RI, the character of the aquitard changes at the southwest corner of the landfill, with a more permeable silty sand being present instead of a silt or peat, as evidenced by the log of T-3. This situation is discussed in further detail below. A smaller number of borings (13) fully penetrated the unit and so characterized its thickness. These borings were advanced by a range of drilling and sampling techniques and logged by multiple geologists, therefore, some professional interpretation was necessary. Based on observations by AGI during the original RI and Floyd|Snider in more recent work, these descriptions are sufficient to identify the aquitard as a generally continuous unit, with some lithologic variation that is expected in an alluvial valley geologic setting.

The upper layers of the aquitard generally consist of a repeating pattern of deposits of moist, light grey medium stiff silt of varying plasticity, with thin deposits of dark brown interbedded woody peat. In the soil boring for MW-31B, in the wetlands, this pattern was observed for approximately 7 feet. Beneath the interbedded silt/peat deposit is a more homogeneous, moist grey silt/sandy silt. In MW-31B, this unit was observed to be approximately 6-feet thick. The attached figure, showing cross-section F-F’ (modified from the GAE to include newer data and older deeper borings), shows these units as continuous below the landfill and the wetlands.

Similar sand deposits were consistently identified above and below the Lower Aquitard. Above the aquitard, the base of the Upper Sand Aquifer is generally comprised of medium to coarse sands, with trace gravels identified in some locations. Below the aquitard materials, medium to fine sands or silty sand coarsening downward were typically encountered.

Further descriptions of the aquitard are provided in the following paragraphs. The wetlands area is described separately from the landfill area, where a slurry wall is proposed to contain the plume.

Wetlands Area

The aquitard unit has been identified in all 28 borings that were advanced to sufficient depth beneath the wetlands area. The number and density of confirmatory data points provide a strong indication of the lateral extent and local thickness of the aquitard unit over these several acres. The total thickness of the aquitard unit beneath the wetlands appears to increase to the north, ranging from approximately 4 feet at D-6A to 13 feet thick at the newly-installed MW-31B, as shown in cross section F-F'. The vertical hydraulic conductivity of the aquitard was measured by Hydrometrics to be approximately 10^{-6} cm/sec (Hydrometrics 2001).

Landfill Area

Aquitard continuity beneath the landfill area is more complex and variable than beneath the wetlands. This is likely due to the location of the landfill, which lies in a transitional area between the glacial drift plain hills to the east and the floor of the greater Puyallup River valley to the west and south. Regardless, cross-section A-A (attached)', as reproduced from the RI, shows the aquitard present underneath the landfill (shown prior to the 1993 remedy). Cross sections A-A' and B-B' (attached) reproduced from the GAE, also show the presence of the aquitard in a large number of closely spaced borings drilled along the critical downgradient northern edge of the landfill.

The boring logs for the landfill, except for two in the southwest corner, indicate the presence of the aquitard at the depth that it would be expected based on its occurrence in the wetlands. The logs indicate the thickness of the unit beneath the landfill to be between approximately 4 and 9.5 feet, with thicknesses up to 17 feet identified outside the immediate area of the landfill.

At the southwest corner of the landfill, the boring logs for D-8B and T-3, and arsenic concentrations in D-8B right after it was installed (refer to the April 9 memorandum), indicate that a change in the lithology may be present in this area. The boring log for D-8B, located approximately 50 feet west of the current edge of landfill refuse, indicates that this boring did not encounter the aquitard unit to a depth of 34 feet below ground surface (bgs). According to the boring log, sand was encountered throughout the boring. Additionally, the log of T-3 located at the south western corner indicates a silty sand with interbedded silt at the expected depth of the aquitard. The analysis of these two borings led to the question of whether there was a significant change in the lithology in the area that could result in increased hydraulic connection between the aquifers in this area.

To better understand the aquitard extent and nature, Floyd|Snider advanced four additional direct-push soil borings along the western edge of the landfill on April 4, 2007. Due to time limitations, only four borings could be completed near the location of well D-8. A detailed characterization along the full extent of western boundary could not be performed. The results are incorporated into the attached cross-section G-G' (attached), which is also shown with recent arsenic analytical results. The aquitard was encountered in all borings in which samples were collected at the appropriate depth. In particular, a four-foot layer of silt, underlain by silty sand, was identified approximately 50 feet north of well D-8B, beginning at a depth of 27 feet bgs. The abrupt contact between sand and silt, and gravels consistent with channel lag, suggest a higher-energy depositional environment in the vicinity of D-8B in which a stream channel apparently scoured away some of the underlying silt. Low-permeability aquitard deposits were also identified in borings immediately south of D-8B, at a shallower depth.

These new data clarify that the aquitard is more continuous along the southwest corner of the landfill than indicated by simple review of the older boring logs. In the area near well T-3, the silt unit may be more of a silty sand with silt interbedded, but likely is of low enough permeability to prevent downward dispersion and diffusion. There is also a possible discontinuity in the aquitard at well D-8 that has now been determined to be of very localized extent. Even without a strong indication of an aquitard in this limited location, there is no contamination of deeper groundwater in well D-8B. Groundwater in this location has been monitored and stable since 1998..

SUMMARY AND IMPLICATIONS FOR REMEDY SELECTION

The review of past data and the results of the latest borings confirm the CSM and provide additional detail regarding the geometry of the aquitard.

During the pre-remedial design phase of slurry wall construction, it is standard practice to install a series of closely spaced borings to confirm conditions, and to adjust slurry wall designs to address the exact types of conditions that may be occurring at D-8, (e.g., a breach or thinning in the unit). For sites in alluvial plains with horizontal flow and weak to moderate upward gradients, the solution is simple and well-established: the slurry wall is deepened in those locations to go below the level of contamination and either allowed to “hang” or to tie into another deeper silt zone. Cross-section G-G’ is shown with one possible implementation of the slurry wall in this area.

The key fact to remember at B&L Landfill is that groundwater flow is horizontal. Even without any remedial action the Lower Sand Aquifer did not become contaminated. The existing remedy consolidated and capped the landfill, but allowed this lateral flow to transport arsenic into the Upper Sand Aquifer beneath the wetlands. The intent of the slurry wall would be to stop the on-going releases to the Upper Sand Aquifer by making the landfill and its saturated footprint truly stagnant. This is readily achievable in the hydrogeologic setting of the B&L Landfill.

Long-term monitoring and maintenance is also conceptually simple, and includes the following:

- The existing grade and cap of the landfill need to be maintained to limit the amount of leachate generated by infiltration of rain water. The most important aspect of this is the grade of the landfill.
- Long-term monitoring of groundwater levels in both aquifers and in the landfill sump need to occur.
- A contingency leachate collection system (potentially the existing one) needs to be maintained so that leachate levels within the landfill are not able to rise significantly above the levels of the Lower Sand Aquifer. That is, we do not want to artificially create a downward gradient.

- Groundwater quality in a series of perimeter wells needs to be monitored so that any cracks that may appear in the slurry wall can be fixed in a timely manner, keeping in mind that the site is in an area with low flow rates that allow for repairs to be made with plenty of time to protect receptors.

The most appropriate way to address concerns about the heterogeneities in the Lower Aquitard, therefore, would be through pre-remedial design and long-term monitoring. Built-in contingencies would include pumping if necessary to maintain flat or upward gradients, as discussed in the GAE. We look forward to discussing further the details of this memorandum with you at your earliest convenience.

GENERAL NOTE

This is a draft document that involves the practice of geology as defined by Chapter 18.220 RCW. A geologist stamp or signature is not required for this draft document. It is the expectation of the authors that a final stamped and signed version of this document will be submitted to Ecology following their review, or included as part of another signed and stamped final document.

ATTACHMENTS

Table: Aquitard Thickness and Continuity

Figure: Exploration Locations Showing Aquitard Thickness and Continuity

Figure: Cross-section F-F'

Figures: RI Cross-sections (AGI/KJC 1990)

Figure: Cross Sections A-A' and B-B' from the GAE

Figure: Cross-section G-G'

Figure: Cross-section G-G' Showing Total Arsenic Concentrations in Groundwater

Figure: Cross-section G-G' Showing Slurry Wall

REFERENCES

Ecology and Environment, Inc. (EEI) 1987. *Site Inspection Report for Commencement Bay Nearshore/Tideflats; Tacoma, Washington*. Prepared for Region X EPA. August.

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Hydrometrics 2001. *Review of Remedial Activities at the B&L Landfill.* Prepared for Mr. Thomas E. Martin, Site Manager, ASARCO Incorporated. May.

Kennedy/Jenks/Chilton (K/J/C) and AGI. 1990. *Focused Remedial Investigation B&L Woodwaste Site*. Prepared for Murray Pacific. September.

Summary of Available Lower Aquitard Continuity and Thickness Data

Soil Boring	Date	Total Depth (feet bgs)	Depth to Aquitard (feet bgs)	Total Aquitard Thickness[1] (feet)	Partial Aquitard Thickness[2] (feet)	Aquitard Description Summary
Wetlands Area						
D-1U/L	9/18/1989	30	16	5		Organic silt, stiff, moist, slightly plastic. Peat, stiff, moist, fibrous to moderately woody, with sand and silt interbeds.
D-5U/L	7/25/1989	30.75	16	8		Organic silt, stiff, wet to saturated, with interlayered peat and woody organics
D-6A/B	10/26/1993	33	17	5		Organic silt, moldable, with lenses of peat.
FS-9	9/6/2005	16	15.5		> 0.5	Silt interbedded with peat.
FS-10	9/6/2005	18.5	17.5		> 1	Silt interbedded with peat.
FS-11	9/6/2005	18.5	17.5		> 1	Silt interbedded with peat.
FS-12	9/7/2005	16.5	15.9		> 0.6	Silt interbedded with peat.
FS-13	9/7/2005	17.5	15		> 2.5	Silt interbedded with peat.
FS-15	9/7/2005	16	15.6		> 0.3	Silt, moist.
FS-17	9/9/2005	16	15.5		> 0.5	Silt, moist.
FS-19	9/9/2005	20	16		> 4	Silt with trace sand, moist, interbedded with peat.
FS-20	9/9/2005	20	19		> 1	Silt with trace sand, moist, interbedded with peat.
FS-22	9/9/2005	20.5	19		> 1.5	Silt interbedded with peat.
FS-23	9/12/2005	16	15.7		> 0.3	Silt, moist.
FS-24	9/12/2005	20	19		> 1	Silt, moist, interbedded with peat.
FS-25	9/12/2005	20	16.5		> 3.5	Silt with trace sand, moist, interbedded with peat.
FS-26	9/12/2005	16	15.84		> 0.16	Silt with sand.
FS-27	9/12/2005	16	15.5		> 0.5	Silt interbedded with peat.

Soil Boring	**Date**	**Total Depth (feet bgs)**	**Depth to Aquitard (feet bgs)**	**Total Aquitard Thickness[1] (feet)**	**Partial Aquitard Thickness[2] (feet)**	**Aquitard Description Summary**
FS-28	10/18/2005	24	20.5		> 3.5	Silt, dry to moist, interbedded with wood and peat, dry to moist, with charcoal.
FS-101	9/12/2006	24	23		> 1	Silt, plastic, moist, and silty sand, medium dense, moist, interbedded with peat, moist.
FS-102	9/12/2006	24	22.5		> 1.5	Silt, plastic, moist, and silty sand, medium dense, moist, interbedded with peat, moist.
FS-103	9/13/2006	24	22.5		> 1.5	Sandy silt, dry to moist, with wood fragments.
FS-104	9/13/2006	24	23	(Refer to MW-31A/B)	> 1	(Refer to MW-31A/B)
FS-105	9/13/2006	24	21.5		> 2.5	Silt, plastic, moist, interbedded with peat, moist.
FS-106	9/13/2006	24	22.5		> 1.5	Silt, plastic, moist, interbedded with peat, moist.
FS-107	9/14/2006	24	21.5		> 2.5	Silt, plastic, moist, with wood fragments, interbedded with peat, moist.
FS-108	9/14/2006	24	19.5		> 4.5	Sandy silt and silt, plastic, moist, with wood fragments, interbedded with peat, moist.
MW-31A/B	3/23/2007	40	23	13		Silt and sandy silt, plastic, moist, with trace woody material, interbedded with peat and wood, moist. Sandy silt, moist.
Landfill Area						
EE-23	4/3/1987	80	6	17		Clayey silt. (Boring located sidegradient of landfill).
T-1	4/28/1989	41.5	30	6		Silt, soft to medium stiff, moist, trace organics and thin sand interbeds.
T-2	6/6/1989	38.5	22	7		Organic silt, medium stiff, moist, slightly to medium plastic, with interbeds of peat/decomposed wood. Silty sand, medium dense, saturated, fine to medium grained, trace wood fragments.

Soil Boring	Date	Total Depth (feet bgs)	Depth to Aquitard (feet bgs)	Total Aquitard Thickness[1] (feet)	Partial Aquitard Thickness[2] (feet)	Aquitard Description Summary
T-3	6/2/1989	33.86	26.5	6.5		Silty fine sand, medium dense, saturated, occasional silt interbed.
T-4	5/31/89	41.5	35		> 6	Silty sand, hard, moist, trace organics, thin very fine sand interbeds. (Log classifies silty sand as ML, not SM).
D-3U/L	8/25/1989	26.5	Not encountered	NA		NA. (Sand, loose, saturated, trace gravel and trace silt, medium grained, medium dense to dense. Woody organics at 22 feet. Boring located upgradient of landfill).
D-4U/L	8/28/1989	26.5	Not encountered	NA		NA. (Sand, medium dense, saturated, medium to coarse grained, with trace fine gravel and organics. Boring located sidegradient of landfill).
D-7A/B	10/25/1993	33	22	4		Woody organic material (peat), grey clayey silt.
D-8A/B	11/11/1993	33	Not encountered	NA		NA. (Fine to coarse sand, small gravels at 18 feet, wood log encountered at 30.5 feet).
D-9A/B	11/11/1993	31	13.5	9.5		Clay, stiff, with wood peat mix. Silty clay, stiff, high organics. Wood, peat. Silt 90%, some clay 10%, dense. Silt, some organic material, organic material saturated.
D-11A/B	11/09/1993	33	Not encountered	NA		NA. (Fine to medium sand, 40% rounded ½" gravels at 25 feet. Boring located upgradient of landfill).
FS-1	8/30/2005	22	20		> 2	Silt with interbedded woody peat.
FS-3	8/31/2005	22	21.75		> 0.25	Silt, plastic.
FS-5	9/1/2005	24	21		> 3	Silt with interbedded woody peat.
FS-7	9/2/2005	24	22.5		> 1.5	Silt with woody material, organic silt, woody peat.
FS-29	10/18/2005	20	18		> 2	Silt with sand, moist, with woody material. Fine sand lense. Silt with wood pieces.
FS-30	10/19/2005	24	20		> 4	Silt, moist with interbedded woody peat.

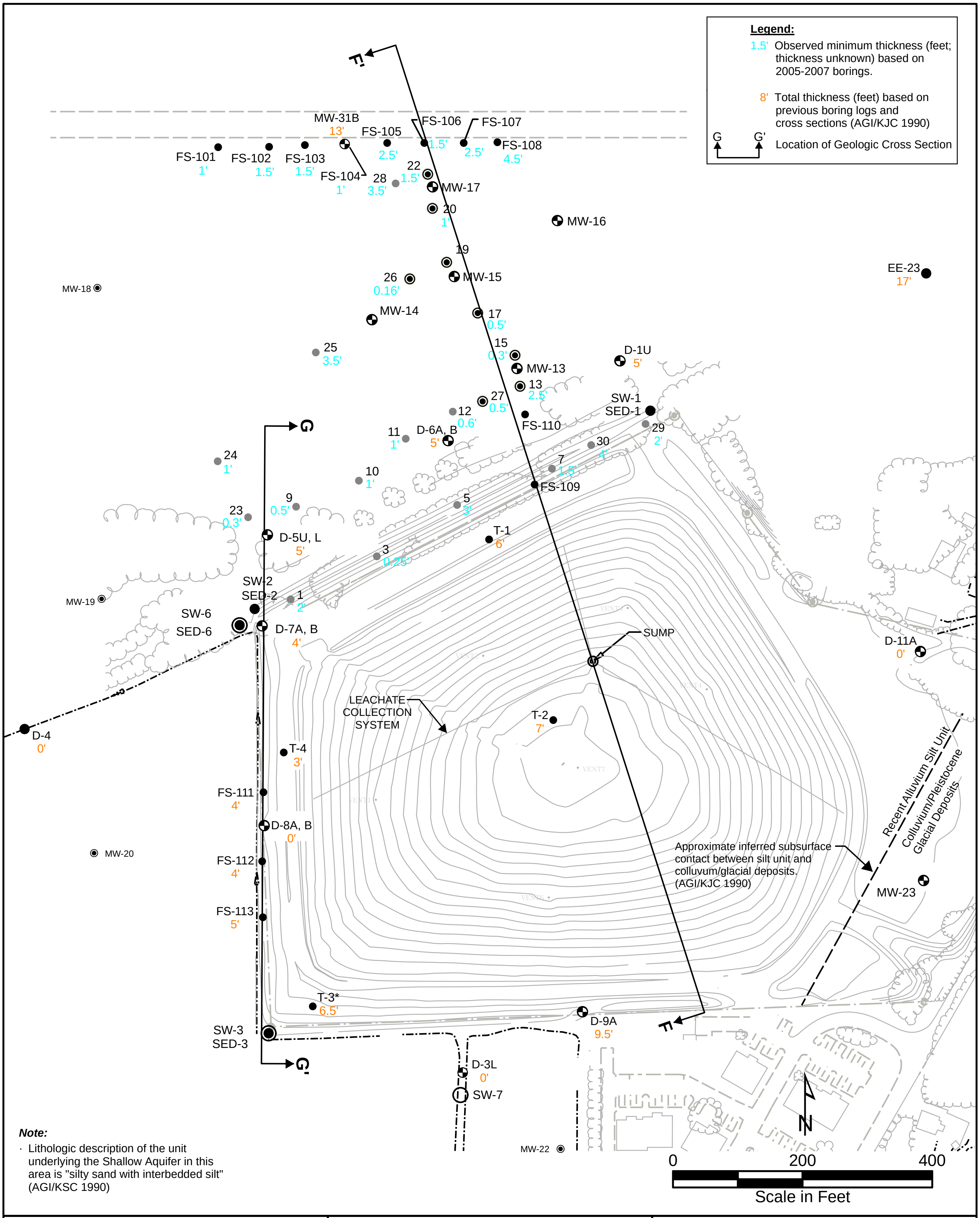
Soil Boring	Date	Total Depth (feet bgs)	Depth to Aquitard (feet bgs)	Total Aquitard Thickness[1] (feet)	Partial Aquitard Thickness[2] (feet)	Aquitard Description Summary
FS-111	4/4/07	32	27	4		Silt, medium stiff, low plasticity, moist, with wood pieces.
FS-112	4/4/07	28	18	4		Organic silt with wood pieces. Silty sand, fine, wet, with fine silt laminations.
FS-113	4/4/07	22	16	5		Silt, moist-dry, medium stiff, varying plasticity, some woody material. Organic silt and fine-grained peat.
FS-114	4/4/07	32	NA[3]	NA[3]		NA

Notes:

1 Indicates the boring was deep enough for complete penetration of the aquitard unit.

2 Indicates the boring was deep enough to encounter and identify the aquitard unit, and measure a partial thickness only.

3 Samples were collected in FS-114 from 24 to 32 feet, beneath the apparent depth of the aquitard based on FS 112 and FS-113.



