Pre-Remedial Design Investigation Data Report

South State Street MGP Site
Bellingham, Washington

for
Puget Sound Energy

June 28, 2023

GeoEngineers
Earth Science + Technology

APPENDICES

APPENDIX E
Data Validation Reports

Project: Puget Sound Energy – South State Street Preliminary Remedial Design Investigation September 2021 and January 2022 Upland Soil Sampling Event

GEI File No: 0186-890-03

Date: February 7, 2022

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of soil samples collected as part of the September 2021 and January 2022 Upland Soil sampling events, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the South State Street Manufactured Gas Plant Site in Bellingham, Washington.

Please note that this report was originally dated October 26, 2021. This report was revised on February 7, 2022 to include the addition of SDG 22A0427.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2020a) and Inorganic Superfund Methods Data Review (USEPA, 2020b) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

The data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times and Sample Preservation
- Surrogate Recoveries
- Method and Trip Blanks
- Matrix Spikes/Matrix Spike Duplicates
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Laboratory and Field Duplicates
- Instrument Tuning
- Internal Standards

- Initial Calibrations (ICALs)
- Continuing Calibrations (CCALs)
- Miscellaneous

VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

TABLE 1: SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

Laboratory SDG	Samples Validated
21I0042	HA-15-0-1, HA-15-1-2, HA-16-0-1, HA-16-1-2, HA-17-1-2, HA-18-1-2, HA-19-0-1, HA-19-1-2, HA-20-0-1, HA-20-1-2, HA-21-1-2, HA-22-0-1, HA-22-1-2, HA-23-1-2, DUP-01-1-2, HA-24-0-1, HA-24-1-2, HA-25-0-1, HA-25-1-2, HA-26-0-1, HA-26-1-2, HA-27-0-1, HA-27-1-2, HA-28-0-1, HA-28-1-2, HA-29-0-1, HA-29-1-2, HA-30-1-2, DUP-02-1-2, HA-31-0-1, HA-31-1-2, HA-32-0-1, HA-32-1-2, HA-33-0-1, HA-33-1-2, HA-34-1-2, HSA-59-9-10.5, HSA-60-9-10.5, HSA-62-13-14, DUP-1-083121, TRIP BLANKS
22A0427	GP-58-13-14, GP-59-12-13, GP-60-14-15, GP-61-13-14, GP-62-14-15, GP-63-14-15, GP-64-14-15, GP-70-3-4, GP-71-3-4, GP-72-3-4, GP-73-2-3, GP-74-15-16, GP-75-15-16, MW-61-15-16

CHEMICAL ANALYSIS PERFORMED

Analytical Resources, Inc. (ARI), located in Tukwila, Washington, performed laboratory analyses on the samples using one or more of the following methods:

- Gasoline-range Hydrocarbons (NWTPH-Gx) by Method NWTPH-Gx;
- Petroleum Hydrocarbons (NWTPH-Dx) by Method NWTPH-Dx;
- Volatile Organic Compounds (VOCs) by Method SW8260D;
- Polycyclic Aromatic Hydrocarbons (PAHs) by Method SW8270E-SIM;
- Total Metals by Method SW6020B;
- Total Cyanide by Method EPA9014;
- Total Organic Carbon (TOC) by Method EPA9060M; and
- Total Solids by Method SM2540G-97

ARI subcontracted to Spectra Laboratories, Inc., (Spectra) located in Tacoma, Washington for laboratory analyses on the samples using the following method:

- Total Cyanide by Method SM4500-CNE

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

ARI provided all required deliverables for the data validation according to the National Functional Guidelines. The laboratory followed adequate corrective action processes and all identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory, with the following exceptions:

SDG 21I0042: The laboratory noted that the trip blank sample was received, but not listed on the COC. The sample was logged for NWTPH-Gx and VOC analyses.

SDG 22A0427: The laboratory noted that Sample GP-59-12-13 was listed as GP-59-13-14 on the sample vial labels. The sample was logged as GP-59-12-13, as written on the COC.

The laboratory noted that for Sample GP-74-15-16 one sample vial had no sample ID listed on the label. It was determined to be for Sample GP-74-15-16 since the date and time listed on the sample vial label matched the date and time listed on the COC.

The laboratory noted that for Sample GP-62-14-15 one sample vial had no sample information listed on the label. It was determined to be for Sample GP-62-14-15 since all of the other samples were received with their respective sample vials.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for all analyses. The sample coolers arrived at the laboratory within the appropriate temperatures of between 2 and 6 degrees Celsius, with the exceptions noted below.

SDG 21I0042: Two sample cooler temperatures recorded at the laboratory were 0.4 and 1.3 degrees Celsius. It was determined through professional judgment that since the samples were not frozen, these temperatures should not affect the sample analytical results.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in any environmental sample. Surrogates are used for organic analyses and are added to all samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries (%R) are calculated following analysis. All surrogate recoveries for field samples were within the laboratory control limits.

Method, Trip, and Rinsate Blanks

Method Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For all sample batches, method blanks were analyzed at the required frequency. None of the analytes of interest were detected in the method blanks.

Trip Blanks

Trip blanks are analyzed to assess whether field sampling or sample transport processes may have introduced measurable concentrations of volatile analytes of interest into project samples. None of the analytes of interest were detected in the trip blank.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a %R is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the results from the MS and MSD, the relative percent difference (RPD) is calculated. The %R control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for all analyses and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 21I0042: (NWTPH-Dx) The laboratory performed an MS/MSD sample set on Sample DUP-1-083121. The %R and RPD values for diesel-range hydrocarbons were greater than the control limits in the MS/MSD extracted on 9/13/2021. The positive result for this target analyte was qualified as estimated (J) in this sample.

(PAHs) The laboratory performed an MS/MSD sample set on Sample HA-24-1-2. The %R and RPD values for the PAH target analytes were outside the control limits in the MS/MSD extracted on 9/10/2021. The positive results for the PAH target analytes were qualified as estimated (J) in this sample.

The laboratory performed an MS/MSD sample set on Sample HA-31-0-1. The %R for benzo(a)anthracene, benzo(a)pyrene, and chrysene were outside the control limits in the MS/MSD extracted on 9/10/2021. The positive results for these target analytes were qualified as estimated (J) in this sample.

Additionally, in the same MS/MSD sample set, the %R for benzo(b)fluoranthene and benzo(k)fluoranthene were less than the control limits in the MS; however, the %R for these target analytes were within the control limits in the corresponding MSD. No action was required for these outliers.

(Total Metals) The laboratory performed an MS/MSD sample set on Sample HSA-59-9-10.5. The %R for total iron was greater than the control limits in the MS/MSD digested on 9/21/2021. The positive result for this target analyte was qualified as estimated (J) in this sample.

The laboratory performed an MS/MSD sample set on Sample HSA-59-9-10.5. The RPD for total copper was greater than the control limits in the MS/MSD digested on 9/21/2021. The positive result for this target analyte was qualified as estimated (J) in this sample.

Additionally, in the same MS/MSD sample set, the %R for total copper was less than the control limits in the MS; however, the %R for this target analyte was within the control limits in the corresponding MSD. No action was required for this outlier.

(Total Cyanide) The laboratory performed an MS/MSD sample set on Sample HSA-59-9-10.5. The %R for total cyanide was less than the control limits in the MS/MSD digested on 9/9/2021. The positive result for this target analyte was qualified as estimated (J) in this sample.

(TOC) The laboratory performed an MS/MSD sample set on Sample HSA-59-9-10.5. The RPD for TOC was greater than the control limit in the MS/MSD extracted on 9/8/2021. The positive result for this target analyte was qualified as estimated (J) in this sample.

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, control limits for accuracy and precision in the LCS and its duplicate (LCSD) are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to each sample in the associated batch, instead of just the parent sample. The %R control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits.

Laboratory Duplicates

Internal laboratory duplicate analyses are performed to monitor the precision of the analyses. Two separate aliquots of a sample are analyzed as distinct samples in the laboratory and the RPD between the two results is calculated. Duplicate analyses should be performed once per analytical batch. If one or more of the samples used has a concentration less than five times the reporting limit for that sample, the absolute difference is used instead of the RPD. The RPD control limits are specified in the laboratory documents. Laboratory duplicates were analyzed at the proper frequency and the specified acceptance criteria were met, with the following exception:

SDG 21I0042: (Total Cyanide) The laboratory performed a laboratory duplicate sample set on Sample HSA-59-9-10.5. The RPD for total cyanide was greater than the control limit in the laboratory duplicate digested on 9/9/2021. The positive result for this target analyte was qualified as estimated (J) in this sample.

Field Duplicates

Field duplicates are similar to laboratory duplicates in that they are used to assess precision. Two samples (parent and duplicate) are created in the field by subsampling the homogenized sample and submitting them to the lab as separate samples. Duplicate samples were collected and analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration greater than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for soil samples is 50 percent.

SDG 21I0042: Three field duplicate sample pairs, HA-23-1-2/DUP-01-1-2, HA-30-1-2/DUP-02-1-2, and HSA-62-13-14/DUP-1-083121, were submitted with this SDG. The precision criteria for the target analytes were met for these sample pairs, with the exceptions noted below:

HA-23-1-2/DUP-01-1-2: The positive results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were qualified as estimated (J) in this sample pair.

HA-30-1-2/DUP-02-1-2: The positive results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were qualified as estimated (J) in this sample pair.

HSA-62-13-14/DUP-1-083121: The positive results for benzene and naphthalene were qualified as estimated (J) in this sample pair.

Instrument Tuning

Instrument tuning for analyses by gas chromatography/mass spectrometry (GC/MS) are completed to ensure that mass resolution, identification, and sensitivity of the analyses are acceptable. Instrument tuning should be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The frequency and specified acceptance criteria were met for each applicable analysis.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in any environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. All internal standard recoveries were within the control limits.

Initial Calibrations (ICALs)

The initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent relative standard deviation (%RSD) and relative response factors (RRF) values were within the control limits stated in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020a), with the following exception:

SDG 21I0042: (PAHs) The %RSD for dibenzo(a,h)anthracene was greater than the control limit in the initial calibration performed on 9/28/2021. The positive results for this target analyte were qualified as estimated (J) in Samples HA-34-1-2, DUP-01-1-2, and DUP-02-1-2.

Continuing Calibrations (CCALs)

The continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent difference (%D) and relative response factors (RRF) values were within the control limits in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020a).

Miscellaneous

SDG 21I0042: (VOCs) The laboratory reported two sets of results for Sample HSA-62-13-14, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for naphthalene and the reanalysis results for benzene were labeled as “do not report” (DNR) and should not be used for any purpose.

(PAHs) The laboratory reported two sets of results for Samples HA-15-0-1, HA-15-1-2, HA-16-0-1, HA-16-1-2, HA-18-1-2, HA-21-1-2, HA-22-0-1, HA-22-1-2, HA-23-1-2, DUP-01-1-2, HA-26-0-1, HA-26-1-2, HA-27-1-2, HA-29-1-2, HA-30-1-2, DUP-02-1-2, HA-31-0-1, HA-31-1-2, HA-32-0-1, HA-32-1-2, and HA-34-1-2, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The following lists which analysis should be used, and which were labeled as DNR and should not be used for any purpose.

Samples HA-15-0-1, HA-15-1-2, HA-22-0-1, HA-34-1-2, DUP-02-1-2: The initial results for the PAH target analytes were labeled as DNR and should not be used for any purpose.

Samples HA-29-1-2, HA-31-0-1: The initial results for chrysene and the reanalysis results for benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were labeled as DNR and should not be used for any purpose.

Samples HA-26-0-1, DUP-01-1-2: The initial results for benzo(a)pyrene and chrysene and the reanalysis results for benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were labeled as DNR and should not be used for any purpose.

Samples HA-16-0-1, HA-18-1-2, HA-32-0-1: The initial results for benzo(a)anthracene, benzo(a)pyrene, and chrysene and the reanalysis results for benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were labeled as DNR and should not be used for any purpose.

Sample HA-16-1-2: The initial results for benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for benzo(a)pyrene and dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Sample HA-27-1-2: The initial results for benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for benzo(a)anthracene, benzo(k)fluoranthene, and dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Samples HA-21-1-2, HA-23-1-2, HA-32-1-2: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for benzo(k)fluoranthene and dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Samples HA-22-1-2, HA-26-1-2, HA-30-1-2, HA-31-1-2: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

SDG 22A0427: (NWTPH-Gx) The laboratory reported two sets of results for Sample GP-62-14-15, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results were labeled as DNR and should not be used for any purpose.

(NWTPH-Dx) The laboratory reported two sets of results for Sample GP-58-13-14, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The reanalysis results were labeled as DNR and should not be used for any purpose.

The laboratory reported two sets of results for Sample GP-61-13-14, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for diesel-range hydrocarbons and the reanalysis results for lube oil-range hydrocarbons were labeled as DNR and should not be used for any purpose.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD %R values, with the exceptions noted above. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and laboratory/field duplicate RPD values, with the exceptions noted above.

All data are acceptable for the intended use, with the following qualifications listed below in Table 2.

TABLE 2: SUMMARY OF QUALIFIED SAMPLES

Sample ID	Analyte	Qualifier	Reason
HA-23-1-2	Benzo(a)anthracene	J	Field Duplicate Precision
	Benzo(a)pyrene	J	Field Duplicate Precision
	Benzo(b)fluoranthene	J	Field Duplicate Precision
	Benzo(k)fluoranthene	J	Field Duplicate Precision
	Chrysene	J	Field Duplicate Precision
	Indeno(1,2,3-cd)pyrene	J	Field Duplicate Precision

DUP-01-1-2	Benzo(a)anthracene	J	Field Duplicate Precision
	Benzo(a)pyrene	J	Field Duplicate Precision
	Benzo(b)fluoranthene	J	Field Duplicate Precision
	Benzo(k)fluoranthene	J	Field Duplicate Precision
	Chrysene	J	Field Duplicate Precision
	Dibenzo(a,h)anthracene	J	ICAL %RSD
	Indeno(1,2,3-cd)pyrene	J	Field Duplicate Precision
HA-24-1-2	Benzo(a)anthracene	J	MS/MSD Recovery and Precision
	Benzo(a)pyrene	J	MS/MSD Recovery and Precision
	Benzo(b)fluoranthene	J	MS/MSD Recovery and Precision
	Benzo(k)fluoranthene	J	MS/MSD Recovery and Precision
	Chrysene	J	MS/MSD Recovery and Precision
	Dibenzo(a,h)anthracene	J	MS/MSD Recovery and Precision
	Indeno(1,2,3-c,d)pyrene	J	MS/MSD Recovery and Precision
HA-30-1-2	Benzo(a)anthracene	J	Field Duplicate Precision
	Benzo(a)pyrene	J	Field Duplicate Precision
	Benzo(b)fluoranthene	J	Field Duplicate Precision
	Benzo(k)fluoranthene	J	Field Duplicate Precision
	Chrysene	J	Field Duplicate Precision
	Dibenzo(a,h)anthracene	J	Field Duplicate Precision
	Indeno(1,2,3-c,d)pyrene	J	Field Duplicate Precision
DUP-02-1-2	Benzo(a)anthracene	J	Field Duplicate Precision
	Benzo(a)pyrene	J	Field Duplicate Precision
	Benzo(b)fluoranthene	J	Field Duplicate Precision
	Benzo(k)fluoranthene	J	Field Duplicate Precision
	Chrysene	J	Field Duplicate Precision
	Dibenzo(a,h)anthracene	J	Field Duplicate Precision/ICAL %RSD
	Indeno(1,2,3-c,d)pyrene	J	Field Duplicate Precision
HA-31-0-1	Benzo(a)anthracene	J	MS/MSD Recovery
	Benzo(a)pyrene	J	MS/MSD Recovery
	Chrysene	J	MS/MSD Recovery
HA-34-1-2	Dibenzo(a,h)anthracene	J	ICAL %RSD
HSA-59-9-10.5	Total copper	J	MS/MSD Precision
	Total cyanide	J	MS/MSD Recovery/Laboratory Duplicate Precision
	Total iron	J	MS/MSD Recovery
	TOC	J	MS/MSD Precision
HSA-62-13-14	Benzene	J	Field Duplicate Precision
	Naphthalene	J	Field Duplicate Precision
DUP-1-083121	Benzene	J	Field Duplicate Precision
	Diesel-range hydrocarbons	J	MS/MSD Recovery and Precision
	Naphthalene	J	Field Duplicate Precision

REFERENCES

U.S. Environmental Protection Agency (USEPA). “Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use,” EPA-540-R-08-005. January 2009.

U.S. Environmental Protection Agency (USEPA) 2020a. Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review, EPA-540-R-20-005. November 2020.

U.S. Environmental Protection Agency (USEPA) 2020b. Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA-542-R-20-006. November 2020.

Project: Puget Sound Energy – South State Street Preliminary Remedial Design Investigation
June and December 2021 Intertidal Sediment and Porewater Sampling Events

GEI File No: 0186-890-03

Date: March 9, 2022

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of intertidal sediment and porewater samples collected as part of the June and December 2021 sampling events, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the South State Street Manufactured Gas Plant Site in Bellingham, Washington.

Please note that this report was originally dated August 25, 2021. This report was revised on March 9, 2022 to include the addition of SDG 21L0100.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2020a) and Inorganic Superfund Methods Data Review (USEPA, 2020b) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
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VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

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Laboratory SDG	Samples Validated
21F0419	PRDI-1-PW-, PRDI-1-SC-0-15, PRDI-1-SC-15-60, PRDI-2-PW-, DUP-1-PW-, PRDI-2-SC-0-15, DUP-2-SC, PRDI-2-SC-15-60, PRDI-3-PW-, PRDI-3-SC-0-15, PRDI-3-SC-15-60, PRDI-4-PW-, PRDI-4-SC-0-15, PRDI-4-SC-15-60, PRDI-5-PW-, PRDI-5-SC-0-15, PRDI-5-SC-15-60, PRDI-6-PW-, PRDI-6-SC-0-15, PRDI-6-SC-15-60, PRDI-7-PW-, PRDI-7-SC-0-15, PRDI-7-SC-15-60, PRDI-8-PW-, PRDI-8-SC-0-15, PRDI-8-SC-15-60, PRDI-9-SC-0-15, PRDI-9-SC-0-45, PRDI-9-SC-15-60, DUP-3-SC, PRDI-9-SS-0-12, PRDI-10-PW-, PRDI-10-SC-0-15, PRDI-10-SC-0-45, PRDI-10-SC-15-60, PRDI-10-SS-0-12, PRDI-11-PW-, PRDI-11-SC-0-15, PRDI-11-SC-0-45, PRDI-11-SC-15-60, PRDI-11-SS-0-12, PRDI-12-PW-, PRDI-12-SC-0-15, PRDI-12-SC-0-45, PRDI-12-SC-15-60, PRDI-12-SS-0-12, TBlank-1_062521
21L0100	PRDI-2A-PW, DUP-101-PW, PRDI-2B-PW, PRDI-2C-PW, PRDI-2D-PW, PRDI-2E-PW, Trip Blanks

CHEMICAL ANALYSIS PERFORMED

Analytical Resources, Inc. (ARI), located in Tukwila, Washington, performed laboratory analyses on the samples using one or more of the following methods:

- Gasoline-range Hydrocarbons (NWTPH-Gx) by Method NWTPH-Gx;
- Petroleum Hydrocarbons (NWTPH-Dx) by Method NWTPH-Dx;
- Volatile Organic Compounds (VOCs) by Method SW8260D;
- Polycyclic Aromatic Hydrocarbons (PAHs) by Method SW8270E-SIM;
- Total Cyanide by Method EPA9014;
- Cyanide. Weak Acid Dissociable by Method SM4500-CN I-97;
- Total Organic Carbon (TOC) by Method EPA9060A; and
- Total Solids by Method SM2540G-97

ARI subcontracted to Materials Testing and Consulting, Inc., (MTC) located in Tukwila, Washington for laboratory analyses on the sediment samples using the following methods:

- Grain Size by Method ASTM D6913

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

ARI and MTC provided the required deliverables for the data validation according to the National Functional Guidelines. The laboratories followed adequate corrective action processes and the identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory, with the following exceptions:

SDG 21L0100: The laboratory noted that the relinquished date on the COC was listed as 9/20/2017. Additionally, the laboratory noted the sample collection times listed on the COC appear to be after times after the samples were relinquished. The date and times were revised by GeoEngineers.

The laboratory noted that the trip blank sample was received at the laboratory, but not listed on the COC. The sample was logged for NWTPH-Gx and VOCs analyses.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for each analysis. The sample coolers arrived at the laboratory within the appropriate temperatures of between 2 and 6 degrees Celsius, with the exceptions noted below.

SDG 21F0419: One sample cooler temperature recorded at the laboratory was 17.3 degrees Celsius. It was determined through professional judgment that since the samples were received on ice at the laboratory the same day they were collected, and the cooling process had begun, this temperature should likely not affect the sample analytical results.

One sample cooler temperature recorded at the laboratory was 1.7 degrees Celsius. It was determined through professional judgment that since the samples were not frozen, this temperature should not affect the sample analytical results.

The laboratory noted that for several samples, one or two sample vials (depending on the sample), were received with a bubble. Since a total of three sample vials were submitted for these samples, the samples were analyzed from the remaining sample vials, accordingly.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in an environmental sample. Surrogates are used for organic analyses and are added to the samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries (%R) are calculated following analysis. The surrogate recoveries for field samples were within the laboratory control limits, with the following exceptions:

SDG 21F0419: (VOCs) The %R for surrogates 1,2-Dichloroethane-d4 and 4-Bromofluorobenzene were less than the control limits in Sample PRDI-11-SC-0-15. The positive results for 1,2,4-Trimethylbenzene, 4-Isopropyltoluene, acetone, benzene, carbon disulfide, chloroform, tetrachloroethene, and toluene and the reporting limits for the remaining VOC target analytes were qualified as estimated (J and UJ, respectively) in this sample.

Method, Trip, and Rinsate Blanks

Method Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For each sample batch, method blanks were analyzed at the required frequency. None of the analytes of interest were detected in the method blanks, with the following exceptions:

SDG 21F0419: (VOCs) There was a positive result for bromomethane and toluene detected above the method detection limit, but below the reporting limit in the soils method blank extracted on 6/29/2021. The positive results for toluene were qualified as non-detected (U) in Samples PRDI-1-SC-0-15, PRDI-2-SC-0-15, PRDI-2-SC-15-60, PRDI-3-SC-0-15, PRDI-4-SC-0-15, PRDI-4-SC-15-60, PRDI-5-SC-0-15, PRDI-5-SC-15-60, PRDI-6-SC-0-15, PRDI-6-SC-15-60, PRDI-7-SC-0-15, and PRDI-8-SC-0-15. The positive results for bromomethane and toluene were qualified as non-detected (U) in Samples PRDI-3-SC-15-60 and PRDI-7-SC-15-60. There were no positive results for bromomethane in Samples PRDI-1-SC-0-15, PRDI-2-SC-0-15, PRDI-2-SC-15-60, PRDI-3-SC-0-15, PRDI-4-SC-0-15, PRDI-4-SC-15-60, PRDI-5-SC-0-15, PRDI-5-SC-15-60, PRDI-6-SC-0-15, PRDI-6-SC-15-60, PRDI-7-SC-0-15, and PRDI-8-SC-0-15; therefore, no qualifications were required.

Trip Blanks

Trip blanks are analyzed to assess whether field sampling or sample transport processes may have introduced measurable concentrations of volatile analytes of interest into project samples. None of the analytes of interest were detected in the trip blanks.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a %R is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the results from the MS and MSD, the relative percent difference (RPD) is calculated. The %R control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 21F0419: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-9-SS-0-12. The %R for most of the target analytes were outside the control limits in the MS/MSD extracted on 7/8/2021; however, it was performed on the initial results which was labeled as do-not-report (DNR). For this reason, no action was required for these outliers.

(Total Cyanide) The laboratory performed an MS/MSD sample set on Sample PRDI-1-SC-0-15. The %R for total cyanide was less than the control limits in the MS/MSD digested on 7/1/2021. The reporting limit for this target analyte was qualified as estimated (UJ) in this sample.

The laboratory performed an MS/MSD sample set on Sample PRDI-11-SC-0-15. The %R for total cyanide was less than the control limits in the MS/MSD digested on 7/6/2021. The reporting limit for this target analyte was qualified as estimated (UJ) in this sample.

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, control limits for accuracy and precision in the LCS and its duplicate (LCSD) are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to each sample in the associated batch, instead of just the parent sample. The %R control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 21F0419: (VOCs) The %R for 2-Chloroethyl vinyl ether was greater than the control limits in the LCS/LCSD extracted on 6/29/2021. There were no positive results for this target analyte in the associated field samples; therefore, no qualifications were required.

The RPD for 2-Chloroethyl vinyl ether was greater than the control limit in the LCS/LCSD extracted on 6/30/2021. There were no positive results for this target analyte in the associated field samples; therefore, no qualifications were required.

Laboratory Duplicates

Internal laboratory duplicate analyses are performed to monitor the precision of the analyses. Two separate aliquots of a sample are analyzed as distinct samples in the laboratory and the RPD between the two results is calculated. Duplicate analyses should be performed once per analytical batch. If one or more of the samples used has a concentration less than five times the reporting limit for that sample, the absolute difference is used instead of the RPD. The RPD control limits are specified in the laboratory documents. Laboratory duplicates were analyzed at the proper frequency and the specified acceptance criteria were met.

Field Duplicates

Field duplicates are similar to laboratory duplicates in that they are used to assess precision. Two samples (parent and duplicate) are created in the field by subsampling the homogenized sample and submitting them to the lab as separate samples. Duplicate samples were collected and analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration greater than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for water samples is 35 percent. The RPD control limit for soil samples is 50 percent.

SDG 21F0419: Three field duplicate sample pairs, PRDI-2-PW-/DUP-1-PW-, PRDI-2-SC-0-15/DUP-2-SC, and PRDI-9-SC-15-60/DUP-3-SC, were submitted with this SDG. The precision criteria for the target analytes were met for these sample pairs, with the exception of 2-Butanone, acetone, and carbon disulfide in Samples PRDI-9-SC-15-60 and DUP-3-SC. The positive results for these target analytes were qualified as estimated (J) in this sample pair.

SDG 21L0100: One field duplicate sample pair, PRDI-2A-PW and DUP-101-PW, was submitted with this SDG. The precision criteria for the target analytes were met for this sample pair, with the exception of benzene and lube oil-range hydrocarbons. The positive results and reporting limit for these target analytes were qualified as estimated (J and UJ, accordingly) in this sample pair.

Instrument Tuning

Instrument tuning for analyses by gas chromatography/mass spectrometry (GC/MS) are completed to ensure that mass resolution, identification, and sensitivity of the analyses are acceptable. Instrument tuning should be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The frequency and specified acceptance criteria were met for each applicable analysis.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in an environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. The internal standard recoveries were within the control limits, with the following exceptions:

SDG 21F0419: (VOCs) The internal standards %R for 1,4-Dichlorobenzene-d4, 1,4-Difluorobenzene, chlorobenzene-d5, and pentafluorobenzene were outside the control limits in Sample PRDI-11-SC-0-15. The positive results for 1,2,4-Trimethylbenzene, 4-Isopropyltoluene, acetone, benzene, carbon disulfide, chloroform, tetrachloroethene, and toluene and reporting limits for the remaining VOC target analytes were qualified as estimated (J and UJ, respectively) in this sample.

Initial Calibrations (ICALs)

The initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent relative standard deviation (%RSD) and relative response factors (RRF) values were within the control limits stated in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020a).

Continuing Calibrations (CCALs)

The continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent difference (%D) and relative response factors (RRF) values were within the control limits in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020a), with the following exceptions:

SDG 21F0419: (VOCs) The %D value for 2-Chloroethyl vinyl ether, dichlorodifluoromethane, and iodomethane was greater than the control limits, which is indicative of a high bias, in the continuing calibration verification performed on 6/29/2021. There were no positive results for these target analytes in the associated field samples; therefore, qualifications were not required for these outliers.

Miscellaneous

SDG 21F0419: (VOCs) The laboratory reported two sets of results for Sample PRDI-2-PW-, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for naphthalene and the reanalysis results for benzene were labeled as DNR and should not be used for any purpose.

The laboratory reported two sets of results for Sample PRDI-11-SC-0-15, initial results and reanalysis results, due to surrogate and internal standards recovery outliers. A reanalysis was performed with the surrogate and internal standard recoveries within the limits; however, the reanalysis was analyzed from an unpreserved sample vial. The reanalysis results were labeled as DNR and should not be used for any purpose.

(PAHs) The laboratory reported two sets of results for Samples PRDI-9-SS-0-12, PRDI-9-SC-0-45, PRDI-10-SS-0-12, PRDI-10-SC-0-45, PRDI-11-SS-0-12, PRDI-11-SC-0-45, and PRDI-12-SC-0-45, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The following lists which analysis should be used, and which were labeled as DNR and should not be used for any purpose.

Samples PRDI-9-SS-0-12 and PRDI-9-SC-0-45: The initial results for the PAH target analytes were labeled as DNR and should not be used for any purpose.

Sample PRDI-10-SS-0-12: The reanalysis results for the PAH target analytes were labeled as DNR and should not be used for any purpose.

Samples PRDI-10-SC-0-45 and PRDI-12-SC-0-45: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for benzo(k)fluoranthene and dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Samples PRDI-11-SS-0-12 and PRDI-11-SC-0-45: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD %R values, with the exceptions noted above. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and laboratory/field duplicate RPD values, with the exceptions noted above.

The data are acceptable for the intended use, with the following qualifications listed below in Table 2.

TABLE 2: SUMMARY OF QUALIFIED SAMPLES

Sample ID	Analyte	Qualifier	Reason
PRDI-2A-PW	Benzene Lube oil-range hydrocarbons	J UJ	Field Duplicate Precision Field Duplicate Precision
DUP-101-PW	Benzene Lube oil-range hydrocarbons	J J	Field Duplicate Precision Field Duplicate Precision
PRDI-1-SC-0-15	Total cyanide Toluene	UJ U	MS/MSD Recovery Method Blank Contamination
PRDI-2-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-2-SC-15-60	Toluene	U	Method Blank Contamination
PRDI-3-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-3-SC-15-60	Bromomethane Toluene	U U	Method Blank Contamination Method Blank Contamination
PRDI-4-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-4-SC-15-60	Toluene	U	Method Blank Contamination
PRDI-5-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-5-SC-15-60	Toluene	U	Method Blank Contamination
PRDI-6-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-6-SC-15-60	Toluene	U	Method Blank Contamination
PRDI-7-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-7-SC-15-60	Bromomethane Toluene	U U	Method Blank Contamination Method Blank Contamination
PRDI-8-SC-0-15	Toluene	U	Method Blank Contamination
PRDI-9-SC-15-60	2-Butanone Acetone Carbon disulfide	J J J	Field Duplicate Precision Field Duplicate Precision Field Duplicate Precision
DUP-3-SC	2-Butanone Acetone Carbon disulfide	J J J	Field Duplicate Precision Field Duplicate Precision Field Duplicate Precision

PRDI-11-SC-0-15	1,2,4-Trimethylbenzene	J	Surrogate Recovery/IS Recovery
	4-Isopropyltoluene	J	Surrogate Recovery/IS Recovery
	Acetone	J	Surrogate Recovery/IS Recovery
	Benzene	J	Surrogate Recovery/IS Recovery
	Carbon disulfide	J	Surrogate Recovery/IS Recovery
	Chloroform	J	Surrogate Recovery/IS Recovery
	Total cyanide	UJ	MS/MSD Recovery
	Tetrachloroethene	J	Surrogate Recovery/IS Recovery
	Toluene	J	Surrogate Recovery/IS Recovery
	All other VOC target analytes	UJ	Surrogate Recovery/IS Recovery

REFERENCES

U.S. Environmental Protection Agency (USEPA). "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use," EPA-540-R-08-005. January 2009.

U.S. Environmental Protection Agency (USEPA) 2020a. Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review, EPA-540-R-20-005. November 2020.

U.S. Environmental Protection Agency (USEPA) 2020b. Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA-542-R-20-006. November 2020.

Project: Puget Sound Energy – South State Street Preliminary Remedial Design Investigation September 2021 Subtidal Sediment Sampling Event

GEI File No: 0186-890-03

Date: March 10, 2022

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of sediment samples collected as part of the September 2021 subtidal sediment sampling event, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the South State Street Manufactured Gas Plant Site in Bellingham, Washington.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2020) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

The data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times and Sample Preservation
- Surrogate Recoveries
- Method Blanks
- Matrix Spikes/Matrix Spike Duplicates
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Field Duplicates
- Instrument Tuning
- Internal Standards
- Initial Calibrations (ICALs)
- Continuing Calibrations (CCALs)
- Miscellaneous

VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

TABLE 1: SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

Laboratory SDG	Samples Validated
21I0209	PRDI-15-SS, PRDI-16-SS, PRDI-18-SS, PRDI-19-SS, PRDI-20-SS, PRDI-22-SS, PRDI-24-SS, PRDI-25-SS, PRDI-26-SS, PRDI-27-SS, PRDI-29-SS, PRDI-30-SS, PRDI-31-SS, PRDI-32-SS, PRDI-37-SS, PRDI-40-SS
21I0238	PRDI-36-SC-0-15, PRDI-Dup-1-SC, PRDI-36-SC-15-30, PRDI-37-SC-0-15, PRDI-Dup-2-SC, PRDI-37-SC-15-30, PRDI-39-SC-0-15, PRDI-39-SC-15-30, PRDI-40-SC-0-15, PRDI-40-SC-15-30
21J0467	PRDI-13-SS, PRDI-14-SS, PRDI-23-SS, PRDI-34-SS

CHEMICAL ANALYSIS PERFORMED

Analytical Resources, Inc. (ARI), located in Tukwila, Washington, performed laboratory analyses on the samples using the following method:

- Polycyclic Aromatic Hydrocarbons (PAHs) by Method SW8270E-SIM

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

ARI provided the required deliverables for the data validation according to the National Functional Guidelines. The laboratory followed adequate corrective action processes and the identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for each analysis. The sample coolers arrived at the laboratory within the appropriate temperatures of between 2 and 6 degrees Celsius, with the exception noted below.

SDGs 21I0209, 21I0238, and 21J0467: One sample cooler temperature recorded at the laboratory was 1.7 degrees Celsius. It was determined through professional judgment that since the samples were not frozen, this temperature should not affect the sample analytical results.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in an environmental sample. Surrogates are used for organic analyses and are added to the samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries (%R) are calculated following analysis. The surrogate recoveries for field samples were within the laboratory control limits, with the following exceptions:

SDG 21I0209: (PAHs) The %R values for surrogates 2-Methylnaphthalene-d10, dibenzo[a,h]anthracene-d14, and fluoranthene-d10 were not recoverable in Samples PRDI-18-SS and PRDI-22-SS, because of sample dilution (50X and 100X, respectively). The surrogates are added to the sample when it is extracted. If the sample is diluted 10X or more, recovery of the surrogates is often not possible because it is also diluted below the linear calibration range of the instrument. No action was required for these outliers.

SDG 21I0238: (PAHs) The %R values for surrogates 2-Methylnaphthalene-d10, dibenzo[a,h]anthracene-d14, and fluoranthene-d10 were not recoverable in Samples PRDI-36-SC-0-15, PRDI-Dup-1-SC, PRDI-36-SC-15-30, PRDI-39-SC-0-15, and PRDI-39-SC-15-30, because of sample dilution (100X). The surrogates are added to the sample when it is extracted. If the sample is diluted 10X or more, recovery of the surrogates is often not possible because it is also diluted below the linear calibration range of the instrument. No action was required for these outliers.

SDG 21J0467: (PAHs) The %R for surrogate fluoranthene-d10 was greater than the control limits in Samples PRDI-14-SS, PRDI-23-SS, and PRDI-34-SS; however, the samples were spiked with two additional surrogates and in each case the %R values were within their respective control limits. No action was required for these outliers.

Method Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For each sample batch, method blanks were analyzed at the required frequency. None of the analytes of interest were detected in the method blanks.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a %R is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the results from the MS and MSD, the relative percent difference (RPD) is calculated.

The %R control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 21I0209: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-29-SS. The %R values for benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the MS/MSD extracted on 9/23/2021. The positive results for these target analytes were qualified as estimated (J) in this sample.

Additionally, in the same MS/MSD sample set, the %R values for benzo(b)fluoranthene and benzo(k)fluoranthene were greater than the control limits in the MSD; however, the %R values for these target analytes were within the control limits in the corresponding MS. No action was required for these outliers.

SDG 21I0238: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-37-SC-0-15. The %R values for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were less than the control limits in the MS/MSD extracted on 9/23/2021. The positive results for these target analytes were qualified as estimated (J) in this sample.

Additionally, in the same MS/MSD sample set, the %R for benzo(a)anthracene was less than the control limits in the MS; however, the %R for this target analyte was within the control limits in the corresponding MSD. No action was required for this outlier.

SDG 21J0467: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-13-SS. The %R values for benzo(a)pyrene, chrysene, and dibenzo(a,h)anthracene were greater than the control limits in the MSD extracted on 11/10/2021; however, the %R values for these target analytes were within the control limits in the corresponding MS. No action was required for these outliers.

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, control limits for accuracy and precision in the LCS and its duplicate (LCSD) are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to each sample in the associated batch, instead of just the parent sample. The %R control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 21J0467: (PAHs) The %R values for benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the LCS extracted on 11/10/2021. The positive results for these target analytes were qualified as estimated (J) in Samples PRDI-13-SS, PRDI-14-SS, PRDI-23-SS, and PRDI-34-SS.

Field Duplicates

Field duplicates are similar to laboratory duplicates in that they are used to assess precision. Two samples (parent and duplicate) are created in the field by subsampling the homogenized sample and submitting them to the lab as separate samples. Duplicate samples were collected and analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration greater than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for soil samples is 50 percent.

SDG 21I0238: Two field duplicate sample pairs, PRDI-36-SC-0-15/PRDI-Dup-1-SC and PRDI-37-SC-0-15/PRDI-Dup-2-SC, were submitted with this SDG. The precision criteria for the target analytes were met for these sample pairs.

Instrument Tuning

Instrument tuning for analyses by gas chromatography/mass spectrometry (GC/MS) are completed to ensure that mass resolution, identification, and sensitivity of the analyses are acceptable. Instrument tuning should be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The frequency and specified acceptance criteria were met for each applicable analysis.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in an environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. The internal standard recoveries were within the control limits, with the following exceptions:

SDG 21I0209: (PAHs) The internal standard recoveries for chrysene-d12 and perylene-d12 were greater than the control limits in Sample PRDI-25-SS. The positive result for dibenzo(a,h)anthracene was qualified as estimated (J) in this sample.

The internal standard recoveries perylene-d12 were greater than the control limits in Samples PRDI-26-SS and PRDI-29-SS. The positive results for dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene were qualified as estimated (J) in these samples.

Initial Calibrations (ICALs)

The initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent relative standard deviation (%RSD) and relative response factors (RRF) values were within the control limits stated in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020).

Continuing Calibrations (CCALs)

The continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent difference (%D) and relative response factors (RRF) values were within the control limits in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020).

Miscellaneous

SDG 21I0209: (PAHs) The laboratory reported two sets of results for Samples PRDI-15-SS, PRDI-16-SS, PRDI-18-SS, PRDI-22-SS, PRDI-24-SS, PRDI-25-SS, PRDI-26-SS, PRDI-29-SS, PRDI-31-SS, PRDI-37-SS, and PRDI-40-SS, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The following lists which analysis should be used, and which were labeled as do not report (DNR) and should not be used for any purpose.

Samples PRDI-15-SS and PRDI-24-SS: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for benzo(k)fluoranthene and dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Samples PRDI-16-SS, PRDI-26-SS, and PRDI-37-SS: The initial results for benzo(a)pyrene and the reanalysis results for benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were labeled as DNR and should not be used for any purpose.

Samples PRDI-18-SS, PRDI-25-SS, PRDI-29-SS, and PRDI-31-SS: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Sample PRDI-22-SS: The initial results for the PAH target analytes were labeled as DNR and should not be used for any purpose.

Sample PRDI-40-SS: The initial results for benzo(a)anthracene, benzo(a)pyrene, and chrysene and the reanalysis results for benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were labeled as DNR and should not be used for any purpose.

SDG 21I0238: (PAHs) The laboratory reported two sets of results for Samples PRDI-36-SC-0-15, PRDI-Dup-1-SC, PRDI-36-SC-15-30, PRDI-37-SC-0-15, PRDI-Dup-2-SC, PRDI-37-SC-15-30, PRDI-39-SC-0-15, PRDI-39-SC-15-30, and PRDI-40-SC-15-30, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The following lists which analysis should be used, and which were labeled as DNR and should not be used for any purpose.

Samples PRDI-36-SC-0-15, PRDI-Dup-1-SC, PRDI-36-SC-15-30, and PRDI-39-SC-15-30: The initial results for the PAH target analytes were labeled as DNR and should not be used for any purpose.

Samples PRDI-37-SC-0-15, PRDI-Dup-2-SC, and PRDI-40-SC-15-30: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for benzo(k)fluoranthene and dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

Samples PRDI-37-SC-15-30 and PRDI-39-SC-0-15: The initial results for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and the reanalysis results for dibenzo(a,h)anthracene were labeled as DNR and should not be used for any purpose.

SDG 21J0467: (PAHs) The laboratory reported two sets of results for Sample PRDI-13-SS, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for benzo(a)anthracene, benzo(a)pyrene, and chrysene and the reanalysis results for benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were labeled as DNR and should not be used for any purpose.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD %R values, with the exceptions noted above. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and laboratory/field duplicate RPD values.

The data are acceptable for the intended use, with the following qualifications listed below in Table 2.

TABLE 2: SUMMARY OF QUALIFIED SAMPLES

Sample ID	Analyte	Qualifier	Reason
PRDI-13-SS	Benzo(b)fluoranthene	J	LCS Recovery
	Benzo(k)fluoranthene	J	LCS Recovery
	Dibenzo(a,h)anthracene	J	LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	LCS Recovery
PRDI-14-SS	Benzo(b)fluoranthene	J	LCS Recovery
	Benzo(k)fluoranthene	J	LCS Recovery
	Dibenzo(a,h)anthracene	J	LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	LCS Recovery
PRDI-23-SS	Benzo(b)fluoranthene	J	LCS Recovery
	Benzo(k)fluoranthene	J	LCS Recovery
	Dibenzo(a,h)anthracene	J	LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	LCS Recovery
PRDI-25-SS	Dibenzo(a,h)anthracene	J	Internal Standard Recovery
PRDI-26-SS	Dibenzo(a,h)anthracene	J	Internal Standard Recovery
	Indeno(1,2,3-cd)pyrene	J	Internal Standard Recovery
PRDI-29-SS	Benzo(a)anthracene	J	MS/MSD Recovery
	Benzo(a)pyrene	J	MS/MSD Recovery
	Chrysene	J	MS/MSD Recovery
	Dibenzo(a,h)anthracene	J	MS/MSD Recovery/Internal Standard Recovery
	Indeno(1,2,3-cd)pyrene	J	MS/MSD Recovery/Internal Standard Recovery
PRDI-34-SS	Benzo(b)fluoranthene	J	LCS Recovery
	Benzo(k)fluoranthene	J	LCS Recovery
	Dibenzo(a,h)anthracene	J	LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	LCS Recovery

PRDI-37-SC-0-15	Benzo(a)pyrene	J	MS/MSD Recovery
	Benzo(b)fluoranthene	J	MS/MSD Recovery
	Benzo(k)fluoranthene	J	MS/MSD Recovery
	Chrysene	J	MS/MSD Recovery
	Indeno(1,2,3-cd)pyrene	J	MS/MSD Recovery

REFERENCES

U.S. Environmental Protection Agency (USEPA). “Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use,” EPA-540-R-08-005. January 2009.

U.S. Environmental Protection Agency (USEPA) 2020. Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review, EPA-540-R-20-005. November 2020.

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Project: Puget Sound Energy – South State Street Preliminary Remedial Design Investigation September 2021, January 2022, February 2022, and April 2022 Groundwater Sampling Events

GEI File No: 0186-890-03

Date: July 29, 2022

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of groundwater samples collected as part of the September 2021, January 2022, February 2022, and April 2022 groundwater sampling events, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the South State Street Manufactured Gas Plant Site in Bellingham, Washington.

Please note that this report was originally dated February 22, 2022. This report was revised on April 3, 2022 to include the addition of SDGs 22B0103, 22B0129, and 22B0161. This report was revised again on July 20, 2022 to include the addition of SDG 22D0188.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2020a) and Inorganic Superfund Methods Data Review (USEPA, 2020b) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

The data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times and Sample Preservation
- Surrogate Recoveries
- Method and Trip Blanks
- Matrix Spikes/Matrix Spike Duplicates
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Laboratory and Field Duplicates

- Instrument Tuning
- Internal Standards
- Initial Calibrations (ICALs)
- Continuing Calibrations (CCALs)
- Miscellaneous

VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

TABLE 1: SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

Laboratory SDG	Samples Validated
21I0294	MW-24_092021, MW-28_092021, MW-42_092021, MW-54_092021, MW-55_092021, MW-60_092021, TB-1_092021, TB-2_092021
21I0320	MW-29_092121, MW-34_092121, MW-36_092121, MW-38_092121, MW-40_092121, MW-45_092121, MW-46_092121, MW-59_092121, MW-62_092121, Dup-1_092121, TB-3_092121, TB-4_092121, TB-5_092121
21I0331	MW-53-092221, TB-6-092221
22A0426	GP-62-GW-011022, GP-64-GW-011022, GP-65-GW-011122, DUP-1-GW-011122, GP-66-GW-011222, GP-67-GW-011222, GP-68-GW-011222, GP-69-GW-011222, GP-74-GW-011322, GP-75-GW-011322, Trip Blank
22B0103	MW-40-020722, MW-53-020722, MW-54-020722, MW-55-020722, MW-59-020722, MW-61-020722, Dup-1-020722, TB-1-020722, TB-2-020722
22B0129	MW-29-020822, MW-34-020822, MW-36-020822, MW-42-020822, MW-46-020922, MW-62-020822, TB-3-020922, TB-4-020922
22B0161	MW-07-020922, MW-19-020922, MW-24-020922, MW-28-020922, MW-31-021022, MW-38-021022, MW-45-021022, MW-60-021022, TB-5-020922, TB-6-020922
22D0188	MW-07-040622, MW-19-040722, MW-24-040722, MW-28-040622, MW-31-040622, MW-38-040722, MW-45-040622, MW-60-040622

CHEMICAL ANALYSIS PERFORMED

Analytical Resources, Inc. (ARI), located in Tukwila, Washington, performed laboratory analyses on the samples using one or more of the following methods:

- Gasoline-range Hydrocarbons (NWTPH-Gx) by Method NWTPH-Gx;
- Petroleum Hydrocarbons (NWTPH-Dx) by Method NWTPH-Dx;
- Volatile Organic Compounds (VOCs) by Method SW8260D;

- Total and Dissolved Metals by Method SW6020B;
- Nitrate, Nitrite, and Nitrate + Nitrite by Method EPA353.2;
- Sulfate by Method EPA375.2;
- Total Cyanide by Methods EPA9014 or SM4500-CNE-99;
- Cyanide, Weak Acid Dissociable by Method SM4500-CNI-97; and
- Total Organic Carbon (TOC) by Method SM5310B-00

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

ARI provided the required deliverables for the data validation according to the National Functional Guidelines. The laboratory followed adequate corrective action processes and the identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory, with the following exceptions:

SDG 21I0320: The laboratory noted that Sample TB-3_092121 was listed as TB-6_092121 on the sample vial labels. The laboratory logged the sample as TB-3_092121, as written on the COC.

SDG 22A0426: The laboratory noted that the trip blank sample was received, but not listed on the COC. The laboratory logged the sample for NWTPH-Gx and VOC analyses.

SDG 22B0103: The laboratory noted that the sample vial label on one sample vial was smeared for Sample MW-55-020722. It was determined to be for this sample by matching the sample collection time on the label to the COC.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for each analysis, with the exceptions noted below. The sample coolers arrived at the laboratory within the appropriate temperatures of between 2 and 6 degrees Celsius, with the exception noted below.

SDG 21I0294: (Nitrate, Nitrite, and Nitrate + Nitrite) The 48-hour holding time for nitrate and nitrite analyses was exceeded in Samples MW-24_092021, MW-28_092021, and MW-60_092021. The positive results and reporting limits for these target analytes were qualified as estimated (J and UJ, accordingly) in these samples.

The 48-hour holding time for nitrate was exceeded in Sample MW-55_092021. The positive result for this target analyte was qualified as estimated (J) in this sample.

SDG 21I0331: One sample cooler temperature recorded at the laboratory was 0.8 degrees Celsius. It was determined through professional judgment that since the samples were not frozen, this temperature should not affect the sample analytical results.

SDG 22A0426: (NWTPH-Dx) The 7-day holding time for NWTPH-Dx analysis was exceeded in Samples GP-62-GW-011022 and GP-64-GW-011022. The positive results and reporting limit for diesel- and lube oil-range hydrocarbons were qualified as estimated (J and UJ, accordingly) in these samples.

SDG 22B0103: (Nitrate, Nitrite, and Nitrate + Nitrite) The 48-hour holding time for nitrate analysis was exceeded in Samples MW-40-020722, MW-53-020722, MW-54-020722, MW-55-020722, MW-59-020722, MW-61-020722, and Dup-1-020722. The positive results and reporting limit for these target analytes were qualified as estimated (J and UJ, accordingly) in these samples.

SDG 22B0161: (Nitrate, Nitrite, and Nitrate + Nitrite) The 48-hour holding time for nitrate and nitrite analyses was exceeded in Sample MW-28-020922. The reporting limits for these target analytes were qualified as estimated (UJ) in this sample.

The following preservation outliers were noted on the cooler receipt forms:

SDG 21I0294: (VOCs) The laboratory noted that sample vials were received with bubbles for Sample MW-42_092021. Since a total of five sample vials were submitted for these samples, the samples were analyzed from the remaining vials, accordingly.

SDG 22A0426: (VOCs) The laboratory noted that sample vials were received with bubbles for Sample GP-62-GW-011022. Since a total of three sample vials were submitted for these samples, the samples were analyzed from the remaining vials, accordingly.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in an environmental sample. Surrogates are used for organic analyses and are added to the samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries (%R) are calculated following analysis. The surrogate recoveries for field samples were within the laboratory control limits, with the following exceptions:

SDG 22A0426: (NWTPH-Dx) The %R values for surrogate o-Terphenyl were less than the control limits in Samples GP-69-GW-011222 and GP-74-GW-011322. The positive results for lube oil-range hydrocarbons were qualified as estimated (J) in these samples.

Method, Trip, and Rinsate Blanks

Method Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For each sample batch, method blanks were analyzed at the required frequency. None of the analytes of interest were detected in the method blanks, with the following exceptions:

SDG 22A0426: (VOCs) There was a positive result for naphthalene detected above the method detection limit, but below the reporting limit in the method blank extracted on 1/20/2022. The positive results for this target analyte were greater than 2X the concentration in the method blank in the associated field samples; therefore, no qualifications were required.

(Total Cyanide) There was a positive result for total cyanide detected in the method blank digested on 1/24/2022. The positive results for this target analyte were greater than 2X the concentration in the method blank in the associated field samples; therefore, no qualifications were required.

SDG 22B0103: (Total Cyanide) There was a positive result for total cyanide detected in the method blank digested on 2/11/2022. The positive results for this target analyte were qualified as non-detected (U) in Samples MW-40-020722, MW-53-020722, MW-54-020722, MW-55-020722, MW-61-020722, and Dup-1-020722.

SDG 22B0129: (Total Cyanide) There was a positive result for total cyanide detected in the method blank digested on 2/16/2022. The positive results for this target analyte were greater than 2X the concentration in the method blank in the associated field samples; therefore, no qualifications were required.

<u>Trip Blanks</u>

Trip blanks are analyzed to assess whether field sampling or sample transport processes may have introduced measurable concentrations of volatile analytes of interest into project samples. None of the analytes of interest were detected in the trip blanks.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a %R is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the results from the MS and MSD, the relative percent difference (RPD) is calculated. The %R control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exception:

SDG 21I0294: (Dissolved Metals) The laboratory performed an MS/MSD sample set on Sample MW-28_092021. The %R for dissolved iron was less than the control limits in the MS digested on 10/7/2021; however, the %R for this target analyte was within the control limits in the corresponding MSD. No action was required for this outlier.

SDG 22B0103: (Total Metals) The laboratory performed an MS/MSD sample set on Sample MW-59-020722. The %R for total iron was less than the control limits in the MSD digested on

2/18/2022; however, the %R for this target analyte was within the control limits in the corresponding MS. No action was required for this outlier.

SDG 22B0161: (Total Metals) The laboratory performed an MS/MSD sample set on Sample MW-28-020922. The %R for total iron was less than the control limits in the MS digested on 2/23/2022; however, the %R for this target analyte was within the control limits in the corresponding MSD. No action was required for this outlier.

(Nitrate, Nitrite, and Nitrate + Nitrite) The laboratory performed an MS/MSD sample set on Sample MW-24-020922. The %R values for nitrate + nitrite as N were less than the control limits in the MS/MSD digested on 2/21/2022. The reporting limit for this target analyte was qualified as estimated (UJ) in this sample.

(Sulfate) The laboratory performed an MS/MSD sample set on Sample MW-28-020922. The %R values for sulfate were less than the control limits in the MS/MSD digested on 2/16/2022. The positive result for this target analyte was qualified as estimated (J) in this sample.

(Cyanide, Weak Acid Dissociable) The laboratory performed an MS/MSD sample set on Sample MW-28-020922. The %R for cyanide, weak acid dissociable was less than the control limits in the MSD digested on 2/22/2022; however, the %R for this target analyte was within the control limits in the corresponding MS. No action was required for this outlier

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, control limits for accuracy and precision in the LCS and its duplicate (LCSD) are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to each sample in the associated batch, instead of just the parent sample. The %R control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits.

Laboratory Duplicates

Internal laboratory duplicate analyses are performed to monitor the precision of the analyses. Two separate aliquots of a sample are analyzed as distinct samples in the laboratory and the RPD between the two results is calculated. Duplicate analyses should be performed once per analytical batch. If one or more of the samples used has a concentration less than five times the reporting limit for that sample, the absolute difference is used instead of the RPD. The RPD control limits are specified in the laboratory documents. Laboratory duplicates were analyzed at the proper frequency and the specified acceptance criteria were met, with the following exception:

SDG 22B0129: (Cyanide, Weak Acid Dissociable) The laboratory performed a laboratory duplicate sample set on Sample MW-62-020822. The RPD for cyanide, weak acid dissociable was greater than the control limit in the laboratory duplicate digested on 2/17/2022. The positive result for this target analyte was qualified as estimated (J) in this sample.

Field Duplicates

Field duplicates are similar to laboratory duplicates in that they are used to assess precision. Two samples (parent and duplicate) are created in the field by subsampling the homogenized sample and submitting them to the lab as separate samples. Duplicate samples were collected and analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration greater than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for water samples is 20 percent.

SDG 21I0320: One field duplicate sample pair, MW-62_092121 and Dup-1_092121, was submitted with this SDG. The precision criteria for the target analytes were met for this sample pair, with the exception of sulfate. The positive results for this target analyte were qualified as estimated (J) in this sample pair.

SDG 22A0426: One field duplicate sample pair, GP-65-GW-011122 and DUP-1-GW-011122, was submitted with this SDG. The precision criteria for the target analytes were met for this sample pair, with the exception of diesel- and lube oil-range hydrocarbons. The positive results for these target analytes were qualified as estimated (J) in this sample pair.

SDG 22B0103: One field duplicate sample pair, MW-61-020722 and Dup-1-020722, was submitted with this SDG. The precision criteria for the target analytes were met for this sample pair, with the exception of total cyanide, nitrate, nitrate + nitrite as N, and dissolved selenium. The positive results for these target analytes were qualified as estimated (J) in this sample pair.

Instrument Tuning

Instrument tuning for analyses by gas chromatography/mass spectrometry (GC/MS) are completed to ensure that mass resolution, identification, and sensitivity of the analyses are acceptable. Instrument tuning should be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The frequency and specified acceptance criteria were met for each applicable analysis.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in an environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. The internal standard recoveries were within the control limits.

Initial Calibrations (ICALs)

The initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent relative standard deviation (%RSD) and relative response factors (RRF) values were within the control limits stated in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020a, USEPA 2020b).

Continuing Calibrations (CCALs)

The continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent difference (%D) and relative response factors (RRF) values were within the control limits in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020a, USEPA 2020b), with the following exceptions:

SDG 21I0294: (VOCs) The %D for naphthalene was outside the control limits in the continuing calibration performed on 9/23/2021. The positive result for this target analyte was qualified as estimated (J) in Sample MW-24_092021.

SDG 21I0320: (VOCs) The %D for naphthalene was outside the control limits in the continuing calibration performed on 9/28/2021. The positive results for this target analyte were qualified as estimated (J) in Samples MW-62_092121 and Dup-1_092121.

SDG 22A0426: (NWTPH-Gx) The %D for gasoline-range hydrocarbons was outside the control limits in the continuing calibration performed on 9/28/2021. The positive result for this target analyte was qualified as estimated (J) in Sample GP-62-GW-011022.

(VOCs) The %D for naphthalene was outside the control limits in the continuing calibration performed on 9/28/2021. The positive results for this target analyte were qualified as estimated (J) in Samples GP-62_GW-011022, GP-65-GW-011122, GP-68-GW-011222, GP-74-GW-011322, GP-75-GW-011322, and DUP-1-GW-011122.

Miscellaneous

SDG 21I0294: (VOCs) The laboratory reported two sets of results for Sample MW-24_092021, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial result for naphthalene and the reanalysis result for benzene were labeled as “do not report” (DNR) and should not be used for any purpose.

SDG 21I0320: (NWTPH-Dx) The laboratory reported two sets of results for Samples MW-62_092121 and Dup-1_092121, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for diesel-range hydrocarbons and the reanalysis results for lube oil-range hydrocarbons were labeled as DNR and should not be used for any purpose.

SDG 22A0426: (NWTPH-Gx) The laboratory reported two sets of results for Samples GP-62-GW-011022, GP-74-GW-011322, and GP-75-GW-011322, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results were labeled as DNR and should not be used for any purpose.

(NWTPH-Dx) The laboratory reported two sets of results for Samples GP-69-GW-011222, GP-74-GW-011322, and GP-75-GW-011322, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for diesel-range hydrocarbons and the reanalysis results for lube oil-range hydrocarbons were labeled as DNR and should not be used for any purpose.

(VOCs) The laboratory reported two sets of results for Samples GP-62-GW-011022 and GP-68-GW-011222, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial result for naphthalene and the reanalysis result for benzene were labeled as DNR and should not be used for any purpose.

The laboratory reported two sets of results for Samples GP-65-GW-011122, GP-74-GW-011322, GP-75-GW-011322, and DUP-1-GW-011122, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for benzene and naphthalene were labeled as DNR and should not be used for any purpose.

SDG 22B0103: (NWTPH-Gx) The laboratory reported two sets of results for Samples MW-40-020722, MW-53-020722, MW-54-020722, MW-55-020722, MW-59-020722, MW-61-020722, and Dup-1-020722, initial results and reanalysis results, due to ICV and CCV frequency exceedance. The initial results were labeled as DNR and should not be used for any purpose.

SDG 22B0161: (NWTPH-Gx) The laboratory reported two sets of results for Sample MW-31-021022, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial result was labeled as DNR and should not be used for any purpose.

(VOCs) The laboratory reported two sets of results for Sample MW-31-021022, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for benzene and naphthalene were labeled as DNR and should not be used for any purpose.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD %R values, with the exceptions noted above. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and laboratory/field duplicate RPD values, with the exceptions noted above.

The data are acceptable for the intended use, with the following qualifications listed below in Table 2.

TABLE 2: SUMMARY OF QUALIFIED SAMPLES

Sample ID	Analyte	Qualifier	Reason
GP-62-GW-011022	Diesel-range hydrocarbons	J	Holding Time
	Gasoline-range hydrocarbons	J	CCAL
	Lube oil-range hydrocarbons	UJ	Holding Time
	Naphthalene	J	CCAL
GP-64-GW-011022	Diesel-range hydrocarbons	J	Holding Time
	Lube oil-range hydrocarbons	J	Holding Time
GP-65-GW-011122	Diesel-range hydrocarbons	J	Field Duplicate Precision
	Lube oil-range hydrocarbons	J	Field Duplicate Precision
	Naphthalene	J	CCAL
DUP-1-GW-011122	Diesel-range hydrocarbons	J	Field Duplicate Precision
	Lube oil-range hydrocarbons	J	Field Duplicate Precision
	Naphthalene	J	CCAL

GP-68-GW-011222	Naphthalene	J	CCAL
GP-69-GW-011222	Lube oil-range hydrocarbons	J	Surrogate Recovery
GP-74-GW-011322	Lube oil-range hydrocarbons Naphthalene	J J	Surrogate Recovery CCAL
GP-75-GW-011322	Naphthalene	J	CCAL
MW-24_092021	Naphthalene Nitrate Nitrite	J UJ J	CCAL Holding Time Holding Time
MW-24-020922	Nitrate + nitrite as N	UJ	MS/MSD Recovery
MW-28_092021	Nitrate Nitrite	UJ UJ	Holding Time Holding Time
MW-28-020922	Nitrate Nitrite Sulfate	UJ UJ J	Holding Time Holding Time MS/MSD Recovery
MW-40-020722	Total cyanide Nitrate	U UJ	Method Blank Contamination Holding Time
MW-53-020722	Total cyanide Nitrate	U J	Method Blank Contamination Holding Time
MW-54-020722	Total cyanide Nitrate	U J	Method Blank Contamination Holding Time
MW-55_092021	Nitrate	J	Holding Time
MW-55-020722	Total cyanide Nitrate	U J	Method Blank Contamination Holding Time
MW-59-020722	Nitrate	J	Holding Time
MW-60_092021	Nitrate Nitrite	UJ UJ	Holding Time Holding Time
MW-61-020722	Total cyanide Nitrate Nitrate + Nitrite as N Dissolved selenium	UJ J J J	Method Blank Contamination/Field Duplicate Precision Holding Time/Field Duplicate Precision Field Duplicate Precision Field Duplicate Precision
Dup-1-020722	Total cyanide Nitrate Nitrate + Nitrite as N Dissolved selenium	UJ J J J	Method Blank Contamination/Field Duplicate Precision Holding Time/Field Duplicate Precision Field Duplicate Precision Field Duplicate Precision
MW-62_092121	Naphthalene Sulfate	J J	CCAL Field Duplicate Precision

MW-62-020822	Cyanide, Weak Acid Dissociable	J	Laboratory Duplicate Precision
Dup-1_092121	Naphthalene Sulfate	J J	CCAL Field Duplicate Precision

REFERENCES

U.S. Environmental Protection Agency (USEPA). "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use," EPA-540-R-08-005. January 2009.

U.S. Environmental Protection Agency (USEPA) 2020a. Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review, EPA-540-R-20-005. November 2020.

U.S. Environmental Protection Agency (USEPA) 2020b. Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA-542-R-20-006. November 2020.

Project: Puget Sound Energy – South State Street Preliminary Remedial Design Investigation March and April 2022 Sampling Event

GEI File No: 0186-890-03

Date: August 12, 2022

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of sediment samples collected as part of the March and April 2022 sampling events, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the South State Street Manufactured Gas Plant Site located in Bellingham, Washington.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2020) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

The data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times and Sample Preservation
- Surrogate Recoveries
- Method Blanks
- Matrix Spikes/Matrix Spike Duplicates
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Field Duplicates
- Instrument Tuning
- Internal Standards
- Initial Calibrations (ICALs)
- Continuing Calibrations (CCALs)
- Miscellaneous

VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

TABLE 1: SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

Laboratory SDG	Samples Validated
22D0021	PRDI-42-SS, PRDI-45-SS, PRDI-46-SS, PRDI-DUP-01
22D0310	PRDI-47-SS, PRDI-50-SS
22D0397	PRDI-58-SS, PRDI-DUP-2-SS, PRDI-59-SS
22E0022	PRDI-48-SS, PRDI-51-SS
22E0279	PRDI-47-SS, PRDI-49-SS, PRDI-50-SS, PRDI-52-SS
22F0067	PRDI-43-SS, PRDI-44-SS, PRDI-53-SS
22F0336	PRDI-60-SS, PRDI-61-SS, PRDI-62-SS

CHEMICAL ANALYSIS PERFORMED

Analytical Resources, Inc. (ARI), located in Tukwila, Washington, performed laboratory analyses on the samples using the following method:

- Polycyclic Aromatic Hydrocarbons (PAHs) by Method SW8270E-SIM

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

ARI provided the required deliverables for the data validation according to the National Functional Guidelines. The laboratory followed adequate corrective action processes and the identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for each analysis. The sample coolers arrived at the laboratory within the appropriate temperatures of between 2 and 6 degrees Celsius, with the exception noted below.

SDG 22D0397: One sample cooler temperature recorded at the laboratory was 14.3 degrees Celsius. This cooler was sent to the laboratory without sufficient ice. The positive results for the PAH target analytes were qualified as estimated (J) in Samples PRDI-58-SS, PRDI-59-SS, and PRDI-DUP-2-SS.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in an environmental sample. Surrogates are used for organic analyses and are added to the samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries (%R) are calculated following analysis. The surrogate recoveries for field samples were within the laboratory control limits.

Method Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For each sample batch, method blanks were analyzed at the required frequency. None of the analytes of interest were detected in the method blanks, with the following exceptions:

SDG 22D0021: (PAHs) There was a positive result for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene detected above the method detection limit, but below the reporting limit in method blank extracted on 4/12/2022. The positive results for these target analytes were greater than 5X the concentration in the method blank in the associated field samples; therefore, no qualifications were required.

SDG 22D0310: (PAHs) There was a positive result for benzo(a)pyrene detected above the method detection limit, but below the reporting limit in method blank extracted on 4/22/2022. The positive results for this target analyte were greater than 5X the concentration in the method blank in the associated field samples; therefore, no qualifications were required.

