REPUBLIC
SERVICES

Div of Waste Management
and Radiation Control

OCT 25 2021

DSHW-2021-019801

September 7, 2021

Doug Hansen, Director
Utah Department of Environmental Quality
Division of Waste Management & Radiation Control
195 North 1950 West
Salt Lake City, Utah 84114-4880

Re: Washington County Landfill Solid Waste Permit Renewal/Modification

Dear Mr. Hansen,

On behalf of the Washington County Special Services District #1, please find enclosed a Major Permit Modification/Permit Renewal package. The Permit Modification request is due to the purchase of 55 additional acres from the Bureau of Land Management, BLM.

As a result of the land purchase an updated Landfill Master Plan was developed. The Master Plan includes both a vertical and lateral landfill footprint expansion.

The Permit document includes the requested items listed in the Division's letter dated August 15, 2016 to Fay Reber.

Washington County Landfill asks the Division to consider this submittal as a Permit Renewal as well as a Permit Modification and thanks the Division for timely review and approval of this submittal. If you have any questions or comments pleased contact me at 435-888-4115.

Sincerely,

Darin Olson
Republic Services, Environmental Manager

cc: Kevin Kunz, WCSSD#1 District Manager

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Sincerely,

D Olson

Darin Olson
Republic Services, Environmental Manager

cc: Kevin Kunz, WCSSD#1 District Manager

Permit Renewal Application
Washington County Landfill
Washington City, Utah

Submitted to

Washington County Solid Waste
325 North Landfill Road
Washington, Utah 84780

Prepared by

143E Spring Hill Drive
Grass Valley, California 95945
www.geo-logic.com
Project #AU21.1210.00

October 2021

Utah Division of Solid and Hazardous Waste

Solid Waste Management Program

Mailing Address
P.O. Box 144880
Salt Lake City, Utah 84114-4880

Office Location
195 North 1950 West
Salt Lake City, Utah 84116

Phone (801) 536-0200
Fax (801) 536-0222
www.deq.utah.gov

APPLICATION FOR A PERMIT TO OPERATE A CLASS I OR CLASS V LANDFILL

Please read the instructions that are found in the document, INSTRUCTIONS FOR APPLICATION FOR A PERMIT TO OPERATE A CLASS I OR CLASS V LANDFILL. This application form shall be used for all Class I or V solid waste disposal facility permits and modifications. Part I GENERAL INFORMATION must accompany a permit application. Part II, APPLICATION CHECKLIST, is provided to assist applicants and, if included with the application, will assist review. Part II is provided to assist in preparation and review of a permit application; it is not required by rule. The text of the rule governs all permit application contents and should be consulted when questions arise.

Please note the version date of this form found on the lower right of the page; if you have received this form more than six months after this date it is recommended you contact our office at (801) 536-0200 to determine if this form is still current. When completed, please return this form and support documents, forms, drawings, and maps to:

Doug Hansen, Director
Division of Solid and Hazardous Waste
Utah Department of Environmental Quality
PO Box 144880
Salt Lake City, Utah 84114-4880

(Note: When the Director has determined that the application is complete, two clean copies of the application as determined complete must be submitted to the Director. One copy is to be available at the Division offices and one copy will be available at a site near the facility for public viewing during the public comment period.)

Utah Class I and V Permit Application Checklist

Part I General Information APPLICANT: PLEASE COMPLETE ALL SECTIONS.

***I.* Landfill Type** ☒ Class I ☐ Class V

***II.* Application Type** ☐ New Application ☐ Renewal Application ☒ Facility Expansion ☒ Modification

For Renewal Applications, Facility Expansion Applications and Modifications Enter Current Permit Number 9410R3

III. Facility Name and Location

Name of Facility Washington County Landfill Facility

Site Address (street or directions to site) 325 North Landfill Road

County Washington

City Washington City | Zip Code 84780 | Telephone 435-628-2821

Township 42S | Range 14W | Section(s) 8,9,17 | Quarter/Quarter Section N/A | Quarter Section N/A

Main Gate Latitude degrees 37 minutes 8 seconds 17 | Longitude degrees 113 minutes 27 seconds 5

IV. Facility Owner(s) Information

Name of Facility Owner Washington County Solid Waste Special District #1

Address (mailing) 325 North Landfill Road

City Washington | State UT | Zip Code 84780 | Telephone 435-673-2813

V. Facility Operator(s) Information

Name of Facility Operator Washington County Landfill Inc.

Address (mailing) 330 North Landfill Road

City Washington | State UT | Zip Code 84780 | Telephone 435-619-0141

VI. Property Owner(s) Information

Name of Property Owner Washington County

Address (mailing) 178 North 200 East

City St. George | State UT | Zip Code 84770 | Telephone 435-634-5723

VII. Contact Information

Owner Contact Name Kevin Kunz | Title District manager

Address (mailing) 325 North Landfill Road

City Washington | State UT | Zip Code 84780 | Telephone 435-673-2813

Email Address Kevin@wcsw.org | Alternative Telephone (cell or other)

Operator Contact Name Rick Downey | Title Operations Manager

Address (mailing) 330 North Landfill Road

City Washington | State UT | Zip Code 84780 | Telephone 707-239-3241

Email Address RDowney@republicservices.com | Alternative Telephone (cell or other)

Property Owner Contact Name Kevin Kunz | Title District Manager

Address (mailing) 325 North Landfill Road

City Washington | State UT | Zip Code 84780 | Telephone 435-673-2813

Part I General Information (Continued)

VIII. Waste Types (check all that apply)

☒ All non-hazardous solid waste (see R315-315-7(3) for PCB special requirements) **OR** the following specific waste types:

Waste Type	Combined Disposal Unit	Monofill Unit
☐ Municipal Waste	☐	☐
☐ Construction & Demolition	☐	☐
☐ Industrial	☐	☐
☐ Incinerator Ash	☐	☐
☐ Animals	☐	☐
☐ Asbestos	☐	☐
☐ PCB's (R315-315-7(3) only)	☐	☐
☐ Other ____________	☐	☐

IX. Facility Area

Facility Area.......... 550 acres

Disposal Area.......... 276 acres

Design Capacity

Years.......... as of March 2021 89

Cubic Yards.......... 79,908,200

Tons.......... 72,876,200

X. Fee and Application Documents

Indicate Documents Attached To This Application

☐ Application Fee: Amount $

☒ Facility Map or Maps ☒ Facility Legal Description ☒ Plan of Operation ☒ Waste Description

☒ Ground Water Report ☒ Closure Design ☒ Cost Estimates ☒ Financial Assurance

Class V Special Requirements

☐ Documents required by UCA 19-6-108(9) and (10)

I HEREBY CERTIFY THAT THIS INFORMATION AND ALL ATTACHED PAGES ARE CORRECT AND COMPLETE.

Signature of Authorized Owner Representative

Kevin Kunz

Name typed or printed

Title District Manager

Date 8/31/2021

Address

325 North Landfill Road, Washington, UT. 84780

Email Address Kevin@wcsw.org

Alternative Telephone (cell or other) (435)673-2813

Signature of Authorized Land Owner Representative (if applicable)

NA

Name typed or printed

Title

Date

Address

Email Address

Alternative Telephone (cell or other)

Signature of Authorized Operator Representative (if applicable)

Darin Olson

Name typed or printed

Title Environmental Manager

Date 9-2-2021

Address

330 North Landfill Road, Washington, UT 84780

Email Address DOlson@republicservices.com

Alternative Telephone (cell or other) (435)619-0141

Utah Class I and V Permit Application Checklist

Important Note: The following checklist is for the permit application and addresses only the requirements of the Division of Solid and Hazardous Waste. Other federal, state, or local agencies may have requirements that the facility must meet. The applicant is responsible to be informed of, and meet, any applicable requirements. Examples of these requirements may include obtaining a conditional use permit, a business license, or a storm water permit. The applicant is reminded that obtaining a permit under the *Solid Waste Permitting and Management Rules* does not exempt the facility from these other requirements. Please take note of the heading of each section for the facilities that the section applies to.

An application for a permit to construct and operate a landfill is the documentation that the landfill will be located, designed, constructed, operated, and closed in compliance with the requirements of Utah Administrative Code R315-301 through 320 (*Utah Solid Waste Permitting and Management Rules*) and Utah Code Annotated 19-6-101 through 123 (*Utah Solid and Hazardous Waste Act*). The application should be written to be understandable by regulatory agencies, landfill operators, and the general public. The application should also be written so that the landfill operator, after reading it, will be able to operate the landfill according to the requirements with a minimum of additional training.

Copies of the *Solid Waste Permitting and Management Rules*, the *Utah Solid and Hazardous Waste Act*, along with many other useful guidance documents can be obtained by contacting the Division of Solid and Hazardous Waste at 801-536-0200. Most of these documents are available on the Division’s web page at www.hazardouswaste.utah.gov. Guidance documents can be found at the solid waste section portion of the web page.

When the Director has determined that the application is complete, submit two paper copies of the application as determined complete by the Director, and an electronic copy of the application.

Part II Application Checklist

I. **Facility General Information**	
Description of Item	Location In Document
Ia. Information Required for All Class I and V Landfills	
Completed Part I General information Form (See form above)	Page 0
General description of the facility (R315-310-3(1)(b))	Page 1
Legal description of property (R315-310-3(1)(c))	Page 2
Proof of ownership, lease agreement, or other mechanism (R315-310-3(1)(c))	Page 3
Area served by the facility including population (R315-310-3(1)(d))	Page 3
If the permit application is for a class I landfill a demonstration that the landfill is not a commercial facility	Page 3
Waste type and anticipated daily volume (R315-310-3(1)(d))	Page 3
Ib. Information Required for All New Or Laterally Expanding Class I and V Landfills	
Intended schedule of construction (R315-302-2(2)(a))	Page 4
Name and address of all property owners within 1000 feet of the facility boundary (R315-310-3(2)(a)(i))	NA
Documentation that a notice of intent to apply for a permit has been sent to all property owners listed above (R315-310-3(2)(ii))	NA
Name of the local government with jurisdiction over the facility site (R315-310-3(2)(iii))	Page 6

I. **Facility General Information**	
Description of Item	Location In Document
Ic. Location Standards for All New Or Laterally Expanding Class I and V Landfills (R315-302-1)	
Documentation that the facility has met the historical survey requirement of R315-302-1(2)(f)	Page 6
Land use compatibility (R315-302-1(2)(a))	Page 5
Maps showing the existing land use, topography, residences, parks, monuments, recreation areas or wilderness areas within 1000 feet of the site boundary	Attachment J
Certifications that no ecologically or scientifically significant areas or endangered species are present in site area	Page 5
List of airports within five miles of facility and distance to each	Page 5
Geology (R315-302-1(2)(b))	Page 5
Geologic maps showing significant geologic features, faults, and unstable areas	Attachment J
Maps showing site soils	Attachment J
Surface water (R315-302-1(2)(c))	Page 5
Magnitude of 24 hour 25 year and 100 year storm events	Page 5
Average annual rainfall	Page 5
Maximum elevation of flood waters proximate to the facility	Page 5
Maximum elevation of flood water from 100 year flood for waters proximate to the facility	Page 5
Wetlands (R315-302-1(2)(d))	Page 5
Ground water (R315-302-1(2)(e))	Page 5
Id. Plan of Operations Requirements for All Class I And V Landfills (R315-310-3(1)(e) and R315-302-2(2))	
Forms and other information as required in R315-302-2(3) including a description of on-site waste handling procedures and an example of the form that will be used to record the weights or volumes of waste received (R315-302-2(2)(b) And R315-310-3(1)(f))	Page 6
Schedule for conducting inspections and monitoring, and examples of the forms that will be used to record the results of the inspections and monitoring (R315-302-2(2)(c), R315-302-2(5)(a), and R315-310-3(1)(g))	Page 9
Contingency plans in the event of a fire or explosion (R315-302-2(2)(d))	Page 10
Corrective action programs to be initiated if ground water is contaminated (R315-302-2(2)(e))	Page 11
Contingency plans for other releases, e.g. explosive gases or failure of run-off collection system (R315-302-2(2)(f))	Page 11
Plan to control fugitive dust generated from roads, construction, general operations, and covering the waste (R315-302-2(2)(g))	Page 13

***I.* Facility General Information**	
Description of Item	Location In Document
Plan for litter control and collection (R315-302-2(2)(h))	Page 13
Description of maintenance of installed equipment (R315-302-2(2)(i))	Page 13
Procedures for excluding the receipt of prohibited hazardous or PCB containing wastes (R315-302-2(2)(j))	Page 14
Procedures for controlling disease vectors (R315-302-2(2)(k))	Page 15
A plan for alternative waste handling (R315-302-2(2)(l))	Page 15
A general training plan for site operations (R315-302-2(2)(o))	Page 17
Any recycling programs planned at the facility (R315-303-4(6))	Page 18
Closure and post-closure care Plan (R315-302-2(2)(m))	Page 19
Procedures for the handling of special wastes (R315-315)	Page 19
Plans and operation procedures to minimize liquids (R315-303-3(1))	Page 19
Plans and procedures to address the requirements of R315-303-3(7)(c) through (i) and R315-303-4	Page 19-20
Any other site-specific information pertaining to the plan of operation required by the Director (R315-302-2(2)(p))	Page 21
Ie. Special Requirements for New Or Laterally Expanding Class V Landfill (R315-310-3(3))	
Submit information required by the *Utah Solid and Hazardous Waste Act* Subsections 19-6-108(9) and 19-6-108(10) (R315-310-3(2)(a))	NA
Note the following information must be provided following issuance of the permit but prior to Director approval to take waste for a new Class V facility.	
Approval from the local government within which the solid waste facility sits	NA
Approval from the Legislature and the Governor	NA

***II* Facility Technical Information**	
Description of Item	Location In Document
IIa. Maps for All Class I and V Landfills	
Topographic map drawn to the required scale with contours showing the boundaries of the landfill unit, ground water monitoring well locations, gas monitoring points, and the borrow and fill areas (R315-310-4(2)(a)(i))	Page 21
Most recent U.S. Geological Survey topographic map, 7-1/2 minute series, showing the waste facility boundary; the property boundary; surface drainage channels; any existing utilities and structures within one-fourth mile of the site; and the direction of the prevailing winds (R315-310-4(2)(a)(ii))	Page 21
IIb. Geohydrological Assessment for All Class I and V Landfills (R315-310-4(2)(b))	
Local and regional geology and hydrology including faults, unstable slopes and subsidence areas on site (R315-310-4(2)(b)(i))	Page 21

***II* Facility Technical Information**	
Description of Item	Location In Document
Evaluation of bedrock and soil types and properties including permeability rates (R315-310-4(2)(b)(ii))	Page 22
Depth to ground water (R315-310-4(2)(b)(iii))	Page 22
Direction and estimated flow rate of ground water (R315-310-4(2)(b)(iv))	Page 22
Quantity, location, and construction of any private or public wells on-site or within 2,000 feet of the facility boundary (R315-310-4(2)(b)(v))	Page 23
Tabulation of all water rights for ground water and surface water on-site and within 2,000 feet of the facility boundary (R315-310-4(2)(b)(vi))	Page 23
Identification and description of all surface waters on-site and within one mile of the facility boundary (R315-310-4(2)(b)(vii))	Page 24
Background ground water and surface water quality assessment and, for an existing facility, identification of impacts upon the ground water and surface water from leachate discharges (R315-310-4(2)(b)(viii))	Page 24
Ground Water Monitoring (R315-303-3(7)(b) and R315-308)	Page 25
Statistical method to be used (R315-308-2(8))	Page 26
Calculation of site water balance (R315-310-4(2)(b)(ix))	Page 26
IIc. **Engineering Report - Plans, Specifications, And Calculations for All Class I and V Landfills**	
Documentation that the facility will meet all of the performance standards of R315-303-2	Page 27
Engineering reports required to meet the location standards of R315-302-1 including documentation of any demonstration or exemption made for any location standard (R315-310-4(2)(c)(i))	Page 27
Anticipated facility life and the basis for calculating the facility's life (R315-310-4(2)(c)(ii))	Page 27
Cell design to include liner design, cover design, fill methods, elevation of final cover including plans and drawings signed and sealed by a professional engineer registered in the State of Utah (R315-303-3(3), R315-303-3(6) and (7)(a), R315-310-3(1)(b) and R315-310-4(2)(c)(iii))	Page 28
Leachate collection system design and calculations showing system meets the requirements of R315-303-3(2)	Page 30
Equipment requirements and availability (R315-310-4(2)(c)(iii))	Page 29
Identification of borrow sources for daily and final cover and for soil liners (R315-310-4(2)(c)(iv))	Page 29
Run-On and run-off diversion designs (R315-303-3(1)(c), (d) and (e))	Page 30
Leachate collection, treatment, and disposal and documentation to show that any treatment system is being or has been reviewed by the Division of Water Quality (R315-310-4(2)(c)(v) and R315-310-3(1)(i))	Page 30

***II* Facility Technical Information**	
Description of Item	Location In Document
Ground water monitoring plan that meets the requirements of Rule R315-308 including well locations, design, and construction (R315-310-4(2)(b)(x) and R315-310-4(2)(c)(vi))	Page 31
Landfill gas monitoring and control plan that meets the requirements of Subsection R315-303-3(5) (R315-310-4(2)(c)(vii))	Page 31
Slope stability analysis for static and under the anticipated seismic event for the facility (R315-310-4(2)(b)(i) and R315-302-1(2)(b)(ii))	Page 31
Design and location of run-on and run-off control systems (R315-310-4(2)(c)(viii))	Page 31
IId. Closure Plan for All Class I and V Landfills (R315-310-3(1)(h))	
Closure Plan (R315-302-3(2) and (3))	Page 32
Closure schedule (R315-310-4(2)(d)(i))	Page 32
Design of final cover (R315-303-3(4) and R315-310-4(2)(c)(iii))	Page 32
Capacity of site in volume and tonnage (R315-310-4(2)(d)(ii))	Page 32
Final inspection by regulatory agencies (R315-310-4(2)(d)(iii))	Page 32
IIe. Post-Closure Care Plan for All Class I and V Landfills (R315-310-3(1)(h))	
Post-Closure Plan (R315-302-3(5) and (6))	Page 33
Site monitoring of landfill gases, ground water, and surface water, if required (R315-310-4(2)(e)(i))	Page 33
Changes to record of title, land use, and zoning restrictions (R315-310-4(2)(e)(v))	Page 34
Maintenance activities to maintain cover and run-on/run-off control systems (R315-310-4(2)(e)(iii))	Page 34
List the name, address, and telephone number of the person or office to contact about the facility during the post-closure care period (R315-310-4(2)(e)(vi))	Page 35
IIf. Financial Assurance for All Class I and V Landfills (R315-310-3(1)(j))	
Identification of closure costs including cost calculations (R315-310-4(2)(d)(iv)) and (R315-302-2(2)(n))	Page 36
Identification of post-closure care costs including cost calculations (R315-310-4(2)(e)(iv))	Page 36
Identification of the financial assurance mechanism that meets the requirements of Rule R315-309 and the date that the mechanism will become effective (R315-309-1(1))	Page 36

Certification

This Permit Renewal Application was prepared in accordance with generally accepted professional engineering principles and practices. This Permit Renewal Application makes no other warranties, either expressed or implied as to the professional advice or data included in it. This Permit Renewal Application has not been prepared for use by parties or projects other than those named or described herein. It may not contain sufficient information for other parties or purposes.

GEO-LOGIC ASSOCIATES

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
3-31-2023
State of Utah

Jake Russell, PE
Principal Engineer
Geo-Logic Associates
143E Spring Hill Drive
Grass Valley, California 95945

October 7, 2021

Table of Contents

List of Attachments

1. Facility General Information

The Name and Address of the Applicant, Property Owner, and Responsible Party for the Site Operation (R315-310-3(1)(a))

Landfill Name:	Washington County Class I Landfill
Owner Name:	Washington County Solid Waste Special Service District #1
Owner Address:	325 North Landfill Road, Washington, Utah 84780
Owner Phone No.:	(435) 673-2813
Operator Name:	Allied Waste Transportation, Inc.
Operator Address:	557 North Industrial Road, St. George, Utah 84770
Operator Phone No.:	(435) 628-2821

General Description of the Facility (R315-310-3(1)(b))

Since 1980 Washington County has been operating a sanitary landfill through the Washington County Solid Waste Special Service District #1. This landfill is located in the south central portion of Washington County just east and south of the Washington City limits in an isolated drainage known as Purgatory Flat.

In the original siting of the landfill, extensive geologic data were used. The data had been previously developed by the U.S. Bureau of Reclamation on the proposed Laverkin Springs Desalinization Ponds; which were proposed to be located just north of the landfill site. The geologic investigations which have been completed, to date, indicate that the present landfill site can be designed and operated so as to meet all subtitle "D" criteria as administered by the state of Utah.

Since the beginning of landfill operations at the site, the landfill waste stream has consisted of municipal solid waste and other non-hazardous municipal and industrial wastes, including green wastes and construction and demolition materials. This general waste stream will continue through the upcoming permit period.

Prior to the opening and operation of the Washington County Landfill Facility, many of the local communities operated their own landfills for their citizens which often included open burning of solid waste materials. In order to consolidate efforts, conserve resources, and minimize environmental impacts, the Washington County Solid Waste Special Service District #1 was created. The District's Board, which consists of at least one representative from every community within Washington County, oversees the operation of the Washington County Landfill Facility. Since the onset of operation of this facility, all of the other landfills throughout Washington County have been closed. This has proven to be a substantial improvement in the handling of solid waste generated by the citizens of Washington County.

The landfill facility is currently operated by Washington County Landfill Inc. The landfill facility is situated on ground owned by Washington County. The County has leased 500 acres of land to the Washington County Special Service District #1, a special service district organized and existing under the laws of the State of Utah, for the express purpose of construction and operation of a landfill facility. The lease agreement between Washington County and the Washington County Special Service District #1 is provided in Attachment A of this permit application.

Legal Description Of Property (R315-310-3(1)(c))

The location of the facility is at:

Latitude 37^0 08' 15" North
Longitude 113^0 27' 10" West

The legal description of the landfill facility is as follows:

Salt Lake Meridian, Utah
Township 42 South, Range 14 West,
Section 8, SE ¼ SE ¼ NE ¼, SE ¼ SE ¼ SW ¼, NE ¼ SE ¼, S ½ SE ¼, SE ¼ NW ¼ SE ¼;
Section 9, SE ¼ NW ¼ NW ¼, SW ¼ NW ¼, NW ¼ SW ¼, N ½ SW ¼ SW ¼, SW ¼ SW ¼ SW ¼;
Section 17, N ½ NE ¼ NE ¼, SW ¼ NE ¼ NE ¼, NW ¼ NE ¼, NW ¼ SW ¼ NE ¼, E ½ NW ¼, E ½ W ½ NW ¼, SW ¼ NW ¼ NW ¼, W ½ SW ¼ NW ¼.
Containing 500.00 acres

In addition, the Washington County Solid Waste Special Service District #1 has recently acquired several additional parcels of land from the Bureau of Land Management (BLM). The legal descriptions of said parcels are as follows:

Salt Lake Meridian, Utah
Township 42 South, Range 14 West,
Section 8, SW ¼ SE ¼ NE ¼, NE ¼ NE ¼ SE ¼ SW ¼, S ½ NE ¼ SE ¼ SW ¼, NE ¼ SW ¼ SE ¼ SW ¼, S ½ SW ¼ SE ¼ SW ¼, NE ¼ NW ¼ SE ¼, and SW ¼ NW ¼ SE ¼.
Section 9, SW ¼ NW ¼ NW ¼.

The areas described aggregate 55.0 acres.

Proof of Ownership, Lease Agreement, or Other Mechanism (R315-310-3(1)(c))

The proof of ownership by Washington County is contained in Attachment B of this permit application. The lease agreement is contained in Attachment A of this permit application.

Area Served By The Facility Including Population (R315-310-3(1)(d))

The Washington County Sanitary Landfill Facility serves mostly but is not limited to Washington County, Utah. Located within Washington County are several communities, a national park, and a national forest. Each of these has access to this landfill facility.

A Demonstration That The Landfill Is Not A Commercial Facility

The Washington County Sanitary Landfill Facility complies with subsection R315-301-2(7) of the Solid Waste Permitting and Management Rules. The landfill is operated as a Class I landfill.

Waste Type And Anticipated Daily Volume (R315-310-3(1)(d))

The Washington County Sanitary Landfill Facility accepts non-hazardous solid waste that may include municipal solid waste, commercial waste, industrial waste, construction/demolition waste, and special waste as allowed by UAC R315-315. The landfill may accept conditionally exempt small quantity generator hazardous waste as specified in UAC R315-303-4(7)(a)(i)(B) and PCB's as specified by UAC R315-315-7(2).

The landfill does not accept hazardous waste as defined by UAC R315-1 and R315-2 or PCB's as defined by UAC R315-301-2, except as allowed by its permit for treatment, storage, or disposal at the landfill.

The Washington County Sanitary Landfill Facility receives an average of approximately 1,000 tons/day of waste. This equates to an average daily volume of 1,100 cubic yards (cy). This volume is anticipated to continue and to increase in the future. The anticipated volume includes waste and daily cover material.

Intended Schedule of Construction (R315-302-2(2)(a))

The landfill cell presently in use is Cell 4D, which is a portion of Phase 4 described in the WCL Master Plan Report dated September, 2020 by Geo-Logic Associates, included as Attachment O. Cell 4D was constructed in 2020 and will provide capacity through 2022, after which Cell 5A will need to be constructed. The entire existing permitted and planned landfill footprint is approximately 276 acres out of the total permitted leased area of 555 acres. The Master Plan identifies the remaining undeveloped units as Phase 5-12 with a total remaining capacity of approximately 73,779,100 cy including waste and daily soil cover. Based on the most recent aerial topographical survey date of March 9, 2021, the total remaining capacity of the site (including the remaining available airspace in Phase 4 and future Phases 5-12) is approximately 74,683,700 cy. Assuming an average operational density of 1,824 lbs/cy, this equates to approximately 68,111,500 tons of waste including soil covers. Based on the annual waste projections shown in Attachment C, Phases 5-12 will provide an estimated 90 years of capacity for the site. The landfill is estimated to reach final grades at the beginning of the year 2011.

Upon completion of each phase, successive phases or units will be constructed directly adjacent to the previous phase, each phase comprising of sub-units designed with four to five year capacity each, incorporating each existing unit and extending easterly along the westerly to the east property line.

Washington County Landfill, Inc. will submit detailed construction plans for each construction phase prior to the planned construction. These plans will be submitted to the Director for review and approval.

Attachment C of this document provides a table addressing the demographics of Washington County with population and solid waste projections upon which the landfill layout was based. Current population and population projections were taken from the U.S. Census Bureau. The typical per capita MSW generation which is estimated by the EPA, is approximately 4.5 pounds per person per day. This number was used in developing the annual waste disposal rates shown on the table in Attachment C.

Demonstration The Facility Meets The Location Standards (R315-302-1)

1. Airport
   The site is approximately seven miles west of the Hurricane City airport, approximately seven miles northwest from a private air strip just south of the Hurricane City airport, seven and a half miles northeast of the St. George City airport, and 6 miles north of an abandoned landing field now used only for sanctioned auto drag racing.

2. Flood Plains
   Not Applicable

3. Wetlands
   Not Applicable

4. Fault Areas and Seismic Impact Zones
   Not Applicable

5. Unstable Areas
   Based on the information contained in the site's geologic reports (Attachment K), the facility is founded on stable geologic formations that are not susceptible to significant amounts of differential settling. A hogback ridge comprised of varying layers of limestone, sandstone, and shale parallels the west-northwestern perimeter of the existing facility and proposed expansion areas. Visual inspection suggests that the perimeter of the facility could be susceptible to boulder-sized rockfall from said hogback ridge. To account for any potential rockfall, the west-northwestern perimeter of the facility (Phases 5, 6, 7, and 8) has been designed with a 50-foot wide perimeter access road and a minimum 20-foot wide and 10-foot deep trapezoidal channel to catch any potential rockfall before reaching the facility (see Master Plan Report, Attachment O).

6. Closure of Existing Municipal Solid Waste Landfill Units
   Not Applicable

7. Historic Preservation Survey

A historic preservation survey was conducted on the newly acquired 55-acre property in accordance with R315-302-1(2)(f). The survey was performed on August 5-7, 2021 by Cottonwood Archaeology. The survey identified a single isolated find of historic cultural material, a broken glass insulator which is not eligible for National Register of Historic Places inclusion. A determination of "no historic properties affected" was recommended. The historic preservation survey report is included in Attachment R.

Plan of Operation (R315-310-3(1)e and R315-302-2(2))

Description Of On-Site Waste Handling Procedures And An Example Of The Form That Will Be Used To Record The Weights Or Volumes Of Waste Received (R315-302-2(2)(b) And R315-310-3(1)(f))

All solid wastes deposited in the landfill will first cross a truck scale located adjacent to the scale house at the front gate. Haulers of the solid waste are divided into two categories by Washington County Landfill, Inc. as being either licensed or unlicensed. Commercial solid waste haulers are considered licensed haulers as they must obtain a license from Washington County Solid Waste Special Service District #1 to operate commercially in the landfill. The application that will be used by Washington County Solid Waste Special Service District #1 is contained in Attachment D of this permit application. Along with the application, each licensed hauler must submit proof of insurance with certification to Washington County, a copy of their current city or county business license, and their truck(s) number, serial number, body capacity, weight, and date of manufacture. Licensing is required of each commercial hauler annually.

All other solid waste haulers are classified as unlicensed. Included as unlicensed haulers are general contractors hauling construction and demolition materials and private citizens who haul their own trash and yard wastes.

Regardless of whether a solid waste hauler is classified as licensed or unlicensed, they are required to stop at the scale house and be weighed. Attachment E of this permit application contains a copy of a weigh ticket each hauler receives which is the basis for the assessment of the tipping fees.

A copy of the form used by Washington County Landfill, Inc. to track those loads hauled into the landfill by licensed and unlicensed haulers is presently contained in Attachment F of this permit application. When tires are brought to the landfill, the appropriate information is logged on a form for tracking and billing purposes. This form is also contained in Attachment E of this permit application.

After the initial stop at the scale house, the haulers of solid waste then proceed to the landfill site, and are directed to the active face by way of signing. As the haulers approach the working face of the landfill, they are further directed by the landfill spotter to a specific unloading location. As the waste material is off loaded, it is the spotter's responsibility to visually inspect the waste to determine the specific composition of the load being deposited. Provided at the landfill are 6 drop boxes to be used by residents of the district. These drop boxes are taken to the active face and off loaded. A camera is installed to monitor the activity at the drop boxes.

All waste material placed in the landfill cell is compacted to minimize air space usage and maximize unit weight. Waste is spread in lifts and compacted with a Cat D7 dozer and Cat 836 compactor to achieve maximum compaction.

At the end of each production day the solid waste placed in the landfill is covered with six inches of soil cover material or an Alternative Daily Cover (ADC). Following are the ADC's that may be utilized.

1. Compost

   Compost may be used as an ADC when required.

The current daily cover needs are met by Alternative Daily Covers (ADCs) or the soil excavated from on-site. When either of these sources becomes inadequate, the importation of soil cover material from a nearby gravel crushing operation will be utilized. This operation procedure will continue through the next permit period.

The following special handling procedures apply for certain waste streams:

1. Odoriferous Wastes - All odoriferous wastes placed in the landfill cell are covered with six inches of cover material and/or ADC within the current work period or day's end.
2. Ash- All ash which presents a blowing concern will be covered with six inches of material and/or ADC within four hours after disposal of the waste in the unit before day's end. Water may be sprayed on the ash if required to control dust emissions during covering activities.

3. Bulky Wastes - The landfill is not utilized as an appliance or automobile junkyard. If these items are delivered to the landfill, they are removed and taken to a recycler.

4. Water Treatment or Wastewater Treatment Sludges, Non-Hazardous or Exempt Petroleum Contaminated Soils - Sludges including exempt petroleum contaminated soils, grease trap materials, oily water, and sand trap wastes that fail the Paint Filter Liquids Test method will be solidified/evaporated prior to their disposal in the landfill unit. Solidification methods include the addition of absorbent materials, after which the solidified wastes must pass the Paint Filter Liquids Test method before disposal. These solidified wastes are then placed on the working face and covered with other solid wastes or cover material. Sludges consisting of exempt petroleum contaminated soils may be used as daily cover. Sludges which are brought into the landfill shall be certified as non-hazardous by the generator. Analytical data may be required to certify waste as non-hazardous.

   Generators/haulers of non-hazardous or exempt petroleum contaminated soils, water treatment or wastewater treatment sludges will be encouraged to solidify their sludges to ensure passage of the Paint Filter Liquids test prior to their placement in the landfill. However, the generator/hauler of these sludges may bring sludges which do not pass the Paint Filter Liquids test to the landfill for solidification and disposal. Upon arrival at the scale house, the gate keeper will verify certification as non-hazardous and direct the hauler to the Sludge Solidification Site. At this point a landfill operator will visually inspect the load prior to unloading to verify content. If it does not appear that the sludge will then pass the Paint Filter Liquids test, it will be distributed on the ground at the Sludge Solidification Site. The sludge will be placed on the solidification site by means of a tremie or flexible metal spout to allow for even distribution. As the sludge is being unloaded, the hauler will proceed under the direction of the operator at a speed which will minimize ponding of the liquids. Upon completion of unloading, all valves and external openings of the hauler's vehicle will be stopped prior to the hauler's departure from the Sludge Solidification Site. The sludge at the solidification site will be blended with native absorbent material until the sludge passes the Paint Filter Liquids test. The solidified sludges will then be placed at the landfill working face for disposal.

   As liquids in delivered sludges are evaporated or absorbed into the surrounding soils, the dikes will be leveled. The impacted soils which made up the dikes and floor will be blended with other native absorbent material until the soil passes the Paint Filter Liquids test. The soils which pass this test may be stockpiled and used as a source of daily cover material.

5. Tires - It is the policy of Washington County Landfill, Inc. to have the landfill stockpile all tires brought into the landfill. Tires are removed from the site and delivered to a commercial recycler of tires.
6. Dead Animals - Animal carcasses received at the facility will be deposited onto the working face at or near the bottom of the cell with other solid waste, or into a separate disposal trench where they will be covered daily with a minimum of six inches of earth to prevent odors and the propagation and harborage of rodents and insects.

Schedule For Conducting Inspections And Monitoring, And Examples Of The Forms That Will Be Used To Record The Results Of The Inspections And Monitoring (R315-302-2(2)(c), R315-302-2(5)(a), And R315-310-3(1)(g))

Inspections of the facility will be conducted quarterly by Washington County Landfill, Inc. or its representative. The purpose of these inspections is to prevent any problems with the facility and to identify any deterioration of the facility and operator errors or malfunctions which may cause a release of wastes to the environment or threaten human health. The inspection logs will be kept at the facility in the scale house. Attachment G of this permit application is an example of the inspection log. All inspections will conform to subsection R315-302-2(5)(a) of the Solid Waste Permitting and Management Rules. The Washington County Landfill, Inc. inspection log program will consist of a summary of the following information:

1. Total Containment Evaporation Pond - Inspection of inlet and overflow structures for blockage, failure, and erosion. Inspection of rock-lined dikes and rock-lined drainage channel around the pond for potential erosion and washout. Inspection of lining systems for possible damage from men, equipment, root systems of surrounding vegetation, and burrowing animals will be conducted. Inspection of fence line and gates to ensure security of the total containment evaporation pond facility will be conducted. Inspection of containment dikes that lie below the pond will occur.

2. 18" Diameter Leachate Outfall Line - Inspection of manholes and outfall line for signs of blockage, leakage, or infiltration.

3. 12" Diameter Leachate Collection Line - Inspection of cleanouts and collection line for signs of blockage and failure. Should it be suspected that either has occurred to the collection line, a mandrel will be pulled through the suspected section to determine the extent and location of the damage.

4. Run-off Drainage Channel - Inspection of the lined channel and culverts for erosion and blockage.

5. Run-on Drainage Channel - Inspection of the rock-lined channel and culverts for erosion and blockage.

6. Perimeter Fencing and Access Gates - Inspection of fencing for breach of security and litter accumulation. Inspection of gates and other points of access for security and restriction of unauthorized access will be conducted.

7. Landfill Cell - Inspection of the active landfill face for placement and compaction of imported waste stream. Inspection of the access roads for settlement and stability and inspection of covered portions of the landfill cell for erosion and excessive settlement.

Contingency Plans In The Event Of A Fire Or Explosion (R315-302-2(2)(d))

Washington County Landfill, Inc. will implement various procedures to minimize and control fire, explosion, and release of explosive gases. Training for facility operations personnel will be provided. The procedures will include:

1. Washington County Landfill, Inc. will provide training to all facility employees regarding fire prevention and firefighting at the facility.

2. All supervisory personnel will maintain radio communication with personnel in the scale house and the Washington County Landfill, Inc. office. If required, the Washington County Landfill, Inc. office will contact the Washington City Fire Department for emergency assistance.

3. Dozers will be available to spread burning materials in the landfill so that water can be applied, to smother the burning material with non-ignitable material, or to build berms to contain the fire.

4. Stockpiled soil cover materials will be available in the vicinity to spread on burning materials.

5. All facility vehicles will contain a portable fire extinguisher which can be utilized to extinguish small fires.

6. A fire hydrant is located within 300 feet of the scale house. The hydrant is connected to a 36" water transmission line running through the landfill property. Water from this hydrant will be used to suppress fires.

7. In case off-site firefighting assistance is needed, the Washington City Fire Department will respond. The Washington City Fire Department should be able to respond to a fire within 15 minutes.

Corrective Action Programs To Be Initiated If Ground Water Is Contaminated (R315-302-2(2)(e))

In the event ground water contamination is detected, an appropriate remediation plan will be developed. The plan may include pumps placed in monitoring Well 1 and monitoring Well 2 with the intent of removing the perched water from the ground, therefore stopping transmission of the release. Water pumped from the monitoring wells will be land applied within the boundaries of the landfill facility where it will be evaporated. In the event that the perched aquifer is too large to practically draw down, pumping will continue until all constituents being analyzed are shown to be at or below established background values. This plan may be modified upon completion of investigations related to ground water contamination.

Contingency Plans For Other Releases, E.G. Explosive Gases Or Failure Of Run-Off Collection System (R315-302-2(2)(f))

In the event of a run-off containment system failure, the procedures for taking corrective action will include:

1. Washington County Landfill, Inc. will provide necessary training to facility employees regarding landfill emergency procedures.

2. All supervisory personnel will maintain radio communication with personnel in the scale house and the Washington County Landfill, Inc. office. The Washington County Landfill, Inc. office would then be able to contact the Washington County Emergency Management Personnel as required.

3. Dozers and compactors and other earth-moving equipment will be available to move earth material as necessary to seal off any breach to the run-off containment system until other permanent corrective measures can be taken.

In the event of a gas explosion, the procedures for taking corrective action will include:

1. Washington County Landfill, Inc. will provide necessary training to facility employees regarding landfill emergency procedures.
2. All supervisory personnel will maintain radio communication with personnel in the scale house and the Washington County Landfill, Inc. office. The Washington County Landfill, Inc. office would then be able to contact the Washington County Emergency Management Personnel as required.
3. Dozers and compactors and other earth-moving equipment will be available to move earth material as necessary to contain an emergency.

In the event of an overflow in the Total Containment Evaporation Pond, the procedures for taking corrective action will include:

1. Washington County Landfill, Inc. will provide necessary training to facility employees regarding landfill emergency procedures.
2. All supervisory personnel will maintain radio communication with personnel in the scale house and the Washington County Landfill, Inc. office. The Washington County Landfill, Inc. office would then be able to contact the Washington County Emergency Management Personnel as required.
3. Dozers and compactors and other earth-moving equipment will be available to move earth material as necessary to seal off any breach to the run-off containment system until other permanent corrective measures can be taken.
4. Contained waste water will be pumped into a water truck and returned to the Total Containment Evaporation Pond, solidified with on-site material and hauled to the landfill and used as daily cover, or taken to the local sewer district for disposal. Upon removal of the captured waste water, the affected native soil material will be removed and used for daily cover on the landfill cell.

5. Any damage to the Total Containment Evaporation Pond caused by the overflow will be repaired and the area will be restored to its original condition.

Plan To Control Fugitive Dust Generated From Roads, Construction, General Operations, And Covering The Waste (R315-302-2(2)(g))

It is Washington County Landfill, Inc. policy that all unpaved traveled roadways within the landfill facility are sprayed with water and that waste material be wetted or covered as necessary to control dust. Also, any solid waste material, such as ash, which presents a blowing concern, is covered with six inches of material or an ADC by the end of the day of disposal or water is sprayed on the waste material to control dust emissions. Air emissions will fall within state Air Quality Standards. Operator will log water truck loads.

Plan For Litter Control And Collection (R315-302-2(2)(h))

Wind-blown litter control will be performed by use of fencing, daily cover, and ADC. Litter collection will be performed by the Spotter at the active face and other landfill personnel as required. Fencing will be inspected for wind-blown litter as required to ensure containment and disposal of the litter materials.

Description Of Maintenance Of Installed Equipment (R315-302-2(2)(i))

Ground water monitoring equipment will be maintained in accordance with the landfill's groundwater monitoring plan and equipment manufacturers' instructions.

The current design of the leachate collection system and the contaminated run-off waters collection system operate in conjunction with the old system. The leachate collection system in the current and future cells consist of a network of leachate collection pipes and were sized to carry the anticipated leachate volumes over the life of the landfill. Each new cell has a sump and a riser for periodic extraction of leachate. The extracted leachate is recirculated back to the landfill. The old system which mainly served the old landfill, consists of a French drain that collects very little leachate from the old landfill and discharges into the Total Containment Evaporation Pond for evaporation. The Total Containment Evaporation Pond is lined with a membrane liner to prevent seepage of the leachates into the surrounding ground. Maintenance of the leachate collection system in the lined cells is via a cleanout riser pipe installed along each sump riser and at the other end of the leachate pipe header as a second access point. The leachate pump in the sump is maintained and serviced regularly for proper and efficient operation. Maintenance of the channel system and the Total Containment Evaporation Pond will consist mainly of weed control.

Methane gas monitoring is performed quarterly using a hand-held probe. The hand-held probe is calibrated prior to each use by the gas sample collector. This will be done in conformance with the manufacturer's recommendations. The calibration of the probe will then be documented on the landfill gas quarterly monitoring results form. (See Attachment H of this permit application). Periodic inspection and repairs/replacements will be made to the LFG control system as necessary, including wellheads and collection piping system due to damage caused by accident, settlement, environmental factors and aging. Wellheads and casings will be adjusted vertically to conform to the surface elevation of the landfill. During each daily monitoring event at the blower-flare facility, all chart recorders should be checked for proper performance. Equipment performance should be observed during each facility visit. Condensate drain systems should be checked to make sure that they are functioning as designed. Condensate sumps and pumps should be serviced frequently.

Procedures For Excluding The Receipt Of Prohibited Hazardous Or PCB Containing Wastes (R315-302-2(2)(j))

Inspections of wastes for hazardous materials or waste containing PCBs will be performed at random or as deemed necessary by Washington County Landfill, Inc. A copy of the Random Load Inspection Record form is provided in Attachment I of this permit application. Although private individuals who haul only their personal solid waste are exempt, any load, private or commercial, suspected of containing hazardous materials or wastes containing PCBs will be subject to inspection.

The randomly inspected loads, as well as loads suspected of containing hazardous materials or wastes containing PCBs, will be off loaded at a predetermined inspection site. This inspection site will always be located away from the current working face of the landfill. Upon completion of the inspection Washington County Landfill, Inc. will remove the solid wastes passing inspection and place them at the working face of the landfill for burial. If inspection reveals that the load contains suspected hazardous materials or wastes containing PCBs the following measures will be taken by landfill personnel:

1. Immediately notify the Generator
2. Notify the Director of the DWMRC within 24 hours
3. Restrict the area from public access and from facility personnel
4. Assure proper cleanup, transport and disposal of the waste as per DWMRC recommendations

Inspection training of the landfill personnel will be performed by a qualified person from the landfill operator.

Extensive documentation will be maintained on special waste received. Individual files will be maintained for each generator. Each file will typically contain the following information:

1. Profile sheet
2. Appropriate analytical data
3. Correspondence with the generator

Procedures For Controlling Disease Vectors (R315-302-2(2)(k))

Various procedures are incorporated into the operation of the landfill to prevent, as much as possible, the transmittal of disease through disease vector control. Washington County Landfill, Inc. landfill operating procedures are intended to control disease vectors such as rodents, insects, and air borne particulates.

It is Washington County landfill, Inc. policy to keep the working face exposure to a minimum. In so doing, compaction efforts are maximized. Proper compacting procedures will help ensure not only the most effective use of available landfill space, but also reduces the likelihood of a rodent infestation.

To prevent an infestation of insects at the landfill, it is the policy of Washington County Landfill, Inc. to cover all odoriferous wastes with 6 inches of soil cover weekly.

A Plan For Alternative Waste Handling (R315-302-2(2)(l))

In the event that normal land filling operations are impeded or all together terminated through equipment breakdown or other unforeseen event, then an alternative location within the landfill boundaries will be designated as a temporary handling and stockpiling facility. This alternative location will be as nearly adjacent to the existing working face as possible but maintaining sufficient distance for public safety. It is intended to use the ground which is currently approved for disposal of solid waste as a temporary stockpiling area first. However, should it become necessary to move off the approved site for the safety and general welfare of the public, the temporary stockpiling facility would then be located on ground which is proposed for the next unit to be constructed. As there are 500 acres within the sanitary landfill boundaries, it is unlikely that the occasion would arise that would require the complete closure of the landfill facility. In the event that the entire landfill facility was closed to public access due to a major catastrophe, then an alternative landfill site would need to be located for the temporary solid waste handling and stockpile facility as an emergency measure.

A temporary solid waste handling and stockpile facility would of necessity have to be versatile and mobile yet be conducive to securing the temporarily stockpiled solid waste from wind, salvagers, and animal scavengers. To construct such a facility, temporary fencing would be constructed along the perimeter of the proposed temporary stockpiling area. These fenced in areas could easily be enlarged or reduced in size as necessary to accommodate the expanding or reducing stockpile size. Sizing each individual stockpile area would be important in combating the effects of wind. In addition to securing the stockpiling area with fencing, it would also be necessary to channel and berm completely around the solid waste stockpiling area to protect the facility and surrounding area from run-on/run-off water and leachate.

After the working face of the existing landfill unit was re-established and was deemed safe to resume standard landfill operating practices, the solid waste which had previously been stockpiled at the temporary solid waste handling and stockpiling facility would then be transported to the landfill unit and deposited at the working face for compaction and burial. Upon completion of the removal of all the solid waste from the temporary stockpiling facility, the fencing would then be removed. Any impacted native soil would be removed and used as daily cover in the Washington County Landfill Facility. All run-on/run-off waters and leachate collected in the stockpiling area perimeter channel would then be pumped out and used as dust control at the landfill site. All channels would then be backfilled, all berms would be leveled, and the entire temporary stockpiling area would be scarified and contoured to its original condition.

A General Training And Safety Plan For Site Operations (R315-302-2(2)(o))

The manager of Washington County Landfill, Inc. will ensure that the required safety and training programs are conducted for the employees of the Washington County Landfill Facility. These topics will be taught from the Allied Waste Services Safety and Training Manual. A copy of the safety and training manual will be on file in the office of Washington County landfill, Inc. The order of training may change to suit the needs of the facility. All safety meetings and training will be documented by indicating the topic covered and main points discussed. Employees will be required to sign and date the appropriate forms.

Following is a list of the safety and training topics addressed, by month, over the course of the year.

MONTH	TRAINING TOPICS
January	Adverse Weather Hazardous Communication
February	Backing PPE – Conduct Hazardous Assessments, Industrial Truck Training Recertification for Forklift Operators
March	Push, Pull, Lift Lock Out/Tag Out Conduct Annual LOTO Documented Observations
April	Intersections/Pedestrians Accident Prevention Signs/Tags First Aid/CPR Training for Designated Employees
May	Heat Considerations Heat Stress Prepare Summer Safety Plans
	Load Inspections & Hazardous Waste identification

June	Backing
	Blood Borne Pathogens
July	Rear Collisions
	Emergency Response Training
	Fire Drill
August	Push, Pull, Lift
	Fire Extinguisher Training
	Hearing Conservation
September	Roll-Over
	Spill Prevention
October	Intersection
	Confined Spaces
November	Pedestrians
	Respiratory Protection
	Fall Protection
	Asbestos Safety
	Respirator Fit Tests
December	Drug and Alcohol Awareness

Any Recycling Programs Planned At The Facility (R315-303-4(6))

The Washington County Landfill Facility has programs to recycle metal and tires. A drop off area is provided for citizens to drop off recyclables.

A composting program has also been implemented at the landfill. The compost is produced by landfill personnel and sold to the public. If a surplus of compost is produced, the extra material may be used as an ADC. The landfill is also providing to the local communities a paint exchange program. Surplus paint is brought to the landfill by the public and exchanged for other paint. The public is not required to take paint with them when they drop off unused paint.

Closure and Post-closure Care Plan (R315-302-2(2)(m))

The closure and post-closure care plan for the Washington County Landfill Facility will be as cited in _Closure Plan (R315-310-3(1)(h))_ and the _Post-Closure Care Plan (R315-310-3(1)(h))_ contained in this permit application. The current cost estimates for closure and post closure maintenance was recently updated, in February 2021, and included as Attachment P.

Procedures For The Handling Of Special Wastes (R315-315)

The procedures for handling special wastes is as cited in _Procedures for excluding the receipt of prohibited hazardous or PCB containing wastes (R315-302-2(2)(j))_ of this permit application.

Plans And Operation Procedures To Minimize Liquids (R315-303-3(1)(a) and (b))

The plans and operation procedures to minimize liquids will be as cited in _Description of on-site waste handling procedures and an example of the form that will be used to record the weights or volumes of waste received (R315-302-2(2)(b) And R315-310-3(1)(f)):_ of this permit application.

Plans And Procedures To Address The Requirements of R315-303-3(7)(c)

The plans and procedures to address these requirements will be as cited in _Description of on-site waste handling procedures and an example of the form that will be used to record the weights or volumes of waste received (R315-302-2(2)(b) And R315-310-3(1)(f)):_ of this permit application.

Plans And Procedures To Address The Requirements of R315-303-3(7)(d)

The Washington County Landfill Facility has erected signs at the entrance of the facility. The signs identify the hours during which the facility is open, what the acceptable wastes are, emergency phone numbers, and the name of the facility.

Plans And Procedures To Address The Requirements of R315-303-3(7)(e)

The plans and procedures to address these requirements will be as cited in *Contingency plans in the event of a fire or explosion (R315-302-2(2)(d)):* of this permit application.

Plans And Procedures To Address The Requirements of R315-303-3(7)(f)

The plans and procedures to address these requirements will be as cited in *Procedures for controlling disease vectors (R315-302-2(2)(k)):* of this permit application.

Plans And Procedures To Address The Requirements of R315-303-3(7)(g)

The Washington County Landfill Facility is operated in a manner that minimizes the active face area. Traffic is managed with safety of operators, equipment, and personnel as the guiding factor.

Plans And Procedures To Address The Requirements of R315-303-3(7)(h)

The traffic at the Washington County Landfill Facility is managed to preclude tracking of waste materials outside of the landfill area. Also, traffic is managed to facilitate safety of operators, equipment, and personnel.

Plans And Procedures To Address The Requirements of R315-303-3(7)(i)

The Washington County Landfill Facility personnel have access to radio, telephones, and vehicles to handle emergencies at the facility.

Plans And Procedures To Address The Requirements Of R315-303-4

The plans and procedures to address these requirements will be as cited in various sections and of this permit application.

Any Other Site Specific Information Pertaining To The Plan Of Operation Required By The Director (R315-302-2(2)(o))

Information for this section will be provided upon request by the Director.

2. Facility Technical Information

Topographic Map Drawn To The Required Scale With Contours Showing The Boundaries Of The Landfill Unit, Ground Water Monitoring Well Locations, Gas Monitoring Points, And The Borrow And Fill Areas (R315-310-4(2)(a)(i))

The required map is located in Attachment J of this permit application. Also contained in the Attachment J provides a 200-foot scale topographical map depicting the boundaries of the borrow sites.

Most Recent U.S. Geological Survey Topographic Map, 7-1/2 Minute Series, Showing The Waste Facility Boundary; The Property Boundary; Surface Drainage Channels; Any Existing Utilities And Structures Within One-Fourth Mile Of The Site; And The Direction Of The Prevailing Winds (R315-310-4(2)(a)(ii))

The required map is located in Attachment J of this permit application.

Geohydrological Assessment (R315-310-4(2)(b))

Local And Regional Geology And Hydrology Including Faults, Unstable Slopes And Subsidence Areas On Site (R315-310-4(2)(b)(i))

This section has been adequately addressed in Mr. Bryce Montgomery's August 23, 1993 geologic report and his subsequent January 10, 1994 letter. These documents are contained in Attachment K of this permit application.

Evaluation Of Bedrock And Soil Types And Properties Including Permeability Rates (R315-310-4(2)(b)(ii))

This section has been adequately addressed using the above-referenced geologic reports and the current regulatory approval of using the two down gradient wells as the only monitoring wells. These documents are contained in Attachment K of this permit application.

Depth To Ground Water (R315-310-4(2)(b)(iii))

This section has been adequately addressed as detailed in the hydrogeologic evaluation provided by S. Bryce Montgomery. This document is contained in Attachment K of this permit application. Additional hydrogeological investigation and monitoring well installations associated with future expansion areas are described in the 10-Year Ground Water Analysis Plan below.

Direction And Flow Rate Of Ground Water (R315-310-4(2)(b)(iv))

As referenced in the geologic reports, regional groundwater appears to flow near the facility at a depth of approximately 800 feet. Based on studies conducted in the area by the U.S. Bureau of Reclamation, the rate and direction of groundwater flow in this "regional" system are probably highly affected by the geologic structure of the Harrisburg Dome and associated anticline. These data suggest that the flow of groundwater in the "regional" aquifer is to the southwest.

However, faulting and fracturing in the vicinity of the site has created localized zones of flow from nearby recharge areas. As discussed in the above-referenced reports, groundwater appears to flow from the outcrop of the Purgatory Buff Member of the Moenkopi formation to the southeast through a mapped fault towards MW-1. The aquifer which contains this groundwater appears to be perched and of local areal extent, with depths to groundwater of 15 to 20 feet.

There are insufficient data to make quantitative estimates of groundwater flow rate. However, based on interpretive geology in the above-referenced reports, the rate of groundwater flow appears to be extremely slow within the small perched aquifer near the site.

Quantity, Location, And Construction Of Any Private Or Public Wells On-Site Or Within 2,000 Feet Of The Facility Boundary (R315-310-4(2)(b)(v))

Other than two monitor wells which have been installed near the southwest end of the existing landfill cell, there are no on-site wells within the facility boundary. In addition, a search of records on file with the Utah Division of Water Rights indicates that no other permitted wells are located within 2,000 feet of the facility boundary. One well that has been listed in past permit renewal applications for the WCL is now listed as rejected in an updated search of the database provided by the Utah Division of Water Rights. That rejected well was previously described as follows:

1. No. 81-1211, a well water right for 1 cfs issued to Dixie Basin Smelters, Inc. The diversion is stated for use as domestic and mining. The referenced point of diversion is approximately 2,000 feet north of the northeast corner of the landfill cell. A copy of the water right is found in Attachment L of this permit application.

There are no applications for new wells on record within 2,000 feet of the facility boundary.

Tabulation Of All Water Rights For Ground Water And Surface Water On-Site And Within 2,000 Feet Of The Facility Boundary (R315-310-4(2)(b)(vi))

A water right search was performed for Sections 8, 9, 17, 18, 20 and 21 in T. 42S, R14W. In addition to the above-mentioned well, the following are the water rights that were found on record within 2,000 feet of the facility boundary:

1. No. 81-415, a surface water right for 2.06 acre-feet issued to the United States Bureau of Land Management. The diversion is on an “unnamed wash” with the stated use as stock watering. The referenced point of diversion is approximately 700 feet southwest of the northwest corner of the landfill cell.

2. No. 81-2827, a surface water right for 0.20 acre-feet issued to the United States Bureau of Land Management. The diversion is on an “unnamed wash” with the stated use as stock watering. The referenced point of diversion is approximately 1800 feet northwest

of the northwest corner of the landfill cell. A copy of the water right is found in Attachment L of this permit application.

3. No. 81-2828, a surface water right for 0.20 acre-feet issued to the United States Bureau of Land Management. The diversion is on an “unnamed wash” with the stated use as stock watering. The referenced point of diversion is approximately 1700 feet northwest of the northwest corner of the landfill cell. A copy of the water rights is found in Attachment L of this permit application.

Location the water rights are also shown on an aerial map included in Attachment L.

Identification And Description Of All Surface Waters On-Site And Within One Mile Of The Facility Boundary (R315-310-4(2)(b)(vii))

There are no surface water bodies within one mile of the facility boundary other than the Total Containment Evaporation Pond contained within the facility boundary. Water right 81-415, referenced above, apparently contains enough water on a seasonal basis to justify issuance of the right. Review of the file for this right indicates that a structure was constructed to catch run-off from the unnamed wash during periods of heavy rainfall. The file contains a detail of the resulting reservoir/impoundment and the associated control structures.

Background Ground Water And Surface Water Quality Assessment And, For An Existing Facility, Identification Of Impacts Upon The Ground Water And Surface Water From Leachate Discharges (R315-310-4(2)(b)(viii))

The following subsections contain the applicable analyses and recommendations for this permit application.

Current Groundwater Conditions And Analysis

As indicated above, groundwater flow patterns in the vicinity of the site appear to be highly influenced by local fracturing. ”Regional” flow directions appear to be to the southwest, while flow in a localized, shallow perched aquifer appears to be to the southeast. The two existing monitor wells at the site are both located southwest of the landfill and completed in the shallow, perched aquifer (where groundwater is suspected to flow to the southeast). Hence, these wells are likely located cross gradient from the landfill (as opposed to down gradient as desired). As a result, insufficient data are available to properly evaluate what impacts the landfill may have on groundwater. Since monitoring began in 1995, there have been low level detections of 1,1-dichloroethane and tetrachloroethylene. These detections have been below the Maximum Contaminant Levels (MCL) established by the U.S. Environmental Protection Agency for drinking water. Because of the complex geologic environment and the localized aquifer conditions referenced in the geologic investigation, these VOC detections have been noted as insignificant.

Per the Groundwater Sampling and Analysis Plan (GWSAP) for the Washington County Landfill, prepared by Converse Consultants, dated October 5, 2021 (see Attachment N), several statistical analysis methods are utilized for groundwater monitoring at the site. For routine detection monitoring, intra-well comparisons for metals and inorganic indicator parameters is conducted using Shewhart-CUSUM (cumulative sum) control charts. Non-parametric prediction limits combined with Sen's Slope/Mann Kendall trend analysis is applied to those parameters with greater than 50 percent non-detections in the background dataset. Statistical limits for volatile organic compounds (VOCs) in detection monitoring wells is based on the reporting limits. Additional information on the statistical methods used for groundwater constituent analysis can be found in the site GWSAP (Attachment N).

Note that the groundwater monitoring network at the WCL currently consists of two compliance wells (MW-1, and MW-2). Historical attempts to construct additional groundwater monitoring wells upgradient of the landfill have been unsuccessful, with the upgradient well installations not intersecting groundwater (see Attachment M). As part of the 10-Year Groundwater Analysis Plan described below, another attempt at establishing upgradient monitoring wells will be performed in conjunction with the WCL's planned future expansion area. If groundwater is found and upgradient monitoring well(s) are successfully established, then a review of the statistical analysis methodology used at the WCL for groundwater monitoring may be warranted.

10-Year Groundwater Analysis Plan

The objective of the 10-Year Groundwater Analysis Plan is to provide additional hydrogeologic data and monitoring well locations to accommodate groundwater sampling and analysis compliance as the landfill grows into future expansion areas. The WCL plans to expand the hydrogeologic data of the site and groundwater sampling and analysis capabilities with the addition of two monitoring well locations. The proposed additional monitoring wells will consist of a minimum of one upgradient well and either one additional downgradient well or a second upgradient well. The projected well locations are shown in Attachment N. Note that the actual well locations are subject to change based on the findings of hydrogeologic assessments. The depths of the additional monitoring wells will be determined based on the depth of groundwater at the time of drilling and will not exceed 300 feet below the ground surface.

Within two years of acceptance of this Permit Renewal Application, the WCL will conduct a geologic and hydrogeologic mapping study that will consist of compiling existing background data and well logs and performing surficial geologic mapping of the site to document locations of contacts between geologic formations and orientation of geologic strata and faults. Based on the findings of the geologic and hydrogeologic mapping study, a subsurface drilling and well installation plan will be developed. The two additional monitoring wells will be constructed and developed within 5 years of this Permit Renewal Application.

Beyond the 10-Year Groundwater Analysis Plan and prior to the development of Phase 12 of the landfill as shown in Appendix O, the two existing downgradient monitoring wells will be decommissioned in accordance with applicable State regulations and moved to locations outside and downgradient of the Phase 12 lined waste footprint.

Surface Water

There are no surface water bodies of any substance in the vicinity of the landfill. Drainage from the landfill is controlled by engineered site drainage.

Impact of Leachate of Groundwater and Surface Water

No impact from leachate is evident on the groundwater or in the ephemeral surface water drainage features.

Ground Water Monitoring (R315-303-3(7)(B) And R315-308)

Ground water monitoring is addressed in the previous section and as cited in the ground water monitoring plan in Attachment N that meets the requirements of Rule R315-308 including well locations, design, and construction (R315-310-4(2)(b)(x) and R315-310-4(2)(c)(i) of this permit application.

Statistical Method To Be Used (R315-308-2(7))

Statistical method to be used is addressed in the section "Background Groundwater and Surface Water Quality Assessment And, For an Existing Facility, Identification of Impacts Upon the Ground Water and Surface Water from Leachate Discharges (R315-310-4(2)(b)(viii))" of this permit application. See also Attachment N.

Calculation Of Site Water Balance (R315-310-4(2)(b)(ix))

A negative water balance, where evaporation and transpiration greatly exceed precipitation, exists in the area and will minimize the production of leachate. Calculation of the site water balance is as follows: The average annual precipitation received in this area is approximately 8 inches while the average pan evaporation is approximately 80 inches making for a substantial negative water balance of approximately 72 inches.

3. Engineering Report – Plans, Specifications, and Calculations

Engineering Reports Required To Meet The Location Standards Of R315-302-1 Including Documentation Of Any Demonstration Or Exemption Made For Any Location Standard (R315-310-4(2)(c)(i))

See R315-302-1, above.

Anticipated Facility Life And The Basis For Calculating The Facility's Life (R315-310-4(2)(c)(ii))

The landfill cell presently in use is Cell 4D, which is a portion of Phase 4 described in the WCL Master Plan Report dated September, 2020 by Geo-Logic Associates, included as Attachment O. Cell 4D was constructed in 2020 and will provide capacity through 2022, after which Cell 5A will need to be constructed. The entire existing permitted and planned landfill footprint is approximately 276 acres out of the total permitted leased area of 555 acres. The Master Plan identifies the remaining undeveloped units as Phase 5-12 with a total remaining capacity of approximately 73,779,100 cy including waste and soil cover. Based on the most recent aerial topographical survey date of March 9, 2021, the total remaining capacity of the site (including the remaining available airspace in Phase 4 and future Phases 5-12) is approximately 74,683,700 cy. Assuming an operational density of 1,824 lbs/cy, this equates to approximately 68,111,500 tons of waste including soil covers. Based on the annual waste projections shown in Attachment C, Phases 5-12 will provide an estimated 90 years of capacity for the site. The landfill is estimated to reach final grades at the beginning of the year 2011.

Upon completion of each phase, successive phases or units will be constructed directly adjacent to the previous phase, each phase comprising of sub-units designed with four to five year capacity each, incorporating each existing unit and extending easterly along the westerly to the east property line.

Washington County Landfill, Inc. will submit detailed construction plans and specifications for each construction phase prior to the planned construction. These plans will be submitted to the Director for approval.

Attachment C of this document provides a table addressing the demographics of Washington County with population and solid waste projections upon which the landfill layout was based. Current population and population projections were taken from the U.S. Census Bureau. The typical per capita MSW generation which is estimated by the EPA, is approximately 4.5 pounds per person per day. This number was used in developing the annual waste disposal rates shown on the table in Attachment C.

Cell Design To Include Liner Design, If Liner Is To Be Used; Cover Design; Fill Methods; And Elevation Of Final Cover Including Plans And Drawings Signed And Sealed By A Professional Engineer Registered In The State Of Utah, When Required (R315-310-3(1)(b) And R315-310-4(2)(c)(iii))

The current cell design including liner design, leachate collection and removal system (LCRS) design, cover design, fill sequencing, final grading showing final elevation of final cover, and construction details, as shown in Appendix A of the Master Plan Report (Attachment O to this permit application). Washington County Landfill, Inc. will submit detailed construction plans and specifications for each construction phase prior to the planned construction. These plans will be submitted to the Director for approval prior to construction.

Equipment Requirements And Availability (R315-310-4(2)(C)(iii))

The equipment list may change as a result of a change in the operational requirements. The following equipment is presently being used at the landfill site in the landfilling operations and cover operations:

Trash Compactors
Rubber tired Backhoe
Excavators
Motor Graders
Dozers
Articulated Dump Trucks
Pick Up Trucks
Service Truck & Lube Trucks
1 – International 4300 Vac Truck

Roll Off Truck

Front End Loaders
Compost equipment
Water Trucks
Vac Truck
Air Compressors & Pressure Washer
ADC Machine

Identification Of Borrow Sources For Daily And Final Cover And For Soil Liners (R315-310-4(2)(c)(iv))

The current daily cover needs are met by Alternative Daily Covers (ADCs) or the soil excavated from on-site cells/expansion areas. When either of these sources becomes inadequate, the importation of soil cover material from a nearby gravel crushing operation will be utilized. This operation procedure will continue through the next permit period. The natural material at the site is a very stable material and averages 10 feet thick. This material will be used as daily cover material during construction of the units as well as part of the final closure cap system. During the course of landfill operation, native soil may be excavated to provide for added solid waste volume as well as to provide for daily cover material. Upon closure of the existing landfill unit, native soil material will be excavated from on-site and deposited on the landfill units as native cover soil. The additional BLM land that WCL has recently acquired will also be utilized as a borrow source.

Leachate Collection System Design And Calculations Showing System Meets The Requirements Of R315-303-3(2) If A Liner Is To Be Used

A leachate collection system has been constructed for the existing cells (Phase 1 through 4) and designed for future cells (Phase 5-12) as shown in the Master Plan Drawings, included in this Permit Application as Attachment O, to comply with subsection R315-303-3(2) of the Solid Waste Permitting and Management Rules and subject to approval by the Director prior to construction.

The design of the leachate collection system and the contaminated run-off waters collection system operate in conjunction with the existing system. The leachate collection system in the existing and future cells consist of a network of leachate collection pipes and were sized to carry twice the anticipated leachate volumes over the life of the landfill, using leachate flows generated through the HELP Model computer program developed by the US Army Corps of Engineers (USCOE). Results of the HELP Model simulations can be found in Attachment O, the Master Plan Report, as Appendix B.

Run-Off Or Leachate Collection, Treatment, And Disposal And Documentation To Show That Any Treatment System Is Being Or Has Been Reviewed By The Division Of Water Quality (R315-310-4(2)(c)(v) And R315-310-3(1)(i))

It has been determined that there exists no potable water source in the Purgatory Flat area which would require extensive monitoring. Therefore, there will be no permanent ground water monitoring equipment installed which will require maintenance.

As described above, the leachate collection system consists mainly of a network of collection piping and a sump and discharged into the existing evaporation pond. A more detailed description of the system can be found in Attachment O, the Master Plan Report.

Ground Water Monitoring Plan That Meets The Requirements Of Rule R315-308 Including Well Locations, Design, And Construction (R315-310-4(2)(b)(x) And R315-310-4(2)(c)(vi))

The ground water monitoring plan is included in Attachment N of this permit application, and existing well locations are included in Attachment J.

Landfill Gas Monitoring And Control Plan That Meets The Requirements Of Subsection R315-303-3(5) (R315-310-4(2)(c)(vii))

Methane gas monitoring will be performed quarterly using a hand-held probe. The hand-held probe is to be calibrated prior to each use by the District's gas sample collector. This is to be done in conformance with the manufacturer's recommendations. The calibration of the probe will then be documented on the landfill gas quarterly monitoring results form. See Attachment H. Any required maintenance or repair, other than calibration, will be performed by the manufacturer of the probe or a licensed representative of the manufacturer. A landfill gas control system has been installed and is currently operating at WCL.

Slope Stability Analysis For Static And Under The Anticipated Seismic Event For The Facility (R315-310-4(2)(B)(I) And R315-302-1(2)(B)(ii))

The Slope Stability Analysis can be found in Appendix C of the Master Plan Report in Attachment O.

Design And Location Of Run-On And Run-Off Control Systems (R315-310-4(2)(c)(viii))

The run-on/run-off collection system consists mainly of an open ditch channelizing system which will also handle run-off water from those open portions of the landfill unit. Any leachate contaminated run-off water is collected at the open lined pond for containment for evaporation. The containment pond is lined with a membrane liner to prevent seepage of the leachates into the surrounding ground. Maintenance of the channel system and containment pond will consist mainly of weed control. Details of the stormwater management and collection system can be found in Attachment O, Master Plan Drawings as Appendix A. Drainage calculations and design can be found in Appendix D of the said Master Plan report.

Site Closure And Post-Closure Plan (R315-310-3(1)(h))

Closure Plan (R315-310-3(1)(h))

Closure Schedule (R315-310-4(2)(d)(I))

The closure schedule of the Washington County Landfill Facility will be as cited in section *Anticipated facility life and the basis for calculating the facility's life (R315-310-4(2)(c)(ii))* of this permit application.

Design Of Final Cover (R315-310-4(2)(c)(iii))

The cell design including liner design, cover design, fill methods, elevation of final cover including plans and drawings are contained in Master Plan Report, Appendix A, in Attachment O of this permit application. Detailed landfill final closure construction drawings will be submitted prior to any future closure construction to the Director for approval.

Capacity Of Site In Volume And Tonnage (R315-310-4(2)(d)(ii))

The capacity of the site in volume and tonnage has been calculated using latest topographic maps of the facility and the Master Plan fill plans (Attachment O). The total capacity of the site (including consumed airspace) is approximately 79,908,200 cy. Assuming an average operational density of 1,824 lbs/cy, this equates to approximately 72,876,200 tons of waste including daily soil cover. Based on the most recent aerial topographical survey date of March 9, 2021, the total remaining volume and tonnage capacity of the site (including the remaining available airspace in Phase 4 and future Phases 5-12) is approximately 74,683,700 cy and 68,111,500 tons, respectively.

Final Inspection By Regulatory Agencies (R315-310-4(2)(d)(iii))

All items of closure work performed by the contractor will be subject to inspection by the District, its representatives or representatives of regulatory agencies having jurisdiction over the operation of the landfill. To ensure compliance with all rules and regulations that apply to the landfill, a final closure plan will be submitted prior to any closure construction to the Director for approval.

Prior to the existing landfill unit closure construction, the District will notify the regulatory agency responsible for the operations of the landfill facility in order that inspection trips may be planned.

All test results for all phases of closure construction will be kept on file as part of the landfill record.

Post-Closure Care Plan (R315-310-3(1)(h))

Site Monitoring Of Landfill Gases, Ground Water, And Surface Water, If Required (R315-310-4(2)(e)(i))

Ground water monitoring will continue during the post-closure care period as it is apparent that there is a perched water aquifer requiring the installation of ground water monitoring equipment. Maintenance of water monitoring equipment during this period consists of protection and maintaining of the monitoring well heads.

As there are no surface water sources on the landfill property, it will not be required of the District to conduct surface water monitoring as part of the post-closure care activities.

Upon closure of the landfill facility, leachate will be collected and treated as needed. During the years of operation prior to closure, a de-watering/run-off system has been and will be constructed to collect and remove all contaminated water from unclosed units and deposit the water in a total containment evaporation pond. After all units are covered with a protective cap system, the de-watering systems will remain in-place and continue to drain any moisture within the units. Post-closure maintenance of this system will consist of maintaining the integrity of the evaporation pond membrane lining system through weed and erosion control. It is expected that the facility will be entirely capped. There will be little, if any, leachate collected in the evaporation pond during the actual post-closure care period.

Gas monitoring will continue after closure of the landfill facility during the post-closure care period. Maintenance of gas monitoring equipment during this period consists of regular calibrations, and occasional repair or replacement of the actual gas equipment as per manufactures recommendations.

Withdrawals from the selected financial assurance instrument for the costs incurred by the District for performing the regularly scheduled quarterly inspections and methane gas monitoring will be requested at the end of each quarter that the inspections are made. Withdrawals for any required additional inspection trips and maintenance work performed will also be made at the as needed in which it was performed.

Changes To Record Of Title, Land Use, And Zoning Restrictions (R315-310-4(2)(e)(ii))

Change of ownership of the property has occurred. On January 21, 1994, the United States of America gave and granted the property that contains the original 500-acre footprint of the Washington County Landfill Facility to Washington County. On October 5, 2018 an additional 55 acres of adjacent property was acquired by Washington County from the BLM. Washington County leases the property to the Washington County Solid Waste Special Service District #1. Washington County Landfill Inc. operates the landfill facility. A copy of the deed and the lease agreement are contained in Attachments A and B of this permit application.

Maintenance Activities To Maintain Cover And Run-On/Run-Off Control Systems (R315-310-4(2)(e)(iii))

There are no surface water sources on the landfill property, other than normal stormwater runoff. As a result, Washington County Landfill will not conduct surface water monitoring as part of the post-closure care activities.

The water balance indicates that, upon closure of the landfill facility, there will be no leachate collection or associated treatment. A leachate collection and extraction system has been provided however in the new cells, where leachate is extracted from sumps and recirculated back to the landfill. A run-off control system has been constructed to collect and remove all contaminated water from unclosed units and deposit the water in a Total Containment Evaporation Pond. After all units are covered with a protective cap system, the leachate collection system and run-off control systems will remain in-place and continue to drain any moisture within the units. Post-closure maintenance of this system will consist of maintaining the integrity of the evaporation pond membrane lining system through weed and erosion control. It is expected that the facility will be entirely capped, there will be little, if any, leachate collected in the evaporation pond during the actual post-closure care period.

Maintenance of the leachate evaporation pond as discussed previously will consist of weed and erosion control to ensure that any collected leachate is contained. Regular inspection will be made to determine the integrity of the pond and volume of collected leachates if any.

The run-off water channels along the perimeter of the closed landfill unit will require routine inspection and cleaning to ensure that obstructions do not occur. In conjunction with the routine inspection of the run-off water channels, inspection of the protective cap system will be performed to ensure that the vegetation continues to protect the cover soil from erosion.

Regular inspections will be made to ensure the integrity of the protective cap system and the run-on/run-off systems. It is understood that erosion can have an adverse effect upon the landfill facility, and, if left unchecked or not maintained, could become a public health hazard. It is Washington County Landfill, Inc.'s intention to implement a maintenance program to ensure the integrity of the landfill facility and remaining structures during the post-closure period, thus protecting the public and the environment.

It is anticipated that weed control in the run-off water channels and evaporation pond will require maintenance annually. This post-closure maintenance should be performed mid to late winter prior to the germination of the seeds in the spring.

List The Name, Address, And Telephone Number Of The Person Or Office To Contact About The Facility During The Post-Closure Care Period (R315-310-4(2)(e)(vi))

The names, address, and telephone number of the person or office to contact about the facility during the post-closure care period is as follows:

Name:	Washington County Special Services District #1 Kevin Kunz, District Manager
Address:	325 North Landfill Road Washington, Utah 84780
Phone #:	(435) 673-2813

Financial Assurance (R315-310-3(1)(j))

Identification Of Closure Costs Including Cost Calculations (R315-310-4(2)(d)(iv))

The closure costs associated with closing the existing landfill as modified through the year 2021 are contained in Attachment P of this permit application.

Identification Of Post-Closure Care Costs Including Cost Calculations (R315-310-4(2)(e)(iv))

The costs associated with post-closure care of the existing landfill through the 30-year post-closure period, are contained in Attachment P of this permit application.