Note:
- Lithologic description of the unit underlying the Shallow Aquifer in this area is "silty sand with interbedded silt" (AGI/KSC 1990)

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B & L Landfill
Milton, WA

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Exploration Locations Showing Aquitard Thickness and Continuity

F:\projects\H&H B&L Landfill\GIS\MXD\Figure X (Exploration Locations Showing Aquitard Thickness and Continuity).mxd

SOURCES:

AGI/KJC 1990
Hydrometrics 2001
Floyd Snider 2006
Floyd Snider 2007

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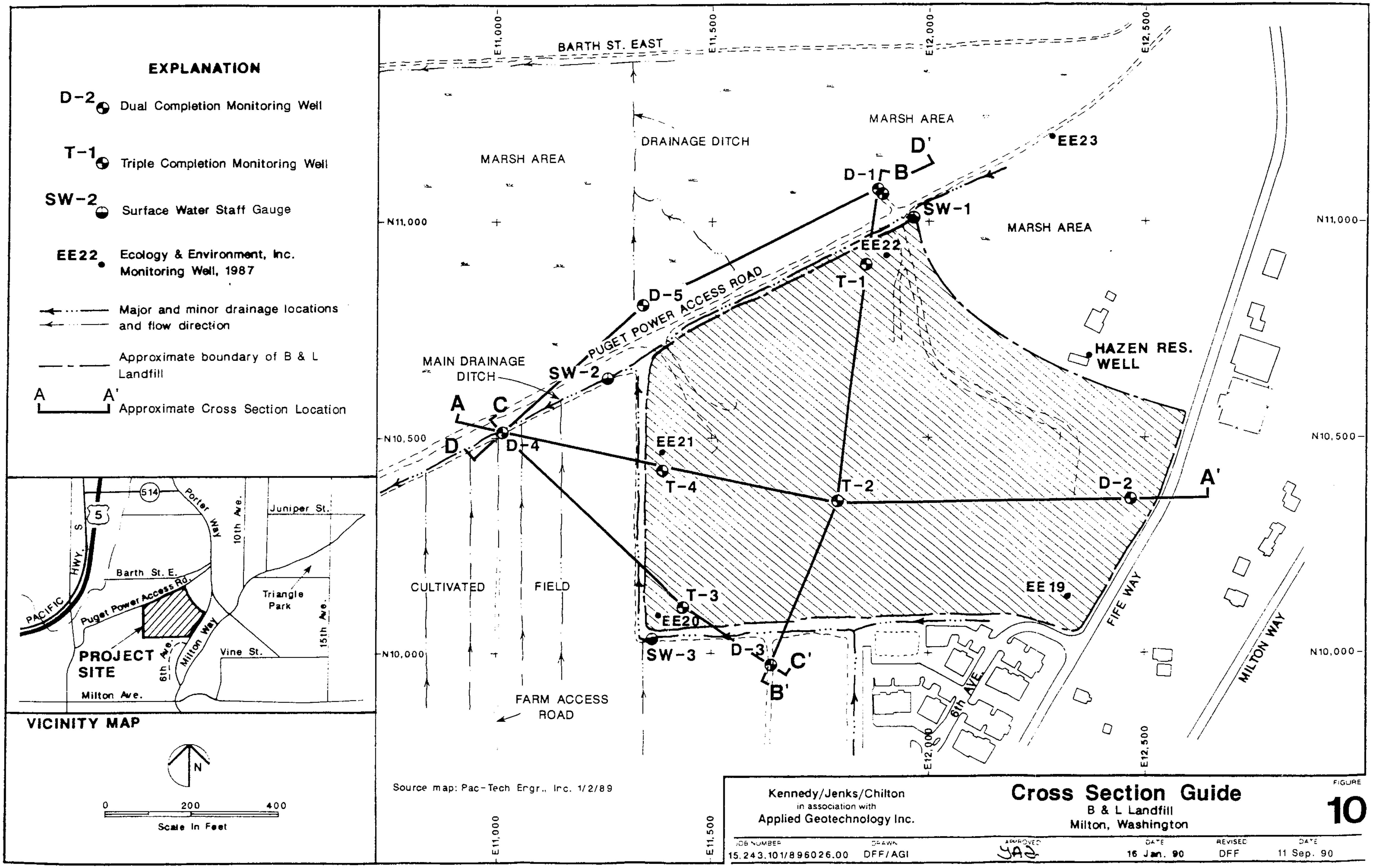
Cross Section F-F'



Source map: Pac-Tech Engr., Inc. 1/2/89

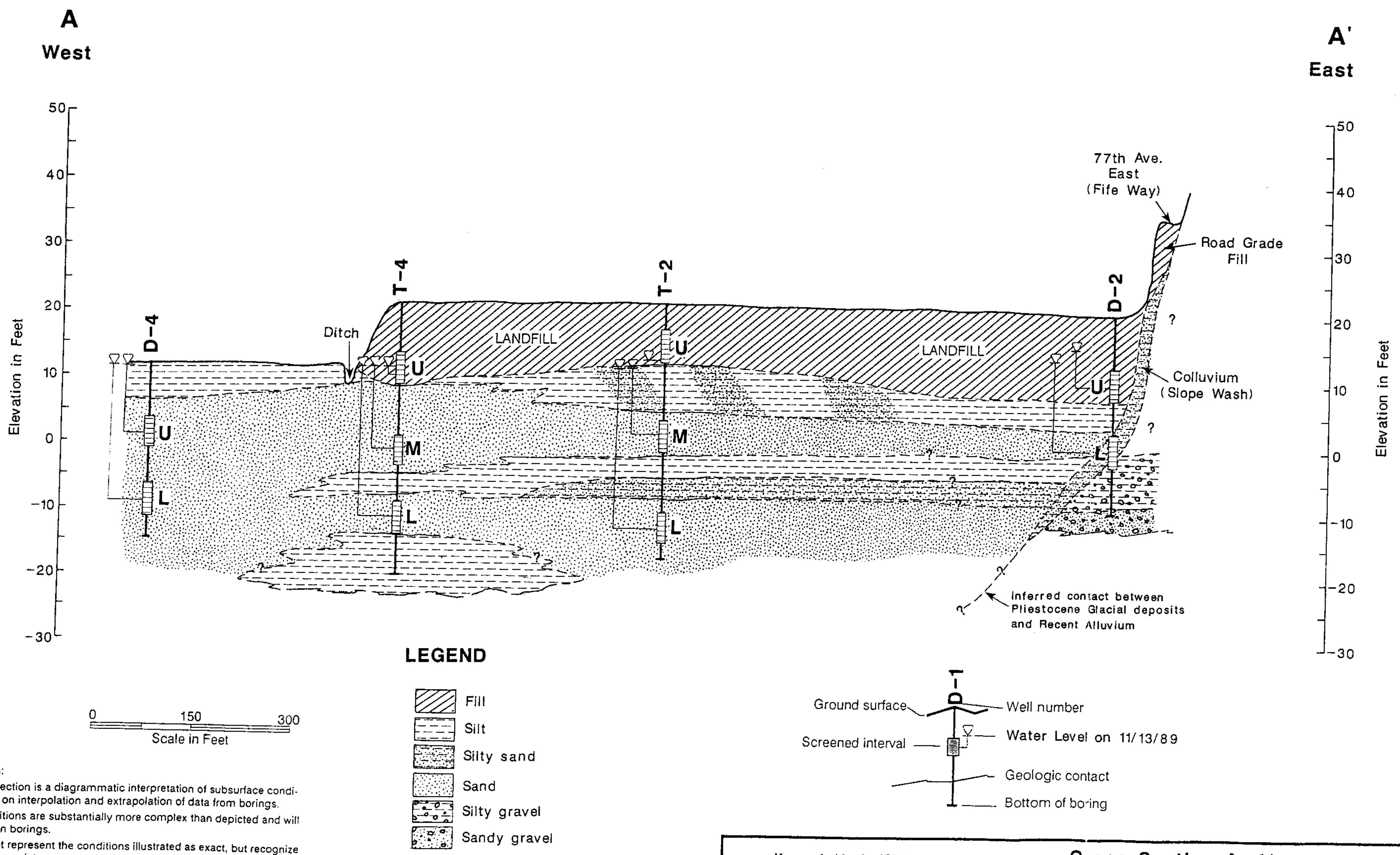
Kennedy/Jenks/Chilton
in association with
Applied Geotechnology Inc.

Cross Section Guide

B & L Landfill
Milton, Washington

FIGURE
10

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15.243.101/896026.00	DFF/AGI	YAZ	16 Jan. 90	DFF	11 Sep. 90



Explanation:

This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings.

Actual conditions are substantially more complex than depicted and will vary between borings.

AGI does not represent the conditions illustrated as exact, but recognize that variations exist.

Ditch depths are approximated based on measurements at nearby staff gauges only.

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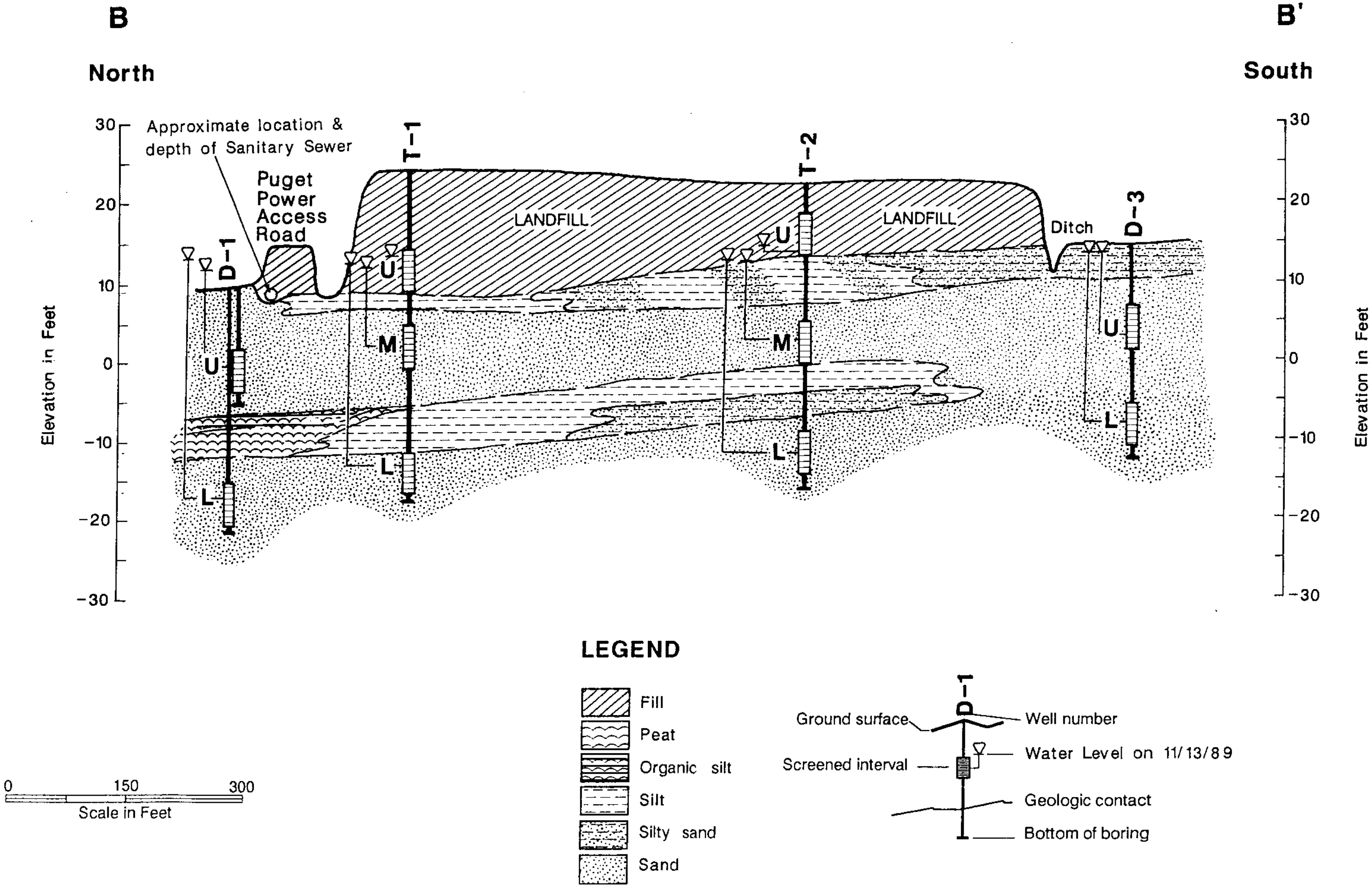
Cross Section A-A'
B & L Landfill
Milton, Washington

FIGURE
11

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,243.101/896026.00	DFF/AGI	YAG	15 Feb. 90		



Explanation:

This cross section is a diagrammatic interpretation of subsurface conditions based on interpolation and extrapolation of data from borings.

Actual conditions are substantially more complex than depicted and will vary between borings.

AGI does not represent the conditions illustrated as exact, but recognize that variations exist.

Ditch depths are approximated based on measurements at nearby staff gauges only.

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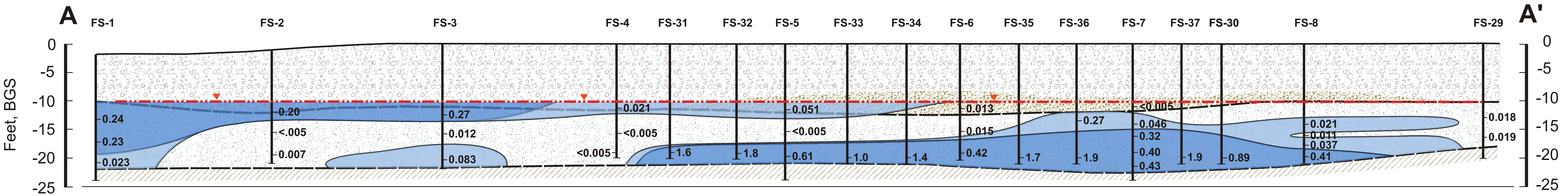
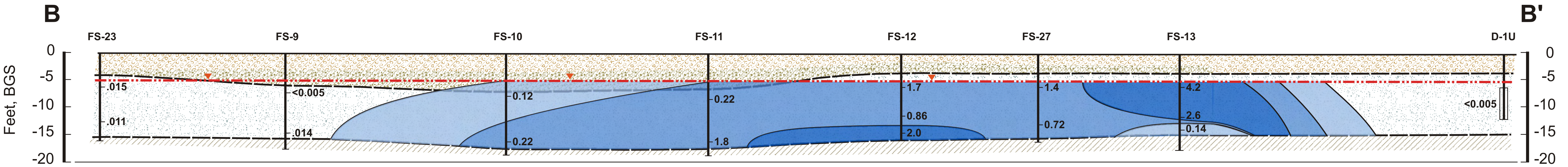
Cross Section B-B'
B & L Landfill
Milton, Washington

FIGURE
12

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,243.101/896026.00	KLC	JAJ	27 November 89	DFF	



Approximate Ground Surface along Transect = 15 Feet MSL



Approximate Ground Surface Elevation in Wetlands = 10 Feet MSL

LEGEND

Approximate Potentiometric Surface Elevation

BGS = Below Ground Surface

Notes: Geologic cross sections and arsenic concentration contours are based on 2005 direct-push borings and discrete-depth sampling results (Floyd Snider, 2006).

D-1U geology after AGI/K/JL (1990).

D-1U arsenic concentrations have never exceeded 0.005 μg/L.

Dissolved Arsenic (mg/L)

- ☐ <0.005 - 0.020
- 🟦 0.020 - 0.200
- 🟦 0.200 - 2.000
- 🟦 >2.0
- 0.054 Actual Concentration

Geology Key

- ▨ Fill
- ▨ Organic Silt with Peat
- ▨ Silt with Sand
- ▨ Sand
- ▨ Silt Interbedded with Peat

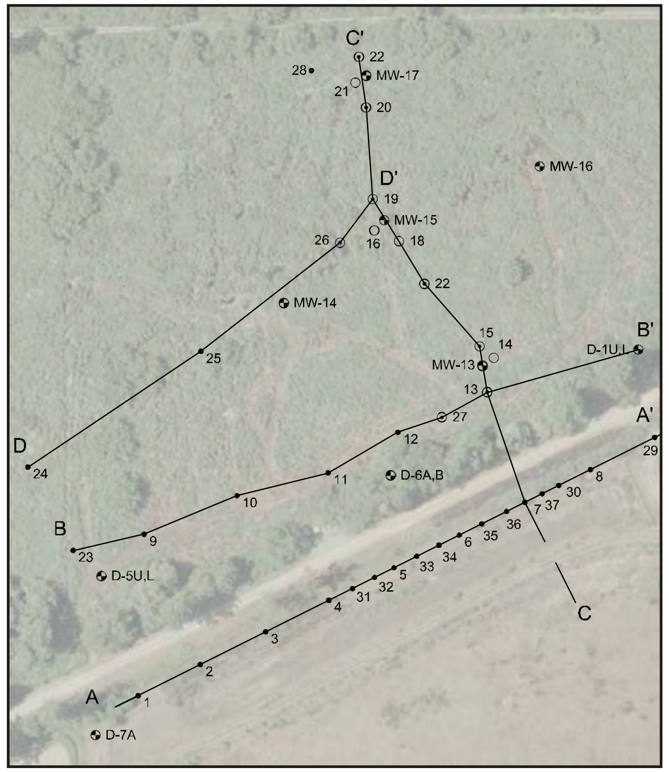
Horizontal Scale in Feet

0 50 100

0 20 40

Vertical Scale in Feet

Vertical Exaggeration x 2.5



Cross Section Locations

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B&L Landfill
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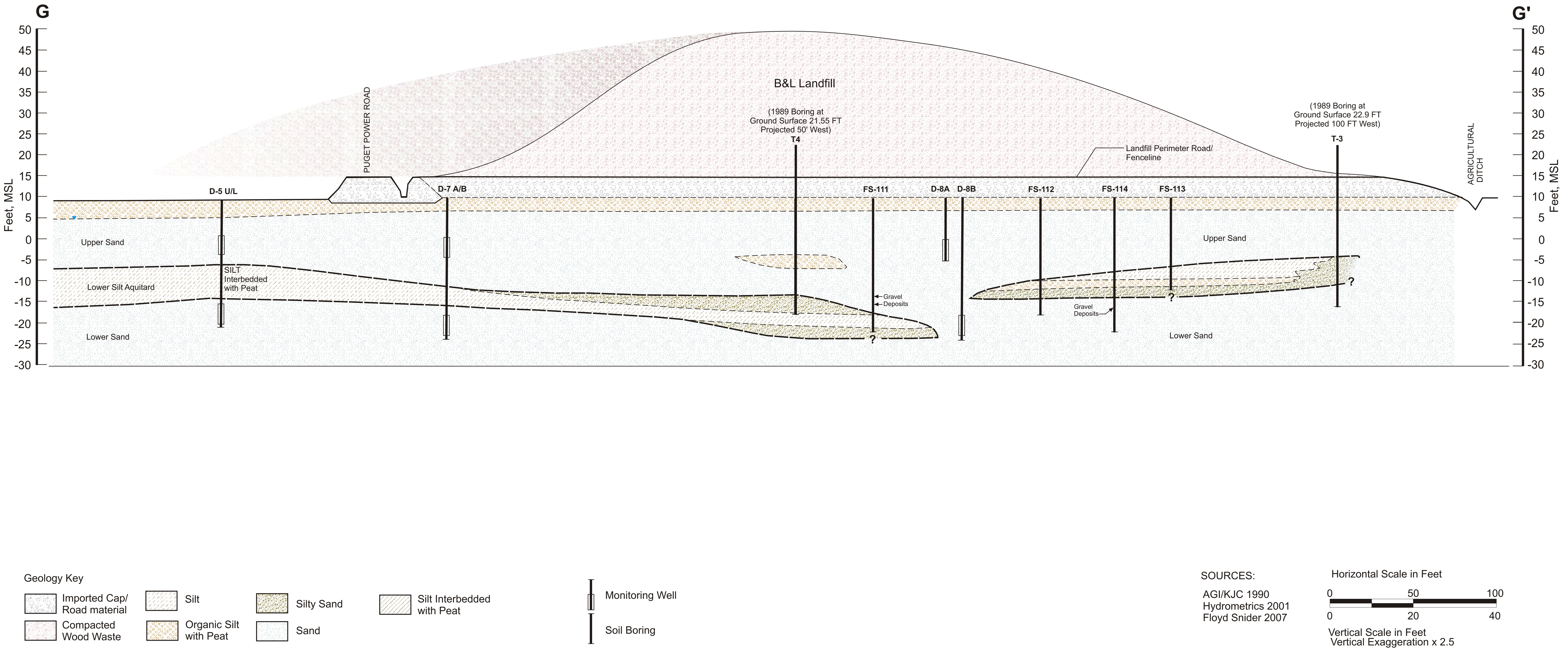
Figure 3.4
Cross Sections A-A' and B-B' Showing
Dissolved Arsenic Concentration Contours



SOURCES:

AGI/KJC 1990
Hydrometrics 2001
Floyd Snider 2007

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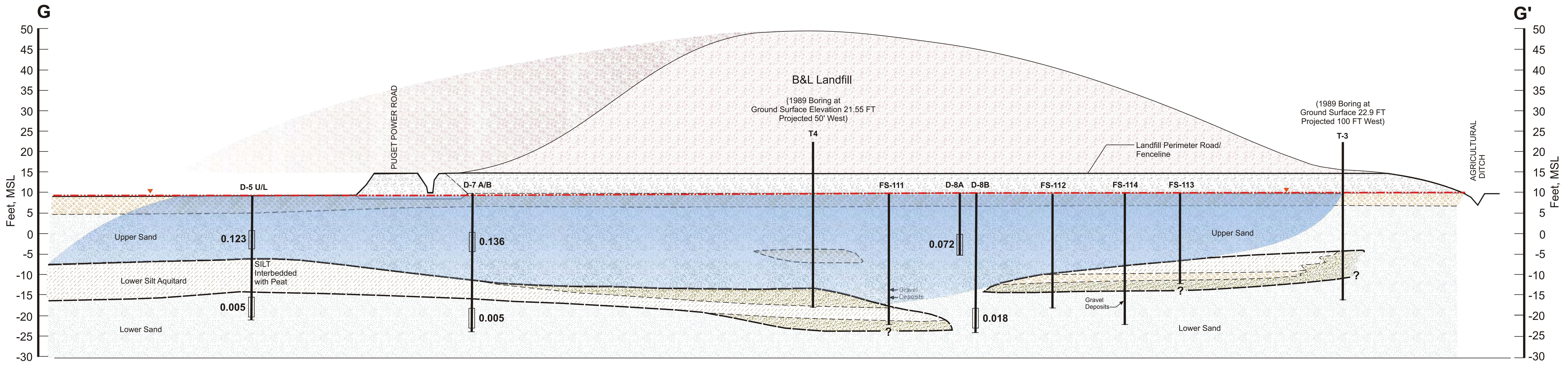
Cross Section G-G'



Geology Key

- ▨ Imported Cap/ Road material
- ▨ Compacted Wood Waste
- ▨ Silt
- ▨ Organic Silt with Peat
- ▨ Silty Sand
- ▨ Sand
- ▨ Silt Interbedded with Peat

Dissolved Arsenic (mg/L)

- ☐ <0.005 - 0.020
- 🟦 0.020 - 0.200
- 🟦 0.200 - 2.000
- 🟦 >2.0

0.054 Actual Concentration

Approximate Potentiometric Surface

Monitoring Well

Soil Boring

SOURCES:

AGI/KJC 1990
Hydrometrics 2001
Floyd Snider 2007

Horizontal Scale in Feet
0 50 100
0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 2.5

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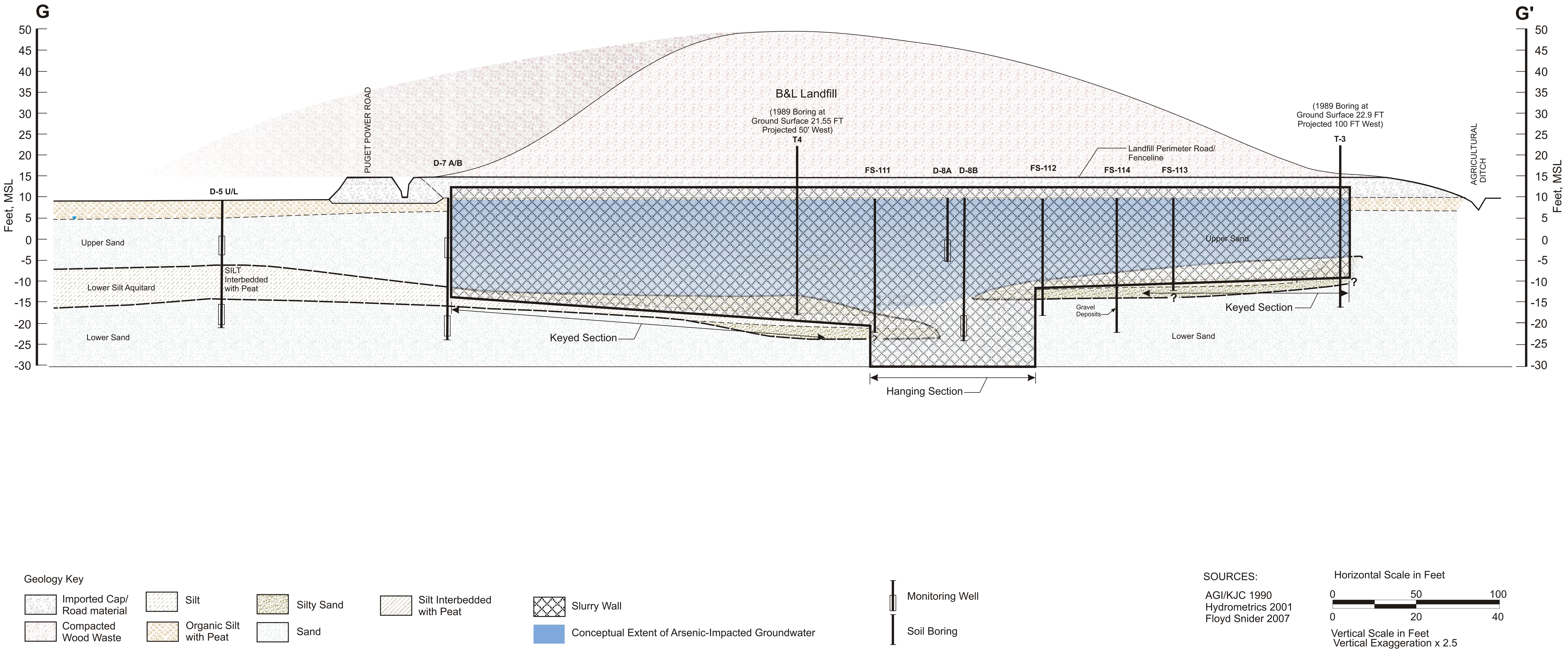
Cross Section G-G'
Showing Total Arsenic
Concentrations in Groundwater



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Cross Section G-G'
Showing Slurry Wall

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Two Union Square 601 Union Street Suite 600
Seattle, Washington 98101 tel: 206.292.2078 fax: 206.682.7867

Memorandum

To: Dom Reale, Department of Ecology
Copies: Murray Pacific Corporation
From: Teri Floyd, Tom Colligan, and Brett Beaulieu, Floyd|Snider
Date: April 9, 2007
Project No: MPC – B & L
Re: **Arsenic in the Lower Sand Aquifer at the B&L Landfill**

INTRODUCTION

This memorandum was prepared on behalf of Murray Pacific Corporation at the request of the Washington State Department of Ecology to support decision making on remedial alternatives at the B & L landfill.

BACKGROUND

The hydrogeologic units underlying the B & L Landfill, characterized by several investigations, consist primarily of an Upper Sand Aquifer and a Lower Sand Aquifer, which are separated by a low-permeability unit called the Lower Aquitard (see, for example, Floyd|Snider 2007). Previous investigations have determined that Lower Sand Aquifer groundwater is not materially impacted by arsenic from the landfill. This finding is thought to result from the protective combination of the Lower Aquitard and upward gradients that together prevent migration of arsenic downward into deeper groundwater.

These findings have been confirmed through recent sampling and analytical testing of well pairs at the B & L Landfill site, including a new monitoring well couplet MW-31, installed two weeks ago along the 12th Avenue right-of-way in the wetlands. These results are presented in this memorandum.

RESULTS

Recent Sampling

On March 28 through March 30, 2007, groundwater samples were collected according to standard low-flow methods from well pairs comprised of one monitoring well with a screened interval in the Upper Sand Aquifer, and one monitoring well with a screened interval in the Lower Sand Aquifer.

As shown on the accompanying figure, these new data confirm the previously reported findings and demonstrate that the Lower Sand Aquifer remains unimpacted by arsenic.

As part of these recent activities, an additional well pair (MW-31A and MW-31B) was installed along 12th Street E. (refer to the attached figure), to provide better coverage of the northern part of the wetlands area. The boring logs from this well pair are attached.

Historical results

A summary of the new and historical arsenic data for Lower Sand Aquifer well pairs is presented in the accompanying table covering investigation activities beginning in 1989 through measurements collected by Floyd|Snider in March 2007. The existing remedy, which consolidated and capped the landfill, was constructed in 1992 and 1993. Wells D-5L, D-6B, D-1L, and MW-31B all show that the Lower Sand Aquifer in the wetlands has not been impacted by B&L Landfill, either historically (pre-remedy) or since the remedy has been installed. The groundwater plume in the wetlands in the Upper Sand Aquifer has not migrated to nor impacted the Lower Sand Aquifer. Data supporting this conclusion begins in 1993 indicating that even without the existing remedy, impacts were not occurring in this area.

A single well, D-8B, shows elevated arsenic concentrations. This well also has the weakest expression of the aquitard encountered in the investigation area. The data in the attached table, presented graphically for this well in the accompanying chart, indicate that the highest concentrations were just after installation, with concentrations falling after remedy implementation in 1992-93. Concentrations in the well appeared to have reached steady state in 1999 and have remained between 0.02 and 0.03 mg/L since that time.

As this table also indicates, the elevated concentrations in D-8B have not migrated to impact groundwater measured by other Lower Sand Aquifer wells, such as monitoring well D-7B. Monitoring well D-7B has consistently been at or below a detection level of 0.005 mg/L arsenic. Well D-8B lack of impact on the rest of the Lower Sand Aquifer is likely a result of the upward gradients and geometry of the Lower Aquitard beneath this area of the site.

Leachate indicators and comparison with Upper Sand Aquifer results

Leachate plume indicators other than arsenic, including dissolved organic carbon (DOC), total dissolved solids (TDS), and dissolved iron provide additional evidence that the plume has not reached into the Lower Sand Aquifer. These parameters are strongly correlated with arsenic and are indicators of landfill leachate (Floyd|Snider 2007).

As shown in the attached figure, Upper Sand Aquifer groundwater downgradient of the landfill is significantly elevated in dissolved iron, DOC, and TDS, while Lower Sand Aquifer groundwater is not. These constituents are also not elevated in MW-8B, supporting the insignificant migration through this location in the last decade.

SUMMARY AND IMPLICATIONS FOR REMEDY SELECTION

The review of past data and the results of the latest testing confirm the site conceptual model: arsenic and other leachate indicators occur only in shallow groundwater in the Upper Sand Aquifer above the Lower Aquitard. Groundwater in the Lower Sand Aquifer is not affected by the arsenic plume or other groundwater constituents from the landfill. The Lower Sand Aquifer also shows no indication that it was impacted historically (pre-remedy), except potentially for localized effects at D-8.

In addition, the evidence indicates that there is a very low risk of future contamination of the Lower Sand Aquifer. Over 30 years have elapsed since slag was first deposited at the site and this aquifer is still not impacted. This length of time represents enough time for the system to approach equilibrium, and so there is no reason to suspect future contamination of the Lower Sand Aquifer.

The lack of contamination in deeper groundwater is in full agreement with the model of arsenic fate and transport in this setting (for further discussion, refer to Floyd|Snider 2007):

- Arsenic, transported by advection in groundwater as dissolved ions, does not “sink” like a dense non-aqueous phase liquid (DNAPL).
- The wetlands, as the floodplain for Hylebos Creek, is a permanent discharge area for regional groundwater, resulting in upward groundwater gradients, from the Lower to the Upper Sand Aquifer. This situation provides a fundamental protection for the Lower Sand Aquifer. The upward gradients are not subject to change as they are a function of area topography and geologic setting.
- There is an intervening aquitard that further limits the ability of arsenic to migrate downwards, for example, by diffusion. The aquitard is comprised of silts, clays and peats, with a low permeability of 10^{-6} cm/sec or 0.004 feet/day (Hydrometrics 2001). Leakage of groundwater through this aquitard would be expected to be very low, even in the presence of downward gradients. Arsenic is also readily adsorbed by fine-grained and organic-rich materials.
- The current shape of the plume mimics the natural flow of groundwater with some spreading laterally due to diffusion. There is no downward component of groundwater flow due to the upward gradients.

Therefore, the upward gradients and the intervening aquitard comprise a two-part system of protection for the Lower Sand Aquifer outside of the landfill boundary.

The most appropriate way to address concerns about the Lower Sand Aquifer appears to be through long-term groundwater monitoring. Groundwater quality in this aquifer can easily be monitored and appropriate contingencies can be established. The cost for the remedy proposed in the Groundwater Alternatives Evaluation (GAE) includes a rigorous long-term monitoring scheme, using a trust fund to support the costs.

ATTACHMENTS

Figure: Comparison of Water Quality, Upper and Lower Sand Aquifers, March 2007

Table: Dissolved and Total Arsenic (mg/L) Results from Historical Monitoring Well Sampling

Chart: Dissolved and Total Arsenic in Lower Sand Aquifer Well D-8B

Laboratory Analytical Results

Wells Logs for Wells MW-31A and MW-31B

REFERENCES

Floyd|Snider 2007. *Groundwater Alternatives Evaluation*, Ecology Preliminary Review Draft. Prepared for Murray Pacific. January.

Hydrometrics 2001. *Review of Remedial Activities at the B&L Landfill.* Prepared for Mr. Thomas E. Martin, Site Manager, ASARCO Incorporated. May.

Dissolved and Total Arsenic (mg/L) Results from Historic Monitoring Well Sampling

	Lower Sand Aquifer Monitoring Wells											
	D-1L		D-5L		D-6B		D-7B		D-8B		D-11B	
Sampling Event	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic
Sep-89	0.01	0.02										
Dec-89	0.008	0.007										
Aug-90		0.008										
May-93	0.02 U	0.02 U	0.02 U	0.02 U								
Jan-94	0.009	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.005 U	0.8	0.8	0.005 U	0.005 U
May-94	0.01	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.009	0.7	0.7	0.005 U	0.005 U
May-94 D							0.005 U	0.005				
Aug-94	0.007	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.4	0.4	0.005 U	0.005 U
Aug-94 D					0.005 U	0.005 U						
Dec-94	0.009	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.3	0.3	0.005 U	0.005 U
Mar-95	0.008	0.007	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.3	0.2	0.005 U	0.005 U
Mar-95 D											0.005 U	0.005 U
Jun-95	0.01	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.2	0.2	0.005 U	0.005 U
Dec-95							0.005 U	0.005	0.1	0.1	0.005 U	0.007
Mar-96							0.006	0.005 U	0.1	0.1	0.005	0.005 U
Mar-96 D							0.006	0.005 U				
Jun-96							0.005	0.005	0.1	0.1	0.005 U	0.005 U
Jun-96 D									0.1	0.1		
Sep-96	0.01	0.01	0.006	0.005	0.005	0.006	0.007	0.005	0.1	0.1	0.005 U	0.005 U
Sep-96 D			0.005	0.005								
Jan-97	0.009	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.1	0.09	0.005 U	0.005 U
Jan-97 D							0.005 U	0.005 U				
Mar-97	0.01	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.007	0.07	0.06	0.005 U	0.005 U
Jun-97	0.01	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.005	0.07	0.06	0.005 U	0.005 U
Sep-97	0.01	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.006	0.005 U	0.07	0.06	0.005 U	0.005 U
Dec-97	0.007	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.007	0.06	0.06	0.005 U	0.005 U
Mar-98	0.009	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.04	0.04	0.005 U	0.005 U
Jun-98	0.01	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.005 U	0.03	0.02	0.005 U	0.005 U
Sep-98	0.005 U	0.008	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.03	0.02	0.005 U	0.005 U

	Lower Sand Aquifer Monitoring Wells											
	D-1L		D-5L		D-6B		D-7B		D-8B		D-11B	
Sampling Event	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic	Dissolved Arsenic	Total Arsenic
Sep-98 D											0.005 U	0.005 U
Dec-98	0.009	0.008	0.005 U	0.005 U	0.005 U	0.005 U	0.006	0.007	0.03	0.03	0.005 U	0.005 U
Mar-99	0.009	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.006	0.03	0.03	0.005 U	0.005 U
Mar-99 D											0.005 U	0.005 U
Jun-99	0.009	0.008	0.006	0.005 U	0.005 U	0.005 U	0.005	0.005 U	0.02	0.02	0.005 U	0.005 U
Jun-99 D											0.005 U	0.005 U
Sep-99	0.009	0.009	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.005	0.02	0.02	0.005 U	0.005 U
Jan-00	0.01	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.006	0.03	0.03	0.005 U	0.005 U
Mar-00	0.009	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.02	0.02	0.005 U	0.005 U
Mar-00 D			0.005 U	0.005 U			0.005 U	0.005 U				
Jun-00	0.01	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.02	0.02	0.005 U	0.005 U
Jun-00 D							0.005 U	0.005 U				
Sep-00	0.01	0.01	0.003	0.004	0.004	0.005	0.003	0.006	0.02	0.02	0.002 U	0.002 U
Dec-00	0.01	0.01	0.003	0.004	0.005	0.004	0.005	0.006	0.03	0.02	0.002 U	0.002 U
Dec-00 D			0.003	0.004	0.005	0.004					0.002 U	0.002 U
Mar-01	0.009	0.009	0.003	0.003	0.003	0.003	0.005	0.006	0.03	0.03	0.002 U	0.002 U
Mar-01 D							0.005	0.006				
Jun-01	0.01	0.01	0.003	0.004	0.004	0.004	0.005	0.006	0.03	0.03	0.002 U	0.002
Jun-01 D	0.009	0.01							0.03	0.03		
Dec-01	0.01	0.02	0.005 U	0.008	0.005 U	0.008	0.005	0.005 U	0.03	0.03	0.005 U	0.005 U
Apr-02	0.008	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.03	0.03	0.005 U	0.005 U
Apr-02 D			0.005 U	0.005 U							0.005 U	0.005 U
Jun-02	0.009	0.008	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.006	0.03	0.03	0.005 U	0.005 U
Jun-02 D									0.03	0.03		
Sep-02	0.01	0.01	0.005 U	0.005 U	0.005 U	0.005 U	0.005	0.005	0.02	0.02	0.005 U	0.005 U
Dec-02	0.006	0.006	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.02	0.02	0.005 U	0.005 U
Dec-02 D			0.005 U	0.005 U								
Mar-03	0.01	0.02	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.03	0.03	0.005 U	0.005 U
Jun-03	0.008	0.009	0.005 U	0.005	0.005 U	0.005 U	0.005 U	0.006	0.03	0.03	0.005 U	0.005 U
Jun-03 D	0.008	0.009										
Sep-03	0.009	0.009	0.005 U	0.006	0.005	0.005	0.005	0.008	0.02	0.02	0.005 U	0.005 U

