REPORT

LOWER DISPOSAL AREA INTERCEPTOR TRENCH BOREHOLE INVESTIGATION WORK PLAN

RAVENSDALE SITE, WASHINGTON

Submitted To: Holcim (US) Inc.
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Washington State Department of Ecology
Reserve Silica Corp.
Holcim (US) Inc.
Golder Associates Inc.

September 18, 2017 **Project No. 152030401.001**

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1.0 INTRODUCTION

1.1 Background

The Ravensdale site (site) is located at 28131 Ravensdale-Black Diamond Road in Ravensdale, Washington (Figure 1). Historically, sand and coal mining operations occurred on the site until 2007. The site is currently owned by the Reserve Silica Corporation (Reserve Silica). Reserve Silica is backfiling the remaining historical excavation areas under an inert waste landfill permit (Permit #PR0082027). Holcim (US) Inc. (Holcim) has entered into agreements with Reserve Silica for addressing environmental conditions associated with historic disposal of cement kiln dust (CKD) at the site by predecessor companies.

The Lower Disposal Area (LDA) is a former open pit sand mine that was backfilled by placing cement kiln dust CKD and other materials into the mine excavation from June 1979 to October 1982. The approximate location of the LDA is shown in Figure 2. Historically, high-pH seepage has surfaced along the down-slope area west of the LDA. The seeps are primarily located along the northern half of the western boundary of the LDA. The seepage historically drained through low-lying, marshy areas and commingled with stormwater before flowing to the infiltration ponds. Currently, the seepage is collected in a ditch and catch basin system and piped to the infiltration ponds at the northern end of the site.

Holcim is addressing the high-pH seepage from the LDA through two primary methods:

1. Reducing, to the extent practical, the amount of meteoric and groundwater entering the LDA and contacting the CKD, thereby reducing the volume of high pH seepage.

2. Capturing and directing the high pH seepage to a treatment system (scheduled for construction in the fall of 2017) for neutralization and removal of dissolved arsenic prior to discharge to the existing infiltration ponds.

1.2 Previous Remediation Activities

In September and October 2007, the soil cover on the LDA was upgraded to meet industry standards and to reduce infiltration that could contribute to high-pH seepage observed in this area. Specific activities included regrading the cover to provide positive surface water runoff at all locations, increasing the thickness of the low-permeability cover soil layer to a minimum of two feet at all locations, and constructing a surface water diversion ditch around the upslope boundary of the cover.

Qualitative observations after construction of the improved cover, however, did not indicate a significant reduction in seepage volume. On this basis, it was considered most likely that the primary cause of seepage is up-gradient shallow groundwater inflow into the LDA, rather than surface water or infiltration through the cover.

Under this interpretation, the most practical approach for reducing seepage would be to reduce the influx of groundwater to the LDA. Therefore, a comprehensive program of test pit excavations, borehole drilling, piezometer measurements, tracer tests, and geophysical investigations was performed during 2010 to 2012. The results of these investigations were summarized in the *Lower Disposal Area Hydrogeologic Investigation* report (Golder 2013), and strongly suggested that groundwater was entering the LDA from the southern end and flowing to the north, producing the observed high-pH seeps and shallow groundwater impacts.

A groundwater interceptor trench was constructed at the south end of the LDA during August through October of 2013 as a first phase of reducing groundwater inflow to the LDA. The trench is approximately 220 feet long and up to 20 feet deep. Only about 50 feet of the trench length extends up the east side of the LDA from the southern end. Figure 2 shows the location of the existing interceptor trench. The trench is filled with gravel with a perforated drainage pipe in the bottom that discharges diverted shallow groundwater via gravity drainage to a point on the hillside to the south of the LDA. Flows from this trench are clean (non-impacted) groundwater and generally range between about 0.5 and 2.5 gallons per minute (gpm), although flows of 5 gpm have been measured following periods of heavy rainfall. The attached Table 1 presents monthly measurements of clean water discharging from the existing interceptor trench during the period of August 2016 to August 2017. Since construction of this trench, seepage along the western side of the LDA has continued, although any volume changes have not been measured.