Identification Of The Financial Assurance Mechanism That Meets The Requirements Of Rule R315-309 And The Date That The Mechanism Will Become Effective (R315-309-1(1))

The Washington County Solid Waste Special Service District entered into an escrow agreement with the State of Utah as a financial assurance mechanism to provide funding for closure of its existing cells. The Utah State Treasurer is acting as the escrow agent. The terms of the agreement include the Washington County Special Service District #1 making monthly payments into the escrow account such that the funds would be available to complete the closure and post closure requirements. The balance of the funds as of July 31, 2021 is included in Attachment Q which shows the Statement of Accounts with a total fund balance of $7,857,888.96. There will be adequate funds in the account to cover closure and post-closure care costs of the existing landfill cell. Funds could be withdrawn for payment of closure and post closure expenses upon authorization by both the Washington County Special Service District #1 and the Director of the Solid and Hazardous Waste Control Board.

Attachment P of this permit application contains a table showing the cost calculations for post-closure care costs for the 30 years.

ATTACHMENT A

LEASE AGREEMENT

LEASE AGREEMENT

This LEASE AGREEMENT is made on this 14th day of February, 1994, by and between WASHINGTON COUNTY SPECIAL SERVICE DISTRICT NO. 1, a special service district organized and existing under the laws of the State of Utah, hereinafter referred as the "District", and WASHINGTON COUNTY, UTAH, a body politic of the State of Utah, hereinafter referred to as the "County."

RECITALS

1. The District was created by resolution of the Washington County Commission for the purpose of providing solid waste collection and disposal services to the residents of the County.

2. The District is responsible for operation and maintenance of a sanitary landfill on certain real property located in the County, said property being more particularly described in Exhibit A, a copy of which is attached hereto and by this reference incorporated herein.

3. From the period of time since the organization of the District to approximately the present time, the sanitary landfill site was owned by the Bureau of Land Management, who leased said site to the County for use as a sanitary landfill.

4. The Bureau of Land Management has recently conveyed title to the landfill site to the County, who now desires to lease said site to the District for continued use as a sanitary landfill.

5. The District and the County desire to enter into a formal lease agreement, specifying the terms and conditions upon which said property shall continue to be used as a landfill site.

NOW, THEREFORE, IN CONSIDERATION of the mutual covenants and obligations contained herein, the parties hereto agree as follows:

1. The County hereby leases to the District that certain real property described in Exhibit A, a copy of which is attached hereto and incorporated herein as if fully set forth.

2. As consideration for said lease, the parties acknowledge that the District has paid all accrued rent owed by the County to the Bureau of Land Management for the period of time that said property has been used as a sanitary landfill. In addition, the District hereby agrees to pay to the County the sum of one dollar ($1.00) per year for rent during the period of this agreement, for a total of fifty dollars ($50.00), payable in advance at the time of execution of this agreement.

3. The term of the lease shall be for a period of fifty (50) years, commencing on January 1, 1994 and ending on December 31, 2044, or until such time as the District ceases to exist, whichever first occurs.

4. The County covenants and warrants that it has fee title to said real property, free and clear of all encumbrances, restrictions or reservations which would in any way impair the validity of this lease agreement or the right of the District to

utilize said property for disposal of solid waste.

5. The parties hereto agree that said real property shall be utilized solely for continued operation and maintenance of a sanitary landfill site, and that District shall be solely responsible for operation, maintenance and control of said landfill in accordance with all state and federal statutes, rules and regulations, as well as any rules or regulations adopted by resolution of said District's Administrative Control Board.

6. The parties hereto agree that, as between the District and the County, all responsibility and liability in connection with the use of the property as a sanitary landfill site shall be borne solely by the District. The District further agrees to indemnify and hold the County harmless from and against any and all claims, demands or causes of action that may be asserted against the County by any other person or entity in connection with the use of said property as a sanitary landfill site, and to procure and maintain public liability and property damage insurance, with the County named as an additional insured, in such amounts as may be established from time to time by resolution of the Board of Washington County Commissioners. The parties acknowledge and agree that as of the date hereof, the amount of such insurance shall be the sum of not less than Five Hundred Thousand Dollars ($500,000.00) for each occurrence, and One Million Dollars ($1,000,000.00) for property damage and liability per one year, and that the insurance required hereby shall remain at said amounts until such time that the County shall send the District written notice of any change.

7. This lease shall be binding upon and shall inure to the benefit of the parties hereto, their successors and assigns.

8. This lease, or any right hereunder, shall not be assigned to any other person or entity except upon written consent of both parties hereto.

9. This lease shall be governed by and construed under the laws of the State of Utah.

10. This lease agreement constitutes the entire agreement of the parties, all negotiations and representations having been included herein, and shall not be modified except upon written agreement duly executed by the parties hereto.

IN WITNESS WHEREOF the parties have executed this agreement on the date first above written.

WASHINGTON COUNTY

Gayle M Aldred

Gayle Aldred, Chairman
Washington County Commission

Attest:

Carolyn Sutterfield

Carolyn Sutterfield, Deputy Clerk

WASHINGTON COUNTY SPECIAL
SERVICE DISTRICT NO. 1

Barbara Beckstrom

Barbara Beckstrom, Chariman
Administrative Control Board

Attest:

Joan Bills

Joan Bills, Secretary

ATTACHMENT B

PROOF OF OWNERSHIP

Form 1860-9
(January 1988)

The United States of America

To all to whom these presents shall come, Greeting:

Serial: Utah 40541

WHEREAS,

Washington County

is entitled to a land patent pursuant to the Recreation and Public Purposes Act of June 14, 1926 (44 Stat. 741), as amended and supplemented (43 U.S.C. 869; et. seq.), for the following described land:

Salt Lake Meridian, Utah

T. 42 S., R. 14 W.,
sec. 8, SE¼SE¼NE¼, SE¼SE¼SW¼, NE¼SE¼,
S½SE¼, SE¼NW¼SE¼;
sec. 9, SE¼NW¼NW¼, SW¼NW¼, NW¼SW¼,
N½SW¼SW¼, SW¼SW¼SW¼;
sec. 17, N½NE¼NE¼, SW¼NE¼NE¼, NW¼NE¼,
NW¼SW¼NE¼, E½NW¼, E½W½NW¼,
SW¼NW¼NW¼, W½SW¼NW¼.

containing 500.00 acres

NOW KNOW YE, that the UNITED STATES OF AMERICA, in consideration of the premises, and in conformity with said Act of Congress, HAS GIVEN AND GRANTED, and by these presents DOES GIVE AND GRANT unto the said Washington County, the land above described, for use as a solid waste sanitary landfill: TO HAVE AND TO HOLD the same, together with all rights, privileges, immunities, and appurtenances, of whatsoever nature, thereunto belonging, unto the same Washington County, forever; and

EXCEPTING AND RESERVING TO THE UNITED STATES:

1. A right-of-way thereon for ditches or canals constructed by the authority of the United States. Act of August 30, 1890 (43 U.S.C. 945); and

2. All mineral deposits in the lands so patented, and the right of the United States, or persons authorized by the United States, to prospect for, mine, and remove such deposits from the same under applicable laws and regulations as the Secretary of the Interior may prescribe; and

Washington County, its successors or assigns, assumes all liability for and shall defend, indemnify, and save harmless the United States and its officers, agents, representatives, and employees, from all claims, loss, damage, actions, causes of action, expense, and liability (hereinafter referred to in this clause as claims) resulting from, brought for, or on account of, any personal injury, threat of personal injury, or property damage received or sustained by any person or persons (including the patentee's employees) or property growing out of, occurring, or attributable directly or indirectly, to the disposal of solid waste on, or the release of

Patent Number 43-94-0009

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Patent Page 1 of 4
Russell Shirts Washington County Recorder
10/05/2018 08:40:52 AM Fee $ 0.00
By WASHINGTON COUNTY UTAH

The United States of America

To all to whom these presents shall come, Greetings:

WHEREAS,

Washington County, Utah

is entitled to a land patent pursuant to the Recreation and Public Purposes Act of June 14, 1926 (44 Stat. 741), as amended and supplemented (43 U.S.C. 869; et. seq.), for the following described land:

Salt Lake Meridian, Utah

T. 42 S., R. 14 W.,
    sec. 8, SW1/4SE1/4NE1/4, NE1/4NE1/4SE1/4SW1/4,
        S1/2NE1/4SE1/4SW1/4, NE1/4SW1/4SE1/4SW1/4,
        S1/2SW1/4SE1/4SW1/4, NE1/4NW1/4SE1/4, and
        SW1/4NW1/4SE1/4;
    sec. 9, SW1/4NW1/4NW1/4.

The areas described aggregate 55 acres.

NOW KNOW YE, that the UNITED STATES OF AMERICA, in consideration of the premises, and in conformity with said Act of Congress, HAS GIVEN AND GRANTED, and by these presents DOES GIVE AND GRANT unto the said **Washington County, Utah,** the land above described for the use as a landfill: TO HAVE AND TO HOLD the same, together with all rights, privileges, immunities, and appurtenances, of whatsoever nature, thereunto belonging, unto the same, **Washington County, Utah,** forever; and

EXCEPTING AND RESERVING TO THE UNITED STATES:

1. A right-of-way thereon for ditches or canals constructed by the authority of the United States. Act of August 30, 1890 (43 U.S.C. 945).
2. All mineral deposits in the lands so patented, and to it, or persons authorized by it, the right to prospect for, mine and remove such deposits from the same under applicable law and regulations to be established by the Secretary of the Interior.

Washington County, its successors or assigns, shall comply with all Federal and State laws applicable to the disposal, placement, or release of hazardous substances (substance as defined in 40 CFR Part 302).

Washington County, its successors or assigns, assumes all liability for and shall defend, indemnify, and save harmless the United States and its officers, agents, representatives, and employees (hereinafter referred to in the clause as the United States), from all claims, loss, damage, actions, causes of action, expense, and liability (hereinafter referred to in this clause as claims) resulting from, brought for, or on account of, any personal injury, threat of personal injury, or property damage received or sustained by any person or persons including the patentee's employees) or property growing out of, occurring, or attributable directly or indirectly, to the disposal, placement, or release of hazardous substances from, sec. 8, SW1/4SE1/4NE1/4, NE1/4NE1/4SE1/4SW1/4, S1/2NE1/4SE1/4SW1/4, NE1/4SW1/4SE1/4SW1/4, S1/2SW1/4SE1/4SW1/4, NE1/4NW1/4SE1/4, and SW1/4NW1/4SE1/4, sec. 9, SW1/4NW1/4NW1/4, T.42 S., R. 14 W., SLM, regardless of whether such claims shall be attributable to: (1) the concurrent, contributory, or partial fault, failure, or negligence of the United States, or (2) the sole fault, failure, or negligence of the United States.

The above described land has been conveyed for utilization as a solid waste disposal site. Upon closure, the site may contain small quantities of commercial and household hazardous waste as determined in the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6901), and defined in 40 CFR 261.4 and 261.5. Although there is no indication these materials pose any significant risk to human health or the environment, future land uses should be limited to those which do not penetrate the liner or final cover of the landfill unless excavation is conducted subject to applicable State and Federal requirements.

No portion of the land shall under any circumstances revert to the United States if any such portion has been used for any purpose which may result in the disposal, placement, or release of any hazardous substance.

Provided, that title shall revert to the United States upon a finding, after notice and opportunity for a hearing, that, without the approval of the Secretary of Interior or his delegate, the patentee or its successor attempts to transfer title to or control over the lands to another, the lands have been devoted to a use other than that for which the lands were conveyed, the lands have not been used for the purpose for which the lands were conveyed for a 5-year period, or the patentee has failed to follow the approved development plan or management plan.

If, at any time, the patentee transfers to another party ownership of any portion of the land not used for the purpose(s) specified in the application and approved plan of development, the patentee shall pay the Bureau of Land Management the fair market value, as determined by the authorized officer, of the transferred portion as of the date of the transfer, including the value of any improvements thereon.

Provided further, that the Secretary of Interior may take action to revest title in the United States if the patentee directly or indirectly permits its agents, employees, contractors, or subcontractors (including without limitations lessees, sublessees, and permittees) to prohibit or restrict the use of any part of the patented lands or any of the facilities thereon by any person because of such person's race, creed, color, sex, national origin, or handicap.

In addition to the above the grant of the herein described lands is subject to the following reservations, conditions and limitations:

1. The patentee or its successors in interest shall comply with and shall not violate any of the terms or provisions of Title VI of the Civil Rights Act 1964 (78 Stat. 241), and requirements of the regulations, as modified or amended, of the Secretary of the Interior issued pursuant thereto (43 CFR 17) for the period that the lands conveyed herein are for the purpose for which the grant was made pursuant to the act cited above, or for another purpose involving the provision of similar services or benefits.

2. If the patentee or its successor in interest does not comply with the terms or provisions of Title VI of the Civil Rights Act of 1964, and the requirements imposed by the Department of the Interior issued pursuant to that title, during the period during which the property described herein is used for the purpose for which the grant was made pursuant to the act cited above, or for another purpose involving the provision of similar services or benefits, the Secretary of the Interior or his delegate may declare the terms of this grant terminated in whole or in part.

3. The patentee, by acceptance of this patent, agrees for itself or its successors in interest that a declaration of termination in whole or in part of this grant shall, at the option of the Secretary or his delegate, operate to revest in the United States full title to the lands involved in the declaration.

4. The United States shall have the right to seek judicial enforcement of the requirements of Title VI of the Civil Rights Act of 1964, and the terms and conditions of the regulations, as modified or amended, of the Secretary of the Interior issued pursuant to said Title VI, in the event of their violation by the patentee.

5. The Patentee and its successors in interest will, upon request of the Secretary of the Interior or his delegate, post and maintain on the property conveyed by this document signs and posters bearing a legend concerning the applicability of Title VI of the Civil Rights Act of 1964 to the area or facility conveyed.

6. The reservations, conditions, and limitations contained in paragraphs (1) through (5) shall constitute a covenant running with the land, binding on the patentee and its successors in interest for the period for which the land described herein is used for the purpose for which this grant was made, or for another purpose involving the provision of similar services or benefits.

7. The assurances and covenant required by sections (1) through (6) above shall not apply to

ultimate beneficiaries under the program for which this grant is made. "Ultimate beneficiaries" are identified in 43 CFR 17.12(h).

IN TESTIMONY WHEREOF, the undersigned authorized officer of the Bureau of Land Management, in accordance with the provisions of the Act of June 17, 1948 (62 Stat. 476), has, in the name of the United States, caused these letters to be made Patent, and the Seal of the Bureau to be hereunto affixed.

GIVEN under my hand, in SALT LAKE CITY, UTAH, the TWENTY-SIXTH day of SEPTEMBER in the year of our Lord TWO THOUSAND and EIGHTEEN and the Independence of the United States the Two Hundred and Forty-Third.

By Edwin L Roberson

Edwin L. Roberson
Utah State Director
Bureau of Land Management

ATTACHMENT C

POPULATION AND SOLID WASTE GENERATION PROJECTIONS

WASHINGTON COUNTY LANDFILL

LANDFILL SITE LIFE PROJECTION
Operational Density: 1,824 lbs/cy, Cover Soil Estimated at 15% Soil to Waste
Loading Rate: Waste 960 tons/day and 286 days/yr
2020 Master Plan Configuration (Waste Fill_Phases 5 through 12)

Operational Density (lb/cy)	1824	0.912	tons/cy
Waste accepted (days)	286		
Waste tons per day	960		
Soil to waste (%)	0.15		
% growth	**1.020**	2.00%	

Year	Waste (tons/yr)	Waste (cy/yr)	Daily Soil Cover @15% (cy)	Total Waste and Cover Soil Landfilled (cy/yr)	Cumulative Airspace Used (cy)	Remaining Airspace (cy)		
						1,087,388	**(based on 2021 ABM, remaining airspace from Phase 4D fill plan based on 3/3/2020 top**	
2020	226,560	211,158	37,263	248,421	248,421	838,967	(partial year beginning 3/3/2020)	
2021	274,560	255,895	45,158	301,053	549,474	537,914		
2022	280,051	261,013	46,061	307,074	856,547	230,841		
2023	285,652	266,233	46,982	313,215	1,169,763	7,574,625	Construct Phase 5	7,657,000 cy added
2024	291,365	271,558	47,922	319,479	1,489,242	7,255,146		
2025	297,193	276,989	48,880	325,869	1,815,111	6,929,277		
2026	303,136	282,528	49,858	332,386	2,147,497	6,596,891		
2027	309,199	288,179	50,855	339,034	2,486,532	6,257,856		
2028	315,383	293,943	51,872	345,815	2,832,346	5,912,042		
2029	321,691	299,821	52,910	352,731	3,185,078	5,559,310		
2030	328,125	305,818	53,968	359,786	3,544,863	5,199,525		
2031	334,687	311,934	55,047	366,981	3,911,845	4,832,543		
2032	341,381	318,173	56,148	374,321	4,286,166	4,458,222		
2033	348,208	324,536	57,271	381,808	4,667,973	4,076,415		
2034	355,173	331,027	58,417	389,444	5,057,417	3,686,971		
2035	362,276	337,648	59,585	397,233	5,454,650	3,289,738		
2036	369,522	344,401	60,777	405,177	5,859,827	2,884,561		
2037	376,912	351,289	61,992	413,281	6,273,108	2,471,280		
2038	384,450	358,314	63,232	421,546	6,694,654	2,049,734		
2039	392,139	365,481	64,497	429,977	7,124,631	1,619,757		
2040	399,982	372,790	65,787	438,577	7,563,208	1,181,180		
2041	407,982	380,246	67,102	447,348	8,010,557	733,831		
2042	416,141	387,851	68,444	456,295	8,466,852	277,536		
2043	424,464	395,608	69,813	465,421	8,932,273	5,343,715	Construct Phase 6	5,531,600 cy added
2044	432,953	403,520	71,209	474,730	9,407,003	4,868,985		
2045	441,613	411,591	72,634	484,224	9,891,227	4,384,761		
2046	450,445	419,822	74,086	493,909	10,385,136	3,890,852		
2047	459,454	428,219	75,568	503,787	10,888,923	3,387,065		
2048	468,643	436,783	77,079	513,863	11,402,785	2,873,203		
2049	478,016	445,519	78,621	524,140	11,926,925	2,349,063		
2050	487,576	454,429	80,193	534,623	12,461,548	1,814,440		
2051	497,327	463,518	81,797	545,315	13,006,863	1,269,125		
2052	507,274	472,788	83,433	556,221	13,563,085	712,903		
2053	517,419	482,244	85,102	567,346	14,130,431	145,557		
2054	527,768	491,889	86,804	578,693	14,709,123	5,105,665	Construct Phase 7	5,538,800 cy added
2055	538,323	501,727	88,540	590,267	15,299,390	4,515,398		
2056	549,090	511,761	90,311	602,072	15,901,462	3,913,326		
2057	560,071	521,996	92,117	614,113	16,515,576	3,299,212		
2058	571,273	532,436	93,959	626,396	17,141,971	2,672,817		
2059	582,698	543,085	95,839	638,924	17,780,895	2,033,893		
2060	594,352	553,947	97,755	651,702	18,432,597	1,382,191		
2061	606,239	565,026	99,710	664,736	19,097,333	717,455		
2062	618,364	576,326	101,705	678,031	19,775,364	39,424		
2063	630,731	587,853	103,739	691,591	20,466,956	1,960,732	Construct Phase 8	2,612,900 cy added
2064	643,346	599,610	105,813	705,423	21,172,379	1,255,309		
2065	656,213	611,602	107,930	719,532	21,891,911	535,777		
2066	669,337	623,834	110,088	733,922	22,625,833	4,334,355	Construct Phase 9	4,532,500 cy added
2067	682,724	636,311	112,290	748,601	23,374,434	3,585,754		
2068	696,378	649,037	114,536	763,573	24,138,007	2,822,181		
2069	710,306	662,018	116,827	778,844	24,916,851	2,043,337		
2070	724,512	675,258	119,163	794,421	25,711,272	1,248,916		
2071	739,002	688,763	121,546	810,310	26,521,582	438,606		
2072	753,782	702,538	123,977	826,516	27,348,098	11,481,090	Construct Phase 10	11,869,000 cy added
2073	768,858	716,589	126,457	843,046	28,191,144	10,638,044		
2074	784,235	730,921	128,986	859,907	29,051,051	9,778,137		
2075	799,920	745,539	131,566	877,105	29,928,156	8,901,032		
2076	815,918	760,450	134,197	894,647	30,822,804	8,006,384		
2077	832,237	775,659	136,881	912,540	31,735,344	7,093,844		

WASHINGTON COUNTY LANDFILL

LANDFILL SITE LIFE PROJECTION
Operational Density: 1,824 lbs/cy, Cover Soil Estimated at 15% Soil to Waste
Loading Rate: Waste 960 tons/day and 286 days/yr
2020 Master Plan Configuration (Waste Fill_Phases 5 through 12)

Operational Density (lb/cy)	1824	0.912	tons/cy
Waste accepted (days)	286		
Waste tons per day	960		
Soil to waste (%)	0.15		
% growth	**1.020**	2.00%	

Year	**Waste (tons/yr)**	**Waste (cy/yr)**	**Daily Soil Cover @15% (cy)**	**Total Waste and Cover Soil Landfilled (cy/yr)**	**Cumulative Airspace Used (cy)**	**Remaining Airspace (cy) 1,087,388**	**(based on 2021 ABM, remaining airspace from Phase 4D fill plan based on 3/3/2020 top**	
2078	848,881	791,172	139,619	930,791	32,666,135	6,163,053		
2079	865,859	806,996	142,411	949,407	33,615,542	5,213,646		
2080	883,176	823,136	145,259	968,395	34,583,937	4,245,251		
2081	900,840	839,599	148,164	987,763	35,571,700	3,257,488		
2082	918,857	856,390	151,128	1,007,518	36,579,218	2,249,970		
2083	937,234	873,518	154,150	1,027,669	37,606,887	1,222,301		
2084	955,978	890,989	157,233	1,048,222	38,655,109	174,079		
2085	975,098	908,808	160,378	1,069,186	39,724,295	16,994,893	Construct Phase 11	17,890,000 cy added
2086	994,600	926,985	163,586	1,090,570	40,814,865	15,904,323		
2087	1,014,492	945,524	166,857	1,112,382	41,927,247	14,791,941		
2088	1,034,782	964,435	170,194	1,134,629	43,061,876	13,657,312		
2089	1,055,477	983,723	173,598	1,157,322	44,219,198	12,499,990		
2090	1,076,587	1,003,398	177,070	1,180,468	45,399,666	11,319,522		
2091	1,098,119	1,023,466	180,612	1,204,078	46,603,743	10,115,445		
2092	1,120,081	1,043,935	184,224	1,228,159	47,831,902	8,887,286		
2093	1,142,483	1,064,814	187,908	1,252,722	49,084,625	7,634,563		
2094	1,165,332	1,086,110	191,667	1,277,777	50,362,401	6,356,787		
2095	1,188,639	1,107,832	195,500	1,303,332	51,665,734	5,053,454		
2096	1,212,412	1,129,989	199,410	1,329,399	52,995,133	3,724,055		
2097	1,236,660	1,152,589	203,398	1,355,987	54,351,119	2,368,069		
2098	1,261,393	1,175,641	207,466	1,383,107	55,734,226	984,962		
2099	1,286,621	1,199,153	211,615	1,410,769	57,144,995	17,721,493	Construct Phase 12	18,147,300 cy added
2100	1,312,354	1,223,136	215,848	1,438,984	58,583,979	16,282,509		
2101	1,338,601	1,247,599	220,165	1,467,764	60,051,743	14,814,745		
2102	1,365,373	1,272,551	224,568	1,497,119	61,548,862	13,317,626		
2103	1,392,680	1,298,002	229,059	1,527,061	63,075,923	11,790,565		
2104	1,420,534	1,323,962	233,640	1,557,603	64,633,526	10,232,962		
2105	1,448,944	1,350,442	238,313	1,588,755	66,222,281	8,644,207		
2106	1,477,923	1,377,450	243,079	1,620,530	67,842,810	7,023,678		
2107	1,507,482	1,404,999	247,941	1,652,940	69,495,751	5,370,737		
2108	1,537,631	1,433,099	252,900	1,685,999	71,181,750	3,684,738		
2109	1,568,384	1,461,761	257,958	1,719,719	72,901,469	1,965,019		
2110	1,599,752	1,490,997	263,117	1,754,114	74,655,583	210,905		
Total:	**68,085,892**	**63,457,245**	**11,198,337**	**74,655,583**				

ATTACHMENT D

HAULER LICENSE APPLICATION FORM

Administrative Control Board
WASHINGTON COUNTY SOLID WASTE
Special Service District Number 1
197 East Tabernacle - St. George, Utah 84770

APPLICATION FOR LICENSE AS COMMERCIAL HAULER

All commercial haulers of solid waste operating within the boundaries of Washington County Special Service District No. 1 are required by resolution of said District to obtain an annual license therefor by completing the following application and submitting it to the office District at 197 East Tabernacle, St. George, Utah 84770 prior to December 31 of each year.

****

APPLICATION

DATE:
____

NAME OF BUSINESS:
____

BUSINESS ADDRESS:
____
____

BUSINESS MAILING ADDRESS:
____

TELEPHONE:________________

NAME AND ADDRESSES OF ALL OWNERS, PARTNERS OR CORPORATE OFFICERS:
NAME(S):________________
____
____

ADDRESS(ES):____________
____
____
____
____
____
____

TELEPHONE:______________

ORGANIZATION:
Individual______ Partnership______ Corporation______

****

In consideration of the granting of this license, applicant hereby understands and agrees:

1. To submit to District at the end of each calendar month books and records showing the volume of solid waste disposed of at the sanitary landfill site during the prior month.
2. To pay commercial fees, as fixed from time to time by resolution of District, for each calendar month within fifteen (15) days of the end of said calendar month.
3. That all commercial fees not paid within 15 days of the end of the calendar month shall bear interest at the rate of 12% per annum until paid.
4. To pay all costs of collection incurred by District in enforcing payment of commercial fees, including court costs and a reasonable attorney's fee.
5. To be responsible for maintaining at all times a policy of general liability insurance in an amount of not less than $1 million ($1,000,000.00), covering applicant's commercial hauling activities during the term of any license granted; and to indemnify and hold District harmless from and against any and all claims, causes of action or demands resulting or arising from Applicant's commercial hauling activities pursuant to said license.
6. To abide by all rules and regulations of District now in effect or which may hereafter be adopted from time to time by resolution of District.
7. That any license granted pursuant to this application may be denied or revoked for violation of any of the terms of this agreement or any other rules or regulations of the District as adopted from time to time by resolution.

DATED this _______ day of ____________________, 199___.

____
APPLICANT/TITLE

(for office use only)

New or renewal license: _________
Date Application Reviewed: _________
Application: Granted _________
Denied _________
Expiration Date _________

____
District's Signature

ATTACHMENT E

WEIGHT TICKET

SITE **TICKET** **GRID**

WEIGHMASTER

DATE IN **TIME IN**

DATE OUT **TIME OUT**

VEHICLE **ROLL OFF**

REFERENCE **ORIGIN**

QTY.	UNIT	DESCRIPTION	RATE	EXTENSION	FEE	TOTAL

NET AMOUNT

TENDERED

CHANGE

CHECK NO.

FORM # WW5T2

SIGNATURE ______________________________

ATTACHMENT F

WASTE INSPECTION REPORT

WASTE INSPECTION REPORT

DATE ____________ **INSPECTORS** ______________________________

TIRE REPORT

$1.50	$2.00	$4.00	BY WEIGHT	LOCATION	NIGHT CANS	COUNTY CLEAN UP

LOCATIION	HAULER	LIC-TRUCK	VEHICLE TYPE	WASTE COMPOSITION

ATTACHMENT G

INSPECTION LOG

INSPECTION LOG

Washington County Landfill Facility

Name of Area Inspected	OK	Needs Repair	Comments
Total Containment Evaporation Pond			
18" Leachate Outfall Line			
12" Leachate Collection Line			
Run-off Drainage Channel			
Run-on Drainage Channel			
Perimeter Fencing and Access Gates			
Landfill Cell			
TIME:	**DATE:**	**INSPECTOR:**	**SIGNATURE:**

ATTACHMENT H

LANDFILL GAS MONITORING RESULTS FORM

WASHINGTON COUNTY
SOLID WASTE SPECIAL SERVICE DISTRICT NO. 1
LANDFILL GAS QUARTERLY MONTORING RESULTS
YEAR ____ QUARTER ____

Date: ________________ Time: ________________

Name of Gas Sample Collector________________________________

Temperature____________ Weather______________

Monitoring device should be calibrated prior to initiating sampling.
Accomplished? Yes No

Methane Monitoring Location		Measured %LEL	Internal Action Limit: Half of Regulatory Limit (%LEL)	Regulatory Action Limit (%LEL)
1. NW Corner of the Scale House	Outside		12	25
	Inside		12	25
2. North Boundary			50	100
3. South Boundary			50	100
4. NW Corner of Treatment Pond			12	25
5. SW Corner of Composting Area			12	25

- **Gas Sample Collector:** If measured % LEL equals or exceeds internal action limit, contact the facility manager.
- **Facility Manager:** If measured % LEL equals or exceeds regulatory action limit, notify the State Director in compliance with 40 CFR 258.23(c).

Comments:

____

____

____

____

____

____

____
Gas Sample Collector

ATTACHMENT I

RANDOM LOAD INSPECTION FORM

WASHINGTON COUNTY SANITARY LANDFILL
Random Load Inspection Record

INSPECTION INFORMATION

Inspector's Name: ______________________________
Date of Inspection: ______________________________
Time of Inspection: ______________________________
Facility Name: ______________________________

TRANSPORTATION COMPANY INFORMATION

Name: ______________________________
Address: ______________________________
____

Phone Number: ______________________________

VEHICLE INFORMATION

Driver's Name: ______________________________
Vehicle Type: ______________________________
Vehicle License Number: ______________________________
Vehicle's Last Stop: ______________________________
Vehicle Contents: ______________________________

OBSERVATIONS AND ACTIONS TAKEN

____
____
____
____

Photo Documentation: ___ Yes ___ No

Driver's Signature*: ______________________ Date: ______________

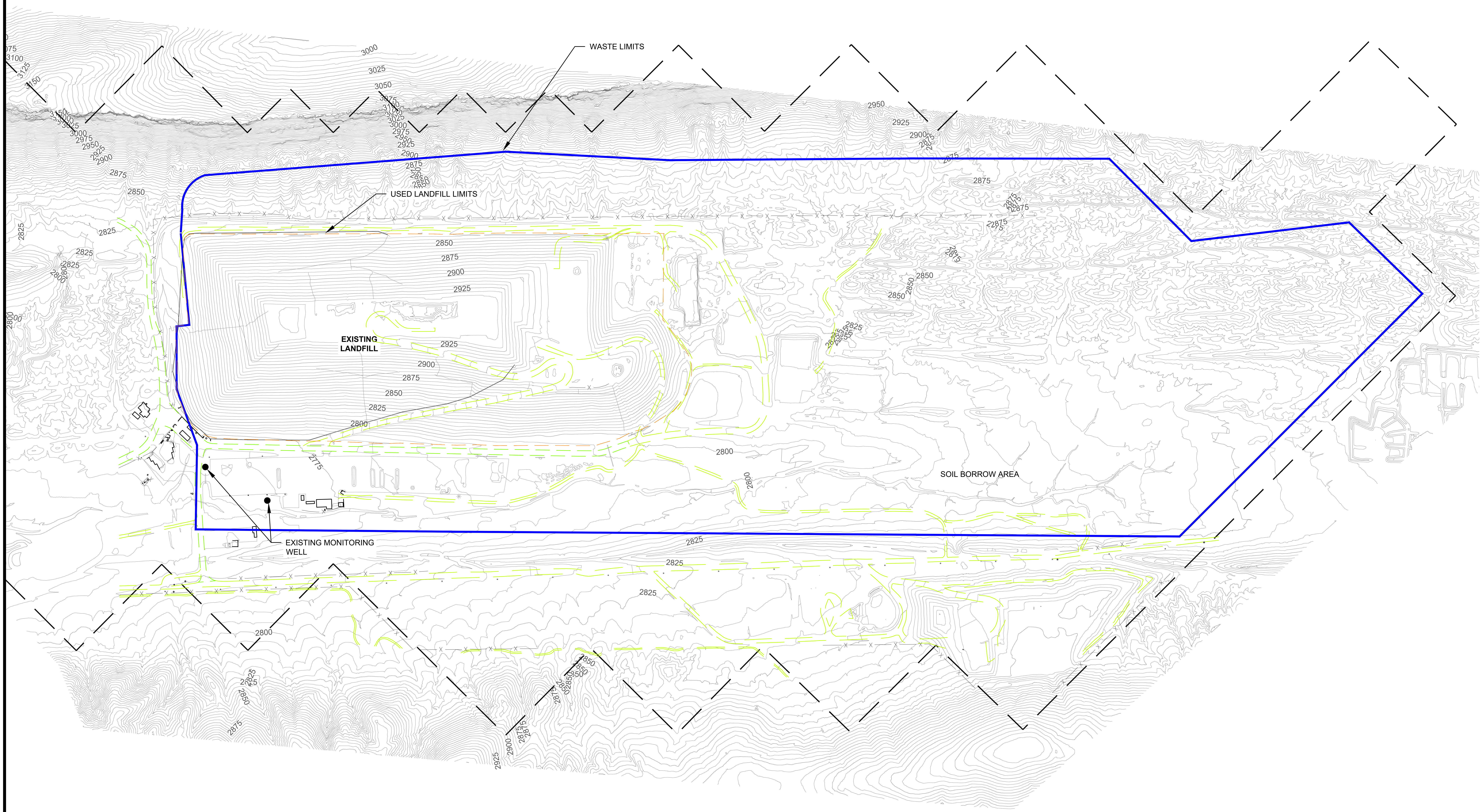
Inspector's Signature: ______________________ Date: ______________

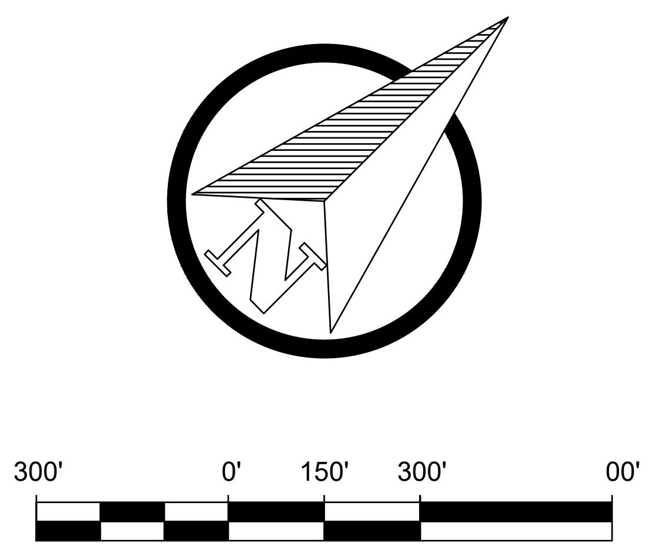
* Driver's signature hereon denotes: His presence during the inspection and does not admit, confirm or identify liability.

ALL DISTRICT EMPLOYEES PRESENT MUST SIGN BOTTOM OF FORM

ATTACHMENT J

USGS MAPS





LEGEND

—— 2800 ——	EXISTING 25' CONTOUR
——————	EXISTING 5' CONTOUR
—— —— ——	PROPERTY LINE
—x—x—x—	EXISTING FENCE
– – – – –	EXISTING PAVED ROAD
—— —— ——	EXISTING UNPAVED ROAD
– – – – –	USED LANDFILL LIMITS
——————	WASTE LIMITS
●	APPROXIMATE LOCATION OF EXISTING GROUNDWATER MONITORING WELL

NOTES

1. REFERENCE AERIAL TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS CO.

WASHINGTON COUNTY LANDFILL

PERMIT MODIFICATION

WASHINGTON COUNTY, UTAH

SITE PLAN

FIGURE NO.
1

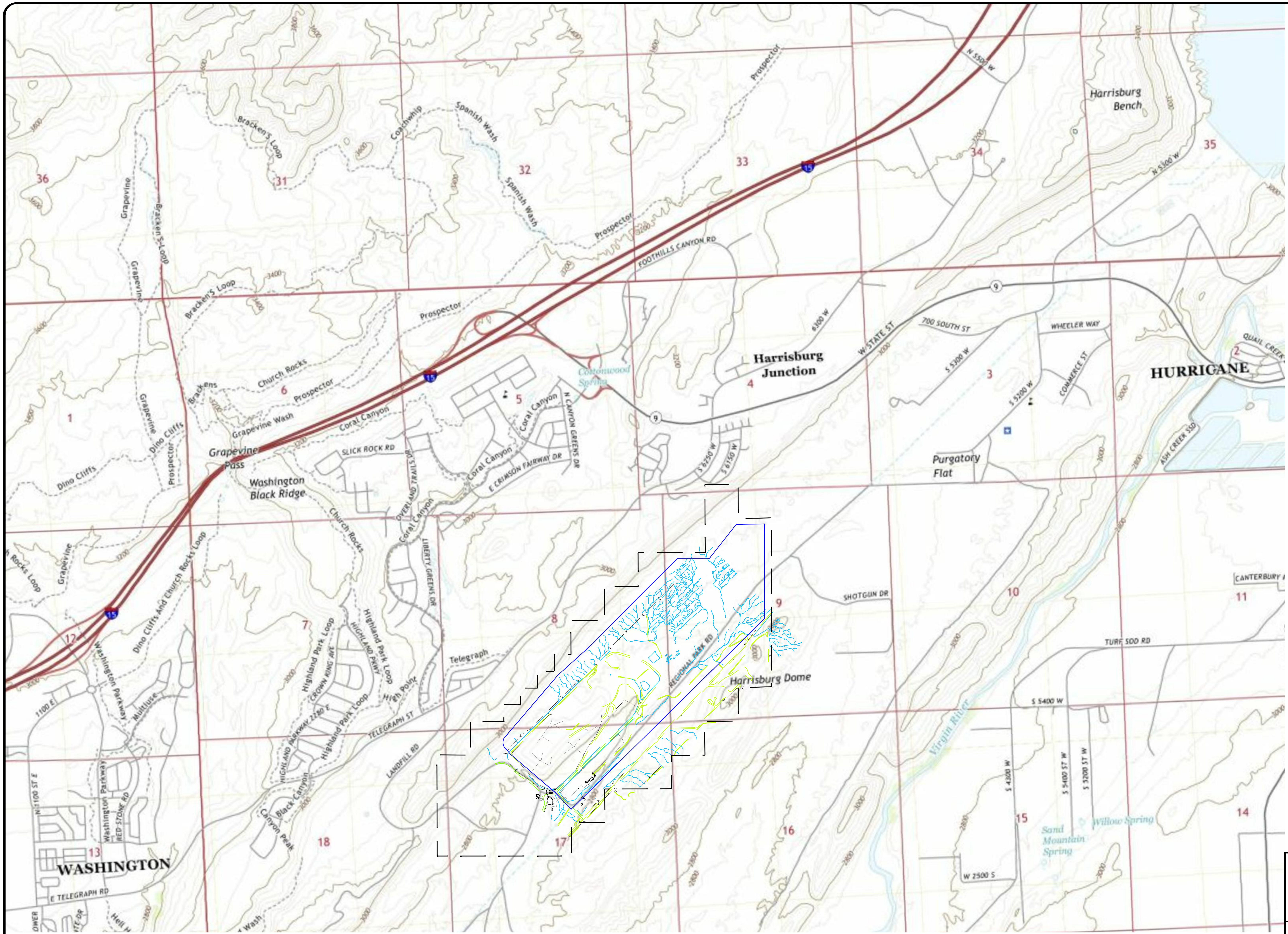
PROJECT NO.
AU21.1210.00

DATE OF ISSUE: 08/20/2021
DRAWN BY: SAH
APPROVED BY: SAH

Geo-Logic
ASSOCIATES
143E Spring Hill Dr, Grass Valley, California 95945
geo-logic.com | 530.272.2448

This figure has not been published but rather has been prepared by Geo-Logic Associates, Inc. for use by the client named in the title block, solely in respect of the construction operation, and maintenance of the facility named in the title block. Geo-Logic Associates, Inc. shall not be liable for the use of this figure on any other facility or for any other purpose.

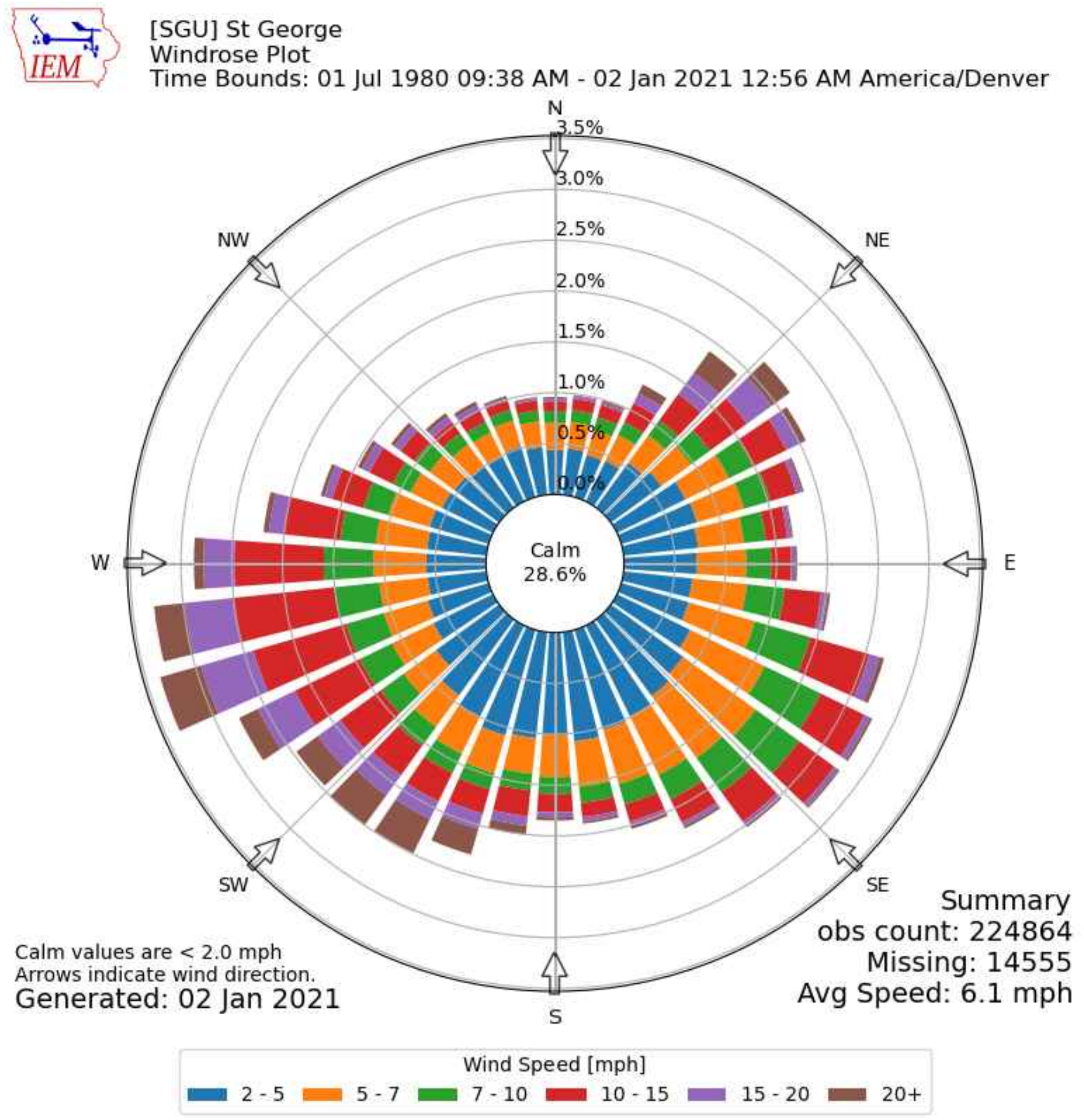
N:\WASHINGTON COUNTY LANDFILL\AU21.1210.00_2021 PERMIT MODIFICATION\5_CAD\ARCHIVE\1 - SITE PLAN.DWG August 31, 2021 - 1:17 PM BY: GLA-USER



1000' 0' 500' 1000' 2000'

LEGEND

2800	EXISTING 25' CONTOUR
	EXISTING 5' CONTOUR
	PROPERTY LINE
—x—x—x—	EXISTING FENCE
	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
	EXISTING DRAINAGE PATHS
	USED LANDFILL LIMITS
	WASTE LIMITS


[SGU] St George
Windrose Plot
Time Bounds: 01 Jul 1980 09:38 AM - 02 Jan 2021 12:56 AM America/Denver

Calm values are < 2.0 mph
Arrows indicate wind direction.
Generated: 02 Jan 2021

Summary
obs count: 224864
Missing: 14555
Avg Speed: 6.1 mph

NOTES

1. REFERENCE TOPOGRAPHY BASED ON USGS TOPOGRAPHIC MAP (2020).

WASHINGTON COUNTY LANDFILL

PERMIT RENEWAL

WASHINGTON COUNTY, UTAH

USGS MAP

FIGURE NO.
2

PROJECT NO.
AU21.1210.00

DATE OF ISSUE: 08/20/2021 **DRAWN BY:** SAH **APPROVED BY:** SAH

Geo-Logic
ASSOCIATES

143E Spring Hill Dr, Grass Valley, California 95945
geo-logic.com | 530.272.2448

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ATTACHMENT K

GEOLOGIC REPORTS

August 23, 1993

Mr. Reed Noble
Mr. Steven E. Layton
Creamer & Noble Engineers
P. O. Box 1094
St. George, Utah 84770

RE: Washington County Landfill Site geologic study and report

Gentlemen:

In response to your request of July 7, 1993, I have completed my geologic study of the Washington County Landfill Site and submit to you the following report. See the attached geologic map and section, with other supplemental maps and diagram, in reference to the following analysis, conclusions and recommendations.

In addition to my recent field examinations on July 26-28, 1993, and previous work in the region I have researched the following references:

Adair, J. W., and others, 1975, Guide for Planning and Preliminary Design of earth Dams in Seismically Active Areas: Engineering and Watershed Planning Unit No. 45, U. S. Soil Conservation Service, South Technical Service Center, Fort Worth, Texas;

Algermissen, S. T., 1980, The Wasatch Fault Zone, The Earthquake Ground Shaking Hazard and Estimation of Damage: presentation at Earthquake Engineering Research Institute Seminar Fundamentals of Intra-Plate Earthquakes, Salt Lake City, Utah;

Arabasz, W. J. and others, 1992, Observational Seismology and the Evaluation of Earthquake Hazards and Risk in the Wasatch Front Area, Utah: in U. S. Geol. Sur. Prof. Paper 1500-A-J, Assessment of Regional Earthquake Hazards and Risk Along the Wasatch Front, Utah, P. L. Gori and W.W. Hays, editors, p. D1-D36;

Black, B. D. and Christenson, G. E., 1993, M 5.8 St. George Earthquake, September 2, 1992: Utah Geological Survey, Survey Notes Vol. 25, Number 3-4, p. 25-29;

Cook, E. F., 1960, Geologic Atlas of Washington County, Utah: Utah Geol. and Min. Survey Bulletin 70;

Cordova, R. M., and others, 1972, Ground-water Conditions in

the Central Virgin River Basin, Utah: Utah Dept. of Nat. Resources, Div. of Water Rights Tech. Pub. No. 40, prepared by the U. S. Geol. Survey;

Cordova, R. M., 1978,Ground-water Conditions in the Navajo Sandstone in the Central Virgin River Basin, Utah: Utah Dept. of Nat. Res., Division of Water Rights Tech. Pub. No. 61, prepared by the U. S. Geol. Survey;

Gourley, C., 1992, Geologic Aspects of the Quail Creek Dike Failure: in Engineering and Environmental Geology of Southwestern Utah, Utah Geol. Assoc. Pub. 21, edited by K. M. Harty, p. 17-38;

Hansen, G. H. and Scoville, H. C., 1955, Drilling Records for Oil and Gas in Utah: Utah Geol. and Min. Survey Bulletin 50;

James, R. L., and others, 1989, Investigation of the Cause of Quail Creek Dike Failure: Independent Review Team;

Mortensen, V. L. and others, 1977, Soil Survey of Washington County Area, Utah: U. S. Soil Conservation Service,Dept. of Agriculture in cooperation with others;

Mulvey, W. E., 1992, Engineering Geologic Problems Caused by Soil and Rock in Southwestern Utah: in Engineering and Environmental Geology of Southwestern Utah, Utah Geol. Assoc. Pub. 21, edited by K. M. Harty, p. 139-144;

Payton, C. C., 1992, Geotechnical Investigation and Foundation Design for the Reconstruction of Quail Creek Dike: in Engineering and Environmental Geology of Southwestern Utah, Utah Geol. Assoc. Pub. 21, edited by K. M. Harty, p. 39-51;

Smith, R. B., 1982, Earthquakes, Seismic Geology and Earthquake-Hazards of the Wasatch Front and Intermountain Region: Earthquake Engineering Research Institute Regional Seminar, Salt Lake City, Utah;

Stearns, C. E., 1974, Seismic Risk Evaluations: Geologist-Design Engineers Workshop in Portland, Oregon;

Taylor, C. L. and Cluff, L. S., 1977, Fault Displacement and Ground Deformation Associated with Surface Faulting: Proceedings of Current State of Knowledge of Lifeline Earthquake Engineering, ASCE, Los Angeles, Calif.;

U. S. Bureau of Reclamation, 1969, Definite Plan Report on Dixie Project: Utah, Region 3, Appendix B-Geology, Boulder City, Nevada:

U. S. Bureau of Reclamation, 1979, Preliminary LaVerkin Springs Unit, Utah, Colorado River Water Quality Improvement Program, Point Source Division: Appendices A-B; and

Ward, P. L. and others, 1990, The Loma Prieta Earthquake of October 17, 1989, and Earthquake Map of the United States: U. S. Geological Survey pamphlet.

The existing and proposed landfill site is mainly underlain with the Shnabkaib Member of the Triassic-age Moenkopi Formation which is part of the northwest limb of the Harrisburg Dome-Virgin Anticline. The Shnabkaib Member, including the Middle Red Member, comprises about 1300 feet of an approximate total Moenkopi thickness of 2200 feet. It consists of gray, white, light green-gray, pink and light rust-maroon, gypsiferous, silty and sandy shale, dolomitic siltstone, gypsum, and silty dolomite. Bedding of differential hardness produces a low-relief erosion surface of small, narrow hogback ridges and strike valleys, striking northeastward, cut normally by small ravines, and having the depressions filled partially with residual soil. The eroded surface and residual soil presents a dry, fluffy, popcorn surface of powdery, gypsiferous, fine-grained soil consisting of silt, silty clay and fine-grained sand (ML, Unified Soil Classification System).

Included within the lower part of the mapped Shnabkaib Member is the Middle Red Member of the Moenkopi Formation. It consists of approximately 350 feet (of the total 1300 feet previously stated) of rust-red-brown, gypsiferous, soft, shaley, fine-grained sandstone, inpart-clayey siltstone, and gypsum, which produces and erosion slope. The produced residual soil is more sandy and clayey (ML-SM) than that yielded by the Shnabkaib Member.

Underlying the Shnabkaib-Middle Red Members, and forming a sharp, narrow, conspicuous hogback ridge with its hardest limestone unit, is the Virgin Limestone Member of the Moenkopi Formation. The dirt road trending northeasterly through Purgatory Flat and through the eastern portion of the Washington County Landfill property, parallels this narrow hogback ridge. The Virgin Limestone Member consists of 100-150 feet of light brown-gray, fine crystalline limestone which is inpart sandy and silty. The limestone is sandwiched between interbedded, purple and maroon-red-brown and light green, gypsiferous, silty shale and white-light gray gypsum. The resistant limestone unit is approximately 30-50 feet thick and is well jointed and permeable thereby, with the intersecting joints striking N 20-45 degrees E, dipping 26-45 degrees SE, spaced 2-24 inches apart and open to a half inch at the weathered surface; and N 38-57 degrees

W, dipping 59-79 degrees SW, spaced 4-36 inches apart and open to a half inch at the weathered surface.

The Virgin Limestone Member is underlain by the Lower Rid Member of the Moenkopi Formation which is approximately 300-400 feet thick. It consists of a slope-forming, gypsiferous, reddish-brown siltstone and mudstone with some thin-bedded dolomite, which unconformably overlies the Kiabab Limestone.

The underlying Permian-age Kiabab Limestone is exposed within the core and crest of the Harrisburg Dome. It consists of at least 600 feet of well jointed, vuggy, light brown-gray, fine-crystalline, medium-bedded limestone containing an abundance of brown weathering chert blebs up to 8-inch size. It weathers-out as an angular gravel. Abundant jointing strikes N 11-84 degrees west, dipping 75-77 degrees NE and some 15 degrees SW; and intersecting with N 20-88 degrees E, dipping 72-85 degrees SE. These joints are spaced 2-36 inches apart and are open from a quarter inch to 4 inches at the weathered surface. Thus, because of these joints and bedding planes, the formation is pervious.

Overlying the Shnabkaib Member of the Moenkopi Formation is the Upper Red Member of that formation. It is exposed in the lower to upper slope of the prominent, high hogback ridge immediately west of the subject landfill property. It consists of 400 feet of well-jointed, rust-red to maroon-rust brown, very fine to fine grained sandstone which is in thin to thick beds with siltstone and lesser, maroon and brown silty shale and shaley siltstone. A prominent yellow-brown weathering, cliff-forming, fine grained, jointed sandstone of variable thickness comprises its base. However, due to an overthrust fault and possibly, but not likely, inpart due to lack of deposition or alteration, this sandstone unit is missing or only is a very broken remnant, and generally smeared-out throughout the SE/4 Sec. 8, T 42 S, R 14 W.

The Moenkopi Formation is capped unconformably by the Triassic-age Shinarump Sandstone, about 200 feet thick, on the high prominent hogback ridge at the west edge of the landfill property. It is a hard, inpart silica-cemented, fine-coarse, subangular and lenticular, yellow-gray-brown sandstone. It contains a conspicuous, intersecting set of joints which provides for the formation to weather-out in angular gravel, cobbles, boulders and large blocks up to 12 feet in size. Because of overthrust faulting through it within the ridge immediately southwest and west of the present landfill, where the paved road transects it, segments of the formation have been thrust over other

CENTER UNIT				
Station	**End Area (SQ.')**	**Ave. End Area (SQ.')**	**Int. (FT.)**	**Vol (CY)**
29+50	0	0	0	0
30+00	4,250	2,125	50	3,935
32+00	23,000	13,625	200	100,926
36+00	74,150	48,575	400	719,630
40+00	83,800	78,975	400	1,170,000
44+00	77,250	80,525	400	1,192,963
48+00	90,500	83,875	400	1,242,593
52+00	85,800	88,150	400	1,305,926
56+00	98,850	92,325	400	1,367,778
60+00	83,150	91,000	400	1,348,148
64+00	80,050	81,600	400	1,208,889
68+00	83,250	81,650	400	1,209,630
72+00	73,850	78,550	400	1,163,704
76+00	75,800	74,825	400	1,108,519
80+00	77,950	76,875	400	1,138,889
84+00	42,150	60,050	400	889,630
88+00	0	21,075	400	312,222
TOTAL:				**15,483,382**

segments of the formation and over its top, including a small amount of the younger Chinle Shale. The sandstone within the upper overthrust plates is very broken and shattered. Where measurable, the thrust faulting planes are dipping about 35 degrees to the northwest, north and northeast.

Prominent joints within the sandstone strike N 10-65 degrees W, having dips 69-88 degrees SW and some 66 degrees E, spaced 2-12 feet apart and open to an inch at the weathered surface; intersecting with less prominent joints striking N 20-37 degrees E, and dipping 63-70 degrees SE.
The Shinarump Sandstone is overlain by the Triassic-age Chinle shale which has been either greatly eroded or mantled with alluvium is approximately 800 feet thick, some of which is probably thickening due to overthrusting. It consists generally of gray, purple and maroon siltstone and bentonitic shale, with lesser interbeds of sandstone and conglomeratic sandstone. It is generally easily eroded and underlies strike valleys that are commonly covered with alluvium, but is exposed within ravines and roadcuts. Because of the massive erosion of the Virgin Anticline (including the Harrisburg Dome) there is none of it remaining within the Purgatory Flat and landfill property area.

The Chinle Shale is overlain by the Triassic-age Moenave, exposed about a mile west of the landfill property. It consists of about 500 feet of gray-dark-brown, maroon, rust-red and purple shale, fine-grained sandstone, and siltstone, being capped with the Springdale (Silver Reef) Sandstone member. It is a lavender, buff to white weathering, fine-medium grained sandstone which is about 150 feet thick and forms a conspicuous hogback from differential erosion.

Overlying the Moenave Formation is the rust-red-brown, interbedded siltstone, shale and sandstone, of the Triassic-Jurassic age Kayenta Formation, which is about 700 feet thick.

The well-known, Jurassic-age Navajo Sandstone which is a massive, cross-bedded, yellow-orange-reddish brown, fine grained sandstone, overlies the Kayenta Formation, and is a regional aquifer. It is at least 2000 feet thick in the region, where not reduced by erosion.

A conspicuous Quaternary-age, curved tongue of well jointed basalt caps the Washington Black Ridge, within 1-1 1/2 miles west of the landfill property. It is the erosion-resistant flow of lava that once filled an ancient erosion channel, which is now elevated above the less-resistant-to-erosion bedrock formations on either side of it.

Quaternary-age deposits of alluvium occur on the high bench, west of the landfill property as sand and clay colluvium and capping terrace gravels and sand, of variable thickness.

On the landfill property, the alluvial cover is thin, probably less than 10 feet thick, with the thickest deposits being aprons along the edges of the Purgatory Flats and at the toes of the steeper slopes. The soil generally is a clayey, sandy silt with a high content of calcium sulfate (gypsum powder) (ML), but becomes gravelly and more sandy within the alluvial aprons. Test pits need to be dug in the various areas to more adequately determine the composition and thickness of the deposits. It is possible that the land strip between the outcrop of the Virgin Limestone Member and the steeper, northwest slope of the Harrisburg Dome, west of the Kiabab Limestone outcrop may contain at depth sufficient clay content to make it an adequate, impervious blanketing material. On the surface it is gravelly, sandy silt (ML-SC).

The alluvial apron within the west edge of the landfill property is composed of silty sand and sandy silt that is gravelly with larger clasts next to the steep slope contain blocks up to 12 feet in size, mainly from the Shinarump Sandstone, let down by erosion. Although zones of it may be clayey, because of the large clasts included, such would be difficult to compact properly as an impervious blanket, unless the coarser fraction is first removed.

All of the rock strata except the Quaternary deposits have been involved in overthrust folding and faulting, with resultant shearing and jointing. The Virgin Anticline (Harrisburg Dome) is a result of it. Subsequent tensional forces exerted regionally has resulted in further jointing, and to the east 7 miles, normal faulting. No normal faulting was detected beneath or adjacent to the landfill property, but a prominent thrust fault surfaces within the northwest edge of the property, having a slippage plane extending to the northwest and north, with some local short segments to the east. Associated with this thrusting are small shear faults detected within the floor of Purgatory Flats beneath the main landfill property. Some beds of the upper part of the Shnabkaib Member within the west edge of the landfill property, near the overthrust fault, have been tilted to vertical and even over-turned to dip steeply southeastward, as shown on the geologic map. Generally the bedding beneath the landfill property is dipping northwestward 54-75 degrees, with the lesser dips in the southeast edge of the property.

The U. S. Bureau of Reclamation (1969) drilled three test holes (DH-1P, DH-2P and DH-3P) along the axis of a proposed dike in Purgatory Flat, within the S/2 Sec. 3, T 42 S,R 14 W, approximately a mile northeast of the landfill property. Total depths were 103, 204 and 153 feet, respectively. Water percolation test were also conducted in these holes at successive intervals of penetration. See attached log copies. Permeability or hydraulic conductivity of the Shnabkaib Member was nil in all three holes except for the interval from 12.2-22.2 feet in DH-2P which took 6-11 gpm with water pressure of 15-25 p.s.i. over a 20 minute period. Since water was injected into the tight holes both during drilling and water testing, water level measurements in the holes included such injected standing water. However, in DH-3P, upon completion of the drilling to a depth of 153 feet, the water in the hole was bailed down to 148 feet depth on March 14, 1966, and then the water level was measured in the hole three days later on March 17, 1966, and found to be at a depth of 139 feet. This may represent a perched aquifer level, the principal "aquifer" level, or just drill water that seeped back into the drill hole out of the sidewalls after sitting three days.

The U. S.Bureau of Reclamation (1969) also shows a reported water level elevation 2158 feet in an abandoned oil test drilled on the crest of the Harrisburg Dome. This old oil test hole within the NE/4 NW/4 NW/4 Sec. 16, T 42 S, R 14 W, and another located about 700 feet northeast of it also on the ridge crest, both had junk in them when I examined them, which prevented getting any kind of measurement of water level. The reported water level of 2158 feet elevation would be at a depth of approximately 680 feet below the land surface at the landfill property. The oil test well was commenced in the top of the Kiabab Limestone at an approximate elevation of 2950 feet, and drilled to a reported depth of 3508 feet. This depth would have penetrated the Callville Limestone of Pennsylvanian age. A reported water elevation of 2158 feet would project to be at a depth of about 800 feet from land surface at the well.

It is my opinion at this point of available data that the Shnabkaib Member beneath the landfill property is not serving nor will serve as an aquifer, and any water contained therein is far from potable in its natural state. Any such water contained therein would probably drain towards the Virgin River to the south and exit from the subsurface at an elevation of 2650 feet. Projecting a gentle potentiometric surface from this elevation back to a surface elevation of 2840 feet at the landfill property would mean that any ground water present here would be encountered within a depth of 190 feet or higher.

Because of the close proximity of the landfill property to the major Hurricane Fault with related parallel Washington Fault, and the fact that these faults are of late geologic occurrence, the potential exists for a major earthquake in the area, resulting from movement on either or both of them. The Hurricane Fault extends southward into Arizona for 100 miles and northward past Cedar City and farther north for at least 50 miles. The Washington Fault located within three miles west of the land fill property, is approximately 100 miles long.

The subject property is located within the southeast edge of the Intermountain Seismic Belt where historic earthquakes as large as Richter Magnitude 7 have occurred (Yellowstone Park area). See attached seismic maps. The latest of those nearest to the project site was of Richter Magnitude 5.8 with its epicenter near the Quaternary-age Washington Fault, about 4 miles to the SSW. See attached location map. This occurred on September 2, 1992, which caused some liquefaction and landsliding with some structural damage to buildings within the region. The project site falls into Seismic Risk Zone 2 of moderate damage corresponding to Modified Mercalli Intensity VII of Moderate Damage, corresponding to Richter Magnitude 5.5 (Algermissen, 1969). Based upon the geologic recency and amount of displacement of the Hurricane Fault, on-going historical earthquakes in the region, the length of the Hurricane Fault, and empirically obtained data of world-wide faulting and earthquakes, I estimate the potential of a future earthquake in the project vicinity of a maximum Richter Magnitude 6.5, Mercalli Intensity IX, and maximum horizontal rock acceleration of 0.3 g (gravity of 32 ft/squared second). However, there is no way of knowing or predicting when such potential earthquake will occur in the area.

The foundation of the landfill property is stable, and under the existing dry conditions, or similar in the future, it will remain so. There are no underlying potable aquifers, and it is not a recharge area to any potable aquifer. Therefore, it is my conclusion that the proposed use of the landfill property for refuse disposal is practical and feasible. However, to maintain the stability of the foundation, any appreciable water flow into the foundation, beyond that amount of existing natural conditions, should be prevented. Since the Virgin Limestone Member is pervious, its outcrop band should be excluded from the placement of landfill on it. Furthermore, there is both a water pipeline and a natural gas pipeline that parallel this Virgin Limestone outcrop within a couple hundred feet of it, which should obviously not be covered with landfill. The overthrust fault bounding the northwestern edge of the landfill property should also be avoided for landfill burial, as the fault plane may inpart be permeable.

Proven experience with the foundation of the Quail Creek Dike, which has a foundation almost entirely on the Shnabkaib Member, has shown that not all joints or shear planes within the formation are tight, which can allow water to enter into the formation. If such amount of water is sufficient to circulate, it can dissolve existing gypsum in both beds and joints, and permit piping of overlying, fine-grained sediments into any existing or enlarged and created openings.

Thus, it is my recommendation to dig sufficient test pits to a depth of at least 12 feet over the subject property area that contains alluvial cover to quantify the amount and composition of potential borrow material that could be used for an impervious blanket to be placed beneath the future refuse landfill. Some of these same test pits could be used to conduct water percolation tests to determine permeabilities for the soil zone. The preferred area for such borrow is probably within the southeastern edge of the property on both sides of the Virgin Limestone outcrop, with obvious avoidance of the two pipelines buried through this area. If possible, test pits should also be dug around the northeast end and southeast flank of the Harrisburg Dome, on both sides of the Virgin Limestone outcrop to quantify the amount and composition of potentially usable, clayey soil, that might also be borrowed from there.

An alternative source of known plastic clayey soil is the weathered Chinle Shale formation that is present on the bench to the west of the landfill area, within the SE/4 Sec. 7 and the N/2 Sec. 8, T 42 S, R 14 W. This will require a haulage of about 2 miles via the existing roadways.

In placing the impervious clayey blanket as a bottom seal to the future landfill placement, I recommend that the fluffy topsoil be first removed (perhaps to a depth of 3-4 feet) and stockpiled to be later used as a covering over the landfill. The clayey soil foundation blanket should be compacted in lifts with optimum moisture content over the underlying, exposed and smoothed-out, naturally compacted material (both alluvium and bedrock).

The final top of the deposited refuse landfill should also be blanketed to prevent or minimize the infiltration of water into the compacted landfill mass.

At least two initial test holes, which could also be used as on-going monitoring wells, should be drilled to depths of 200 feet, one near the southwest end of the existing landfill and another about a mile to the northeast near the center of the proposed landfill, about 600 feet west of the roadway near the existing pipelines. These holes should be drilled first with dry, air-rotary method to detect any water-table and collect samples of any encountered water, followed by water pressure testing by the use of inflatable rubber packers to isolate various zones and determine hydraulic conductivity of the underlying Shnabkaib Member. This would be followed by the insertion of plastic casing, slot perforated near the bottom, and sealed around it at the top, to gather any available water levels and samples in the future.

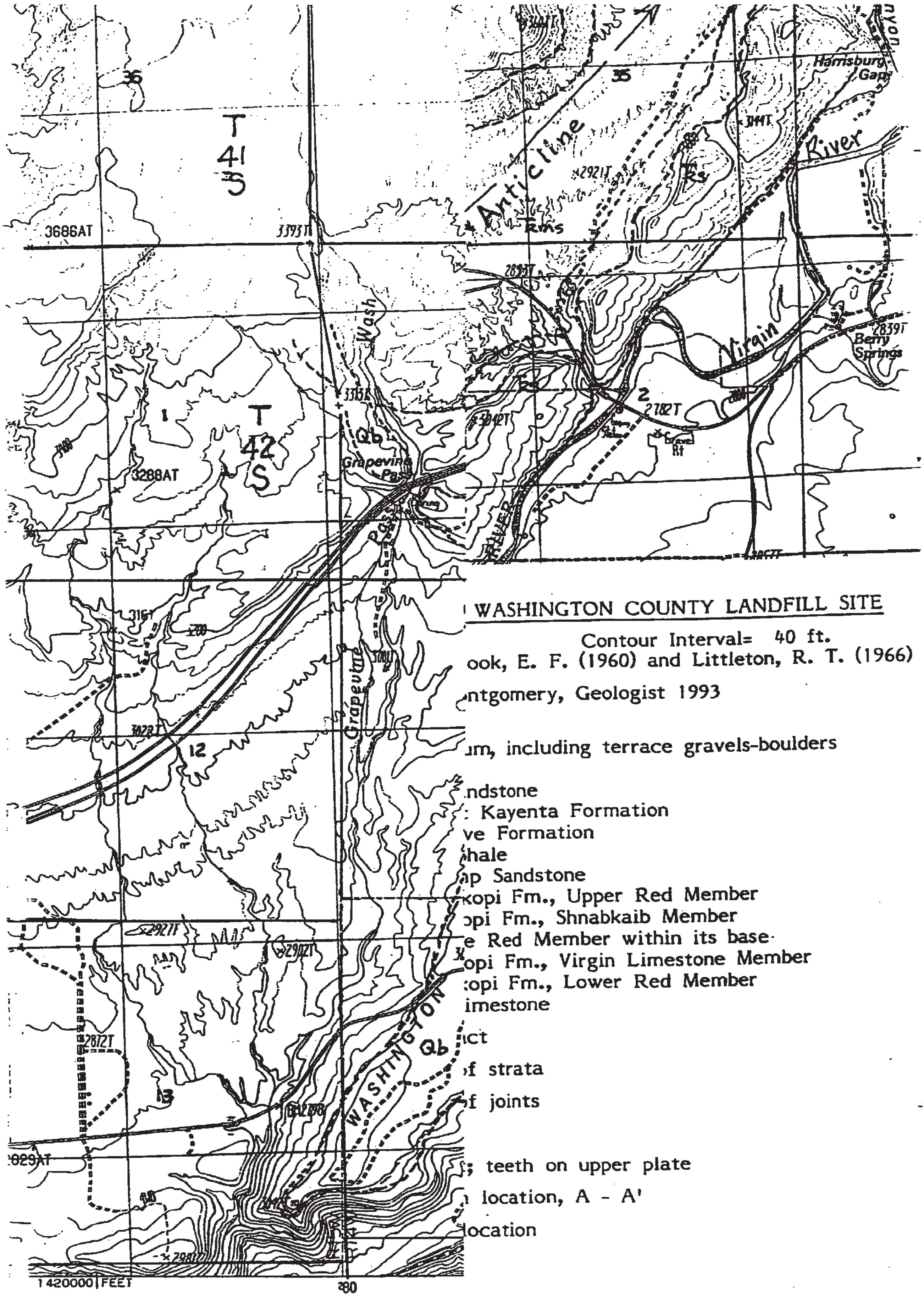
I also recommend that permeability tests be conducted on optimally compacted soil samples collected over the proposed landfill area and potential borrow area to be used for impervious blanketing material, in addition to the percolation tests conducted in selected test pits under natural conditions.

Respectfully submitted,

S Bryce Montgomery

S. Bryce Montgomery
Professional Geologist
3512 South 100 East
Bountiful, Utah 84010 Telephone 295-8592

Attachments



WASHINGTON COUNTY LANDFILL SITE

Contour Interval= 40 ft.

ook, E. F. (1960) and Littleton, R. T. (1966)

ntgomery, Geologist 1993

ım, including terrace gravels-boulders

ndstone

: Kayenta Formation

ve Formation

hale

ıp Sandstone

kopi Fm., Upper Red Member

opi Fm., Shnabkaib Member

e Red Member within its base

opi Fm., Virgin Limestone Member

:opi Fm., Lower Red Member

imestone

ıct

ıf strata

ıf joints

; teeth on upper plate

ı location, A - A'

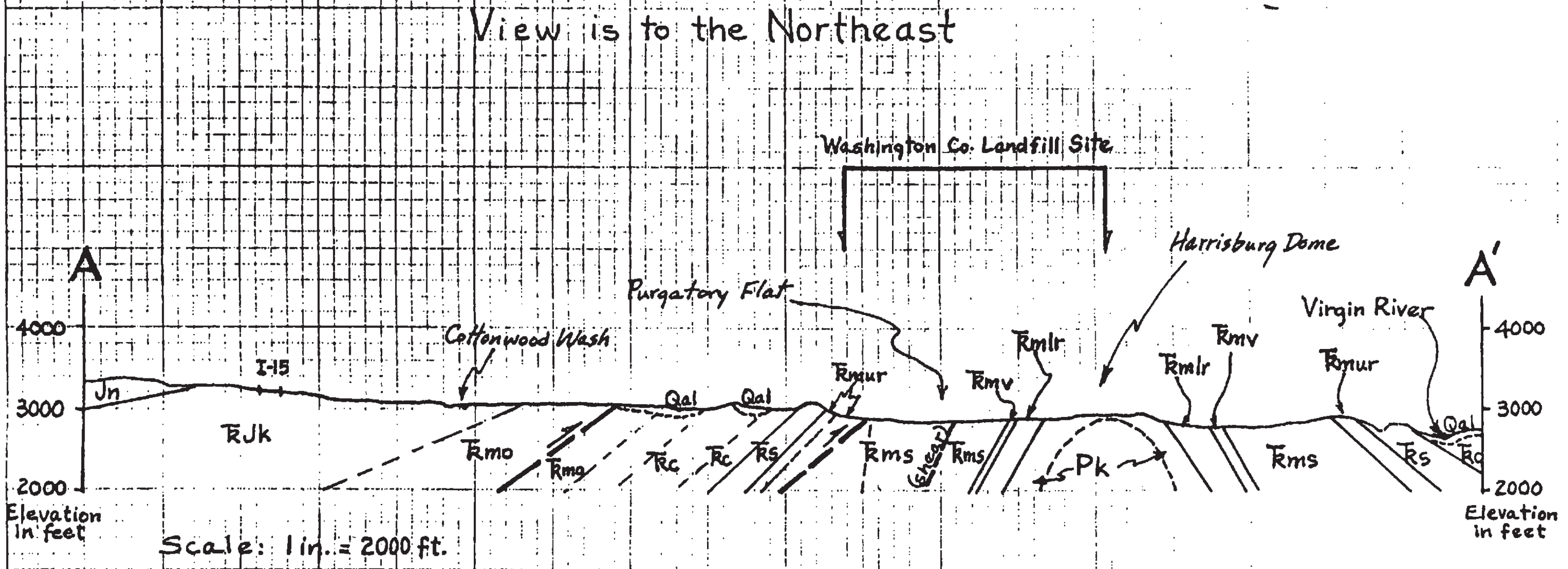
location

BY THE UNITED STATES GEOLOGICAL SURVEY

. . . . USGS, NOS/NOAA

AERIAL PHOTOGRAPHS TAKEN 1978

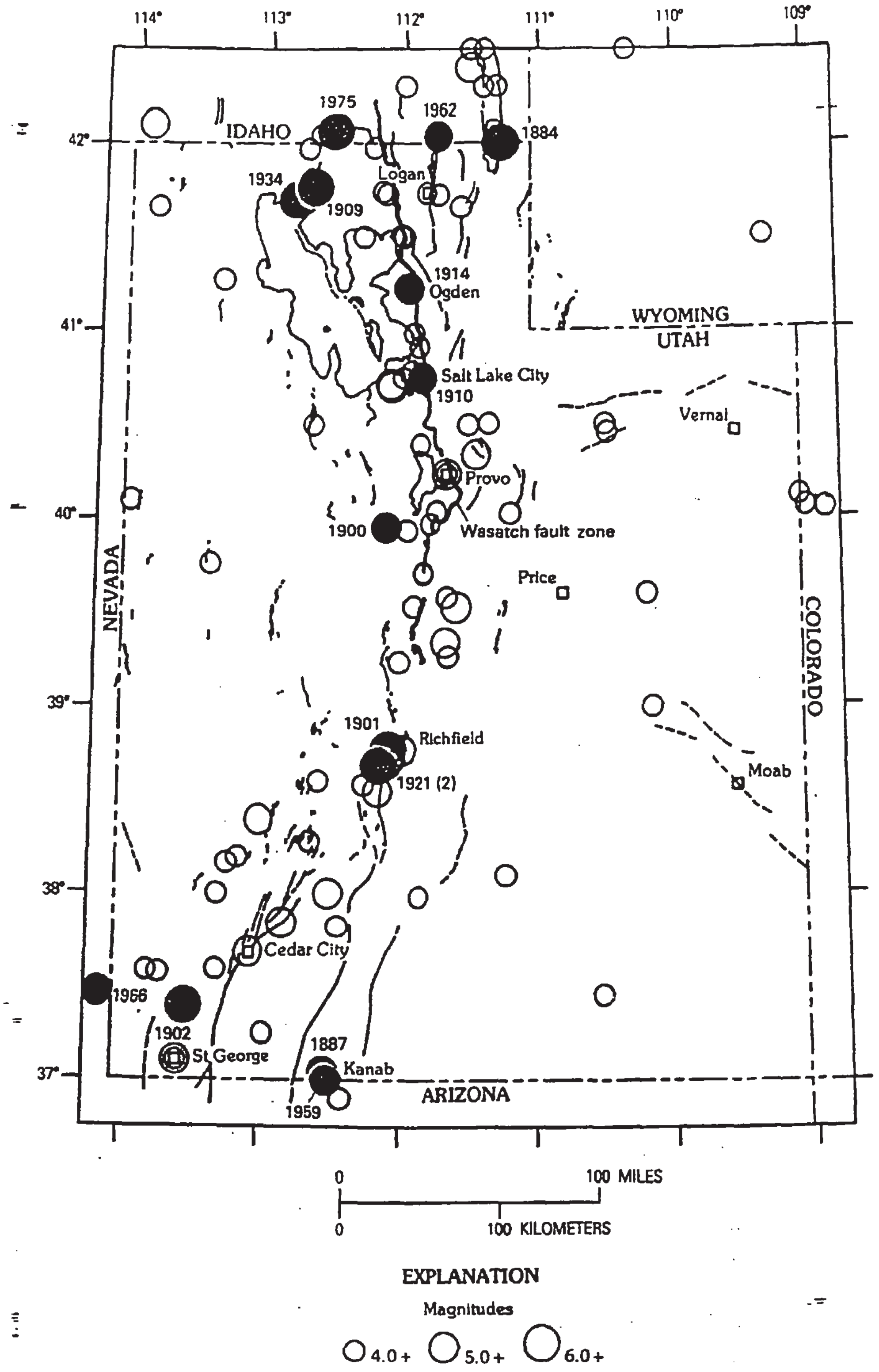
NO. 340-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH
DIETZGEN CORPORATION
MADE IN U.S.A.