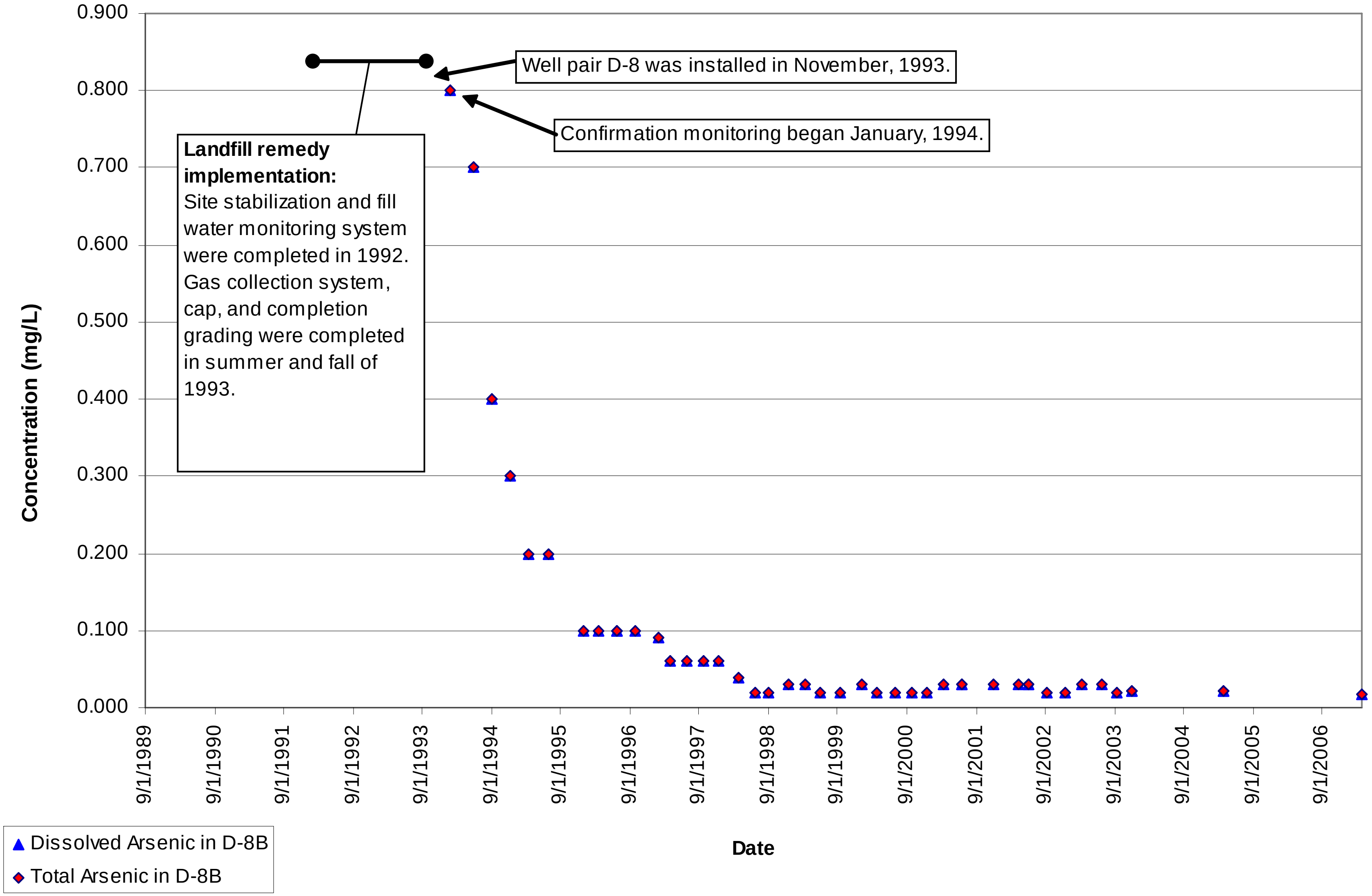
	Lower Sand Aquifer Monitoring Wells											
	D-1L		**D-5L**		**D-6B**		**D-7B**		**D-8B**		**D-11B**	
Sampling Event	**Dissolved Arsenic**	**Total Arsenic**	**Dissolved Arsenic**	**Total Arsenic**	**Dissolved Arsenic**	**Total Arsenic**	**Dissolved Arsenic**	**Total Arsenic**	**Dissolved Arsenic**	**Total Arsenic**	**Dissolved Arsenic**	**Total Arsenic**
Dec-03	0.008	0.009	0.005 U	0.006	0.005 U	0.005 U	0.005 U	0.006	0.02	0.021	0.005 U	0.005 U
Dec-03 D									0.02	0.021		
Mar-05	0.00895	0.0068	0.00443	0.0074	0.0048	0.0025 U	0.0052	0.0052	0.0225	0.0212	0.0025 U	0.0025 U
Mar-05 D									0.022	0.0209		
Mar-07	0.009	0.01	0.005	0.005	0.003	0.003	0.005	0.005	0.018	0.018	0.0002	0.001

Notes:

D Duplicate

U Analyte not detected greater than laboratory detection limit.

Dissolved and Total Arsenic in Lower Sand Aquifer Monitoring Well D-8B



Well pair D-8 was installed in November, 1993.

Confirmation monitoring began January, 1994.

Landfill remedy implementation:
Site stabilization and fill water monitoring system were completed in 1992. Gas collection system, cap, and completion grading were completed in summer and fall of 1993.

FLOYD | SNIDER
strategy ▪ science ▪ engineering

Arsenic in Lower Sand Aquifer Memorandum
B&L Landfill
Milton, WA

Dissolved Arsenic in Lower Sand Aquifer
Monitoring Well D-8B
DRAFT March 2007

F:\projects\MPC B&L WETLANDS\CAP development GAE revision 2007\Recent data memos\Lower Sand Aquifer memo\Dissolved Arsenic Chart.vsd

4/9/2007

Laboratory Analytical Results

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: MW-31A
SAMPLE

Lab Sample ID: KT15A
LIMS ID: 07-5409
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/28/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	0.5	**14.6**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	200	**57,400**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: MW-31A-F
SAMPLE

Lab Sample ID: KT15B
LIMS ID: 07-5410
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/28/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	0.5	**13.1**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	200	**57,600**	

U-Analyte undetected at given RL
RL-Reporting Limit

ANALYTICAL
RESOURCES
INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: MW-31B
SAMPLE

Lab Sample ID: KT15C
LIMS ID: 07-5411
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/28/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	0.2	**3.3**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**4,920**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: MW-31B-F
SAMPLE

Lab Sample ID: KT15D
LIMS ID: 07-5412
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/28/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**3**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**4,170**	

U-Analyte undetected at given RL
RL-Reporting Limit

ANALYTICAL
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INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

Page 1 of 1

Sample ID: D-8B
SAMPLE

Lab Sample ID: KT15E
LIMS ID: 07-5413
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**18**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**9,250**	

U-Analyte undetected at given RL
RL-Reporting Limit

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INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: D-8B-F
SAMPLE

Lab Sample ID: KT15F
LIMS ID: 07-5414
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**18**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**7,490**	

U-Analyte undetected at given RL
RL-Reporting Limit

ANALYTICAL
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INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

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Sample ID: D-8A
SAMPLE

Lab Sample ID: KT15G
LIMS ID: 07-5415
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**72**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**10,800**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-8A-F
SAMPLE

Lab Sample ID: KT15H
LIMS ID: 07-5416
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**69**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**10,400**	

U-Analyte undetected at given RL
RL-Reporting Limit

ANALYTICAL
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INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: D-7B
SAMPLE

Lab Sample ID: KT15I
LIMS ID: 07-5417
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**5**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**15,700**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-7B-F
SAMPLE

Lab Sample ID: KT15J
LIMS ID: 07-5418
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**5**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**14,400**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

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Sample ID: D-7A
SAMPLE

Lab Sample ID: KT15K
LIMS ID: 07-5419
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**136**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**122,000**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-7A-F
SAMPLE

Lab Sample ID: KT15L
LIMS ID: 07-5420
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**134**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**122,000**	

U-Analyte undetected at given RL
RL-Reporting Limit

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TOTAL METALS
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Sample ID: D-5L
SAMPLE

Lab Sample ID: KT15M
LIMS ID: 07-5421
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**5**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**14,400**	

U-Analyte undetected at given RL
RL-Reporting Limit

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INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

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Sample ID: D-5L-F
SAMPLE

Lab Sample ID: KT15N
LIMS ID: 07-5422
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**5**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**14,100**	

U-Analyte undetected at given RL
RL-Reporting Limit

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TOTAL METALS
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Sample ID: D-5U
SAMPLE

Lab Sample ID: KT150
LIMS ID: 07-5423
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**126**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**87,200**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-5U-F
SAMPLE

Lab Sample ID: KT15P
LIMS ID: 07-5424
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**123**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**89,700**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-6B
SAMPLE

Lab Sample ID: KT15Q
LIMS ID: 07-5425
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**3**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**8,710**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-6B-F
SAMPLE

Lab Sample ID: KT15R
LIMS ID: 07-5426
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**3**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**9,190**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-6A
SAMPLE

Lab Sample ID: KT15S
LIMS ID: 07-5427
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**1,420**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**80,700**	

U-Analyte undetected at given RL
RL-Reporting Limit

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Sample ID: D-6A-F
SAMPLE

Lab Sample ID: KT15T
LIMS ID: 07-5428
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**1,410**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**80,500**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-11B
SAMPLE

Lab Sample ID: KT15U
LIMS ID: 07-5429
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**1**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**520**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-11B-F
SAMPLE

Lab Sample ID: KT15V
LIMS ID: 07-5430
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/05/07	**7440-38-2**	**Arsenic**	0.2	**0.6**	
200.8	04/02/07	200.8	04/05/07	7439-89-6	Iron	20	20	U

U-Analyte undetected at given RL
RL-Reporting Limit

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TOTAL METALS
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Sample ID: D-11A
SAMPLE

Lab Sample ID: KT15W
LIMS ID: 07-5431
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/05/07	**7440-38-2**	**Arsenic**	0.2	**0.5**	
200.8	04/02/07	200.8	04/05/07	**7439-89-6**	**Iron**	20	**50**	

U-Analyte undetected at given RL
RL-Reporting Limit

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TOTAL METALS
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Sample ID: D-11A-F
SAMPLE

Lab Sample ID: KT15X
LIMS ID: 07-5432
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/05/07	**7440-38-2**	**Arsenic**	0.2	**0.5**	
200.8	04/02/07	200.8	04/05/07	7439-89-6	Iron	20	20	U

U-Analyte undetected at given RL
RL-Reporting Limit

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Sample ID: D-1L
SAMPLE

Lab Sample ID: KT15Y
LIMS ID: 07-5433
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**10**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**1,500**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
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Sample ID: D-1L-F
SAMPLE

Lab Sample ID: KT15Z
LIMS ID: 07-5434
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**9**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**1,410**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET

TOTAL METALS
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Sample ID: D-1U
SAMPLE

Lab Sample ID: KT15AA
LIMS ID: 07-5435
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	7440-38-2	Arsenic	1	4	
200.8	04/02/07	200.8	04/04/07	7439-89-6	Iron	100	37,200	

U-Analyte undetected at given RL
RL-Reporting Limit

ANALYTICAL
RESOURCES
INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: D-1U-F
SAMPLE

Lab Sample ID: KT15AB
LIMS ID: 07-5436
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: 03/29/07
Date Received: 03/30/07

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	**7440-38-2**	**Arsenic**	1	**3**	
200.8	04/02/07	200.8	04/04/07	**7439-89-6**	**Iron**	100	**36,100**	

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: METHOD BLANK

Lab Sample ID: KT15MB
LIMS ID: 07-5409
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: NA
Date Received: NA

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	7440-38-2	Arsenic	0.2	0.2	U
200.8	04/02/07	200.8	04/04/07	7439-89-6	Iron	20	20	U

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: LAB CONTROL

Lab Sample ID: KT15LCS
LIMS ID: 07-5409
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: NA
Date Received: NA

BLANK SPIKE QUALITY CONTROL REPORT

Analyte	Analysis Method	Spike Found	Spike Added	% Recovery	Q
Arsenic	200.8	24.6	25.0	98.4%	
Iron	200.8	5170	5000	103%	

Reported in µg/L

N-Control limit not met
Control Limits: 80-120%

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: METHOD BLANK

Lab Sample ID: KT15MB
LIMS ID: 07-5429
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: NA
Date Received: NA

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	RL	µg/L	Q
200.8	04/02/07	200.8	04/04/07	7440-38-2	Arsenic	0.2	0.2	U
200.8	04/02/07	200.8	04/04/07	7439-89-6	Iron	20	20	U

U-Analyte undetected at given RL
RL-Reporting Limit

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: LAB CONTROL

Lab Sample ID: KT15LCS
LIMS ID: 07-5429
Matrix: Water
Data Release Authorized:
Reported: 04/05/07

QC Report No: KT15-Floyd|Snider
Project: MPC-BL

Date Sampled: NA
Date Received: NA

BLANK SPIKE QUALITY CONTROL REPORT

Analyte	**Analysis Method**	**Spike Found**	**Spike Added**	**% Recovery**	**Q**
Arsenic	200.8	24.8	25.0	99.2%	
Iron	200.8	5060	5000	101%	

Reported in µg/L

N-Control limit not met
Control Limits: 80-120%

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/28/07
Date Received: 03/30/07

Client ID: MW-31A-F
ARI ID: 07-5410 KT15B

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	48.4

RL   Analytical reporting limit
U   Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/28/07
Date Received: 03/30/07

Client ID: MW-31B-F
ARI ID: 07-5412 KT15D

Analyte	**Date Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	5.61

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-8B-F
ARI ID: 07-5414 KT15F

Analyte	**Date** **Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	2.34

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-8A-F
ARI ID: 07-5416 KT15H

Analyte	**Date** **Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	5.45

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-7B-F
ARI ID: 07-5418 KT15J

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	3.95

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-7A-F
ARI ID: 07-5420 KT15L

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	6.00	84.0

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-5L-F
ARI ID: 07-5422 KT15N

Analyte	**Date Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	3.12

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-5U-F
ARI ID: 07-5424 KT15P

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	3.00	55.2

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-6B-F
ARI ID: 07-5426 KT15R

Analyte	**Date** **Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	3.23

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-6A-F
ARI ID: 07-5428 KT15T

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	3.00	46.0

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL
RESOURCES
INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-11B-F
ARI ID: 07-5430 KT15V

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	1.64

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL
RESOURCES
INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-11A-F
ARI ID: 07-5432 KT15X

Analyte	**Date Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	1.97

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-1L-F
ARI ID: 07-5434 KT15Z

Analyte	Date Batch	Method	Units	RL	Sample
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	1.54

RL	Analytical reporting limit
U	Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/29/07
Date Received: 03/30/07

Client ID: D-1U-F
ARI ID: 07-5436 KT15AB

Analyte	**Date** **Batch**	**Method**	**Units**	**RL**	**Sample**
Dissolved Organic Carbon	04/02/07 040207#1	EPA 415.1	mg/L	1.50	18.8

RL Analytical reporting limit
U Undetected at reported detection limit

METHOD BLANK RESULTS-CONVENTIONALS
KT15-Floyd|Snider

Matrix: Water
Data Release Authorized
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: NA
Date Received: NA

Analyte	**Method**	**Date**	**Units**	**Blank**
Dissolved Organic Carbon	EPA 415.1	04/02/07	mg/L	< 1.50 U

STANDARD REFERENCE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: NA
Date Received: NA

Analyte/SRM ID	**Method**	**Date**	**Units**	**SRM**	**True Value**	**Recovery**
Dissolved Organic Carbon ERA #0206-02-02	EPA 415.1	04/02/07	mg/L	20.0	20.0	100.0%

REPLICATE RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/28/07
Date Received: 03/30/07

Analyte	Method	Date	Units	Sample	Replicate(s)	RPD/RSD
ARI ID: KT15B Client ID: MW-31A-F						
Dissolved Organic Carbo	EPA 415.1	04/02/07	mg/L	48.4	48.1	0.6%

MS/MSD RESULTS-CONVENTIONALS
KT15-Floyd|Snider

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/03/07

Project: NA
Event: MPC-BL
Date Sampled: 03/28/07
Date Received: 03/30/07

ARI ID: KT15B Client ID: MW-31A-F

Analyte	**Method**	**Date**	**Units**	**Sample**	**Spike**	**Spike Added**	**Recovery**
Dissolved Organic Carbon	EPA 415.1	04/02/07	mg/L	48.4	133	80.0	105.8%

Wells Logs for
Wells MW-31A and MW-31B

Log of Soil Boring and Well Installation MW-31A

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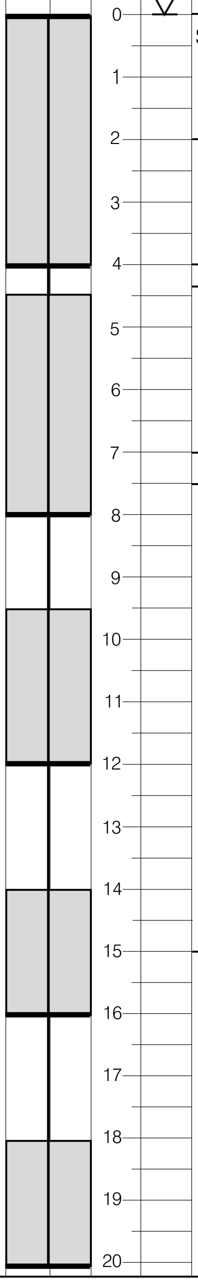
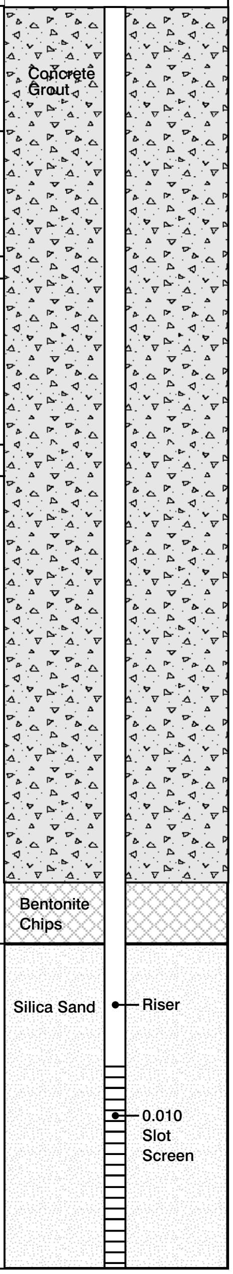
Floyd Snider
Boring MW-31A Date 3-23-07 Sheet 1 of 2
Job MPC-B&L
Logged By Brett Beaulieu Weather Overcast, 50s
Drilled By Cascade, Steve
Drill Type/Method Track-Mounted Hollow Stem Auger
Sampling Method No Samples Collected*
Bottom of Boring 22 FT BGS ATD Water Level Depth 0 BGS
Ground Surface Elevation Approx. 11 FT NAVD 88

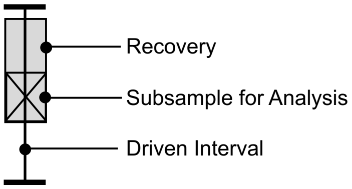
Obs. Well Install. ☒ Yes ☐ No



SAMPLE ID	Blow Count N/6"	RECOVERY From	RECOVERY To	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
				SW	Brown, well-graded, silty gravelly SAND (FILL). Medium, wet.
				PT	Dark brown PEAT (>90% organic). Woody, wet.
				OL	4" organic SILT (OL) lense @ 4 Ft. BGS
				PT	Dark brown PEAT (>90% organic). Woody, wet.
				ML	Grey plastic SILT. Wet.
				SM	Grey silty SAND. Fine, medium dense, wet to moist. Finely laminated. Decreasing silt content with depth.
				SP	Grey, poorly-graded SAND. Fine, medium dense. (Grades to)
			Disturbed Recovery	SW	Grey, well-graded SAND, fine to medium, medium dense.

WELL CONSTRUCTION





▽ Groundwater Observed At Time of Drilling

* Lithology from FS-104 (9-13-06 direct-push boring).

