Olalla Landfill Cleanup Action Plan

Prepared for

Kitsap County Department of Public Works
Solid Waste Division

December 2014

Prepared by
Parametrix

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Kitsap County Department of Public Works
Solid Waste Division
614 Division Street (MS-27)
Port Orchard, WA 98336-4699

Prepared by

Parametrix
4660 Kitsap Way, Suite A
Bremerton, WA 98312-2357
T. 360.377.0014 F. 360.479.5961
www.parametrix.com

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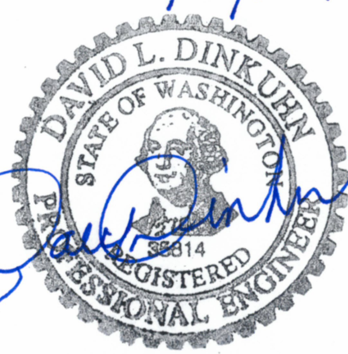
CERTIFICATION

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

12/23/2014



Prepared by David Dinkuhn, P.E.

Checked by Dwight Miller, P.E.

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KEY TERMS

ARARs	applicable, relevant, and appropriate requirements
bgs	below ground surface
CAP	Cleanup Action Plan
COCs	constituents of concern
County	Kitsap County
CPOC	conditional point of compliance
CULs	Cleanup levels
DCA	disproportionate cost analysis
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
HQ	Hazard Quotient
KCPW	Kitsap County Department of Public Works
KPHD	Kitsap Public Health District
Landfill	Olalla Landfill
MCLs	maximum contaminant levels
MFS	minimal functional standards
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
µg/L	micrograms per liter
mV	millivolts
MW	monitoring wells
O&M	operation and maintenance
ORP	oxidation-reduction potential
OW	off-site well
PLP	potentially liable party
POC	point of compliance
PVC	polyvinyl chloride
RCW	Revised Code of Washington
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SFVs	standard formula values
SW	surface water
SWHP	Post Closure Solid Waste Handling Permit
VOCs	volatile organic compounds
WAC	Washington Administrative Code

EXECUTIVE SUMMARY

This Cleanup Action Plan (CAP) presents the proposed cleanup action to be performed at the Olalla Landfill (Landfill) located approximately 0.75 mile east of Highway 16 on SE Burley-Olalla Road in Kitsap County (County), Washington. The proposed cleanup action will address cleanup of several hazardous substances in groundwater that are related to the Landfill. This plan was prepared by the Kitsap County Department of Public Works (KCPW) Solid Waste Division as an Independent Remedial Action following the requirements of the Model Toxics Control Act (MTCA) regulations (Chapter 173-340 Washington Administrative Code [WAC]). The results of the Remedial Investigation/Feasibility Study (RI/FS) conducted for the Landfill and finalized in May 2014 were used to select the proposed cleanup action.

The Landfill stopped accepting solid waste in 1985 and was officially closed in 1989. At the time of closure, active portions of the Landfill were capped using a combination of a 2-foot-thick bentonite clay cap and a compacted soil cap. All Landfill areas were then stabilized with a healthy stand of vegetation (grass). A monitoring well network was installed at closure to provide for long-term groundwater monitoring during the post-closure care period of the Landfill. Post-closure quarterly groundwater monitoring began in 1992 and is currently ongoing. Monitoring is conducted to meet the requirements of the Landfill's Post Closure Solid Waste Handling Permit (SWHP) issued annually by the Kitsap Public Health District (KPHD).

The purpose of this DCAP is to summarize the RI/FS activities performed at the Landfill and present the preferred cleanup action selected based on the results of the RI/FS. RI/FS activities were conducted between May 2010 and May 2014. The investigation approach used during the RI/FS was to sample site soil, groundwater, landfill gas, and surface water in order to develop information as to the origin, nature, and extent of the constituents of concern (COCs) in groundwater at the Landfill. The procedure used to select the COCs was to compare existing long-term monitoring results to regulatory screening levels defined as constituent concentrations above which the levels may pose a threat to human health or the environment. The COCs originally selected for investigation during the RI/FS consisted of arsenic, iron, manganese, and vinyl chloride. Although RI/FS results support the removal of vinyl chloride, it has been retained as a COC and will be included in the groundwater monitoring conducted for the cleanup action.

Remedial Investigation (RI) sampling was conducted between October 2010 and June 2011 and consisted of the collection of four quarterly rounds of groundwater samples from nine Landfill monitoring wells, a single round of groundwater samples from six downgradient off-site water supply wells, and a single round of surface water samples from three locations on the Landfill. Sampling results indicated that groundwater located immediately downgradient of the encapsulated refuse in the Landfill is impacted with elevated concentrations of arsenic, iron, and manganese from Landfill activities. None of the off-site water supply well samples were found to be similarly impacted. Surface water was also not found to be impacted.

A feasibility study was performed that evaluated and compared three alternatives identified as appropriate for cleanup of groundwater at the Landfill. The alternatives consisted of:

- Alternative 1 – Monitored Natural Attenuation (MNA) and Land Use Controls.
- Alternative 2 – Low Permeability Geomembrane Cap with MNA and Land Use Controls.
- Alternative 3 – In-Situ Physical/Chemical/ Treatment: Air Sparging and Complexation.

All three alternatives met minimum requirements for cleanup actions under MTCA with the exception of the requirement to use permanent solutions to the maximum extent practicable. A permanence assessment of the alternatives was performed in order to select a preferred alternative (Alternative 1) based on the permanence requirement.

Groundwater MNA relies upon natural attenuation processes to achieve cleanup. Natural attenuation is the process by which concentrations of chemicals introduced into the environment are reduced over time by natural physical, biological, and chemical processes. Groundwater monitoring is currently ongoing in accordance with the SWHP and will continue under Alternative 1. Quarterly monitoring results will be used to evaluate the effectiveness of the cleanup action and to verify that natural attenuation is continuing to occur. The overall effectiveness of the alternative will be evaluated at 5-year intervals as part of the periodic review process.

1. INTRODUCTION

This Cleanup Action Plan (DCAP) presents a proposed cleanup action to be performed at the Olalla Landfill (Landfill) located approximately 0.75 mile east of Highway 16 on SE Burley-Olalla Road in Kitsap County (County), Washington (see Figure 1). The plan was developed using information presented in the final Remedial Investigation and Feasibility Study (RI/FS) report (Parametrix 2014) prepared for Kitsap County, the potentially liable party (PLP) for the Landfill. This plan was prepared by Kitsap County Department of Public Works (KCPW) as an Independent Remedial Action following the requirements of the Model Toxics Control Act (MTCA) regulations (Chapter 173-340 Washington Administrative Code [WAC]).

1.1 PURPOSE

The purpose of this DCAP is to summarize the RI/FS activities performed (Parametrix 2014) and present the preferred cleanup action selected for the site. This DCAP includes:

- A summary of RI/FS activities.
- Applicable state and federal laws for the proposed cleanup action.
- Cleanup standards for each hazardous substance.
- A brief summary of the other cleanup alternatives evaluated as part of the RI/FS.
- A description of the proposed cleanup action.
- A schedule for implementation of the proposed cleanup action.

2. SITE BACKGROUND

2.1 SITE DESCRIPTION AND HISTORY

The current tax identification number for the Landfill property is 012201-1-029-2003. The original Landfill parcel consisted of approximately 75 acres, which contained an old gravel pit. In 1996, the original parcel was subdivided into two parcels, a 45-acre parcel to the north and a 30-acre parcel to the south. The parcel to the south was not used as a landfill and was not considered to be part of the Landfill for the purposes of the RI/FS.

The north parcel contains the closed Landfill and a drop box facility, known as a Recycling and Garbage Facility in Kitsap County, which was established as a transfer station at the time the Landfill stopped accepting waste. The section of the north parcel containing the Recycling and Garbage Facility was never used as a landfill and was also not considered to be part of the Landfill for the RI/FS.

The Landfill currently consists of an area capped by a low-permeability soil barrier and vegetated protective soil cap (Phase I Area) and an area covered with vegetated soil (Phase II Area; Figure 2). Both areas of the Landfill are surrounded by a gravel perimeter access road that encompasses approximately 12 acres. The Phase I area encompasses approximately 6.5 acres and the Phase II area encompasses approximately 4.5 acres. The Landfill is unlined and is situated in the old gravel pit. The Landfill area also contains a groundwater monitoring well network, a passive landfill gas collection system, a surface water conveyance system, a stormwater detention pond, public access controls, and a surrounding vegetation buffer.

Records indicate that waste disposal at the Landfill started in the late 1950s or early 1960s; however, the exact timeframe is unknown. During that time, the Landfill accepted solid waste from residential and light commercial self-haulers. The waste types disposed at the Landfill were mixed municipal solid waste, demolition, and construction materials, and a small volume of septic sludge.

Initial Landfill operations reportedly consisted of burning the refuse and covering the waste with soil on monthly intervals. Open burning was stopped in the early 1970s. In late 1971, KCPW took over operation of the Landfill and operated the facility in accordance with the solid waste landfill practices at the time, which included compaction of the waste and daily soil cover of the compacted waste.

The earliest known operating permit for the Landfill is dated 1969 and was issued by the Bremerton Kitsap County Health District, which is now known as the Kitsap Public Health District (KPHD). The 1969 permit was issued to a private operator, and the permit allowed the Landfill to accept waste from residential and light commercial self-haulers. Language in the 1969 permit letter indicates that the Landfill might have been permitted several years earlier than 1969.

In 1978, KPHD approved a request to dispose of 300,000 gallons of septic tank sludge at the Landfill. The actual volume of septic tank sludge that the Landfill accepted is unknown. According to estimates performed in 1982, the Landfill received approximately 2,000 cubic yards of mixed municipal solid waste per month. The transfer station began operations in the northern part of the property in the spring of 1985, and the Landfill no longer accepted waste after that time. The transfer station now operates as a drop box facility.

After the Landfill stopped accepting waste in 1985, four groundwater monitoring wells (MW), designated MW-1 through MW-4 were installed (Figure 2) for the purposes of long-term groundwater monitoring. Wells MW-5, MW-5A, MW-6, and MW-7 were subsequently installed between 1988 and 1993 to expand the monitoring well network.

The Landfill was officially closed in 1989 and the Landfill was divided into the Phase I and Phase II Areas at this time. Closure activities included grading the surface of the Phase I and Phase II areas to drain and construction of a 2-foot-thick bentonite clay cap over the Phase I area. A landfill gas collection system was installed beneath the cap that included three passive landfill gas flares connected by underground perforated piping. Following cap installation, both the Phase I and Phase II landfill areas were vegetated with grass. Long-term monitoring activities have been conducted at the Landfill since closure and are ongoing. These activities include quarterly groundwater monitoring from the Landfill monitoring well network, quarterly landfill gas monitoring, and annual surface water monitoring. Monitoring is conducted to meet the requirements of the Landfill Post Closure SWHP issued annually by KPHD.

2.2 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES

Remedial Investigation activities were conducted between May 2010 and May 2014, when the final RI/FS report was submitted to the Washington State Department of Ecology (Ecology) and KPHD. The investigation approach used for the RI/FS was to sample site soil, groundwater, surface water, and landfill gas in order to develop information as to the origin, nature, and extent of the constituents of concern (COCs) at the Landfill. Principal investigation activities consisted of the following.

- Collection of groundwater samples from existing Landfill groundwater monitoring wells (MW-1 through MW-4, MW-5A, MW-6, and MW-7; see Figure 2). Four sets of samples were collected at quarterly intervals between October 2010 and June 2011.

- Installation of two new monitoring wells (MW-8 and MW-10) at the downgradient Landfill boundary and collection of samples at the same time as the other wells.
- Collection of drinking water samples from off-site water supply wells located hydraulically downgradient of the Landfill (see Figure 3).
- Collection of a single set of surface water (SW) samples from three locations (SW-2, SW-3, and SW-4; see Figure 2).
- Excavation of five test trenches (Trench 1 through Trench 5; see Figure 4) in the Phase II Landfill area to investigate for the presence of refuse. Limited amounts of refuse and inert demolition debris were observed in all of the test pits with the exception of Trench 2.
- Collection of landfill gas samples during each groundwater sampling event to monitor field parameters. A single set of landfill gas samples was submitted for volatiles analysis.

Figures 5 through 9 provide hydrogeologic and geologic maps developed during the RI/FS. Figure 10 provides an elevation contour map for the Landfill. On- and off-site groundwater and surface water sampling locations and results from the RI/FS are provided in Figures 11 through 13. The Conceptual Model of Contaminant Transport through Olalla Landfill as developed in the RI/FS is provided in Figure 14.

Groundwater COCs identified for the RI, arsenic, iron, manganese, and vinyl chloride, were based on existing long-term monitoring results for the Landfill. The procedure used for selecting the COCs was to compare analytical results from long-term monitoring to regulatory screening levels defined as constituent concentrations above which the levels may pose a threat to human health or the environment. A summary of groundwater screening levels is provided in Table 1. Groundwater samples were analyzed for the COCs identified, as well as the full WAC 173-351-990 Appendix III constituent list, which is the list of hazardous inorganic and organic constituents under the Municipal Solid Waste Landfill regulations. A summary of the RI groundwater data is provided in Table 2.

3. SITE CLEANUP STANDARDS

3.1 MINIMUM REQUIREMENTS FOR CLEANUP ACTIONS

The MTCA regulations specify minimum requirements for cleanup actions. Minimum regulatory requirements that every cleanup action must meet include:

- Protect Human Health and the Environment – Cleanup actions that achieve cleanup levels at the applicable point of compliance and comply with applicable laws are presumed to be protective of human health and the environment.
- Comply with Cleanup Standards and Applicable State and Federal Laws – Cleanup standards are those standards adopted under Revised Code of Washington (RCW) 70.105D.030(2)(e) and the MTCA regulations. Establishing cleanup standards requires specification of hazardous substance concentrations that protect human health and the environment (cleanup levels), the location where those concentrations must be attained (point of compliance), and additional regulatory requirements that apply to a cleanup action because of the type of action and/or the location of the site. Cleanup Standards for the Landfill are discussed in Sections 3.2 through 3.4.

- Provide for Compliance Monitoring – Each cleanup action must include plans for compliance monitoring to ensure human health and the environment are protected, to confirm the action has attained cleanup standards, and confirm the long-term effectiveness of the cleanup action once cleanup standards have been attained.
- Use permanent solutions to the maximum extent practicable including consideration for public concerns.
- Provide for a reasonable restoration timeframe.
- Consider additional performance criteria.

3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Performance of cleanup actions under MTCA (WAC173-340-710) requires identification of applicable, relevant, and appropriate requirements (ARARs). ARARs are regulatory requirements that apply to a cleanup action because of the nature of the hazardous substances, the type of action, the location of the site, or other circumstances at the site. Applicable state and federal laws for the Landfill groundwater cleanup action consist of the MTCA law and associated regulations in addition to federal maximum contaminant levels (MCLs). Table 3 is a summary of the ARARs for the Olalla Landfill.

3.3 CLEANUP LEVELS

Cleanup levels (CULs) were developed for the COCs according to the requirements of the MTCA regulations, which stipulate that cleanup levels be "at least as stringent as all applicable state and federal laws" (RCW 70.105D.030 [2][e]). The Final RI/FS Report (Parametrix 2014) described the process for evaluating the indicator hazardous substances and identified the following remaining indicator hazardous substances that must be addressed by the selected cleanup action at the Landfill:

- Arsenic in groundwater;
- Iron in groundwater;
- Manganese in groundwater; and
- Vinyl chloride in groundwater.

The CULs for the COCs are summarized in Table 4. Although vinyl chloride was initially identified as a COC for the RI/FS, vinyl chloride was not detected at concentrations that exceeded the CUL within the past three years. Vinyl chloride, however, will continue to be monitored.

3.4 GROUNDWATER CONDITIONAL POINT OF COMPLIANCE

The point of compliance (POC) is the point or points where cleanup levels established in accordance with WAC 173-340-720 through 173-340-760 shall be attained. WAC 173-340-720(8) defines the standard groundwater POC for all sites as the groundwater throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site. However, WAC 173-340-720(8)(c) allows for a conditional point of compliance (CPOC) where it is not practicable to meet the cleanup level throughout the site within a reasonable restoration timeframe. The regulation requires that the CPOC shall be as close as practicable to the source of hazardous substances and shall not exceed the property boundary.

The Landfill property meets the conditions for a CPOC because leachate will continue to be released from the Landfill for years thereby creating an ongoing source of contaminants and maintaining reducing geochemical conditions that are anticipated to impact groundwater under the capped or covered refuse. Since the source will not be completely mitigated without complete removal of all refuse at the Landfill, it will not be practicable to meet the cleanup levels throughout the Landfill within a reasonable restoration timeframe. The County property boundaries are appropriate as the Landfill CPOC. Based on the west-northwest regional groundwater flow direction established during the RI, the western property boundary is a downgradient boundary, the north and south boundaries are roughly parallel to regional groundwater flow, and the eastern boundary is upgradient. The County property boundary is also within the 1,000-foot minimum distance required for water supply wells located near solid waste landfills (WAC 173-160-171). The wells located along the western property boundary (MW-3, MW-6, MW-7, MW-8, and MW-10) are close to the refuse limits and will serve as the monitoring points for the CPOC.

