Ahtna
Engineering Services, LLC

PROPOSED WRANGELL MONOFILL
REPORT OF FINDINGS
WRANGELL, ALASKA
27 JANUARY 2017

Prepared For:
Alaska Department of Environmental Conservation
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APPROVAL PAGE

This report of findings has been reviewed and approved for the use in the geotechnical and hydrological evaluation of the proposed Wrangell Monofill site.

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ACRONYMS AND ABBREVIATIONS

ADEC.............Alaska Department of Environmental Conservation
ADNR............Alaska Department of Natural Resources
Ahtna..............Ahtna Engineering Services, LLC
ASTM............ASTM International
CQA...............Construction Quality Assurance
ft bgs...............Feet below ground surface
GCL................Geosynthetic Clay Liner
Geosyntec.......Geosyntec Consultants, Inc.
HASP.............Health and Safety Plan
HDPE.............High-Density Polyethylene
HELP..............Hydrological Evaluation of Landfill Performance
HSA................Hollow Stem Auger
POL................Petroleum, Oil and Lubricant
PVC................Polyvinyl Chloride
USGS.............United States Geological Survey

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1.0 INTRODUCTION

This report of findings has been prepared by Geosyntec Consultants, Inc. (Geosyntec) on behalf of Ahtna Engineering Services, LLC (Ahtna) to present the results from the geotechnical and hydrological investigation at the inactive rock pit near Pat Creek near Wrangell, Alaska (site) and the results of infiltration modeling through an engineered cap. The inactive rock pit is managed by the Alaska Department of Natural Resources (ADNR) and has been identified by the Alaska Department of Environmental Conservation (ADEC) as a candidate for construction of a monofill to encapsulate treated lead impacted soil currently stockpiled at the Wrangell Junkyard in Wrangell, Alaska. The work was conducted under term contract No. 18-8036-13, NTP No. 170007506. The purpose of the investigation was to characterize the subsurface conditions at the site and to gather site-specific geotechnical and hydrological information, including rock characteristics, groundwater depth, and groundwater quality. This information was used, along with climatological data for the site and conceptual engineered cap designs, to model groundwater infiltration and evaluate the suitability of the site as a treated soil repository. A summary of the investigation, analyses, and laboratory test results are discussed herein.

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2.0 FIELD INVESTIGATION

2.1 Work Plan

In preparation for the hydrological and geotechnical investigation at the proposed disposal site, Ahtna prepared a Work Plan for gathering site-specific geotechnical and hydrological information. The Work Plan was prepared by Ahtna (Ahtna, 2016) and reviewed by the ADEC for compliance with local procedures and regulations. The Work Plan outlined pre-field and field activities, such as the drilling of geotechnical borings, installation of groundwater monitor wells, development of the wells for groundwater sampling, groundwater sampling, and restoration of the exploration locations.

2.2 Pre-Field Activities

As part of the Work Plan, Ahtna prepared a site-specific health and safety plan (HASP), coordinated site access with the ADNR, and contacted Alaska Digline to identify existing underground utilities within the vicinity of the proposed exploration locations. Discovery Drilling and Andrew DuComb, EIT of Ahtna mobilized to the site from Anchorage, Alaska for the hydrological and geotechnical investigation.

2.3 Subsurface Investigation

Three exploratory borings were advanced at the site from 29 November to 3 December 2016 and were designated Borings P-01, MW-02, and MW-03. The purpose of drilling was to characterize subsurface conditions, determine groundwater impacts (if any) from metals for background information, and determine depth to groundwater. The borings were advanced to depths ranging from approximately 6 feet below ground surface (ft bgs) to 34 ft bgs. Borings MW-02 and MW-03 were terminated at the top of bedrock (approximately 10 ft bgs and 6 ft bgs, respectively) due to an oily sheen observed in the encountered groundwater. The approximate locations of the exploratory borings are presented on Figure 1.

The borings were advanced by Discovery Drilling of Anchorage, Alaska utilizing a light-weight rubber track mounted Geoprobe 6712 DT drill rig under the supervision of Ahtna personnel. Borings were drilled using a combination of 8-inch diameter hollow-stem auger (HSA) and 2 3/8-inch diameter core drilling (HX) methods. HSA drilling was performed through the entire overburden material profile and into underlying bedrock, to the extent practical. Core drilling was not performed at Borings MW-02 and MW-03 due to presence of an oily sheen.

At Boring P-01, boring drilling methodology was switched to core drilling methods after auger refusal. The core drilling process required circulation of water to regulate the temperature of the core bit, to carry cuttings to the surface, and promote borehole stability. During the coring process, water was pumped through the drill rods and past the bit before returning to the surface with cuttings through the annular space between the drill rods and the wall of the boring. At the surface, the fluid and cuttings were discharged into a baffled sump to allow the cuttings to fall out prior to recirculating the water back down the borehole.

The borings were logged by Athna personnel in accordance with ASTM International (ASTM) D2488 based on the recovered cuttings and rock core. The individual boring logs from this subsurface investigation are presented in Attachment A. Additionally, recovered cores were logged to record structural orientation and discontinuities. Upon completion of logging, the cores were photographed and retained in core boxes for subsequent sample selection and/or archiving.

The subsurface conditions consisted of crushed rock overburden overlying fractured schist and hornfels (USGS, 2017). Within the exploratory borings, overburden material ranged from approximately 1 to 10 ft thick. Rock cores collected from Boring P-01 indicate zones of variable fracture intensity as shown on the boring logs (Attachment A).

2.4 Observed Groundwater Impacts

Ahtna personnel observed the presence of oil in the drilling fluids and water extracted from boreholes P-01, MW-02 and MW-03. Oil impacts were not observed in P-01 until after the development of the well, but oil impacts were observed in MW-02 and MW-03 during the beginning of rock coring and drilling was subsequently stopped. The source of the contamination was unknown and Bruce Wanstall of the Alaska Department of Environmental Conservation (ADEC) and the ADEC Spill Prevention and Response department were contacted and informed of the situation. Sorbent booms and pads were deployed to absorb observed oil as it flowed out of the borehole. These boreholes were terminated at the overburden/bedrock interface and completed as monitor wells to allow for potential future sampling and groundwater elevation measurements.

2.5 Well Installation and Groundwater Sampling

2.5.1 Well Installation

The three boreholes were completed as monitoring wells after they were advanced to their final depths. The wells were constructed using either 1 or 2-inch machine-slotted schedule 40 polyvinyl chloride (PVC) pipe with 0.010" slotted screen. MW-02 and MW-03 were screened in the crushed rock layer from 5 to 10 ft bgs and 2 to 5 ft bgs, respectively. P-01 was screened in the fractured bedrock from 20 to 30 ft bgs. The annular space around the pipes was backfilled with No. 20-40 silica sand filter pack in accordance with the Work Plan (Ahtna, 2016). Bentonite grout was placed from the top of the filter pack to the ground surface. A security casing was installed and extends above the ground surface to identify the well location and prevent damage to the casing. Well construction logs are provided in Attachment B.

2.5.2 Groundwater Sampling

The workplan indicated the three proposed borehole locations would be drilled to 35 ft bgs, completed as groundwater monitor wells, and sampled for metals. However, oil was observed in the drilling fluid and extracted water at the beginning of rock coring for MW-02 and MW-03. These boreholes were terminated at the top of bedrock (due to the presence of an oily sheen) to avoid creating a conduit to deeper groundwater and potentially increasing the extent of potential oil impacts. Background samples for metals were collected from P-01 but not from MW-02 and MW-03 because the groundwater appeared to be already impacted with oil. MW-02 and MW-03 were completed as monitor wells to allow for future groundwater elevation measurements and to allow for future groundwater sampling if desired.

Development of monitor well P-01 began approximately 24 hours after completion of the well in accordance with the Work Plan (Ahtna, 2016). The groundwater elevation was measured to the nearest 0.01 feet using a water level meter prior to purging. Approximately five volumes of water were pumped from the well during purging. After allowing for recharge, the well was surged for 10 minutes and the purging process was repeated a second time. After purging and surging was completed, the groundwater was sampled. The purged water, at the direction of Bruce Wanstall of the ADEC, was disposed of in a dry portion of the site away from the three monitor wells. One primary water sample, designated 16-WMF-PO1-01, and one duplicate water sample, designated 16-WMF-P10-02, were collected from P-01 for laboratory analysis. SGS North America Inc. of Anchorage, Alaska was contracted to analyze the groundwater samples for the full suite of metals in accordance with EPA Method SW6020A for background information. While the full suite of metals was sampled for background purposed, the evaluation discussed in Section 3 is focused only on lead.

Laboratory results for the groundwater samples are presented in Attachment C. The results of the laboratory analysis of metals from P-01 provide baseline concentrations of groundwater at the site.

2.6 Site Specific Hydrogeology

Groundwater was encountered at approximately 2.5 to 3.2 ft bgs in monitor wells P-01, MW-02, and MW-03. Groundwater elevations are consistent in all wells. MW-02 and MW-03 are in the crushed rock overburden and P-01 is in deeper fractured bedrock. Therefore, the overburden and bedrock appear hydraulically connected, however a pumping test is required to confirm this. Based on these three monitoring points, groundwater flows northeast toward Pat Creek Road with a gradient of 0.0077 ft/ft, or 0.77% (Figure 1).

Groundwater elevations and flow directions are based on a single reading performed as part of the site investigation and does not account for seasonal effects on groundwater depth and flow.

2.6.1 Separation from Groundwater Requirements

In accordance with AAC 60.217, a new unlined landfill must have at least 10 feet of separation between the highest measured level of an aquifer of resource value and the bottom of waste unless the landfill is constructed two feet or more above the natural ground surface.

2.7 Site Restoration

Following the completion of drilling activities, Discovery Drilling demobilized from the site and excess cuttings and soil were spread onsite. The rock cores sampled during drilling were packaged and brought back to Ahtna for archiving and review. Following completion of the surface seal, the borehole elevations were surveyed using an optical transit level by Ahtna personnel. Ahtna personnel demobilized from the site on 3 December 2016 after completion of well development and groundwater sampling.

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3.0 LEACHABILITY EVALUATION

3.1 Purpose

In accordance with AAC 60.025, the disposal of polluted soil will be approved by the ADEC on a case-by-case basis if the owner or operator can demonstrate the following:

1. The waste in the landfill cannot be washed into nearby surface water, and leachate from the landfill cannot reach nearby surface water;
2. The polluted soil, if it is disposed in the landfill, will not cause a threat to public health, safety, or welfare, or to the environment;
3. A practical potential does not exist for migration of a hazardous constituent from the landfill to an aquifer during the active life and post-closure care of the landfill; and
4. The owner of the landfill agrees to implement institutional controls that the department (ADEC) determines are necessary for long-term protection of public health, safety, and welfare, and to the environment.

The purpose of this evaluation is to demonstrate that a monofill of treated soil with an engineered cap constructed at the site meets these criteria. This evaluation assumes that:

- water introduced into the waste mass will be generated over a 30-year period from stormwater that infiltrates through the cap;
- the placement of the waste in the monofill will occur over a relatively short duration (i.e. approximately one month);
- stormwater controls will be in place during construction to minimize stormwater infiltration into the waste and erosion of the waste; and
- capping will occur immediately after waste placement is completed.

This evaluation also considers the leaching potential of lead from the treated soil, discussed in detail in Section 3.4. The evaluation does not include the leaching potential of metals other than lead.

3.2 Monofill Construction

The active life of the monofill is assumed to consist of transportation and placement of the impacted soil in the proposed monofill over a relatively short duration. Conceptually, we estimate transportation and placement of impacted soil will be on the order of one month, assuming the following:

- Newly transported soil will be covered during transport and at the end of each work day (tarps or clean soil, depending on availability) to minimize migration of waste by wind, erosion, or animal intrusion. The temporary cover will also minimize surface water migration into the waste material during transportation and after placement into the monofill.
- Once the material has been placed to final grades, an engineered cap will be installed to minimize migration of water through the cap.

Based on these assumptions, the modeling assumes a closed condition for the monofill with an engineered cap. The cap will be constructed of geosynthetic materials and provide sufficient stormwater drainage, cover drainage to minimize migration of water into the treated soil monofill. Detailed design of the monofill is not included as part of the report.

3.3 Hydrological Evaluation of Landfill Performance Modeling

The performance of the proposed cap was modeled using the Hydraulic Evaluation of Landfill Performance (HELP) model developed by the United States Army Corps of Engineers (USACE) and the United States Environmental Protection Agency (USEPA 1997). Inputs used to develop the HELP model for this site were selected based on site-specific geotechnical and hydrological information gathered during the investigation, treated soil characteristics (NRC Alaska and Nortech, 2016), and conceptual cap and monofill designs. The modeling was performed to estimate the amount of infiltration expected through the proposed cap, through the treated soil, and into the groundwater to evaluate the potential to leach lead from the treated soil. A detailed calculation package for the HELP modeling, including outputs from the model, is presented in Attachment D.

3.3.1 Procedure

The HELP model evaluates infiltration using the following equation:

$$I = P - (R + ET)$$

Where:

I = Infiltration through the top layer of the landfill (i.e., cap)

P = Precipitation (i.e., rainfall)

R = surface runoff which includes interception by the ground cover and actual runoff

ET = evapotranspiration

The HELP model simulates daily liquid movement into, through, and out of a landfill. Precipitation infiltrating into a layer is either stored in the layer, removed by evapotranspiration, removed by lateral drainage (for layers specified as lateral drainage layers), or conveyed into lower layers. Factors affecting liquid movement include the initial moisture content of each layer, the storage available in each layer, the additional moisture that reaches the particular layer from the layer above it, and the hydraulic conductivity of the layer. The HELP program uses location-specific weather data to determine the amount of precipitation and evaporation expected to calculate the amount of infiltration through the cover system. The conceptual engineered cap is expected to be comprised of the following, from top to bottom:

- 2 feet vegetative cover soil;
- Geocomposite (nonwoven geotextile heat bonded to both sides of a geonet);
- 60-mil high-density polyethylene (HDPE) geomembrane, textured on both sides; and
- Geosynthetic clay liner (GCL) (optional).

The conceptual monofill geometry assumes the top deck of the treated soil will be constructed to a maximum height of approximately 40 feet above the existing ground surface at a 3 percent grade with 3:1(H:V) side slopes at an average height of 20 feet above the existing ground surface. The model assumes the treated soil is underlain by the crushed rock overburden without a base liner system.