SDG 22E0279: (PAHs) There was a positive result for dibenzo(a,h)anthracene detected above the method detection limit, but below the reporting limit in method blank extracted on 5/20/2022. The positive results for this target analyte were greater than 5X the concentration in the method blank in the associated field samples; therefore, no qualifications were required.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a %R is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the results from the MS and MSD, the relative percent difference (RPD) is calculated. The %R control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 22D0021: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-42-SS. The %R and RPD values for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the MS/MSD extracted on 4/12/2022. The positive results for these target analytes were qualified as estimated (J) in Sample PRDI-42-SS.

SDG 22D0310: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-47-SS. The %R values for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the MS/MSD extracted on 4/22/2022. The positive results for these target analytes were qualified as estimated (J) in Sample PRDI-47-SS.

Additionally, in the same MS/MSD sample set, the %R values for benzo(k)fluoranthene and dibenzo(a,h)anthracene were greater than the control limits in the MSD; however, the %R values for these target analytes were within the control limits in the corresponding MS. No action was required for these outliers.

SDG 22D0397: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-58-SS. The RPD values for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the MS/MSD extracted on 5/4/2022. The positive results for these target analytes were qualified as estimated (J) in Sample PRDI-58-SS.

Additionally, in the same MS/MSD sample set, the %R values for benzo(a)anthracene, benzo(a)pyrene, and chrysene were greater than the control limits in the MS; however, the %R values for these target analytes were within the control limits in the corresponding MSD. No action was required for these outliers.

SDG 22F0067: (PAHs) The laboratory performed an MS/MSD sample set on Sample PRDI-43-SS. The RPD values for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the MS/MSD extracted on 6/8/2022. The positive results for these target analytes were qualified as estimated (J) in Sample PRDI-43-SS.

Additionally, in the same MS/MSD sample set, the %R values for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the MS; however, the %R values for these target analytes were within the control limits in the corresponding MSD. No action was required for these outliers.

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, control limits for accuracy and precision in the LCS and its duplicate (LCSD) are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to each sample in the associated batch, instead of just the parent sample. The %R control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for each analysis and the %R and RPD values were within the proper control limits, with the following exceptions:

SDG 22D0021: (PAHs) The %R values for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were greater than the control limits in the LCS extracted on 4/12/2022. The positive results for these target analytes were qualified as estimated (J) in Samples PRDI-42-SS, PRDI-45-SS, PRDI-46-SS, and PRDI-DUP-01.

Field Duplicates

Field duplicates are similar to laboratory duplicates in that they are used to assess precision. Two samples (parent and duplicate) are created in the field by subsampling the homogenized sample and submitting them to the lab as separate samples. Duplicate samples were collected and analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration less than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for sediment samples is 50 percent.

SDG 22D0397: One field duplicate sample pair, PRDI-58-SS and PRDI-DUP-2-SS, were submitted with this SDG. The precision criteria for the target analytes were met for these sample pairs, with the exception of benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. The positive results for these target analytes were qualified as estimated (J) in this sample pair.

SDG 22D0021: One field duplicate sample, PRDI-DUP-01, was submitted with this SDG. However, the parent sample, PRDI-55-SS, was archived and not submitted for chemical analysis.

Instrument Tuning

Instrument tuning for analyses by gas chromatography/mass spectrometry (GC/MS) are completed to ensure that mass resolution, identification, and sensitivity of the analyses are acceptable. Instrument tuning should be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The frequency and specified acceptance criteria were met for each applicable analysis.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in an environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. The internal standard recoveries were within the control limits.

Initial Calibrations (ICALs)

The initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent relative standard deviation (%RSD) and relative response factors (RRF) values were within the control limits stated in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020).

Continuing Calibrations (CCALs)

The continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. For inorganic analyses, the %R values were within the control limits of 90% and 110%. For organic analyses, the percent difference (%D) and relative response factors (RRF) values were within the control limits in the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 2020).

Miscellaneous

SDG 22F0067: (PAHs) The laboratory reported two sets of results for Sample PRDI-43-SS, initial results and reanalysis results, due to target analyte instrument calibration range exceedance. The initial results for benzo(a)anthracene, benzo(a)pyrene, and chrysene and the reanalysis results for all other PAH target analytes were labeled as DNR and should not be used for any purpose.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD %R values, with the exceptions noted above. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and field duplicate RPD values, with the exceptions noted above.

The data are acceptable for the intended use, with the following qualifications listed below in Table 2.

TABLE 2: SUMMARY OF QUALIFIED SAMPLES

Sample ID	Analyte	Qualifier	Reason
PRDI-42-SS	Benzo(a)anthracene	J	MS/MSD Recovery and Precision/LCS Recovery
	Benzo(a)pyrene	J	MS/MSD Recovery and Precision/LCS Recovery
	Benzo(b)fluoranthene	J	MS/MSD Recovery and Precision/LCS Recovery
	Benzo(k)fluoranthene	J	MS/MSD Recovery and Precision/LCS Recovery
	Chrysene	J	MS/MSD Recovery and Precision/LCS Recovery
	Dibenzo(a,h)anthracene	J	MS/MSD Recovery and Precision/LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	MS/MSD Recovery and Precision/LCS Recovery
PRDI-43-SS	Benzo(a)anthracene	J	MS/MSD Precision
	Benzo(a)pyrene	J	MS/MSD Precision
	Benzo(b)fluoranthene	J	MS/MSD Precision
	Benzo(k)fluoranthene	J	MS/MSD Precision
	Chrysene	J	MS/MSD Precision
	Dibenzo(a,h)anthracene	J	MS/MSD Precision
	Indeno(1,2,3-cd)pyrene	J	MS/MSD Precision
PRDI-45-SS	Benzo(a)anthracene	J	LCS Recovery
	Benzo(a)pyrene	J	LCS Recovery
	Benzo(b)fluoranthene	J	LCS Recovery
	Benzo(k)fluoranthene	J	LCS Recovery
	Chrysene	J	LCS Recovery
	Dibenzo(a,h)anthracene	J	LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	LCS Recovery
PRDI-46-SS	Benzo(a)anthracene	J	LCS Recovery
	Benzo(a)pyrene	J	LCS Recovery
	Benzo(b)fluoranthene	J	LCS Recovery
	Benzo(k)fluoranthene	J	LCS Recovery
	Chrysene	J	LCS Recovery
	Dibenzo(a,h)anthracene	J	LCS Recovery
	Indeno(1,2,3-cd)pyrene	J	LCS Recovery
PRDI-47-SS	Benzo(a)anthracene	J	MS/MSD Recovery
	Benzo(a)pyrene	J	MS/MSD Recovery
	Benzo(b)fluoranthene	J	MS/MSD Recovery
	Chrysene	J	MS/MSD Recovery
	Indeno(1,2,3-cd)pyrene	J	MS/MSD Recovery

PRDI-58-SS	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene	J J J J J J J	Sample Preservation/MS/MSD Precision Sample Preservation/MS/MSD Precision/Field Duplicate Precision Sample Preservation/MS/MSD Precision/Field Duplicate Precision Sample Preservation/MS/MSD Precision Sample Preservation/MS/MSD Precision Sample Preservation Sample Preservation/MS/MSD Precision/Field Duplicate Precision
PRDI-DUP-2-SS	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene	J J J J J J J	Sample Preservation Sample Preservation/Field Duplicate Precision Sample Preservation/Field Duplicate Precision Sample Preservation Sample Preservation Sample Preservation Sample Preservation/Field Duplicate Precision
PRDI-59-SS	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene	J J J J J J J	Sample Preservation Sample Preservation Sample Preservation Sample Preservation Sample Preservation Sample Preservation Sample Preservation
PRDI-DUP-01	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Indeno(1,2,3-cd)pyrene	J J J J J J J	LCS Recovery LCS Recovery LCS Recovery LCS Recovery LCS Recovery LCS Recovery LCS Recovery

REFERENCES

U.S. Environmental Protection Agency (USEPA). "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use," EPA-540-R-08-005. January 2009.

U.S. Environmental Protection Agency (USEPA). "Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review," EPA-540-R-20-005. November 2020.

APPENDIX F

Evaluation of Pre-Remedial Design Investigation Data Related to Permeable Reactive Barrier Treatment

Technical Memorandum

TO: Neil Morton, GeoEngineers, Inc.

FROM: Clint Jacob, PE, LG

DATE: September 27, 2022

RE: **Evaluation of Pre-Remedial Design Investigation Data Related to Permeable Reactive Barrier Treatment**
Former South State Street Manufactured Gas Plant Site
Bellingham, Washington
Project No. 0611004.020

Introduction

This technical memorandum evaluates data collected during the Pre-Remedial Design Investigation (PRDI), completed by GeoEngineers, Inc. (GeoEngineers) in 2021 and 2022, at the former South State Street Manufactured Gas Plant (MGP) in Bellingham, Washington (Site). PRDI data are being used to evaluate technical feasibility of a permeable reactive barrier (PRB) to treat groundwater contaminants migrating from the uplands portion of the Site to the marine portion of the Site. This memorandum also discusses the target treatment area and contaminants, aquifer redox conditions, remedial approach, conceptual design of a PRB, and additional design data needs to be resolved through groundwater flux testing, bench testing, and possible pilot testing. Design testing is described in a separate work plan (Landau 2022). This memorandum is included as an appendix to the PRDI report (GeoEngineers 2022) and, therefore, only briefly summarizes and discusses data which are presented comprehensively in that report. The information covered in this memorandum assumes that the reader is familiar with the content and conclusions of the PRDI report.

Target Treatment Zone and Contaminants

As will be further discussed in this memorandum, the target treatment zone consists of the shallow groundwater zone present on top of the bedrock on the east side of the pedestrian path, east of the BNSF railroad tracks to the nearest possible point of discharge at the "pocket beach" (Figure 1), where groundwater discharges to marine surface water. Groundwater from the upland portion of the Site carries contaminants from the vicinity of the former gas holders, through the soil and steep, weathered bedrock, and into groundwater within fill material beneath the pedestrian path and the railroad tracks. The shallow groundwater zone begins at the top of the bedrock outcrop on the east side of the pedestrian path and extends approximately northwest beneath the path, adjacent vegetated slope, and railroad grade toward the pocket beach.

Stratigraphy and groundwater conditions near the path are defined by three monitoring wells (MW-28, MW-29, and MW-62) and by nine PRDI borings (GP-58 through GP-64, GP-74, GP-75), as shown on Figure 1. As shown on cross-section C-C', which is oriented through these wells and borings (Figure 2), approximately 16 feet (ft) of fill overlies bedrock at the three monitoring wells. Fill consists of relatively conductive sand and gravel (GP, SP) ranging to sand with silt (SP-SM).[1] Observed depth to groundwater in monitoring wells MW-28, MW-29, and MW-62 during the dry season (September 2021) and wet season (February 2022) ranged from 8 to 12 ft below ground surface (bgs). As shown on Figure 2, the depth to bedrock decreases abruptly to the north. North of GP-58, the depth to bedrock decreases substantially to approximately 3 ft bgs, and groundwater was not observed at borings GP-70 through GP-73 during the PRDI. Monitoring well MW-58 that was installed in 2016 is located between GP-71 and GP-72 and extends approximately 10 ft into bedrock. Water has periodically been detected in MW-58. However, when the water has been purged from MW-58 prior to sampling the well, the well has remained dry indicating that the bedrock is not a groundwater bearing unit. Monitoring well MW-58 likely acts as a sump and accumulates minor perched water over a long period of time.

Benzene, naphthalene, total petroleum hydrocarbons gasoline- and diesel-range (TPH-G and TPH-Dx, respectively; collectively TPH), and cyanide (CN) are groundwater contaminants targeted for treatment over the southern portion of the cross section C-C' transect (Figure 2); these contaminants were detected above cleanup levels (CULs) or screening levels (SLs) at monitoring wells MW-28, MW-29, and MW-62. PRDI results are shown for benzene and naphthalene on Figure 3, for TPH-G and TPH-Dx on Figure 4, and for CN on Figure 5. The data for TPH, benzene, and naphthalene show a similar distribution, with the highest concentrations occurring at the north end of this segment (MW-28), while the highest concentrations of CN occur at the south end (MW-29), as summarized below:

- Benzene was detected at more than 1,000 times the CUL at MW-28, in the range of 10 to 1,000 times the CUL at MW-62, and less than 10 times the CUL (wet season) and below the CUL (dry season) at southern well MW-29.
- Naphthalene concentrations were highest (less than 100 times the CUL) at MW-28 to the north, lower at MW-62, and below the CUL at MW-29 to the south.
- TPH-G exceeded SLs by less than 100 times at both MW-28 and MW-62 but was below the SL at southern well MW-29. TPH-Dx was detected at all three wells at less than 10 times the SL.
- CN was detected above the CUL at all three wells, with the highest concentrations occurring to the south. CN concentrations at south well MW-29 were in the range of 10 to 100 times the CUL but decreased to less than 10 times the CUL at north well MW-28.

Moving west from the pedestrian path to the pocket beach, detections of TPH are collocated together in a localized area at the north end of the beach. TPH were below SLs at all monitoring wells west of the railroad tracks, near the pocket beach, and at most PRDI porewater sample locations at the pocket beach. However, SLs for TPH were exceeded in one or more porewater samples near the north end of the pocket beach. At porewater location PRDI-2 sampled in June 2021, benzene was detected at more than 1,000 times the CUL, and naphthalene was detected between 10 and 100 times the CUL. In December 2021, the PRDI-2 location was resampled (PRDI-2A) and other nearby step out locations

[1] Contains 5 to 30 percent silt.

(PRDI-2B through PRDI-2E) were also sampled. Benzene detections less than 10 times the CUL occurred at nearby porewater locations PRDI-2A and PRDI-2C. TPH-G was also detected at PRDI-2 between 10 and 100 times the CUL. TPH-Dx results at less than 10 times the CUL were detected at PRDI-2 and PRDI-2A.

CN exceeded the CUL at just one of the pocket beach porewater sample locations (PRDI-4). CN at porewater sample location PRDI-4 was less than 10 times the CUL. Similarly, CN was detected at the three monitoring wells, located west of the railroad tracks and near the head of the beach (MW-34, MW-46, and MW-61), at less than 10 times the CUL. Well MW-46, where the CUL was exceeded in both the dry and wet season, is in line with the estimated groundwater flow path between the highest CN detections east of the railroad tracks (MW-29 and MW-62) and the beach porewater exceedance at PRDI-4.

Aquifer Redox Conditions

PRDI total organic carbon (TOC) and aquifer redox data collected in the targeted treatment area (MW-28, MW-29, and MW-62) indicate anaerobic conditions. PRDI groundwater data for these three wells are presented in Table 1. TOC ranges from 5 to 12 milligrams per liter (mg/L) at the middle (MW-62) and south wells (MW-29) and is higher (between 17 and 19 mg/L) at the northern well (MW-28) where TPH concentrations are the highest. TOC of between 5 and 10 mg/L generally presents enough oxygen demand to result in anaerobic conditions. Anaerobic conditions were further indicated by the sampling results for the natural electron acceptors nitrate, iron, and sulfate, which are utilized by anaerobic bacteria for TPH biodegradation, as follows:

- Nitrate, the first natural electron acceptor to be consumed following depletion of oxygen, was low to not detected; three detections out of seven samples ranged from 0.05 to 1.5 mg/L.
- Maximum concentrations of dissolved (ferrous) iron, which is generated under anaerobic conditions, ranged from 0.5 to 18 mg/L at the three wells.
- The distribution of sulfate at the three wells is consistent with sulfate utilization by anerobic bacteria for TPH biodegradation. The lowest sulfate (between 5 and 10 mg/L) was measured at well MW-28 where the highest concentrations of TPH occur. Sulfate concentrations at the wells with lower TPH concentrations (MW-29 and MW-62) was much higher, ranging from 73 to 203 mg/L.

  Sulfate in groundwater at the Site is the result of tidal-influenced intrusion of seawater. Seawater contains approximately 2,600 mg/L of sulfate. At other monitoring wells nearer to the pocket beach and where TPH concentrations were below CULs (i.e., MW-34 and MW-46), sulfate is much higher with maxima ranging from to 1,420 to 1,750 mg/L (see PRDI Table 4); these higher sulfate concentrations result from both low TPH concentrations and more intrusion of seawater occurring closer to the beach. This intrusion of seawater provides sulfate for natural attenuation of TPH through anaerobic biodegradation. The spatial distribution of sulfate indicated by the PRDI data indicates that natural attenuation occurs all along the flow path from the impacted monitoring wells east of the railroad tracks to the pocket beach.

- It is notable, that nitrate was higher and ferrous iron was lower in the wet season (February) samples, consistent with an influx of aerobic water from infiltration of precipitation.

The anaerobic conditions indicated by PRDI data likely result from both the natural depositional environment and the presence of TPH contamination. Marine shoreline aquifer conditions are often naturally anaerobic due to naturally occurring organic carbon. The presence of TPH contamination also results in anaerobic conditions. The sulfate-reducing condition observed at the TPH-impacted wells is likely the result of this contamination, while less reducing (nitrate- to iron-reducing conditions) at wells with lower concentrations of TPH may represent the natural environment.

Remedial Approach

The recommended remedial approach is construction of a PRB to treat TPH and CN. A PRB consists of a trench oriented perpendicular to groundwater flow. The PRB is backfilled with reactive media that treats contaminated groundwater as it flows through the trench. The PRB will be located east of the railroad tracks and pedestrian footpath, at the base of the bedrock outcrop, to intercept and treat contaminated groundwater flowing from the upland area in advance of its discharge at the pocket beach.

PRB Conceptual Design

The PRB will be approximately 160 ft long and extend from GP-70 to a location south of MW-29.[2] The anticipated length and location of the PRB is presented on Figure 6. The PRB will be located hydraulically upgradient (east) of monitoring wells MW-28, MW-29, and MW-62, which will be used to monitor the treatment effects of the PRB.

The PRB will extend from above the seasonal high water table to bedrock. As shown on cross-section C-C’ (Figure 2), the highest groundwater level observed during the PRDI was approximately 8 ft bgs (elevation 12 ft) and the bedrock was encountered at elevation 4 or 5 ft (approximately 16 ft bgs). It is anticipated that the PRB will be constructed from 6 to 16 ft bgs (between elevations 4 to 14 ft), as shown in profile on Figure 7. It is anticipated that the PRB will be constructed using standard excavator and trench box methods commonly used to install subsurface utilities.

Trench backfill will consist of mixed sand, gypsum, and granular zero-valent iron (ZVI). Sand is required to maintain the hydraulic conductivity of the PRB and to prevent excessive settling of backfill as the gypsum dissolves over time. Gypsum ($CaSO_4$) will provide a slow release of sulfate, as the electron acceptor, to enhance biodegradation of TPH. ZVI is known to immobilize CN through

[2] The southern end of the PRB will be as near as is convenient to the railroad signal controls located approximately 35 ft south of well MW-29.

adsorption and through precipitation of insoluble iron-cyanides (commonly known as Turnbull's Blue and Prussian Blue; Adams 1992, Dzombak et al. 2005, Ghosh et al. 1999). Likely percentages of PRB materials are 55 percent sand, 30 percent gypsum, and 15 percent ZVI.

Over time, the gypsum or ZVI may become depleted, and the barrier would need to be refreshed if continued treatment is needed to achieve and maintain CULs. ZVI may last approximately 10 to 20 years, while the longevity of gypsum may be between 3 and 5 years. It is anticipated that the gypsum and ZVI components of the PRB could be refreshed through injection of gypsum and ZVI slurries along the PRB alignment using direct-push drilling, avoiding replacement of the PRB backfill. The sand matrix of the PRB will allow for effective injection and distribution of the injected slurries.

Design Testing Data Needs

Aquifer flux testing and bench testing are recommended to collect design-level data and evaluate treatment effectiveness. A field pilot test may also be performed if the cleanup schedule allows and additional proof of concept is desired. The design testing elements are summarized below and described in further detail in the design test work plan (PRDI Appendix G; Landau 2022).

- <u>Aquifer flux testing:</u> It is anticipated that aquifer flux testing would allow estimation of groundwater and contaminant flux through the PRB. Wet season measurement will represent maximum flux used to design PRB thickness for adequate residence time to treat groundwater contaminants. Dry season measurements will be combined with wet season results to calculate average flux, which will be used to estimate the longevity of the gypsum and ZVI components of the PRB.
- <u>Bench testing</u>: It is anticipated that bench testing would primarily answer design questions related to optimal percent ZVI and gypsum and gypsum size to be used in PRB backfill to achieve the desired treatment and longevity. The ZVI particle size will be based on literature values and consultation with vendors
- <u>Field pilot testing (optional):</u> A field pilot test may be performed if the cleanup schedule allows and additional proof of concept is desired. It is anticipated that pilot testing would consist of two short PRB segments (e.g., 30 ft) located upgradient of the maximum TPH concentrations in groundwater at MW-28 and the maximum CN concentrations in groundwater at MW-29. Pilot test groundwater monitoring performed at these two wells would be used to evaluate treatment effectiveness. One to 2 years of pilot testing monitoring would likely be required to evaluate treatment effects over wet and dry seasons. Furthermore, although the PRB is expected to immediately treat contaminant flux passing through it, a period of flushing and treatment will be required in the zone between the PRB and downgradient monitoring wells before the treatment effects will be fully observed at the monitoring wells.

Use of This Technical Memorandum

This technical memorandum has been prepared for the exclusive use of GeoEngineers and Puget Sound Energy (PSE) for specific application to the South State Street MGP Site project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau, shall be at the user's sole risk. Landau warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

LANDAU ASSOCIATES, INC.

Clint Jacob, PE, LG
Principal

CLJ/JAF/ljl
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Attachments

Figure 1. Target Treatment Zone
Figure 2. Target Treatment Zone Cross Section C-C'
Figure 3. PRDI Groundwater/Porewater Analytical Results, Benzene and Naphthalene
Figure 4. PRDI Groundwater/Porewater Analytical Results, Gasoline and Diesel/Heavy Oil
Figure 5. PRDI Groundwater/Porewater Analytical Results, WAD Cyanide
Figure 6. Anticipated PRB Alignment
Figure 7. Anticipated PRB Profile
Table 1. PRDI Groundwater Data for PRB Alignment

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Adams, M.D. 1992. "The Removal of Cyanide from Aqueous Solution by the Use of Ferrous Sulphate." *Journal of the South African Institute of Mining and Metallurgy* 92 (1):17-25. January.

Dzombak, D.A, R.S. Ghosh, and G.M. Wong-Chong. 2005. *Cyanide in Water and Soil: Chemistry, Risk, and Management*. Boca Raton, FL: CRC Press.

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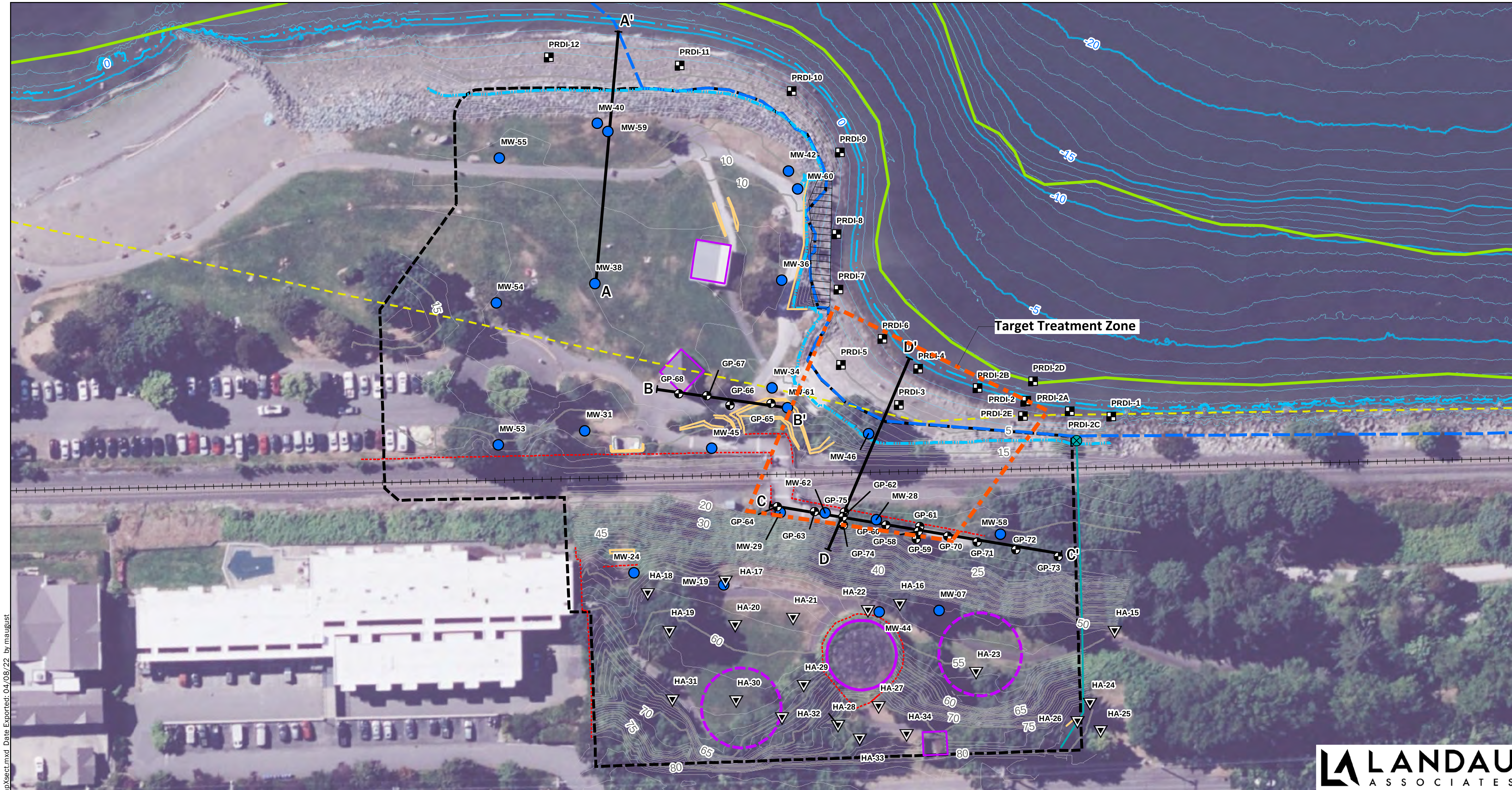

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Notes:
1. The locations of all features shown are approximate.
2. Mean High Tide defines the boundary between the Upland Unit and Marine Unit.
3. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Base upland survey from Larry Steel Associates, 2022. Base bathymetric survey from David Evans and Assocates, 2021. Aerial from Bing.

Projection: NAD83 WA State Plane, N Zone, US Foot
Vertical Datum: NAVD88

Legend

- Direct Push Soil Boring
- Shallow Hand Auger Soil Sample
- Monitoring Well
- Intertidal Sediment and Porewater Sample Location
- Stormwater Outfall
- Stormwater Pipe
- Approximate Limits of Aquatic Vegetation
- Fence
- Retaining Wall
- BNSF Centerline
- Inner Harbor Line
- OHWM (9.70' NAVD88)
- MLLW (el. 0.48' NAVD88)
- Wood Pilings Area
- Site Structures
- Former Gas Holder
- Marine Unit Boundary
- Upland Unit Boundary

Bathymetry Contours
- 1-Foot Contour
- 5-foot Contour

Upland Contours
- 1-Foot Contour
- 5-foot Contour

Project North   True North

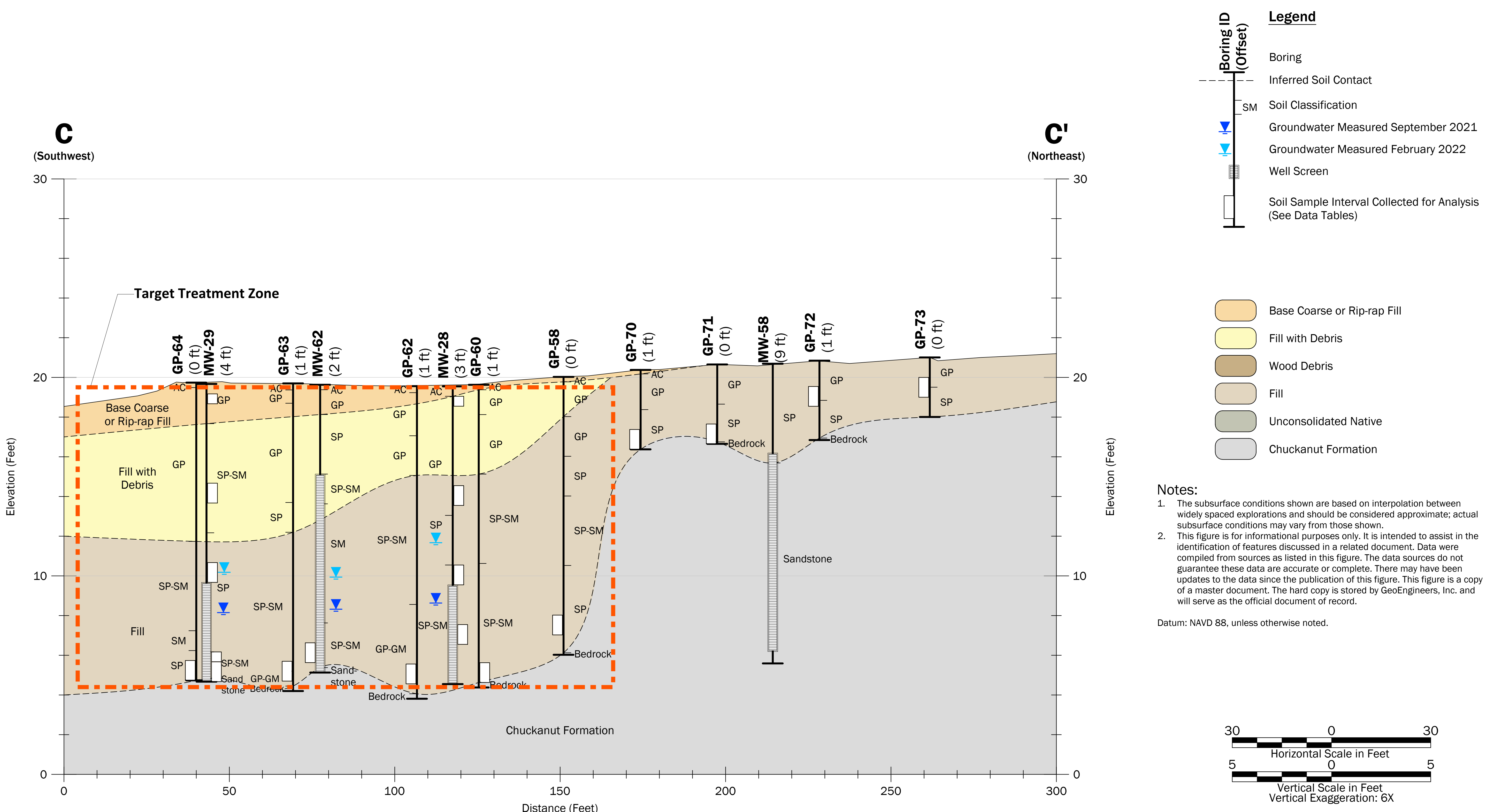
75   0   75
Feet

Target Treatment Zone

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 1



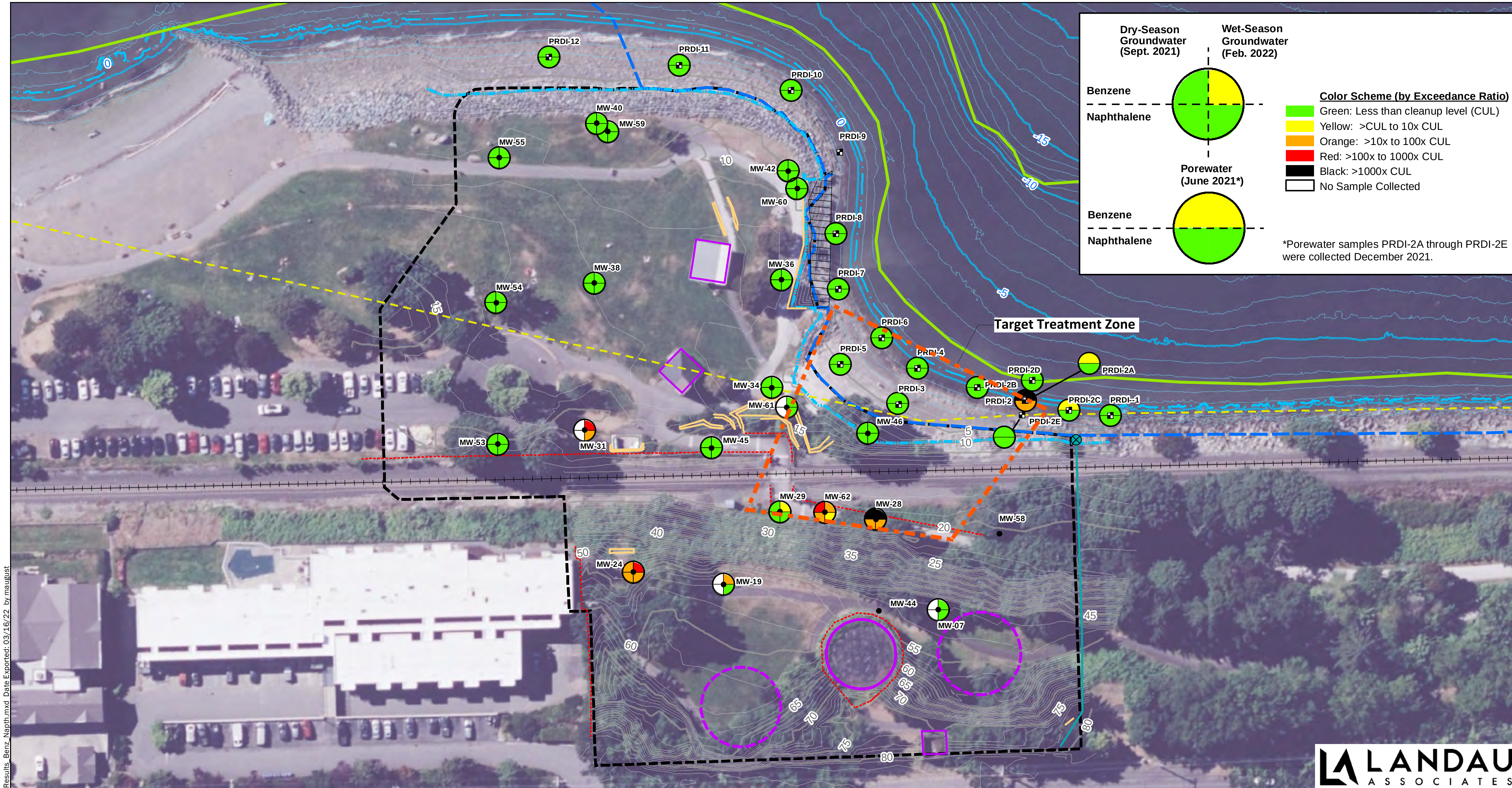
Target Treatment Zone Cross Section C-C'

South State Street MGP Site
Bellingham, Washington

LANDAU ASSOCIATES

Presentation and information as extracted directly from GeoEngineers 2022

Figure 2



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Projection: NAD83 WA State Plane, N Zone, US Foot
Vertical Datum: NAVD88

Legend

- Monitoring Well
- Intertidal Sediment and Porewater Sample Location
- Stormwater Outfall
- Stormwater Pipe
- Approximate Limits of Aquatic Vegetation
- Fence
- Retaining Wall
- BNSF Centerline
- Inner Harbor Line
- OHWM (9.70' NAVD88)
- MLLW (el. 0.48' NAVD88)
- Wood Pilings Area
- Site Structures
- Former Gas Holder
- Marine Unit Boundary
- Upland Unit Boundary

Bathymetry Contours

- 1-Foot Contour
- 5-foot Contour

Upland Contours

- 1-Foot Contour
- 5-foot Contour

Project North   True North

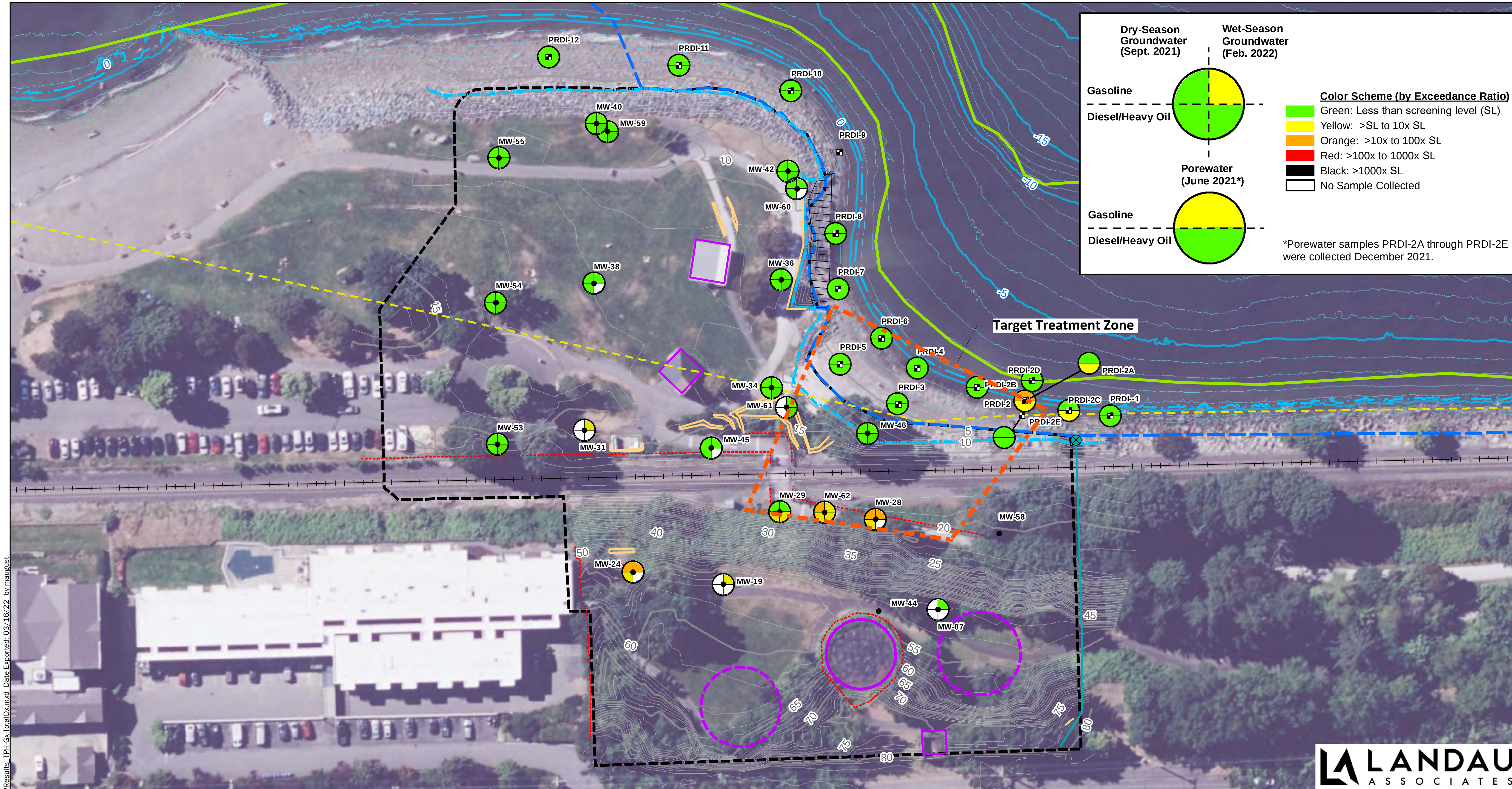
75   0   75
Feet

PRDI Groundwater/Porewater Analytical Results Benzene & Naphthalene

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 3



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Projection: NAD83 WA State Plane, N Zone, US Foot
Vertical Datum: NAVD88

Legend

- Monitoring Well
- Intertidal Sediment and Porewater Sample Location
- Stormwater Outfall
- Stormwater Pipe
- Approximate Limits of Aquatic Vegetation
- Fence
- Retaining Wall
- BNSF Centerline
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- OHWM (9.70' NAVD88)
- MLLW (el. 0.48' NAVD88)
- Wood Pilings Area
- Site Structures
- Former Gas Holder
- Marine Unit Boundary
- Upland Unit Boundary

Bathymetry Contours

- 1-Foot Contour
- 5-foot Contour

Upland Contours

- 1-Foot Contour
- 5-foot Contour

Project North   True North

75 0 75
Feet

PRDI Groundwater/Porewater Analytical Results Gasoline & Diesel/Heavy Oil

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 4

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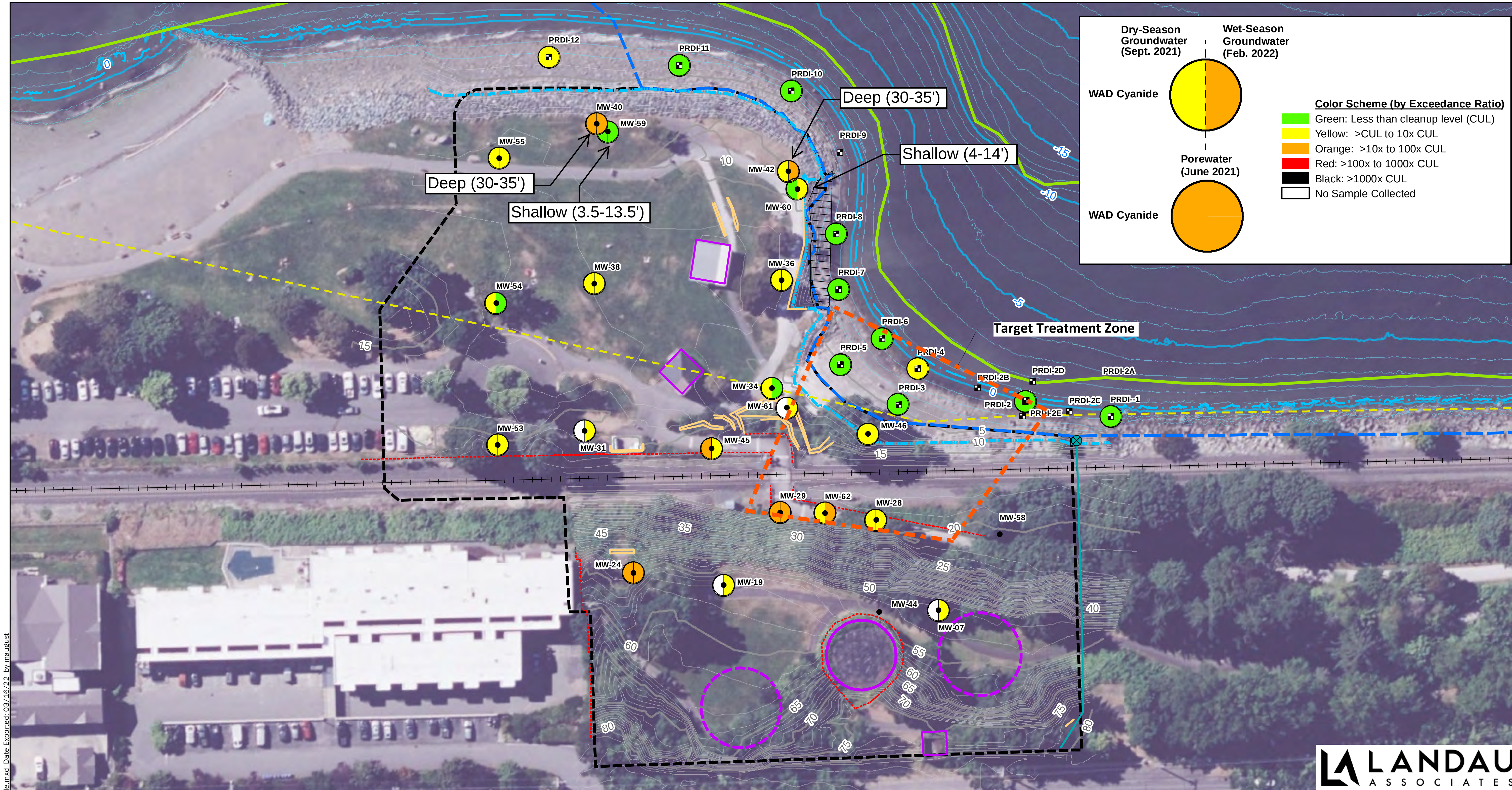

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Projection: NAD83 WA State Plane, N Zone, US Foot
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Legend

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- Marine Unit Boundary
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Bathymetry Contours
- 1-Foot Contour
- 5-foot Contour

Upland Contours
- 1-Foot Contour
- 5-foot Contour

Project North   True North

75   0   75
Feet

PRDI Groundwater/Porewater Analytical Results WAD Cyanide

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 5

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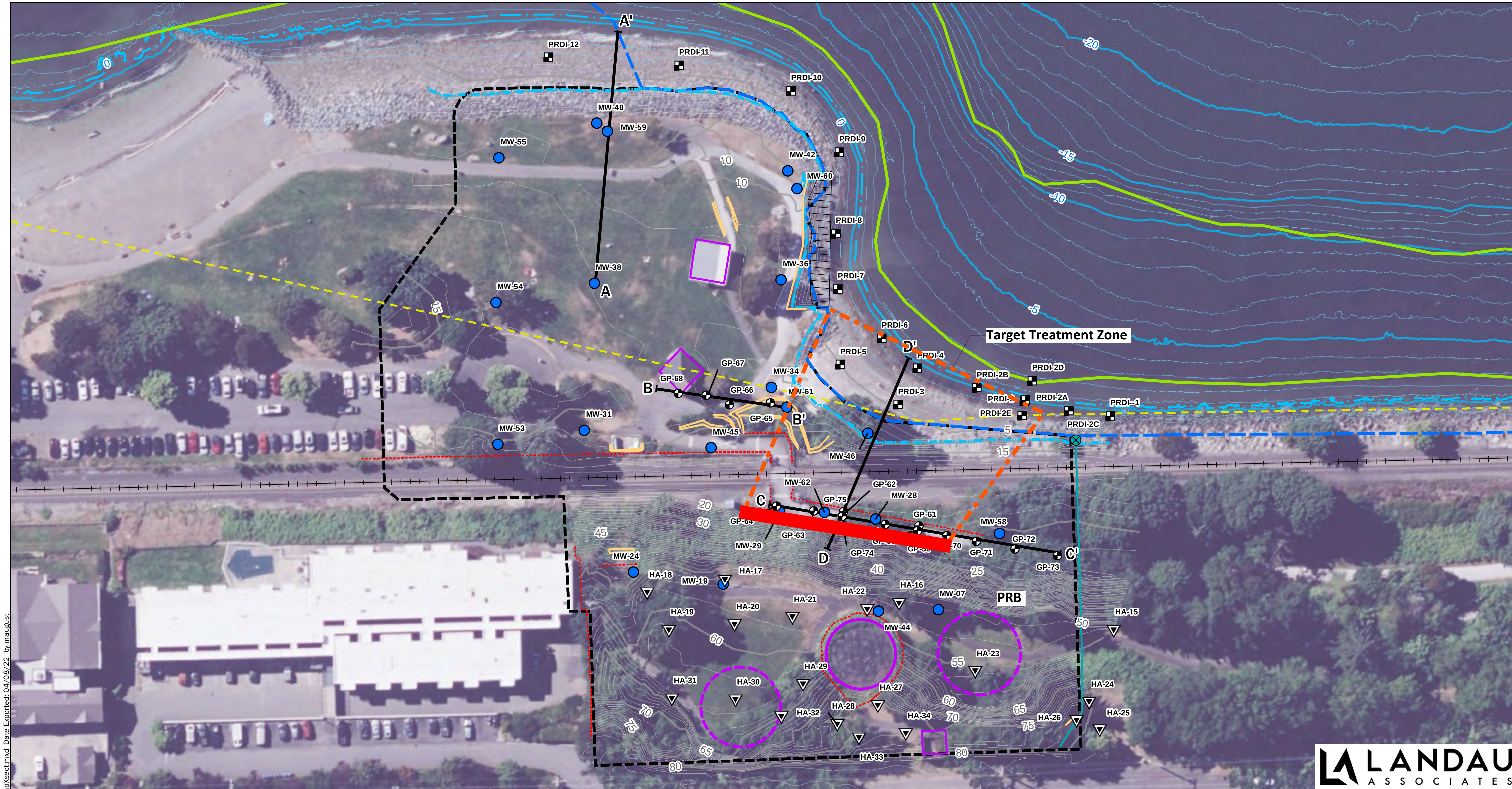

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Projection: NAD83 WA State Plane, N Zone, US Foot
Vertical Datum: NAVD88

Legend

- Direct Push Soil Boring
- Shallow Hand Auger Soil Sample
- Monitoring Well
- Intertidal Sediment and Porewater Sample Location
- Stormwater Outfall
- Stormwater Pipe
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Bathymetry Contours
- 1-Foot Contour
- 5-foot Contour

Upland Contours
- 1-Foot Contour
- 5-foot Contour

Project North   True North

75 0 75
Feet

Anticipated PRB Alignment

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 6

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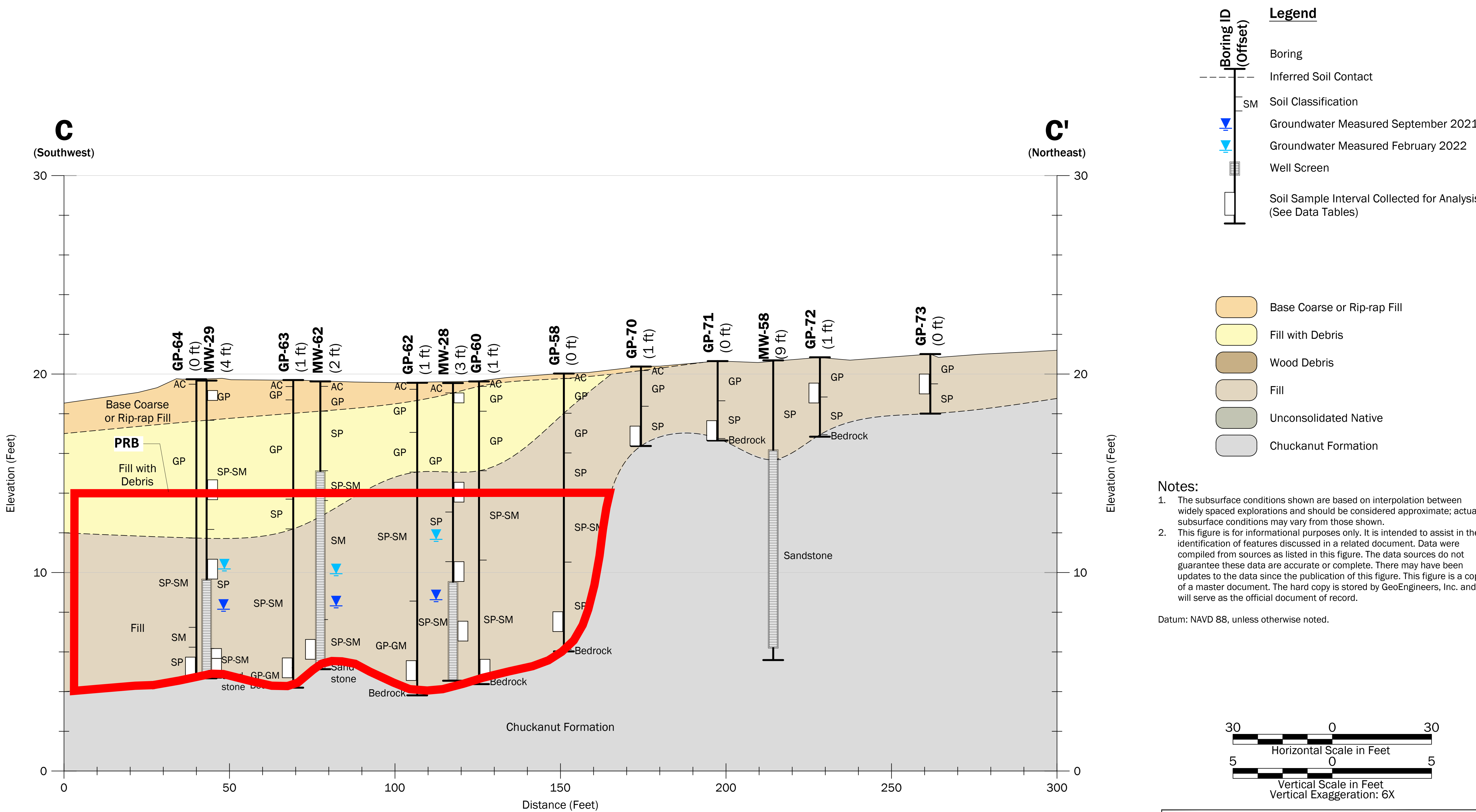

Notes:
1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Datum: NAVD 88, unless otherwise noted.

Anticipated PRB Profile

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 7

TABLE 1

PSE - South State Street, September 2021, January 2022, and February 2022 Groundwater Data (DRAFT)

(Validated) (check against GeoEngineers final)

			Location ID	MGP-MW-28	MGP-MW-28	MGP-MW-29	MGP-MW-29	MGP-MW-62	MGP-MW-62	MGP-MW-62
			Sample ID	MW-28_092021	MW-28-020922	MW-29_092121	MW-29-020822	MW-62_092121	DUP-1_092121	MW-62-020822
			Sample Date	9/20/2021	2/9/2022	9/21/2021	2/8/2022	9/21/2021	9/21/2021	2/8/2022
Method	Analyte	Project CULs	Units							
Conventionals	Total Organic Carbon	NE	mg/L	**18.97**	**16.8**	**7.17**	**10.5**	**12.24**	**11.83**	**5.40**
	Nitrate	NE	mg/L	2.00 UJ	0.0200 UJ	**0.0493**	**1.54**	0.200 U	0.200 U	**0.729**
	Nitrate-Nitrite	NE	mg/L	1.00 U	0.010 U	**0.049**	**1.56**	0.100 U	0.100 U	**0.729**
	Nitrite	NE	mg/L	1.00 UJ	0.010 UJ	0.010 U	**0.025**	0.100 U	0.100 U	0.010 U
	Sulfate	NE	mg/L	**5.40**	**10.6 J**	**95.5**	**72.6**	**88.9 J**	**203 J**	**172**
	Cyanide	0.005	mg/L	**0.155**	**0.106**	**1.14**	**0.955**	**0.280**	**0.274**	**0.270**
	Cyanide (Weak & Dissociable)	0.005	mg/L	**0.033**	**0.016**	**0.073**	**0.091**	**0.048**	**0.048**	**0.058 J**
NWTPH-GX	Gasoline-range hydrocarbons	NE	µg/L	**22600**	**32500**	100 U	**484**	**27800**	**27000**	**2850**
NWTPH-DX	Diesel-range hydrocarbons	NE	mg/L	**2.84**	--	**0.521**	**2.53**	**5.11**	**5.75**	**1.06**
	Lube oil-range hydrocarbons	NE	mg/L	0.200 U	--	**0.229**	**0.724**	**0.231**	**0.273**	0.200 U
	Total TPH	NE	mg/L	**2.84**	--	**0.750**	**3.254**	**5.341**	**6.023**	**1.06**
Metals	Iron (Total)	NE	µg/L	**17100**	**21100**	**1700**	**975**	**4050**	**4210**	**260**
	Iron (Dissolved)	NE	µg/L	**17300**	**18200**	**440**	**455**	**2990**	**3000**	**285**
	Lead (Dissolved)	NE	µg/L	0.100 U	0.500 U	0.100 U	0.500 U	0.100 U	0.100 U	0.500 U
	Selenium (Dissolved)	71	µg/L	**0.307 J**	**0.995 J**	**0.560**	**0.995 J**	0.500 U	**0.222 J**	2.50 U
VOCs	Benzene	1.6	µg/L	**4890**	**3720**	**1.48**	**9.78**	**926**	**876**	**58.0**
	Naphthalene	83	µg/L	**4170**	**3550**	**0.48 J**	**48.6**	**6920 J**	**6650 J**	**780**

Notes:

CUL = cleanup level

ID = identification

mg/L = milligrams per liter

µg/L = micrograms per liter

NE = not established

ND = not detected

NWTPH-DX = Northwest total petroleum hydrocarbon diesel-range extended

NWTPH-GX = Northwest total petroleum hydrocarbon gasoline-range extended

VOC = volatile organic compound

TPH = total petroleum hydrocarbon

U = The analyte was not detected at a concentration greater than the value identified.

J = The analyte was detected and the detected concentration is considered an estimate.

Bold font type indicates the analyte was detected at the reported concentration.

Grey shading indicates exceedance of the project cleanup level.

(GeoEngineers 2022)

APPENDIX G

Work Plan for Column Study and Pilot Test for Evaluation of Permeable Reactive Barrier

Technical Memorandum

TO: Neil Morton, GeoEngineers, Inc.

FROM: Jenny Green, EIT, and Clint Jacob, PE, LG

DATE: September 27, 2022

RE: **Work Plan for Design Testing**
Permeable Reactive Barrier
Former South State Street Manufactured Gas Plant Site
Bellingham, Washington
Project No. 0611004.020

Introduction

This technical memorandum presents a work plan to conduct design testing for evaluation and design of a permeable reactive barrier (PRB) at the former South State Street Manufactured Gas Plant (MGP) in Bellingham, Washington (Site; Figure 1). This work plan describes aquifer flux testing, bench testing, and optional pilot testing. Aquifer flux testing and bench testing will be performed to collect design data and to evaluate treatment effectiveness. A field pilot test may also be performed if the cleanup schedule allows and additional proof of concept is desired.

GeoEngineers, Inc. (GeoEngineers) performed a pre-remedial design investigation (PRDI) in 2021–2022. The PRDI and prior groundwater monitoring identified benzene, naphthalene, and cyanide (CN) in groundwater at concentrations above cleanup levels (CULs) at the Site (GeoEngineers 2022). Additionally, gasoline-range total petroleum hydrocarbons (TPH-G) and diesel-range total petroleum hydrocarbons (TPH-D) were detected at concentrations above MTCA Method A groundwater cleanup levels (GeoEngineers 2022). A technical memorandum (Landau Associates, Inc. [Landau] 2022), presented as Appendix F to the PRDI report, evaluates PRB treatment of a shallow groundwater target treatment zone which discharges to marine surface water at the "pocket beach" (Figure 1). That memorandum describes, in detail, the target treatment area and contaminants, aquifer redox conditions, remedial approach, the conceptual design of the PRB, and the design data to be addressed by the design testing described in this work plan.

This work plan is also included as an appendix to the PRDI report and, therefore, only briefly summarizes and discusses data which are presented comprehensively in that report. The information covered in this memorandum assumes that the reader is familiar with the content and conclusions of the PRDI report and the Appendix F evaluation memorandum.

Summary of Remedial Approach and Conceptual Design

As presented in Appendix F of the PRDI report (Landau 2022), the recommended remedial approach is construction of a PRB to treat benzene, naphthalene, TPH-G, TPH-D, and CN. A PRB consists of a trench oriented perpendicular to groundwater flow, which is backfilled with a mixture of sand and reactive media that treats contaminated groundwater as it flows through the trench. The Site PRB will be located east of the railroad tracks and pedestrian footpath, at the foot of the bedrock outcrop, to intercept and treat contaminated groundwater flowing from the upland area in advance of its discharge at the pocket beach. The target treatment zone, in plan and profile views, is presented on Figures 1 and 2, respectively.

The PRB will be approximately 160 feet (ft) long and extend from GP-70 to a location south of MW-29. The anticipated length and location of the PRB is presented on Figure 3. The PRB will be located hydraulically upgradient (east) of monitoring wells MW-28, MW-29, and MW-62, which will be used to monitor the treatment effects of the PRB (Figure 1).

The PRB will extend from above the seasonal high water table to bedrock. As shown on cross-section C-C' (Figure 2), the highest groundwater level observed during the PRDI was approximately 8 ft below ground surface (bgs; elevation 12 ft), and the bedrock was encountered at elevation 4 or 5 ft (approximately 16 ft bgs). It is anticipated that the PRB will be constructed from 6 to 16 ft bgs (between elevations 4 to 14 ft), as shown in profile on Figure 4.

Trench backfill will consist of mixed sand, gypsum, and granular zero-valent iron (ZVI). Sand is required to maintain the hydraulic conductivity of the PRB and to prevent excessive settling of backfill as the gypsum dissolves over time. Gypsum ($CaSO_4$) will provide a slow release of sulfate, as the electron acceptor, to enhance biodegradation of total petroleum hydrocarbons (TPH) within and downgradient of the PRB. ZVI is known to immobilize CN through adsorption and through precipitation of insoluble iron-cyanides (commonly known as Turnbull's Blue and Prussian Blue; Adams 1992; Dzombak, et al. 2005; Ghosh, et al. 1999). Likely percentages of PRB materials are 55 percent sand, 30 percent gypsum, and 15 percent ZVI.

Design Testing

Aquifer flux testing and bench testing will be performed to collect design data and evaluate treatment effectiveness. A field pilot test may also be performed if the cleanup schedule allows and additional proof of concept is desired.

- Aquifer flux testing: Aquifer flux testing data will be used to estimate groundwater and contaminant flux through the PRB. Wet season measurement will represent maximum flux used to design PRB thickness for adequate residence time for treatment of groundwater contaminants. Dry season and wet season results will be used to calculate average flux which will be used to estimate the longevity of gypsum and ZVI components of the PRB.
- Bench study: The bench study will consist of column tests to answer design questions related to the optimal ZVI percentage in PRB backfill and the optimal gypsum particle size.
    - Column tests with ZVI will verify that it can remove CN, as indicated in the literature (Adams 1992; Dzombak, et al. 2005; Ghosh, et al. 1999), evaluate required residence

time and the appropriate the percentage of ZVI in the PRB backfill for efficient removal over the anticipated 5-ft thickness of the PRB.

  - Column tests with gypsum will evaluate different particle sizes and percentages to optimize longevity and sulfate loading.

- Field pilot test (optional): A field pilot test may be performed if the cleanup schedule allows and additional proof of concept is desired. The field pilot test will consist of two short PRB segments (e.g., 30 ft) located upgradient of the maximum TPH concentrations in groundwater at MW-28 and the maximum CN concentrations in groundwater at MW-29. Pilot test groundwater monitoring performed at these two wells will be used to evaluate treatment effectiveness. One to 2 years of pilot test monitoring is proposed in order to evaluate treatment effectiveness over wet and dry seasons. Furthermore, although the PRB is expected to immediately treat contaminant flux passing through it, a period of flushing and treatment will be required in the zone between the PRB and monitoring wells before the treatment effects will be fully observed at the monitoring wells.

These design test components are described in the following sections.

Aquifer Flux Measurements

Before the bench study, wet season contaminant and groundwater flux will be measured at the two downgradient wells (MW-28 and MW-29) using Passive Flux Meter™ devices (EnviroFlux, LLC). These are passive devices that are deployed down existing groundwater monitoring wells and contain a tracer compound and an absorbent material. EnviorFlux will calculate groundwater flux from the amount of tracer compound lost during deployment. EnviorFlux will calculate contaminant flux from the amount of contaminant (TPH and CN) absorbed during deployment.

EnviroFlux recommends deploying the Passive Flux Meter™ devices for 1–4 weeks. Once the devices are retrieved, they will be sent to the EnviroFlux laboratory in Gainesville, Florida for analysis. A deployment time of 3 weeks is anticipated and may be adjusted following initial results and consultation with EnviroFlux. Results are available within 4 weeks of Passive Flux Meter™ retrieval. At the time of meter collection, groundwater samples will also be collected from each well for laboratory analysis of TPH-G, TPH-D, benzene, CN, sulfate, and ferrous iron for comparison to Passive Flux Meter™ results.

The wet season flux measurements will be made before performing the bench testing, while dry season measurements will be completed after bench testing due to schedule constraints. Wet season measurements will represent maximum groundwater and contaminant flux used to design the bench column studies and ultimately to design PRB thickness for adequate residence time for treatment of groundwater contaminants. Dry season flux measurements will be combined with wet season results to calculate average flux; average flux together with column study results will be used to estimate the longevity of the gypsum and ZVI components of the PRB.

If optional pilot testing is performed, flux measurements will also be performed during the pilot test to evaluate treatment effectiveness and impacts of the PRBs on groundwater flow over time. It is anticipated that flux meter measurement and concurrent groundwater sampling would occur quarterly during the pilot test.

Bench Study

Two groups of column tests will be performed to evaluate the percent ZVI and gypsum and gypsum particle size to be used as reactive PRB construction materials. Up to four sequential column tests will be run using different percent weight of ZVI (e.g., Ferox PRB and Ferox Flow, Hepure) to evaluate CN degradation rates. Each ZVI test is expected to take 5 days, with samples analyzed twice per day. At the same time, a 6-week test will be performed on three columns packed with sand and different particle size gypsum to evaluate gypsum dissolution as it affects TPH treatment and PRB longevity. The three sulfate column tests will run concurrently with sulfate samples collected twice per week. CN and sulfate will be measured in-house using compound-specific photometers.

The gypsum column setup will feature three columns, each with a rotameter (flow meter) and three ports for sampling along the length of the column. Each column will be constructed with clear, 2-inch-diameter, Schedule 40 polyvinyl chloride (PVC) and will be 2 ft long. PRB backfill material will be secured in the main body of the column using fine mesh filters or cheesecloth. A sand grain size will be selected in consultation with the ZVI vendor. A summary of flow parameters for typical sand grit sizes in provided in Table 1.

The group of three columns will be fed simultaneously by a peristaltic pump. A basic setup diagram is provided on Figure 5. A summary of design parameters for each column study is presented in Table 2. The column flow rate will approximate the maximum groundwater flux measured at well MW-28 and MW-29 during the wet season flux testing.

The column setup for ZVI testing will be similar but will be performed on one column at a time due to the short time (1 week) required for each test. By this approach, percent ZVI can be modified for each subsequent test as needed based on data obtained from prior tests.

Cyanide Removal by ZVI

Mixtures of sand and granular ZVI will be tested in the column study to evaluate removal of CN by ZVI. Coarse-grained, granular ZVI (mesh -8/+50) will be used (e.g., Hepure PRB). The percent of ZVI will be varied in each column; a range of 10–20 percent ZVI will be evaluated.