In September 2008 in order to evaluate remedial options for the seepage water along the western side of the LDA, two test trenches were installed to collect high-pH seepage from the LDA. One trench was located on the bench immediately to the west of the LDA, where several seeps (and resulting carbonate deposits) had been observed over the course of several years. The second trench was located at the toe of the cover slope near the south end of the LDA. The trenches themselves were backfilled with gravel and each included a perforated drain pipe and a standpipe system to measure flow rate. Collected seepage was discharged through a 4-inch tightline pipe installed from the trenches to the infiltration ponds. The purpose of this test program was to determine the effectiveness of gravel-filled trenches in collecting seepage, evaluate the construction methods used for the trenches and to provide data for estimating the quantity and chemical characteristics of the seepage. The last objective would, in turn, help to identify the most appropriate method for managing the seepage.

In February 2013, a collection ditch was excavated along the bench below the western seepage zone to collect seepage, and a drop inlet structure was installed to direct seepage into the tightline and convey it directly to the infiltration ponds, thereby reducing the volume that commingles with surface water. In 2015, the 4-inch tightline downstream of the drop inlet was replaced with a 10-inch pipe to reduce the required frequency of cleaning resulting from carbonate precipitation in the pipe. Table 2 presents monthly flow measurements of the collected seepage water discharging from the 10-inch pipe to the infiltration ponds during the period of August 2016 to August 2017. The collection ditch proved effective in capturing and conveying seepage, and the discharge pipe will be re-routed to convey the collected seepage to a seepage water treatment system. The design, construction, and operation of the seepage collection treatment system are being submitted to the Washington State Department of Ecology (Ecology) and to the Public Health Seattle and King County department under separate cover.

Chain-link fencing with 3-strand barbed wire at the top has been placed around site areas where high pH surface water is present. The fenced areas include: the seepage area and seepage collection ditch located west of the LDA; the South Pond located west of the LDA; and the infiltration ponds that receive the collection trench water discharge via the tightline. In addition, minor seepage water exposures observed along the southwest toe of the LDA were covered with coarse rock to allow flow of the water into the collection ditch system, while preventing direct contact by humans or animals at the ground surface.

1.3 Purpose and Scope

The existing interceptor trench demonstrates that shallow groundwater flowing along the top of the bedrock at the south end LDA can be diverted around the LDA. The existing 220-foot-long interceptor trench, however, only extends approximately 50 feet along the southeast upgradient side of the LDA. The purpose of the proposed borehole investigation program is to determine if constructing an additional branch of the interceptor trench upgradient of the southeast side of the LDA could effectively divert additional shallow groundwater around the LDA, thus potentially reducing the volume of high pH seepage discharging from the downgradient side of the LDA.

The scope of the current investigation is to determine the depth to bedrock and to identify shallow groundwater flow zones on top of the bedrock in the area along the southeast, hydrologically upgradient, side of the LDA. If the initial borehole investigation indicates that constructing an additional branch of the interceptor trench is feasible, installation of additional groundwater piezometers/wells may be necessary to evaluate the effectiveness of the interceptor trench extension. An additional work plan would be prepared for if additional piezometers/wells they are considered necessary.

2.0 BOREHOLE INVESTIGATION ACTIVITIES

2.1 Preliminary Investigation

In October 2016, Golder performed a preliminary investigation along the southeast side of the LDA. A total of 9 boreholes were drilled to depths of between 10 and 30 feet below ground surface. As shown in Figure 3, the boreholes were located on a line that started near the end of the existing interceptor trench and extended along the southeast side of the LDA. In summary, fill material comprised of mine spoils and CKD was encountered in most of the boreholes, and the competent bedrock needed for effective installation of the interceptor trench was not detected along this line. Shallow groundwater was encountered in most of the boreholes.

Results of the preliminary investigation indicate that the interceptor trench extension alignment would need to be moved further to the east and constructed as a separate branch, connected to the existing interceptor trench, so as to be hydraulically upgradient of the fill and CKD material, and located in an area where competent bedrock and shallow groundwater are potentially present.

2.2 Proposed Field investigations

A targeted field investigation program will be performed to determine the depth to bedrock and to identify shallow groundwater flow zones in the area east of the preliminary borehole alignment. This activity will primarily involve drilling approximately 8 boreholes along or near the proposed interceptor trench extension alignment as shown on Figure 3. Figure 3 only shows the proposed location for 4 of the potential 8 boreholes included in this investigation. Following drilling of the first 4 boreholes, the additional boreholes will be located in the field in an adaptive and iterative approach. Data collected from each borehole(s) will be used to locate additional boreholes as necessary to collect data on the depth to bedrock and presence of shallow groundwater along the alignment of the proposed interceptor trench branch. Drilling will be conducted using a track-mounted sonic drill rig to provide better core recovery and less disturbance than other methods. Drilling will extend until bedrock is encountered or until 30 feet, whichever is less. Stratigraphic and groundwater data will be obtained, and if shallow groundwater is encountered, several of the holes may be completed as 2-inch diameter wells for measurement of water levels and potential additional hydraulic testing if necessary.