4. DESCRIPTION OF THE SELECTED CLEANUP ACTION

Alternative 1, Monitored Natural Attenuation (MNA) and Land Use Controls is the selected cleanup action alternative. This alternative was selected using the MTCA Feasibility Study process and is described in detail in the RI/FS report (Parametrix 2014).

The cleanup action consists of:

- Continued quarterly monitoring of five (5) groundwater monitoring wells (MW-1, MW-3, MW-6, MW-8, and MW-10) and annual monitoring of two (2) wells (MW-5A and MW-7) and one (1) surface water location (SW-2) with quarterly reporting. For the purposes of the feasibility study, it was assumed that monitoring would occur for 30 years.
- Continued inspection, maintenance, and repair of Landfill closure systems, including the cap, drainage ditches, and the Landfill gas system.
- Continued quarterly monitoring, maintenance, and operation of the Landfill gas system.
- Preparation of a Restrictive Covenant, Land Use Control Implementation Plan, and Notice of Conveyance or Other Transfer of an Interest in the Property upon property transfer. The Restrictive Covenant will also be put in place when the cleanup action is complete or when the facility no longer operates under a post-closure permit.

4.1 MONITORED NATURAL ATTENUATION

Groundwater MNA relies upon natural attenuation processes (within the context of controlled and monitored site conditions) to achieve cleanup levels at the CPOC within a reasonable restoration timeframe. Natural attenuation is the process by which concentrations of chemicals introduced into the environment are reduced over time by natural physical, biological, and chemical processes.

Characteristics of sites where MNA may be appropriate (WAC 173-340-370(7)) are provided below followed by a description of conditions at the Landfill that meet each characteristic.

Characteristic	Conditions at Olalla Landfill
Source control, including removal and/or treatment of hazardous substances, has been conducted to the maximum extent practicable.	The Olalla Landfill Phase I Area was closed with a low permeability bentonite-amended soil cap in accordance with Chapter 173-304 WAC. The cap is monitored and maintained in accordance with the Landfill closure plan and the SWHP. The Phase II area is covered by a minimum of 1 foot of vegetated soil, and wastes remain dry and are separated from the uppermost aquifer by 40 to 50 feet, indicating no direct contact between waste and groundwater.
Leaving contaminants on-site during the restoration timeframe does not pose an unacceptable threat to human health or the environment.	Groundwater at the Olalla Landfill exceeds CULs at the CPOC; however, no direct contact exposure route for groundwater ingestion or contact is identified. Continued post-closure operation and land use controls will reduce the potential for future changes to groundwater exposure scenarios.
There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site.	Based on typical trends observed with other similar closed Chapter 173-304 WAC landfills, declining leachate releases and landfill gas production over time lead to long-term declining trends in groundwater contaminant concentrations. Groundwater concentrations of COCs at the Landfill have been steady or declining during the monitoring period and would be expected to continue to decline and ultimately achieve CULs.
Appropriate monitoring requirements are conducted to evaluate if conditions favorable for natural attenuation processes are maintained and that human health and the environment are protected.	Quarterly groundwater monitoring is required at the Landfill as part of the SWHP and will continue in accordance with the SWHP. Monitored parameters include parameters used to evaluate if natural attenuation processes are taking place including specific conductance, pH, dissolved oxygen, and oxidation-reduction potential. Land use restrictions currently in place and permit limitations on developing adjacent properties within 1,000 feet of the Landfill will continue to protect potential exposure through direct contact or ingestion of groundwater that exceeds CULs.

Natural attenuation processes at the Landfill that may reduce the COC concentrations in groundwater during transport downgradient are dispersion, dilution, chemical stabilization, and sorption. Dispersion and dilution appear to be the current dominant attenuation processes at the Landfill; however, as the leachate generation and anaerobic conditions beneath the Landfill dissipate over time, the geochemistry within the subsurface will change and chemical stabilization and sorption will become the dominant attenuation processes. Supporting information for this statement includes:

- pH is neutral or slightly acidic in samples collected from all Landfill wells which allows for the mobilization of metals in reducing conditions or the precipitation or re-adsorption of metals to the aquifer matrix in oxidizing conditions;
- Dissolved oxygen and oxidation-reduction potential (ORP) levels are generally low in samples collected from Landfill wells that demonstrate elevated metals concentrations. This demonstrates that anaerobic (reducing) biodegradation is occurring; and
- Dissolved oxygen and ORP levels are generally high (>100 millivolts [mV]) in samples collected from Landfill wells where metals concentrations are low indicating oxidizing conditions and the ability to decrease metals concentrations where oxidizing conditions exist.

4.2 GROUNDWATER MONITORING

MNA requires long-term groundwater monitoring to verify that natural attenuation is continuing to occur and that constituent concentrations will meet cleanup levels within a reasonable timeframe. The proposed groundwater monitoring program will continue in accordance with the current SWHP. Groundwater monitoring will continue on a quarterly basis.

During each sampling event, depth-to-water measurements will be measured at wells MW-1, MW-2, MW-3, MW-4, MW-5, MW-5A, MW-6, MW-7, MW-8, and MW-10. These wells were selected because the wells provide appropriate upgradient, cross gradient, and downgradient coverage of groundwater elevations at the Landfill. Wells MW-1, MW-3, MW-5A, MW-6, MW-7, MW-8, and MW-10 will be sampled for laboratory analyses. Of the wells sampled, MW-3, MW-6, MW-7, MW-8, and MW-10 also represent locations for monitoring the CPOC. Depth to water at well MW-5 will be monitored to track changes in the water level of the shallow perched groundwater north of the Landfill.

The constituents to be analyzed will include field parameters (i.e., pH, specific conductance, dissolved oxygen [DO], temperature, and ORP), dissolved metals (i.e., iron, manganese, and arsenic), volatile organic compounds (VOCs) including vinyl chloride, and conventional constituents (e.g., ammonia, chloride, total organic carbon, bicarbonate, carbonate, nitrate, nitrite, sulfate, and alkalinity).

Measured field parameters, specifically DO and ORP, provide an indication of the geochemical characteristics of the aquifer. These parameters will be evaluated over time to determine if, and to what extent, natural attenuation is occurring. Natural attenuation will be indicated by geochemical conditions becoming more aerobic as evidenced primarily by increasing DO concentrations and higher ORP values. As the geochemical conditions become more aerobic, the dissolved metals should show a downward trend over time. To assist in evaluating these trends, DO and ORP time series graphs will be provided in all future monitoring reports and Mann-Kendall statistical trend analysis will be performed.

4.3 INSTITUTIONAL CONTROLS

Land Use Controls are currently in place in the form of requirements established in the SWHP and Kitsap County Board of Health Solid Waste Ordinance 2010-01. These controls will continue until CULs are achieved and other Landfill post-closure criteria are achieved. Controls include fencing, locked gates, and signage to limit access to the Landfill. The Landfill property is also listed in County and State records as a landfill and water well installation and residential development is restricted within 1,000 feet of the property boundary. The Landfill is regulated under Washington State Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC). Existing deed restrictions for the Landfill property are in place and will be maintained.

The preparation of a Restrictive Covenant, Land Use Control Implementation Plan, and Notice of Conveyance or Other Transfer of an Interest in the Property upon property transfer is also part of the institutional controls. The preparation of these plans will be delayed until the time that the property is transferred. In addition, the Restrictive Covenant will be put in place when the cleanup action is complete or when the facility no longer operates under a post-closure permit. These actions are appropriate for cleanup actions under MTCA.

5. EVALUATION OF CLEANUP ACTION ALTERNATIVES

A total of three cleanup action alternatives were developed for analysis in the feasibility study. Alternative 1 is described in Section 4. This section provides brief descriptions of alternatives 2 and 3 and presents the evaluation process and rationale used to select Alternative 1 as the preferred alternative. As part of the evaluation of the cleanup alternatives, a disproportionate cost analysis (DCA) was performed which is further discussed in Section 6.2 of this DCAP. Tables 5 and 6 provide the scoring matrix and estimated costs for the alternative cleanup actions that are discussed in Section 6.2.

5.1 ALTERNATIVE 2 – LOW PERMEABILITY CAP WITH MNA AND LAND USE CONTROLS

Alternative 2 consists of installation of a geomembrane cap over the existing low permeability soil cap on the Phase I Area (Figure 15). The geomembrane cap would be constructed using Chapter 173-351 WAC, Criteria for Municipal Solid Waste Landfills, as a guide. The top liner would consist of a compacted bedding layer and an overlying 30 mil polyvinyl chloride (PVC) geomembrane. A 24-inch vegetated soil layer would be placed on top of the liner. The installation of a geomembrane would require reconstruction of the passive Landfill gas system including installation of new gas collection piping, new flares, and four new soil gas wells for landfill gas migration monitoring. Depending on methane concentrations measured in the new Landfill gas system, active gas collection and treatment might be necessary.

Groundwater MNA for Alternative 2 would be identical to Alternative 1 with the exception that monitoring frequency would be reduced from quarterly to semi-annually in years 20 through 30. This reduction is based on the assumption that groundwater concentrations would reach CULs at year 20 and that confirmation monitoring would be required from year 20 through year 30 to ensure that the geomembrane cap maintained functionality.

Similar to Alternative 1, Alternative 2 includes continuing post-closure care of the Landfill as required by the SWHP and long-term groundwater monitoring.

5.2 ALTERNATIVE 3 – IN-SITU PHYSICAL/CHEMICAL TREATMENT: AIR SPARGING AND COMPLEXATION

Alternative 3 consists of installation of an air sparging system to add oxygen to the subsurface in order to create an aerobic subsurface environment at the CPOC and a remediation substrate injection system to provide remediation products designed for metals complexation (Figure 16).

An air sparging system would be installed consisting of up to 10 air injection wells installed in intervals of approximately 50 feet along the western boundary of the Landfill property. The air injection wells would be connected to a piping manifold at the surface that would allow compressed air to be equally distributed between the wells.

The air sparging system would be operated for approximately 25-day intervals (monthly), followed by 5-day shutdown periods to allow for aquifer stabilization, which is necessary for static water level measurements and groundwater sampling to occur. The air sparging system would be operated in cycles of approximately 25 days on with 5 days off for the first year as described above. After the first year of operation, the air sparging system would be operated for approximately 3-month intervals (quarterly) followed by 5-day shutdown periods to allow for aquifer stabilization, water level measurements, groundwater sampling, and maintenance. For the feasibility study, it was assumed that the air sparging system would operate for 30 years.

Alternative 3 also includes installation of up to 21 injection points in intervals of approximately 25 feet along the eastern edge of the eastern perimeter road. The injection points would extend approximately 60 to 70 feet below ground surface (bgs) and 20 feet below the seasonal low groundwater level. The bottom of the injection points would be fitted with 20 feet of slotted well screen set in a sand filter pack that would allow for the injection of MRC™ at a rate of approximately 100 pounds per injection point. It was assumed that a total of five annual treatments would be necessary to reduce groundwater metals concentrations to near cleanup levels. After 5 years of MRC™ treatment, it was assumed that air sparging alone would be sufficient to maintain the reduced metals concentrations. Metals concentrations would be measured during ongoing minimal functional standards (MFS) groundwater sampling at monitoring wells MW-3, MW-6, MW-8, and MW-10.

Alternative 3 also includes continuing post-closure care of the Landfill as required by the SWHP and long-term groundwater monitoring.

6. JUSTIFICATION OF THE SELECTED CLEANUP ACTION

6.1 COMPLIANCE WITH MTCA REQUIREMENTS

The selected cleanup action was evaluated against the minimum requirements for cleanup actions (described in Section 3.1) and was found to meet the minimum requirements with the exception of the requirement to use permanent solutions to the maximum extent practicable. The following discussion summarizes the analysis and evaluations presented in detail in Section 13 (Evaluation of Cleanup Action Alternatives) of the Final RI/FS Report (Parametrix 2014) required by WAC 173-340-360.

6.1.1 Threshold Requirements

- Protect human health and the environment

  The selected cleanup action provides for the protection of human health and the environment because the existing cap and soil cover reduces the leaching potential through the wastes and eliminates exposures to contaminants above CULs by human and ecological receptors.

- Comply with cleanup standards

  The selected cleanup action complies with cleanup standards by attaining cleanup levels at the CPOCs within a reasonable period of time and in accordance with WAC 173-340-7208)(c). The selected cleanup action relies on natural attenuation, which typically takes decades to achieve applicable cleanup levels.

- Comply with ARARs

  The selected cleanup action complies with all cleanup standards presented in Table 4 of this CAP.

- Provide compliance monitoring

  Compliance monitoring requirements are defined in WAC 173-340-410. Each cleanup action must include plans for compliance monitoring to ensure human health and the environment are protected, to confirm the action has attained cleanup standards, and confirm the long-term effectiveness of the cleanup action once cleanup standards have been attained. The selected cleanup provides for compliance monitoring and is discussed in Section 4.2 of this DCAP.

6.1.2 Compliance with other MTCA Requirements

In addition to the threshold requirements, WAC 173-340-360(2)(b) requires cleanup actions to meet “other requirements” or “additional requirements” as follows:

- Use Permanent Solutions to the Maximum Extent Possible

  WAC 173-340-360(2)(b)(i) requires selected cleanup actions to use permanent solutions to the maximum extent practicable. To determine if the selected cleanup action met this test, a disproportionate cost analysis (DCA) was performed and presented in the RI/FS Report (Parametrix 2014). The DCA involved ranking the cleanup action alternatives from most to least permanent based on the benefits provided by each alternative. Alternatives were then compared on the basis of cost. Costs are considered disproportionate to benefits if the incremental cost of an alternative over that of a lower cost alternative exceeds the degree of benefits achieved (WAC 173-340-360[3][e][i] and WAC 173-340-360[3][f]). Based on the DCA, the selected alternative was the preferred alternative as described in the Final RI/FS Report (Parametrix 2014).

- Provide a Reasonable Restoration Timeframe

  The estimated restoration timeframe for the selected cleanup action is 30 years. This timeframe is considered reasonable for former landfills using natural attenuation, and considering the institutional controls in place

- Consider Public Concerns

  The selected cleanup action considers perceived public concern; however, WAC 173-340-515, independent remedial actions do not require a formal public participation plan.

6.2 DISPROPORTIONATE COST ANALYSIS (DCA) AND PREFERRED ALTERNATIVE

Table 5 presents a permanent solutions scoring matrix for a qualitative comparison of alternatives. Each alternative was scored relative to the other alternatives with a “3” signifying that the alternative provided the most benefit under the criterion and a “1” signifying that the alternative provided the least benefit. The scoring provided reflects the ranking discussions provided in Section 13.2.2.1 of the Final RI/FS (Parametrix 2014).

Estimated costs for each alternative are presented in Table 6. Because Alternative 3 is more costly than the baseline alternative, while providing less benefit, no further comparison will be made. A benefit versus cost comparison for Alternatives 1 and 2 is provided below.

The assumed benefit under Alternative 2 is that groundwater CULs are attained at the CPOC sooner than under Alternative 1, which may result in a reduction in human health risk. However, this benefit has value only if human health risks under Alternative 1 are unacceptable, which may not be supported by the data.

Dissolved arsenic, iron, and manganese are expected to undergo attenuation within a relatively short distance downgradient of the landfill. This occurs as oxygen-depleted groundwater mixes with fresh groundwater, geochemical conditions become less reducing, and the dissolved metals become less soluble and less mobile (see next paragraph for supporting reference). The current horizontal extent of the dissolved arsenic, iron, and manganese plume may be approximated by the location of off-site downgradient and cross gradient water supply wells sampled during the RI. These wells, which represent neighboring water supply wells, were not found to be impacted by the landfill. The wells range in distance from approximately 930 to

1,660 feet to the nearest edge of solid waste in the landfill. The off-site well (OW) data, specifically for OW-2, OW-4, and OW-9 that are screened in the uppermost aquifer beneath the landfill, indicate that water supply wells located greater than approximately 1,000 feet from the edge of the solid waste are not currently impacted, and are not expected to be impacted, by dissolved metals associated with the Landfill in the future. The risk of new water supply wells being installed closer than 1,000 feet from the Landfill is eliminated by the prohibition against installation of water supply wells within 1,000 feet of the Landfill boundary in accordance with WAC 173-160-171.