The influent solution will contain CN at a concentration of 1.0 milligrams per liter (mg/L), which represents a concentration of 200 times the CN cleanup level and approximately the highest concentration in the Site target treatment area. The solution will be made using CN standard

(1,000 mg/L) purchased from a laboratory supply vendor. Waste influent and effluent solution containing CN will be disposed of according to local laboratory waste regulations.

Twice per day for 5 days, samples will be collected from all three ports on the ZVI column to evaluate CN removal along the length of the column. Temperature and pH will be measured in each sample using a water quality meter (YSI Professional Plus, or similar), and CN will be measured in each sample using a portable photometer (Hanna® Instruments Cyanide Photometer HI97714, or similar).

The plug flow model, including dispersion, will be used to determine the CN removal/reaction rate in ZVI. Using CN concentrations measured at known distances along the length of the column, a plot can be generated showing CN versus distance. The equation for the exponential trendline that fits the data (generated using Microsoft Excel) is then used to solve for the reaction rate:

$$C(x) = C(0)\exp\left(-\frac{kx}{u}\right) \rightarrow y = C(0)\exp\left(\left(-\frac{k}{u}\right)x\right)$$

The reaction rate(s) determined during the ZVI column study will inform ZVI percentage in the PRB backfill and the required PRB width to provide adequate residence time for CN removal. Column results will also be input to the Hepure model used for ZVI PRB design.

Sulfate Loading and Longevity of Gypsum

Mixtures of sand and gypsum will be tested in the column study to evaluate the longevity of gypsum and the concentration of dissolved sulfate leaving the column. The grain size/shape of gypsum will be varied in each column; it is anticipated that crushed, pelleted, and pulverized gypsum will be tested. Gypsum will be added to each column at approximately 30 percent by weight. The weight of gypsum added to each column will be precisely measured for comparison to the calculated mass of dissolved sulfate removed in the effluent from each column during the test.

The influent solution will be plain tap water. Waste effluent solution containing sulfate will be disposed of according to local laboratory waste regulations.

Twice per week, samples will be collected from the effluent sample port on each of the three columns to evaluate sulfate loading over time. Temperature and pH will be measured in each sample using a water quality meter (YSI Professional Plus, or similar), and sulfate will be measured in each sample using a portable photometer (Hanna® Instruments Sulfate Photometer HI97751, or similar). Total sulfate mass removed from each column during the test period will be used to estimate the longevity of the different grain sizes used and the theoretical mass of TPH that could be degraded.

Column test results will be used to select the optimal grain size used for the pilot test PRB. A sulfate effluent concentration of 50–100 mg/L is desired for effective treatment of petroleum within the PRB and for some distance downgradient. A gypsum longevity of 3–5 years or greater is also desired. Gypsum longevity will be a function of the sulfate removed (dissolution rate) for each gypsum grain size and the percent of gypsum in the PRB backfill; the percent of gypsum in the PRB may be modified based on the column test results.

Field Pilot Test(Optional)

A field pilot test may be performed if the cleanup schedule allows and additional proof of concept is desired. The pilot test would include construction of two short PRB segments upgradient of monitoring wells MW-28 and MW-29 and the measurement of contaminant and groundwater flux at the site over 1–2 years. The pilot test would be used to evaluate short-term effectiveness and longevity under Site-specific field conditions. A summary of the pilot test PRB segments is provided in Table 3. Anticipated PRB segment alignments are presented on Figure 6.

Construction of PRB Segments

Each PRB segment would be approximately 30 ft long and 5 ft wide. Reactive backfill would extend from just above the water table (6 ft bgs) into the top of bedrock (16 ft bgs; i.e., reactive backfill between elevations 4 and 14 ft bgs). For each segment, the total volume of reactive media would be approximately 2,400 cubic feet (89 cubic yards). A geofabric would be placed on top of the reactive media and granular excavation spoils may be used to backfill to the surface.

Stacked trench boxes would be used for installation of the pilot test segments. Sidewall stability would be evaluated to determine if trench boxes will be required for full-scale installation.

PRB material mixing procedures may also be evaluated for efficiency and feasibility, including the use of transit mixers (i.e., cement trucks from batch facility), *ex situ* soil mixing with excavator bucket on site, and *in situ* soil mixing methods (e.g., mixing with excavator bucket in the trench or other excavator-fitted mixing attachment). Hepure would be consulted regarding recommended mixing procedures.

Use of This Technical Memorandum

This technical memorandum has been prepared for the exclusive use of GeoEngineers and Puget Sound Energy (PSE) for specific application to the South State Street MGP Site project. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau, shall be at the user's sole risk. Landau warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

LANDAU ASSOCIATES, INC.

Jenny Green, EIT
Senior Project EIT

Clint Jacob, PE, LG
Principal

JKG/CLJ/ljl
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Attachments

Figure 1. Target Treatment Zone
Figure 2. Target Treatment Zone Cross Section C-C'
Figure 3. Anticipated PRB Alignment
Figure 4. Anticipated PRB Profile
Figure 5. Column Study Setup
Figure 6. Anticipated Pilot Test PRB Alignments
Table 1. Hydrogeologic Parameters for Typical Sand Grits
Table 2. Column Study Summary
Table 3. Pilot Test Summary

References

Adams, M.D. 1992. "The Removal of Cyanide from Aqueous Solution by the Use of Ferrous Sulphate." *Journal of the South African Institute of Mining and Metallurgy* 92 (1):17-25. January.

Dzombak, D.A, R.S. Ghosh, and G.M. Wong-Chong. 2005. *Cyanide in Water and Soil: Chemistry, Risk, and Management*. Boca Raton, FL: CRC Press.

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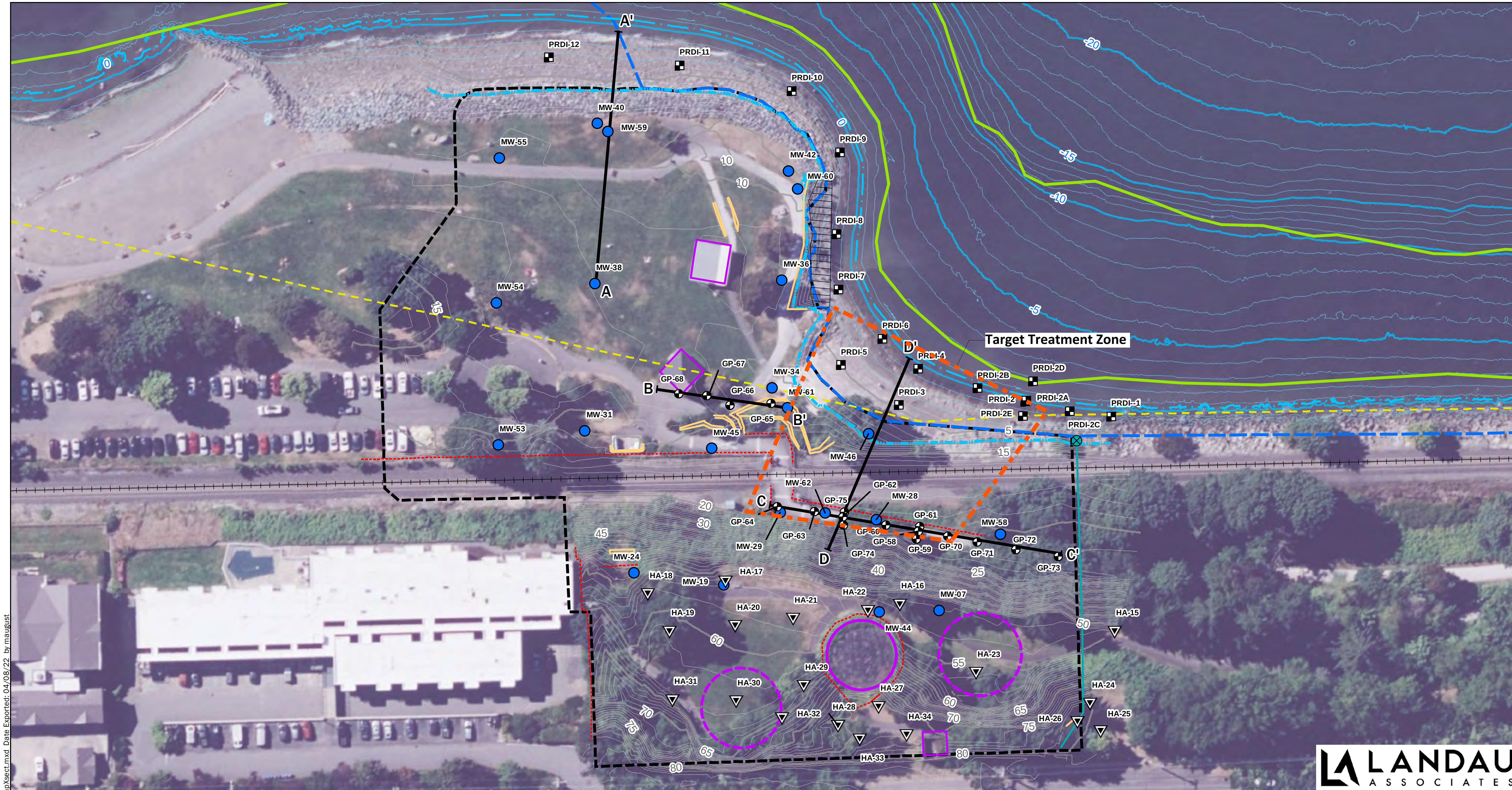
Ghosh, R.S., D.A. Dzombak, R.G. Luthy, and J.R. Smith. 1999. "*In Situ* Treatment of Cyanide-Contaminated Groundwater by Iron Cyanide Precipitation." *Water Environment Research* 71 (6):1217-1228.

Landau. 2022. Technical Memorandum: Evaluation of Pre-Remedial Design Investigation Data Related to Permeable Reactive Barrier Treatment, Former South State Street Manufactured Gas Plant Site, Bellingham, Washington. Landau Associates, Inc. September 27.



Notes:
1. The locations of all features shown are approximate.
2. Mean High Tide defines the boundary between the Upland Unit and Marine Unit.
3. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Base upland survey from Larry Steel Associates, 2022. Base bathymetric survey from David Evans and Assocates, 2021. Aerial from Bing.

Projection: NAD83 WA State Plane, N Zone, US Foot
Vertical Datum: NAVD88

Legend

- Direct Push Soil Boring
- Shallow Hand Auger Soil Sample
- Monitoring Well
- Intertidal Sediment and Porewater Sample Location
- Stormwater Outfall
- Stormwater Pipe
- Approximate Limits of Aquatic Vegetation
- Fence
- Retaining Wall
- BNSF Centerline
- Inner Harbor Line
- OHWM (9.70' NAVD88)
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- Wood Pilings Area
- Site Structures
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- Marine Unit Boundary
- Upland Unit Boundary

Bathymetry Contours
- 1-Foot Contour
- 5-foot Contour

Upland Contours
- 1-Foot Contour
- 5-foot Contour

Project North   True North

75   0   75
Feet

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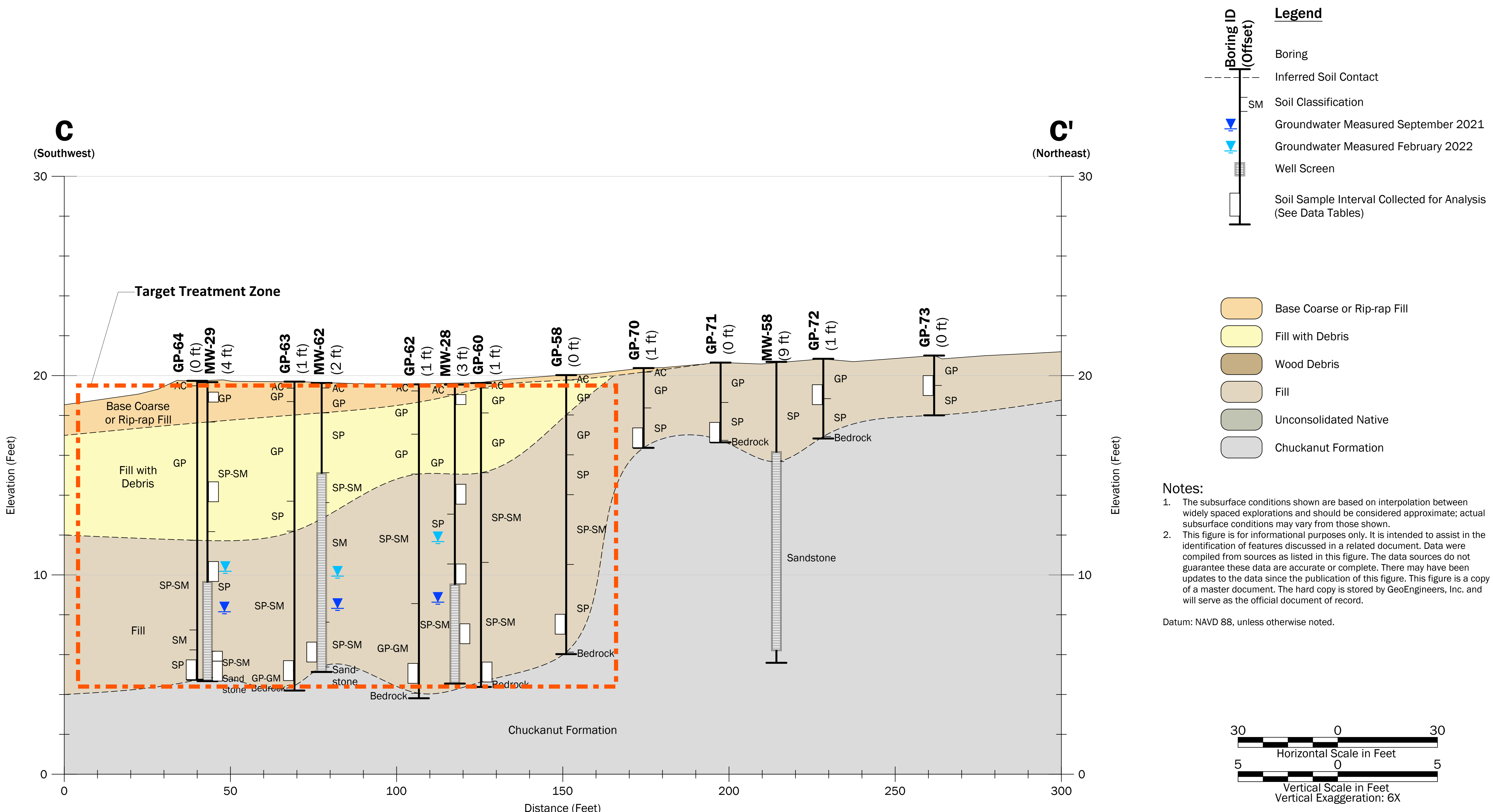
Target Treatment Zone

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 1



Target Treatment Zone Cross Section C-C'

South State Street MGP Site
Bellingham, Washington

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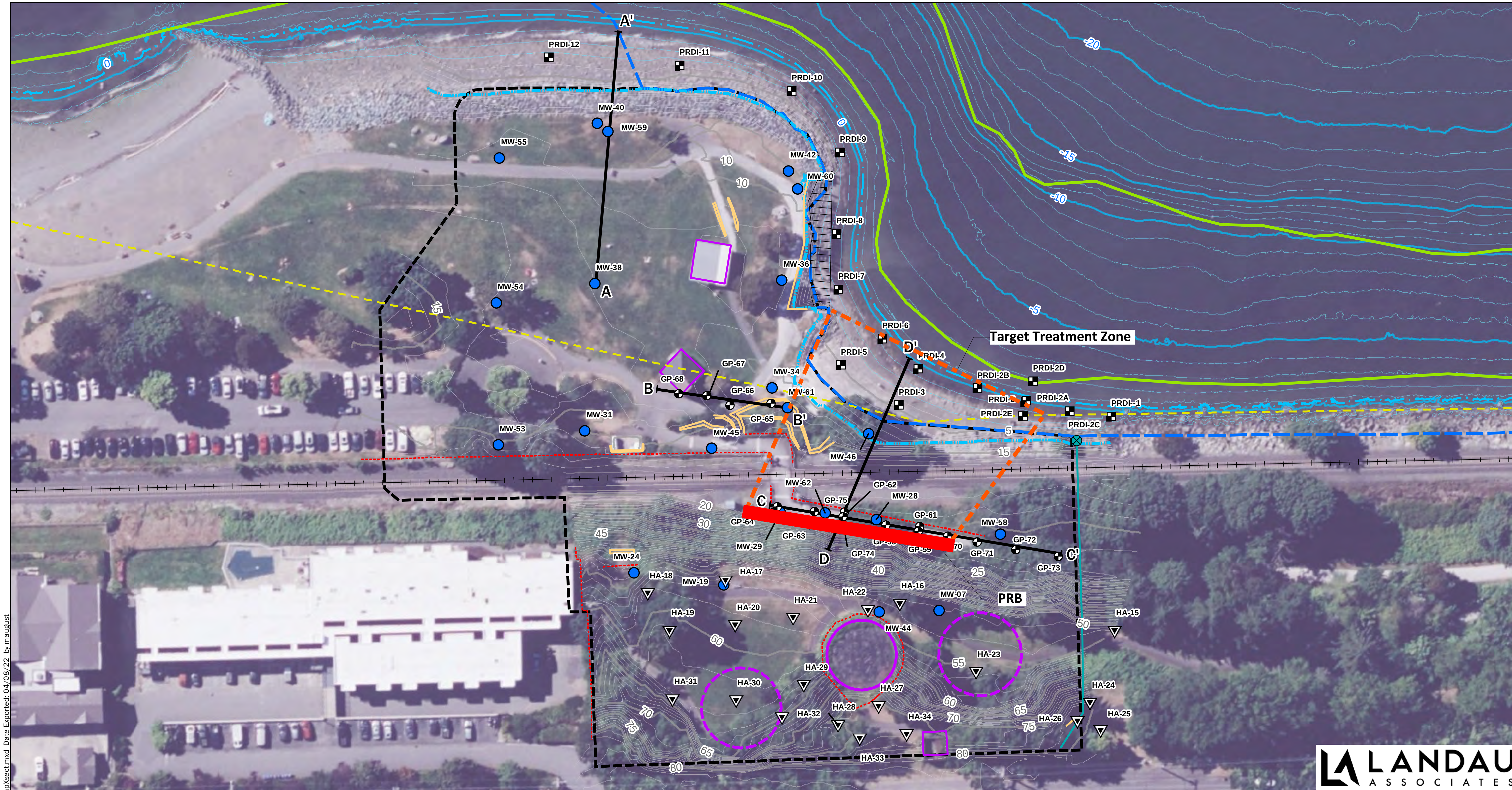
Presentation and information as extracted directly from GeoEngineers 2022

Figure 2



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- 1-Foot Contour
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Project North   True North

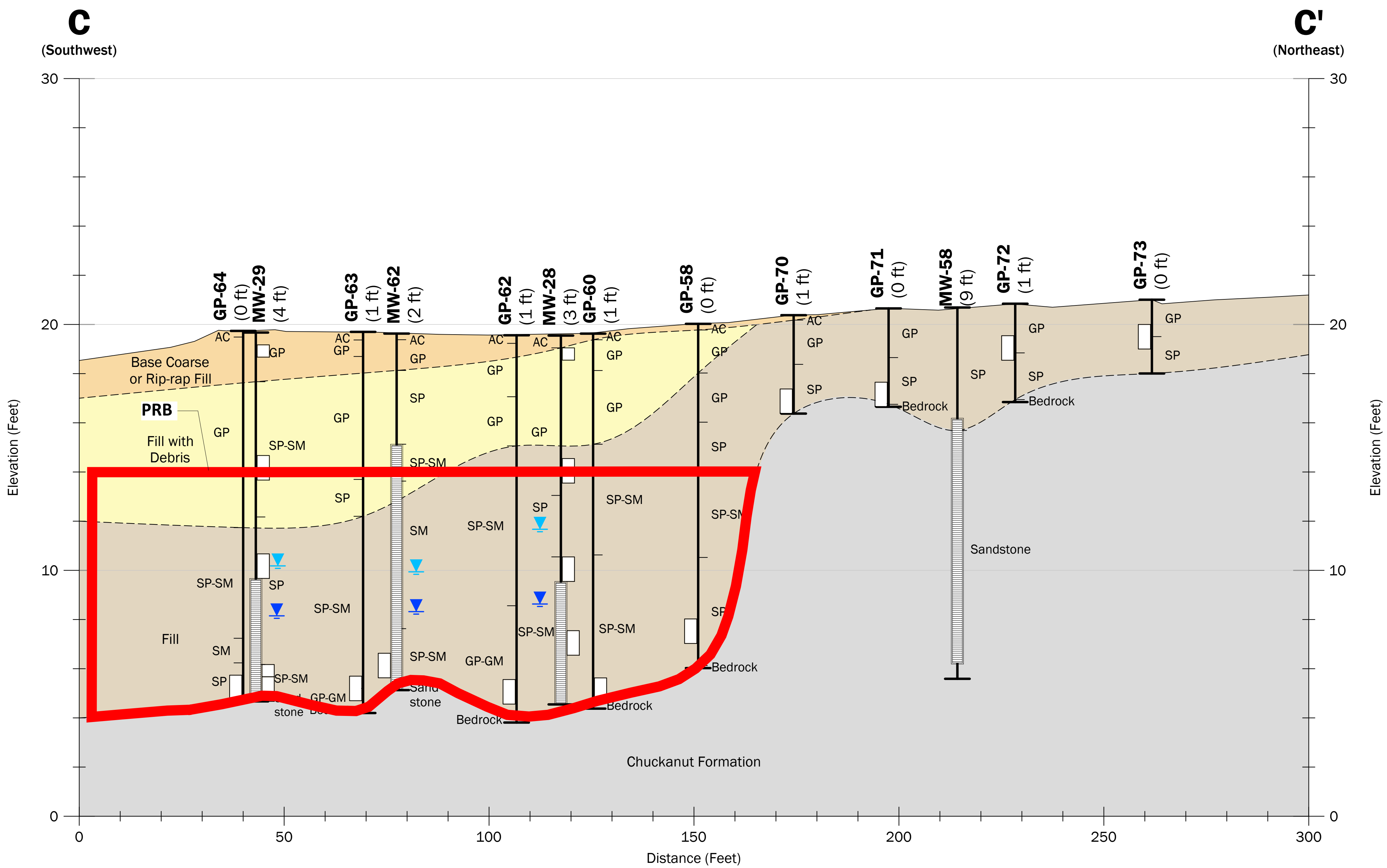
75 0 75
Feet

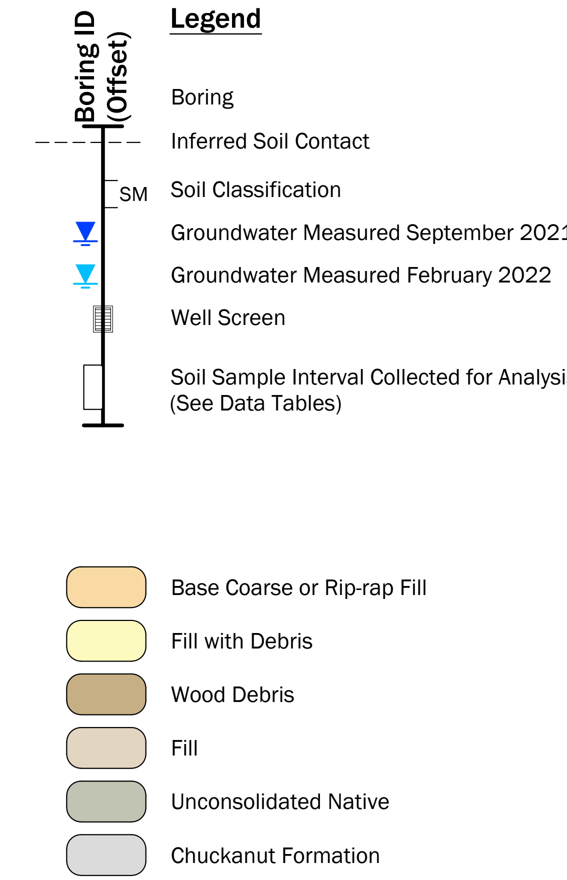
Anticipated PRB Alignment

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 3

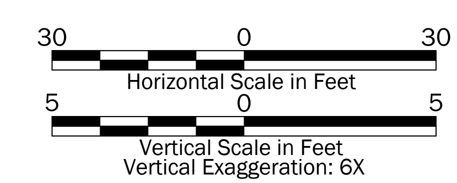




Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Datum: NAVD 88, unless otherwise noted.



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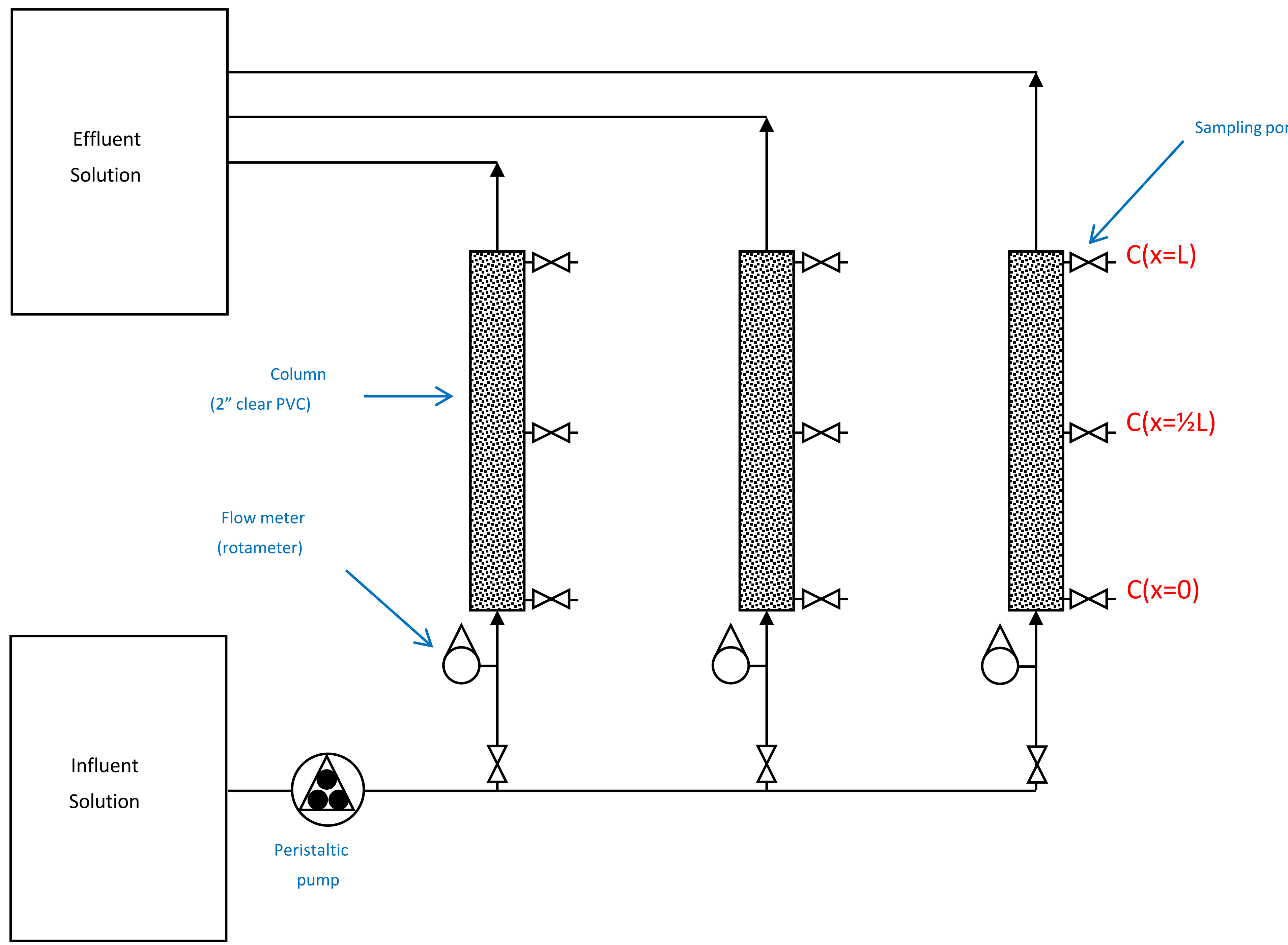
Anticipated PRB Profile

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 4



Column Study Setup

South State Street MGP Site
Bellingham, Washington

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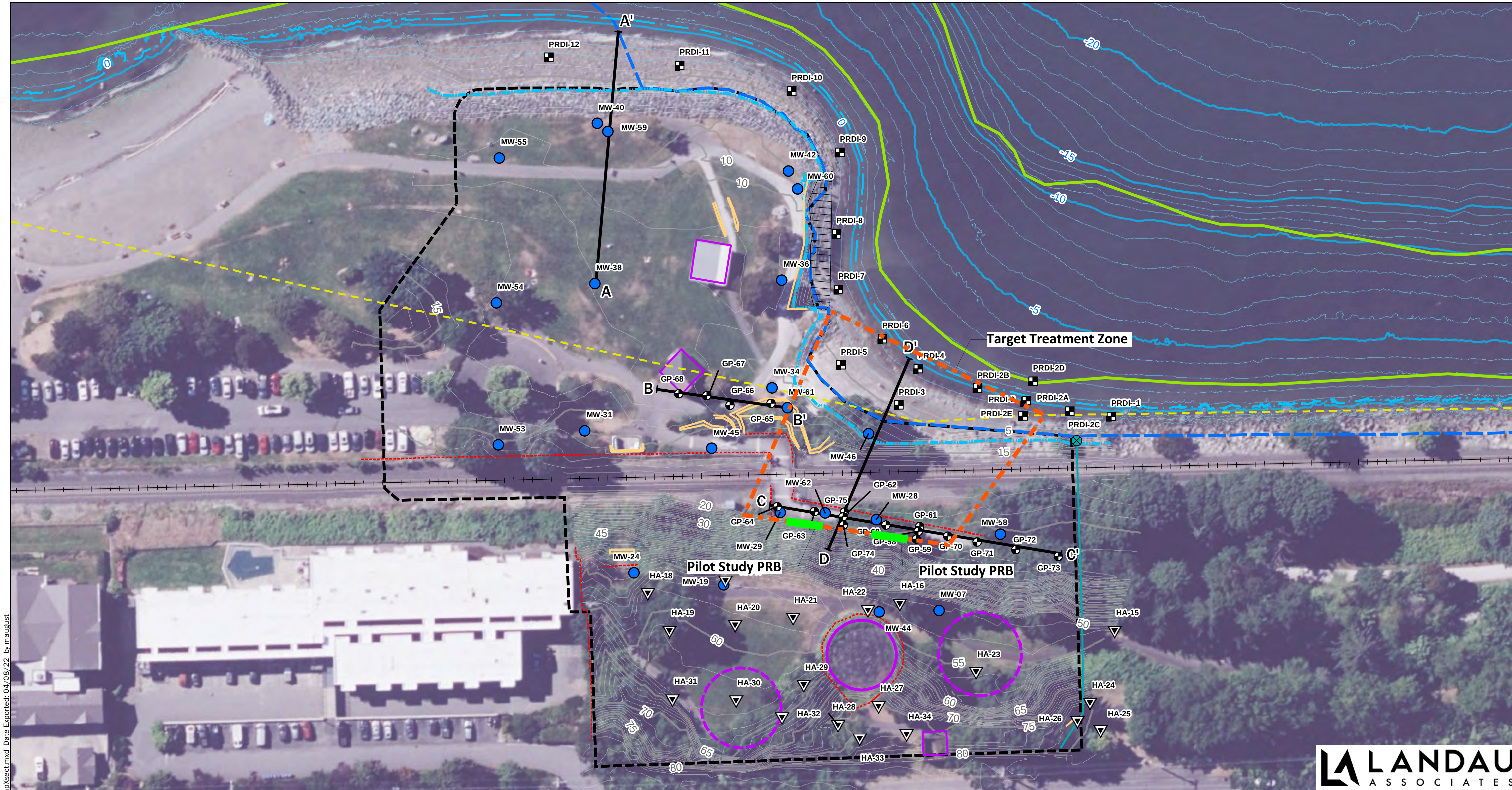
Presentation and information as extracted directly from GeoEngineers 2022

Figure 5



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Project North

True North

75 0 75

Feet

Anticipated Pilot Test PRB Alignments

South State Street MGP Site
Bellingham, Washington

Presentation and information as extracted directly from GeoEngineers 2022

Figure 6

Table 1
Hydrogeologic Parameters of Typical Sand Grits
Former South State Street MGP
Bellingham, Washington

Sand Grit	Hydraulic Conductivity (cm/s) (a)	Hydraulic Conductivity (cm/min)	Effective Porosity (b)	Approx. Hydraulic Gradient (cm/cm) (c)	Seepage Velocity (cm/s)	Fluid Velocity (cm/s)	Nominal Column Size	Column Inner Diameter (cm)	Flow Area (cm^2)	Flow Rate (cm^3/s)	Flow Rate (cm^3/min)
40/50	0.072	4.32	0.20	-0.078	0.006	0.028	2"	5.20	21.2	0.119	7
30/40	0.149	8.94	0.20	-0.078	0.012	0.058	2"	5.20	21.2	0.245	15
20/30	0.250	15.0	0.20	-0.078	0.019	0.097	2"	5.20	21.2	0.411	25
12/20	0.503	30.2	0.20	-0.078	0.039	0.195	2"	5.20	21.2	0.828	50

Notes:

(a) Schroth, M.H., S.J. Ahearn, J.S. Selker, and J.D. Istok. 1996. Characterization of Miller-Similar Silica Sands for Laboratory Hydrologic Studies*Soil Science Society of America* , 60(5): 1331-1339.

(b) Typical mid-range value reported in literature.

(c) Approximated using groundwater contours for the site in the proposed location for the permeable reactive barrier

Abbreviations and Acronyms:

cm = centimeters

s = second

min = minute

Table 2
Column Study Summary
Former South State Street MGP
Bellingham, Washington

Column ID	Reactive Material		Inert Material (b)		Influent Solution		Effluent Measurements					Test Parameters	
	Type (Percent)	Grit or Grain Size (a)	Type (Percent)	Grit or Grain Size (b)	Solution Composition	Concentration (mg/L) (c)	pH	Temperature	CN	Fe2+	Sulfate	Sampling Frequency	Test Duration
Z1	Granular ZVI (10%)	16	Sand (90%)	12/20	CN/Water	1.0	X	X	X	X		2x/day	5 days
Z2	Granular ZVI (15%)	16	Sand (85%)	12/20	CN/Water	1.0	X	X	X	X		2x/day	5 days
Z3	Granular ZVI (20%)	16	Sand (80%)	12/20	CN/Water	1.0	X	X	X	X		2x/day	5 days
G1	Crushed Gypsum (30%)	3/8" and less	Sand (70%)	12/20	Water	---	X	X			X	1-4 days	4-6 weeks
G2	Pulverized Gypsum (30%)	1/4" and less	Sand (70%)	12/20	Water	---	X	X			X	1-4 days	4-6 weeks
G3	Pelleted Gypsum (30%)	1/8" to 1/4"	Sand (70%)	12/20	Water	---	X	X			X	1-4 days	4-6 weeks

Notes:
(a) Common grit size for ZVI on the market. May be adjusted based on an evaluation of current products and their availability.
(b) Coarse-grained sand. May be adjusted based on consultation with ZVI vendor.
(c) The maximum CN concentration measured in the treatment zone is 1.14 mg/L.

Abbreviations and Acronyms:
CN = cyanide
Fe2+ = ferrous iron
ID = identification
mg/L = milligrams per liter
PRB = permeable reactive barrier
ZVI = zero-valent iron

Table 3
Pilot Test Summary
Former South State Street MGP
Bellingham, Washington

Dimension/ Parameter (a)	Pilot Study PRB Segment	
	MW-28	MW-29
Physical Dimensions		
Length	30 ft	30 ft
Width (a)	5 ft	5 ft
Depth	16 ft	16 ft
Volume (a)	2,400 ft^3	2,400 ft^3
Volume (a)	89 cy	89 cy
*Po*tential *Backfill Composition*		
Sand (a)	60 %	65 %
Granular ZVI (a)	10 %	15 %
Gypsum (a)	30 %	20 %
Indicators of Treatment Effects		
Decreased…	TPH concentrations	CN concentrations
Increased…	Sulfate concentrations	Fe2+ concentrations

Notes:

(a) Subject to change based on the results of the column tests

TPH = total petroleum hydrocarbons. In this context, collectively benzene, naphthalene, total petroleum hydrocarbons gasoline- range and diesel-range.

Abbreviations and Acronyms:

% = percent
CN = cyanide
cy = cubic yard
Fe2+ = ferrous iron
ft = feet
ft^3 = cubic feet
ZVI = zero-valent iron

APPENDIX H
Coastal MetOcean Conditions and Geomorphologic Assessment

Coastal MetOcean Conditions and Geomorphologic Assessment – Final
Pre-Remedial Design Investigation
South State Street Manufactured Gas Plant

Prepared for GeoEngineers Inc.
Prepared by Coastal Geologic Services, Inc.

COASTAL GEOLOGIC SERVICES

September 28, 2022

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Introduction

This report summarizes the results and main findings of a coastal process and coastal geomorphology assessment to provide baseline data and a fundamental understanding of the seabed stability and accretion (deposition) and erosion potential to assist with shoreline, intertidal, and subtidal cap design for the South State Street Manufactured Gas Plant Site (SSSMGP).

The site is located on a highly modified section of shore, at the northeast end of Bellingham Bay, WA (Figure 1). The site was classified as a contaminated coastal site by Washington Department of Ecology (WDOE) due to historical manufactured gas plant (MGP), sawmill and other industrial uses in water and on land including areas of fill. The majority of the site is heavily armored with a riprap revetment, as well as one pocket-like beach.

Cleanup efforts at the site are currently underway conducted between the Washington State Department of Ecology (Ecology), the City of Bellingham (City), and Puget Sound Energy (PSE). A Cleanup Action Plan (CAP) has been prepared that outlines the elements of the cleanup action for the site (GeoEngineers, 2020). Components of the cleanup action proposed for the marine portion of the site include:

- Sediment capping – A conventional sand cap will be constructed in the intertidal and shallow subtidal zones (above approximately -10 feet NAVD88 at, and slightly beyond). A thin sand cap (1-foot-thick) will be constructed in deeper subtidal (below -10 feet MLLW) (GeoEngineers, 2020).
- Sediment natural recovery – Monitored Natural Recovery (MNR) and Enhanced Natural Recovery (ENR) will be used in portions of the Marine Unit where surface sediment concentrations of cPAHs are lower and natural deposition of clean sediment is anticipated to achieve cleanup levels within a reasonable timeframe on a surface weighted average concentration (SWAC) basis. The selected cleanup action relies on natural recovery to be effective in deeper offshore areas where lower energy conditions allow net deposition (accretion) of clean sediment, and where periodic high-energy events (e.g. storms) will not affect recovery on a large scale (GeoEngineers, 2020).

Coastal Geologic Services, Inc. (CGS) was contracted by GeoEngineers, the prime consultant contracted with PSE, to perform coastal components of the Pre-Remedial Design Investigation (PRDI) for the SSSMGP. The goal of the PRDI is to obtain additional data to support design of the cleanup action for the site.

The purpose of this report is to assess coastal MetOcean conditions, coastal processes, and coastal geomorphology including an assessment of:

- Historic shore changes
- Surface and subsurface sediments
- Water levels, winds, waves, and currents (MetOcean conditions)
- Change in site bathymetry
- Historic seabed sediment accretion/erosion patterns

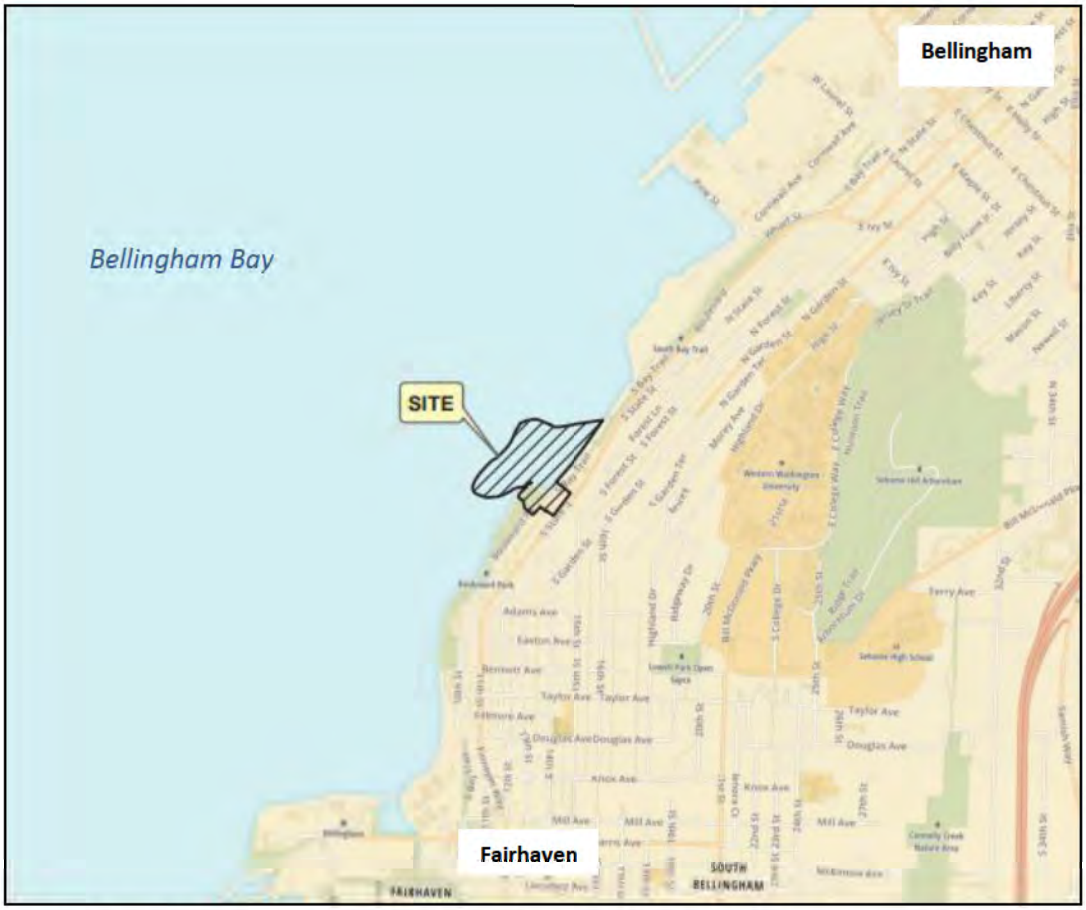


Figure 1. Site and vicinity map adapted from GeoEngineers (2020; Figure 1). Site boundary shown in black with hashmarks.

Together these assessments help characterize the site marine unit and allows us to understand shore stability and morphological conditions. The final objective of this investigation is to provide recommendations for the next stage engineering design, including design requirements for capping and shore protection, refine limits of conventional and thin layer capping, and determine where ENR and MNR can be applied.

Site Conditions

Overview

The SSSMGP site is located on northern Boulevard Park and adjacent waters along the eastern shore of Bellingham Bay between the Fairhaven District (south) and the Bellingham Waterfront District (north) (Figure 1).

The site is divided into two units by the mean high tide line, the Upland Unit and the Marine Unit (Figure 2). The Upland Unit is comprised of the northern portion of Boulevard Park and is divided into the upper park, the slope, and the lower park areas. The upper park is where the former SSSMGP was located.

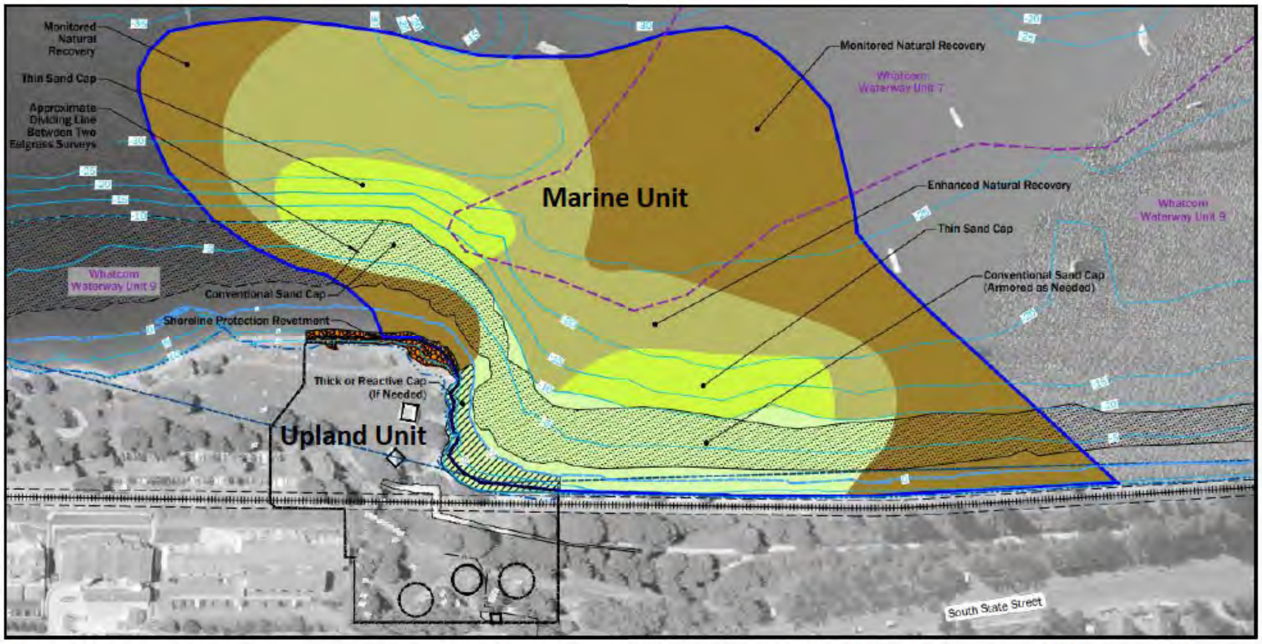


Figure 2. Site units and cleanup action map adapted from Cleanup Action Plan (GeoEngineers, 2020; Figure 6). Note that the Marine Unit boundary will change based on measured contamination.

The Upland Unit encompasses property owned by the City, Burlington Northern/Santa Fe Railroad (BNSF), and Washington State (see Figure 3 from GeoEngineers, 2020). The Marine Unit encompasses State Owned Aquatic Land (SOAL). The Marine Unit of the site extends down to approximately -35 FT elevation relative to NAVD88 datum.

Since circa 1980 the site has been a public park. The lower park area and vicinity were constructed by placing fill on the existing tidelands which was formerly the site of a historic sawmill. The fill in the lower park area is comprised of wood waste from the former lumber mill and log-rafting operations as well as material from local demolition and construction activities. Beneath the lower park area are pilings associated with the former lumber mill. A component of a former above-ground gas holder (concrete cylinder) remains in the upper park area.

Geology

The shores of Bellingham Bay area are generally composed of Chuckanut Formation Bedrock and post-glacial deposits, as well as more recent Nooksack River and beach deposits, and fill material. Bedrock is exposed at a number of locations along the eastern shore of Bellingham Bay and is generally comprised of several members of the Chuckanut Formation, an arkosic sandstone with lesser amounts of siltstone and conglomerate. These were mostly deposited during the Eocene time of the Cretaceous period. Members of the Chuckanut Formation found in Bellingham Bay consist of Government Point, Bellingham Bay, and Padden members (Lapen, 2000). The outcrops that are present in the intertidal area are more erosion resistant beds of sandstone than other rocks within the formation that are not cemented well enough to persist in the erosive environment of the shore.

Overlying the Chuckanut Formation in many parts of the shore is glacial outwash deposited during the Sumas Stade of the Pleistocene epoch, roughly 11,000 – 13,500 years before present. These units are commonly loose, moderately to well-sorted gravel with local boulders, sandy gravel, and minor gravelly medium to coarse sand and rare sand to silt. Glaciomarine drift, deposited during the more recent Everson Interstade (also of the Pleistocene epoch) is slightly less abundant. This geologic unit is characterized by moderately to well-sorted gravel within a fine-grained matrix that can contain marine shells (Easterbrook, 1976; Lapen, 2000).

Above the bedrock and glacial deposits, substantial amounts of fill material are found throughout much of the downtown Bellingham region and almost all of the eastern Bellingham Bay shore at and surrounding the site. Much of the fill material was placed near the turn of the century through the 1930's. The historical configuration of the marine shoreline in the lower park was considerably landward of the current shoreline at the site. Changes in the position of the shore were analyzed and more details are presented in the *Historic Shore Change* section below.

Geologic Unit Descriptions

Select geologic descriptions of units mapped by previous studies in the site vicinity are summarized below.

Post Glacial Fluvial/Deltaic Deposits (Holocene) – Silty, fine to medium sand, shell fragments, and occasional gravel. This unit represents native deltaic sediments from the Nooksack River Delta and fluvial sediments, primarily from Whatcom Creek. Coarser deposits represent rapidly advancing deltaic growth or fluvial outflow events, while fine grained sediments (silts) represent deposition in lower energy environments.

Artificial Fill (Holocene) (Qf) – Composed of earth debris, demolition debris, and refuse. Thickness is generally more than 2 m. Many wharves and structures, including industrial buildings, are built on unit Qf in Bellingham Bay (Lapen, 2000).

Glacial Outwash, Sumas Stade (Pleistocene) (Qgo_s) – Loose, moderately to well-sorted gravel with local boulders, sandy gravel, minor gravelly medium to coarse sand, and rare sand to silt. Clasts are generally subrounded to rounded and derived from the Coast Plutonic Complex in British Columbia and nearby sources. Bedding is massive to well-stratified; stratified sections are generally planar with bedding thickness ranging from a few centimeters to a few meters, depending on clast size; beds are rarely cross-stratified. Color is brown to gray, depending on oxidation state (Lapen, 2000).

Padden Member (Eocene) (Chuckanut Formation) (Ec_{cp}) – Moderately to well sorted sandstone and conglomerate alternating with mudstone and minor coal. Sandstone ranges from fine to coarse grained, with pebbly to conglomeratic sandstone layers common. Planar cross-bedding (2 m high), flat-bedding, trough cross-bedding, and ripple lamination are common bedding features. Sandstone is rich in chert and volcanic lithic clasts. Conglomerate is commonly massive to poorly stratified or cross-bedded and composed primarily of rounded chert, volcanic, and plutonic clasts as much as 16 cm in diameter. The matrix is commonly medium- to coarse-grained sandstone. Mudstone is commonly massive to thinly laminated and usually associated with coal; sandstone and conglomerate layers as much as 50 m thick alternate with mudstone. Color is light olive-gray to pale yellowish brown. Thickness is possibly more than 3000 m (Johnson, 1984). Honeycomb weathering patterns are common on exposures near sea water (Mustoe, 1982). Outcrops are widespread on the mainland and occur on Lummi, Matia, Sucia, and Patos Islands. The Padden Member has been the source of substantial amounts of coal in the vicinity of the city of Bellingham.

Subsurface Conditions

Several previous investigations within the site and in the vicinity have characterized the subsurface conditions by collecting geotechnical borings. Generally, these studies found several layers including fill material, wood waste, beach deposits, and bedrock. Two of these studies and the main findings are summarized below.

Focused Environmental Site Assessment, Herrenkohl Consulting/Landau Associates 2009 (Herrenkohl Consulting, LLC et al., 2009)

- Mapped distinct layers (see Figure 3), as listed below starting from the surface:
  - Fill – Silty sand and silty sand and gravel
  - Wood Debris – saw dust, chips, bark
  - Native Sediment – clayey silt with sand
  - Chuckanut Formation – Sandstone, siltstone

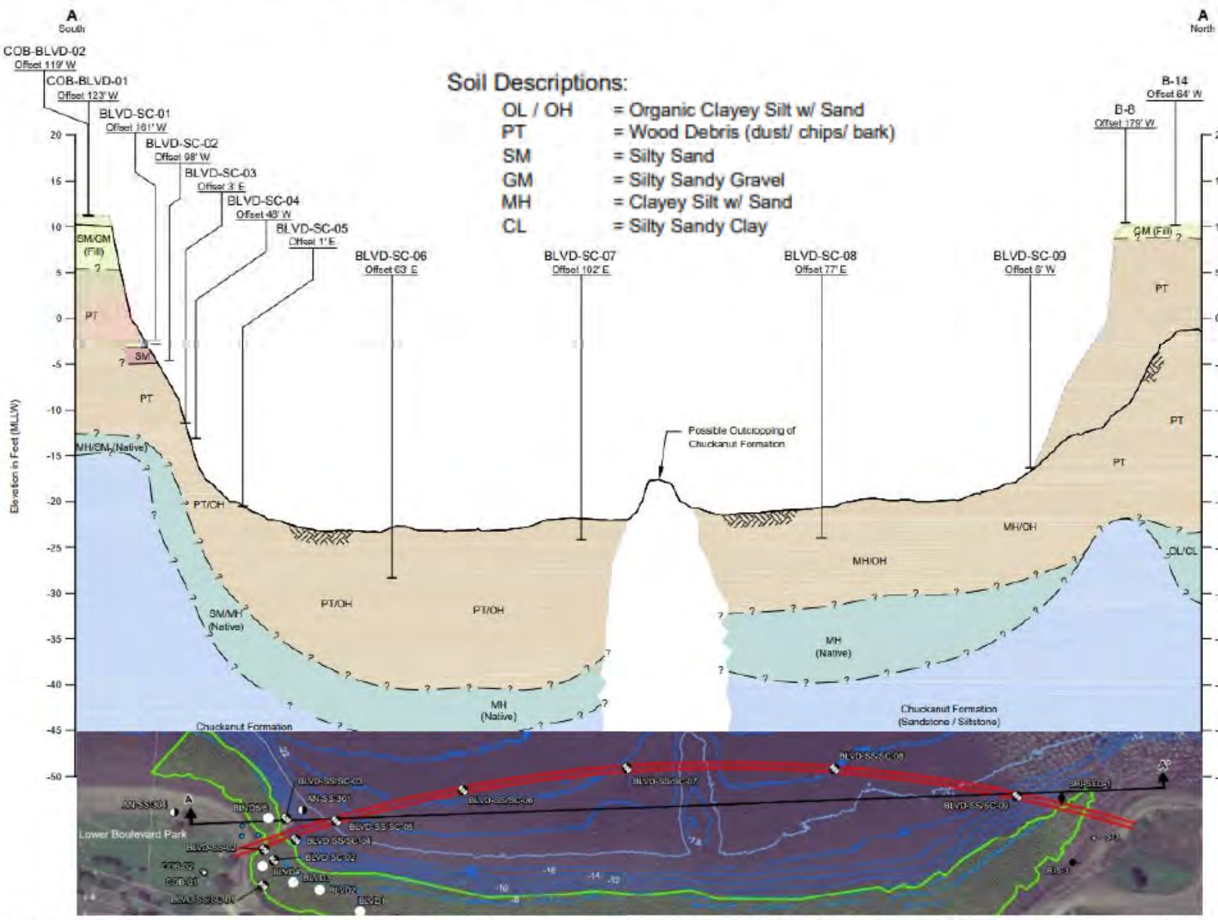


Figure 3. Subsurface conditions from Herrenkohl Consulting, LLC et al. (2009), Cross Section A-A'. Cross section following the previously proposed overwater walkway.

South State Street Manufactured Gas Plant RI/FS, Landau Associates/GeoEngineers 2019

- Encountered 7 distinct layers (Figure 4), listed below starting at the surface (generally).
  - Rip rap – Angular cobble-sized rock
  - Nooksack Deposits – Sandy silt, silty clay

- Debris – brick, coal-like material, clinker soil, and black granular material
- Fill – silts, clays, sands, gravel and other debris
- Wood – fresh and peat-like wood debris with sand lenses
- Bellingham drift (glaciomarine drift) – silt and silty sands
- Chuckanut Formation (bedrock) – sandstone carbonaceous shale

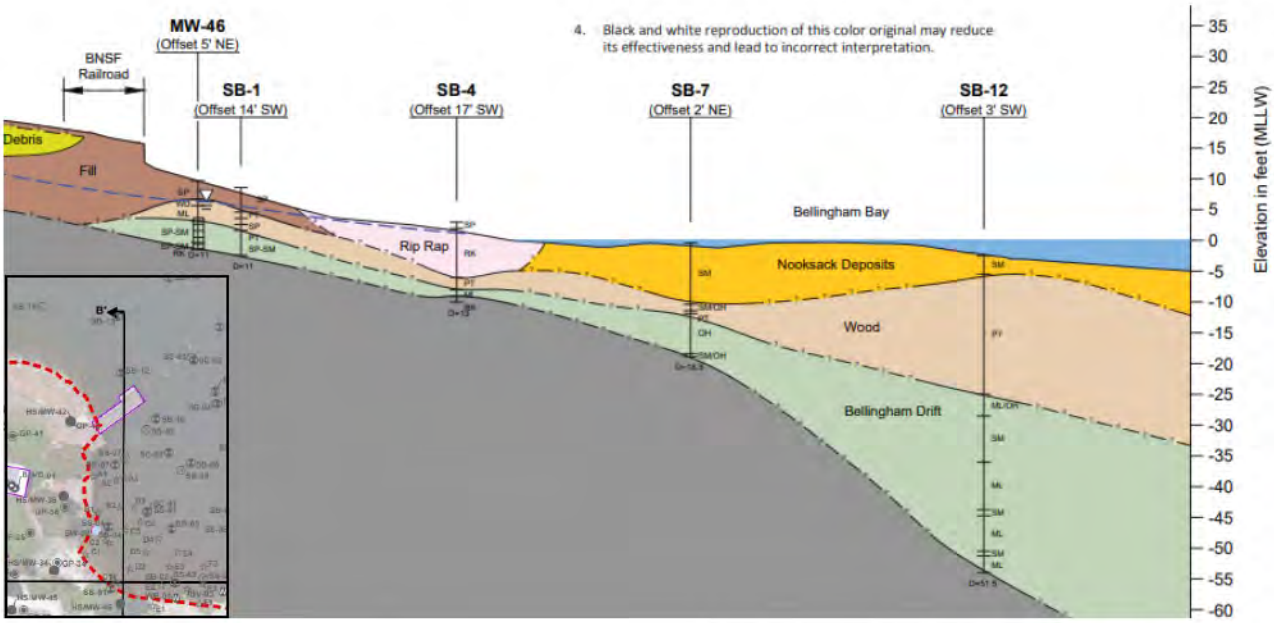


Figure 4. Subsurface conditions from Landau Associates, Inc. and GeoEngineers (2019), Cross Section B-B'. Inset shows cross section location.

Coastal Processes

The term "net shore-drift" refers to the long-term, net effect of littoral (sediment) drift along particular reaches of coast (Jacobsen and Schwartz, 1981). While littoral drift can go in opposite directions along a shore during short periods of time, when driven by changing wind and wave conditions, net shore-drift refers to the net effect of littoral drift over a period of many years at a particular location.

Historical Conditions Littoral Drift

The historic net shore-drift cells were mapped as part of the "Change Analysis" with the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) several years ago (MacLennan and Johannessen, 2008) (Figure 5). The immediate site area was historically within a cell with northward net shore-drift, as shown in Figure 5. This cell originated at a zone of drift divergence centered on Pattle Point in the southern end of Boulevard Park. This cell had northward drift to downtown Bellingham, which continued alongshore over sandstone outcrops.

Figure 5. Historic net shore-drift (MacLennan and Johannessen, 2008). Direction of net shore-drift from the perspective of the water facing the shore.

Since the mid-1800s, the eastern Bellingham Bay shore has been highly altered, which has drastically changed the characteristics of waves approaching shore and the processes of littoral sediment transport. The fill also buried natural coastal features and caused the loss of much of the remaining littoral sediment to deep water. The extensive rock revetment along the rail line has also greatly reduced sediment supply to the shore. The position of the shoreline in the site has moved waterward on the order of 100-250 FT since pre-development conditions. Currently, the majority of the site shoreline has a low to moderate height embankment and is generally armored with riprap.

Current Conditions Littoral Drift

Mapping of net shore-drift in Whatcom County in current conditions was completed in 1980 (Jacobsen, 1980; Schwartz et al., 1991) (Figure 6). Physical conditions along the Bellingham shoreline have seen little change since 1980 such that this mapping is still applicable. The site shore and the surrounding urbanized Bellingham Bay shore was mapped as “no appreciable net shore-drift”. This current lack of net shore-drift was caused by the extensive fill and shore armor that had been placed from south Bellingham to the site and along the remainder of the City shore which has blocked most of the historically limited amount of littoral transport.

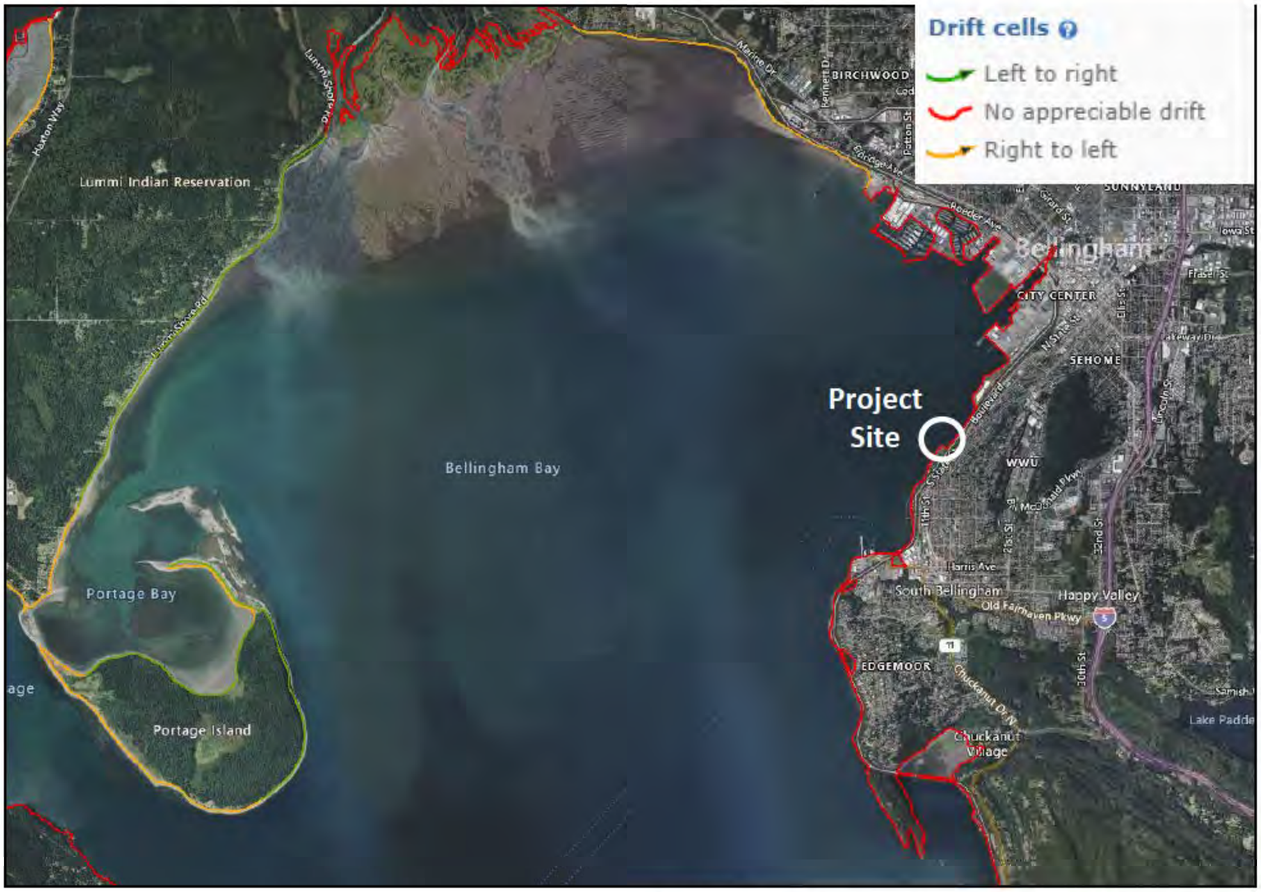


Figure 6. Modern net shore-drift in Bellingham Bay (Jacobsen, 1980) from the WA Coastal Atlas. Direction of net shore-drift from the perspective of the water facing the shore.

The existing upper intertidal beach area within the site is limited to a small pocket-like beach at the north end of the park (Figure 7). Pocket beaches are beaches that are typically contained between two bedrock headlands, essentially creating a closed system in terms of sediment transport. Within the site, the pocket beach is located between armored fill areas at the north end of the park adjacent to the railroad. Outside of the site, another larger pocket beach was constructed just south of the site in 2013, designed by CGS. Pocket beaches are typically not located within net shore-drift cells. As compared to typical bluff-backed beaches in drift cells of the Puget Sound region, pocket beaches are typically swash-aligned, shorter in length, crescentic in plan shape, and often display well-sorted sediment.

Figure 7. Coastal landforms at the site from the WA Coastal Atlas (data from Simenstad et al., 2011). Note that the artificial characterization was not always used accurately in this mapping, as all of the pocket beaches in this figure have been highly modified since pre-development conditions.

The small pocket beach at the northeast corner of the park within the site is the only shore area without exposed armor in the site shore. The remainder of the shore in the site is heavily armed with rock and concrete rip rap as well as old, scattered wood pilings.

Historic Shore Change

A 2009 report (Wahl, 2009) assembled for Wessen and Associates details the history of the site from 1855 to 2009 which encompassed maps showing the historic shoreline configuration. A summary of the shoreline history and figures from that report are detailed in this section.

1855 – USCS Hydrographic Survey

One of the earliest maps of the site was completed in 1855 by McMurtrie as part of a USCS Hydrographic Survey (Figure 8). This shows Pattle Point as a prominent feature, which is the current location of Woods Coffee in Boulevard Park. Further north, the shoreline within the site is much further landward, in the range of 100-250 FT. Figure 8 shows buildings of the Puget Sound Coal Company mine village at Pattle Point in 1855.