An investigation report will be prepared presenting the results of the field investigation and an assessment of the efficacy of adding a new branch to the existing interceptor trench. The report will be submitted to Ecology and Public Health.

3.0 SCHEDULE

In January 2011, an Easement Agreement involving Site Environmental Activities (Easement) was filed on record between Reserve Silica and Holcim (Reserve 2010). The areas covered by the Easement include both the DSP and LDA, access roads, monitoring wells, and the LDA leachate seepage areas and infiltrations ponds as shown in Exhibit A. The proposed borehole investigation area is just outside of the existing easement, and Holcim and Reserve Silica are working on an agreement to include the proposed drilling in this area. Additionally, the Bonneville Power Administration (BPA) requires permitting for drilling under their power lines and the presence of a qualified "safety watcher". The BPA permit has been obtained, but the availability of the safety watcher could also affect the schedule.

We would like to obtain regulatory approval to proceed, so the field investigation could occur upon finalization of the access agreement and scheduling of the BPA safety watcher.

4.0 CLOSING

The information presented in this work plan is intended solely for the purpose described herein and should not be used for any other purposes without written authorization from Golder Associates Inc.

GOLDER ASSOCIATES INC.

Frank S. Shuri

Frank S. Shuri, PE, LG, LEG
Principal

Gary L. Zimmerman
Principal

FS/GLZ/sb

5.0 REFERENCES

Golder Associates Inc. (Golder) 2013. *Lower Disposal Area Hydrogeological Investigations, Ravensdale Site*. Prepared for Holcim (US) Inc. June 11.

Golder 2014. Technical Memorandum: *Ravensdale Site Groundwater and Surface Water Statistical Characterization: Arsenic Background Level Evaluation.* Prepared for Holcim (US) Inc. January 3.

TABLES

Table 1: Monthly Flow Volumes of Clean Water Diverted Around the Lower Disposal Area by the Interceptor Trench

Location	Date	Time	Flow (ml/min)	Flow gpm	pH	Notes
Interceptor Trench	8/22/2016	11:00	312	0.08	7.8	measured with pH meter
Interceptor Trench	9/14/2016	9:15	262	0.07	8.0	measured with pH strip
Interceptor Trench	10/18/2016	12:13	7,966	2.07	7.0	measured with pH strip
Interceptor Trench	11/1/2016	14:40	8,900	2.31	8.2	measured with pH meter
Interceptor Trench	12/8/2016	11:55	8,200	2.13	7.0	measured with pH strip
Interceptor Trench	1/6/2017	9:05	5,817	1.51	7.0	measured with pH strip
Interceptor Trench	2/2/2017	9:25	7,933	2.06	7.6	measured with pH meter
Interceptor Trench	3/8/2017	12:15	10,033	2.61	7.2	measured with pH meter
Interceptor Trench	4/11/2017	8:40	5,167	1.34	7.7	measured with pH meter
Interceptor Trench	5/30/2017	15:45	4,000	1.04	7.3	measured with pH meter
Interceptor Trench	6/16/2017	7:38	19,333	5.03	6.9	>1" rain previous day pH measured with YSI multimeter
Interceptor Trench	7/21/2017	8:15	706	0.18	7.2	measured with pH meter
Interceptor Trench	8/18/2017	8:50	460	0.12	7.6	measured with pH meter

Table 2: Monthly Flow Volumes of Collected Seepage Water Discharged to the Infiltration Ponds