GEOLOGIC SECTION THROUGH WASHINGTON COUNTY LANDFILL SITE

(See attached geologic map for location, position of landfill, and geologic symbols)

S. Bryce Montgomery, Geologist 1993



–Epicenters of all independent main shocks of M_L 4.0 or greater (or Modified Mercalli intensity V or greater) in the Utah region, 1850–1986, and Quaternary faults. Earthquakes of estimated M_L 5.5 or greater are indicated by solid circles, labeled with date. Data from University of Utah Seismograph Stations.

from- Arabasz, W. J. and others, 1992

Modified Mercalli Intensity Scale, Horizontal Acceleration, and Richter Magnitude Scale Relationships

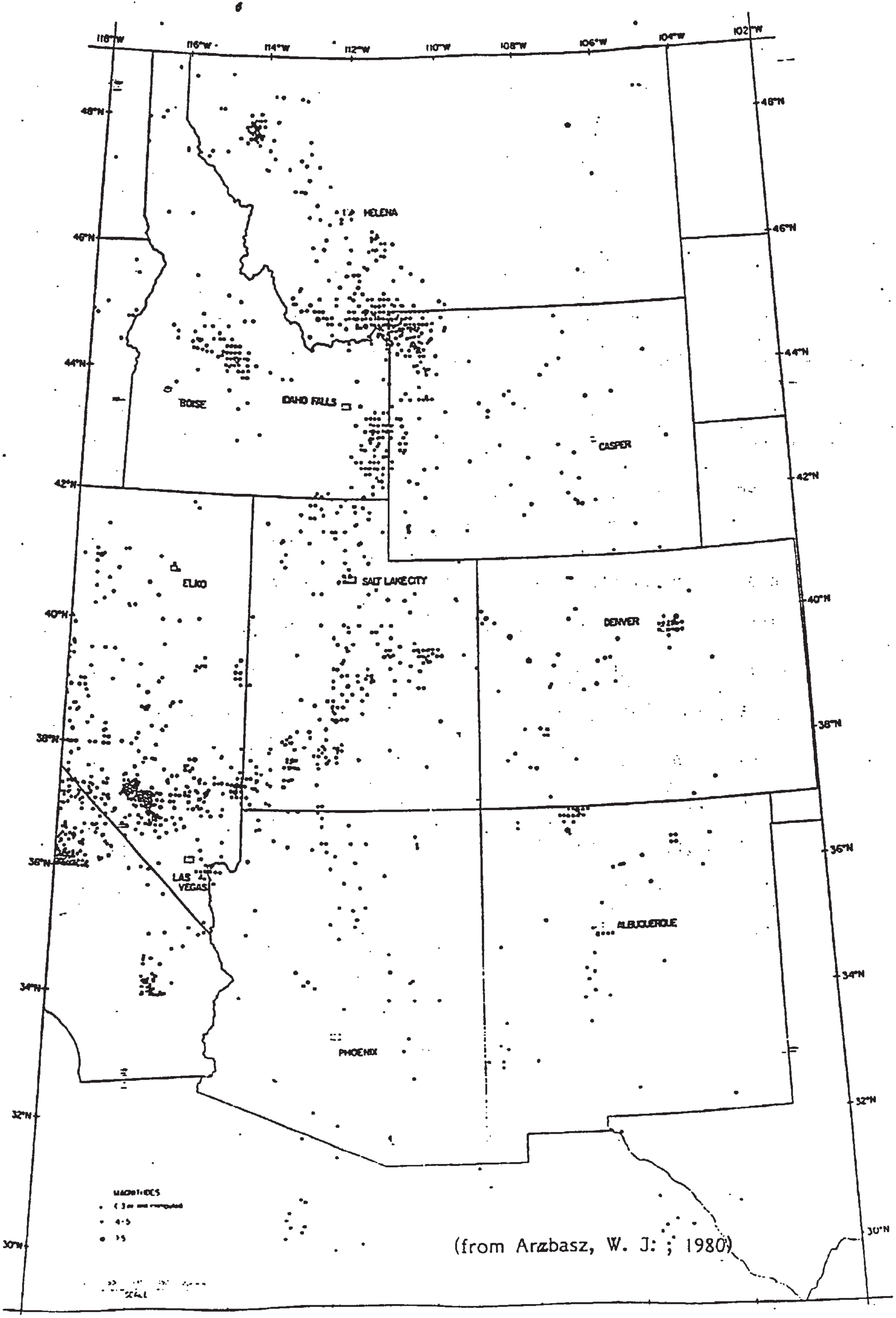
from- Adair, J. W., etal (1975)

Modified Mercalli Intensity Scale (1931, Wood and Neumann)	Horizontal Acceleration (g=32ft/sec^2)	Magnitude (Richter Scale)	Approx. Dist. Felt (miles)
I. Detected only by sensitive instruments.		2	
II. Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing			15
III. Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly; vibration like passing truck	0.01g	3	
IV. Felt indoors by many, outdoors by few; at night some awaken; dishes, windows, doors disturbed; motor cars rock noticeably		4	30
V. Felt by most people, some breakage of dishes, windows, and plaster; disturbance of tall objects.			
VI. Felt by all; many frightened and run outdoors; falling plaster and chimneys; damage small	0.05g	5	70
VII. Everybody runs outdoors; damage to buildings varied depending on quality of construction; noticed by drivers of automobiles.	0.1g		125
VIII. Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed		6	
IX. Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken.	0.2g		250
X. Most masonry and frame structures destroyed; ground cracked; rails bent; landslides.	0.5g	7	
XI. Few structures remain standing, bridges destroyed; fissures in ground;pipes broken, landslides, rails bent.	1.0g	8	450
XII. Damage total, waves seen on ground surface, lines of sight and level distorted, objects thrown up into air.			

Note: The correlations shown above are for illustration only, as they are not based on statistical data, and do not include other important considerations.

INTERMOUNTAIN SEISMIC BELT

~1850-1974

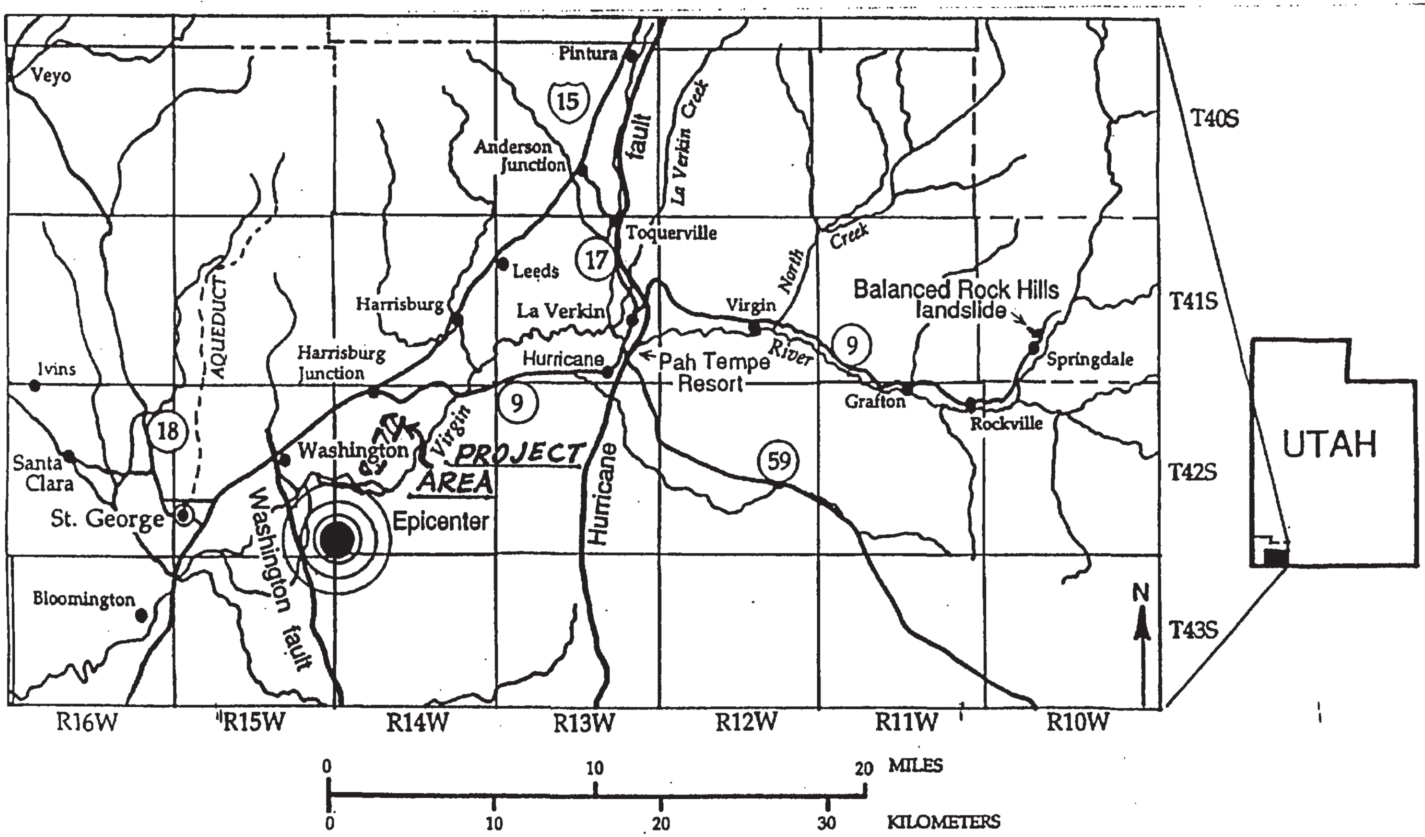


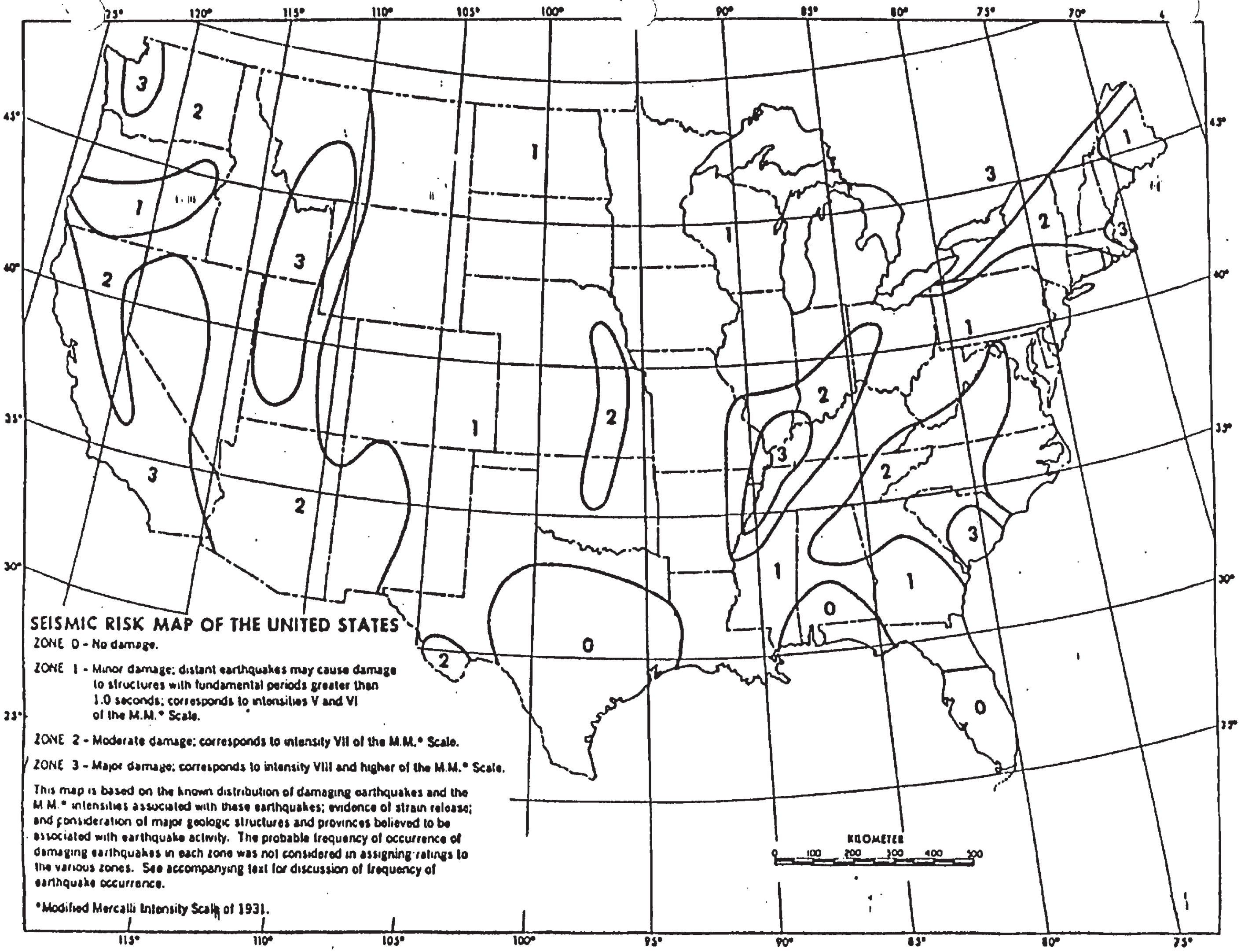
(from Arzbasz, W. J. ; 1980)

LOCATION MAP OF M 5.8 ST. GEORGE EARTHQUAKE, SEPTEMBER 2, 1992

relative to Washington County Landfill Site

base map from Black, B. D. and Christensen, G. E., 1993





SEISMIC RISK MAP OF THE UNITED STATES

ZONE 0 - No damage.

ZONE 1 - Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 seconds; corresponds to intensities V and VI of the M.M.* Scale.

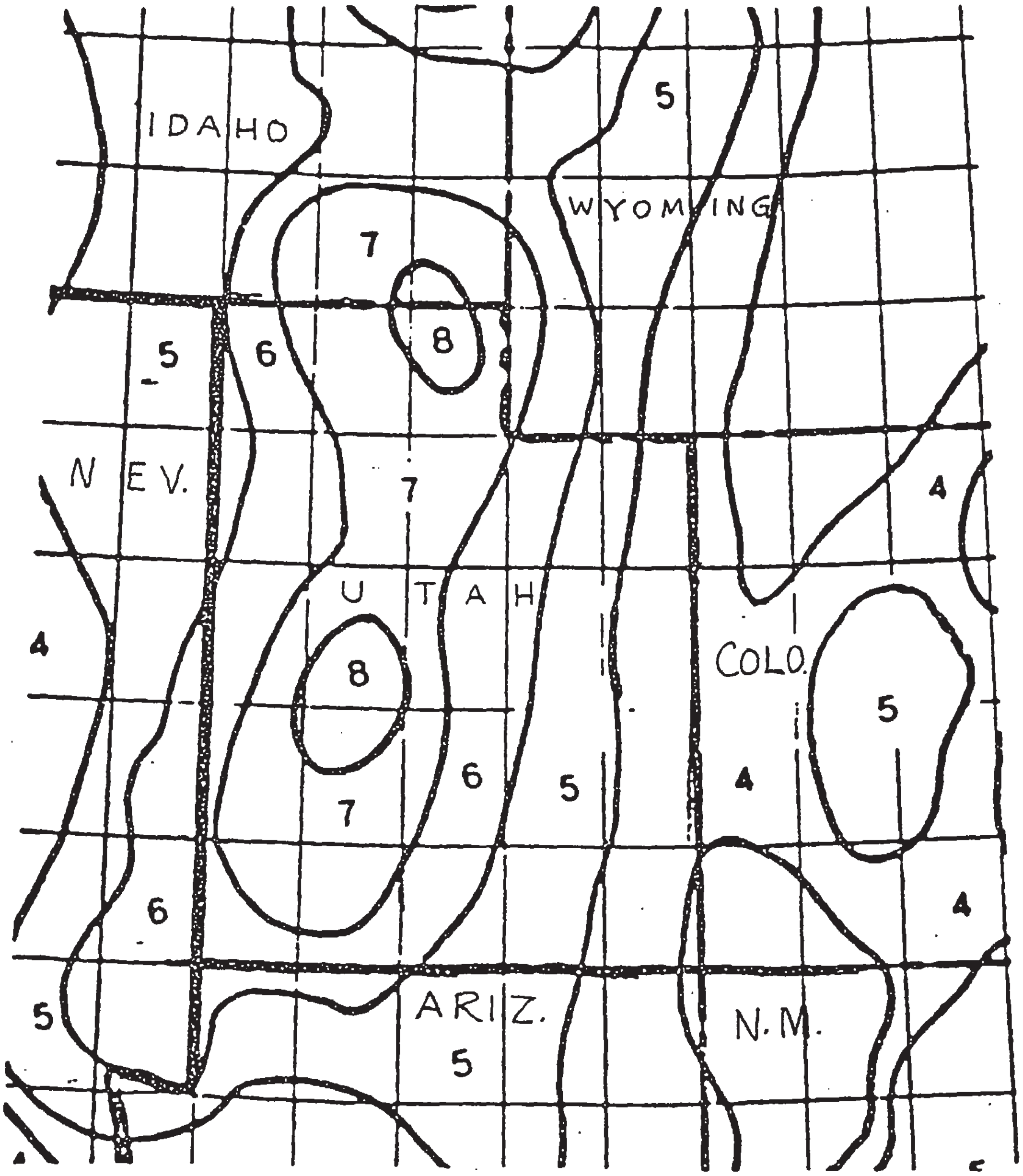
ZONE 2 - Moderate damage; corresponds to intensity VII of the M.M.* Scale.

ZONE 3 - Major damage; corresponds to intensity VIII and higher of the M.M.* Scale.

This map is based on the known distribution of damaging earthquakes and the M.M.* intensities associated with these earthquakes; evidence of strain release; and consideration of major geologic structures and provinces believed to be associated with earthquake activity. The probable frequency of occurrence of damaging earthquakes in each zone was not considered in assigning ratings to the various zones. See accompanying text for discussion of frequency of earthquake occurrence.

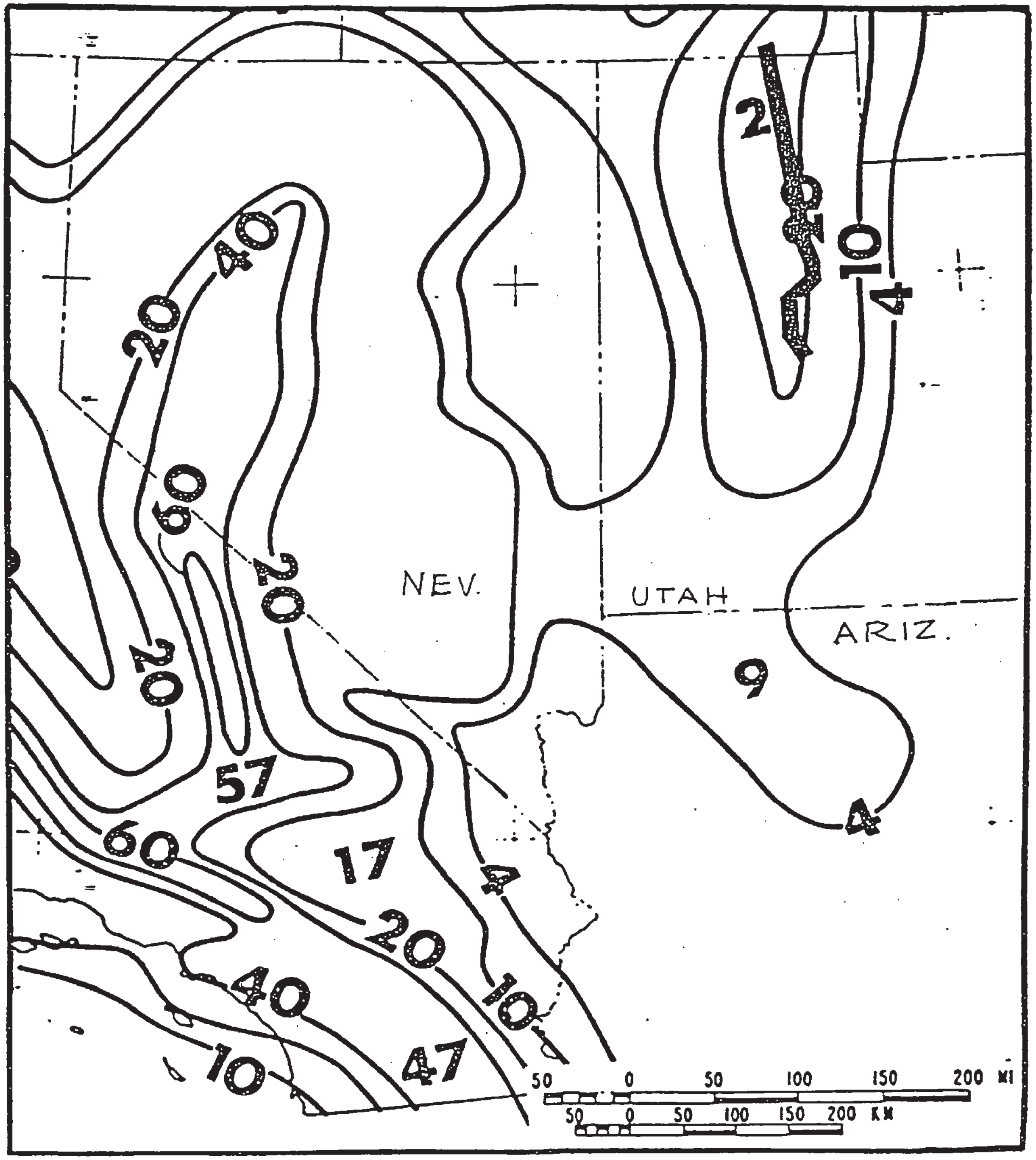
*Modified Mercalli Intensity Scale of 1931.

Algermissen, 1969



—Probabilistic intensity hazard map, 100 year return period, 99 percent extreme probability (after Liu and de Capua, 1975).

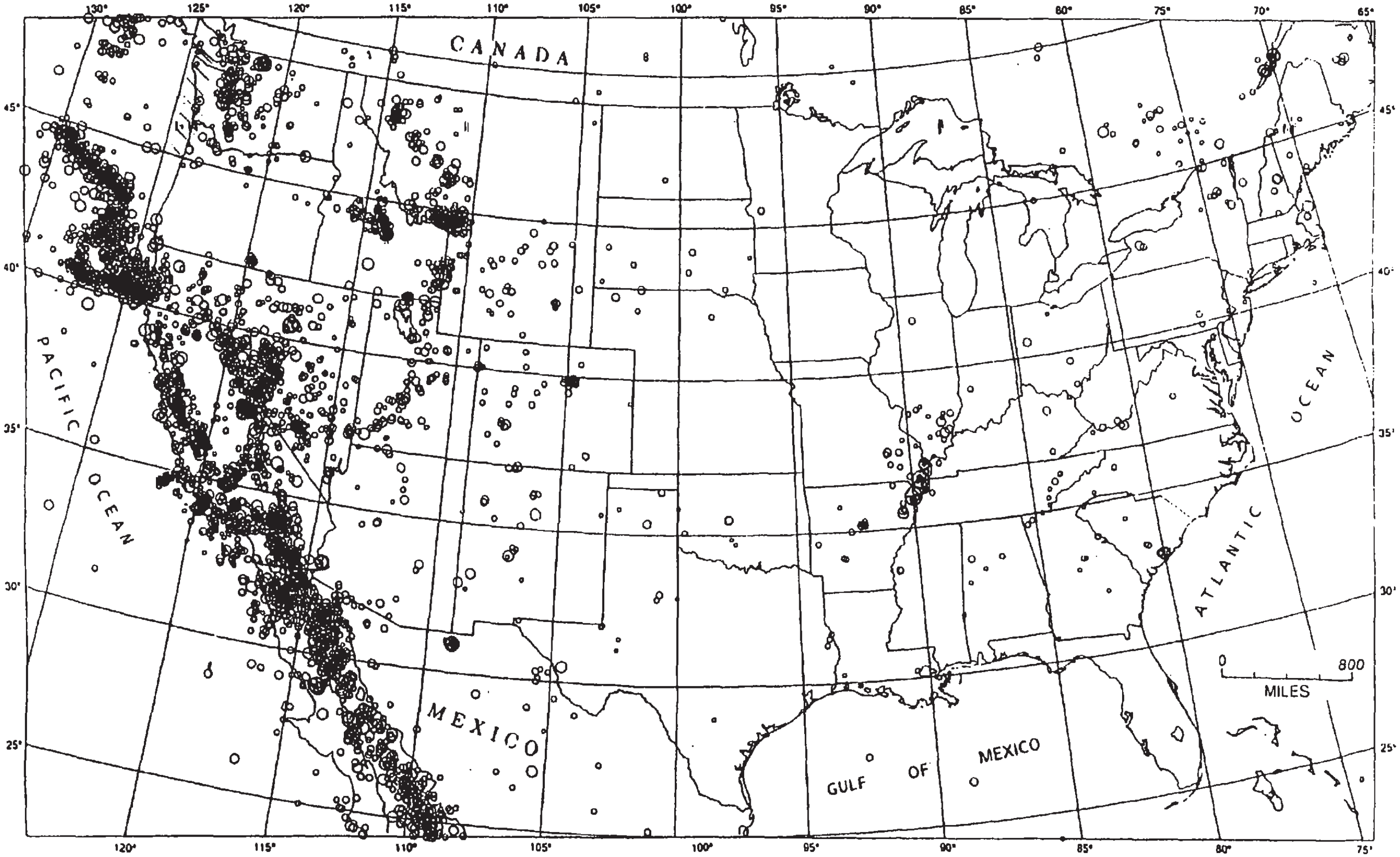
from- Algermissen, S. T. (1980)



-Acceleration in rock (percent of g) for an exposure time of 50 years at the 90 percent probability level (after Algermissen and Perkins, 1976).

from- Algermissen, S. T. (1980)

EARTHQUAKES OCCUR THROUGHOUT THE UNITED STATES.



Although earthquakes are most common in California and Alaska, they have shaken all States. Earthquakes as large or larger than the Loma Prieta event (red dots) have occurred in Alaska, California, Hawaii, Idaho, Missouri/Tennessee, Montana, Nevada, South Carolina, Washington, and in Quebec, just northwest of Maine; also, prehistorical evidence (red pattern) indicates that events of this size have occurred in Oregon, Washington, and Utah. This map shows the locations of all historical earthquakes of magnitude 5.5 or larger (largest circles), all earthquakes of magnitude 5 to 5.4 since 1925 (smaller circles), all recorded earthquakes of magnitude 4 to 4.9 since 1962 (still smaller circles), and all recorded earthquakes of magnitude 3.5 to 3.9 since 1975 (smallest circles). Clearly, earthquakes are a nationwide problem.

This U.S. Geological Survey pamphlet was written by Peter L. Ward and Robert A. Page and edited by Laurie D. Hodgen and Jeffrey A. Troll. Graphics by T.R. Alpha, R.D. Borcherdt, L.E. Buchholz, M.E. Coveau, L.D. Dietz, E.R. Engdahl, Tim Hitchcock, J.C. Lahr, F.W. Lester, S.E. Mayfield, M.J. Rymer, D. Tsoi, and J.F. Vigil.

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U. S. Geological Survey

7-1337
(1-55)
BUREAU OF RECLAMATION

GEOLOGIC LOG OF DRILL HOLE

FEATURE Purgatory Dike Virgin River Damsite PROJECT Dixie STATE Utah
HOLE NO. DH-1P LOCATION (C-42-14) 3cad GROUND ELEVATION 2887.8 ANGLE FROM VERTICAL None
COORDINATES N. 185,144.3; E. 1,442,329.7
BEGUN 1/19/66 FINISHED 1/24/66 DEPTH OF OVERBURDEN 8.3 TOTAL DEPTH 102.9 BEARING OF ANGLE HOLE None
DEPTH OR ELEV. OF WATER TABLE See Note Below HOLE LOGGED BY C. Swapp FOREMAN O. Hopkin

NOTES On water table levels, water return, character of drilling etc.

Drilling Equipment
Joy Rotary Model 22

Drilling Fluid
Water: 0.0 to 102.9

Casing
4" casing set at 21 feet but not cemented.

100% water return from 0-102.9.

Water level at 12.9 after standing overnight with a hole depth of 34.9.

Water level at 33.0 feet after standing overnight with the hole at a depth of 72.7 feet.

Hole caved before the water table could be established.

TYPE AND SIZE OF HOLE

RB 5 5/8"
D NX
RB 5 5/8"
D NX

CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FT.) FROM (P, Cs or Cm)	TO	LOSS IN (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (min)
	Bedrock at 8.3 feet in Middle Red member of the Moenkopi formation.				
0					
100	P 24.9	34.9	0 0	15 25	5 5
62	P 34.0	44.0	0 0	15 25	5 5
100	P 43.0	53.0	0 0	15 25	5 5
	P 52.7	62.7	0 0	15 25	5 5
95	P 62.7	72.7	0 0	15 25	10 10
99	P 72.9	82.9	0 0	15 25	10 10
100	P 82.9	92.9	0 0	15 25	10 10
	P 92.9	102.9	0 0	15 25	10 10
	Bottom of hole				

ELEVATION	DEPTH
2879.5	8.3
2866.7	21.1
2837.8	50
2832.8	55.0
2784.9	102.9

LOG SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

0-8.3 Alluvium; silt, sand, and clay.

8.3-21.1 Shale; reddish brown with some gray streaks. Generally weathered and soft with clay streaks. Formation too soft for core recovery. Gypsiferous with selenite crystals comprising over 25% of sample. Very slightly calcareous.

21.1-50.0 Shale; reddish brown. Contains some interbedded silt and claystone. Gypsum beds 1/8 to 1/4 inch thick comprise 5 to 20% of the core. Strata dipping about 28°. Recovered core generally soft and breaks easily by hand. Pieces range from 1/2 to 6 inches in length.

50.0-55.0 Claystone; reddish brown. Silty and slightly gypsiferous with most gypsum being bedded. Core breaks easily by hand. Core recovered as pieces 1/2 to 6 inches in length. Core crumbles as it dries on exposure to air.

55.0-102.9 Shale; reddish brown with gray from 58.0 to 63.0 feet. This interval is gradational with some zones being silty and clayey. Gypsum beds (selenite) 1/16 to 1/4 inch thick comprise 5 to 25% of core. Some high angle fracturing from 64.0 to 65.0 feet. All fractures are well healed with gypsum. Zone from 97.5 to 98.5 feet contains irregualr shaped inclusions of alabaster gypsum ranging in size from pinpoint up to 1/2 inch in diameter. Core recovered as pieces 1/2 to 6 inches long and can be broken by hand or with a light hammer tap.

RB = Rock roller bit

☐ CORE LOSS
▨ CORE RECOVERY

Type of hole . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X-series) Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (X-series) Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (X-series) Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (X-series) Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐
VERTICAL HOLE ☒

HOLE NO. DH-1P

7-1337
(1-55)
BUREAU OF RECLAMATION

Sheet 1 of 2

Virgin River Inmsite GEOLOGIC LOG OF DRILL HOLE

FEATURE Purgatory Dike PROJECT Dixie STATE Utah
HOLE NO. DH-2P LOCATION (C-42-14) 3dcb GROUND ELEVATION 2902.1 ANGLE FROM VERTICAL None
COORDINATES N. 184,521.7; E. 1,443,[illegible]
BEGUN 2/24/66 FINISHED 3/3/66 DEPTH OF OVERBURDEN 3.0 TOTAL DEPTH 203.5 BEARING OF ANGLE HOLE None
DEPTH OR ELEV. OF WATER TABLE See Notes Below. HOLE LOGGED BY C. Swapp FOREMAN O. Hopkin

NOTES On water table levels, water return, character of drilling etc.

Drilling Equipment
Joy Rotary Model 22

Drilling Medium
Water: 0.0 to 203.5 feet

Casing
Set 10.0 feet of 4" while drilling and removed on completion.

About 90% water return during drilling from 0 to total depth. (Drilling day shift only.)

Water Table Data

Date	CS Depth At start of shift	Hole Depth	Depth to Water
2-28-66	10.0	74.2	68.0
3- 1-66	10.0	103.2	60.5
3- 2-66	10.0	134.2	63.8(over week-end)
3- 3-66	10.0	173.8	60.7
3-19-66	0.0	203.5	68.4
3-17-66	0.0	203.5	68.6

TYPE AND SIZE OF HOLE: RB 7/8" ; D HX

CORE RECOVERY (%): 38, 100, 98, 100, 98, 98, 100

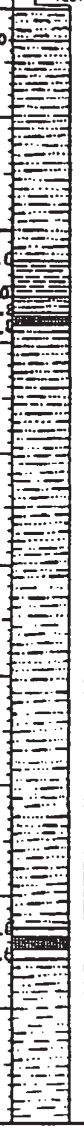
Bedrock at 3.0 feet in Shnabkaib member of Moenkopi formation.

PERCOLATION TESTS

DEPTH (FT.) FROM (P, Cs or Cm)	TO	LOSS IN (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (min)
P 12.6	22.6	6 11	15 25	10 10
P 22.6	32.6	0 0	15 25	10 10
P 31.6	41.6	0 0	15 25	10 10
P 39.2	54.2	0 0	15 25	10 10
P 54.2	64.2	0 0	15 25	10 10
P 64.2	74.2	0 0	15 25	10 10
P 73.2	84.2	0 0	15 25	10 10
P 82.3	93.3	0 0	15 25	10 10
P 92.2	103.2	0 0	15 25	10 10

ELEVATION	DEPTH
2899.1	3.0
2879.5	22.0
2876.1	26.0
2874.9	27.
2873.7	28.
2809.3	82.
2817.3	84.

LOG — SAMPLES FOR TESTING



CLASSIFICATION AND PHYSICAL CONDITION

0.0-3.0 Alluvium; silty, gypsiferous, gray weathered Schnabkaib surface zone.

3.0-22.6 Siltstone; medium gray. Contains gypsum in the form of disseminated crystals, veinlets, fracture fillings and lenses up to 1/4 inch thick. Fractures occur at random angles and are well healed with gypsum from 17.0 to 18.0. The interval from 6.0 to 10.5 feet was recovered in shattered pieces from 1/4 to 3.0 inches in diameter. The zone from 10.0 to 11.0 feet is slightly fissile. The core is weak to moderately strong and is recovered in pieces 1/4 inch to 8.0 inches long. It has medium density.

22.6-26.0 Claystone; light green to medium gray and silty. Beds of satin spar gypsum, 1/8 to 1/4 inch thick parallel the bedding. (Average about 1 zone per foot interval) This zone very weak and can be broken easily by hand. Pieces as recovered are 1/2 to 4.0 inches long. Density is medium to high.

26.0-27.2 Siltstone; medium gray and thin bedded. Bands of gypsum 1/16 to 1/2 inch thick lie parallel to bedding and comprise 5 to 15% of interval. Some minor fracturing at random angles but all well healed with gypsum. Core moderately strong and has medium density. May be broken by hand or with light hammer tap.

27.2-28.4 Gypsum; medium gray with irregular shaped inclusions of siltstone Core weak to moderately strong and has medium density. May be broken with light to medium hammer tap. Recovered pieces 1.0 to 8.0 inches long.

28.4-82.8 Siltstone; medium to light gray with some zones having a brown or light green cast. Intervals up to 10.0 inches thick grade into a clayey siltstone with some being slightly fissile. Gypsum occurs disseminated and as irregualr lenses and beds up to 1.0 inch thick. Percentage of gypsum in core is about 5-20%. Core is generally weak to moderately strong and can be broken by hand or with light to medium hammer tap. The zone has medium density and some minor fracturing at random angles. All fractures are well healed with gypsum. Core recovered in pieces averaging 2.0 to 6.0 inches long.

82.8-84.8 Gypsum; light gray to white with irregular shaped inclusions of siltstone. Core has medium density and is moderately strong. May be broken with medium hammer tap. Recovered pieces 2.0 to 12.0 inches long.

EXPLANATION RB : Rock roller bit

▯ CORE LOSS
▮ CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X-series). Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (X-series) ... Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (X-series). Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (X-series) ..... Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐
VERTICAL HOLE ☒

7-1337
(1-55)
BUREAU OF RECLAMATION

GEOLOGIC LOG OF DRILL HOLE

FEATURE .. Virgin River Damsite Purgatory Dike .... PROJECT .... Dixie .... STATE .— Utah

HOLE NO. DH-2P .. LOCATION (C-42-14) 3dcb .... COORDINATES N. 184,521.7; E. 1,443,204.9 GROUND ELEVATION 2902.1 .... ANGLE FROM VERTICAL .. None

BEGUN 2/24/66 .. FINISHED 3/3/66 .. DEPTH OF OVERBURDEN 3.0 ..... TOTAL DEPTH 203.5 BEARING OF ANGLE HOLE None

DEPTH OR ELEV. OF WATER TABLE See Notes Below. HOLE LOGGED BY ... C. Bwapp ...... FOREMAN .... O. Hopkin

NOTES On water table levels, water return, character of drilling etc.

After completing hole at a total depth of 203.5 on 3/3/66, water level was bailed down from 60.3 to 90.0 feet from surface.

3/4/66
After standing overnight the water level had raised from 90.0 to 68.2 feet (probably due to drilling water returning from formation.)

Bailed water level on down to 199.0 feet from surface on 3/4/66.

Pulled the 10.0 feet of 4" casing and installed 204.0 feet of 1-1/4" observation pipe with bottom 42.0 feet perforated.

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS				
		DEPTH (FT.) FROM (P, Cs or Cm)	DEPTH (FT.) TO	LOSS IN (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (min)
D BX	100					
	98	P 102.2	113.2	0 0	15 25	10 10
	100	P 113.2	124.2	0 0	15 25	10 10
		P 124.2	134.2	0 0	15 25	10 10
		P 134.2	144.2	0 0	15 25	10 10
		P 144.0	154.0	0 0	15 25	10 10
		P 154.0	164.0	0 0	15 25	10 10
		P 163.8	173.8	0 0	15 25	10 10
		P 173.7	183.7	0 0	15 25	10 10
		P 183.7	193.7	0 0	15 25	10 10
		P 193.5	203.5	0 0	15 25	10 10

Transitional top of Middle Red member of Moenkopi at 187.0 feet.

Bottom of hole

ELEVATION	DEPTH
2767.7	134.4
2765.2	136.9
2755.0	147.1
2754.3	147.8
2715.1	187.0
2698.6	203.5

LOG SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

84.8-134.4 Siltstone; medium to light gray. Some zones (2.0-12.0 inches thick) are slightly clayey and fissile. Gypsum as satin spar occurs in lenses, veinlets, and beds up to 1/2 inch thick. Gypsum content of core about 5 to 20 percent. Some light shows of sulfur associated with gypsum. Core is weak to moderately strong and has medium density. Fractures at random angles averaging 2 to 3 per foot interval. These are all well healed with gypsum. Recovered core pieces average 2.0 to 6.0 inches long.

134.4-136.9 Gypsum; light gray to white. Generally a granular medium to low density variety. Core breaks by hand or with light hammer tap. Recovered in pieces 1/2 to 5.0 inches long.

136.9-147.1 Siltstone; light to medium gray. Gypsum present as lenses, bedded and as fracture fillings in thicknesses up to 1.0 inch. Some disseminated crystals. Total gypsum percent not over 15 percent. The fracturing is very limited and all well healed with gypsum. The zone from 146.6 to 147.1 has a mottled breccia appearance but has medium density with no unhealed fractures. Core is moderately strong and may be broken with light hammer tap. Recovered pieces are 1/2 to 6.0 inches in length.

147.1-147.8 Gypsum; medium gray to white with irregular-shaped inclusions of siltstone. The gypsum is generally silty. The interval has medium density and is moderately strong.

147.8-203.5 Siltstone; generally light to medium gray down to about 187.0 feet. From this point to the bottom, there is considerable brown and tan coloring with some gray zones interbedded. Gypsum occurs as beds, lenses, fracture fillings, and is disseminated. The fractures occur at random angles and average about two per foot interval. All are well healed with gypsum. The core is recovered in pieces 1/2 inch to 1.5 feet long. The entire interval has medium density with the core being weak to moderately strong. Core requires light to medium hammer tap to break.

RB - Rock roller bit

▯ CORE LOSS
▮ CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X-series) ...... Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (X-series) ...... Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (X-series) ...... Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (X-series) ...... Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐
VERTICAL HOLE ☒

7-1337
(1-55)
BUREAU OF RECLAMATION

Sheet 1 of 2

Virgin River Damsite GEOLOGIC LOG OF DRILL HOLE

FEATURE . . Purgatory Dike . . . . PROJECT . . . . Dixie . . . . STATE . . . Utah
HOLE NO. . DH-3P . LOCATION (C-42-14) . 3ca . . . . GROUND ELEVATION . 2901.0 . . . . ANGLE FROM VERTICAL . None
COORDINATES N. 185,548.0; E. 1,441,388.6
BEGUN 3/7/66 . . . FINISHED 3/14/66 DEPTH OF OVERBURDEN . . 3.5 . . . . . TOTAL DEPTH 152.8 . . . BEARING OF ANGLE HOLE . None.
DEPTH OR ELEV. OF WATER TABLE See Notes Below . HOLE LOGGED BY . . . . C. Svapp . . . . FOREMAN . . . . O. Hopkin . . . . . .

NOTES On water table levels, water return, character of drilling etc.

Drilling Equipment
Joy Rotary Model 22

Drilling Medium:
Water: 0.0 to 152.8

Casing
Set 3.5 feet of 4" loose in top of hole.

About 95-100% water return during drilling from 0 to total depth. (Drilling day shift only)

Water Table Data

Date	CS Depth At start of shift	Hole Depth	Depth to Water
3-8-66	3.5	24.5	9.4
3-9-66	3.5	64.5	48.7
3-10-66	3.5	104.2	35.8
3-14-66	3.5	133.2	41.5
3-17-66	3.5	152.8	139.2

Upon completion of hole on 3/14/66, the water was bailed down to 148.0-foot depth.

TYPE AND SIZE OF HOLE: RB 5 7/8" (0-3.5); D NX

CORE RECOVERY (%): 0; 64; 98; 100; 97; 100

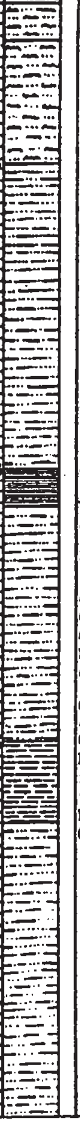
PERCOLATION TESTS

Bedrock at 3.5 feet in Middle Red member of Moenkopi formation.

DEPTH (FT.) FROM (P, Cs or Cm)	TO	LOSS IN (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (min)
P 9.5	24.5	0 0	15 25	10 10
P 23.6	33.6	0 0	15 25	10 10
P 33.6	43.6	0 0	15 25	10 10
P 43.6	53.6	0 0	15 25	10 10
P 52.5	64.5	0 0	15 25	10 10
P 64.3	47.3	0 0	15 25	5 5
P 74.3	84.3	0 0	15 25	5 5
P 84.2	94.2	0 0	15 25	5 5
P 94.2	104.2	0 0	15 25	5 5

ELEVATION	DEPTH
2897.5	3.5
2886.5	14.5
2858.7	42.3
2855.5	45.5
2834.2	66.8
2827.0	74.0

LOG SAMPLES FOR TESTING



CLASSIFICATION AND PHYSICAL CONDITION

0-3.5 Alluvium; silt and fine-grained sand with some weathered gypsum. No sample taken.

3.5-14.5 Alluvium; weathered gypsiferour siltstone and claystone. Core generally very soft and can be broken or crumbled by hand.

14.5-42.3 Siltstone; medium gray to brown or red. Contains gypsum as disseminated crystals and as thin (up to 1/4 inch thick) beds and fracture fillings. Core is generally argillaceous with some clay zones up to 8.0 inches thick. Fractures are at random angles (average 2 to 3 per 1 foot interval) and are all well healed with gypsum. Core is weak and friable. Bedding in core dipping at 55° from horizontal.

42.3-45.5 Shale; medium gray with some brown. Contains beds and stringers of gypsum up to 1/2 inch thick. Gypsum comprises 5-10% of core. Core is weak to moderately strong and can be broken by hand or with light hammer tap. Recovered pieces 1.0 to 8.0 inches long.

45.5-66.8 Siltstone; dark brown to red. Contains satin spar gypsum as beds and stringers up to 1/2 inch thick. Gypsum comprises about 5-10% of core. Core is weak to moderately strong and has medium density. Recovered pieces are from 1.0 to 12.0 inches long.

66.8-74.0 Claystone; medium gray and silty. Slightly fissile or shaley. Core is weak and may be broken by hand. Breaks up on loss of moisture. Highly fractured at random angles but fractures fit tight together and are well healed. Recovered pieces are 1/2 to 6.0 inches in length.

EXPLANATION RB = Rock roller bit

☐ CORE LOSS
■ CORE RECOVERY

Type of hole . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X-series) . . . Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (X-series) . . . . Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (X-series) . . . Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (X-series) . . . . . Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐
VERTICAL HOLE ☒

Sheet 1 of 2 HOLE NO. DH-3P

7-1337
(1-59)
BUREAU OF RECLAMATION

Sheet 2 of 2

GEOLOGIC LOG OF DRILL HOLE

FEATURE Virgin River Damsite Purgatory Dike PROJECT Dixie STATE Utah
HOLE NO. DH-3P LOCATION (C-42-14) 3ca COORDINATES N. 185,548.0; E. 1,441,388.6 GROUND ELEVATION 2901.0 ANGLE FROM VERTICAL None
BEGUN 3/7/66 FINISHED 3/14/66 DEPTH OF OVERBURDEN 3.5 TOTAL DEPTH 152.8 BEARING OF ANGLE HOLE None
DEPTH OR ELEV. OF WATER TABLE See Notes Below HOLE LOGGED BY C. Swapp FOREMAN O. Hopkin

NOTES On water table levels, water return, character of drilling etc.	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS DEPTH (FT.) FROM (P, Cs or Cm)	TO	LOSS IN (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (min)	ELEVATION	DEPTH	LOG SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
	D NX	100	P 104.2	114.2	0 0	15 25	5 5				74.0-152.8 <u>Siltstone</u>; dark brown to red with gray streaks up to 1.0 inch thick. Slightly clayey with some zones 6.0 inches to 3.0 feet thick being fissile. Stringers of satin spar gypsum up to 1.0 inch thick and running at random angles make up 5 to 15% of the core. Bedding planes dipping about 50° from horizontal. Fractures averaging 1 to 2 per 1.0 foot interval are at random angles and all well healed with gypsum. Core weak to moderately strong and has medium to high density. Recovered pieces are 1.0 to 12.0 inches long.
			P 114.2	124.2	0 0	15 25	5 5				
			P 123.2	133.2	0 0	15 25	5 5				
		99	P 132.4	143.4	0 0	15 25	10 10				
		100	P 142.8	152.8	0 0	15 25	10 10				
			Bottom of hole					2748.2	152.8		

EXPLANATION RB = Rock roller bit

CORE LOSS

CORE RECOVERY

Type of hole..........D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed..........P = Packer, Cm = Cemented, Cs = Bottom of casing
Approximate size of hole (X-series)..........Ex = 1 1/2", Ax = 1 7/8", Bx = 2 3/8", Nx = 3"
Approximate size of core (X-series)..........Ex = 7/8", Ax = 1 1/8", Bx = 1 5/8", Nx = 2 1/8"
Outside diameter of casing (X-series)..........Ex = 1 13/16", Ax = 2 1/4", Bx = 2 7/8", Nx = 3 1/2"
Inside diameter of casing (X-series)..........Ex = 1 1/2", Ax = 1 29/32", Bx = 2 3/8", Nx = 3"

ANGLE HOLE ☐
VERTICAL HOLE ☒

Sheet 2 of 2 HOLE NO. DH-3P

January 10, 1994

Mr. Steven E. Layton
Mr. Reed Noble
Creamer & Noble Engineers
P. O. Box 37
St. George, Utah 84771

RE: Washington County Landfill hydrogeologic evaluation, your letter of December 29, 1993.

Gentlemen:

As per our previous conversations, my study-report of August 23, 1993, subsequent test drilling results, and your letter of December 29, 1993, regarding the Washington County landfill site, I submit the following.

Attached to this letter is a copy of a hydrogeologic map which I have prepared on the base of your prepared topographic map of the site, upon which are shown the locations of the test wells (drill holes abbreviated DH) and their data. Also, attached are the driller's records of the five subsequent test wells drilled along with copies of the chemical analysis of ground water from test wells Nos. 1 and 4.

As I had concluded in my previous report, the test drilling has shown that there are no potable aquifers underlying the existing and projected landfill site. Test wells Nos. 2, 3 and 5 located directly under the projected landfill extension were dry to total depths of 200 feet. However, test wells Nos. 1 and 4 located at the very south and southeast end of the existing landfill unit did encounter small yields of ground water with high total dissolved mineral contents of 12,000 mg/l and 4,000 mg/l respectively.

In test well No. 4, the encountered ground water is most probably originating from spillage into a southwesterly trending fracture system within the underlying bedrock of the Middle Red Member siltstone-shale of the Moenkopi Formation, from the steeply dipping (54-60 degrees NW), well jointed Virgin Limestone Member of the Moenkopi Formation. This limestone unit is confined by silty-shaley beds to the northwest and southeast. As this ground water moves within and along the fracture system present in the limestone unit, it is also able to move at a much slower rate through the cross, diagonally fracture system that is present, into the silty Middle Red Sandstone Member and on into the shaley, gyppy, dolomitic siltstone of the Shnabkaib Member of the Moenkopi Formation. The Shnabkaib Member contains a much higher content (near 10-20 percent) of gypsum and other salts such as magnesium sulfate, sodium sulfate, and sodium chloride, than the Middle Red or Virgin Limestone Members.

The Virgin Limestone Member is less than 100 feet thick and outcrops as a prominent, narrow hogsback or cockscomb along the east side of Purgatory Flat, in which the landfill site is located. Precipitation and runoff has been able to partially infiltrate the fractures and joints, along with upward tilted bedding planes of the limestone unit, allowing limited groundwater to be stored and slowly recharged over the historic past. Successively, this limited ground water of poor quality degrades further in quality as it moves slowly from the Virgin Limestone Member into the Middle Red and Shnabkaib Members.

The Purgatory or buff-yellow sandstone unit near the base of the silty, Upper Red Member of the Moenkopi Formation is also well jointed and fractured, and contains intergranular porosity and permeability, and thus is pervious, similar to the Virgin Limestone Member. This sandstone also outcrops upgradient to test well No. 1, as a prominent, narrow hogback (about 100 feet wide) within the southwest edge of the Purgatory Flat area of the landfill site, where it dips steeply northwestward 60-83 degrees. It is sheared-off by overthrust faulting, farther northward along the westward side of Purgatory Flat and the projected landfill area. It too acts as a thin aquifer similar to the Virgin Limestone, and is apparently, slowly spilling poor quality ground water into the adjacent Shnabkaib Member, by the same fracture trend, where its quality is rapidly degraded further. This is evidenced by the high total dissolved mineral solids content found in the ground water encountered in test well No. 1.

Thus, the intermittent surface drainage located adjacent to test well No. 4 and immediately east of test well No. 1, is apparently near the low gradient position of the shallow ground water encountered within the fracture system of these two drill holes. This small flow of ground water has historically moved slowly, down-gradient to the southwest towards the Virgin River, through the existing Moenkopi Formation bedrock, beneath any shallow, perched alluvial aquifer within the floodplain of the Virgin River valley, more than a mile away.

The encountered ground water of high mineral content in test wells Nos. 1 and 4 is from a very limited, small-yielding aquifer which is not useable for potable purposes, and does not supply recharge to an aquifer located down-gradient that is being or could be used for potable purposes. To maintain this natural, existing condition, it is my recommendation to avoid or minimize the introduction of water into the landfill site, so as to prevent the circulation and movement of it into the existing bedrock fracture system and upward-tilted bedding planes. This will prevent its dissolving of gypsum and other salts, without

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                         xxx ECXX ENROUTE COLJCT - BARRY    xxx
                                                                 03 30 0641

    GENERAL INQUIRY REPORT SENT FROM TCS SERVICE CENTER
    GENERAL INQUIRY TYPE- DY                           REPETITIVE INQUIRY - 12919
    RESPONSIBILITY AREA GRP UW813
    CONSIGNEE       EQUIPMT-ID L CURRENT                                  ETA
                    INT NUMBER E LOCATION                                DA HR

       YARD UW813 COLJCT     UT
    ECDC ENVIRONM   UPCX 96109 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96099 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96106 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96051 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96075 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96114 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96091 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96086 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96066 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96120 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96067 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96118 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96055 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96031 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96003 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96036 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96112 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96007 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   UPCX 96039 L DP   MCHNP  29 CORTLAND  IL 03   30 0612 05 19
    ECDC ENVIRONM   ECXX 96115 L TA   LUH44  29 HELPER    UT 03   29 2000 30 18
    ECDC ENVIRONM   UPCX 96027 L TA   MESNP  27 NP TWEST  NE 03   29 1347 03 19
    SUB-TOT 00021 LOADS   00000 MTYS   00000 UNKNOWNS


    TOTALS  00021 LOADS   00000 MTYS   00000 UNKNOWNS


    THE ABOVE GENERAL INQUIRY REPORT IS FROM THE FOLLOWING INPUT
    S/D-D,L/E-A
    CT-CAR TYPE MOP-K,AAR-T,MACRO-M
       K G5
    CS-CONSIGNEE NAME
       ECDC;
    EQ-EQUIP OWNER-O,INITIAL-I,SERIES-S
       S ECXX   096000 096999 UPCX   096000 096999
    SW-SORT/SUMMARY/WT
       N CS  CL
    FM-FORMAT
       CS  EQD LE      CL  TME
```

aquifer.

Sincerely,

S Bryce Montgomery

S. Bryce Montgomery
Professional Geologist
3512 South 100 East
Bountiful, Utah 84010 Telephone 295-8592

ATTACHMENT L

WATER RIGHTS MAP AND TABLES

Water Rights Map

Water Right Details for 81-1211

Utah Division of Water Rights 8/30/2021 3:26 PM

(WARNING: Water Rights makes NO claims as to the accuracy of this data.)

Water Right: 81-1211 Application/Claim: A40615 Certificate:

Owners:

Name: Dixie Basin Smelters Inc.
Address: PO Box 280
Hurricane UT 84737
Interest:
Remarks:

General:

Type of Right: Application To Appropriate
Source of Info.: Application to Appropriate
Status: Rejected
Quantity of Water: 1 CFS

Source: Underground Water Well
County: Washington
Common Description:
Proposed Det. Book: 81-
Map:
Pub. Date:
Land Owned by Appl.: No
County Tax Id#:

Dates:

Filing:

Filed: 04/28/1971
Priority: 04/28/1971
Decree/Class:

Advertising:

Publication Began: 06/03/1971
Publication End: 06/17/1971
Newspaper: Washington County
Protest End Date: 07/17/1971
Protested: Protested and
Hearing Held: 03/24/1972

Approval:

State Eng. Action: Rejected
Action Date: 01/07/2009
Recon. Req. Date:
Recon. Req Action:

Certification:

Proof Due Date:
Extension Filed Date:
Election or Proof:
Election/Proof Date:
Certificate Date:
Lapsed, Etc. Date:
Lapsed Letter

Wells:

Prov. Well Date:
Most Recent Well Renovate/Replace Date:

Points of Diversion:

Points of Diversion - Underground:

(1) S 100 ft. E 2300 ft. from NW corner, Sec 08 T 42S R 14W SLBM
Well Diameter: 12 in. Depth: 150 to ft. Year Drilled: Well Log: Well Id#:
Elevation: UTM: 282442.565, 4114853.835 (NAD83)
Source/Cmnt:

(2) S 620 ft. E 2500 ft. from NW corner, Sec 08 T 42S R 14W SLBM
Well Diameter: 12 in. Depth: 150 to ft. Year Drilled: Well Log: Well Id#:
Elevation: UTM: 282503.525, 4114695.339 (NAD83)
Source/Cmnt:

Points of Diversion - Underground:

(3) S 1200 ft. E 2040 ft. from NW corner, Sec 08 T 42S R 14W SLBM

Well Diameter: 12 in. Depth: 150 to ft. Year Drilled: Well Log: Well Id#:

Elevation: UTM: 282363.317, 4114518.555 (NAD83)

Source/Cmnt:

Proposed Water Uses:

Proposed Water Uses - Group Number: 609120

Group Comment: 3/16/2007 -- admin decision to convert SS PER/5 to FAM and not use PER -- (Orig SS Per: 30)

Water Use Types:

Domestic-Beneficial Use Amount: 6 EDUs | Group Total: 6 | Period of Use: 01/01 to 12/31

Comments: Mar 16, 2007 -- admin decision to convert PERSONS/5 to FAMILIES and not use PERSONS.

Mining: District: Harrisburg | Name: Burg Property | Period of Use: 01/01 to 12/31

Acre Feet Contributed by this Right for this Use: 721.2799805403 | Ores: Copper,Silver,Uranium

Place Of Use:	North West				North East				South West				South East				Section Totals
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	
Sec 08 T 42S R 14W	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Group Acreage Total :																	

Use Totals:

Domestic sole-supply total: 6 EDUs for a group total of: 6 EDUs

Mining sole-supply total: 721.28 acft

Other Comments:

```
The area is now held by State of Utah and the Bureau of Land Management.
Application protested by the Bureau of Land Management.
This application is not to be approved or rejected until it is determined if t
here is unappropriated water in the source.
```

Protestants:

Application Protestants:

Received: 06/10/1971 Type: Application

Name: United States Department of the Interior Bureau of Land Management

Address: PO Box 729
Cedar City, UT 84720

Comments:

Water Right Details for 81-415

Utah Division of Water Rights 8/30/2021 1:16 PM

(WARNING: Water Rights makes NO claims as to the accuracy of this data.)

Water Right: 81-415 Application/Claim: A32060 Certificate: 7190

Owners:

Name: Cedar City District USA Bureau of Land Management
Address: 176 East DL Sargent Drive
Cedar City UT 84720
Interest:
Remarks:

General:

Type of Right: Application To Appropriate Source of Info.: Water User's Claim Status: Certificated
Quantity of Water: 2.061 ACFT

Source: Unnamed Wash
County: Washington
Common Description:
Proposed Det. Book: 81- Map: 135 Pub. Date:
Land Owned by Appl.: County Tax Id#:

Dates:

Filing:
Filed: 06/17/1960
Priority: 06/17/1960 Decree/Class:

Advertising:
Publication Began: Publication End: Newspaper:
Protest End Date: Protested: Not Protested Hearing Held:

Approval:
State Eng. Action: Approved Action Date: 09/20/1960
Recon. Req. Date: Recon. Req Action:

Certification:
Proof Due Date: Extension Filed Date:
Election or Proof: Election/Proof Date:
Certificate Date: Lapsed, Etc. Date: Lapsed Letter

Wells:
Prov. Well Date: Most Recent Well Renovate/Replace Date:

Points of Diversion:

Points of Diversion - Surface:
Stream Alteration Required:

(1) S 1101 ft. W 4001 ft. from NE corner, Sec 17 T 42S R 14W SLBM
Diverting Works: Source:
Elevation: UTM: 282083.008, 4112977.703

Proposed Water Uses:

Proposed Water Uses - Group Number: 610258

Water Rights Appurtenant to the following use(s):
81-415(CERT), 81-808(CERT), 81-2827(PAC), 81-2828(PAC), 81-2829(PAC),
81-2830(PAC),

Water Use Types:

Stock Water-Beneficial Use Amount: Group Total: 250 Period of Use: 01/01 to 12/31

Comments: Red Cliff Allotment

Use Totals:

Stock Water sole-supply total: Unevaluated ELUs for a group total of: 250 ELUs

Reservoirs:

Reservoir/Storage Name: Sullivan Stockwater

Dam Number:

Capacity: 2.061 acre-feet

Area Inundated: 0 acres

Dam Height: 13 feet

From: 01/01 to 12/31 inclusive

	North West Quarter				North East Quarter				South West Quarter				South East Quarter			
Area	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 17 T 42S R 14W SLBM	X															

Water Right Details for 81-2827

Utah Division of Water Rights 8/30/2021 1:19 PM

(WARNING: Water Rights makes NO claims as to the accuracy of this data.)

Water Right: 81-2827 Application/Claim: Certificate:

Owners:

Name: Cedar City District USA Bureau of Land Management
Address: 176 East DL Sargent Drive
Cedar City UT 84720
Interest:
Remarks:

General:

Type of Right: Pending Adjudication Claim Source of Info.: Water User's Claim Status:
Quantity of Water: 0.2 ACFT

Source: Unnamed Wash
County: Washington
Common Description:
Proposed Det. Book: 81- Map: 135 Pub. Date:
Land Owned by Appl.: County Tax Id#:

Dates:

Filing:
Filed:
Priority: / /1856 Decree/Class:

Advertising:
Publication Began: Publication End: Newspaper:
Protest End Date: Protested: Not Protested Hearing Held:

Approval:
State Eng. Action: Action Date:
Recon. Req. Date: Recon. Req Action:

Certification:
Proof Due Date: Extension Filed Date:
Election or Proof: Election/Proof Date:
Certificate Date: 10/15/1986 Lapsed, Etc. Date: Lapsed Letter

Wells:
Prov. Well Date: Most Recent Well Renovate/Replace Date:

Points of Diversion:

Points of Diversion - Point to Point:

(1) Reservoir directly on point at S 660 feet E 660 feet from N4 corner, Sec 18 T 42S R 14W SLBM

Comment: Administratively updated by State Engineer.
Source:

Proposed Water Uses:

Proposed Water Uses - Group Number: 610258

Water Rights Appurtenant to the following use(s):
81-415(CERT), 81-808(CERT), 81-2827(PAC), 81-2828(PAC), 81-2829(PAC),
81-2830(PAC),

Water Use Types:

Stock Water-Beneficial Use Amount: Group Total: 250 Period of Use: 01/01 to 12/31
Comments: Red Cliff Allotment

Place of Use Stock:

	North West				North East				South West				South East			
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 18 T 42S R 14W SLBM					X											

Use Totals:

Stock Water sole-supply total: Unevaluated ELUs for a group total of: 250 ELUs

Reservoirs:

Small Dam Required: No

Reservoir/Storage Name: Unnamed
Dam Number:
Capacity: 0.2 acre-feet
Area Inundated: 0 acres
Dam Height: 3 feet
From: 01/01 to 12/31 inclusive

	North West Quarter				North East Quarter				South West Quarter				South East Quarter			
Area	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE

Water Right Details for 81-2828

Utah Division of Water Rights 8/30/2021 1:20 PM

(WARNING: Water Rights makes NO claims as to the accuracy of this data.)

Water Right: 81-2828 Application/Claim: Certificate:

Owners:

Name: Cedar City District USA Bureau of Land Management
Address: 176 East DL Sargent Drive
Cedar City UT 84720
Interest:
Remarks:

General:

Type of Right: Pending Adjudication Claim Source of Info.: Water User's Claim Status:
Quantity of Water: 0.2 ACFT

Source: Unnamed Wash
County: Washington
Common Description:
Proposed Det. Book: 81- Map: 135 Pub. Date:
Land Owned by Appl.: County Tax Id#:

Dates:

Filing:
Filed:
Priority: / /1856 Decree/Class:

Advertising:
Publication Began: Publication End: Newspaper:
Protest End Date: Protested: Not Protested Hearing Held:

Approval:
State Eng. Action: Action Date:
Recon. Req. Date: Recon. Req Action:

Certification:
Proof Due Date: Extension Filed Date:
Election or Proof: Election/Proof Date:
Certificate Date: 10/16/1986 Lapsed, Etc. Date: Lapsed Letter

Wells:
Prov. Well Date: Most Recent Well Renovate/Replace Date:

Points of Diversion:

Points of Diversion - Point to Point:

(1) Reservoir directly on point at S 1980 feet E 660 feet from N4 corner, Sec 18 T 42S R 14W SLBM

Comment: Administratively updated by State Engineer.
Source:

Proposed Water Uses:

Proposed Water Uses - Group Number: 610258

Water Rights Appurtenant to the following use(s):
81-415(CERT), 81-808(CERT), 81-2827(PAC), 81-2828(PAC), 81-2829(PAC),
81-2830(PAC),

Water Use Types:

Stock Water-Beneficial Use Amount: Group Total: 250 Period of Use: 01/01 to 12/31

Comments: Red Cliff Allotment

Place of Use Stock:

	North West				North East				South West				South East			
	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE
Sec 18 T 42S R 14W SLBM							X									

Use Totals:

Stock Water sole-supply total: Unevaluated ELUs for a group total of: 250 ELUs

Reservoirs:

Small Dam Required: No

Reservoir/Storage Name: Unnamed Dam Number:

Capacity: 0.2 acre-feet Area Inundated: 0 acres

Dam Height: 2 feet From: 01/01 to 12/31 inclusive

	North West Quarter				North East Quarter				South West Quarter				South East Quarter			
Area	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE	NW	NE	SW	SE

ATTACHMENT M

BACKGROUND GROUNDWATER AND SURFACE WATER REPORT

1 BACKGROUND GROUND AND SURFACE WATER QUALITY

1.1 Site Geology

The Washington County Landfill is situated on an outcrop the Shnabkaib Member of the Triassic-age Moenkopi Formation, which is a part of the northwest limb of the Harrisburg Dome-Virgin Anticline (Montgomery, 1993).

The Shnabkaib Member is about 1,300 feet thick. It consists of gray, white, light green-gray, pink and light rust-maroon, gypsiferous, silty and sandy shale, dolomitic siltstone, gypsum, and silty dolomite. The eroded surface and residual soil presents a dry, fluffy, popcorn surface of powdery, gypsiferous, fine-grained soil consisting of silt, silty clay and fine-grained sand (Montgomery, 1993). Included within the lower part of the mapped Shnabkaib Member is the Middle Red Member of the Moenkopi Formation. It consists of approximately 350 feet of rust-red-brown, gypsiferous, soft, shaley, fine-grained sandstone, impart-clayey siltstone, and gypsum, which produces an erosion slope. The produced residual soil is more sandy and clayey than that yielded by the Shnabkaib Member (Montgomery, 1993).

Monitor wells W-1 and W-2 are located in the southern portion of the facility and are reported to yield small quantities of groundwater with high dissolved mineral content. Precipitation and runoff are thought to infiltrate the fractures and joints, along with tilted bedding planes, allowing limited groundwater to be stored and slowly recharged over time. Monitor well W-1 is completed in the light to dark brown shales of the Moenkopi Formation. Monitor well W-2 is completed in dipping, interbedded white sandstone and Moenkopi Formation brown shale. Permeability is low for both rock types. Both wells are drilled to depths of 100 feet. Screen intervals are from 20 to 100 feet for each well.

1.2 Groundwater Quality

Groundwater monitoring was initiated in August 1995 at the site. The groundwater monitoring parameters consist of 15 inorganic indicator parameters, 16 heavy metals, and 47 volatile organic compounds in accordance with UAC R315-308-4. Table 1 provides a summary of the inorganic parameters, Table 2 provides a summary of the heavy metals, and the detected VOCs are summarized in Table 3. Each table contains Maximum Contaminant Levels (MCL) established by the USEPA and those concentrations exceeding their respective MCL are designated in bold. Time-series plots of the inorganic constituents, heavy metals, and multiple detected VOCs are provided in Appendix A. Wells W-1 and W-2 are currently undergoing assessment monitoring as per Utah Department of Environmental Quality (UDEQ) correspondence dated March 13, 2003.

The extent of groundwater underlying the Washington County facility is limited in nature, slow moving, and of poor natural quality (high TDS) (Montgomery, 1993; Montgomery, 1994). No upgradient water source has been found to a depth of 200 feet below ground surface (bgs) (EarthFax, 1999). The Montgomery reports indicate shallow groundwater does not provide a potable or otherwise usable water source, and does not contact any regional aquifer system. Minor recharge appears to be occurring from the well-jointed Virgin Limestone Member of the Moenkopi formation to the southwesterly trending fracture system of the Middle Red Member siltstone and shale of the Moenkopi Formation and eventually into fracture systems of the shaley, gypsiferous, dolomitic siltstone of the Shnabkaib Member of the same formation. All formations are steeply dipping. The groundwater quality appears to naturally degrade through interaction with the variable lithologies during migration.

1.3 Inorganic Parameters

Groundwater can be classified by its major ion compositions. Analysis of the major ion chemistry in W-1 and W-2 indicates that sulfate is the dominant anion in both W-1 and W-2 followed by chloride. The dominant cation in W-1 is magnesium followed by sodium and potassium; whereas, the dominant cation in W-2 is calcium followed by magnesium. The calcium, magnesium, sulfate and general water chemistry appear to be indicative of the gypsiferous ($CaSO_4 \cdot 2H_2O$), dolomitic ($CaMg(CO_3)_2$) siltstone of the Shnabkaib Member. As the groundwater flows through this siltstone, gypsum and dolomite are dissolved into their respective ions: calcium, magnesium, sulfate and carbonate.

Nitrate is the only inorganic indicator parameter with a MCL established by the USEPA. The nitrate concentrations in both wells typically exceed the MCL of 10 mg/L. Nitrate has exhibited elevated concentrations throughout the monitoring history of both wells. Potential nitrate sources include an adjacent composting operation that uses sewage sludge in the composting process, prior agricultural activities, and leaching of natural strata. Based on the nature of the groundwater system underlying the Washington County landfill area, conditions are favorable for the occurrence of nitrate at elevated concentrations. Nitrate is an easily-mobilized compound that can remain mobile in the absence of significant denitrifying conditions and/or biota. The semi-arid conditions and limited extent of the shallow water-bearing zone may allow for elevated concentrations of nitrate within the groundwater. It is noted that other inorganic constituents (e.g. TDS, calcium, magnesium, sulfate, potassium, sodium, chloride, etc.) naturally exhibit elevated concentrations in the groundwater at the site.

1.4 Heavy Metals

Most of the heavy metal concentrations have been below reporting limits. A few random, low level detections of antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, thallium and zinc have occurred since monitoring began in 1995. The random nature of these low level concentrations suggests that they are false positives, possibly field or laboratory artifacts.

Low concentrations of nickel, silver and vanadium have been occasionally detected during the monitoring period. Moderate concentrations of selenium have been detected throughout the monitoring history in both wells. The selenium concentrations in W-1 typically exceed the MCL of 0.05 mg/L. Selenium can naturally occur at significant concentrations within soils of semi-arid regions (Fairbridge, 1972). Freeze and Cherry (1979) note that selenium is of interest primarily because of natural sources rather than human-derived sources.

1.5 Volatile Organic Compounds

1.5.1 Historical VOC Detections

Carbon disulfide, dibromochloromethane, methyl bromide, and toluene have each had a single detection in W-1 since 1995. Chloroform has shown minor detections, in W-1, since June 2000; however, all concentrations have been below the laboratory PQL and the GWPS. 1,1 Dichloroethane (1,1-DCA) has not been detected in W-1 since December 1998. Methylene chloride has not been detected in W-1 since May 1999. Tetrachloroethylene (PCE) has not been detected in W-1 since November 1999.

Acetone, bromodichloromethane, carbon disulfide, dibromochloromethane, and toluene have each had a single detection in W-2 since 1995. Chloroform has shown minor detections, in W-2, since December 1998; however, all concentrations have been below the GWPS and have not exceeded the laboratory PQL since February 2001. Methylene chloride has not been detected in W-2 since September 2001.

1.5.2 Current VOC Detections

Chloroform was the only VOC detected during the December 2003 event. Chloroform occurred in W-1 and W-2 at concentrations of 1.2 µg/L and 2.5 µg/L, respectively, during the December 2003 event. Both reported chloroform concentrations were below the laboratory PQL of 5 µg/L. The Groundwater Protection Standard (GWPS) for chloroform, provided in UAC R315-308-4, is 100 µg/L. Current chloroform concentrations occur well below the UAC R315-308-4 GWPS. Chloroform does not have a primary EPA maximum contaminant level (MCL).

1.6 Statistical Analysis of Groundwater Data

Data collected during the most recent groundwater monitoring event (December 2003) were statistically evaluated using either Shewhart-CUSUM Control Charts or 95-Percent Lower Confidence Limits. Details are provided below.

1.6.1 Shewhart-CUSUM Control Charts

Inorganic and heavy metal constituents without a UAC R315-308-4 GWPS were statistically evaluated using combined Shewhart-CUSUM control charts and Sen's Slope/Mann Kendall trend analyses for informational purposes. Shewhart-CUSUM control charts allow detection of both major and gradual changes in groundwater quality independent of the spatial variation. This procedure is specifically recommended in the USEPA document *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (April 1989). A few constituents could not be statistically evaluated by control charts due to greater than 50 percent non-detections in the background pool. These constituents were statistically evaluated using a non-parametric prediction limit. The initial eight background concentrations were updated with the first four detection monitoring results following procedures discussed in Gibbons (1994), prior to the June 2000 monitoring event. The background pool now includes samples collected from January 1996 through November 1999. Sen's Slope/Mann Kendall trend analyses were also performed to evaluate the significance of potential trends. A summary of the constituents that exceeded control limits is as follows:

Well	Constituent	Result	CUSUM Value	h	SCL	NP Prediction Limit	Significant Upward Trend ?	Slope (mg/L/yr)
W-1	Alkalinity	114	204.6	184.31	176.76	127	Yes	5.331
	COD	90.9	n/a	n/a	n/a	50	Yes	9.636
	Chloride	2330	6219	3127.05	2930.27	1830	No	106.471
	Nitrate	516	191.5	613.30	577.06	330	Yes	41.939
W-2	Alkalinity	94	501.7	171.85	159.02	112	Yes	6.431
	Bicarbonate	94	202.8	177.18	167.79	134	Yes	5.873
	Nitrate	44.1	124.1	112.52	103.53	69	Yes	5.785

Notes: CUSUM - Cumulative Sum
h - CUSUM Limit
SCL - Shewhart Control Limit
n/a - Method not used

Non-UAC R315-308-4 GWPS parameters exceeding statistical limits during the December 2003 event include alkalinity, chemical oxygen demand (COD), chloride, nitrate, selenium, and silver in W-1, and alkalinity, bicarbonate, nitrate, selenium, silver and thallium in W-2. The statistical analysis results appear to be reflective of poor natural groundwater quality in the shallow water-bearing zone underlying the site as previously discussed.

1.6.2 95-Percent Lower Confidence Limits

Analytical results for W-1 and W-2 were also statistically evaluated by comparing lower 95 percent confidence limits (LCL) to GWPS provided in UAC R315-308-4 and by the USEPA. This procedure is typically applied to monitor wells in assessment monitoring. Results in which the LCL exceeds the GWPS indicate statistically significant evidence that a constituent occurs at a concentration greater than the GWPS. For LCL analyses, data older than two years preceding the subject monitoring event was not used in order to better reflect current conditions. Data collected from November 2001 through November 2003 was used to calculate the LCLs during this event.

A summary of results for detected VOCs and other constituents with a GWPS in UAC R315-308-4 is provided on the following table:

Constituent	Well	November 2003 Result	95% LCL	GWPS	Exceeds?
Chloroform (ug/l)	W-1	1.2 J	1.273222	100	No
Barium Total (mg/l)	W-1	0.0097 J	0.003297	2	No
Nitrate (mg/l)	W-1	516	448.07994	10	Yes
Selenium Total (mg/l)	W-1	0.14 J	0.12198	0.05	Yes
Silver Total (mg/l)	W-1	0.0061 J	0.001676	0.1	No
Vanadium Total (mg/l)	W-1	0.0162	0.017043	0.3	No
Chloroform (ug/l)	W-2	2.5 J	2.790024	100	No
Barium Total (mg/l)	W-2	0.0099 J	0.003729	2	No
Nitrate (mg/l)	W-2	44.1	42.394286	10	Yes
Silver Total (mg/l)	W-2	0.0061 J	0.002347	0.1	No
Thallium Total (mg/l)	W-2	0.22 J	0.0001	2	No
Vanadium Total (mg/l)	W-2	0.014 J	0.0075	0.3	No

Notes: J - Laboratory Qualifier (constituent detected below PQL)
LCL – Lower Confidence Limit
GWPS – UAC R315-308-4 Groundwater Protection Standard
* - EPA Primary Maximum Contaminant Level

The 95 percent LCL for selenium in well W-1 exceeded its UAC R315-308-4 GWPS. It is noted that the concentration in selenium in W-1 is below the laboratory PQL of 0.25 mg/L. Nitrate does not have a UAC R315-308-4 GWPS, but does have a primary MCL of 10 mg/L, established by the USEPA. Nitrate concentrations reported in both W-1 and W-2 exceed the MCL at concentrations of 516 mg/L and 44.1 mg/L, respectively. No other parameter's 95 percent LCL exceeded a GWPS during the December 2003 groundwater monitoring event.

1.7 Surface Water Quality

There are no surface water bodies of any substance in the vicinity of the landfill. Drainage from the landfill is controlled by engineered site drainage.

1.8 Groundwater Monitoring (UAC R315-308):

Groundwater monitoring and report procedures are addressed in the attached Groundwater Sampling and Analysis Plan which meets the requirements of UAC R315-308 of this permit application.

1.9 Statistical method to be used (R315-308-2(7)):

Statistical method to be used is addressed in Appendix A of the Groundwater Sampling and Analysis Plan.

2 REFERENCES

Earthfax Engineering, Inc. 1999. Water Data Collection Quality Assurance Plan for the Washington County Landfill Facility.

Fairbridge, R. W. (ed.). 1972. The Encyclopedia of Geochemistry and Environmental Sciences. Van Nostrand Reinhold Company. New York. 1321 p.

Freeze, R. A. and Cherry, J. A. 1979. Groundwater. Prentice-Hall. New Jersey. 604 p.

Gibbons, Robert D. 1994. Statistical Methods for Groundwater Monitoring. John Wiley and Sons, Inc.

Kerfoot, H. B. Landfill Gas Effects on Groundwater Samples at a Municipal Solid Waste Facility. Journal of Air and Waste Management Association. 44. 1293-1298.

Montgomery, S. Bryce. 1993. August 23, Letter regarding geologic study of proposed landfill site.

Montgomery, S. Bryce. 1994. January 10, Letter regarding hydrogeologic evaluation of proposed landfill site.

Smith, Roy-Keith. 2000. Interpretation of Organic Data. Genium Publishing. Schenectady, NY.

TABLES

Table 1 - Washington County Landfill

Historic Inorganic Parameters

		pH (Field) (su)	pH (Lab) (su)	TOC	COD	Iron	Manganese	Magnesium	Calcium	Potassium	Sodium	Ammonia, as N	Bicarbonate	Carbonate as CaCO3	Chloride	Sulfate	Nitrate	TDS
	MCL	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	10	none
Well	Date																	
W-1	8/14/1995	n/a	7.86	3.21	n/a	1.02	0.2	1030	416	30.5	3730	2.1	74	<1	1630	9700	**102**	18200
	11/27/1995	n/a	7.94	3.01	n/a	<0.5	0.23	874	423	30.9	3640	1.1	74	<1	1830	9310	**171**	17500
	1/25/1996	7.67	6.9	5	<50	<0.5	<0.3	1490	482	41	1170	0.59	85	<10	1270	7100	**310**	11900
	5/9/1996	7.1	6.8	7	<50	<0.6	<0.3	1400	509	43	1170	<0.3	90	<10	1180	7300	**302**	12000
	7/31/1996	7.1	7.2	5	<50	<0.6	<0.3	1380	468	40	1160	<0.3	93	<10	1170	7300	**316**	11900
	11/1/1996	7.3	7.3	5	<50	<0.5	<0.3	1520	536	44	1260	<0.3	96	<10	1280	7500	**280**	12500
	1/21/1997	7.31	7.6	<5	<50	<0.6	<0.3	1420	494	42	1210	<0.3	115	<10	1220	7010	**230**	11500
	4/24/1997	7.19	7.2	<5	<50	<0.6	<0.3	1590	538	46	1410	0.25	108	<10	1200	7010	**279**	12100
	7/31/1997	7.1	7.4	6	<50	<0.6	<0.3	1510	510	47	1300	<0.3	119	<10	<100	8380	**271**	12000
	10/31/1997	7.21	7.3	18	<50	0.08	<0.03	987	549	34	1020	0.62	121	<10	1030	4960	**113**	9160
	5/12/1998	7	7.4	5	<50	<0.6	<0.3	1360	547	44	1280	<0.3	121	<10	960	7230	**268**	12600
	12/31/1998	7.15	6.9	5	<50	<0.5	<0.3	1510	527	45	1220	0.58	122	<10	1020	7360	**290**	13000
	5/18/1999	7.21	7.4	5	<50	<0.3	<0.1	1670	525	48	1330	<0.3	127	<10	1210	7210	**260**	13200
	11/16/1999	7.01	7.2	2	n/a	<0.02	<0.01	1500	420	48	1200	<0.2	156	<1	1180	6590	**330**	14200
	6/12/2000	7.08	7.22	2.55	72.1	<1	0.016	1420	638	50.2	2080	<1	158	<10	2160	6280	**560**	14500
	9/11/2000	7.11	7.14	2.38	90.6	<1	<0.015	1350	554	54.7	2060	<1	150	<10	<1120	5570	**480**	15900
	2/28/2001	7.05	7.2	2.11	96.5	n/a	<0.015	1310	553	44	2070	<1	138	<10	2390	6720	**580**	12000
	6/13/2001	7.06	7.14	2.33	86.4	n/a	<0.015	1380	548	53.1	2120	<0.5	137	<10	2170	6720	**625**	15500
	9/20/2001	n/a	7.2	3.64	110	n/a	<0.015	1400	581	48.1	2160	<0.5	140	<10	2290	7020	**610**	18700
	5/16/2002	n/a	7.28	n/a	80.7	<5	0.0066	1370	566	46.6	2040	<0.5	132	<10	2300	5990	**423**	16200
	11/5/2002	n/a	7.07	1.4 (J)	101	<0.5	0.0051 (J)	1330	570	49	2050	<0.5	120	<10	2040	6150	**469**	15100
	6/16/2003	n/a	7.49	1.4 (J)	72.3	0.11	0.006 (J)	1290	543	48.7	1910	<1	122	<10	2410	6270	**521**	15700
	11/17/2003	n/a	7.22	1.89	90.9	<0.5	0.0073 (B)	1400	600 (B)	51.7	2100	<1	114	<10	2330	5960	**516**	13900
W-2	8/14/1995	n/a	7.51	0.72	n/a	<0.5	0.03	208	485	11.5	473	<0.5	76	<1	162	2920	4.64	4600
	11/27/1995	n/a	7.55	0.89	n/a	<0.5	0.06	205	510	11.9	445	<0.5	76	<1	160	2510	0.39	4360
	1/25/1996	7.7	6.8	<5	<50	<0.1	<0.05	163	549	11.9	219	1.33	67	<10	126	2240	**28**	3380
	5/9/1996	7.37	6.8	<5	<50	<0.1	<0.06	188	507	12	389	<0.3	79	<10	190	2900	**16.1**	4250
	7/31/1996	7.2	7.3	<5	<50	<0.6	<0.3	205	519	12.8	466	<0.3	80	<10	150	2740	**16.9**	4160
	11/1/1996	7.1	7.4	<5	<50	<0.2	<0.1	174	575	12	313	<0.3	74	<10	162	2510	**17.8**	3810
	1/21/1997	7.73	7.9	<5	<50	<0.2	<0.08	217	483	12.5	506	<0.3	90	<10	74	2640	**15.5**	4000
	4/24/1997	7.31	7.2	<5	<50	<0.3	0.05	207	525	12.6	548	<0.3	78	<10	155	2820	**14.6**	4330
	7/31/1997	7.21	7.5	<5	<50	<0.1	<0.06	157	553	13.1	226	<0.3	67	<10	98	2020	**17**	3180
	10/31/1997	7.1	7.4	<5	<50	0.08	<0.03	158	566	13.1	215	<0.3	70	<10	92	2010	**21.4**	3190
	5/12/1998	7.41	7.4	<5	<50	<0.1	<0.06	175	638	12.9	236	<0.3	72	<10	270	2110	**49**	3700
	12/31/1998	7.37	7.2	<5	<50	<0.1	<0.06	216	697	15	274	<0.3	91	<10	380	2250	**69**	4190
	5/18/1999	7.25	7.5	<5	<50	<0.1	<0.06	200	588	13.1	264	<0.3	112	<10	230	2160	**35**	3680
	11/16/1999	7.27	7.3	<1	n/a	<0.02	<0.01	200	460	13	550	<0.2	134	<1	213	2590	**13**	4640
	6/12/2000	7.26	7.54	1.65	78.2	<1	<0.015	252	606	14	269	<1	128	<10	315	2210	**82**	4040
	2/28/2001	7.28	7.52	1.5	<55	n/a	<0.015	202	560	12.4	215	<1	130	<10	215	2270	**60**	<6500
	6/13/2001	7.12	7.36	<1.5	<55	n/a	<0.015	203	565	12.7	218	<0.5	128	<10	194	2200	**47.6**	4540
	9/20/2001	n/a	7.49	<1.5	<40	n/a	<0.015	209	595	13.2	224	<0.5	120	<10	205	2250	**53.6**	4020
	5/16/2002	n/a	7.46	0.8	<35	<5	<0.015	202	593	13	225	<0.5	114	<10	600	2150	**44.2**	3670
	11/5/2002	n/a	7.45	0.54 (J)	8.6 (J)	0.22 (J)	<0.015	202	601	14.2	229	<0.5	104	<10	195	2060	**52.6**	3610
	6/16/2003	n/a	7.55	0.38 (J)	13 (J)	0.23 (J)	<0.015	195	557	12.6	219	<1	118	<10	178	2220	**42.5**	3910
	11/17/2003	n/a	7.53	0.56 (J)	28 (J)	0.15 (J)	0.003 (B)	204	595 (B)	13.4	246	0.34 (J)	94	<10	186	2060	**44.1**	3740

Notes: All units in mg/L except for pH
COD = Chemical Oxygen Demand
TDS = Total Dissolved Solids
MCL = Maximum Contaminant Level
n/a = not available
(B) = Detected in Blank
(J) = Concentration Estimated

Table 2 - Washington County Landfill

Historic Heavy Metal Parameters

		Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
	MCL	0.006	0.01	2.0	0.004	0.005	0.1	none	none	none	0.002	none	0.05	none	0.002	none	10
Well	Date																
W-1	8/14/1995	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<0.06	<0.05	n/a	n/a	<0.01	n/a
	11/27/1995	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<0.06	<0.2	n/a	n/a	<0.01	n/a
	1/25/1996	<0.01	<0.006	<0.1	<0.003	<0.2	<0.5	<0.5	<0.5	<0.006	<0.001	<0.5	**0.08**	<0.3	<0.01	<0.3	<0.5
	5/9/1996	<0.01	<0.006	<0.1	<0.006	<0.01	<0.01	<0.6	<0.6	<0.01	<0.001	0.055	**0.086**	<0.006	<0.006	0.025	<0.6
	7/31/1996	<0.01	<0.03	<0.1	<0.006	<0.01	<0.01	<0.6	<0.6	<0.01	<0.001	<0.03	**0.077**	<0.006	<0.006	0.017	<0.6
	11/1/1996	<0.002	<0.03	<0.01	<0.001	<0.002	0.0038	<0.5	<0.5	<0.002	<0.001	0.03	**0.074**	<0.001	<0.001	<0.002	<0.5
	1/21/1997	<0.02	<0.006	<0.1	<0.01	<0.02	<0.02	<0.6	<0.6	<0.02	<0.001	0.2	**0.078**	<0.01	<0.01	0.3	<0.6
	4/24/1997	<0.002	0.004	<0.1	<0.001	<0.002	0.0067	<0.6	<0.6	<0.01	<0.001	0.061	**0.071**	<0.001	<0.006	0.0181	<0.6
	7/31/1997	<0.02	<0.03	<0.1	<0.03	<0.02	<0.02	<0.6	<0.6	<0.02	<0.001	<0.07	**0.083**	<0.01	<0.01	0.02	<0.6
	10/31/1997	<0.002	<0.006	0.011	<0.001	<0.002	<0.002	<0.06	<0.06	<0.002	<0.001	0.019	**0.068**	<0.001	<0.001	0.0155	0.11
	5/12/1998	<0.02	<0.005	<0.1	<0.01	<0.02	0.023	<0.6	<0.6	<0.02	<0.001	0.07	**0.07**	<0.01	<0.01	0.023	<0.6
	12/31/1998	<0.02	<0.006	<0.1	<0.01	<0.02	<0.02	<0.6	<0.6	<0.02	<0.001	<0.07	**0.077**	<0.01	<0.01	0.025	<0.6
	5/18/1999	<0.01	<0.005	<0.06	<0.006	<0.01	<0.01	<0.3	<0.3	<0.01	<0.001	<0.03	**0.079**	<0.006	<0.006	0.016	<0.3
	11/16/1999	<0.0005	<0.005	0.005	<0.001	<0.001	0.028	0.02	<0.01	<0.005	0.0002	<0.01	**0.122**	<0.0005	<0.0005	<0.01	0.04
	6/12/2000	<.030	<0.1	<0.015	<0.001	<0.015	<0.05	<0.015	<0.05	<0.020	<0.0005	<0.025	**0.219**	<0.02	<0.04	0.0386	<0.25
	9/11/2000	n/a	<0.1	<0.015	<0.001	<0.015	<0.05	<0.015	<0.05	0.001	<0.0005	<0.025	**0.181**	<0.02	<0.0005	0.0315	<0.25
	2/28/2001	<0.001	<0.1	<0.015	0.00216	<0.015	<0.05	<0.005	<0.05	<0.0005	<0.0005	<0.05	**0.179**	<0.025	<0.0003	0.029	<0.25
	6/13/2001	<0.001	<0.1	<0.015	<0.001	<0.015	<0.05	<0.005	<0.05	<0.0006	<0.0005	<0.05	**0.175**	<0.025	<0.0003	0.0286	<0.25
	9/20/2001	<0.001	<0.1	<0.015	<0.001	<0.015	<0.05	<0.025	<0.05	<0.001	n/a	<0.05	**0.171**	<0.025	<0.0005	0.0308	<0.25
	5/16/2002	<0.002	<0.15	0.0085	0.00021	<0.015	<0.05	<0.015	<0.05	<0.001	<0.0005	0.032	**0.12**	0.0084	0.0004	0.021	0.068
	11/5/2002	0.0004	<0.15	0.0089 (J)	0.0004 (J)	<0.015	<0.05	<0.015	<0.05	0.00024 (J)	<0.0005	0.055 (J)	**0.13 (J)**	0.0031 (J)	<0.000278	0.0238	<0.25
	6/16/2003	<0.00222	<0.15	0.0085	<0.001	<0.015	<0.05	<0.015	<0.05	<0.00222	<0.0005	0.023 (J)	**0.14 (J)**	0.01 (J)	0.00028 (J)	0.0196 (J)	0.063 (J)
	11/17/2003	<0.00222	<0.15	0.0097 (J)	<0.001	<0.015	<0.05	<0.015	<0.05	<0.00222	<0.001	<0.1	**0.14 (J)**	0 0061 (J)	<0.000556	0.0162	<0.25
W-2																	
	1/25/1996	<0.01	<0.03	<0.02	<0.003	<0.03	<0.1	<0.1	<0.1	<0.03	<0.001	<0.1	0.015	<0.05	<0.06	<0.05	<0.1
	5/9/1996	<0.002	<0.006	<0.02	<0.001	<0.002	<0.002	<0.1	<0.1	<0.002	<0.001	0.038	0.017	<0.001	<0.001	0.0058	<0.1
	7/31/1996	<0.01	<0.03	<0.1	<0.006	<0.01	<0.01	<0.6	<0.6	<0.01	<0.001	<0.03	0.015	<0.006	<0.006	<0.01	<0.6
	11/1/1996	<0.002	<0.006	<0.01	<0.001	<0.002	<0.002	<0.2	<0.2	<0.002	<0.001	0.021	0.016	<0.001	<0.001	0.0083	<0.2
	1/21/1997	<0.01	<0.06	<0.03	<0.005	<0.01	<0.01	<0.2	<0.2	<0.01	<0.001	0.08	0.017	<0.005	<0.005	<0.01	<0.2
	4/24/1997	<0.002	<0.01	<0.06	<0.001	0.0022	<0.002	<0.3	<0.3	<0.005	<0.001	0.058	0.016	<0.001	<0.003	<0.002	<0.3
	7/31/1997	<0.006	<0.006	<0.02	<0.006	<0.006	<0.006	<0.1	<0.1	<0.006	<0.001	<0.02	0.017	<0.003	<0.003	0.014	<0.1
	10/31/1997	<0.002	<0.03	0.01	<0.001	<0.002	<0.002	<0.06	0.53	<0.002	<0.001	0.028	0.013	<0.001	<0.001	0.0152	<0.006
	5/12/1998	<0.006	<0.005	<0.02	<0.003	<0.006	<0.006	<0.1	<0.1	<0.006	<0.001	0.069	0.039	<0.003	<0.003	0.015	<0.1
	12/31/1998	<0.006	<0.006	<0.02	<0.003	<0.006	<0.006	<0.1	<0.1	<0.006	<0.001	0.026	0.048	<0.003	<0.003	0.017	<0.1
	5/18/1999	<0.006	<0.03	<0.02	<0.003	<0.006	<0.006	<0.1	<0.1	<0.006	<0.001	<0.02	0.028	<0.003	<0.003	0.013	<0.1
	11/16/1999	<0.0005	<0.005	0.01	<0.001	<0.001	<0.005	<0.01	<0.01	<0.005	<0.0002	<0.01	<0.002	<0.0005	<0.0005	<0.01	0.02
	6/12/2000	<0.03	<0.1	<0.015	<0.001	<0.015	<0.05	<0.015	<0.05	<0.020	<0.0005	<0.025	<0.015	<0.02	<0.4	<0.02	<0.25
	2/28/2001	<0.001	<0.1	<0.015	0.00221	<0.015	<0.05	<0.025	<0.05	<0.0005	<0.0005	<0.05	<0.15	<0.025	<0.0003	<0.015	<0.25
	6/13/2001	<0.001	<0.1	<0.015	<0.001	<0.015	<0.05	<0.005	<0.05	<0.0006	<0.0005	<0.05	<0.15	<0.025	<0.0003	<0.015	<0.25
	9/20/2001	<0.001	<0.1	<0.015	<0.001	<0.015	<0.05	<0.025	<0.015	<0.0005	n/a	<0.05	<0.15	<0.025	<0.0003	<0.015	<0.25
	5/16/2002	<0.002	<0.15	0.01	<0.001	<0.015	<0.05	<0.015	<0.05	<0.001	<0.0005	0.033	0.045	0.0056	0.0001	0.0132	<0.25
	11/5/2002	0.00032 (J)	<0.15	0.011 (J)	0.00029 (J)	<0.015	<0.05	<0.015	<0.05	<0.00111	<0.0005	0.067 (J)	<0.2	0.0068 (J)	<0.000278	0.0126	<0.25
	6/16/2003	<0.00222	<0.15	0.0094	<0.001	<0.015	<0.05	<0.015	<0.05	<0.000222	0.00162	<0.1	<0.25	0.0081 (J)	<0.000556	0.014 (J)	<0.05
	11/17/2003	<0.00222	<0.15	0.0099 (J)	<0.001	<0.015	<0.05	<0.015	<0.05	<0.00222	<0.001	<0.1	<0.25	0.0061 (J)	**0.22 (J)**	0.014 (J)	<0.25
	Notes:	All units in mg/L															
		MCL = Maximum Contaminant Level															
		n/a = not available															
		(J) = Concentration Estimated															

Table 3 -- Washington County Landfill
Historic Volatile Organic Compound (VOC) Detections
Groundwater Well W-1

	1,1-DCA	Carbon disulfide	Chloroform	Dibromochloromethane	Methyl bromide	Methylene chloride	Tetrachloroethylene	Toluene
MCL	none	none	none	none	none	5	5	1000
Date								
8/14/1995	<5	n/a	<5	<5	n/a	**12**	<5	16
11/27/1995	<5	n/a	<1	<1	n/a	**26**	<5	<5
1/25/1996	<5	<5	<5	<5	<10	<5	<5	<5
5/9/1996	<5	<5	<5	<5	<10	<5	<5	<5
7/31/1996	1.8	<1	<1	<1	<2	<1	3.3	<1
11/1/1996	1.9	<1	<1	<1	<2	<1	3.2	<1
1/21/1997	<1	<1	<1	<1	<2	<1	**5.2**	<1
4/24/1997	2.3	<1	<1	<1	<2	<1	3.4	<1
7/31/1997	2.9	<1	<1	<1	<2	<1	3.8	<1
10/31/1997	<1	<1	<1	<1	<2	**8.2**	<1	<1
5/12/1998	2.2	<1	<1	<1	<2	<1	3	<1
12/31/1998	1.3	<1	<1	<1	<2	<1	2.1	<1
5/18/1999	<1	<1	<1	<1	<2	3.4	<1	<1
11/16/1999	<1	<1.2	<1.2	<1	<4	<2	1.21	<2
6/12/2000	<5	<5	3.1	<5	<5	<5	<5	<5
9/11/2000	<5	<5	3.2	0.97	<5	<5	<5	<5
2/28/2001	<5	<5	2.8	<5	<5	<5	<5	<5
6/13/2001	<5	<5	<0.3	<5	<5	<5	<5	<5
9/20/2001	<5	<5	2.1	<5	<5	<5	<5	<5
5/16/2002	<5	<5	1.9	<5	<5	<5	<5	<5
11/5/2002	<5	1.6 (J)	1.7 (J)	<5	5.92	<5	<5	<5
6/16/2003	<5	<5	1.3 (J)	<5	<5	<5	<5	<5
11/17/2003	<5	<5	1.2 (J)	<5	<5	<5	<5	<5

Notes: All units in µg/L.
1,1-DCA = 1,1-Dichloroethane
n/a = not available
MCL = Maximum Contaminant Level
(J) = Concentration Estimated

Table 3 continued -- Washington County Landfill

Historic Volatile Organic Compound (VOC) Detections

Groundwater Well W-2

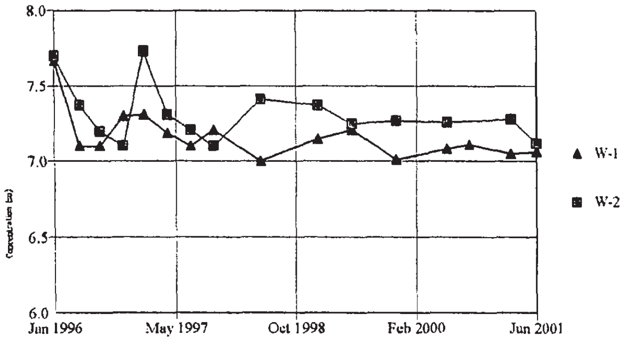
	Acetone	Bromodichloromethane	Carbon disulfide	Chloroform	Dibromochloromethane	Methylene chloride	Toluene
MCL	none	none	none	none	none	5	1000
Date							
8/14/1995	n/a	<5	n/a	<5	<5	**11**	7
11/27/1995	n/a	<5	n/a	<5	<5	**13**	<5
1/25/1996	<10	<5	<5	<5	<5	<5	<5
5/9/1996	<10	<5	<5	<5	<5	<5	<5
7/31/1996	<2	<1	<1	<1	<1	<1	<1
11/1/1996	<2	<1	<1	<1	<1	<1	<1
1/21/1997	<3	<1	<1	<1	<1	<1	<1
4/24/1997	<2	<1	<1	<1	<1	<1	<1
7/31/1997	<2	<1	<1	<1	<1	<1	<1
10/31/1997	<2	<1	<1	<1	<1	2.4	<1
5/12/1998	<2	<1	<1	<1	<1	<1	<1
12/31/1998	<2	2.8	<1	3.1	2	<1	<1
5/18/1999	<2	<1	<1	<1	<1	2.7	<1
11/16/1999	<20	<1	<1.2	<1.2	<1	<2	<2
6/12/2000	<12.5	<5	<5	7.56	<5	<5	<5
9/11/2000	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2/28/2001	<12.5	<5	<5	6.27	<5	<5	<5
6/13/2001	<12.5	<5	<5	4.8	<5	<5	<5
9/20/2001	7.5	<5	<5	3.5	<5	4.8	<5
5/16/2002	<12.5	<5	<5	3.8	<5	<5	<5
11/5/2002	<12.5	<5	1.2 (J)	3.1 (J)	<5	<5	<5
6/16/2003	<12.5	<5	<5	3.4 (J)	<5	<5	<5
11/17/2003	<12.5	<5	<5	2.5 (J)	<5	<5	<5

Notes: All units in µg/L.
n/a = not available
MCL = Maximum Contaminant Level
(J) = Concentration Estimated

APPENDIX A

v.8.02 For the statistical analyses of groundwater by The Carol Corporation only CAS# n/a EPA Sanitas™

TIME SERIES

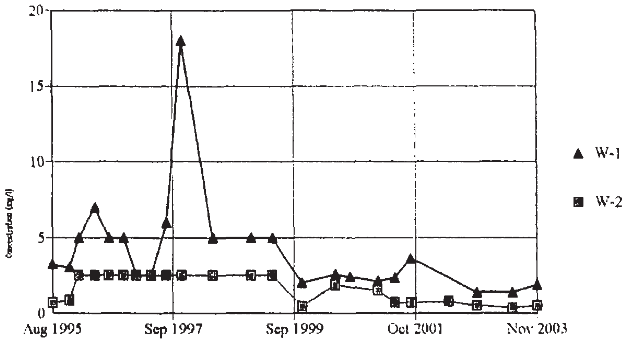


Constituent: pH [Field] (su) Facility: Washington County LF Data File: wdbase

Date: 6/23/04, 11:51 AM Client: AWI View: Batch

v.8.02 For the statistical analyses of groundwater by The Carol Corporation only CAS# n/a EPA Sanitas™

TIME SERIES

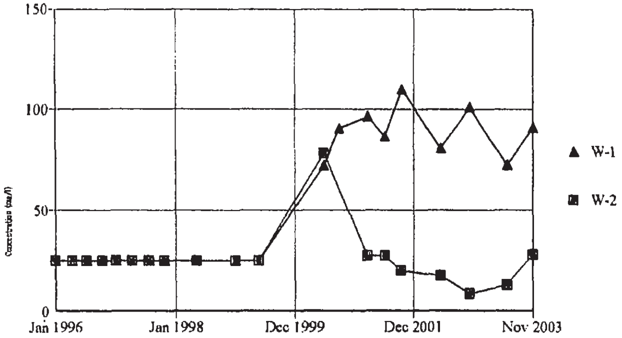


Constituent: TOC (mg/l) Facility: Washington County LF Data File: wdbase

Date: 6/23/04, 11:51 AM Client: AWI View: Batch

v.8.02 For the statistical analyses of groundwater by The Carol Corporation only CAS# n/a EPA Sanitas™

TIME SERIES

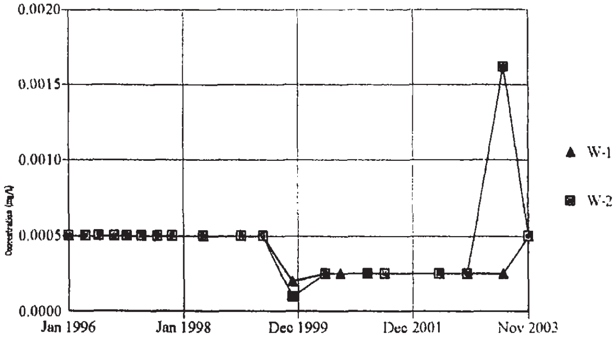


Constituent: Chemical Oxygen Demand [COD] (mg/l) Facility: Washington County LF Data File: wdbase

Date: 6/23/04, 11:51 AM Client: AWI View: Batch

v.8.02 For the statistical analyses of groundwater by The Carol Corporation only CAS# n/a EPA Sanitas™

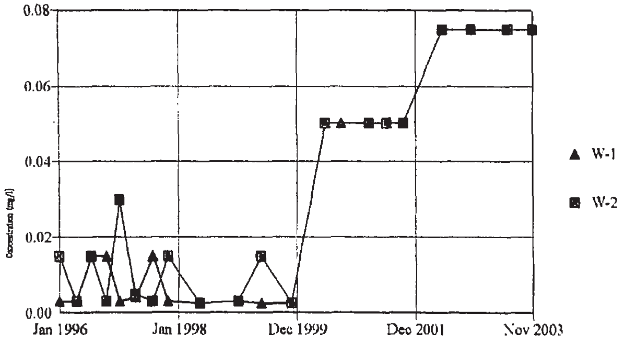
TIME SERIES



Constituent: Mercury Total (mg/L) Facility: Washington County LF Data File: wdbase

Date: 6/23/04, 11:51 AM Client: AWI View: Batch v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

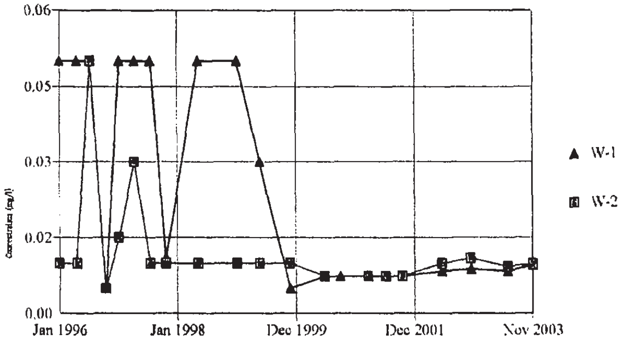
TIME SERIES



Constituent: Arsenic Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:24 AM Client: AWI View: _Batch_

v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

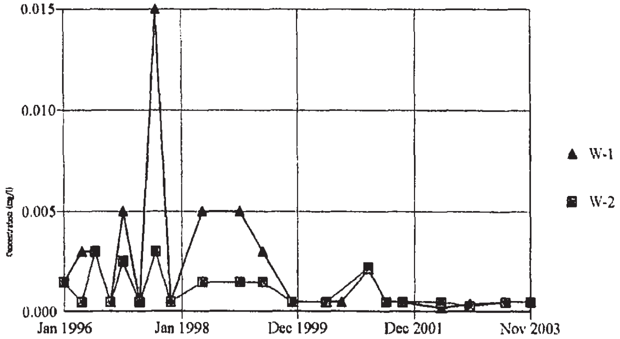
TIME SERIES



Constituent: Barium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:26 AM Client: AWI View: _Batch_

v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

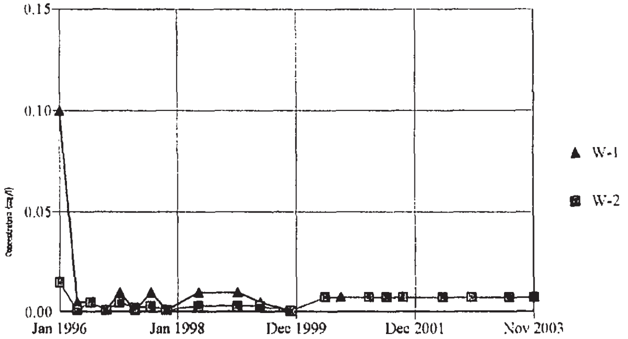
TIME SERIES



Constituent: Beryllium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:29 AM Client: AWI View: _Batch_

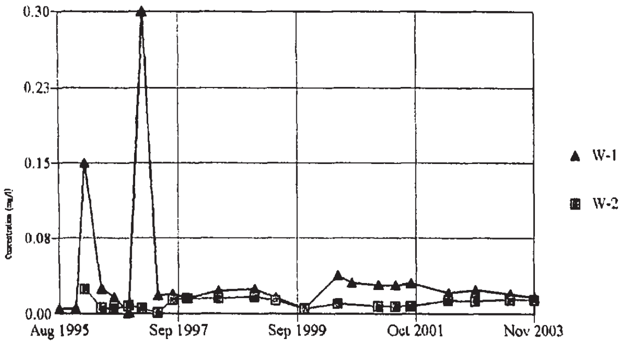
v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

TIME SERIES



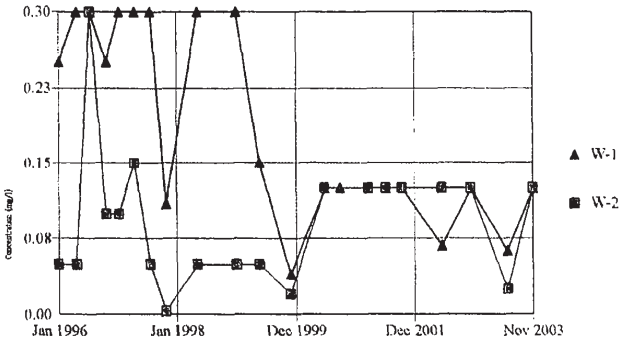
Constituent: Cadmium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:31 AM Client: AWI View: _Batch_

TIME SERIES



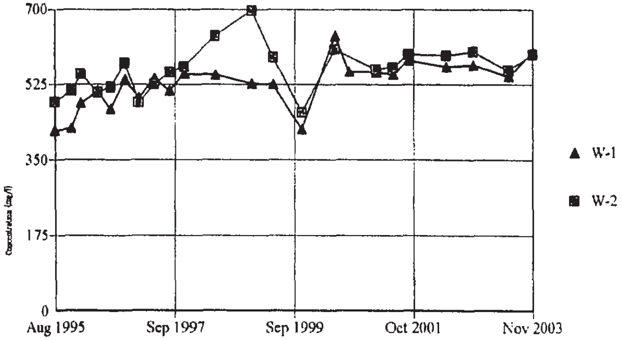
Constituent: Vanadium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:49 AM Client: AWI View: _Batch_

TIME SERIES



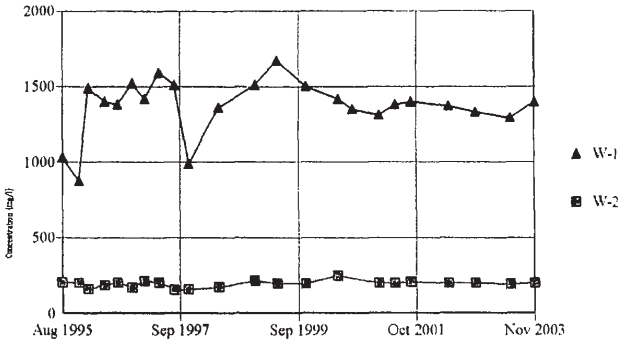
Constituent: Zinc Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:52 AM Client: AWI View: _Batch_

TIME SERIES



Constituent: Calcium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:54 AM Client: AWI View: _Batch_

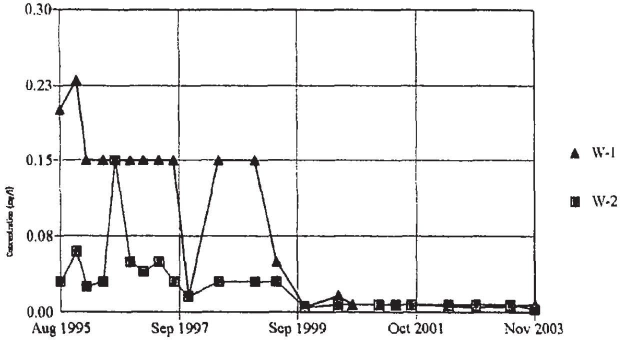
TIME SERIES



Constituent: Magnesium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:56 AM Client: AWI View: _Batch_

Sanitas™

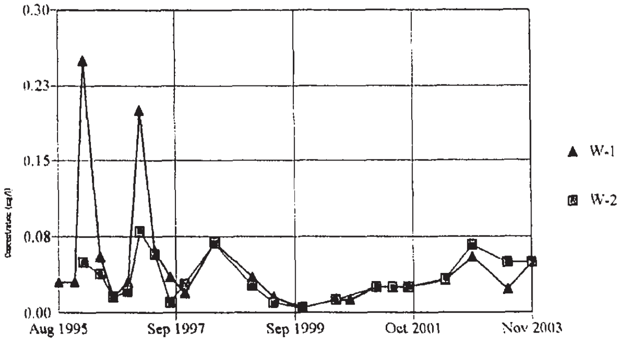
TIME SERIES



Constituent: Manganese Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:41 AM Client: AWI View: _Batch_

Sanitas™

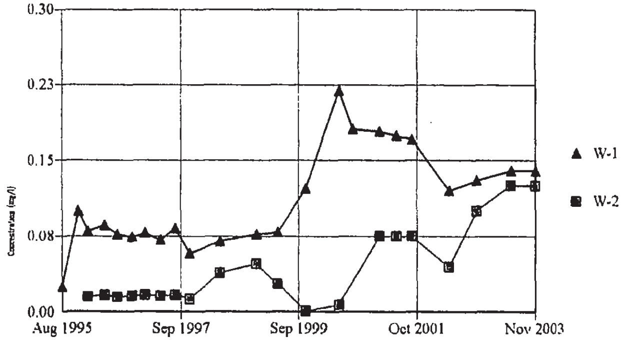
TIME SERIES



Constituent: Nickel Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:43 AM Client: AWI View: _Batch_

Sanitas™

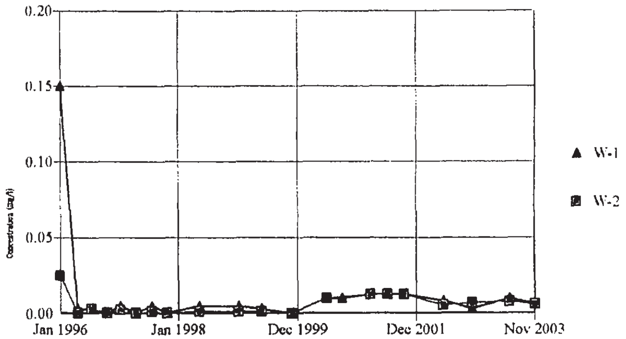
TIME SERIES



Constituent: Selenium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:45 AM Client: AWI View: _Batch_

Sanitas™

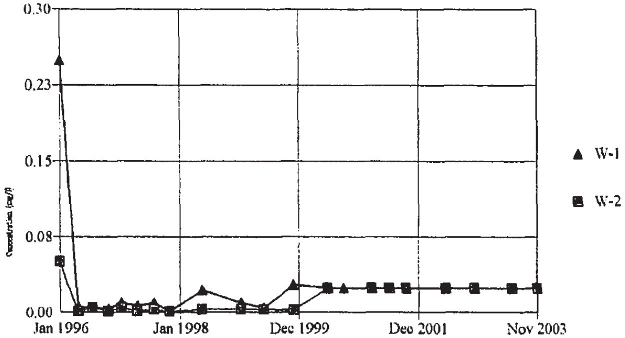
TIME SERIES



Constituent: Silver Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:48 AM Client: AWI View: _Batch_

v.1.02 For the statistical analysis of groundwater by The Carl Corporation only CAS# n/a EPA Sanitas™

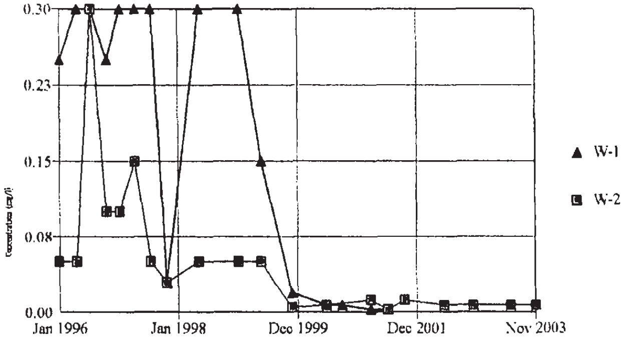
TIME SERIES



Constituent: Chromium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:32 AM Client: AWI View: _Batch_

v.1.02 For the statistical analysis of groundwater by The Carl Corporation only CAS# n/a EPA Sanitas™

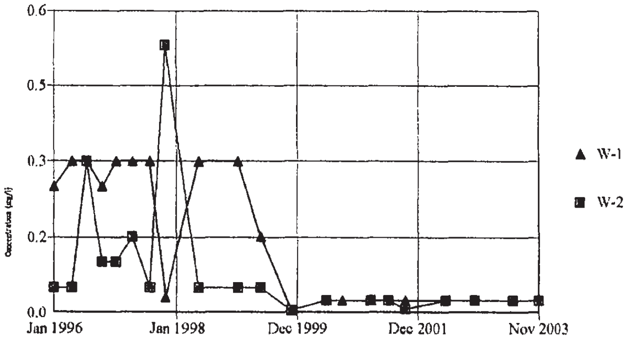
TIME SERIES



Constituent: Cobalt Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:35 AM Client: AWI View: _Batch_

v.1.02 For the statistical analysis of groundwater by The Carl Corporation only CAS# n/a EPA Sanitas™

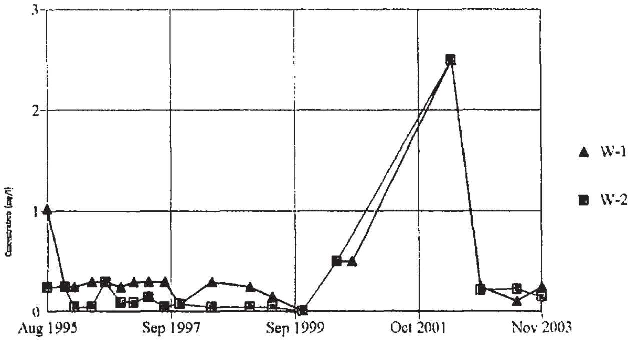
TIME SERIES



Constituent: Copper Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:37 AM Client: AWI View: _Batch_

v.1.02 For the statistical analysis of groundwater by The Carl Corporation only CAS# n/a EPA Sanitas™

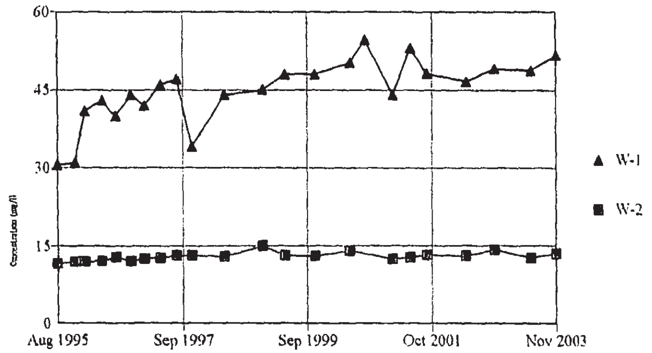
TIME SERIES



Constituent: Iron (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:39 AM Client: AWI View: _Batch_

v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

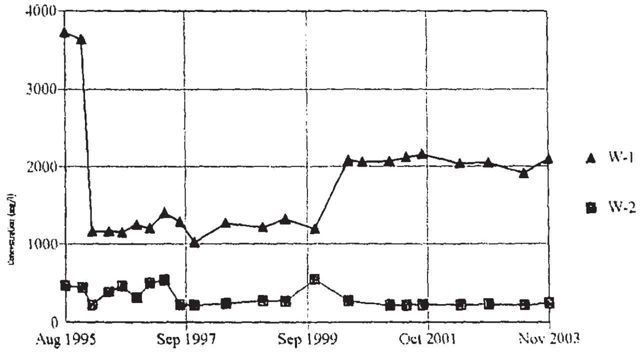
TIME SERIES



Constituent: Potassium Dissolved (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 9:58 AM Client: AWI View: _Batch_

v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

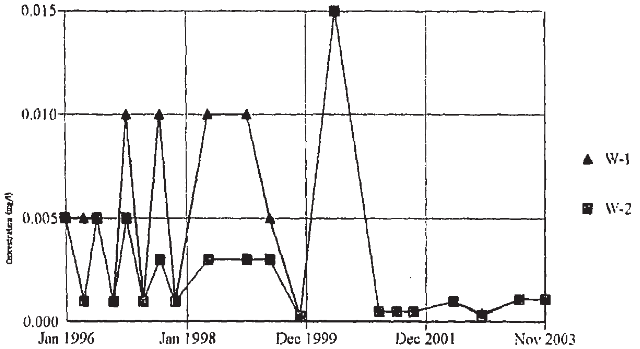
TIME SERIES



Constituent: Sodium Dissolved (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:00 AM Client: AWI View: _Batch_

v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

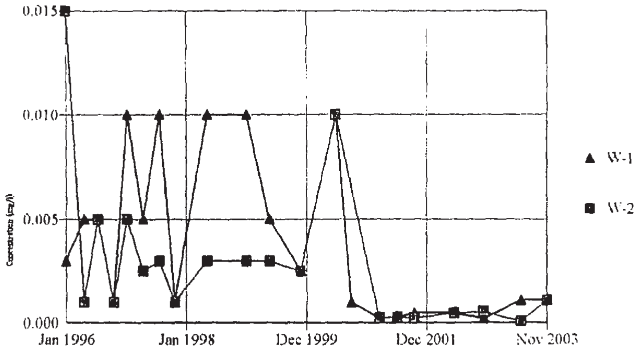
TIME SERIES



Constituent: Antimony Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:02 AM Client: AWI View: _Batch_

v.8.02 For the statistical analysis of groundwater by The Carel Corporation only. CAS# n/a EPA Sanitas™

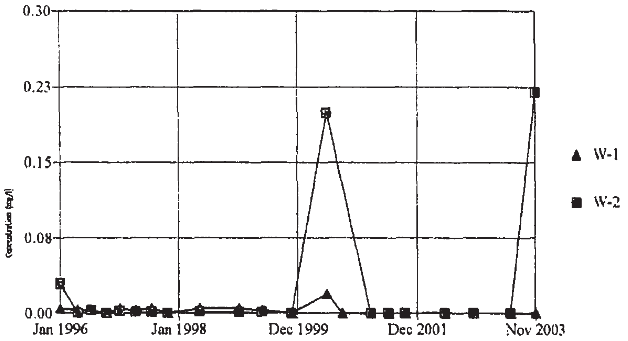
TIME SERIES



Constituent: Lead Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:04 AM Client: AWI View: _Batch_

Sanitas™

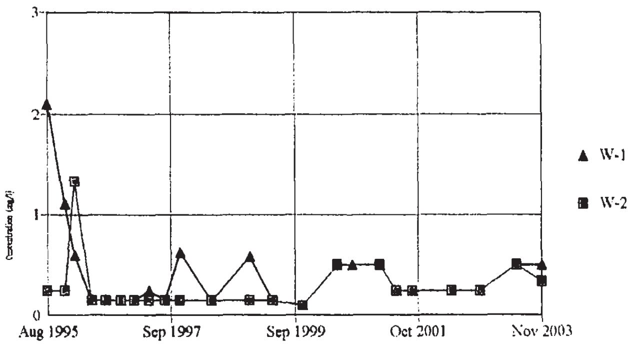
TIME SERIES



Constituent: Thallium Total (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:06 AM Client: AWI View: _Batch_

Sanitas™

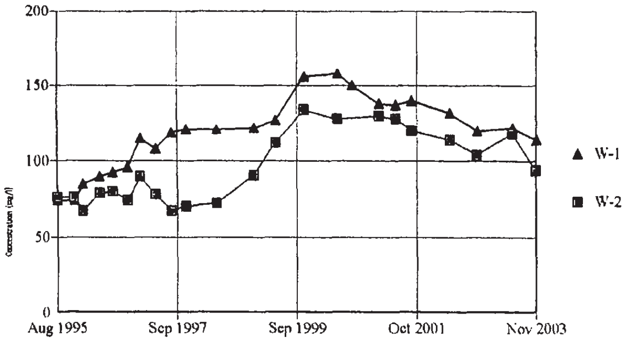
TIME SERIES



Constituent: Ammonia, as N (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:08 AM Client: AWI View: _Batch_

Sanitas™

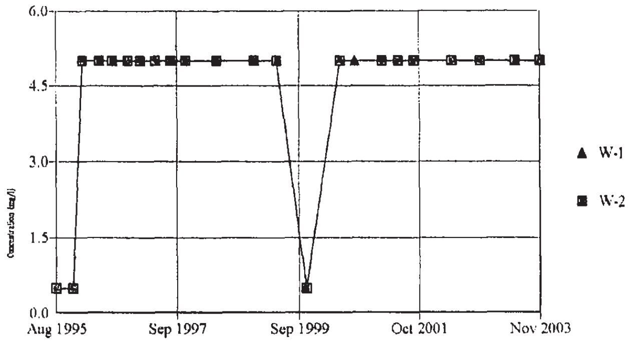
TIME SERIES



Constituent: Bicarbonate (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:11 AM Client: AWI View: _Batch_

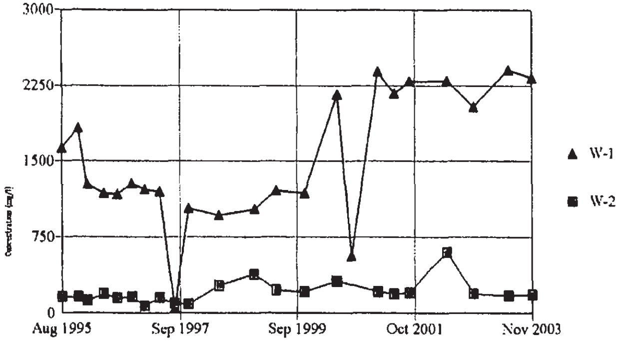
Sanitas™

TIME SERIES



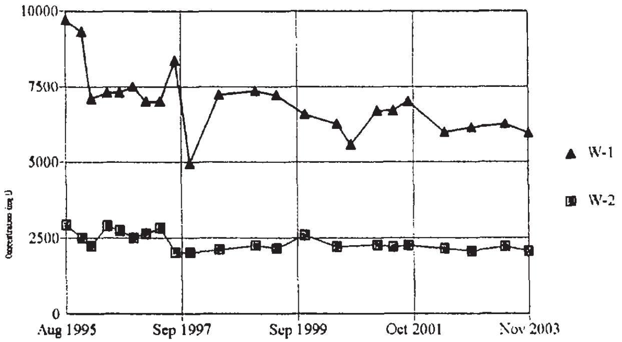
Constituent: Carbonate as CaCO3 (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:13 AM Client: AWI View: _Batch_

TIME SERIES



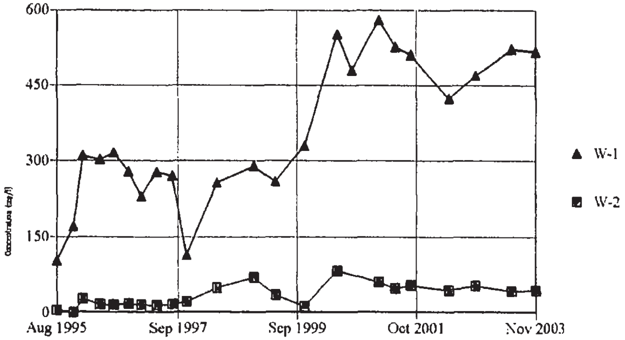
Constituent: Chloride (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:14 AM Client: AWI View: _Batch_

TIME SERIES



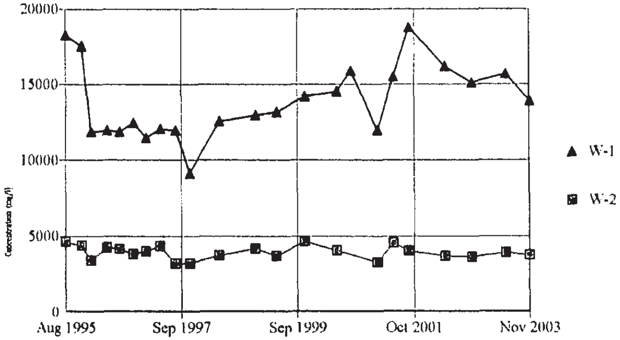
Constituent: Sulfate (mg/L) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:17 AM Client: AWI View: _Batch_

TIME SERIES



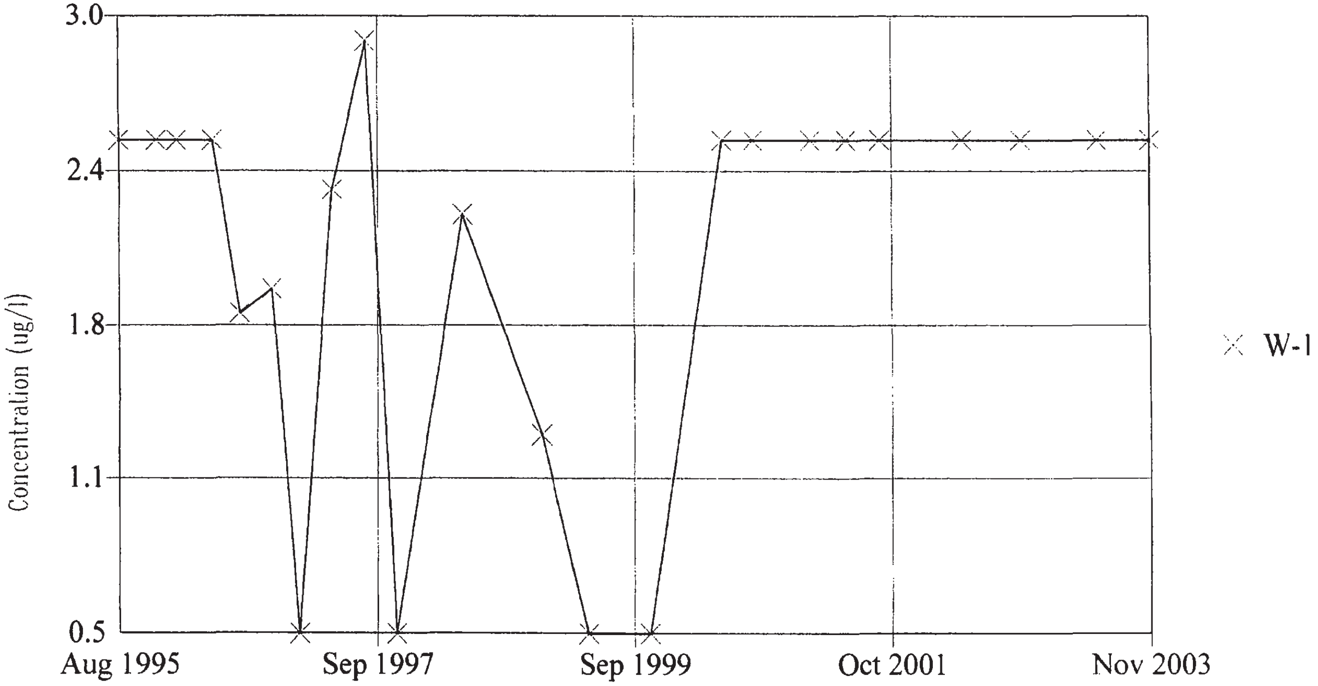
Constituent: Nitrate (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:19 AM Client: AWI View: _Batch_

TIME SERIES



Constituent: Total Dissolved Solids [TDS] (mg/l) Facility: Washington County LF Data File: wdbase
Date: 6/23/04, 10:21 AM Client: AWI View: _Batch_

TIME SERIES

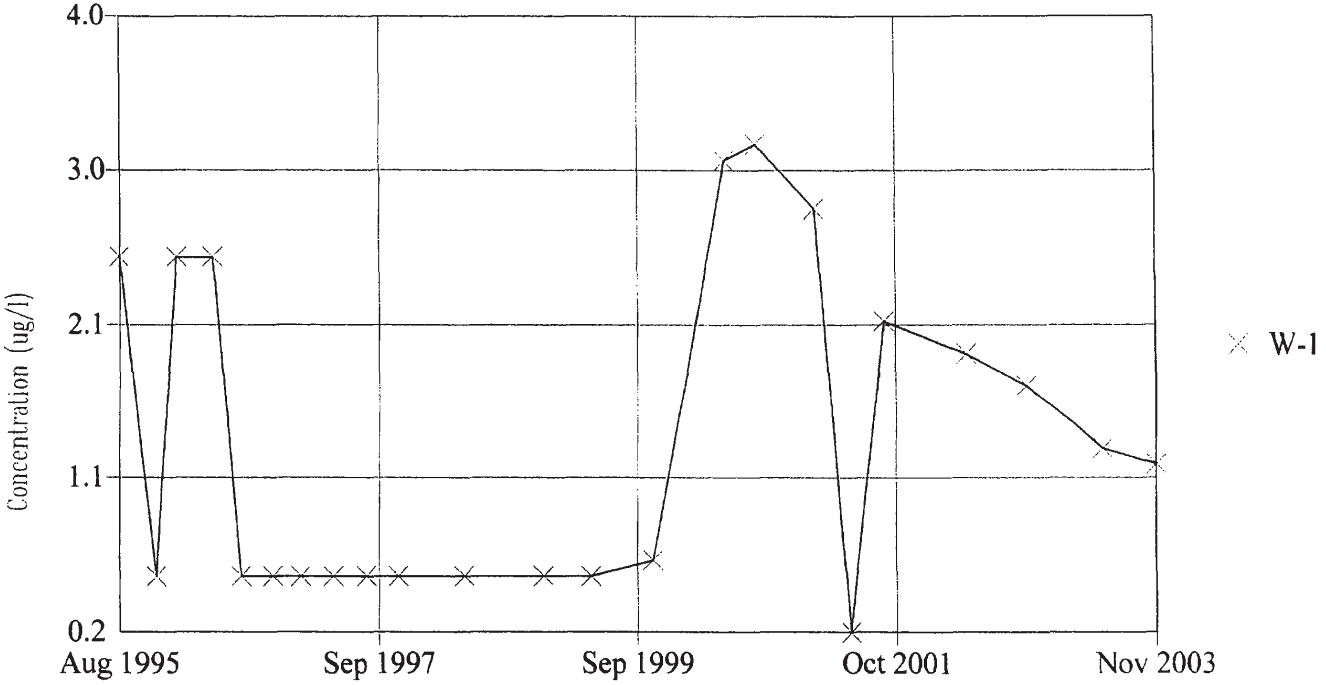


Constituent: 11-Dichloroethane (ug/l)
Date: 6/24/04, 10:32 AM

Facility: Washington County LF
Client: AWI

Data File: wdbase
View: VOC

TIME SERIES

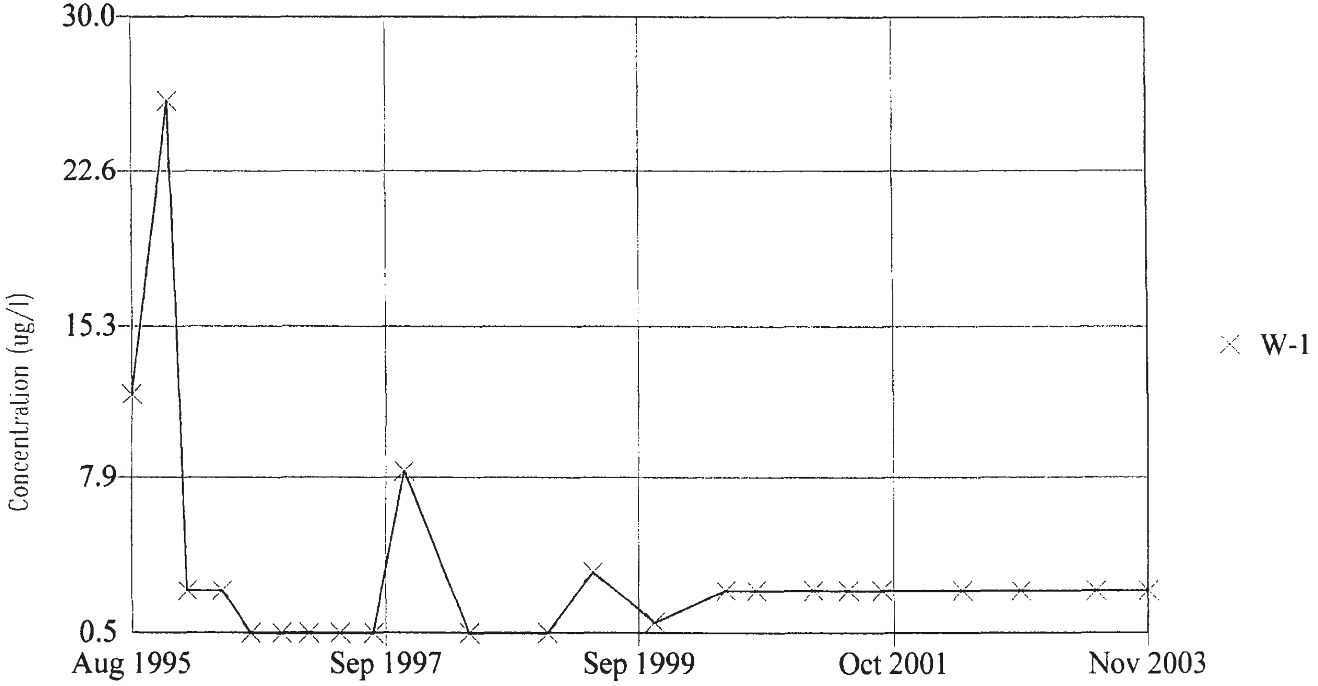


Constituent: Chloroform (ug/l)
Date: 6/24/04, 10:32 AM

Facility: Washington County LF
Client: AWI

Data File: wdbase
View: VOC

TIME SERIES



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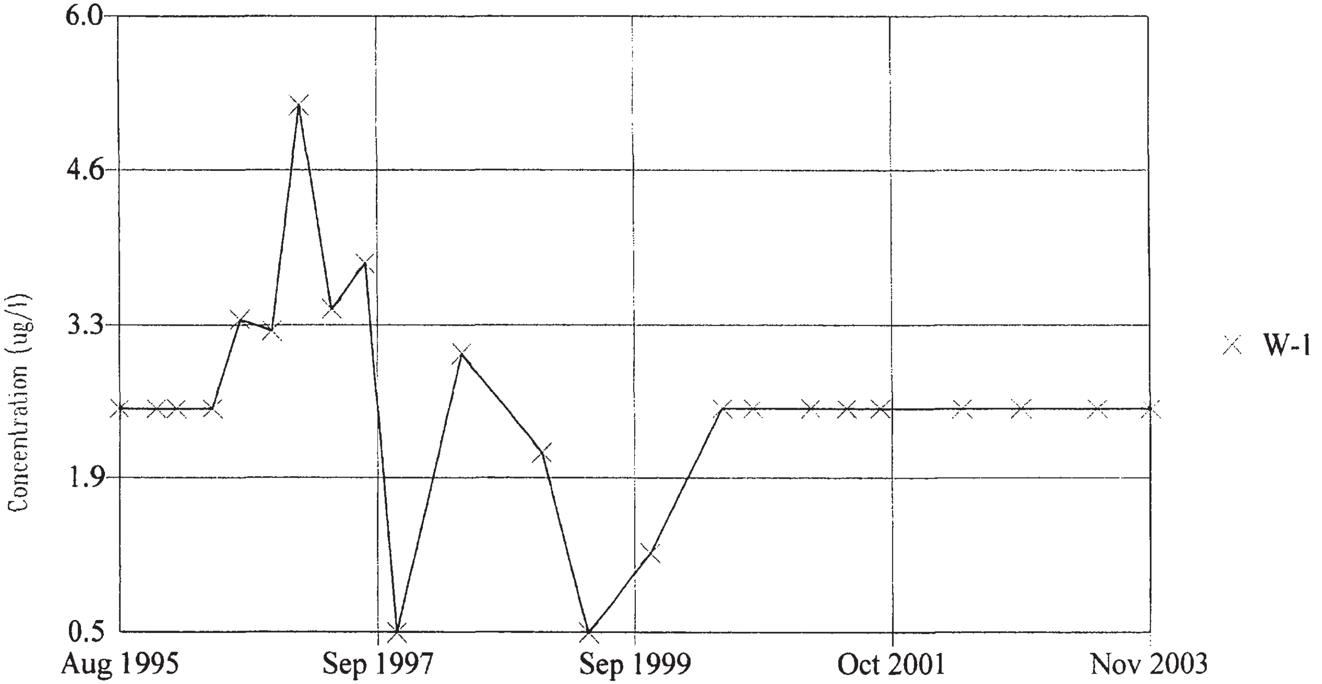
Facility: Washington County LF

Client: AWI

Data File: wdbase

View: VOC

TIME SERIES



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Facility: Washington County LF

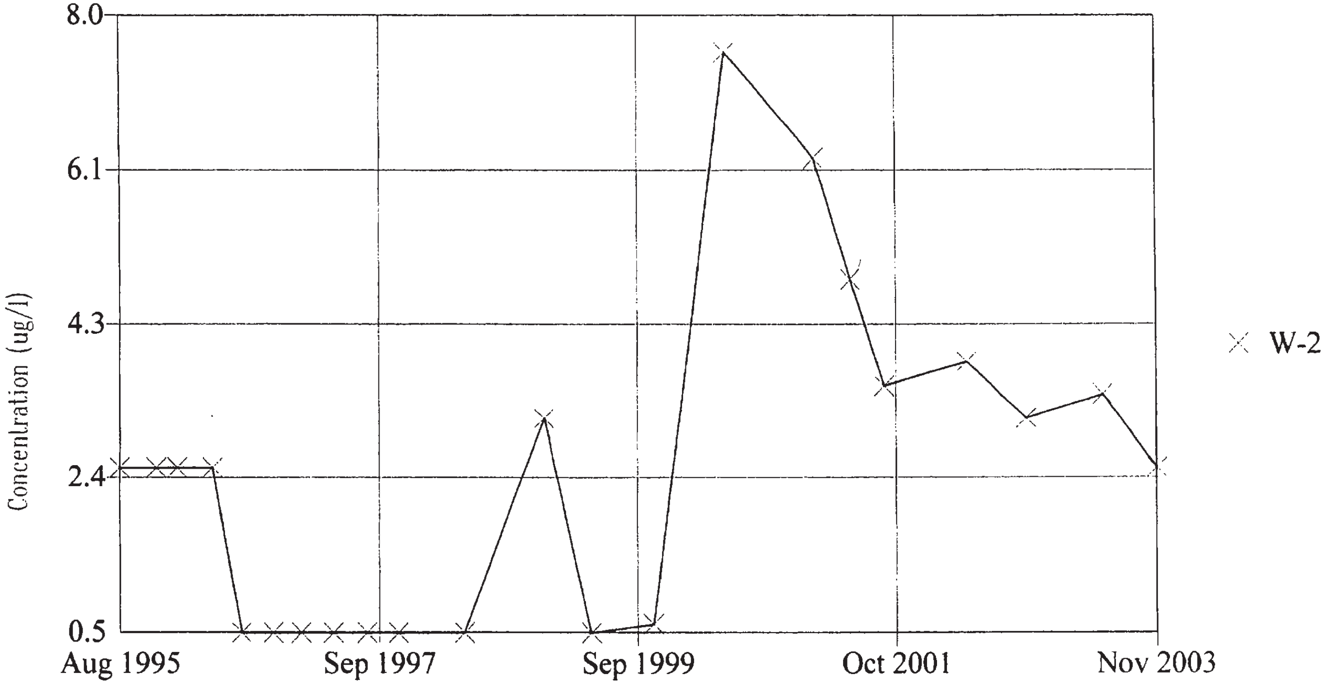
Data File: wdbase

Date: 6/24/04, 10:35 AM

Client: AWI

View: VOC

TIME SERIES



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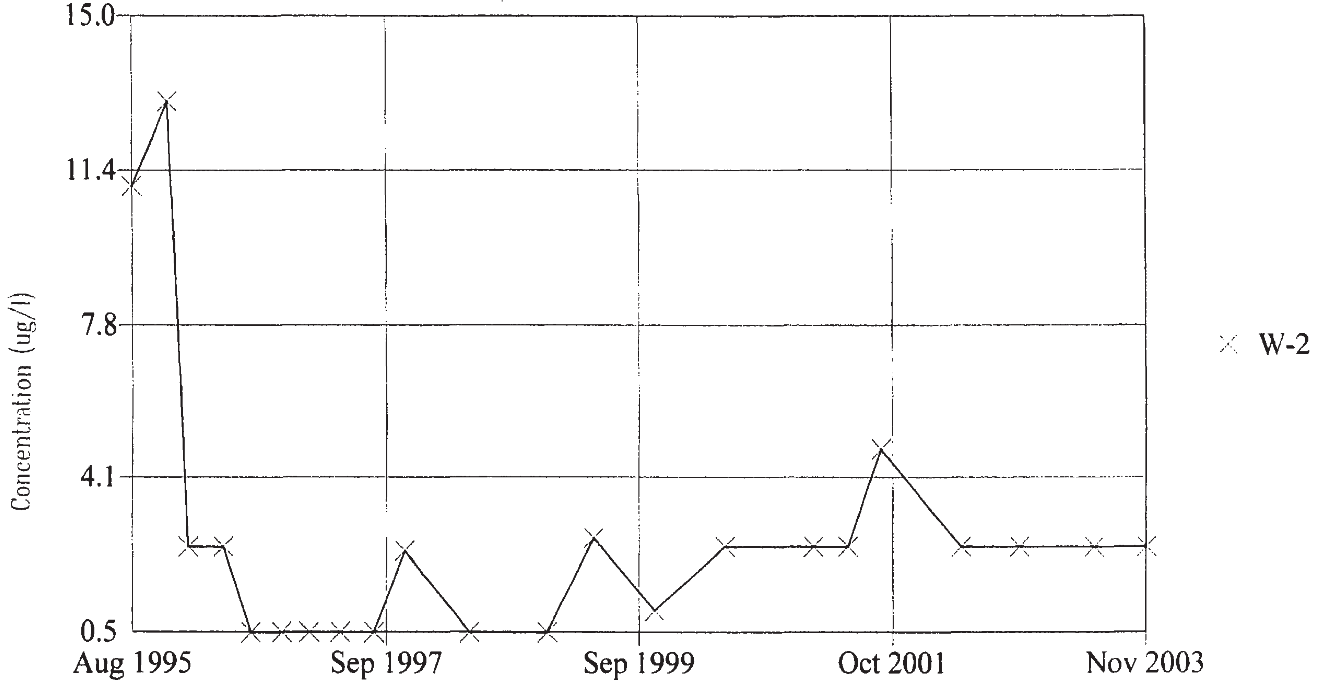
TIME SERIES



Constituent: Methylene chloride (ug/l)
Date: 6/24/04, 10:37 AM

Facility: Washington County LF
Client: AWI

Data File: wdbase
View: VOC

ATTACHMENT N

GROUNDWATER SAMPLING PLAN

GROUNDWATER SAMPLING AND ANALYSIS PLAN (GSAP)

WASHINGTON COUNTY LANDFILL
ST. GEORGE, UTAH

Project No. 21-43102-05

Prepared for

Washington County Landfill

October 5, 2021

Prepared by:

Converse Consultants

6610 West Arby Ave., Suite 104

Las Vegas, NV 89118

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1 INTRODUCTION

On behalf of Washington County Special Services District #1, Converse Consultants (Converse) has prepared this Groundwater Sampling and Analysis Plan (GSAP) to provide guidelines to be followed for water quality monitoring, data analysis, and reporting for the Washington County Landfill in Washington, Utah. The following sampling and analysis plan covers the procedures for collecting representative samples from groundwater monitoring wells and the laboratory requirements for obtaining valid, defensible data. The scope is limited to sampling and analysis requirements and does not include monitoring well placement, design and construction, or well development procedures. The GSAP will be reviewed and updated as necessary to include any future changes to landfill, such as adding additional wells.

The plan is a general requirement for groundwater monitoring sampling and analysis based primarily on the federal requirements in 40 CFR Part 258, current EPA guidance documents, and Utah Administrative Code (UAC) R315-308-2 Solid Waste Permitting and Management Rules.

The GSAP has been designed to assess data quality within current US EPA established limits, and the related protocols in the GSAP are tailored to both the project objectives and the data quality objectives. Quality Assurance/Quality Control (QA/QC) associated with the sampling and screening methodologies will consist of the following activities:

- Sample collection, preservation, transportation, and storage
- Sample custody documentation
- Calibration and preventive maintenance of analytical instrumentation and apparatus
- Data reduction, validation, and reporting
- Data quality assessment
- Analytical laboratory QA/QC
- Statistical and Non-Statistical Data Analysis and Reporting
- Monitoring Report Preparation

During the assessment of field and laboratory analytical data, qualitative limitations associated with the individual measurements will be identified and defined. Several types of QA/QC samples will be used in the program (e.g., duplicates and field equipment trip blanks) to provide the primary basis for quantitatively estimating data quality. The QA/QC activities proposed will include an evaluation of the analytical results obtained from samples collected during the sampling program so that data quality can be assessed relative to individual analyses and overall sampling program performance.

The following sections describe field operations, environmental sampling, field measurements, equipment to be used, field and laboratory QA/QC, laboratory data quality, and record keeping requirements for the monitoring program. This plan also presents the approach to data analysis and report preparation.

2 FIELD PROCEDURES

2.1 Field Sampling Health and Safety Plan

A health and safety plan is required for all groundwater sampling events at the Washington County Landfill. Prior to monitoring well purging and sampling, the sampling contractor’s Groundwater Sampling Health and Safety Plan must be in place. Designing the site Groundwater Sampling Health and Safety Plan will be the duty of the party performing the actual work.

In addition, each laboratory facility should have their own standard laboratory health and safety plan as required by current Occupational Safety and Health Administration (OSHA) regulations.

2.2 Sample Event Preparation and QA/QC

2.2.1 General Event Preparation

The laboratory performing the groundwater analysis shall supply all necessary coolers, pre-cleaned sample containers, trip blanks, chemical preservatives, labels, custody seals, and chain-of-custody forms. Field data shall be entered on a Field Data Sheet (see example provided as Appendix A) or equivalent form. Adequate instructions to the laboratory must be given in advance of each monitoring event. Details concerning any changes to the monitoring plan and/or procedures need to be provided to the laboratory prior to the field sampling personnel arriving on the site. The field team or project manager shall have communication between the two (2) parties to make sure that the sample containers, volume of water collected, quality control, hold times, preservation of samples and shipping of the containers to the laboratory are accurate.

2.2.2 Sample Container Selection

Sample containers need to be constructed of a material compatible and non-reactive with the material it is to contain. Consult the laboratory to determine the number, type and volume of appropriate containers. The contract laboratory performing the analysis shall supply all the required containers.

2.2.3 Container Preparation

Sample containers will be provided by the laboratory in a manner consistent with EPA protocol.

2.2.4 Sample Equipment Decontamination Procedures

This equipment preparation includes minimum decontamination procedures for water level indicator(s), water quality meter(s), and filtration device. Operation and calibration of equipment will be as per the manufacturer’s instructions. Non-dedicated equipment will be thoroughly cleaned prior to arrival at the site between sampling points and at the end of each day of use as follows:

- Water Level Indicator (s) – Water level indicator(s) will be decontaminated prior to initial site arrival by hand washing the sensor probe and entire length of tape in a non-phosphate detergent followed by rinsing with deionized water. While the tape is reeled back onto the carrying spool, the tape and probe will be wiped down with a clean dry paper towel.

- Field Parameter (Temperature, pH, Specific Conductivity, Turbidity, etc.) Measuring Device(s) – Field parameter measuring device(s) will be decontaminated by hand washing the probes in a non-phosphate detergent followed by rinsing with deionized water. Meters will then be checked for proper calibration and operation as per the manufacturer's instructions. Field calibration results will be recorded on a Calibration Data Sheet (Appendix C). Any malfunctioning meters will be replaced.

- Sampling devices associated with groundwater sampling will be cleaned in a non-phosphate detergent, followed by rinsing with deionized water. Temporary equipment such as grab plates or bladders will be discarded after use.

Multiple-use equipment (e.g. water level indicators and filter chambers) must be thoroughly decontaminated and cleaned as described in this section to prevent cross contamination from prior use at other facilities. All field instruments must be properly checked and calibrated prior to arrival on-site at a sampling location.

2.2.5 Field QA/QC Samples