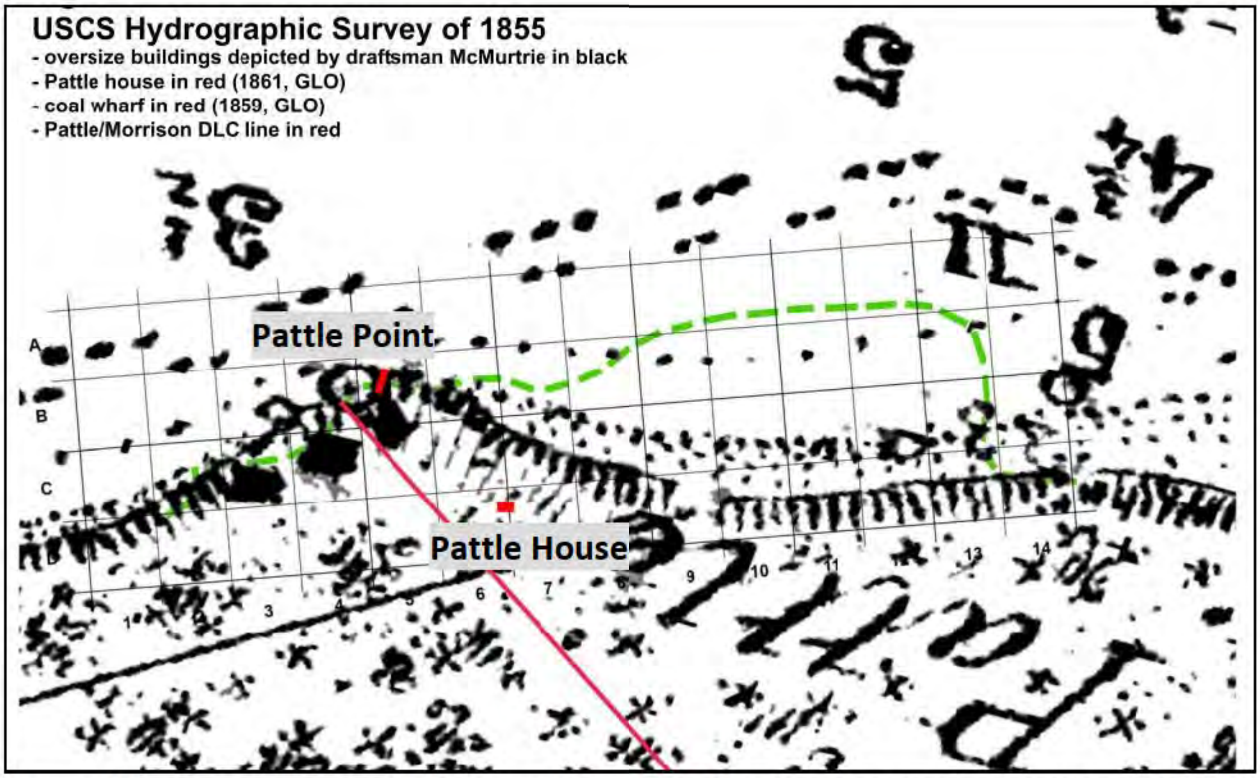


Figure 8. USCS Hydrographic Survey of the site and vicinity from 1855. Green line represents shoreline as of 2002. Map from Wahl (2009).

1887 – USCGS Topographic Survey

In 1883 or 1884, a sawmill was built at Pattle Point. In 1887, a topographic survey was conducted by the US Coast and Geodetic Survey's captain J.J. Gilbert. Figure 9 shows the shore bank/bluff lines and tidal flats overlaid on a 2002 aerial photo imagery. Contour lines on the original 1887 T-Sheet indicate Pattle's house was perched up to 40 FT above the elevation of the high tide, where today's lower park and railroad elevations are now 19 or 20 FT above sea level.

Figure 9. USCGS map from 1887 on 2002 orthophoto. Map from Wahl (2009).

1891 – USCGS Topographic Survey

The mainline BNSF Railway grade was cut directly through Pattle Point and the Morrison Point headland to the south, in 1889 or 1890. During or just prior to 1891, a spur line from the Great Northern Railway (GNRW) was constructed through the site to the sawmill, as shown in Figure 10. The spur line appears to run beside the north side of the bedrock headland, but likely required some rock removal. The difference between the 1887 and 1891 may be due to apparent filling.

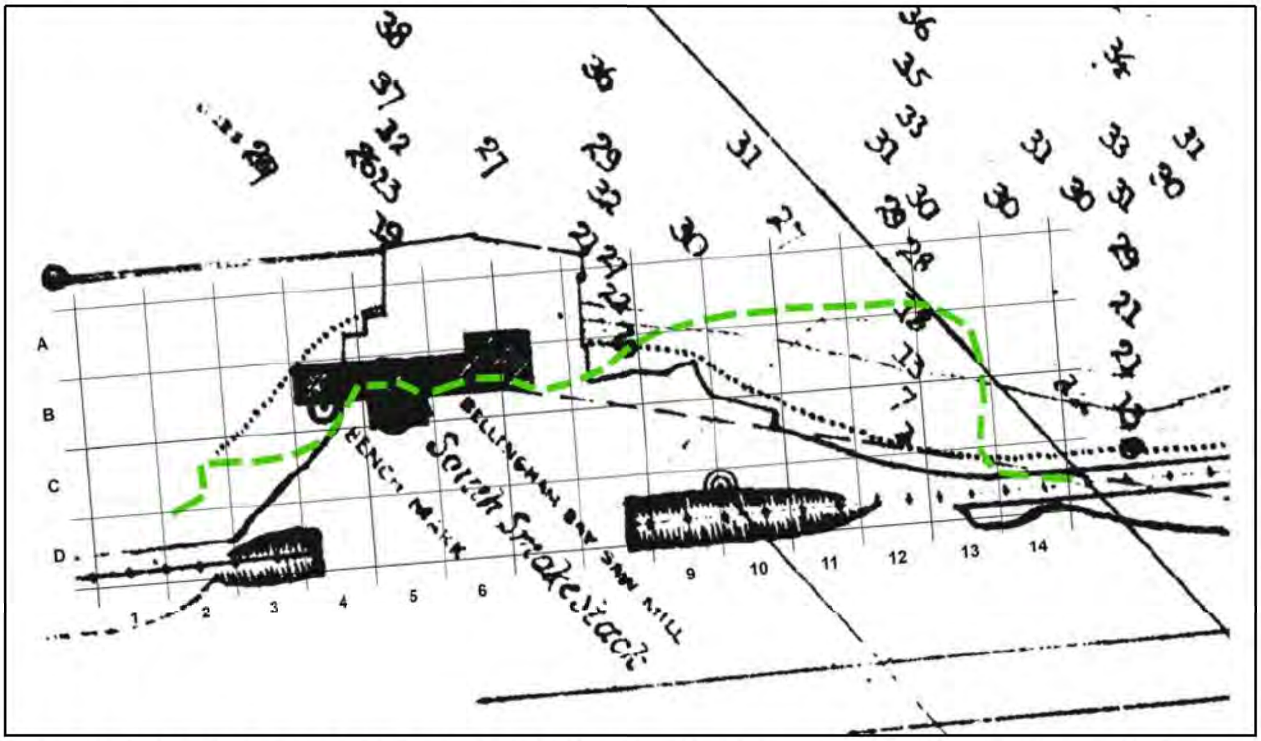


Figure 10. 1891 USCGS Harbor Survey with the GNRW constructed. Green line represents shoreline as of 2002 (Wahl, 2009).

Circa 1901, the Bellingham Bay and Eastern Railroad was built through the site and was in use until the 1940s. The era of intense and profitable milling started around this time, peaking in the late teens, but then dwindled with decreasing timber supplies and ceased in 1925 when the sawmill was destroyed in a fire. Stacked lumber on the site tidelands is thought to be a relic associated with the fire.

20th Century Aerial Photographs

The open water around Pattle Point and to its northeast was gradually filled during the development of the lumber mill but took place mostly after the mill burned in 1925. Maps made between 1920 and 1952 suggest that areas where today is filled were inundated enough that it was mapped as partly bay bedland. By 1943, the tideland fill was comparable to, or even slightly more extensive than the current site park area (Figure 11). North of where Woods Coffee stands currently appears to have had more extensive filling, however it is likely that wave action may have eroded the less stable fill material.

Various other filling and industrial activities have occurred since the 1940s including placement of brick fill from the demolition of the Fairhaven Hotel in 1955, boat building, extensive log booming (Figures 11 and 12), and rip rap placement with broken concrete from public streets. The waterward portions of the

park away from the current coffee shop were filled and then leveled for park construction in the early 1980s. Figures 11-16 show the progression of the site from 1943 to 2016.

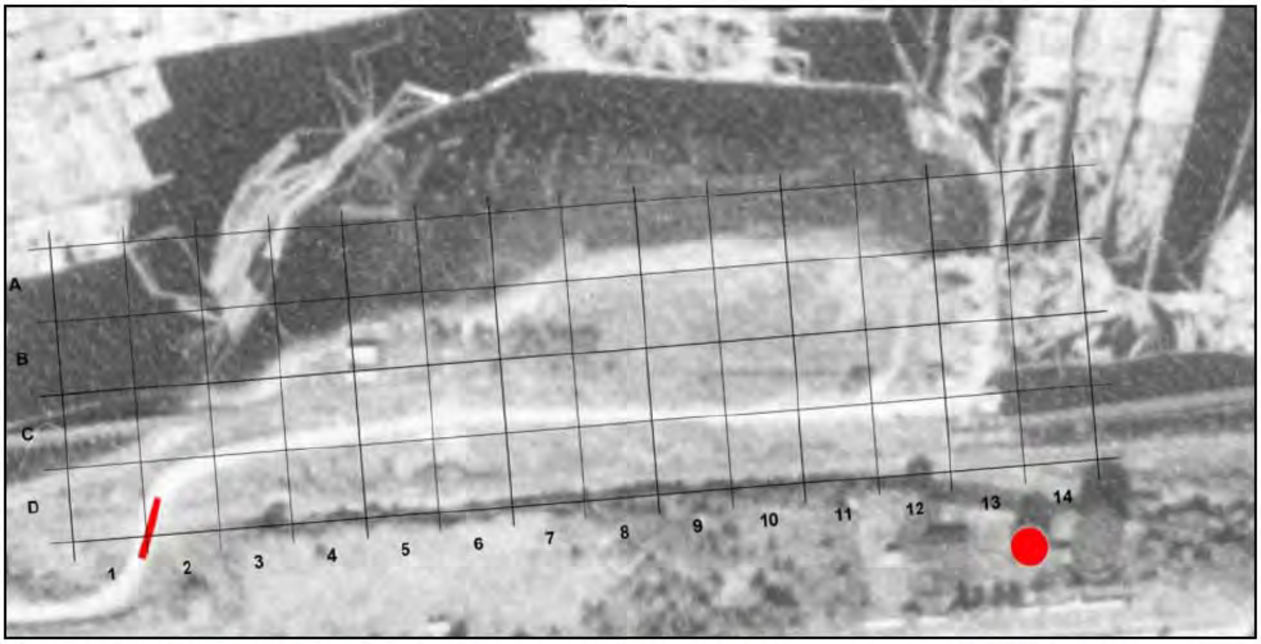


Figure 11. 1943 aerial photo. Earliest aerial of the site following the sawmill fire in 1925 (Wahl, 2009). Red markings were used to georeferenced imagery (Wahl, 2009).

Figure 12. 1950 aerial photograph of the site and vicinity (Landau Associates, Inc. and GeoEngineers, 2019).

Figure 13. 1963 aerial photograph of the site and vicinity (Landau Associates, Inc. and GeoEngineers, 2019).

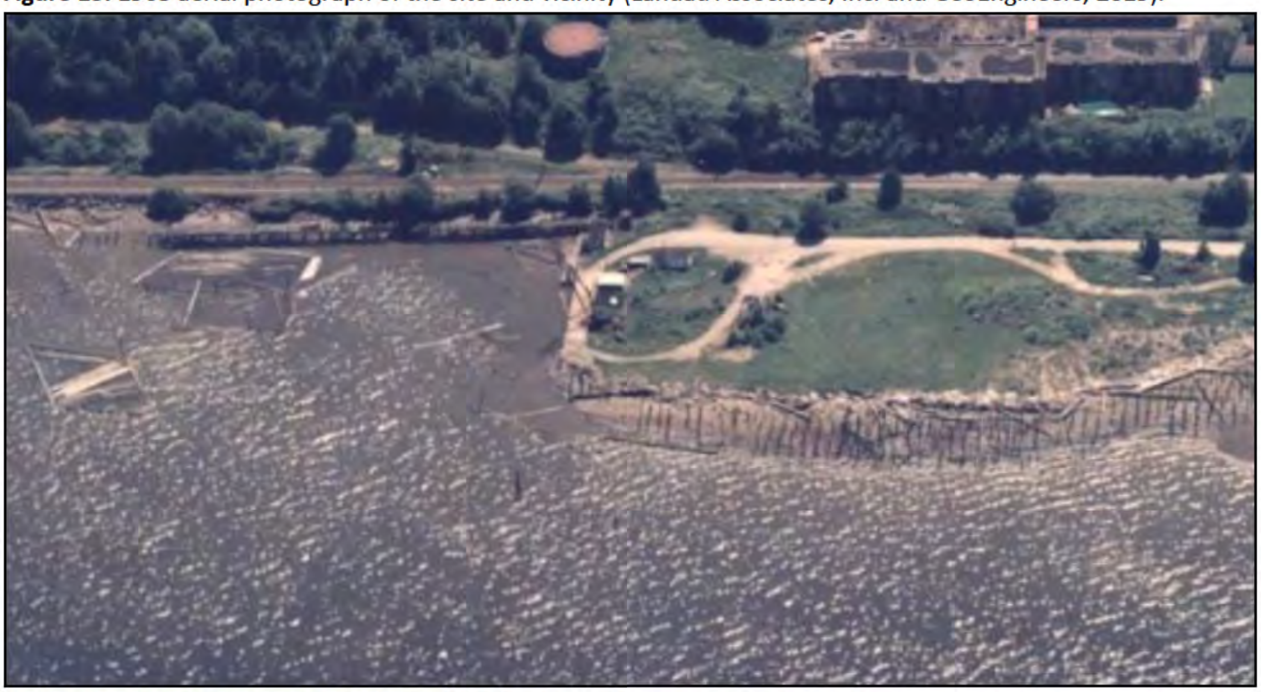


Figure 14. 1977 oblique aerial photograph of the site and vicinity (WDOE, 2016).

Figure 15. 1994 oblique aerial photograph of the site and vicinity (WDOE, 2016).

Figure 16. 2016 oblique aerial photograph of the site and vicinity (WDOE, 2016).

MetOcean Conditions

MetOcean data available and relevant to the site were collected and evaluated to assess site conditions and data adequacy in support of cleanup design in the next phase of the project. Figure 17 shows the locations of different MetOcean data stations.

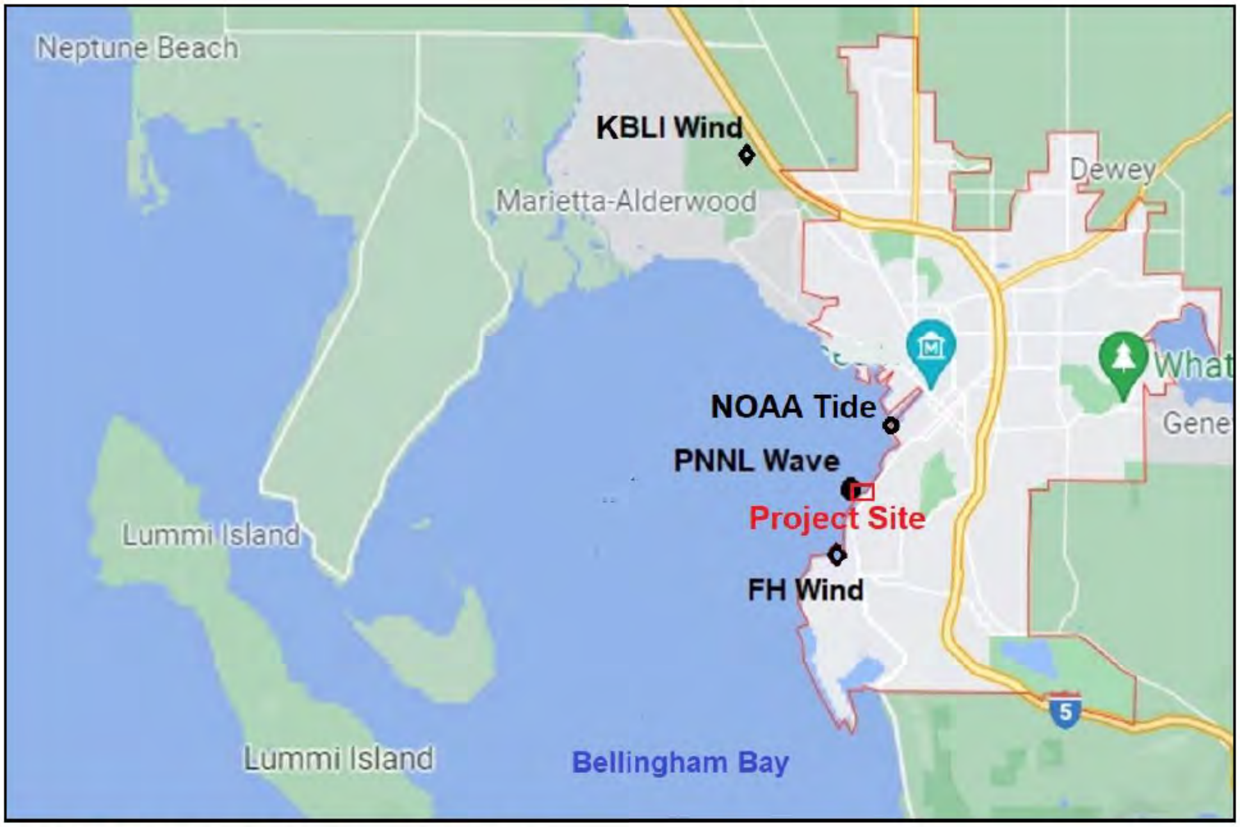


Figure 17. MetOcean data stations and locations.

Tides and Water Levels

Tides

Tides at the project site are semi-diurnal. Tidal levels published by NOAA for the Bellingham Station, WA (ID 9449880) are presented in Table 1. The elevation of the High Tide Line, defined by US Army Corps of Engineers (USACE) as the national water jurisdiction boundary, was sourced from USACE.

All elevations for this project are in reference to the NAVD 88 datum. The conversion from MLLW datum to NAVD 88 is -0.48 FT according to NOAA tidal datum sheet for the Bellingham Station.

Table 1. Tidal elevations at the project site (NOAA).

Tides	Tidal Level (FT, NAVD88)
High Tide Line (HTL)	9.29
Mean Higher High Water (MHHW)	8.03
Mean High Water (MHW)	7.31
Mean Tidal Level (MTL)	4.59
Mean Sea Level (MSL)	4.47
Mean Low Water (MLW)	1.87
North American Vertical Datum (NAVD88)	0.00
Mean Lower Low Water (MLLW)	-0.48

Extreme Water Levels

Extreme water level is a combination of storm surge and a high astronomical tide (spring tide, king tide). The recurrence extreme water levels at the NOAA stations at Friday Harbor (10.1 miles northwest of the site) have been published by NOAA. The extreme water level conditions at Bellingham were derived based on the storm surge ratio as predicted by Pacific Northwest National Laboratory (PNNL) Coastal Sciences Division wave hindcast model (Yang et al., 2019) and the known tidal differences between the Bellingham and Friday Harbor reference sites.

The resulting return-period extreme water levels for the project area are presented in Table 2.

Table 2. Extreme water levels.

Return Period (year)	2	10	30	50	100
Water level, Bellingham (FT, MLLW)	10.4	11.0	11.2	11.3	11.4
Water Level, Friday Harbor (FT, MLLW)	9.67	10.26	10.51	10.60	10.68

It should be noted that the extreme water levels given in Table 2 have not accounted for the effect of sea level rise (SLR) and wave runup.

Sea Level Rise

Climate-change induced SLR is projected to increase water elevations because of global warming, melting of glaciers and ice sheets, and land water storage changes, which will generally lead to higher coastal water levels that pose a high risk for low-lying coasts and communities (IPCC, 2019).

According to recent study completed by Miller et al. (2018), the projected SLR by year 2100 for Washington State for the high greenhouse gas emission scenario (Representative Concentration Pathways (RCP) 8.5, Lavin et al., 2019) is presented in Table 3, with two probability levels, the 50% likelihood and 10% likelihood levels.

Table 3. SLR projections for the high greenhouse gas scenarios (RCP 8.5, Miller et al., 2018) and Bellingham's SLR standard for 2120.

Year	SLR (FT, 10% likelihood)	SLR (FT, 50% likelihood)
2030	0.3	0.2
2050	0.9	0.6
2070	1.6	1.1
2100	3.0	2.0
2120	4.2 (City of Bellingham)	

The City of Bellingham has adopted a stringent SLR projection as a standard for all critical shoreline infrastructure and development projects, which is 50-inches (4.2 FT) of SLR by 2120 (Table 3). This is in line with Miller et al. (2018)'s high emission and 10% likelihood projection. This SLR projection is required for the cleanup design consideration for this project.

Currents

Currents in Bellingham Bay are primarily caused by the rise and fall of the tides. Tidal currents are generally weak inside the bay due to its large and wide, (nearly) semi-enclosed water body. Rivers or large streams discharging runoff water into the bay may only affect a very limited shallow water area nearshore. Wind-driven currents can be large compared to the tidal current under the storm conditions, however wind driven currents or circulations are only limited to surface waters which would have little effect on the stability of the seabed within the subtidal zone.

Figure 18 shows typical peak flood and ebb tidal currents in the Bellingham Bay for a spring tide event as modeled by Yang et al. (2021). These results were provided by PNNL extracted from a calibrated 3-D Salish Sea tidal hydrodynamics model. The maximum depth averaged tidal currents, whether flood or ebb current, are less than 0.1 m/s or 0.3 FT/sec along the coast of the City of Bellingham, including the project site. The near-bed current would be even less. Therefore tidal currents are not expected to cause significant disturbance to the settled seabed in the project area outside the shallow areas near the shore. Currents may play a role in maintaining a dynamic balance of very fine sediment material in the near-bed boundary layer but do not have enough velocity to cause substantial net sediment transport.

It can be concluded that the tidally-induced currents are too weak to alter the stability of the proposed cap material in the intertidal and subtidal areas or in deeper waters proposed for natural recovery. As a result, currents caused by wind-driven wave action would be the predominant natural force in the shoreline and intertidal area for consideration in the cleanup action design.

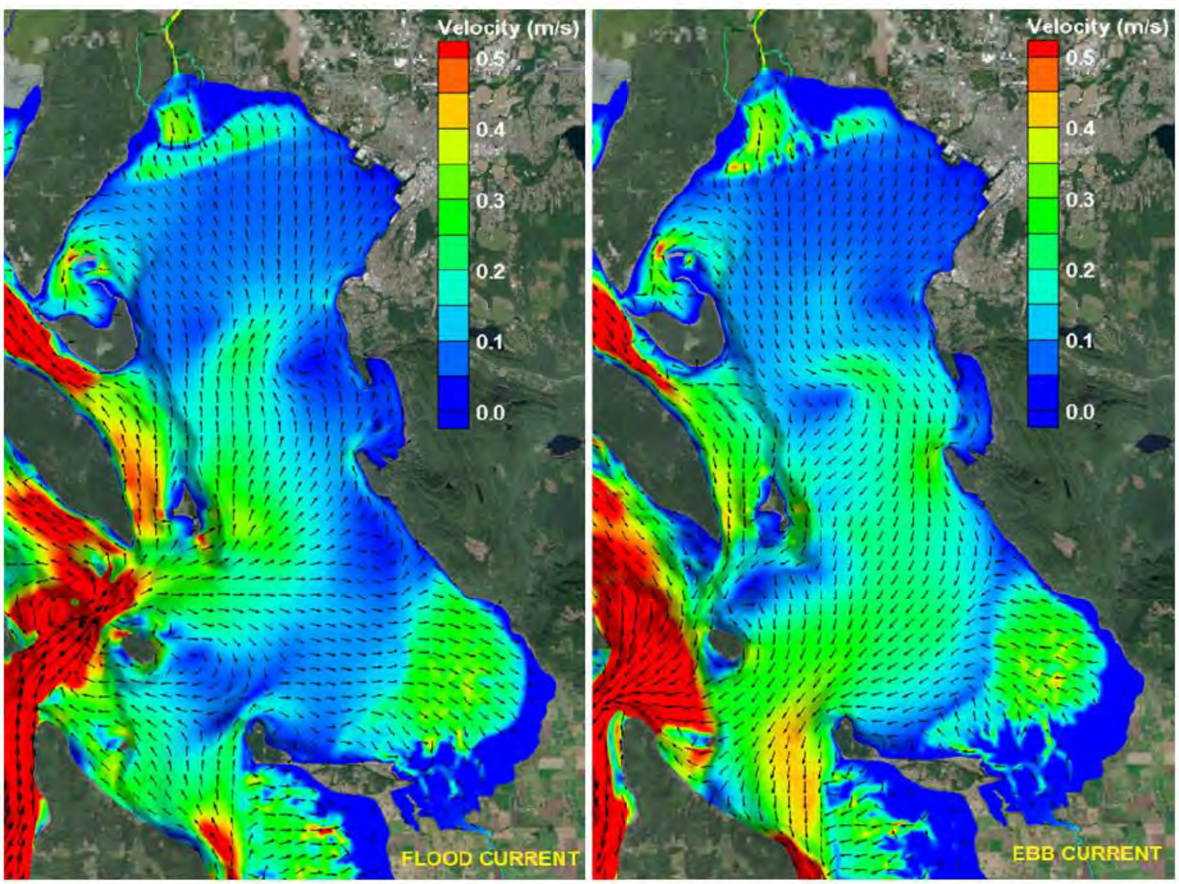


Figure 18. Snapshots of peak flood and ebb currents in the Bellingham Bay, spring tide (Yang et al., 2021).

Winds

Data Sources

In Bellingham Bay, regional storm winds are the primary driving force of waves. Long-term wind records were obtained and analyzed from two weather stations in the area, one from Bellingham International Airport (Station KBLI) and the other from Fairhaven Ferry Terminal Dock (Station FH -D8969). The locations of these wind gage stations are shown in Figure 17.

The KBLI data set consists of 66 years of data from 1948 to 2021, excluding missing data for the period of 1965 to 1972. The station is located 2 miles inland north of Bellingham Bay and 4.5 miles from the project site. The FH data set consists of only 10 years of wind data from 2012 to 2021. The station is located only 0.8 miles south of the project site at the shore, therefore this wind data better represents local wind climate, especially for wind directions. However, the station location is quite shielded inside a small semi-circular bay and the wind anemometer is only 10 FT from the deck of the floating dock. Height and overwater (shore effect) corrections have been made to this wind data set following recommendations of Coastal Engineering Manual (USACE, 2002).

Wind Climate

The wind data sets were processed and then plotted in wind roses to describe predominant wind climate of the area. Figure 19 shows the annual average wind roses of KBLI winds and FH winds in comparison. Tables 4 and 5 show the joint frequency of the wind occurrence for different directions and wind speeds.

The KBLI wind rose and the joint occurrence frequency distribution show winds from more concentrated directions, largely from southern directions (S and SSE, 39%) and secondly from northerly directions (NNE and N, 14%), but very low percentage of winds from SW-W-NW directions (10%). It is also noted that the KBLI winds have higher occurrence of strong northerly (NNE and N) storm winds even when at times the winds in Bellingham Bay were blowing westerly or southwesterly.

The FH wind rose shows more distributed winds from different directions. Even though the directional pattern looks similar, the SW winds, which have the longest direct fetch length to the project site, are observed more frequently at the FH station. This further indicates that the wind direction recorded at KBLI station may not well represent the actual wind directions in Bellingham Bay. This could likely be due to the changing direction of a strong weather system as it moves over from Bellingham Bay to the northern area landward. Data quality and accuracy in recording actual wind directions in earlier time periods could also be a potential cause. Therefore, for this project the KBLI wind data will be mainly used for extremal wind analysis without considering wind directions.

Based on our analysis of the wind rose and joint frequency distribution the FH wind data after station height and land-effect corrections (Figure 19 and Table 5) are considered to better reflect the general wind climate of Bellingham Bay, in particular the variations and occurrence frequencies of windstorms in different directions. Storm wind directions are also critical to the design of remedial actions. Table 5 shows that SW winds of speed greater than 25 mph has only slightly less frequency (0.03%) compared to strong winds from S (0.04%) and SSW (0.03%). On the other hand, the FH wind data does not well capture actual offshore extreme wind conditions in the Bellingham Bay due to its relatively short data record and the local shielding effect at the weather station. The station height and land-effect correction

approaches following Coastal Engineering Manual (2003) are rather simplified and unilateral. The speed of winds in the bay from South and North may still be underestimated.

As a result, for this study the extreme wind speed for the southerly and northerly winds will be derived in the next section based on the KBLI wind data. The extreme winds from other directions such as southwesterly and westerly may be factored lower based on the directional wind data from FH station.

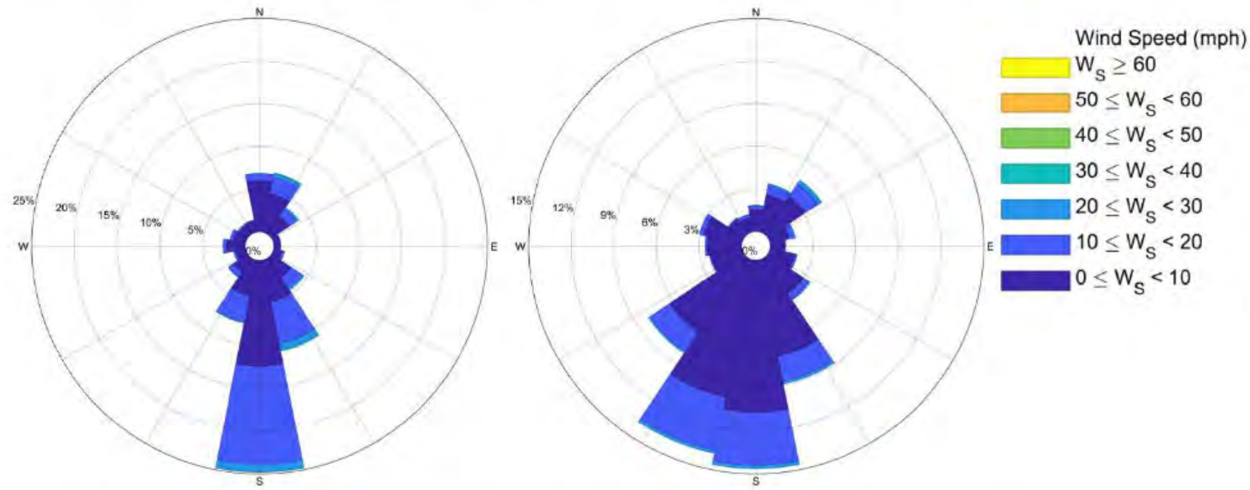


Figure 19. Wind roses, (a) Bellingham Airport (KBLI); (b) Fairhaven Ferry Terminal (FH-D8969).

Table 4. Joint frequency of wind speed (mph) against wind direction at KBLI Station.

N=576160	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total	Cumul.
0–0 (Calm)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16.68	100.00
0–5	2.98	1.63	1.03	0.34	0.44	0.44	1.10	1.40	3.09	1.12	0.70	0.41	0.78	0.44	0.53	0.69	17.13	83.32
5–10	3.52	3.50	1.71	0.40	0.35	0.67	1.99	4.57	11.75	3.79	1.51	0.83	1.65	1.15	0.75	0.72	38.86	66.19
10–15	0.51	1.21	0.60	0.07	0.05	0.19	0.95	3.09	7.52	2.20	0.48	0.18	0.29	0.31	0.17	0.10	17.91	27.33
15–20	0.11	0.56	0.33	0.04	0.01	0.06	0.46	1.42	2.67	0.63	0.14	0.04	0.04	0.03	0.02	0.01	6.55	9.42
20–25	0.03	0.29	0.18	0.01	*	0.01	0.18	0.60	0.68	0.10	0.03	*	*	*	*	*	2.14	2.87
25–30	*	0.10	0.06	*	–	*	0.04	0.15	0.10	*	*	*	*	*	*	*	0.48	0.74
30–35	*	0.04	0.02	*	–	*	0.01	0.06	0.03	*	*	–	–	*	–	–	0.17	0.25
35–40	*	0.02	*	*	*	*	*	0.02	*	*	*	–	–	–	–	–	0.06	0.08
40–45	*	*	*	–	–	–	*	*	*	*	–	–	–	–	–	–	0.01	0.02
45–50	*	*	–	–	–	–	*	*	*	–	–	*	–	–	–	–	*	*
50–55	–	*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*	*
55–60	–	*	–	–	–	–	–	*	–	–	–	–	–	–	–	–	*	*
>60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total **	8.19	8.40	4.98	1.92	1.90	2.41	5.79	12.36	26.90	8.90	3.89	2.51	3.80	2.98	2.51	2.56		
Cumul.	8.19	16.59	21.58	23.49	25.39	27.80	33.59	45.95	72.85	81.75	85.64	88.16	91.95	94.93	97.44	100.00		

Note: * denotes values less than 0.01%; - denotes no record in bin.

Table 5. Joint frequency of wind speed (mph) against wind direction at FH Station (after height correction factor of 1.185 and land correction factor of 1.2).

N=89184	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total	Cumul.
0-0 (Calm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.27	100.00
0-5	1.17	1.87	2.09	1.17	0.96	1.66	2.63	5.20	6.40	5.77	4.58	2.11	2.28	2.27	1.04	0.76	41.97	82.73
5-10	0.61	1.19	1.54	0.40	0.18	0.38	0.79	2.62	5.84	5.50	2.55	0.37	0.42	0.76	0.37	0.38	23.91	40.76
10-15	0.19	0.43	0.74	0.23	0.05	0.09	0.34	1.26	2.69	2.83	1.15	0.07	0.09	0.25	0.07	0.15	10.63	16.85
15-20	0.06	0.22	0.38	0.11	0.02	0.05	0.18	0.62	1.10	1.09	0.57	0.02	0.05	0.06	0.02	0.07	4.63	6.22
20-25	0.02	0.07	0.17	0.08	*	*	0.05	0.16	0.22	0.18	0.09	*	*	*	0.01	0.02	1.12	1.59
25-30	0.01	0.05	0.10	0.03	*	-	*	0.03	0.04	0.03	0.03	*	*	*	*	*	0.36	0.47
30-35	*	0.01	0.02	*	*	-	*	*	*	*	*	-	*	-	-	*	0.07	0.11
35-40	*	*	0.01	*	-	-	-	-	-	*	-	-	-	-	-	*	0.02	0.04
40-45	*	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	*	0.01
45-50	-	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
>50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total **	3.16	4.93	6.14	3.12	2.30	3.27	5.07	10.97	17.38	16.50	10.06	3.67	3.93	4.43	2.60	2.48		
Cumul.	3.16	8.09	14.23	17.36	19.65	22.92	27.99	38.96	56.34	72.84	82.90	86.56	90.49	94.93	97.52	100.00		

Note: * denotes values less than 0.01%; - denotes no record in bin.

Extreme Winds

The preliminary extreme wind speeds were derived utilizing the 66-year hourly wind speed data from KBLI airport. The 48 highest-ranking historic wind storm events were selected to fit the Gumbel Distribution. The resulting return-period hourly wind speeds are presented in Table 6.

Table 6. Extreme winds.

Return Period (year)	10	30	50	100
Design Wind Speed (mph)	49	53	55	58

The extreme wind speeds given by Table 6 can be considered as the design wind speeds for the Southerly and Northerly storms. The reduction factors for design winds from other directions will be further derived in the EDR phase as longer wind data at FH station or other weather station data become available.

Waves

The project site is exposed to winds and waves almost entirely from the southwest to west (Figure 20). However, the fetch length varies from southwesterly directions (approximately 7 miles) to northerly directions (less than 1.3 miles). Waves from the longest fetch of 12 miles in the SSW or S directions may also reach and significantly impact the site through wave diffraction.

For this study a 5-year wave hindcast data (2011 - 2015) for a location approximately 900 FT off the Boulevard Park shore was acquired and analyzed. The 5-year wave data is the only available data modeled and provided by PNNL, extracted from PNNL Puget Sound Wave Hindcast Model (Yang et al., 2019). The data is not long enough to derive extreme design waves, such as the 100-year return period wave conditions required for the design of remedial action for this cleanup project, but it provides site-specific annual-average wave climate information, including seasonal variations and occurrence distributions of wave conditions.

Figure 20 and Table 7 below presents the wave rose and the joint frequency distribution table.

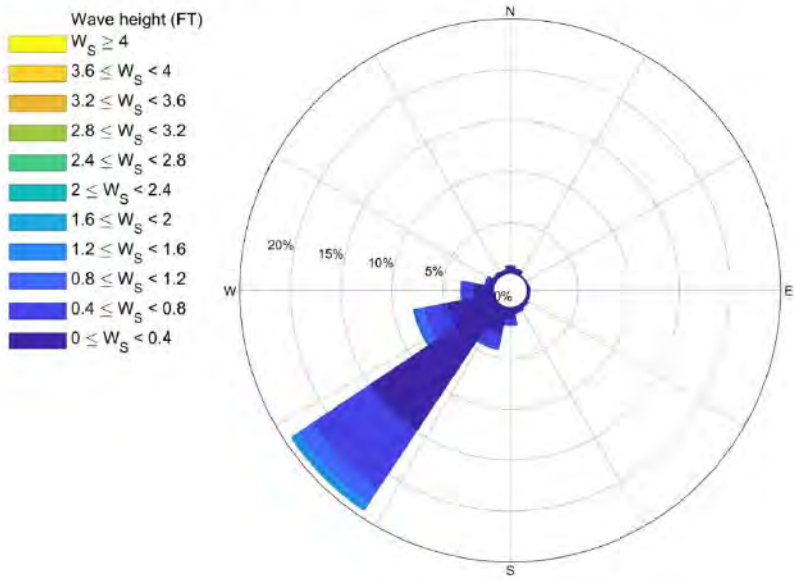


Figure 20. Wave rose off the coast of project site.

Table 7. Wave joint occurrence frequency table, wave height vs. wave direction

N=43824	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total	Cumul.
0–0.2 (Calm)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	72.88	100.00
0.2–0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	27.12
0.2–0.4	0.03	0.02	–	–	–	–	–	–	–	0.03	7.59	0.61	0.18	0.05	–	*	8.51	27.12
0.4–0.6	–	–	–	–	–	–	–	–	–	0.01	8.83	0.24	0.06	0.02	–	*	9.17	18.61
0.6–0.8	–	–	–	–	–	–	–	–	–	*	4.05	0.17	0.02	*	–	*	4.26	9.44
0.8–1	–	–	–	–	–	–	–	–	–	–	2.17	0.15	0.06	*	–	*	2.38	5.18
1–1.2	–	–	–	–	–	–	–	–	–	*	0.95	0.16	0.13	*	–	–	1.25	2.80
1.2–1.4	–	–	–	–	–	–	–	–	–	0.02	0.46	0.10	0.10	*	–	*	0.69	1.55
1.4–1.6	–	–	–	–	–	–	–	–	–	0.02	0.26	0.07	0.03	–	–	–	0.38	0.86
1.6–1.8	–	–	–	–	–	–	–	–	*	0.01	0.18	0.07	0.02	–	–	–	0.28	0.49
1.8–2	–	–	–	–	–	–	–	–	*	*	0.05	0.02	*	–	–	–	0.08	0.20
2–2.2	–	–	–	–	–	–	–	–	*	*	0.05	*	*	–	–	–	0.07	0.13
2.2–2.4	–	–	–	–	–	–	–	–	–	–	0.01	–	*	–	–	–	0.02	0.05
2.4–2.6	–	–	–	–	–	–	–	–	–	–	*	–	*	–	–	–	0.01	0.04
2.6–2.8	–	–	–	–	–	–	–	–	–	–	*	*	*	–	–	–	0.02	0.02
2.8–3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*
3–3.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*
3.2–3.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*
3.4–3.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*
3.6–3.8	–	–	–	–	–	–	–	–	–	–	–	*	–	–	–	–	*	*
3.8–4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	*
>4	–	–	–	–	–	–	–	–	–	–	–	*	–	–	–	–	*	*
subTot.	0.03	0.02	–	–	–	–	–	–	0.02	0.11	24.61	1.61	0.63	0.09	–	0.03		
Total **	4.58	4.57	4.56	4.56	4.56	4.56	4.56	4.56	4.57	4.66	29.16	6.16	5.18	4.64	4.56	4.58		
Cumul.	4.58	9.16	13.71	18.27	22.82	27.38	31.93	36.49	41.06	45.72	74.88	81.04	86.22	90.86	95.42	100.00		

Note: * denotes values less than 0.01%; - denotes no record in bin.

According to the data, waves for the site are mostly from the SW direction. However, high storm waves with wave height ranging 2.2 to 2.6 FT can also be from WSW and W directions. The significant wave height at the top 0.01% is 2.8 FT with a period of 3.9 seconds. The wave heights at the 1% and 5% exceedance levels are much lower, at 1.4 FT and 0.8 FT respectively, indicating that the site is generally in calm conditions except during southerly or westerly storm events. The maximum significant wave height that occurred during the 5-year period is 4.1 FT with a peak wave period of 4.3 seconds and an approaching direction of 240 °N.

For the design of remedial action, wind-growth wave modeling would be required to determine the 100-year design extreme wave conditions, taking into account complex nearshore bathymetry and shoreline geometry and varying fetch lengths over the Bellingham Bay region for different wind directions. This will be conducted in the next phase of the project as the design wind conditions are further confirmed.

Geomorphologic Assessment

Bathymetric Change Analysis

An assessment of the historical changes in site bathymetry was performed to evaluate bathymetric changes over time and to assess the rates and areas of accretion and erosion of sediment at the site. The assessment of historical changes in site bathymetry was performed based on direct comparison of the current bathymetry (2021) to the historical site bathymetry (2019 and 2005). A few other bathymetry survey datasets were initially processed and evaluated but were abandoned due to survey resolution or data quality reasons.

The existing nearshore bathymetry and inter-tidal to upland topography for the site were surveyed by David Evans and Associates Inc. (DEA) in 2021 and by Larry Steele and Associates in 2021-2022 respectively. The survey is a part of the PRDI to support the geomorphologic assessment and to serve as the basis for developing cleanup action design for the Marine Unit. The bathymetric survey was performed during a high tide with a multibeam echosounder system deployed from a marine vessel. Along the upper beach and backshore, land-based topographic survey methods were used to survey the areas above where the multibeam survey were not able to cover due to shallow water.

More details of the three datasets used in this analysis are as follows:

- **2021 David Evans Associates Inc (DEA) Multibeam Bathymetric Survey** (Figure 21) – The provided data has a 50-cm spatial resolution, collected using a Teledyne Reason Seabat Multibeam sonar operating at 240KHZ equipped with an APPLANIX POS/MV. The land-based topographic survey was performed in accordance with WAC 332-130 and other Washington State requirements for land surveys. The results of the multibeam and topographic surveys were combined to provide a complete bathymetric survey of the site.
- **2005 National Oceanic and Atmospheric Administration (NOAA) bathymetric survey (H11420) of Anacortes and Bellingham, WA** (Figure 22) – The provided data has a 0.5-m grid resolution, collected with a Reason 8101 and 8125 multibeam echosounder and a Knudsen 320M echosounder. The dataset was referenced to the MLLW, tidally corrected based on the tide records from NOAA Friday Harbor tidal station.
- **2019 United States Geologic Survey (USGS) of eelgrass and bathymetry in Bellingham Bay, WA** – The dataset consists of point data along a series of single-boat track lines running back and forth in cross-shore directions. Figure 23 shows the survey line track in the vicinity of the site. The spacing between cross-shore track lines are approximately 83 FT on average. The survey used a single beam sonar system (echosounder) and global navigation satellite system (GNSS) receiver. Depths from the echosounder were computed with sound velocity data collected with a YSI Cast Away CTD (CTD stands for conductivity, turbidity, and depth). For comparison with the multibeam survey data, 6 cross-sections (A to F) were designated in line closely with the 2019 USGS survey track lines (Figure 28), and the extracted cross-section bathy profile data along these section lines were compared.

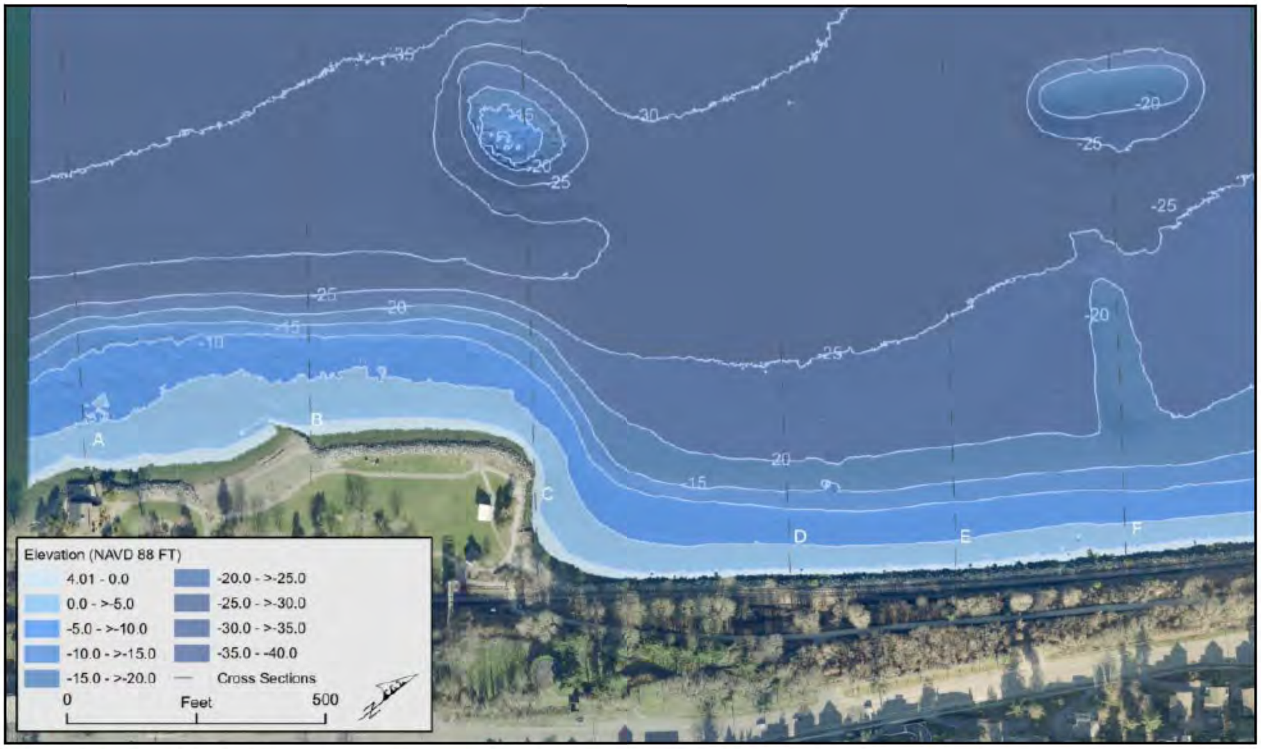


Figure 21. DEA 2021 bathymetry survey map in the project area.

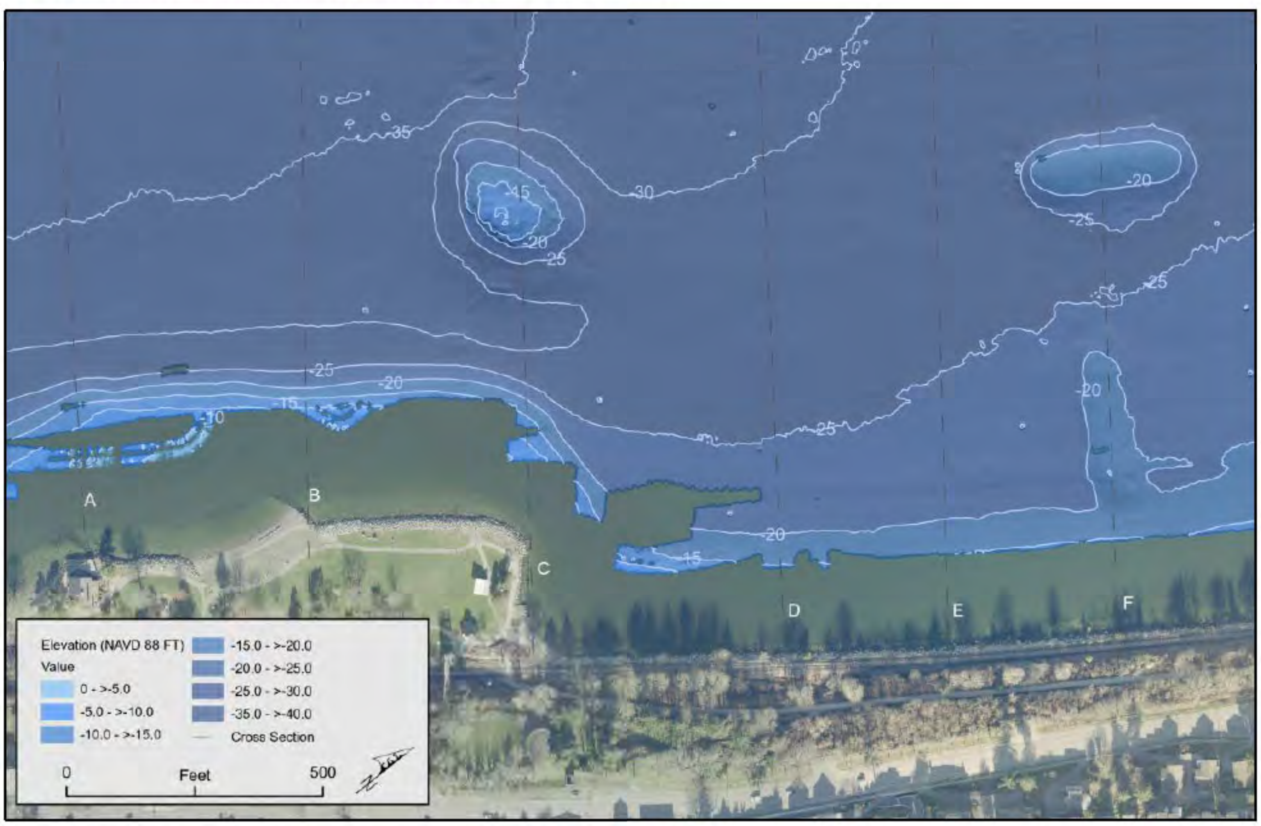


Figure 22. NOAA 2005 bathymetry survey map in the project area.

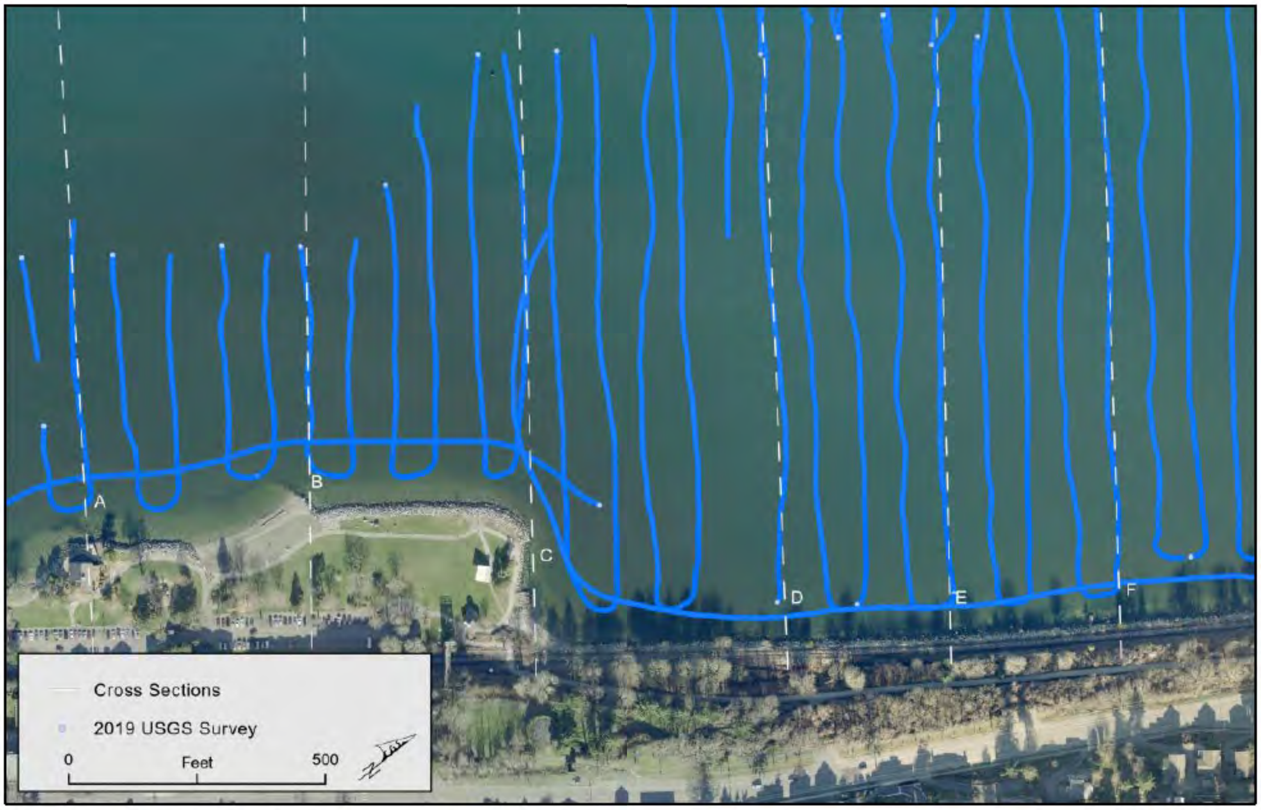


Figure 23. USGS 2019 bathymetry survey track lines.

Results

Bathymetric difference between the 2021 DEA data and the 2005 NOAA data under the same resolution is shown in Figure 24. This provides an approximately 16-year period to evaluate recently changing conditions at the site and vicinity.

A summary of the primary observations from Figure 24 are as follows:

- Areas with the highest erosion are visible in the southeastern part of the area alongshore. This is along the edge of the 2005 survey in the shallowest water area, where the 2005 NOAA dataset has been purposely cut out due to quality concerns. Therefore, data quality along this edge area is uncertain, and there is no additional information to explain such dramatic and consistent seabed erosions/changes in a water depth of 10 to 20 FT.
- There are two noticeable spots with significant erosion at the bed, one just off cross section D at the west of Starr Rock (the south underwater mound), the other just on the south side of cross section C (Figure 24). It is not known what has caused increased seabed depressions at these two spots.
- High levels of accretion appear on the southeastern side of Starr Rock off cross section C, and around the northern underwater mound near cross section F.
- Figure 24 shows clear striping erosion pattern near the eastern part of cross sections D, E and F, which continues southwestward. Such strips are visible in the 2005 bathymetry map (Figure 22) but not in the 2021 bathymetry map (Figure 21). The stripping lines of erosion look superficial and unexplainable in nature, as under such water depths both wave actions and tidal currents

are minimal, and do not create this type of change. Further investigation was conducted and the findings are explained below.

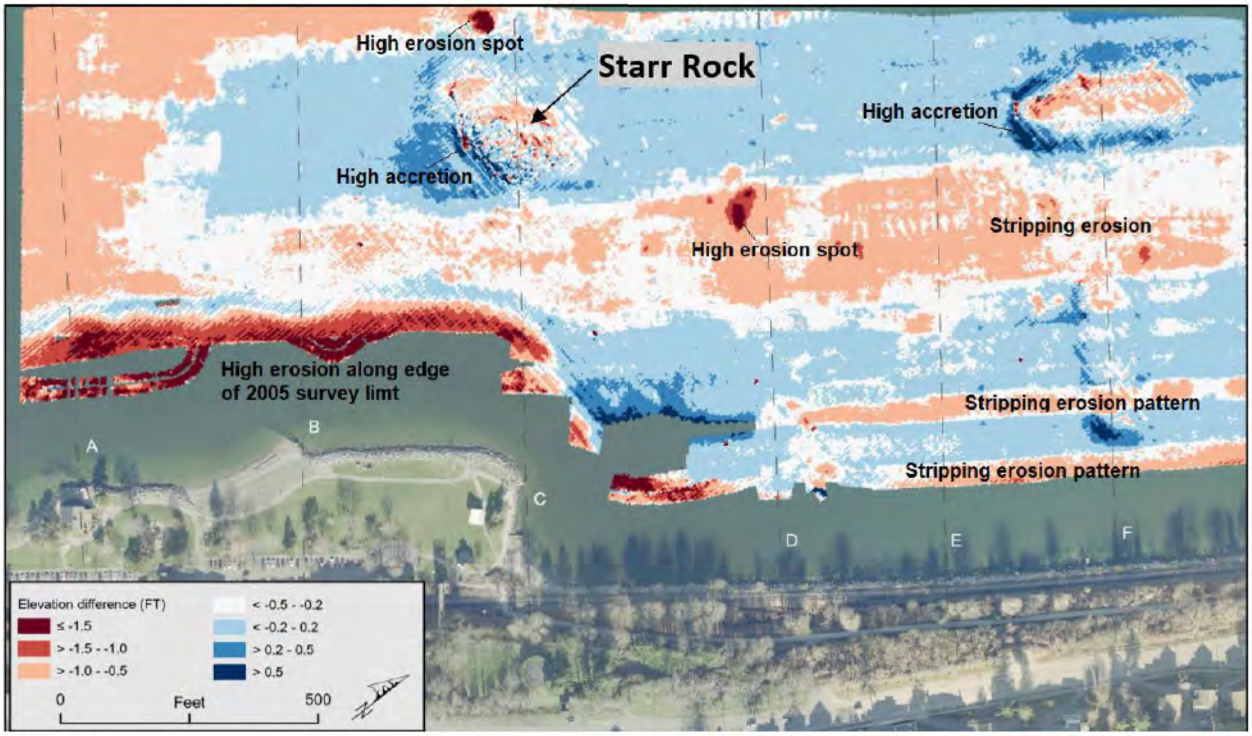


Figure 24. Bathymetry change over the period of 2005 to 2021.

After contacting NOAA's survey department, it was conveyed that there was sizeable freshwater runoff from rivers and streams during the 2005 survey period. Varying water density in the nearshore (due to freshwater discharge) would affect sound velocity measurements, which was not corrected in the post-processing of the survey data. Therefore, lower accuracy of bathymetry would be expected in the northeastern part of the Bellingham coast. However, such effects may be limited in the project area as it is not close to any significant freshwater discharge sources.

Further looking into NOAA 2005 bathymetry survey documentations, it was understood that the 2005 multibeam water depth survey was conducted during the period of Oct. 15 – Nov. 09, 2005 and was tidally corrected to seabed elevation utilizing recorded tidal data from NOAA Friday Harbor tidal station (ID 9449880). The Friday Harbor tide was adjusted by a fixed factor of 1.1 for the tidal range relative to MLLW and a fixed phase lag of 18 minutes to represent the real-time tides of Bellingham Bay during the period the survey was conducted. Errors could have been introduced in such a process of tidal correction when there was no simultaneous and more relevant local tide measurement for tidal correction.

To analyze potential errors from tidal correction in the 2005 NOAA bathymetry dataset, we duplicated the adjusted tide time series during the 2005 survey period potentially used for the tidal correction. Figure 25 shows the predicted Friday Harbor tides (blue line) and its high- and low-tide points (blue) after adjusted by a factor of 1.1 (according to NOAA documents), as compared to the predicted high and low tides at Bellingham station (ID 9449211) (orange points). In terms of tidal magnitude, the adjusted higher-high tides and lower-low tides from Friday Harbor match relatively well with those at the Bellingham station, but there are large differences for most of the higher low tides. A magnitude of approximately 0.5 to 1 FT error on the high end could have been introduced as the survey was likely conducted during those high-tide periods during daylight. Over-correction of tides to the surveyed data would result in lower seabed elevation, and as a result, higher erosion areas. On the other hand, time-lag statistics for all high tide and low tide occurrences during the period revealed that the average time lag is only 5.3 minutes (vs. 18 mins used for the tide correction). Inaccurate time-lag adjustment would also introduce error from tidal corrections.

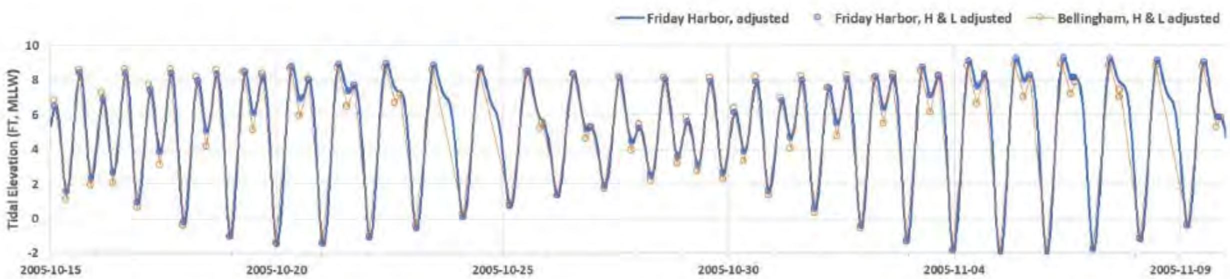


Figure 25. Comparison between Friday Harbor predicted tide adjusted for Bellingham Bay (used by NOAA 2005 bathy survey correction) and Bellingham predicted tide.

It is believed that the striping lines of erosion/accretion, and erosion in particular, as shown in Figure 24 is likely caused by the inaccuracy of real-time tide correction. If these errors were corrected these stripping lines of erosion areas could mostly disappear.

It can be concluded based on the above assessment that the erosion patterns shown in Figure 24 are not reliable due to expected errors from tidal correction in the 2005 NOAA bathymetry dataset. However, the two survey dataset can still be compared at a qualitative level as both multibeam sidescan surveys are capable of resolving large seabed features.

Figure 26 and Figure 27 shows the zoomed-in views of seabed topographic features at and surrounding the two underwater mounds. Both images from 2005 map and 2021 map have the same spatial resolution. It can be seen that in both zoomed-in areas, features such as oversized logs/pilings and likely boulders are all visible and look undisturbed and unchanged in locations. The 2021 map also shows a slightly smoother bed surface and more burial of some features surrounding the south sides of the mounds, indicating potential accretion in the area. There is no identifiable evidence of erosion except for the two depression spots as revealed in Figure 24.

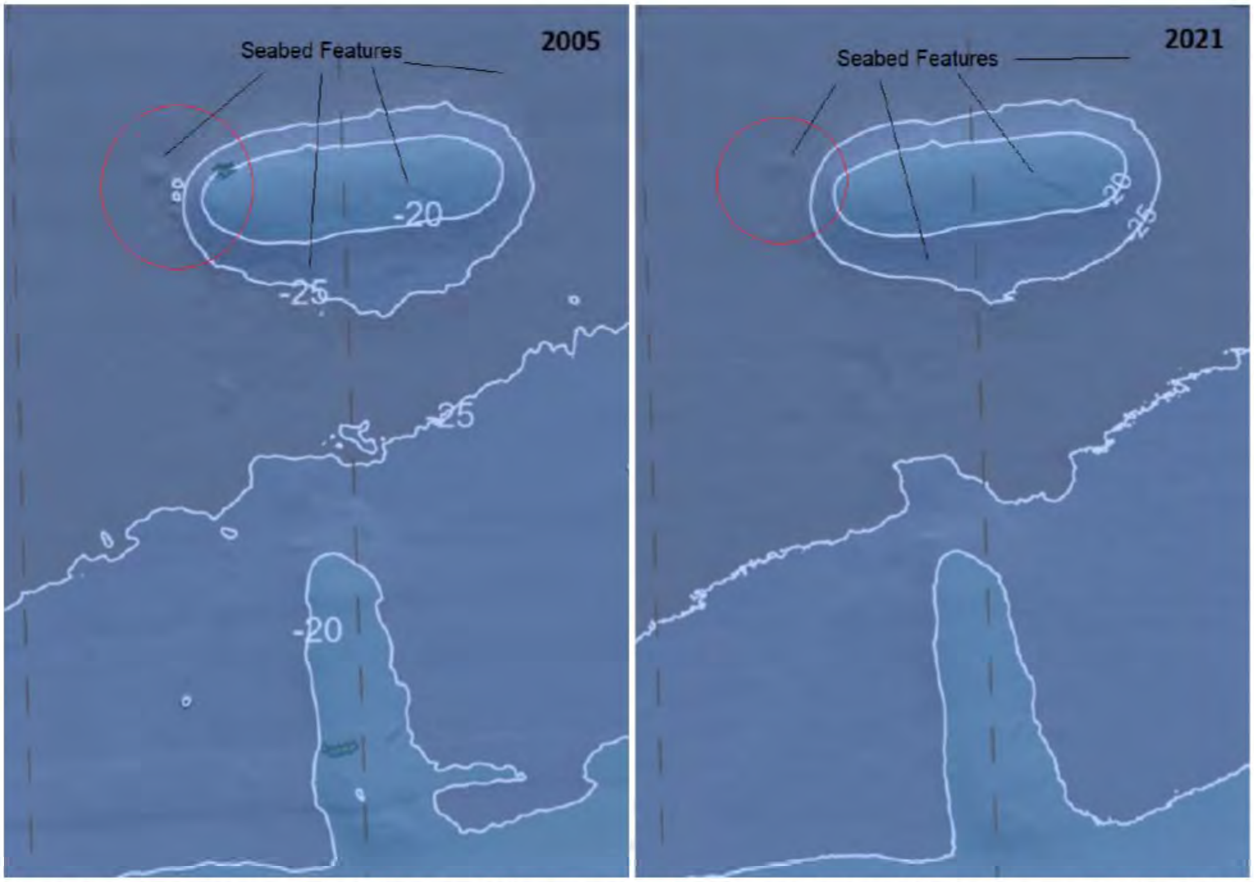


Figure 26. Comparison of seabed elevation features revealed by 2005 and 2021 multibeam surveys, northeastern underwater mound area. Some features are called out as examples.