Location	Date	Time	Flow (ml/min)	Flow gpm	pH	Notes
Infiltration Discharge	8/23/2016	8:50	4,400	1.1	11.8	pH from sampling location
Infiltration Discharge	9/14/2016	8:25	4,467	1.2	12.0	measured with pH strip
Infiltration Discharge	10/18/2016	12:42	8,283	2.2	11-12	measured with pH strip
Infiltration Discharge	11/1/2016	11:00	24,800	6.4	13.0	measured with pH meter
Infiltration Discharge	12/8/2016	12:10	29,000	7.5	12.0	measured with pH strip
Infiltration Discharge	1/6/2017	8:18	27,333	7.1	13.0	measured with pH strip
Infiltration Discharge	2/1/2017	8:55	17,600	4.6	13.3	measured with pH meter
Infiltration Discharge	3/8/2017	12:35	32,667	8.5	13.2	measured with pH meter
Infiltration Discharge	4/11/2017	9:05	26,000	6.8	13.2	measured with pH meter
Infiltration Discharge	5/30/2017	10:22	21,000	5.5	13.0	measured with pH meter
Infiltration Discharge	6/16/2017	8:00	21,133	5.5	12.7	>1" rain previous day pH measured with YSI multimeter
Infiltration Discharge	7/21/2017	8:40	5,533	1.4	12.8	measured with pH meter
Infiltration Discharge	8/17/2017	9:20	2,540	0.7	11.9	measured with pH meter

FIGURES

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NGVD 29
   CONTOUR INTERVAL: 5 FT

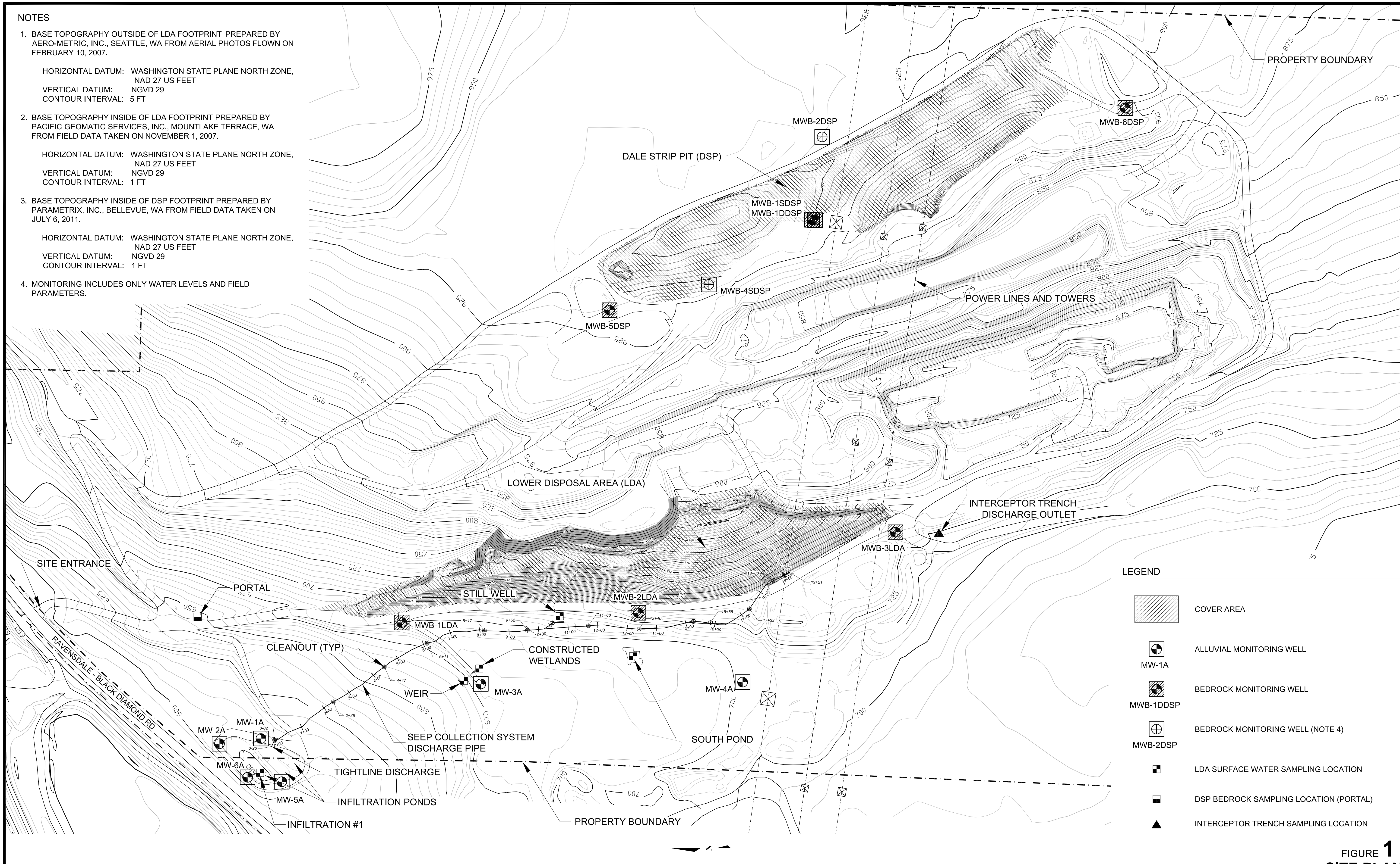
2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NGVD 29
   CONTOUR INTERVAL: 1 FT