The above observations are supported by available information from Fort Lewis Landfill No. 5. This landfill, located on Fort Lewis, Washington, is similar to the Olalla Landfill in that it is an unlined landfill that accepted mixed municipal and demolition waste from 1962 to 1990, when it was closed. Data from the RI/FS performed for the landfill indicated that, at the time of closure, dissolved iron and manganese concentrations decreased to near background levels at a distance of approximately 2,000 feet downgradient of the landfill boundary (USEPA 1992; Woodward-Clyde 1991). In this instance, the solid wastes were relatively fresh and manganese concentrations at the edge of the landfill were over 10,000 micrograms per liter (μg/L), much higher than concentrations detected at the edge of the Olalla Landfill during the RI.

Risks to human health from drinking Landfill impacted groundwater appear to be nonexistent at the current time and minimal under potential future exposure scenarios. The apparent increase in benefits regarding reductions in human health risk under Alternative 2 are not significant and do not justify the additional $1,753,192 in total costs for Alternative 2 over Alternative 1. Based on this DCA, Alternative 1 was selected as the preferred alternative.

7. IMPLEMENTATION OF THE CLEANUP ACTION

Quarterly monitoring is currently ongoing in accordance with the SWHP and will continue under Alternative 1. Quarterly reports will be used to evaluate the effectiveness of the cleanup action on an ongoing basis. The overall effectiveness of the alternative will be evaluated at 5-year intervals as part of the periodic review process. The first quarter of the 5-year interval will correspond with the first quarterly monitoring event following Ecology and KPHD approval of the selected cleanup action in May 2014. The first quarterly monitoring event under Alternative 1 will be the June 2014 event and the first 5-year period review will be performed following the March 2019 quarterly monitoring event.

The 5-year review process will include an evaluation of human exposure to impacted drinking water similar to the evaluation conducted during the RI. All six off-site water supply wells sampled during the RI will be sampled concurrently with the final quarterly monitoring at the end of the 5-year period. Prior to sampling, a review of the Ecology Well Log database will be conducted to evaluate if new water supply wells have been installed that could be potentially impacted by the Landfill. If KCPW determines that new wells exist that could be potentially impacted, the wells will be sampled along with the other six water supply wells. All water supply well samples will be analyzed for dissolved arsenic, iron, and manganese. Sampling of the water supply wells will be conducted by KCPW in partnership with KPHD under an inter-agency agreement.

The County may consider performing a technical analysis demonstrating the effectiveness of semi-annual sampling after collecting 5 years of quarterly data. Adjustments to the monitoring frequency will require approval from the KPHD.

If significant changes to the current environmental conditions at the Landfill occur during future monitoring, KCPW will evaluate the changes and respond appropriately as required under the SWHP. Example of changes include increases in COCs concentrations outside of historical trends or detection of new constituents at concentrations potentially harmful to human health or the environment. Investigations as to potential causes will be performed on a case by case basis and appropriate responses developed in coordination with KPHD.

No later than 10 years after commencing the implementation of Alternative 1, KCPW will thoroughly re-evaluate all available performance data and reconsider viable alternatives versus monitored natural attenuation, including Alternative 2 (Geomembrane cap over Phase I), for the remedial action of the Landfill.

8. REFERENCES

Ecology (Washington State Department of Ecology). 2007. Model toxics control act cleanup regulations. Washington Administrative Code (WAC) 173-340. November 2007.

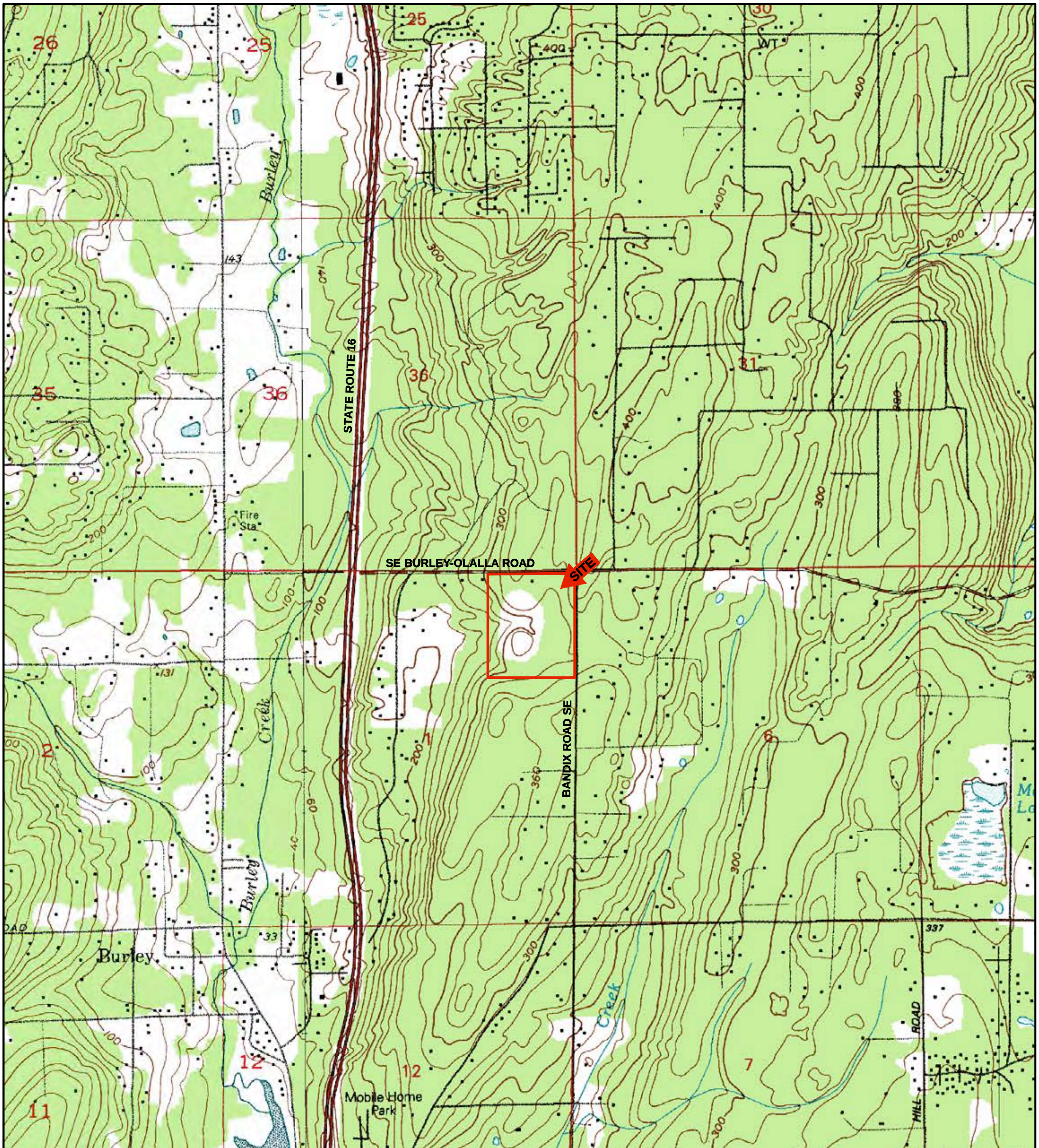
Parametrix. 2010. Olalla Landfill remedial investigation/feasibility study work plan. Prepared by Parametrix, Inc., Bellevue, Washington. August 2010.

Parametrix. 2014. Olalla Landfill remedial investigation/feasibility study. Prepared for Kitsap County Department of Public Works. May 2014.

USEPA (United States Environmental Protection Agency). 1992. Superfund record of decision: Fort Lewis (Landfill No. 5), WA. EPA/ROD/R10-92/049. July 1992.

Woodward-Clyde Consultants. 1991. Fort Lewis Landfill No. 5 remedial investigation/ feasibility study. Remedial investigation report volume 1. Prepared for the U.S. Army Corps of Engineers, Seattle District. November 1991.

Figures



KEY:

SOURCE: USGS 7.5 MINUTE QUADRANGLE (TOPOGRAPHIC)

BURLEY, WA
1953; REVISED 1994

OLALLA, WA
1953; REVISED 1994

SCALE = 1:24,000

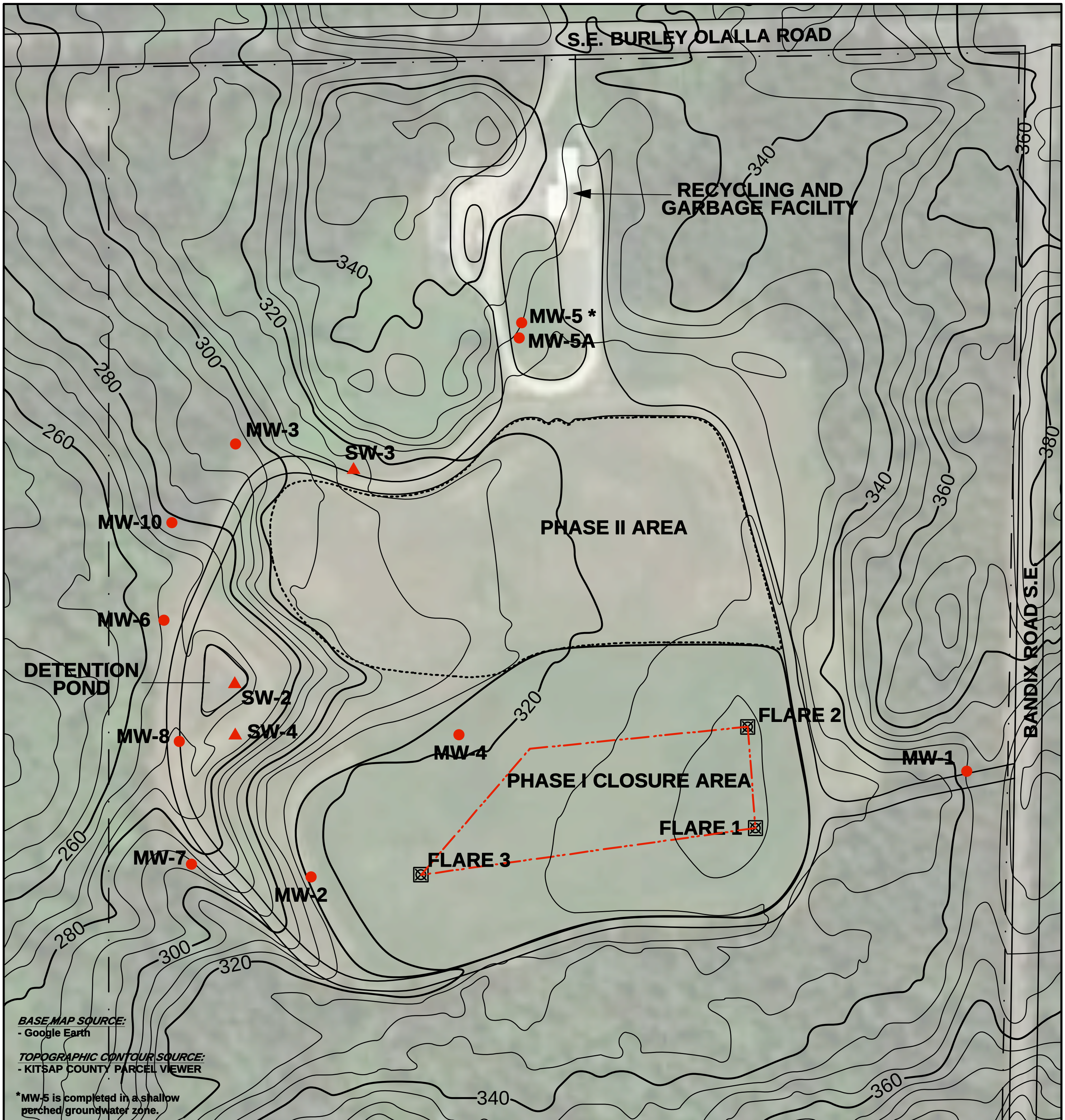
ENVIRONMENTAL PARTNERS INC

FIGURE 1

OLALLA LANDFILL LOCATION MAP

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	2850 SE BURLEY-OLALLA ROAD OLALLA, WASHINGTON

SHEET	***DRAWN BY***	***REVIEWED BY***	***DATE***
1 of 1	*ARM/MMM*	*DCK*	*08/25/14*



KEY:
- : APPROXIMATE PROPERTY BOUNDARY
- : PERIMETER ACCESS ROAD
- MW-2 : MONITORING WELL
- SW-2 : SURFACE WATER SAMPLING LOCATION
- 300 : TOPOGRAPHIC ELEVATION CONTOURS
- : LANDFILL GAS FLARE
- : APPROXIMATE ALIGNMENT OF UNDERGROUND PIPING SYSTEM

N

0 50 100 200

SCALE: 1" = 200'

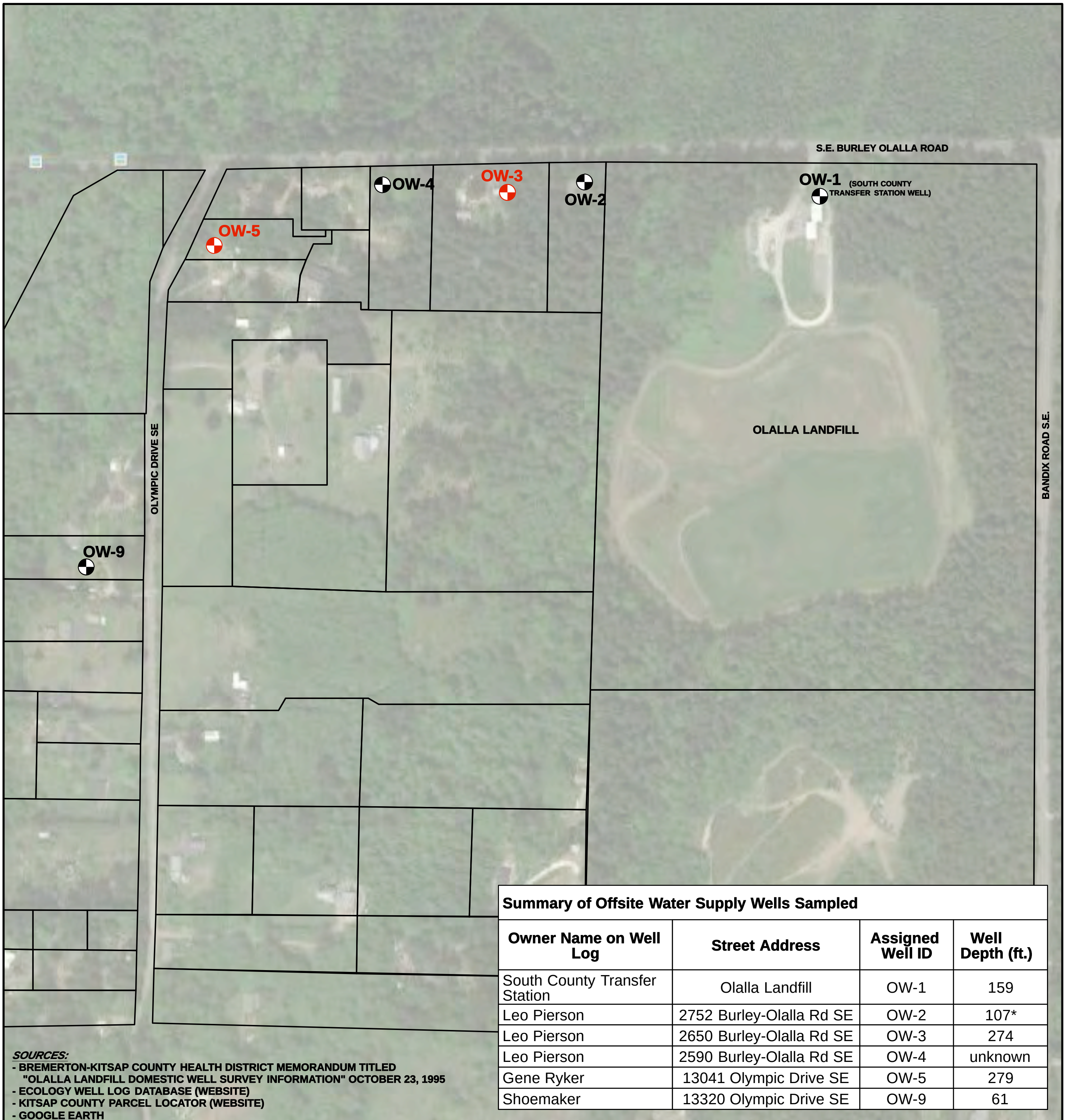
ENVIRONMENTAL PARTNERS INC

FIGURE 2

OLALLA LANDFILL
SITE MAP AND FEATURES
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	***DRAWN BY***	***REVIEWED BY***	***DATE***
1 of 1	*ARM/MMM*	*DCK*	*08/25/14*



Summary of Offsite Water Supply Wells Sampled

Owner Name on Well Log	Street Address	Assigned Well ID	Well Depth (ft.)
South County Transfer Station	Olalla Landfill	OW-1	159
Leo Pierson	2752 Burley-Olalla Rd SE	OW-2	107*
Leo Pierson	2650 Burley-Olalla Rd SE	OW-3	274
Leo Pierson	2590 Burley-Olalla Rd SE	OW-4	unknown
Gene Ryker	13041 Olympic Drive SE	OW-5	279
Shoemaker	13320 Olympic Drive SE	OW-9	61

SOURCES:
- BREMERTON-KITSAP COUNTY HEALTH DISTRICT MEMORANDUM TITLED "OLALLA LANDFILL DOMESTIC WELL SURVEY INFORMATION" OCTOBER 23, 1995
- ECOLOGY WELL LOG DATABASE (WEBSITE)
- KITSAP COUNTY PARCEL LOCATOR (WEBSITE)
- GOOGLE EARTH

KEY:

* Well information provided by owner. Well log not available in KCHD records or Ecology Well Log database.