Field QA/QC samples consist of two (2) primary areas of quality control. The first part is the quality control of sample contamination, which may occur in the field and/or during sample shipping. This is monitored by trip blank(s), field blank (s), and the equipment (rinsate) blank(s). A basic description of each is as follows:

- Trip Blank – These samples will be prepared in the laboratory by filling the appropriate clean sample containers with organic-free water and adding the applicable chemical preservative, if any, for each type of sample. These containers are to be labeled "TB-Month/Day/Year" with the associated date sampled. The analyses to be performed will be indicated on each container, and the sample will then be shipped in the typical transportation cooler to the field and back to the laboratory along with the other sample set containers for a given event. This blank is to evaluate if any contamination has occurred as a result of the containers, sample coolers, cleaning procedures, or chemical preservatives used. Trip blanks shall be taken and analyzed for each day of sampling for volatile organic compounds (VOCs) only using the same analytical method as the actual samples.

- Field Blank – Field blank containers will be prepared in the field at a routine sample collection point during a monitoring event by filling the appropriate sample containers from the field supply of deionized water. This blank is tested for contamination that may occur as a result of site ambient air conditions and serves as an additional check for contamination in the containers, sample transport coolers, and chemical preservatives. Field blanks shall be taken and analyzed for each sampling event for VOCs using the same analytical method as the actual samples.

- Equipment (Rinsate) Blank – These blanks will be prepared in the field immediately following decontamination cleaning procedures on non-dedicated equipment used for purging, sampling, or sample filtration. Following decontamination, field supply organic-free water is passed through the non-dedicated equipment in the same procedure as a groundwater sample. This blank confirms proper field decontamination procedures on non-dedicated equipment utilized. Equipment blanks shall be taken and analyzed for applicable parameters anytime non-dedicated equipment is used or new equipment is being dedicated to a well at a batch minimum of one (1) in twenty (20) wells per monitoring event.

Other Field QA/QC Samples – A second area of standard field QA/QC samples are field duplicates.

- Field duplicates are an extra set of samples taken at a particular monitoring point and labeled "Field Duplicate". These are independent samples that are collected as close as possible to the same point in space and time. They are two (2) separate samples taken from the same source, stored in separate containers, and analyzed independently. The Field Duplicate containers shall be labeled "FD-Month/Day/Year" with the associated date sampled. Field Duplicates are useful in documenting the precision of the sampling and analytical process. Samples shall be collected in proper alternating order for the sample point and field duplicate for each parameter (e/g/ VOA – VOA, metals – metals, etc.). Field duplicates shall be taken and analyzed at a batch minimum of one (1) in twenty (20) per monitoring event.

Appropriate field QA/QC documentation should be recorded in the field notes (e.g. locations where the field blank or duplicate were collected).

2.3 Well Purge

2.3.1 General Well Purge Information

Purging of a monitoring well must be conducted prior to sampling of the well. Water standing in a monitor well over a certain period of time may become unrepresentative of formation water because of chemical and biochemical changes which may cause water quality alterations. Prior to monitoring well purge, inspection of the monitoring well integrity will be performed utilizing the Field Data Sheet (Appendix A) or equivalent form.

2.3.2 Water Level Measurement

Prior to any purge or sampling activity at each monitoring well, a water level measurement is required to be taken. Measurement of the static water level is important in determining the hydrogeologic characteristics of the subsurface (e.g. groundwater gradient). The water level indicator will be an electronic sensor device, which signals by audio and/or light indicator when the probe contacts water.

Water level indicator equipment will be constructed of chemically inert materials. Additionally, during mobilization preparation and following each monitoring point it will be decontaminated with a non-phosphate detergent followed with multiple deionized water rinses. Water levels will be measured with a precision of +/- 0.01 foot. Water level indicator devices will be periodically checked for proper calibration. Calibration shall be performed at a frequency recommended by the manufacturer. Each monitor well shall have a reference elevation point located and properly marked at the top of the riser casing established by a licensed surveyor. This reference point elevation is measured in relation to Mean Sea Level (MSL). Ground water elevations in wells that monitor the same waste management area must be measured with a forty-eight (48) hour period to avoid temporary variation in groundwater flow, which could preclude accurate determination of groundwater flow rate and direction.

2.3.3 Purge Equipment and Procedure

Groundwater wells will be purged with dedicated bladder pumps. These pumps will remain dedicated to each respective well throughout monitoring unless replacement is necessary due to damage or wear, in which case repairs will be completed or a new pump will be installed. Purge procedures for dedicated equipment are described in Section 2.3.3.1. Pump intakes will be located as close as possible to the middle of the screened interval of each well.

2.3.3.1 Dedicated Equipment

Low Flow Technique

Low-flow purging is the preferred pumping and sampling technique and will be employed using dedicated bladder pumps if proper pump controller and field instruments are available to the sampling personnel. Well purging will be conducted at a rate of approximately 100 milliliters per minute until stabilization of field parameters is achieved. Field parameters include temperature, specific conductivity, pH, turbidity, ORP, Salinity, and TDS.

Parameter stabilization is defined as:

- Temperature = ± 10% for three (3) consecutive measurements
- pH = ± 0.2 standard pH units for three (3) consecutive measurements
- Specific Conductivity = ± 3% for three (3) consecutive measurements
- Turbidity = ± 10% for three (3) consecutive measurements
- ORP = ± 10% for three (3) consecutive measurements

Measurements will be recorded on the field data sheet every three minutes. Water level measurements will also be taken every three minutes and recorded on the field data sheet. An initial increase in water level may be expected due to pump and tubing evacuation however, minimal subsequent continuous drawdown is to be expected. Should a well repeatedly not meet one or more criteria, alternate criteria may be implemented with UDEQ approval.

Fixed Volume Technique

If Low-flow techniques are not used, wells will be purged a minimum of three (3) well casing volumes of water or until dryness of the well occurs prior to removal of the three well casing volumes. Measurement of temperature, pH, conductivity, turbidity, etc. will be recorded at intervals of approximately three (3) minutes on a Field Data Sheet (see Appendix A) during purging.

2.3.3.2 Non-Dedicated Equipment

In the event of a non-operative dedicated pump, the pump and tubing apparatus will be removed for repairs or replacement and the well will be purged by means of either a disposable bailer or a portable pump until such time the bladder pump is repaired/replaced and rededicated to the well. Purging will be performed by removing a minimum of three well-casing volumes of water from the well or until stabilization of field parameters (as defined in Section 2.3.3.1) occurs. Purging will be deemed complete if the well goes dry before three well-casing volumes of water have been removed. Field parameters will be measured after each well-casing volume of water removed.

Equipment:

- Non-dedicated pump/bailer
- Pump controller (if required)
- Generator or other power source/driving mechanism for pumps/appropriate disposable string or rope for bailer, downrigger (optional)
- New disposable tubing
- New disposable gloves of appropriate material (nitrile)
- Graduated pail or other appropriate container
- Field parameter measurement device(s)
- Container for laboratory grade, non-phosphate soap/reagent-grade deionized water solution
- Container for reagent-grade deionized water rinse

Procedure: (Specific operating instructions vary depending on the type of portable pump used. The steps listed below are generalized procedures)

- Don a new pair of gloves.
- Cleanse portable pump/bailer with a non-phosphate, laboratory grade detergent solution followed by a reagent-grade deionized water rinse. Sufficient water should be passed through a non-dedicated pump to ensure proper cleansing.

- Remove gloves worn during cleaning and don a new pair of gloves.
- Attach new disposable tubing to pump or new disposable string to bailer.
- Insert pump and tubing/bailer into well.
- Start the portable pump by the appropriate method and adjust flow to desired rate/initiate removal of water from well with bailer. Ensure bailer and string do not touch ground during purging.

When purging with a bailer, introduce bailer into water column slowly (i.e. do not “drop” into water column) to avoid agitation of water in the well and immediate formation area.

Non-dedicated equipment will be constructed of chemically inert materials and will be decontaminated at each well with a non-phosphate detergent followed with a reagent-grade deionized water rinse. Additional cleaning procedures will be performed as deemed necessary.
Rate of discharge and volume purged will be checked periodically with a graduated bucket and/or timer. Field parameter (temperature, pH, specific conductivity, and turbidity) measurements will be recorded on Field Sampling Form (Appendix A) after each well volume of water is removed during purging.

2.3.4 Purge Water Management

If purge water is known to be historically contaminated or suspect due to prior analytical data, the water shall be stored in appropriate containers until analytical results are available. After review of these analyses, proper arrangements for disposal or treatment of the water shall be made. Otherwise, purge water will be discarded on the ground away from the monitoring well area.

2.4 Monitoring Well Sample Collection

Sampling should take place as soon as purging is complete, once the well reaches stabilization and the well has sufficient recharge. If the well was purged dry or significant drawdown of the water level exists immediately after purge, the monitor well should be sampled as soon as the well recharges to at least 80% of the static water level or sufficient water is present for all analytes to be collected. The time interval between the completion of well purge and sample collection normally should not exceed 48 hours.

2.4.2 Sample Collection Order

Monitoring well sampling during each event shall proceed from the point with the highest water level elevation to those with successively lower elevations unless contamination is known to be present. If contamination is known to be present, samples will be collected from the least to most contaminated wells, to minimize the potential for any cross-contamination. Samples will be collected and containerized according of the volatility of the requested analyses. A specific collection order is as follows:

- Field Parameters (Temperature, pH, Specific Conductivity, Turbidity)
- Volatile Organics
- Metals
- Inorganics

2.4.3 Sampling Equipment/Procedures

Groundwater wells will be sampled using dedicated bladder pumps. These are the same pumps used for well purging. A bailer can be used to collect a sample if the pump is out of operation.

2.4.4 VOC Sample Collection

When filling VOC sample containers, the water should be gently added to each vial until a positive meniscus is formed over the top of the container. This insures no headspace is present in the sample vial upon replacing the cap. After the cap has been placed on the vial and tightened, the vial should be checked for air bubbles by turning upside down and tapping with finger. If a bubble is seen rising to the top of the inverted vial, repeat the process outlined above, remove the cap and add more water and repeat as necessary. If no air bubbles are seen in each vial, the process is complete.

2.4.5 Sample Filtration

All efforts must be made to delete or minimize controllable factors to allow the collection of as representative and turbid-free sample as possible. Utah DEQ, UAC, Solid Waste Permitting and Management Rules does not currently allow for field sample filtration of constituents listed in R315-308-4 prior to laboratory analysis (R315-308-02 (4)(d)). The facility may collect samples for laboratory filtration and analysis of dissolved metals when deemed necessary. Otherwise, metal and inorganic indicator analyses will be for total concentrations.

2.4.6 Sample Preservation

All samples will be containerized and preserved on wet ice or with a preservative within the bottle. In the goal to obtain the most representative sample possible, preserving the sample for transportation and storage to the laboratory is also important.

Methods of preservation are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce volatility of constituents. Samples requiring refrigeration to four degrees Centigrade will be accomplished by placing the sample containers immediately into coolers containing wet ice and delivering to the analytical laboratory as soon as possible.

2.4.7 Field Measurements

Required field measurements include water levels, temperature, pH, specific conductivity, and turbidity. All instruments shall be properly calibrated and checked with standards according to the manufacturer’s instructions and/or the field crew’s standard operating procedures. Any improper operating instruments must be replaced prior to continuing sample collection operations.

2.5 Record Keeping

2.5.1 Field Logs

All field notes must be completely and accurately documented to become part of the final report for a monitoring event. Field information will be entered on a Field Data Sheet (see Appendix A) or equivalent form.

All entries shall be legible and made in indelible ink. Entry errors will be crossed out with a single line, dated, and initialed by the person making the corrections.

2.5.2 Chain-of-Custody

Proper chain-of-custody records are required to insure the integrity of the samples and the conditions of the samples upon receipt at the laboratory, including the temperature of the samples at the time of log in. The sample collector shall fill in all applicable sections and forward the original, with the respective sample(s), to the laboratory performing the analysis. Upon receipt of the samples at the laboratory, the sample coordinator is to complete the chain of custody, make a copy for his/her files, and make the original documents part of the final analytical report (see example provided as Appendix D). All sample containers will be labeled to prevent misidentification. The following will be indicated on an adhesive label with a waterproof pen:

- Collector’s name, date and time of sampling
- Sample source
- Sample identification number
- Sample preservative
- Analytical test(s) to be performed on the sample

Sample shuttle kits (coolers) will employ a tamper proof seal.

2.6 Sample Transport

Samples shall be shipped from the field back to the analytical laboratory either by hand delivery or utilizing an overnight courier service. Samples are to be shipped in sealed insulated shipping containers. Standard shipping containers must be a sturdy waterproof design (ice chests are commonly used) equipped with bottle dividers and cushion material to prevent breakage during shipment. Since ice is the most common means by which to refrigerate the samples, appropriate measures need to be taken to fully waterproof the contents from leakage. The field crew shall contact the laboratory each time samples are sent to identify the samples being sent and the transportation carrier along with the shipping identification number.

The laboratory shall provide a notification concerning the receipt of the groundwater samples as soon as practical after they have been received. The notification will include the date, temperature, and condition of sample bottles received.

3 LABORATORY PROCEDURES/PERFORMANCE STANDARDS

3.1 Analytical Methods

Chemical analyses will be performed by a laboratory that is certified by the State of Utah to analyze each Table 1 constituent. Methods and reporting limits will conform to Table 1 and will be performed in accordance with test procedures presented in USEPA *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, September 1986 and any subsequent revisions or additions.

Alternative methods that provide equivalent or better performance than those listed in EPA publication SW-846 and analytical methods for constituents not listed in EPA publication SW-846 may be implemented.

3.2 Deliverables (General and Supplemental QA/QC)

3.2.1 General Requirements

For general reporting of quantitative results for Subtitle D groundwater monitoring projects, the following reporting requirements apply:

- Methodology Summary – reporting of the analytical test methods used in the analyses of the samples with a reference made for each to the method manual and the test method number to confirm compliance with Table 1.
- Summary of the analytical results, indicating appropriate unit, and reporting R.L. and supervisor approval – concentration units must be consistently applied throughout report. Data cannot be method blank corrected. It must be appropriately flagged.
- Chain-of-Custody Form – As per Section 2.5.2.
- Field Data Sheets (see Appendix A) or equivalent form.

3.2.2 Supplemental QA/QC Reporting Requirements

- Laboratory Chronicles – must include date of sampling, sample receipt, preservation, preparation, analysis, and supervisor approval signature.
- Non Conformance Summary for GC/MS Data Report – must state if the following do not meet QA/QC requirements:

  GC/MS Tune Specifications
  GC/MS Tune Frequency
  Calibration Frequency
  Calibration Requirements – System Performance Check
  Compounds, Calibration Check Compounds
  Blank Contamination
  Surrogate Recoveries
  Sample Holding Times
  Minimum Detection Limits

3.2.3 Requirements for Organics: Volatiles

1. Quality Assurance (QA) Data Form – must include minimum detection limits, method blanks, field/trip blanks if specified in Sampling Plan, lab replicate. Quality Control (QC) samples may be other than project samples, but must be of same batch and similar matrix. A single QA Data Form should be used for a number of samples; however, pertinent sample numbers must be listed on the form.
2. Surrogate Compound Recovery Summary – for samples and blanks – as per most recent version of applicable SW-846 method 8260.
3. Other requirements per Laboratory Quality Assurance Plan and regulatory requirements.

3.2.4 Laboratory Requirement for Metals

At a minimum, method detection limits must be established and method blank results are mandatory.

3.2.5 Requirements for Inorganic – General Chemistry

Quality Assurance (QA) Date Form – must include minimum detection limits, method blanks, field/trip blanks as specified in Sampling Plan, lab replicate. Quality Control (QC) samples may be other than project samples, but must be of same batch and similar matrix.

A single QA Data Form should be used for a number of samples; however, pertinent sample numbers must be listed on the form. In addition, spiked sample results must be included.

3.3 Data Quality Objectives

3.3.1 Required Reporting Limits

Data reported must be such that the method used shall achieve the nominal reporting limits (RLs) listed in Table 1 – Background/Detection Monitoring Parameters.

3.3.2 Precision

Precision refers to the reproducibility of method results when a second aliquot of the same sample undergoes duplicate analysis. The degree of agreement is expressed as the Relative Percent Difference (RPD). Precision requirements shall be as per applicable method and laboratory standards.

3.3.3 Accuracy

Accuracy refers to the agreement between the amount of a constituent measured by a test method and the amount actually known to be present. Accuracy is usually expressed as a percent Recovery (R). Accuracy shall be as per applicable method and laboratory standards.

4 SAMPLING FREQUENCY AND REPORTING REQUIREMENTS

4.1 Background

As per UAC R315-308-1 (4)(a), a minimum of eight (8) independent samples will be collected and analyzed to establish background for the constituents listed in Table 1 to establish background concentrations. Each monitoring well in the site groundwater monitoring program will be defined as background or detection.

4.2 Detection Monitoring Events

After establishment of background values, sampling and analysis for both upgradient and downgradient detection monitoring wells will be conducted on a semi-annual basis (every six (6) months) for constituents listed in Table 1.

4.3 Groundwater Analysis Result Submittals

Two (2) bound copies of a report or an electronic report of groundwater sampling and analytical results will be submitted to the Executive Secretary. The report will be submitted in standard laboratory format and on any applicable state agency reporting forms. Within a reasonable period of time after completing sampling, the owner/operator must determine whether there has been a statistically significant increase (SSI) over background at each monitoring well as per UAC R315-308-2 (4) (f) (v).

Per UAC R315-308-2 (11) if the owner or operator determines that there is a statistically significant increase over background in any parameter or constituent at any monitoring well at the compliance point, the owner or operator must:

(a) within 14 days of the completion of the statistical analysis of the sample results and within 30 days of the receipt of the sample results, enter the information in the operating record and notify the Director of this finding in writing. The notification must indicate what parameters or constituents have shown statistically significant changes; and

(b) immediately resample the ground water in all monitoring wells, both background and downgradient, or in a subset of wells specified by the Director.

5 STATISTICAL METHODOLOGY – GROUND WATER DATA ANALYSIS

Statistical comparisons will be performed using DUMPStat^{TM}, a commercial software program developed by Discerning Systems Inc, or another comparable computer program. Statistical analyses of groundwater data will be performed in accordance with UAC R315-308-2 (7). A statistical analysis plan has been prepared and included as Appendix D. Appendix D Statistical Analysis Plan has been prepared using generally accepted statistical analysis principles and practices (IDT,2002). However, it is not possible to predict all of the potential future circumstances. Therefore, alternative methods may be used that are more appropriate for the data distribution of the constituents being evaluated. Appendix D - Statistical Analysis Plan provides a statistical methodology for groundwater monitoring at the Washington County Landfill.

5.1 Statistically Significant Constituents and Verification Resampling

Statistical analysis of constituents in Table 1 will commence within six (6) months after completion of eight (8) quarterly background events for a particular well. An initial Statistically Significant Increase (SSI) will be based on any compound detected in any downgradient monitor well at a concentration above the specific constituent's statistical limit. If an initial SSI of any constituent is indicated at any downgradient monitoring well, a notice will be made to the Department in the form of a statistical analysis report as referenced in Section 4.3 of this plan.

Verification resampling is an integral part of the presented statistical methodology. In the event of an initial SSI, verification resampling may be conducted and the results provided to the Executive Secretary in accordance with UAC R315-308-2 (10)(b).

As per UAC R315-308-2 (10)(c), the owner/operator may demonstrate, to the satisfaction of the Executive Secretary, within 90 days of the finding that the SSI is the result of a source other than the Municipal Solid Waste Landfill (MSWLF), such as error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Otherwise, the owner/operator must initiate an assessment monitoring program under UAC R315-308-2 (11).

6 REFERENCES

American Society of Testing and Materials (ASTM), 1986. *Standard Guide for Sampling Groundwater Monitoring Wells.* D 4448 -850

Intelligent Decision Technologies (IDT), 2002. Sanitas For Groundwater User's Guide. Longmont, Colorado.

Gibbons, Robert, D. 1994. Statistical Methods for Groundwater Monitoring, John Wiley & Sons, Inc. New York.

Gibbons, Robert, D. and Coleman, David, E. 2001. Statistical Methods for Detection and Quantification of Environmental Contamination. John Wiley and Sons. New York. 384 p.

Gilbert, R. O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York.

Martin, W.F., Lippitt, J.M., and Protherd, T.G. 1987. *Hazardous Waste Handbook For Health and Safety,* Butterworth Publishers, Stoneham, Massachusetts, pp. 28 – 30.

State of Utah, Utah Administrative Code, Solid Waste Permitting and Management Rules R315-301 through 320, Department of Environmental Quality, Revised June 15, 2000.

U.S. Environmental Protection Agency, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document.* OSWER – 99550.1, Office of Waste Programs Enforcement, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, 1989. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance. Office of Solid Waste Management Division, U.S. Environmental Protection Agency, Washington D.C.

U.S. Environmental Protection Agency, 1992. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Addendum to Interim Final Guidance. Office of Solid Waste Management Division, U.S. Environmental Protection Agency, Washington D.C.

U.S. Environmental Protection Agency, 1992. *RCRA Groundwater Monitoring: Draft Technical Guidance.* EPA/530-R-93-001, NTIC # PB93-139-350, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, 1991b. *Handbook – Groundwater, Volume II: Methodology.* EPA/625/6-90/0166.

U.S. Environmental Protection Agency, November 1986. *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, Third Edition (Revised),* SW-846. Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, November 1993. *Solid Waste Disposal Facility Criteria Technical Manual.* EPA/530-R-93-017, NTIC #PB94-100-450, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency, Federal Register, 40 CFR 258, October 9, 1991.

Table 1
List of Analytical Parameters
Washington County Landfill

Inorganic Constituents	CAS	Method[1]	RL[2] (mg/L)
Ammonia as Nitrogen	7664-41-7	350.1	1
Carbonate/Bicarbonate		31.1	10
Calcium		6010 or 6020	0.6
Chemical Oxygen Demand (COD)		410.2	10
Chloride		300	10
Iron	7439-89-6	6010 or 6020	0.1
Mangesium		6010 or 6020	0.2
Manganese	7439-96-5	6010 or 6020	0.015
Nitrate as Nitrogen		300.0 or 353.2	5
pH		150.1	N/A
Potassium		6010 or 6020	5
Sodium		6010 or 6020	5
Sulfate		300.0 or 375.4	10
Total Dissolved Solids (TDS)		160.1	1000
Total Organic Carbon (TOC)		415.1	1
Heavy Metals	**CAS**	**Method[1]**	**RL[2] (mg/L)**
Antimony	7440-36-0	6010 or 6020 or 200.8	0.005
Arsenic	7440-38-2	7041 or 6020	0.04
Barium	7440-39-3	6010 or 6020	0.01
Beryllium	7440-41-7	7091 or 6020	0.002
Cadmium	7440-43-9	6010 or 6020	0.05
Chromium		6010 or 6020	0.05
Cobalt	7440-48-4	6010 or 6020	0.07
Copper	7440-50-8	6010 or 6020	0.05
Lead		7421 or 6020 or 200.8	0.01
Mercury	7439-97-6	6020 or 7470	0.0017
Nickel	7440-02-0	6010 or 6020	0.01
Selenenium	7782-49-2	7740 or 6010 or 6020	0.02
Silver	7440-22-4	6010 or 6020	0.07
Thallium		7840 or 6020 or 200.8	0.002
Vanadium	7440-62-2	6010 or 7911	0.02
Zinc	7440-66-6	6010 or 6020	0.01
Volatile Organic Compounds (VOC)	**CAS**	**Method[1]**	**RL[2] (mg/L)**
Acetone	67-54-1	8260B	10
Acrylonitrile	107-13-1	8260B	50
Benzene	71-43-2	8260B	4
Bromochloromethane	74-97-5	8260B	4
Bromodichloromethane	75-27-4	8260B	4
Bromoform (tribromemthane)	75-25-2	8260B	4
Carbon disulfide	75-15-0	8260B	4

Table 1
List of Analytical Parameters
Washington County Landfill

Carbon tertachloride	56-23-5	8260B	4
Clorobenzene	108-90-7	8260B	4
Chloroethane (ethyl chloride)	75-00-3	8260B	8
Chloroform (trichloromethane)	67-66-3	8260B	4
Dibromochloromethane (Chlorodibromomethane)	124-48-1	8260B	4
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	8011	0.2
1,2-Bibromoethane (ethylene dibromide, EDB)	106-93-4	8011	0.05
o-Dichlorobezen (1,2-dichlorobenzene)	95-50-1	8260B	4
p-Dichlorobenzene (1,4 dichlorobenzene)	106-46-7	8260B	4
trans-1,4-Dichloro-2-butane	110-57-6	8260B	4
1,1-Dichloroethane (ethylide chloride)	75-34-3	8260B	4
1,2-Dichloroethane (ethylene dichloride)	107-06-2	8260B	4
1,1-Dichloroethylene (1,1-dichloroethene)	75-35-4	8260B	4
cis-1,2-Dichlororthylene (trans-1,1-dichloroethene)	156-59-2	8260B	4
trans-1,2-Dichloroethylene (trans-1,2-dichloroethene)	156-60-5	8260B	4
1,2-Dichloropropane (propylene dichloride)	78-87-5	8260B	4
cis-1,3-dichloropropane	10061-01-5	8260B	2
trans-1,3-dichloropropene	10060-02-6	8260B	2
Ethylbenzene	100-41-4	8260B	4
2-Hexanone (methyl butyl ketone)	591-78-6	8260B	5
Methyl bromide (bromomethane)	74-83-9	8260B	4
Metyl chloride (chloromethane)	74-87-3	8260B	2
Methylene bromide (dibromomethane)	74-95-3	8260B	4
Methylene chloride (dichloromethane)	75-09-2	8260B	4
Methyl ethyl ketone (MEK, 2-butanone)	78-93-3	8260B	5
Methyl iodide (iodomethane)	74-88-4	8260B	4
4-Methyl-2-pentanone (methyl isobutyl ketone)	108-10-1	8260B	5
Styrene	100-42-5	8260B	4
1,1,1,2-Tetrachloroethane	630-20-6	8260B	4
1,1,2,2-Tetrachloroethane	79-34-5	8260B	4
Tetrachloroethylene (tetrachloroethene)	127-18-4	8260B	4
Toluene	108-88-3	8260B	4
1,1,1-Trichloroethane (tetrachlorothane)	71-55-6	8260B	4
1,,1,2-Trichloroethane	79-00-5	8260B	4
Trichloroethylene (trichloroethene)	79-01-6	8260B	4
Trichlorofluoromethane (CFC-11)	75-69-4	8260B	4
1,2,3-Trichloropropane	96-18-4	8260B	4
Vinyl acetate	108-05-4	8260B	5
Vinyl chloride	75-01-4	8260B	2
Xylenes (total)	1330-20-7	8260B	4

1. Equivalent or better methods may be submitted as appropriate

2. Reporting Limits

For the compounds DBCP and EDB, any detectable amount between RL and MCL will be estimated and flagged with an appropriate symbol.

APPENDIX A

FIELD DATA SHEET

Page_1_of_1_

Monitoring Well Low-Flow Purge/Sampling Form

Project: Washington County Landfill

Well ID: ____________
Date: ____________
Sample ID ____________
Time: ____________
Dup ID: ____________
Rinsate ID: ____________
Field Blank ID: ____________
Analysis: ____________

Screened Interval (ft) ____________
Pump Intake Depth (ft) ____________
Purging/ Sample Device: ____________
PID Reading at TOC: ____________
Water Level Instrument : ____________
WLI Serial #: ____________
Water Quality Meter: ____________
Water Quality Meter Serial #: ____________
WQM Cal. Date & Time: ____________

Well Diameter (in): ____________
Static Water Level (ft): ____________
Total Well depth (ft): ____________
Water Column Length: ____________
Minimum Purge Volume: ____________
Samplers Name: ____________
Optimal Pump Setting: PSI____ CPM____ ID:_____
Low-Flow or Net Purge: Low-Flow

Time	Volume Purged	Flow Rate	Water Level (feet - BTOC)	Specific Conductance (mS/cm)	pH	Temp.	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Salinity	TDS
	Liters	**ml/min**	**± 0.1 ft**	**3%**	**± 0.1**	**± 0.2**	**± 10%**	**± 10%**	**± 10%**	**%**	**g/L**

Comments: ____________

Maximum permissable drawdown = __________ ft BTOC, water level not to draw down below _________ ft BTOC

Optimal drawdown for low-flow micropurge sampling is less than 0.3 ft at a flow rate of 0.1 to 1.0 L/min.

If drawdown exceeds 0.3 ft at a flow rate of 0.1 L/min....then attempt to achieve drawdown less than or equal to 25% of the available screen interval at flow rate equal to 0.1 to 1.0 L/min. This is performed by subtracting pump intake and top of screen for fully submerged screens then multiplying by 25%, or subtracting the distance between pump intake and static water level and multiplying by 25% for water table wells with partly submerged screens.

APPENDIX B

CALIBRATION DATA SHEET

ELECTRICAL CONDUCTIVITY METER CALIBRATION FORM

PROJECT NUMBER:________________

MONTH/YEAR:________________

PAGE _______ OF _______

DATE	TIME	EC STANDARD SOLUTION (umhos/cm @ 25°C)	TEMPERATURE OF SOLUTION °C	EC METER READINGS (umhos/cm)	REDLINES (Y/N)	BATTERY GOOD (Y/N)	METER TYPE	METER SERIAL #	COMMENTS	INITIALS

FOOTNOTES

umhos/cm = Microhmos per centimeter
°C = Degrees Centigrade

Project __________

DISSOLVED OXYGEN METER CALIBRATION FORM
(AIR METHOD)

Page ____ of ____

DATE	TIME	METER MODEL	TEMP (°C)	ELEVATION (ft msl)	SOLUBILITY OF OXYGEN (a)	ALTITUDE CORRECTION FACTOR (b)	CALIBRATION VALUE(c) (mg/l)	COMMENTS	INITIALS

FOOTNOTES

(a) Solubility of oxygen.
(b) Altitude correction factor.
(c) Calibration value determined by multiplying solubility value by altitude correction factor.
°C = degrees Celsius
ft msl = Feet mean sea level
mg/l = Milligrams per liter

pH METER CALIBRATION FORM

PROJECT NUMBER:_______________

MONTH/YEAR:_______________

PAGE ______ OF ______

DATE	TIME	pH BUFFER	TEMPERATURE OF BUFFER, °C	pH READING	METER TYPE	METER SERIAL NO.	COMMENTS	INITIALS

FOOTNOTE

°C = degrees Celsius

WATER-LEVEL INDICATOR CALIBRATION FORM

PROJECT NUMBER:________________

DATE	TIME	WATER LEVEL INDICATOR TYPE	WATER LEVEL INDICATOR NUMBER	CALIBRATION METHOD	CALIBRATED BY (INITIALS)	REMARKS

APPENDIX C

SAMPLE CHAIN-OF-CUSTODY

Eurofins TestAmerica, Denver
4955 Yarrow Street
Arvada, CO 80002
Phone (303) 736-0100 Fax (303) 431-7171

eurofins | Environment Testing TestAmerica

Chain of Custody Record

Client Information

Client Contact: Darin Olson
Company: Republic Services, Inc
Address: 111 West highway 123
City: East Carbon
State, Zip: UT, 84520
Phone: 435-888-4418(Tel)
Email: dolson@republicservices.com
Project Name: Washington Cty LF
Site:UTAH Semiannual Groundwater

Sampler:
Phone:
Due Date Requested:
TAT Requested (days):
PO #: Purchase Order Requested
WO #:
Project #: 28002706
SSOW#:

Lab PM: Harrington, Danielle M
E-Mail: danielle.harrington@testamericainc.com

Carrier Tracking No(s):

COC No: 280-32417-13380.1
Page: Page 1 of 1
Job #:

Analysis Requested

Preservation Codes:

A - HCL	M - Hexane
B - NaOH	N - None
C - Zn Acetate	O - AsNaO2
D - Nitric Acid	P - Na2O4S
E - NaHSO4	Q - Na2SO3
F - MeOH	R - Na2S2SO3
G - Amchlor	S - H2SO4
H - Ascorbic Acid	T - TSP Dodecahydrate
I - Ice	U - Acetone
J - DI Water	V - MCAA
K - EDTA	W - ph 4-5
L - EDA	Z - other (specify)

Other:

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	Total Metals6010B, 6020, 7470A	Ammonia, TOC, COD	8260B - (MOD) 8260B VOCs	T Alk, pH, 300. Cl, SO4, NO3, TDS	8011 - (MOD) 8011 EDB & DBCP									Total Number of containers	Special Instructions/Note:
				Preservation Code:	X	X	D	S	A	N	R									X	
				Water																	Short Holds: Include pH and NO3 Method 300.0
				Water																	
				Water																	
				Water																	
				Water																	
Trip Blank				Water																	

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ________ *Months*

Deliverable Requested: I, II, III, IV, Other (specify)

Special Instructions/QC Requirements:

Empty Kit Relinquished by: Date: Time: Method of Shipment:

Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company

Custody Seals Intact:
Δ Yes Δ No

Custody Seal No.:

Cooler Temperature(s) °C and Other Remarks:

APPENDIX D

STATISTICAL ANALYSIS PLAN

CONTENTS

FIGURES

1 INTRODUCTION

This document provides a statistical methodology for groundwater monitoring at the Washington County Landfill. A tiered evaluation approach has been developed for detection monitoring wells. Intra-well comparisons of metals and inorganic indicator parameters will be conducted using Shewhart-CUSUM control charts. Non-parametric prediction limits combined with Sen's Slope/Mann Kendall trend analysis will be applied to those parameters with greater that 50 percent non-detections (25 percent under ASTM standards) in the background data set. Statistical limits for volatile organic compounds in detection monitoring wells will be based on reporting limits (RLs). Assessment monitoring constituents will be statistically evaluated using detection monitoring statistics and 95 percent confidence interval analysis. Details of each method are provided in the following sections. Statistical comparisons will be performed using DUMPStat^{TM}, a commercial software program developed by Discerning Systems Inc. or another comparable computer program.

This document has been prepared using generally accepted statistical analysis principles and practices. However, it is not possible to predict all the potential future circumstances. Therefore, alternative methods may be used that are more appropriate for the data distribution of the constituents being evaluated.

2 DETECTION MONITORING STATISTICAL ANALYSES

2.1 Metals and Inorganic Indicator Constituents

2.1.1 Shewhart-CUSUM Control Charts

Metals and inorganic indicator constituents will be statistically evaluated using combined Shewhart-CUSUM (cumulative sum) Control Charts. This procedure assumes that the data are independent and normally distributed with a fixed mean and constant variance. The most important assumption is independence; therefore, wells should be sampled no more frequently than quarterly (Gibbons, 1994). The assumption of normality is less of a concern, and natural log or ladder of powers transformation are adequate for most applications. The analysis is only applied to constituents that have greater than 50 percent detections (25 percent under ASTM standards) in the background data. For those metals and inorganic indicator constituents with fewer than 50 percent detections in the background data set, a non-parametric prediction limit/Sen’s Slope/Mann Kendall trend analysis will be used.

Shewhart-CUSUM control charts allow detection of both major and gradual releases from the facility independent of spatial variation. The procedure is specifically recommended in the USEPA document *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (April 1989). Control charts are an alternative to Prediction limits for performing either intra-well comparisons or comparisons to historically monitored background wells during detection monitoring. The baseline parameters for control charts are estimated from historical data, the method is best suited for initially uncontaminated compliance wells. Control charts allow data to be graphically viewed over time. Prediction limits allow only one point-in-time comparisons between the most recent data and past information, making long-term trends difficult to identify.

2.1.2 Procedure

Control charts are a form of time-series graph, on which a parametric statistical representation of concentrations of a given constituent are plotted at intervals over time. A control chart is constructed by first collecting an initial sample data from the specific compliance well in an intra-well comparison or from background wells in comparisons of compliance data with background data in order to establish estimates of the well mean and well variance. The statistics are computed and plotted together with an upper and/or lower control limit on a chart where the x-axis represents time (years) and the y-axis represents the constituent concentration (µg/L).

The Procedure for conducting the intra-well analysis using combined Shewhart-CUSUM Control Charts is provided below and a flow chart illustrating the decision-making process is provided as **Figure E-1**.

Three parameters are selected prior to plotting:

h – The control limit to which the cumulative sum (CUSUM) values are compared. The EPA recommended value for **h** is 5 units of standard deviation.

k - A reference value that establishes the upper limit for the acceptable displacement of the standardized mean. The EPA recommended value for k is 1.

SCL – The upper Shewhart control limit to which the standardized mean will be compared. The EPA recommended value for **SCL** is 4.5.

For each time-period, $\mathbf{T_i}$, take $\mathbf{n_i}$ independent samples ($\mathbf{n_i}$ may be one), and calculate the mean, $\mathbf{X_i}$. Compute the standardized mean $\mathbf{Z_i}$ of the measured concentrations where only a single new measurement is obtained for each constituent at each event as:

$$Z_i = \sqrt{n_i}\,(X_i - \bar{X})/S$$

Where:

$\mathbf{X_i}$ = value obtained for a constituent during monitoring event **i**.

S = The standard deviation obtained from prior monitoring data from the same well.

When applicable, for each time period, $\mathbf{T_i}$, compute the cumulative sum, $\mathbf{S_i}$, as:

$$S_i = \max\{0,(Z_i - k) + S_{i-1}\}$$

Where max {A,B} is the maximum of A and B, and $S_o = 0$.

Plot $\mathbf{Z_i}$ and S_i against $\mathbf{T_i}$ on the control chart and the results may be plotted in standardized units or converted to the concentration units of the constituents being evaluated. An “out-of-control” situation (potential contamination) occurs whenever $Z_i \geq$ SCL or $S_i \geq$ h. Two different types of situations are controlled by the limits. Too large a standardized mean will occur if there is a rapid increase in concentration in the well. Too large a cumulative sum may also occur for a more gradual trend. A verified statistically significant change (SSC) will occur if both the initial result and a verification sample result consecutively exceed one of the above-mentioned statistical limits. Upgradient wells will be monitored for informational purposed only and will not be part of the verification resampling program.

2.1.2.1 Verification Resamples

The Shewhart and CUSUM portions of the control chart are affected differently by initial statistically significant changes (SSCs) from background. The Shewhart portion of the control chart compares each individual new measurement to the control limit, therefore the next monitoring event constitutes an independent verification of the original result. However, the CUSUM procedure incorporates all historical values in the computation, therefore, the effect of the apparent SSC will be present in both the initial and verification sample. Hence, the statistical test will be invalid unless the verification sample value replaces the initial SSC value. Therefore, initial SSC values will be replaced by verification resample results in order to confirm a SSC (Gibbons, 1994).

2.1.2.2 Updating Control Charts

As monitoring continues, the background mean and variance will be updated periodically to incorporate new data. At a minimum, every four years (eight sampling events), all new data that are in control will be pooled with the initial eight background samples and the mean and variance will be recomputed and used in constructing future control charts. The UDEQ (Utah Department of Environmental Quality) will be notified in our reports when we have updated the background data pool.

2.1.2.3 Censored Data

If less than 15 percent of the background observations are non-detects, these will be replaced with one half of the laboratory reporting limit prior to running the analysis (U.S. EPA, April 1989). If more than 15 percent but less that 50 percent of the background data are less than the detection limit, the data's sample mean and sample standard deviation are adjusted according to the methods of Cohen or Aitchison.

If more than 50 percent of the background data are less than the detection limit, a non-parametric prediction limit will be computed.

2.1.3 Non-Parametric Prediction Limits and Sen's Slope/Mann Kendall Trend Analysis

For those metals and inorganic indicator constituents with fewer than 50-percent detections within the background pool, a combined non-parametric upper prediction limit/Sen's Slope/Mann Kendall trend analysis will be applied. The Mann-Kendall analysis is a non-parametric test for a significant slope in a linear regression of the concentration values plotted against time of sampling. The Mann Kendall does not indicate the magnitude of the slope or estimate the trend itself, even when present. The Theil-Sen trend line is a non-parametric alternative to linear regression which can be used in conjunction with the Mann Kendall test. The analysis assigns each non-detect a common value less than any other detected measurement. An average slope is calculated by estimating the slope for every pair of distinct measurements in the sample, as such the analysis estimates the change in median concentration over time and not the mean. Parameters will be initially tested using the non-parametric prediction limit analysis. Constituents exceeding the non-parametric prediction limit will then be tested using the Sen's Slope/Mann Kendall trend analysis. An initial statistical exceedance will be indicated if the measured concentration exceeds both the non-parametric prediction limit and exhibits a significant upward trend. The combined methods provide a non-parametric control chart equivalent to allow detection of both major and gradual releases from the facility independent of spatial variation.

2.1.3.1 Non-Parametric Prediction Limit Analysis

An upper prediction limit is a statistical limit calculated to include one or more observations from the same population with a specified confidence. In groundwater monitoring, an upper prediction limit approach may be used to make comparisons between background and compliance well data. The limit is constructed to contain all **k** observations with stated confidence. Any observation exceeding the upper prediction limit provides statistically significant evidence that the observation is not representative of the background group. The number of observations, **k**, to be compared to the limit must be specified in advance. A flow chart illustrating the decision-making process during the analysis is provided as **Figure E-2**.

The highest value from the background data is used to set the upper prediction limit. In the case of a two-tailed test, the lowest value from the background data is used to set the lower prediction limit. Under EPA Standards, the false positive rate is based upon the formula:

$$\mathbf{1-(n/(n+k))}$$

Where:

$\mathbf{n}$ = The background sample size

$\mathbf{k}$ = The number of future values being compared to the limit.

2.1.3.2 Sen's Slope/Mann Kendall Trend Analysis

The Sen's Slope/Mann Kendall trend analysis procedure determines the significance of an apparent trend and evaluates the magnitude (slope) of that trend (IDT, 2002). The Mann Kendall test for temporal trend is a non-parametric procedure designed to test the null hypothesis, $\mathbf{H_0}$.

$\mathbf{H_0}$: No significant trend of a constituent exists over time.

And the alternative hypothesis, H_A:

$\mathbf{H_A}$: A significant upward trend of a constituent concentration exists over time.

Wells for which less than 41 data points are available, the exact test is applied. For 41 or more data points, the Normal Approximation test is used.

The Sen's Slope estimator portion of the combined method provides an estimate of the true slope. The method is a non-parametric procedure not greatly affected by gross data errors or outliers, and can be computed when data are missing.

2.2 Statistical Evaluation of Volatile Organic Compounds

Volatile organic compounds (VOCs) will be routinely monitored during the detection monitoring program. The statistical limit for VOCs detected in wells under detection monitoring will be set equal to the laboratory reporting limit (RL). RLs are provided in Table 1 of the facility's Groundwater Sampling and Analysis Plan (GWSAP). As with the prediction limit statistical method, VOC detections will not be considered statistically significant unless conformed by verification resampling. Verification resampling procedures are provided in **Section 2.3** and in the GWSAP.

2.3 Verification Resampling