3. BASE TOPOGRAPHY INSIDE OF DSP FOOTPRINT PREPARED BY PARAMETRIX, INC., BELLEVUE, WA FROM FIELD DATA TAKEN ON JULY 6, 2011.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NGVD 29
   CONTOUR INTERVAL: 1 FT

4. MONITORING INCLUDES ONLY WATER LEVELS AND FIELD PARAMETERS.



LEGEND

	COVER AREA
MW-1A	ALLUVIAL MONITORING WELL
MWB-1DDSP	BEDROCK MONITORING WELL
MWB-2DSP	BEDROCK MONITORING WELL (NOTE 4)
	LDA SURFACE WATER SAMPLING LOCATION
	DSP BEDROCK SAMPLING LOCATION (PORTAL)
	INTERCEPTOR TRENCH SAMPLING LOCATION

FIGURE 1
SITE PLAN
HOLCIM / RAVENSDALE PROJECT / WA

Golder Associates

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

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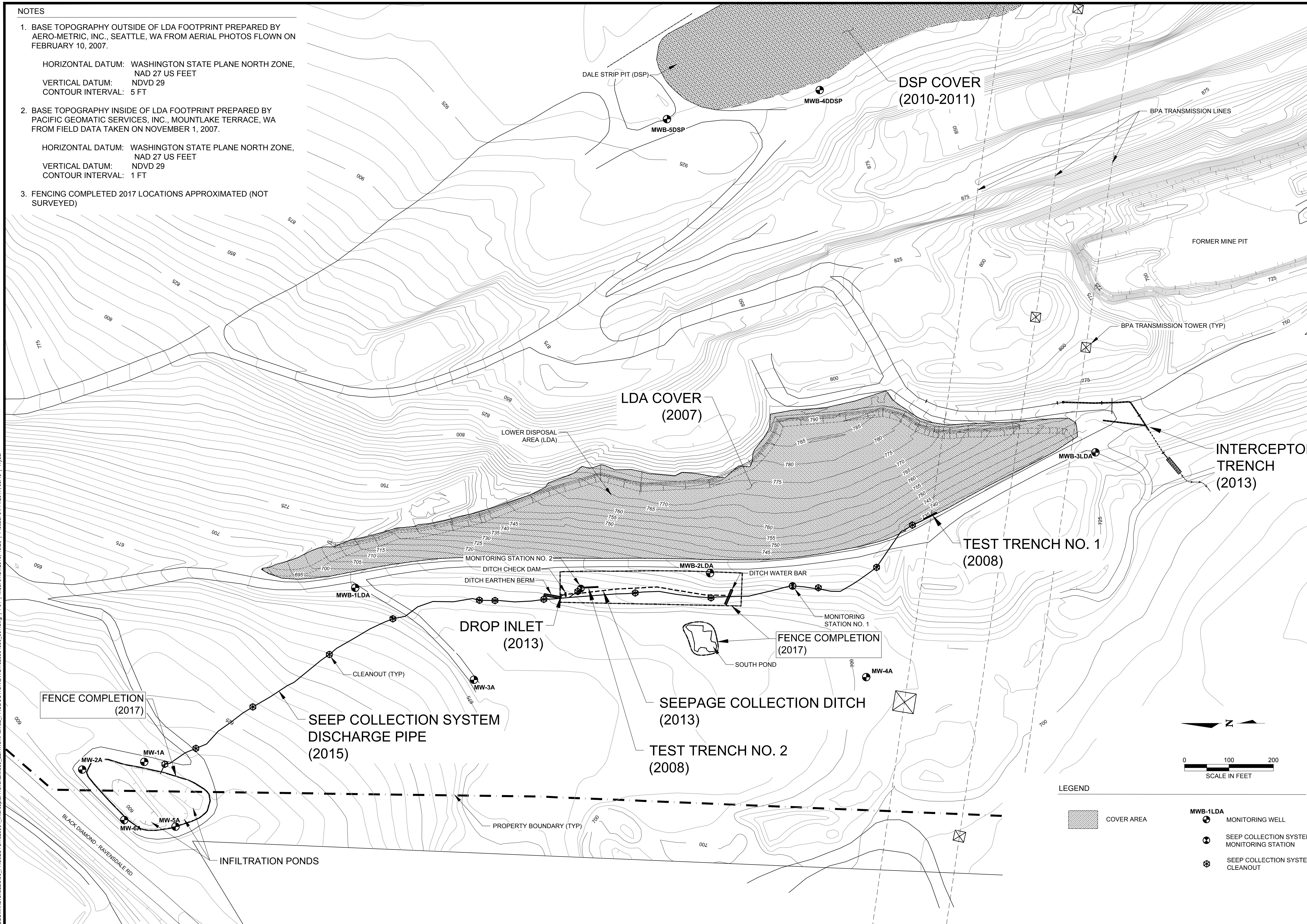
   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. FENCING COMPLETED 2017 LOCATIONS APPROXIMATED (NOT SURVEYED)