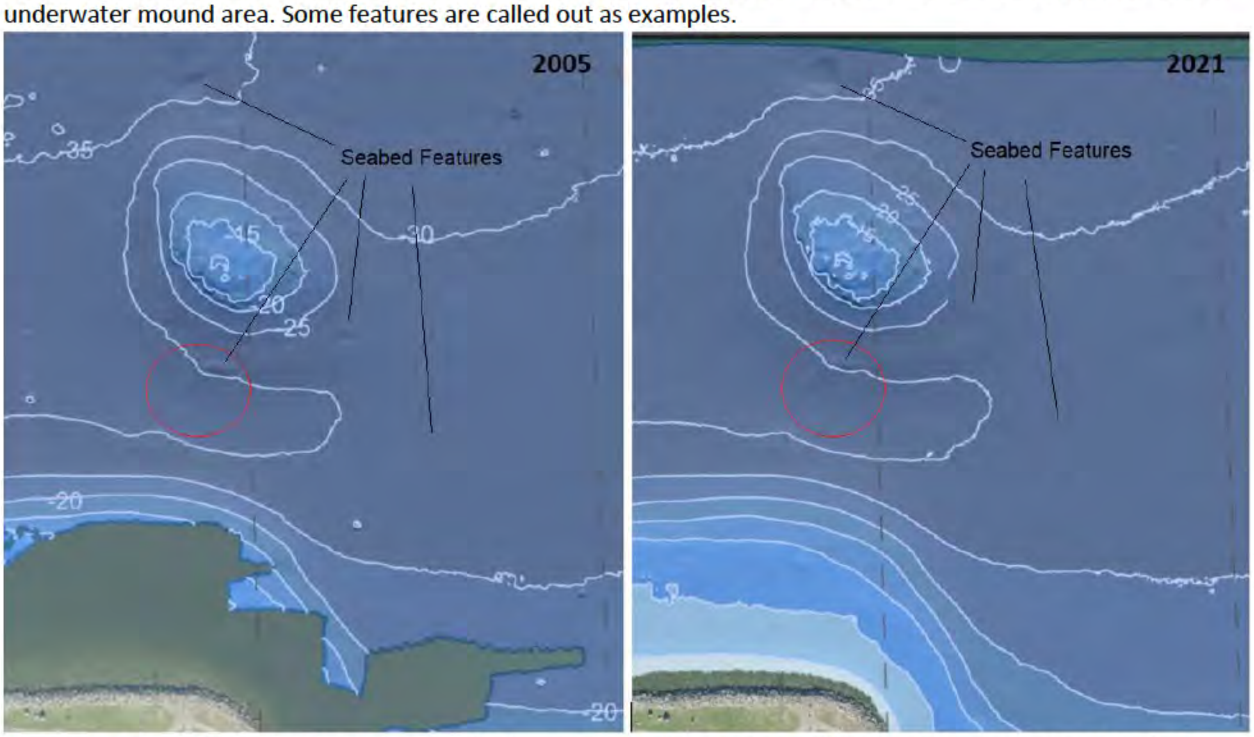
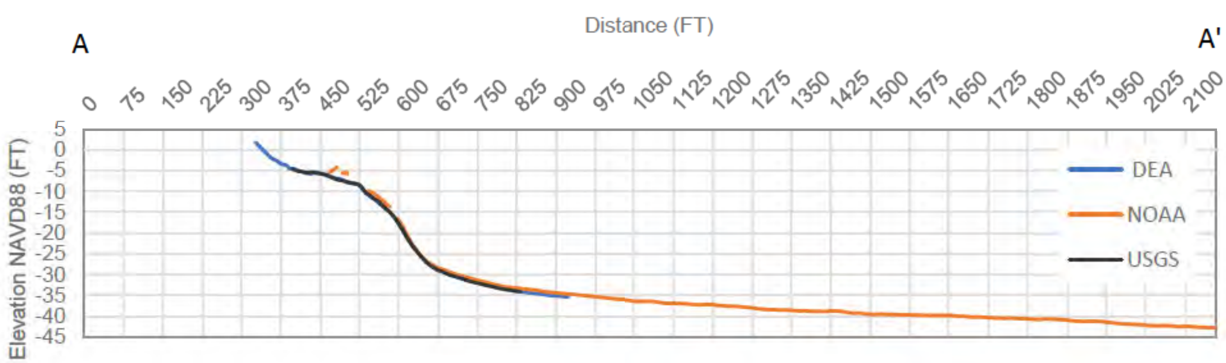


Figure 27. Comparison of seabed elevation features revealed by 2005 and 2021 multibeam surveys, Starr Rock area. Some features are called out as examples.

Bathymetric data were also compared along 6 cross sections (A-F, Figure 28; the locations of the cross sections are shown on Figure 24). Trends observed from the eight cross sections of the 2021 DEA, 2019 USGS and 2005 NOAA bathymetric data include the following:

- Cross sections of all three bathymetric datasets shared similar profile trends. The 2021 DEA and 2019 USGS cross sections consistently and closely match each other, showing no notable differences or bathymetric changes over the period, except for Section F. The 2019 cross section profile appears to have a slight horizontal shift in the cross-shore direction.
- The 2005 NOAA profiles had visible elevation high points closest to shore. This was apparent in cross sections A through C, while less discernable in the subsequent cross sections. The 2005 profiles also show slight highs and lows (fluctuation) across the profiles, which are more apparent in Sections D, E and F. As discussed above these likely resulted from the errors introduced in the inaccurate tidal correction.
- Cross sections C and F appeared to cross sandstone exposures with shallower depths that decreased eastward in the profiles. At cross section C the top elevation of the underwater sandstone is approximately -11.5 FT, while at cross section F the top elevation is 16 FT.
- Cross sections A and B had the steepest slopes observed. In cross section A this occurred between approximately 600 FT and 650 FT horizontal, while in cross section B this occurred between approximately 540 FT and 625 FT.



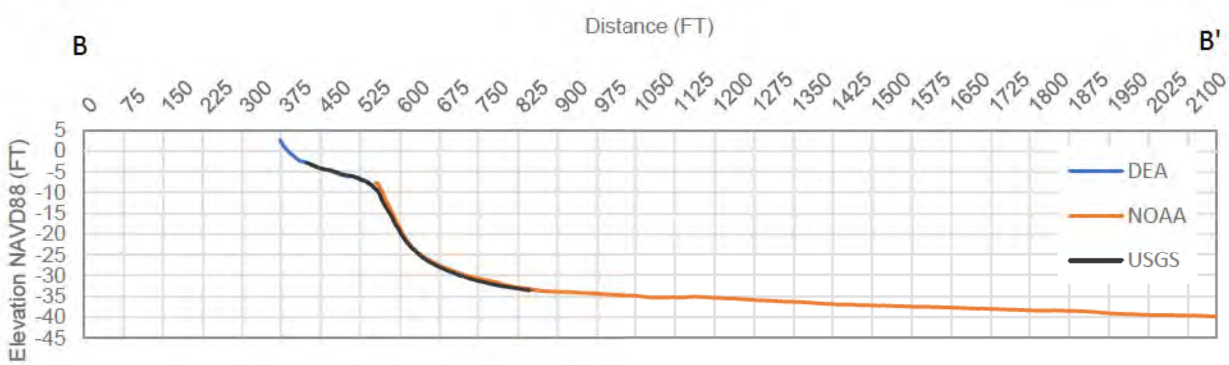


Figure 28. Cross section bathymetry comparison.

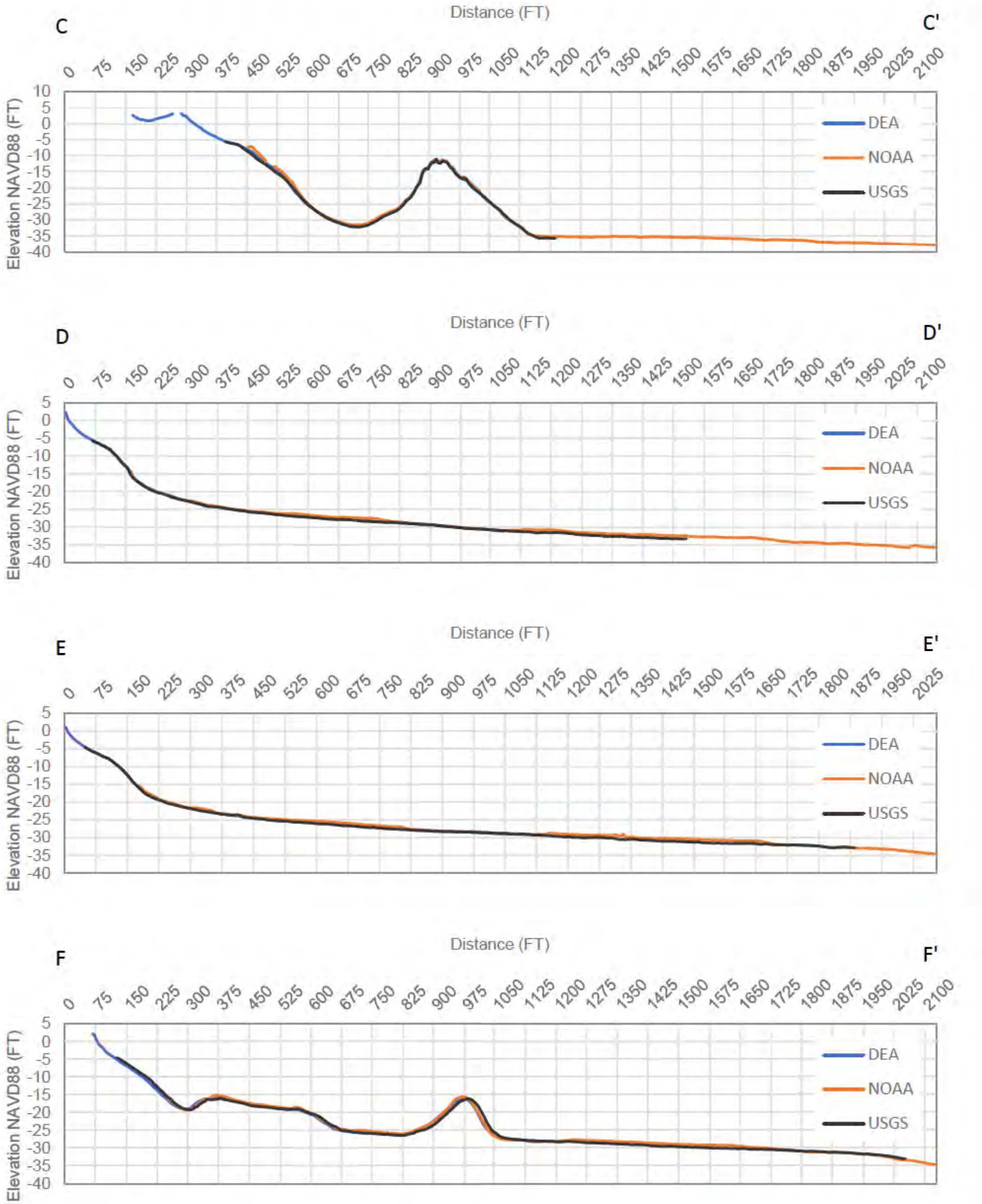


Figure 28 (continued). Cross section bathymetry comparison.

Historic Seabed Erosion and Accretion

The depositional history of the existing sediment deposits and potential for accretion and erosion was evaluated based on review of previous investigations of the site and sediment coring and sampling performed as a part of the PRDI. Dating of sediment deposition was based on core sample collection and radiocarbon dating and radioisotope analysis to estimate sediment accumulation rates (SARs) and to understand seabed stability and accretion and erosion potential.

Sediment Core Sampling and Analysis

Seven (7) sediment core locations (PRDI-35-SC to PRDI-41-SC, Figure 29) were collected to between approximately 3 to 7 FT bml (Table 8). The sediment core samples were collected by GeoEngineers from a vibracore sampler between 9/14/21 to 9/15/21 using a subcontracted marine research vessel (see Section 3.7 of the PRDI report for details and field procedures).

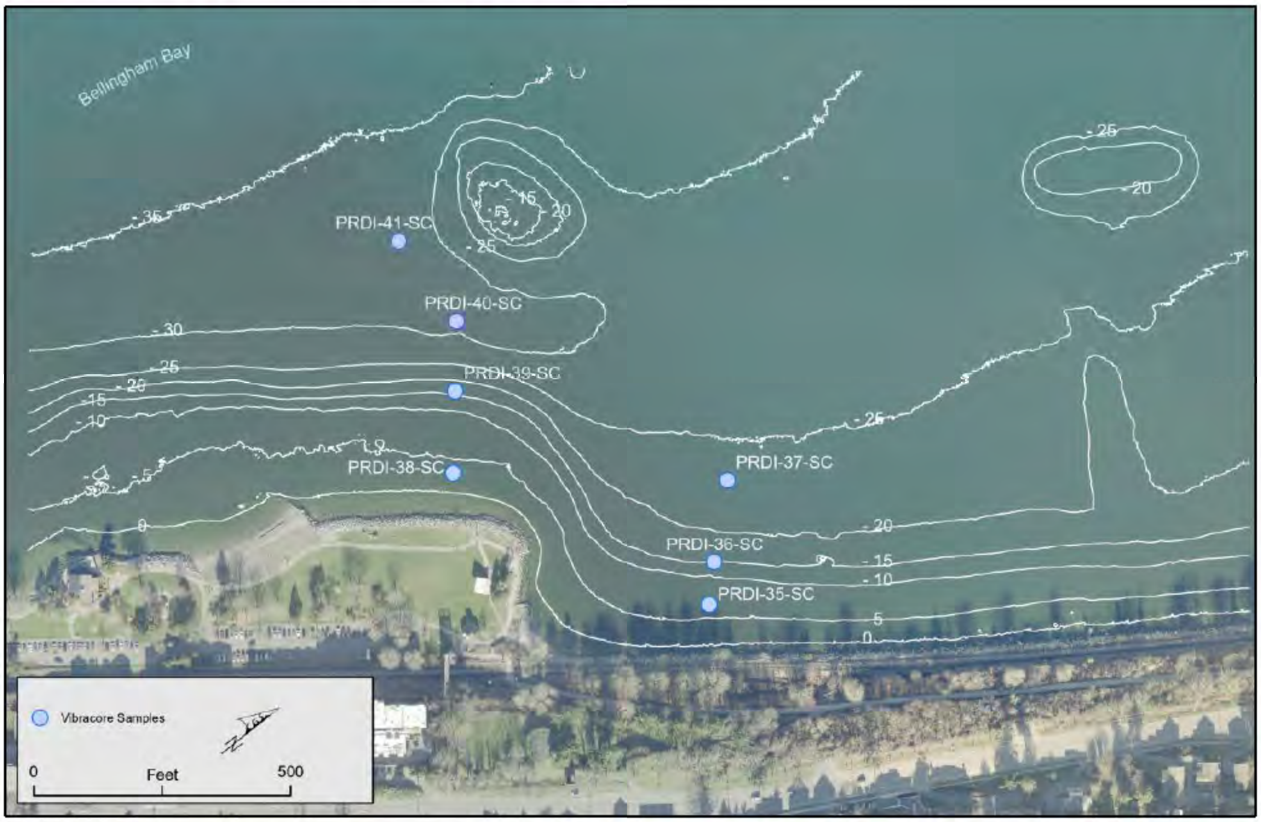


Figure 29. Vibracore sample locations. Imagery Whatcom County 2019. Elevation source DEA 2021 in FT NAVD88.

Cores were capped and picked up by CGS and inspected by the principal engineering geologist and coastal geologist. Preliminary visual classification of sediment layers was logged, and cores were photographed (Attachments A-B). Depth intervals to be sampled for laboratory analyses were identified. Visual observations and sample collection for grain size analysis by Materials Testing & Consulting (Attachment C) and sediment dating (radiocarbon and/or radioisotope analysis) was completed to assess depositional history.

Core sediment samples were sent to General Engineering Laboratories (GEL) LLC to analyze SARs and absolute sediment ages using ^{210}Pb and ^{137}Cs radiochemistry. These methods are explained in detail in the final Report from GEL labs (General Engineering Laboratories and Burnett, 2022; Attachment D).

Many of the samples contained an abundant amount of wood chips and therefore, a correction was applied by determining the ash weight after ignition. One core (PRDI-29-SC) was also analyzed for activities of ^{137}Cs to corroborate the ^{210}Po analysis for sediment ages and accumulation rates.

Results

The seven cores (PRDI-25-SC – PRDI-41-SC) were logged and sampled, with samples sent to two analytical labs to be analyzed for grain size and SARs. Core logs include depth below ground surface (bgs; same as below mud line or bml), locations of samples collected, illustrative symbology, description, and wet and dry weights used to calculate the mass accumulation rates (MARs) and are found in Attachment D. Table 8 provides a summary of the results for each core. Wood waste, often in the form of sawdust, was common in cores from the shallow subtidal in the southern portion of the Marine Unit.

The SARs for all seven cores fell into a relatively narrow range from 0.77±0.06 cm/yr to 1.8±0.2 cm/yr with an average of 1.2 ±0.2 cm/yr. This is very similar to a current unpublished USGS study which analyzed SARS from cores within Bellingham Bay, where the average SAR was 1.27 cm/yr near the site (Liam Horner, USGS, per communication, 2022).

Table 8. Summary of core elevations, lengths, descriptions, sediment accumulation rates (SARs), and mass accumulation rates (MARs) (from GEL labs final report; Attachment D). See core logs (Attachment A) for more details.

Core	Core Top Elev. (FT, NAVD88)	Core Bottom Elev. (FT, NAVD88)	Core Length (FT)	Description	SAR cm/yr	MAR mg/cm^2yr
PRDI-35-SC	-6.8	-12.5	5.7	Top 0-60 cm bgs clay-silt with trace organics. 60 cm bgs to base clay-sand with wood and bark fragments, increasing from approx. 20% to 90% with depth.	1.3±0.2	1870±330
PRDI-36-SC	-15.7	-21.6	5.9	Clay-silt with fine wood fragments increasing with depth, with trace shell. Some larger wood (~10 cm long).	1.2±0.3	1800±400
PRDI-37-SC	-23.7	-31.1	7.4	Clay-silt with trace sand, no wood until approx. 96 cm bgs then trace wood (bark) increasing to approx. 25-35%. Trace shell.	1.6±0.1	2200±160
PRDI-38-SC	-3.7	-6.8	3.1	Wood chips and saw dust >60% and increasing with depth to >90%. Minor silt-coarse sand.	0.9±0.2	460±40
PRDI-39-SC	-17.1	-22.1	5.0	Wood chips, saw dust, wood splinters (bark) >50% with clay-silt. Trace shells.	0.77±0.06	500±50
PRDI-40-SC	-32.8	-37.4	4.6	Clay-silt with small amounts of wood fragments and bark, increasing with depth.	1.8±0.2	2060±300
PRDI-41-SC	-33.1	-37.2	4.1	Clay-silt with up to approx. 10% wood chips/splinters. Trace shell. Pebbles and sand from 86 cm bgs increasing at depth to approx. 60%.	1.0±0.01	520±50

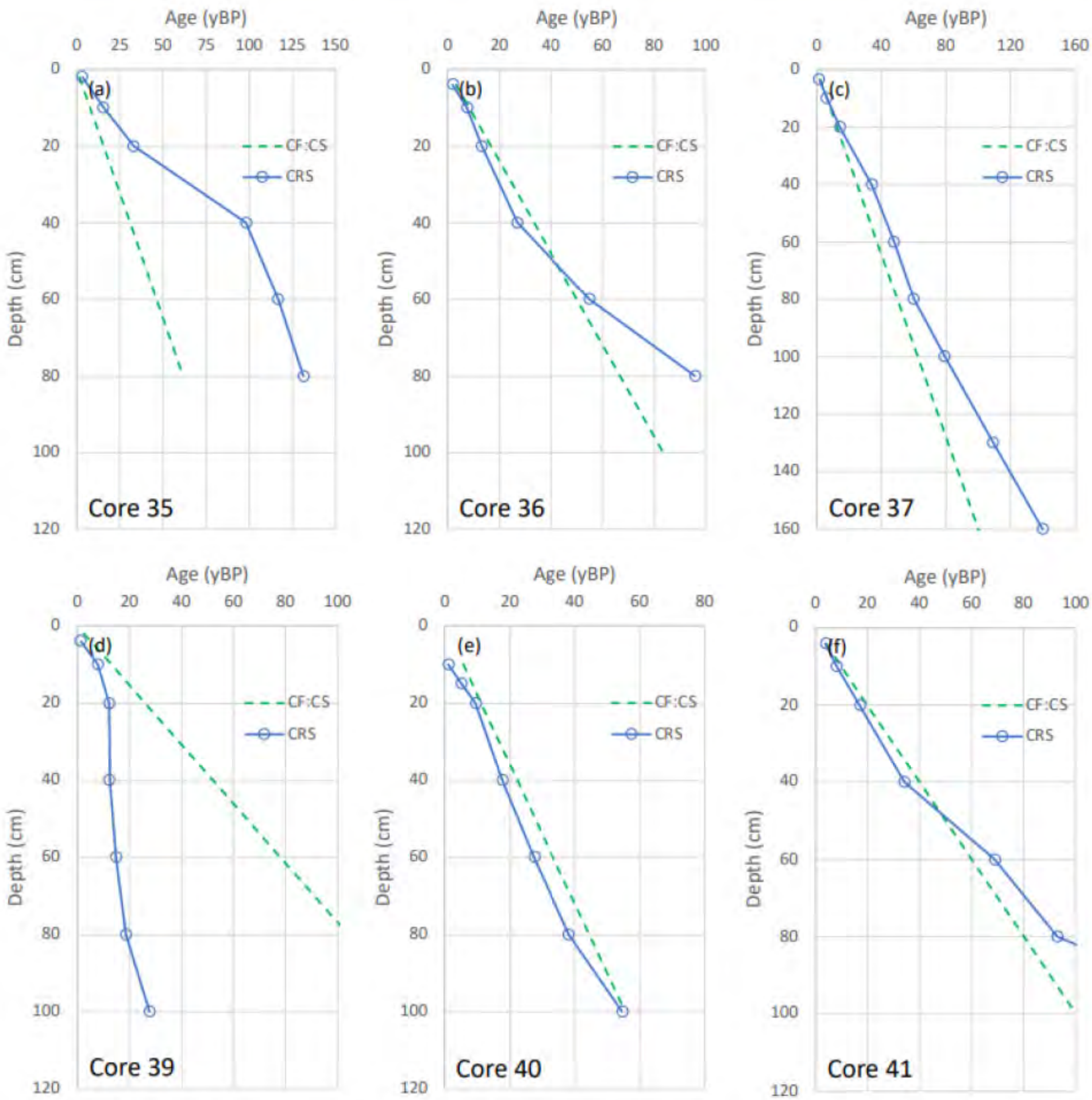


Figure 30. Age in years before present (yBP) compared to depth (cm) for all cores except PRDI-38-SC (too few layers to allow estimation of CRS ages). Comparison of Constant Flux: Constant Sedimentation (CF:CS) and Constant Rate of Supply (CRS) models ages show good to excellent agreement between the two age models except at cores PRDI-35-SC and PRDI-39-SC. GEL labs favored CF:CS model when the two approaches do not agree (cores PRDI-35-SC and PRDI-39-SC). See GEL's final report for more details (Attachment D).

Comparing the ages to the depth plotted in Figure 30, these data show a general transition to less sediment accumulation in the last 35-45 years shown by a change in steepness of the Constant Rate of Supply (CRS) model curve. PRDI-37-SC shows some of the fastest and most consistent SAR which we attribute to the closer proximity to Whatcom Creek and the Nooksack River as well as being more sheltered from southerly storms by the northwest point of Boulevard Park.

While PRDI-39-SC did not show great agreement between the models, it had peak activity of ^{137}Cs at 40 cm which indicates an approximate age of 1963 and the CF:CS model produced an age of the same layer of 1970 (See Figure 7 in Attachment D). This represents excellent agreement according to GEL labs. Using this we can estimate that the SAR for the last approximately 50 years was approximately 0.7 cm/yr. We attribute the slower SAR for PRDI-39-SC to its location on the steeper slope between the intertidal and deep-water region where it is more difficult to accumulate and retain sediment. PRDI-38-SC also had a relatively slower SAR, which is likely due to it being affected by wave energy in the shallow nearshore region.

There is some evidence that SARs are slowing in the last 10-15 years based on the gentler slope shown at the top of PRDI-36-SC, PRDI-39-SC, and PRDI-40-SC. Decreased logging in the Nooksack watershed starting in the late 1990's, partially due to improved Washington State forest practice rules (the Forest & Fish Law, 1999[1]), likely led to less sediment input into the Nooksack River. This as well as possible increased storminess in the region in the last decade or so is likely the driving factor for slowing SARs within the site.

Sediment Grab Sampling and Analysis

Seven (7) intertidal surface samples were collected (PRDI-SS-100 through PRDI-SS-106, Figure 31) using hand tools as part of the PRDI. The samples were collected from 0 to 15 cm bml and submitted for laboratory analysis of:

- ASTM D422 – Hydrometer Analysis
- ASTM C136 – Sieve Analysis
- ASTM 2487 – Unified Soil Classification System (USCS)

Twenty-two (22) subtidal surface sediment samples (PRDI-13-SS to PRDI-34-SS) were collected using a Power Grab sampler operated off of a subcontracted marine research vessel (see Section 3.7 of the PRDI report for details and field procedures). At each sample station, discrete surface grab samples were collected from the upper 12 cm from the sampler for processing on board the vessel.

All sediment samples were analyzed by Materials Testing & Consulting, and their results are found in Attachment C.

[1] https://www.forestsandfish.com/about/

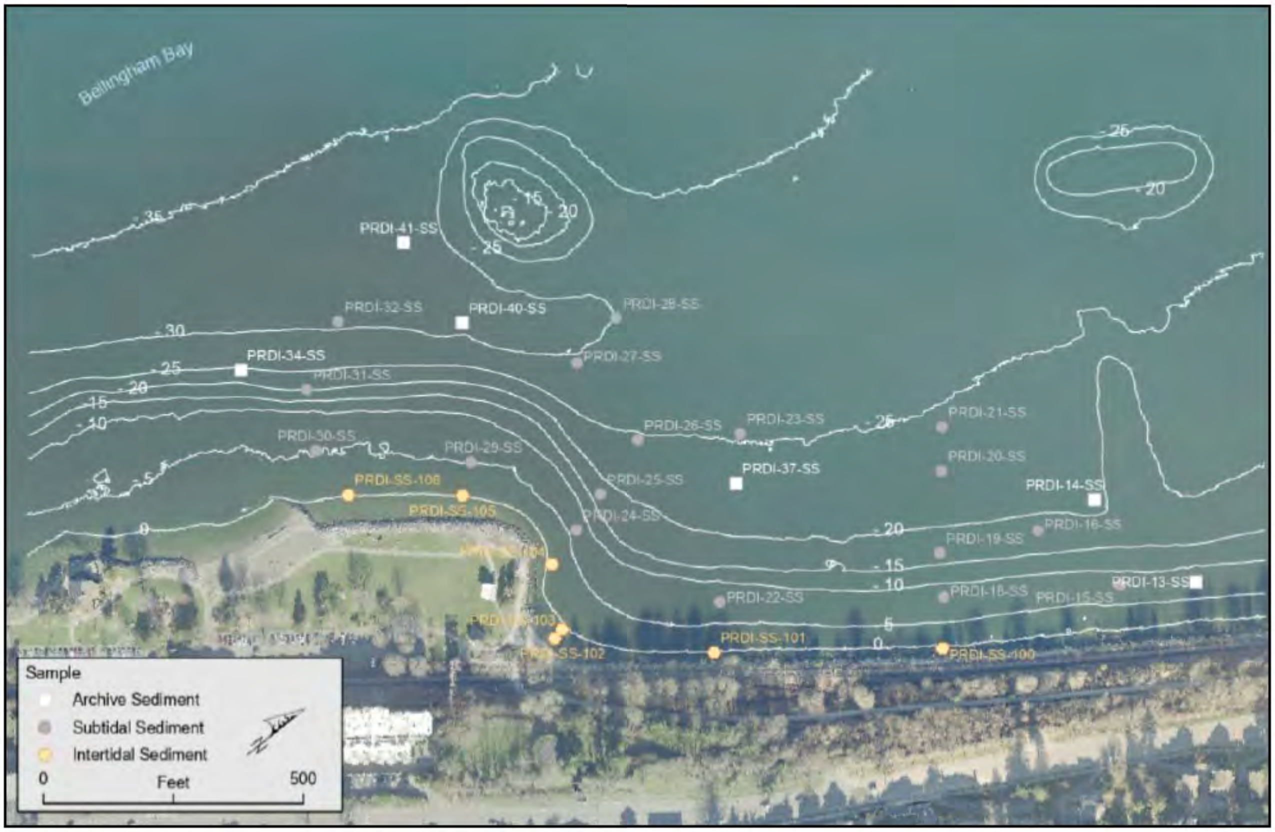


Figure 31. Surface sediment sample locations. Imagery Whatcom County 2019. Elevation source DEA 2021 in FT NAVD88.

Results

A summary of the results of surface samples is shown in Table 9, which presents the D10, D50, and D90 sizes in mm. These correspond to the particle diameter representing the 10%, 50%, and 90% cumulative percentile value. In other words, for example, 10% of the particles in the sample are finer than the D10 grain size.

Table 9. Surface and shallow subsurface (0 to 15 cm bml) sediment samples D50 and Unified Soil Classification System description. See Figure 31 for sample locations.

Sample ID	D10 (mm)	D50 (mm)	D90 (mm)	USCS Description/Visual Inspection
PRDI-15-SS	0.02	0.09	0.57	SM, Silty Sand
PRDI-16-SS	0.01	0.04	0.07	Clayey Silt with Sand
PRDI-18-SS	0.01	0.07	1.79	Silty Sand with Clay
PRDI-19-SS	0.01	0.04	1.29	Clayey Silt with Sand
PRDI-20-SS	0.01	0.04	0.07	Clayey Silt
PRDI-21-SS	0.00	0.05	3.76	Silt with Sand and Organics
PRDI-22-SS	0.01	0.06	1.21	Sandy Silt with Clay
PRDI-23-SS	0.01	0.06	4.37	Silt with Sand and Organics
PRDI-24-SS	0.02	0.11	1.42	SM, Silty Sand

PRDI-25-SS	0.02	0.06	1.70	Sandy Silt with Clay
PRDI-26-SS	0.01	0.04	0.00	Clayey Silt with Sand
PRDI-27-SS	0.01	0.04	0.07	Clayey Silt with Sand
PRDI-28-SS	0.01	0.06	3.70	Silt with Sand and Organics
PRDI-29-SS	0.05	0.31	21.87	SM, Silty Sand with Gravel
PRDI-30-SS	0.02	0.14	3.11	SM, Silty Sand
PRDI-31-SS	0.01	0.06	4.07	Sandy Silt with Clay
PRDI-32-SS	0.01	0.04	0.07	Silty and Clay
PRDI-SS-100	0.35	27.87	65.78	GP, Poorly graded gravel and sand
PRDI-SS-101	0.14	3.35	48.93	SW-SC, Well-graded sand with silty clay and gravel
PRDI-SS-102	0.81	4.61	15.85	SP, Poorly graded sand with gravel
PRDI-SS-103	0.06	3.08	31.20	SM, Silty sand with gravel
PRDI-SS-104	0.08	1.99	26.86	SW-SC, Well-graded sand with silty clay and gravel
PRDI-SS-105	0.10	2.16	32.33	SW-SC, Well-graded sand with silty clay and gravel
PRDI-SS-106	0.11	6.72	40.22	GW-GC, Well-graded gravel with silty clay and sand

Figures 32-33 show the location and grain sizes, with the symbol size changing based on sediment size measured on the Wentworth scale (Wentworth, 1922). These maps illustrate that sediment sizes range from coarse sand to fine cobble in the intertidal transitioning to finer material offshore, however still retaining minor gravel at the surface. Below approximately -5 FT (NAVD88), the D50 surface grain sizes (which can be used as a proxy for mean grain size) were all sand sized or finer and were largely categorized as coarse silt with trace fine silt and gravel.

Comparing the core SARs to the D50 grain size shown in Figure 35, generally we see a trend that areas with finer surface grain sizes correspond to higher SARs. Finer surface grains sizes indicates that these sediments were deposited in lower energy environments than coarser grain sizes.

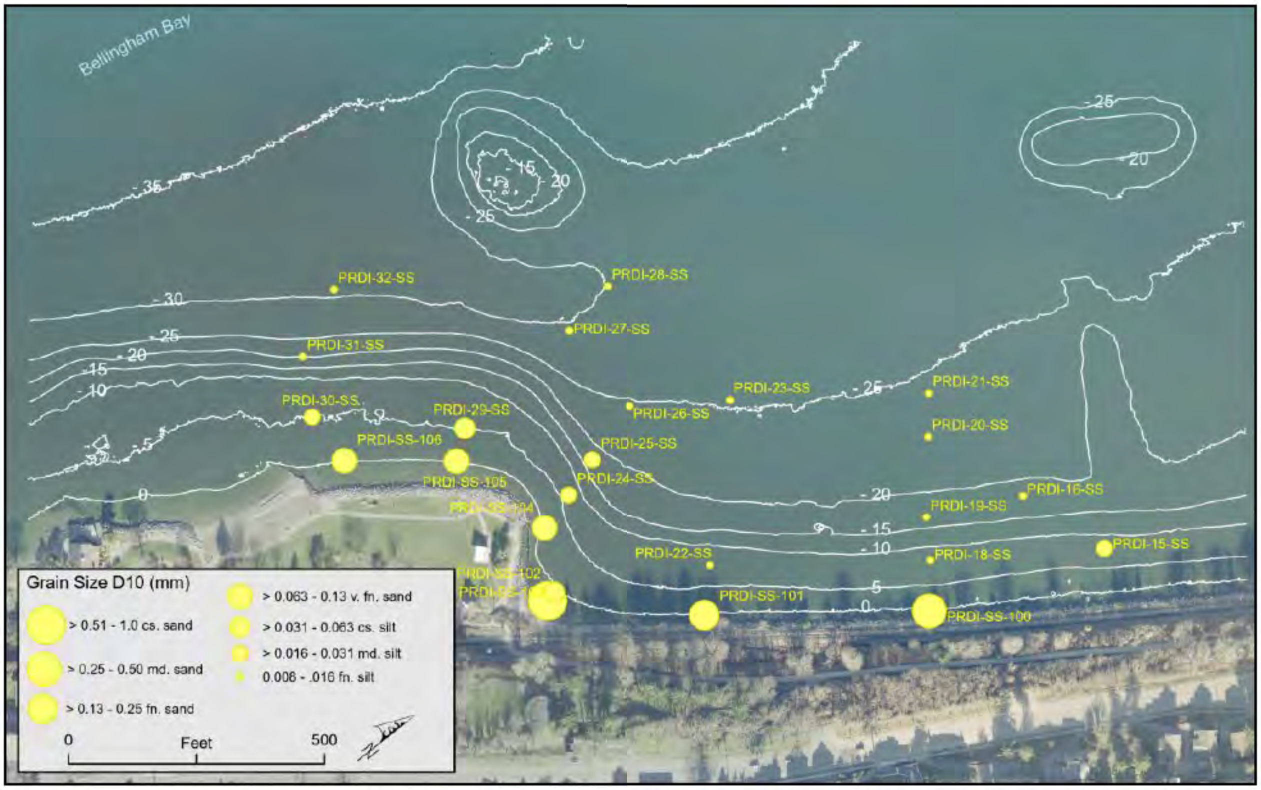


Figure 32. Surface sediment sample D10 grain size. Imagery Whatcom County 2019. Elevation source DEA 2021 in FT NAVD88.

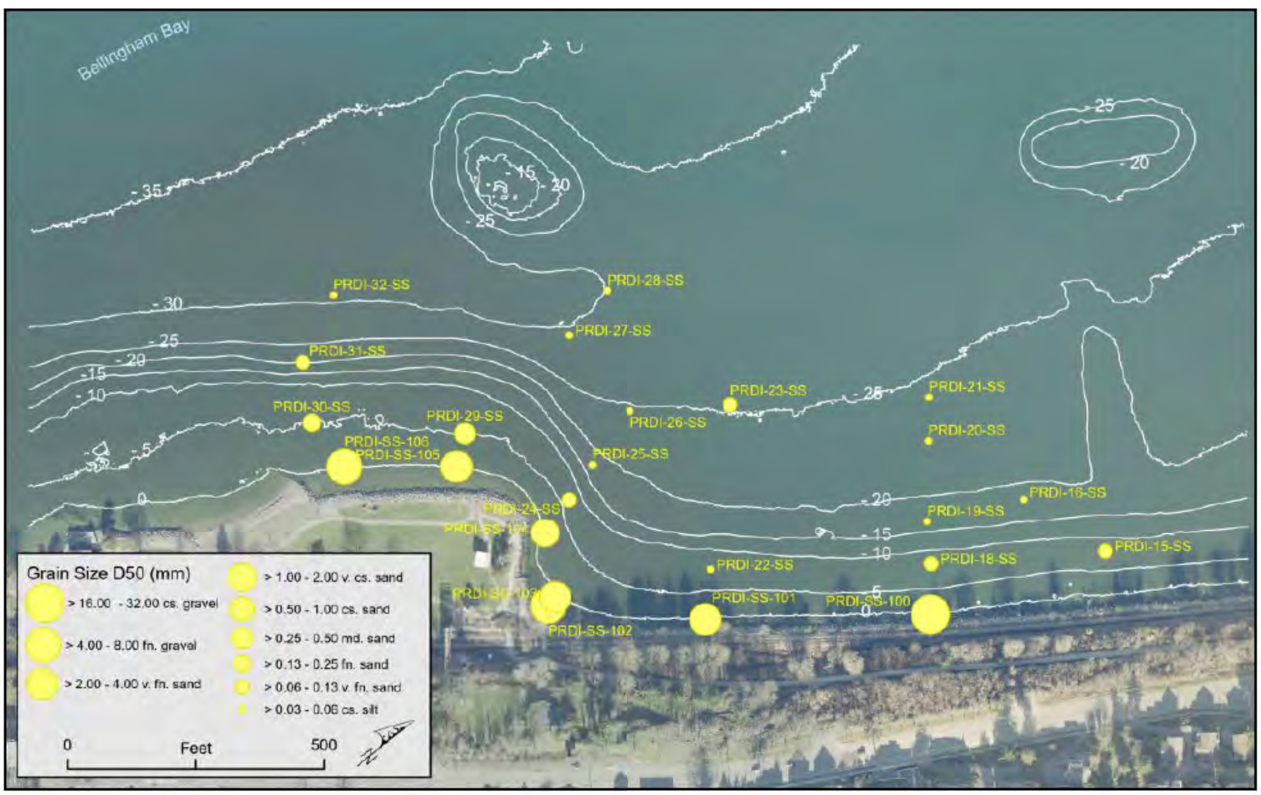


Figure 33. Surface sediment sample D50 grain size. Imagery Whatcom County 2019. Elevation source DEA 2021 in FT NAVD88.

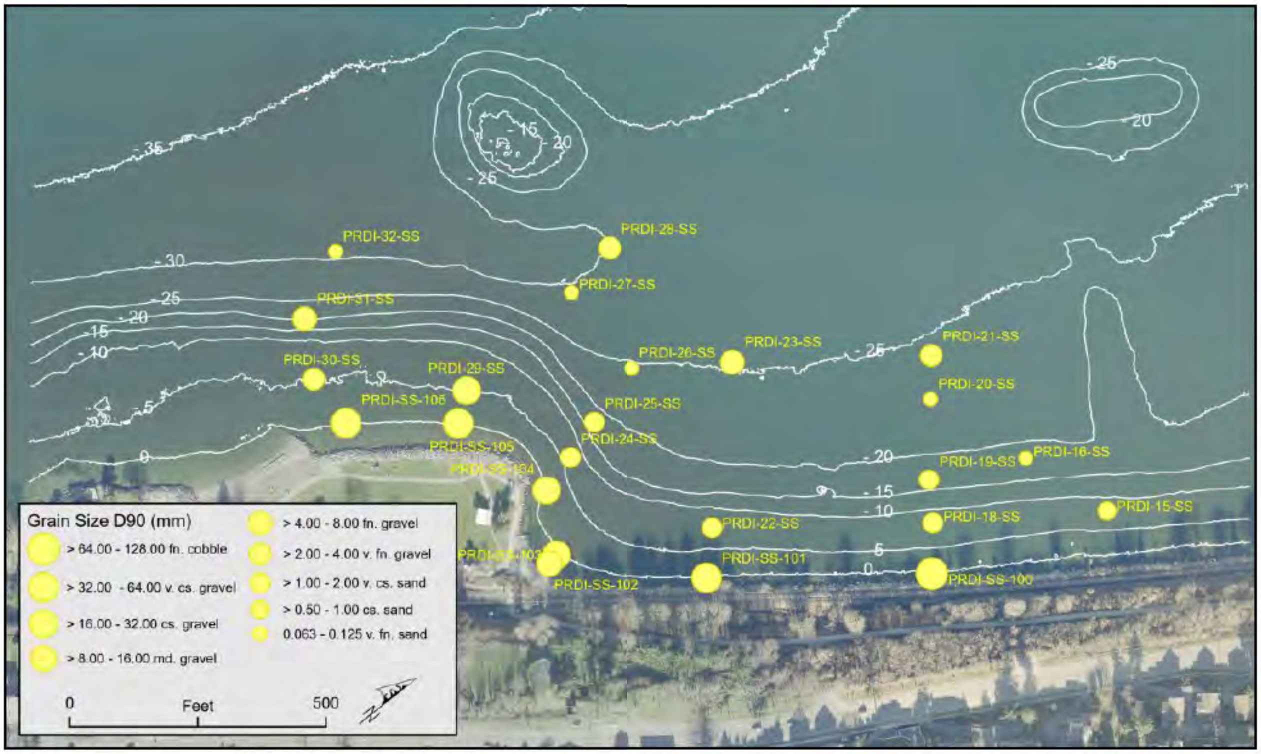


Figure 34. Surface sediment sample D90 grain size. Imagery Whatcom County 2019. Elevation source DEA 2021 in FT NAVD88.

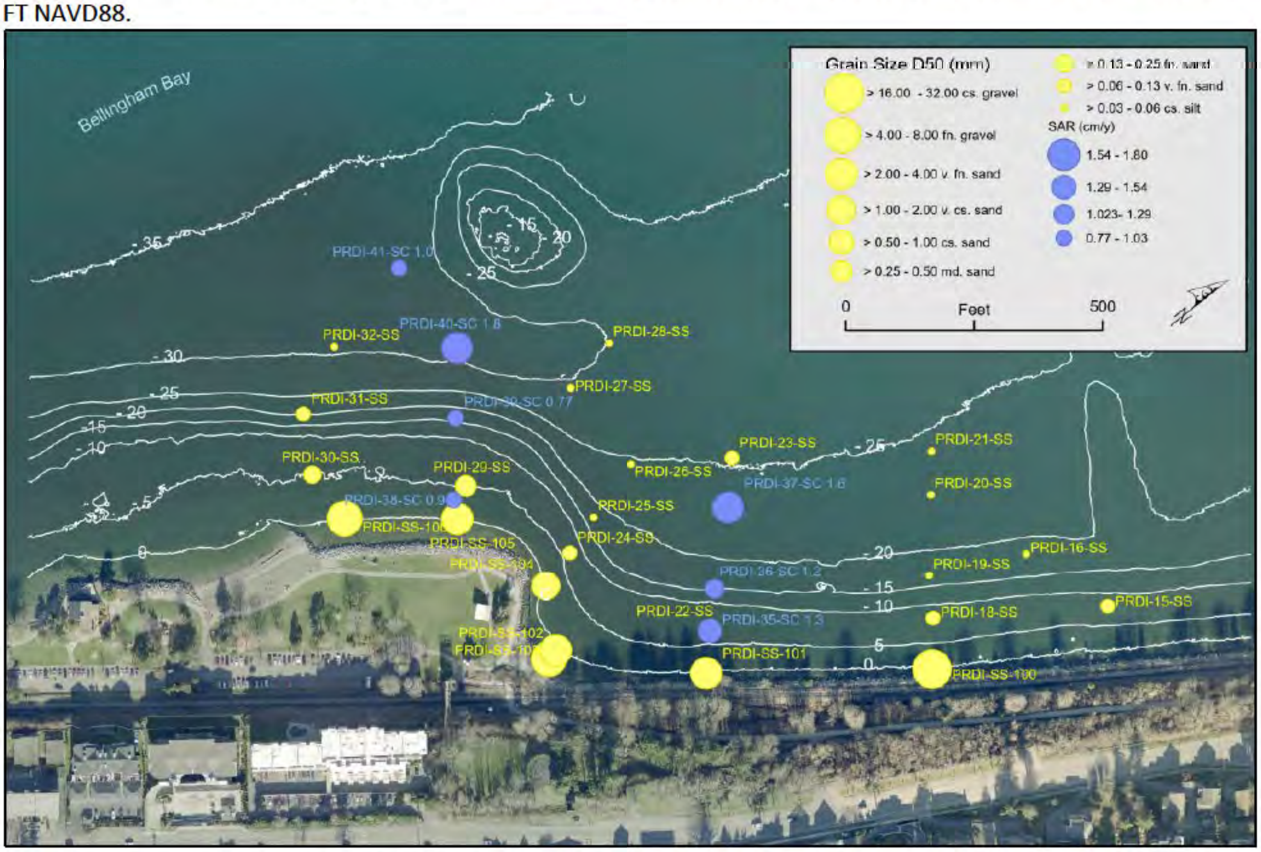


Figure 35. Surface sediment sample D50 grain size (mm) and sediment accumulation rates (cm/yr) from core data. Imagery Whatcom County 2019. Elevation source DEA 2021 in FT NAVD88.

Conclusions

The data presented in this report developed as part of the PRDI will be used to support the design of remedial actions to be performed at the Site. The information concerning site conditions, coastal processes, MetOcean conditions, geomorphology and historic seabed erosion and accretion will be used to evaluate the remedial actions that can be implemented in the shoreline, intertidal and subtidal areas of the marine portion of the Site. The information will also be used to model coastal conditions as a result of SLR at the Site.

Data collected and analyzed as part of this study have identified general erosion and accretion patterns at the site based on new and existing data. The shoreline and intertidal area exposed to marine forces are subject to erosion. This includes the entire intertidal shore which is almost completely armored with rock, concrete, bricks, and other debris. Data collected as part of the PRDI and abundant observational evidence indicates the erosional nature at these elevations. Historical filling along with Bay-wide installation of the railroad revetment has reduced littoral sediment transport in the intertidal area which has greatly limited littoral sediment transport (and input) to replenish beach features and elevations.

Wood waste, in the shallow subtidal in the southern portion of the Marine Unit was deposited many decades ago and the lack of sediment cover is indicative of erosion. These shallow subtidal elevations (0 to -5 FT or deeper) and intertidal beaches receive a moderate amount of wave energy as the causation for erosion. This erosional zone also appears to extend waterward into the shallow subtidal due to wave scour at low tide in combination with steeper slopes between -10 and -15 FT NAVD88 on the west shore. The potentially erosional area is interpreted to extend to as low as elevation -15 FT NAVD88 on the west shore of the site and to lesser depths (-5 to -7 FT NAVD88) on the northeast shore of the site, as shown in Figure 36.

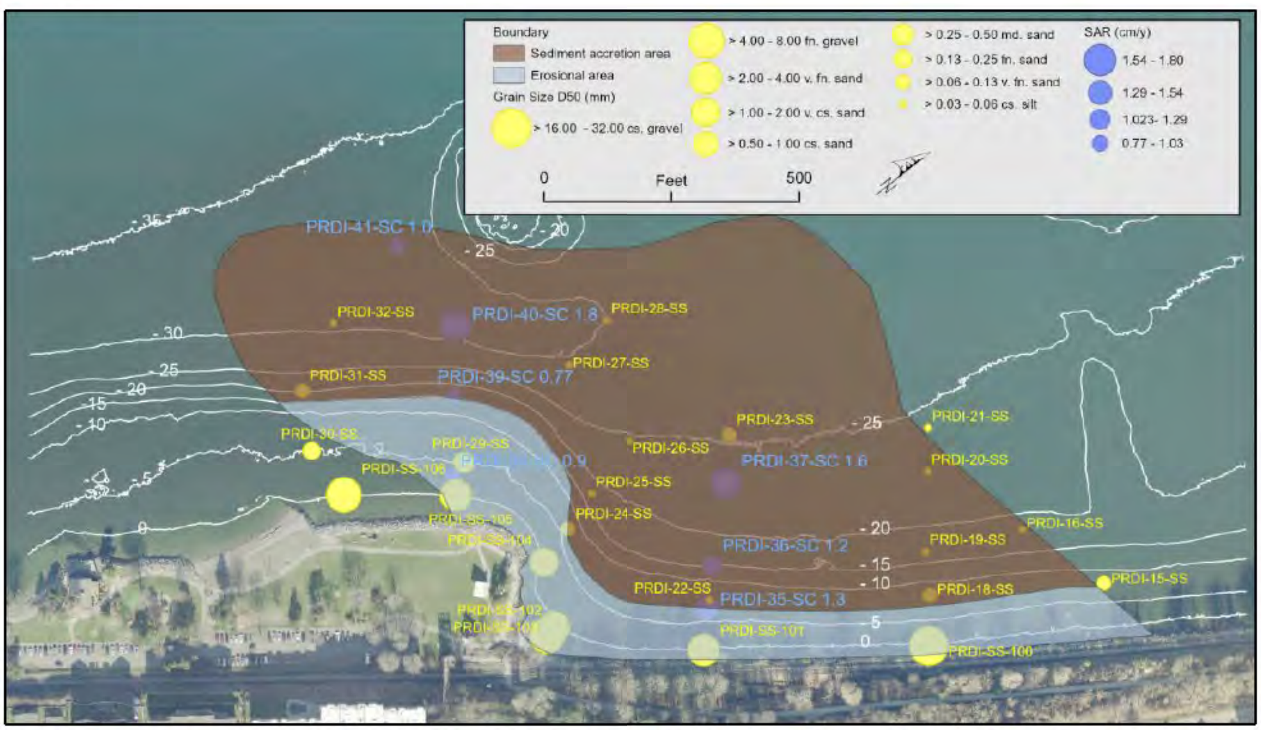


Figure 36. Erosion and Accretion Areas, shown on top of surface sediment D50 grain size and sediment accumulation rate data.

Subtidal areas waterward and deeper than the erosional intertidal and shallow subtidal (described above) appear to be accreting sediment. This includes areas up to approximately -6 FT NAVD88 in the area near the railroad and the north end of the site where wave energy is much less than at the west shore. As described in the *MetOcean* section above, wave energy does not generally affect these depths and near-bottom current velocities are very low. Sediment core age data shows these deeper areas as generally having a SAR of 0.8 – 1.8 cm/yr. These areas may be suitable for natural recovery based on contamination levels.

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Attachments:

Attachment A – Core logs

Attachment B – Core Mosaics

Attachment C – MTC sediment size reports

Attachment D – GEL labs final report

Core #/ID: PRDI-35-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 173 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0268-332-0287

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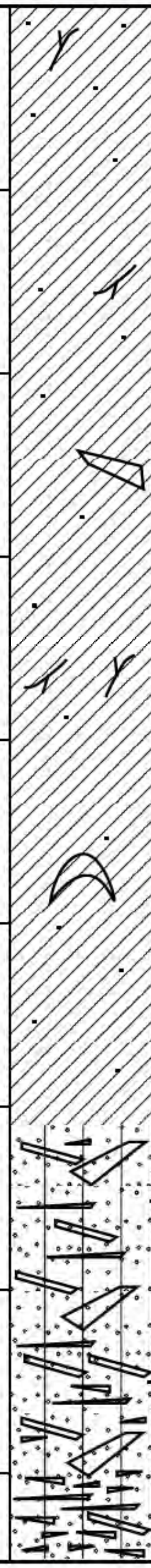
1711 Ellis St suite 103 Bellingham WA 98225
360-647-1845 coastalgeo.com



Depth cm bgs	Sample IDs	Description	Wet Weight (g)	Dry Weight (g)
0	PRDI-35-01: 0-4 cm	*Possibly off by ~10cm because top of core was liquid	602.2	521.8
	PRDI-35-SC-06: 6 cm	Gray, saturated, fines, clay-silts, no wood waste, massive, trace organics (leaf and twigs), with trace sand		
	PRDI-35-02: 9-11 cm		189.0	147.0
	PRDI-35-03: 19-21 cm		214.4	153.5
24	PRDI-35-SC-28: 27-29 cm	Trace bark		
35		Increased organics		
39	PRDI-35-04: 39-41 cm	Shell with barnacles at 48 cm	221.0	164.5
	PRDI-35-05: 59-61 cm		257.5	181.9
62	PRDI-35-06: 79-81 cm	Clay-silt ~60%, sand ~20%, wood ~20%, wood splintery bark, not saw-dust	252.9	172.9
80		Silt-clay ~40-50%, wood fragments ~50-60%		

Core #/ID: PRDI-35-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 173 cm

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Photos: 332-0268-332-0287

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Depth cm bgs	Sample IDs	Depth cm bgs	Description	Wet Weight (g)	Dry Weight (g)
		80	Silt and clay with moderate fine wood debris		
		90			
100	PRDI-35-07: 99-101 cm	100	Silt-clay ~40%, wood fragments, organics and needles ~60%, trace sand	248.1	166.9
		110			
112	No more samples because >90% wood		~90% wood, splintery bark, no saw dust to bottom of core		
		120			
		130			
		150			
		160			

Core #/ID: PRDI-36-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 180 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0288-332-0298

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Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
	PRDI-36-01: 0-8 cm*	0		*Possibly off by 5 cm or more at the top because of water at top of core barrel Wood chips ~15-20%, silt-clay ~60-75%, sand ~10-20%	349.3	255.1
8	PRDI-36-02: 9-11 cm	10		Fine wood fragments ~30-40%, silt-clay ~40-50%, sand ~10-20%	293.1	248.5
	PRDI-36-SC-13: 11-13cm					
	PRDI-36-03: 19-21 cm	20			338.2	262.7
21		30		Grades to more fine woody waste & organics Fine wood fragments ~50-60%, silt-clay ~30-40%, sand <10% Trace shell		
	PRDI-36-04: 39-41 cm	40			372.0	281.5
41		50		Large woody waste, bark, splinters, misc. wood fragments Wood ~50-60%, silt-clay ~30-40%, sand <10-20% Trace shell		
	PRDI-36-05: 59-61 cm	60			390.4	295.4
		70		Large wood fragment ~10 cm long @ 70cm		
74	PRDI-36-06: 79-81 cm	80		Slightly finer wood waste Wood ~40-50%, silt-clay 30-40%, sand <10%, shell fragments ~5%	345.9	271.7

Core #/ID: PRDI-36-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 180 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0288-332-0298

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Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
		80				
		90				
	PRDI-36-07: 99-101cm	100		Broken shell layer @ 97-98 cm	639.7	542.4
		110				
		120		Broken shell layer @ 120-122 cm		
122	PRDI-36-SC-128: 126-128 cm	130		Fine wood decreases to ~30-40%, silt-clay ~40-50%, sand <10%, trace shells		
	PRDI-36-08: 139-141 cm	140			615.9	537.5
143		150		Fine wood ~50-60% (fibers + organics), silt-clay ~30-40%, sand <10%, shells ~3%		
		160				
163						

Core #/ID: PRDI-36-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 180 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0288-332-0298

COASTAL GEOLOGIC SERVICES
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360-647-1845 coastalgeo.com

Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
164		160				
		180		Wood (splinters, no saw dust) ~80-90%, ~10% silt-clay, trace shell Core catcher had massive amount of wood at 180 cm (bottom)		

Core #/ID: PRDI-37-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 226 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0299-332-0314

COASTAL GEOLOGIC SERVICES
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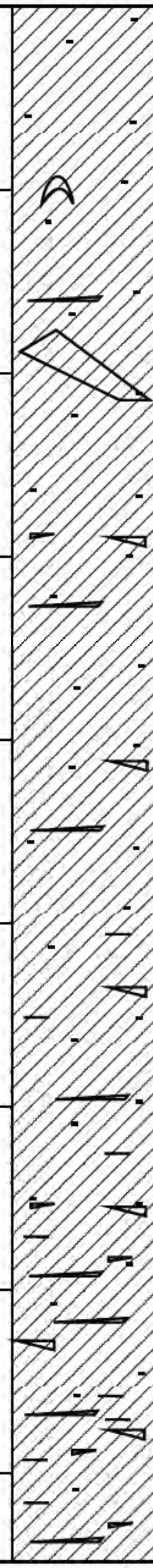
360-647-1845 coastalgeo.com

Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
		0		Silt-clay ~90%, sand <10% No wood		
	PRDI-37-01: 0-7 cm				818.5	587.9
	PRDI-37-02: 9-11 cm	10			585.7	527.2
	PRDI-37-03: 19-21 cm	20			615.0	535.2
	PRDI-37-SC-24: 24 cm					
		30				
	PRDI-37-04: 39-41 cm	40			640.4	555.6
		50				
	PRDI-37-05: 59-61 cm	60		Trace shells @ 60cm	332.6	276.5
		70				
	PRDI-37-06: 79-81 cm	80			388.6	301.5

Core #/ID: PRDI-37-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 226 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0299-332-0314

COASTAL GEOLOGIC SERVICES
1711 Ellis St suite 103 Bellingham WA 98225
360-647-1845 coastalgeo.com



Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
		80				
		90		Trace shell @ 90 cm		
96				Silt-clay ~90%, sand ~5%, wood ~5%		
	PRDI-37-07: 99-101 cm PRDI-37-SC-102: 102cm	100		1 larger bark piece	403.4	336.0
		110				
		120				
	PRDI-37-08: 129-131 cm	130			218.2	149.2
		140				
144				Silt-clay ~75%, wood ~15-25%, sand <5%		
		150				
	PRDI-37-09: 159-161	160			402.8	309.1

Core #/ID: PRDI-37-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 226 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 332-0299-332-0314

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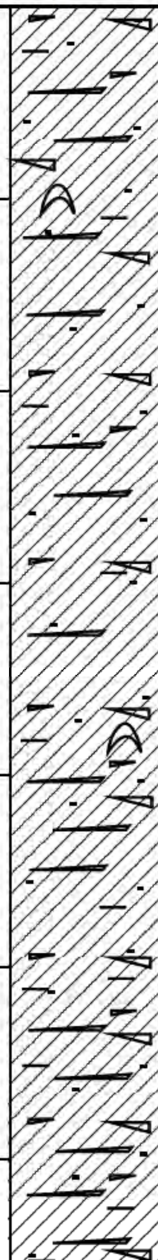
Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
		160				
		170				
174				Silt-clay ~60-70%, wood ~25-35%, sand <5%, trace shell		
		180				
	PRDI-37-10: 189-191 cm	190			173.5	95.8
		200				
	PRDI-37-SC-208: 208 cm	210				
	PRDI-37-11: 219-220 cm	220			443.7	370.1
		230				
		240				

Core #/ID: PRDI-38-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 94 cm

Date Collected: 9/16/2021
Logged By: AFM +JJ
Photos: 330-0223 - 330-0232

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360-647-1845 coastalgeo.com

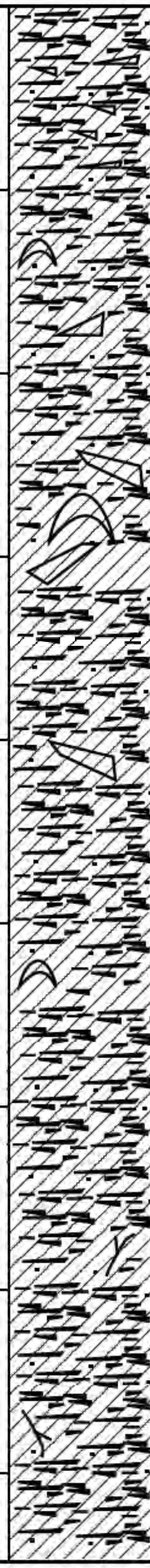
Depth cm bgs	Sample IDs	Depth cm bgs	Description	Wet Weight (g)	Dry Weight (g)
		0	Wood chips ~60-70%, up to 1" long, coarse sand ~30-40%, trace silt and fine sand, no bedding		
	PRDI-38-01: 9-11cm	10		422.4	302.4
			Decreasing sand at depth		
	PRDI-38-02: 19-21cm	20		510.8	385.5
	PRDI-38-SC-24: Grain size				
		30			
	PRDI-38-03: 39-41cm	40		424.4	308.7
		50			
	PRDI-38-04 : 59-61cm	60	Grades into more pure sawdust	404.1	287.3
68		70	Sawdust ~50%, wood chips ~50%, trace sand and silt		
80		80	Sawdust >90% with trace sand and silt until bottom of core at 94cm		

Core #/ID: PRDI-39-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 154 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 331-0233-331-0255

COASTAL GEOLOGIC SERVICES
1711 Ellis St suite 103 Bellingham WA 98225
360-647-1845 coastalgeo.com

Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
	PRDI-39-01: 0-4 cm	0		Silt-clay ~30-40%, saw dust ~50%, wood chips ~10-20%	419.1	225.2
11	PRDI-39-02: 9-11 cm	10			266.6	179.6
				Silt-clay ~20%, saw dust ~40%, wood chips ~20-30%, trace shell 1 cm x 3 cm wood chips		
	PRDI-39-03: 19-21 cm	20			305.4	188.4
		30		Whole bivalve shell Large wood chip 4 cm x 6 cm		
39	PRDI-39-04: 39-41 cm	40		Large wood chip, 3 cm x 5 cm Clay-sand ~20%, saw dust ~40-50%, wood chips ~30-40%, trace shell	243.8	155.2
		50				
	PRDI-39-05: 59-61 cm	60		Slightly more wood splinters, trace leaves, organics, and twig, slightly less shells	264.2	167.0
		70				
	PRDI-39-06: 79-81 cm	80			280.7	171.4



Core #/ID: PRDI-39-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 154 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 331-0233-331-0255

COASTAL GEOLOGIC SERVICES
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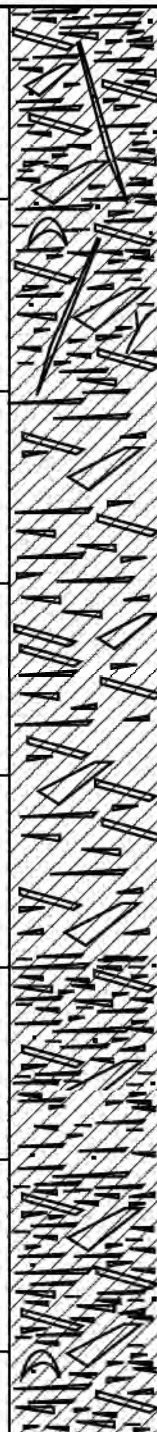
Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
		80		Silt-clay ~40-50%, wood chips ~50-60%, trace shell and organics Splinters up to 10 cm long		
		90				
	PRDI-39-07: 99-101 cm	100			353.7	272.1
104		110		Silt-clay ~50-60%, wood chips ~40-50%, gradually no shells		
		120				
128		130		Grades back into more wood Silt-clay ~40%, wood chips 60%		
135	PRDI-39-08: 139-141 cm	140		Increasingly more wood Silt-clay 30-40%, 60-70% wood chips, trace shells	366.8	282.3
		150				
		160				

Core #/ID: PRDI-40-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 141 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 330-0199-330-0222

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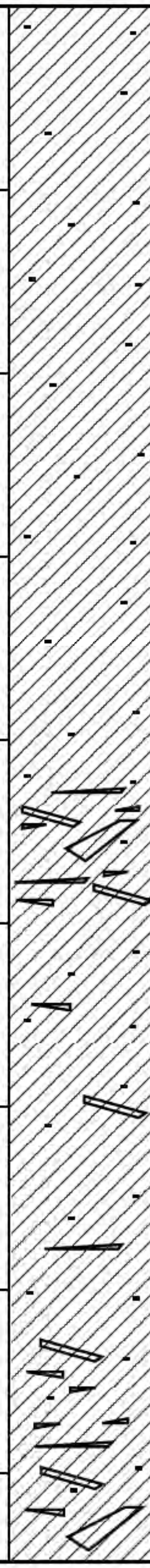
Depth cm bgs	Sample IDs	Depth cm bgs	Description	Wet Weight (g)	Dry Weight (g)
		0	0-5 cm lost - fell out of the bag when opening. Black-brown silty mud		
			Silt and clay with very trace coarse sand. Dark gray to dark brown. Massive with no beds.		
	PRDI-40-01: 9-11 cm	10		186.6	149.8
	PRDI-40-02: 14-16 cm			221.3	165.1
	PRDI-40-03: 19-21 cm	20		209.0	162.0
	PRDI-40-SC-25: 25 cm				
		30			
	PRDI-40-04: 39-41 cm	40		233.1	173.2
43			Silt and clay with wood fragments, small and large bark.		
		50			
55			Silt and clay with trace small wood fragments		
	PRDI-40-05: 59-61 cm	60		207.7	162.7
64			Silt and clay with very trace wood fragments		
		70			
71			Silt and clay with moderate wood fragments		
	PRDI-40-06: 79-81 cm	80		280.1	198.7

Symbol:



Core #/ID: PRDI-40-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 141 cm

Date Collected: 9/16/2021
Logged By: JWJ + AFM
Photos: 330-0199-330-0222

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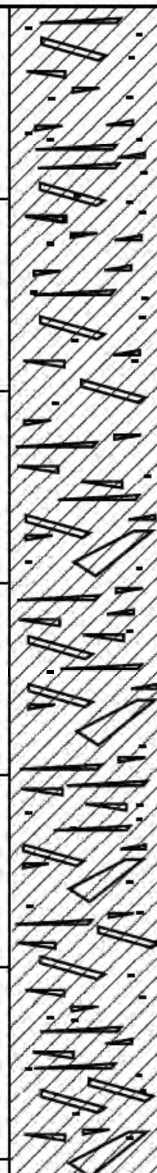
Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
		80		Silt and clay with moderate fine wood debris		
	PRDI-40-SC-92: 92 cm	90				
	PRDI-40-07: 99-101 cm	100			317.9	269.6
102				Silt and clay with moderate dense wood fragments		
		110				
		120				
		130				
	PRDI-40-08: 139-141 cm	140			294.2	258.9
		150				
		160				

Core #/ID: PRDI-41-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 124 cm

Date Collected: 9/16/2021
Logged By: AFM +JJ
Photos: 331-0256 - 331-0267

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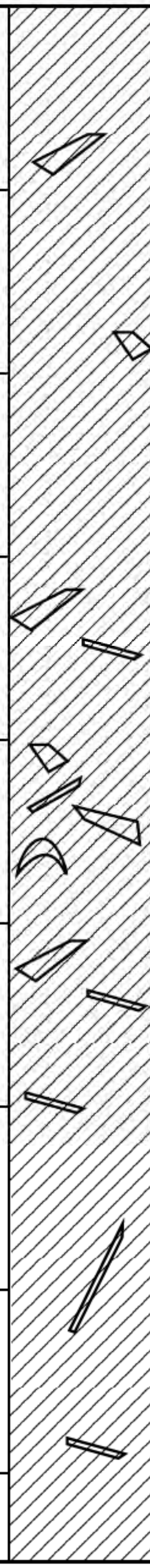
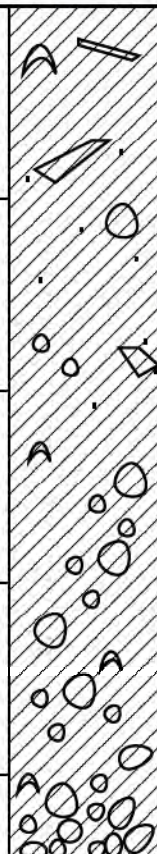
Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
0	PRDI-41-01: 0-8cm	0		Gray, medium-dense, clay - silt, massive. no bedding, homogeneous, no wood fragments (possibly trace), saturated	655.0	399.3
8	PRDI-41-02: 9-11cm	10			423.3	309.7
	PRDI-41-03: 19-21cm	20			351.8	285.6
	PRDI-41-SC-25: 24-26cm					
30		30		Gray, clay-silt ~90%, wood chips/splinters ~10%, some wood chips up to 5cm long and 2cm wide, no bedding, massive		
	PRDI-41-04: 39-41cm	40			351.1	278.0
	PRDI-41-SC-S1: Shell at 46cm			Half clam shell at 46cm		
		50				
56				Decreasing wood, clay-silt ~95%, splintery wood ~5%		
	PRDI-41-05: 59-61cm	60			625.2	551.7
		70				
		80				

Core #/ID: PRDI-41-SC
Project Name: South State Street MGP
Project Site: Boulevard Park
Total Depth: 124 cm

Date Collected: 9/16/2021
Logged By: AFM +JWJ
Photos: 331-0256 - 331-0267

COASTAL GEOLOGIC SERVICES
1711 Ellis St suite 103 Bellingham WA 98225
360-647-1845 coastalgeo.com

Depth cm bgs	Sample IDs	Depth cm bgs	Symbol	Description	Wet Weight (g)	Dry Weight (g)
86	PRDI-41-06: 79-81cm PRDI-41-SC-S2: Shell at 82cm	80		Decreasing wood, clay-silt ~95%, splintery wood ~5%, mostly intact shell at 82 cm	626.1	546.7
109	PRDI-41-07: 99-101cm PRDI-41-SC-100: Grain size at 102-104cm	90 100		Silt-clay ~90%, ~5-10% pebbles with max size 1 x 2cm, trace shell fragments and wood Pebbles and sand increases at depth PRDI-41-SC-100: Silt-clay ~80-90%, small gravels ~10-15%, trace fossils and wood	676.7	600.0
124	PRDI-41-08: 119-121cm PRDI-41-SC-120: Grain size at 120-124cm	110 120		Increasing grain size, silt-clay ~60-70%, shell fragments ~5%. 30-40% fine sand-pebbles Very pebbly at base of core, pebbles up to 3/4" diameter with silt and clay, no wood visible Sandstone pebbles disintegrates easily, ~40% rock fragments Angular metamorphic rock, sub-angular, very hard, ~60% of rock fragments	716.5	678.1
	Bottom of core	130 140 150 160				

-12.5 FT

E 35

-21.59 FT

CORE 36

-31.08 FT

CORE 37

-6.8 FT

CORE 38

-22.14 FT

CORE 39

-37.4

CORE 40

MATERIALS TESTING & CONSULTING, INC.