Log of Soil Boring and Well Installation MW-31A

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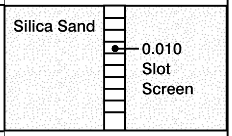
Floyd Snider
Boring MW-31A Date 3-23-07 Sheet 2 of 2
Job MPC-B&L
Logged By Brett Beaulieu Weather Overcast, 50s
Drilled By Cascade, Steve
Drill Type/Method Track-Mounted Hollow Stem Auger
Sampling Method No Samples Collected*
Bottom of Boring 22 FT BGS ATD Water Level Depth 0 BGS
Ground Surface Elevation Approx. 11 FT NAVD 88

Obs. Well Install. ☒ Yes ☐ No

SAMPLE ID	Blow Count N/6"	RECOVERY From	RECOVERY To	GRAPHIC RECOVERY		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	WELL CONSTRUCTION
					20			
					21	SW	Grey, well-graded SAND, fine to medium, medium dense.	
					22		Bottom of Boring at 22 Feet.	
					23			
					24			
					25			
					26			
					27			
					28			
					29			
					30			
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					36			
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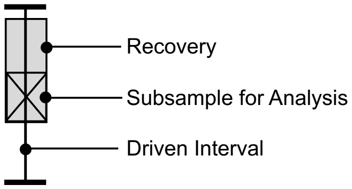
					38			
					39			
					40			



∇ Groundwater Observed
At Time of Drilling

Log of Soil Boring and Well Installation MW-31B

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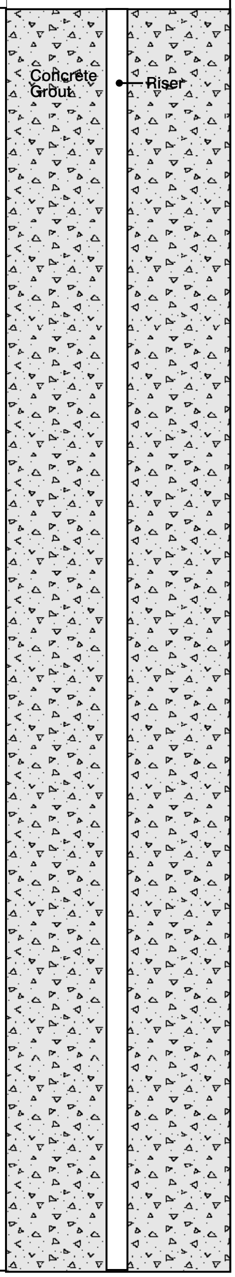
Floyd Snider
Boring MW-31B Date 3-23-07 Sheet 1 of 2
Job MPC-B&L
Logged By Brett Beaulieu Weather Overcast, 50s
Drilled By Cascade, Steve
Drill Type/Method Track-Mounted Hollow Stem Auger
Sampling Method 3" x 18" Split Spoon
Bottom of Boring 40 FT BGS ATD Water Level Depth 0 BGS
Ground Surface Elevation Approx. 11 FT NAVD 88

Obs. Well Install. ☒ Yes ☐ No

SAMPLE ID	Blow Count N/6"	RECOVERY From	RECOVERY To	GRAPHIC RECOVERY		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	WELL CONSTRUCTION
				0	▽			
				1				
				2				
				3			Same as MW-13A and FS-104.	
				4				
				5				
				6				
				7				
				8				
				9				
				10				
				11				
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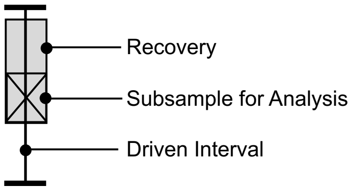
				17				
				18				
				19				
				20				



▽ Groundwater Observed
At Time of Drilling

Log of Soil Boring and Well Installation MW-31B

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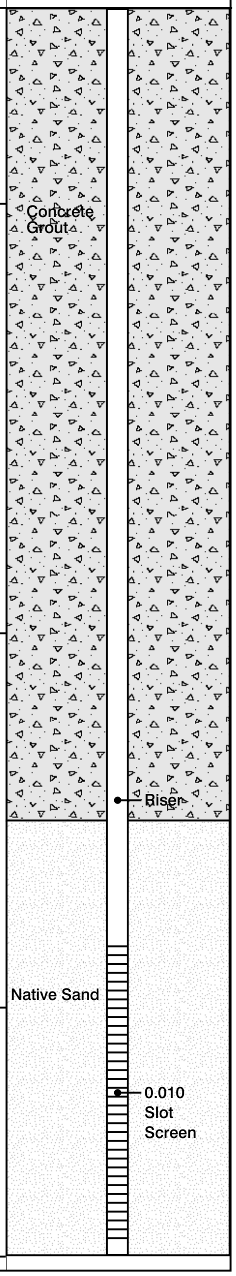
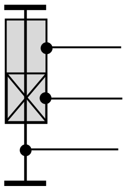
Obs. Well Install. ~~Yes~~ No

Floyd Snider
Boring MW-31B Date 3-23-07 Sheet 2 of 2
Job MPC-B&L
Logged By Brett Beaulieu Weather Overcast, 50s
Drilled By Cascade, Steve
Drill Type/Method Track-Mounted Hollow Stem Auger
Sampling Method 3" x 18" Split Spoon
Bottom of Boring 22 FT BGS ATD Water Level Depth 0 BGS
Ground Surface Elevation Approx. 11 FT NAVD 88

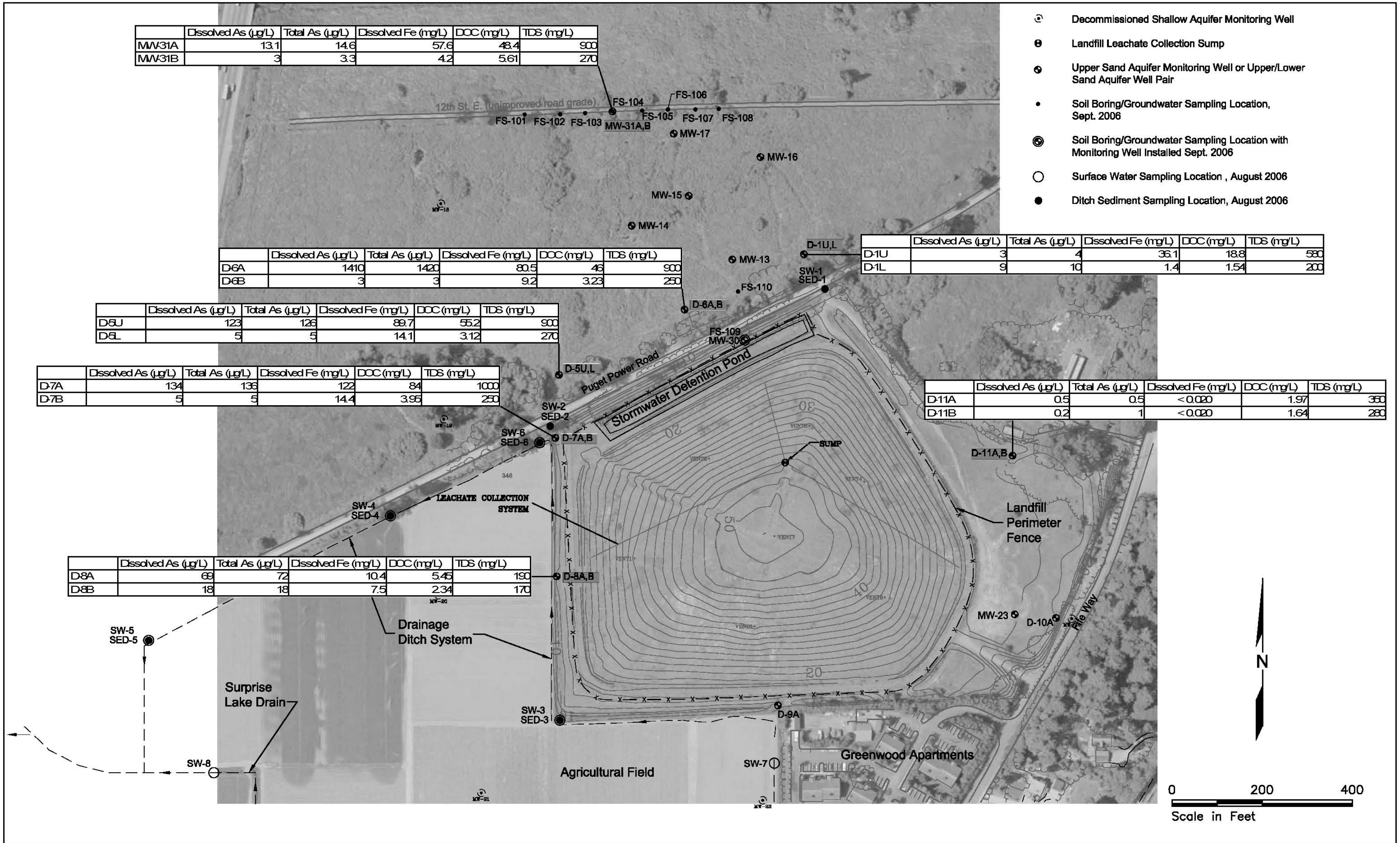
SAMPLE ID	Blow Count N/6"	RECOVERY From	RECOVERY To	GRAPHIC RECOVERY		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
					20	SW	Same as MW-31A and FS-104
	12 12 15			▨	23	ML/PT	Light grey and light brown SILT and sandy SILT, plastic, dense, moist, trace woody material. Interbedded with dark brown PEAT and wood, moist.
	15 15 50"/6			▨	26		
	15 20 24			▨	28		
	22 20 26			▨	30	ML	Light grey sandy SILT, moist.
	25 30 22			▨	35		
					36	SP	Dark grey, poorly-graded SAND, fine, wet.
					40		Bottom of Boring at 40 Feet.

WELL CONSTRUCTION





∇ Groundwater Observed At Time of Drilling



	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
MW-31A	13.1	14.6	57.6	48.4	900
MW-31B	3	3.3	4.2	5.61	270

	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
D-1U	3	4	36.1	18.8	580
D-1L	9	10	1.4	1.54	200

	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
D-6A	1410	1420	80.5	46	900
D-6B	3	3	9.2	3.23	250

	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
D-5U	123	126	89.7	55.2	900
D-5L	5	5	14.1	3.12	270

	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
D-7A	134	136	122	84	1000
D-7B	5	5	14.4	3.95	250

	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
D-11A	0.5	0.5	< 0.020	1.97	350
D-11B	0.2	1	< 0.020	1.64	280

	Dissolved As (µg/L)	Total As (µg/L)	Dissolved Fe (mg/L)	DOC (mg/L)	TDS (mg/L)
D-8A	69	72	10.4	5.45	190
D-8B	18	18	7.5	2.34	170

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Arsenic in Lower Sand Aquifer Memorandum
B&L Landfill
Milton, WA

Comparison of Groundwater Quality
Upper and Lower Sand Aquifer
March, 2007

DWG NAME: G:\project\Clients\Floyd and Snider\BandL\BandL030.dwg
DATE: 04/06/07 3:21pm

DRAFT

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Memorandum

To: Dom Reale, Department of Ecology
Copies: Murray Pacific Corp.
From: Tom Colligan, and Brett Beaulieu, Floyd|Snider
Date: April 5, 2007
Project No: MPC – B&L
Re: **Vertical gradients at the B&L Landfill**

INTRODUCTION

This memorandum was prepared on behalf of Murray Pacific Corporation at the request of the Washington State Department of Ecology to support decision-making on remedial alternatives at the B & L landfill.

BACKGROUND

The hydrogeologic units underlying the B & L Landfill, characterized by several investigations, consist primarily of an Upper Sand Aquifer and a Lower Sand Aquifer, which are separated by a low-permeability unit called the Lower Aquitard (Floyd|Snider 2007).

Data collected as part of the past remedial investigations of the B & L Landfill and adjacent wetlands have supported that vertical gradients are upwards between cleaner deeper groundwater and arsenic-impacted shallower groundwater. In particular, vertical gradients are generally flat beneath the landfill and are strongly upward beneath the wetlands area north of the landfill. This pattern is consistent with the location of the landfill at the transition from a higher elevation recharge area, the hills adjacent the site to the south, and a lower elevation discharge area, the Hylebos Creek wetlands floodplain.

These findings have been confirmed through recent measurements that include a new monitoring well couplet and are presented in this memorandum.

VERTICAL GRADIENT DATA

A summary of available vertical gradient data is presented in the accompanying table. Elevation data is included as far back as the original remedial investigation (AGI/KJC 1990) and post RI monitoring (Hydrometrics 2001), as well as from recent measurements collected by Floyd|Snider on March 29, 2007. As part of these activities, an additional well pair was installed along 12th Street E., to provide better coverage of the northern part of the wetlands area. Boring logs for these new wells will be provided at a later date.

Water level measurements are provided for well pairs only. That is, one monitoring well with a screened interval in the Upper Sand Aquifer, and one monitoring well with a screened interval in the Lower Sand Aquifer. The vertical gradient is calculated by dividing the difference in head between the two aquifers by the vertical distance between the centerpoint of the two screened intervals.

As shown on the accompanying figure, these new data confirm the previously reported findings and demonstrate upward gradients in the wetlands and generally flat gradients in the landfill area. The difference in head between the Upper and Lower Sand Aquifers in the wetlands was generally between 0.5 and 1.5 feet, which is significantly greater than the margin of error for water level measurement. These measurements indicate that Lower Sand Aquifer beneath the wetlands exhibits significant hydraulic pressure upon the aquitard, even during periods of significant flooding in the wetlands, and so acts as a hydraulic barrier to downward migration of contaminated groundwater.

In the landfill area, the difference in head between the shallow and deeper groundwater was typically within one or two hundredths, which is considered within the margin of measurement error. These gradients are therefore considered to be flat, and therefore there is no significant upward or downward component of flow.

ATTACHMENTS

Table: Summary of Available Vertical Gradients at the B & L Landfill

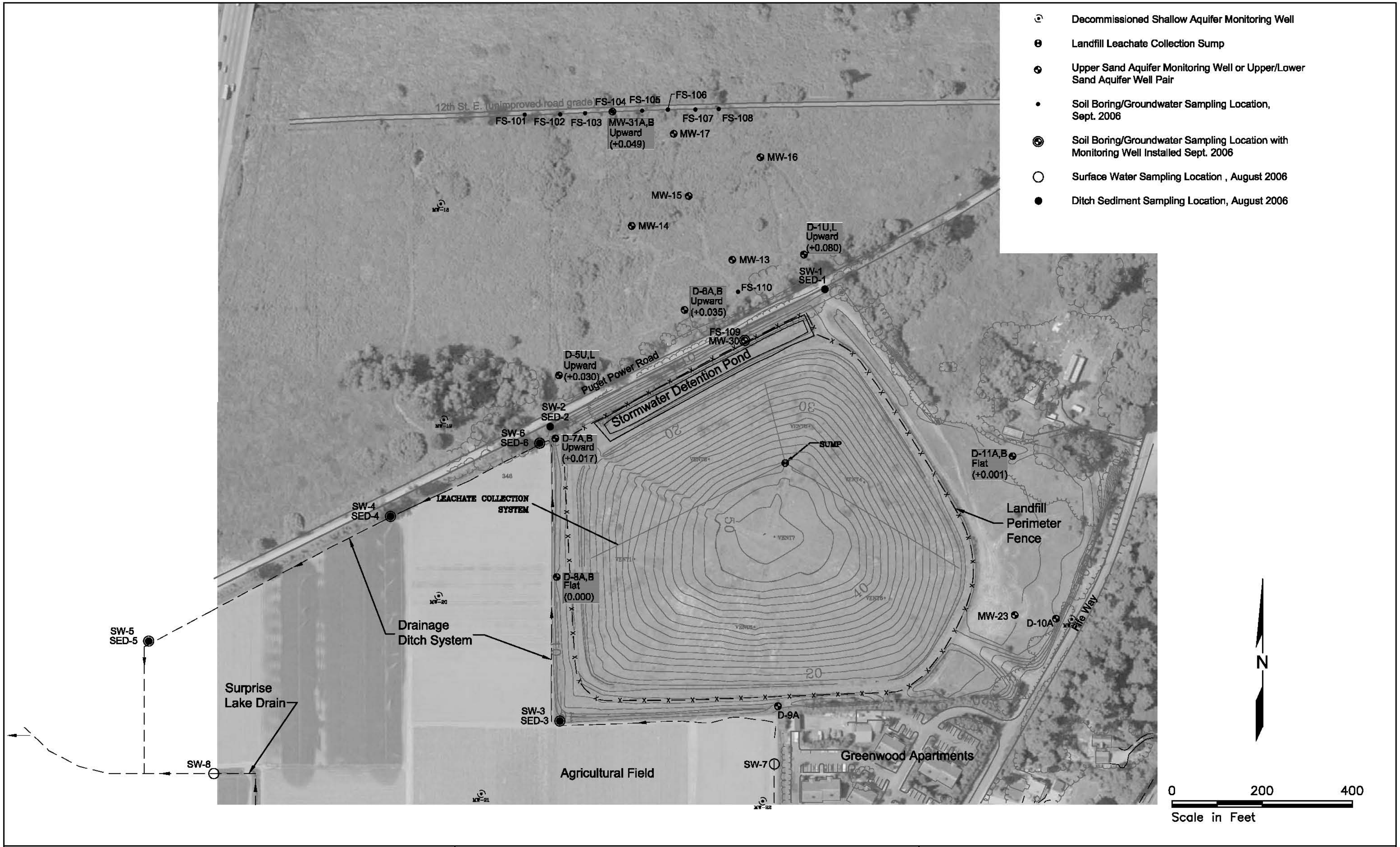
Figure: Vertical Gradients, March 29, 2007

REFERENCES

Floyd|Snider, 2007. *Groundwater Alternatives Evaluation*, Ecology Preliminary Review Draft. Prepared for Murray Pacific. January.

Kennedy/Jenks/Chilton (K/J/C) and AGI. 1990b. *Focused Remedial Investigation B&L Woodwaste Site.* Prepared for Murray Pacific. September.

Hydrometrics 2001. *Review of Remedial Activities at the B&L Landfill.* Prepared for Mr. Thomas E. Martin, Site Manager, ASARCO Incorporated. May.



FLOYD | SNIDER
strategy ▪ science ▪ engineering

Vertical Gradients Memorandum
B&L Landfill
Milton, WA

Vertical Gradients, March 29, 2007

DWG NAME: G:\project\Clients\Floyd and Snider\BandL\BandL029.dwg
DATE: 04/05/07 2:59pm

DRAFT

Draft: 02/21/2008

Exhibit B: Scope of Work and Schedule

B.1 OVERVIEW

As part of the B&L Landfill Consent Decree (Consent Decree), Murray Pacific Corporation (MPC) has agreed to perform certain elements of the Remedial Action defined in the 2007 Final Cleanup Action Plan (CAP)(Exhibit A to the Consent Decree). Upon completion of these elements the State of Washington will assume complete responsibility for the Site, including the operations, maintenance, and monitoring requirements of the remedy, which comprise the remaining remedial actions specified in the CAP (see Section VI of the Consent Decree). This scope of work (SOW) describes in further detail those elements of the CAP that MPC will perform in order to comply with the terms of the Consent Decree. Terms used in this SOW are as defined in the Consent Decree.

Implementation of the remedial action specified in the CAP will occur in three major phases, with MPC performing Phases 1 and 2. Phase 1 and Phase 2 form the “Initial Construction Phase” of *Section VI: Work to Be Performed* of the Consent Decree. Phase 3, to be performed by Ecology, includes Operation, Maintenance, and Monitoring (OMM) of the remedy at the Site, after completion of all work required to be performed by MPC under the Consent Decree. The Phases are used to describe the timing and sequencing of cleanup elements, rather than the geographic location of such elements. The CAP presented the remedy in three geographic cleanup action areas (CAAs): the Landfill CAA, the Wetlands CAA, and the End-of-Plume CAA, as shown in Exhibit F to the Consent Decree. Work within each of these CAAs may occur during all three phases. The Phases are defined below.

B.1.1 Phase 1: Primary Source Control and End-of-Plume Treatment.

Phase 1 includes additional design-related investigation in all three CAAs, followed by design and construction in the Landfill, Wetlands, and End-of-Plume CAAs. Studies needed to complete design and permitting, including an archaeological assessment of the site, will be carried out in this phase. Phase 1 construction is comprised of three major elements performed concurrently:

(A) Design, permitting, and construction of a barrier wall and upgradient interceptor trench,

(B) Design, permitting, and construction of an interim system to recover and treat groundwater from the hotspot within the Wetlands CAA, and

(C) Pilot testing, design, and implementation of the End-of-Plume CAA remedy.

This approach will complete the physical containment design for the Landfill and will include an expedited mass-removal action to begin remediation of the Wetlands CAA. The mass-removal action for the wetlands will also serve as a preliminary/pilot study to provide information needed for design of the final Phase 2 Wetland CAA remediation system. The End-of-Plume remedial action will allow downgradient restoration projects by others (for example, relocation of Hylebos Creek) to proceed at their own pace.

Phase 1 will be complete when the barrier wall and interceptor trench are installed and functional, the mass removal action for the wetlands is installed and operational, and the first round of the End of Plume remedial action is completed. Installation of the barrier wall and interceptor trench in the Landfill CAA will significantly change the hydrological conditions in the landfill and in the wetlands. Field measurements and evaluation of actual hydrological conditions after the installation are necessary to correctly place and size both the extraction and treatment systems contained in the Phase 2 implementation. Without this critical information, the Phase 2 groundwater extraction and treatment system would need to be over-designed and built to account for significant uncertainties.

B.1.2 Phase 2: Hydraulic Control and Off-Property Groundwater Remediation.

Phase 2 consists of:

(A) Design and installation of the hydraulic control system within the barrier wall;

(B) Design, permitting, and installation of the final groundwater remedy for the Wetlands CAA;

(C) Cleanup of the ditch and the “groundwater halo” adjacent to, and outside, the barrier wall; and

(D) Initial operation of the remediation components.

This Phase will involve several field investigations to understand how the installations of the barrier wall, upgradient interceptor trench, and mass-removal action in the wetland have affected site-wide groundwater conditions. This information will be used to design the groundwater extraction and treatment components of hydraulic control within the landfill and in the wetlands CAA (and potentially in the halo areas). Phase 2 will also include the development of a long-term Operations, Maintenance, and Monitoring Plan (OMMP) for the Site.