: OFFSITE WELL LOCATION (UPPER AQUIFER)

: OFFSITE WELL LOCATION (DEEPER AQUIFER)

: PARCEL BOUNDARY

N

0 100 200 400

SCALE: 1" = 400'

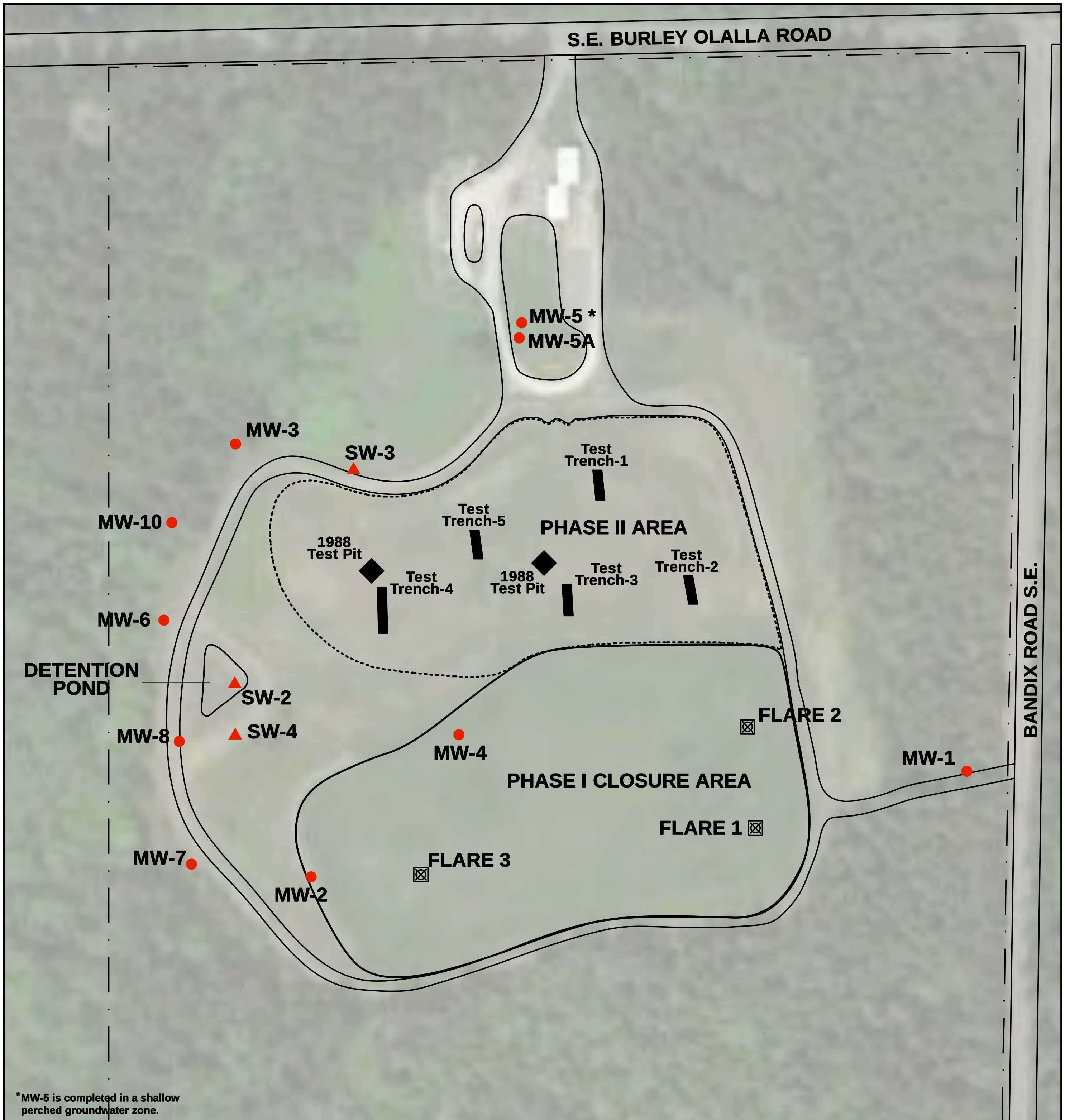
ENVIRONMENTAL PARTNERS INC

FIGURE 3

OFFSITE WATER SUPPLY WELL
SAMPLING LOCATIONS
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL RI/FS KITSAP COUNTY, WASHINGTON

SHEET	***DRAWN BY***	***REVIEWED BY***	***DATE***
1 of 1	*ALW/MMM*	*DCK*	*08/25/14*



KEY:

- : APPROXIMATE PROPERTY BOUNDARY
- : PERIMETER ACCESS ROAD
- MW-2 : MONITORING WELL
- SW-2 : SURFACE WATER SAMPLING LOCATION
- : LANDFILL GAS FLARE
- : EXPLORATORY TEST TRENCH
- : MAY 3, 1988 TEST PITS

N

0 50 100 200

SCALE: 1" = 200'

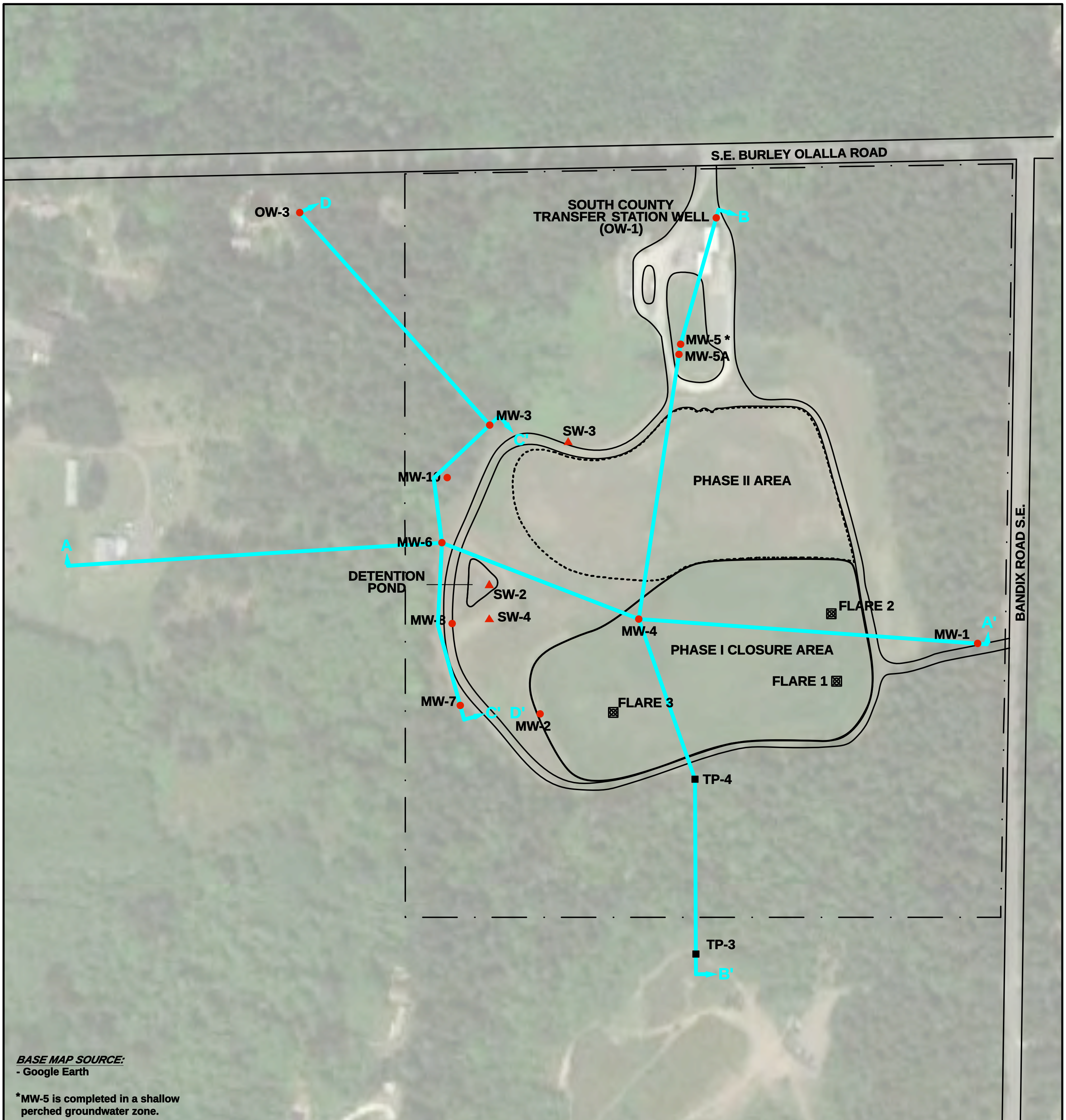
ENVIRONMENTAL PARTNERS INC

FIGURE 4

EXPLORATORY TEST TRENCH LOCATIONS
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	ALW/MMM	DCK	08/25/14



KEY:
- : APPROXIMATE PROPERTY BOUNDARY
- : PERIMETER ACCESS ROAD
- MW-2 : MONITORING WELL
- SW-2 : SURFACE WATER SAMPLING LOCATION
- : TEST PIT LOCATION
- : LANDFILL GAS FLARE
- A A' : CROSS SECTION ALIGNMENT

N

0 75 150 300

SCALE: 1" = 300'

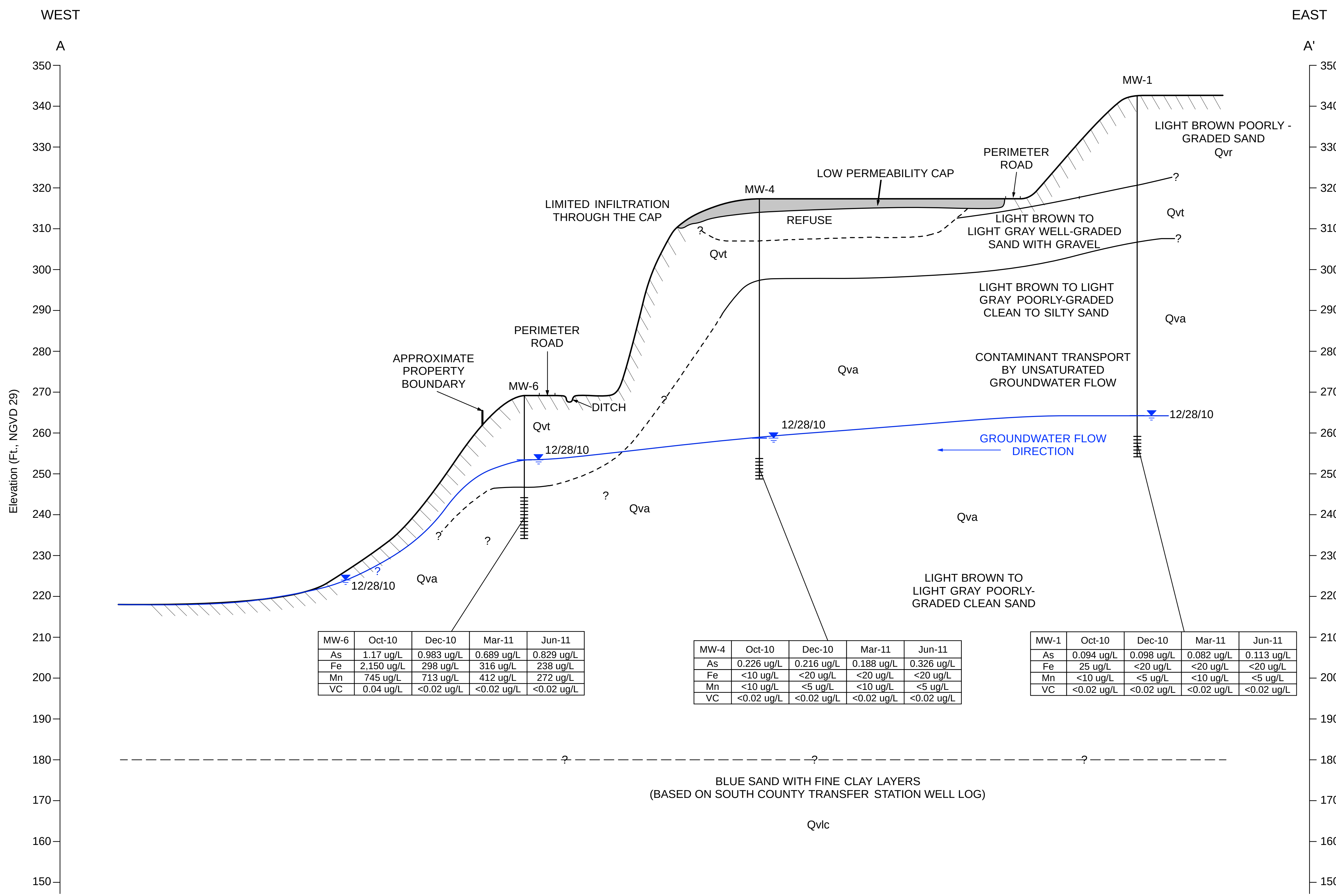
ENVIRONMENTAL PARTNERS INC

FIGURE 5

HYDROGEOLOGIC CROSS SECTION ALIGNMENTS
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	ALW/MMM	DCK	08/25/14



MW-6	Oct-10	Dec-10	Mar-11	Jun-11
As	1.17 ug/L	0.983 ug/L	0.689 ug/L	0.829 ug/L
Fe	2,150 ug/L	298 ug/L	316 ug/L	238 ug/L
Mn	745 ug/L	713 ug/L	412 ug/L	272 ug/L
VC	0.04 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-4	Oct-10	Dec-10	Mar-11	Jun-11
As	0.226 ug/L	0.216 ug/L	0.188 ug/L	0.326 ug/L
Fe	<10 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-1	Oct-10	Dec-10	Mar-11	Jun-11
As	0.094 ug/L	0.098 ug/L	0.082 ug/L	0.113 ug/L
Fe	25 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

KEY:

- GROUND SURFACE
- LITHOLOGIC CONTACT, DASHED WHERE INFERRED.
- MONITORING WELL AND SCREENED INTERVAL
- WATER LEVEL ON 12/28/10

0 50 100 200

SCALE: 1" = 200'

Qvr **Recessional Outwash Deposits -** Stratified sand and gravel moderately well sorted to well sorted; less common silty sand and silt. Exposed primarily on floors of outwash channels that trend south-southwest between flutes molded by glacial flow.

Qvi **Ice-Contact Deposits -** Deposits similar in texture to unit Qvr but locally containing much higher percentage of silt intermixed with granular sediments; also includes lenses and pods of till.

Qvt **Till -** Compact very poorly sorted sediment containing subrounded to well-rounded clasts; glacially transported and deposited. Generally forms undulating surface a few tens of meters thick. Also found sporadically within areas mapped as unit Qvi.

Qva **Advance Outwash Deposits -** Well-bedded sand and gravel; deposited by streams and rivers that issued from front of advancing ice sheet. Generally unoxidized; almost devoid of silt or clay, except near base of unit.

Qvlc **Lawton Clay -** Laminated to massive silt, clayey silt, and silty clay; deposited in proglacial or lowland lakes.

Source: Geologic map of the Olalla 7.5' Quadrangle, King, Kitsap and Pierce Counties, WA. By Derek B. Booth and Kathy Goetz Troost 2005.