Results for constituents that exceed statistical limits will not be considered statistically significant unless they are confirmed through verification resampling.

If a statistically significant change (SSC) from background of any tested constituent at any monitor well has occurred (i.e. is confirmed) and there is reasonable cause that a source other than the landfill exists, then a report will be submitted documenting the source as per **Section 5.1** of the GWSAP and UAC R315-308-2 (10)(c). Otherwise, assessment monitoring will be implemented in accordance with **Section 5.1** of the GWSAP and UDEQ regulations.

3 ASSESSMENT MONITORING STATISTICAL ANALYSIS

For assessment wells, constituents exceeding detection monitoring statistical limits and that have a groundwater protection standard (GWPS) established by the USEPA or the UDEQ, and/or any VOC detections will be statistically compared to GWPS using on-sided 95-percent lower confidence limits (LCL). Evaluations are conducted per Gibbons and Coleman (2001). The method constructs a normal confidence interval on the mean concentration of a constituent incorporating, at a minimum, the four most recent semi-annual measurements. A separate interval is constructed for each constituent of interest in each well of interest. A confidence interval is generally used when downgradient samples are being compared to a GWPS. A flow chart depicting the decision-making process during the analysis is provided as **Figure E-3**.

The lower 95-percent confidence limit on the mean will be compared to a GWPS to decide initially whether the mean concentration of a constituent of interest has exceeded a GWPS. If the lower 95-percent confidence limit on the mean exceeds the GWPS, then there is statistically significant evidence that the mean concentration of that constituent exceeds the GWPS. Upper 95-percent confidence limit analyses may be applied to constituents in which its 95 percent LCL has exceeded a GWPS. If the upper 95-percent confidence limit on the mean occurs lower than the GWPS then there is statistically significant evidence that the mean concentration of that constituent has returned to less than the GWPS.

3.1 Assumptions

The sample data used to construct the limits must be normally or transformed-normally distributed. In the case of a transformed-normal distribution, the confidence limit must be constructed on the transformed sample concentration value. In addition to the limit construction, the comparison must be made to the transformed GWPS value. When none of the transformed models can be justified, a nonparametric version of each limit may be utilized.

3.2 Distribution

The distribution of the data is evaluated by applying the Shapiro-Wilk or Shapiro-Francia test for normality to the raw data or, when applicable, to the Ladder of Powers (Helsel & Hirsch, 1992) transformed data. The null hypothesis, **H_O,** to be tested is:

H_O: The population has a normal (or transformed-normal) distribution.

The alternative hypothesis, **H_A**, is:

H_A: The population does not have a normal (or transformed-normal) distribution.

3.3 Censored Data

If less than 15 percent of the observations are non-detects, these will be replaced with one half the method detection limit prior to running the normality test and constructing the confidence limit.

If more than 15 percent, but less than 50 percent, of the data are less than the detection limit, the data's sample mean and standard deviation are adjusted according to the method of Cohen or Aitchison (U.S. EPA, April 1989). This adjustment is made prior to construction of the confidence limit.

If more than 50 percent of the data are less than the detection limit, these values are replaced with one half the method detection limit and a nonparametric confidence limit is constructed.

3.4 Parametric Confidence Limit Procedures

A minimum of four sample values is required for the construction of the parametric confidence limit. The mean, $\bar{\mathbf{X}}$, and standard deviation, **S**, of the sample concentration values are calculated separately for each compliance well. For each well, the confidence limit is calculated as:

$$\bar{X} \pm t_{(1-a,n-1)}\frac{S}{\sqrt{n}}$$

Where:

S = The compliance point's standard deviation

n = The number of observations for the compliance point and $t_{(1-a,n-1)}$ is obtained from the Student's t-Distribution (appendix B; U.S. EPA, April 1989) with (n-1) degrees of freedom.

The use of the 95th percentile of the t-Distribution is consistent with the 5 percent α – level of individual well comparisons. If the lower limit is above the compliance limit, there is statistically significant evidence that the constituent exceeds a GWPS.

3.5 Nonparametric Confidence Limit Procedure

The nonparametric confidence limit procedure requires at least seven observations in order to obtain a one-sided significance level of 1 percent. The observations are ordered from smallest to largest and ranks are assigned separately within each well. Average ranks are assigned to tied values. The critical values of the order statistics are determined as follows.

If the minimum seven observations are used, the critical values are the first and seventh values. Otherwise, the smallest integer, **M**, is found such that the cumulative binomial distribution with parameters **n** (sample size) and probability of success, p=0.5, is at least 0.99.

The exact confidence coefficient for sample sizes from 4 to 11 are given by the EPA (Table 6-3; U.S. EPA, April 1989). For larger samples, take as an approximation the nearest integer value to:

$$\mathbf{M} = \frac{n}{2}\mathbf{+1+Z}_{(1-\alpha)}\sqrt{\frac{n}{4}}$$

Where:

$\mathbf{Z}_{(1-\alpha)}$ = The $_{1-\alpha}$ percentile from the normal distribution found in Table 4 (appendix B; U.S. EPA, April 1989)

n = The number of observations in the sample.

Once **M** has been determined, (**n+1-M**) is computed and the confidence limits are taken as the order statistics, **X(M)** and **X(n+1-M)**. These confidence limits are compared to the GWPS as discussed in **Section 3**.

4 REFERENCES

Davis, Charles B. and McNichols, R.J., 1993. Exploring Ideas of “Background” in Groundwater Monitoring, Waste Management Update

Gibbons, Robert, D. 1994. Statistical Methods for Groundwater Monitoring, John Wiley & Sons, Inc. New York

Horsey, Henry R., and Carosone-Link, P., 1995. Managing RCRA Statistical Requirements to Minimize Ground Water Monitoring Costs, Proceeding of the American Chemical Society’s Eleventh Annual Waste Testing and Quality Assurance Symposium

Discerning Systems Inc., 2003. DUMPStat User’s Manual, Version 2.1.8, Burnaby, British Columbia

International Ground Water Modeling Center, 1995. Ground Water Statistics and Regulations, Colorado School of Mines, Golden, Colorado.

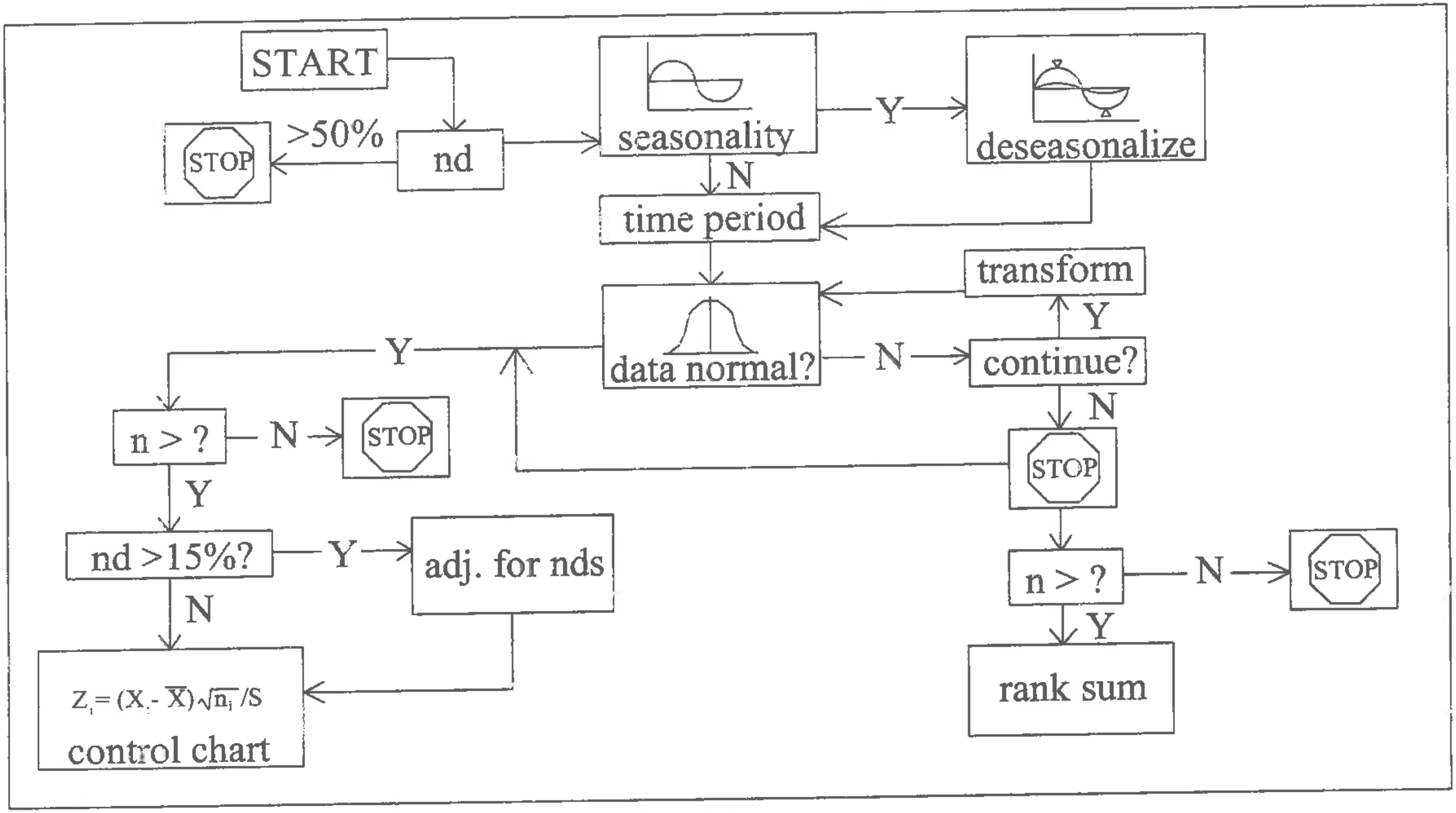
Lichaa, Ada. 1998. MSW Groundwater Monitoring Regulatory Procedures, Proceedings of the 1998 Environmental Trade Fair, Austin, Texas.

U.S. Environmental Protection Agency Office of Solid Waste, 1992. Statistical Training Course for Ground-Water Monitoring Data Analysis.

U.S. Environmental Protection Agency, 1989. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance, EPA/530/SW-89/026.

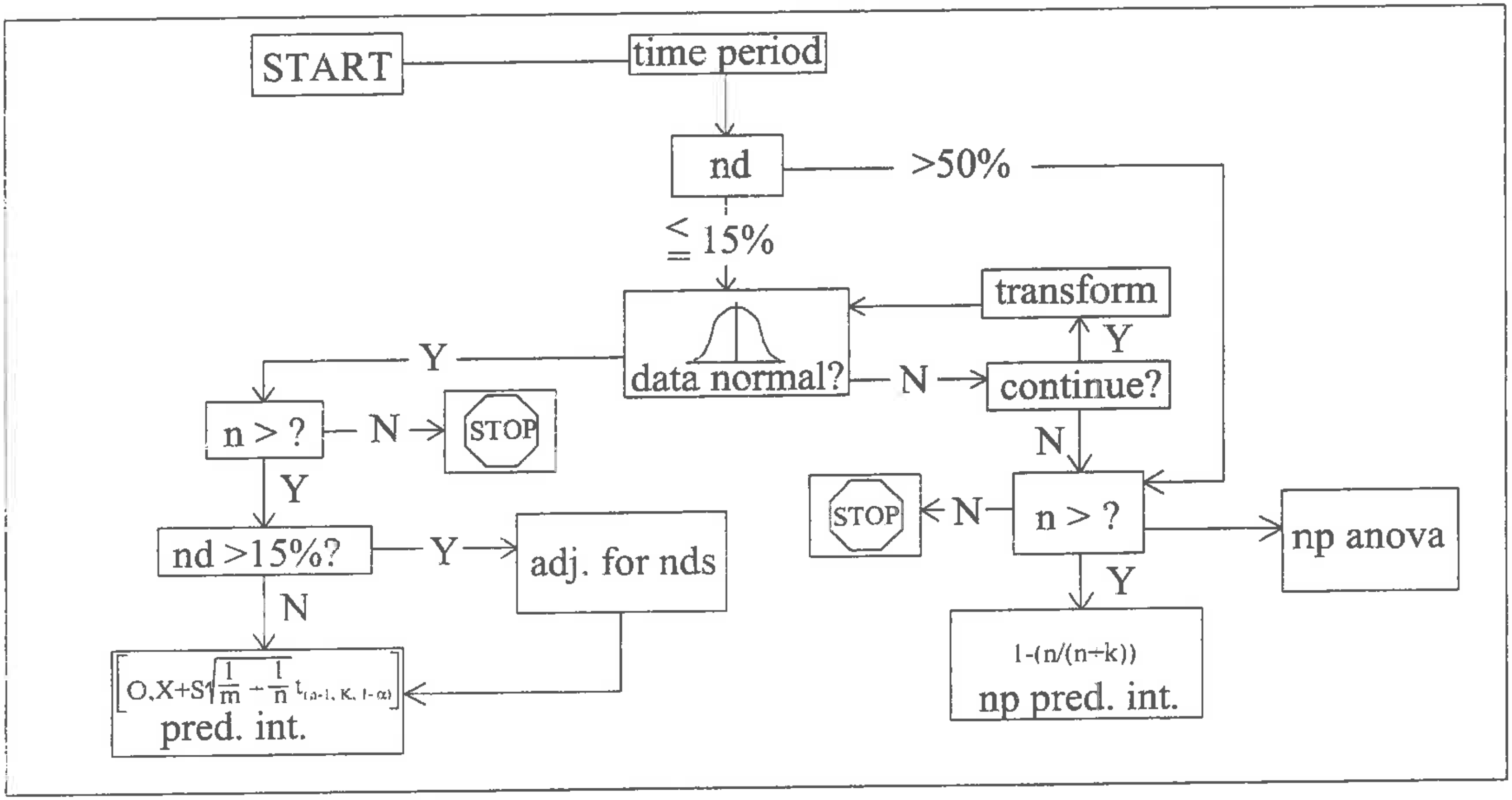
USEPA, 1992. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance (Draft).

FIGURE E-1
CONTROL CHART FLOWCHART



Source: Sanitas™ version 7.5

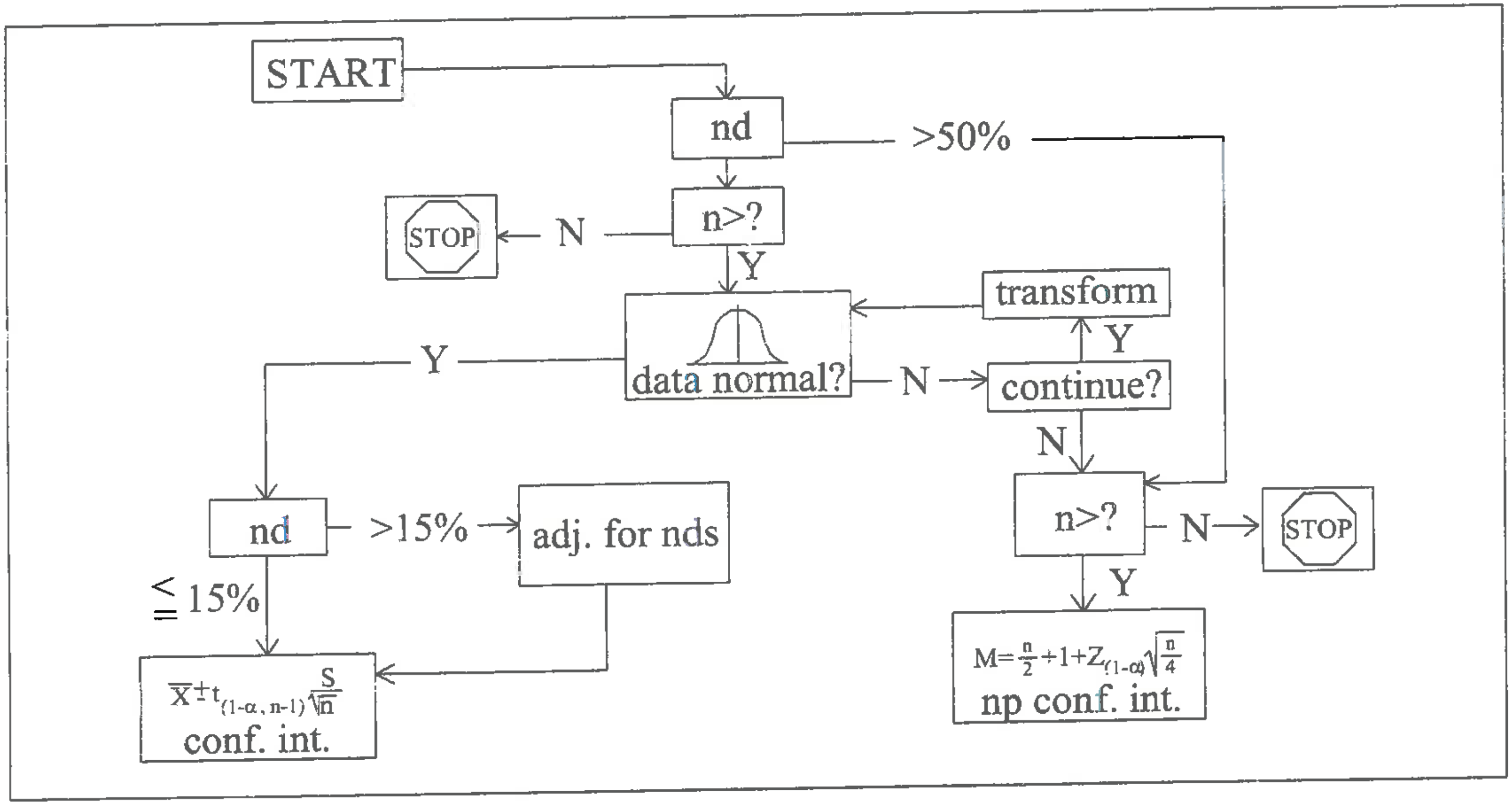
FIGURE E-2
PREDICTION LIMIT FLOWCHART



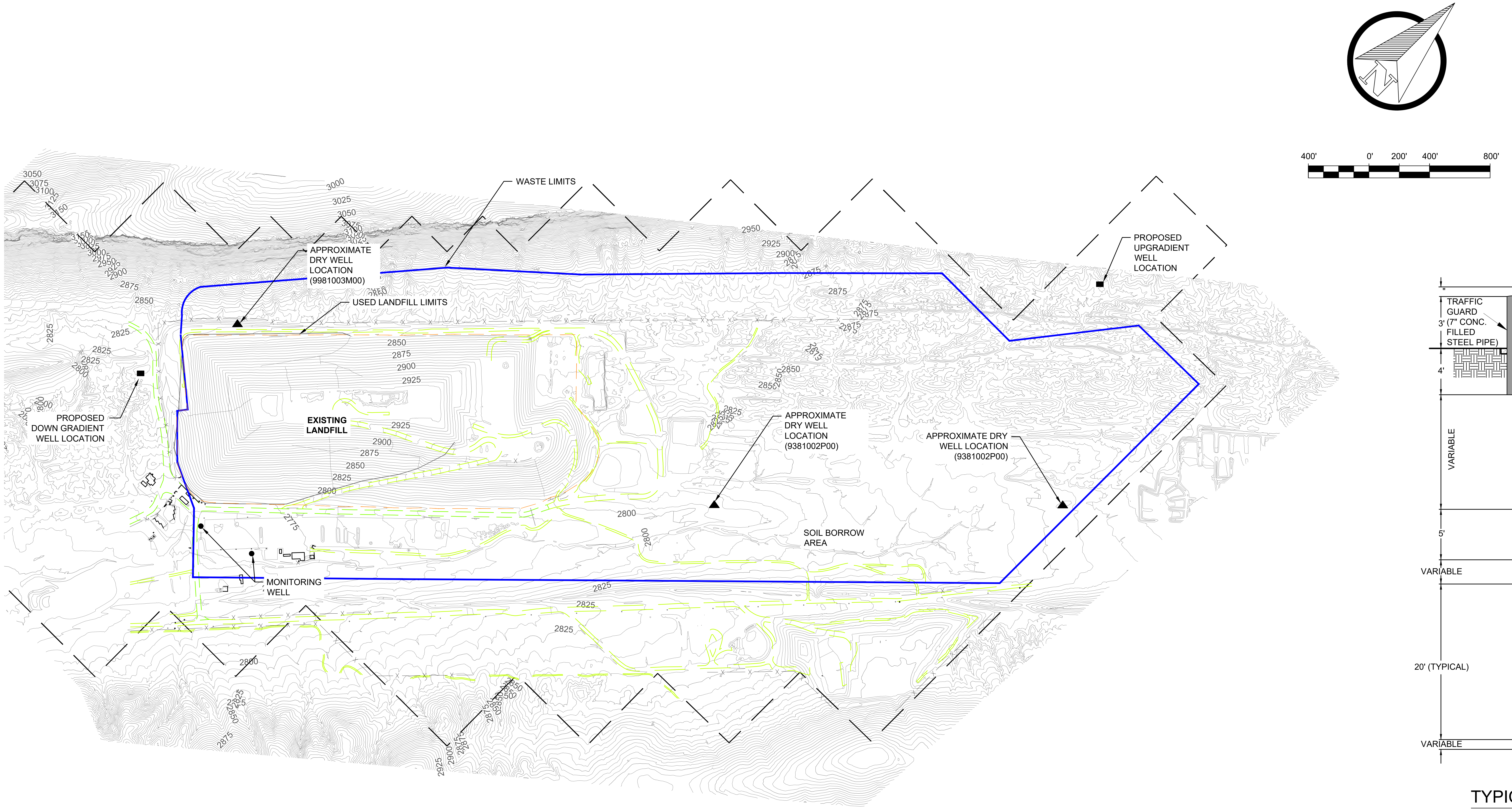
Source: Sanitas™ version 7.5

FIGURE E-3

95% CONFIDENCE INTERVAL FLOWCHART

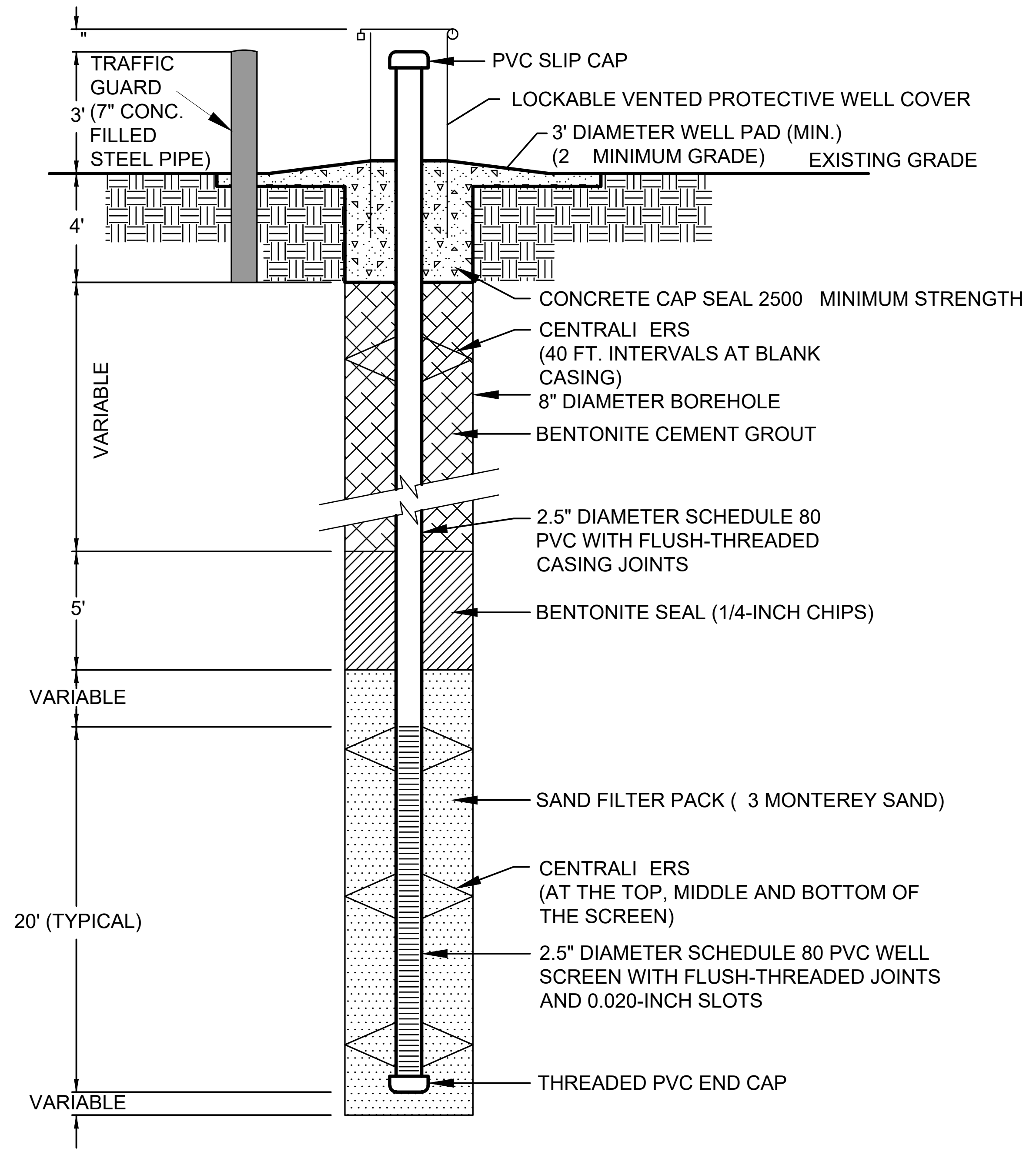


Source: Sanitas™ version 8.0



LEGEND

2800	EXISTING 25' CONTOUR
	EXISTING 5' CONTOUR
— — —	PROPERTY LINE
—x—x—x—	EXISTING FENCE
— — —	EXISTING PAVED ROAD
— — —	EXISTING UNPAVED ROAD
— — —	USED LANDFILL LIMITS
——	WASTE LIMITS
●	APPROXIMATE LOCATION OF EXISTING GROUNDWATER MONITORING WELL
▲	APPROXIMATE DRY WELL LOCATION
■	PROPOSED WELL LOCATION



TYPICAL PROPOSED WELL DETAIL$^{(2)}$

NOTES

1. REFERENCE AERIAL TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS CO.
2. PROPOSED WELL LOCATIONS AND DETAILS ARE APPROXIMATE AND SUBJECT TO CHANGE BASED ON INFORMATION AVAILABLE AT THE TIME OF DRILLING.

WASHINGTON COUNTY LANDFILL

PERMIT RENEWAL

WASHINGTON COUNTY, UTAH

PROJECTED WELL LOCATION

FIGURE NO.
1

PROJECT NO.
AU21.1210.00

DATE OF ISSUE: 10/05/2021 **DRAWN BY:** SAH **APPROVED BY:** SAH

Geo-Logic ASSOCIATES
143E Spring Hill Dr, Grass Valley, California 95945
geo-logic.com | 530.272.2448

N:\WASHINGTON COUNTY LANDFILL\AU21.1210.00_2021 PERMIT MODIFICATIONS\5_CAD\FIGURES\1 - SITE PLAN.DWG October , 2021 - 2:5 PM BY: GLA-USER

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ATTACHMENT O

WASHINGTON COUNTY LANDFILL MASTER PLAN REPORT

Master Plan Report
Washington County Landfill

Submitted to

Don't Waste Dixie

WCSW

WASHINGTON COUNTY SOLID WASTE

Washington County Solid Waste
325 North Landfill Road
Washington, Utah 84780

Prepared by

Geo-Logic
ASSOCIATES

143E Spring Hill Drive
Grass Valley, California 95945
www.geo-logic.com
Project #AU19.1274

September 2020

Certification

This Master Plan Report was prepared in accordance with generally accepted professional engineering principles and practices. This Master Plan Report makes no other warranties, either expressed or implied as to the professional advice or data included in it. This Master Plan Report has not been prepared for use by parties or projects other than those named or described herein. It may not contain sufficient information for other parties or purposes.

GEO-LOGIC ASSOCIATES

REGISTERED PROFESSIONAL ENGINEER
No. 5881834-2202
JACOB V. RUSSELL
3-31-2021
STATE OF UTAH

Jacob Russell, PE
Principle Engineer
jrussell@geo-logic.com
143E Spring Hill Drive
Grass Valley, CA 95945

Date signed: September 29, 2020

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1. Introduction

1.1 Overview

The Washington County Landfill (WCL) is currently operated under a landfill master plan prepared by Vector Engineering, Inc. in 2007. Since the 2007 Master Plan document, the owner of the facility, Washington County Solid Waste Special Service District #1 (WCSW), acquired approximately 65 acres of land from the Bureau of Land Management (BLM) that is adjacent to the western portion of the current WCL footprint. In December 2019, WCSW awarded a contract to Geo-Logic Associates, Inc. (GLA) to prepare a comprehensive update to the master development plan for landfill planning purposes that will incorporate the newly acquired land into future landfill expansion area. This document comprises the updated Master Plan for the WCL.

1.2 Site Description

The WCL is located at 37°08’15” N and 113°27’10” W in Washington County, Utah and has been operated by WCSW since 1980. This landfill is located in the south central portion of Washington County just east and south of the Washington City limits in an isolated drainage known as Purgatory Flat. Since the beginning of landfill operations at the site, the landfill waste stream has consisted of municipal solid waste and other non-hazardous municipal and industrial wastes, including green wastes and construction and demolition materials. The landfill facility is currently operated under contract by Washington County Landfill Inc., a wholly owned subsidiary of Republic Waste Services. The landfill facility is situated on ground owned by Washington County and leased to WCSW.

1.3 Regulatory Standards

The applicable regulations for design and permitting of the WCL are defined in the Utah Administrative Code (UAC), Title R315 – Environmental Quality, Waste Management and Radiation Control, Waste Management and the Code of Federal Regulations (CFR), Title 40, Part 258 (Resource Conservation & Reclamation Act, RCRA, Subtitle D).

The WCL is operated as a Class I solid waste facility as defined by UAC, R315-301-2(7). Solid waste facility location standards, general requirements, and closure requirements are described in R315-302, and solid waste facility standards for performance and design are described in R315-303.

1.4 Project Scope

The intent of this Master Plan is to provide a "blueprint" for development of the site in the short, medium, and long terms. GLA's scope of work consisted of defining the expansion limits of the landfill, developing revised subgrade grading plans and final fill grading plans, and providing detail of the expansion phases and sequencing plans. GLA's scope of work also consisted of performing the engineering evaluations necessary for the landfill development such as liner system design, leachate collection and stormwater system design, slope stability analysis, site capacity and service life calculations, closure design, and planning level construction cost estimates.

1.5 Report Organization

Section 2 of this Master Plan describes the characterization of the site. Section 3 contains a description of the expansion area development including phase excavation and sequencing, liner system, phase capacities, soil management, and the final closure configuration. The leachate collection and removal system (LCRS) design is presented in Section 4. Slope stability analyses for the critical final site configuration are detailed in Section 5. The surface water drainage analysis of the final site configuration and design of the drainage structures necessary to control both storm water run-on and run-off is described in Section 6. The estimated life-of-site calculations for the landfill development is detailed in Section 7. Planning level construction cost estimates associated with phase construction and the closure construction of the final site configuration is presented in Section 8.

2. Site Characterization

2.1 Regional and Site Geology

The regional and site geology were described in detail by Montgomery (1993) as part of the original siting of the landfill. The geologic data that was used to characterize the WCL site had been previously developed by the U.S. Bureau of Reclamation on the proposed Laverkin Springs Desalinization Ponds that were proposed to be located just north of the landfill site. The geologic investigations that have been completed to date indicate that the existing landfill site and proposed expansion areas can be designed and operated so as to meet all RCRA Subtitle D criteria and UAC R315-302 criteria, as administered by the State of Utah.

2.2 Hydrogeologic Conditions

Hydrogeologic conditions were described as part of the original site development by Montgomery (1993) and Montgomery (1994). As referenced in those geologic and hydrogeologic reports, regional groundwater appears to flow near the facility at a depth of approximately 800 feet. Based on studies conducted in the area by the U.S. Bureau of Reclamation, the rate and direction of groundwater flow in this "regional" system are probably highly affected by the geologic structure of the Harrisburg Dome and associated anticline. These data suggest that the flow of groundwater in the "regional" aquifer is to the southwest.

Faulting and fracturing in vicinity of the site has created localized zones of flow from nearby recharge areas. As discussed in the above-referenced reports, groundwater appears to flow from the outcrop of the Purgatory Buff Member of the Moenkopi formation to the southeast through a mapped fault. The aquifer which contains this groundwater appears to be perched and of local areal extent, with depths to groundwater of 15 to 20 feet. Two monitoring wells that were completed into this perched aquifer, denoted as MW-1 and MW-2, are used for ongoing groundwater monitoring of the site. Both MW-1 and MW-2 were drilled to depths of 100 feet below ground surface (bgs) with screen intervals from 20 feet bgs to 100 feet bgs. The monitoring wells are sampled semi-annually in accordance with the Groundwater Sampling and Analysis Plan (Carel Corporation, 2005).

There are insufficient data to make quantitative estimates of groundwater flow rate and the depths of groundwater within the perched aquifer near the site. However, based on interpretive geology in the above-referenced reports and the small quantities of groundwater yielded from MW-1 and MW-2, the rate of groundwater flow appears to be extremely slow within the perched aquifer. A hydrological investigation is recommended to define groundwater elevation in the future landfill phases. The hydrological study could be used to develop a groundwater model for the site.

2.3 Geotechnical Characterization

Montgomery (1993) reported a thin alluvial cover across the site, approximately 10 feet or less, with the thickest deposits being aprons along the edges of the Purgatory Flats and at the toes of the steeper slopes. The soil was described as clayey, sandy silt to silty sand with increasing gravel and sand content within the alluvial aprons.

Vector Engineering (2007) conducted a test pit investigation consisting of excavating and logging seventeen test pits across the landfill property as part of the previous Master Plan document for the WCL. That document described two primary types of soil material present at the site: 1) fine-grained silty sand, and 2) hard fractured rock that generally requires blasting during excavation. Fifteen of the seventeen test pits encountered the fine-grained soils within the upper 8 to 10 feet bgs, while two of the test pits encountered hard rock immediately at the surface. The test pit logs were used to give a general understanding of the overall site soil balance. Geotechnical laboratory testing on the materials was not reported.

3. Facility and Landfill Development

3.1 Overview

The WCL facility includes an existing landfill, WCSW office, shop building, scale and scale house, recycling area, composting area, and leachate evaporation pond. Future facility area developments are discussed in Section 3.2 while future landfill developments are detailed in the remaining sections, Section 3.3-3.8.

3.2 Facility Development

The existing site facilities area consists of one inbound and one outbound scale, a small scale house, a relatively small office building, and concrete pad with drop boxes used as public recycling area. The current location, layout, and size of the facilities area may not provide for the future increases in incoming recycling, composting, and solid waste. In addition, the current infrastructure layout has resulted in issues related to stormwater and sediment control. It is recommended that WCSW evaluate options to expand and modernize the facilities area for future expansion, increasing tonnage and growth, to meet the rising demand in recycling programs and improve stormwater control. Design criteria for future facilities area expansion and modernization could include:

- Scalehouse relocation, with 2 inbound and 2 outbound scales to accommodate increased traffic and RFID automatic scales
- Household hazardous waste area

- Community recycling drop off area
- Public convenience center
- New public drop off facility, located away from the current landfill operations
- Hazardous waste drop off
- Covered storage facility for garbage cans
- Improved stormwater management infrastructure
- New office building, located away from the landfill operations, larger building with sufficient space to host board meetings and a public interface area

3.3 Landfill Development

The existing landfill consists of an approximate 44-acre pre-Subtitle D area and adjacent Subtitle D lined cells designated Phases 1 through 4 totaling approximately 22.2 acres of total landfill footprint. Phase 4 was divided into four sub phases designated Phase 4A through Phase 4D. The existing lined landfill footprint encompasses Phase 1 through Phase 4D with 2.6-acre Phase 4D liner system constructed in 2020. This Master Development Plan provide and details the development of landfill Phases 5 through 12, which provide a plan for the ultimate build-out of the site and the final configuration of the landfill. The sub phasing of each individual unit will be developed as landfill development progresses and demands dictate. All Master Plan Drawings referred to in this text are presented in Appendix A of this document. The locations of Phases 1 through 12 are shown in Drawing C01.

The previous Master Plan for the WCL detailed Phase 3 and 4 footprints as they currently exist, and Phases 5-8 were planned to the north of the existing landfill (Vector Engineering, 2007). This Master Plan update utilizes the strip of land that has become available for landfilling along the previous western Master Plan boundary. The proposed phase layout is shown in Drawing C01, and phase sequencing plans are shown in Drawings C02 through C08. As shown in Drawing C01, Phase 5 is now adjacent to the western boundary of existing Phases 1-4. Phases 6-11 are to the north of the existing landfill representing an expanded footprint of the former Phases 5-8. Phase 12 is located directly adjacent to the eastern boundary of the existing landfill where the composting area and ancillary facilities currently exist.

3.4 Base Grades

The proposed base grades of the WCL will generally consist of interior side slopes cut at 2:1 (horizontal: vertical) down to a floor that will be graded with a series of ridges and swales at a minimum slope of 1.4% in Phase 5 and 2% in Phases 6-12. In general, the phased grading scheme is designed to promote positive drainage towards LCRS pipes and sumps. The base grading plan is shown in Drawing C01.

The estimated earthwork quantities to develop the proposed base grades are summarized in Table 1. The excavation materials are anticipated to consist of two general material types: 1) fine grained soil, and 2) hard fractured rock. The estimated quantities and management of these excavation materials is discussed in Section 3.8, below.

Table 1

Excavation/Fill Quantities by Phase

Landfill Phase	Planimetric Area (Acres)	Excavation (CY)	Fill (CY)
Phase 5	23.6	423,900	210,300
Phase 6	32.3	1,870,100	493,100
Phase 7	30.0	2,815,700	119,700
Phase 8	19.6	2,334,400	16,100
Phase 9	15.3	1,000,300	82,200
Phase 10	28.8	1,320,000	53,200
Phase 11	28.9	453,500	37,400
Phase 12	29.5	359,300	154,800
Total	**208.0**	**10,577,200**	**1,166,800**

CY = cubic yards.

3.5 Liner System

The liner system for the future expansion phases will be constructed in the same manner as the existing lined phases of the landfill. The liner system is depicted in Detail 1 on Drawing C10. This liner system is comprised of the following, from top to bottom:

- 18-inches Operations Layer
- Geocomposite Drainage Layer
- 60-mil Double-Sided Textured HDPE Geomembrane

- Geosynthetic Clay Liner (GCL)
- Prepared Subgrade

As each phase or sub-phase is constructed, the composite liner system from the new phase will be tied into the composite liner of the existing phase. Plywood or other protective material will be placed on the leading edge of the geomembrane along future tie-in areas to minimize damage and aid in construction. This will enable the contractor building the new cell to expose the previous geomembrane. Once the existing liner is cleaned and any damage repaired, the new geomembrane will be overlapped and seamed to the existing geomembrane. The underlying foundation layer will also be overlapped, as will the GCL and overlying LCRS materials.

Each of the liner system components mentioned above is discussed in more detail in the following sections.

3.5.1 Prepared Subgrade

The prepared subgrade will be constructed to provide a firm, unyielding surface for the GCL. Due to the rocky conditions of the excavation, it may be necessary for the contractor to over-excavate the subgrade and replace it with fine-grained soil to the design grades. The finished surface will be prepared by grading the subgrade soil and then rolling the surface with a smooth-drum vibratory compactor.

3.5.2 Geosynthetic Clay Liner

A GCL will be placed on the prepared subgrade as an alternative to a compacted clay liner. GCLs are manufactured by encapsulating granular sodium bentonite between geosynthetic materials. The bentonite is typically encased between two geotextiles. The geotextile encapsulated GCLs are sandwiched between woven slit-film, needle-punched nonwoven, or spun-laced nonwoven polymer fabric. The GCL for the future expansion phases will consist of a needle-punched nonwoven geotextile and a slit-film woven (or another nonwoven) geotextile, which encapsulates the bentonite and is then needle-punched together to provide strength and reinforcement. In accordance with the manufacturer’s recommendations, the GCL will be placed so that the nonwoven material is face up, putting that surface in contact with the overlying HDPE geomembrane.

3.5.3 HDPE Geomembrane

The geomembrane component of the composite liner system is a 60-mil, double-sided, textured HDPE film. The HDPE geomembrane has stringent manufacturer quality control (MQC) criteria as well as construction quality control (CQC) criteria, which will be outlined in Technical Specifications and a CQA Plan for each individual construction project. The interfaces of the geomembrane with the underlying GCL and the overlying geocomposite have shear strength requirements that are based on the slope stability analyses presented in Section 6.0, below.

3.5.4 Geocomposite Drainage Layer

Similar to the existing phases, the primary leachate collection layer will consist of a double-sided geocomposite. The geocomposite will consist of an HDPE drainage net bonded on both sides with a non-woven geotextile filter fabric. The geocomposite will be placed across the entire bottom and side slopes of the expansion areas, and will be anchored at the crest of the slope in a 2-foot deep anchor trench along with the HDPE geomembrane and GCL.

Many factors can affect geocomposite performance, such as geotextile intrusion, the chemistry of the leachate, migration of fine sediments, and biological activity. These factors have all been considered in the design of the LCRS at the WCL. A complete discussion of the LCRS is provided in Section 4.0 of this document.

3.5.5 Operations Layer

An 18-inch thick operations layer will be placed on the composite liner system to protect it from damage during waste placement. The operations layer will consist of on-site soils or other imported fine-grained materials. The operations layer will be screened or excavated from select areas to have a maximum particle size of one inch. To prevent damage to the liner system, the operations layer will be placed using low ground pressure equipment in a single lift.

3.6 Phase Capacities

The proposed future developments at the WCL will provide an estimated 73.8 million cy of total air space for solid waste disposal operations. The phase-by-phase fill plans are shown in Drawings C02-C08, and the final buildout fill plan is shown in Drawing C09. A summary of the approximate estimated capacities of the major phases of development are shown in Table 2.

Table 2

Waste Fill Capacity by Phase

Landfill Phase	Planimetric Area (Acres)	Estimated Capacity (CY)
Phase 5	23.6	7,657,000
Phase 6	32.3	5,531,600
Phase 7	30.0	5,538,800
Phase 8	19.6	2,612,900
Phase 9	15.3	4,532,500
Phase 10	28.8	11,869,000
Phase 11	28.9	17,890,00
Phase 12	29.5	18,147,300
Total	**208.0**	**73,779,100**

3.7 Soil Management

The quantities of soil generated or consumed at each stage of the landfill's development provide useful information for soil management purposes. The rocky nature of the soils in the excavation area and the shallow excavations create the potential for a soil shortage at the site. This section presents an assessment of the on-site soils and the sequential balance of soil for each phase of development.

As mentioned above, the subgrade materials at the WCL generally consist of a thin alluvial cover across the site, approximately 10 feet or less that is described as clayey, sandy silt to silty sand with increasing gravel and sand content within the alluvial aprons. Below the finer grained alluvial soils exists a hard fractured rock that typically requires blasting to excavate. The volume of the fine-grained soil material versus hard rock material in excavations was estimated based on the assumption of 6 feet of fine-grained soil across the site. This assumption was based on the geotechnical information presented by Vector Engineering (2007). GLA recommends that an updated geological/geotechnical site investigation be performed to confirm or refine the assumptions of this report. The estimated quantities of soil and rock excavation volumes are summarized in Table 3.

Table 3

Excavation Materials by Phase

	Fine Grained Soil (CY)	Rock Material (CY)	Total Excavation Volume (CY)
Phase 5	84,800	339,100	423,900
Phase 6	346,500	1,523,600	1,870,100
Phase 7	267,300	2,548,400	2,815,700
Phase 8	179,200	2,155,200	2,334,400
Phase 9	137,100	863,200	1,000,300
Phase 10	267,700	1,052,300	1,320,000
Phase 11	253,500	200,000	453,500
Phase 12	282,300	77,000	359,300
Total	**1,818,400**	**8,758,800**	**10,577,200**

Quantities of construction materials were calculated for each phase of the landfill development and closure, and are shown in Table 4. The excavation and engineered fill volumes were calculated from the liner system grading plan. Volumes were calculated for the operations layer of the liner system and the final cover system. In addition, volumes were calculated for the daily cover soil needed for the landfill operations, based on 15% of the total airspace.

Table 4 depicts the required soil quantities and type of material for each phase of the WCL development. The tables also include the fine-grained soil available from on-site borrow areas.

Table 4

Required Soil Material Quantities by Phase

	Engineered Fill (CY) (Rock)	Daily Cover Soil (CY) (Rock)	Total Quantities of Rock Material (CY)	Operations Layer (CY) (Fine-Grained)	Final Cover (CY) (Fine-Grained) (see note)	Total Excavation Volume (CY)
Phase 5	210,300	1,148,600	1,358,900	60,000	**1,379,100**	423,900
Phase 6	493,100	829,800	1,322,900	80,900		1,870,100
Phase 7	119,700	830,900	950,600	74,900		2,815,700
Phase 8	16,100	392,000	408,100	49,900		2,334,400
Phase 9	82,200	679,900	762,100	38,200		1,000,300
Phase 10	53,200	1,780,400	1,833,600	70,700		1,320,000

Phase 11	37,400	2,683,500	2,720,900	70,600		453,500
Phase 12	154,800	2,722,100	2,876,900	71,400		359,300
Total	**1,166,800**	**11,067,200**	**12,234,000**	**516,600**		**10,577,200**

NOTE: Based on a final cover with 12-inches of foundation layer, a geomembrane and 18 inches of protective soil and 6 inches vegetative cover.

These calculations consider a standard geosynthetic cover system consisting of a one-foot foundation layer, a geomembrane liner, a granular or synthetic drainage layer, eighteen inches of protective soil cover, and six inches of vegetative cover. The use of an alternative final cover system, such as an evapotranspirative (ET) cover, could significantly change the soil balance; however, an ET cover would require a reliable source of fine-grained soil in the vicinity of the site.

Table 4 shows that the total required quantity of fine-grained soil totals 1,895,700 cubic yards, and the estimated volume of fine-grained soil available from future excavations totals approximately 1,818,400. Thus, there is an approximate balance of fine-grained soil based on the assumptions of this report with a slight deficiency of 77,300 cy. Further geotechnical investigation is recommended to classify and quantify available materials on site.

The total soil balance of all materials required (i.e. rock and fine-grained soil) is estimated to be approximately 14,129,700 cy, and the total excavation volume of future cells was estimated to be approximately 10,577,200 cy. Thus, based on the assumptions stated in this report, there is an approximate shortage of 3,552,500 cy of material.

Vector Engineering (2007) reported a nearby source of approximately 600,000 cy of fine-grained material and as well as 2,000,000 to 3,000,000 cy of rock material available for landfill use from the area to the east of the landfill iithin the property boundary. The County-owned property to the southwest of the WCSW office and the landfill, which was not investigated or considered in the Vector Engineering (2007) borrow investigation, could provide an additional source for soil and rock materials. A geotechnical investigation is recommended to identify additional borrow sources of rock and fine-grained soil materials.

3.8 Closure Configuration

The top of waste configuration of the WCL after the filling of all the Phases is shown in Drawing C09. This drawing shows the 3:1 refuse side-slopes and a sloped peak along the spine of the landfill leading to a maximum elevation of approximately 3,102 feet above mean sea level (amsl). The 3% top deck grades leading to the side-slopes maintain positive drainage after waste settlement. One access roads lead to the top deck and intermediate drainage benches are placed every 50 feet in vertical elevation. These benches run from the north side of the landfill to the south. Additional drainage features are presented in Section 6.0 of this document.

The final cover system is depicted in Detail 10 on Drawing C12 and consists of the following from top to bottom:

- 6-inch Vegetative Cover
- 18-inch Protective Soil Cover
- Geocomposite Drainage Layer
- HDPE Geomembrane Liner
- 12-inch Foundation Layer

4. Leachate Collection and Recovery System (LCRS)

4.1 Overview

The base grades of the WCL will generally consist of interior side slopes cut at 2:1 down to a floor that will be graded with a series of ridges and swales at a minimum slope of 2 percent. The bottom containment system (i.e. liner system) design for the WCL consists of a composite liner system on the floor and side slopes. The primary leachate collection layer consists of a geocomposite drainage layer above the primary geomembrane liner to collect and convey leachate that may be generated within the disposal area. The geocomposite drainage layer will be double sided with nonwoven geotextile fabric bonded both above and below to act as a filter to control clogging from above and to act as a cushion and provide shear strength below. The general flow of leachate is into a network of perforated leachate collection pipes that will convey leachate by gravity flow to one of sixteen main leachate sumps where leachate will then be extracted through perimeter side slope riser pipes. The proposed base grading plan and leachate collection system layout of the landfill is shown in C01. The LCRS was designed to collect and remove twice the maximum anticipated daily volume of leachate from the unit while maintaining no more than one foot of leachate head on the liner.

4.2 Leachate Generation

The leachate generation of future expansions at the WCL was estimated by modeling the water balance of the proposed facility using the USEPA model Hydrologic Evaluation of Landfill Performance (HELP), version 3.07. The HELP model was used to calculate the maximum impingement rate for purposes of drainage layer transmissivity calculations, leachate collection pipe design, as well as the calculated maximum leachate head on the liner. Leachate generation potential for this analysis was evaluated for the critical active cell condition of the landfill operations, described below.

4.2.1 HELP Model Description

The HELP model is a 'quasi 2-dimensional' deterministic water balance model that uses daily climate data, soil and refuse characteristics, and liner system design data to predict the movement of water into, within, and leakage out of the landfill boundaries. The US Army Corps of Engineers first generated the HELP model in 1983 under a contract with the United States Environmental Protection Agency (USEPA). Documentation of Version 3.07 of the HELP model can be found in Schroeder et al. (1994).

4.2.2 Landfill Profiles Simulated

Peak daily leachate generation potential is typically highest during the early stages of landfill operations when a relatively thin (i.e. 10 foot) layer of waste has been placed across the entire floor of the cell. As waste thickness increases, the storage capacity of the landfill tends to go up, which provides a buffer to large storm events and generally leads to attenuated peaks in leachate production. After closure construction, leachate production is expected to be greatly reduced. As such, the simulated profile consisted of a 10-foot waste thickness to represent the critical stage of leachate production for the future WCL expansions. The simulated liner system is consistent with that described in Section 4.0, above.

4.2.3 Climate Input

Climate data required as input into the HELP model consists of evapotranspiration (ET) parameters and daily values for precipitation, temperature, and solar radiation. Daily climate input was synthetically generated based on the HELP model's synthetic weather generator using the default model coefficients for Cedar City and Milford, Utah.

Precipitation input was specified based on historical climate data from the St. George (COOP) weather station (No. 427516) (www.wrcc.dri.edu). The St. George weather station reports an average annual precipitation of 8.3 inches based on a period of record from 1893 through 2019. The maximum precipitation year consisted of 16.2 inches of rainfall during 2019.

Two precipitation scenarios were considered for the design simulations. The first scenario consisted of a ten-year simulation period with average monthly totals from the St. George weather station used as model input. The peak daily event resulting from that scenario was 1.12 inches, and the maximum annual precipitation from that scenario was 10.6 inches. The second scenario consists of a single year with the maximum annual precipitation of 16.2 inches used as model input. The peak daily event resulting from the maximum year scenario was 1.42 inches. The scenario using the maximum precipitation year yields the highest amount of water collected and is considered the critical design scenario for all LCRS calculations discussed below.

In addition to daily precipitation, temperature, and solar radiation, climate input pertinent to evapotranspiration (ET) calculations within the HELP model include the evaporative zone depth, maximum leaf area index, growing season start and end dates, average annual wind speed, and the average relative humidity for each quarter in the year. HELP model defaults for Cedar City, Utah were specified. An evaporative zone depth of 16 inches was used, which corresponds to a "bare" ground surface. Plants were conservatively not included in the analyses, as represented by a leaf area index of 0.0

4.2.4 Material Properties

A summary of the soil and material properties used for HELP analyses are shown in Table 5. The HELP model defaults were used for characterizing the daily cover, waste, operations layer, drainage layer, geomembrane, GCL, and subgrade layers. The daily cover, operations layer, and foundation/subgrade layers were assumed to have properties of a clayey sand (SC) with a saturated permeability of 1.2×10^{-4} cm/s (default material texture No. 10). This assumption was based on the work presented by Vector Engineering (2007). Steady state initial moistures were specified for all layers. The percentage area susceptible to runoff was conservatively assumed to be 0 percent.

The slope and drainage length of the drainage layer was varied for different Phases of the design. For Phase 5, the maximum drainage distance of 300 feet was specified with a 2% floor slope. For Phases 6-12, the maximum drainage distance of 215 feet was specified with a 2.8% floor slope.

Table 5

Summary of HELP Model Material Properties

Layer Description	Thickness (in)	Hydraulic Conductivity (cm/s)	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)
Daily Cover	6	1.2x10-4	0.398	0.244	0.136
Municipal Solid Waste	120	1.0x10-3	0.671	0.292	0.077
Operations Layer	18	1.2x10-4	0.398	0.244	0.136
Geocomposite Drainage Layer	0.2	Varies [1]	0.850	0.010	0.005
HDPE Geomembrane	0.06	2.0x10-13	NA	NA	NA
GCL	0.2	3.0x10-9	0.75	0.747	0.40
Foundation/Subgrade	12	1.2x10-4	0.398	0.244	0.136

Notes: 1. See drainage layer design section, below.

4.2.5 Results

Water balance predictions for the four landfill profiles are shown in Table 6, and HELP model output files are included in Appendix B.1. Peak daily drainage results were used as the 'impingement rates' for maximum head calculations, drainage layer permeability calculations, collection pipe sizing, and leachate storage calculations, which are described in the following sections. The maximum predicted head is less than the drainage layer thickness of 0.2 inches, thus confirming the condition of unconfined flow, which makes the maximum head equations valid (Giroud et al., 2000) and satisfies the criteria set forth in UAC R315-303-3(2)(a)(ii).

Table 6

Summary of HELP Model Predictions

Landfill Phase	Climate Scenario	Average Annual Results				Peak Daily Results	
		Precip (in/yr)	Runoff (in/yr)	ET (in/yr)	LCRS Drainage (in/yr)	Maximum Head (in)	LCRS Drainage (in/yr)
Phase 5	Avg	8.46	0.00	8.35	0.014	0.01	0.006
	Max	13.22	0.00	11.62	1.64	0.19	0.13
Phases 6-12	Avg	8.46	0.00	8.35	0.014	0.01	0.006
	Max	13.22	0.00	11.62	1.64	0.19	0.13

4.3 Drainage Layer Design

4.3.1 Geocomposite Transmissivity

The transmissivity of the geocomposite drainage layer for future expansions of the WCL was evaluated using a method described by Giroud et al. (2000). The equations described provide a method to evaluate liquid collection layers comprised of a single slope that contains a drain at the toe. In the case of the WCL design layout, the critical single slope with respect to geocomposite transmissivity was judged to be the floor slopes where collected leachate will flow through the drainage geocomposite into perforated drainage pipes that will be placed at the bottom of swales and at the toes of the transition between floor and side slope. Because the proposed Phase 5 base grades differ from the remaining expansion phases, the geocomposite drainage layer is specified for Phase 5 and for Phases 6-12 separately, based on the maximum drainage distance and floor slope.

The required transmissivity of the geocomposite drainage layer was calculated by multiplying the peak daily lateral drainage from the critical case of HELP model simulations (i.e. the maximum impingement rate of 0.13 inches/day, see Table 6) by the representative drainage length, divided by the sin of the slope angle. The resulting required transmissivities are 1.8 x 10^{-4} m^2/s for Phase 5 and 9.0 x 10^{-5} m^2/s for Phases 6-12.

The allowable (or specified) transmissivity was calculated by multiplying the required transmissivity by a series of Safety Factors (SFs) to account for intrusion/elastic deformation, creep deformation, chemical clogging, and biological clogging. The values used for SFs were based on the recommendations in Koerner and Koerner (2007) for primary leachate collection (landfills), resulting in an overall SF ranging from 8.4 for Phase 5 to 9.8 for Phases 6-12. Note that the difference in overall SFs between Phase 5 and Phases 6-12 is due to the higher waste heights and normal loads anticipated on the liner in Phases 6-12 (i.e. a higher SF for creep deformation was used for Phases 6-12, see transmissivity calculations in Appendix B.2). The resulting allowable transmissivities are 1.5 x 10^{-3} m^2/s for the Phase 5 geocomposite drainage layer, and 8.9 x 10^{-4} m^2/s for the Phases 6-12 geocomposite drainage layer. Transmissivity calculations are shown in Appendix B.2.

4.3.2 Geocomposite Compressive Strength

The required strength of the geocomposite should be at least twice the maximum expected vertical stress that the geocomposite will be exposed to. Geocomposite compressive strengths were evaluated for three general areas of the proposed landfill development based on maximum waste height from the proposed master fill plan grades. Phase 5 will have a maximum waste height of 180 feet above the liner system, Phases 6-11 will have a maximum waste height of 300 feet, and Phase 12 will have a maximum waste height of 250 feet (in the northern corner of that phase). Assuming a unit weight of 90 pcf for municipal solid waste, the vertical stress the geocomposite is expected to experience is approximately 16,200 psf, 27,000 psf, and 22,500 psf for Phase 5, Phases 6-11, and Phase 12, respectively. Assuming a 2.0 factor of safety for material compressive strength, the geocomposite should have the minimum compressive strengths that are listed in Table 7. Products are commercially available that meet these compressive strengths.

Table 7

Geocomposite Compressive Strength by Phase

Landfill Phase	Geocomposite Compressive Strength (psf)
Phase 5	32,400
Phases 6 -11	54,000
Phase 12	45,000

4.4 Collection Pipe Design

4.4.1 Pipe Capacity/Sizing

Leachate will be collected from the geocomposite drainage layer by 6-inch diameter perforated pipes located in the valleys of each swale that flow at slopes of approximately 1.4% (Phase 5) to 2.0% (Phases 6-12) into a respective sump (see C01). The pipes were sized to accommodate peak leachate generation from the maximum contributing area of lined cell. Pipe capacity calculations were performed using the methodologies described in Qian, et al. (2002) and are included in Appendix B.3.

Manning's equation was used to calculate the ultimate flow (Q_{ult}) of the recommended 6-inch diameter collection pipes for each phase based on the following assumptions: minimum drain slope (1.4% for Phase 5 and 2.0% for Phases 6-12), a Manning's roughness coefficient of 0.011

(typical value for HDPE pipe Qian et al., 2002) and full pipe flow. Based the peak daily flow from HELP model drainage predictions (see Table 6) multiplied by the maximum contributing area to a single collection pipe from each phase, the maximum flow (Q_{reqd}) through the 6-inch collection pipes was estimated. Results are summarized in Table 8. The factors of safety (FS) for pipe capacity were calculated by dividing Q_{ult} by Q_{reqd}, and are also summarized in Table 8.

Table 8

Summary of Collection Pipe Capacity by Phase

Landfill Phase	Maximum Contributing Area (acres)	Q_{ult} (gpm)	Q_{reqd} (gpm)	FS
Phase 5	10.5	206.7	25.9	8.0
Phase 6	5.5	179.6	13.6	13.2
Phase 7	5.8	179.6	14.3	12.6
Phase 8	3.3	179.6	8.1	22.1
Phase 9	5.7	179.6	14.1	12.8
Phase 10	6.3	179.6	15.5	11.6
Phase 11	6.8	179.6	16.8	10.7
Phase 12	3.9	247.0	9.6	25.7

The LCRS riser pipe from the sump is sized at 18-inch diameter, which will provide additional capacity to accommodate higher pump rates for leachate removal.

4.4.2 Pipe Perforation Sizing

The size of the perforations in the leachate drainage pipes are designed for maximum leachate inflow per unit length of pipe as well as for compatibility with the grain size distribution of the filter material (i.e. gravel) in contact with the pipe. Perforation size calculations based on maximum estimated leachate inflow are included in Appendix B.3 and suggest that a minimum perforation size of 3/8-inch diameter results in a requirement of approximately 1 perforation per foot of pipe. The recommended perforation pattern provides 8 perforations per foot, resulting in a FS of 8 for pipe inflow with the recommended minimum perforation size of 3/8-inch diameter. Note that larger perforations are desired where pipe strength/overburden pressure allows, and that the perforation size recommended herein represents the minimum size for design pipe inflow. The recommended maximum perforation size by Phase is discussed in the Pipe Strength section below, and perforation size for each subphase may be evaluated by a qualified engineer during detailed construction-level design.

The grain size distribution of the drainage gravel that is in contact with the pipe is designed for compatibility with the recommended perforation size. The US Bureau of Reclamation (1973) suggests the following criteria for grain size of filter materials in relation to openings in pipes:

$$\frac{D_{85}\ of\ Filter\ Gravel}{Perforation\ Diameter} \geq 2$$

Thus, with a perforation diameter of 3/8 inch, the D_{85} of the drainage gravel in contact with the pipe should be $\underline{>}$ 3/4 inch. Any changes or nonconformances related to the grain size distribution of the drainage gravel or the pipe perforation size or frequency should be verified by the design engineer at the time of construction.