Phase 2 will be complete when hydraulic control is established within the barrier wall, groundwater is in compliance with cleanup standards at an interim point of compliance at 12th Street East, and the groundwater remedy for the wetland and halo areas is constructed and operational. The monitoring components of the OMMP will define the measurement protocols and criteria for compliance. It is expected that groundwater in the Wetland CAA will not be in compliance at that time but rather is the objective of Phase 3.

Phase 2 includes operation, maintenance, and monitoring of the entire remediation system for a period of at most 2 years following commissioning of the groundwater extraction and treatment system, unless determined otherwise by Ecology in accordance with the terms of the Consent Decree. This operation time requirement is intended to ensure that the remediation systems and the OMMP are functioning per design. It is Ecology’s intention that a “turn-key” system will be delivered at the end of Phase 2.

B1.3 Phase 3: Long-Term Operations, Maintenance, and Monitoring.

Ecology will assume responsibility for the Site for Phase 3 after Ecology has determined that the work required to be performed by MPC under the Consent Decree has been completed and the terms of the Consent Decree have been met. Phase 3 includes long-term operations, maintenance and monitoring of all remedy components consistent with the OMMP developed in Phase 2. Off-property groundwater is not expected to be in compliance between the Landfill and the interim point of compliance at 12th Street East at the end of Phase 2. Phase 3 will include operations of the wetlands, end of plume, and halo groundwater remedies, until such time as Ecology approves their termination, or has determined that the groundwater is in compliance.

Throughout the groundwater remedy construction, the existing landfill cap and stormwater system will need to be maintained in accordance with current requirements, and the existing groundwater monitoring program must be conducted. These two programs will be carried out during Phases 1 and 2 by MPC. After completion of Phase 2, these programs will be incorporated into the OMMP and will be performed during Phase 3 by Ecology. Phase 3 implementation of the OMMP by Ecology, including maintaining institutional controls and necessary access agreements, is expected to continue indefinitely.

Further details of the SOW elements for Phase 1 and 2 are described below, along with a description of the managerial and reporting requirements.

B.2 PHASE 1 SCOPE OF WORK

Specific work elements to be completed in Phase 1 include the following (the overall remedy is described in Section 6 of the CAP; specific terms from the CAP are used below):

1. Pre-Design Studies as appropriate to design the barrier wall, interceptor trench and End-of Plume CAA remedy, including the following:
    - A geotechnical study to assess subsurface soil characteristics needed for design, and to determine the alignment and necessary depth of barrier wall, and interceptor trench.
    - A hydrologic study to support design of the upgradient interceptor trench.
    - Additional delineation of the halo areas as appropriate for design of the barrier wall alignment.
    - Bench and/or pilot studies related to the in situ treatment of arsenic at the End-of-Plume area.
    - The Archaeological Assessment will be performed in accordance with the requirements of WAC 197-11, RCW 27.44, and RCW 27.53.
    - A wetland delineation study will be performed in accordance with the requirements of WAC 173-22-080.
2. Coordination with parties interested in or affected by the planned remedial actions as appropriate to facilitate implementation of the work.

3. Design, permitting, and installation of the barrier wall and upgradient interceptor trench.
4. Design, permitting, and implementation of insitu treatment at the End-of-Plume CAA.
5. Design, permitting, installation and operation of an early mass-removal action in the Wetlands groundwater hotspot. This mass-removal action was described in general terms in the Groundwater Alternatives Evaluation Report that is an appendix to the CAP.
6. Installation of an interim compliance well network in the vicinity of 12th Street East.
7. Development of an interim compliance monitoring plan for the entire site for that will be implemented during Phases 1 and 2. This plan will include compliance monitoring at an interim point of compliance along 12th Street East, performance monitoring for the barrier wall and interceptor trench, monitoring of the mass-removal action in the Wetlands, and the appropriate elements of the existing groundwater monitoring program.
8. Establishing access agreements (with Ecology assistance as needed) to complete the above work elements.

B.2.1 Phase 1 Deliverables

Draft plans and reports will be prepared and submitted to Ecology for review and approval in accordance with the Consent Decree and MTCA regulations. Final reports will be prepared after receipt of Ecology comments. Progress reports as described in Section B.4 will also be prepared and submitted to Ecology.

The following plans and reports will be prepared under Phase 1 of this scope of work (a preliminary schedule is included in Section B.4):

1. Draft Groundwater Remediation Work Plan. This work plan will include at least the following:
    - A detailed description of the work to be performed in Phases 1 and 2, including identification of the relationships between tasks and development of process flow diagrams.
    - Technical description of the chemical and physical information database for the site, including the specification of electronic data deliverables to Ecology.
    - Technical description of the Administrative File/Administrative Record document database for the Site, including, but not limited the following: specification of how to identify those documents within it that form the Administrative Record; clarification as to how additional documents will be added to the Administrative Record; and procedures for electronic updating and delivery to Ecology at key administrative milestones (such as the completion of Phases 1 and 2).
    - Clarification of any assistance needed from Ecology with respect to permits and access agreements.
    - A proposed schedule for Phase 1 and Phase 2 work and associated Gantt Charts.
    - Work Plans for Pre-Design Studies (as described above) for Ecology review and approval.

- Appendices containing the site-wide Health and Safety Plan, the Data Management Plan, and Sampling and Analysis Plans for specific events/investigations.

2. A Final Groundwater Remediation Work Plan, addressing Ecology comments, shall be submitted to Ecology

3. Draft Phase 1 Engineering Design Report (EDR) prepared in accordance with, and explicitly documenting compliance with each applicable provision of, WAC 173-340-400(4)(a) and (5). This report will include the following:

    - Results of Phase 1 Pre-Design Studies (listed above) may be submitted as individual Technical Memos in advance of the EDR at the discretion of the Project Coordinators.
    - An Archaeological Assessment report will be appended to the Engineering Design Report. This report will also be submitted separately to the Washington State Department of Archaeology and Historic Preservation (DAHP) and the Puyallup Tribe.
    - A Wetlands Delineation Report will be appended to the Engineering Design Report.
    - Permitting and approval requirements for Phase 1 construction and operation;
    - The basis for the design;
    - Preliminary Design of the Phase 1 construction elements: barrier wall, interceptor trench, mass-removal action in the wetlands, and end-of-plume in situ treatment system.
    - An updated and more detailed schedule for Phase 1 permitting and construction.
    - A description, if needed, of the access that will be required to implement Phase 1 construction activities.
    - A copy of the deed restriction for the B&L Landfill property where the refuse is located.
    - Appendices for the Interim Compliance Monitoring Plan and the Barrier Wall Performance Monitoring Plan.
    - Construction Implementation and Construction Quality Control Plans

4. A Final Phase 1 Engineering Design Report, addressing Ecology comments, shall be submitted to Ecology.

5. Draft Plans and Specifications suitable for Phase 1 construction prepared in accordance with WAC 173-340-400(4)(b) and (5). This deliverable will likely also be used for permitting; thus copies of all permits and approvals required for Phase 1 construction and operation will be included in the final version.

6. Final Plans and Specifications addressing Ecology comments on the draft documentation shall be submitted to Ecology. The Final Plans and Specifications shall also include written documentation demonstrating compliance with substantive requirements for any permits exempted under WAC 173-340-710. Written documentation of determination(s) that substantive requirements have been met will be included in the Final Plans and Specifications.

7. Construction Oversight Reports to MPC with copies to Ecology.
8. Construction Completion Report for Phase 1 Elements prepared in accordance with WAC 173-340-400(6)(b).

Phase 1 work will be completed after Ecology approval of the Construction Completion Report. Phase 2 is expected to begin before Phase 1 is complete.

B.3 PHASE 2 SCOPE OF WORK

The final remediation components specified in the 2007 CAP that were not completed in Phase 1 will be designed, constructed, and commissioned under Phase 2. Initial operations will also be performed for some systems constructed in Phase 1. While the 2007 CAP comprehensively addresses remediation issues related to the Site, it is possible that MPC or Ecology may identify more technically and/or financially effective methods for obtaining the remedial action objectives and cleanup levels specified in the CAP. If it is determined by Ecology that it is appropriate to substantially modify the remedial action(s) specified in the 2007 CAP, MPC shall work with Ecology as appropriate to modify the CAP, including any public comment and review processes. Any revisions to the CAP will be incorporated into the deliverables and actions described below for Phase 2.

Specific work elements to be completed in Phase 2 include the following:

1. Post-barrier wall hydrogeological study including the following elements:
    - The effect of the barrier wall and interceptor trench on the overall groundwater system at the Site.
    - Pump tests and other testing within the barrier wall as needed for the design of hydraulic controls.
    - Pump tests, monitoring of the mass-removal action in the wetlands hotspot, and/or other testing within the wetlands as needed for the design of the wetlands groundwater remedy.
    - Modeling as appropriate to support the design of a hydraulic control system for the landfill and for the groundwater remediation systems for the wetlands and halo areas.
2. Bench or pilot studies related to the treatment of extracted groundwater.
3. Use of Phase 1 and 2 Hydrogeological Investigation results to assess the technical feasibility, practicality, limitations, and design for Landfill hydraulic control and for the groundwater extraction and treatment component of the Wetlands remediation.
4. Design, permitting, and implementation for excavation and off-site disposal of arsenic-contaminated ditch sediment in the perimeter ditches, including verification sampling.
5. Design, permitting, and construction of the hydraulic control system for the Landfill CAA, including the halo areas.

6. Design, permitting, and construction of the final groundwater remediation system for the Wetlands CAA.

7. Continued operation, monitoring, and maintenance of the Phase 1 remediation components as needed to achieve their remediation objectives.

8. Commissioning, startup, and initial operation and monitoring of barrier wall hydraulic control system, including the treatment and disposal of arsenic-contaminated groundwater recovered from the Site.

9. Commissioning, startup, and initial operation and monitoring of the wetlands remedy.

10. Commissioning, startup, and initial operation and monitoring of the remedial action to address the groundwater halo areas.

11. Design, and construction of a long-term groundwater monitoring system, including installation of any additional compliance wells.

12. Development of a long-term Operations, Monitoring and Maintenance Plan.

B.3.1 Phase 2 Deliverables

Draft plans and reports will be prepared and submitted to Ecology for review and approval in accordance with the Consent Decree and MTCA regulations. Final reports will be prepared after receipt of Ecology comments. Progress reports as described in Section B.4 will also be prepared and submitted to Ecology.

The following plans and reports will be prepared under Phase 2 of this scope of work (a preliminary schedule is included in Section B.4):

1. Draft Addendum to the Groundwater Remediation Work Plan describing any additional studies needed for the Phase 2 design work, that were not covered in the original Work Plan.

2. A Final Addendum to the Groundwater Remediation Work Plan, addressing Ecology comments, shall be submitted to Ecology

3. Draft Phase 2 Engineering Design Report prepared in accordance with, and explicitly documenting compliance with each applicable provision of, WAC 173-340-400(4)(a) and (5). This report will include the following:

    - Results of Phase 2 Field, Bench, and Pilot Studies, including any modeling needed to support the Phase 2 designs (these may be submitted as individual Tech Memos if that will result in more efficient implementation of the remedy)
    - Identification of permit requirements and a plan for obtaining permits and approvals and/or a demonstration showing substantive permit requirements which have been met.

- The basis for the design.
- Preliminary design of the Phase 2 construction elements.
- Construction Implementation and Construction Quality Control Plans.

3. A Final Phase 2 Engineering Design Report, addressing Ecology comments, shall be submitted to Ecology
4. Construction Oversight Reports, including treatment system optimization.
5. Draft Plans and Specifications suitable for Phase 2 construction prepared in accordance with WAC 173-340-400(4)(b) and (5). This deliverable will likely also be used for permitting; thus copies of all permits required for Phase 2 construction and operation will be included in the final version.

6. Final Plans and Specifications addressing Ecology comments on the draft documentation shall be submitted to Ecology in accordance with the schedule presented in Section B.4 of this Scope of Work. The Final Plans and Specifications shall also include written documentation demonstrating compliance with substantive requirements for any permits exempted under WAC 173-340-710. Written documentation of determination(s) that substantive requirement have been complied with will also be included in the Final Plans and Specifications.

7. Operation, Maintenance, and Monitoring Plan prepared in accordance with, and explicitly documenting compliance with each applicable provision of, WAC 173-340-400(4)(c) that addresses long-term operations, inspection, and maintenance of remediation systems installed under Phases 1 and 2 as well as the current landfill capping remedy; and in accordance with WAC 173-340-410 that addresses long-term monitoring at the Site. This plan shall include Protection, Performance, and Confirmation Monitoring Plans per WAC 173-340-410. The operations and maintenance sections of the plan will include provisions for the malfunction or failure of the remedial action systems or components, including, but not limited to, barrier wall failure, capping system failure, loss of hydraulic control within the barrier wall, and/or operations problems. The plan will also describe measures that may be taken in the event of failure of the remedy to attain or maintain compliance at points of compliance or to achieve performance objectives specified in the CAP.
8. Construction Completion Documentation prepared in accordance with, and explicitly documenting compliance with each applicable provision of, WAC 173-340-(6)(b), (c), and (d) that documents completion of Phase 1 and 2 construction elements and that the treatment systems are operational and working as designed.

B.4 Phase 1 and 2 Schedule, Progress Reporting, and Meetings

The schedule for completion of work required by this Consent Decree shall, in general, follow the schedule set forth below. Because the schedule may be affected by field conditions, investigative findings, design constraints, the permitting process, and other developments, it is approximate and subject to revision, as approved by Ecology. Schedules will be revised for Ecology approval, as part of the semi-annual reporting described below.

Table 1 – Preliminary Schedule

Deliverable/Milestone	Completion/Due Date
Draft Groundwater Remediation Work Plan	90 days after effective date of the Consent Decree
Final Groundwater Remediation Work Plan	30 days after receipt of Ecology Comments on draft plan
Draft Phase 1 Engineering Design Report	February 2009[1]
Final Phase 1 Engineering Design Report	30 days after receipt of Ecology comments on draft
Draft Phase 1 Plans and Specifications	April 2009[1]
Final Phase 1 Plans and Specifications	30 days after receipt of Ecology comments on draft
Completion of Phase 1 Construction and Implementation Tasks, and Submission of Phase 1 Completion Report	April 2010[1]
Draft Addendum to the Groundwater Remediation Work Plan	June 2010[1]
Final Addendum to the Groundwater Remediation Work Plan	30 days after receipt of Ecology comments on draft
Draft Phase 2 Engineering Design Report	February 2011[1]
Final Phase 2 Engineering Design Report	30 days after receipt of Ecology comments on draft
Draft Phase 2 Plans and Specifications	April 2011[1]
Final Phase 2 Plans and Specifications	30 days after receipt of Ecology comments on draft
Completion of Phase 2 Construction and Tasks, and Submission of Phase 2 Completion Report	November 2012[1]

[1] These dates are contingent on filing of the Consent Decree with the Pierce County Superior Court so that implementation of this Scope of Work can commence under the terms of the Consent Decree no later than January 15, 2008. If this Scope of Work cannot commence under the terms of the Consent Decree until after January 15, 2008, the scheduled completion dates shall be revised as appropriate, considering constraints to conducting site investigation and construction work during the wet seasons. These dates are also contingent on the timely review and approval of deliverables by Ecology; in establishing these dates, it has been assumed that Ecology will issue all comments on draft documents within 14 days after receipt and that final documents will be formally approved by Ecology within 14 days after receipt. Additionally, dates associated with construction may be affected by obtaining permits and/or approvals from governmental agencies and by obtaining access agreements with property owners; delays in permitting, governmental agency approval, and/or obtaining access agreements may be due to circumstances beyond control of the Defendant. If longer review, approval, or access agreement times occur due to circumstances beyond the reasonable control of the Defendant, the dates specified in this table will require revision to accommodate the delay(s).

The completion and/or due dates identified above may be modified upon written or electronic request by MPC and written or electronic concurrence by Ecology.

The following table provides a preliminary estimate of the projected Phase1 and Phase 2 tasks, which are expected to be completed within each calendar semi-annual period, as well as the projected budget for that period and for accomplishment of those tasks. This preliminary estimate is approximate and is based on a number of assumptions to address uncertainties. As work is completed under the Order the uncertainties will be resolved and the accuracy of the estimated costs can be improved. These estimated costs are not intended to define the budget for performing this Scope of Work. Ecology plans to refer to this Table, along with other task, schedule and budget documentation developed in the future, as part of the assessment as to whether the proper tasks are being completed within expected timeframes and budgets. MPC reports and notifications to Ecology, and meetings with Ecology regarding project status and budget are detailed below.

Table 2 -- Preliminary Estimate of Costs to Complete the Scope of Work

Reporting Period	Tasks	Estimate/Period	Cumulative Estimate
Jan-June 2008	Groundwater Remediation Workplan, Contracting	$170,000	$170,000
July-Dec 2008	Predesign Studies, Reporting, Design	$490,000	$660,000
Jan-June 2009	Phase 1 Design, Engineering Design Report, Reporting	$370,000	$1,030,000
July-Dec 2009	Contracting, Phase 1 Construction	$3,370,000	$4,400,000
Jan-June 2010	Phase 1 Completion Report, Groundwater Remediation Workplan Addendum, Field Studies, Operations	$330,000	$4,730,000
July-Dec 2010	Work Plan, Design, Modeling, Operations	$500,000	$5,230,000
Jan-June 2011	Phase 2 Engineering Design Report, Permitting, Reporting, Operations	$530,000 - $910,000	$5,760,000 - $6,140,000
July-Dec 2011	Phase 2 Construction, Operations, Develop Institutional Controls	$3,010,000 - $5,150,000	$8,770,000 - $11,290,000
Jan-June 2012	Reporting, Long Term O&M Plan Preparation, Operations	$280,000 - $380,000	$9,050,000 - $11,670,000
July-Dec 2012	Phase 2 Completion Report, Operations	$180,000 - $250,000	$9,230,000 - $11,920,000

Schedule. The Groundwater Remediation Work Plan will contain a detailed **schedule** in the form of a Gantt Chart that includes, but is not limited to the tasks in Table 1. This Gantt Chart will be revised by the MPC Project Coordinator as appropriate throughout the duration of the project as discussed below under Monthly Meetings.

Cost Estimate. The Groundwater Remediation Work Plan will contain a detailed **cost projection** in the form of an Excel spreadsheets or Microsoft Project report for the completion of the Scope of Work. This cost projection will be revised and compared to Table 2 by the MPC Project Coordinator as appropriate throughout the duration of the project as discussed below under Semi-Annual Reporting. The estimated costs to complete the Scope of Work will be updated as discussed below. As the project proceeds, cost estimates will include both the actual costs incurred to date for work that has been performed and estimated costs for work that has not yet been performed.

Semi-Annual Progress Reports. Consistent with the CD, Semi-Annual Progress Reports will be submitted to Ecology by the MPC Project Coordinator that detail the work performed and MPC's implementation costs during the reporting period and projections of the work to be completed and expected MPC implementation costs during the next reporting period. In addition, the reports will document key personnel changes and other pertinent information. The Semi-Annual Progress Reports will include updates to the detailed cost projection included with the Groundwater Remediation Work Plan. The projection will present estimates of the future costs to complete the Scope of Work" based on decisions made during the reporting period. The MPC Project Coordinator will provide Ecology with a copy of all invoices, including invoice backup materials, submitted to MPC (or the Trustee) during the six-month period related to the implementation of the CD semiannually as an attachment to the Semi-Annual Progress Reports.

Monthly Meetings. Ecology and MPC will schedule monthly meetings to go over the progress being made, key findings, the schedule, and other materials needed to for the efficient implementation of the remedial action. Other materials may include, but are not limited to, estimate of the effect of key design and implementation decisions on "total project costs." These meetings may be rescheduled or cancelled at Ecology's discretion, with appropriate notice to attendees.

Special Notice. MPC Project Coordinator will provide notification to the Ecology Project Coordinator either by email or in writing within three working days (if possible) of any significant delay or significant cost increase that was not discussed or foreseen during the monthly meetings.