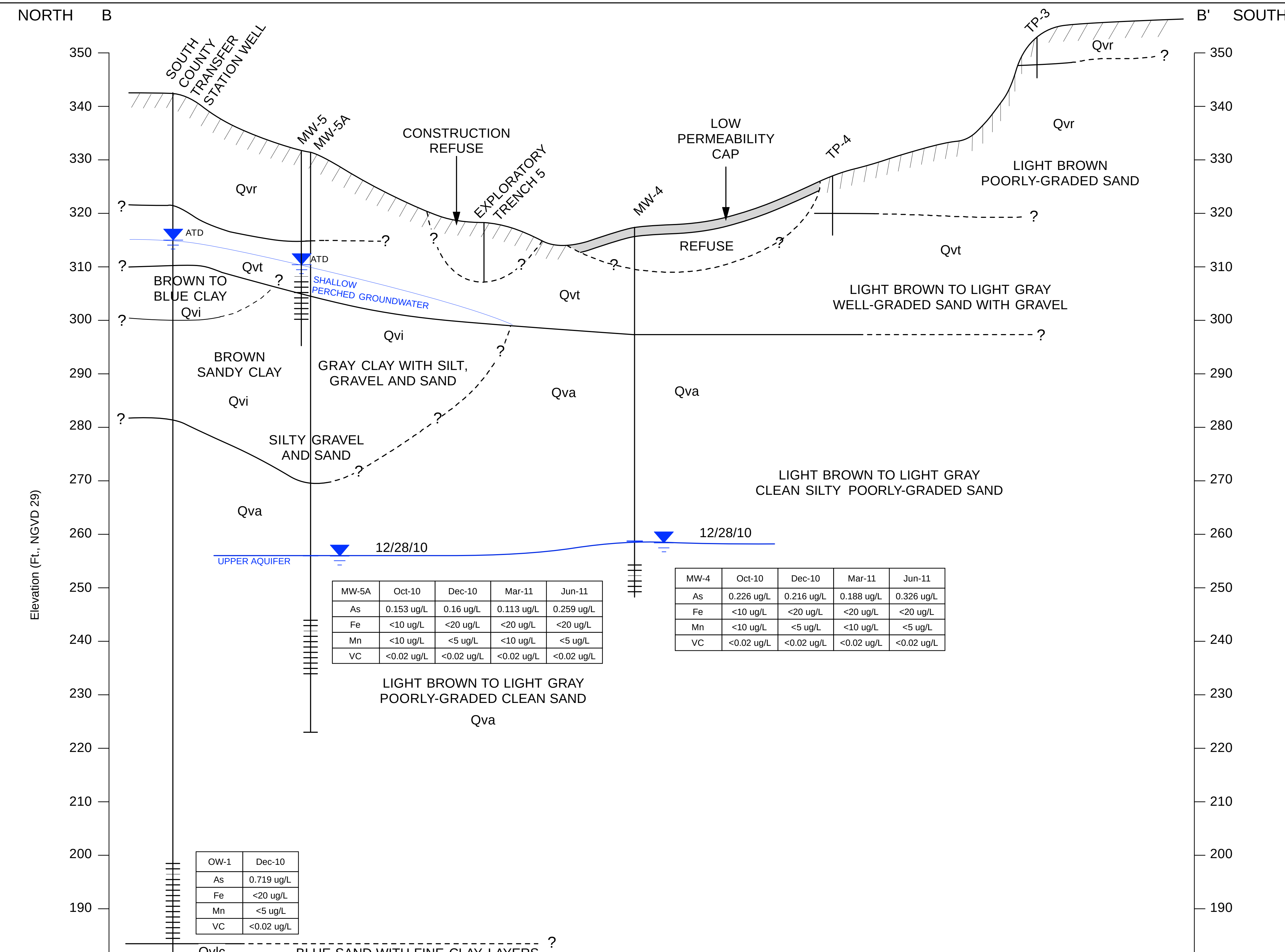
PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	KLA/MMM	DCK	08/25/14

ENVIRONMENTAL PARTNERS INC

FIGURE 6

GEOLOGIC CROSS SECTION A - A'
THROUGH OLALLA LANDFILL
KITSAP COUNTY, WASHINGTON



MW-5A	Oct-10	Dec-10	Mar-11	Jun-11
As	0.153 ug/L	0.16 ug/L	0.113 ug/L	0.259 ug/L
Fe	<10 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-4	Oct-10	Dec-10	Mar-11	Jun-11
As	0.226 ug/L	0.216 ug/L	0.188 ug/L	0.326 ug/L
Fe	<10 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

OW-1	Dec-10
As	0.719 ug/L
Fe	<20 ug/L
Mn	<5 ug/L
VC	<0.02 ug/L

KEY:

- GROUND SURFACE
- LITHOLOGIC CONTACT, DASHED WHERE INFERRED.
- MONITORING WELL AND SCREENED INTERVAL
- WATER LEVEL ON 12/28/10
- ATD AT TIME OF DRILLING
- TP TEST PIT

0 50 100 200

SCALE: 1" = 200'

Qvr **Recessional Outwash Deposits -** Stratified sand and gravel moderately well sorted to well sorted; less common silty sand and silt. Exposed primarily on floors of outwash channels that trend south-southwest between flutes molded by glacial flow.

Qvi **Ice-Contact Deposits -** Deposits similar in texture to unit Qvr but locally containing much higher percentage of silt intermixed with granular sediments; also includes lenses and pods of till.

Qvt **Till -** Compact very poorly sorted sediment containing subrounded to well-rounded clasts; glacially transported and deposited. Generally forms undulating surface a few tens of meters thick. Also found sporadically within areas mapped as unit Qvi.

Qva **Advance Outwash Deposits -** Well-bedded sand and gravel; deposited by streams and rivers that issued from front of advancing ice sheet. Generally unoxidized; almost devoid of silt or clay, except near base of unit.

Qvlc **Lawton Clay -** Laminated to massive silt, clayey silt, and silty clay; deposited in proglacial or lowland lakes.

Source: Geologic map of the Olalla 7.5' Quadrangle, King, Kitsap and Pierce Counties, WA. By Derek B. Booth and Kathy Goetz Troost 2005.

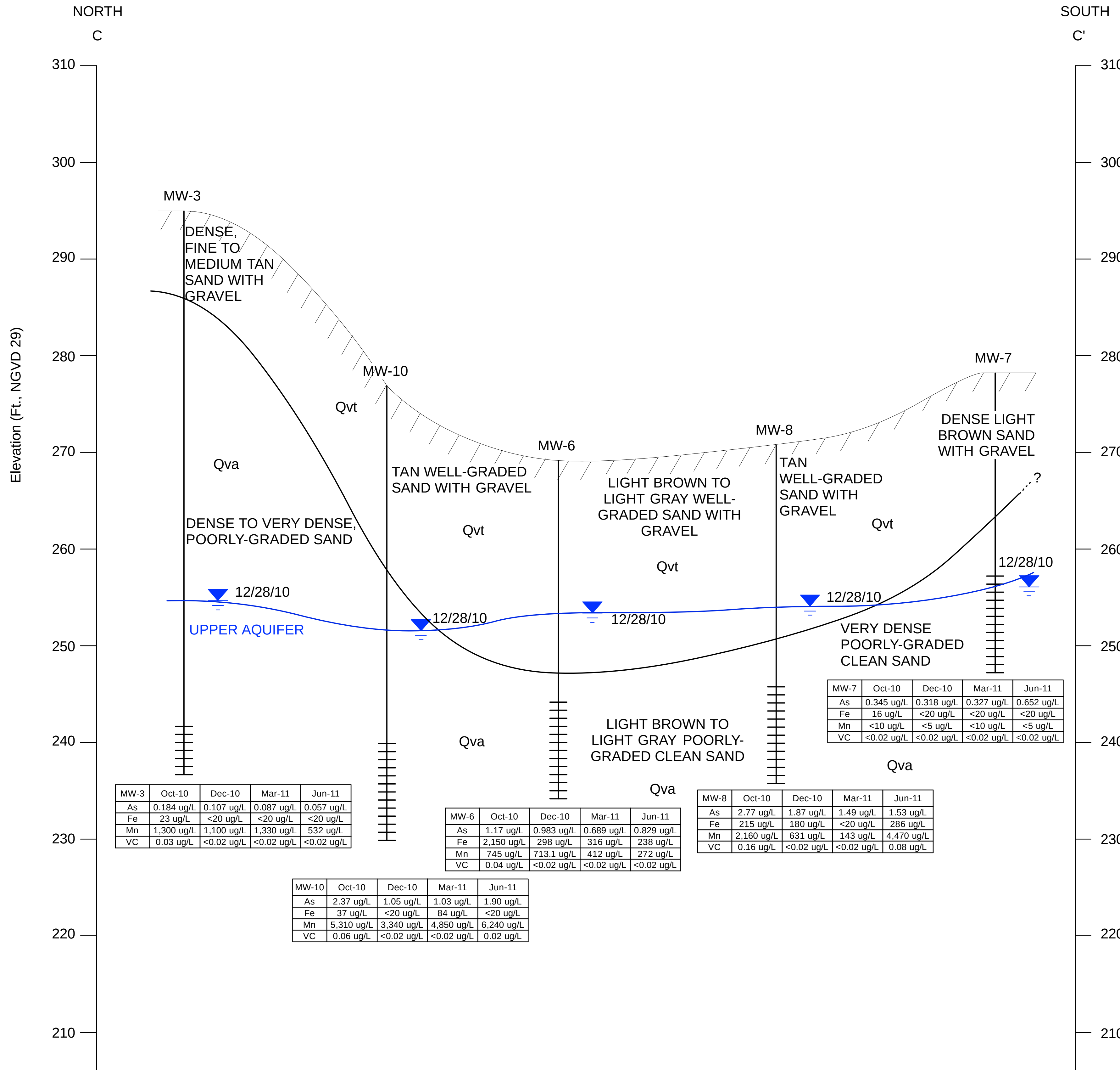
PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	*DRAWN BY*	*REVIEWED BY*	*DATE*
1 of 1	*KLA/MMM*	*DCK*	*08/25/14*

ENVIRONMENTAL PARTNERS INC

FIGURE 7

GEOLOGIC CROSS SECTION B - B'
THROUGH OLALLA LANDFILL
KITSAP COUNTY, WASHINGTON



MW-3	Oct-10	Dec-10	Mar-11	Jun-11
As	0.184 ug/L	0.107 ug/L	0.087 ug/L	0.057 ug/L
Fe	23 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	1,300 ug/L	1,100 ug/L	1,330 ug/L	532 ug/L
VC	0.03 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-10	Oct-10	Dec-10	Mar-11	Jun-11
As	2.37 ug/L	1.05 ug/L	1.03 ug/L	1.90 ug/L
Fe	37 ug/L	<20 ug/L	84 ug/L	<20 ug/L
Mn	5,310 ug/L	3,340 ug/L	4,850 ug/L	6,240 ug/L
VC	0.06 ug/L	<0.02 ug/L	<0.02 ug/L	0.02 ug/L

MW-6	Oct-10	Dec-10	Mar-11	Jun-11
As	1.17 ug/L	0.983 ug/L	0.689 ug/L	0.829 ug/L
Fe	2,150 ug/L	298 ug/L	316 ug/L	238 ug/L
Mn	745 ug/L	713.1 ug/L	412 ug/L	272 ug/L
VC	0.04 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-8	Oct-10	Dec-10	Mar-11	Jun-11
As	2.77 ug/L	1.87 ug/L	1.49 ug/L	1.53 ug/L
Fe	215 ug/L	180 ug/L	<20 ug/L	286 ug/L
Mn	2,160 ug/L	631 ug/L	143 ug/L	4,470 ug/L
VC	0.16 ug/L	<0.02 ug/L	<0.02 ug/L	0.08 ug/L

MW-7	Oct-10	Dec-10	Mar-11	Jun-11
As	0.345 ug/L	0.318 ug/L	0.327 ug/L	0.652 ug/L
Fe	16 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

KEY:

- GROUND SURFACE
- LITHOLOGIC CONTACT, DASHED WHERE INFERRED.
- MONITORING WELL AND SCREENED INTERVAL
- WATER LEVEL ON 12/28/10

0 25 50 100

SCALE: 1" = 100'

Qvr **Recessional Outwash Deposits -** Stratified sand and gravel moderately well sorted to well sorted; less common silty sand and silt. Exposed primarily on floors of outwash channels that trend south-southwest between flutes molded by glacial flow.

Qvi **Ice-Contact Deposits -** Deposits similar in texture to unit Qvr but locally containing much higher percentage of silt intermixed with granular sediments; also includes lenses and pods of till.

Qvt **Till -** Compact very poorly sorted sediment containing subrounded to well-rounded clasts; glacially transported and deposited. Generally forms undulating surface a few tens of meters thick. Also found sporadically within areas mapped as unit Qvi.

Qva **Advance Outwash Deposits -** Well-bedded sand and gravel; deposited by streams and rivers that issued from front of advancing ice sheet. Generally unoxidized; almost devoid of silt or clay, except near base of unit.

Qvlc **Lawton Clay -** Laminated to massive silt, clayey silt, and silty clay; deposited in proglacial or lowland lakes.

Source: Geologic map of the Olalla 7.5' Quadrangle, King, Kitsap and Pierce Counties, WA. By Derek B. Booth and Kathy Goetz Troost 2005.

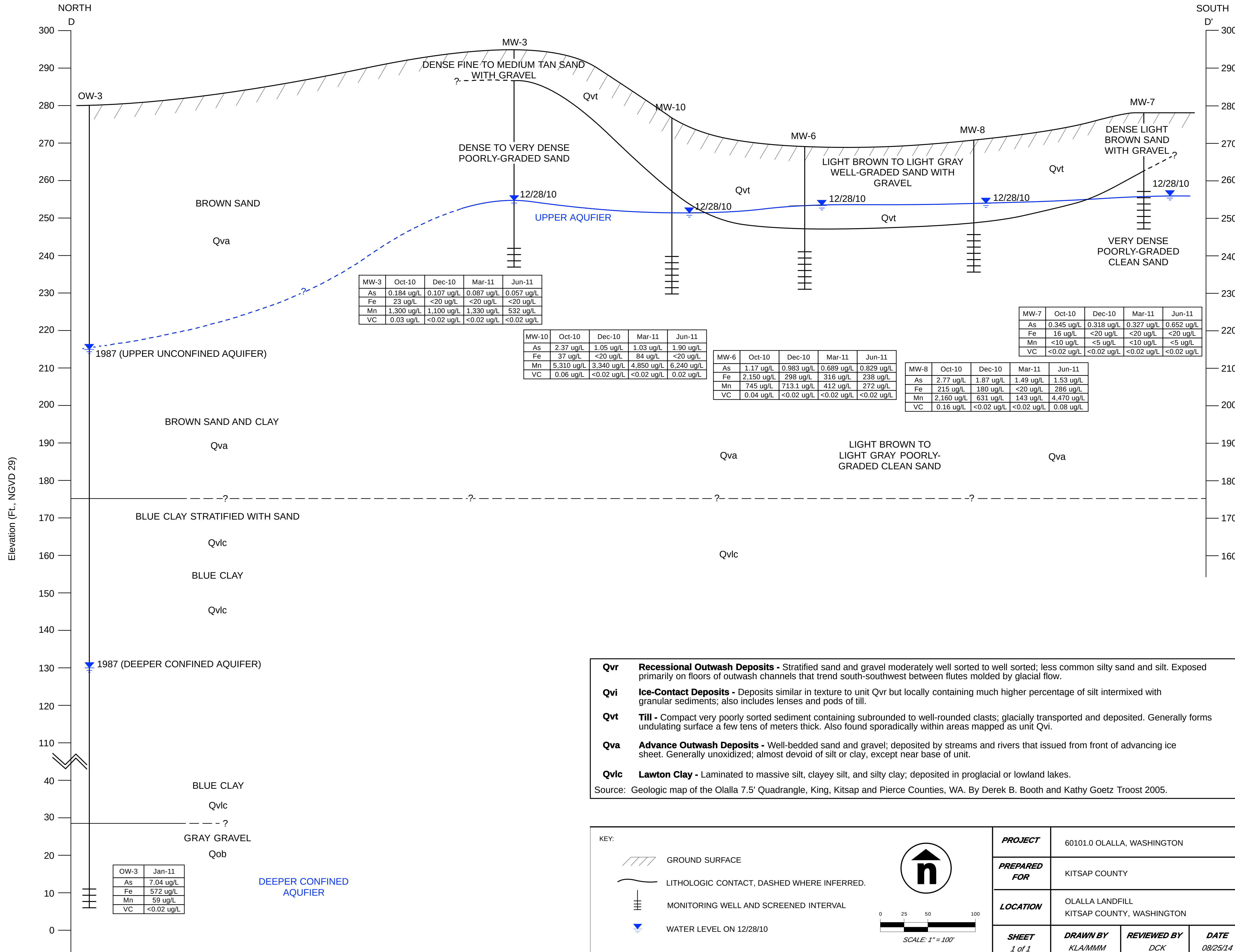
PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	*DRAWN BY*	*REVIEWED BY*	*DATE*
1 of 1	*KLA/MMM*	*DCK*	*08/25/14*

ENVIRONMENTAL PARTNERS INC

FIGURE 8

GEOLOGIC CROSS SECTION C - C'
THROUGH OLALLA LANDFILL
KITSAP COUNTY, WASHINGTON



MW-3	Oct-10	Dec-10	Mar-11	Jun-11
As	0.184 ug/L	0.107 ug/L	0.087 ug/L	0.057 ug/L
Fe	23 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	1,300 ug/L	1,100 ug/L	1,330 ug/L	532 ug/L
VC	0.03 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-10	Oct-10	Dec-10	Mar-11	Jun-11
As	2.37 ug/L	1.05 ug/L	1.03 ug/L	1.90 ug/L
Fe	37 ug/L	<20 ug/L	84 ug/L	<20 ug/L
Mn	5,310 ug/L	3,340 ug/L	4,850 ug/L	6,240 ug/L
VC	0.06 ug/L	<0.02 ug/L	<0.02 ug/L	0.02 ug/L

MW-6	Oct-10	Dec-10	Mar-11	Jun-11
As	1.17 ug/L	0.983 ug/L	0.689 ug/L	0.829 ug/L
Fe	2,150 ug/L	298 ug/L	316 ug/L	238 ug/L
Mn	745 ug/L	713.1 ug/L	412 ug/L	272 ug/L
VC	0.04 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-8	Oct-10	Dec-10	Mar-11	Jun-11
As	2.77 ug/L	1.87 ug/L	1.49 ug/L	1.53 ug/L
Fe	215 ug/L	180 ug/L	<20 ug/L	286 ug/L
Mn	2,160 ug/L	631 ug/L	143 ug/L	4,470 ug/L
VC	0.16 ug/L	<0.02 ug/L	<0.02 ug/L	0.08 ug/L

MW-7	Oct-10	Dec-10	Mar-11	Jun-11
As	0.345 ug/L	0.318 ug/L	0.327 ug/L	0.652 ug/L
Fe	16 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

OW-3	Jan-11
As	7.04 ug/L
Fe	572 ug/L
Mn	59 ug/L
VC	<0.02 ug/L

Qvr **Recessional Outwash Deposits -** Stratified sand and gravel moderately well sorted to well sorted; less common silty sand and silt. Exposed primarily on floors of outwash channels that trend south-southwest between flutes molded by glacial flow.