3.3.2 Results

The HELP program analysis estimates average annual and peak daily values for precipitation, runoff, evapotranspiration, lateral drainage, percolation/leakage, and change in water storage on a per-acre basis. Two different conceptual cap systems were analyzed using the HELP model; 1) a single liner system consisting of (from top to bottom) vegetative cover soil, a geocomposite drainage layer, and a geomembrane barrier layer; and 2) a composite liner system consisting of (from top to bottom) vegetative cover soil, a geocomposite drainage layer, a geomembrane barrier, and a GCL. Each cap system was evaluated for both the conceptual top deck (i.e. 3% grade) and side slope (i.e. 3H:1V grade) configurations.

Using site-specific geotechnical and hydrological data, the HELP model estimates the volume of water expected to percolate through the cap and treated soil into groundwater. The volume of water expected to infiltrate into the groundwater for the four conditions evaluated are presented in the following table:

Table 1: HELP Modeling Results

Case Analyzed	Average Annual Infiltration into Bedrock (gallons/year/acre)
Top Deck - No GCL	280.0
Top Deck - GCL	0.6
Side Slope - No GCL	22.9
Top Deck - GCL	0.0

3.4 Soil Treatment

Waste generated at the Wrangell Junkyard was determined to have elevated concentrations of lead in surface soils on-site and in areas downgradient of the Wrangell Junkyard. In order to reduce the risk posed to human health and the environment, remedial action was performed in early 2016. Approximately 18,350 cubic yards of soil impacted with lead was excavated and treated with ECOBOND®. ECOBOND® reduces the solubility and leaching potential of the lead and retains the lead within the soil matrix. TCLP and SPLP testing performed on the treated soil confirmed lead is not leaching from the treated soil and the soil is not classified as a hazardous waste (NRC Alaska and Nortech, 2016). The leaching potential for metals other than lead were not evaluated.

4.0 CONCLUSIONS AND RECOMMENDATIONS

During the geotechnical and hydrological investigation at the site, Ahtna advanced three exploratory borings from 29 November to 3 December 2016. The purpose of the investigation was to characterize the subsurface, collect background concentrations of metals from the groundwater, and determine the depth to groundwater. The borings were advanced to depths ranging from approximately 6 ft bgs to 34 ft bgs. The explorations indicate the subsurface of the site is comprised of crushed rock overburden underlain by fractured bedrock. The overburden was encountered from approximately 1 to 10 ft bgs, and groundwater was observed within the overburden and fractured rock. Initial groundwater measurements indicate groundwater depths of approximately 2.5 to 3.2 ft bgs in monitoring wells P-01, MW-02, and MW-03. Due to the screening intervals occurring within both overburden and fractured bedrock and consistent groundwater elevations between the three monitor wells, the groundwater observed in P-01 appears to be hydraulically connected to the groundwater observed in MW-02 and MW-03 and not perched on top of bedrock however a pumping test is required to confirm. The groundwater flows northeast toward Pat Creek Road with a gradient of 0.0077 ft/ft, or 0.77%.

In accordance with AAC 60.217, a new unlined landfill must have at least 10 feet of separation between the highest measured level of an aquifer of resource value and the bottom of waste unless the landfill is constructed two feet or more above the natural ground surface. Due to the shallow depth of groundwater, the construction of a foundation layer between the unlined surface and treated soil would be required to adequately separate the treated soil from the groundwater. The groundwater measurements taken and reported herein do not consider seasonal effects and may not represent the highest groundwater elevation. In the event this site is selected as a disposal site for the monofill, future groundwater measurements should be taken to determine seasonal groundwater elevations.

Treatment of the soil with ECOBOND® and encapsulation will minimize the potential for exposure to the environment. Treatment with ECOBOND® reduces the solubility of lead and retains the lead within the soil matrix. TCLP and SPLP confirmation laboratory testing on the treated soil confirmed lead does not leach from the treated soil and that the treated material is not hazardous (NRC Alaska and Nortech, 2016).

Modeling of infiltration volumes through the landfill cap indicates that the amount of leachate expected to percolate through the treated soil to groundwater is dependent on the cap design. The use of a single liner cap consisting of (from top to bottom) vegetative cover soil, a geocomposite drainage layer, and a geomembrane barrier could result in infiltration of up to 280 gallons per acre per year. A composite liner system consisting of (from top to bottom) vegetative cover soil, a geocomposite drainage layer, a geomembrane barrier, and a GCL is expected to infiltrate less than 1 gallon per acre per year. Leachate generated from infiltration through the cap is not expected to contain lead from the treated soil because of the ECOBOND treatment. Therefore, the leachate generated from the treated soil repository is not anticipated to be a public health concern for lead. This analysis did not evaluate other metals that could be present in the impacted soil.

The results and design discussed herein are conceptual. Long term performance of the monofill will be dependent on detailed design for specific materials to achieve the goals of the project in a cost effective, low maintenance manner. Final design will include slope stability evaluations, surface water management design, cap drainage layer design, settlement analysis, geosynthetic barrier layer material selection, grading and other relevant analyses and recommendations.

5.0 REFERENCES

Ahtna Engineering Services, LLC (Ahtna), 2016. *Wrangell Monofill Draft Geotechnical and Hydrological Investigation Workplan,* November.

NRC Alaska and Nortech, 2016. *Remedial Action Report, Wrangell Junkyard, Alaska*, Prepared for the State of Alaska Department of Environmental Conservation, Division of Spill Response. September.

United States Environmental Protection Agency (USEPA), 1997 *Hydrologic Evaluation of Landfill Performance (HELP) Model,* Version 3.07.

United States Geologic Survey (USGS), 2017. *National Geologic Map Database,* United States Department of the Interior. https://ngmdb.usgs.gov/ngmdb/ngmdb_home.html

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FIGURES

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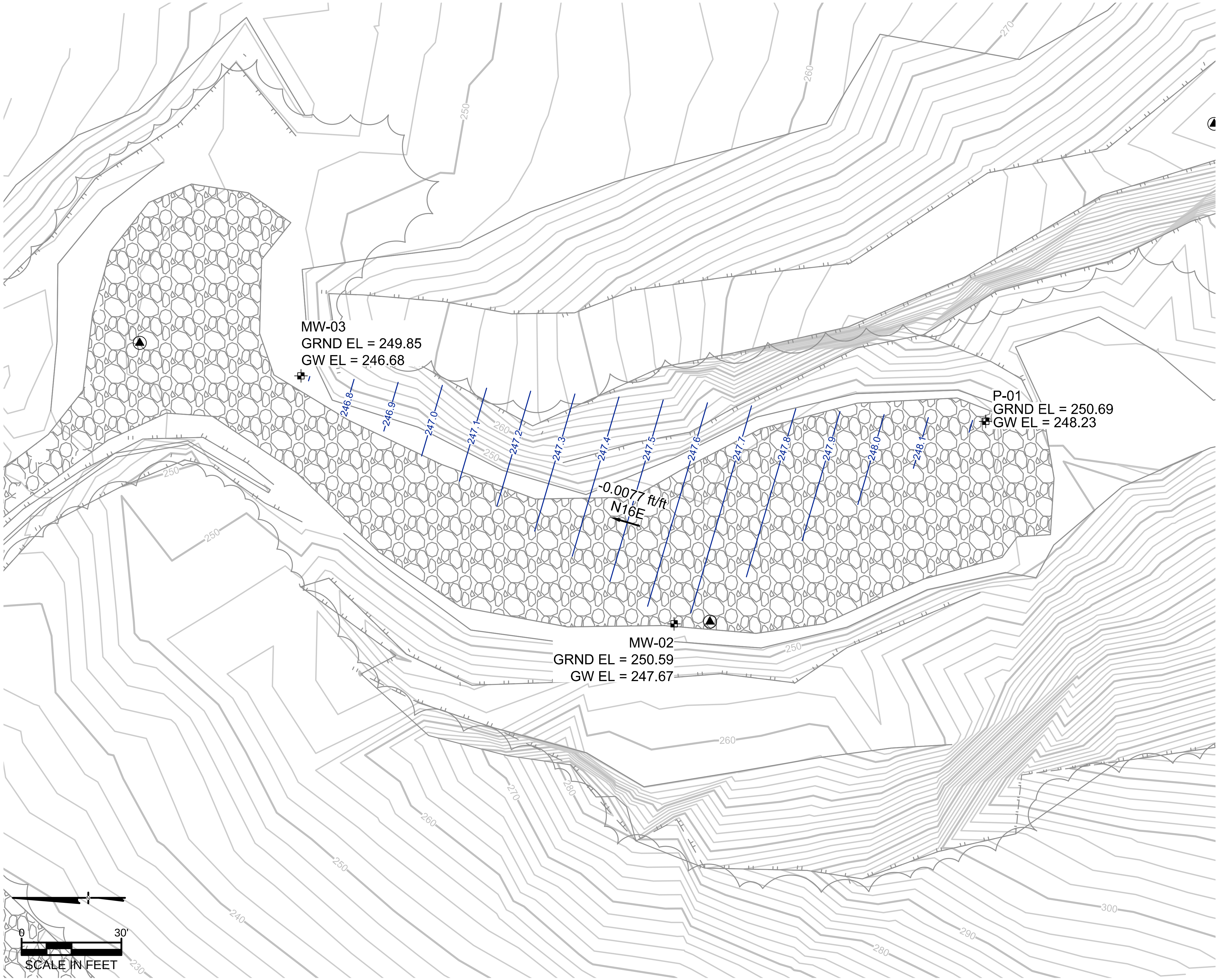
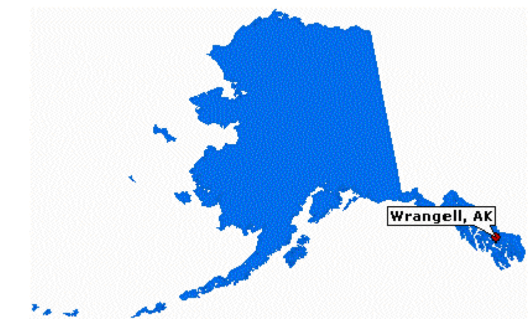


VICINITY MAP



LOCATION MAP

LEGEND

300	EXISTING GROUND MAJOR CONTOURS (5')
	EXISTING GROUND MINOR CONTOURS (1')
248.0	GROUNDWATER CONTOURS (0.1')
	GROUNDWATER WELL
	SURVEY CONTROL MONUMENT

NOTES

1. TOPOGRAPHIC SURVEY PERFORMED BY R&M ENGINEERING/PDC, INC. ENGINEERS ON OCTOBER 25 - 28, 2016.
2. THE HORIZONTAL DATUM FOR THIS SURVEY IS NORTH AMERICAN DATUM 1983, ALASKA STATE COORDINATE SYSTEM ZONE1 (NAD83 AK SPC Z1)[5001].
3. THE VERTICAL DATUM FOR THIS SURVEY IS NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88).

GROUNDWATER CONTOURS
WRANGELL MONOFILL
WRANGELL ISLAND, ALASKA

Geosyntec consultants

FIGURE 1

PROJECT NO: PNG0736 | JANUARY 2017

P:\PRJ\SDCADD\CADD\PNG0736 WRANGELL\C3D\WORKING SURFACES\GROUNDWATER

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APPENDIX A

BORING LOGS

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Ahtna Engineering

SOIL BORING LOG

PROJECT NUMBER:	BORING NUMBER:	SHEET:
20266022	AES16-TB01	1 of 2

Project Name	Wrangell MonoFill	Site	Pat Creek
Client	ADEC	Geologist	DuComB
Date	29-Nov-2016	Weather	Rain 40°F
Drilling Company	Discovery	Rig Type/ Drilling	6712DT/Rock Core
Boring Size	3.75"	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	~~35'~~ 19.3	Depth to GW	—
Northing/ Easting	—	Elevation	— 247.96

LOCATION SKETCH/EXTRA FIELD NOTES: N ↑
[surface condition, ie. Asphalt, grass]

See well Sheet

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
0					1300		gray, gravel Over Burden
0.8 (Run 1 Box 1)		5'	4.4				Gray-Dark Rock, Fractured
5.8 (Run 2 Box 1)		4'	3.7		1350 / 1430		gray, Dark, Rock
9.8 (Run 3 Box 1/ Box 2)		4.6 / 5	5.0' / 4.6		1500		gray, Dark, Rock * Measured Hole Run #2 was NOT A Full 4.0' TD@ 14.3'
~~13.5~~ 14.3 → Measured (Run 4 Box 2)		5	5		1530 / 1545 / 1615		Gray, Dark Rock Fewer Fractures
19.3							

SOIL BORING LOG

Ahtna Engineering

PROJECT NUMBER:	BORING NUMBER:	SHEET:
20266022	AES16-TB01	2 of 2

Project Name	Wrangell Monofill	Site	Pat Creek
Client	ADEC	Geologist	DuComB
Date	29-Nov-2016	Weather	Rain 40°F
Drilling Company	Discovery	Rig Type/ Drilling	6712DT/Rock core
Boring Size	3.75"	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	34'	Depth to GW	—
Northing/ Easting	—	Elevation	— 247.96

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]

N ↑

See well Sheet

Margin notes	DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
19.3	0					1615		
Run 5 Box 2/3	1		5'	4.7'				gray, Dark, more white veins, more frequent fracturing
24.3	2					1633		
Run 6 Box 3	3		4.9	5.0'				gray, Dark Fractures every 0.3-0.4' * >100% recovery
29.2	4					1724		* Vertical Fracturing Bottom Foot of interval
Run 7 Box 3/4	5							gray Dark, Fractured
34.2	6					1810		End of Boring
	7							
	8							
	9							

Ahtna Engineering	SOIL BORING LOG	PROJECT NUMBER: 20266.022	BORING NUMBER: AES16-TB02	SHEET: 1 of 1

Project Name	Wrangell Mono Fill	Site	Pat Creek
Client	ADEC	Geologist	Ducomb
Date	1-Dec-2016	Weather	Rain
Drilling Company	Discovery	Rig Type/ Drilling	6712DT / Auger
Boring Size	8" Auger	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	9.83'	Depth to GW	Surface
Northing/ Easting	—	Elevation	247.97

LOCATION SKETCH/EXTRA FIELD NOTES: [surface condition, ie. Asphalt, grass] N ↑

See well sheet

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES RECVED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
0–2							Crushed shot rock. 0.1-0.2' in size. Water just below ground surface in open hole. See photos
2–5							Assumed to be boulders up to 7" in size. A squared straight edge boulder is spit up by auger through smaller shot rock
5–9.83							↑ Same? Hole to 10' is cased w/ auger flights, refusal is hit @ ~10.0'. Drillers believe they are in competent rock and begin rock coring when POL contamination is pumped to surface.