Exhibit C: Administrative File/Record Outline

The Administrative File for the B&L Landfill is comprised of an index and documents derived primarily from three sources: Ecology records (including those in the Washington State Archives), the records of Floyd|Snider (technical documents supporting the cleanup decision) and the records of Murray Pacific (including documents relating to the L.P. et al. v. ASARCO et al. federal trial and the ASARCO bankruptcy matter). The Administrative File is intended to provide the historical, technical, and legal support for the Ecology/Murray Pacific Consent Decree and to embody the facts known to the parties at the time the Consent Decree is entered.

The Administrative File will be delivered to Ecology in a digital format. It will serve as the basis for the ongoing Administrative Record for the site.

The Administrative Record will be comprised of documents selected from the Administrative File, as well as documents created after the entry of the Consent Decree that relate to the implementation of the remedy, the public participation process, cost accounting, etc.

The digital documents will be organized by category as shown below. In general, the categories follow the major milestones for the site. Sections 1 through 11 represent information that was known to Ecology and the parties at the time of the Consent Decree. Sections 12 through 19 document work performed after the signing of the Consent Decree. Sections 20 and beyond are chronological and topical categories that contain both information that was known at the time of the signing of the Consent Decree and documents developed after that time.

ADMINISTRATIVE FILE/RECORD OUTLINE

SECTION	SUB-SECTION	CATEGORY/DESCRIPTION	EXAMPLES OF MATERIALS TO BE INCLUDED
1.0		**CBN/T FEDERAL LISTING**	
	1.1	Technical Reports	Commencement Bay RI/FS, history of individual upland properties in RI/FS
	1.2	Decision documents	Federal listing, ROD, Explanation of Significant Differences 1997 and 2000
2.0		**B&L FEDERAL/STATE LISTING**	
	2.1	Technical documents	Documents regarding discovery of arsenic problem, Norton & Johnson sampling, B&L MTCA scoring, Milton well sampling
	2.2	State/federal coordination	Correspondence, EPA/Ecology MOUs, Commencement Bay source control documents regarding B&L
	2.3	PLP identification	Ecology enforcement, PLP research, decision documents
	2.3.1	Notice letters and negotiations	PLP responses, correspondence w/Ecology and Washington State Attorney General
	2.3.2	Fjetland dump logs and invoices	Including related correspondence

SECTION	SUB-SECTION	CATEGORY/DESCRIPTION	EXAMPLES OF MATERIALS TO BE INCLUDED
	2.3.3	Meetings	Key Ecology meetings, internal within Ecology and with PLPs
3.0		**MURRAY PACIFIC/ECOLOGY 1988 CONSENT DECREE**	
	3.1	Correspondence	Negotiations re cost sharing, terms of Consent Decree
	3.2	Lodged Decree	State Court complaint, Consent Decree exhibits
4.0		**REMEDIAL INVESTIGATION/ FEASIBILITY STUDY 1990**	Including minimum functional standards for landfills (WAC 173-205 1987), EPA presumptive remedy for landfills
	4.1	Correspondence	Negotiations, scheduling, cost estimates
	4.2	Comments and responses	Ecology responsiveness summary
	4.3	Data/Laboratory reports	Soil and groundwater sampling
	4.4	Final RI/FS	Including appendices
	4.5	Technical reference	Documents cited in the RI /FS
	4.6	Progress reports	Weekly reports
5.0		**FINAL CLEANUP ACTION PLAN 1991**	
	5.1	Correspondence	Negotiations, cost estimates
	5.2	Comments and responses	Including Hydrometrics, 1990 Groundwater Aspects of Remediation
	5.3	Final CAP	Including appendices
	5.4	Fjetland alternative cleanup proposals	Ecology responses, consultant proposals
6.0		**LOUISIANA PACIFIC ET AL V. ASARCO ET AL**	Including proof of ASARCO violation of Consumer Protection Act, documents regarding slag leaching arsenic
	6.1	Complaints	Amendments and consolidation
	6.2	Depositions relating to B&L or slag	Key depositions and exhibits, including entire Fjetland deposition
	6.3	Trial testimony relating to B&L or slag	Key trial exhibits
	6.4	Orders and Judgments	Regarding liability (including dismissals) and allocation
	6.5	Murray Pacific/ASARCO settlement agreement	Establishing B&L cost allocation
7.0		**ECOLOGY ENFORCEMENT ORDERS**	
	7.1	Correspondence	Negotiations
	7.2	Orders	Amendments and exhibits
	7.3	Draft (unsigned) ASARCO/Fjetland Consent Decrees	Correspondence regarding negotiations
8.0		**INITIAL 1993 REMEDY**	
	8.1	Landfill closure	Closure report

SECTION	SUB-SECTION	CATEGORY/DESCRIPTION	EXAMPLES OF MATERIALS TO BE INCLUDED
	8.1.1	Technical reports	Engineering Design Report, closure report, off-property soil investigation in 1992
	8.1.2	Correspondence regarding remedy installation (Ecology and respondents)	Schedules, cost estimates
	8.2.	Post-closure monitoring and identification of off-property groundwater problem	Correspondence
	8.2.1	Data and reports	Groundwater and soil sampling
	8.2.2	Correspondence following remedy installation	Including correspondence regarding delays
	8.3	ASARCO bankruptcy announcement and Murray Pacific assumption of work	Correspondence with Ecology
	8.4	Progress reports	Weekly reports
9.0		**GROUNDWATER ALTERNATIVES EVALUATION**	
	9.1	Reports	Wetlands investigation, GAE, tech memos
	9.2	Comments and responses	Ecology responsiveness summary
	9.3	Correspondence	Ecology/MPC communications
	9.4	Data and lab reports	Groundwater sampling
	9.5	Related technical documents	Including WSDOT EIS
10.0		**ASARCO BANKRUPTCY 2005-FORWARD**	
	10.1	Initial filing	Court document
	10.2	Pleadings regarding the B&L	Motions and orders
	10.3	Discovery	Expert reports
	10.4	Agreement in Principle	Signed agreement
	10.5	Bankruptcy Settlement Consent Decree	
11.0		**CLEANUP ACTION PLAN 2007 AND CONSENT DECREE**	
	11.1	Draft CAP	Comments and responses
	11.2	Approved CAP	Including attachments
	11.3	Ecology/Murray Pacific/LP/Wasser Winters Consent Decree(s)	Comments and responses, Final CD(s)
12.0 - 19.0		**ADMINISTRATIVE RECORD: RESERVED FOR WORK IMPLEMENTED UNDER THE 2007 CAP AND CONSENT DECREE**	Deliverables required under the CD, including supporting documents; other pertinent materials related to the Work being performed under the CD.
Chronological and Topical Files			
20.0		**PROGRESS REPORTS TO ECOLOGY**	1989 forward
21.0		**CORRESPONDENCE BETWEEN ECOLOGY AND MPC**	Regarding original 1988 CD, 1991 Final CAP, GAE, 2007 groundwater CAP, groundwater CD (Duplicative of other

SECTION	SUB-SECTION	CATEGORY/DESCRIPTION	EXAMPLES OF MATERIALS TO BE INCLUDED
			categories but will stand alone as a chronological resource)
22.0		**COORDINATION/ CORRESPONDENCE WITH OTHER AGENCIES**	
	22.1	Federal	USEPA, NOAA, USACE, etc.
	22.2	State	WSDOT, WADFW, etc.
	22.3	Local	Milton, Fife, Pierce County, etc.
23.0		**COORDINATION/ CORRESPONDENCE WITH TRIBES**	
24.0		**CORRESPONDENCE WITH OTHER PLPS**	(Duplicative of other categories but will stand alone as a chronological resource)
25.0		**PUBLIC PARTICIPATION PROCESS**	Including 1993 (FCAP), 2007 (GAE)
	25.1	Public participation plans	1990s and current
	25.2	Fact sheets	1990s and present
	25.3	Meetings	Attendance sheets
	25.4	Correspondence	Including with regard to the1993 remedy, public comments, meetings, etc.
26-29		**RESERVED**	
30.0		**B&L LANDFILL RECORDS**	Correspondence and public records including corporate and conveyance documents
31.0		**PIERCE COUNTY HEALTH DEPARTMENT FILE**	(Duplicative of other categories but will stand alone as comprehensive reference)
32.0		**NRDA SETTLEMENTS**	
	32.1	MPC	Settlement Agreement
	32.2	Asarco	Settlement Agreement
	32.3	Other PLPs	Complaint(s), agreements

Exhibit D: Covered Substances

Remedial and Pre-remedial Investigations

Early work at B&L Landfill included investigation of the following substances:

- Wood, wood debris, bark, total volatile solids, total organic carbon, and grain size.
- Methane and hydrogen sulfide gases
- EPA's Target Analyte List of volatile and semi-volatile organic compounds, PCBs and pesticides, and metals (see list below)
- Total petroleum hydrocarbons
- EP-Tox and TCLP testing characterization of the landfill solids
- EP-Tox, TCLP, and assay results (MSDS) for Asarco's copper slag.
- General water quality parameters including specific conductance, redox, dissolved oxygen, major cations and anions, hardness, nitrate, nitrite, ammonia, sulfate, sulfide, total dissolved solids, total suspended solids, total organic carbon, total dissolved carbon, and turbidity.

These studies resulted in the following being known substances and/or conditions:

- Asarco slag
- Bark, deck debris, wood debris, and related materials
- Landfill gases
- Landfill leachate
- EPA's Target Analyte List of volatile and semi-volatile organic compounds, PCBs and pesticides, and metals (see list below)
- Groundwater and surface water quality
- Soil, refuse, and ditch sediment quality

Metals

The full list of metals that have been analyzed for in environmental sampling at B&L Landfill include the following:

aluminum
antimony
arsenic
arsenic (III)
arsenic (V)
methylated arsenic
barium
beryllium
cadmium
calcium
chromium
chromium (VI)
cobalt
copper
iron
iron (II)
iron (III)
lead
magnesium
manganese
mercury
nickel
potassium
selenium
silver
sodium
thallium
vanadium
zinc

Full Analyte List

The complete list of analytes and substances studied during the in the B&L Landfill investigations includes the following:

Slag and its constituents
slag
reverberatory slag
copper slag
crushed slag
slow cooled slag
industrial slow-cooled slag
industrial granulated slag
slow-cooled product slag
slag constituents

Wood and its constituents
untreated wood
woodwaste or wood debris
deck debris
logs, bark, branches, trees, roots
woodwaste, slag and soil mixture
woodwaste/slag mixture
bark/slag
wood degradation products
burned wood
wood constituents

Other landfill materials
shredded car interiors
autofluff
shredded plastic, rubber
waste rock wool
insulation
soil from log yards and decks
soil
TPH-contaminated soil
Parameters
alkalinity
ammonia
bicarbonate
carbonate
chemical oxygen demand
chloride
color
conductivity
density
dissolved organic carbon (DOC)
dissolved oxygen (DO)

Volatile Organic Compounds
volatile organic compounds (VOCs) EPA 8260
volatile organic compounds (VOCs) EPA 8240
1, 1-dichloroethane
1, 1-dichloroethene
1, 2-dichloroethane
1, 2-dichloropropane
1, 3-dichloropropane
1,1,1,2-tetrachloroethane
1,1,1-trichloroethane
1,1,2,2-tetrachloroethane
1,1,2-trichloroethane
1,1-dichloropropene
1,2,3-trichlorobenzene
1,2,3-trichloropropane
1,2,4-trichlorobenzene
1,2,4-trimethylbenzene
1,2-dibromo-3-chloropropane
1,2-dichlorobenzene
1,3,5-trimethylbenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
2,2-dichloropropane
2-butanone (MEK)
2-chlorotoluene
2-hexanone
2-hexanone (MBK)
4-chlorotoluene
4-isopropyltoluene
4-methyl-2-pentanone
4-methyl-2-pentanone (MIBK)
acetone
acetonitrile
benzene
bromobenzene
bromodichloromethane
bromoform
bromomethane
carbon disulfide
carbon tetrachloride
chlorobenzene
chlorobromomethane
chlorodibromomethane
chloroethane

Parameters, continued
fluoride
eH
grain size
hardness
major anions
major cations
moisture
nitrate
nitrite
oxidation-reduction potential (ORP)
percent moisture
pH
phosphate
redox
salinity
soil pH
specific conductance
sulfate
temperature
texture
total dissolved solids (TDS)
total organic carbon (TOC)
total suspended solids
total volatile solids (TVS)
turbidity

Metals and metalloids
aluminum
antimony
arsenic
arsenic (III)
arsenic (V)
barium
beryllium
cadmium
calcium
chromium
chromium (VI)
cobalt
copper
iron
iron (II)
iron (III)
lead
magnesium
manganese
mercury
nickel

Volatile Organic Compounds, continued
chloroform
chloromethane
cis-1,2-dichloroethene
cis-1,3-dichloropropene
dibromochloromethane
dibromomethane
dichlorobromomethane
dichlorodifluoromethane
ethylbenzene
ethylene dibromide
hexachlorobutadiene
isopropylbenzene
methylene chloride
m-xylene & p-xylene
naphthalene
n-butylbenzene
n-propylbenzene
o-xylene
sec-butylbenzene
styrene
tert-butlybenzene
tetrachloroethene
toluene
total 1,2-dichloroethene
total xylenes
trans- 1,2-dichloroethene
trans-1, 3-dichloropropene
trichloroethene
trichlorofluoromethane
vinyl acetate
vinyl chloride

Semivolatile Organic Compounds (SVOCs)
semivolatile organic compounds (SVOCs) EPA 8270
1,2,4-trichlorobenzene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
1-methylnapthalene
2,3,4,6-tetrachlorophenol
2,4,5-trichlorophenol
2,4,6-trichlorophenol
2,4-dichlorophenol
2,4-dimethylphenol
2,4-dinitrophenol
2,4-dinitrotoluene
2,6-dichlorophenol
2,6-dinitrotoluene

Metals, Continued
potassium
selenium
silver
sodium
thallium
vanadium
zinc

Petroleum Hydrocarbons
TPH-Diesel Range
TPH-Lube Oil Range

PCBs
EPA-8082 MOD
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260

Pesticides
EPA-8081
a-BHC
g-BHC
b-BHC
heptachlor
d-BHC
aldrin
heptachlor epoxide
chlordane
endosulfan I
4,4' DDE
dieldren
endrin
4,4'-DDD
endosulfan II
4,4'-DDT
endrin aldehyde
endosulfan sulfate
methoxychlor
toxaphene

Semi-Volatile Organic Compounds, Continued
2-chloronapthalene
2-chlorophenol
2-methylnaphthalene
2-methylphenol
2-nitroaniline
2-nitrophenol
3,3-dichlorobenzidine
3-nitroaniline
4,6-dinitro-2-methylphenol
4-bromophenyl-phenylether
4-chloro-3-methylphenol
4-chloroaniline
4-chlorophenyl-phenylether
4-methylphenol
4-nitroaniline
4-nitrophenol
acenapthene
acenapthylene
aniline
anthracene
azobenzene
benzidine
benzo(a)anthracene
benzo(a)pyrene
benzo(b)flouranthene
benzo(g,h,i)perylene
benzo(k)fluoranthene
benzoic acid
benzyl alcohol
bis(2-chloroethoxy)methane
bis(2-chloroethyl)ether
bis(2-chloroisopropyl)ether
bis(2-ethylhexyl)phthalate
butylbenzylphthalate
carbazole
chrysene
dibenz(a,h)anthracene
dibenzofuran
diethylphthalate
dimethylphthalate
di-n-butylphthalate
di-n-octylphthalate
fluoranthene
fluorene
hexachlorobenzene
hexachlorobutadiene
hexachlorocyclopentadiene
hexachloroethane

Semi-Volatile Organic Compounds, Continued

indeno(1,2,3-cd)pyrene
isophorone
napthalene
nitrobenzene
n-nitrosodimethylamine
n-nitroso-di-n-propylamine
n-nitrosodiphenylamine
pentachlorophenol
phenanthrene
phenol
pyrene
pyridine
siophorone

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

PUBLIC PARTICIPATION PLAN

B&L Woodwaste
2201 6th Avenue, Milton, WA 98354

Prepared by
Washington State Department of Ecology
Southwest Regional Office
Toxics Cleanup Program
300 Desmond Drive
Olympia, Washington 98504-7775

Updated January 2008

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INTRODUCTION

The Washington State Department of Ecology (Ecology) has developed this public participation plan in cooperation with Murray Pacific Corporation (Murray Pacific), Louisiana Pacific Corporation (Louisiana Pacific) and Wasser & Winters Corporation (Wasser & Winters), pursuant to the Model Toxics Control Act (MTCA) and Agreed Order No. DE 07/1-TC-S3938 to promote meaningful community involvement during the investigation and cleanup of B&L Woodwaste site. **This plan outlines and describes the tools that Ecology uses to inform the public about site activities and identifies opportunities for the community to become involved.**

SITE BACKGROUND

The B&L Woodwaste site is located at 2201 6th Avenue in Milton in a mixed residential/ agricultural and wetland area. It is southeast of Interstate 5 between Fife Way and the Puget Power access road.

This site was used as an industrial landfill from mid 1970's until the early '80's. Wood chips from log sort yards which contained slag from the old Asarco smelter in North Tacoma as well as soil from the Commencement Bay Nearshore/Tideflats area were dumped here.

In 1982, the Commencement Bay Nearshore/Tideflats area, including Hylebos Waterway and the B&L Woodwaste site, were added to the National Priorities List by the Environmental Protection Agency (EPA). The B&L Woodwaste site was named as a source of arsenic, copper and lead.

In 1992, Ecology issued an Enforcement Order requiring Asarco, Inc., Murray Pacific Corporation and Executive Bark, Inc, site owner, to do the following:

- Consolidate the 18 acre site into an 11 acre pile.
- Construct a multi-layer capping system to prevent metals from escaping from the site.
- Install and operate a groundwater monitoring well system
- Create a plan to address any failure of the original remedy

Monitoring during the mid-1990's discovered elevated arsenic in the ditch system that surrounds the pile and increased arsenic in groundwater outside of the landfill containment system, including a wetland next to the site.

In response to these findings, Ecology completed an extensive study of the wetland area. Results of the study showed:

- Dissolved arsenic levels in the groundwater in a nearby wetland were above Model Toxics Control Act cleanup standards.
- Some waste from the bottom of the pile was in contact with the water table during the winter months.
- Plants and animals in the nearby wetland did not appear to be experiencing any toxic effects.

In 2002, Asarco's funds became unavailable and they were unable to complete the rest of the Cleanup Action Plan. In 2005, Ecology amended the original Enforcement Order and required the PLPs to complete:

- Evaluation of several potential remedies to contain the release of contaminated groundwater from the site
- Investigation of the wetland area to determine what remedial action is needed.

In 2006, Asarco entered into bankruptcy proceedings and has not contributed towards cleanup efforts since that time. Murray Pacific has contributed to the preparation of a Cleanup Action Plan.

CURRENT ACTIVITY

The draft Cleanup Action Plan (CAP) was finalized after public comment in July 2007. Since then, Ecology has been in bankruptcy negotiations with Asarco and settlement negotiations with Murray Pacific and Louisiana Pacific and Wasser & Winters.

The majority of cleanup funding will come from the bankruptcy trial. Murray Pacific and Louisiana Pacific and Wasser &Winters will contribute additional funding. Negotiations with Murray Pacific and Louisiana Pacific and Wasser & Winters resulted in the proposed Consent Decree.