Client:	GeoEngineers	**Date:**	March 15, 2022
Address:	17425 NE Union Hill Rd., Suite 250	**Project:**	Q.C. - South State Street Preliminary Remedial Design Investigation
	Redmond, WA 98052	**Project #:**	21B288
Attn:	Neil Morton	**Sample #:**	B22-0201 - B22-0210
Revised on:		**Date sampled:**	September 14, 2021 & March 1, 2022

As requested MTC, Inc. has performed the following test(s) on the sample referenced above. The testing was performed in accordance with current applicable AASHTO or ASTM standards as indicated below. The results obtained in our laboratory were as follows below or on the attached pages:

	Test(s) Performed:	Test Results		Test(s) Performed:	Test Results
X	Sieve Analysis	See Attached Reports		Sulfate Soundness	
	Proctor			Bulk Density & Voids	
	Sand Equivalent			WSDOT Degradation	
	Fracture Count			LA Abrasion	
	Moisture Content				
	Specific Gravity, Coarse				
	Specific Gravity, Fine				
X	Hydrometer Analysis	See Attached Reports			
	Atterberg Limits				

If you have any questions concerning the test results, the procedures used, or if we can be of any further assistance please call on us at the number below.

Alex Eifrig

Respectfully Submitted,
Alex Eifrig
WABO Supervising Laboratory Technician

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - SS - 100
Sample#: B22-0201

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 11-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
GP, Poorly graded Gravel with Sand
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

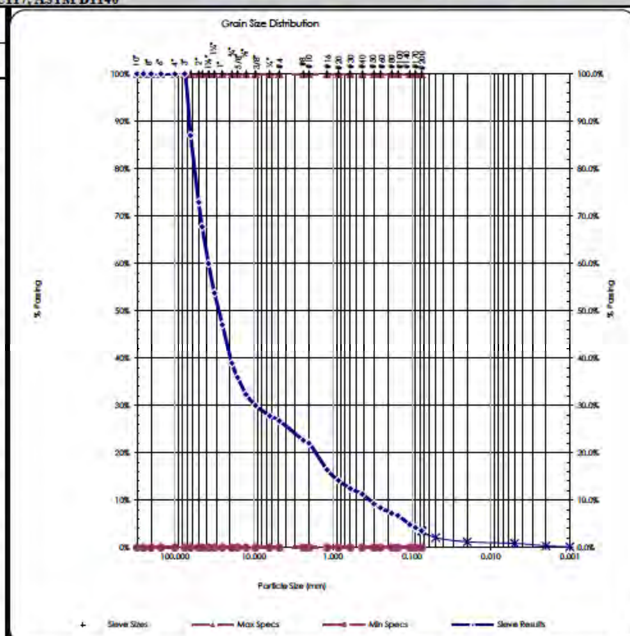
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.109 mm	% Gravel = 73.3%	Coeff. of Curvature, C_C = 6.95
$D_{(10)}$ = 0.347 mm	% Sand = 23.2%	Coeff. of Uniformity, C_U = 108.19
$D_{(15)}$ = 0.970 mm	% Silt & Clay = 3.5%	Fineness Modulus = 6.64
$D_{(30)}$ = 9.511 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 27.874 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 37.537 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 65.776 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 16/51	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00	100%	100%	100.0%	0.0%
2.50"	63.00		87%	100.0%	0.0%
2.00"	50.00	73%	73%	100.0%	0.0%
1.75"	45.00		68%	100.0%	0.0%
1.50"	37.50		60%	100.0%	0.0%
1.25"	31.50		54%	100.0%	0.0%
1.00"	25.00	47%	47%	100.0%	0.0%
3/4"	19.00	39%	39%	100.0%	0.0%
5/8"	16.00		36%	100.0%	0.0%
1/2"	12.50	32%	32%	100.0%	0.0%
3/8"	9.50	30%	30%	100.0%	0.0%
1/4"	6.30		28%	100.0%	0.0%
#4	4.75	27%	27%	100.0%	0.0%
#8	2.36		23%	100.0%	0.0%
#10	2.00	22%	22%	100.0%	0.0%
#16	1.18		16%	100.0%	0.0%
#20	0.850		14%	100.0%	0.0%
#30	0.600		12%	100.0%	0.0%
#40	0.425	11%	11%	100.0%	0.0%
#50	0.300		9%	100.0%	0.0%
#60	0.250		8%	100.0%	0.0%
#80	0.180		7%	100.0%	0.0%
#100	0.150	7%	7%	100.0%	0.0%
#140	0.106		5%	100.0%	0.0%
#170	0.090		4%	100.0%	0.0%
#200	0.075	3.5%	3.5%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI - SS - 100
Sample#: B22-0201

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 11-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
GP, Poorly graded Gravel with Sand
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	99.94	grams
Hydroscopic Moist.:	2.08%	
Adj. Sample Wgt :	97.90	grams

ACCREDITED
Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	6	1.3%	0.0372 mm
5	5.5	1.2%	0.0237 mm
15	5.5	1.2%	0.0137 mm
30	5.5	1.2%	0.0097 mm
60	5	1.1%	0.0068 mm
250	3	0.7%	0.0034 mm
1440	1	0.2%	0.0014 mm

% Gravel:	73.3%	**Liquid Limit:**	n/a
% Sand:	23.2%	**Plastic Limit:**	n/a
% Silt:	2.7%	**Plasticity Index:**	n/a
% Clay:	0.9%		

ASTM C136

Sieve Analysis
Grain Size Distribution

	Sieve Size	Percent Passing	Soils Particle Diameter
	3.0"	100%	75.000 mm
	2.0"	100%	50.000 mm
	1.5"	73%	37.500 mm
	1.25"	60%	31.500 mm
	1.0"	54%	25.000 mm
	3/4"	39%	19.000 mm
	5/8"	36%	16.000 mm
	1/2"	32%	12.500 mm
	3/8"	30%	9.500 mm
	1/4"	28%	6.300 mm
	#4	27%	4.750 mm
	#10	22%	2.000 mm
	#20	14%	0.850 mm
	#40	11%	0.425 mm
	#100	7%	0.150 mm
	#200	3.5%	0.075 mm
Silts		3.5%	0.074 mm
		2.1%	0.050 mm
		1.2%	0.020 mm
Clays		0.9%	0.005 mm
		0.4%	0.002 mm
Colloids		0.2%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - SS - 101
Sample#: B22-0202

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SW-SC, Well-graded Sand with Silty Clay and Gravel
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

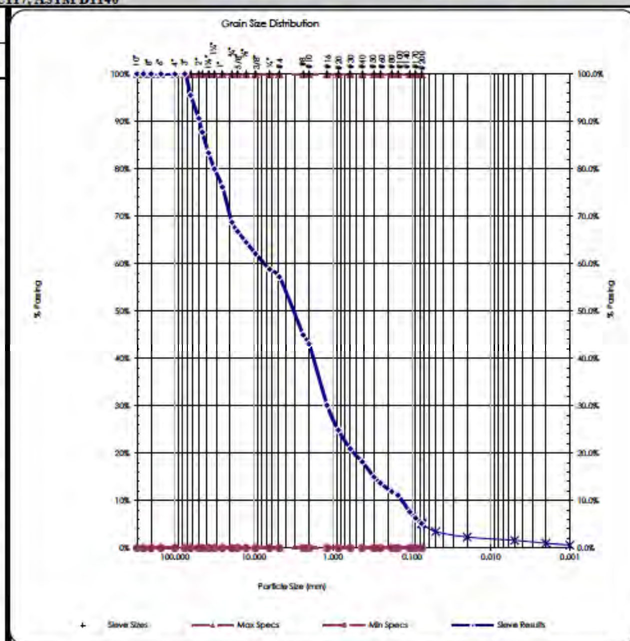
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.073 mm	% Gravel = 42.8%	Coeff. of Curvature, C_C = 1.36
$D_{(10)}$ = 0.136 mm	% Sand = 52.1%	Coeff. of Uniformity, C_U = 55.09
$D_{(15)}$ = 0.301 mm	% Silt & Clay = 5.2%	Fineness Modulus = 4.99
$D_{(30)}$ = 1.174 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 3.349 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 7.485 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 48.931 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 23/81	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00	100%	100%	100.0%	0.0%
2.50"	63.00		95%	100.0%	0.0%
2.00"	50.00	91%	91%	100.0%	0.0%
1.75"	45.00		88%	100.0%	0.0%
1.50"	37.50		83%	100.0%	0.0%
1.25"	31.50		80%	100.0%	0.0%
1.00"	25.00	76%	76%	100.0%	0.0%
3/4"	19.00	69%	69%	100.0%	0.0%
5/8"	16.00		67%	100.0%	0.0%
1/2"	12.50	64%	64%	100.0%	0.0%
3/8"	9.50	62%	62%	100.0%	0.0%
1/4"	6.30		59%	100.0%	0.0%
#4	4.75	57%	57%	100.0%	0.0%
#8	2.36		45%	100.0%	0.0%
#10	2.00	43%	43%	100.0%	0.0%
#16	1.18		30%	100.0%	0.0%
#20	0.850		25%	100.0%	0.0%
#30	0.600		21%	100.0%	0.0%
#40	0.425	18%	18%	100.0%	0.0%
#50	0.300		15%	100.0%	0.0%
#60	0.250		14%	100.0%	0.0%
#80	0.180		12%	100.0%	0.0%
#100	0.150	11%	11%	100.0%	0.0%
#140	0.106		8%	100.0%	0.0%
#170	0.090		6%	100.0%	0.0%
#200	0.075	5.2%	5.2%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:** 3-Mar-22
Project #: 21B288	**Sampled By:** Other
Client : GeoEngineers	**Date Tested:** 14-Mar-22
Source: PRDI - SS - 101	**Tested By:** K. Mendez
Sample#: B22-0202	

Unified Soil Classification System, ASTM-2487
SW-SC, Well-graded Sand with Silty Clay and Gravel
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	100.30	grams
Hydroscopic Moist.:	2.51%	
Adj. Sample Wgt :	97.84	grams

ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	6	2.6%	0.0372 mm
5	5.5	2.4%	0.0237 mm
15	5	2.2%	0.0137 mm
30	4.5	2.0%	0.0097 mm
60	4.5	2.0%	0.0069 mm
250	3	1.3%	0.0034 mm
1440	2	0.9%	0.0014 mm

% Gravel:	42.8%	**Liquid Limit:**	n/a
% Sand:	52.1%	**Plastic Limit:**	n/a
% Silt:	3.5%	**Plasticity Index:**	n/a
% Clay:	1.6%		

ASTM C136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	91%	37.500 mm
1.25"	83%	31.500 mm
1.0"	80%	25.000 mm
3/4"	69%	19.000 mm
5/8"	67%	16.000 mm
1/2"	64%	12.500 mm
3/8"	62%	9.500 mm
1/4"	59%	6.300 mm
#4	57%	4.750 mm
#10	43%	2.000 mm
#20	25%	0.850 mm
#40	18%	0.425 mm
#100	11%	0.150 mm
#200	5.2%	0.075 mm
Silts	5.1%	0.074 mm
	3.5%	0.050 mm
	2.3%	0.020 mm
Clays	1.6%	0.005 mm
	1.0%	0.002 mm
Colloids	0.6%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - SS - 102
Sample#: B22-0203

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SP, Poorly graded Sand with Gravel
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

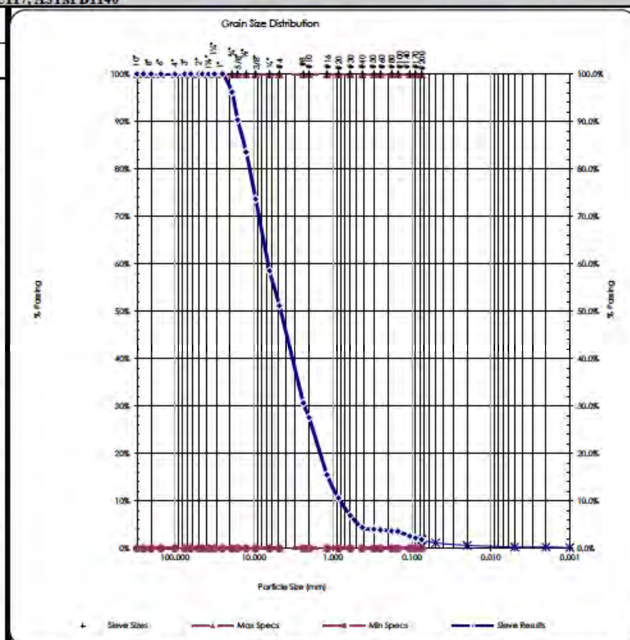
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.466 mm	% Gravel = 48.8%	Coeff. of Curvature, C_C = 0.98
$D_{(10)}$ = 0.806 mm	% Sand = 49.3%	Coeff. of Uniformity, C_U = 8.21
$D_{(15)}$ = 1.145 mm	% Silt & Clay = 1.9%	Fineness Modulus = 5.18
$D_{(30)}$ = 2.282 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 4.613 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 6.617 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 15.845 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 11/26	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	96%	96%	100.0%	0.0%
5/8"	16.00		90%	100.0%	0.0%
1/2"	12.50	83%	83%	100.0%	0.0%
3/8"	9.50	74%	74%	100.0%	0.0%
1/4"	6.30		59%	100.0%	0.0%
#4	4.75	51%	51%	100.0%	0.0%
#8	2.36		31%	100.0%	0.0%
#10	2.00	28%	28%	100.0%	0.0%
#16	1.18		16%	100.0%	0.0%
#20	0.850		11%	100.0%	0.0%
#30	0.600		7%	100.0%	0.0%
#40	0.425	4%	4%	100.0%	0.0%
#50	0.300		4%	100.0%	0.0%
#60	0.250		4%	100.0%	0.0%
#80	0.180		4%	100.0%	0.0%
#100	0.150	4%	4%	100.0%	0.0%
#140	0.106		3%	100.0%	0.0%
#170	0.090		2%	100.0%	0.0%
#200	0.075	1.9%	1.9%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI - SS - 102
Sample#: B22-0203

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SP, Poorly graded Sand with Gravel
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	100.12	grams
Hydroscopic Moist.:	2.65%	
Adj. Sample Wgt :	97.54	grams

ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	3	0.8%	0.0378 mm
5	2.5	0.7%	0.0240 mm
15	2	0.6%	0.0139 mm
30	2	0.6%	0.0098 mm
60	1	0.3%	0.0070 mm
250	1	0.3%	0.0034 mm
1440	1	0.3%	0.0014 mm

% Gravel:	48.8%	**Liquid Limit:**	n/a
% Sand:	49.3%	**Plastic Limit:**	n/a
% Silt:	1.6%	**Plasticity Index:**	n/a
% Clay:	0.3%		

ASTM C136

Sieve Analysis
Grain Size Distribution

	Sieve Size	Percent Passing	Soils Particle Diameter
	3.0"	100%	75.000 mm
	2.0"	100%	50.000 mm
	1.5"	100%	37.500 mm
	1.25"	100%	31.500 mm
	1.0"	100%	25.000 mm
	3/4"	96%	19.000 mm
	5/8"	90%	16.000 mm
	1/2"	83%	12.500 mm
	3/8"	74%	9.500 mm
	1/4"	59%	6.300 mm
	#4	51%	4.750 mm
	#10	28%	2.000 mm
	#20	11%	0.850 mm
	#40	4%	0.425 mm
	#100	4%	0.150 mm
	#200	1.9%	0.075 mm
Silts		1.8%	0.074 mm
		1.2%	0.050 mm
		0.6%	0.020 mm
Clays		0.3%	0.005 mm
		0.3%	0.002 mm
Colloids		0.2%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - SS - 103
Sample#: B22-0204

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SM, Silty Sand with Gravel
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

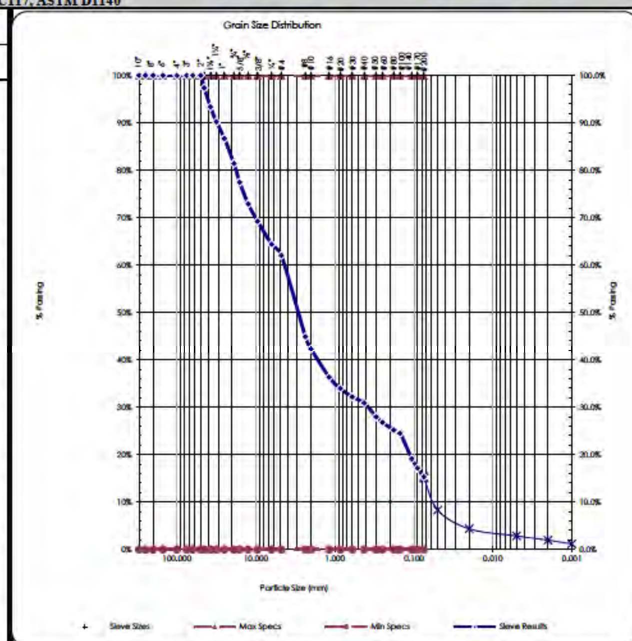
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.038 mm	% Gravel = 38.0%	Coeff. of Curvature, C_C = 0.60
$D_{(10)}$ = 0.056 mm	% Sand = 46.7%	Coeff. of Uniformity, C_U = 79.86
$D_{(15)}$ = 0.074 mm	% Silt & Clay = 15.3%	Fineness Modulus = 4.21
$D_{(30)}$ = 0.387 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 3.075 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 4.467 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 31.199 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 1/2	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		97%	100.0%	0.0%
1.50"	37.50		93%	100.0%	0.0%
1.25"	31.50		90%	100.0%	0.0%
1.00"	25.00	87%	87%	100.0%	0.0%
3/4"	19.00	81%	81%	100.0%	0.0%
5/8"	16.00		77%	100.0%	0.0%
1/2"	12.50	73%	73%	100.0%	0.0%
3/8"	9.50	69%	69%	100.0%	0.0%
1/4"	6.30		64%	100.0%	0.0%
#4	4.75	62%	62%	100.0%	0.0%
#8	2.36		45%	100.0%	0.0%
#10	2.00	42%	42%	100.0%	0.0%
#16	1.18		36%	100.0%	0.0%
#20	0.850		34%	100.0%	0.0%
#30	0.600		32%	100.0%	0.0%
#40	0.425	31%	31%	100.0%	0.0%
#50	0.300		28%	100.0%	0.0%
#60	0.250		27%	100.0%	0.0%
#80	0.180		25%	100.0%	0.0%
#100	0.150	25%	25%	100.0%	0.0%
#140	0.106		19%	100.0%	0.0%
#170	0.090		17%	100.0%	0.0%
#200	0.075	15.3%	15.3%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI - SS - 103
Sample#: B22-0204

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SM, Silty Sand with Gravel
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	100.60	grams
Hydroscopic Moist.:	31.04%	
Adj. Sample Wgt :	76.77	grams

ACCREDITED
Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	8.5	4.6%	0.0368 mm
5	8	4.4%	0.0233 mm
15	8	4.4%	0.0134 mm
30	7.5	4.1%	0.0096 mm
60	5.5	3.0%	0.0068 mm
250	5	2.7%	0.0033 mm
1440	3	1.6%	0.0014 mm

% Gravel:	38.0%	**Liquid Limit:**	n/a
% Sand:	46.7%	**Plastic Limit:**	n/a
% Silt:	12.5%	**Plasticity Index:**	n/a
% Clay:	2.9%		

ASTM C136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	93%	31.500 mm
1.0"	90%	25.000 mm
3/4"	81%	19.000 mm
5/8"	77%	16.000 mm
1/2"	73%	12.500 mm
3/8"	69%	9.500 mm
1/4"	64%	6.300 mm
#4	62%	4.750 mm
#10	42%	2.000 mm
#20	34%	0.850 mm
#40	31%	0.425 mm
#100	25%	0.150 mm
#200	15.3%	0.075 mm
Silts	15.1%	0.074 mm
	8.3%	0.050 mm
	4.4%	0.020 mm
Clays	2.9%	0.005 mm
	2.0%	0.002 mm
Colloids	1.2%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Loamy Sand

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:** 3-Mar-22
Project #: 21B288	**Sampled By:** Other
Client: GeoEngineers	**Date Tested:** 14-Mar-22
Source: PRDI - SS - 104	**Tested By:** K. Mendez
Sample#: B22-0205	

Unified Soil Classification System, ASTM-2487
SW-SC, Well-graded Sand with Silty Clay and Gravel
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

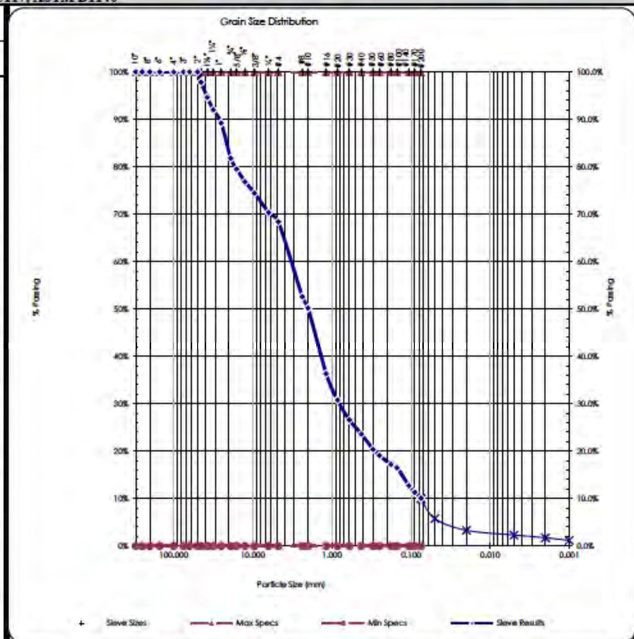
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.045 mm	% Gravel = 31.6%	Coeff. of Curvature, C_C = 2.48
$D_{(10)}$ = 0.075 mm	% Sand = 58.3%	Coeff. of Uniformity, C_U = 46.67
$D_{(15)}$ = 0.133 mm	% Silt & Clay = 10.1%	Fineness Modulus = 4.23
$D_{(30)}$ = 0.804 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 1.990 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 3.483 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 26.857 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 23/54	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		98%	100.0%	0.0%
1.50"	37.50		95%	100.0%	0.0%
1.25"	31.50		92%	100.0%	0.0%
1.00"	25.00	89%	89%	100.0%	0.0%
3/4"	19.00	82%	82%	100.0%	0.0%
5/8"	16.00		79%	100.0%	0.0%
1/2"	12.50	77%	77%	100.0%	0.0%
3/8"	9.50	74%	74%	100.0%	0.0%
1/4"	6.30		70%	100.0%	0.0%
#4	4.75	68%	68%	100.0%	0.0%
#8	2.36		53%	100.0%	0.0%
#10	2.00	50%	50%	100.0%	0.0%
#16	1.18		36%	100.0%	0.0%
#20	0.850		31%	100.0%	0.0%
#30	0.600		27%	100.0%	0.0%
#40	0.425	24%	24%	100.0%	0.0%
#50	0.300		20%	100.0%	0.0%
#60	0.250		19%	100.0%	0.0%
#80	0.180		17%	100.0%	0.0%
#100	0.150	16%	16%	100.0%	0.0%
#140	0.106		13%	100.0%	0.0%
#170	0.090		11%	100.0%	0.0%
#200	0.075	10.1%	10.1%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:** 3-Mar-22
Project #: 21B288	**Sampled By:** Other
Client : GeoEngineers	**Date Tested:** 14-Mar-22
Source: PRDI - SS - 104	**Tested By:** K. Mendez
Sample#: B22-0205	

Unified Soil Classification System, ASTM-2487
SW-SC, Well-graded Sand with Silty Clay and Gravel
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	101.06	grams
Hydroscopic Moist.:	12.14%	
Adj. Sample Wgt :	90.12	grams

ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	6.5	3.6%	0.0372 mm
5	6	3.3%	0.0235 mm
15	6	3.3%	0.0136 mm
30	5.5	3.0%	0.0097 mm
60	5	2.8%	0.0068 mm
250	3.5	1.9%	0.0034 mm
1440	3	1.7%	0.0014 mm

% Gravel:	31.6%	**Liquid Limit:**	n/a
% Sand:	58.3%	**Plastic Limit:**	n/a
% Silt:	7.7%	**Plasticity Index:**	n/a
% Clay:	2.3%		

ASTM C136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	95%	31.500 mm
1.0"	92%	25.000 mm
3/4"	82%	19.000 mm
5/8"	79%	16.000 mm
1/2"	77%	12.500 mm
3/8"	74%	9.500 mm
1/4"	70%	6.300 mm
#4	68%	4.750 mm
#10	50%	2.000 mm
#20	31%	0.850 mm
#40	24%	0.425 mm
#100	16%	0.150 mm
#200	10.1%	0.075 mm
Silts	9.9%	0.074 mm
	5.8%	0.050 mm
	3.3%	0.020 mm
Clays	2.3%	0.005 mm
	1.7%	0.002 mm
Colloids	1.2%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - SS - 105
Sample#: B22-0206

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SW-SC, Well-graded Sand with Silty Clay and Gravel
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

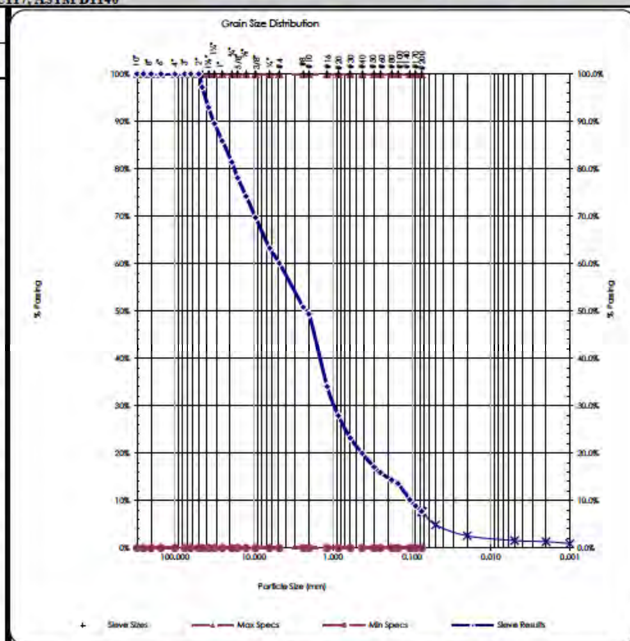
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.051 mm	% Gravel = 39.9%	Coeff. of Curvature, C_C = 1.89
$D_{(10)}$ = 0.104 mm	% Sand = 52.4%	Coeff. of Uniformity, C_U = 45.53
$D_{(15)}$ = 0.210 mm	% Silt & Clay = 7.7%	Fineness Modulus = 4.50
$D_{(30)}$ = 0.963 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 2.159 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 4.727 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 32.334 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 19/49	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		97%	100.0%	0.0%
1.50"	37.50		93%	100.0%	0.0%
1.25"	31.50		90%	100.0%	0.0%
1.00"	25.00	86%	86%	100.0%	0.0%
3/4"	19.00	81%	81%	100.0%	0.0%
5/8"	16.00		78%	100.0%	0.0%
1/2"	12.50	74%	74%	100.0%	0.0%
3/8"	9.50	70%	70%	100.0%	0.0%
1/4"	6.30		63%	100.0%	0.0%
#4	4.75	60%	60%	100.0%	0.0%
#8	2.36		51%	100.0%	0.0%
#10	2.00	49%	49%	100.0%	0.0%
#16	1.18		34%	100.0%	0.0%
#20	0.850		28%	100.0%	0.0%
#30	0.600		23%	100.0%	0.0%
#40	0.425	20%	20%	100.0%	0.0%
#50	0.300		17%	100.0%	0.0%
#60	0.250		16%	100.0%	0.0%
#80	0.180		14%	100.0%	0.0%
#100	0.150	14%	14%	100.0%	0.0%
#140	0.106		10%	100.0%	0.0%
#170	0.090		9%	100.0%	0.0%
#200	0.075	7.7%	7.7%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI - SS - 105
Sample#: B22-0206

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
SW-SC, Well-graded Sand with Silty Clay and Gravel
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	100.65	grams
Hydroscopic Moist.:	9.69%	
Adj. Sample Wgt :	91.76	grams

ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	6.5	3.5%	0.0372 mm
5	5	2.7%	0.0237 mm
15	4.5	2.4%	0.0137 mm
30	4	2.1%	0.0097 mm
60	3.5	1.9%	0.0069 mm
250	2.5	1.3%	0.0034 mm
1440	2.5	1.3%	0.0014 mm

% Gravel:	39.9%	**Liquid Limit:**	n/a
% Sand:	52.4%	**Plastic Limit:**	n/a
% Silt:	6.2%	**Plasticity Index:**	n/a
% Clay:	1.6%		

ASTM C136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	93%	31.500 mm
1.0"	90%	25.000 mm
3/4"	81%	19.000 mm
5/8"	78%	16.000 mm
1/2"	74%	12.500 mm
3/8"	70%	9.500 mm
1/4"	63%	6.300 mm
#4	60%	4.750 mm
#10	49%	2.000 mm
#20	28%	0.850 mm
#40	20%	0.425 mm
#100	14%	0.150 mm
#200	7.7%	0.075 mm
Silts	7.6%	0.074 mm
	4.9%	0.050 mm
	2.6%	0.020 mm
Clays	1.6%	0.005 mm
	1.3%	0.002 mm
Colloids	0.9%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments: ______

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - SS - 106
Sample#: B22-0207

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Unified Soil Classification System, ASTM-2487
GW-GC, Well-graded Gravel with Silty Clay and Sand
Sample Color:
gray-brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

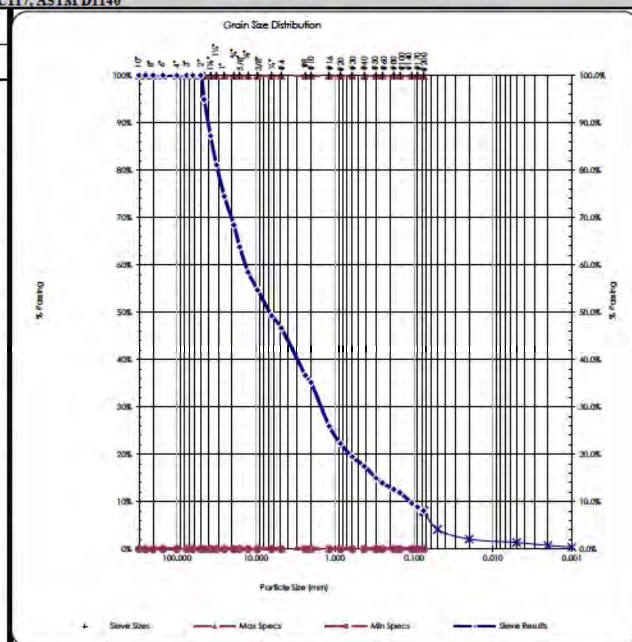
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.055 mm	% Gravel = 53.3%	Coeff. of Curvature, C_C = 1.57
$D_{(10)}$ = 0.112 mm	% Sand = 38.6%	Coeff. of Uniformity, C_U = 120.38
$D_{(15)}$ = 0.301 mm	% Silt & Clay = 8.1%	Fineness Modulus = 5.21
$D_{(30)}$ = 1.541 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 6.717 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 13.510 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 40.216 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 6/13	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		95%	100.0%	0.0%
1.50"	37.50		87%	100.0%	0.0%
1.25"	31.50		81%	100.0%	0.0%
1.00"	25.00	74%	74%	100.0%	0.0%
3/4"	19.00	68%	68%	100.0%	0.0%
5/8"	16.00		64%	100.0%	0.0%
1/2"	12.50	58%	58%	100.0%	0.0%
3/8"	9.50	55%	55%	100.0%	0.0%
1/4"	6.30		49%	100.0%	0.0%
#4	4.75	47%	47%	100.0%	0.0%
#8	2.36		37%	100.0%	0.0%
#10	2.00	35%	35%	100.0%	0.0%
#16	1.18		26%	100.0%	0.0%
#20	0.850		22%	100.0%	0.0%
#30	0.600		19%	100.0%	0.0%
#40	0.425	18%	18%	100.0%	0.0%
#50	0.300		15%	100.0%	0.0%
#60	0.250		14%	100.0%	0.0%
#80	0.180		13%	100.0%	0.0%
#100	0.150	12%	12%	100.0%	0.0%
#140	0.106		10%	100.0%	0.0%
#170	0.090		9%	100.0%	0.0%
#200	0.075	8.1%	8.1%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

Hydrometer Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:**	3-Mar-22
Project #:	21B288	**Sampled By:**	Other
Client :	GeoEngineers	**Date Tested:**	14-Mar-22
Source:	PRDI - SS - 106	**Tested By:**	K. Mendez
Sample#:	B22-0207		

Unified Soil Classification System, ASTM-2487
GW-GC, Well-graded Gravel with Silty Clay and Sand
Sample Color
gray-brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	100.39	grams
Hydroscopic Moist.:	13.68%	
Adj. Sample Wgt :	88.31	grams

ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	5.5	2.2%	0.0374 mm
5	5.5	2.2%	0.0237 mm
15	5	2.0%	0.0137 mm
30	4.5	1.8%	0.0097 mm
60	4	1.6%	0.0069 mm
250	3	1.2%	0.0034 mm
1440	1.5	0.6%	0.0014 mm

% Gravel:	53.3%	**Liquid Limit:**	n/a
% Sand:	38.6%	**Plastic Limit:**	n/a
% Silt:	6.7%	**Plasticity Index:**	n/a
% Clay:	1.4%		

ASTM C136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	87%	31.500 mm
1.0"	81%	25.000 mm
3/4"	68%	19.000 mm
5/8"	64%	16.000 mm
1/2"	58%	12.500 mm
3/8"	55%	9.500 mm
1/4"	49%	6.300 mm
#4	47%	4.750 mm
#10	35%	2.000 mm
#20	22%	0.850 mm
#40	18%	0.425 mm
#100	12%	0.150 mm
#200	8.1%	0.075 mm
Silts	7.9%	0.074 mm
	4.1%	0.050 mm
	2.1%	0.020 mm
Clays	1.4%	0.005 mm
	0.8%	0.002 mm
Colloids	0.4%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - 23 - SS
Sample#: B22-0208

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Visual Soils Classification
Silt with Sand and Organics
Sample Color:
brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

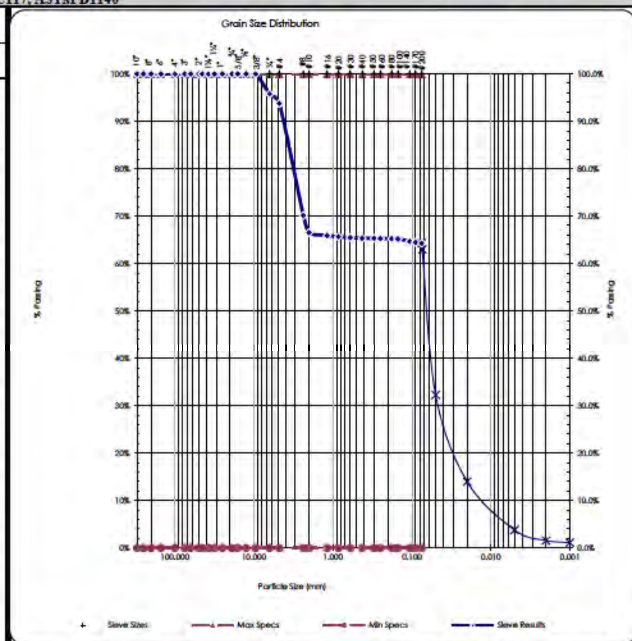
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.006 mm	% Gravel = 6.3%	Coeff. of Curvature, C_C = 3.04
$D_{(10)}$ = 0.011 mm	% Sand = 29.4%	Coeff. of Uniformity, C_U = 6.71
$D_{(15)}$ = 0.035 mm	% Silt & Clay = 64.3%	Fineness Modulus = 1.74
$D_{(30)}$ = 0.048 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.064 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.072 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 4.372 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 61/62	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		96%	100.0%	0.0%
#4	4.75	94%	94%	100.0%	0.0%
#8	2.36		70%	100.0%	0.0%
#10	2.00	67%	67%	100.0%	0.0%
#16	1.18		66%	100.0%	0.0%
#20	0.850		66%	100.0%	0.0%
#30	0.600		65%	100.0%	0.0%
#40	0.425	65%	65%	100.0%	0.0%
#50	0.300		65%	100.0%	0.0%
#60	0.250		65%	100.0%	0.0%
#80	0.180		65%	100.0%	0.0%
#100	0.150	65%	65%	100.0%	0.0%
#140	0.106		65%	100.0%	0.0%
#170	0.090		64%	100.0%	0.0%
#200	0.075	64.3%	64.3%	100.0%	0.0%



Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Hydrometer Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI - 23 - SS
Sample#: B22-0208

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Visual Soils Classification
Silt with Sand and Organics
Sample Color
brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	50.27	grams
Hydroscopic Moist.:	21.02%	
Adj. Sample Wgt :	41.54	grams

A2LA ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	9.5	15.1%	0.0366 mm
5	9	14.3%	0.0231 mm
15	8.5	13.5%	0.0134 mm
30	5.5	8.7%	0.0097 mm
60	4	6.3%	0.0069 mm
250	1	1.6%	0.0034 mm
1440	1	1.6%	0.0014 mm

% Gravel:	6.3%	**Liquid Limit:**	n/a
% Sand:	29.4%	**Plastic Limit:**	n/a
% Silt:	60.5%	**Plasticity Index:**	n/a
% Clay:	3.8%		

ASTM C136

Sieve Analysis
Grain Size Distribution

	Sieve Size	Percent Passing	Soils Particle Diameter
	3.0"	100%	75.000 mm
	2.0"	100%	50.000 mm
	1.5"	100%	37.500 mm
	1.25"	100%	31.500 mm
	1.0"	100%	25.000 mm
	3/4"	100%	19.000 mm
	5/8"	100%	16.000 mm
	1/2"	100%	12.500 mm
	3/8"	100%	9.500 mm
	1/4"	96%	6.300 mm
	#4	94%	4.750 mm
	#10	67%	2.000 mm
	#20	66%	0.850 mm
	#40	65%	0.425 mm
	#100	65%	0.150 mm
	#200	64.3%	0.075 mm
Silts		63.0%	0.074 mm
		32.3%	0.050 mm
		14.0%	0.020 mm
Clays		3.8%	0.005 mm
		1.6%	0.002 mm
Colloids		1.1%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sandy Loam

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:** 3-Mar-22
Project #: 21B288	**Sampled By:** Other
Client: GeoEngineers	**Date Tested:** 14-Mar-22
Source: PRDI - 28 - SS	**Tested By:** K. Mendez
Sample#: B22-0209	

Visual Soils Classification
Silt with Sand and Organics
Sample Color:
brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

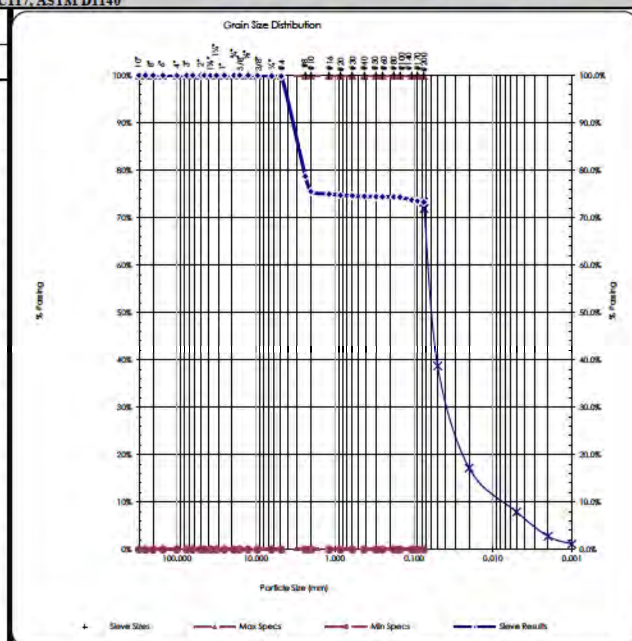
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.003 mm	% Gravel = 0.2%	Coeff. of Curvature, C_C = 4.51
$D_{(10)}$ = 0.006 mm	% Sand = 26.5%	Coeff. of Uniformity, C_U = 10.09
$D_{(15)}$ = 0.011 mm	% Silt & Clay = 73.3%	Fineness Modulus = 1.23
$D_{(30)}$ = 0.044 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.058 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.065 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 3.639 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 61/62	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		79%	100.0%	0.0%
#10	2.00	76%	76%	100.0%	0.0%
#16	1.18		75%	100.0%	0.0%
#20	0.850		75%	100.0%	0.0%
#30	0.600		75%	100.0%	0.0%
#40	0.425	74%	74%	100.0%	0.0%
#50	0.300		74%	100.0%	0.0%
#60	0.250		74%	100.0%	0.0%
#80	0.180		74%	100.0%	0.0%
#100	0.150	74%	74%	100.0%	0.0%
#140	0.106		74%	100.0%	0.0%
#170	0.090		73%	100.0%	0.0%
#200	0.075	73.3%	73.3%	100.0%	0.0%



All results apply only to actual locations and materials tested. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

Hydrometer Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:**	3-Mar-22
Project #:	21B288	**Sampled By:**	Other
Client :	GeoEngineers	**Date Tested:**	14-Mar-22
Source:	PRDI - 28 - SS	**Tested By:**	K. Mendez
Sample#:	B22-0209		

Visual Soils Classification
Silt with Sand and Organics
Sample Color
brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	50.77	grams
Hydroscopic Moist.:	9.02%	
Adj. Sample Wgt :	46.57	grams

ACCREDITED
Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	12	19.3%	0.0359 mm
5	11	17.7%	0.0229 mm
15	10	16.1%	0.0133 mm
30	9	14.4%	0.0094 mm
60	6.5	10.4%	0.0068 mm
250	3.5	5.6%	0.0034 mm
1440	1	1.6%	0.0014 mm

% Gravel:	0.2%	**Liquid Limit:**	n/a
% Sand:	26.5%	**Plastic Limit:**	n/a
% Silt:	65.4%	**Plasticity Index:**	n/a
% Clay:	7.9%		

ASTM C136

Sieve Analysis
Grain Size Distribution

	Sieve Size	Percent Passing	Soils Particle Diameter
	3.0"	100%	75.000 mm
	2.0"	100%	50.000 mm
	1.5"	100%	37.500 mm
	1.25"	100%	31.500 mm
	1.0"	100%	25.000 mm
	3/4"	100%	19.000 mm
	5/8"	100%	16.000 mm
	1/2"	100%	12.500 mm
	3/8"	100%	9.500 mm
	1/4"	100%	6.300 mm
	#4	100%	4.750 mm
	#10	76%	2.000 mm
	#20	75%	0.850 mm
	#40	74%	0.425 mm
	#100	74%	0.150 mm
	#200	73.3%	0.075 mm
Silts		71.9%	0.074 mm
		38.7%	0.050 mm
		17.2%	0.020 mm
Clays		7.9%	0.005 mm
		2.8%	0.002 mm
Colloids		1.1%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sandy Loam

Comments: ____________________

Reviewed by: Alex Eifrig

Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State Street Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI - 21 - SS
Sample#: B22-0210

Date Received: 3-Mar-22
Sampled By: Other
Date Tested: 14-Mar-22
Tested By: K. Mendez

Visual Soils Classification
Silt with Sand and Organics
Sample Color:
brown

ACCREDITED
Certificate #: 1366.01

ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

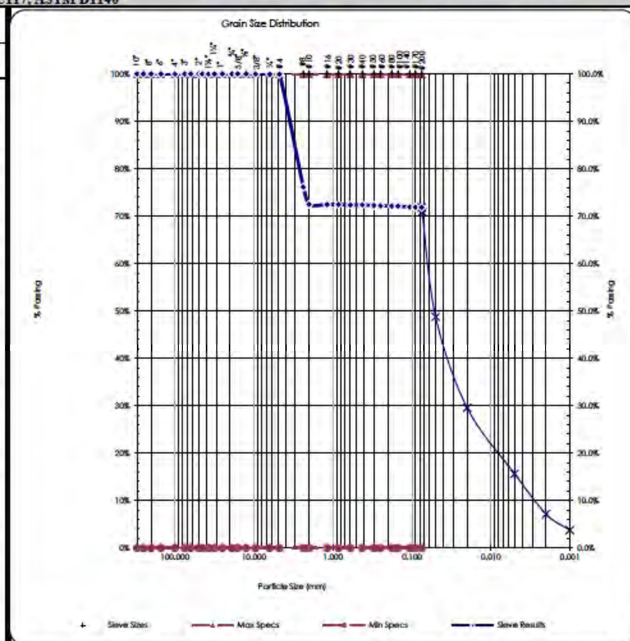
Specifications
No Specs

Sample Meets Specs ? N/A

$D_{(5)}$ = 0.001 mm	% Gravel = 0.1%	Coeff. of Curvature, C_C = 2.50
$D_{(10)}$ = 0.003 mm	% Sand = 28.1%	Coeff. of Uniformity, C_U = 21.43
$D_{(15)}$ = 0.005 mm	% Silt & Clay = 71.8%	Fineness Modulus = 1.35
$D_{(30)}$ = 0.021 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.051 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.062 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 3.756 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 1	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		76%	100.0%	0.0%
#10	2.00	73%	73%	100.0%	0.0%
#16	1.18		72%	100.0%	0.0%
#20	0.850		72%	100.0%	0.0%
#30	0.600		72%	100.0%	0.0%
#40	0.425	72%	72%	100.0%	0.0%
#50	0.300		72%	100.0%	0.0%
#60	0.250		72%	100.0%	0.0%
#80	0.180		72%	100.0%	0.0%
#100	0.150	72%	72%	100.0%	0.0%
#140	0.106		72%	100.0%	0.0%
#170	0.090		72%	100.0%	0.0%
#200	0.075	71.8%	71.8%	100.0%	0.0%



All results apply only to actual locations and materials tested. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

Comments:

Reviewed by: Alex Eifrig
Alex Eifrig

MATERIALS TESTING & CONSULTING, INC.

Hydrometer Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:**	3-Mar-22
Project #:	21B288	**Sampled By:**	Other
Client :	GeoEngineers	**Date Tested:**	14-Mar-22
Source:	PRDI - 21 - SS	**Tested By:**	K. Mendez
Sample#:	B22-0210		

Visual Soils Classification
Silt with Sand and Organics
Sample Color
brown

ASTM D422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.70	
Sample Weight:	51.18	grams
Hydroscopic Moist.:	7.44%	
Adj. Sample Wgt :	47.64	grams

ACCREDITED Certificate #: 1366.01

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	22.5	33.9%	0.0339 mm
5	20	30.1%	0.0217 mm
15	18	27.1%	0.0127 mm
30	16	24.1%	0.0091 mm
60	13	19.6%	0.0065 mm
250	7.5	11.3%	0.0033 mm
1440	3.5	5.3%	0.0014 mm

% Gravel:	0.1%	**Liquid Limit:**	n/a
% Sand:	28.1%	**Plastic Limit:**	n/a
% Silt:	56.2%	**Plasticity Index:**	n/a
% Clay:	15.6%		

ASTM C136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	73%	2.000 mm
#20	72%	0.850 mm
#40	72%	0.425 mm
#100	72%	0.150 mm
#200	71.8%	0.075 mm
Silts	70.9%	0.074 mm
	48.8%	0.050 mm
	29.6%	0.020 mm
Clays	15.6%	0.005 mm
	7.1%	0.002 mm
Colloids	3.7%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by: Alex Eifrig

Alex Eifrig

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Chain of Custody Record & Laboratory Analysis Request

Received 3-3-22 in Burl

MTC Project Number: 21B288	Turn-around Time Requested: standard.	Page: 1	of: 1	
Client Company: Geo Engineers		Date: 3/2/22	Ice Present: n/A	
Client Contact: Avery Mavenda	Phone: 4154976667	# of Coolers: 1	Cooler Temps: n/A	
Client Project Name: Q.C. - S. State St. Prelim. Remedial Design invest.				
Client Project #: 0186-980-03	Samplers: Avery Mavenda.			

Sample ID	Date	Time	Matrix	# of Containers	Sieve	Hydrometer								Comments: Please use same methods as 11/30/21 submittal
PRDI-SS-100	3/1/22	9:04pm	S	1	X	X		B22-0201						Grey-brown sand w/ organics & gravel
PRDI-SS-101	↓	9:15pm	↓	↓	↓	↓		B22-0202						" "
PRDI-SS-102	↓	9:20pm	↓	↓	↓	↓		B22-0203						" "
PRDI-SS-103	↓	9:25pm	↓	↓	↓	↓		B22-0204						" "
PRDI-SS-104	↓	9:33pm	↓	↓	↓	↓		B22-0205						" "
PRDI-SS-105	↓	9:43pm	↓	↓	↓	↓		B22-0206						" "
PRDI-SS-106	↓	9:47pm	↓	↓	↓	↓		B22-0207						" "
PRDI-23-SS	9/14/21	15:20	↓	↓	↓	↓		B22-0208						Brown silt w/ organics
PRDI-28-SS	9/14/21	15:40	↓	↓	↓	↓		B22-0209						" "
PRDI-21-SS	9/14/21	14:25	↓	↓	↓	↓		B22-0210						" "

Special Instructions:				
Please provide excel file of results.	Relinquished By: Avery Mavenda	Received By: J Baptist	Relinquished By:	Received By:
	Printed Name: Avery Mavenda	Printed Name: Jen Baptist	Printed Name:	Printed Name:
	Company: CGS	Company: MTC	Company:	Company:
	Date & Time: 3/2/22 13:48	Date & Time: 3/2/22 13:48	Date & Time:	Date & Time:

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Client:	GeoEngineers	**Date:**	October 14, 2021
Address:	17425 NE Union Hill Rd., Suite 250	**Project:**	Q.C. - South State St. Preliminary Remedial Design Investigation
	Redmond, WA 98052	**Project #:**	21B288
Attn:	Neil Morton	**Sample #:**	B21-1897 - 1916
Date Revised:		**Date Sampled:**	9-14-21 through 9-21-21

As requested MTC, Inc. has performed the following test(s) on the sample referenced above. The testing was performed in accordance with current applicable AASHTO or ASTM standards as indicated below. The results obtained in our laboratory were as follows below or on the attached pages:

	Test(s) Performed:	Test Results		Test(s) Performed:	Test Results
X	Sieve Analysis	Please See Attached Reports		Sulfate Soundness	
	Proctor			Bulk Density & Voids	
	Sand Equivalent			WSDOT Degradation	
	Fracture Count				
	Moisture Content				
	Specific Gravity, Coarse				
	Specific Gravity, Fine				
X	Hydrometer Analysis	Please See Attached Reports			
	Atterberg Limits				
	Asphalt Extraction/Gradation				
	Rice Density				

If you have any questions concerning the test results, the procedures used, or if we can be of any further assistance please call on us at the number below.

Respectfully Submitted,
Meghan Blodgett-Carrillo
WABO Supervising Laboratory Technician

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-40-SC-25
Sample#: B21-1897

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silt and Clay
Sample Color:
gray

ACCREDITED

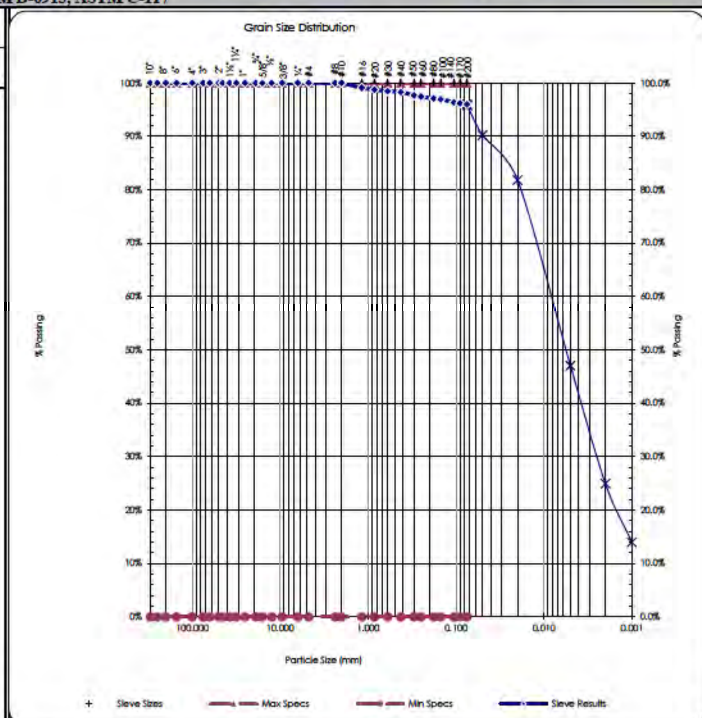
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.004 mm	% Gravel = 0.0%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.008 mm	% Sand = 4.0%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.012 mm	% Silt & Clay = 96.0%	Fineness Modulus = 0.08
$D_{(30)}$ = 0.023 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.039 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.047 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.070 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 42/43	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		100%	100.0%	0.0%
#10	2.00	100%	100%	100.0%	0.0%
#16	1.18		99%	100.0%	0.0%
#20	0.850		99%	100.0%	0.0%
#30	0.600		98%	100.0%	0.0%
#40	0.425	98%	98%	100.0%	0.0%
#50	0.300		98%	100.0%	0.0%
#60	0.250		97%	100.0%	0.0%
#80	0.180		97%	100.0%	0.0%
#100	0.150	97%	97%	100.0%	0.0%
#140	0.106		96%	100.0%	0.0%
#170	0.090		96%	100.0%	0.0%
#200	0.075	96.0%	96.0%	100.0%	0.0%



Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-40-SC-25
Sample#: B21-1897
Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silt and Clay
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	52.71	grams
Hydroscopic Moist.:	7.33%	
Adj. Sample Wgt :	49.11	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	42	85.5%	0.0296 mm
5	40	81.4%	0.0190 mm
15	35	71.3%	0.0115 mm
30	31	63.1%	0.0083 mm
60	26.5	54.0%	0.0061 mm
250	17.5	35.6%	0.0032 mm
1440	9.5	19.3%	0.0014 mm

% Gravel:	0.0%	**Liquid Limit:**	n/a
% Sand:	4.0%	**Plastic Limit:**	n/a
% Silt:	48.9%	**Plasticity Index:**	n/a
% Clay:	47.1%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	100%	2.000 mm
#20	99%	0.850 mm
#40	98%	0.425 mm
#100	97%	0.150 mm
#200	96.0%	0.075 mm
Silts	95.8%	0.074 mm
	90.2%	0.050 mm
	81.8%	0.020 mm
Clays	47.1%	0.005 mm
	25.0%	0.002 mm
Colloids	14.0%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by:

Meghan Blodgett-Carrillo

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-40-SC-92
Sample#: B21-1898

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silty Clay with Sand
Sample Color:
gray

ACCREDITED

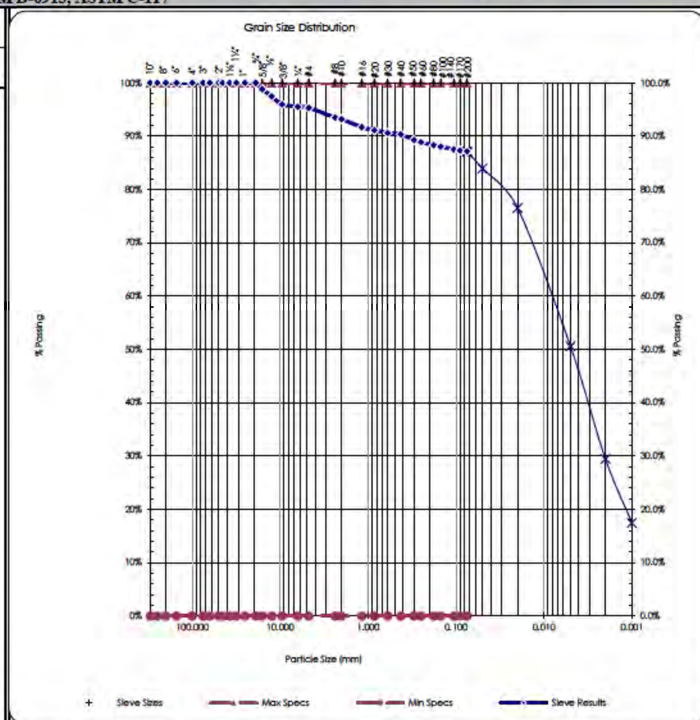
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.004 mm	% Gravel = 4.7%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.009 mm	% Sand = 8.2%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.013 mm	% Silt & Clay = 87.2%	Fineness Modulus = 0.56
$D_{(30)}$ = 0.026 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.043 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.052 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.385 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 55/57	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		99%	100.0%	0.0%
1/2"	12.50	97%	97%	100.0%	0.0%
3/8"	9.50	96%	96%	100.0%	0.0%
1/4"	6.30		96%	100.0%	0.0%
#4	4.75	95%	95%	100.0%	0.0%
#8	2.36		93%	100.0%	0.0%
#10	2.00	93%	93%	100.0%	0.0%
#16	1.18		92%	100.0%	0.0%
#20	0.850		91%	100.0%	0.0%
#30	0.600		91%	100.0%	0.0%
#40	0.425	90%	90%	100.0%	0.0%
#50	0.300		89%	100.0%	0.0%
#60	0.250		89%	100.0%	0.0%
#80	0.180		88%	100.0%	0.0%
#100	0.150	88%	88%	100.0%	0.0%
#140	0.106		88%	100.0%	0.0%
#170	0.090		87%	100.0%	0.0%
#200	0.075	87.2%	87.2%	100.0%	0.0%



Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-40-SC-92
Sample#: B21-1898

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silty Clay with Sand
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	61.86	grams
Hydroscopic Moist.:	7.63%	
Adj. Sample Wgt :	57.47	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	50	81.1%	0.0275 mm
5	46.5	75.4%	0.0181 mm
15	42	68.1%	0.0108 mm
30	37	60.0%	0.0080 mm
60	34	55.1%	0.0058 mm
250	24	38.9%	0.0030 mm
1440	14.5	23.5%	0.0013 mm

% Gravel: 4.7%
% Sand: 8.2%
% Silt: 36.6%
% Clay: 50.6%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	99%	16.000 mm
1/2"	97%	12.500 mm
3/8"	96%	9.500 mm
1/4"	96%	6.300 mm
#4	95%	4.750 mm
#10	93%	2.000 mm
#20	91%	0.850 mm
#40	90%	0.425 mm
#100	88%	0.150 mm
#200	87.2%	0.075 mm
Silts	87.0%	0.074 mm
	84.0%	0.050 mm
	76.5%	0.020 mm
Clays	50.6%	0.005 mm
	29.5%	0.002 mm
Colloids	17.5%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silty Clay Loam

Comments:

Reviewed by:

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-38-SC-24
Sample#: B21-1899

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color:
brown

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

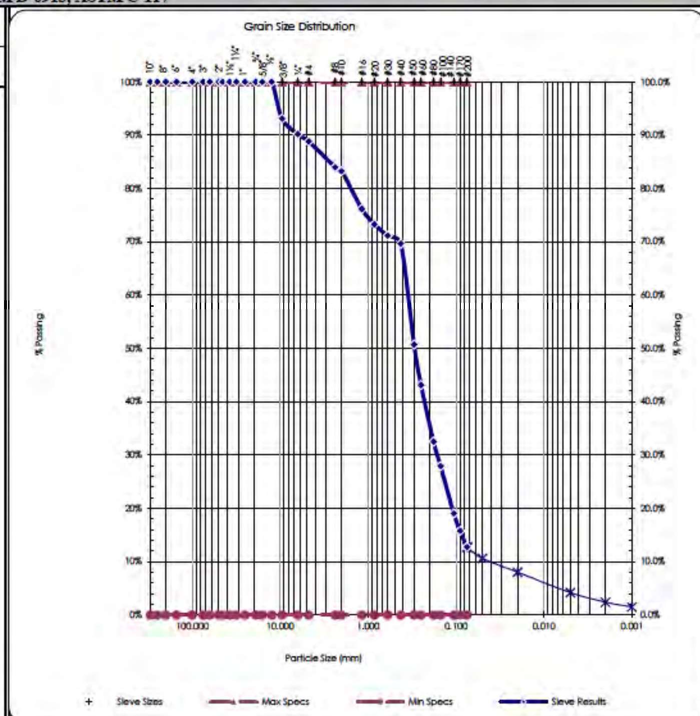
$D_{(5)}$ = 0.029 mm
$D_{(10)}$ = 0.059 mm
$D_{(15)}$ = 0.086 mm
$D_{(30)}$ = 0.164 mm
$D_{(50)}$ = 0.295 mm
$D_{(60)}$ = 0.361 mm
$D_{(90)}$ = 6.058 mm
Dust Ratio = 15/82

% Gravel = 11.2%
% Sand = 76.1%
% Silt & Clay = 12.7%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.26
Coeff. of Uniformity, C_U = 6.14
Fineness Modulus = 2.08
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	93%	93%	100.0%	0.0%
1/4"	6.30		90%	100.0%	0.0%
#4	4.75	89%	89%	100.0%	0.0%
#8	2.36		84%	100.0%	0.0%
#10	2.00	83%	83%	100.0%	0.0%
#16	1.18		76%	100.0%	0.0%
#20	0.850		73%	100.0%	0.0%
#30	0.600		71%	100.0%	0.0%
#40	0.425	70%	70%	100.0%	0.0%
#50	0.300		51%	100.0%	0.0%
#60	0.250		43%	100.0%	0.0%
#80	0.180		33%	100.0%	0.0%
#100	0.150	28%	28%	100.0%	0.0%
#140	0.106		19%	100.0%	0.0%
#170	0.090		16%	100.0%	0.0%
#200	0.075	12.7%	12.7%	100.0%	0.0%



Comments:

Reviewed by: Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-38-SC-24
Sample#: B21-1899

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color
brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	100.11	grams
Hydroscopic Moist.:	3.80%	
Adj. Sample Wgt :	96.45	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	11	9.5%	0.0368 mm
5	10	8.6%	0.0234 mm
15	8	6.9%	0.0137 mm
30	7	6.0%	0.0097 mm
60	6.5	5.6%	0.0069 mm
250	3.5	3.0%	0.0034 mm
1440	2.5	2.2%	0.0014 mm

% Gravel:	11.2%
% Sand:	76.1%
% Silt:	8.5%
% Clay:	4.2%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	93%	9.500 mm
1/4"	90%	6.300 mm
#4	89%	4.750 mm
#10	83%	2.000 mm
#20	73%	0.850 mm
#40	70%	0.425 mm
#100	28%	0.150 mm
#200	12.7%	0.075 mm
Silts	12.7%	0.074 mm
	10.6%	0.050 mm
	8.0%	0.020 mm
Clays	4.2%	0.005 mm
	2.4%	0.002 mm
Colloids	1.5%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sand

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

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Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-41-SC-25
Sample#: B21-1900

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silty Clay
Sample Color:
gray

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

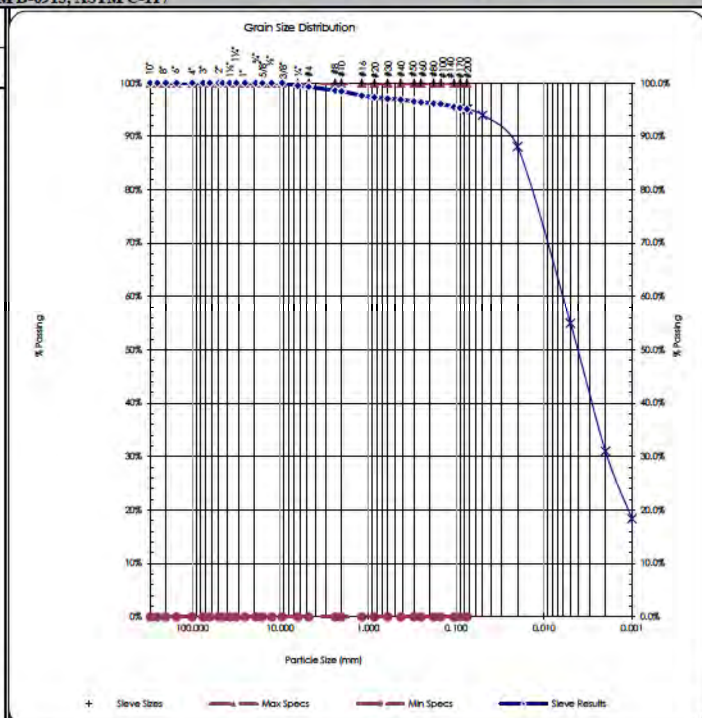
$D_{(5)}$ = 0.004 mm
$D_{(10)}$ = 0.008 mm
$D_{(15)}$ = 0.012 mm
$D_{(30)}$ = 0.024 mm
$D_{(50)}$ = 0.039 mm
$D_{(60)}$ = 0.047 mm
$D_{(90)}$ = 0.071 mm
Dust Ratio = 54/55

% Gravel = 0.7%
% Sand = 4.2%
% Silt & Clay = 95.1%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.50
Coeff. of Uniformity, C_U = 6.00
Fineness Modulus = 0.15
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		99%	100.0%	0.0%
#10	2.00	98%	98%	100.0%	0.0%
#16	1.18		98%	100.0%	0.0%
#20	0.850		97%	100.0%	0.0%
#30	0.600		97%	100.0%	0.0%
#40	0.425	97%	97%	100.0%	0.0%
#50	0.300		97%	100.0%	0.0%
#60	0.250		96%	100.0%	0.0%
#80	0.180		96%	100.0%	0.0%
#100	0.150	96%	96%	100.0%	0.0%
#140	0.106		96%	100.0%	0.0%
#170	0.090		95%	100.0%	0.0%
#200	0.075	95.1%	95.1%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
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Hydrometer Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client :	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-41-SC-25	**Tested By:**	C. Kriss
Sample#:	B21-1900		

Visual Identification
Silty Clay
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	50.26	grams
Hydroscopic Moist.:	11.78%	
Adj. Sample Wgt :	44.96	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	42.5	93.1%	0.0296 mm
5	40	87.6%	0.0190 mm
15	35.5	77.7%	0.0115 mm
30	32	70.1%	0.0083 mm
60	28.5	62.4%	0.0060 mm
250	19	41.6%	0.0031 mm
1440	11.5	25.2%	0.0014 mm

% Gravel:	0.7%	**Liquid Limit:**	n/a
% Sand:	4.2%	**Plastic Limit:**	n/a
% Silt:	40.1%	**Plasticity Index:**	n/a
% Clay:	55.0%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	99%	4.750 mm
#10	98%	2.000 mm
#20	97%	0.850 mm
#40	97%	0.425 mm
#100	96%	0.150 mm
#200	95.1%	0.075 mm
Silts	95.1%	0.074 mm
	94.0%	0.050 mm
	88.1%	0.020 mm
Clays	55.0%	0.005 mm
	31.0%	0.002 mm
Colloids	18.4%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silty Clay Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	Date Received:	27-Sep-21
Project #:	21B288	Sampled By:	Client
Client:	GeoEngineers	Date Tested:	30-Sep-21
Source:	PRDI-41-SC-100	Tested By:	C. Kriss
Sample#:	B21-1901		

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color:
gray

ACCREDITED

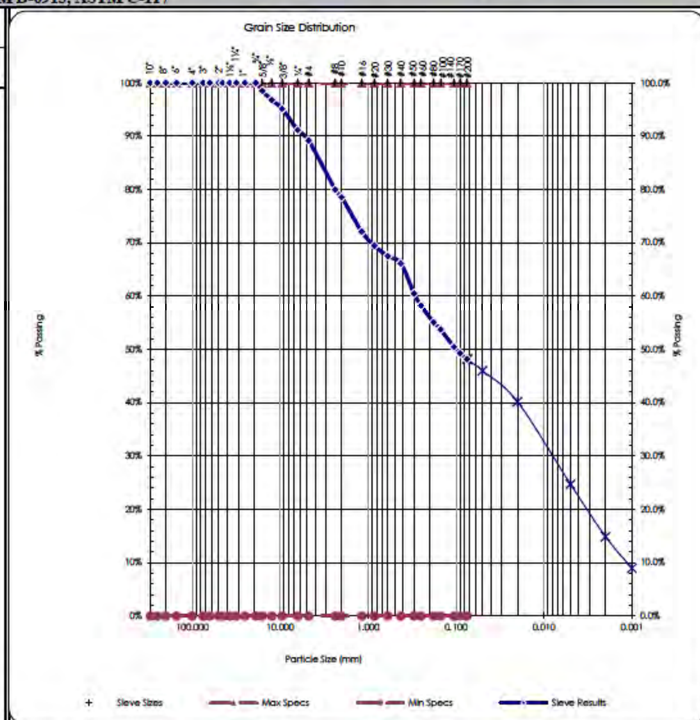
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.008 mm	% Gravel = 10.8%	Coeff. of Curvature, C_C = 0.48
$D_{(10)}$ = 0.016 mm	% Sand = 41.0%	Coeff. of Uniformity, C_U = 18.56
$D_{(15)}$ = 0.023 mm	% Silt & Clay = 48.2%	Fineness Modulus = 1.82
$D_{(30)}$ = 0.047 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.100 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.289 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 5.374 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 51/70	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		99%	100.0%	0.0%
1/2"	12.50	97%	97%	100.0%	0.0%
3/8"	9.50	95%	95%	100.0%	0.0%
1/4"	6.30		91%	100.0%	0.0%
#4	4.75	89%	89%	100.0%	0.0%
#8	2.36		80%	100.0%	0.0%
#10	2.00	79%	79%	100.0%	0.0%
#16	1.18		72%	100.0%	0.0%
#20	0.850		70%	100.0%	0.0%
#30	0.600		68%	100.0%	0.0%
#40	0.425	66%	66%	100.0%	0.0%
#50	0.300		61%	100.0%	0.0%
#60	0.250		58%	100.0%	0.0%
#80	0.180		55%	100.0%	0.0%
#100	0.150	54%	54%	100.0%	0.0%
#140	0.106		50%	100.0%	0.0%
#170	0.090		49%	100.0%	0.0%
#200	0.075	48.2%	48.2%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
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Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-41-SC-100
Sample#: B21-1901

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 75.17 grams
Hydroscopic Moist.: 1.97%
Adj. Sample Wgt : 73.72 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	41.5	44.2%	0.0299 mm
5	37.5	40.0%	0.0195 mm
15	33.5	35.7%	0.0116 mm
30	30	32.0%	0.0084 mm
60	26	27.7%	0.0061 mm
250	18.5	19.7%	0.0031 mm
1440	11.5	12.3%	0.0014 mm

% Gravel: 10.8%
% Sand: 41.0%
% Silt: 23.5%
% Clay: 24.7%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	99%	16.000 mm
1/2"	97%	12.500 mm
3/8"	95%	9.500 mm
1/4"	91%	6.300 mm
#4	89%	4.750 mm
#10	79%	2.000 mm
#20	70%	0.850 mm
#40	66%	0.425 mm
#100	54%	0.150 mm
#200	48.2%	0.075 mm
Silts	48.1%	0.074 mm
	46.0%	0.050 mm
	40.2%	0.020 mm
Clays	24.7%	0.005 mm
	14.9%	0.002 mm
Colloids	8.9%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Loam

Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-41-SC-120
Sample#: B21-1902

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
GM, Silty Gravel with Sand
Sample Color:
gray

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

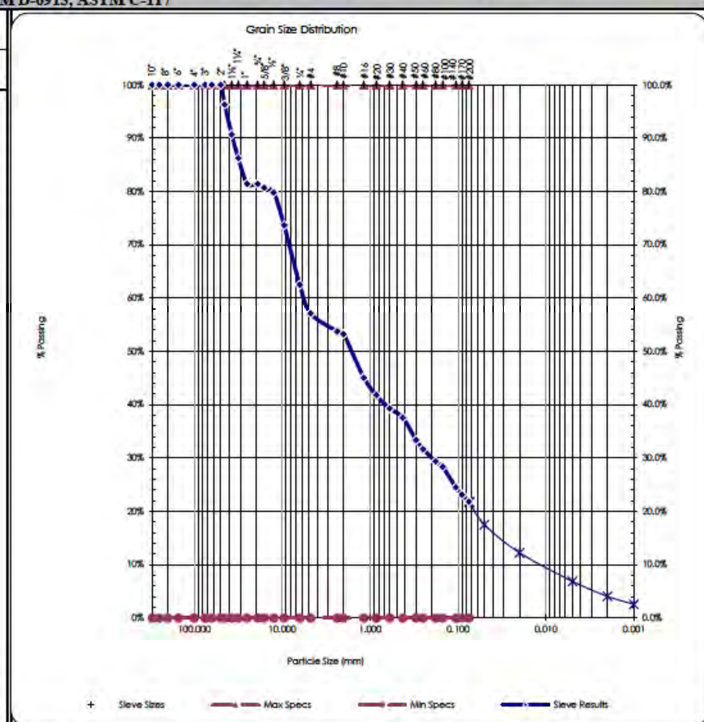
$D_{(5)}$ = 0.017 mm
$D_{(10)}$ = 0.034 mm
$D_{(15)}$ = 0.052 mm
$D_{(30)}$ = 0.199 mm
$D_{(50)}$ = 1.675 mm
$D_{(60)}$ = 5.574 mm
$D_{(90)}$ = 36.521 mm
Dust Ratio = 43/74

% Gravel = 42.9%
% Sand = 35.3%
% Silt & Clay = 21.8%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 0.21
Coeff. of Uniformity, C_U = 162.20
Fineness Modulus = 3.88
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		96%	100.0%	0.0%
1.50"	37.50		91%	100.0%	0.0%
1.25"	31.50		86%	100.0%	0.0%
1.00"	25.00	81%	81%	100.0%	0.0%
3/4"	19.00	81%	81%	100.0%	0.0%
5/8"	16.00		81%	100.0%	0.0%
1/2"	12.50	80%	80%	100.0%	0.0%
3/8"	9.50	74%	74%	100.0%	0.0%
1/4"	6.30		63%	100.0%	0.0%
#4	4.75	57%	57%	100.0%	0.0%
#8	2.36		54%	100.0%	0.0%
#10	2.00	53%	53%	100.0%	0.0%
#16	1.18		45%	100.0%	0.0%
#20	0.850		42%	100.0%	0.0%
#30	0.600		39%	100.0%	0.0%
#40	0.425	38%	38%	100.0%	0.0%
#50	0.300		33%	100.0%	0.0%
#60	0.250		32%	100.0%	0.0%
#80	0.180		29%	100.0%	0.0%
#100	0.150	28%	28%	100.0%	0.0%
#140	0.106		25%	100.0%	0.0%
#170	0.090		23%	100.0%	0.0%
#200	0.075	21.8%	21.8%	100.0%	0.0%



Comments:

Reviewed by:

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-41-SC-120
Sample#: B21-1902

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
GM, Silty Gravel with Sand
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 75.21 grams
Hydroscopic Moist.: 2.56%
Adj. Sample Wgt : 73.33 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	20.5	14.9%	0.0348 mm
5	17.5	12.7%	0.0224 mm
15	15	10.9%	0.0131 mm
30	13	9.4%	0.0094 mm
60	12	8.7%	0.0067 mm
250	7	5.1%	0.0034 mm
1440	5	3.6%	0.0014 mm

% Gravel: 42.9%
% Sand: 35.3%
% Silt: 14.9%
% Clay: 6.9%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	91%	31.500 mm
1.0"	86%	25.000 mm
3/4"	81%	19.000 mm
5/8"	81%	16.000 mm
1/2"	80%	12.500 mm
3/8"	74%	9.500 mm
1/4"	63%	6.300 mm
#4	57%	4.750 mm
#10	53%	2.000 mm
#20	42%	0.850 mm
#40	38%	0.425 mm
#100	28%	0.150 mm
#200	21.8%	0.075 mm
Silts	21.7%	0.074 mm
	17.5%	0.050 mm
	12.2%	0.020 mm
Clays	6.9%	0.005 mm
	4.1%	0.002 mm
Colloids	2.6%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sandy Loam

Comments:

Reviewed by:

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Sieve Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-15-SS	**Tested By:**	C. Kriss
Sample#:	B21-1903		

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color:
gray

ACCREDITED

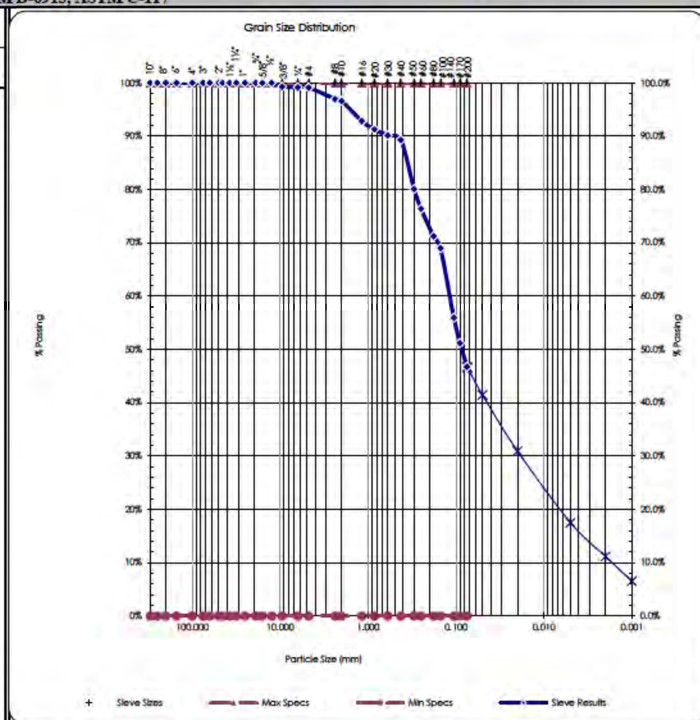
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.008 mm	% Gravel = 0.9%	Coeff. of Curvature, C_C = 1.21
$D_{(10)}$ = 0.016 mm	% Sand = 52.4%	Coeff. of Uniformity, C_U = 7.46
$D_{(15)}$ = 0.024 mm	% Silt & Clay = 46.8%	Fineness Modulus = 0.73
$D_{(30)}$ = 0.048 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.086 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.120 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.566 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 11/21	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	99%	99%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		97%	100.0%	0.0%
#10	2.00	97%	97%	100.0%	0.0%
#16	1.18		93%	100.0%	0.0%
#20	0.850		91%	100.0%	0.0%
#30	0.600		90%	100.0%	0.0%
#40	0.425	89%	89%	100.0%	0.0%
#50	0.300		80%	100.0%	0.0%
#60	0.250		76%	100.0%	0.0%
#80	0.180		71%	100.0%	0.0%
#100	0.150	69%	69%	100.0%	0.0%
#140	0.106		56%	100.0%	0.0%
#170	0.090		51%	100.0%	0.0%
#200	0.075	46.8%	46.8%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-15-SS
Sample#: B21-1903

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	50.38	grams
Hydroscopic Moist.:	7.98%	
Adj. Sample Wgt :	46.66	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	18.5	38.3%	0.0352 mm
5	15.5	32.1%	0.0227 mm
15	13.5	28.0%	0.0133 mm
30	11.5	23.8%	0.0095 mm
60	9.5	19.7%	0.0068 mm
250	7.5	15.5%	0.0034 mm
1440	4.5	9.3%	0.0014 mm

% Gravel: 0.9%
% Sand: 52.4%
% Silt: 29.2%
% Clay: 17.5%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	99%	9.500 mm
1/4"	99%	6.300 mm
#4	99%	4.750 mm
#10	97%	2.000 mm
#20	91%	0.850 mm
#40	89%	0.425 mm
#100	69%	0.150 mm
#200	46.8%	0.075 mm
Silts	46.5%	0.074 mm
	41.5%	0.050 mm
	30.9%	0.020 mm
Clays	17.5%	0.005 mm
	11.2%	0.002 mm
Colloids	6.6%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sandy Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-16-SS
Sample#: B21-1904

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color:
brown

ACCREDITED

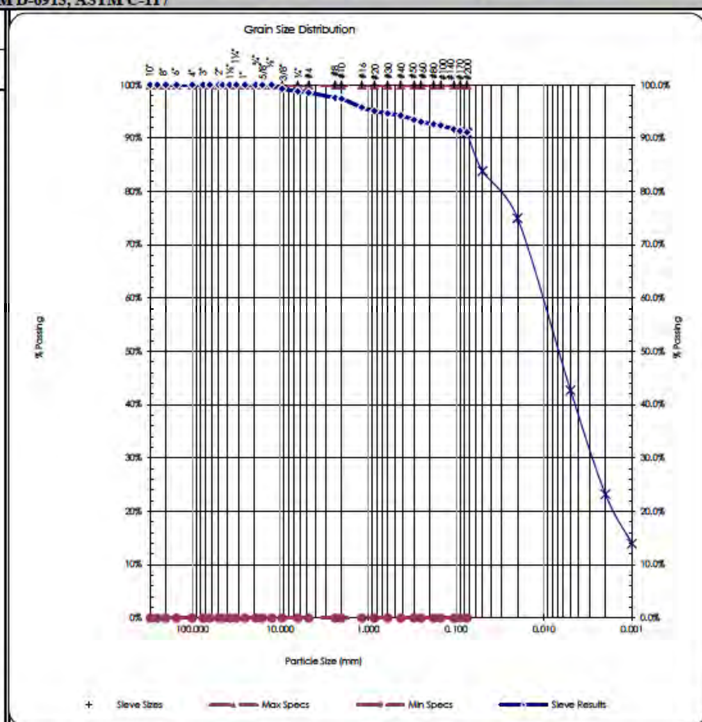
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.004 mm	% Gravel = 1.4%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.008 mm	% Sand = 7.4%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.012 mm	% Silt & Clay = 91.1%	Fineness Modulus = 0.28
$D_{(30)}$ = 0.025 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.041 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.049 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.074 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 29/30	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	99%	99%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		98%	100.0%	0.0%
#10	2.00	97%	97%	100.0%	0.0%
#16	1.18		96%	100.0%	0.0%
#20	0.850		95%	100.0%	0.0%
#30	0.600		95%	100.0%	0.0%
#40	0.425	94%	94%	100.0%	0.0%
#50	0.300		93%	100.0%	0.0%
#60	0.250		93%	100.0%	0.0%
#80	0.180		93%	100.0%	0.0%
#100	0.150	92%	92%	100.0%	0.0%
#140	0.106		92%	100.0%	0.0%
#170	0.090		91%	100.0%	0.0%
#200	0.075	91.1%	91.1%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-16-SS
Sample#: B21-1904

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color
brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 74.02 grams
Hydroscopic Moist.: 10.46%
Adj. Sample Wgt : 67.01 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	53	77.1%	0.0266 mm
5	51	74.1%	0.0172 mm
15	45	65.4%	0.0105 mm
30	39	56.7%	0.0078 mm
60	33	48.0%	0.0058 mm
250	21	30.5%	0.0031 mm
1440	13	18.9%	0.0014 mm

% Gravel: 1.4%
% Sand: 7.4%
% Silt: 48.4%
% Clay: 42.7%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	99%	9.500 mm
1/4"	99%	6.300 mm
#4	99%	4.750 mm
#10	97%	2.000 mm
#20	95%	0.850 mm
#40	94%	0.425 mm
#100	92%	0.150 mm
#200	91.1%	0.075 mm
Silts	90.8%	0.074 mm
	83.8%	0.050 mm
	75.0%	0.020 mm
Clays	42.7%	0.005 mm
	23.2%	0.002 mm
Colloids	13.9%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-18-SS
Sample#: B21-1905

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silty Sand with Clay
Sample Color:
gray

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

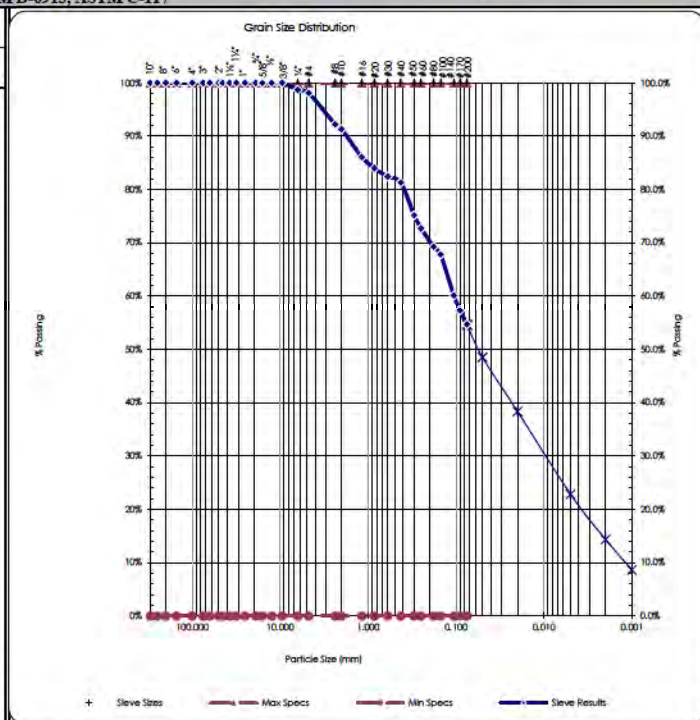
$D_{(5)}$ = 0.007 mm
$D_{(10)}$ = 0.014 mm
$D_{(15)}$ = 0.021 mm
$D_{(30)}$ = 0.041 mm
$D_{(50)}$ = 0.069 mm
$D_{(60)}$ = 0.105 mm
$D_{(90)}$ = 1.790 mm
Dust Ratio = 37/55

% Gravel = 1.9%
% Sand = 43.4%
% Silt & Clay = 54.7%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.17
Coeff. of Uniformity, C_U = 7.68
Fineness Modulus = 0.98
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	98%	98%	100.0%	0.0%
#8	2.36		92%	100.0%	0.0%
#10	2.00	91%	91%	100.0%	0.0%
#16	1.18		86%	100.0%	0.0%
#20	0.850		84%	100.0%	0.0%
#30	0.600		82%	100.0%	0.0%
#40	0.425	81%	81%	100.0%	0.0%
#50	0.300		75%	100.0%	0.0%
#60	0.250		73%	100.0%	0.0%
#80	0.180		69%	100.0%	0.0%
#100	0.150	68%	68%	100.0%	0.0%
#140	0.106		60%	100.0%	0.0%
#170	0.090		57%	100.0%	0.0%
#200	0.075	54.7%	54.7%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-18-SS
Sample#: B21-1905
Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Silty Sand with Clay
Sample Color
gray

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 50.17 grams
Hydroscopic Moist.: 11.44%
Adj. Sample Wgt : 45.02 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	22	44.6%	0.0344 mm
5	19.5	39.6%	0.0222 mm
15	17	34.5%	0.0129 mm
30	14.5	29.4%	0.0093 mm
60	13	26.4%	0.0066 mm
250	9.5	19.3%	0.0033 mm
1440	6	12.2%	0.0014 mm

% Gravel: 1.9%
% Sand: 43.4%
% Silt: 31.8%
% Clay: 22.9%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	99%	6.300 mm
#4	98%	4.750 mm
#10	91%	2.000 mm
#20	84%	0.850 mm
#40	81%	0.425 mm
#100	68%	0.150 mm
#200	54.7%	0.075 mm
Silts	54.5%	0.074 mm
	48.5%	0.050 mm
	38.4%	0.020 mm
Clays	22.9%	0.005 mm
	14.4%	0.002 mm
Colloids	8.7%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Loam

Comments:

Reviewed by: Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-19-SS
Sample#: B21-1906

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color:
brown

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

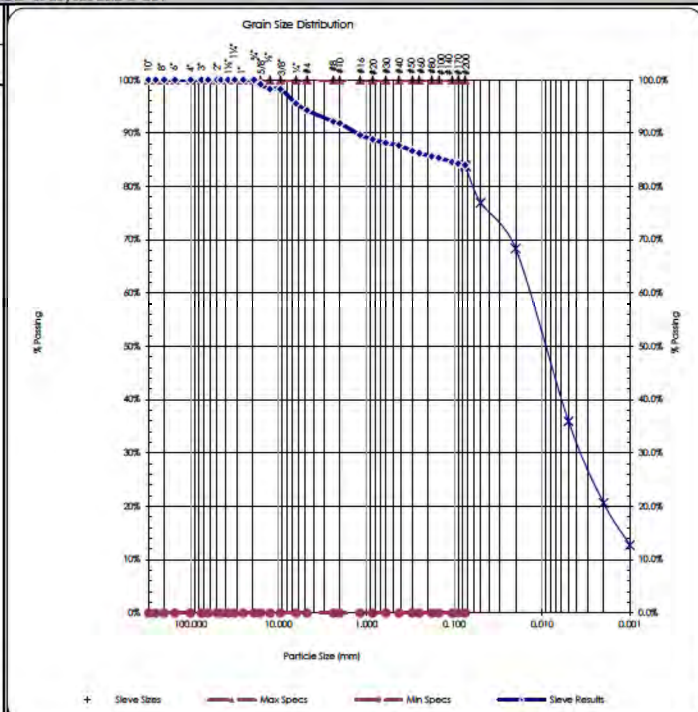
$D_{(5)}$ = 0.004 mm
$D_{(10)}$ = 0.009 mm
$D_{(15)}$ = 0.013 mm
$D_{(30)}$ = 0.027 mm
$D_{(50)}$ = 0.045 mm
$D_{(60)}$ = 0.054 mm
$D_{(90)}$ = 1.293 mm
Dust Ratio = 23/24

% Gravel = 5.7%
% Sand = 10.3%
% Silt & Clay = 84.0%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.50
Coeff. of Uniformity, C_U = 6.00
Fineness Modulus = 0.65
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		99%	100.0%	0.0%
1/2"	12.50	98%	98%	100.0%	0.0%
3/8"	9.50	98%	98%	100.0%	0.0%
1/4"	6.30		96%	100.0%	0.0%
#4	4.75	94%	94%	100.0%	0.0%
#8	2.36		92%	100.0%	0.0%
#10	2.00	92%	92%	100.0%	0.0%
#16	1.18		90%	100.0%	0.0%
#20	0.850		89%	100.0%	0.0%
#30	0.600		88%	100.0%	0.0%
#40	0.425	88%	88%	100.0%	0.0%
#50	0.300		87%	100.0%	0.0%
#60	0.250		86%	100.0%	0.0%
#80	0.180		86%	100.0%	0.0%
#100	0.150	85%	85%	100.0%	0.0%
#140	0.106		85%	100.0%	0.0%
#170	0.090		84%	100.0%	0.0%
#200	0.075	84.0%	84.0%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-19-SS
Sample#: B21-1906
Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color
brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	72.62	grams
Hydroscopic Moist.:	13.97%	
Adj. Sample Wgt :	63.72	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	49	70.7%	0.0278 mm
5	47	67.8%	0.0179 mm
15	40.5	58.4%	0.0110 mm
30	34.5	49.7%	0.0082 mm
60	28.5	41.1%	0.0060 mm
250	18.5	26.7%	0.0031 mm
1440	12	17.3%	0.0014 mm

% Gravel:	5.7%
% Sand:	10.3%
% Silt:	48.1%
% Clay:	35.9%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	99%	16.000 mm
1/2"	98%	12.500 mm
3/8"	98%	9.500 mm
1/4"	96%	6.300 mm
#4	94%	4.750 mm
#10	92%	2.000 mm
#20	89%	0.850 mm
#40	88%	0.425 mm
#100	85%	0.150 mm
#200	84.0%	0.075 mm
Silts	83.7%	0.074 mm
	76.9%	0.050 mm
	68.4%	0.020 mm
Clays	35.9%	0.005 mm
	20.7%	0.002 mm
Colloids	12.7%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-20-SS
Sample#: B21-1907

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt
Sample Color:
brown

ACCREDITED
Certificate #: 1366.01, 1366.02 & 1366.04

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

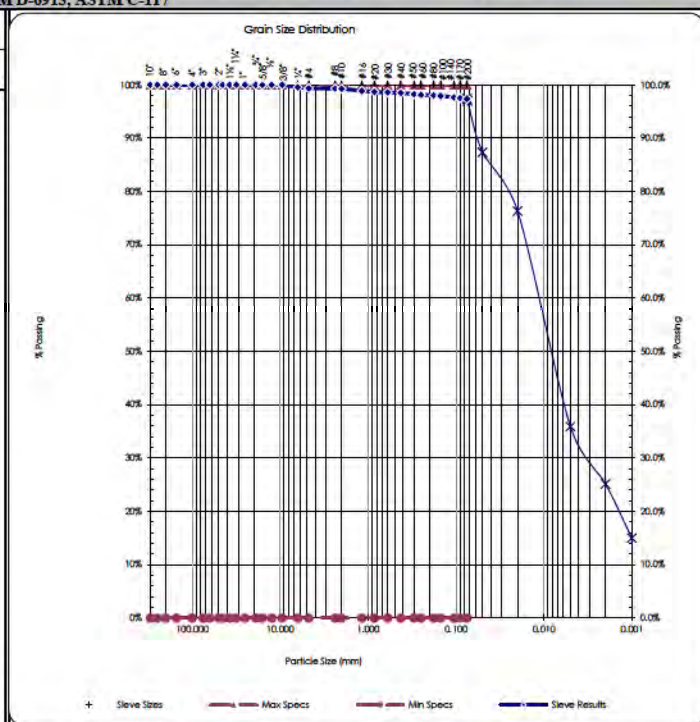
$D_{(5)}$ = 0.004 mm
$D_{(10)}$ = 0.008 mm
$D_{(15)}$ = 0.012 mm
$D_{(30)}$ = 0.023 mm
$D_{(50)}$ = 0.038 mm
$D_{(60)}$ = 0.046 mm
$D_{(90)}$ = 0.069 mm
Dust Ratio = 91/92

% Gravel = 0.6%
% Sand = 2.0%
% Silt & Clay = 97.4%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.50
Coeff. of Uniformity, C_U = 6.00
Fineness Modulus = 0.08
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		99%	100.0%	0.0%
#10	2.00	99%	99%	100.0%	0.0%
#16	1.18		99%	100.0%	0.0%
#20	0.850		99%	100.0%	0.0%
#30	0.600		99%	100.0%	0.0%
#40	0.425	98%	98%	100.0%	0.0%
#50	0.300		98%	100.0%	0.0%
#60	0.250		98%	100.0%	0.0%
#80	0.180		98%	100.0%	0.0%
#100	0.150	98%	98%	100.0%	0.0%
#140	0.106		98%	100.0%	0.0%
#170	0.090		98%	100.0%	0.0%
#200	0.075	97.4%	97.4%	100.0%	0.0%



Comments:

Reviewed by: (signature)
Meghan Blodgett-Carrillo

Hydrometer Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client :	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-20-SS	**Tested By:**	C. Kriss
Sample#:	B21-1907		

Visual Identification
Clayey Silt
Sample Color
brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	73.83	grams
Hydroscopic Moist.:	7.15%	
Adj. Sample Wgt :	68.90	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	54	77.8%	0.0263 mm
5	52.5	75.7%	0.0170 mm
15	44.5	64.1%	0.0106 mm
30	38	54.8%	0.0079 mm
60	26	37.5%	0.0061 mm
250	23	33.1%	0.0031 mm
1440	14	20.2%	0.0013 mm

% Gravel:	0.6%	**Liquid Limit:**	n/a
% Sand:	2.0%	**Plastic Limit:**	n/a
% Silt:	61.5%	**Plasticity Index:**	n/a
% Clay:	35.9%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	99%	4.750 mm
#10	99%	2.000 mm
#20	99%	0.850 mm
#40	98%	0.425 mm
#100	98%	0.150 mm
#200	97.4%	0.075 mm
Silts	97.0%	0.074 mm
	87.4%	0.050 mm
	76.4%	0.020 mm
Clays	35.9%	0.005 mm
	25.1%	0.002 mm
Colloids	15.0%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by: Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-22-SS
Sample#: B21-1908

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Sandy Silt with Clay
Sample Color:
brown

ACCREDITED

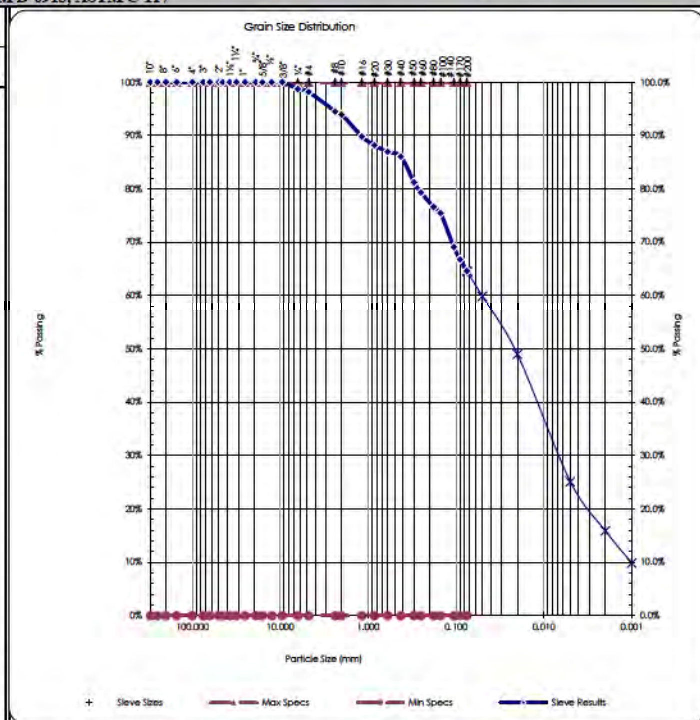
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.006 mm	% Gravel = 1.8%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.012 mm	% Sand = 33.5%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.017 mm	% Silt & Clay = 64.6%	Fineness Modulus = 0.74
$D_{(30)}$ = 0.035 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.058 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.070 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 1.210 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 3/4	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	98%	98%	100.0%	0.0%
#8	2.36		95%	100.0%	0.0%
#10	2.00	94%	94%	100.0%	0.0%
#16	1.18		90%	100.0%	0.0%
#20	0.850		88%	100.0%	0.0%
#30	0.600		87%	100.0%	0.0%
#40	0.425	86%	86%	100.0%	0.0%
#50	0.300		81%	100.0%	0.0%
#60	0.250		79%	100.0%	0.0%
#80	0.180		77%	100.0%	0.0%
#100	0.150	75%	75%	100.0%	0.0%
#140	0.106		69%	100.0%	0.0%
#170	0.090		67%	100.0%	0.0%
#200	0.075	64.6%	64.6%	100.0%	0.0%



Comments:

Reviewed by:

Meghan Blodgett-Carrillo

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Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-22-SS
Sample#: B21-1908

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Sandy Silt with Clay
Sample Color
brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 70.31 grams
Hydroscopic Moist.: 13.61%
Adj. Sample Wgt : 61.89 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	37	56.2%	0.0308 mm
5	32.5	49.3%	0.0203 mm
15	27	41.0%	0.0122 mm
30	23	34.9%	0.0088 mm
60	19	28.8%	0.0064 mm
250	13.5	20.5%	0.0033 mm
1440	9	13.7%	0.0014 mm

% Gravel: 1.8%
% Sand: 33.5%
% Silt: 39.5%
% Clay: 25.1%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

	Sieve Size	Percent Passing	Soils Particle Diameter
	3.0"	100%	75.000 mm
	2.0"	100%	50.000 mm
	1.5"	100%	37.500 mm
	1.25"	100%	31.500 mm
	1.0"	100%	25.000 mm
	3/4"	100%	19.000 mm
	5/8"	100%	16.000 mm
	1/2"	100%	12.500 mm
	3/8"	100%	9.500 mm
	1/4"	99%	6.300 mm
	#4	98%	4.750 mm
	#10	94%	2.000 mm
	#20	88%	0.850 mm
	#40	86%	0.425 mm
	#100	75%	0.150 mm
	#200	64.6%	0.075 mm
Silts		64.5%	0.074 mm
		59.9%	0.050 mm
		49.0%	0.020 mm
Clays		25.1%	0.005 mm
		15.9%	0.002 mm
Colloids		9.9%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-24-SS
Sample#: B21-1909

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color:
dark brown

ACCREDITED

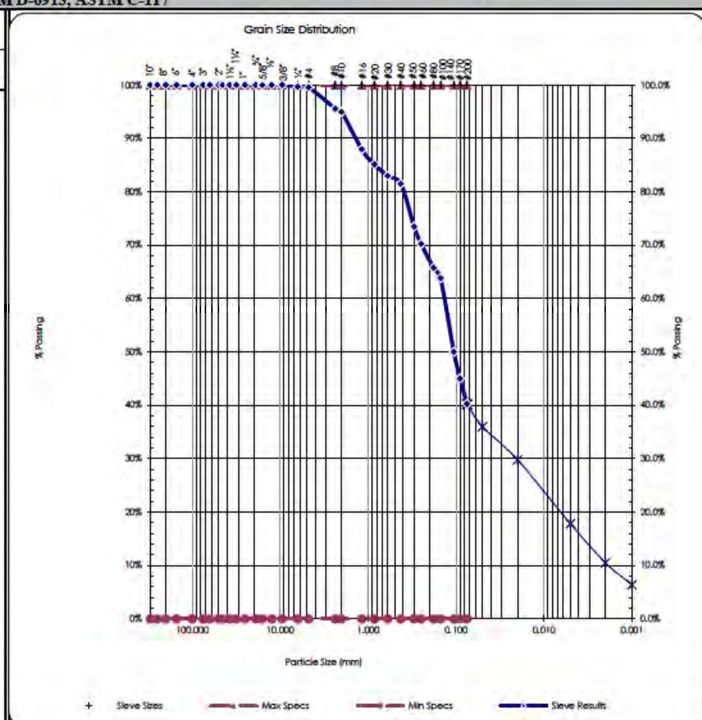
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.009 mm	% Gravel = 0.4%	Coeff. of Curvature, C_C = 1.22
$D_{(10)}$ = 0.019 mm	% Sand = 59.3%	Coeff. of Uniformity, C_U = 7.40
$D_{(15)}$ = 0.028 mm	% Silt & Clay = 40.3%	Fineness Modulus = 0.97
$D_{(30)}$ = 0.056 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.106 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.138 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 1.418 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 43/87	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		96%	100.0%	0.0%
#10	2.00	95%	95%	100.0%	0.0%
#16	1.18		88%	100.0%	0.0%
#20	0.850		85%	100.0%	0.0%
#30	0.600		83%	100.0%	0.0%
#40	0.425	82%	82%	100.0%	0.0%
#50	0.300		73%	100.0%	0.0%
#60	0.250		70%	100.0%	0.0%
#80	0.180		66%	100.0%	0.0%
#100	0.150	64%	64%	100.0%	0.0%
#140	0.106		50%	100.0%	0.0%
#170	0.090		45%	100.0%	0.0%
#200	0.075	40.3%	40.3%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-24-SS
Sample#: B21-1909

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color
dark brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 74.15 grams
Hydroscopic Moist.: 8.10%
Adj. Sample Wgt : 68.59 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	24	33.2%	0.0340 mm
5	22	30.5%	0.0218 mm
15	19.5	27.0%	0.0128 mm
30	17	23.5%	0.0092 mm
60	15.5	21.5%	0.0065 mm
250	10	13.8%	0.0033 mm
1440	6.5	9.0%	0.0014 mm

% Gravel: 0.4%
% Sand: 59.3%
% Silt: 22.5%
% Clay: 17.8%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	95%	2.000 mm
#20	85%	0.850 mm
#40	82%	0.425 mm
#100	64%	0.150 mm
#200	40.3%	0.075 mm
Silts	40.1%	0.074 mm
	36.0%	0.050 mm
	29.8%	0.020 mm
Clays	17.8%	0.005 mm
	10.5%	0.002 mm
Colloids	6.4%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sandy Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-25-SS
Sample#: B21-1910

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Sandy Silt with Clay
Sample Color:
dark brown

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

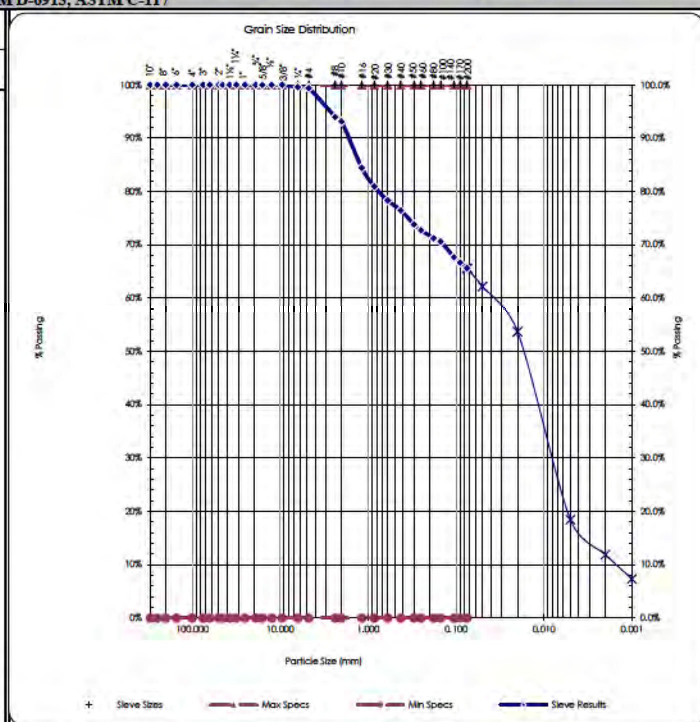
$D_{(5)}$ = 0.006 mm
$D_{(10)}$ = 0.011 mm
$D_{(15)}$ = 0.017 mm
$D_{(30)}$ = 0.034 mm
$D_{(50)}$ = 0.057 mm
$D_{(60)}$ = 0.069 mm
$D_{(90)}$ = 1.702 mm
Dust Ratio = 85/99

% Gravel = 0.6%
% Sand = 33.8%
% Silt & Clay = 65.7%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.50
Coeff. of Uniformity, C_U = 6.00
Fineness Modulus = 0.99
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		94%	100.0%	0.0%
#10	2.00	93%	93%	100.0%	0.0%
#16	1.18		84%	100.0%	0.0%
#20	0.850		81%	100.0%	0.0%
#30	0.600		78%	100.0%	0.0%
#40	0.425	76%	76%	100.0%	0.0%
#50	0.300		74%	100.0%	0.0%
#60	0.250		73%	100.0%	0.0%
#80	0.180		71%	100.0%	0.0%
#100	0.150	71%	71%	100.0%	0.0%
#140	0.106		68%	100.0%	0.0%
#170	0.090		67%	100.0%	0.0%
#200	0.075	65.7%	65.7%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-25-SS
Sample#: B21-1910

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Sandy Silt with Clay
Sample Color
dark brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr: 2.65
Sample Weight: 73.07 grams
Hydroscopic Moist.: 15.05%
Adj. Sample Wgt: 63.51 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	40.5	59.4%	0.0301 mm
5	36.5	53.5%	0.0197 mm
15	23.5	34.5%	0.0125 mm
30	17	24.9%	0.0092 mm
60	14.5	21.3%	0.0066 mm
250	10.5	15.4%	0.0033 mm
1440	7	10.3%	0.0014 mm

% Gravel: 0.6%
% Sand: 33.8%
% Silt: 47.2%
% Clay: 18.4%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	99%	4.750 mm
#10	93%	2.000 mm
#20	81%	0.850 mm
#40	76%	0.425 mm
#100	71%	0.150 mm
#200	65.7%	0.075 mm
Silts	65.5%	0.074 mm
	62.2%	0.050 mm
	53.7%	0.020 mm
Clays	18.4%	0.005 mm
	11.9%	0.002 mm
Colloids	7.3%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by: Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
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Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-26-SS
Sample#: B21-1911

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color:
dark brown

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

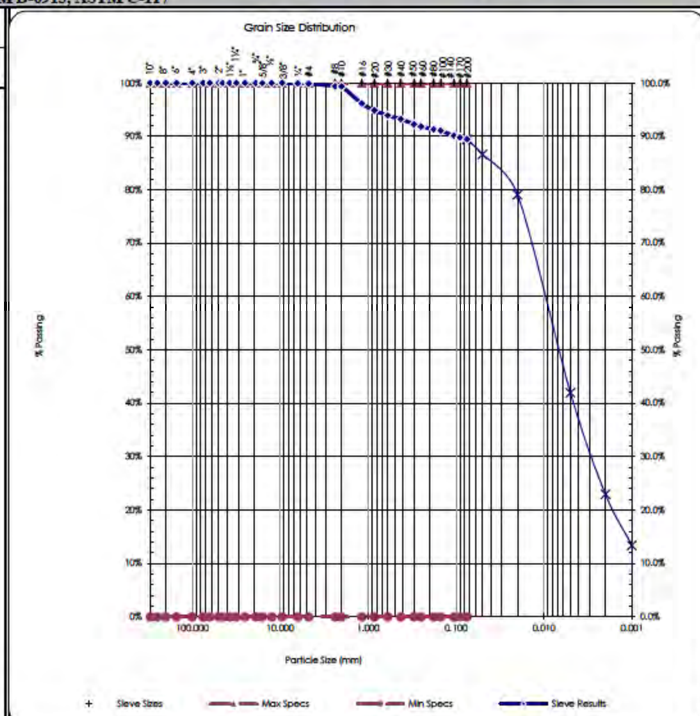
$D_{(5)}$ = 0.004 mm
$D_{(10)}$ = 0.008 mm
$D_{(15)}$ = 0.013 mm
$D_{(30)}$ = 0.025 mm
$D_{(50)}$ = 0.042 mm
$D_{(60)}$ = 0.050 mm
$D_{(90)}$ = mm
Dust Ratio = 24/25

% Gravel = 0.1%
% Sand = 10.4%
% Silt & Clay = 89.5%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 1.50
Coeff. of Uniformity, C_U = 6.00
Fineness Modulus = 0.27
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		99%	100.0%	0.0%
#10	2.00	99%	99%	100.0%	0.0%
#16	1.18		96%	100.0%	0.0%
#20	0.850		95%	100.0%	0.0%
#30	0.600		94%	100.0%	0.0%
#40	0.425	93%	93%	100.0%	0.0%
#50	0.300		92%	100.0%	0.0%
#60	0.250		92%	100.0%	0.0%
#80	0.180		91%	100.0%	0.0%
#100	0.150	91%	91%	100.0%	0.0%
#140	0.106		90%	100.0%	0.0%
#170	0.090		90%	100.0%	0.0%
#200	0.075	89.5%	89.5%	100.0%	0.0%



Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
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Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-26-SS
Sample#: B21-1911

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color
dark brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 50.39 grams
Hydroscopic Moist.: 11.21%
Adj. Sample Wgt : 45.31 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	38.5	84.4%	0.0307 mm
5	36	78.9%	0.0197 mm
15	30	65.8%	0.0119 mm
30	26.5	58.1%	0.0086 mm
60	22.5	49.3%	0.0063 mm
250	14.5	31.8%	0.0032 mm
1440	8.5	18.6%	0.0014 mm

% Gravel: 0.1%
% Sand: 10.4%
% Silt: 47.5%
% Clay: 42.0%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	99%	2.000 mm
#20	95%	0.850 mm
#40	93%	0.425 mm
#100	91%	0.150 mm
#200	89.5%	0.075 mm
Silts	89.4%	0.074 mm
	86.6%	0.050 mm
	79.1%	0.020 mm
Clays	42.0%	0.005 mm
	23.0%	0.002 mm
Colloids	13.4%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-27-SS	**Tested By:**	C. Kriss
Sample#:	B21-1912		

Visual Identification
Clayey Silt with Sand
Sample Color:
brown

ACCREDITED

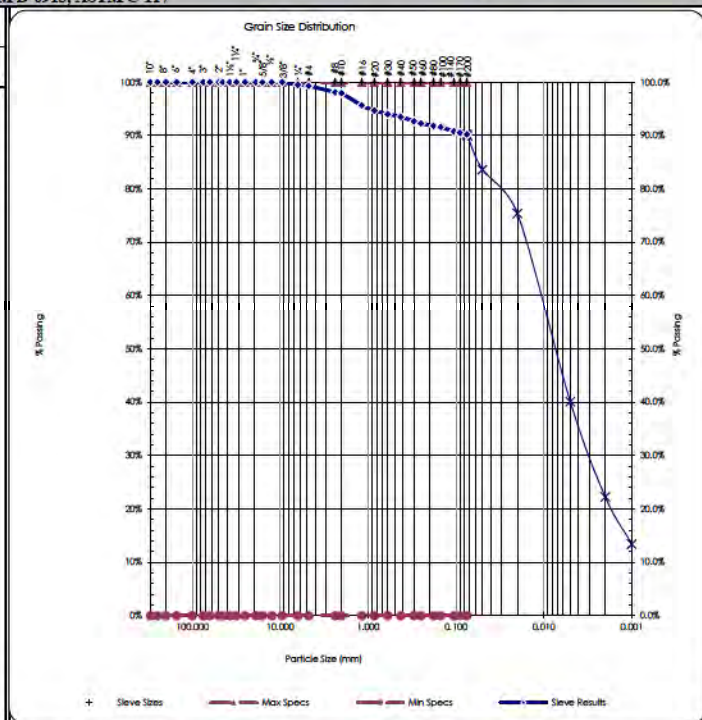
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.004 mm	% Gravel = 0.7%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.008 mm	% Sand = 9.1%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.012 mm	% Silt & Clay = 90.2%	Fineness Modulus = 0.29
$D_{(30)}$ = 0.025 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.042 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.050 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.075 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 27/28	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		98%	100.0%	0.0%
#10	2.00	98%	98%	100.0%	0.0%
#16	1.18		96%	100.0%	0.0%
#20	0.850		95%	100.0%	0.0%
#30	0.600		94%	100.0%	0.0%
#40	0.425	94%	94%	100.0%	0.0%
#50	0.300		93%	100.0%	0.0%
#60	0.250		92%	100.0%	0.0%
#80	0.180		92%	100.0%	0.0%
#100	0.150	92%	92%	100.0%	0.0%
#140	0.106		91%	100.0%	0.0%
#170	0.090		90%	100.0%	0.0%
#200	0.075	90.2%	90.2%	100.0%	0.0%



All results apply only to actual locations and materials tested. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval.

Comments:

Reviewed by:

Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.
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Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-27-SS
Sample#: B21-1912

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Clayey Silt with Sand
Sample Color
brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 75.59 grams
Hydroscopic Moist.: 12.77%
Adj. Sample Wgt : 67.03 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	53	77.4%	0.0266 mm
5	51	74.5%	0.0172 mm
15	43	62.8%	0.0107 mm
30	37	54.1%	0.0080 mm
60	31	45.3%	0.0059 mm
250	20	29.2%	0.0031 mm
1440	12.5	18.3%	0.0014 mm

% Gravel: 0.7%
% Sand: 9.1%
% Silt: 50.1%
% Clay: 40.1%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	99%	4.750 mm
#10	98%	2.000 mm
#20	95%	0.850 mm
#40	94%	0.425 mm
#100	92%	0.150 mm
#200	90.2%	0.075 mm
Silts	90.0%	0.074 mm
	83.6%	0.050 mm
	75.4%	0.020 mm
Clays	40.1%	0.005 mm
	22.3%	0.002 mm
Colloids	13.4%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-29-SS
Sample#: B21-1913

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand with Gravel
Sample Color:
dark brown

ACCREDITED

ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

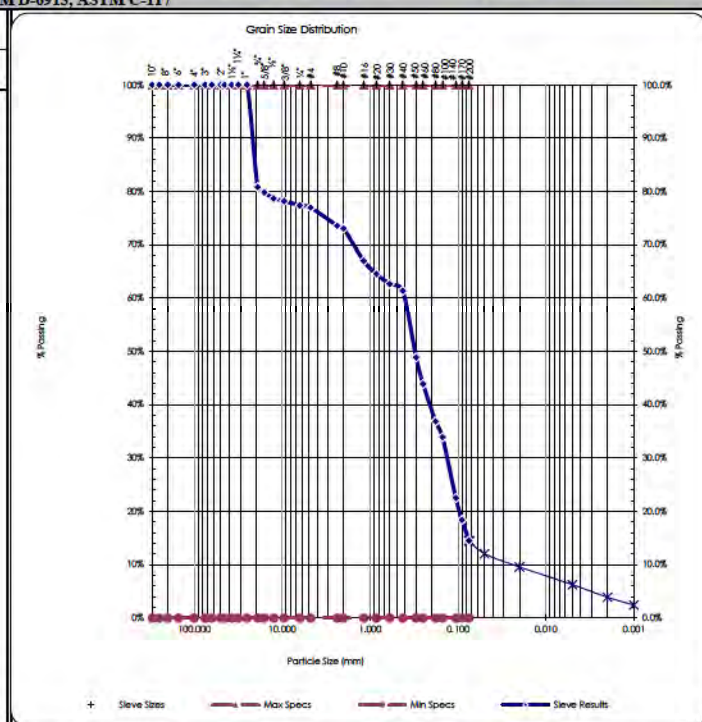
$D_{(5)}$ = 0.026 mm
$D_{(10)}$ = 0.052 mm
$D_{(15)}$ = 0.077 mm
$D_{(30)}$ = 0.135 mm
$D_{(50)}$ = 0.311 mm
$D_{(60)}$ = 0.411 mm
$D_{(90)}$ = 21.871 mm
Dust Ratio = 13/55

% Gravel = 23.0%
% Sand = 62.5%
% Silt & Clay = 14.5%
Liquid Limit = n/a
Plasticity Index = n/a
Sand Equivalent = n/a
Fracture %, 1 Face = n/a
Fracture %, 2+ Faces = n/a

Coeff. of Curvature, C_C = 0.86
Coeff. of Uniformity, C_U = 7.95
Fineness Modulus = 2.78
Plastic Limit = n/a
Moisture %, as sampled = n/a
Req'd Sand Equivalent =
Req'd Fracture %, 1 Face =
Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	81%	81%	100.0%	0.0%
5/8"	16.00		80%	100.0%	0.0%
1/2"	12.50	79%	79%	100.0%	0.0%
3/8"	9.50	78%	78%	100.0%	0.0%
1/4"	6.30		77%	100.0%	0.0%
#4	4.75	77%	77%	100.0%	0.0%
#8	2.36		74%	100.0%	0.0%
#10	2.00	73%	73%	100.0%	0.0%
#16	1.18		67%	100.0%	0.0%
#20	0.850		65%	100.0%	0.0%
#30	0.600		63%	100.0%	0.0%
#40	0.425	61%	61%	100.0%	0.0%
#50	0.300		49%	100.0%	0.0%
#60	0.250		44%	100.0%	0.0%
#80	0.180		37%	100.0%	0.0%
#100	0.150	34%	34%	100.0%	0.0%
#140	0.106		23%	100.0%	0.0%
#170	0.090		18%	100.0%	0.0%
#200	0.075	14.5%	14.5%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation **Date Received:** 27-Sep-21
Project #: 21B288 **Sampled By:** Client
Client : GeoEngineers **Date Tested:** 30-Sep-21
Source: PRDI-29-SS **Tested By:** C. Kriss
Sample#: B21-1913

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand with Gravel
Sample Color
dark brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	100.09	grams
Hydroscopic Moist.:	4.67%	
Adj. Sample Wgt :	95.62	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	14	10.7%	0.0361 mm
5	13	9.9%	0.0230 mm
15	11.5	8.8%	0.0134 mm
30	11	8.4%	0.0095 mm
60	10	7.6%	0.0068 mm
250	6.5	5.0%	0.0034 mm
1440	4.5	3.4%	0.0014 mm

% Gravel:	23.0%	**Liquid Limit:**	n/a
% Sand:	62.5%	**Plastic Limit:**	n/a
% Silt:	8.3%	**Plasticity Index:**	n/a
% Clay:	6.3%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	81%	19.000 mm
5/8"	80%	16.000 mm
1/2"	79%	12.500 mm
3/8"	78%	9.500 mm
1/4"	77%	6.300 mm
#4	77%	4.750 mm
#10	73%	2.000 mm
#20	65%	0.850 mm
#40	61%	0.425 mm
#100	34%	0.150 mm
#200	14.5%	0.075 mm
Silts	14.4%	0.074 mm
	12.1%	0.050 mm
	9.6%	0.020 mm
Clays	6.3%	0.005 mm
	3.9%	0.002 mm
Colloids	2.4%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Loamy Sand

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

Materials Testing & Consulting, Inc.

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Sieve Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-30-SS	**Tested By:**	C. Kriss
Sample#:	B21-1914		

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color:
light brown

ACCREDITED

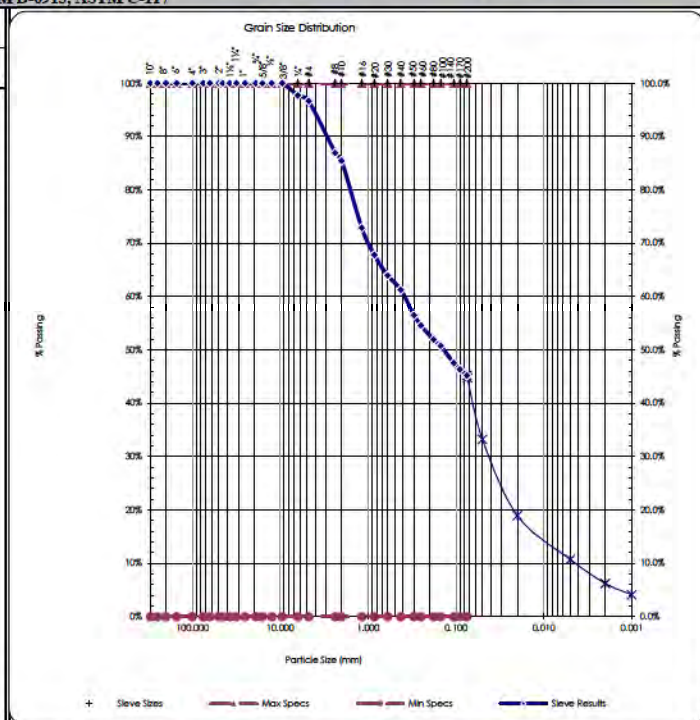
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.008 mm	% Gravel = 3.3%	Coeff. of Curvature, C_C = 0.38
$D_{(10)}$ = 0.017 mm	% Sand = 51.4%	Coeff. of Uniformity, C_U = 23.58
$D_{(15)}$ = 0.025 mm	% Silt & Clay = 45.2%	Fineness Modulus = 1.72
$D_{(30)}$ = 0.050 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.139 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.391 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 3.109 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 45/61	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		98%	100.0%	0.0%
#4	4.75	97%	97%	100.0%	0.0%
#8	2.36		87%	100.0%	0.0%
#10	2.00	86%	86%	100.0%	0.0%
#16	1.18		73%	100.0%	0.0%
#20	0.850		68%	100.0%	0.0%
#30	0.600		64%	100.0%	0.0%
#40	0.425	61%	61%	100.0%	0.0%
#50	0.300		57%	100.0%	0.0%
#60	0.250		55%	100.0%	0.0%
#80	0.180		52%	100.0%	0.0%
#100	0.150	51%	51%	100.0%	0.0%
#140	0.106		48%	100.0%	0.0%
#170	0.090		46%	100.0%	0.0%
#200	0.075	45.2%	45.2%	100.0%	0.0%



Comments:

Reviewed by: *(signature)*

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-30-SS
Sample#: B21-1914

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Unified Soils Classification System, ASTM D-2487
SM, Silty Sand
Sample Color
light brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr: 2.65
Sample Weight: 100.06 grams
Hydroscopic Moist.: 70.12%
Adj. Sample Wgt: 58.82 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	18	26.2%	0.0352 mm
5	13.5	19.6%	0.0230 mm
15	12	17.4%	0.0133 mm
30	11	16.0%	0.0095 mm
60	10	14.5%	0.0068 mm
250	5	7.3%	0.0034 mm
1440	4	5.8%	0.0014 mm

% Gravel: 3.3%
% Sand: 51.4%
% Silt: 34.5%
% Clay: 10.7%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	98%	6.300 mm
#4	97%	4.750 mm
#10	86%	2.000 mm
#20	68%	0.850 mm
#40	61%	0.425 mm
#100	51%	0.150 mm
#200	45.2%	0.075 mm
Silts	44.7%	0.074 mm
	33.3%	0.050 mm
	18.9%	0.020 mm
Clays	10.7%	0.005 mm
	6.2%	0.002 mm
Colloids	4.1%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Sandy Loam

Comments:

Reviewed by: Meghan Blodgett-Carrillo

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Sieve Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client: GeoEngineers
Source: PRDI-31-SS
Sample#: B21-1915

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Sandy Silt with Clay
Sample Color:
dark brown

ACCREDITED

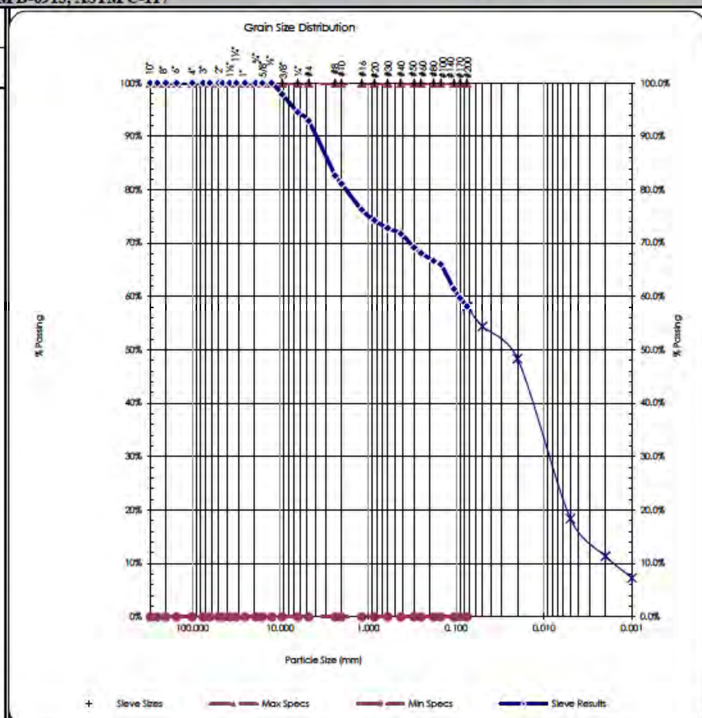
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.006 mm	% Gravel = 7.1%	Coeff. of Curvature, C_C = 1.26
$D_{(10)}$ = 0.013 mm	% Sand = 34.7%	Coeff. of Uniformity, C_U = 7.17
$D_{(15)}$ = 0.019 mm	% Silt & Clay = 58.2%	Fineness Modulus = 1.42
$D_{(30)}$ = 0.039 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.064 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.092 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 4.072 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 47/58	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	98%	98%	100.0%	0.0%
1/4"	6.30		95%	100.0%	0.0%
#4	4.75	93%	93%	100.0%	0.0%
#8	2.36		83%	100.0%	0.0%
#10	2.00	81%	81%	100.0%	0.0%
#16	1.18		76%	100.0%	0.0%
#20	0.850		74%	100.0%	0.0%
#30	0.600		73%	100.0%	0.0%
#40	0.425	72%	72%	100.0%	0.0%
#50	0.300		69%	100.0%	0.0%
#60	0.250		68%	100.0%	0.0%
#80	0.180		67%	100.0%	0.0%
#100	0.150	66%	66%	100.0%	0.0%
#140	0.106		61%	100.0%	0.0%
#170	0.090		60%	100.0%	0.0%
#200	0.075	58.2%	58.2%	100.0%	0.0%



Comments: ______

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project: Q.C. - South State St. Preliminary Remedial Design Investigation
Project #: 21B288
Client : GeoEngineers
Source: PRDI-31-SS
Sample#: B21-1915

Date Received: 27-Sep-21
Sampled By: Client
Date Tested: 30-Sep-21
Tested By: C. Kriss

Visual Identification
Sandy Silt with Clay
Sample Color
dark brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr : 2.65
Sample Weight: 73.74 grams
Hydroscopic Moist.: 15.27%
Adj. Sample Wgt : 63.97 grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	40.5	51.4%	0.0301 mm
5	38	48.2%	0.0194 mm
15	29	36.8%	0.0120 mm
30	22	27.9%	0.0089 mm
60	17.5	22.2%	0.0065 mm
250	11	13.9%	0.0033 mm
1440	8	10.1%	0.0014 mm

% Gravel: 7.1%
% Sand: 34.7%
% Silt: 39.8%
% Clay: 18.4%

Liquid Limit: n/a
Plastic Limit: n/a
Plasticity Index: n/a

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	98%	9.500 mm
1/4"	95%	6.300 mm
#4	93%	4.750 mm
#10	81%	2.000 mm
#20	74%	0.850 mm
#40	72%	0.425 mm
#100	66%	0.150 mm
#200	58.2%	0.075 mm
Silts	58.0%	0.074 mm
	54.4%	0.050 mm
	48.4%	0.020 mm
Clays	18.4%	0.005 mm
	11.4%	0.002 mm
Colloids	7.3%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by:
Meghan Blodgett-Carrillo

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Sieve Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-32-SS	**Tested By:**	C. Kriss
Sample#:	B21-1916		

Visual Identification
Silt and Clay
Sample Color:
dark brown

ACCREDITED

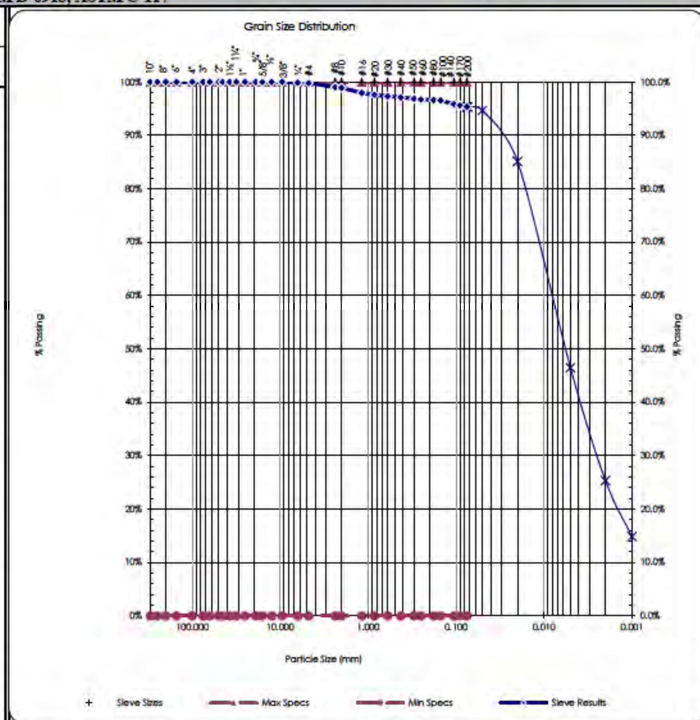
ASTM D-2216, ASTM D-2419, ASTM D-4318, ASTM D-5821

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.004 mm	% Gravel = 0.2%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.008 mm	% Sand = 4.4%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.012 mm	% Silt & Clay = 95.4%	Fineness Modulus = 0.12
$D_{(30)}$ = 0.024 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.039 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.047 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.071 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 54/55	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C-136, ASTM D-6913, ASTM C-117

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00	100%	100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00	100%	100%	100.0%	0.0%
3/4"	19.00	100%	100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		99%	100.0%	0.0%
#10	2.00	99%	99%	100.0%	0.0%
#16	1.18		98%	100.0%	0.0%
#20	0.850		98%	100.0%	0.0%
#30	0.600		97%	100.0%	0.0%
#40	0.425	97%	97%	100.0%	0.0%
#50	0.300		97%	100.0%	0.0%
#60	0.250		97%	100.0%	0.0%
#80	0.180		97%	100.0%	0.0%
#100	0.150	97%	97%	100.0%	0.0%
#140	0.106		96%	100.0%	0.0%
#170	0.090		96%	100.0%	0.0%
#200	0.075	95.4%	95.4%	100.0%	0.0%



Comments:

Reviewed by: [signature]

Meghan Blodgett-Carrillo

Hydrometer Report

Project:	Q.C. - South State St. Preliminary Remedial Design Investigation	**Date Received:**	27-Sep-21
Project #:	21B288	**Sampled By:**	Client
Client :	GeoEngineers	**Date Tested:**	30-Sep-21
Source:	PRDI-32-SS	**Tested By:**	C. Kriss
Sample#:	B21-1916		

Visual Identification
Silt and Clay
Sample Color
dark brown

ASTM D-422, HYDROMETER ANALYSIS

Assumed Sp Gr :	2.65	
Sample Weight:	50.41	grams
Hydroscopic Moist.:	10.23%	
Adj. Sample Wgt :	45.73	grams

ACCREDITED

Hydrometer Reading Minutes	Corrected Reading	Percent Passing	Soils Particle Diameter
2	43.5	94.1%	0.0293 mm
5	39	84.3%	0.0192 mm
15	34	73.5%	0.0115 mm
30	30	64.9%	0.0084 mm
60	25	54.1%	0.0062 mm
250	16	34.6%	0.0032 mm
1440	9.5	20.5%	0.0014 mm

% Gravel:	0.2%	**Liquid Limit:**	n/a
% Sand:	4.4%	**Plastic Limit:**	n/a
% Silt:	48.9%	**Plasticity Index:**	n/a
% Clay:	46.5%		

ASTM C-136

Sieve Analysis
Grain Size Distribution

Sieve Size	Percent Passing	Soils Particle Diameter
3.0"	100%	75.000 mm
2.0"	100%	50.000 mm
1.5"	100%	37.500 mm
1.25"	100%	31.500 mm
1.0"	100%	25.000 mm
3/4"	100%	19.000 mm
5/8"	100%	16.000 mm
1/2"	100%	12.500 mm
3/8"	100%	9.500 mm
1/4"	100%	6.300 mm
#4	100%	4.750 mm
#10	99%	2.000 mm
#20	98%	0.850 mm
#40	97%	0.425 mm
#100	97%	0.150 mm
#200	95.4%	0.075 mm
Silts	95.3%	0.074 mm
	94.7%	0.050 mm
	85.1%	0.020 mm
Clays	46.5%	0.005 mm
	25.3%	0.002 mm
Colloids	14.8%	0.001 mm

USDA Soil Textural Classification

	Particle Size
% Sand:	2.0 - 0.05 mm
% Silt:	0.05 - 0.002 mm
% Clay:	< 0.002 mm

USDA Soil Textural Classification
Silt Loam

Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

MATERIALS TESTING & CONSULTING, INC.