Qvi **Ice-Contact Deposits -** Deposits similar in texture to unit Qvr but locally containing much higher percentage of silt intermixed with granular sediments; also includes lenses and pods of till.

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Qva **Advance Outwash Deposits -** Well-bedded sand and gravel; deposited by streams and rivers that issued from front of advancing ice sheet. Generally unoxidized; almost devoid of silt or clay, except near base of unit.

Qvlc **Lawton Clay -** Laminated to massive silt, clayey silt, and silty clay; deposited in proglacial or lowland lakes.

Source: Geologic map of the Olalla 7.5' Quadrangle, King, Kitsap and Pierce Counties, WA. By Derek B. Booth and Kathy Goetz Troost 2005.

KEY:

- GROUND SURFACE
- LITHOLOGIC CONTACT, DASHED WHERE INFERRED.
- MONITORING WELL AND SCREENED INTERVAL
- WATER LEVEL ON 12/28/10

0 25 50 100

SCALE: 1" = 100'

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	KLA/MMM	DCK	08/25/14

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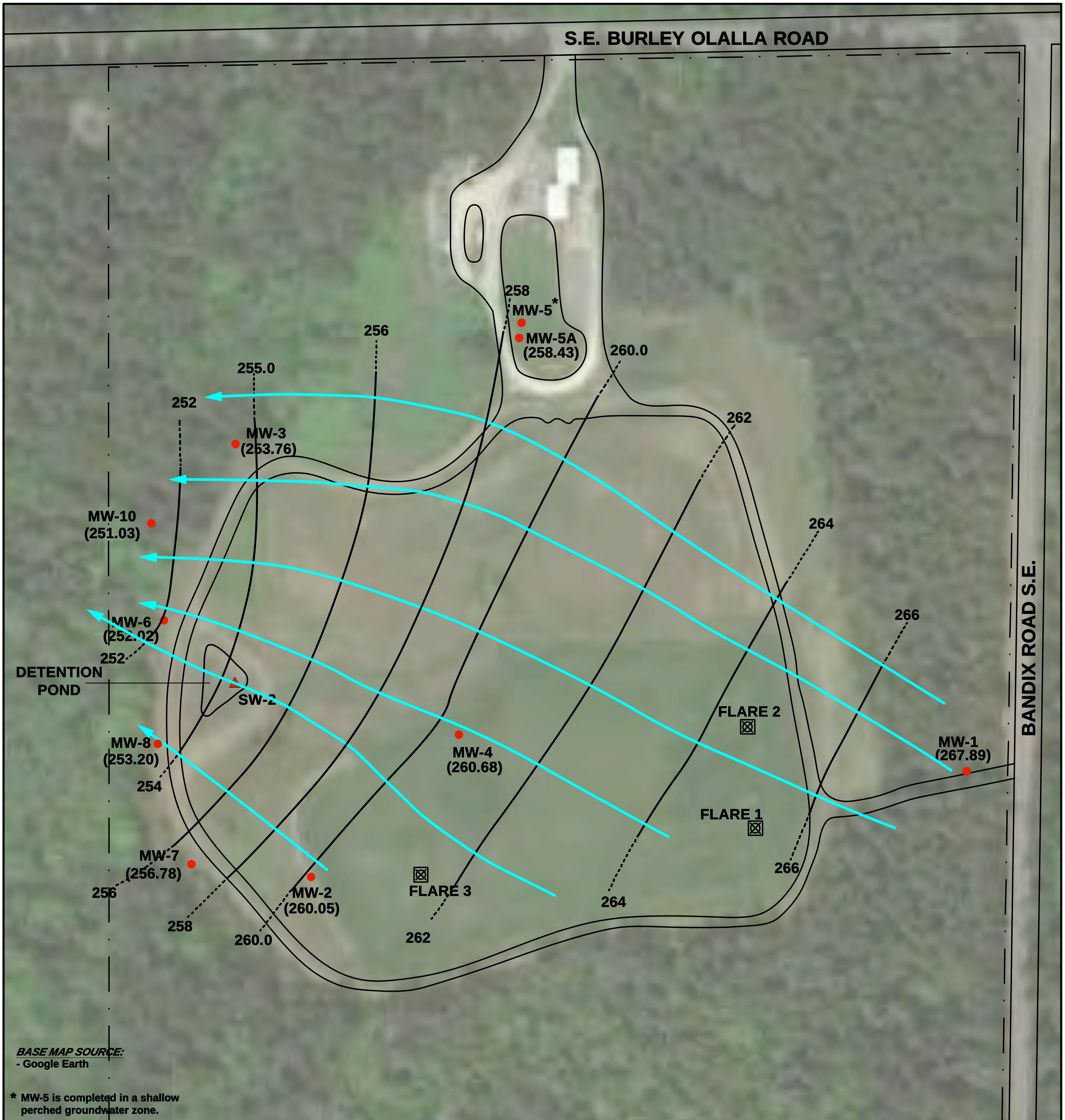
FIGURE 9

GEOLOGIC CROSS SECTION D - D'
THROUGH OLALLA LANDFILL
KITSAP COUNTY, WASHINGTON



KEY:
- : GROUNDWATER ELEVATION CONTOUR
- : INFERRED GROUNDWATER FLOW PATH
- : APPROXIMATE PROPERTY BOUNDARY
- : PERIMETER ACCESS ROAD
- MW-2 : MONITORING WELL
- SW-2 : SURFACE WATER SAMPLING LOCATION
- : LANDFILL GAS FLARE

N

0 50 100 200

SCALE: 1" = 200'

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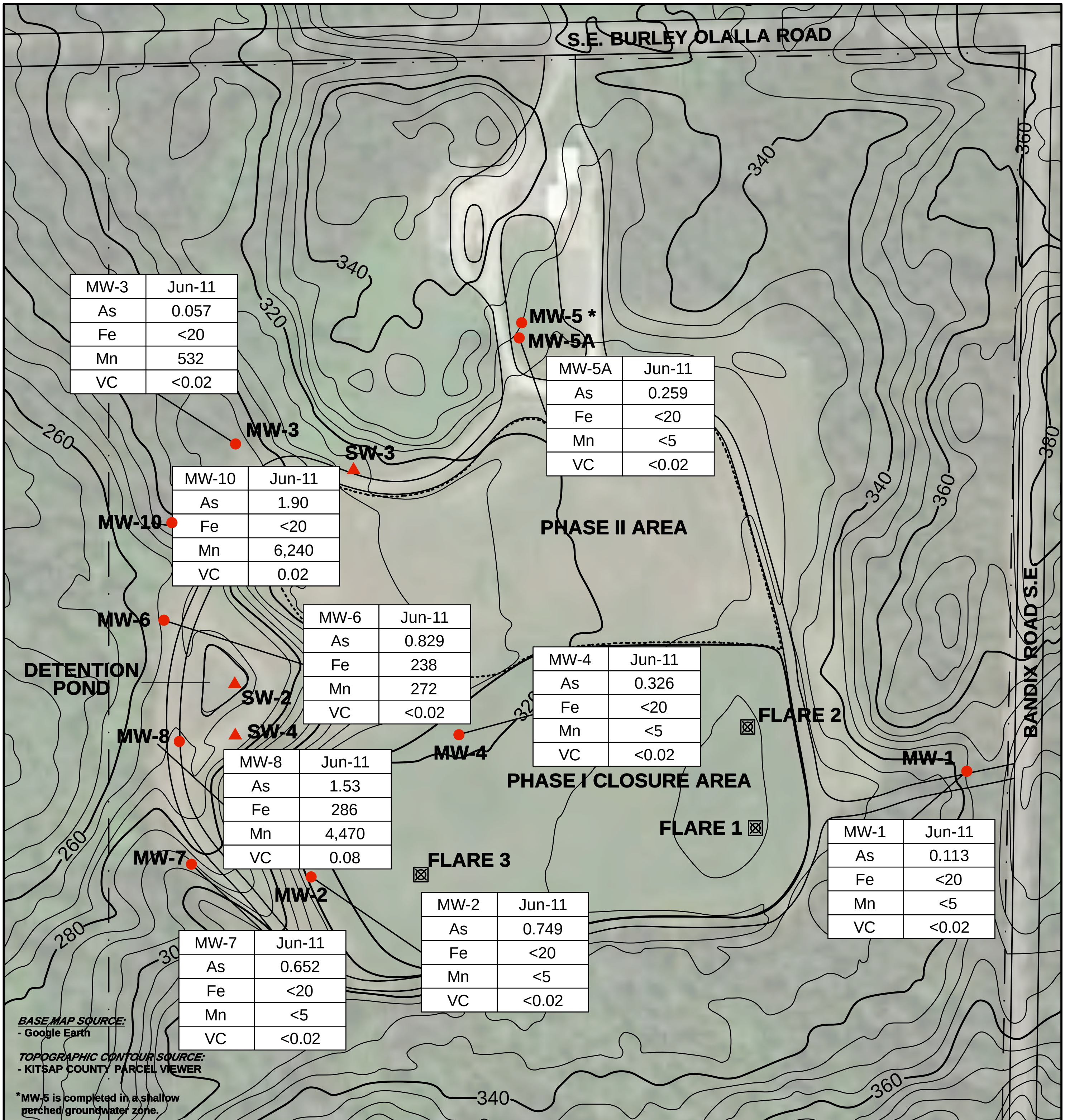
FIGURE 10

OLALLA LANDFILL GROUNDWATER ELEVATION CONTOUR MAP
JUNE 1 AND 2, 2011
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	ALW/MMM	DCK	08/25/14



MW-3	Jun-11
As	0.057
Fe	<20
Mn	532
VC	<0.02

MW-5A	Jun-11
As	0.259
Fe	<20
Mn	<5
VC	<0.02

MW-10	Jun-11
As	1.90
Fe	<20
Mn	6,240
VC	0.02

MW-6	Jun-11
As	0.829
Fe	238
Mn	272
VC	<0.02

MW-4	Jun-11
As	0.326
Fe	<20
Mn	<5
VC	<0.02

MW-8	Jun-11
As	1.53
Fe	286
Mn	4,470
VC	0.08

MW-1	Jun-11
As	0.113
Fe	<20
Mn	<5
VC	<0.02

MW-2	Jun-11
As	0.749
Fe	<20
Mn	<5
VC	<0.02

MW-7	Jun-11
As	0.652
Fe	<20
Mn	<5
VC	<0.02

KEY:

— · —: APPROXIMATE PROPERTY BOUNDARY
: PERIMETER ACCESS ROAD
MW-2 ●: MONITORING WELL
SW-2 ▲: SURFACE WATER SAMPLING LOCATION
300: TOPOGRAPHIC ELEVATION CONTOURS
⊠: LANDFILL GAS FLARE

N

0 50 100 200

SCALE: 1" = 200'

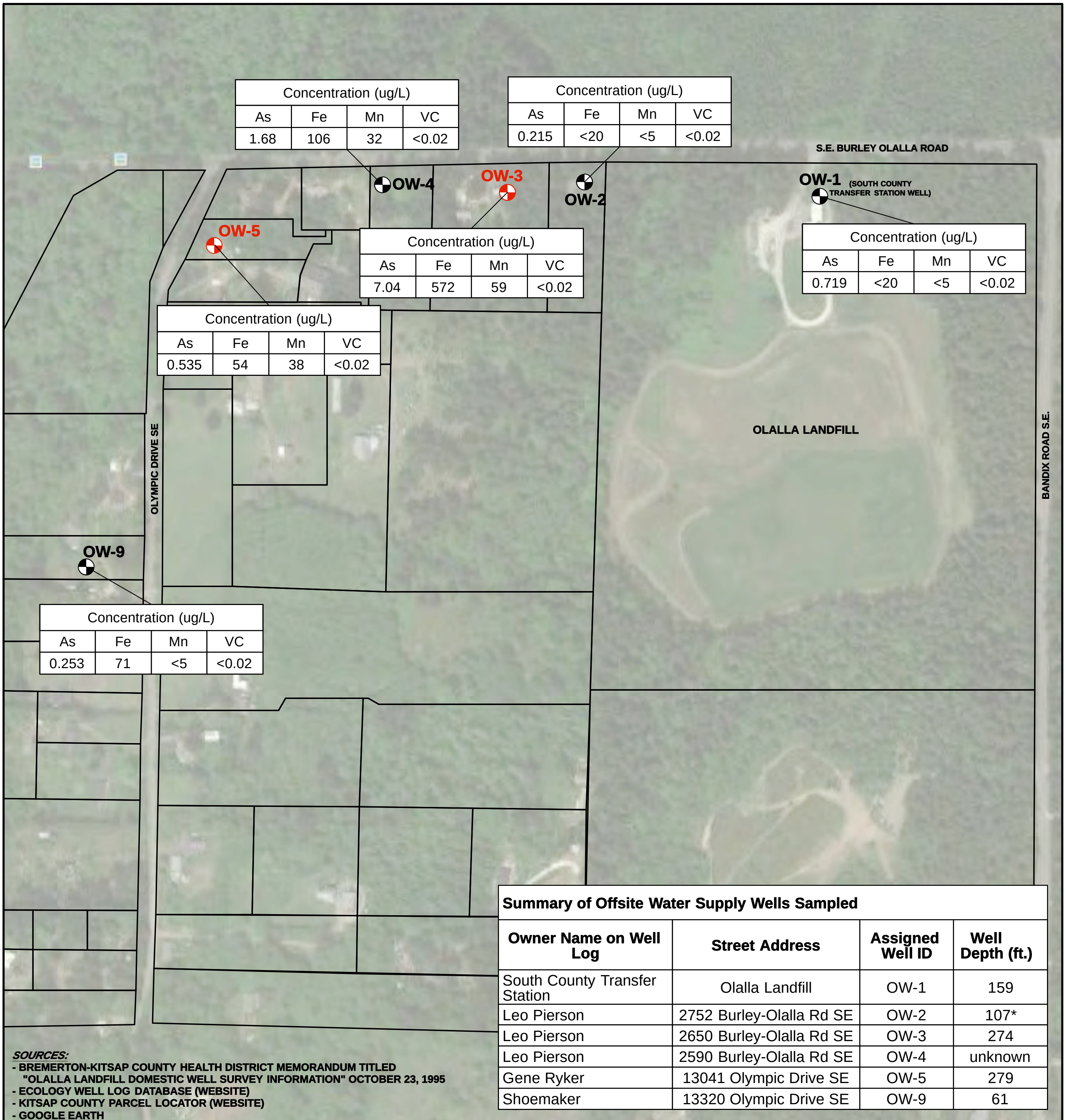
ENVIRONMENTAL PARTNERS INC

FIGURE 11

JUNE 2011 MONITORING WELL
ANALYTICAL RESULTS IN µg/L

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	MMM	DCK	08/25/14



OW-4

Concentration (ug/L)			
As	Fe	Mn	VC
1.68	106	32	<0.02

OW-2

Concentration (ug/L)			
As	Fe	Mn	VC
0.215	<20	<5	<0.02

OW-3

Concentration (ug/L)			
As	Fe	Mn	VC
7.04	572	59	<0.02

OW-1

Concentration (ug/L)			
As	Fe	Mn	VC
0.719	<20	<5	<0.02

OW-5

Concentration (ug/L)			
As	Fe	Mn	VC
0.535	54	38	<0.02

OW-9

Concentration (ug/L)			
As	Fe	Mn	VC
0.253	71	<5	<0.02

Summary of Offsite Water Supply Wells Sampled

Owner Name on Well Log	Street Address	Assigned Well ID	Well Depth (ft.)
South County Transfer Station	Olalla Landfill	OW-1	159
Leo Pierson	2752 Burley-Olalla Rd SE	OW-2	107*
Leo Pierson	2650 Burley-Olalla Rd SE	OW-3	274
Leo Pierson	2590 Burley-Olalla Rd SE	OW-4	unknown
Gene Ryker	13041 Olympic Drive SE	OW-5	279
Shoemaker	13320 Olympic Drive SE	OW-9	61

SOURCES:
- BREMERTON-KITSAP COUNTY HEALTH DISTRICT MEMORANDUM TITLED "OLALLA LANDFILL DOMESTIC WELL SURVEY INFORMATION" OCTOBER 23, 1995
- ECOLOGY WELL LOG DATABASE (WEBSITE)
- KITSAP COUNTY PARCEL LOCATOR (WEBSITE)
- GOOGLE EARTH

KEY:

* Well information provided by owner. Well log not available in KCHD records or Ecology Well Log database.