Contamination POL (margin note, depths ~1–10')

Ahtna Engineering

SOIL BORING LOG

PROJECT NUMBER:	BORING NUMBER:	SHEET:
20266.022	AES16-~~MW03~~ TB	1 of 1

Project Name	Wrangell Monofill	Site	Pat Creek
Client	AOEC	Geologist	Ducomb
Date	2-Dec-2016	Weather	Rain
Drilling Company	Discovery	Rig Type/ Drilling	6712DT / Auger
Boring Size	8" Auger	Hammer Drop	—
Sample Method	—	# of Samples	—
Total Depth	6.3'	Depth to GW	~~3.17' BTOC~~ Below Surface
Northing/ Easting	—	Elevation	246.93'

LOCATION SKETCH/EXTRA FIELD NOTES: [surface condition, ie. Asphalt, grass] N

See well Sheet

DEPTH (FEET)	BLOWS/FT	INCHES DRIVEN	INCHES REC'VED	PID	TIME	USCS Classification	SOIL DESCRIPTION AND NOTES (color, major constituents/minor constituents [particle distribution and particle shape], density, plasticity, cohesiveness, moisture content, fracturing, weathering, depositional environment, stratigraphic unit)
0							
							Shot Rock
1							Augered to Bedrock Refusal
2							0.1 - 0.2' in size
3							POL Contamination in Groundwater
4							
5							
6							6.3' BGS Stop @ Refusal Bedrock
7							
8							
9							

APPENDIX B

WELL CONSTRUCTION LOGS

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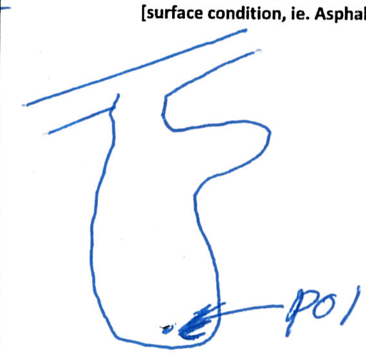
WELL CONSTRUCTION LOG

Ahtna Engineering

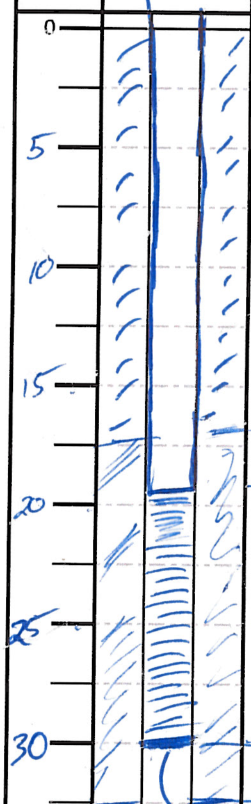
PROJECT NUMBER:	WELL NUMBER:	SHEET:
20266022	AES16-P01	1 of 1

PROJECT NAME	Wrangell Monofill	SITE	Rock Pit Pat Creek
CLIENT	ADEC	SCIENTIST	DuComb
DATE	2-Dec-2016	WEATHER	Rain 40°F
DRILLING COMPANY	Discovery	RIG TYPE	6712DT
BORING SIZE	3.75"	DRILLING METHOD	Rock Core / DHH
TOTAL DEPTH	32.30'	WELL TYPE	1" PVC
NORTHING	—	DEPTH TO GW	2.46'
EASTING	—	ELEVATION	250.69'

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]



DEPTH (FEET)	FIELD ILLUSTRATION	WELL INSTALLATION INFO	SOIL DESCRIPTION	WELL DATA
0–18.5		Bentonite 0-18.5'	See Soil Boring Log for AES16-TB01	Monument Type: Security Casing
		Sand		Surface Seal: Bentonite
		Screen		Stickup Height: 2.73'
		Sand		40 -inch Schedule PVC Well Casing
		Capped		Screened Interval: 19.6 - 29.6' BGS
				0.010 " Slotted Screen
				Other:



Ahtna Engineering

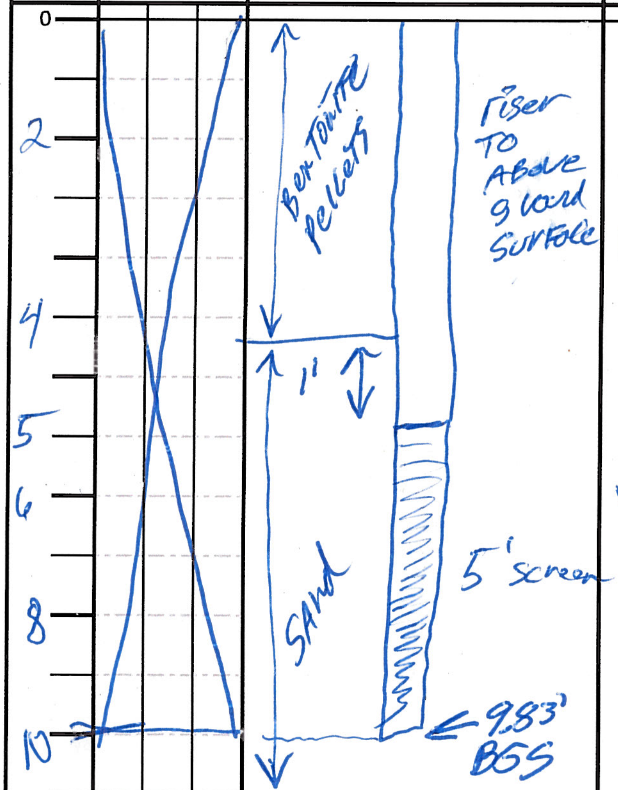
WELL CONSTRUCTION LOG

PROJECT NUMBER:	WELL NUMBER:	SHEET:
20266.022	16AES-MW02	1 of 1

PROJECT NAME	Wrangell Monofill	SITE	ROCK PIT
CLIENT	ADEC	SCIENTIST	DUCOMB
DATE	21-Dec-2016	WEATHER	RAIN
DRILLING COMPANY	DISCOVERY	RIG TYPE	6712 DT
BORING SIZE	Auger casing	DRILLING METHOD	Auger TO refusal
TOTAL DEPTH	10'	WELL TYPE	2"
NORTHING	—	DEPTH TO GW	2.92'
EASTING	—	ELEVATION	250.59'

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]

DEPTH (FEET)	FIELD ILLUSTRATION	WELL INSTALLATION INFO	SOIL DESCRIPTION	WELL DATA



Soil description: See AES16-TB02 core FORM
* HIT CONTAMINATION POL

Monument Type: Security Casing

Surface Seal: Bentonite

Stickup Height: 2.62'

40 -inch Schedule PVC Well Casing

Screened Interval: 5-10' BGS

0.010" Slotted Screen

Other:

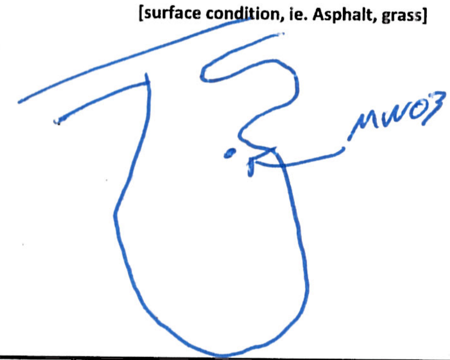
Ahtna Engineering

WELL CONSTRUCTION LOG

PROJECT NUMBER:	WELL NUMBER:	SHEET:
20266.022	16 AES-MW03	1 of 1

PROJECT NAME	Wrangel Mono Fill	SITE	ROCK PIT
CLIENT	ADEC	SCIENTIST	DeComB
DATE	2-Dec-2016	WEATHER	Rain
DRILLING COMPANY	Discovery	RIG TYPE	6712 DT
BORING SIZE	Auger Casing	DRILLING METHOD	Auger To Refusal
TOTAL DEPTH	5'	WELL TYPE	2"
NORTHING	—	DEPTH TO GW	3.17'
EASTING	—	ELEVATION	249.85

LOCATION SKETCH/EXTRA FIELD NOTES:
[surface condition, ie. Asphalt, grass]



DEPTH (FEET)	FIELD ILLUSTRATION	WELL INSTALLATION INFO	SOIL DESCRIPTION
0		Bentonite; Riser to above ground surface	AES16-TB01 core
1			See form
2		3' screen	* HIT contamination POL
3			
4			
5		Sand; 6.31' BGS	Bed rock Refusal

WELL DATA

Monument Type: Security casing

Surface Seal: Bentonite

Stickup Height: 2.92'

40 -inch Schedule PVC Well Casing

Screened Interval: 2-5' BGS

0.010 " Slotted Screen

Other:

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APPENDIX C

GROUNDWATER SAMPLING RESULTS

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SGS

Laboratory Report of Analysis

To: Ahtna Engineering Svs
110 West 38th Avenue Suite 200A
Anchorage, AK 99503
(907)433-0725

Report Number: **1167058**

Client Project: **Wrangell Monofill Pat Creek**

Dear Emily Freitas,

Enclosed are the results of the analytical services performed under the referenced project for the received samples and associated QC as applicable. The samples are certified to meet the requirements of the National Environmental Laboratory Accreditation Conference Standards. Copies of this report and supporting data will be retained in our files for a period of ten years in the event they are required for future reference. All results are intended to be used in their entirety and SGS is not responsible for use of less than the complete report. Any samples submitted to our laboratory will be retained for a maximum of fourteen (14) days from the date of this report unless other archiving requirements were included in the quote.

If there are any questions about the report or services performed during this project, please call Justin at (907) 562-2343. We will be happy to answer any questions or concerns which you may have.

Thank you for using SGS North America Inc. for your analytical services. We look forward to working with you again on any additional analytical needs.

Sincerely,
SGS North America Inc.

SGS North America Inc.
Environmental Services – Alaska Division
Project Manager

Justin Nelson
2016.12.29
07:59:53 -09'00'

Justin Nelson — Date
Project Manager
Justin.Nelson@sgs.com

Case Narrative

SGS Client: **Ahtna Engineering Svs**
SGS Project: **1167058**
Project Name/Site: **Wrangell Monofill Pat Creek**
Project Contact: **Emily Freitas**

Refer to sample receipt form for information on sample condition.

1167252005(1368718MS) (1368719) MS

6020A - Metals MS recoveries for multiple analytes do not meet QC criteria. The post digestion spike was successful.

1167252005(1368718MSD) (1368720) MSD

6020A - Metals MSD recoveries for multiple analytes do not meet QC criteria. The post digestion spike was successful.

*QC comments may be associated with the field samples found in this report. When applicable, comments will be applied to associated field samples.

SGS North America Inc.
200 West Potter Drive, Anchorage, AK 99518
t 907.562.2343 f 907.561.5301 www.us.sgs.com
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Laboratory Qualifiers

Enclosed are the analytical results associated with the above work order. All results are intended to be used in their entirety and SGS is not responsible for use of less than the complete report. This document is issued by the Company under its General Conditions of Service accessible at <http://www.sgs.com/en/Terms-and-Conditions.aspx>. Attention is drawn to the limitation of liability, indenmification and jurisdiction issues defined therein.

Any holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Any unauthorized alteration, forgery or falsification of the context or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.

SGS maintains a formal Quality Assurance/Quality Control (QA/QC) program. A copy of our Quality Assurance Plan (QAP), which outlines this program, is available at your request. The laboratory certification numbers are AK00971 (DW Chemistry & Microbiology) & UST-005 (CS) for ADEC and 2944.01 for DOD ELAP/ISO17025 (RCRA methods: 1020B, 1311, 3010A, 3050B, 3520C, 3550C, 5030B, 5035A, 6020A, 7470A, 7471B, 8015C, 8021B, 8082A, 8260C, 8270D, 8270D-SIM, 9040C, 9045D, 9056A, 9060A, AK101 and AK102/103). Except as specifically noted, all statements and data in this report are in conformance to the provisions set forth by the SGS QAP and, when applicable, other regulatory authorities.

The following descriptors or qualifiers may be found in your report:

*	The analyte has exceeded allowable regulatory or control limits.
!	Surrogate out of control limits.
B	Indicates the analyte is found in a blank associated with the sample.
CCV/CVA/CVB	Continuing Calibration Verification
CCCV/CVC/CVCA/CVCB	Closing Continuing Calibration Verification
CL	Control Limit
DF	Dilution Factor
DL	Detection Limit (i.e., maximum method detection limit)
E	The analyte result is above the calibrated range.
GT	Greater Than
IB	Instrument Blank
ICV	Initial Calibration Verification
J	The quantitation is an estimation.
LCS(D)	Laboratory Control Spike (Duplicate)
LLQC/LLIQC	Low Level Quantitation Check
LOD	Limit of Detection (i.e., 1/2 of the LOQ)
LOQ	Limit of Quantitation (i.e., reporting or practical quantitation limit)
LT	Less Than
MB	Method Blank
MS(D)	Matrix Spike (Duplicate)
ND	Indicates the analyte is not detected.
RPD	Relative Percent Difference
U	Indicates the analyte was analyzed for but not detected.

Note: Sample summaries which include a result for "Total Solids" have already been adjusted for moisture content.
All DRO/RRO analyses are integrated per SOP.