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FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT: RAVENSDALE SITE

TITLE: LDA FACILITIES LAYOUT

PROJECT No.		1520304.350
FILE No.		AS SHOWN
REV. A	SCALE	AS SHOWN
DESIGN	SJM	07-21-16
CADD	VMN	07-21-16
CHECK	VMN	07-21-16
REVIEW	FSS	07-21-16

FIGURE 2

G:\HOLCIM\Ravensdale\99_PROJECTS\1520304_InterceptorTrenchExt\350_LDAWorkPlan\02_PRODUCTION\DWG\1520304350_001.dwg | F01 | Mod: 07/21/2016, 18:26 | Plotted: 04/14/2017, 08:48 | Trybar

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

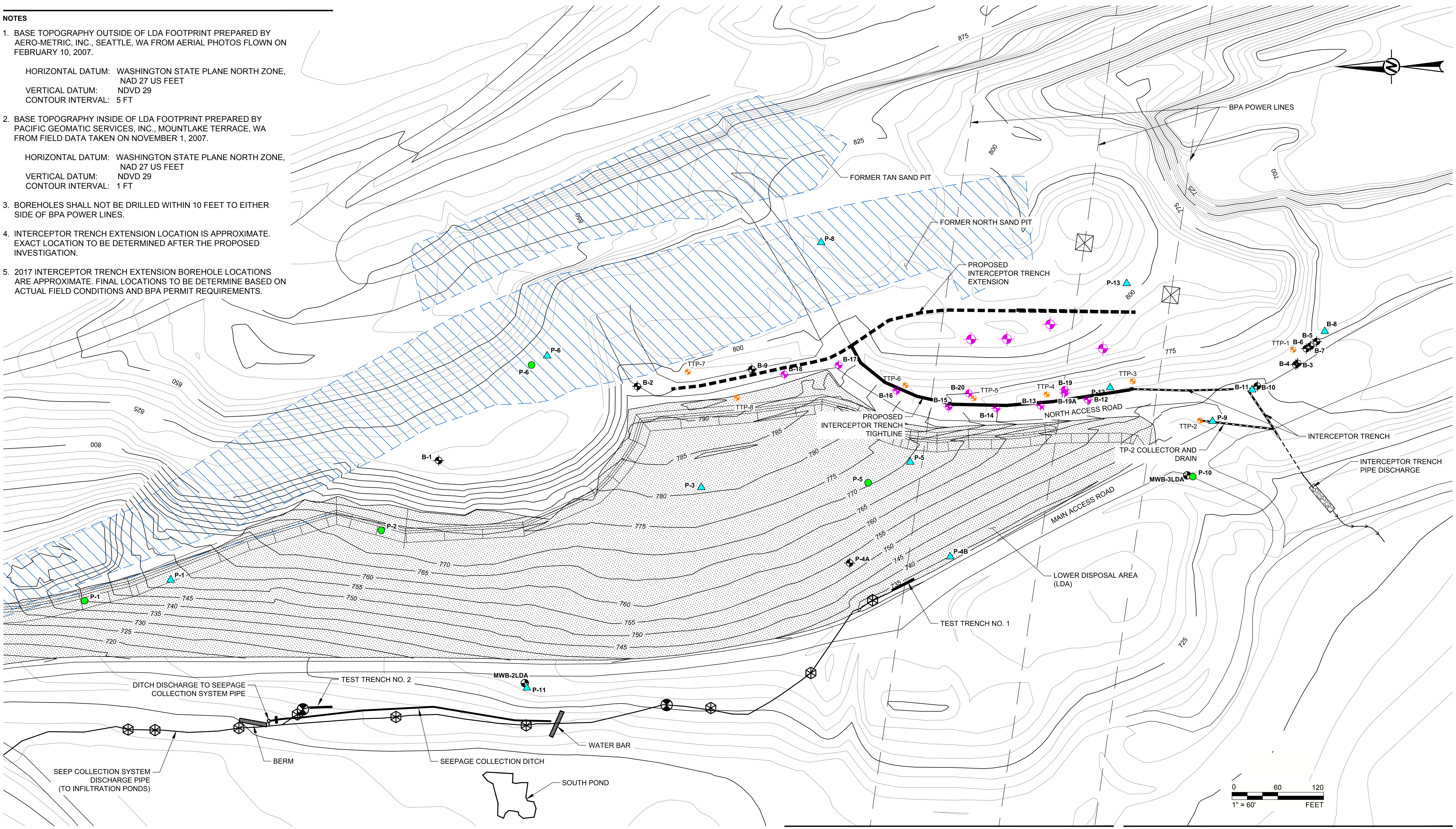
2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. BOREHOLES SHALL NOT BE DRILLED WITHIN 10 FEET TO EITHER SIDE OF BPA POWER LINES.