- : OFFSITE WELL LOCATION (UPPER AQUIFER)
- : OFFSITE WELL LOCATION (DEEPER AQUIFER)
- ———— : PARCEL BOUNDARY

N

0 100 200 400

SCALE: 1" = 400'

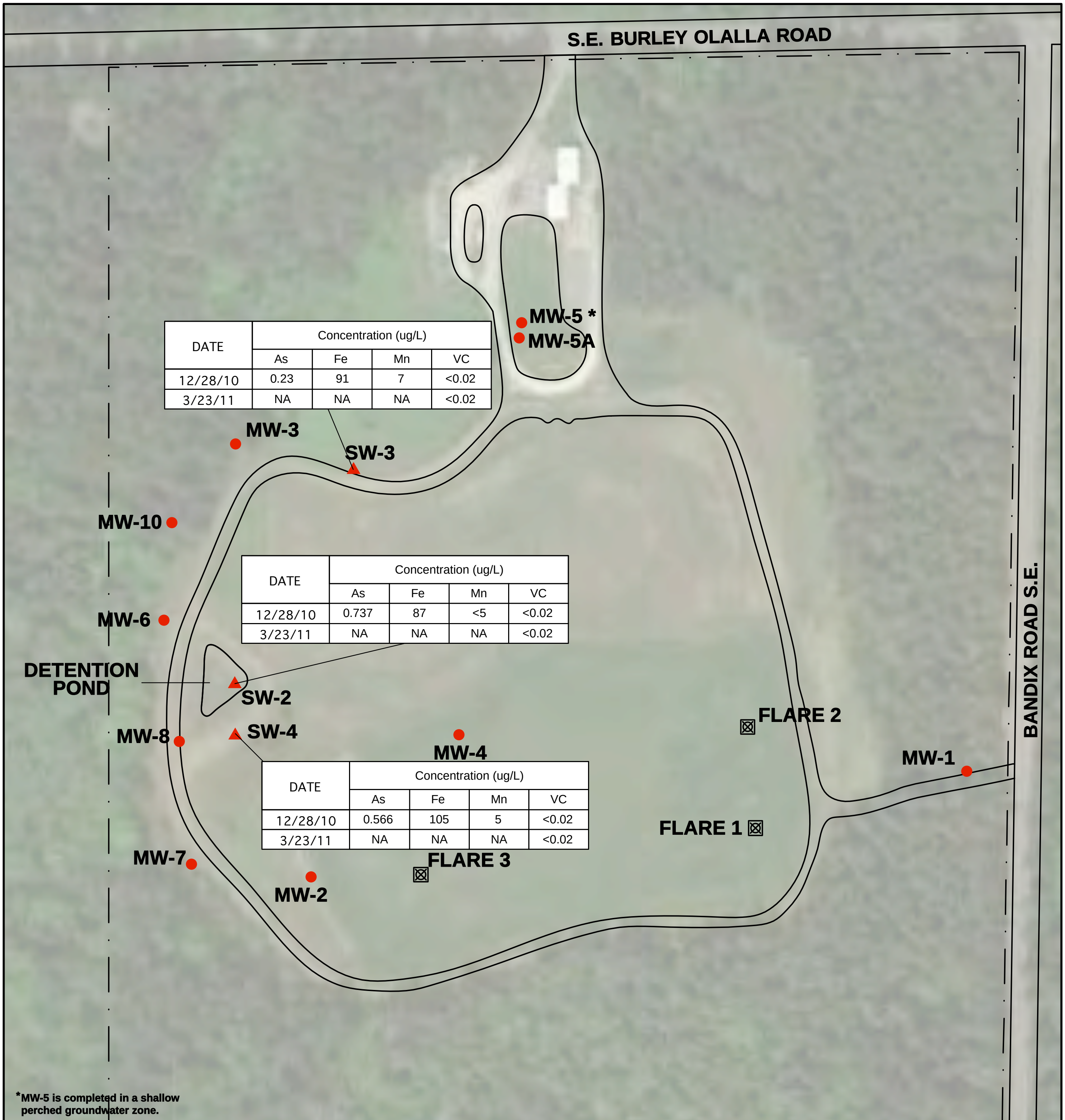
ENVIRONMENTAL PARTNERS INC

FIGURE 12

WATER SUPPLY WELL
LOCATIONS WITH ANALYTICAL RESULTS
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL RI/FS KITSAP COUNTY, WASHINGTON

SHEET	***DRAWN BY***	***REVIEWED BY***	***DATE***
1 of 1	*ARM/MMM*	*DCK*	*08/25/14*



DATE	Concentration (ug/L)			
	As	Fe	Mn	VC
12/28/10	0.23	91	7	<0.02
3/23/11	NA	NA	NA	<0.02

DATE	Concentration (ug/L)			
	As	Fe	Mn	VC
12/28/10	0.737	87	<5	<0.02
3/23/11	NA	NA	NA	<0.02

DATE	Concentration (ug/L)			
	As	Fe	Mn	VC
12/28/10	0.566	105	5	<0.02
3/23/11	NA	NA	NA	<0.02

KEY:

- : APPROXIMATE PROPERTY BOUNDARY
- : PERIMETER ACCESS ROAD
- MW-2 : MONITORING WELL
- SW-2 : SURFACE WATER SAMPLING LOCATION
- : LANDFILL GAS FLARE
- NA: NOT ANALYZED

N

0 50 100 200

SCALE: 1" = 200'

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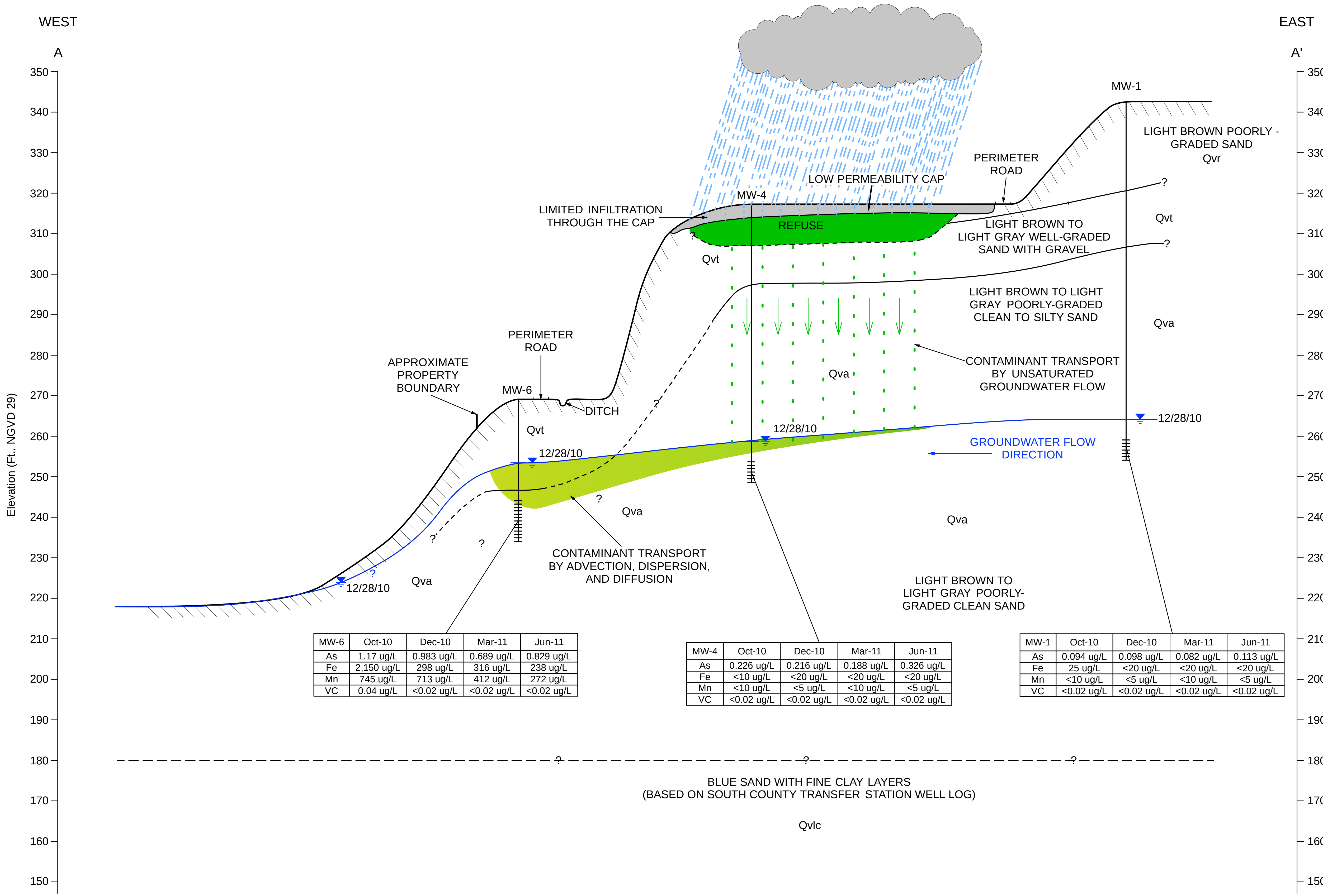
FIGURE 13

SURFACE WATER SAMPLE LOCATIONS
WITH ANALYTICAL RESULTS
KITSAP COUNTY, WASHINGTON

PROJECT	60101.0 OLALLA, WASHINGTON
PREPARED FOR	KITSAP COUNTY
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	ALW/MMM	DCK	08/25/14



MW-6	Oct-10	Dec-10	Mar-11	Jun-11
As	1.17 ug/L	0.983 ug/L	0.689 ug/L	0.829 ug/L
Fe	2,150 ug/L	298 ug/L	316 ug/L	238 ug/L
Mn	745 ug/L	713 ug/L	412 ug/L	272 ug/L
VC	0.04 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-4	Oct-10	Dec-10	Mar-11	Jun-11
As	0.226 ug/L	0.216 ug/L	0.188 ug/L	0.326 ug/L
Fe	<10 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

MW-1	Oct-10	Dec-10	Mar-11	Jun-11
As	0.094 ug/L	0.098 ug/L	0.082 ug/L	0.113 ug/L
Fe	25 ug/L	<20 ug/L	<20 ug/L	<20 ug/L
Mn	<10 ug/L	<5 ug/L	<10 ug/L	<5 ug/L
VC	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L	<0.02 ug/L

KEY:

GROUND SURFACE

LITHOLOGIC CONTACT, DASHED WHERE INFERRED.

MONITORING WELL AND SCREENED INTERVAL

WATER LEVEL ON 12/28/10

0 50 100 200

SCALE: 1" = 200'

Qvr **Recessional Outwash Deposits -** Stratified sand and gravel moderately well sorted to well sorted; less common silty sand and silt. Exposed primarily on floors of outwash channels that trend south-southwest between flutes molded by glacial flow.

Qvi **Ice-Contact Deposits -** Deposits similar in texture to unit Qvr but locally containing much higher percentage of silt intermixed with granular sediments; also includes lenses and pods of till.

Qvt **Till -** Compact very poorly sorted sediment containing subrounded to well-rounded clasts; glacially transported and deposited. Generally forms undulating surface a few tens of meters thick. Also found sporadically within areas mapped as unit Qvi.

Qva **Advance Outwash Deposits -** Well-bedded sand and gravel; deposited by streams and rivers that issued from front of advancing ice sheet. Generally unoxidized; almost devoid of silt or clay, except near base of unit.

Qvlc **Lawton Clay -** Laminated to massive silt, clayey silt, and silty clay; deposited in proglacial or lowland lakes.

Source: Geologic map of the Olalla 7.5' Quadrangle, King, Kitsap and Pierce Counties, WA. By Derek B. Booth and Kathy Goetz Troost 2005.

PROJECT	60101.0 OLALLA, WASHINGTON		
PREPARED FOR	KITSAP COUNTY		
LOCATION	OLALLA LANDFILL KITSAP COUNTY, WASHINGTON		
SHEET 1 of 1	**DRAWN BY** ALW/MMM	**REVIEWED BY** DCK	**DATE** 08/25/14

ENVIRONMENTAL PARTNERS INC

FIGURE 14

CONCEPTUAL MODEL OF CONTAMINANT TRANSPORT THROUGH OLALLA LANDFILL
KITSAP COUNTY, WASHINGTON

Parametrix DATE: August 26, 2014 FILE: PU1578121-F01-1

Figure 15
Alternative 2
Ollala Landfill
Kitsap County

Parametrix DATE: August 26, 2014 FILE: PU1578121-F01-1

N

0 200
SCALE IN FEET

LEGEND

△ AIR SPARGE WELLS

⦿ INJECTION WELLS

Figure 16
Alternative 3
Ollala Landfill
Kitsap County

Tables

Table 1. Olalla Landfill RI/FS Groundwater Screening Level Summary

Landfill-Specific COC	WA State Drinking Water Standard	WA State Groundwater Standard	MTCA Method A	MTCA Method B, Carcinogenic	MTCA Method B, Non-Carcinogenic
Arsenic	10 μg/L	0.05 μg/L	5.0 μg/L	0.058 μg/L	4.8 μg/L
Iron	300 μg/L[a]	300 μg/L[a]	NA	NA	11,000 μg/L
Manganese	50 μg/L[a]	50 μg/L[a]	NA	NA	2,200 μg/L
Vinyl Chloride	2.0 μg/L	0.02 μg/L	0.2 μg/L	0.029 μg/L	240 μg/L

[a] Secondary standard.