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Sample Summary

Client Sample ID	Lab Sample ID	Collected	Received	Matrix
16-WMF-P01-01	1167058001	12/03/2016	12/05/2016	Water (Surface, Eff., Ground)
16-WMF-P10-02	1167058002	12/03/2016	12/05/2016	Water (Surface, Eff., Ground)

Method	Method Description
SW6020A	Metals by ICP-MS

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Detectable Results Summary

Client Sample ID: **16-WMF-P01-01**
Lab Sample ID: 1167058001
Metals by ICP/MS

Parameter	Result	Units
Aluminum	6210	ug/L
Barium	49.0	ug/L
Calcium	55400	ug/L
Chromium	7.44	ug/L
Cobalt	3.02	ug/L
Iron	4750	ug/L
Lead	0.749J	ug/L
Magnesium	3640	ug/L
Manganese	277	ug/L
Molybdenum	2.55J	ug/L
Nickel	7.53	ug/L
Potassium	3560	ug/L
Sodium	3820	ug/L
Vanadium	13.4J	ug/L
Zinc	19.6J	ug/L

Client Sample ID: **16-WMF-P10-02**
Lab Sample ID: 1167058002
Metals by ICP/MS

Parameter	Result	Units
Aluminum	5660	ug/L
Barium	50.6	ug/L
Calcium	58400	ug/L
Chromium	7.03	ug/L
Cobalt	3.04	ug/L
Copper	1.90J	ug/L
Iron	4970	ug/L
Lead	0.838J	ug/L
Magnesium	3680	ug/L
Manganese	275	ug/L
Molybdenum	2.74J	ug/L
Nickel	7.54	ug/L
Potassium	3710	ug/L
Sodium	3940	ug/L
Vanadium	15.3J	ug/L
Zinc	21.6J	ug/L

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Results of **16-WMF-P01-01**

Client Sample ID: **16-WMF-P01-01**
Client Project ID: **Wrangell Monofill Pat Creek**
Lab Sample ID: 1167058001
Lab Project ID: 1167058

Collection Date: 12/03/16 13:30
Received Date: 12/05/16 13:27
Matrix: Water (Surface, Eff., Ground)
Solids (%):
Location:

Results by **Metals by ICP/MS**

Parameter	Result Qual	LOQ/CL	DL	Units	DF	Allowable Limits	Date Analyzed
Aluminum	6210	1000	310	ug/L	25		12/21/16 14:22
Antimony	1.50 U	3.00	0.940	ug/L	5		12/21/16 11:01
Arsenic	2.50 U	5.00	1.50	ug/L	5		12/21/16 11:01
Barium	49.0	3.00	0.940	ug/L	5		12/21/16 11:01
Beryllium	0.500 U	1.00	0.310	ug/L	5		12/21/16 11:01
Boron	100 U	200	62.0	ug/L	5		12/21/16 11:01
Cadmium	1.00 U	2.00	0.620	ug/L	5		12/21/16 11:01
Calcium	55400	2500	750	ug/L	25		12/21/16 14:22
Chromium	7.44	4.00	1.30	ug/L	5		12/21/16 11:01
Cobalt	3.02	1.00	0.310	ug/L	5		12/21/16 11:01
Copper	3.00 U	6.00	1.80	ug/L	5		12/21/16 11:01
Iron	4750	500	150	ug/L	5		12/21/16 11:01
Lead	0.749 J	1.00	0.310	ug/L	5		12/21/16 11:01
Magnesium	3640	500	150	ug/L	5		12/21/16 11:01
Manganese	277	2.00	0.620	ug/L	5		12/21/16 11:01
Molybdenum	2.55 J	5.00	1.50	ug/L	5		12/21/16 11:01
Nickel	7.53	2.00	0.620	ug/L	5		12/21/16 11:01
Potassium	3560	1000	310	ug/L	5		12/21/16 11:01
Selenium	10.0 U	20.0	6.20	ug/L	5		12/21/16 11:01
Silver	1.00 U	2.00	0.620	ug/L	5		12/21/16 11:01
Sodium	3820	1000	310	ug/L	5		12/21/16 11:01
Thallium	1.00 U	2.00	0.620	ug/L	5		12/21/16 11:01
Vanadium	13.4 J	20.0	6.20	ug/L	5		12/21/16 11:01
Zinc	19.6 J	25.0	7.80	ug/L	5		12/21/16 11:01

Batch Information

Analytical Batch: MMS9650
Analytical Method: SW6020A
Analyst: VDL
Analytical Date/Time: 12/21/16 11:01
Container ID: 1167058001-A

Prep Batch: MXX30402
Prep Method: SW3010A
Prep Date/Time: 12/20/16 08:35
Prep Initial Wt./Vol.: 25 mL
Prep Extract Vol: 25 mL

Analytical Batch: MMS9650
Analytical Method: SW6020A
Analyst: VDL
Analytical Date/Time: 12/21/16 14:22
Container ID: 1167058001-A

Prep Batch: MXX30402
Prep Method: SW3010A
Prep Date/Time: 12/20/16 08:35
Prep Initial Wt./Vol.: 25 mL
Prep Extract Vol: 25 mL

Results of **16-WMF-P10-02**

Client Sample ID: **16-WMF-P10-02**
Client Project ID: **Wrangell Monofill Pat Creek**
Lab Sample ID: 1167058002
Lab Project ID: 1167058

Collection Date: 12/03/16 13:35
Received Date: 12/05/16 13:27
Matrix: Water (Surface, Eff., Ground)
Solids (%):
Location:

Results by **Metals by ICP/MS**

Parameter	Result Qual	LOQ/CL	DL	Units	DF	Allowable Limits	Date Analyzed
Aluminum	5660	1000	310	ug/L	25		12/21/16 14:26
Antimony	1.50 U	3.00	0.940	ug/L	5		12/21/16 11:14
Arsenic	2.50 U	5.00	1.50	ug/L	5		12/21/16 11:14
Barium	50.6	3.00	0.940	ug/L	5		12/21/16 11:14
Beryllium	0.500 U	1.00	0.310	ug/L	5		12/21/16 11:14
Boron	100 U	200	62.0	ug/L	5		12/21/16 11:14
Cadmium	1.00 U	2.00	0.620	ug/L	5		12/21/16 11:14
Calcium	58400	2500	750	ug/L	25		12/21/16 14:26
Chromium	7.03	4.00	1.30	ug/L	5		12/21/16 11:14
Cobalt	3.04	1.00	0.310	ug/L	5		12/21/16 11:14
Copper	1.90 J	6.00	1.80	ug/L	5		12/21/16 11:14
Iron	4970	500	150	ug/L	5		12/21/16 11:14
Lead	0.838 J	1.00	0.310	ug/L	5		12/21/16 11:14
Magnesium	3680	500	150	ug/L	5		12/21/16 11:14
Manganese	275	2.00	0.620	ug/L	5		12/21/16 11:14
Molybdenum	2.74 J	5.00	1.50	ug/L	5		12/21/16 11:14
Nickel	7.54	2.00	0.620	ug/L	5		12/21/16 11:14
Potassium	3710	1000	310	ug/L	5		12/21/16 11:14
Selenium	10.0 U	20.0	6.20	ug/L	5		12/21/16 11:14
Silver	1.00 U	2.00	0.620	ug/L	5		12/21/16 11:14
Sodium	3940	1000	310	ug/L	5		12/21/16 11:14
Thallium	1.00 U	2.00	0.620	ug/L	5		12/21/16 11:14
Vanadium	15.3 J	20.0	6.20	ug/L	5		12/21/16 11:14
Zinc	21.6 J	25.0	7.80	ug/L	5		12/21/16 11:14

Batch Information

Analytical Batch: MMS9650
Analytical Method: SW6020A
Analyst: VDL
Analytical Date/Time: 12/21/16 11:14
Container ID: 1167058002-A

Prep Batch: MXX30402
Prep Method: SW3010A
Prep Date/Time: 12/20/16 08:35
Prep Initial Wt./Vol.: 25 mL
Prep Extract Vol: 25 mL

Analytical Batch: MMS9650
Analytical Method: SW6020A
Analyst: VDL
Analytical Date/Time: 12/21/16 14:26
Container ID: 1167058002-A

Prep Batch: MXX30402
Prep Method: SW3010A
Prep Date/Time: 12/20/16 08:35
Prep Initial Wt./Vol.: 25 mL
Prep Extract Vol: 25 mL

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Method Blank

Blank ID: MB for HBN 1751413 [MXX/30402]
Blank Lab ID: 1368716

Matrix: Water (Surface, Eff., Ground)

QC for Samples:
1167058001, 1167058002

Results by **SW6020A**

Parameter	Results	LOQ/CL	DL	Units
Aluminum	100U	200	62.0	ug/L
Antimony	1.50U	3.00	0.940	ug/L
Arsenic	2.50U	5.00	1.50	ug/L
Barium	1.50U	3.00	0.940	ug/L
Beryllium	0.500U	1.00	0.310	ug/L
Boron	100U	200	62.0	ug/L
Cadmium	1.00U	2.00	0.620	ug/L
Calcium	250U	500	150	ug/L
Chromium	2.00U	4.00	1.30	ug/L
Cobalt	0.500U	1.00	0.310	ug/L
Copper	3.00U	6.00	1.80	ug/L
Iron	250U	500	150	ug/L
Lead	0.500U	1.00	0.310	ug/L
Magnesium	250U	500	150	ug/L
Manganese	1.00U	2.00	0.620	ug/L
Molybdenum	2.50U	5.00	1.50	ug/L
Nickel	1.00U	2.00	0.620	ug/L
Potassium	500U	1000	310	ug/L
Selenium	10.0U	20.0	6.20	ug/L
Silver	1.00U	2.00	0.620	ug/L
Sodium	500U	1000	310	ug/L
Thallium	1.00U	2.00	0.620	ug/L
Vanadium	10.0U	20.0	6.20	ug/L
Zinc	12.5U	25.0	7.80	ug/L

Batch Information

Analytical Batch: MMS9650
Analytical Method: SW6020A
Instrument: Perkin Elmer Nexlon P5
Analyst: VDL
Analytical Date/Time: 12/21/2016 10:21:10AM

Prep Batch: MXX30402
Prep Method: SW3010A
Prep Date/Time: 12/20/2016 8:35:56AM
Prep Initial Wt./Vol.: 25 mL
Prep Extract Vol: 25 mL

SGS

Blank Spike Summary

Blank Spike ID: LCS for HBN 1167058 [MXX30402]
Blank Spike Lab ID: 1368717
Date Analyzed: 12/21/2016 10:25

Matrix: Water (Surface, Eff., Ground)

QC for Samples: 1167058001, 1167058002

Results by SW6020A

Parameter	Blank Spike (ug/L) Spike	Result	Rec (%)	CL
Aluminum	800	805	101	(84-117)
Antimony	800	812	102	(85-117)
Arsenic	800	778	97	(84-116)
Barium	800	812	101	(86-114)
Beryllium	80	84.6	106	(83-121)
Boron	800	831	104	(73-130)
Cadmium	80	83.2	104	(87-115)
Calcium	8000	8460	106	(87-118)
Chromium	320	306	96	(85-116)
Cobalt	400	394	99	(86-115)
Copper	800	806	101	(85-118)
Iron	4000	3990	100	(87-118)
Lead	800	857	107	(88-115)
Magnesium	8000	8320	104	(83-118)
Manganese	400	387	97	(87-115)
Molybdenum	320	314	98	(83-115)
Nickel	800	790	99	(85-117)
Potassium	8000	8000	100	(87-115)
Selenium	800	773	97	(80-120)
Silver	80	84.5	106	(85-116)
Sodium	8000	8450	106	(85-117)
Thallium	8	8.45	106	(82-116)
Vanadium	160	152	95	(86-115)
Zinc	800	778	97	(83-119)

Batch Information

Analytical Batch: **MMS9650**
Analytical Method: **SW6020A**
Instrument: **Perkin Elmer Nexlon P5**
Analyst: **VDL**

Prep Batch: **MXX30402**
Prep Method: **SW3010A**
Prep Date/Time: **12/20/2016 08:35**
Spike Init Wt./Vol.: 800 ug/L Extract Vol: 25 mL
Dupe Init Wt./Vol.: Extract Vol:

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Matrix Spike Summary

Original Sample ID: 1368718
MS Sample ID: 1368719 MS
MSD Sample ID: 1368720 MSD

QC for Samples: 1167058001, 1167058002

Analysis Date: 12/21/2016 10:30
Analysis Date: 12/21/2016 10:34
Analysis Date: 12/21/2016 10:39
Matrix: Water (Surface, Eff., Ground)

Results by **SW6020A**

		Matrix Spike (ug/L)				Spike Duplicate (ug/L)						
Parameter	Sample	Spike	Result	Rec (%)		Spike	Result	Rec (%)		CL	RPD (%)	RPD CL
Aluminum	100U	800	1010	126	*	800	1000	125	*	84-117	0.77	(< 20)
Antimony	3.13	800	961	120	*	800	908	113		85-117	5.64	(< 20)
Arsenic	9.30	800	963	119	*	800	919	114		84-116	4.67	(< 20)
Barium	12.4	800	981	121	*	800	944	116	*	86-114	3.77	(< 20)
Beryllium	0.500U	80.0	90.9	114		80.0	86.8	109		83-121	4.56	(< 20)
Boron	1530	800	2360	103		800	2280	93		73-130	3.40	(< 20)
Cadmium	1.00U	80.0	94.3	118	*	80.0	88.4	110		87-115	6.51	(< 20)
Calcium	135000	8000	138000	39	*	8000	135000	-10	*	87-118	2.87	(< 20)
Chromium	7.78	320	355	108		320	347	106		85-116	2.14	(< 20)
Cobalt	4.56	400	454	112		400	445	110		86-115	2.08	(< 20)
Copper	9.90	800	888	110		800	872	108		85-118	1.83	(< 20)
Iron	6920	4000	11100	104		4000	11800	121	*	87-118	6.20	(< 20)
Lead	0.505J	800	957	120	*	800	908	113		88-115	5.23	(< 20)
Magnesium	38100	8000	46400	104		8000	45100	88		83-118	2.90	(< 20)
Manganese	666	400	1080	104		400	1060	98		87-115	2.49	(< 20)
Molybdenum	2.60J	320	381	118	*	320	368	114		83-115	3.33	(< 20)
Nickel	24.3	800	894	109		800	903	110		85-117	0.98	(< 20)
Potassium	96000	8000	103000	82	*	8000	100000	55	*	87-115	2.15	(< 20)
Selenium	10.0U	800	917	115		800	882	110		80-120	3.86	(< 20)
Silver	1.00U	80.0	56.7	71	*	80.0	61.0	76	*	85-116	7.28	(< 20)
Sodium	330000	8000	322000	-97	*	8000	324000	-73	*	85-117	0.59	(< 20)
Thallium	1.00U	8.00	9.3	116		8.00	8.75	109		82-116	6.13	(< 20)
Vanadium	10.0U	160	188	118	*	160	181	113		86-115	3.91	(< 20)
Zinc	34.0	800	932	112		800	897	108		83-119	3.85	(< 20)