4.4.3 Pipe Strength

The strength of the LCRS drainage pipes has been designed to accommodate the weight of the overlying waste. Similar to the geocomposite compressive strength calculations, the calculations of pipe strength at the WCL were evaluated for different phases of the landfill based on maximum waste heights from the proposed master fill plan grades. Under the final closure scenario, it is anticipated that up to approximately 300 feet of waste and 4 feet of cover soil will overlay the leachate collection pipes in Phases 6 through 11. Phase 5 has a maximum waste height of 180 feet over the LCRS pipes, and Phase 12 has a maximum waste height of 200 feet over LCRS pipes. Pipe strength for sump/riser pipes were also calculated separately by phase based on the maximum waste heights over respective sump areas.

Pipe strength calculations were based on the methodologies described in the Handbook of Polyethylene Pipe, Installation Category #3: Deep Fill Installation (PPI, 2012). These methods consist of discrete computations for 1) compressive ring thrust stress, 2) ring deflection, and 3) constrained pipe wall buckling. The calculations account for an increase in design overburden stress due to perforation size and frequency, elevated temperature of 100 °F for landfill leachate, load duration of 100 years, and the resulting reduction of the long-term modulus of elasticity of the pipe. Other assumptions that were made for the pipe, waste, and embedment material properties are shown in the calculation spreadsheets included in Appendix B.3. The results are presented in Table 9 in the form of recommended maximum standard dimension ratio (SDR) and maximum perforation size for pipes in each Phase of the proposed WCL expansions.

Table 9

Recommended Pipe Standard Dimension Ratios (SDR)

Landfill Phase	Perforated Collection Pipe		Sump/Riser Pipe	
	SDR	Maximum Perforation Size (in)	SDR	Maximum Perforation Size (in)
Phase 5	11	0.5	17	0.625
Phase 6	7.3	0.375	11	0.5
Phase 7	7.3	0.375	11	0.5
Phase 8	7.3	0.375	13.5	0.625
Phase 9	7.3	0.375	13.5	0.625
Phase 10	7.3	0.375	13.5	0.625
Phase 11	7.3	0.375	17	0.625
Phase 12	11	0.5	17	0.625

5. Slope Stability Analyses

5.1 Overview

The following sections summarize the methodology, assumptions, and results of evaluations to assess the stability of the proposed slopes for the WCL. The objectives of the slope stability analyses are to assess the grades of the proposed development while establishing shear strength criteria for the liner system components. The stability of the proposed development at WCL was evaluated in the context of the global stability of the waste mass on the liner system for the critical cross sections of Phases 5 through 12 for the final buildout condition.

5.2 Seismic Hazard

5.2.1 General

UAC R315-302-1(2)(b)(iii) and 40 CFR § 258.14(a) requires that new landfills or lateral expansions of an existing facility that are located in a seismic impact zone be designed to withstand the effects of ground shaking associated with the maximum horizontal acceleration for the site. 40 CFR § 258.14(b)(1) defines a seismic impact zone as, "*an area with a 10% or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of* *the earth's gravitational pull (g), will exceed 0.10g in 250 years,"* and CFR § 258.14(b)(2) defines the maximum horizontal acceleration as ,"*the maximum expected horizontal acceleration depicted on a seismic hazard map, with a 90 percent or greater probability that the acceleration will not be exceeded in 250 years, or the maximum expected horizontal acceleration based on a site-specific seismic risk assessment.*"

Like most of the State of Utah, the WCL site is considered to be in a seismic impact zone, as shown in Figure 1. This section addresses the seismic hazard for the site, consisting of an evaluation of historical earthquakes, nearby faults, and probabilistic estimates of the maximum horizontal ground motion from tectonic sources that might affect the site.

5.2.2 Historical Seismicity

A search of historical earthquakes occurring between 1850 and 2020 was performed for a 100-mile radius around the project site using the U.S. Geological Survey's ANSS Comprehensive Earthquake Catalog. During this time period, 63 earthquakes with magnitudes (M) equal to or greater than 4.0 were recorded. Of these 63 recorded earthquakes, 8 were strong earthquakes with M > 5. The strongest earthquake during this period was recorded along the Hurricane fault zone in September 1992 and had a magnitude, M = 5.9. The epicenter for this earthquake was approximately 5 km from the site, and happens to be the closest to the site for recorded events. The results of the historical earthquake search are included in Appendix C.1.

5.2.3 Regional Faults

The regional and local quaternary faults in the vicinity of the WCL were described by Vector Engineering (2007) and are summarized below.

Table 10

Closest Quaternary Age Faults

Fault Name	Most Recent Movement	Distance from Site (Miles)
Washington Fault Zone	<130,000 years ago	3.5
Volcano Mountain Faults	<750,000 years ago	7.5
Hurricane Fault Zone (Anderson Junction)	<15,000 years ago	8.1
Hurricane Fault Zone (Ash Creek)	<15,000 years ago	12
Hurricane Fault Zone (Cedar City)	<15,000 years ago	15
Gunlock Fault	<1,600,000 years ago	19

The proposed expansion meets the location siting requirement set forth in UAC R315-302-1(2)(b)(ii), which states that "*a new facility or lateral expansions of an existing facility shall not be located within 200 feet of a Holocene fault….*"

5.2.4 Probabilistic Estimates of Ground Motions

A site specific probabilistic seismic hazard assessment was performed for the WCL using up-to-date tools for probabilistic earthquake assessment provided by the United States Geological Survey (USGS). Generally speaking, past ground motion characterizations for landfill stability evaluations have focused solely on peak ground acceleration (PGA). More recently, practical methods for incorporating the ground response at the fundamental period of vibration of a potential slide mass have been developed (e.g., Bray and Travasarou, 2007). Since seismically-induced permanent displacements of a slide mass are correlated more closely with higher periods of vibration than the PGA, ground motions have been characterized herein using acceleration response spectra (ARS) curves, which include the PGA.

A USGS seismic hazard deaggregation analysis was performed through the USGS website, employing the site latitude and longitude of 37.14107° and 113.44769° for the design probabilistic event (maximum horizontal acceleration) with a 10% probability of exceedance in 250 years, or 2% probability of exceedance in 50 years. The deaggregation analysis indicated a site PGA of 0.255g resulting from a mean (over all sources) Magnitude 6.6 earthquake located approximately 13.5 km from the site assuming an average shear wave velocity in the top 30 m (VS-30) of 760 m/s (Site Class B/C). The modal contributing source is a Magnitude 6.5 earthquake from the Hurricane fault located approximately 11.8 km from the site. It should be noted that the PGA and ensuing ARS curve used herein is greater (i.e., more conservative) than the 2% in 50-year PGA of 0.24g that was used in the Vector Engineering (2007) stability analyses. The USGS deaggregation analyses and the design ARS curve are shown in Appendix C.1.

5.3 Design Criteria

For slope stability design of landfills, results are typically expressed by a factor of safety (FS) against failure. UAC R315 nor 40 CFR § 258 do not contain specific design criteria with respect to a static FS for landfill slopes. The state of practice for static stability of landfill slopes is to design for a FS equal to or greater than 1.5 for final slopes. This criterion is consistent with past analyses at this site and was adopted for use in the current design evaluation.

For seismic stability of landfill slopes, the state-of-practice approach is not to express a FS, but to calculate the amount of permanent displacement accumulated during a design seismic event. For landfill liners, a displacement threshold of no more than 12 inches is generally considered acceptable, and for unlined facilities and landfill covers that do not contain geosynthetic components, a threshold of up to 1 meter is considered acceptable (Seed and Bonaparte, 1992). A seismic displacement threshold of 6 inches was conservatively adopted for use in this evaluation.

5.4 Method of Analyses

The computer program SLOPE/W, version 10.1.1 (GeoStudio, 2019) was used to perform the slope stability analysis. SLOPE/W is a two-dimensional slope stability analysis program based on limit equilibrium approach and method of slices for evaluating the stability of circular or non-circular failure surfaces in soil, rock, or waste slopes. The FS against failure is defined as the ratio of total equilibrium shear stress acting on the failure surface to available shear strength along that same surface. The calculations of FS of a slope were performed using Morgenstern-Price (1965) method, as coded in SLOPE/W.

The seismic stability was evaluated by calculating the intensity of permanent seismic displacement or deformation (u_{max}) from the results of seismic hazard analysis (acceleration response spectrum), assumed stiffness of the waste profile, and results of seismic deformation analysis (yield acceleration, k_y and shape of the critical pseudostatic failure surface). The deformation caused by the design earthquake was calculated using the method proposed by Bray and Travasarou (2007). This model has been shown to provide estimates of seismic displacements that are generally consistent with documented cases of earth dam and solid waste landfill performance, and has become widely accepted throughout the industry. The magnitude and spectral acceleration values of the design earthquake are described in Section 5.2, above.

5.5 Slope Geometry

The slope geometry is defined by the proposed Liner and Leachate Collection Plan grades and the final Top of Waste grading plan, shown in C01 and C09, respectively. The bottom liner grades consist of 2% floor slopes that flow outwards towards sump locations near the perimeter of the landfill. Perimeter side slopes extend upwards from the floor at a grade of 2:1 until existing grades and the perimeter road are tied into. The final waste fill grades consist of overall 3:1 side slopes that extend up to a top deck with a 3% grade sloping outward for drainage.

One cross section (A-A′) was developed for stability calculations, representing the critical two-dimensional (2D) cross section of the buildout grades of the landfill with respect to slope stability. The location of cross section A-A′ is shown in Figure 2. Cross section A-A′ represents the maximum height of the proposed waste fill grades combined with the lowest height of the perimeter side slopes that provide resistance to sliding.

The bottom and side slope liner systems were modeled as a single layer with the strength parameters of the weakest interface. Stability calculations were performed for block-type failure surfaces along the bottom liner to assess the interface shear strength requirements for the liner system. Stability calculations were also performed for rotational failure surfaces through subgrade materials to assess overall landfill stability.

5.6 Material Properties

The material properties used in the stability analyses are summarized in Table 11. The floor and slope liner systems were modeled based on assumed properties of the critical interface, which was judged to be between the textured HDPE geomembrane and either the overlying geocomposite drainage layer or the underlying GCL, or internally within the GCL. GLA developed a site-specific shear-normal function specification for the liner system interface strengths given the profiles and configurations assessed herein. Shear-normal functions are shown in Figure 3.

Typically, waste settlement and corresponding downdrag forces can mobilize side slope liner systems into residual strength mode; however, downdrag forces on floor liners are minimal due to the relatively shallow slope. Therefore, post-peak strengths (measured at 3 inches of displacement) were used to characterize the side slope liner, and peak strengths were used to characterize the floor liner (for static analyses only) (Stark and Choi, 2004; Koerner and Bowman, 2003; Thiel, 2001; Gilbert, 2001; Stark and Peoppel, 1994). For seismic analyses, ground shaking can mobilize floor liners into residual strength mode, thus post-peak strengths were used to characterize both floor and side slope liner systems.

The foundation materials beneath the lined area consists primarily of sedimentary bedrock materials, weathered to various degrees (Vector, 2007). Based on documented experience with soils of different types, a conservative set of shear strength parameters, usually associated with sandy soils (30° internal angle of friction and zero cohesion), was assumed for the rotational failure analyses through subgrade materials, consistent with Vector Engineering (2007). For the evaluations of block-type failures along the liner system, an infinite strength model was assigned to subgrade materials below the liner to force block failures along or above the landfill liner. The material properties of the municipal solid waste were based on information published by Kavazanjian et al. (2013).

Table 11

Slope Stability Material Properties

Material	Total Moist Unit Weight (PCF)	Friction Angle (Degrees)	Cohesion (PSF)
Waste	90	31	900
Floor Liner	100	Shear-Normal Function^1	
Slope Liner	100	Shear-Normal Function^1	
Subgrade or the Native Soil	120	30	0

Notes: 1. See Figure 3

5.7 Results

The stability analysis results are summarized in Table 12, and slope stability calculation files consisting of SLOPE/W output are included in Appendix C.2, and seismic displacement calculation spreadsheets are included in Appendix C.3. The results meet the design criteria outlined in Section 5.3 of this report with a static FS greater than 1.5 and an estimated permanent seismic deformation less than 6 inches using the design seismic event.

Table 12

Summary of Stability Analysis Results

Cross Section	Failure Mode	Static FS_{MIN}	Seismic Yield, K_Y	Median Seismic Displacement (in)
A-A'	Block (Liner)	1.8	0.067g	0.6
	Rotational (Subgrade)	2.4	0.390g	< 0.1

5.8 Recommendations

Based on the assumptions and slope stability calculations presented herein, GLA recommends the shear strength requirements listed in Table 13 as suggested minimums for all materials and material interfaces used in future expansions at the WCL. Required liner shear strengths for individual expansion cells should be evaluated on an individual basis during detailed construction-level design based on subgrade/fill geometry and maximum anticipated normal loads. The interface shear strengths for the specific materials that will be used for individual liner expansion construction projects should be verified by construction quality assurance (CQA) testing prior to construction, and the acceptability of test results below those values recommended herein should be verified by additional slope stability analyses by GLA. Recommended test conditions should be developed by a qualified engineer as part of the Technical Specifications and CQA Plan for each individual expansion construction project.

Table 13
Recommended Liner Shear Strength Requirements

Normal Stress (PSF)	Peak Shear Strength (PSF)	Post-Peak[1] Shear Strength (PSF)
3,500	1,070	680
7,000	2,140	1,235
14,000	4,280	2,217
28,000	8,560	3,438

Notes: 1. Measured at 3.0 inches of displacement.

6. Surface Water Analysis

Stormwater management for the WCL consists of a network of drainage control systems designed to accommodate the anticipated volume of precipitation and the resulting run-off generated from the waste fill and run-on generated from surrounding surfaces during a design precipitation event.

The surface hydrology of the WCL was calculated using the Tabular Hydrograph method within Technical Release 55 (TR-55) developed by the Soil Conservation Service (SCS). This method calculates the peak run-off amounts that are generated during a specific rainfall event for a drainage area. The size of the open channels and drainage structures were designed to accommodate the calculated peak run-off amount generated from the prescribed design storm.

6.1 Analysis Design Criteria and Methodology

6.1.1 Design Storm

WCL has been designed to accommodate the anticipated volume of precipitation generated from during the design storm. UAC R315-303-3(1)(c) & (d) define the design event as a 25-year, 24-hour storm. The 25-year, 24-hour storm event for the WCL was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall frequency map as a 1.94 inch storm. The rainfall data used in the hydrologic analysis of WCL was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall frequency maps shown in Appendix D.1.

6.1.2 Drainage Areas and Peak Run-off and Run-on Determination

WCL was divided into drainage areas and peak discharges were calculated for each drainage areas. Approximately 400 acres were divided into 99 drainage areas. Figure 1 in Appendix D delineates the drainage areas used in the surface water calculations. The drainage areas were then used to calculate the run-on and run-off potential for the surrounding areas and built-out landfill.

The Tabular Hydrograph method within the program WinTR-55 (TR-55) was used to calculate the peak run-off generated from the design storm events (USDA, Soil Conservation Service, 1986). This method is widely accepted for determining stormwater run-off for small watersheds and can be used to describe a heterogeneous watershed that is divided into a number of homogeneous sub-watersheds. The Tabular Hydrograph method relates rainfall depth, a run-off curve number (CN), time of concentration (T_c), and drainage area to develop the peak run-off from a drainage area. See Appendix D.2 for the TR-55 output.

The following assumptions were made in estimating the peak run-off in TR-55:

- It is conservatively assumed that all the precipitation impacting a particular drainage area is 100% runoff and all flows eventually enter designed drainage channels. It is also assumed that the design storm event will have a duration that exceeds the time of concentration of overland flow.
- A CN was selected for each drainage area based on the hydrologic soil group, cover type, soil treatment, hydrologic condition, and antecedent run-off condition. WCL has a cover consistent with desert shrub with poor hydrologic condition and is rated 25% C and 75% D for its hydrologic soil groups. An overall CN of 87 was selected for all of the WCL drainage areas.

- The time of concentration was calculated using TR-55 for each drainage area. In general, the drainage path that results in the longest time of concentration will be the one comprised of greater lengths of sheet and shallow flow.
- After a maximum of 100 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be obtained from Figure 3-1 in the TR-55 Manual, or directly from within the WinTR-55 program, in which average velocity is a function of watercourse slope and surface lining. After establishing the average velocity using Figure 3-1, WinTR-55 program uses the equation Tt =L/3600V to estimate travel time for the shallow concentrated flow segment. Where Tt is the concentrated flow travel time (hr), L is the flow length (ft), and V is the velocity (ft/s).

6.1.3 Open Channel and Culvert Sizing

All open channels were sized using Manning's open channel flow equation within the computer program Flow Master (Haested, 1997). Each channel was sized using the worst-case scenario in regards to flow volume. The detailed calculations and reports for open channel and other drainage structure sizing are available in Appendix D.3.

All culverts were sized using the computer program Culvert Master (Haested, 1995). The culvert calculations and the report sheets for the culvert sizing are detailed in Appendix D.3.

The assumptions and design are further discussed in Section 6.2.

6.2 Stormwater Management and Design

6.2.1 Overview

The WCL final buildout is configured as having 3:1 side slopes on all slopes and a top deck slope of 3%. Run-off from a portion of the northwest and the entire southwest waste fill surface is directed around the landfill from north to west via perimeter V-notch channels, benches and downdrains. From there, the stormwater crosses the access road through drop inlets and culverts and is diverted to the perimeter run-on trapezoidal channel. The run-off from the remainder of the waste fill surfaces is directed towards the southern end of the landfill in perimeter V-notch channels, benches, and downdrains. The run-off will converge in the perimeter trapezoidal channel and then enter the existing drainage or a future pond at the southern end of the landfill. Figure 2 in Appendix D details the overall stormwater management plan for the site. The design 25-year, 24-hour storm event will generate a peak flow of 480 cubic feet/second over the entire contributing WCL area.

The future pond is not designed in this Master Plan document, but should be sized during the entrance facility design. It should be designed to hold the 25-year, 24-hour storm before it discharges to the existing drainage.

6.2.2 Open Channel and Culverts

To reduce the degree of erosion during peak run-off events, most of the drainage channels are to be lined with either an erosion control blanket along the top deck, or armored with durable rip-rap in designated areas, as identified in the Master Plan drawings. The requirements for channel linings are presented in Appendix D.3.

All of the channels, with the exception of the top deck area and the perimeter trapezoidal channels, are designed as V-notch channels with 2:1 side-slopes, and will vary between 1 and 2 feet deep. Run-off from the top deck will be diverted to either run-off channels or downdrains by utilizing a top deck perimeter berm. This berm will range in height from a minimum of 1 foot to a maximum of 3 feet near the downdrain inlets, with 2 to 1 (H:V) side-slopes, and will be lined with an erosion control blanket.

All of the off-site runoff will be diverted through perimeter trapezoidal drainage channels. These channels have been designed to accommodate the flow of the off-site runoff and the flow from the landfill area. The southeastern perimeter channel flow will be diverted into the existing drainage or future pond.

Run-off from the northern top deck and southern top deck areas are diverted south along the top deck perimeter berms toward multiple downdrains for each area. Each of the intermediate bench channels have drop inlets and downdrains located around the perimeter of the landfill. These downdrains terminate at the bottom perimeter channel. The perimeter run-off channel will have drop inlets leading to culverts at each downdrain termination that will convey the flow from the perimeter run-off channel to the perimeter run-on channel.

7. Site Life Calculations

Site life calculations were performed for the WCL to estimate the overall life span of the landfill and the general schedule required for construction of the major individual phases. The site life calculations were based on (1) the volumetric capacities of the phases as shown on the Master

Plan Drawings in Appendix A, (2) an operational density of 1,824 lbs/cy (from 2021 site density calculations), (3) a soil to waste ratio of 15% (for daily cover), (4) an incoming tonnage of 960 tons per day (April 23, 2019 to March 2020 average daily tonnage), and (5) an assumed 2% average annual incoming waste growth rate for the area serviced by the landfill. The capacity of each phase was volumetrically calculated from the top of waste design grades to the design liner grade using AutoCAD Civil 3D software. The volume of soil for the operations layer was subtracted from the gross air space. Supporting documentation for the site life calculations is presented in Appendix E.

The net available airspace volume available for disposal in Phases 5 through 12, as of the March 03, 2020 topographical map, totals approximately 73,779,100 cy. For the purposes of this report, airspace is defined as the volume available for waste, daily cover, and interim cover. Soil for daily and intermediate cover is estimated to consume approximately 11,066,865 cy of this volume, based on an assumed soil to waste ratio of 15% by volume. Using the above stated parameters, the landfill was calculated to reach final grades at the beginning of the year 2111. Table 14 summarizes the site life projections for the landfill.

Table 14

Site Life Projection

	Year Phase Reaches Capacity	Total Volume of Waste and Soil (CY)	Total Cumulative Volume of Waste and Soil (CY)	Total Life of Phase (Years)
Phase 5	2043	7,657,000	7,657,000	20
Phase 6	2054	5,531,600	13,188,600	11
Phase 7	2063	5,538,800	18,727,400	9
Phase 8	2066	2,612,900	21,340,300	3
Phase 9	2072	4,532,500	25,872,800	6
Phase 10	2085	11,869,000	37,741,800	13
Phase 11	2099	17,890,000	55,631,800	14
Phase 12	2111	18,147,300	73,779,100	12

8. Planning Level Construction Cost Estimates

Planning level construction cost estimates were compiled based on actual estimated material quantities for each phase, and averaged unit cost data for similar projects. Costs for all phases were based on 2020 US dollars, with no inflation. A summary of the estimated construction costs for each major expansion phase described in this Master Development Plan is presented in Section 8.1, and a summary of the estimated landfill closure construction cost is presented in Section 8.2.

8.1 Expansion Phase Construction Costs

Estimated construction costs for Phases 5 through 12 are presented in Appendix F. The cost estimates include earthwork, surveying, liner construction, drainage control, leachate collection system, and design and CQA costs for the construction of each major phase of landfill development. The unit rates were based on recent construction cost estimate of similar projects. The costs presented in Appendix F assume that each phase is built in its entirety during one construction event. Construction will most likely be conducted annually or every two years, with each phase constructed in several smaller sub-phases. Staging the construction may result in additional mobilizations, surveying, liner termination, liner tie, stormwater, and other incidental costs. Table 15 shows construction cost estimates for each major phase of construction in 2020 dollars.

Table 15

Planning Level Construction Cost Estimates

Phase	**Estimated Construction Costs**
Phase 5	$ 9,836,805
Phase 6	$ 25,548,910
Phase 7	$ 30,846,077
Phase 8	$ 24,009,374
Phase 9	$ 12,180,128
Phase 10	$ 17,239,847
Phase 11	$ 9,709,946
Phase 12	$ 9,838,257
Total	**$ 139,209,344**

8.2 Closure Construction Costs

The planning level cost estimate, in 2020 dollars, for the final closure construction, including earthwork and geosynthetics, is presented in Appendix F. The cost estimate also includes drainage and erosion control features, security features, settlement monuments, surveying, and engineering and CQA required for closure of the landfill. The cost estimate does not include the construction of monitoring devices or post-closure monitoring and maintenance. The total cost of closure construction of the WCL in 2020 dollars, is estimated to be $37,563,444.

References

Autodesk Inc., Storm and Sanitary Sewer Analysis 2018 Version 12.0.42.0, March 1, 2017.

Carel Corporation, The (2005), "Groundwater Sampling and Analysis Plan (GWSAP)," Washington County Landfill, St. George, Utah, Project No: 05-09-21, September.

Code of Federal Regulations, Title 40, Part 258, Government Printing Office, Washington, D.C.

GeoStudio (2019 R2). Version 10.1.1, July 2019 Release, GEO-SLOPE International Ltd., Calgary, Alberta, Canada.

Gilbert, R.B. (2001). "Peak vs. Residual Strength for Waste Containment Systems," Proceedings GRI-15, Hot Topics in Geosynthetics II, GSI Publ., Folsom, PA., pp. 29-39.

Giroud, J.P. et. al. (2000), "Design of Lateral Drainage Systems for Landfills", Proceedings: Geosynthetics for Advanced Solutions, Houston, TX.

Kavazanjian, E., Matasovic, N. and R.C. Bachus, (2013). 11th Peck Lecture: Predesign Geotechnical Investigation for the OII Superfund Site Landfill, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, November 2013.

Koerner, R.M., and Bowmand, H.L. (2003). "A recommendation to use peak shear strengths for geosynthetic interface design," GFR Magazine, April, 2003, pp. 28-30.

Koerner, R.M. and Koerner, G.R. (2007). Reduction Factors (RFs) Used in Geosynthetic Design, GSI White Paper #4, Geosynthetic Institute, Folsom, PA, Revision #1, March 1, 2007.

Montgomery, B., August (1993). "Washington County Landfill Site Geologic Study and Report," Consultant's Report.

Montgomery, B., January (1994). "Washington County Landfill Hydrogeologic Evaluation," Consultant's Report.

Morgenstern, N.R. and Price, V.E. (1965). "The Analysis of the Stability of General Slip Surfaces," Geotechnique, Vol. 15, pp. 70-93.

NOAA, National Weather Service, "Precipitation-Frequency Atlas of the United States", Atlas 14, Vol. 1, Ver. 3, Maryland, 2020.

Plastic Pipe Institute (2012). *Handbook of Polyethylene Pipe*, 2nd Edition, June 6. Retrieved from: https://plasticpipe.org/publications/pe-handbook.html. Retrieved on April 17, 2018.

Qian, X., Koerner, R.M., and Gray, D.H. (2002). Geotechnical Aspects of Landfill Design and Construction, Prentice Hall Inc., Upper Saddle River, New Jersey.

Seed, R.B., and Bonaparte, R. (1992). "Seismic Analysis and Design of Lined Waste Fills: Current Practice," Proceedings of the Conference on Stability and Performance of Slopes and Embankments – II, ASCE Special Geotechnical Publication No. 31, pp. 1521-1545.

Schroeder, P., Lloyd, C. and Zappi, P. (1994). The hydrologic evaluation of landfill performance (HELP) model user's guide for version 3.0. Environmental Protection Agency, Cincinnati, OH.

Stark, T.D., and Choi, H. (2004). "Peak versus residual interface strengths for landfill liner and cover design," Geosynthetics International, 11, No. 6, pp. 1-8.

Stark, T.D., and Peoppel, A.R. (1994). "Landfill Liner Interface Strengths from Torsional-Ring – Stress Tests," Journal of Geotechnical Engineering, ASCE 120(3), pp. 597-617.

Thiel, R.S. (2001). "Peak versus Residual Strength for Bottom Liner Stability Analyses," Proceedings of the 15th Annual Geosynthetics Research Institute Conference, Hot Topics in Geosynthetics II, Houston, TX, Geosynthetics Institute, Folsom, PA.

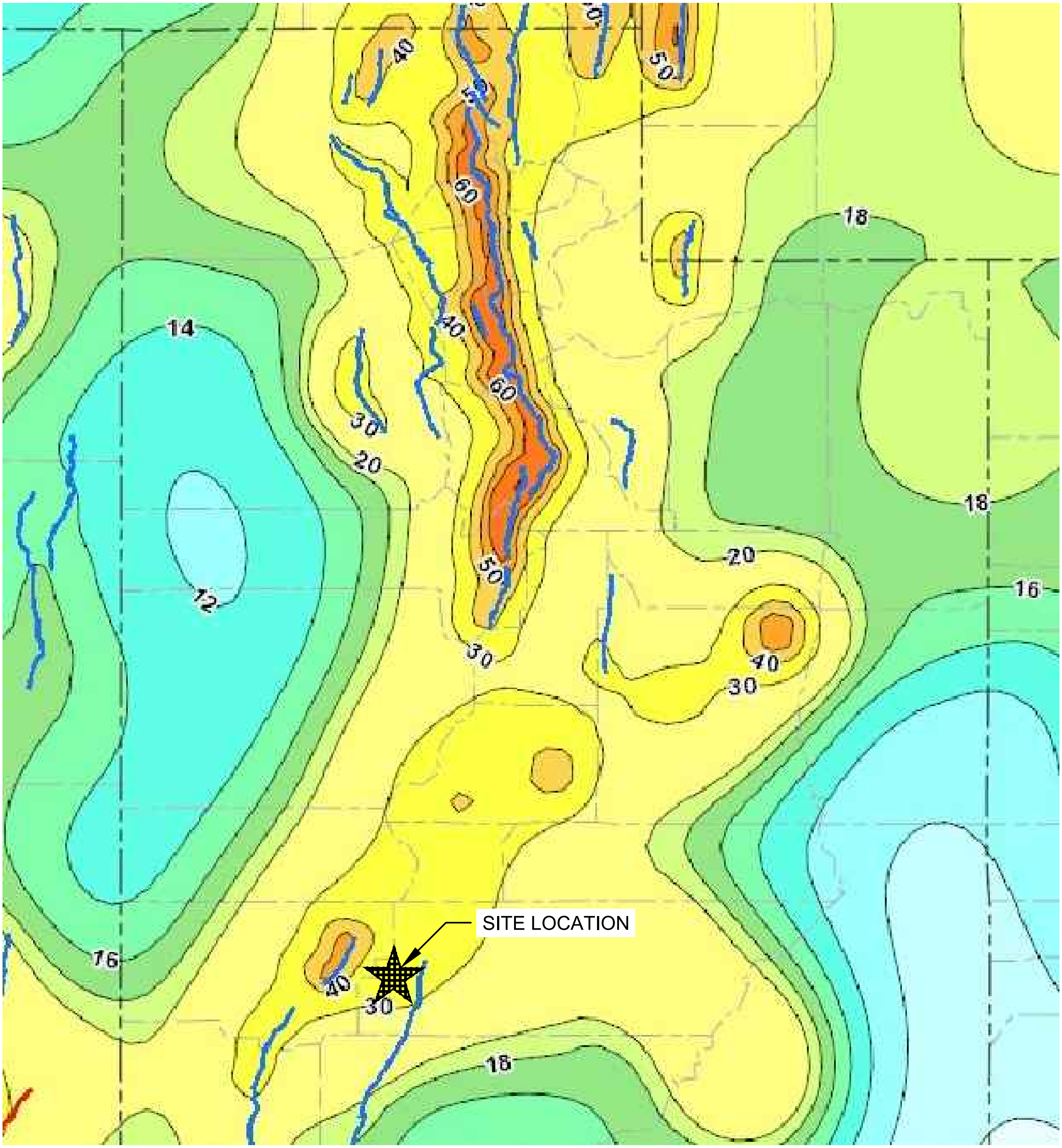
U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, Technical Release 55, (1986), "Urban Hydrology for Small Watersheds, Second Edition", U.S. Government Printing Office, Washington, D.C.

Utah Administrative Code, Solid Waste Permitting and Management Rules, R315-301 through 320, Utah Department of Environmental Quality, Salt Lake City, Utah.

Vector Engineering, Inc., (August, 2004), "Design Report for the Salt Disposal Area at the Washington County Landfill," Consultant Report.

Vector Engineering, Inc., (August, 2007), "Master Plan Report for the Washington County Landfill," Consultant Report.

FIGURES



WASHINGTON COUNTY LANDFILL

2020 MASTER PLAN DRAWINGS

WASHINGTON, UTAH

UTAH EARTHQUAKE PROBABILITY MAP (PGA)

FIGURE NO.

1

PROJECT NO.

AU19.1274.00

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NOTE:
1. EARTHQUAKE PROBABILITY MAP OF PEAK GROUND ACCELERATION WITH A 10 PROBABILITY OF EXCEEDANCE IN 250 YEARS SOURCE:
https://www.usgs.gov/natural-hazards/earthquake-hazards/hazards

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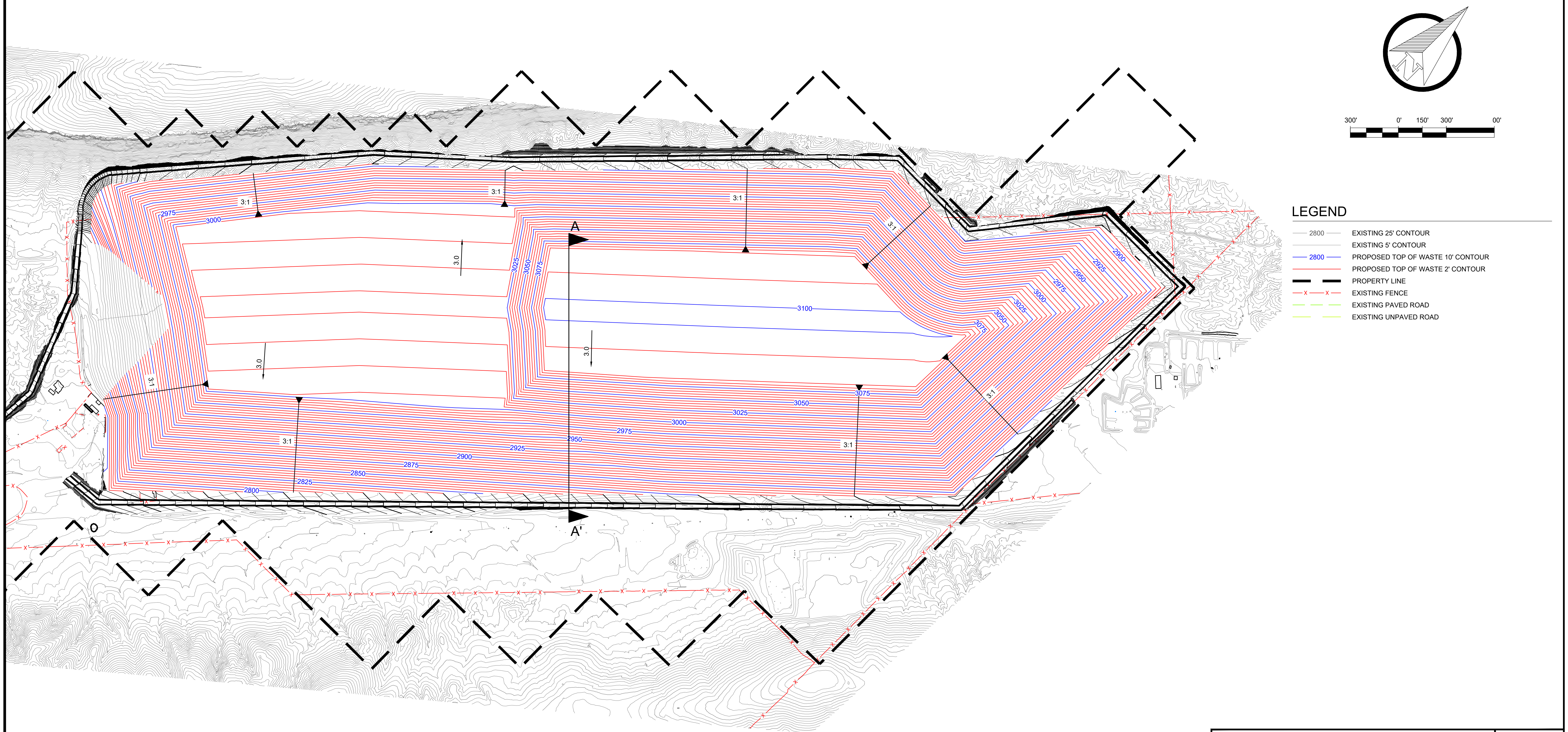

LEGEND

2800	EXISTING 25' CONTOUR
	EXISTING 5' CONTOUR
2800	PROPOSED TOP OF WASTE 10' CONTOUR
	PROPOSED TOP OF WASTE 2' CONTOUR
▬ ▬	PROPERTY LINE
—x—x—	EXISTING FENCE
— — —	EXISTING PAVED ROAD
— — —	EXISTING UNPAVED ROAD

WASHINGTON COUNTY LANDFILL

2020 MASTER PLAN DRAWINGS

WASHINGTON, UTAH

STABILITY CROSS SECTION LOCATION

FIGURE NO.
2

PROJECT NO.
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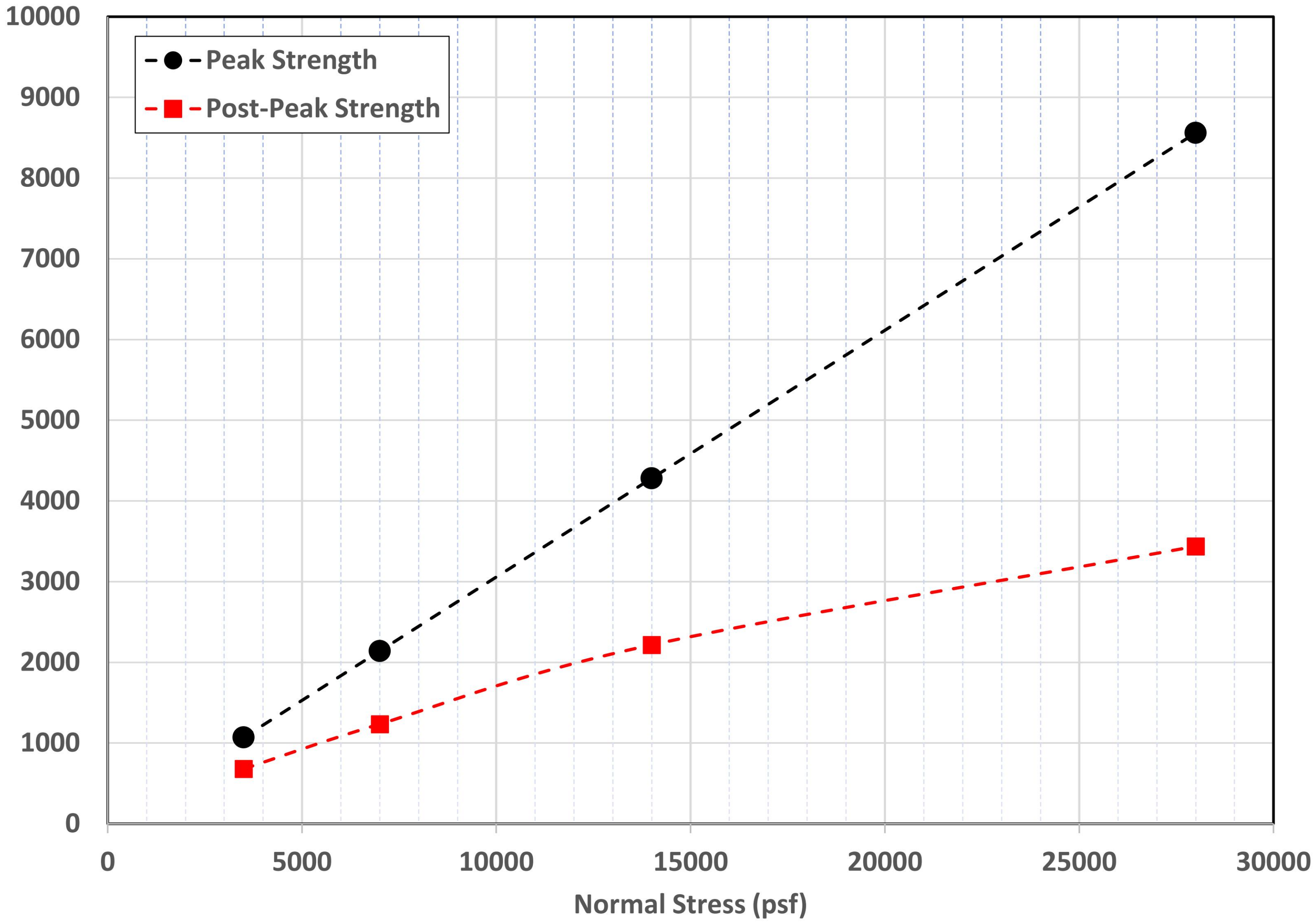

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2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH

INTERFACE SHEAR STRENGTHS

FIGURE NO.
3

PROJECT NO.
AU19.1274.00

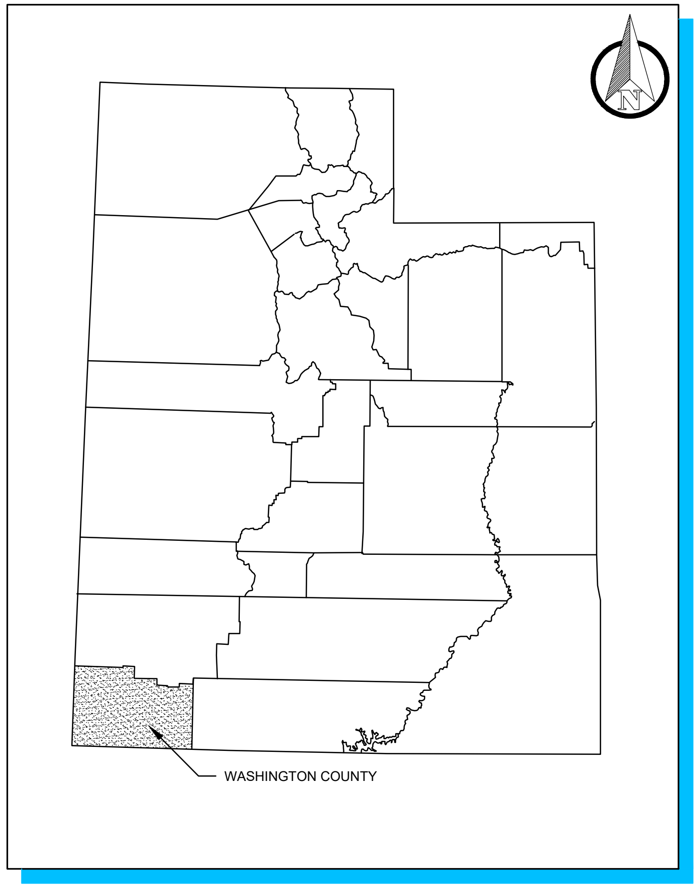
APPENDIX A

MASTER PLAN DRAWING SET

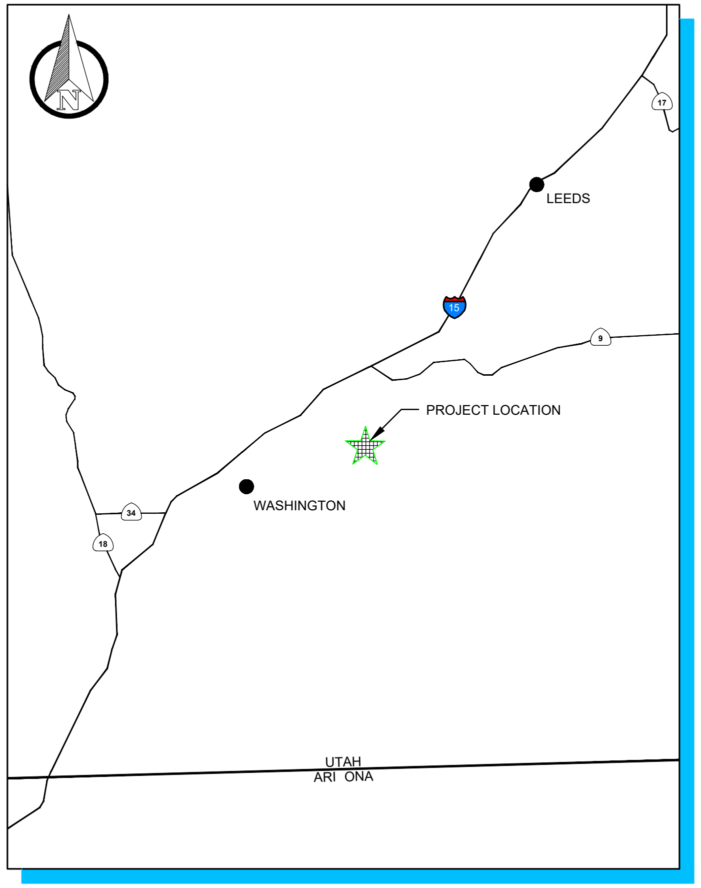
WASHINGTON COUNTY LANDFILL
2020 MASTER PLAN DRAWINGS

PREPARED FOR:

WCSW
WASHINGTON COUNTY SOLID WASTE
Don't Waste Dixie



UTAH COUNTIES

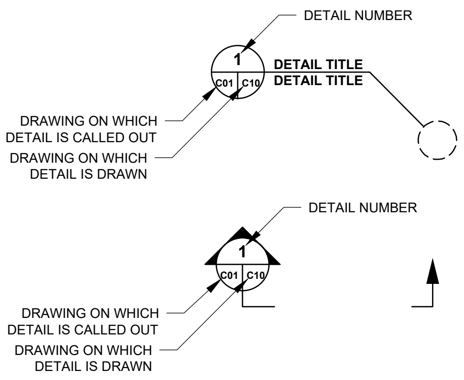


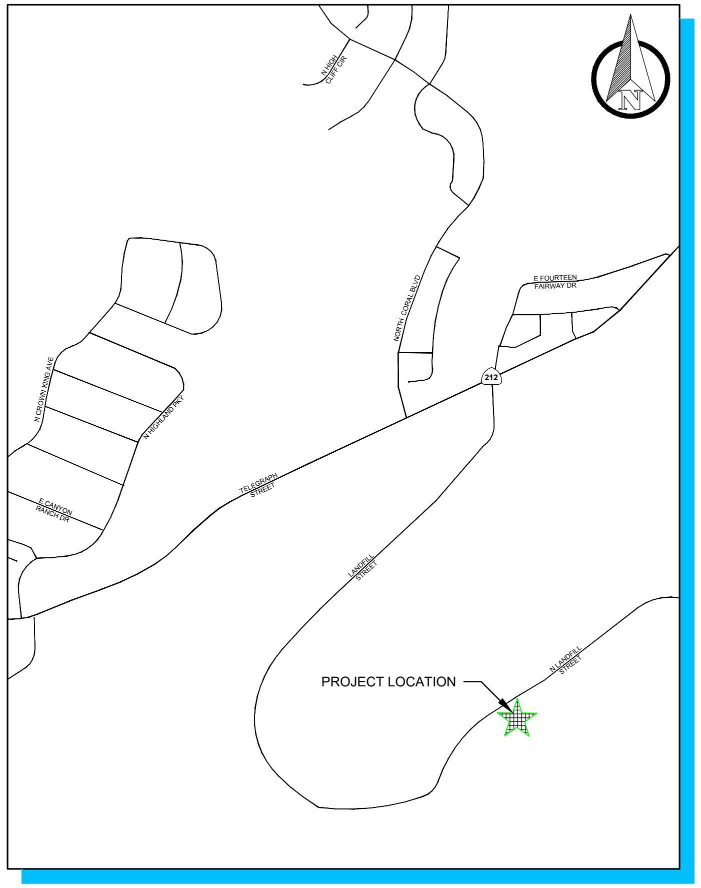
REGIONAL MAP

ABBREVIATIONS

℄	CENTERLINE	MIN	MINIMUM
	DIAMETER	N	NORTHING
E	EASTING	NIS	NOT IN SECTION
EL	ELEVATION	NTS	NOT TO SCALE
FT	FEET	OC	ON CENTER
GCL	GEOSYNTHETIC CLAY LINER	o	OUNCE
HDPE	HIGH DENSITY POLYETHYLENE		PERCENT
MAX	MAXIMUM	TYP	TYPICAL

SYMBOLS





VICINITY MAP

DRAWING INDEX

DRAWING NUMBER	TITLE AND DESCRIPTION	LATEST REVISION NUMBER	LATEST REVISION DATE
GENERAL			
G01	TITLE PAGE	A	09/11/2020
G02	SITE PLAN AND EXISTING CONDITIONS	A	09/11/2020
CIVIL			
C01	LINER AND LEACHATE COLLECTION PLAN	A	09/11/2020
C02	PHASE 5 WASTE FILL - PHASE LINER PLAN	A	09/11/2020
C03	PHASE WASTE FILL - PHASE 7 LINER PLAN	A	09/11/2020
C04	PHASE 7 WASTE FILL - PHASE 8 LINER PLAN	A	09/11/2020
C05	PHASE 8 WASTE FILL - PHASE 9 LINER PLAN	A	09/11/2020
C0	PHASE 9 WASTE FILL - PHASE 10 LINER PLAN	A	09/11/2020
C07	PHASE 10 WASTE FILL - PHASE 11 LINER PLAN	A	09/11/2020
C08	PHASE 11 WASTE FILL - PHASE 12 LINER PLAN	A	09/11/2020
C09	MASTER PLAN TOP OF WASTE	A	09/11/2020
C10	DETAILS	A	09/11/2020
C11	DETAILS	A	09/11/2020
C12	DETAILS	A	09/11/2020
C13	DETAILS	A	09/11/2020

NOTES

1. PIPE BENDS AND GEOSYNTHETICS ARE SHOWN NTS.

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A	09/11/20	ISSUED FOR REVIEW	JVR

DATE OF ISSUE: 09/11/2020
DESIGNED BY: SAH
DRAWN BY: AV
CHECKED BY: SAH
APPROVED BY: JRV

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2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
TITLE PAGE

DRAWING NO.
G01
PROJECT NO.
AU19.1274.00

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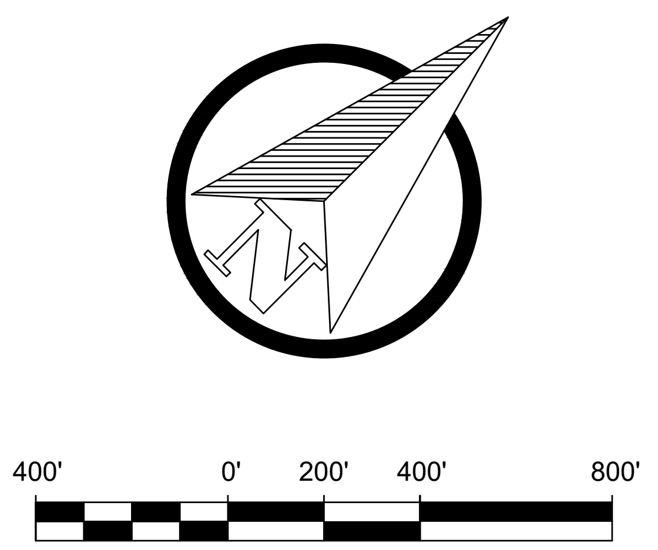

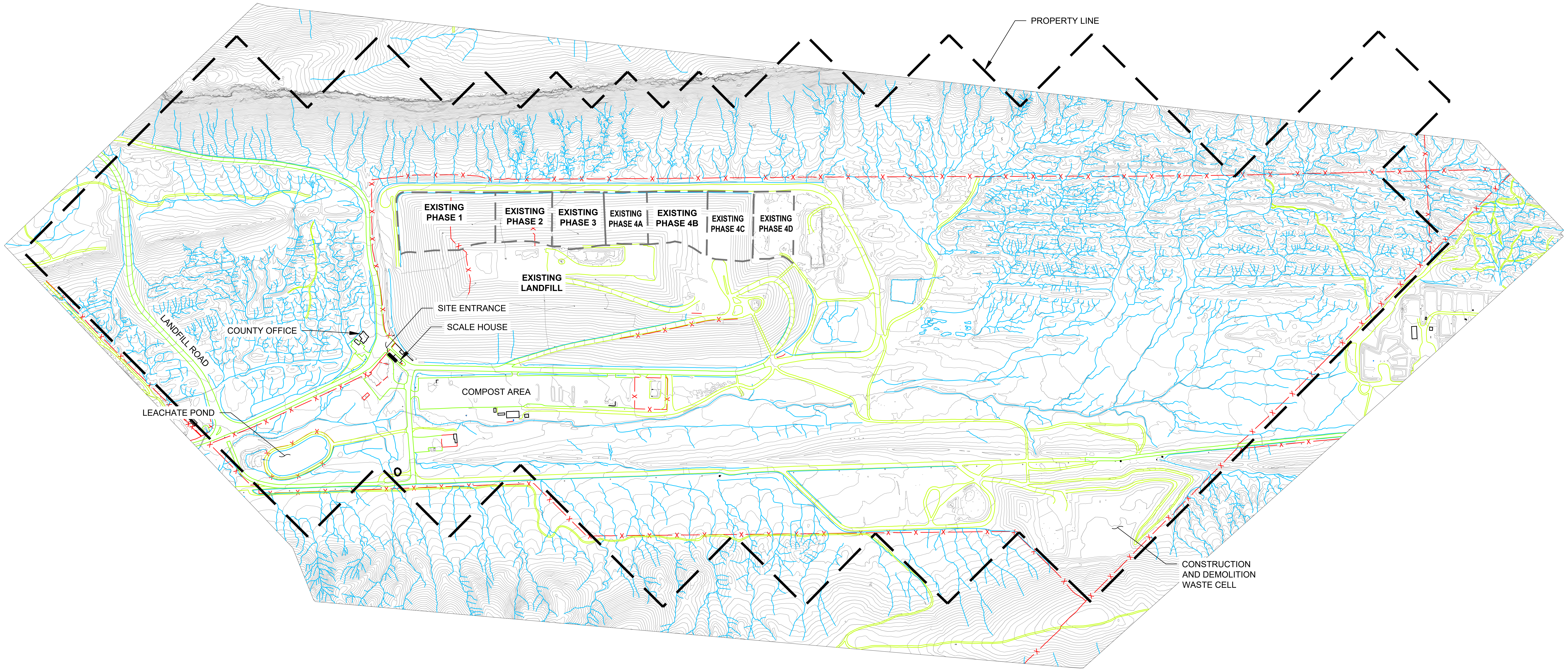

LEGEND

2800	EXISTING 25' CONTOUR$^{(1)}$
	EXISTING 5' CONTOUR$^{(1)}$
▬ ▬	PROPERTY LINE
—x—x—	EXISTING FENCE
— —	EXISTING PAVED ROAD
— —	EXISTING UNPAVED ROAD
— · —	EXISTING DRAINAGE
— —	USED LANDFILL LIMITS
— —	EXISTING LINER LIMITS

NOTES

1. EXISTING TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

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CHECKED BY:	SAH
APPROVED BY:	JRV

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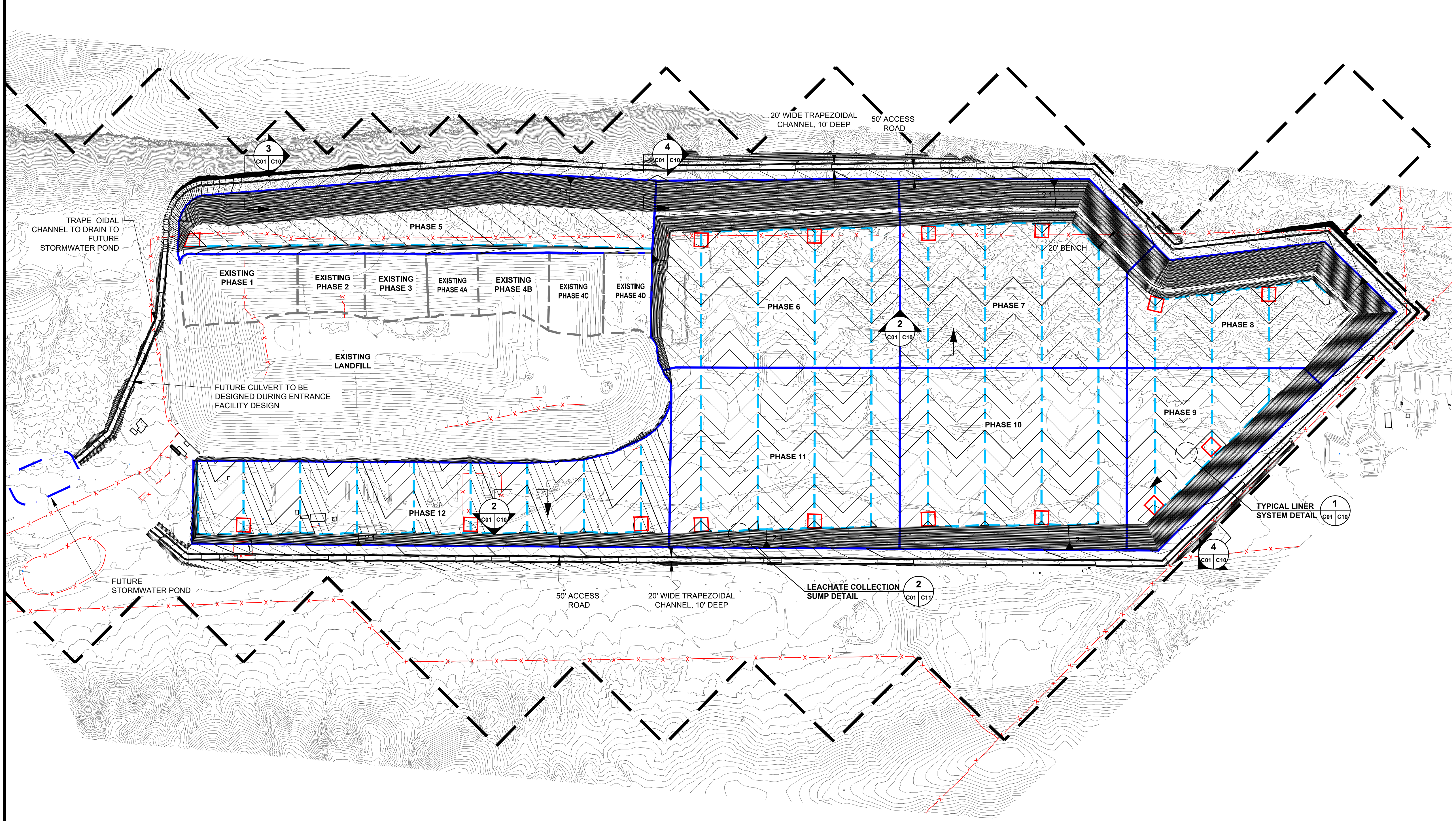
WASHINGTON COUNTY LANDFILL
2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
SITE PLAN AND EXISTING CONDITIONS

DRAWING NO.
G02
PROJECT NO.
AU19.1274.00



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——	EXISTING 5' CONTOUR(1)
— 2800 —	PROPOSED 25' CONTOUR(1)
——	PROPOSED 5' CONTOUR(1)
▬ ▬	PROPERTY LINE
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— — —	EXISTING PAVED ROAD
— —	EXISTING UNPAVED ROAD
— — —	USED LANDFILL LIMITS
— — —	EXISTING LINER LIMITS
———	PROPOSED LINER LIMITS
— — —	PROPOSED LEACHATE COLLECTION PIPE
🟥	PROPOSED SUMP

LINER CONSTRUCTION UANTITIES

PHASE 5 EXCAVATION	423,900 CY
PHASE 5 FILL	210,300 CY
PHASE EXCAVATION	1,870,100 CY
PHASE FILL	493,100 CY
PHASE 7 EXCAVATION	2,815,700 CY
PHASE 7 FILL	119,700 CY
PHASE 8 EXCAVATION	2,334,400 CY
PHASE 8 FILL	1 ,100 CY
PHASE 9 EXCAVATION	1,000,300 CY
PHASE 9 FILL	82,200 CY
PHASE 10 EXCAVATION	1,320,000 CY
PHASE 10 FILL	53,200 CY
PHASE 11 EXCAVATION	453,500 CY
PHASE 11 FILL	37,400 CY
PHASE 12 EXCAVATION	359,300 CY
PHASE 12 FILL	210,280 CY
TOTAL EXCAVATION	10,577,200 CY
TOTAL FILL	1,222,280 CY

OPERATIONS LAYER

PHASE 5	59,911 CY
PHASE	80,900 CY
PHASE 7	74,818 CY
PHASE 8	49,8 2 CY
PHASE 9	38,108 CY
PHASE 10	70, 75 CY
PHASE 11	70,544 CY
PHASE 12	71,347 CY
TOTAL	51 ,1 0 CY

LINER AREAS

PHASE 5	23. AC
PHASE	32.3 AC
PHASE 7	30.0 AC
PHASE 8	19. AC
PHASE 9	15.3 AC
PHASE 10	28.8 AC
PHASE 11	28.9 AC
PHASE 12	29.5 AC
TOTAL	208 AC

NOTES

1. EXISTING TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\C01 LINER AND LEACHATE COLLECTION PLAN.DWG September 21, 2020 - 11:33 AM BY: GLA USER

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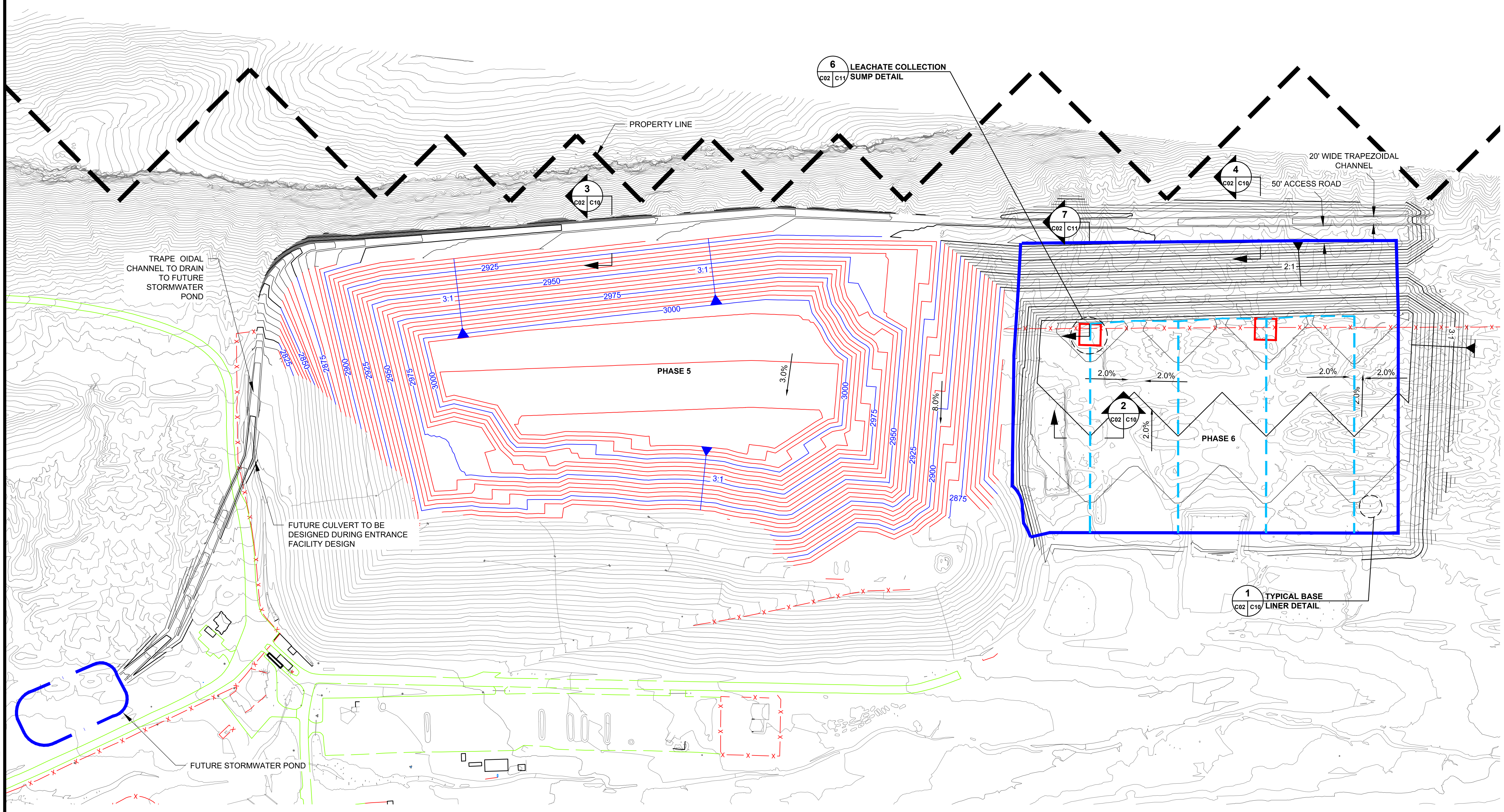
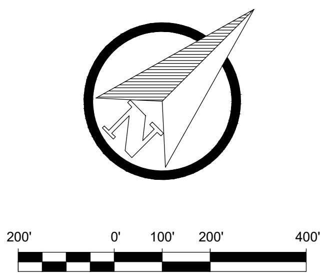
2020 MASTER PLAN DRAWINGS

WASHINGTON, UTAH

LINER AND LEACHATE COLLECTION PLAN

DRAWING NO.
C01
PROJECT NO.
AU19.1274.00





LEGEND

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	EXISTING 5' CONTOUR(1)
	PROPERTY LINE
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	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
2800	PROPOSED SUBGRADE 25' CONTOUR
	PROPOSED SUBGRADE 5' CONTOUR
2800	PROPOSED PHASE 5 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE 5 TOP OF WASTE 5' CONTOUR
	PROPOSED PHASE LINER LIMIT
	LEACHATE COLLECTION PIPE
	EXISTING LINER LIMITS
🟥	PROPOSED SUMP

AIRSPACE

PHASE 5 3,904, CY

PHASE CONSTRUCTION UANTITIES

EXCAVATION	1,870,100 CY
FILL	493,100 CY
OPERATION LAYER	80,900 CY
LINER AREA	32.3 AC

NOTES

1. EXISTING TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

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WASHINGTON COUNTY LANDFILL
2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
PHASE 5 WASTE FILL - PHASE 6 LINER PLAN

DRAWING NO.
C02
PROJECT NO.
AU19.1274.00

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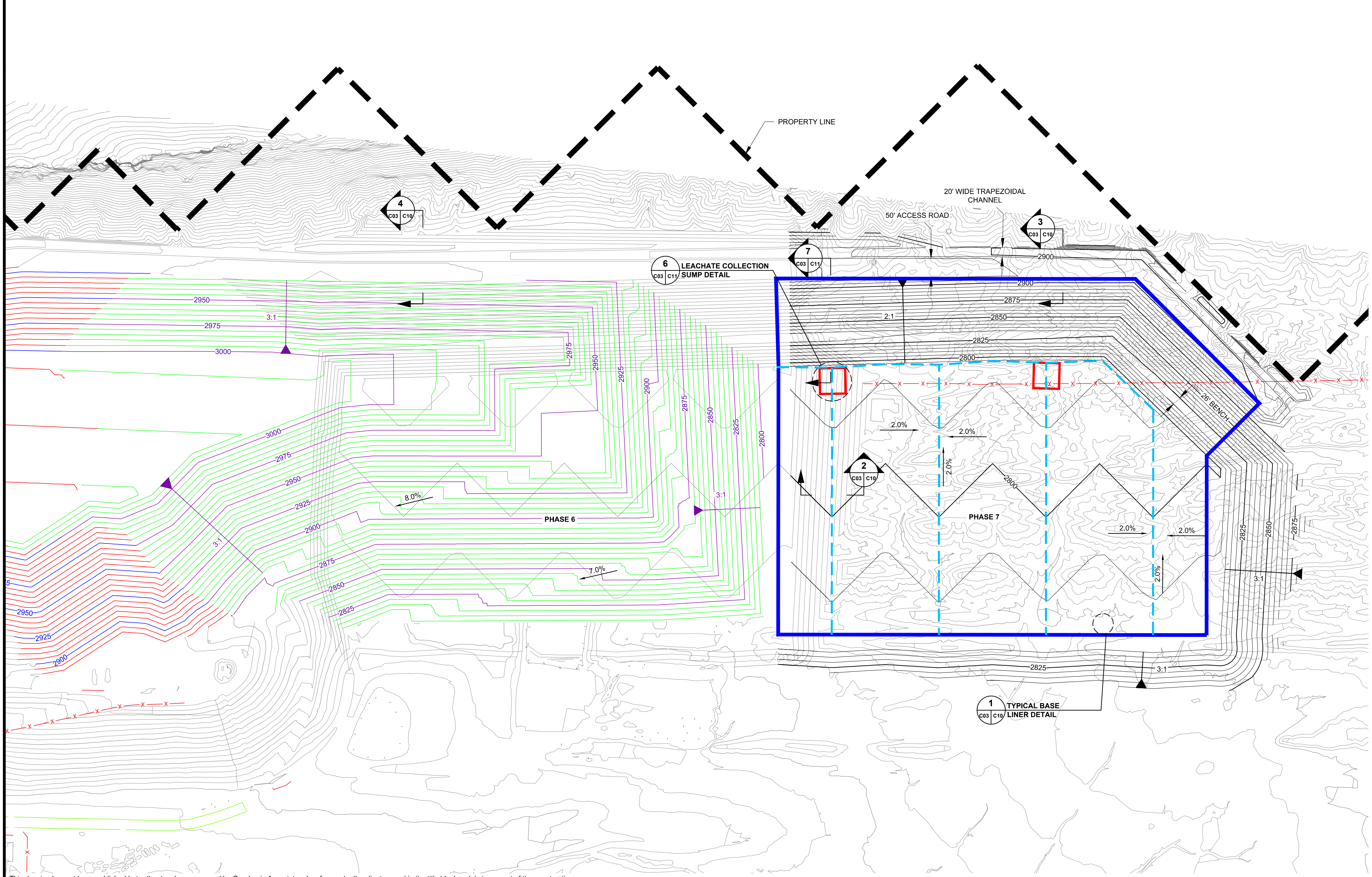

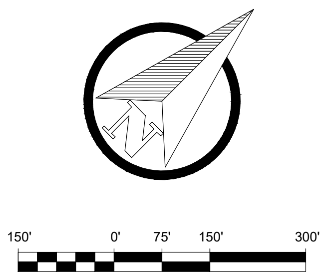

LEGEND

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——	EXISTING 5' CONTOUR(1)
▬ ▬	PROPERTY LINE
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— — —	EXISTING PAVED ROAD
— —	EXISTING UNPAVED ROAD
— 2800 —	PROPOSED SUBGRADE 25' CONTOUR
——	PROPOSED SUBGRADE 5' CONTOUR
— 2800 —	PROPOSED PHASE TOP OF WASTE 10' CONTOUR
——	PROPOSED PHASE TOP OF WASTE 2' CONTOUR
— 2800 —	PROPOSED PHASE 5 TOP OF WASTE 10' CONTOUR
——	PROPOSED PHASE 5 TOP OF WASTE 2' CONTOUR
▬▬	PROPOSED PHASE 7 LINER LIMIT
▬ ▬ ▬	LEACHATE COLLECTION PIPE
▬ ▬ ▬	EXISTING LINER LIMITS
□	PROPOSED SUMP

AIRSPACE

PHASE AIRSPACE	5,531,541 CY
PHASE 1- CUMULATIVE AIRSPACE	9,43 ,207 CY

PHASE 7 CONSTRUCTION UANTITIES

EXCAVATION	2,815,700 CY
FILL	119,700 CY
OPERATION LAYER	74,900 CY
LINER AREA	30.0 AC

NOTES

1. EXISTING TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

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CHECKED BY: SAH
APPROVED BY: JRV

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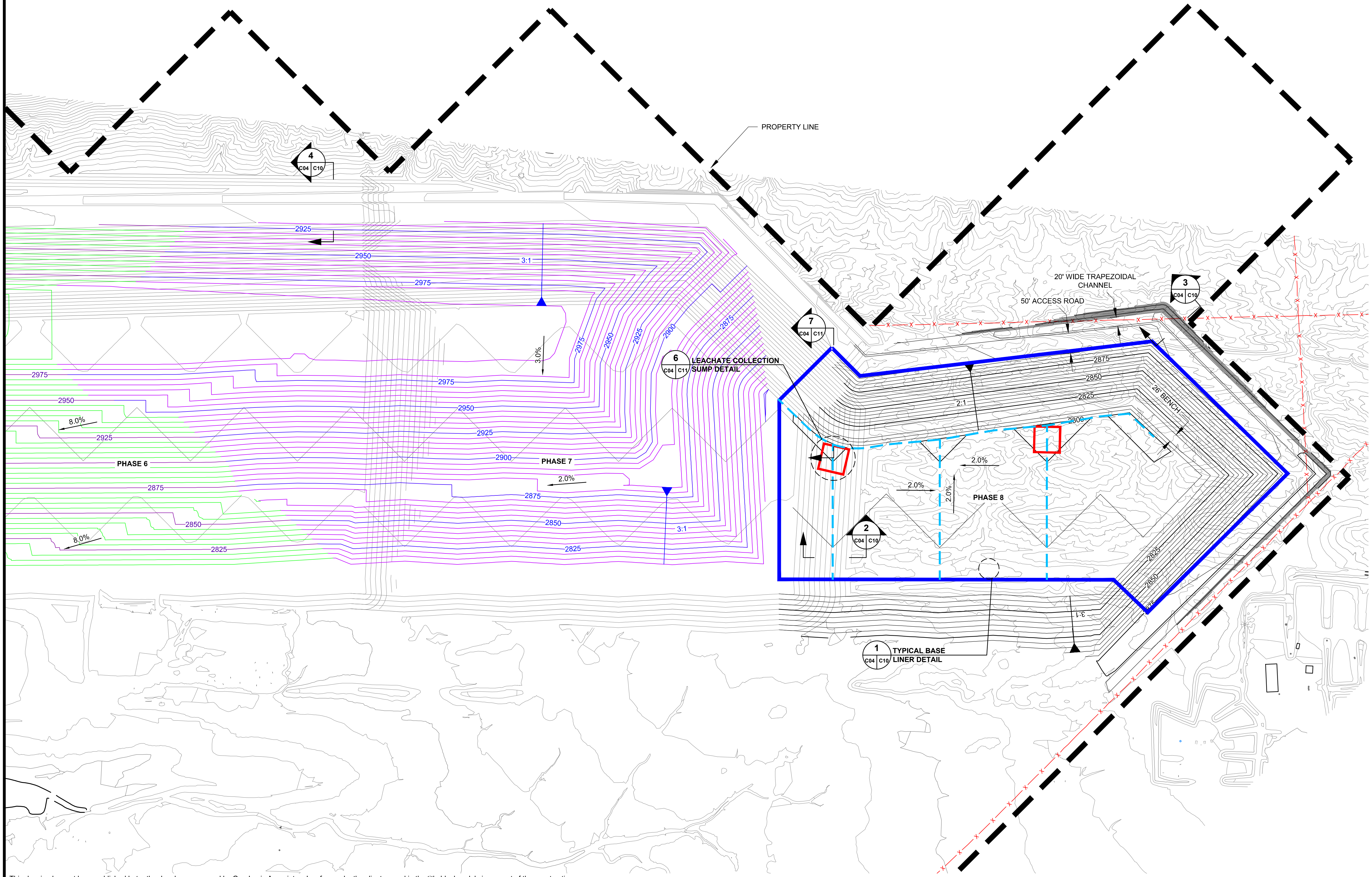
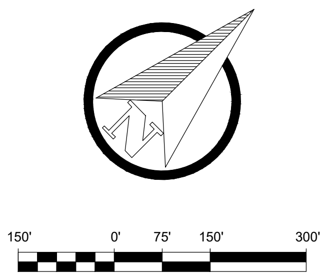
WASHINGTON COUNTY LANDFILL
2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
PHASE 6 WASTE FILL - PHASE 7 LINER PLAN

DRAWING NO.
C03
PROJECT NO.
AU19.1274.00

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\C03 PHASE WASTE FILL - PHASE 7 LINER PLAN.DWG September 8, 2020 - 3:00 PM BY: GLA USER





LEGEND

2800	EXISTING 25' CONTOUR(1)
	EXISTING 5' CONTOUR(1)
	PROPERTY LINE
x — x	EXISTING FENCE
	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
2800	PROPOSED SUBGRADE 25' CONTOUR
	PROPOSED SUBGRADE 5' CONTOUR
2800	PROPOSED PHASE TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE TOP OF WASTE 5' CONTOUR
2800	PROPOSED PHASE 7 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE 7 TOP OF WASTE 5' CONTOUR
	PROPOSED PHASE 8 LINER LIMIT
	LEACHATE COLLECTION PIPE
	EXISTING LINER LIMITS
🟥	PROPOSED SUMP

AIRSPACE

PHASE 7 AIRSPACE	5,538,7 0 CY
PHASE 1-7 CUMULATIVE AIRSPACE	14,974,9 7 CY

PHASE 8 CONSTRUCTION UANTITIES

EXCAVATION	2,334,400 CY
FILL	1 ,100 CY
OPERATION LAYER	49,8 2 CY
LINER AREA	19. AC

NOTES

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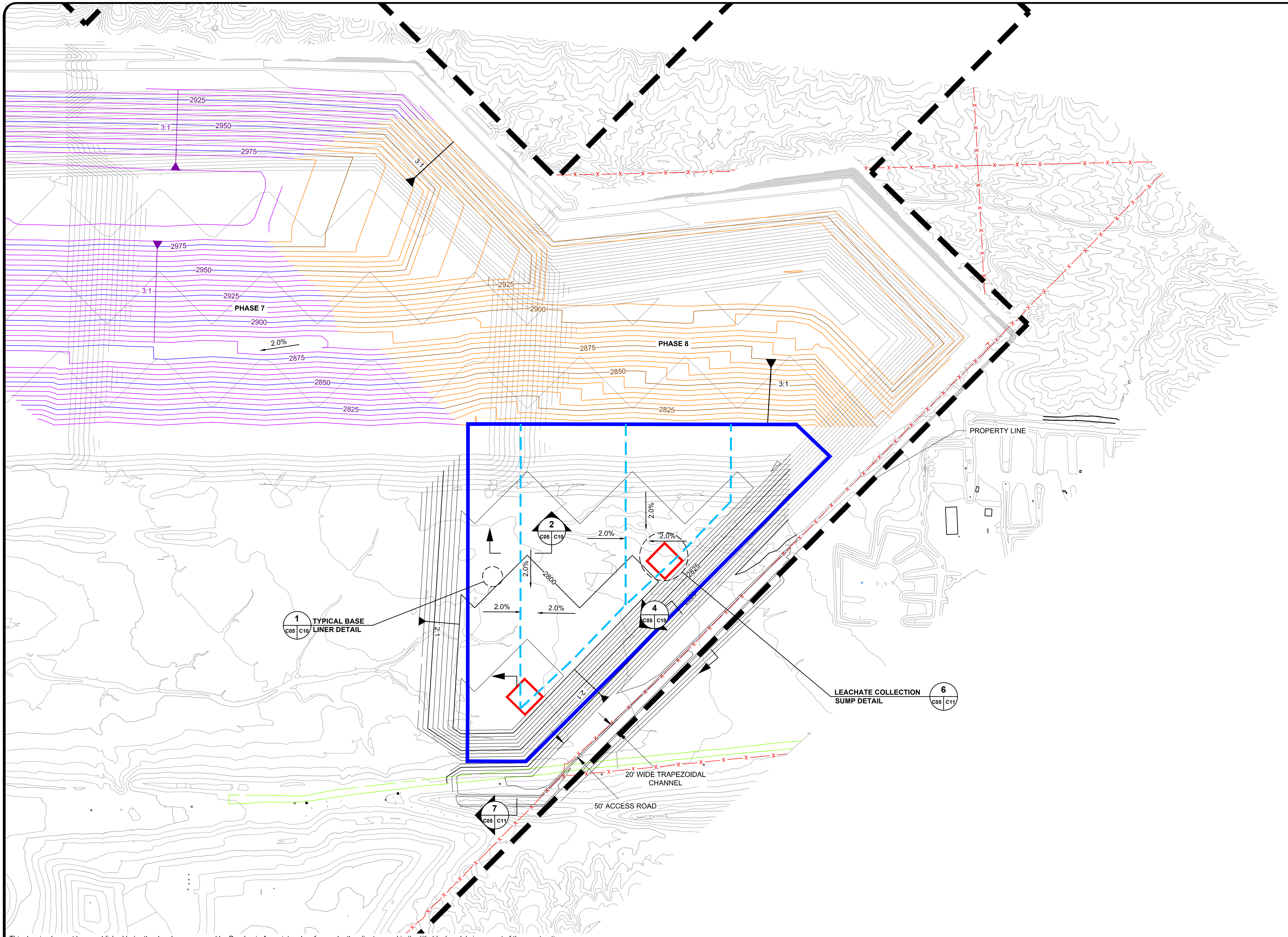
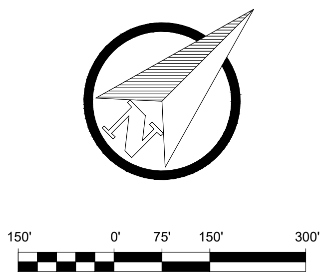
2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
PHASE 7 WASTE FILL - PHASE 8 LINER PLAN

DRAWING NO.
C04
PROJECT NO.
AU19.1274.00





LEGEND

2800	EXISTING 25' CONTOUR(1)
	EXISTING 5' CONTOUR(1)
	PROPERTY LINE
—X——X—	EXISTING FENCE
	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
2800	PROPOSED SUBGRADE 25' CONTOUR
	PROPOSED SUBGRADE 5' CONTOUR
2800	PROPOSED PHASE 7 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE 7 TOP OF WASTE 5' CONTOUR
2800	PROPOSED PHASE 8 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE 8 TOP OF WASTE 5' CONTOUR
	PROPOSED PHASE 9 LINER LIMIT
	LEACHATE COLLECTION PIPE
	EXISTING LINER LIMITS
🟥	PROPOSED SUMP

AIRSPACE

PHASE 8 AIRSPACE	2, 12,819 CY
PHASE 1-8 CUMULATIVE AIRSPACE	17,587,78 CY

PHASE 9 CONSTRUCTION UANTITIES

EXCAVATION	1,000,00 CY
FILL	82,200 CY
OPERATION LAYER	38,108 CY
LINER AREA	15.3 AC

NOTES

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WASHINGTON, UTAH
PHASE 8 WASTE FILL - PHASE 9 LINER PLAN

DRAWING NO.
C05
PROJECT NO.
AU19.1274.00

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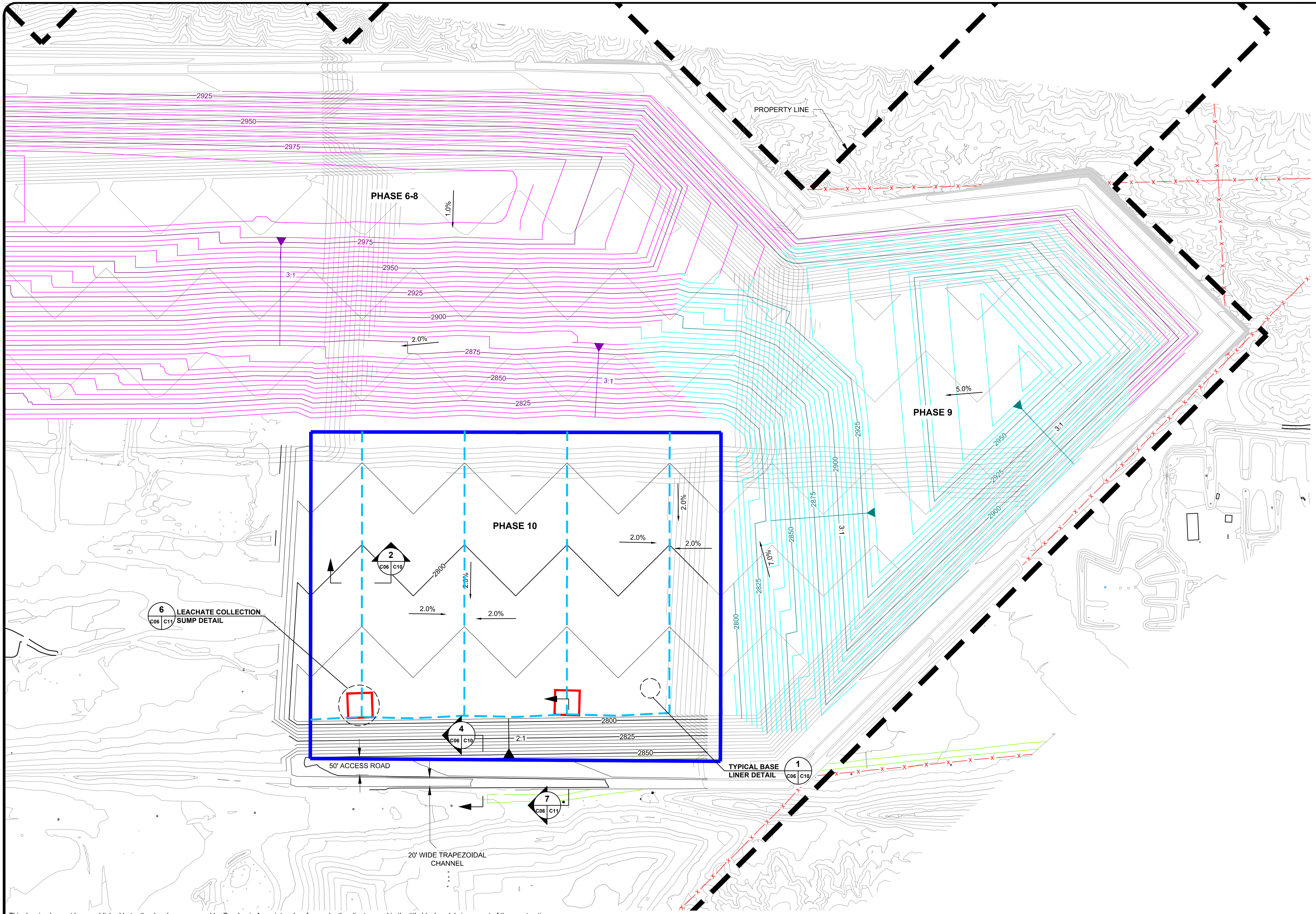
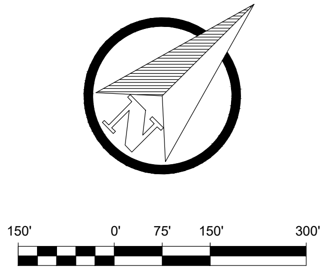
N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\C0 PHASE 9 WASTE FILL - PHASE 10 LINER PLAN.DWG September 8, 2020 - 3:40 PM BY: GLA USER





LEGEND

2800	EXISTING 25' CONTOUR[1]
	EXISTING 5' CONTOUR[1]
	PROPERTY LINE
—x—x—	EXISTING FENCE
	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
2800	PROPOSED SUBGRADE 25' CONTOUR
	PROPOSED SUBGRADE 5' CONTOUR
2800	PROPOSED PHASE -8 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE -8 TOP OF WASTE 5' CONTOUR
2800	PROPOSED PHASE 9 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE 9 TOP OF WASTE 5' CONTOUR
	PROPOSED PHASE 10 LINER LIMIT
	LEACHATE COLLECTION PIPE
	EXISTING LINER LIMITS
🟥	PROPOSED SUMP

AIRSPACE

PHASE 9 AIRSPACE	4,532,442 CY
PHASE 1-9 CUMULATIVE AIRSPACE	22,120,227 CY

PHASE 10 CONSTRUCTION UANTITIES

EXCAVATION	1,320,000 CY
FILL	53,200 CY
OPERATION LAYER	70, 75 CY
LINER AREA	28.8 AC

NOTES

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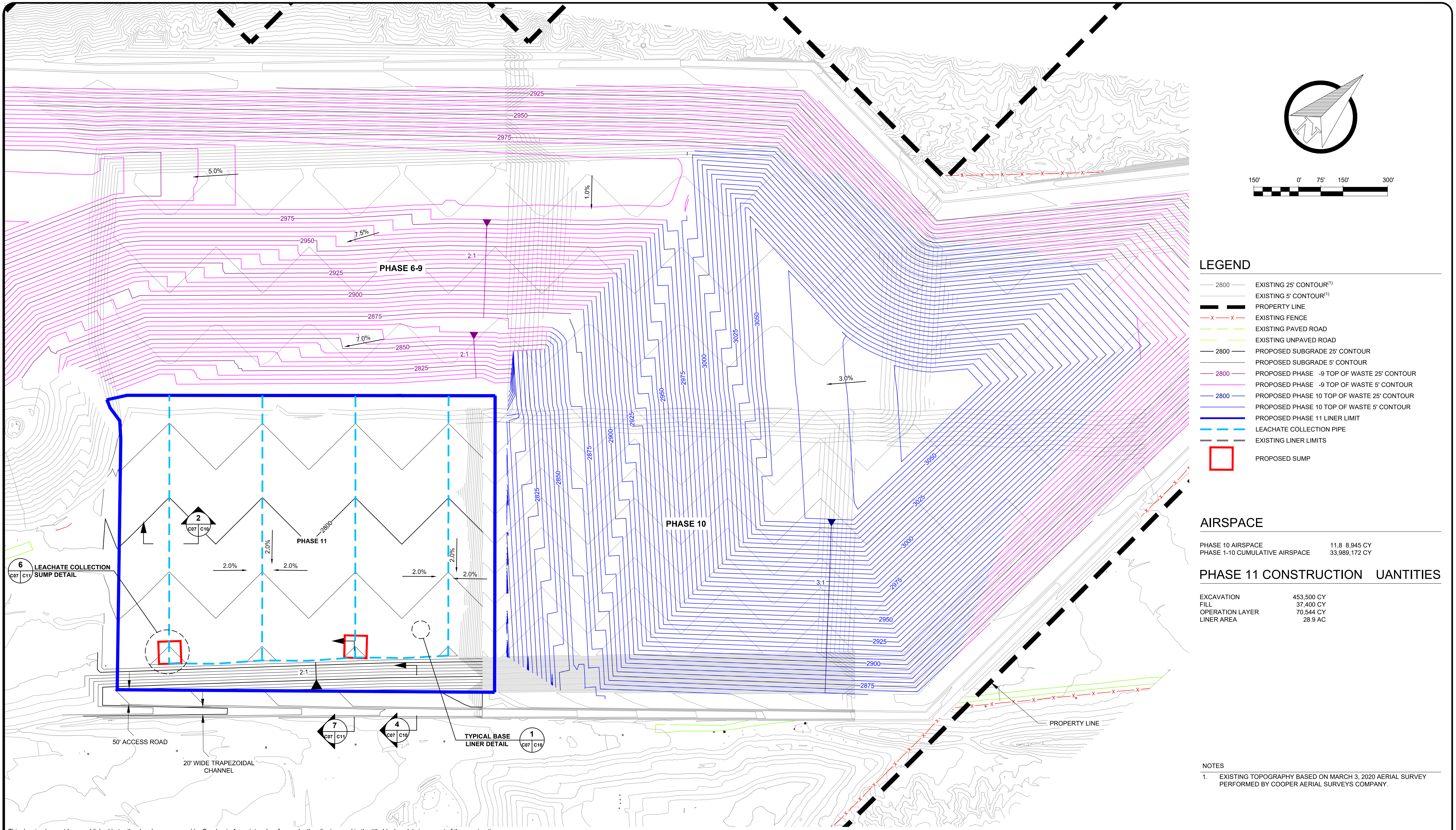
PHASE 9 WASTE FILL - PHASE 10 LINER PLAN

DRAWING NO.
C06
PROJECT NO.
AU19.1274.00



LEGEND

2800	EXISTING 25' CONTOUR(1)
	EXISTING 5' CONTOUR(1)
	PROPERTY LINE
—x—x—	EXISTING FENCE
	EXISTING PAVED ROAD
	EXISTING UNPAVED ROAD
2800	PROPOSED SUBGRADE 25' CONTOUR
	PROPOSED SUBGRADE 5' CONTOUR
2800	PROPOSED PHASE -9 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE -9 TOP OF WASTE 5' CONTOUR
2800	PROPOSED PHASE 10 TOP OF WASTE 25' CONTOUR
	PROPOSED PHASE 10 TOP OF WASTE 5' CONTOUR
	PROPOSED PHASE 11 LINER LIMIT
	LEACHATE COLLECTION PIPE
	EXISTING LINER LIMITS
🟥	PROPOSED SUMP

AIRSPACE

PHASE 10 AIRSPACE	11,8 8,945 CY
PHASE 1-10 CUMULATIVE AIRSPACE	33,989,172 CY

PHASE 11 CONSTRUCTION UANTITIES

EXCAVATION	453,500 CY
FILL	37,400 CY
OPERATION LAYER	70,544 CY
LINER AREA	28.9 AC

NOTES

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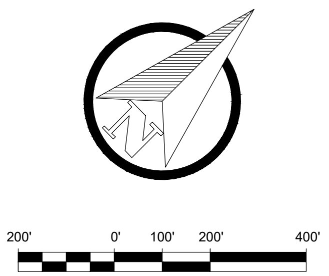
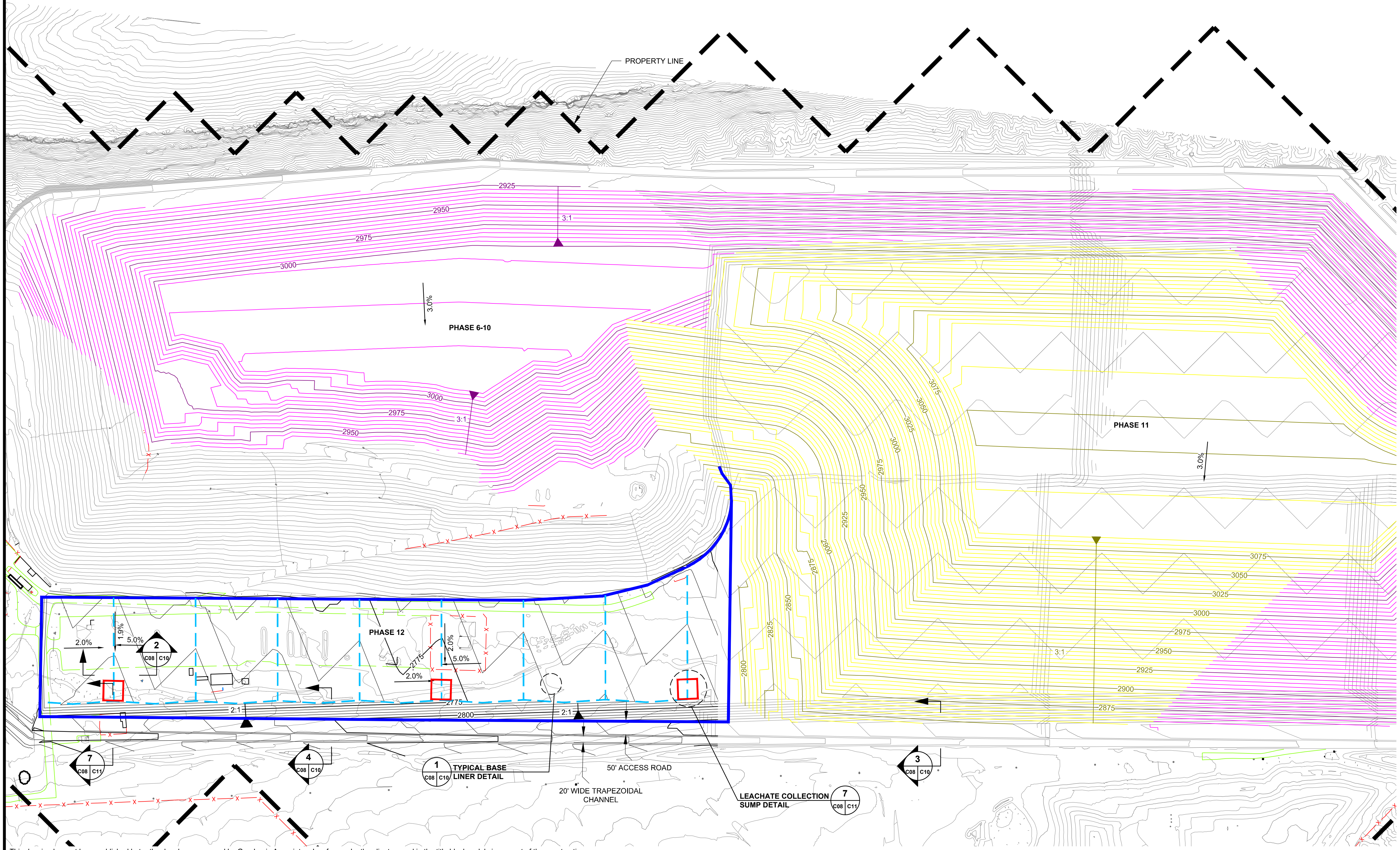
PHASE 10 WASTE FILL - PHASE 11 LINER PLAN

DRAWING NO.
C07
PROJECT NO.
AU19.1274.00

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\C07 PHASE 10 WASTE FILL - PHASE 11 LINER PLAN.DWG September 8, 2020 - 3:45 PM BY: GLA USER

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\C08 PHASE 11 WASTE FILL - PHASE 12 LINER PLAN.DWG September 18, 2020 - 4:10 PM BY: GLA USER





LEGEND

—— 2800 ——	EXISTING 25' CONTOUR(1)
————	EXISTING 5' CONTOUR(1)
▬ ▬	PROPERTY LINE
—x——x—	EXISTING FENCE
— — —	EXISTING PAVED ROAD
—— ——	EXISTING UNPAVED ROAD
—— 2800 ——	PROPOSED SUBGRADE 25' CONTOUR
————	PROPOSED SUBGRADE 5' CONTOUR
—— 2800 ——	PROPOSED PHASE -10 TOP OF WASTE 25' CONTOUR
————	PROPOSED PHASE -10 TOP OF WASTE 5' CONTOUR
—— 2800 ——	PROPOSED PHASE 11 TOP OF WASTE 25' CONTOUR
————	PROPOSED PHASE 11 TOP OF WASTE 5' CONTOUR
━━━━	PROPOSED PHASE 12 LINER LIMIT
━ ━ ━	LEACHATE COLLECTION PIPE
━ ━ ━	EXISTING LINER LIMITS
🟥	PROPOSED SUMP

AIRSPACE

PHASE 11 AIRSPACE	24,492,073 CY
PHASE 1-11 CUMULATIVE AIRSPACE	58,481,245 CY

PHASE 12 CONSTRUCTION UANTITIES

EXCAVATION	359,300 CY
FILL	154,800 CY
OPERATION LAYER	71,347 CY
LINER AREA	29.5 AC

NOTES

1. EXISTING TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

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2020 MASTER PLAN DRAWINGS
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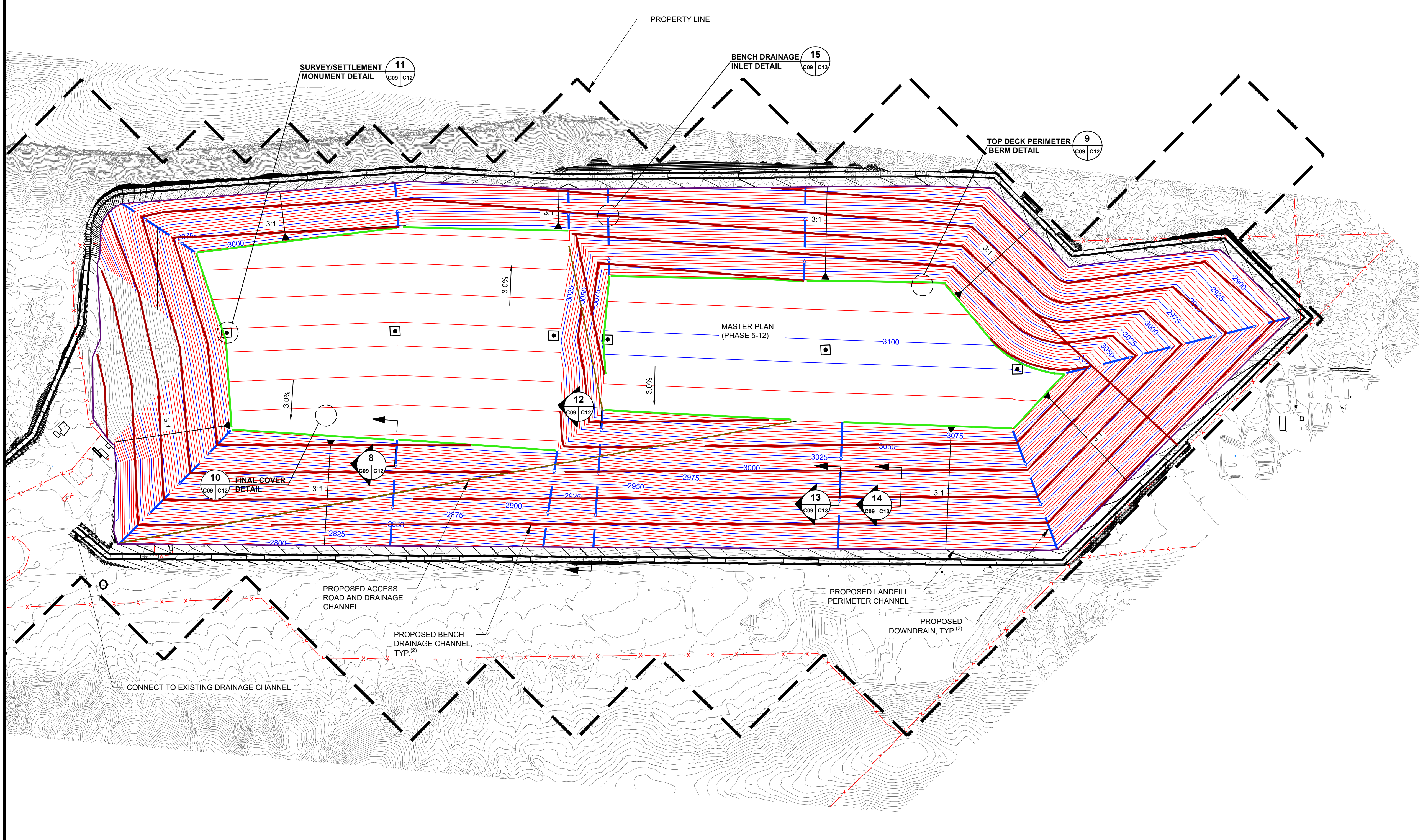
PHASE 11 WASTE FILL - PHASE 12 LINER PLAN

DRAWING NO.
C08

PROJECT NO.
AU19.1274.00



LEGEND

— 2800 —	EXISTING 25' CONTOUR$^{(1)}$
——	EXISTING 5' CONTOUR$^{(1)}$
— 2800 —	PROPOSED TOP OF WASTE 10' CONTOUR$^{(1)}$
——	PROPOSED TOP OF WASTE 2' CONTOUR$^{(1)}$
━ ━	PROPERTY LINE
—x—x—	EXISTING FENCE
— — —	EXISTING PAVED ROAD
— —	EXISTING UNPAVED ROAD
━ ━	PROPOSED CULVERT/DOWNDRAINS$^{(2)}$
━━	PROPOSED BENCH DRAINAGE CHANNEL
——	PROPOSED ACCESS ROAD AND DRAINAGE CHANNEL
━━	PROPOSED TOP DECK BERM
━━	PROPOSED LANDFILL
⊡	SURVEY/SETTLEMENT MONUMENT

TOTAL AIRSPACE

PHASE 1-12 CUMULATIVE AIRSPACE	73,779,100 CY

NOTES

1. EXISTING TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.
2. SEE FIGURE 2 IN APPENDIX D OF REPORT FOR CULVERT/DOWNDRAIN BENCH DRAINAGE CHANNEL.

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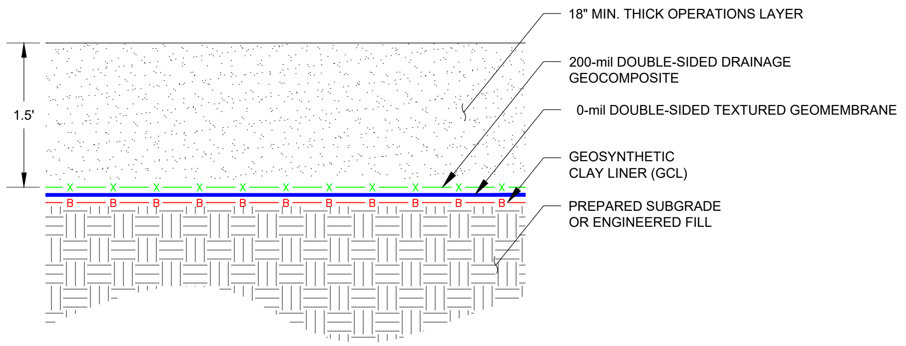
MASTER PLAN TOP OF WASTE

DRAWING NO.
C09
PROJECT NO.
AU19.1274.00

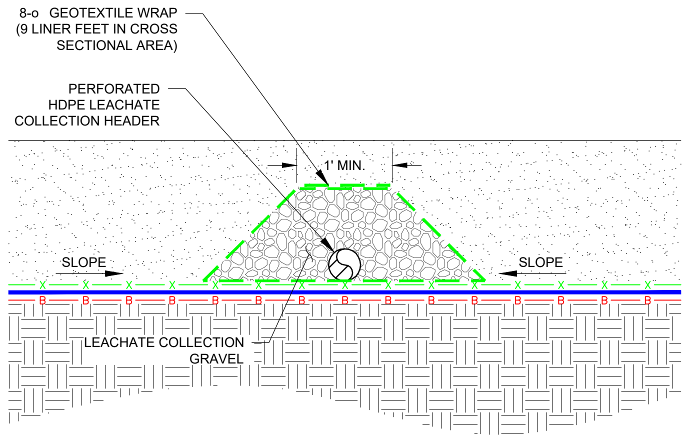
N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\C09 MASTER PLAN TOP OF WASTE.DWG September 21, 2020 - 11:4 AM BY: GLA USER



TYPICAL LINER SYSTEM

DETAIL 1 C01 C10

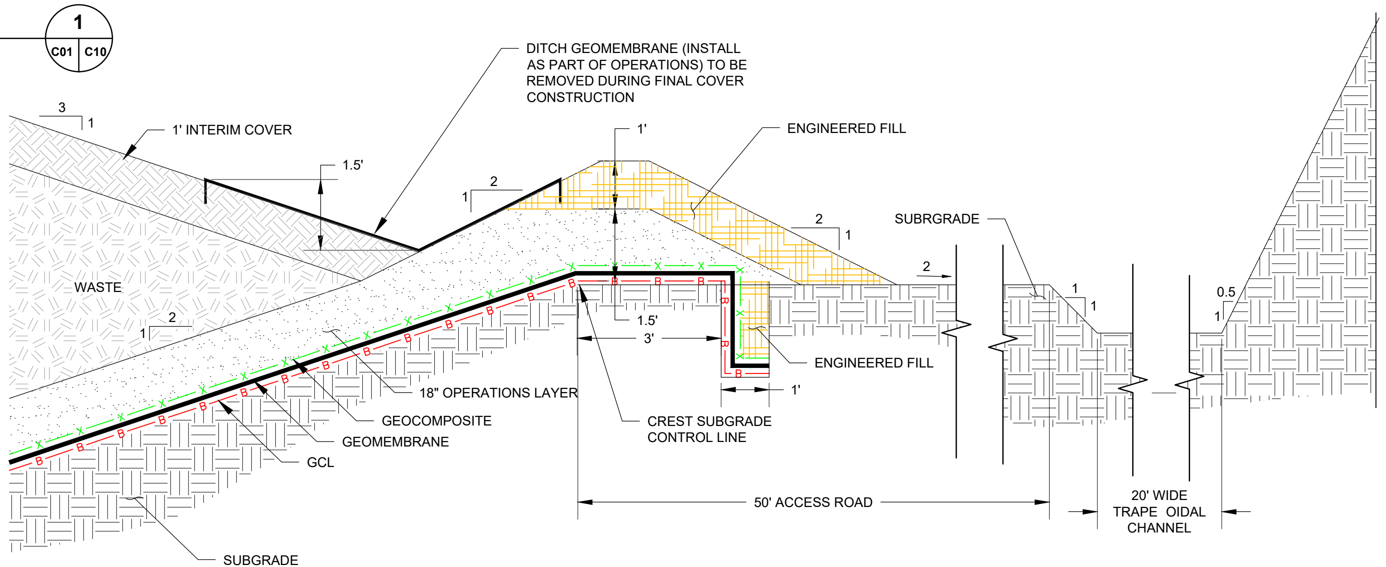
1" = 1'



LEACHATE COLLECTION PIPE

SECTION 2 C01 C10

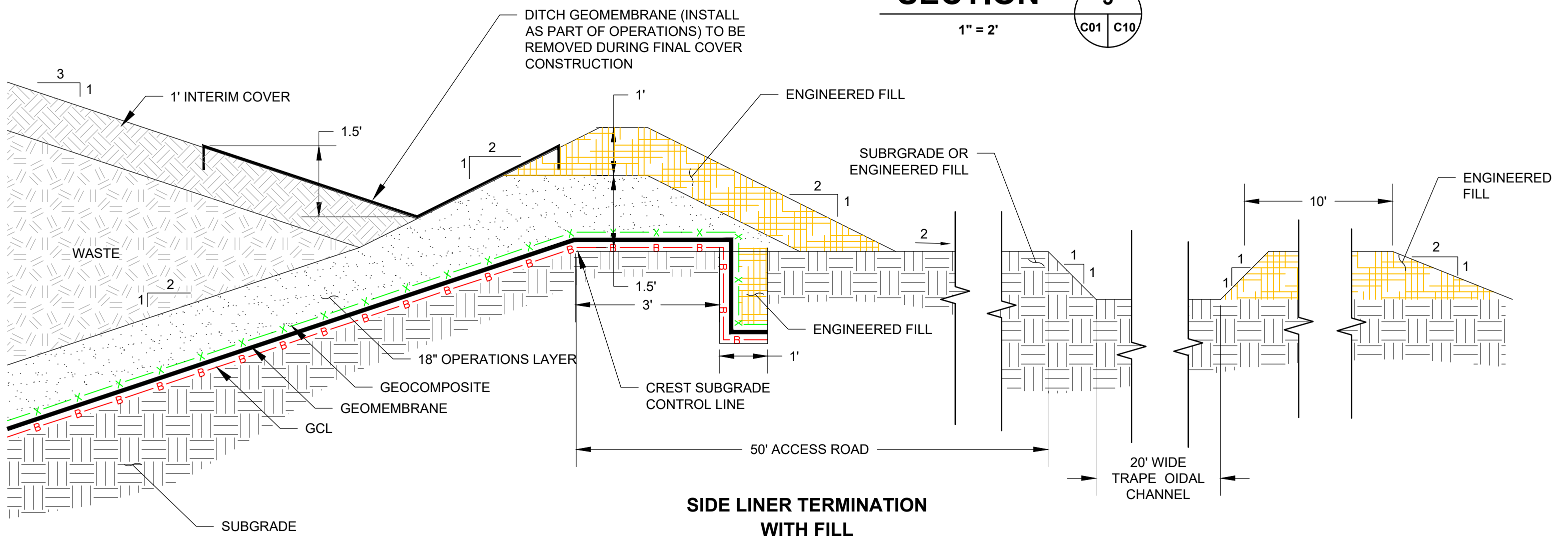
1" = 1'



SIDE LINER TERMINATION WITH EXCAVATION

SECTION 3 C01 C10

1" = 2'



SIDE LINER TERMINATION WITH FILL

SECTION 4 C01 C10

1" = 2'

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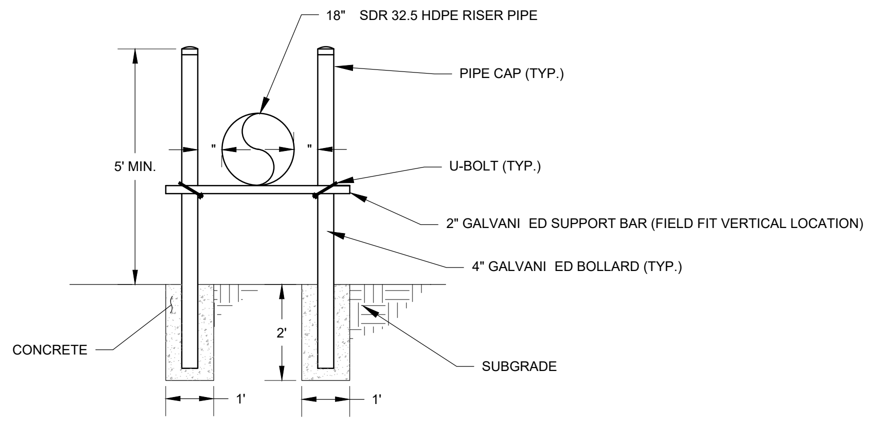
DETAILS

DRAWING NO.
C10
PROJECT NO.
AU19.1274.00

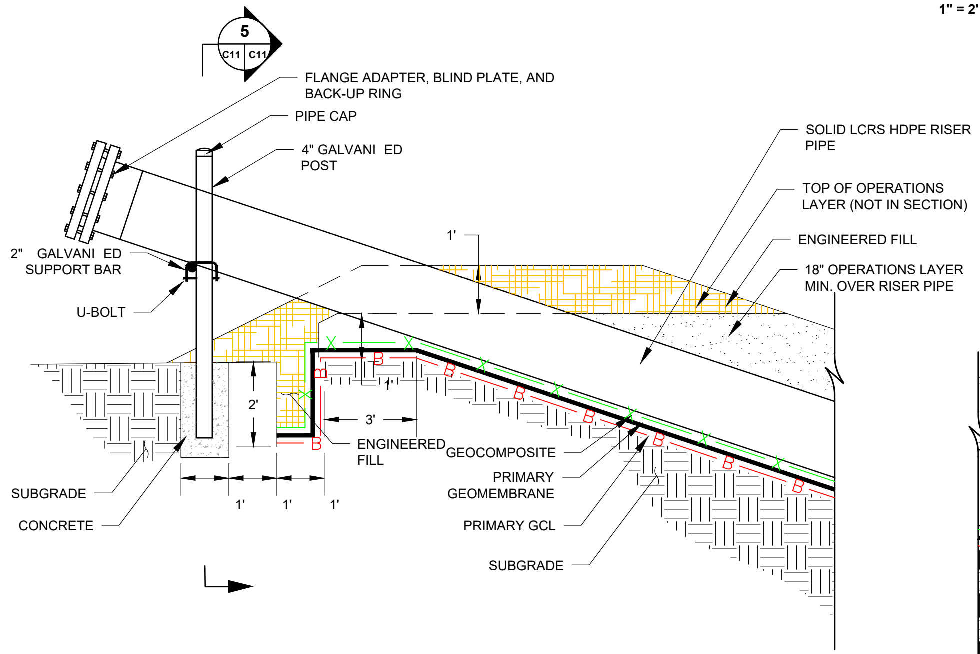
N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\DETAILS.DWG September 15, 2020 - 10:29 AM BY: GLA USER

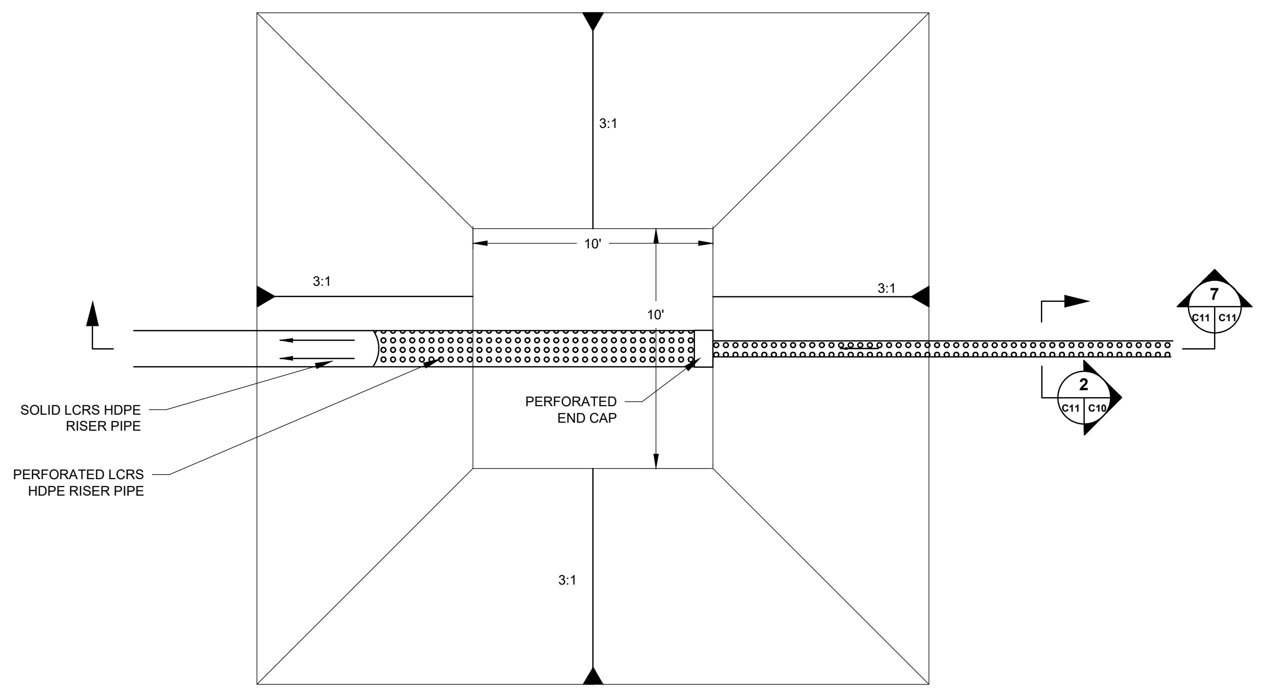


LEACHATE COLLECTION RISER SUPPORT

SECTION 5 C11 C11

1" = 2'

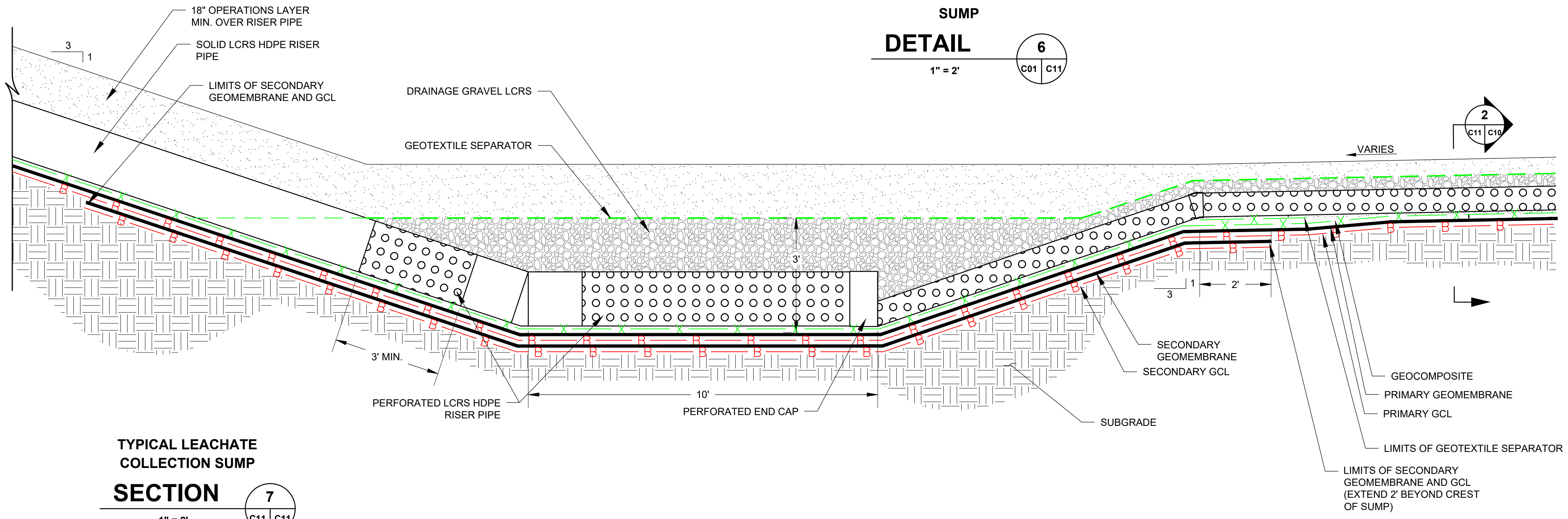




LEACHATE COLLECTION SUMP

DETAIL 6 C01 C11

1" = 2'



TYPICAL LEACHATE COLLECTION SUMP

SECTION 7 C11 C11

1" = 2'

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\DETAILS.DWG September 15, 2020 - 10:29 AM BY: GLA USER

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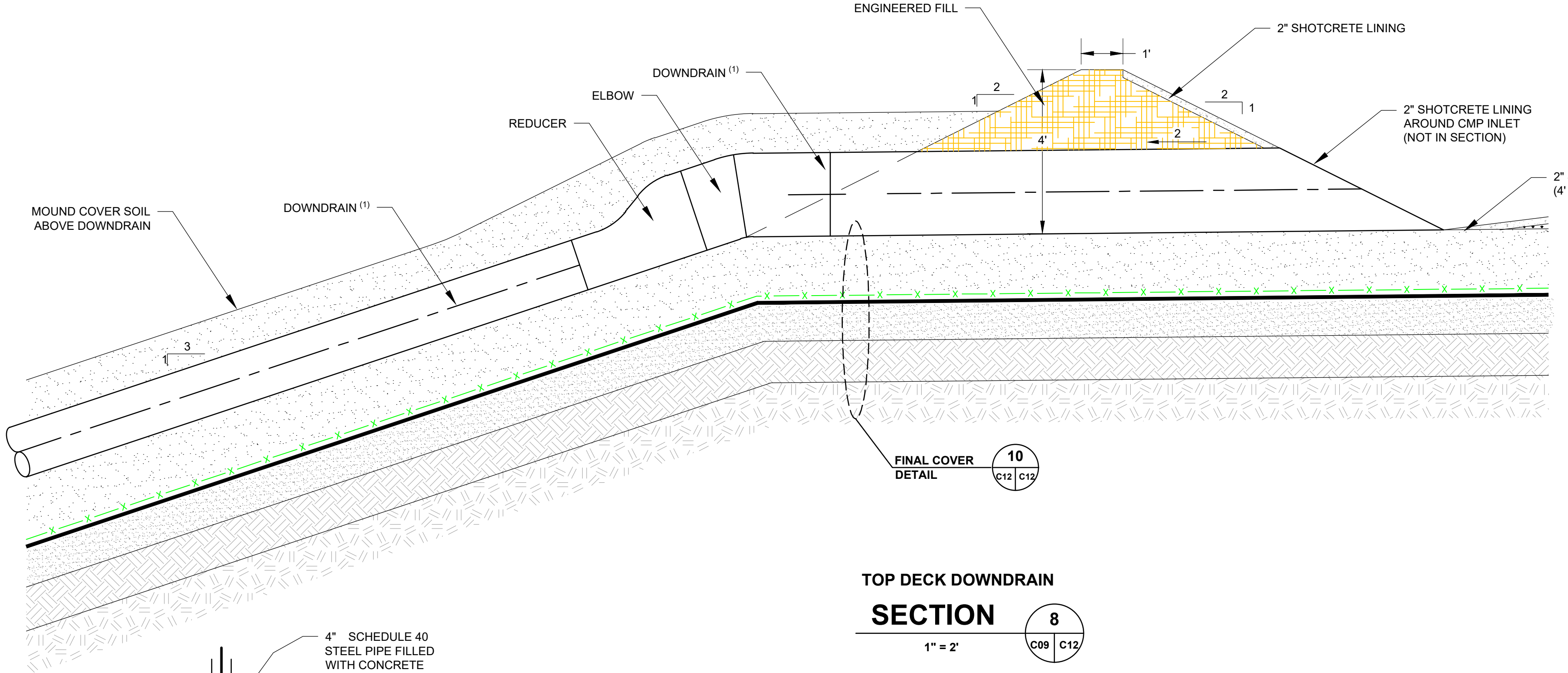
2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
DETAILS

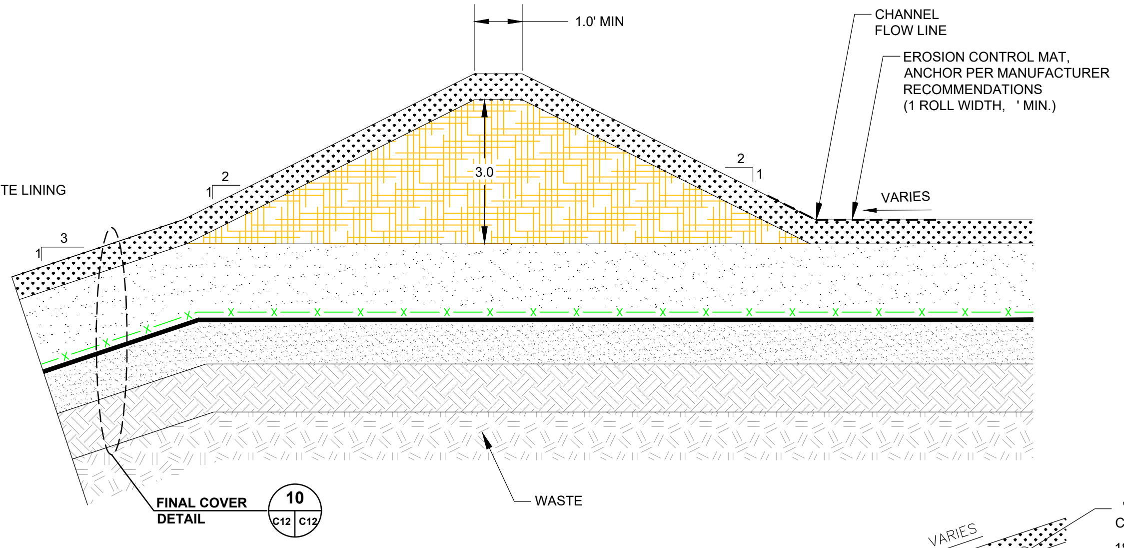
DRAWING NO.
C11
PROJECT NO.
AU19.1274.00



TOP DECK DOWNDRAIN

SECTION 8 C09 C12

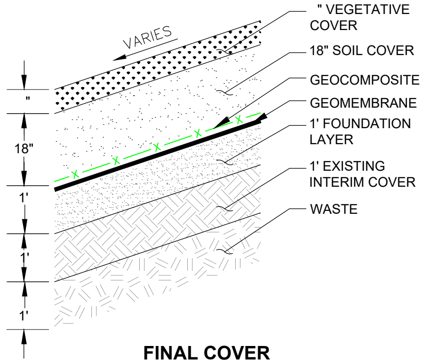
1" = 2'



TOP DECK
PERIMETER BERM

DETAIL 9 C09 C12

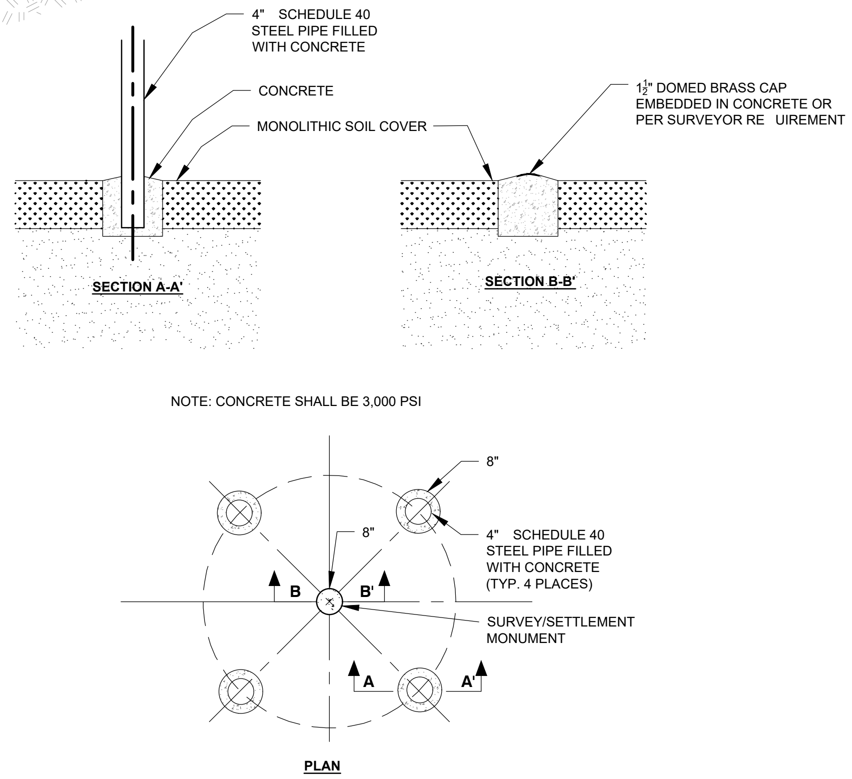
1" = 2'



FINAL COVER

DETAIL 10 C09 C12

1" = 2'

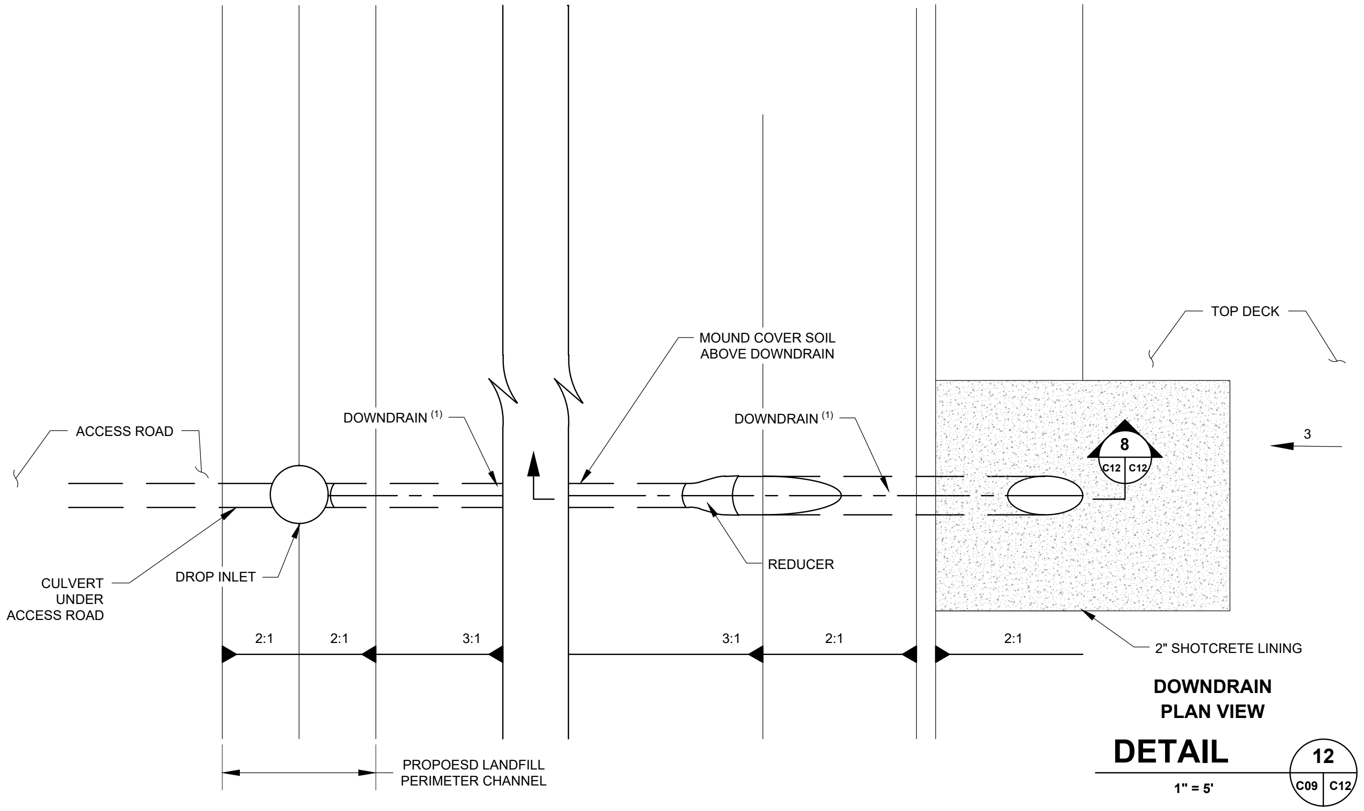


NOTE: CONCRETE SHALL BE 3,000 PSI

SURVEY/SETTLEMENT
MONUMENT

DETAIL 11 C09 C12

1" = 1'



DOWNDRAIN
PLAN VIEW

DETAIL 12 C09 C12

1" = 5'

NOTES

1. SEE APPENDIX D OF REPORT FOR STORMWATER STRUCTURE SI ING.

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\DETAILS.DWG September 15, 2020 - 10:29 AM BY: GLA USER

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REV. NO.	DATE	DESCRIPTION	APPROVED BY
A	09/11/20	ISSUED FOR REVIEW	JVR

DATE OF ISSUE: 09/11/2020
DESIGNED BY: SAH
DRAWN BY: AV
CHECKED BY: SAH
APPROVED BY: JRV

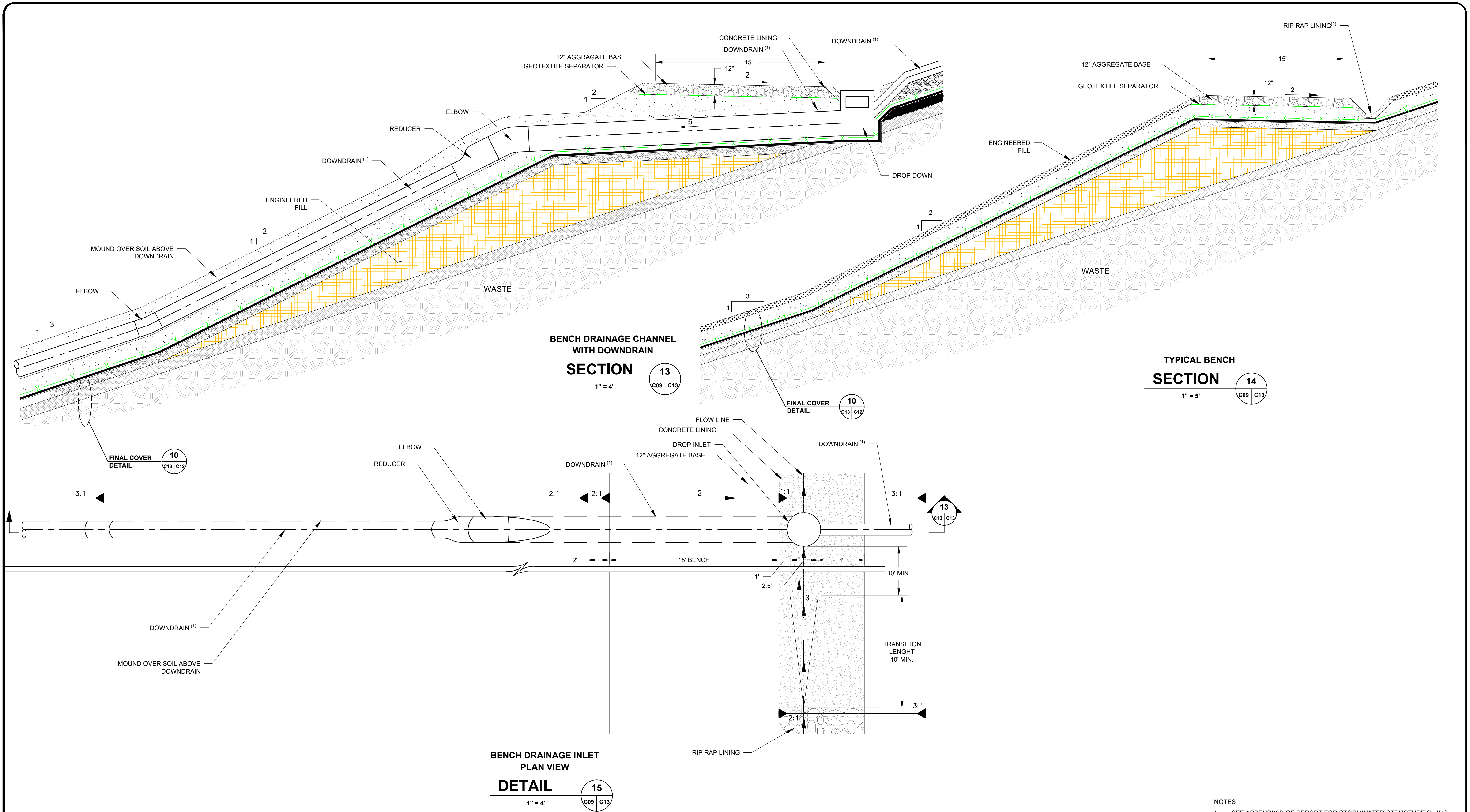
Geo-Logic
ASSOCIATES
143E Spring Hill Dr, Grass Valley, California 95945
geo-logic.com | 530.272.2448

Don't Waste Dixie
WCSW
WASHINGTON COUNTY SOLID WASTE

WASHINGTON COUNTY LANDFILL
2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
DETAILS

DRAWING NO.
C12

PROJECT NO.
AU19.1274.00



BENCH DRAINAGE CHANNEL WITH DOWNDRAIN

SECTION 13 C09 | C13

1" = 4'

TYPICAL BENCH

SECTION 14 C09 | C13

1" = 5'

BENCH DRAINAGE INLET PLAN VIEW

DETAIL 15 C09 | C13

1" = 4'

NOTES

1. SEE APPENDIX D OF REPORT FOR STORMWATER STRUCTURE SI ING.

N:\WASHINGTON COUNTY LANDFILL\AU19.1274.00 WCSW 2020 MASTER PLAN\5_ENGINEERING\1_CIVIL\DRAWINGS\DETAILS.DWG September 15, 2020 - 10:29 AM BY: GLA USER

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2020 MASTER PLAN DRAWINGS
WASHINGTON, UTAH
DETAILS

DRAWING NO.
C13
PROJECT NO.
AU19.1274.00

APPENDIX B

LCRS DESIGN CALCULATIONS

APPENDIX B.1

HELP MODEL OUTPUT