4. INTERCEPTOR TRENCH EXTENSION LOCATION IS APPROXIMATE. EXACT LOCATION TO BE DETERMINED AFTER THE PROPOSED INVESTIGATION.

5. 2017 INTERCEPTOR TRENCH EXTENSION BOREHOLE LOCATIONS ARE APPROXIMATE. FINAL LOCATIONS TO BE DETERMINE BASED ON ACTUAL FIELD CONDITIONS AND BPA PERMIT REQUIREMENTS.



LEGEND

B-16 2016 GOLDER INTERCEPTOR TRENCH EXTENSION BOREHOLE	P-2 GOLDER DIRECT PUSH PROBE
MWB-1LDA MONITORING WELL	B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)
P-1 GOLDER PIEZOMETER	TTP-1 GOLDER TEST PIT (MAY, 2010)
B-16 2017 GOLDER INTERCEPTOR TRENCH EXTENSION BOREHOLE	

CLIENT
HOLCIM

CONSULTANT
Golder Associates

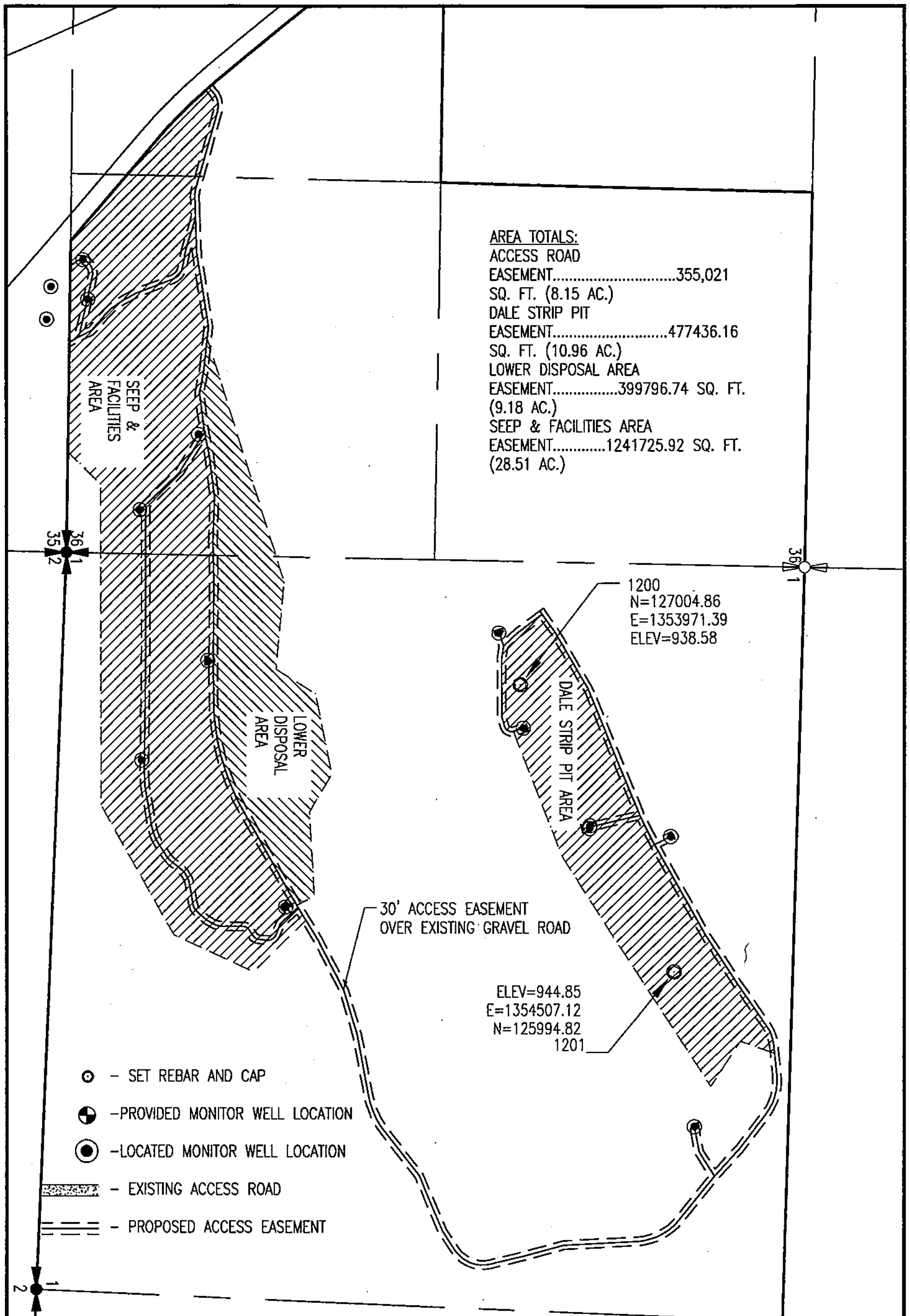
YYYY-MM-DD	2017-04-14
DESIGNED	SJM
PREPARED	REDMOND
REVIEWED	FSS
APPROVED	GZ

PROJECT
RAVENSDALE
INTERCEPTOR TRENCH EXTENSION PREDESIGN INVESTIGATION

TITLE
PROPOSED 2017 INVESTIGATION SITE PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
152030401	100	A	3

EXHIBIT A



DEED LEGAL DESCRIPTION