Batch Information

Analytical Batch: MMS9650
Analytical Method: SW6020A
Instrument: Perkin Elmer NexIon P5
Analyst: VDL
Analytical Date/Time: 12/21/2016 10:34:37AM

Prep Batch: MXX30402
Prep Method: 3010 H20 Digest for Metals ICP-MS
Prep Date/Time: 12/20/2016 8:35:56AM
Prep Initial Wt./Vol.: 25.00mL
Prep Extract Vol: 25.00mL

Print Date: 12/28/2016 8:39:10AM

Bench Spike Summary

Original Sample ID: 1368718
MS Sample ID: 1368721 BND
MSD Sample ID:

Analysis Date: 12/21/2016 10:30
Analysis Date: 12/21/2016 10:43
Analysis Date:
Matrix: Water (Surface, Eff., Ground)

QC for Samples: 1167058001, 1167058002

Results by **SW6020A**

		Matrix Spike (ug/L)			Spike Duplicate (ug/L)					
Parameter	Sample	Spike	Result	Rec (%)	Spike	Result	Rec (%)	CL	RPD (%)	RPD CL
Aluminum	100U	1250	1320	106				80-120		
Antimony	3.13	1250	1180	94				80-120		
Arsenic	9.30	125	135	100				80-120		
Barium	12.4	2500	2550	101				80-120		
Cadmium	1.00U	1250	1190	95				80-120		
Iron	6920	25000	30400	94				80-120		
Lead	0.505J	1250	1190	95				80-120		
Molybdenum	2.60J	250	251	99				80-120		
Silver	1.00U	25.0	24.7	99				80-120		
Vanadium	10.0U	1250	1210	97				80-120		

Batch Information

Analytical Batch: MMS9650
Analytical Method: SW6020A
Instrument: Perkin Elmer Nexlon P5
Analyst: VDL
Analytical Date/Time: 12/21/2016 10:43:36AM

Prep Batch: MXX30402
Prep Method: 3010 H20 Digest for Metals ICP-MS
Prep Date/Time: 12/20/2016 8:35:56AM
Prep Initial Wt./Vol.: 25.00mL
Prep Extract Vol: 25.00mL

SGS North America Inc.
200 West Potter Drive Anchorage, AK 95518
t 907.562.2343 f 907.561.5301 www.us.sgs.com
Member of SGS Group

SGS

SGS Environmental Services Inc.
CHAIN OF CUSTODY RECORD

1167058

ıtionwide
Maryland
New York
Ohio

www.us.sgs.com

CLIENT: AHTNA Engineering Services		SGS Reference #:	page 1 of 1
CONTACT: Emily Freitas	PHONE NO: 646-2969		
PROJECT: Wrangell MonoFill	SITE/PWSID#: PAT Creek		
REPORTS TO: Emily Freitas	E-MAIL: EFreitas@AHTNA.Net		
INVOICE: AHTNA Engineering	QUOTE P.O. #: 20266.~~020~~022		

Preserv Used: HNO3

LAB NO.	SAMPLE IDENTIFICATION	DATE	TIME	MATRIX CODE	# CONTAINERS	SAMPLE TYPE C = COMP G = GRAB Multi Incremental Samples	Metals BY 6020	REMARKS/ LOC ID
①A	16-WMF-P01-01	3-Dec-16	1330	W	1	G	1	
②A	16-WMF-P10-02	3-Dec-16	1335	W	1	G	1	

	Date	Time	Received By:
Collected/Relinquished By: (1) Andrew DuComb	5-Dec-2016	1327	
Relinquished By: (2)	Date	Time	Received By:
Relinquished By: (3)	Date	Time	Received By:
Relinquished By: (4)	12/5/16	13:27	Received For Laboratory By:

DOD Project? NO YES

Special Deliverable Requirements:

Cooler ID

Requested Turnaround Time and-or Special Instructions: Standard TAT Scan Metals

Samples Received Cold? YES (NO) Chain of Custody Seal: (Circle) INTACT BROKEN (ABSENT)

Cooler (TB)

Temperature °C: 7.2 #03

Hand Delivered

❑ 200 W. Potter Drive Anchorage, AK 99518 Tel: (907) 562-2343 Fax: (907) 561-5301
❑ 5500 Business Drive Wilmington, NC 28405 Tel: (910) 350-1903 Fax: (910) `http://www.sgs.com/terms_and_conditions.htm

SGS

e-SAMPLE RECEIPT FORM

1167058

Review Criteria	Y/N (yes/no)	Exceptions Noted below
	Y	exemption permitted if sampler hand carries/delivers.
Were Custody Seals intact? Note # & location		ABSENT
COC accompanied samples?	Y	
	Y	**exemption permitted if chilled & collected <8hrs ago or chlling not required (i.e., waste, oil)
Temperature blank compliant* (i.e., 0-6 °C after CF)?	N	Cooler ID: 1 @ 7.2 °C Therm ID: D3
		Cooler ID: @ °C Therm ID:
		Cooler ID: @ °C Therm ID:
		Cooler ID: @ °C Therm ID:
		Cooler ID: @ °C Therm ID:
If >6°C, were samples collected <8 hours ago?	N	
If <0°C, were sample containers ice free?		
If samples received <u>without</u> a temperature blank, the "cooler temperature" will be documented in lieu of the temperature blank & "**COOLER TEMP**" will be noted to the right. In cases where neither a temp blank nor cooler temp can be obtained, note "ambient" or "chilled".		
Note: Identify containers received at non-compliant temperature . Use form FS-0029 if more space is needed.		
		Note: Refer to form F-083 "Sample Guide" for hold times.
Were samples received within hold time?	Y	
Do samples **match COC**** (i.e.,sample IDs,dates/times collected)?	Y	
**Note: If times differ <1hr, record details & login per COC.		
Were analyses requested unambiguous?	Y	
		***Exemption permitted for metals (e.g,200.8/6020A).
Were proper containers (type/mass/volume/preservative***)used?	Y	
IF APPLICABLE		
Were Trip Blanks (i.e., VOAs, LL-Hg) in cooler with samples?		
Were all VOA vials free of headspace (i.e., bubbles ≤ 6mm)?		
Were all soil VOAs field extracted with MeOH+BFB?		

Note to Client: Any "no" answer above indicates non-compliance with standard procedures and may impact data quality.

Additional notes (if applicable):

Sample Containers and Preservatives

Container Id	Preservative	Container Condition	Container Id	Preservative	Container Condition
1167058001-A	HNO3 to pH < 2	OK			
1167058002-A	HNO3 to pH < 2	OK			

Container Condition Glossary

Containers for bacteriological, low level mercury and VOA vials are not opened prior to analysis and will be assigned condition code OK unless evidence indicates than an inappropriate container was submitted.

OK - The container was received at an acceptable pH for the analysis requested.
BU - The container was received with headspace greater than 6mm.
DM- The container was received damaged.
FR- The container was received frozen and not usable for Bacteria or BOD analyses.
PA - The container was received outside of the acceptable pH for the analysis requested. Preservative was added upon receipt and the container is now at the correct pH. See the Sample Receipt Form for details on the amount and lot # of the preservative added.
PH - The container was received outside of the acceptable pH for the analysis requested. Preservative was added upon receipt, but was insufficient to bring the container to the correct pH for the analysis requested. See the Sample Receipt Form for details on the amount and lot # of the preservative added.

Laboratory Data Review Checklist

Completed by: Emily Freitas

Title: Chemist | Date: 01/11/2017

CS Report Name: Wrangell Monofill Pat Creek | Report Date: December 2016

Consultant Firm: Ahtna Engineering Services

Laboratory Name: SGS Environmental | Laboratory Report Number: 1167058

ADEC File Number: | ADEC RecKey Number:

1. Laboratory
   a. Did an ADEC CS approved laboratory receive and perform all of the submitted sample analyses?
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

      SGS is ADEC certified

   b. If the samples were transferred to another "network" laboratory or sub-contracted to an alternate laboratory, was the laboratory performing the analyses ADEC CS approved?
      ☐Yes ☐ No ☒NA (Please explain.) Comments:

      Samples were not transferred to an additional laboratory

2. Chain of Custody (COC)
   a. COC information completed, signed, and dated (including released/received by)?
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

   b. Correct analyses requested?
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

      Correct analyses were requested.

3. Laboratory Sample Receipt Documentation
   a. Sample/cooler temperature documented and within range at receipt (4° ± 2° C)?
      ☐Yes ☒ No ☐NA (Please explain.) Comments:

      Cooler was hand delivered and received at 7.2°C.

   b. Sample preservation acceptable – acidified waters, Methanol preserved VOC soil (GRO, BTEX, Volatile Chlorinated Solvents, etc.)?
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

      Sample was correctly preserved according to analyses requested.

c. Sample condition documented – broken, leaking (Methanol), zero headspace (VOC vials)?
☒Yes ☐ No ☐NA (Please explain.) Comments:

There were no discrepancies in sample condition upon receipt.

d. If there were any discrepancies, were they documented? For example, incorrect sample containers/preservation, sample temperature outside of acceptable range, insufficient or missing samples, etc.?
☐Yes ☐ No ☒NA (Please explain.) Comments:

There were no discrepancies with sample receipt conditions.

e. Data quality or usability affected? (Please explain.)
Comments:

Data usability or quality is not affected by the sample receipt conditions. No qualifications were made based on the sample receipt temperatures since only metals analyses were requested.

4. Case Narrative

a. Present and understandable?
☒Yes ☐ No ☐NA (Please explain.) Comments:

b. Discrepancies, errors or QC failures identified by the lab?
☒Yes ☐ No ☐NA (Please explain.) Comments:

c. Were all corrective actions documented?
☒Yes ☐ No ☐NA (Please explain.) Comments:

d. What is the effect on data quality/usability according to the case narrative?
Comments:

Data usability was not affected by the case narrative.

5. Samples Results

a. Correct analyses performed/reported as requested on COC?
☒Yes ☐ No ☐NA (Please explain.) Comments:

b. All applicable holding times met?
☒Yes ☐ No ☐NA (Please explain.) Comments:

c. All soils reported on a dry weight basis?
☐Yes ☐ No ☒NA (Please explain.) Comments:

There were no soil samples submitted for analysis.

d. Are the reported PQLs less than the Cleanup Level or the minimum required detection level for the project?
☒Yes ☐ No ☐NA (Please explain.) Comments:

e. Data quality or usability affected?
Comments:

Data quality and usability is not affected with respect to the reported sample results.

6. QC Samples
   a. Method Blank
      i. One method blank reported per matrix, analysis and 20 samples?
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

      ii. All method blank results less than PQL?
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

      iii. If above PQL, what samples are affected?
      Comments:

NA. All results were below PQL.

      iv. Do the affected sample(s) have data flags and if so, are the data flags clearly defined?
      ☐Yes ☐ No ☒NA (Please explain.) Comments:

      v. Data quality or usability affected? (Please explain.)
      Comments:

Data quality and usability was not affected with respect to the reported method blank results.

   b. Laboratory Control Sample/Duplicate (LCS/LCSD)

      i. Organics – One LCS/LCSD reported per matrix, analysis and 20 samples? (LCS/LCSD required per AK methods, LCS required per SW846)
      ☒Yes ☐ No ☐NA (Please explain.) Comments:

ii. Metals/Inorganics – one LCS and one sample duplicate reported per matrix, analysis and 20 samples?
☒Yes ☐ No ☐NA (Please explain.) Comments:

iii. Accuracy – All percent recoveries (%R) reported and within method or laboratory limits? And project specified DQOs, if applicable. (AK Petroleum methods: AK101 60%-120%, AK102 75%-125%, AK103 60%-120%; all other analyses see the laboratory QC pages)
☐Yes ☒ No ☐NA (Please explain.) Comments:

The % R for various analytes were outside of the recommended limits.

iv. Precision – All relative percent differences (RPD) reported and less than method or laboratory limits? And project specified DQOs, if applicable. RPD reported from LCS/LCSD, MS/MSD, and or sample/sample duplicate. (AK Petroleum methods 20%; all other analyses see the laboratory QC pages)
☒Yes ☐ No ☐NA (Please explain.) Comments:

v. If %R or RPD is outside of acceptable limits, what samples are affected?
Comments:

vi. Do the affected sample(s) have data flags? If so, are the data flags clearly defined?
☐Yes ☒ No ☐NA (Please explain.) Comments:

No data flags were necessary. Recovery errors are likely due to matrix effects. Additional quality controls samples provided enough infomration to verify the accuracy of the laboratory methods.

vii. Data quality or usability affected? (Use comment box to explain.)
Comments:

Data quality or usability is not affected with respect to the reported results.

c. Surrogates – Organics Only

i. Are surrogate recoveries reported for organic analyses – field, QC and laboratory samples?
☐Yes ☐ No ☒NA (Please explain.) Comments:

No samples were submitted for organic analyses.

ii. Accuracy – All percent recoveries (%R) reported and within method or laboratory limits? And project specified DQOs, if applicable. (AK Petroleum methods 50-150 %R; all other analyses see the laboratory report pages)
☐Yes ☐ No ☒NA (Please explain.) Comments:

iii. Do the sample results with failed surrogate recoveries have data flags? If so, are the data flags clearly defined?
☐Yes ☐ No ☒NA (Please explain.) Comments:

iv. Data quality or usability affected? (Use the comment box to explain.)
Comments:

d. Trip blank – Volatile analyses only (GRO, BTEX, Volatile Chlorinated Solvents, etc.): Water and Soil

i. One trip blank reported per matrix, analysis and for each cooler containing volatile samples? (If not, enter explanation below.)
☐Yes ☐ No ☒NA (Please explain.) Comments:

No samples were submitted for volatile analyses.

ii. Is the cooler used to transport the trip blank and VOA samples clearly indicated on the COC? (If not, a comment explaining why must be entered below)
☐Yes ☐ No ☒NA (Please explain.) Comments:

iii. All results less than PQL?
☐Yes ☐ No ☒NA (Please explain.) Comments:

iv. If above PQL, what samples are affected?
Comments:

v. Data quality or usability affected? (Please explain.)
Comments:

e. Field Duplicate

i. One field duplicate submitted per matrix, analysis and 10 project samples?
☒Yes ☐ No ☐NA (Please explain.) Comments:

Primary 16-WMF-P01-01 was submitted with duplicate 16-WMF-P10-02.

ii. Submitted blind to lab?