Client:	GeoEngineers	**Date:**	December 15, 2021
Address:	17425 NE Union Hill Road, Suite 250	**Project:**	Q.C. - South State Street Preliminary Remedial Design Investigation
	Redmond, WA 98052	**Project #:**	21B288
Attn:	Neil Morton	**Sample #:**	B21-2438-2444
Revised on:		**Date sampled:**	September 16, 2021

As requested MTC, Inc. has performed the following test(s) on the sample referenced above. The testing was performed in accordance with current applicable AASHTO or ASTM standards as indicated below. The results obtained in our laboratory were as follows below or on the attached pages:

	Test(s) Performed:	Test Results		Test(s) Performed:	Test Results
X	Sieve Analysis	Please See Attached Reports		Sulfate Soundness	
	Proctor			Bulk Density & Voids	
	Sand Equivalent			WSDOT Degradation	
	Fracture Count			LA Abrasion	
	Moisture Content				
	Specific Gravity, Coarse				
	Specific Gravity, Fine				
	Hydrometer Analysis				
	Atterberg Limits				

If you have any questions concerning the test results, the procedures used, or if we can be of any further assistance please call on us at the number below.

Respectfully Submitted,
Meghan Blodgett-Carrillo
WABO Supervising Laboratory Technician

Sieve Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:**	1-Dec-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	13-Dec-21
Source:	PRDI-35-SC-06	**Tested By:**	K. Mendez
Sample#:	B21-2438		

Unified Soil Classification System, ASTM-2487
SM, Silty Sand
Sample Color:
grayish-brown

ACCREDITED Certificate #: 1366.01

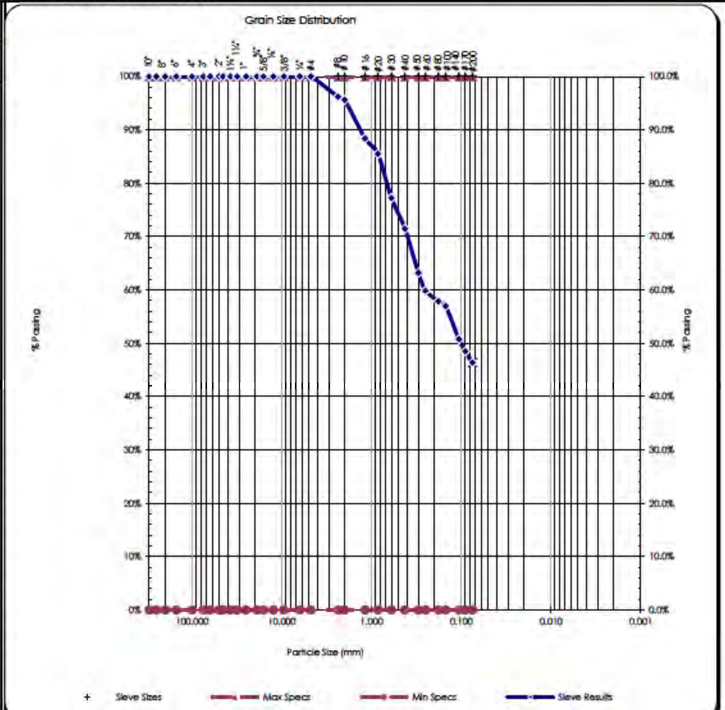
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.008 mm	% Gravel = 0.0%	Coeff. of Curvature, C_C = 0.58
$D_{(10)}$ = 0.016 mm	% Sand = 53.6%	Coeff. of Uniformity, C_U = 15.55
$D_{(15)}$ = 0.024 mm	% Silt & Clay = 46.4%	Fineness Modulus = 1.18
$D_{(30)}$ = 0.049 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.101 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.251 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 1.359 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 24/37	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50		100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		96%	100.0%	0.0%
#10	2.00	96%	96%	100.0%	0.0%
#16	1.18		88%	100.0%	0.0%
#20	0.850	86%	86%	100.0%	0.0%
#30	0.600		77%	100.0%	0.0%
#40	0.425	71%	71%	100.0%	0.0%
#50	0.300		63%	100.0%	0.0%
#60	0.250	60%	60%	100.0%	0.0%
#80	0.180		58%	100.0%	0.0%
#100	0.150	57%	57%	100.0%	0.0%
#140	0.106		51%	100.0%	0.0%
#170	0.090		49%	100.0%	0.0%
#200	0.075	46.4%	46.4%	100.0%	0.0%



Comments:

Reviewed by: Meghan Blodgett-Carrillo

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

	Q.C. - South State Street Preliminary Remedial		
Project:	Design Investigation	**Date Received:**	1-Dec-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	13-Dec-21
Source:	PRDI-35-SC-28	**Tested By:**	K. Mendez
Sample#:	B21-2439		

Unified Soil Classification System, ASTM-2487
SM, Silty Sand
Sample Color:
grayish-brown

ACCREDITED
Certificate #: 1366.01

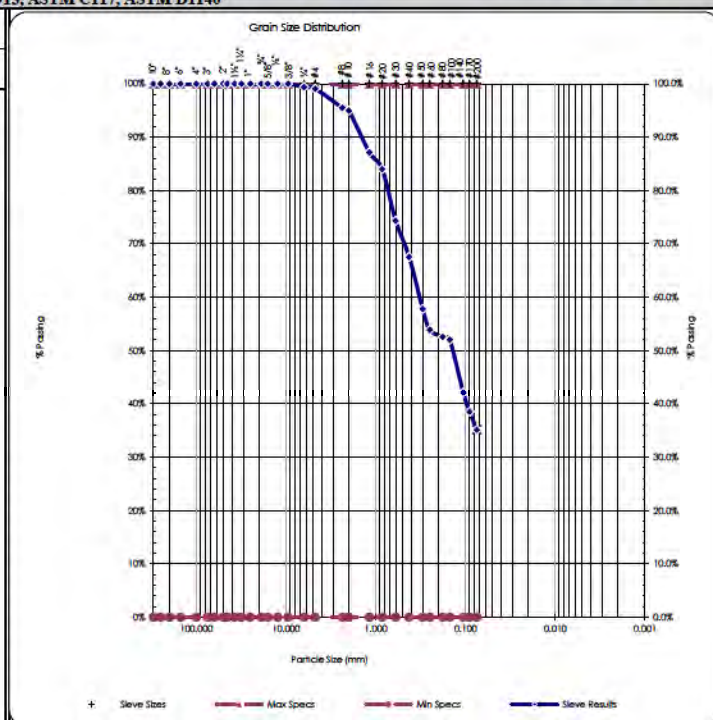
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.011 mm	% Gravel = 0.9%	Coeff. of Curvature, C_C = 0.59
$D_{(10)}$ = 0.021 mm	% Sand = 63.9%	Coeff. of Uniformity, C_U = 15.38
$D_{(15)}$ = 0.032 mm	% Silt & Clay = 35.2%	Fineness Modulus = 1.34
$D_{(30)}$ = 0.064 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.141 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.328 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 1.478 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 13/25	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		96%	100.0%	0.0%
#10	2.00	95%	95%	100.0%	0.0%
#16	1.18		87%	100.0%	0.0%
#20	0.850	84%	84%	100.0%	0.0%
#30	0.600		74%	100.0%	0.0%
#40	0.425	68%	68%	100.0%	0.0%
#50	0.300		58%	100.0%	0.0%
#60	0.250	54%	54%	100.0%	0.0%
#80	0.180		53%	100.0%	0.0%
#100	0.150	52%	52%	100.0%	0.0%
#140	0.106		42%	100.0%	0.0%
#170	0.090		39%	100.0%	0.0%
#200	0.075	35.2%	35.2%	100.0%	0.0%



Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	Date Received:	1-Dec-21
Project #:	21B288	Sampled By:	Client
Client:	GeoEngineers	Date Tested:	13-Dec-21
Source:	PRDI-37-SC-208	Tested By:	K. Mendez
Sample#:	B21-2440		

Visual-Manual Procedures, ASTM-2488
ML, Sandy Silt with Clay
Sample Color:
grayish-brown

ACCREDITED
Certificate #: 1366.01

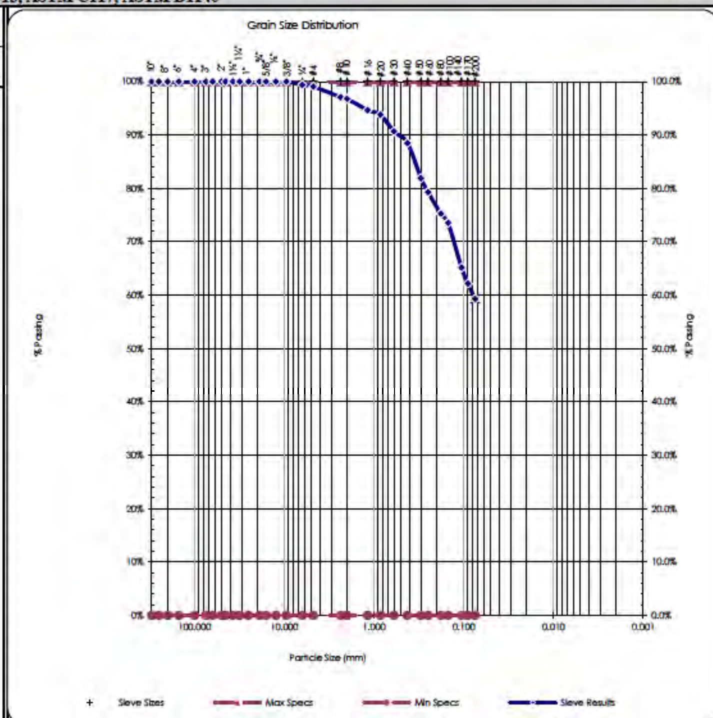
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.006 mm	% Gravel = 0.9%	Coeff. of Curvature, C_C = 1.45
$D_{(10)}$ = 0.013 mm	% Sand = 39.8%	Coeff. of Uniformity, C_U = 6.22
$D_{(15)}$ = 0.019 mm	% Silt & Clay = 59.3%	Fineness Modulus = 0.63
$D_{(30)}$ = 0.038 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.063 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.079 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.545 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 65/97	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		97%	100.0%	0.0%
#10	2.00	97%	97%	100.0%	0.0%
#16	1.18		95%	100.0%	0.0%
#20	0.850	94%	94%	100.0%	0.0%
#30	0.600		91%	100.0%	0.0%
#40	0.425	89%	89%	100.0%	0.0%
#50	0.300		82%	100.0%	0.0%
#60	0.250	79%	79%	100.0%	0.0%
#80	0.180		75%	100.0%	0.0%
#100	0.150	74%	74%	100.0%	0.0%
#140	0.106		65%	100.0%	0.0%
#170	0.090		62%	100.0%	0.0%
#200	0.075	59.3%	59.3%	100.0%	0.0%



Comments:

Reviewed by: Meghan Blodgett-Carrillo

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	Date Received:	1-Dec-21
Project #:	21B288	Sampled By:	Client
Client:	GeoEngineers	Date Tested:	13-Dec-21
Source:	PRDI-37-SC-102	Tested By:	K. Mendez
Sample#:	B21-2441		

Unified Soils Classification System, ASTM-2487
SM, Silty Sand
Sample Color:
grayish-brown

ACCREDITED Certificate #: 1366.01

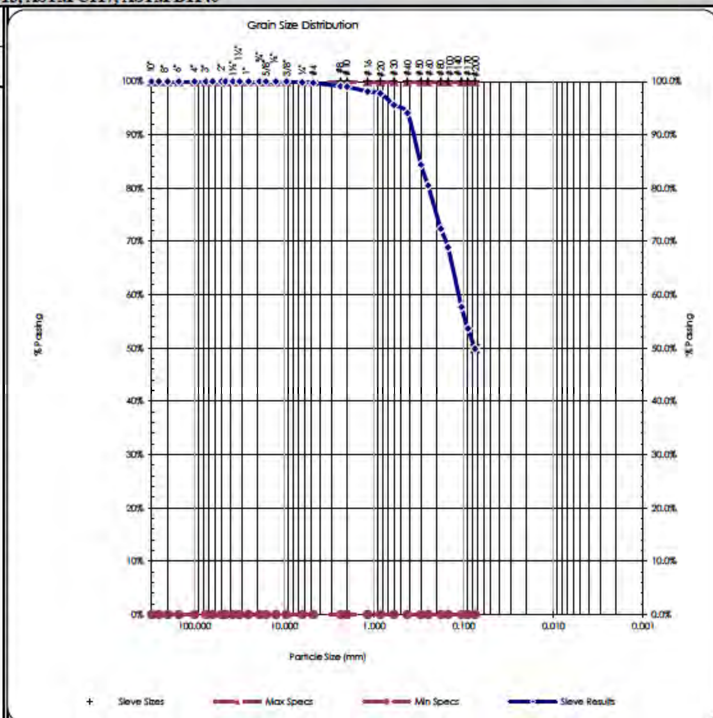
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.008 mm	% Gravel = 0.2%	Coeff. of Curvature, C_C = 1.18
$D_{(10)}$ = 0.015 mm	% Sand = 49.9%	Coeff. of Uniformity, C_U = 7.64
$D_{(15)}$ = 0.023 mm	% Silt & Clay = 49.9%	Fineness Modulus = 0.54
$D_{(30)}$ = 0.045 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.075 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.115 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.373 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 44/83	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	100%	100%	100.0%	0.0%
#8	2.36		99%	100.0%	0.0%
#10	2.00	99%	99%	100.0%	0.0%
#16	1.18		98%	100.0%	0.0%
#20	0.850	98%	98%	100.0%	0.0%
#30	0.600		96%	100.0%	0.0%
#40	0.425	94%	94%	100.0%	0.0%
#50	0.300		84%	100.0%	0.0%
#60	0.250	80%	80%	100.0%	0.0%
#80	0.180		72%	100.0%	0.0%
#100	0.150	69%	69%	100.0%	0.0%
#140	0.106		58%	100.0%	0.0%
#170	0.090		54%	100.0%	0.0%
#200	0.075	49.9%	49.9%	100.0%	0.0%



Comments:

Reviewed by: Meghan Blodgett-Carrillo

Sieve Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:**	1-Dec-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	13-Dec-21
Source:	PRDI-37-SC-24	**Tested By:**	K. Mendez
Sample#:	B21-2442		

Visual-Manual Procedures, ASTM-2488
ML, Silt with Sand
Sample Color:
grayish-brown

ACCREDITED
Certificate #: 1366.01

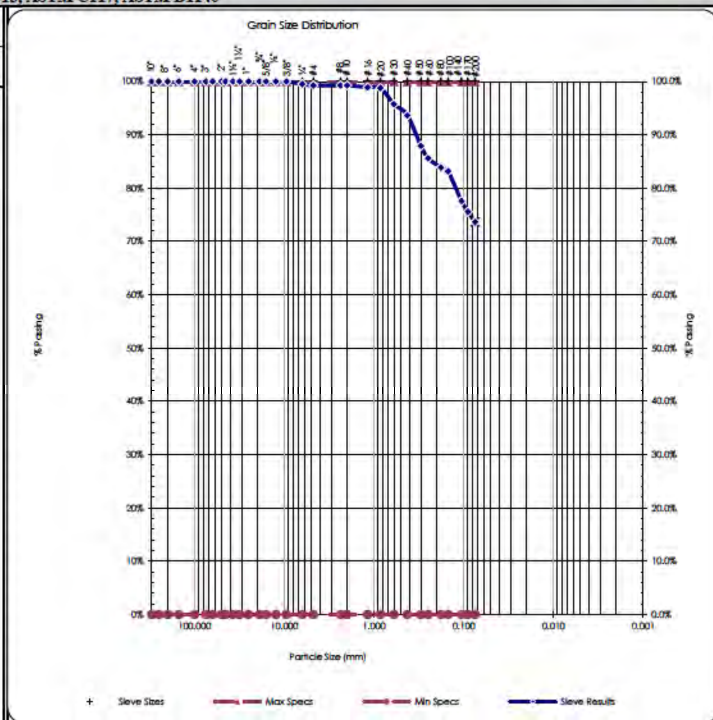
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.005 mm	% Gravel = 0.7%	Coeff. of Curvature, C_C = 1.50
$D_{(10)}$ = 0.010 mm	% Sand = 25.6%	Coeff. of Uniformity, C_U = 6.00
$D_{(15)}$ = 0.015 mm	% Silt & Clay = 73.7%	Fineness Modulus = 0.36
$D_{(30)}$ = 0.031 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.051 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.061 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 0.345 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 70/89	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		100%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		99%	100.0%	0.0%
#10	2.00	99%	99%	100.0%	0.0%
#16	1.18		99%	100.0%	0.0%
#20	0.850	99%	99%	100.0%	0.0%
#30	0.600		96%	100.0%	0.0%
#40	0.425	94%	94%	100.0%	0.0%
#50	0.300		88%	100.0%	0.0%
#60	0.250	86%	86%	100.0%	0.0%
#80	0.180		84%	100.0%	0.0%
#100	0.150	83%	83%	100.0%	0.0%
#140	0.106		78%	100.0%	0.0%
#170	0.090		76%	100.0%	0.0%
#200	0.075	73.7%	73.7%	100.0%	0.0%



Comments:

Reviewed by:

Meghan Blodgett-Carrillo

MATERIALS TESTING & CONSULTING, INC.

Sieve Report

Project:	Q.C. - South State Street Preliminary Remedial Design Investigation	**Date Received:**	1-Dec-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	13-Dec-21
Source:	PRDI-36-SC-13	**Tested By:**	K. Mendez
Sample#:	B21-2443		

Unified Soils Classification System, ASTM-2487
SM, Silty Sand
Sample Color:
grayish-brown

ACCREDITED Certificate #: 1366.01

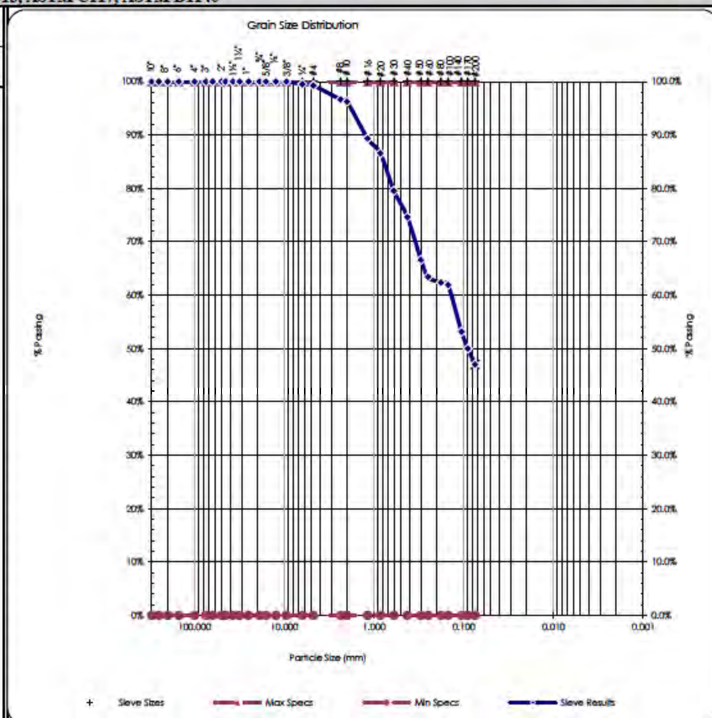
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.008 mm	% Gravel = 0.7%	Coeff. of Curvature, C_C = 1.02
$D_{(10)}$ = 0.016 mm	% Sand = 52.2%	Coeff. of Uniformity, C_U = 8.79
$D_{(15)}$ = 0.024 mm	% Silt & Clay = 47.0%	Fineness Modulus = 1.07
$D_{(30)}$ = 0.048 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.090 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.140 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 1.257 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 46/73	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		99%	100.0%	0.0%
#4	4.75	99%	99%	100.0%	0.0%
#8	2.36		97%	100.0%	0.0%
#10	2.00	96%	96%	100.0%	0.0%
#16	1.18		89%	100.0%	0.0%
#20	0.850	87%	87%	100.0%	0.0%
#30	0.600		80%	100.0%	0.0%
#40	0.425	75%	75%	100.0%	0.0%
#50	0.300		67%	100.0%	0.0%
#60	0.250	63%	63%	100.0%	0.0%
#80	0.180		62%	100.0%	0.0%
#100	0.150	62%	62%	100.0%	0.0%
#140	0.106		53%	100.0%	0.0%
#170	0.090		50%	100.0%	0.0%
#200	0.075	47.0%	47.0%	100.0%	0.0%



Comments:

Reviewed by: [signature]
Meghan Blodgett-Carrillo

Sieve Report

	Q.C. - South State Street Preliminary Remedial		
Project:	Design Investigation	**Date Received:**	1-Dec-21
Project #:	21B288	**Sampled By:**	Client
Client:	GeoEngineers	**Date Tested:**	13-Dec-21
Source:	PRDI-36-SC-128	**Tested By:**	K. Mendez
Sample#:	B21-2444		

Unified Soils Classification System, ASTM-2487
SM, Silty Sand
Sample Color:
grayish-brown

ACCREDITED
Certificate #: 1366.01

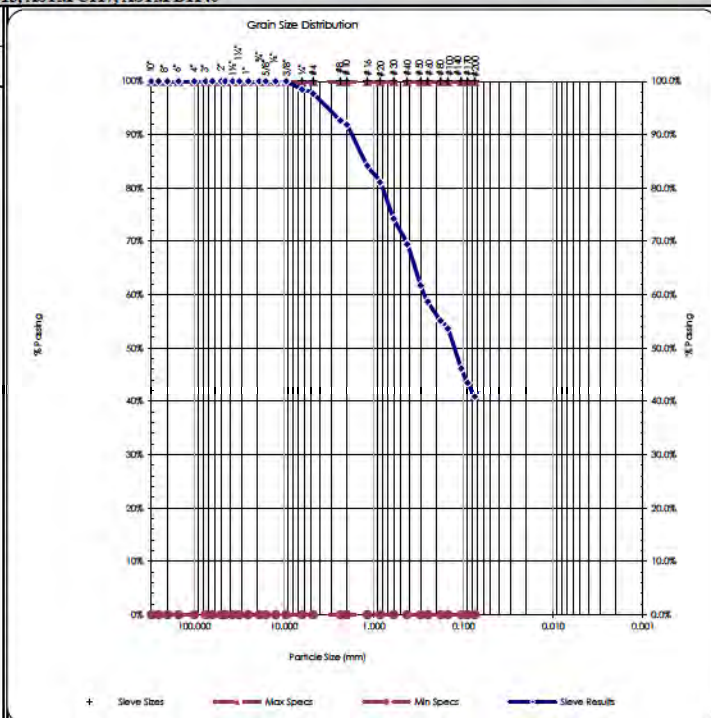
ASTM D2216, ASTM D2419, ASTM D4318, ASTM D5281

Specifications
No Specs
Sample Meets Specs ? N/A

$D_{(5)}$ = 0.009 mm	% Gravel = 2.3%	Coeff. of Curvature, C_C = 0.61
$D_{(10)}$ = 0.018 mm	% Sand = 56.8%	Coeff. of Uniformity, C_U = 14.80
$D_{(15)}$ = 0.027 mm	% Silt & Clay = 40.9%	Fineness Modulus = 1.36
$D_{(30)}$ = 0.055 mm	Liquid Limit = n/a	Plastic Limit = n/a
$D_{(50)}$ = 0.128 mm	Plasticity Index = n/a	Moisture %, as sampled = n/a
$D_{(60)}$ = 0.271 mm	Sand Equivalent = n/a	Req'd Sand Equivalent =
$D_{(90)}$ = 1.799 mm	Fracture %, 1 Face = n/a	Req'd Fracture %, 1 Face =
Dust Ratio = 53/90	Fracture %, 2+ Faces = n/a	Req'd Fracture %, 2+ Faces =

ASTM C136, ASTM D6913, ASTM C117, ASTM D1140

Sieve Size US	Sieve Size Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
12.00"	300.00		100%	100.0%	0.0%
10.00"	250.00		100%	100.0%	0.0%
8.00"	200.00		100%	100.0%	0.0%
6.00"	150.00		100%	100.0%	0.0%
4.00"	100.00		100%	100.0%	0.0%
3.00"	75.00		100%	100.0%	0.0%
2.50"	63.00		100%	100.0%	0.0%
2.00"	50.00		100%	100.0%	0.0%
1.75"	45.00		100%	100.0%	0.0%
1.50"	37.50		100%	100.0%	0.0%
1.25"	31.50		100%	100.0%	0.0%
1.00"	25.00		100%	100.0%	0.0%
3/4"	19.00		100%	100.0%	0.0%
5/8"	16.00		100%	100.0%	0.0%
1/2"	12.50	100%	100%	100.0%	0.0%
3/8"	9.50	100%	100%	100.0%	0.0%
1/4"	6.30		98%	100.0%	0.0%
#4	4.75	98%	98%	100.0%	0.0%
#8	2.36		93%	100.0%	0.0%
#10	2.00	92%	92%	100.0%	0.0%
#16	1.18		84%	100.0%	0.0%
#20	0.850	81%	81%	100.0%	0.0%
#30	0.600		74%	100.0%	0.0%
#40	0.425	69%	69%	100.0%	0.0%
#50	0.300		62%	100.0%	0.0%
#60	0.250	59%	59%	100.0%	0.0%
#80	0.180		55%	100.0%	0.0%
#100	0.150	54%	54%	100.0%	0.0%
#140	0.106		46%	100.0%	0.0%
#170	0.090		43%	100.0%	0.0%
#200	0.075	40.9%	40.9%	100.0%	0.0%



Comments:

Reviewed by:

Meghan Blodgett-Carrillo

Pb-210 Dating Report

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for

General Engineering Laboratories
Charleston, SC

Jan. 17, 2022

Introduction

Pb-210 is a powerful method for dating sediments of various compositions (Goldberg, 1963; Koide et al., 1972; Robbins, 1978). As a decay product in the ^{238}U decay series with a half-life of 22.26 years, it provides an accurate geochronometer for many recent environmental and anthropogenically related changes recorded in sediments (Norton and Kahl, 1986; Sonke et al., 2003) and peat deposits (Shotyk et al., 1998). The open character of sedimentary systems with respect to sedimentation, compaction, nutrient recycling and diagenesis, and the nature of ^{210}Pb pathways (Fig. 1) over time requires the use of different models to interpret ^{210}Pb activity profiles in terms of sediment accumulation rates (SARs) and absolute sediment ages. The use of other, independent geochronological methods to validate a particular ^{210}Pb model is desirable, yet often not feasible.

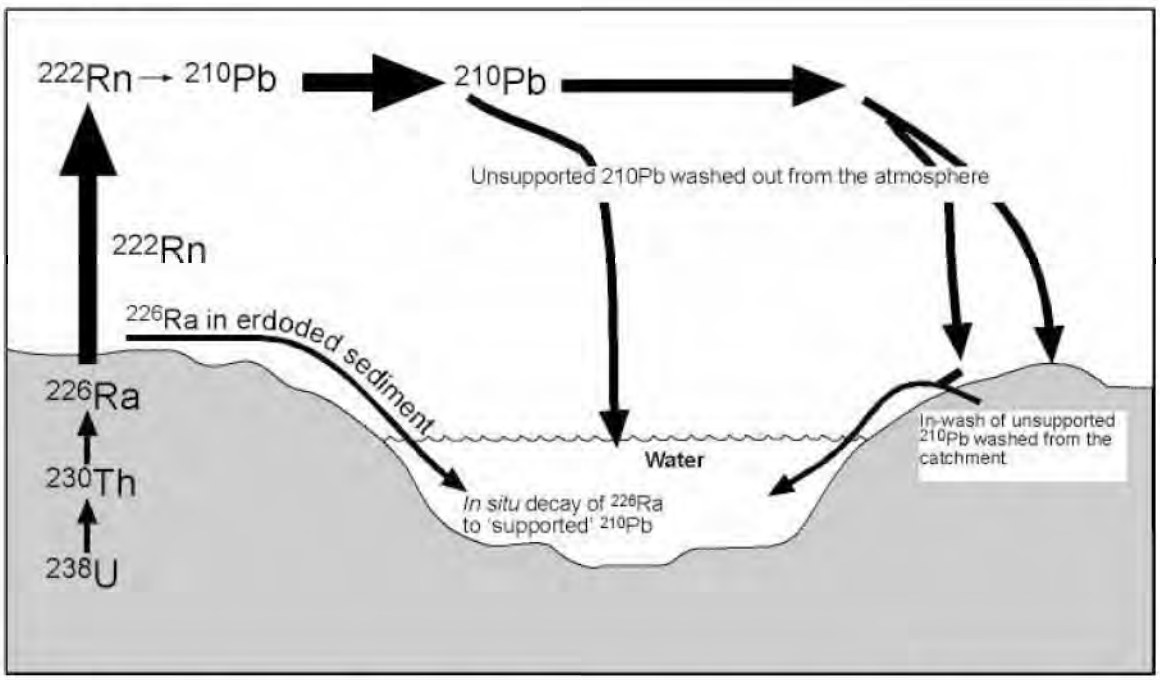

Figure 1. Schematic drawing illustrating the sources and pathways of ^{210}Pb in the environment. In addition to decay from its radioactive parent ^{226}Ra, ^{210}Pb in lake or ocean sediments can be derived from direct atmospheric fallout onto the lake surface or via deposition on land with subsequent runoff.

Experimental

Determinations of ^{210}Pb were performed by analysis of ^{210}Po via alpha spectrometry. Ra-226 and ^{137}Cs were determined by gamma spectrometry using the 662 keV photopeak for ^{137}Cs and radon daughter peaks for ^{226}Ra (295, 352, and 609 keV; Kim and Burnett, 1986). All radionuclide measurements were made at General Engineering Laboratories (GEL) in Charleston, South Carolina. "Excess ^{210}Pb" (not supported by decay of ^{226}Ra in the sediment) is determined either by subtracting the measured ^{226}Ra activity in each interval or estimating a "background" ^{210}Pb activity in each sample from the total ^{210}Pb assuming that what is subtracted represents the supported ^{210}Pb. All excess ^{210}Pb activities were corrected for radioactive decay between sampling and analysis. Standard quality control measures (blanks, spiked samples, etc.) were applied to ensure that the precisions are within the stated uncertainties.

Bulk densities and porosities were calculated from sediment moisture contents, assuming an average mineral density of 2.45 g/cm^3. Based on the observed trends of the excess ^{210}Pb (ex ^{210}Pb) activities we applied both the "Constant Flux: Constant Sedimentation" (CF:CS) model and the "Constant Rate of Supply" (CRS) model to estimate sediment ages (see following section on modeling). All ages were calculated for mid-layer depths. Cs-137 activities were measured in order to be used as a potential guide to a dateable horizon. Generally, the maximum ^{137}Cs activity in a sediment core should represent 1963, the year of maximum atmospheric fall-out of ^{137}Cs from nuclear testing.

Theory: ^{210}Pb models

We used two models to estimate ^{210}Pb SARs and ages. A detailed overview of these models can be found in Appleby and Oldfield (1992). In the simplest approach, the Constant Flux, Constant Sedimentation (CF:CS) model, a constant ^{210}Pb flux and a constant sedimentation rate are assumed. Log-linear regression of cumulative core length (cm) versus ex ^{210}Pb activity yields a slope (m) from which an average long-term SAR can be calculated. The ex ^{210}Pb activity is the activity above that supported by the long-lived parent ^{226}Ra present in the sediment. We evaluate the supported ^{210}Pb level by judging where the declining ^{210}Pb trend has become more-or-less asymptotic to a constant down-core level. The age relationship is based on the basic equation of radioactive decay:

$$A = A_o e^{-\lambda t} \tag{1}$$

where A is the ex ^{210}Pb activity at time t, A_o is the ex ^{210}Pb initial activity and λ is the ^{210}Pb decay constant (0.0312 y^{-1}). We can substitute core depth (x) divided by SAR for t (i.e., t = x/SAR) and take the natural log of both sides of equation 1:

$$Ln\,A = Ln\,A_o - x\frac{\lambda}{SAR} \tag{2}$$

which is in the form of a linear equation with a y-intercept of $Ln\,A_o$ and slope (m) equal to λ/SAR. Thus, we can derive the SAR (cm/y) by plotting the natural logarithm of the ex ^{210}Pb activity versus depth and dividing the ^{210}Pb decay constant by the derived slope of the linear regression. Or, if the axes are reversed as done in the examples shown in this report (x-axis = Ln ex ^{210}Pb, and y-axis = depth), one would multiply the derived slope by the decay constant to estimate the SAR.

In the Constant Rate of Supply (CRS) model, the ^{210}Pb flux is assumed to be constant over the time scale under consideration. The sediment flux is allowed to vary over time and may result in non-exponential depth versus ^{210}Pb activity profiles. Ages are assessed by first calculating a total ex ^{210}Pb inventory (A_{inv}) by integrating the ex ^{210}Pb activities by depth downcore. This is done by summing the ex ^{210}Pb inventories (dpm/cm^2) within each individual layer (ex ^{210}Pb x dry bulk density x interval thickness). The total inventory is then related to the cumulative residual ex ^{210}Pb activity, $A(t)$, below sediment layers of age t:

$$t = \frac{1}{\lambda} \times Ln\left(\frac{A_{inv}}{A(t)}\right) \tag{3}$$

Note that when analyzing long cores in 1-cm thick slices, as done here, there are usually missing layers and the total integrated ex ^{210}Pb (A_{inv}) can be estimated by at least two different integration styles: (1) by interpolating the necessary values (interval thickness, dry bulk density, ex ^{210}Pb) for missing layers between adjacent upper and lower measured intervals; and (2) by extrapolating measured values from one analyzed layer to the next. We used the extrapolation approach here, which has been shown to result in inventories and CRS ages that are within the uncertainty of the interpolation technique (Bidorn et al., 2021).

Mass accumulation rates (MARs; mg/cm^2 y) can be estimated on a layer-by-layer basis by dividing the change in the integrated "mass depth" (MD, g/cm^2 = interval thickness (cm) multiplied by dry bulk density, g/cm^3) by the change in the CRS ages (t) between two respective intervals (i):

$$MAR\left(\frac{mg}{cm^2\,y}\right) = 1000\,\frac{mg}{g} \times \frac{(MD_i - MD_{i-1})\,(g/_{cm^2})}{(t_i - t_{i-1})\,(y)} \tag{4}$$

As mentioned earlier, we estimated the bulk densities in each interval by calculation based on the measured moisture content and an assumed average grain density using the expression:

$$B_D = \frac{1}{\left(\left(\frac{1}{100 - \%M}\right) \cdot 100 + \frac{1}{\rho_s}\right) - 1} \tag{5}$$

where B_D is the dry bulk density (g/cm^3), $\%M$ is the percent moisture, and ρ_s is the average grain density, taken to be 2.5 g/cm^3.

Results:

All radionuclide results from GEL were sent to W. Burnett at Florida State University (FSU) for age interpretation. Pb-210 dates were obtained by using both the CF:CS and CRS models as described above. All calculations and additional data plots are shown on the accompanying spreadsheet.

Core 35:

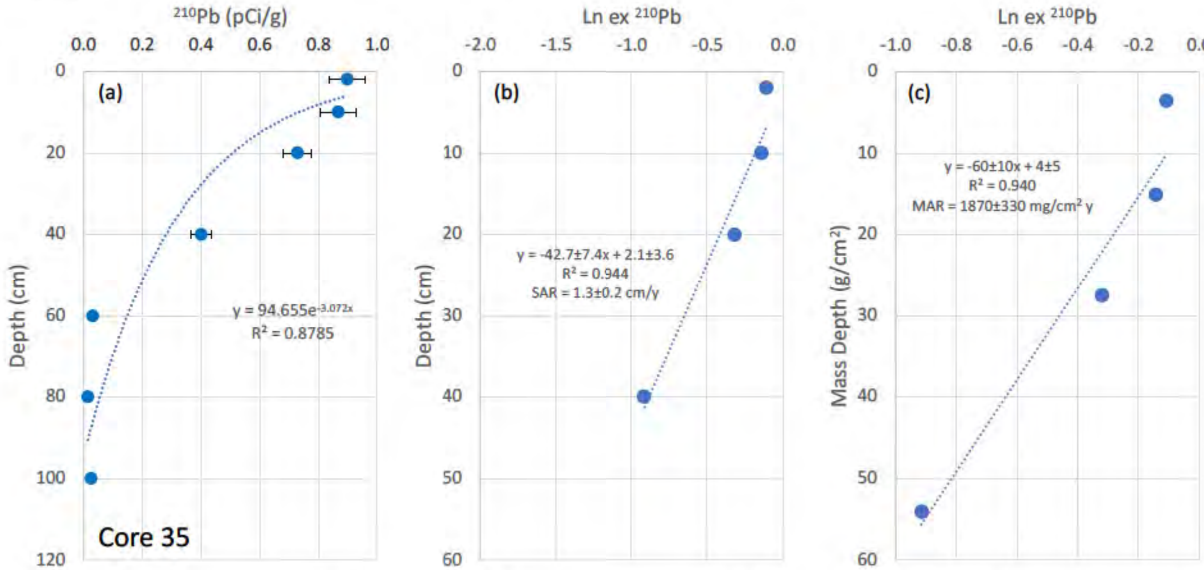

Figure 2. Results for core 35. (a) Total ^{210}Pb vs core depth; (b) Natural logarithm vs core depth (cm); and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 1.3±0.2 cm/y and a MAR of 1870±330 mg/cm^2 y.

Core 36:

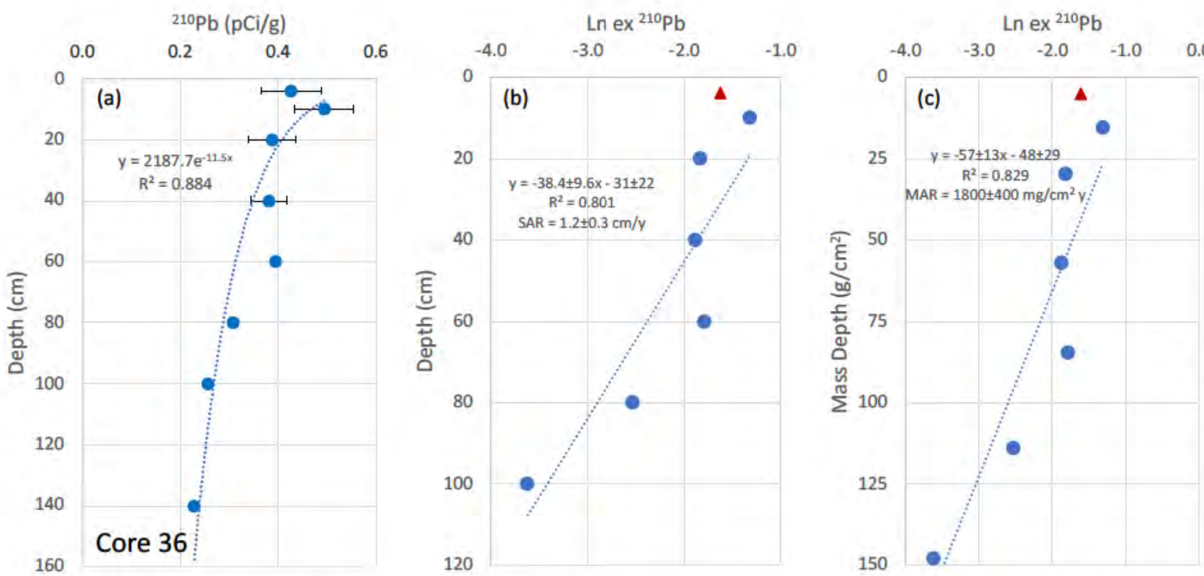

Figure 3. Results for core 36. (a) Total ^{210}Pb vs core depth (cm); (b) Natural logarithm vs core depth (cm); and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 1.2±0.3 cm/y and a MAR of 1800±400 mg/cm^2 y.

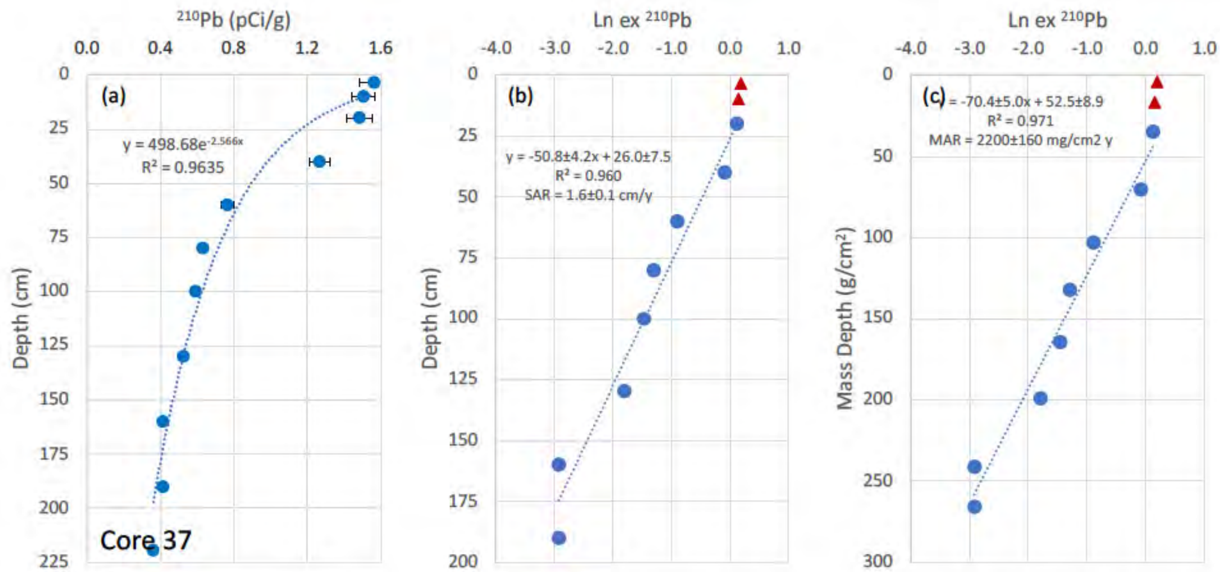

Figure 4. Results for core 37. (a) Total ^{210}Pb vs core depth (cm); (b) Natural logarithm vs core depth (cm); and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 1.6±0.1 cm/y and a MAR of 2200±160 mg/cm^2 y.

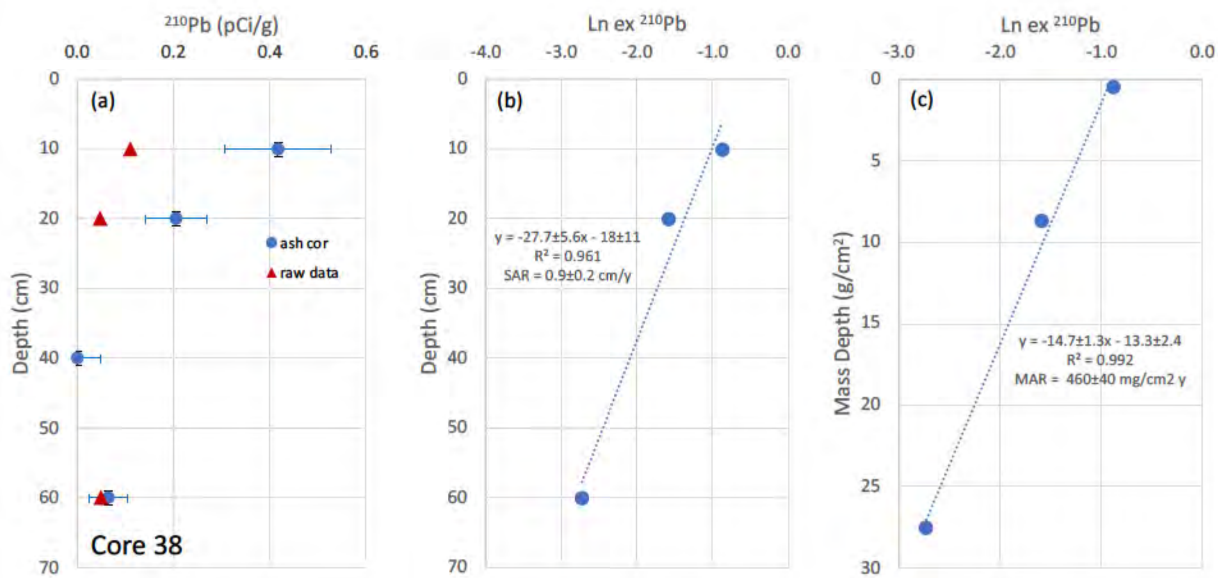

Figure 5. Results for core 38. (a) Total ^{210}Pb vs core depth (cm) shown as both the raw uncorrected data (red triangles) and with a correction for wood chip abundance by determining the ash weight after ignition (blue circles); (b) Natural logarithm vs core depth (cm) based on the ash-corrected ^{210}Pb activities; and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 0.9±0.2 cm/y and a MAR of 460±40 mg/cm^2 y.

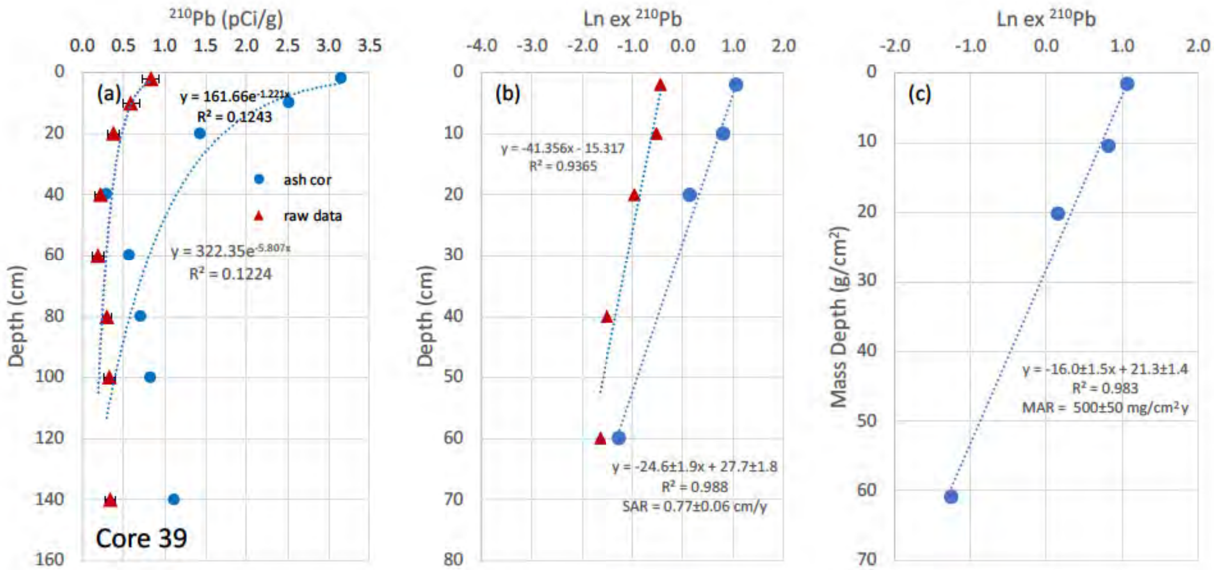

Figure 6. Results for core 39. (a) Total ^{210}Pb vs core depth (cm) shown as both the raw uncorrected data (red triangles) and with a correction for wood chip abundance by determining the ash weight after ignition (blue circles); (b) Natural logarithm vs core depth (cm) based on the ash-corrected ^{210}Pb activities; and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 0.77±0.06 cm/y and a MAR of 500±50 mg/cm^2 y.

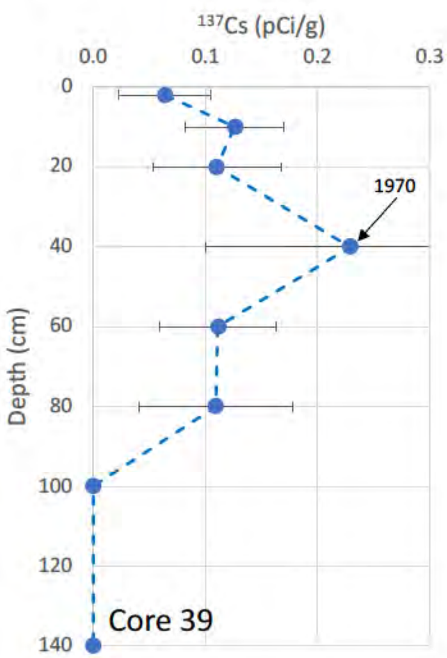

Figure 7. Activities of ^{137}Cs at various depths in core 39. Based on the CF:CS ^{210}Pb model, the calendar age at 40 cm, the approximate peak in the ^{137}Cs activity, is about 1970. Considering the uncertainties in both the CF:CS model age and the location of the ^{137}Cs peak, this represents excellent agreement.

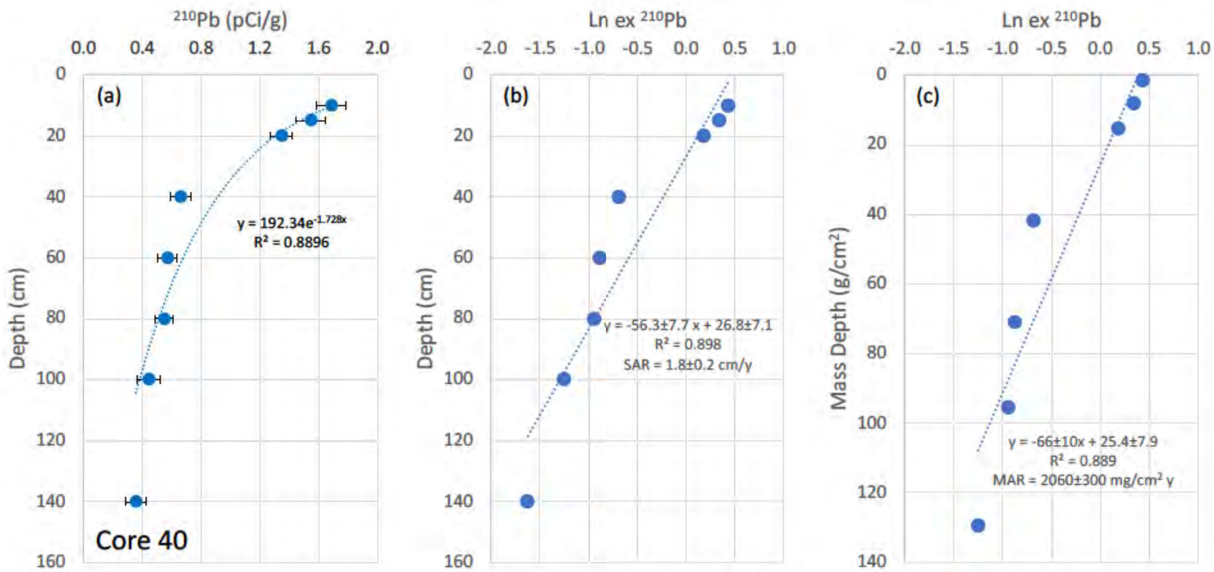

Figure 8. Results for core 40. (a) Total ^{210}Pb vs core depth (cm); (b) Natural logarithm vs core depth (cm); and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 1.8±0.2 cm/y and a MAR of 2060±300 mg/cm^2 y.

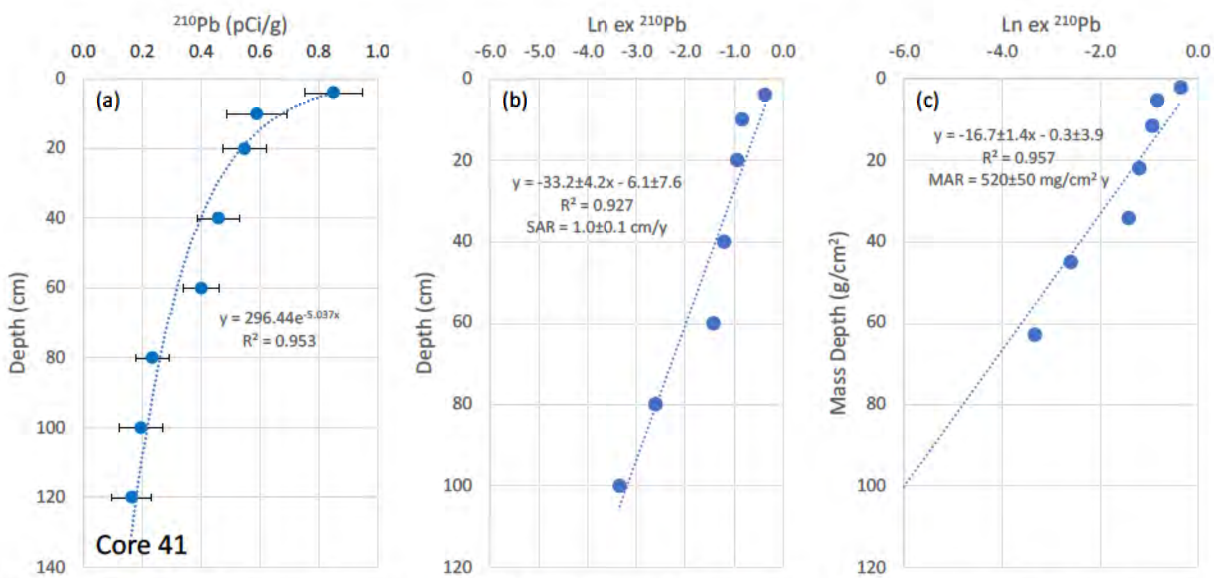

Figure 9. Results for core 41. (a) Total ^{210}Pb vs core depth (cm); (b) Natural logarithm vs core depth (cm); and (c) Natural logarithm vs mass depth (g/cm^2). CF:CS interpretation of these data indicates an average SAR of 1.0±0.1 cm/y and a MAR of 520±50 mg/cm^2 y.

Summary of Results:

We present below a comparison of the CF:CS and CRS model results (Figure 10) and a summary of the main findings (Table 1).

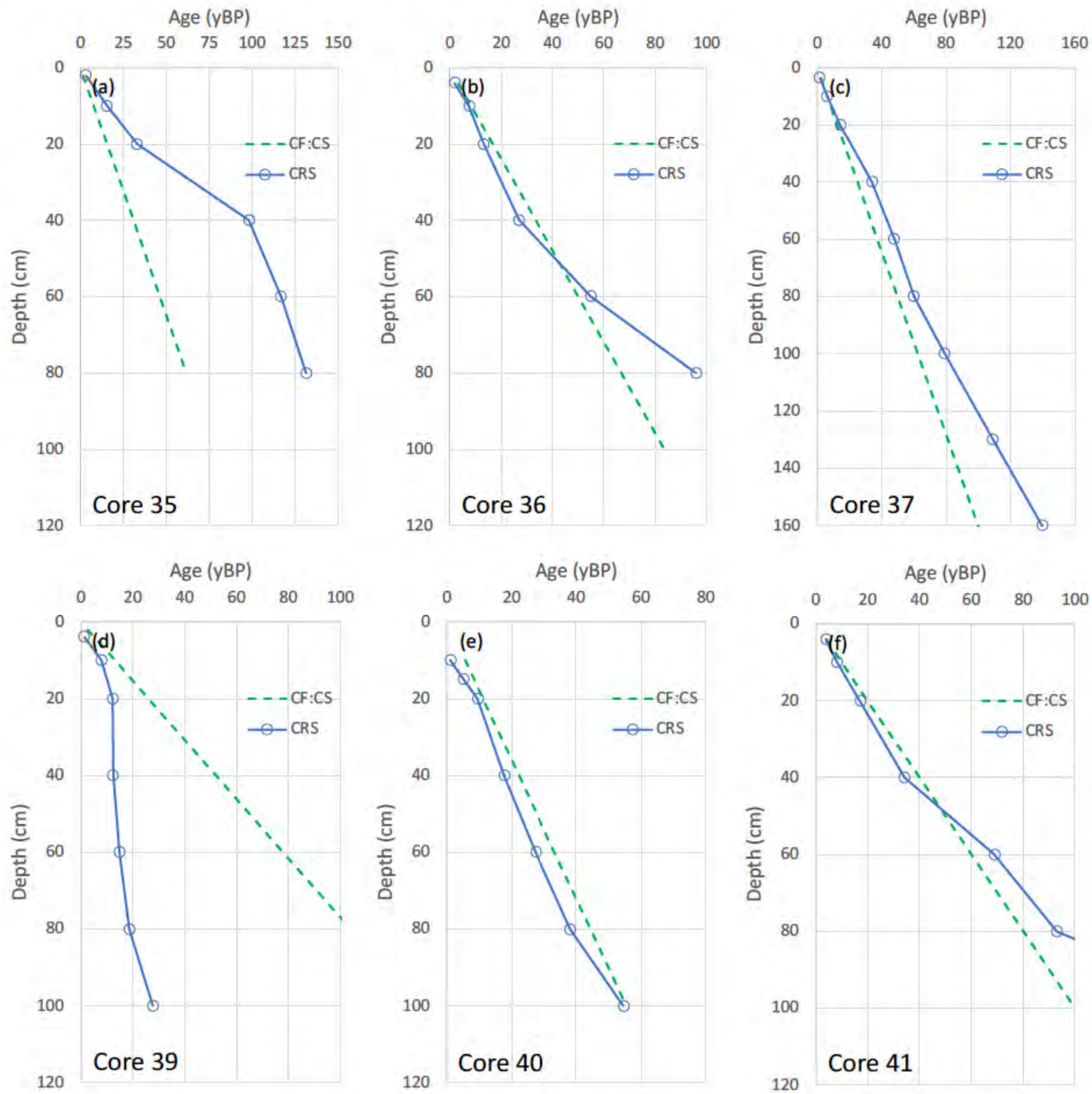

Figure 10. Comparison of CF:CS and CRS model ages for all cores except core 38 that had too few layers to allow estimation of CRS ages. Four of the six cores show good to excellent agreement between the two age models. We favor the CF:CS model when the two approaches do not agree (cores 35 and 39). Core 39 had a ^{137}Cs pattern that showed a peak activity at 40 cm depth that indicates an approximate age of about 1963. The CF:CS model produced an age of that same layer at 1970. Considering the uncertainties in both the CF:CS approach and the location of the ^{137}Cs peak, this suggests excellent agreement.

Table 1. A summary of the sediment accumulation rates (SARs), mass accumulation rates (MARs), total ^{210}Pb inventories, and estimated steady state ^{210}Pb fluxes.

Core #	SAR cm/y	MAR mg/cm^2 y	^{210}Pb Inventories pCi/cm^2	^{210}Pb Fluxes* pCi/cm^2 y	Notes
35	1.3±0.2	1870±330	34.5	1.08	
36	1.2±0.3	1800±400	18.1	0.56	Close to expected atmospheric flux
37	1.6±0.1	2200±160	111	3.47	
38	0.9±0.2	460±40	2.4	0.08	Ash correction Limited to 4 layers
39	0.77±0.06	500±50	112	3.5	Ash correction ^{137}Cs confirmation
40	1.8±0.2	2060±300	79.4	2.5	
41	1.0±0.01	520±50	12.8	0.4	Close to expected atmospheric flux

*Average atmospheric ^{210}Pb flux for this latitude is approximately 0.5 pCi/cm^2 y (Baskaran, 2011).

The sediment accumulation rates (SARs) for all 7 cores fall in the relatively narrow range of 0.77±0.06 cm/y to 1.8±0.2 cm/y with an overall average of 1.2±0.2 cm/y. The mass accumulation rates (MARs) appear to fall into two groups: one at an MAR of 500±50 mg/cm^2 y; and a higher grouping at about 2000±300 mg/cm^2 y. The ex ^{210}Pb inventories and estimated fluxes are mostly higher than expected based on reported values for around 50° N latitude. This may indicate sediment focusing into the areas where these cores were collected or the presence of another unknown ^{210}Pb source (e.g., higher ^{226}Ra in the coastal waters).

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