As part of this agreement, Murray Pacific will:

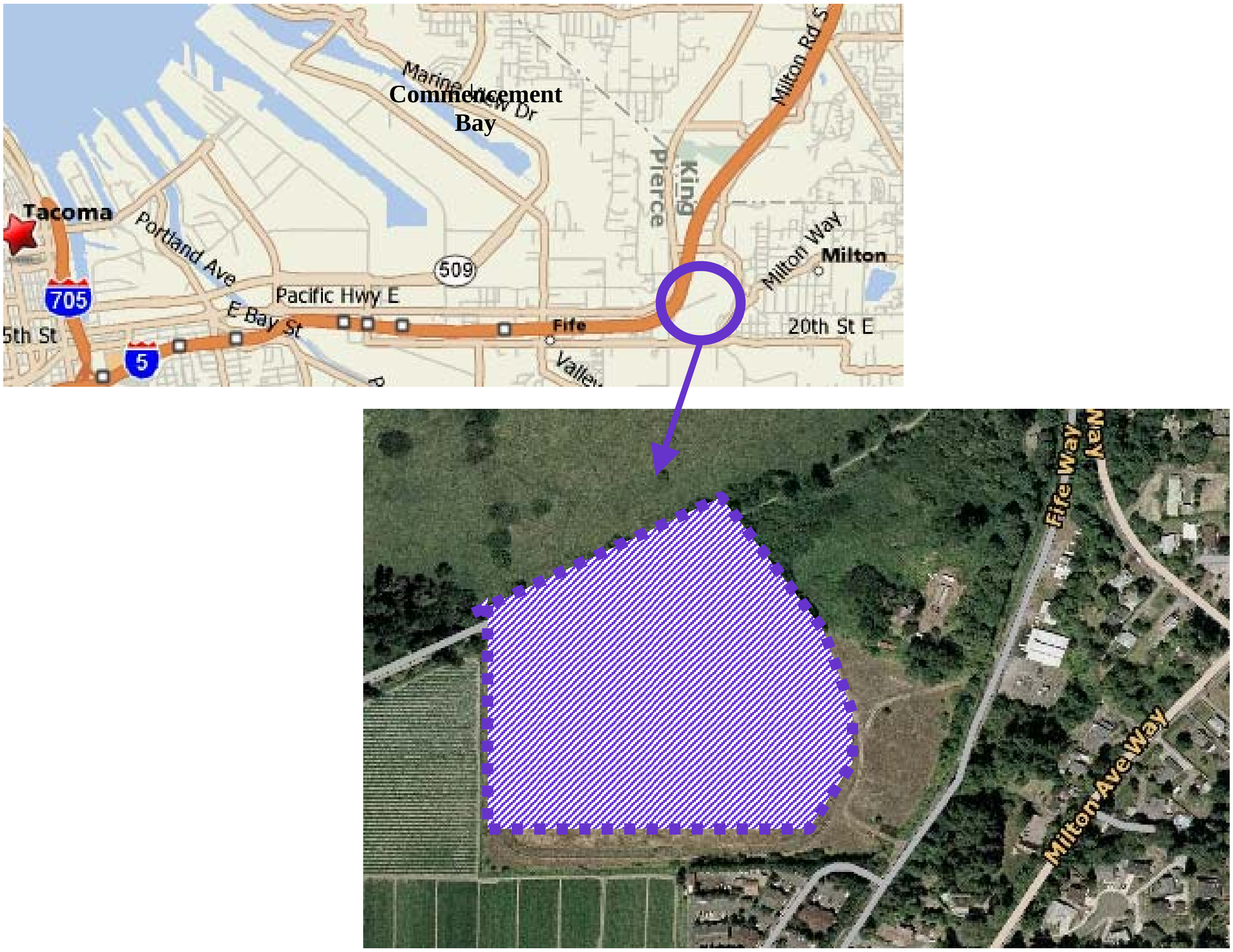
- Complete an archeological survey of the area to determine if cultural artifacts are present.

- Design and build the cleanup remedy detailed in the CAP.

- Perform the design, installation and the initial operation and maintenance of the cleanup remedies.

Ecology (using funds from the settlement) will take on responsibility for the long-term maintenance and operation of the cleanup systems after installation and startup. Once the public comment period has ended, Ecology will consider all comments received and may make changes to the Consent Decree. Ecology will then oversee implementation of the Consent Decree and Cleanup Action Plan.

Figure 1. B&L Woodwaste Site Location



MODEL TOXICS CONTROL ACT CLEANUP STAGES

The Model Toxics Control Act (MTCA) defines each stage of the cleanup process to protect human health and the environment. Figure 2 on page 6 details these stages.

Some steps described in the chart include "agreed orders" or "consent decrees." These are agreements between Ecology and the parties responsible for cleanup of the pollution. In addition to the steps in the chart, "interim actions" may be taken during steps 1 through 5 (the investigation) to reduce or eliminate pollution that poses an immediate threat to human health or the environment.

The cleanup process is complex. Issues often arise that require more attention or evaluation, and may lead to changes in the steps or schedule. Every effort will be made to keep the public well-informed of changes.

Steps in the Model Toxics Control Act Cleanup Process

STEP 1: SITE DISCOVERY AND INVESTIGATION

Sites may be discovered in a variety of ways. These include reports from the owner, an employee, or concerned citizens. Following discovery, an initial investigation is conducted to determine whether or not a site needs further investigation.

STEP 2: SITE HAZARD ASSESSMENT AND HAZARD RANKING

Ecology confirms the presence of hazardous substances and determines the relative threat the site poses to human health and the environment, compared to other known sites. The site is then ranked from 1 (highest) to 5 (lowest).

STEP 3: REMEDIAL INVESTIGATION

A remedial investigation defines the nature, extent, and magnitude of pollution at a site. Before a remedial investigation starts, a detailed work plan is prepared which describes how the investigation will be done.

STEP 4: FEASIBILITY STUDY

The feasibility study takes the information from the remedial investigation and identifies and analyzes cleanup alternatives. As with the remedial investigation, a work plan is prepared which describes how the study will be done.

INTERIM ACTIONS

Actions can be taken at any time during the cleanup process to reduce risk to human health and the environment.

STEP 5: CLEANUP ACTION PLAN

Ecology develops a cleanup action plan using information gathered in the remedial investigation and feasibility study. The plan specifies cleanup standards and methods. It describes the steps to be taken, including any additional environmental monitoring required during and after the cleanup, and the schedule.

STEP 6: CLEANUP!

Implementation of the cleanup action plan includes design, construction, operations and monitoring. A site may be taken off the Hazardous Sites List after cleanup is completed and Ecology determines cleanup standards have been met.

PUBLIC PARTICIPATION ACTIVITIES AND RESPONSIBILITIES

The purpose of this Public Participation Plan is to promote public understanding and participation in the MTCA activities planned for this site. This section of the plan addresses how Ecology will share information and receive public comments and community input on the site activities.

Public Involvement Activities

Ecology uses a variety of activities to facilitate public participation in the investigation and cleanup of MTCA sites. Ecology will implement input provided by the community whenever possible.

The following is a list of the public involvement activities that Ecology will use, their purposes, and descriptions of when and how they will be used during this site cleanup.

Formal Public Comment Periods

Comment periods are the primary method Ecology uses to get feedback from the public on proposed cleanup decisions. Comment periods usually last 30 days and are required at key points during the investigation and cleanup process before final decisions are made.

During a comment period, the public can comment in writing. Verbal comments are taken if a public hearing is held. After formal comment periods, Ecology reviews all comments received and may respond in a document called a Responsiveness Summary.

Ecology will consider the need for changes or revisions based on input from the public. If significant changes are made, then a second comment period may be held. If no significant changes are made, then the draft document(s) will be finalized.

Additional public comment periods will be held for remedial investigation/feasibility study reports, for any draft cleanup action plans that are developed for the site, and for any future legal agreements regarding this site.

Public Meetings and Hearings

Public meetings may be held at key points during the investigation and cleanup process.
Ecology also may offer public meetings for actions expected to be of particular interest to the community. These meetings will be held at locations convenient to the community.

Information Repositories

Information repositories are places where the public may read and review site information, including documents that are the subject of public comment.

Ecology has established four repositories for the B&L Woodwaste cleanup project. Documents available for public review and comment can be found here:

- Pierce County Library, 1000 Laurel Street, Milton WA 98354 Phone: (253) 922-2870
- Tacoma Main Library, 1102 Tacoma Avenue South, Tacoma, WA 98402
  Phone: (253) 591-5666
- Citizens for a Healthy Bay, 917 Pacific Avenue Suite 100, Tacoma, WA 98402
  Phone: (253) 383-2429
- WA State Department of Ecology, Southwest Regional Office, Toxics Cleanup Program
  300 Desmond Dr., Lacey, WA 98503 Phone: (360) 407-6365
- Ecology's Web Site: http://www.ecy.wa.gov/programs/tcp/sites/B_L_Woodwaste/B_L_woodwaste_hp.htm

Site Register

Ecology's Toxics Cleanup Program uses its bimonthly *Site Register* to announce all of its public meetings and comment periods, as well as many other activities. To receive the *Site Register* in electronic or hard copy format, contact Linda Thompson at (360) 407-6069 or by e-mail at Ltho461@ecy.wa.gov. It is also available on Ecology's web site at http://www.ecy.wa.gov/programs/tcp/pub_inv/pub_inv2.html

Mailing List

Ecology has compiled a mailing list for the site. The list includes individuals, groups, public agencies, elected officials, private businesses, potentially affected parties, and other known interested parties. The list will be maintained at Ecology's Southwest Regional Office and will be updated as needed.

Please contact Meg Bommarito at (360) 407-6255 or mbom461@ecy.wa.gov if you would like to be involved or have your address added to or deleted from this mailing list.

Fact Sheets

Ecology will mail fact sheets to persons and organizations interested in the B&L Woodwaste cleanup project to inform them of public meetings and comment opportunities and important site activities. Ecology also may mail fact sheets about the progress of site activities.

Newspaper Display Ads

Ecology may place ads in the *Tacoma News Tribune* to announce public comment periods and public meetings or hearings for the site.

Plan Update

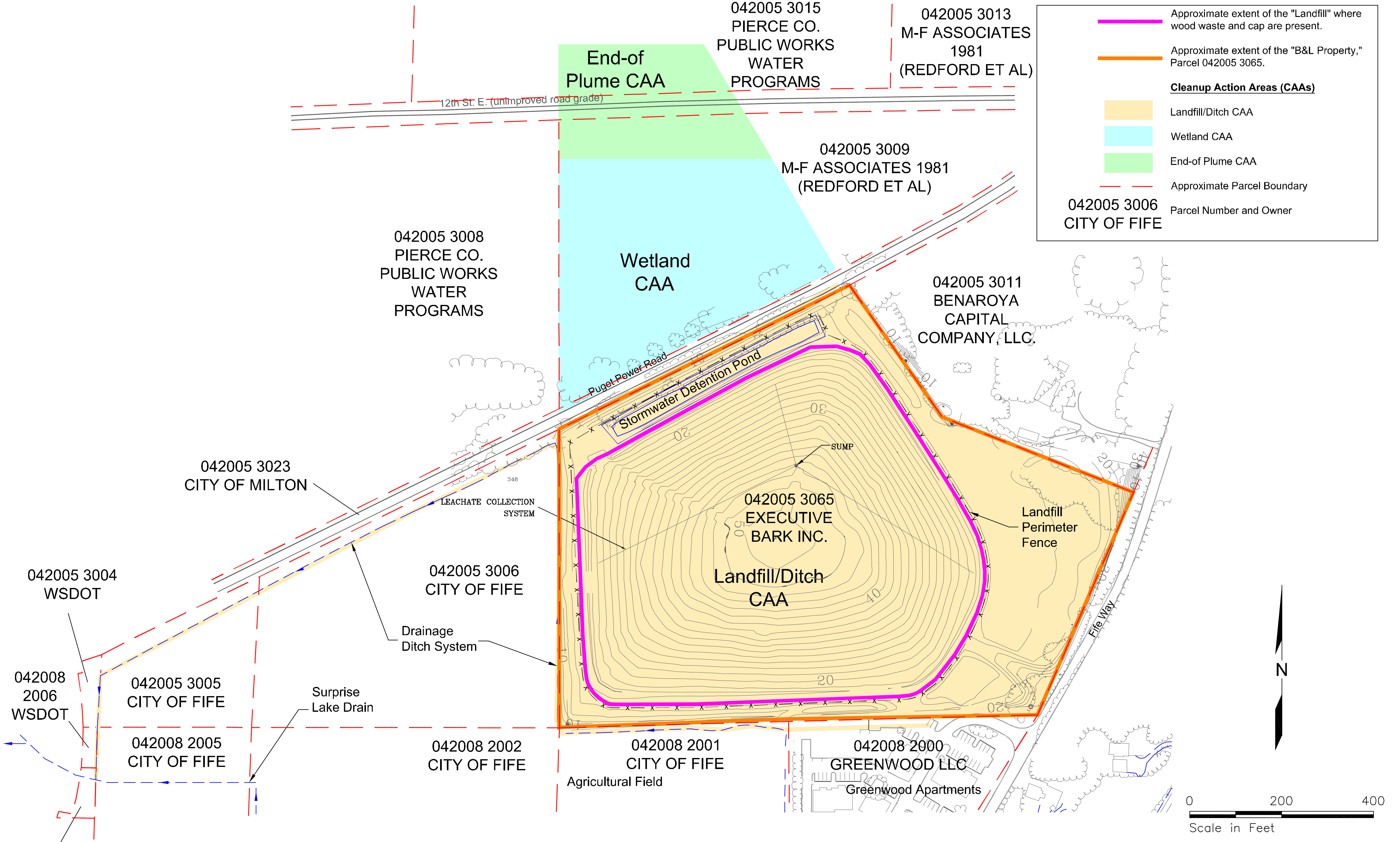
This public participation plan may be updated as the project proceeds. If an update is necessary, the revised plan will be submitted to the public for comment.

Points of Contact

If you have questions or need more information about this plan or the B&L Woodwaste cleanup project, please contact the following:

Dom Reale
Site Manager
Washington State Department of Ecology
Southwest Regional Office
300 Desmond Drive
Lacey, WA 98501
Phone: (360) 407-6266
Email: drea461@ecy.wa.gov

Meg Bommarito
Public Involvement Coordinator
Washington State Department of Ecology
300 Desmond Drive
Lacey, WA 98503
Phone: (360) 407-6255



Consent Decree No. ____________

Exhibit F - Site Diagram

Exhibit G: Election To Create Trust

A . Notwithstanding the other provisions of this Consent Decree, Murray Pacific may elect to have a Settlement Trust established as a Qualified Settlement Fund pursuant to Treasury Regulation §1.468B-1 (the "Settlement Trust"). Murray Pacific shall fund the Settlement Trust by transferring to it all funds received by Murray Pacific from the proceeds of a twenty million dollar allowed general unsecured claim in the ASARCO bankruptcy as provided for in the Bankruptcy Settlement Agreement (the "Allowed Claim"), which was intended to resolve the liability of ASARCO to Ecology and to the other parties to the Bankruptcy Settlement Agreement.

B. The Settlement Trust shall meet the requirements of subparagraphs (C), (D) and (E) of this Exhibit. Upon funding of such Settlement Trust (the "Settlement Trust Effective Date"), the obligations set forth in the following Sections of this Consent Decree shall become those of the Settlement Trust, all references to Murray Pacific in those Sections shall thereafter be deemed to refer to the Settlement Trust, and Murray Pacific shall have no further obligations under such Sections:

VI WORK TO BE PERFORMED
VII. DESIGNATED PROJECT COORDINATORS
VIII. PERFORMANCE
IX. ACCESS
X. SAMPLING, DATA SUBMITTAL, AND AVAILABILITY
XI. PROGRESS REPORTS

XII. RETENTION OF RECORDS

XIII. RESOLUTION OF DISPUTES

XIV. AMENDMENT OF DECREE

XV. EXTENSION OF SCHEDULE

XVI. ENDANGERMENT

XX. COMPLIANCE WITH APPLICABLE LAWS

XXI. REMEDIAL ACTION COSTS

C. The Settlement Trust established hereunder shall meet each of the following requirements:

1. The Settlement Trust Agreement and the Trustee shall be approved as follows:
   - (i) Murray Pacific shall provide to Ecology a draft Settlement Trust Agreement containing the provisions which conform to the general provisions described in Section C, 2. below. Ecology shall notify Murray Pacific within 30 days of receipt of the draft Trust Agreement if it objects to any Trust provision, and shall set forth the basis for any such objection. Any provision not objected to by Ecology shall be deemed approved by Ecology;
   - (ii) The person selected to serve as trustee (the "Trustee") of the Settlement Trust shall be subject to the approval of Ecology, which approval shall not be unreasonably withheld. Murray Pacific shall propose to Ecology one or more persons to serve as trustee, and shall provide information as to the background and credentials of

each such person, and within 30 days thereafter, Ecology shall notify Murray Pacific if it objects to any such persons' serving as trustee, and shall set forth the basis for any such objection. Any person not objected to by Ecology shall be deemed approved by Ecology;

(iii) The final Settlement Trust Agreement, as approved by Ecology, shall be submitted to the Court for approval as a qualified settlement fund within the meaning of the regulations under Section 468B of the Internal Revenue Code.

2. The terms of the Trust Agreement shall provide that:

(iv) The State is the sole beneficiary of the Settlement Trust;

(v) The purpose of the Settlement Trust is to perform the work required under this Consent Decree and to pay any funds remaining in the Settlement Trust after the work is completed to the State;

(vi) The Settlement Trust shall be obligated to perform the Work required under this Consent Decree in accordance with the terms hereof;

(vii) The Settlement Trust and the Trustee shall be subject to the jurisdiction of the Court for the purposes of enforcing the Trust and its obligations to perform work hereunder;

(viii) Any funds in the possession of the Settlement Trust shall be invested in interest bearing obligations of the United States Treasury or of the State of Washington or in such other obligations as may be set forth in investment guidelines contained in the Trust, and any interest earned shall become property of the Settlement Trust, and the Settlement Trust shall be responsible for paying any income taxes owing thereon;

(ix) Any funds in the possession of the Settlement Trust shall be utilized solely to perform the work required under this Consent Decree (including the reimbursement of Ecology's Remedial Action Costs under Section XXI and payment for the MPC Implementation Costs) together with the expenses of administering the Settlement Trust, including reasonable compensation of the Trustee, which compensation shall be set forth in a schedule or formula and be subject to the approval of the parties to this Consent Decree;

(x) Any funds remaining in the Settlement Trust once the work required under the Consent Decree has been completed shall be paid to the State (the "Settlement Trust Final Payment") at the name and address set forth in Section XXII; and

(xi) The Settlement Trust shall be operated in accordance with all requirements applicable to qualified settlement funds, including tax filing requirement.

D . Murray Pacific shall provide Ecology within 15 days of the Settlement Trust Effective Date with evidence that all funds received by Murray Pacific with respect to the Allowed Claim have been transferred to the Settlement Trust. It is understood that Murray

Pacific may sell the Allowed Claim in advance of any distributions thereon in the bankruptcy cases, and in such event, the proceeds from such sale shall be transferred to the Settlement Trust on the Settlement Trust Effective Date.

E. The Trustee shall provide Ecology within 15 days of the Settlement Trust Effective Date with a copy of a contract entered into between the Trustee and Floyd Snider, Inc., which provides, subject to the terms and conditions set forth in the contract, (i) that Floyd Snider, Inc., agrees to undertake those services necessary to manage performance of the work required under the Consent Decree, (ii) that the Trustee will approve specific scope and budgets for the work, and (iii) that the Trustee agrees to pay for the services of Floyd Snider, Inc., using the funds available in the Settlement Trust.

F. The obligations of the Trust to perform work shall be limited by the amount of funds in the Trust. Should the funds in the Trust be wholly depleted, the obligations of the Trust to perform work shall be terminated.

G. Notwithstanding the provisions of this Section, upon completion of the work required by the Consent Decree, Murray Pacific shall remain fully responsible to make the payment required by Section XXII of this Consent Decree, provided that, in the event the Trust is created and funded hereunder, Murray Pacific’s payment obligation shall be reduced by the Settlement Trust Final Payment. In other words, Murray Pacific shall pay the State as set forth in Section XXII the following:

$21,000,000 less (MPC Implementation Costs plus Settlement Trust Final Payment).

For example, if the total MPC Implementation Costs are $10 million and the Settlement Trust Final Payment to the State is $7.5 million, then Murray Pacific's obligation under Section XXII of this Consent Decree is to pay $21 million less $17.5 million for a final payment to the State by Murray Pacific of $3.5 million.

In particular, and without limiting the foregoing, in the event that funds paid by Murray Pacific to the Trust are expended or disbursed by the Trust or the Trustee for purposes other than MPC Implementation Costs or the Settlement Trust Final Payment, and without regard to whether such expenditures or disbursements were authorized by the Settlement Trust Agreement, Murray Pacific shall receive no credit for such amounts in calculating the payment required by Section XXIII. In other words, any risk of misuse of funds in the Trust, or of investment losses by the Trust, shall be borne totally by Murray Pacific and in no way by Ecology.

Additionally, Murray Pacific shall ensure that compensation paid to the trustee as set forth in section 2 (ix) above, as well as any expenses incurred in setting up the trust shall not be deducted from the $21 million owed to the State. In other words, compensation paid to the trustee, as well as trust implementation costs, are not to be considered MPC Implementation Costs.

H. The trust agreement shall provide that the trust will terminate when the trust's obligations under the Consent Decree are fulfilled.