☒Yes ☐ No ☐NA (Please explain.) Comments:

iii. Precision – All relative percent differences (RPD) less than specified DQOs? (Recommended: 30% water, 50% soil)

$$RPD (\%) = \text{Absolute value of: } \frac{(R_1-R_2)}{((R_1+R_2)/2)} \times 100$$

Where R_1 = Sample Concentration
R_2 = Field Duplicate Concentration

☒Yes ☐ No ☐NA (Please explain.) Comments:

iv. Data quality or usability affected? (Use the comment box to explain why or why not.)

Comments:

Data usability was not affected with respect to the reported field duplicate results.

f. Decontamination or Equipment Blank (If not used explain why).

☐Yes ☐ No ☒NA (Please explain.) Comments:

Disposable equipment was used so no equipment blanks were necessary

i. All results less than PQL?

☐Yes ☐ No ☒NA (Please explain.) Comments:

ii. If above PQL, what samples are affected?

Comments:

iii. Data quality or usability affected? (Please explain.)

Comments:

Data quality and usability is not affected

7. <u>Other Data Flags/Qualifiers (ACOE, AFCEE, Lab Specific, etc.)</u>
   a. Defined and appropriate?

All laboratory report related qualifiers have been defined in the data package and were not used in the report table.

☒Yes ☐ No ☐NA (Please explain.) Comments:

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APPENDIX D

HELP MODEL CALCULATION PACKAGE

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Geosyntec
consultants

COMPUTATION COVER SHEET

Client: **ADEC** Project: **Wrangell Monofill** Project No.: **PNG0736**

Title of Computations **COVER DRAINAGE DESIGN AND EVALUATION**

Computations by:	Signature	[signature]	1/27/17 Date
	Printed Name	Cory Russell	
	Title	Senior Staff Engineer	
Assumptions and Procedures Checked by: (peer reviewer)	Signature	[signature]	1/27/17 Date
	Printed Name	Keaton Botelho	
	Title	Senior Engineer	
Computations Checked by:	Signature	[signature]	1/27/17 Date
	Printed Name	Keaton Botelho	
	Title	Senior Engineer	
Computations backchecked by: (originator)	Signature	[signature]	1/27/~~16~~17 CR Date
	Printed Name	Cory Russell	
	Title	Senior Staff Engineer	
Approved by: (pm or designate)	Signature	[signature]	1/27/17 Date
	Printed Name	Gregory Corcoran	
	Title	Senior Principal Engineer	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Written by: C. Russell Date: 12/14/16 Reviewed by: K. Botelho Date: 1/25/17

Client: ADEC Project: Wrangell Monofill Project No.: PNG0736 Task: 03

COVER DRAINAGE DESIGN AND EVALUATION
WRANGELL MONOFILL
WRANGELL, ALASKA

1. OBJECTIVE

The Alaska Department of Environmental Conservation (ADEC) proposes to relocate treated lead impacted soil from the Wrangell Junkyard to a monofill proposed to be constructed at an abandoned rock pit owned by the Alaska Department of Natural Resources (ADNR) in Wrangell, Alaska. The objective of this calculation is to evaluate the ability of the proposed engineered cap system to minimize leakage through the monofill. The analysis evaluates the amount of water expected to percolate through assumed defects in the geomembrane component of the cap and into the waste mass.

The proposed cover system includes the following components from top to bottom (Figure 1):

- 2-foot cover soil;
- Geocomposite (assumed to be double sided);
- 60-mil high-density polyethylene (HDPE) geomembrane;
- Geosynthetic clay liner (GCL) (optional); and
- Prepared treated soil.

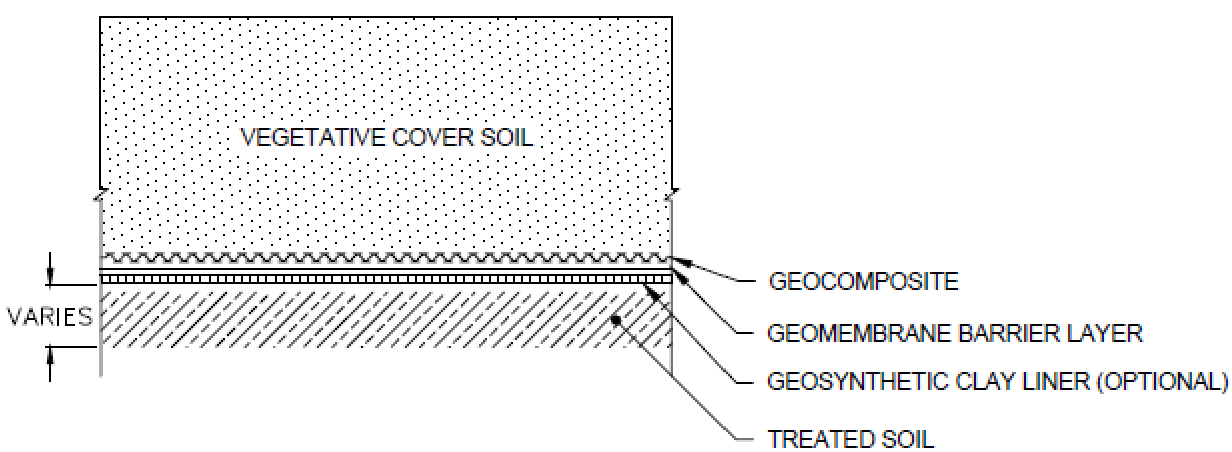

Figure 1: Proposed Liner System

The bottom of the monofill is proposed to be unlined, and underlain by crushed rock and fractured bedrock.

2. ANALYSIS

The amount of infiltration expected through the cover is estimated using the Hydrologic Evaluation of Landfill Performance (HELP) model, developed by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers. Using inputs such as geographic location, material properties, and liner configurations, the HELP program estimates the volume of infiltration expected to percolate through the conceptual engineered cap, through the waste mass, and into the groundwater.

3.1 Help Model Input Parameters

Input parameters needed to perform the HELP analyses include weather information, material-related properties, and landfill configuration properties. The cover system and assumed material properties used to evaluate infiltration through the cap are listed in Table 1.

Written by: **C. Russell** Date: **12/14/16** Reviewed by: **K. Botelho** Date: **1/25/17**

Client: **ADEC** Project: **Wrangell Monofill** Project No.: **PNG0736** Task: **03**

Table 1: HELP Model Input Parameters

Layer Description	Thickness	HELP Material Type	HELP Material Texture No.	Hydraulic Conductivity, k (cm/s)	Other
Cover Soil	24 inches	Vertical Percolation Layer	1	$1.0x10^{-2}$	Fair vegetation growth assumed
Geocomposite	0.20 inches	Lateral Drainage Layer	20	10	Assumed drainage length of 130 ft (top deck) and 120 ft (side slope)
HDPE Geomembrane	0.06 inches	Flexible Membrane Liner	35	$2.0x10^{-13}$	Good installation, 4 pinholes/ac; 1 hole/ac installation defects
Geosynthetic Clay Liner (GCL)	0.23 inches	Soil Barrier Layer	17	$3.0x10^{-9}$	Layer optional
Treated Soil (Side Slope)	20 feet (240 inches)	Vertical Percolation Layer	5	$1x10^{-3}$	Assumed to be half the height of the side slope
Treated Soil (Top Deck)	40 feet (480 inches)	Vertical Percolation Layer	5	$1x10^{-3}$	-
Crushed Rock	5.5 feet (66 inches)	Vertical Percolation Layer	21	$3.0x10^{-1}$	-

The monofill is assumed to be approximately 40 feet high plus a 2-foot thick soil cover. During the geotechnical investigation performed by Ahtna, bedrock was observed at depths of approximately 1, 6 and 10 ft below ground surface (ft bgs). For the purpose of the calculation, the depth to bedrock was modeled with an average depth of 5.5 feet below ground surface and overlain by crushed rock and gravel.

The weather information includes precipitation, temperature, and solar radiation. For the purpose of this calculation, precipitation and temperature data was generated for thirty years using monthly averages collected at the Wrangell Airport (NOAA, 2017). The

HELP model generates 30 years of data using a synthetic weather generator. The precipitation and temperature data is generated using statistical characteristics of the location chosen. Annette, Alaska was chosen for temperature generation, as this location is close in proximity to Wrangell, Alaska. Olympia, Washington was chosen for precipitation data generation, as Olympia has similar rainy seasons and trends in rainfall throughout the year. Solar radiation was calculated in the HELP program using a station latitude corresponding to the site of 56.35 degrees.

Runoff was allowed and was calculated by the HELP program using soil data, a surface slope of 3% for the top deck and 33% (3:1 horizontal:vertical) for the side slope, and a slope length of 130 feet for the top deck and 120 ft for the side slope. Vegetation growth was assumed to be fair to moderate.

3.3 Help Analysis Methodology

The base model assumption used in the HELP program to model landfill performance is:

$$I = P - (R + ET)$$

Where:

I = Infiltration through the top layer of the landfill (i.e., final cover)

P = Precipitation (i.e., rainfall)

R = surface runoff which includes interception by the ground cover and actual runoff

ET = evapotranspiration

The HELP program simulates daily liquid movement into, through, and out of a landfill. Precipitation infiltrating into a layer is either stored in the layer, removed by evapotranspiration, removed by lateral drainage (for layers specified as lateral drainage layers), or conveyed into lower layers. Factors affecting liquid movement include the initial moisture content of each layer, the storage available in each layer, the additional moisture that reaches the particular layer from the layer above it, and the hydraulic conductivity of the layer.

Conservatively, the vegetative soil component of the cover system was assumed to consist of a poorly graded sand, which conservatively allows for higher amounts of infiltration and higher hydraulic head on top of the geomembrane.

3.4 Help Analysis Output

The HELP program analysis estimates average annual and peak daily values for precipitation, runoff, evapotranspiration, lateral drainage, percolation/leakage, and change in water storage on a per-acre basis. The calculation analyzed the top deck and side slope with and without a GCL beneath the geomembrane. The results of the analysis for annual average infiltration are summarized below in Table 2. Peak values are presented in the output files (Attachment C).

Table 2: Analysis Results

Case Analyzed	Average Annual Infiltration into Groundwater (gal/year/acre)
Top Deck - No GCL	280.0
Top Deck - GCL	0.6
Side Slope - No GCL	22.9
Side Slope - GCL	0.0

Results indicate a maximum of approximately 280 gallons per year per acre (gal/year/acre) are expected to infiltrate through the waste mass and into the subsurface. The addition of a GCL to the cover system decreases the estimated infiltration to negligible amounts. Output files are provided in Attachment C.

Given an approximate top deck planar area of 0.38 acres and an approximate side slope planar area of 0.40 acres, the average annual infiltration beneath the monofill is estimated to be 0.3 gallons per year with a GCL and 116 gallons per year without a GCL.

3. CONCLUSION

The calculation provided herein for the proposed cover system at the Wrangell Monofill indicates a maximum average annual volume of approximately 280 gal/year/acre will infiltrate into groundwater at the site calculated using the HELP model. The 280 gal/year/acre is water that has infiltrated through the cover system, percolated through the treated waste, and seeped into groundwater. The HELP model indicates the addition of a GCL would minimize the infiltration to negligible amounts. This analysis is preliminary and for discussion purposes and components such as the geocomposite, geomembrane and soil cover will be optimized during final design.

Written by:	**C. Russell**	Date:	**12/14/16**	Reviewed by:	**K. Botelho**	Date:	**1/25/17**
Client:	**ADEC**	Project:	**Wrangell Monofill**	Project No.:	**PNG0736**	Task:	**03**

4. REFERENCES

Bachus, Narejo, Thiel, Soong and Li (2007), "The GSE Drainage Design Manual," 2nd edition. June 2007.

National Oceanic and Atmospheric Administration, "Data Tools: 1981-2010 Normals, Wrangell Airport, AK US". National Climatic Data Center.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3," EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

United States EPA (1997) "Hydrologic Evaluation of Landfill Performance (HELP) Model" Version 3.07.

ATTACHMENTS

Attachment A – Final Cover Grading Plan
Attachment B – NOAA Weather Data
Attachment C – HELP Output

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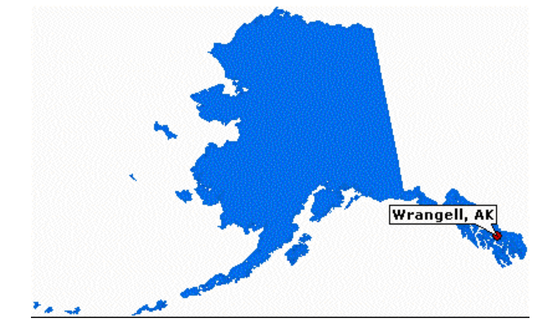
VICINITY MAP

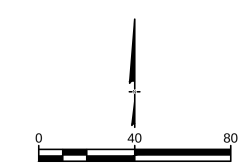


LOCATION MAP

LEGEND

NOTES

1. TOPOGRAPHIC CONTOUR DATA BASED ON ASTER GDEM v.2 (NASA AND METI, 2011).
2. GDEM VERTICAL ACCURACY IS APPROXIMATELY 55 FEET.
3. BASIS FOR HORIZONTAL COORDINATES IS WGS84 UTM, ZONE 8 NORTH.
4. BASIS FOR VERTICAL COORDINATES IS EGM 96 GEOID.
5. 2010 AERIAL IMAGERY PROVIDED BY MICROSOFT BING MAPS.
6. MAXIMUM HEIGHT EXPECTED TO BE APPROXIMATELY 38 FEET ABOVE GRADE.
7. APPROXIMATE SITE LIMITS TO BE CONFIRMED WITH SITE SURVEY EXPECTED TO BE PERFORMED AT THE END OF OCTOBER.



DATE PREPARED: 10-17-16	APPLICANTS NAME: ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROPOSED TREATED SOIL REPOSITORY
WRANGELL MONOFILL
WRANGELL ISLAND, ALASKA

SEC. (S): 4 TOWNSHIP 64S RANGE 84E MERIDIAN COPPER RIVER MERIDIAN

Geosyntec consultants

FIGURE 1

PROJECT NO: PNG0736 | OCTOBER 2016

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Geosyntec consultants

Attachment B
NOAA Weather Data

Data Tools: 1981-2010 Normals

The 1981-2010 Climate Normals are NCDC's latest three-decade averages of climatological variables, including temperature and precipitation. This new product replaces the 1971-2000 Climate Normals (http://hurricane.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select&subrnum=) product, which remains available as historical data.