NA = Not Applicable

Table 2. Summary of Remedial Investigation COC Data

Well	Sample Date	COC Concentrations in μg/L			
		Arsenic	**Iron**	**Manganese**	**Vinyl Chloride**
	Cleanup Levels	**1.29**	**300**	**50**	**0.29**
MW-1	October 28, 2010	0.094	25	10 U	0.02 U
	December 28, 2010	0.098	20 U	5 U	0.02 U
	March 23, 2011	0.082	20 U	10 U	0.02 U
	June 1, 2011	0.113	20 U	5 U	0.02 U
MW-2	October 28, 2010	0.687	10 U	10 U	0.02 U
	December 28, 2010	0.652	20 U	5 U	0.02 U
	March 23, 2011	0.517	20 U	10 U	0.02 U
	June 1, 2011	0.749	20 U	5 U	0.02 U
MW-3	October 28, 2010	0.184	23	1,300	0.03
	December 28, 2010	0.107	20 U	1,100	0.02 U
	March 23, 2011	0.087	20 U	1,330	0.02 U
	June 1, 2011	0.057	20 U	532	0.02 U
MW-4	October 28, 2010	0.226	10 U	10 U	0.02 U
	December 28, 2010	0.216	20 U	5 U	0.02 U
	March 23, 2011	0.188	20U	10 U	0.02 U
	June 1, 2011	0.326	20 U	5 U	0.02 U
MW-5A	October 28, 2010	0.153	10 U	10 U	0.02 U
	December 28, 2010	0.160	20 U	5 U	0.02 U
	March 23, 2011	0.113	20 U	10 U	0.02 U
	June 1, 2011	0.259	20 U	5 U	0.02 U
MW-6	October 28, 2010	1.17	2,150	745	0.04
	December 28, 2010	0.983	298	713	0.02 U
	March 23, 2011	0.689	316	412	0.02 U
	June 1, 2011	0.829	238	272	0.02 U
MW-7	October 28, 2010	0.345	16	10 U	0.02 U
	December 28, 2010	0.318	20 U	5 U	0.02 U
	March 23, 2011	0.327	20 U	10 U	0.02 U
	June 1, 2011	0.652	20 U	5 U	0.02 U
MW-8	October 28, 2010	2.77	215	2,160	0.16
	December 28, 2010	1.87	180	631	0.02 U
	March 23, 2011	1.49	20 U	143	0.02 U
	June 1, 2011	1.53	286	4,470	0.08
MW-10	October 28, 2010	2.37	37	5,310	0.06
	December 28, 2010	1.05	20 U	3,340	0.02 U
	March 23, 2011	1.03	84	4,850	0.02 U
	June 1, 2011	1.90	20 U	6,240	0.02

Notes: U = Indicates compound was analyzed for, but not detected, at the specified detection limit.
COC = Constituents of Concern

Table 3. Applicable or Relevant and Appropriate Requirements (ARARs)

Soil	
	Model Toxics Control Act (WAC 173-340-740, -747)
Groundwater	
	EPA Underground Injection Control Regulations (40 Code of Federal Regulations [CFR] 144 and 146)
	Safe Drinking Water Act, Primary Drinking Water Regulations (40 CFR 141)
	Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200)
	Model Toxics Control Act (WAC 173-340-720)
	State Water Code and Water Rights (WAC 173-150 & 154)
Surface Water	
	Clean Water Act Section 304 – Federal Ambient Water Quality (National Recommended Water Quality Criteria, November 2002) (EPA-822-R-02-047)
	Clean Water Act, National Pollutant Discharge Elimination System (40 CFR Part 122-125) and Washington State National Pollutant Discharge Elimination System Permit Program (Chapter 173-220 WAC).
	Clean Water Act's National Toxics Rule (NTR) (40 CFR 131.36)
	Stormwater Permit Program (40 CFR 122.26)
	Stormwater Management (Chapter 173-220 WAC)
	Washington State Water Quality Standards for Surface Waters (Chapter 173-201A WAC)
	Model Toxics Control Act (WAC 173-340-730)
Air	
	National Ambient Air Quality Standards (40 CFR 50.6, 50.12)
	National Emission Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 261)
	Model Toxics Control Act (WAC 173-340-750)

(Table Continues)

Table 3. Applicable or Relevant and Appropriate Requirements (ARARs) (Continued)

Miscellaneous
Endangered Species Act (50 CFR Parts 17, 402)
Native American Graves Protection and Repatriation Act (43 CFR Part 10)
National Historic Preservation Act (36 CFR Parts 60, 63, and 800)
State Environmental Policy Act (SEPA) (Chapter 197-11 WAC)
Resource Conservation and Recovery Act (RCRA) – Identification and Listing of Hazardous Waste (40 CFR Part 261-265, 270, and 271)
RCRA Land Disposal Restrictions (40 CFR 268)
RCRA Subtitle D Nonhazardous Waste Management Standards (40 CFR 257)
Washington Hazardous Waste Management Act (Chapter 173-303 WAC)
Department of Transportation of Hazardous Materials (49 CFR 105 – 180)
Washington Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC)
Washington Solid Waste Handling Standards (Chapter 173-350 WAC)
Washington Water Well Construction Act Regulations (Chapter 173-160 WAC)
Kitsap County Board of Health Ordinance 2010-1 – Solid Waste Regulations
Kitsap County Municipal Code (Title 12 – Storm Water Drainage)
Kitsap County Municipal Code (Title 13 – Water and Sewers)
Kitsap County Municipal Code (Title 14 – Building and Construction)
Kitsap County Municipal Code (Title 18 – Environment)

Table 4. Cleanup Levels

			MTCA B Groundwater		Groundwater ARARs				Downward-Adjusted ARARs					
Chemical	**CAS #**	**Units**	**Non-Cancer SFV**	**Cancer SFV**	**Federal Primary MCL**	**Federal MCL Goal**	**State Primary MCL**	**State Secondary MCL**	**Adjusted Minimum MCL**	**Hazard Quotient**	**Excess Cancer Risk**	**Standard**	**Background**	**Cleanup Level**
Arsenic, total	7440-38-2	µg/L	4.8	0.058	10	0	10	*NA*	0.58	0.121	1.00E-05	0.58	1.29	1.29
Iron, total	7439-89-6	µg/L	11,000	NR	NR	NR	NR	300	300	0.027	---	300	40	300
Manganese, total	7439-96-5	µg/L	2,200	NR	NR	NR	NR	50	50	0.023	---	50	10	50
Vinyl Chloride	75-01-4	µg/L	24	0.029	2	0	2	NA	0.29	0.012	1.00E-05	0.29	0	0.29

ARAR = Applicable or Relevant and Appropriate Requirement.

Downward-adjusted ARARs (WAC 173-340-705 (2)):

Hazard Quotient (HQ) = Hazard Quotient for Adjusted Minimum MCL based on applicable MTCA B Groundwater non-cancer SFV. If HQ > 1 for the MCL, then the MCL was adjusted downward so that HQ ≤ 1.

Excess Cancer Risk = Cancer risk for Adjusted Minimum MCL based on applicable MTCA B Groundwater cancer SFV. If greater than $1x10^{-5}$ for the MCL, then MCL was adjusted downward so that CR ≤ $1x10^{-5}$.

MCL downward-adjusted so that Hazard Quotient ≤ 1 and Excess Cancer Risk ≤ $1x10^{-5}$.

Standard = Downward-adjusted ARAR or, if no ARARs, minimum of MTCA B groundwater cancer and non-cancer standard formula values (SFVs).

MCL = Maximum Contaminant Level.

NA = Not Applicable.

NR = Not Researched (CLARC Database).

SFV = Standard Formula Value (CLARC Database).

Table 5. Alternative Scoring Matrix

Permanent Solutions Criteria	Alternative 1	Alternative 2	Alternative 3
Protectiveness	1	2	3
Reduction of toxicity, mobility, and volume	1	2	3
Long-term effectiveness	1	2	3
Short-term risks	3	2	1
Implementability	3	2	1
Public concerns	2	3	1
Permanent Solutions Criteria Score:	**11**	**13**	**12**

Table 6. Summary of Remedial Alternatives Estimated Costs

	Remedial Alternatives		
	1. MNA and Land Use Controls	**2. Low Permeability Geomembrane Cap with MNA and Land Use Controls**	**3. In-Situ Physical/Chemical Treatment: Air Sparging and Complexation**
Capital Costs	$0	$1,912,456	$986,475
Operation and Maintenance (O&M) Costs	$2,725,393	$2,566,129	$4,672,556
Total Costs:	**$2,725,393**	**$4,478,585**	**$5,659,031**

Appendix A

Key Elements of the Compliance Monitoring Plan

APPENDIX A
KEY ELEMENTS OF THE COMPLIANCE MONITORING PLAN

As described in this Draft Cleanup Action Plan, compliance monitoring will be performed as part of ongoing post-closure groundwater monitoring under the Landfill's current Solid Waste Handling Permit (SWHP). Monitoring will be performed in accordance with the Landfill's Quality Assurance Project Plan under the SWHP (EPI 2013). The following key elements of the compliance monitoring for the selected cleanup action (Monitored Natural Attenuation and Land Use Controls) are included as follows for monitoring of groundwater and surface water:

- Monitoring locations,
- Monitoring frequency, and
- Monitoring parameters.

Monitoring locations and frequency are described in Table A-l and monitoring parameters are listed in Table A-2. Monitoring locations are shown on Figure 2 of the DCAP.

Monitoring locations and frequency were chosen to provide areal coverage, and to provide the robust data set needed to determine if natural attenuation continues to be an effective remediation strategy. Parameters were chosen based on the list of indicator hazardous substances and on the list of monitoring parameters in Chapter 173-304 WAC an applicable regulation.

All test methods will be sufficient to measure the analyte of interest at the lowest regulated concentration in the matrix of interest.

Table A-1. Compliance Monitoring Network

Station	Function	Frequency	Description
Groundwater Monitoring Wells			
MW-1	Upgradient	Quarterly	Access Road E Side Landfill
MW-3	Downgradient	Quarterly	Adjacent to Landfill
MW-5A	Crossgradient	Annually	Adjacent to Recycling Facility
MW-6	Downgradient	Quarterly	Adjacent to Landfill
MW-7	Crossgradient	Annually	Adjacent to Landfill
MW-8	Downgradient	Quarterly	Adjacent to Landfill
MW-10	Downgradient	Quarterly	Adjacent to Landfill
Surface Water Stations			
SW-2	Downgradient	Annually	Detention Pond

Table A-2. Surface Water and Groundwater Sampling Parameters

Field Parameters – Quarterly (Wells MW-1, MW-3, MW-6, MW-8, & MW-10) and Annually (SW-2):
Groundwater Levels
Oxidation-Reduction Potential (ORP)[a]
Dissolved Oxygen (DO)[a]
pH
Specific Conductance
Temperature
Groundwater Laboratory Parameters – Quarterly (Wells MW-1, MW-3, MW-6, MW-8, & MW-10):
Arsenic (dissolved)
Manganese (dissolved)
Iron (dissolved)
Calcium (total)
Potassium (total)
Sodium (total)
Volatile Organic Compounds (VOCs); 8260 standard list, vinyl chloride by selective ion monitoring (SIM)
Total Coliform
Total Organic Carbon
Chemical Oxygen Demand
Alkalinity
Ammonia
Bicarbonate
Carbonate
Chloride
Nitrate
Nitrite
pH
Sulfate
Groundwater Laboratory Parameters – Annually (Wells MW-5A &MW-7:
Arsenic (dissolved)
Iron (dissolved)
Manganese (dissolved)
pH
Vinyl Chloride (8260 SIM)
Surface Water Laboratory Parameters – Annually (SW-2)
Fecal Coliform
Alkalinity
Ammonia
Bicarbonate
Carbonate
Chloride
Nitrate
Nitrite
pH

[a]Parameters indicative of natural attenuation processes.

Table A-3. Landfill Gas Monitoring

Quarterly (all three passive landfill gas flares):
Methane (% by volume and % lower explosive limit)
Oxygen (% by volume)
CO_2 (% by volume)
Gas Pressure (inches of water)

References

Environmental Partners, Inc. (EPI). 2013. Quality Assurance Program Plan, Post Closure Monitoring Under Minimum Functional Standards for Solid Waste Handling (WAC 173-304-407). Prepared for the Kitsap County Department of Public Works Solid Waste Division. November 22.

Appendix B

Evaluation of Monitoring Data

APPENDIX B

EVALUATION OF MONITORING DATA

1. Statistical Analysis Methods

Groundwater monitoring data from the Olalla Landfill will be evaluated by statistical methods to determine whether the data fall within limits that show progress towards achieving site cleanup levels specified in the Draft Cleanup Action Plan. The procedures outlined below generally employ a weight of evidence approach that considers the following:

1) Time-series plots used to visually identify trends, potential seasonal effects, and compliance with regulatory levels,
2) Statistically derived trend analysis which helps identify downward trends,
3) Statistical analysis for normally of the dataset to determine the appropriate confidence limit comparison, and
4) Confidence limit comparison, which ultimately determines the successful completion of the corrective action.

Statistical analysis will use four tools: time-series plots, Mann-Kendall test for trend, Shapiro-Wilk test for normality, and confidence intervals (parametric and non-parametric). Application of these tools is based on statistical methods identified in the Unified Guidance (EPA 2009). These four statistical tools, along with non-statistical data evaluation tools, are applied to the data following the process shown in Figure 1.

Statistical analyses will be performed on a data set consisting of a moving window of the 20 most recent sampling events (as one new data point is added the oldest data point is dropped). For most wells, this is a five-year moving window of data. However, with MW-5A and MW-7 on an annual sampling schedule SWD has clarified this moving window of data to be defined as 20 sampling events rather than five years of data. The moving window of 20 sampling events provides a sufficient number of data points for adequate statistical power while focusing the statistical evaluations on the most recent and most relevant data. Statistical analyses are performed using the following criteria:

- Statistical tests will not automatically be performed for every constituent or parameter measured. Statistical analysis will not be performed if a constituent has not been detected in the prior five years or does not have a sufficient number of detections to support one or more of the statistical analysis. Data sets that are all non-detects or do not have a sufficient number of detections will be temporarily dropped from the specific statistical evaluations that are not amenable to those data sets.

- Non-detections will be managed by assigning them a uniform value that is less than the reporting limit for that constituent. Recent guidance from the United States Geological Survey (USGS 2008) suggests that censoring values that are less than the detection limit (non-detects) provides more accurate statistical results compared to substituting a value, commonly one half of the reporting limit. The SWD assigns a value of zero to non-detected results as recommended by the USGS and KPHD. J-qualified analytical results are reported as individual detected values as recommended by the USGS guidance.

Chemical Parameters to be Evaluated Statistically

The Contaminants of Concern (COCs) identified for the Landfill (arsenic, iron, manganese, and vinyl chloride) will be evaluated by statistical analysis. In addition to statistical analysis of the Landfill COCs, the water quality parameters dissolved oxygen (DO) and oxidation reduction potential (ORP) will be evaluated by time series plots and Mann-Kendall Trend statistical analyses only. The time series graphs and the Mann-Kendall statistical analysis for trend for DO and ORP will be evaluated to serve as indicators of favorable geochemical conditions for natural attenuation. The statistical analysis methods to be used are described below.

Time–Series Plots (Quarterly/Annually)

Time-series plots will be used to compare field measurements or analytical results from a well or a set of wells over time. The plots provide a convenient graphical means of delineating seasonal trends and large differences in concentration between upgradient and downgradient wells and can be used to readily identify measurements that exceed regulatory levels.

For quarterly reports, the moving window of 20 data points adds new data with each successive sampling event and drops the oldest data point to maintain a consistent sample population of the most current 20 data points. Using data from the most recent 20 sampling events corresponds to the same data set that is used for the other statistical analyses. Annual reports will present both the time-series plots containing the moving window of 20 data points and time-series plots containing the full data set for each constituent.

Applicable Washington State drinking water and groundwater regulatory levels will be shown on the time-series graphs. Note that some constituents may have regulatory levels that are much greater than the concentrations that are detected in samples from the monitoring wells and cannot be shown at the appropriate vertical scale of the time-series graph.

Mann-Kendall Trend Test (Quarterly/Annually)

The Mann-Kendall trend test is a non-parametric statistical method recommended in the Unified Guidance for sites in the compliance assessment and corrective action monitoring phases and is appropriately paired with time-series plots. The Mann-Kendall trend test will be used to determine if data trends graphically presented in time-series plots are statistically significant. The Mann-Kendall test will be applied to the same moving window of 20 most recent data points as described previously.

Shapiro-Wilk Test for Normality (Quarterly/Annually)

The Shapiro-Wilk Test for Normality is a method recommended in the Unified Guidance for evaluating if data sets are normally distributed. The Shapiro-Wilk Test for Normality will be applied quarterly to the 20 data point moving window of analytical data for each well-constituent pair that had a sufficient number of data points to apply this statistical method.

The results of the Shapiro-Wilk Test for Normality will be used to determine which type of confidence interval evaluation is appropriate for each well-constituent combination data set. Data sets that are normally distributed will be evaluated using the 95% confidence interval around the mean (a parametric statistical test). Data sets that are non-normally distributed will be adjusted by log-normal transformation prior to being evaluated using the 95% confidence interval around the median (a non-parametric statistical test).

Confidence Interval (Quarterly/Annually)

The statistical test for the confidence interval is recommended in the Unified Guidance and is appropriate for compliance assessment and corrective action monitoring phases. In addition, evaluation of the confidence interval is appropriate when data are compared to a fixed limit such as a regulatory standard. Confidence intervals are a common and statistically defensible way to assess compliance with a fixed numerical limit.

The moving window of 20 data points will be evaluated for the 95% confidence interval for each well-constituent pair that has a sufficient number of data points to apply this statistical method. The moving window of 20 data points adds new data with each successive sampling event and drops data from the oldest sampling event to maintain a consistent sample population of the most current 20 data points.

Confidence interval results will be compared to cleanup levels established for the site. Exceedance of a regulatory level is triggered when the lower 95% confidence interval is greater than the regulatory level. Successful remediation is attained if the upper 95% confidence limit does not exceed its applicable regulatory level.

2. Chemical Methods (Quarterly/Annually)

The water quality parameters indicative of natural attenuation given in Appendix A will be evaluated to provide evidence of natural attenuation processes. The relative magnitude and trends of such parameters as dissolved oxygen and oxidation/reduction potential will provide insight as to mechanisms of natural attenuation that are occurring in groundwater at the site.

3. References

United States Environmental Protection Agency (EPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

United States Geological Survey (USGS). 2008. Invasive Data – How Substituting Values for Low-Level Trace Element Data Can Ruin Results. Power Point presentation by Dennis Helsel, 2008.