THAT PORTION OF SECTION 1, TOWNSHIP 21 NORTH, RANGE 6 EAST, W.M. AND SECTION 36, TOWNSHIP 22 NORTH, RANGE 6 EAST, W.M., IN KING COUNTY, WASHINGTON, LYING WITHIN THE FOLLOWING FOUR DESCRIBED TRACTS OF LAND:
TRACT 1 – THE NORTH HALF OF THE SOUTHWEST QUARTER OF SAID SECTION 1;
TRACT 2 – ALL OF THE NORTHWEST QUARTER OF SAID SECTION 1;
TRACT 3 – THE SOUTHEAST QUARTER OF THE SOUTHWEST QUARTER OF SECTION 36;
TRACT 4 – THAT PORTION OF THE WEST HALF OF THE SOUTHWEST QUARTER OF SAID SECTION 36, LYING SOUTHEASTERLY OF THE BLACK DIAMOND–RAVENSDALE ROAD.

Parametrix DATE: January 24, 2011 FILE: LEGALDESCRIPTIONSEXHIBIT

N
0 500
1"=500'

NOTE
EASEMENT BOUNDARIES OF THE DALE STRIP PIT AREA, LOWER DISPOSAL AREA, AND SEEP & FACILITIES AREA RUN ALONG THE ROAD CENTERLINE WHEN THEY ARE COINCIDENT WITH THE ACCESS ROAD EASEMENT.

LEGAL DESCRIPTION EXHIBIT

EXHIBIT A: LDA LEACHATE SEEPAGE AREAS AND INFILTRATIONS PONDS

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

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