The tool below provides temperature and precipitation Climate Normals for over 9,800 stations across the United States. Begin by selecting the desired dataset tab to view monthly, daily, annual/seasonal, or hourly Normals. Then select the desired location and a corresponding station.

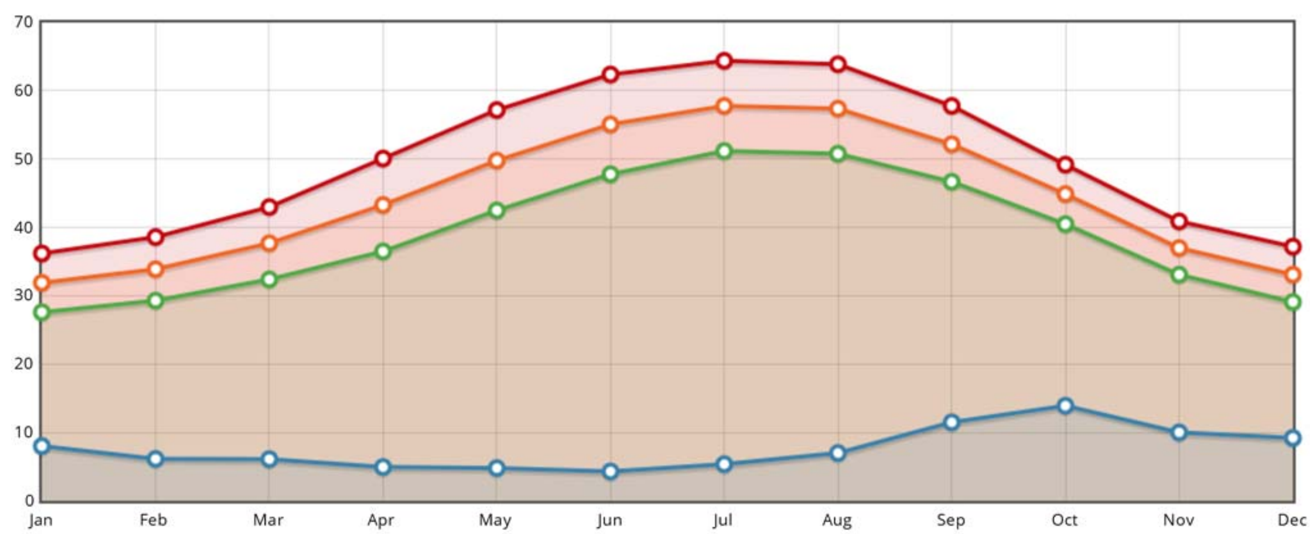
Monthly Normals | Daily Normals | Annual/Seasonal Normals | Hourly Normals

Use the form below to select the geographic region in the first pane, then select the station name in the next pane as the name list is populated.

US STATES	WALLY NOERENBERG HATCH, AK US
ALABAMA	WHITES CROSSING, AK US
ALASKA	WHITESTONE FARMS, AK US
ARIZONA	WHITTIER, AK US
ARKANSAS	WILLOW WEST, AK US
CALIFORNIA	WISEMAN, AK US
COLORADO	WOODSMOKE, AK US
CONNECTICUT	WRANGELL AIRPORT, AK US

WRANGELL AIRPORT, AK US

View Station Details (https://www.ncdc.noaa.gov/cdo-web/datasets/normal_mly/stations/GHCND:USC00509919/detail) | View Station Report



MONTH	PRECIP (IN)	MIN TMP (°F)	AVG TMP (°F)	MAX TMP (°F)
01	8.01	27.6	31.9	36.2
02	6.13	29.3	33.9	38.6
03	6.09	32.4	37.7	43.0
04	4.94	36.5	43.3	50.1

MONTH	PRECIP (IN)	MIN TMP (°F)	AVG TMP (°F)	MAX TMP (°F)
05	4.79	42.5	49.8	57.2
06	4.29	47.8	55.1	62.4
07	5.36	51.2	57.8	64.4
08	6.99	50.8	57.4	63.9
09	11.49	46.7	52.2	57.8
10	13.91	40.5	44.9	49.2
11	10.01	33.1	37.0	40.9
12	9.20	29.1	33.1	37.2

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Attachment C
HELP Output Files

```
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****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                 **
**                    USAE WATERWAYS EXPERIMENT STATION                   **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************
```

```
PRECIPITATION DATA FILE:    C:\WRANG2.D4
TEMPERATURE DATA FILE:      c:\wrang2.D7
SOLAR RADIATION DATA FILE:  c:\wrang2.D13
EVAPOTRANSPIRATION DATA:    C:\wrang2.D11
SOIL AND DESIGN DATA FILE:  C:\wrangcls.D10
OUTPUT DATA FILE:           C:\wrangcls.OUT
```

TIME: 11: 3   DATE: 1/26/2017

****

TITLE: WRANGELL MONOFILL

****

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

```
                        WRANGCLS
              MATERIAL TEXTURE NUMBER   1
 THICKNESS                   =     24.00   INCHES
 POROSITY                    =      0.4170 VOL/VOL
 FIELD CAPACITY              =      0.0450 VOL/VOL
 WILTING POINT               =      0.0180 VOL/VOL
 INITIAL SOIL WATER CONTENT  =      0.1316 VOL/VOL
 EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
       FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                       LAYER  2
                       --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
 THICKNESS                   =      0.20   INCHES
 POROSITY                    =      0.8500 VOL/VOL
 FIELD CAPACITY              =      0.0100 VOL/VOL
 WILTING POINT               =      0.0050 VOL/VOL
 INITIAL SOIL WATER CONTENT  =      0.0147 VOL/VOL
 EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
 SLOPE                       =     33.00   PERCENT
 DRAINAGE LENGTH             =    120.0    FEET


                       LAYER  3
                       --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
 THICKNESS                   =      0.06   INCHES
 POROSITY                    =      0.0000 VOL/VOL
 FIELD CAPACITY              =      0.0000 VOL/VOL
 WILTING POINT               =      0.0000 VOL/VOL
 INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
 EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
 FML PINHOLE DENSITY         =      4.00   HOLES/ACRE
 FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
 FML PLACEMENT QUALITY       =  3 - GOOD
```

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

```
THICKNESS                  =      0.23   INCHES
POROSITY                   =      0.7500 VOL/VOL
FIELD CAPACITY             =      0.7470 VOL/VOL
WILTING POINT              =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.300000003000E-08 CM/SEC
```

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

```
THICKNESS                  =    240.00   INCHES
POROSITY                   =      0.4570 VOL/VOL
FIELD CAPACITY             =      0.1310 VOL/VOL
WILTING POINT              =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC
```

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 21

```
THICKNESS                  =     66.00   INCHES
POROSITY                   =      0.3970 VOL/VOL
FIELD CAPACITY             =      0.0320 VOL/VOL
WILTING POINT              =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.300000012000     CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	52.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.931	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.336	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.144	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	36.885	INCHES
TOTAL INITIAL WATER	=	36.885	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM WRANGELL ALASKA

STATION LATITUDE	=	56.35	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	160	
END OF GROWING SEASON (JULIAN DATE)	=	262	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	80.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OLYMPIA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
8.01	6.13	6.09	4.94	4.79	4.29

WRANGCLS

5.36	6.99	11.49	13.91	10.01	9.20

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.90	33.90	37.70	43.30	49.80	55.10
57.80	57.40	52.20	44.90	37.00	33.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA
AND STATION LATITUDE = 56.35 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	7.76	6.47	5.97	5.67	4.87	3.77
	4.85	5.48	10.60	13.70	9.81	9.20
STD. DEVIATIONS	2.35	2.09	2.07	1.67	2.59	1.87
	4.22	3.37	5.90	5.29	3.73	2.50
RUNOFF						
TOTALS	3.225	5.838	5.066	0.364	0.000	0.000
	0.004	0.033	0.090	0.028	0.006	0.394
STD. DEVIATIONS	3.489	3.764	3.515	0.955	0.000	0.000
	0.021	0.155	0.293	0.105	0.026	1.046

EVAPOTRANSPIRATION

TOTALS	0.496	0.339	0.639	1.734	1.519	1.111
	1.022	1.163	1.334	1.119	0.806	0.544
STD. DEVIATIONS	0.230	0.165	0.459	0.531	0.761	0.659
	0.800	0.487	0.384	0.221	0.157	0.177

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	3.3477	1.1343	2.3961	4.1978	3.5072	2.9624
	3.6819	4.2362	8.7254	12.1111	8.4801	6.4555
STD. DEVIATIONS	3.1808	1.9977	1.9541	1.3732	1.3790	1.4528
	3.5018	2.3346	5.5415	5.0404	3.4720	3.1466

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0008	0.0003	0.0005	0.0010	0.0008	0.0007
	0.0008	0.0010	0.0021	0.0028	0.0020	0.0015
STD. DEVIATIONS	0.0007	0.0005	0.0004	0.0003	0.0003	0.0003
	0.0008	0.0005	0.0013	0.0012	0.0008	0.0007

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	88.17 (13.166)	320045.0	100.00
RUNOFF	15.048 (6.1271)	54624.41	17.068
EVAPOTRANSPIRATION	11.827 (1.8247)	42931.22	13.414
LATERAL DRAINAGE COLLECTED FROM LAYER 2	61.23574 (12.61088)	222285.719	69.45452
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000 (0.00000)	0.009	0.00000
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	0.056 (3.2095)	203.62	0.064

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	8.90	32306.998
RUNOFF	5.122	18591.6934
DRAINAGE COLLECTED FROM LAYER 2	6.41529	23287.50590
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 3	0.046	

```
MAXIMUM HEAD ON TOP OF LAYER  3            0.081

LOCATION OF MAXIMUM HEAD IN LAYER  2
      (DISTANCE FROM DRAIN)                2.6 FEET

PERCOLATION/LEAKAGE THROUGH LAYER  6       0.000000        0.00000

SNOW WATER                                13.33        48399.1367


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4158

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0180
```

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR   30

LAYER	(INCHES)	(VOL/VOL)
1	2.9240	0.1218
2	0.0025	0.0125
3	0.0000	0.0000
4	0.1725	0.7500
5	31.4399	0.1310
6	2.1120	0.0320

WRANGCLS
SNOW WATER 1.917

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**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                 **
**                    USAE WATERWAYS EXPERIMENT STATION                   **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:    C:\WRANG2.D4
TEMPERATURE DATA FILE:      c:\wrang2.D7
SOLAR RADIATION DATA FILE:  c:\wrang2.D13
EVAPOTRANSPIRATION DATA:    C:\wrang2.D11
SOIL AND DESIGN DATA FILE:  C:\wranggcl.D10
OUTPUT DATA FILE:           C:\wranggcl.OUT


TIME:  11: 0     DATE:   1/26/2017


****************************************************************************

     TITLE:  WRANGELL MONOFILL

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
```

WRANGGCL

MATERIAL TEXTURE NUMBER 1

```
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.4170 VOL/VOL
FIELD CAPACITY             =      0.0450 VOL/VOL
WILTING POINT              =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.1301 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC
```

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 20

```
THICKNESS                  =      0.20   INCHES
POROSITY                   =      0.8500 VOL/VOL
FIELD CAPACITY             =      0.0100 VOL/VOL
WILTING POINT              =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0589 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   10.0000000000     CM/SEC
SLOPE                      =      3.00   PERCENT
DRAINAGE LENGTH            =    130.0    FEET
```

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

```
THICKNESS                  =      0.06   INCHES
POROSITY                   =      0.0000 VOL/VOL
FIELD CAPACITY             =      0.0000 VOL/VOL
WILTING POINT              =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD
```

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.23 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	480.00 INCHES
POROSITY	=	0.4570 VOL/VOL
FIELD CAPACITY	=	0.1310 VOL/VOL
WILTING POINT	=	0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	66.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.%
AND A SLOPE LENGTH OF 130. FEET.

SCS RUNOFF CURVE NUMBER	=	45.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.917	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.336	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.144	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	68.299	INCHES
TOTAL INITIAL WATER	=	68.299	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WRANGELL ALASKA

STATION LATITUDE	=	56.35	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	160	
END OF GROWING SEASON (JULIAN DATE)	=	262	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	80.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR OLYMPIA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
8.01	6.13	6.09	4.94	4.79	4.29

WRANGGCL

5.36	6.99	11.49	13.91	10.01	9.20

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.90	33.90	37.70	43.30	49.80	55.10
57.80	57.40	52.20	44.90	37.00	33.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA
AND STATION LATITUDE = 56.35 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	7.76	6.47	5.97	5.67	4.87	3.77
	4.85	5.48	10.60	13.70	9.81	9.20
STD. DEVIATIONS	2.35	2.09	2.07	1.67	2.59	1.87
	4.22	3.37	5.90	5.29	3.73	2.50
RUNOFF						
TOTALS	3.225	5.835	5.056	0.363	0.000	0.000
	0.001	0.014	0.038	0.007	0.000	0.392
STD. DEVIATIONS	3.490	3.765	3.513	0.955	0.000	0.000
	0.004	0.072	0.170	0.036	0.001	1.044

EVAPOTRANSPIRATION

TOTALS	0.496	0.339	0.638	2.072	2.159	1.965
	1.254	1.253	1.442	1.137	0.807	0.542
STD. DEVIATIONS	0.229	0.165	0.491	0.479	0.719	0.816
	0.815	0.475	0.406	0.186	0.150	0.176

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	3.3315	1.1363	2.4961	3.6734	2.9326	2.0729
	3.5283	4.0203	8.7249	12.2210	8.4660	6.4722
STD. DEVIATIONS	3.1655	2.0012	1.9269	1.5136	1.4755	1.4258
	3.5342	2.2103	5.9497	5.0690	3.5137	3.1582

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0087	0.0089	0.0460	0.0218	0.0087	0.0077
	0.0970	0.0885	0.4537	0.2809	0.1059	0.0549
STD. DEVIATIONS	0.0086	0.0232	0.0302	0.0257	0.0096	0.0121
	0.1827	0.1350	0.5307	0.3405	0.1874	0.1055

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	88.17	(13.166)	320045.0	100.00
RUNOFF	14.931	(6.1267)	54197.98	16.934
EVAPOTRANSPIRATION	14.104	(2.0533)	51198.07	15.997
LATERAL DRAINAGE COLLECTED FROM LAYER 2	59.07545	(12.70274)	214443.891	67.00430
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00002	(0.00002)	0.078	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.099	(0.065)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00002	(0.00009)	0.080	0.00002
CHANGE IN WATER STORAGE	0.056	(3.2149)	204.96	0.064

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	8.90	32306.998
RUNOFF	5.122	18591.4512
DRAINAGE COLLECTED FROM LAYER 2	3.10202	11260.31540
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000016	0.05746
AVERAGE HEAD ON TOP OF LAYER 3	19.017	

```
MAXIMUM HEAD ON TOP OF LAYER  3            23.293

LOCATION OF MAXIMUM HEAD IN LAYER  2
      (DISTANCE FROM DRAIN)                56.5 FEET

PERCOLATION/LEAKAGE THROUGH LAYER  6        0.000043         0.15738

SNOW WATER                                 13.33        48399.1367


MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.4159

MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0180


 ***  Maximum heads are computed using McEnroe's equations.  ***

      Reference:  Maximum Saturated Depth over Landfill Liner
                  by Bruce M. McEnroe, University of Kansas
                  ASCE Journal of Environmental Engineering
                  Vol. 119, No. 2, March 1993, pp. 262-270.
```

****

****

FINAL WATER STORAGE AT END OF YEAR   30

LAYER	(INCHES)	(VOL/VOL)
1	2.9043	0.1210
2	0.0072	0.0361
3	0.0000	0.0000
4	0.1725	0.7500
5	62.8796	0.1310
6	2.1120	0.0320

WRANGGCL

SNOW WATER 1.917

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**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                 **
**                    USAE WATERWAYS EXPERIMENT STATION                   **
**               FOR USEPA RISK REDUCTION ENGINEERING LABORATORY          **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:    C:\WRANG2.D4
TEMPERATURE DATA FILE:      c:\wrang2.D7
SOLAR RADIATION DATA FILE:  c:\wrang2.D13
EVAPOTRANSPIRATION DATA:    C:\wrang2.D11
SOIL AND DESIGN DATA FILE:  C:\wrangss.D10
OUTPUT DATA FILE:           C:\wrangss.OUT


TIME:  10:48     DATE:   1/26/2017


****************************************************************************

     TITLE:  WRANGELL MONOFILL

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                    LAYER  1
                                    --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
```

WRANGSS

MATERIAL TEXTURE NUMBER 1

```
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.4170 VOL/VOL
FIELD CAPACITY             =      0.0450 VOL/VOL
WILTING POINT              =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.1316 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC
```

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 20

```
THICKNESS                  =      0.20   INCHES
POROSITY                   =      0.8500 VOL/VOL
FIELD CAPACITY             =      0.0100 VOL/VOL
WILTING POINT              =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0147 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   10.0000000000     CM/SEC
SLOPE                      =     33.00   PERCENT
DRAINAGE LENGTH            =    120.0    FEET
```

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

```
THICKNESS                  =      0.06   INCHES
POROSITY                   =      0.0000 VOL/VOL
FIELD CAPACITY             =      0.0000 VOL/VOL
WILTING POINT              =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD
```

```
                     LAYER  4
                     --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   5
  THICKNESS                    =    240.00   INCHES
  POROSITY                     =      0.4570 VOL/VOL
  FIELD CAPACITY               =      0.1310 VOL/VOL
  WILTING POINT                =      0.0580 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.1310 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                     LAYER  5
                     --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  21
  THICKNESS                    =     66.00   INCHES
  POROSITY                     =      0.3970 VOL/VOL
  FIELD CAPACITY               =      0.0320 VOL/VOL
  WILTING POINT                =      0.0130 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0320 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.300000012000     CM/SEC


         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF 33.%
          AND A SLOPE LENGTH OF  120. FEET.

SCS RUNOFF CURVE NUMBER            =     52.10
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
EVAPORATIVE ZONE DEPTH             =      8.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      0.931  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      3.336  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.144  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     36.713  INCHES
```

WRANGSS

TOTAL INITIAL WATER = 36.713 INCHES
TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WRANGELL ALASKA

STATION LATITUDE	=	56.35	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	160	
END OF GROWING SEASON (JULIAN DATE)	=	262	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	80.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR OLYMPIA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
8.01	6.13	6.09	4.94	4.79	4.29
5.36	6.99	11.49	13.91	10.01	9.20

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.90	33.90	37.70	43.30	49.80	55.10
57.80	57.40	52.20	44.90	37.00	33.10

WRANGSS

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA
AND STATION LATITUDE = 56.35 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	7.76	6.47	5.97	5.67	4.87	3.77
	4.85	5.48	10.60	13.70	9.81	9.20
STD. DEVIATIONS	2.35	2.09	2.07	1.67	2.59	1.87
	4.22	3.37	5.90	5.29	3.73	2.50
RUNOFF						
TOTALS	3.225	5.838	5.066	0.364	0.000	0.000
	0.004	0.033	0.090	0.028	0.006	0.394
STD. DEVIATIONS	3.489	3.764	3.515	0.955	0.000	0.000
	0.021	0.155	0.293	0.105	0.026	1.046
EVAPOTRANSPIRATION						
TOTALS	0.496	0.339	0.639	1.734	1.519	1.111
	1.022	1.163	1.334	1.119	0.806	0.544
STD. DEVIATIONS	0.230	0.165	0.459	0.531	0.761	0.659
	0.800	0.487	0.384	0.221	0.157	0.177
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	3.3477	1.1343	2.3961	4.1977	3.5072	2.9623
	3.6818	4.2361	8.7253	12.1109	8.4800	6.4554
STD. DEVIATIONS	3.1808	1.9976	1.9541	1.3731	1.3790	1.4528
	3.5018	2.3346	5.5414	5.0403	3.4720	3.1466

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000
	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001
STD. DEVIATIONS	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0008	0.0003	0.0005	0.0010	0.0008	0.0007
	0.0008	0.0010	0.0021	0.0028	0.0020	0.0015
STD. DEVIATIONS	0.0007	0.0005	0.0004	0.0003	0.0003	0.0003
	0.0008	0.0005	0.0013	0.0012	0.0008	0.0007

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	88.17 (13.166)	320045.0	100.00
RUNOFF	15.048 (6.1271)	54624.41	17.068
EVAPOTRANSPIRATION	11.827 (1.8247)	42931.22	13.414
LATERAL DRAINAGE COLLECTED	61.23490 (12.61073)	222282.687	69.45358

FROM LAYER 2				
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00085 (	0.00014)	3.071	0.00096
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (	0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00084 (	0.00016)	3.062	0.00096
CHANGE IN WATER STORAGE	0.056 (	3.2095)	203.62	0.064

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	8.90	32306.998
RUNOFF	5.122	18591.6934
DRAINAGE COLLECTED FROM LAYER 2	6.41525	23287.34180
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000045	0.16500
AVERAGE HEAD ON TOP OF LAYER 3	0.046	
MAXIMUM HEAD ON TOP OF LAYER 3	0.082	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000047	0.16886
SNOW WATER	13.33	48399.1367

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4158

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0180

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	2.9240	0.1218
2	0.0025	0.0125
3	0.0000	0.0000
4	31.4400	0.1310
5	2.1120	0.0320
SNOW WATER	1.917	

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\WRANG2.D4
TEMPERATURE DATA FILE:      c:\wrang2.D7
SOLAR RADIATION DATA FILE:  c:\wrang2.D13
EVAPOTRANSPIRATION DATA:    C:\wrang2.D11
SOIL AND DESIGN DATA FILE:  C:\wrangtd.D10
OUTPUT DATA FILE:           C:\wrangtd.OUT


TIME:  10:44     DATE:   1/26/2017


******************************************************************************

     TITLE:  WRANGELL MONOFILL

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

WRANGTD

MATERIAL TEXTURE NUMBER 1

```
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.4170 VOL/VOL
FIELD CAPACITY             =      0.0450 VOL/VOL
WILTING POINT              =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.1301 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999978000E-02 CM/SEC
```

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 20

```
THICKNESS                  =      0.20   INCHES
POROSITY                   =      0.8500 VOL/VOL
FIELD CAPACITY             =      0.0100 VOL/VOL
WILTING POINT              =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0589 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   10.0000000000     CM/SEC
SLOPE                      =      3.00   PERCENT
DRAINAGE LENGTH            =    130.0    FEET
```

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

```
THICKNESS                  =      0.06   INCHES
POROSITY                   =      0.0000 VOL/VOL
FIELD CAPACITY             =      0.0000 VOL/VOL
WILTING POINT              =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD
```

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

THICKNESS	=	480.00	INCHES
POROSITY	=	0.4570	VOL/VOL
FIELD CAPACITY	=	0.1310	VOL/VOL
WILTING POINT	=	0.0580	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1310	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	66.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0321	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 130. FEET.

SCS RUNOFF CURVE NUMBER	=	45.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.917	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.336	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.144	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	68.140	INCHES

TOTAL INITIAL WATER = 68.140 INCHES
TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WRANGELL ALASKA

STATION LATITUDE	=	56.35 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	160
END OF GROWING SEASON (JULIAN DATE)	=	262
EVAPORATIVE ZONE DEPTH	=	8.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	76.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	80.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR OLYMPIA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
8.01	6.13	6.09	4.94	4.79	4.29
5.36	6.99	11.49	13.91	10.01	9.20

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.90	33.90	37.70	43.30	49.80	55.10
57.80	57.40	52.20	44.90	37.00	33.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ANNETTE ALASKA
AND STATION LATITUDE = 56.35 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	7.76	6.47	5.97	5.67	4.87	3.77
	4.85	5.48	10.60	13.70	9.81	9.20
STD. DEVIATIONS	2.35	2.09	2.07	1.67	2.59	1.87
	4.22	3.37	5.90	5.29	3.73	2.50
RUNOFF						
TOTALS	3.225	5.835	5.056	0.363	0.000	0.000
	0.001	0.014	0.038	0.007	0.000	0.392
STD. DEVIATIONS	3.490	3.765	3.513	0.955	0.000	0.000
	0.004	0.072	0.170	0.036	0.001	1.044
EVAPOTRANSPIRATION						
TOTALS	0.496	0.339	0.638	2.072	2.159	1.965
	1.254	1.253	1.442	1.137	0.807	0.542
STD. DEVIATIONS	0.229	0.165	0.491	0.479	0.719	0.816
	0.815	0.475	0.406	0.186	0.150	0.176
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	3.3312	1.1361	2.4955	3.6729	2.9323	2.0726
	3.5271	4.0194	8.7208	12.2173	8.4646	6.4713
STD. DEVIATIONS	3.1652	2.0009	1.9267	1.5135	1.4753	1.4257
	3.5326	2.2096	5.9451	5.0674	3.5125	3.1574

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0003	0.0002	0.0006	0.0005	0.0003	0.0002
	0.0011	0.0011	0.0045	0.0032	0.0014	0.0009
STD. DEVIATIONS	0.0003	0.0003	0.0003	0.0003	0.0001	0.0002
	0.0018	0.0013	0.0048	0.0031	0.0018	0.0011

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0009	0.0008	0.0009	0.0008	0.0009	0.0008
	0.0009	0.0009	0.0008	0.0008	0.0008	0.0010
STD. DEVIATIONS	0.0006	0.0006	0.0006	0.0005	0.0006	0.0005
	0.0005	0.0005	0.0004	0.0005	0.0004	0.0006

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0087	0.0089	0.0460	0.0218	0.0087	0.0077
	0.0969	0.0884	0.4534	0.2799	0.1050	0.0549
STD. DEVIATIONS	0.0086	0.0232	0.0302	0.0257	0.0096	0.0121
	0.1826	0.1349	0.5301	0.3397	0.1854	0.1054

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	88.17 (13.166)	320045.0	100.00
RUNOFF	14.931 (6.1267)	54197.98	16.934
EVAPOTRANSPIRATION	14.104 (2.0533)	51198.06	15.997
LATERAL DRAINAGE COLLECTED	59.06112 (12.69758)	214391.844	66.98804

```
  FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH     0.01437 (  0.00721)        52.152     0.01630
   LAYER  3

 AVERAGE HEAD ON TOP             0.098 (    0.065)
   OF LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.01031 (  0.00294)        37.434     0.01170
   LAYER  5

 CHANGE IN WATER STORAGE         0.061   (  3.2134)        219.68      0.069

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               PEAK DAILY VALUES FOR YEARS    1 THROUGH   30
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------    -------------
      PRECIPITATION                                8.90         32306.998

      RUNOFF                                       5.122        18591.4512

      DRAINAGE COLLECTED FROM LAYER  2             3.10136      11257.94820

      PERCOLATION/LEAKAGE THROUGH LAYER  3         0.005353        19.43092

      AVERAGE HEAD ON TOP OF LAYER  3             19.005

      MAXIMUM HEAD ON TOP OF LAYER  3             23.280

      LOCATION OF MAXIMUM HEAD IN LAYER  2
            (DISTANCE FROM DRAIN)                 56.5 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000095         0.34561

      SNOW WATER                                  13.33         48399.1367


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.4159

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0180
```

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	2.9043	0.1210
2	0.0072	0.0361
3	0.0000	0.0000
4	62.8800	0.1310
5	2.2473	0.0341
SNOW WATER	1.917	

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APPENDIX E

PHOTOGRAPH LOG

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Photo 1: View of the inactive rock pit from Pat Creek road.
Date: 11/30/2016

Photo 2: View of the southern wall of the inactive rock pit.
Date: 11/29/2016

Photo 3: Rock core from 0.8 to 5.8 ft bgs of borehole P-01.
Date: 11/29/2016

Photo 4: Advancement of borehole MW-02 with hollow-stem augers.
Date: 12/1/2016

Photo 5: Installed security casing on MW-02.
Date: 12/2/2016

Photo 6: Surveying borehole MW-02.
Date: 12/2/2016

Photo 7: Observation of oil impacts in vicinity of MW-02 after installation of well.
Date: 12/2/2016

Photo 8: Initial readings of groundwater elevation in P-01 after development of well.
Date: 12/3/2016

Photo 9: View of Site looking toward Pat Creek Road prior to demobilization.
Date: 12/3/2016

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