```
↑
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\HELP3\WCL.D4
TEMPERATURE DATA FILE:      C:\HELP3\WCL.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\WCL.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\WCL.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WCL_002C.D10
OUTPUT DATA FILE:           C:\HELP3\WCL_002C.OUT


TIME:  16:43     DATE:   6/ 3/2020


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

     TITLE:  WASHINGTON COUNTY LF_2020 MASTER PLAN_PHASE 5

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


     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
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =      6.00   INCHES
```

```
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2324 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  18
           THICKNESS                   =    120.00   INCHES
           POROSITY                    =      0.6710 VOL/VOL
           FIELD CAPACITY              =      0.2920 VOL/VOL
           WILTING POINT               =      0.0770 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2804 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                                   LAYER  3
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =     18.00   INCHES
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                                   LAYER  4
                                   --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER   0
           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  =      0.0100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =   3.50000000000     CM/SEC
```

```
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                        LAYER  5
                        --------

            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         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      3.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.20   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  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2236 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER             =     94.00
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     16.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.927  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      9.098  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.586  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     42.274  INCHES
TOTAL INITIAL WATER                 =     42.274  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          CEDAR CITY            UTAH

     STATION LATITUDE                      =  37.14 DEGREES
     MAXIMUM LEAF AREA INDEX               =   0.00
     START OF GROWING SEASON (JULIAN DATE) =    125
     END OF GROWING SEASON (JULIAN DATE)   =    284
     EVAPORATIVE ZONE DEPTH                =  16.0  INCHES
     AVERAGE ANNUAL WIND SPEED             =   8.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY =  64.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY =  36.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY =  34.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY =  58.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    MILFORD             UTAH
```

```
              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

        JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
        -------     -------     -------     -------     -------     -------
          1.04        1.07        0.92        0.56        0.41        0.21
          0.63        0.80        0.58        0.67        0.67        0.83


     NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    CEDAR CITY          UTAH

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

        JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
        -------     -------     -------     -------     -------     -------
         39.90       45.40       52.30       60.00       68.70       78.10
         84.50       82.70       74.30       62.00       48.60       40.20


     NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
              COEFFICIENTS FOR    CEDAR CITY          UTAH
                AND STATION LATITUDE  =  37.14 DEGREES


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

                          ANNUAL TOTALS FOR YEAR    1
-------------------------------------------------------------------------------
                                         INCHES          CU. FEET     PERCENT
                                        --------        ----------    -------
  PRECIPITATION                           7.13          25881.904    100.00

  RUNOFF                                  0.000             0.000      0.00

  EVAPOTRANSPIRATION                      7.188         26093.449    100.82

  DRAINAGE COLLECTED FROM LAYER  4        0.0024            8.893      0.03

  PERC./LEAKAGE THROUGH LAYER  6          0.000000          0.001      0.00

  AVG. HEAD ON TOP OF LAYER  5            0.0000

  PERC./LEAKAGE THROUGH LAYER  7          0.070995        257.712      1.00

  CHANGE IN WATER STORAGE                -0.132          -478.163     -1.85
```

```
  SOIL WATER AT START OF YEAR            42.274        153454.984

  SOIL WATER AT END OF YEAR              42.142        152976.828

  SNOW WATER AT START OF YEAR             0.000             0.000      0.00

  SNOW WATER AT END OF YEAR               0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE             0.0000            0.012      0.00

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



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

                          ANNUAL TOTALS FOR YEAR    2
-------------------------------------------------------------------------------
                                         INCHES          CU. FEET     PERCENT
                                        --------        ----------    -------
  PRECIPITATION                          10.31          37425.297    100.00

  RUNOFF                                  0.000             0.000      0.00

  EVAPOTRANSPIRATION                     10.430         37859.555    101.16

  DRAINAGE COLLECTED FROM LAYER  4        0.0391          142.018      0.38

  PERC./LEAKAGE THROUGH LAYER  6          0.000001          0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5            0.0001

  PERC./LEAKAGE THROUGH LAYER  7          0.092899        337.222      0.90

  CHANGE IN WATER STORAGE                -0.252          -913.482     -2.44

  SOIL WATER AT START OF YEAR            42.142        152976.828

  SOIL WATER AT END OF YEAR              41.891        152063.344

  SNOW WATER AT START OF YEAR             0.000             0.000      0.00

  SNOW WATER AT END OF YEAR               0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE             0.0000           -0.014      0.00

*******************************************************************************
```

```
********************************************************************************

                          ANNUAL TOTALS FOR YEAR     3
--------------------------------------------------------------------------------
                                          INCHES          CU. FEET     PERCENT
                                         --------        ----------    -------
  PRECIPITATION                             9.32          33831.602    100.00

  RUNOFF                                    0.000             0.000      0.00

  EVAPOTRANSPIRATION                        8.695         31563.416     93.30

  DRAINAGE COLLECTED FROM LAYER  4          0.0375          136.302      0.40

  PERC./LEAKAGE THROUGH LAYER  6            0.000001          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5              0.0001

  PERC./LEAKAGE THROUGH LAYER  7            0.050295        182.570      0.54

  CHANGE IN WATER STORAGE                   0.537          1949.319      5.76

  SOIL WATER AT START OF YEAR              41.891        152063.344

  SOIL WATER AT END OF YEAR                42.428        154012.656

  SNOW WATER AT START OF YEAR               0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                 0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE               0.0000           -0.005      0.00

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


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

                          ANNUAL TOTALS FOR YEAR     4
--------------------------------------------------------------------------------
                                          INCHES          CU. FEET     PERCENT
                                         --------        ----------    -------
  PRECIPITATION                             7.09          25736.707    100.00

  RUNOFF                                    0.000             0.000      0.00

  EVAPOTRANSPIRATION                        7.690         27914.734    108.46
```

```
  DRAINAGE COLLECTED FROM LAYER  4          0.0072           25.965      0.10

  PERC./LEAKAGE THROUGH LAYER  6            0.000000          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5              0.0000

  PERC./LEAKAGE THROUGH LAYER  7            0.028090        101.966      0.40

  CHANGE IN WATER STORAGE                  -0.635         -2305.999     -8.96

  SOIL WATER AT START OF YEAR              42.428        154012.656

  SOIL WATER AT END OF YEAR                41.792        151706.656

  SNOW WATER AT START OF YEAR               0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                 0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE               0.0000            0.040      0.00

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


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

                          ANNUAL TOTALS FOR YEAR     5
--------------------------------------------------------------------------------
                                          INCHES          CU. FEET     PERCENT
                                         --------        ----------    -------
  PRECIPITATION                             9.75          35392.500    100.00

  RUNOFF                                    0.000             0.000      0.00

  EVAPOTRANSPIRATION                       10.207         37051.609    104.69

  DRAINAGE COLLECTED FROM LAYER  4          0.0071           25.929      0.07

  PERC./LEAKAGE THROUGH LAYER  6            0.000001          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5              0.0000

  PERC./LEAKAGE THROUGH LAYER  7            0.027933        101.396      0.29

  CHANGE IN WATER STORAGE                  -0.492         -1786.447     -5.05

  SOIL WATER AT START OF YEAR              41.792        151706.656
```

```
  SOIL WATER AT END OF YEAR               41.300       149920.219

  SNOW WATER AT START OF YEAR              0.000            0.000      0.00

  SNOW WATER AT END OF YEAR                0.000            0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000           0.012      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    6
-------------------------------------------------------------------------------
                                        INCHES          CU. FEET     PERCENT
                                       --------        ----------    -------
  PRECIPITATION                           8.27         30020.098    100.00

  RUNOFF                                  0.000            0.000      0.00

  EVAPOTRANSPIRATION                      8.183        29705.902     98.95

  DRAINAGE COLLECTED FROM LAYER  4        0.0036          12.930      0.04

  PERC./LEAKAGE THROUGH LAYER  6          0.000000         0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5            0.0000

  PERC./LEAKAGE THROUGH LAYER  7          0.019340        70.206      0.23

  CHANGE IN WATER STORAGE                 0.064          231.071      0.77

  SOIL WATER AT START OF YEAR            41.300       149920.219

  SOIL WATER AT END OF YEAR              41.364       150151.281

  SNOW WATER AT START OF YEAR             0.000            0.000      0.00

  SNOW WATER AT END OF YEAR               0.000            0.000      0.00

  ANNUAL WATER BUDGET BALANCE             0.0000          -0.010      0.00

*******************************************************************************
```

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

                          ANNUAL TOTALS FOR YEAR    7
-------------------------------------------------------------------------------
                                        INCHES          CU. FEET     PERCENT
                                       --------        ----------    -------
  PRECIPITATION                           7.00         25410.006    100.00

  RUNOFF                                  0.000            0.000      0.00

  EVAPOTRANSPIRATION                      6.931        25160.783     99.02

  DRAINAGE COLLECTED FROM LAYER  4        0.0061          22.203      0.09

  PERC./LEAKAGE THROUGH LAYER  6          0.000001         0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5            0.0000

  PERC./LEAKAGE THROUGH LAYER  7          0.031951       115.981      0.46

  CHANGE IN WATER STORAGE                 0.031          111.028      0.44

  SOIL WATER AT START OF YEAR            41.364       150151.281

  SOIL WATER AT END OF YEAR              41.395       150262.312

  SNOW WATER AT START OF YEAR             0.000            0.000      0.00

  SNOW WATER AT END OF YEAR               0.000            0.000      0.00

  ANNUAL WATER BUDGET BALANCE             0.0000           0.010      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    8
-------------------------------------------------------------------------------
                                        INCHES          CU. FEET     PERCENT
                                       --------        ----------    -------
  PRECIPITATION                           8.25         29947.500    100.00

  RUNOFF                                  0.000            0.000      0.00

  EVAPOTRANSPIRATION                      7.188        26091.336     87.12

  DRAINAGE COLLECTED FROM LAYER  4        0.0078          28.315      0.09
```

```
  PERC./LEAKAGE THROUGH LAYER  6           0.000001          0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5             0.0000

  PERC./LEAKAGE THROUGH LAYER  7           0.026094         94.721      0.32

  CHANGE IN WATER STORAGE                  1.028          3733.094     12.47

  SOIL WATER AT START OF YEAR             41.395        150262.312

  SOIL WATER AT END OF YEAR               42.423        153995.406

  SNOW WATER AT START OF YEAR              0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000            0.033      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    9
--------------------------------------------------------------------------------
                                          INCHES          CU. FEET     PERCENT
                                         --------        ----------    -------
  PRECIPITATION                           6.90          25047.004    100.00

  RUNOFF                                   0.000             0.000      0.00

  EVAPOTRANSPIRATION                       7.507         27250.135    108.80

  DRAINAGE COLLECTED FROM LAYER  4         0.0036           13.149      0.05

  PERC./LEAKAGE THROUGH LAYER  6           0.000001          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5             0.0000

  PERC./LEAKAGE THROUGH LAYER  7           0.014677         53.276      0.21

  CHANGE IN WATER STORAGE                 -0.625         -2269.539     -9.06

  SOIL WATER AT START OF YEAR             42.423        153995.406

  SOIL WATER AT END OF YEAR               41.798        151725.875
```

```
  SNOW WATER AT START OF YEAR              0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000           -0.016      0.00

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


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

                          ANNUAL TOTALS FOR YEAR   10
--------------------------------------------------------------------------------
                                          INCHES          CU. FEET     PERCENT
                                         --------        ----------    -------
  PRECIPITATION                          10.59          38441.703    100.00

  RUNOFF                                   0.000             0.000      0.00

  EVAPOTRANSPIRATION                       9.488         34441.105     89.59

  DRAINAGE COLLECTED FROM LAYER  4         0.0230           83.526      0.22

  PERC./LEAKAGE THROUGH LAYER  6           0.000001          0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5             0.0000

  PERC./LEAKAGE THROUGH LAYER  7           0.016532         60.011      0.16

  CHANGE IN WATER STORAGE                  1.063          3857.055     10.03

  SOIL WATER AT START OF YEAR             41.798        151725.875

  SOIL WATER AT END OF YEAR               42.860        155582.922

  SNOW WATER AT START OF YEAR              0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000            0.004      0.00

********************************************************************************
```

```
*******************************************************************************

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   10
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.80     0.94     0.78     0.50     0.67     0.17
                           0.78     0.76     0.78     0.49     0.97     0.81

    STD. DEVIATIONS        0.55     0.43     0.23     0.38     0.51     0.10
                           0.47     0.34     0.53     0.44     0.79     0.55

  RUNOFF
  ------
    TOTALS                 0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.738    0.837    1.011    0.558    0.629    0.361
                           0.634    0.666    0.656    0.657    0.976    0.627

    STD. DEVIATIONS        0.359    0.385    0.478    0.309    0.356    0.134
                           0.693    0.505    0.435    0.487    0.620    0.196

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
    TOTALS                 0.0022   0.0011   0.0011   0.0009   0.0003   0.0005
                           0.0003   0.0010   0.0005   0.0004   0.0042   0.0014

    STD. DEVIATIONS        0.0059   0.0022   0.0022   0.0013   0.0003   0.0008
                           0.0004   0.0015   0.0007   0.0004   0.0091   0.0029

  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

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    TOTALS                 0.0029   0.0052   0.0046   0.0020   0.0021   0.0031
```

```
                           0.0022   0.0026   0.0034   0.0026   0.0044   0.0027

    STD. DEVIATIONS        0.0040   0.0063   0.0041   0.0020   0.0026   0.0023
                           0.0020   0.0022   0.0039   0.0020   0.0056   0.0030

-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES               0.0001   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0001   0.0000

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

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   10
-------------------------------------------------------------------------------
                                  INCHES           CU. FEET      PERCENT
                             -------------------  -------------  ---------
 PRECIPITATION                 8.46    (   1.440)      30713.4     100.00

 RUNOFF                        0.000   (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION            8.351   (  1.2942)     30313.21     98.697

 LATERAL DRAINAGE COLLECTED    0.01375 (  0.01418)       49.923    0.16254
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH   0.00000 (  0.00000)        0.002    0.00001
   LAYER  6

 AVERAGE HEAD ON TOP           0.000 (    0.000)
   OF LAYER  5

 PERCOLATION/LEAKAGE THROUGH   0.03788 (  0.02579)      137.506    0.44771
   LAYER  7

 CHANGE IN WATER STORAGE       0.059   (  0.6292)       212.79     0.693
*******************************************************************************
```

```
↑
******************************************************************************

             PEAK DAILY VALUES FOR YEARS    1 THROUGH   10
   ------------------------------------------------------------------------
                                            (INCHES)      (CU. FT.)
                                           ----------   -------------
      PRECIPITATION                          1.12          4065.600

      RUNOFF                                 0.000            0.0000

      DRAINAGE COLLECTED FROM LAYER  4       0.00599         21.75427

      PERCOLATION/LEAKAGE THROUGH LAYER  6   0.000000         0.00003

      AVERAGE HEAD ON TOP OF LAYER  5        0.005

      MAXIMUM HEAD ON TOP OF LAYER  5        0.010

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)            0.0 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  7   0.001469         5.33316

      SNOW WATER                             0.46          1682.9304


      MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.2660

      MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0992


       ***  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   10
    ----------------------------------------------------------------------
               LAYER        (INCHES)       (VOL/VOL)
               -----        --------       ---------
                 1            1.7469         0.2911

                 2           34.2648         0.2855

                 3            4.3920         0.2440

                 4            0.0020         0.0100

                 5            0.0000         0.0000

                 6            0.1500         0.7500

                 7            2.3046         0.1921

             SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:\HELP3\WCL_MAX.D4
TEMPERATURE DATA FILE:      C:\HELP3\WCL_MAX.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\WCL_MAX.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\WCL_MAX.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WCL_002C.D10
OUTPUT DATA FILE:           C:\HELP3\WCL_002C.OUT



TIME:  11:20     DATE:   6/ 3/2020




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

     TITLE:  WASHINGTON COUNTY LF_2020 MASTER PLAN_PHASE 5

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




     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
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =      6.00   INCHES
```

```
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1622 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC




                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  18
           THICKNESS                   =    120.00   INCHES
           POROSITY                    =      0.6710 VOL/VOL
           FIELD CAPACITY              =      0.2920 VOL/VOL
           WILTING POINT               =      0.0770 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2868 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC




                                   LAYER  3
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =     18.00   INCHES
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2489 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC




                                   LAYER  4
                                   --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER   0
           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  =      0.0353 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =   3.50000000000     CM/SEC
```

```
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                        LAYER  5
                        --------

            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         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      3.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.20   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  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2157 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER             =     94.00
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     16.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      3.264  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      9.098  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.586  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     42.609  INCHES
TOTAL INITIAL WATER                 =     42.609  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          CEDAR CITY            UTAH

     STATION LATITUDE                       =  37.14 DEGREES
     MAXIMUM LEAF AREA INDEX                =   0.00
     START OF GROWING SEASON (JULIAN DATE)  =    125
     END OF GROWING SEASON (JULIAN DATE)    =    284
     EVAPORATIVE ZONE DEPTH                 =  16.0  INCHES
     AVERAGE ANNUAL WIND SPEED              =   8.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  64.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  36.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  34.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  58.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    MILFORD             UTAH
```

```
              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       1.91        3.63        2.92        1.49        2.05        0.07
       0.00        0.00        0.00        0.00        2.76        1.34


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    CEDAR CITY          UTAH

           NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
      41.10       40.60       52.60       63.10       63.10       79.30
      86.40       86.20       77.40       58.80       50.60       39.90


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    CEDAR CITY          UTAH
                  AND STATION LATITUDE  =  37.14 DEGREES



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

                          ANNUAL TOTALS FOR YEAR    1
-------------------------------------------------------------------------------
                                          INCHES          CU. FEET     PERCENT
                                         --------        ----------    -------
  PRECIPITATION                            13.22          47988.605    100.00

  RUNOFF                                    0.000             0.000      0.00

  EVAPOTRANSPIRATION                       11.621         42185.602     87.91

  DRAINAGE COLLECTED FROM LAYER  4          1.6405         5954.917     12.41

  PERC./LEAKAGE THROUGH LAYER  6            0.000002          0.005      0.00

  AVG. HEAD ON TOP OF LAYER  5              0.0034

  PERC./LEAKAGE THROUGH LAYER  7            0.107076        388.686      0.81

  CHANGE IN WATER STORAGE                  -0.149          -540.628     -1.13
```

```
  SOIL WATER AT START OF YEAR             42.609       154672.453

  SOIL WATER AT END OF YEAR               42.461       154131.812

  SNOW WATER AT START OF YEAR              0.000            0.000      0.00

  SNOW WATER AT END OF YEAR                0.000            0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000           0.028      0.00

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




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

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    1
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.84     2.94     2.94     1.59     0.30     0.06
                           0.00     0.00     0.00     0.00     3.55     1.00

    STD. DEVIATIONS        0.00     0.00     0.00     0.00     0.00     0.00
                           0.00     0.00     0.00     0.00     0.00     0.00

  RUNOFF
  ------
    TOTALS                 0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.711    1.990    3.083    1.670    0.530    0.374
                           0.316    0.275    0.013    0.000    0.837    1.824

    STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
```

```
   TOTALS               0.0931   0.0368   0.3463   0.8317   0.1522   0.0080
                        0.0125   0.0000   0.0000   0.0000   0.0000   0.1598

   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

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ----------------------------------
   TOTALS               0.0165   0.0122   0.0183   0.0175   0.0142   0.0049
                        0.0104   0.0000   0.0000   0.0000   0.0005   0.0126

   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  5
 -----------------------------------
   AVERAGES             0.0023   0.0010   0.0084   0.0210   0.0037   0.0002
                        0.0003   0.0000   0.0000   0.0000   0.0000   0.0039

   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

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    1
-------------------------------------------------------------------------------
                                   INCHES           CU. FEET       PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                 13.22    (   0.000)      47988.6     100.00

 RUNOFF                         0.000   (  0.0000)         0.00      0.000
```

```
 EVAPOTRANSPIRATION             11.621   (  0.0000)      42185.60     87.908

 LATERAL DRAINAGE COLLECTED      1.64047 (  0.00000)      5954.917   12.40902
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.005     0.00001
   LAYER  6

 AVERAGE HEAD ON TOP             0.003 (    0.000)
   OF LAYER  5

 PERCOLATION/LEAKAGE THROUGH     0.10708 (  0.00000)       388.686     0.80996
   LAYER  7

 CHANGE IN WATER STORAGE        -0.149   (  0.0000)       -540.63     -1.127

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                PEAK DAILY VALUES FOR YEARS    1 THROUGH    1
   ------------------------------------------------------------------------
                                                  (INCHES)     (CU. FT.)
                                                 ----------   -------------
      PRECIPITATION                                 1.42         5154.600

      RUNOFF                                        0.000           0.0000

      DRAINAGE COLLECTED FROM LAYER  4              0.13074       474.56915

      PERCOLATION/LEAKAGE THROUGH LAYER  6          0.000000        0.00011

      AVERAGE HEAD ON TOP OF LAYER  5               0.099

      MAXIMUM HEAD ON TOP OF LAYER  5               0.195

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)                   3.8 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  7          0.000826        2.99879

      SNOW WATER                                    0.00            0.0000


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.3382

      MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.0991
```

```
       ***  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    1
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            0.9425         0.1571

                      2           34.4166         0.2868

                      3            4.4634         0.2480

                      4            0.0068         0.0341

                      5            0.0000         0.0000

                      6            0.1500         0.7500

                      7            2.4813         0.2068

                  SNOW WATER       0.000

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```

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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:\HELP3\WCL.D4
TEMPERATURE DATA FILE:      C:\HELP3\WCL.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\WCL.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\WCL.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WCL_003C.D10
OUTPUT DATA FILE:           C:\HELP3\WCL_003C.OUT



TIME:  16:45     DATE:   6/ 3/2020




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     TITLE:  WASHINGTON COUNTY LF_2020 MASTER PLAN_PHASES 6-12

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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
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                  =      6.00   INCHES
```

```
           POROSITY                   =      0.3980 VOL/VOL
           FIELD CAPACITY             =      0.2440 VOL/VOL
           WILTING POINT              =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2324 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC




                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  18
           THICKNESS                  =    120.00   INCHES
           POROSITY                   =      0.6710 VOL/VOL
           FIELD CAPACITY             =      0.2920 VOL/VOL
           WILTING POINT              =      0.0770 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2804 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC




                                   LAYER  3
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                  =     18.00   INCHES
           POROSITY                   =      0.3980 VOL/VOL
           FIELD CAPACITY             =      0.2440 VOL/VOL
           WILTING POINT              =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2440 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.119999997000E-03 CM/SEC




                                   LAYER  4
                                   --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER   0
           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 =      0.0100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =   1.79999995000     CM/SEC
```

```
SLOPE                        =     2.80   PERCENT
DRAINAGE LENGTH              =   215.0    FEET


                        LAYER  5
                        --------

            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          =     1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =     3.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                    =     0.20   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  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3980 VOL/VOL
FIELD CAPACITY               =     0.2440 VOL/VOL
WILTING POINT                =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.2236 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER             =    94.00
FRACTION OF AREA ALLOWING RUNOFF    =     0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     1.000  ACRES
EVAPORATIVE ZONE DEPTH              =    16.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =     2.927  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =     9.098  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =     1.586  INCHES
INITIAL SNOW WATER                  =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    42.274  INCHES
TOTAL INITIAL WATER                 =    42.274  INCHES
TOTAL SUBSURFACE INFLOW             =     0.00   INCHES/YEAR


            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          CEDAR CITY            UTAH

     STATION LATITUDE                        =  37.14 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   0.00
     START OF GROWING SEASON (JULIAN DATE)   =    125
     END OF GROWING SEASON (JULIAN DATE)     =    284
     EVAPORATIVE ZONE DEPTH                  =  16.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =   8.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  64.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  36.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  34.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  58.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    MILFORD             UTAH
```

```
              NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

        JAN/JUL    FEB/AUG    MAR/SEP    APR/OCT    MAY/NOV    JUN/DEC
        -------    -------    -------    -------    -------    -------
          1.04       1.07       0.92       0.56       0.41       0.21
          0.63       0.80       0.58       0.67       0.67       0.83


          NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    CEDAR CITY          UTAH

            NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

        JAN/JUL    FEB/AUG    MAR/SEP    APR/OCT    MAY/NOV    JUN/DEC
        -------    -------    -------    -------    -------    -------
         39.90      45.40      52.30      60.00      68.70      78.10
         84.50      82.70      74.30      62.00      48.60      40.20


          NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                 COEFFICIENTS FOR    CEDAR CITY          UTAH
                  AND STATION LATITUDE  =  37.14 DEGREES



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

                          ANNUAL TOTALS FOR YEAR    1
-------------------------------------------------------------------------------
                                        INCHES          CU. FEET     PERCENT
                                       --------        ----------    -------
  PRECIPITATION                          7.13          25881.904     100.00

  RUNOFF                                 0.000             0.000       0.00

  EVAPOTRANSPIRATION                     7.188         26093.449     100.82

  DRAINAGE COLLECTED FROM LAYER  4       0.0024            8.893       0.03

  PERC./LEAKAGE THROUGH LAYER  6         0.000000          0.001       0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0000

  PERC./LEAKAGE THROUGH LAYER  7         0.070995        257.712       1.00

  CHANGE IN WATER STORAGE               -0.132          -478.163      -1.85

  SOIL WATER AT START OF YEAR           42.274        153454.984

  SOIL WATER AT END OF YEAR             42.142        152976.828

  SNOW WATER AT START OF YEAR            0.000             0.000       0.00

  SNOW WATER AT END OF YEAR              0.000             0.000       0.00

  ANNUAL WATER BUDGET BALANCE            0.0000            0.012       0.00
*******************************************************************************




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

                          ANNUAL TOTALS FOR YEAR    2
-------------------------------------------------------------------------------
                                        INCHES          CU. FEET     PERCENT
                                       --------        ----------    -------
  PRECIPITATION                         10.31          37425.297     100.00

  RUNOFF                                 0.000             0.000       0.00

  EVAPOTRANSPIRATION                    10.430         37859.555     101.16

  DRAINAGE COLLECTED FROM LAYER  4       0.0391          142.025       0.38

  PERC./LEAKAGE THROUGH LAYER  6         0.000001          0.003       0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0001

  PERC./LEAKAGE THROUGH LAYER  7         0.090740        329.387       0.88

  CHANGE IN WATER STORAGE               -0.249          -905.658      -2.42

  SOIL WATER AT START OF YEAR           42.142        152976.828

  SOIL WATER AT END OF YEAR             41.893        152071.172

  SNOW WATER AT START OF YEAR            0.000             0.000       0.00

  SNOW WATER AT END OF YEAR              0.000             0.000       0.00

  ANNUAL WATER BUDGET BALANCE            0.0000           -0.009       0.00
*******************************************************************************
```

```
*******************************************************************************

                          ANNUAL TOTALS FOR YEAR    3
-------------------------------------------------------------------------------
                                        INCHES         CU. FEET     PERCENT
                                       --------       ----------    -------
  PRECIPITATION                           9.32         33831.602    100.00

  RUNOFF                                 0.000             0.000      0.00

  EVAPOTRANSPIRATION                     8.695         31563.416     93.30

  DRAINAGE COLLECTED FROM LAYER  4       0.0375          136.295      0.40

  PERC./LEAKAGE THROUGH LAYER  6         0.000001          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0001

  PERC./LEAKAGE THROUGH LAYER  7         0.050511        183.353      0.54

  CHANGE IN WATER STORAGE                0.537          1948.544      5.76

  SOIL WATER AT START OF YEAR           41.893        152071.172

  SOIL WATER AT END OF YEAR             42.430        154019.703

  SNOW WATER AT START OF YEAR            0.000             0.000      0.00

  SNOW WATER AT END OF YEAR              0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE            0.0000           -0.007      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    4
-------------------------------------------------------------------------------
                                        INCHES         CU. FEET     PERCENT
                                       --------       ----------    -------
  PRECIPITATION                           7.09         25736.707    100.00

  RUNOFF                                 0.000             0.000      0.00

  EVAPOTRANSPIRATION                     7.690         27914.734    108.46
```

```
  DRAINAGE COLLECTED FROM LAYER  4       0.0072           25.965      0.10

  PERC./LEAKAGE THROUGH LAYER  6         0.000000          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0000

  PERC./LEAKAGE THROUGH LAYER  7         0.028423        103.175      0.40

  CHANGE IN WATER STORAGE               -0.636         -2307.204     -8.96

  SOIL WATER AT START OF YEAR           42.430        154019.703

  SOIL WATER AT END OF YEAR             41.794        151712.500

  SNOW WATER AT START OF YEAR            0.000             0.000      0.00

  SNOW WATER AT END OF YEAR              0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE            0.0000            0.036      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    5
-------------------------------------------------------------------------------
                                        INCHES         CU. FEET     PERCENT
                                       --------       ----------    -------
  PRECIPITATION                           9.75         35392.500    100.00

  RUNOFF                                 0.000             0.000      0.00

  EVAPOTRANSPIRATION                    10.207         37051.609    104.69

  DRAINAGE COLLECTED FROM LAYER  4       0.0071           25.929      0.07

  PERC./LEAKAGE THROUGH LAYER  6         0.000001          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0000

  PERC./LEAKAGE THROUGH LAYER  7         0.028211        102.405      0.29

  CHANGE IN WATER STORAGE               -0.492         -1787.458     -5.05

  SOIL WATER AT START OF YEAR           41.794        151712.500
```

```
  SOIL WATER AT END OF YEAR               41.302        149925.047

  SNOW WATER AT START OF YEAR              0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000            0.014      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    6
-------------------------------------------------------------------------------
                                         INCHES          CU. FEET     PERCENT
                                        --------        ----------    -------
  PRECIPITATION                            8.27         30020.098    100.00

  RUNOFF                                   0.000             0.000      0.00

  EVAPOTRANSPIRATION                       8.183         29705.902     98.95

  DRAINAGE COLLECTED FROM LAYER  4         0.0036           12.930      0.04

  PERC./LEAKAGE THROUGH LAYER  6           0.000000          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5             0.0000

  PERC./LEAKAGE THROUGH LAYER  7           0.019506         70.807      0.24

  CHANGE IN WATER STORAGE                  0.063           230.475      0.77

  SOIL WATER AT START OF YEAR             41.302        149925.047

  SOIL WATER AT END OF YEAR               41.365        150155.531

  SNOW WATER AT START OF YEAR              0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000           -0.016      0.00

*******************************************************************************
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                          ANNUAL TOTALS FOR YEAR    7
-------------------------------------------------------------------------------
                                         INCHES          CU. FEET     PERCENT
                                        --------        ----------    -------
  PRECIPITATION                            7.00         25410.006    100.00

  RUNOFF                                   0.000             0.000      0.00

  EVAPOTRANSPIRATION                       6.931         25160.783     99.02

  DRAINAGE COLLECTED FROM LAYER  4         0.0061           22.203      0.09

  PERC./LEAKAGE THROUGH LAYER  6           0.000001          0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5             0.0000

  PERC./LEAKAGE THROUGH LAYER  7           0.031996        116.145      0.46

  CHANGE IN WATER STORAGE                  0.031           110.848      0.44

  SOIL WATER AT START OF YEAR             41.365        150155.531

  SOIL WATER AT END OF YEAR               41.396        150266.375

  SNOW WATER AT START OF YEAR              0.000             0.000      0.00

  SNOW WATER AT END OF YEAR                0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE              0.0000            0.025      0.00

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


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

                          ANNUAL TOTALS FOR YEAR    8
-------------------------------------------------------------------------------
                                         INCHES          CU. FEET     PERCENT
                                        --------        ----------    -------
  PRECIPITATION                            8.25         29947.500    100.00

  RUNOFF                                   0.000             0.000      0.00

  EVAPOTRANSPIRATION                       7.188         26091.336     87.12

  DRAINAGE COLLECTED FROM LAYER  4         0.0078           28.315      0.09
```

```
  PERC./LEAKAGE THROUGH LAYER  6          0.000001         0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5            0.0000

  PERC./LEAKAGE THROUGH LAYER  7          0.025971        94.276      0.31

  CHANGE IN WATER STORAGE                 1.029         3733.551     12.47

  SOIL WATER AT START OF YEAR            41.396       150266.375

  SOIL WATER AT END OF YEAR              42.424       153999.922

  SNOW WATER AT START OF YEAR             0.000            0.000      0.00

  SNOW WATER AT END OF YEAR               0.000            0.000      0.00

  ANNUAL WATER BUDGET BALANCE             0.0000           0.023      0.00

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

                          ANNUAL TOTALS FOR YEAR    9
--------------------------------------------------------------------------------
                                        INCHES         CU. FEET     PERCENT
                                       --------       ----------    -------
  PRECIPITATION                          6.90          25047.004    100.00

  RUNOFF                                 0.000             0.000      0.00

  EVAPOTRANSPIRATION                     7.507         27250.135    108.80

  DRAINAGE COLLECTED FROM LAYER  4       0.0036           13.149      0.05

  PERC./LEAKAGE THROUGH LAYER  6         0.000001          0.002      0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0000

  PERC./LEAKAGE THROUGH LAYER  7         0.014660         53.216      0.21

  CHANGE IN WATER STORAGE               -0.625         -2269.484     -9.06

  SOIL WATER AT START OF YEAR           42.424        153999.922

  SOIL WATER AT END OF YEAR             41.799        151730.437
```

```
  SNOW WATER AT START OF YEAR            0.000             0.000      0.00

  SNOW WATER AT END OF YEAR              0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE            0.0000           -0.012      0.00

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                          ANNUAL TOTALS FOR YEAR   10
--------------------------------------------------------------------------------
                                        INCHES         CU. FEET     PERCENT
                                       --------       ----------    -------
  PRECIPITATION                         10.59          38441.703    100.00

  RUNOFF                                 0.000             0.000      0.00

  EVAPOTRANSPIRATION                     9.488         34441.105     89.59

  DRAINAGE COLLECTED FROM LAYER  4       0.0230           83.526      0.22

  PERC./LEAKAGE THROUGH LAYER  6         0.000001          0.003      0.00

  AVG. HEAD ON TOP OF LAYER  5           0.0000

  PERC./LEAKAGE THROUGH LAYER  7         0.016549         60.074      0.16

  CHANGE IN WATER STORAGE                1.063          3856.986     10.03

  SOIL WATER AT START OF YEAR           41.799        151730.437

  SOIL WATER AT END OF YEAR             42.862        155587.422

  SNOW WATER AT START OF YEAR            0.000             0.000      0.00

  SNOW WATER AT END OF YEAR              0.000             0.000      0.00

  ANNUAL WATER BUDGET BALANCE            0.0000            0.011      0.00

********************************************************************************
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        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   10
------------------------------------------------------------------------------

                        JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                        -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                0.80     0.94     0.78     0.50     0.67     0.17
                          0.78     0.76     0.78     0.49     0.97     0.81

    STD. DEVIATIONS       0.55     0.43     0.23     0.38     0.51     0.10
                          0.47     0.34     0.53     0.44     0.79     0.55

  RUNOFF
  ------
    TOTALS                0.000    0.000    0.000    0.000    0.000    0.000
                          0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS       0.000    0.000    0.000    0.000    0.000    0.000
                          0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                0.738    0.837    1.011    0.558    0.629    0.361
                          0.634    0.666    0.656    0.657    0.976    0.627

    STD. DEVIATIONS       0.359    0.385    0.478    0.309    0.356    0.134
                          0.693    0.505    0.435    0.487    0.620    0.196

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
    TOTALS                0.0022   0.0011   0.0011   0.0009   0.0003   0.0005
                          0.0003   0.0010   0.0005   0.0004   0.0042   0.0014

    STD. DEVIATIONS       0.0059   0.0022   0.0022   0.0013   0.0003   0.0008
                          0.0004   0.0015   0.0007   0.0004   0.0091   0.0029

  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

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    TOTALS                0.0029   0.0053   0.0046   0.0020   0.0021   0.0030
```

```
                          0.0021   0.0025   0.0034   0.0027   0.0044   0.0027

    STD. DEVIATIONS       0.0039   0.0063   0.0041   0.0021   0.0027   0.0022
                          0.0020   0.0021   0.0039   0.0020   0.0056   0.0031


------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES              0.0001   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0001   0.0000

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

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


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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   10
------------------------------------------------------------------------------
                                    INCHES           CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                   8.46    (   1.440)      30713.4     100.00

 RUNOFF                          0.000   (  0.0000)         0.00      0.000

 EVAPOTRANSPIRATION              8.351   (  1.2942)     30313.21     98.697

 LATERAL DRAINAGE COLLECTED      0.01375 (  0.01418)       49.923    0.16254
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.002    0.00001
   LAYER  6

 AVERAGE HEAD ON TOP             0.000 (    0.000)
   OF LAYER  5

 PERCOLATION/LEAKAGE THROUGH     0.03776 (  0.02526)      137.055    0.44624
   LAYER  7

 CHANGE IN WATER STORAGE         0.059   (  0.6291)       213.24      0.694
******************************************************************************
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                PEAK DAILY VALUES FOR YEARS    1 THROUGH   10
   ------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------   -------------
      PRECIPITATION                             1.12         4065.600

      RUNOFF                                    0.000           0.0000

      DRAINAGE COLLECTED FROM LAYER  4          0.00599         21.75616

      PERCOLATION/LEAKAGE THROUGH LAYER  6      0.000000         0.00003

      AVERAGE HEAD ON TOP OF LAYER  5           0.005

      MAXIMUM HEAD ON TOP OF LAYER  5           0.006

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)              82.8 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  7      0.001469         5.33316

      SNOW WATER                                0.46         1682.9304


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.2660

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.0992


       ***  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   10
    ----------------------------------------------------------------------
                   LAYER        (INCHES)       (VOL/VOL)
                   -----        --------       ---------
                     1            1.7469         0.2911

                     2           34.2648         0.2855

                     3            4.3920         0.2440

                     4            0.0020         0.0100

                     5            0.0000         0.0000

                     6            0.1500         0.7500

                     7            2.3059         0.1922

                  SNOW WATER       0.000

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```

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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               **
**                                                                           **
**                                                                           **
*******************************************************************************
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PRECIPITATION DATA FILE:    C:\HELP3\WCL_MAX.D4
TEMPERATURE DATA FILE:      C:\HELP3\WCL_MAX.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\WCL_MAX.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\WCL_MAX.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\WCL_003C.D10
OUTPUT DATA FILE:           C:\HELP3\WCL_003C.OUT



TIME:  11:22     DATE:   6/ 3/2020



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     TITLE:  WASHINGTON COUNTY LF_2020 MASTER PLAN_PHASES 6-12

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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
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =      6.00   INCHES
```

```
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1622 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC



                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  18
           THICKNESS                   =    120.00   INCHES
           POROSITY                    =      0.6710 VOL/VOL
           FIELD CAPACITY              =      0.2920 VOL/VOL
           WILTING POINT               =      0.0770 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2868 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC



                                   LAYER  3
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                   =     18.00   INCHES
           POROSITY                    =      0.3980 VOL/VOL
           FIELD CAPACITY              =      0.2440 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2489 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC



                                   LAYER  4
                                   --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER   0
           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  =      0.0352 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =   1.79999995000     CM/SEC
```

```
SLOPE                        =      2.80   PERCENT
DRAINAGE LENGTH              =    215.0    FEET



                        LAYER  5
                        --------

            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          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      3.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD



                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                    =      0.20   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  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2157 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER             =     94.00
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =     16.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      3.264  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      9.098  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.586  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     42.609  INCHES
TOTAL INITIAL WATER                 =     42.609  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR



            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          CEDAR CITY            UTAH

     STATION LATITUDE                     =  37.14 DEGREES
     MAXIMUM LEAF AREA INDEX              =   0.00
     START OF GROWING SEASON (JULIAN DATE)  =    125
     END OF GROWING SEASON (JULIAN DATE)    =    284
     EVAPORATIVE ZONE DEPTH               =  16.0  INCHES
     AVERAGE ANNUAL WIND SPEED            =   8.80 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  64.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  36.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  34.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  58.00 %


 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    MILFORD             UTAH
```

```
                  NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
       1.91        3.63        2.92        1.49        2.05        0.07
       0.00        0.00        0.00        0.00        2.76        1.34


         NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    CEDAR CITY          UTAH

             NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

     JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
     -------     -------     -------     -------     -------     -------
      41.10       40.60       52.60       63.10       63.10       79.30
      86.40       86.20       77.40       58.80       50.60       39.90


         NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                  COEFFICIENTS FOR    CEDAR CITY          UTAH
                    AND STATION LATITUDE  =  37.14 DEGREES


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

                          ANNUAL TOTALS FOR YEAR    1
-------------------------------------------------------------------------------
                                        INCHES          CU. FEET     PERCENT
                                       --------        ----------    -------
  PRECIPITATION                          13.22          47988.605    100.00

  RUNOFF                                  0.000             0.000      0.00

  EVAPOTRANSPIRATION                     11.621         42185.602     87.91

  DRAINAGE COLLECTED FROM LAYER  4        1.6405         5954.916     12.41

  PERC./LEAKAGE THROUGH LAYER  6          0.000002          0.005      0.00

  AVG. HEAD ON TOP OF LAYER  5            0.0034

  PERC./LEAKAGE THROUGH LAYER  7          0.107076        388.686      0.81

  CHANGE IN WATER STORAGE                -0.149          -540.628     -1.13
```

```
  SOIL WATER AT START OF YEAR            42.609       154672.375

  SOIL WATER AT END OF YEAR              42.461       154131.750

  SNOW WATER AT START OF YEAR             0.000            0.000      0.00

  SNOW WATER AT END OF YEAR               0.000            0.000      0.00

  ANNUAL WATER BUDGET BALANCE             0.0000           0.029      0.00
*******************************************************************************




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

         AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH    1
-------------------------------------------------------------------------------

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                         -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
    TOTALS                 0.84     2.94     2.94     1.59     0.30     0.06
                           0.00     0.00     0.00     0.00     3.55     1.00

    STD. DEVIATIONS        0.00     0.00     0.00     0.00     0.00     0.00
                           0.00     0.00     0.00     0.00     0.00     0.00

  RUNOFF
  ------
    TOTALS                 0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

    STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

  EVAPOTRANSPIRATION
  ------------------
    TOTALS                 0.711    1.990    3.083    1.670    0.530    0.374
                           0.316    0.275    0.013    0.000    0.837    1.824

    STD. DEVIATIONS        0.000    0.000    0.000    0.000    0.000    0.000
                           0.000    0.000    0.000    0.000    0.000    0.000

  LATERAL DRAINAGE COLLECTED FROM LAYER  4
  ----------------------------------------
```

```
   TOTALS                0.0931   0.0368   0.3467   0.8314   0.1522   0.0080
                         0.0125   0.0000   0.0000   0.0000   0.0000   0.1598

   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

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   TOTALS                0.0165   0.0122   0.0183   0.0175   0.0142   0.0049
                         0.0104   0.0000   0.0000   0.0000   0.0005   0.0126

   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  5
 -------------------------------------
   AVERAGES              0.0023   0.0010   0.0084   0.0209   0.0037   0.0002
                         0.0003   0.0000   0.0000   0.0000   0.0000   0.0039

   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

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


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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH    1
-------------------------------------------------------------------------------
                                    INCHES           CU. FEET       PERCENT
                              -------------------  -------------   ---------
 PRECIPITATION                13.22    (   0.000)      47988.6     100.00

 RUNOFF                        0.000   (  0.0000)         0.00      0.000
```

```
 EVAPOTRANSPIRATION            11.621   (  0.0000)      42185.60     87.908

 LATERAL DRAINAGE COLLECTED     1.64047 (  0.00000)      5954.916   12.40902
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.005     0.00001
   LAYER  6

 AVERAGE HEAD ON TOP            0.003 (    0.000)
   OF LAYER  5

 PERCOLATION/LEAKAGE THROUGH    0.10708 (  0.00000)       388.686     0.80996
   LAYER  7

 CHANGE IN WATER STORAGE       -0.149   (  0.0000)       -540.63     -1.127

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


↑
*******************************************************************************

               PEAK DAILY VALUES FOR YEARS    1 THROUGH    1
   ------------------------------------------------------------------------
                                             (INCHES)      (CU. FT.)
                                            ----------    -------------
     PRECIPITATION                             1.42          5154.600

     RUNOFF                                    0.000            0.0000

     DRAINAGE COLLECTED FROM LAYER  4          0.13082        474.88278

     PERCOLATION/LEAKAGE THROUGH LAYER  6      0.000000         0.00011

     AVERAGE HEAD ON TOP OF LAYER  5           0.099

     MAXIMUM HEAD ON TOP OF LAYER  5           0.194

     LOCATION OF MAXIMUM HEAD IN LAYER  4
           (DISTANCE FROM DRAIN)               2.9 FEET

     PERCOLATION/LEAKAGE THROUGH LAYER  7      0.000826         2.99879

     SNOW WATER                                0.00             0.0000


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3382

     MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.0991
```

```
       ***  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    1
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1            0.9425         0.1571

                      2           34.4166         0.2868

                      3            4.4634         0.2480

                      4            0.0068         0.0339

                      5            0.0000         0.0000

                      6            0.1500         0.7500

                      7            2.4813         0.2068

                  SNOW WATER       0.000

******************************************************************************
******************************************************************************
```

APPENDIX B.2

DRAINAGE LAYER DESIGN CALCULATIONS

Geo-Logic
ASSOCIATES

Job Name:	Washington County LF Master Plan		
Client:	Washington County		
Job No.:	AU19.1274.00		
Calc by:	ASO	Date:	6/3/2020
Reviewed by:		Date:	

Transmissivity calculations based on HELP model impingement rate and specified material properties

GEOCOMPOSITE DRAINAGE LAYER_PHASE 5

HELP lat. drainage input here

Input (From HELP Model):

	Symbol	Value	Units			
Impingment Rate (peak daily drainage_from HELP analysis)	q_h =	**3.85E-08**	m/s	=	0.131	in/day
Maximum drainage distance of liquid collection layer	L =	**91.5**	m	=	300	feet
Thickness of liquid collection layer	t =	**0.00508**	m	=	0.20	inches
Slope	b =	**1.15**	degrees	=	2	%

Calculations:

Maximum liquid depth	h_{max}	**0.0050**	m	=	0.20 inches
Required Transmissivity	$T_{required}$	**1.8E-04**	m^2/s		$T_{required} = \frac{q_h \cdot L}{\sin(b)}$
Safety Factor for intrusion/elastic deformation	SF_{in}	**1.7**	1.5 - 2.0		
Safety Factor for creep deformation	SF_{cr}	**1.7**	1.4 - 2.0		
Safety Factor for chemical clogging	SF_{cc}	**1.7**	1.5 - 2.0		
Safety Factor for biological clogging	SF_{bc}	**1.7**	1.5 - 2.0		
Overall Safety Factor	SF_{Total}	**8.4**			
Allowable (Specified) Transmissivity	T_{allow}	**1.5E-03**	m^2/s		$T_{allow} = T_{required} \cdot RF_{Total}$

References:

Giroud, J.P., Zhao, A., and Zornberg, J.G. (2000). Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers, *Geosynthetics International,* Special Issue on Liquid Collection Systems, Vol 7, Nos. 4-6, pp. 285-380.

Koerner, R.M. and Koerner, G.R. (2007). Reduction Factors (RFs) Used in Geosynthetic Design, GSI White Paper #4, *Geosynthetic Institute*, Folsom, PA, Rev. #1, March 1, 2007.

Job Name:	Washington County LF Master Plan
Client:	Washington County
Job No.:	AU19.1274.00
Calc by: ASO	Date: 6/3/2020
Reviewed by:	Date:

Transmissivity calculations based on HELP model impingement rate and specified material properties

GEOCOMPOSITE DRAINAGE LAYER_PHASES 6-12

HELP lat. drainage input here

Input (From HELP Model):

	Symbol	Value	Units			
Impingment Rate (peak daily drainage_from HELP analysis)	q_h =	**3.85E-08**	m/s	=	0.131	in/day
Maximum drainage distance of liquid collection layer	L =	**65.5**	m	=	215	feet
Thickness of liquid collection layer	t =	**0.00508**	m	=	0.20	inches
Slope	b =	**1.60**	degrees	=	2.8	%

Calculations:

Maximum liquid depth	h_{max}	**0.0050**	m	=	0.20 inches
Required Transmissivity	$T_{required}$	**9.0E-05**	m^2/s		$T_{required} = \frac{q_h \cdot L}{\sin(b)}$
Safety Factor for intrusion/elastic deformation	SF_{in}	**1.7**	1.5 - 2.0		
Safety Factor for creep deformation	SF_{cr}	**2.0**	1.4 - 2.0		
Safety Factor for chemical clogging	SF_{cc}	**1.7**	1.5 - 2.0		
Safety Factor for biological clogging	SF_{bc}	**1.7**	1.5 - 2.0		
Overall Safety Factor	SF_{Total}	**9.8**			
Allowable (Specified) Transmissivity	T_{allow}	**8.9E-04**	m^2/s		$T_{allow} = T_{required} \cdot RF_{Total}$

References:

Giroud, J.P., Zhao, A., and Zornberg, J.G. (2000). Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers, *Geosynthetics International,* Special Issue on Liquid Collection Systems, Vol 7, Nos. 4-6, pp. 285-380.

Koerner, R.M. and Koerner, G.R. (2007). Reduction Factors (RFs) Used in Geosynthetic Design, GSI White Paper #4, *Geosynthetic Institute*, Folsom, PA, Rev. #1, March 1, 2007.

APPENDIX B.3

PIPE DESIGN CALCULATIONS

Geo-Logic ASSOCIATES

Job Name: Washington County LF Master Plan
Client: Washington County
Job No.: AU19.1274.00
Calc by: ASO Date: 6/5/2020

PIPE CAPACITY CALCULATION: PHASE 5

Mannings Equation for Pipe Flow:

$$\boxed{Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	11	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	1.4%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	10.5	acres (largest contributing area of 6" pipe)

$$\boxed{FS = \frac{Q_{ult}}{Q_{reqd}}}$$

Calculations

D_i =	4.9	Inner Pipe Diameter (in)
r_h =	0.102	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.131	Area of Pipe in Flow (ft^2)
Q_{ult} =	206.7	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	25.9	Peak Daily Leachate Flow (cfs)
FS =	**8.0**	

PIPE CAPACITY CALCULATION: PHASE 6

Mannings Equation for Pipe Flow:

$$\boxed{Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	7.3	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	5.5	acres (largest contributing area of 6" pipe)

$$\boxed{FS = \frac{Q_{ult}}{Q_{reqd}}}$$

Calculations

D_i =	4.4	Inner Pipe Diameter (in)
r_h =	0.091	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.103	Area of Pipe in Flow (ft^2)
Q_{ult} =	179.6	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	13.6	Peak Daily Leachate Flow (cfs)
FS =	**13.2**	

REFERENCES: Qian, X., Koerner, R.M., and Gray, D.H. (2002). Geotechnical Aspects of Landfill Design and Construction, Prentice-Hall Inc., Upper Saddle River, New Jersey, pp. 304-314.

Geo-Logic
ASSOCIATES

Job Name:	Washington County LF Master Plan		
Client:	Washington County		
Job No.:	AU19.1274.00		
Calc by:	ASO	Date:	6/5/2020

PIPE CAPACITY CALCULATION: PHASE 7

Mannings Equation for Pipe Flow:

$$Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	7.3	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	5.8	acres (largest contributing area of 6" pipe)

$$FS = \frac{Q_{ult}}{Q_{reqd}}$$

Calculations

D_i =	4.4	Inner Pipe Diameter (in)
r_h =	0.091	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.103	Area of Pipe in Flow (ft^2)
Q_{ult} =	179.6	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	14.3	Peak Daily Leachate Flow (cfs)
FS =	**12.6**	

PIPE CAPACITY CALCULATION: PHASE 8

Mannings Equation for Pipe Flow:

$$Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	7.3	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	3.3	acres (largest contributing area of 6" pipe)

$$FS = \frac{Q_{ult}}{Q_{reqd}}$$

Calculations

D_i =	4.4	Inner Pipe Diameter (in)
r_h =	0.091	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.103	Area of Pipe in Flow (ft^2)
Q_{ult} =	179.6	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	8.1	Peak Daily Leachate Flow (cfs)
FS =	**22.1**	

REFERENCES:

Qian, X., Koerner, R.M., and Gray, D.H. (2002). Geotechnical Aspects of Landfill Design and Construction, Prentice-Hall Inc., Upper Saddle River, New Jersey, pp. 304-314.

Job Name: Washington County LF Master Plan
Client: Washington County
Job No.: AU19.1274.00
Calc by: ASO Date: 6/5/2020

PIPE CAPACITY CALCULATION: PHASE 9

Mannings Equation for Pipe Flow:

$$Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	7.3	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	5.7	acres (largest contributing area of 6" pipe)

$$FS = \frac{Q_{ult}}{Q_{reqd}}$$

Calculations

D_i =	4.4	Inner Pipe Diameter (in)
r_h =	0.091	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.103	Area of Pipe in Flow (ft^2)
Q_{ult} =	179.6	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	14.1	Peak Daily Leachate Flow (cfs)
FS =	**12.8**	

PIPE CAPACITY CALCULATION: PHASE 10

Mannings Equation for Pipe Flow:

$$Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	7.3	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	6.3	acres (largest contributing area of 6" pipe)

$$FS = \frac{Q_{ult}}{Q_{reqd}}$$

Calculations

D_i =	4.4	Inner Pipe Diameter (in)
r_h =	0.091	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.103	Area of Pipe in Flow (ft^2)
Q_{ult} =	179.6	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	15.5	Peak Daily Leachate Flow (cfs)
FS =	**11.6**	

REFERENCES:

Qian, X., Koerner, R.M., and Gray, D.H. (2002). Geotechnical Aspects of Landfill Design and Construction, Prentice-Hall Inc., Upper Saddle River, New Jersey, pp. 304-314.

Geo-Logic
ASSOCIATES

Job Name:	Washington County LF Master Plan		
Client:	Washington County		
Job No.:	AU19.1274.00		
Calc by:	ASO	Date:	6/5/2020

PIPE CAPACITY CALCULATION: PHASE 11

Mannings Equation for Pipe Flow:

$$Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	7.3	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	6.8	acres (largest contributing area of 6" pipe)

$$FS = \frac{Q_{ult}}{Q_{reqd}}$$

Calculations

D_i =	4.4	Inner Pipe Diameter (in)
r_h =	0.091	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.103	Area of Pipe in Flow (ft^2)
Q_{ult} =	179.6	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	16.8	Peak Daily Leachate Flow (cfs)
FS =	**10.7**	

PIPE CAPACITY CALCULATION: PHASE 12

Mannings Equation for Pipe Flow:

$$Q_{ult} = (1.49/n) \bullet A \bullet r_h^{2/3} \bullet S^{1/2}$$

Input

D_O =	6	Pipe Outside Diamter (in)
SDR =	11	Standard Dimension Ratio
n =	0.011	Manning's Roughness Coefficient (for HDPE Pipe)
S =	2.0%	Slope of Pipe
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)
Cell Area =	3.9	acres (largest contributing area of 6" pipe)

$$FS = \frac{Q_{ult}}{Q_{reqd}}$$

Calculations

D_i =	4.9	Inner Pipe Diameter (in)
r_h =	0.102	Hydraulic Radius (=D_i/4 for full pipe flow, ft)
A =	0.131	Area of Pipe in Flow (ft^2)
Q_{ult} =	247.0	Ultimate Pipe Capacity (cfs)
Q_{reqd} =	9.6	Peak Daily Leachate Flow (cfs)
FS =	**25.7**	

REFERENCES:

Qian, X., Koerner, R.M., and Gray, D.H. (2002). Geotechnical Aspects of Landfill Design and Construction, Prentice-Hall Inc., Upper Saddle River, New Jersey, pp. 304-314.

Job Name:	Washington County LF Master Plan		
Client:	Washington County		
Job No.:	AU19.1274.00		
Calc by:	ASO	Date:	6/4/2020

PIPE PERFORATION CALCULATION

Bernoulii Equation for Inflow Capacity per Perforation:

$$\boxed{Q_B = C \bullet A_b \bullet v_{ent}}$$

$$\boxed{N = Q_{in} / Q_B}$$

3/8"

Input

d =	0.375	Perforation Diameter (inches)
C =	0.62	Dischage Coefficient
v_{ent} =	0.1	Limiting Entrance Velocity (ft/s)
$(A_u)_{unit}$	300	Unit Width of Maximum Contributing Area (ft)
q_{reqd} =	3,552	gal/acre/day (Peak Daily Rate from HELP Model)

Calculations

A_b =	0.000767	ft^2
Q_B =	4.11	Capacity per Orifice (ft^3/day)
Q_{in} =	3.3	Max Inflow Per Foot of Pipe (ft^3/day/ft)
N	**0.8**	**Number of Perforations Per Foot Required**
		Design has 8 perforations per foot, OK

REFERENCES:

Qian, X., Koerner, R.M., and Gray, D.H. (2002). Geotechnical Aspects of Landfill Design and Construction, Prentice-Hall Inc., Upper Saddle River, New Jersey, pp. 304-314.

STRUCTURAL PIPE CALCULATION WORKSHEET

Geo-Logic ASSOCIATES

Project Name: Washington County Landfill
Master Plan
Project Number: AU19.1274.00
Calculation By: ASO
Calculation Date: June 4, 2020

Description: Establish if the LCRS piping components will be structurally adequate given the waste filling planned for WCL Master Planning: Phases 5-12 collection pipes

Compressive Stress

Description	Units	Phase 5 LCRS Pipes	Phases 6-11 LCRS Pipes	Phase 12 LCRS Pipes
Unit Weight of Waste	pcf	90	90	90
Waste Fill Height	ft	180	300	200
Final Cover Unit Weight	pcf	120	120	120
Final Cover Height	ft	4	4	4
Overburden Stress	psf	16680	27480	18480
Overburden Stress	psi	116	191	128
Outer Diameter of Pipe	in	6	6	6
Dimension Ratio (DR)	--	11	7.3	11
Pipe Wall Thickness (t)	in	0.55	0.82	0.55
Mean Radius of Pipe (r_m)	in	2.73	2.59	2.73
Perforation Diameter	in	0.5	0.375	0.5
Perforation Spacing	in	6	6	6
Number of Perforations Around Pipe	--	4	4	4
Reduced Pipe Length Accounting for Perforations (L_p)	in	4	3	4
Length Based on Overburden Correction	in	1.500	1.333	1.500
Reduced Pipe Area to Account for Perforations (L_a)	in^2	1.57	0.88	1.57
Area Based Overburden Correction	--	1.016	1.009	1.016
Design Overburden Stress	psf	25020	36640	27720
Design Overburden Stress	psi	174	254	193
Constrained Modulus of Soil (M_s) Assumes medium compacted rock (PPI, 2010)	psi	5000	5000	5000
Assumed Pipe Temperature	˚F	100	100	100
Assumed Load Duration	years	100	100	100
Pipe Apparent Elastic Modulus (E)	psi	28000	28000	28000
Temperature Multiplier	--	0.73	0.73	0.73
Long Term Pipe Modulus of Elasticity (E)	psi	20440	20440	20440
Hoop Thrust Stiffness (S_A)	--	1.75	1.10	1.75
Vertical Arching Factor (VAF)	--	0.75	0.86	0.75
Pressure Due to Soil (P_{RD})	psf	18886	31507	20924
Ring Compressive Stress (S)	psi	721.3	798.6	799.2
Allowable Compressive Stress at 100˚F	psi	897	897	897
Compressive Stress OK?	--	YES	YES	YES

Ring Deflection Using the Watkins-Gaube Graph

Description	Units	Phase 5 LCRS Pipes	Phases 6-11 LCRS Pipes	Phase 12 LCRS Pipes
Poisson's Ratio of Backfill Material (μ)	--	0.3	0.3	0.3
Secant Modulus of Soil (E_S)	psi	3714	3714	3714
Ridgitity Factor (R_F)	--	2181	545	2181
Deformation Factor (D_F)	--	1.41	1.05	1.41
Soil Strain (ε_s)	%	4.7	6.9	5.2
Deflection	%	6.6	7.2	7.3
Acceptable Deflection	%	7.5	7.5	7.5
Defelction OK?	--	YES	YES	YES

Moore-Selig Constrained Pipe Wall Buckling (for dry soil)

Description	Units	Phase 5 LCRS Pipes	Phases 6-11 LCRS Pipes	Phase 12 LCRS Pipes
Calibration Factor (φ)	--	0.55	0.55	0.55
Geometry Factor (R_H)	--	1.0	1.0	1.0
Pipe Wall Moment of Inertia (I)	in^4/in	0.014	0.046	0.014
Mod Secant Modulus of Soil (E_S*)	--	5306	5306	5306
Moore-Selig Critical Buckling Pressure (P_{CR})	psi	479.6	761.2	479.6
Acceptable Factor of Safety	--	2	2	2
Factor of Safety	--	2.76	2.99	2.49
Buckling OK?	--	YES	YES	YES

Luscher Constrained Pipe Wall Buckling

Description	Units	Phase 5 LCRS Pipes	Phases 6-11 LCRS Pipes	Phase 12 LCRS Pipes
Height of Fill (H)	ft	180	300	200
Height of Groundwater (H_{GW})	ft	0	0	0
Elastic Support Coefficient (B')	--	1.0	1.0	1.0
Buoyancy Reduction Factor (R)	--	1.0	1.0	1.0
Luscher's Critical Buckling Pressure (P_{CR} @ N=1)	psi	521.4	1042.7	521.4
Acceptable Factor of Safety	--	2	2	2
Factor of Safety	--	3.0	4.1	2.7
Buckling OK?	--	YES	YES	YES

Pipe calculations are as presented by the Plastic Pipe Institute in the Second Edition Handbook of PE Pipe

(3-21) $$VAF = 0.88 - 0.71\left|\frac{S_A - 1}{S_A + 2.5}\right.$$

WHERE
VAF = Vertical Arching Factor
S_A = Hoop Thrust Stiffness Ratio

(3-22) $$S_A = \frac{1.43\, M_S\, r_{CENT}}{EA}$$

WHERE
r_{CENT} = radius to centroidal axis of pipe, in
M_s = one-dimensional modulus of soil, psi
E = apparent modulus of elasticity of pipe material, psi (See Appendix, Chapter 3)
A = profile wall average cross-sectional area, in²/in, or wall thickness (in) for DR pipe

(3-23) $$P_{RD} = (VAF)wH$$

WHERE
P_{RD} = radial directed earth pressure, lb/ft²
W = unit weight of soil, pcf
H = depth of cover, ft

(3-13) $$S = \frac{(P_E + P_L)\, DR}{288}$$

WHERE
P_E = vertical soil pressure due to earth load, psf
P_L = vertical soil pressure due to live-load, psf
S = pipe wall compressive stress, lb/in²
DR = Dimension Ratio, D_O/t
D_O = pipe outside diameter (for profile pipe $D_O = D_I + 2H_P$), in
D_I = pipe inside diameter, in
H_P = profile wall height, in
A = profile wall average cross-sectional area, in²/in
(Obtain the profile wall area from the manufacturer of the profile pipe.)

(3-26) $$E_S = M_S\frac{(1+\mu)(1-2\mu)}{(1-\mu)}$$

TABLE 3-13
Typical range of Poisson's Ratio for Soil (Bowles [21])

Soil Type	Poisson's Ratio, μ
Saturated Clay	0.4-0.5
Unsaturated Clay	0.1-0.3
Sandy Clay	0.2-0.3
Silt	0.3-0.35
Sand (Dense)	0.2-0.4
Coarse Sand (Void Ratio 0.4-0.7)	0.15
Fine-grained Sand (Void Ratio 0.4-0.7)	0.25

(3-24) $$R_F = \frac{12\, E_S\, (DR-1)^3}{E}$$

WHERE
DR = Dimension Ratio
E_S = Secant modulus of the soil, psi
E = Apparent modulus of elasticity of pipe material, psi
I = Pipe wall moment of inertia of pipe, in⁴/in
D_m = Mean diameter (D_I + 2z or D_O – t), in

(3-27) $$\varepsilon_S = \frac{wH}{144 E_S}$$

WHERE
w = unit weight of soil, pcf
H = depth of cover (height of fill above pipe crown), ft
E_S = secant modulus of the soil, psi

The designer can find the pipe deflection as a percent of the diameter by multiplying the soil strain, in percent, by the deformation factor:

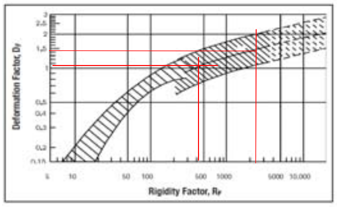

Figure 3-6 Watkins-Gaube Graph

(3-28) $$\frac{\Delta X}{D_M}(100) = D_F\varepsilon_S$$

(3-29) $$P_{CR} = \frac{2.4\,\varphi\, R_H}{D_M}(EI)^{\frac{1}{3}}(E_S^*)^{\frac{2}{3}}$$

WHERE
P_{CR} = Critical constrained buckling pressure, psi
φ = Calibration Factor, 0.55 for granular soils
R_H = Geometry Factor
E = Apparent modulus of elasticity of pipe material, psi
I = Pipe wall moment of Inertia, in⁴/in (t³/12, if solid wall construction)
E_S^* = E_S /(1-μ)
E_S = Secant modulus of the soil, psi
μ_S = Poisson's Ratio of Soil (Consult a textbook on soil for values. Bowles (1982) gives typical values for sand and rock ranging from 0.1 to 0.4.)

(3-17) $$R = 1 - 0.33\frac{H_{GW}}{H}$$

WHERE
R = buoyancy reduction factor
H_{GW} = height of ground water above pipe, ft
H = depth of cover, ft

(3-18) $$B' = \frac{1}{1+4e^{(-0.065H)}}$$

WHERE
e = natural log base number, 2.71828
E' = soil reaction modulus, psi
E = apparent modulus of elasticity, psi
DR = Dimension Ratio
I = pipe wall moment of inertia, in⁴/in (t³/12, if solid wall construction)
D_M = Mean diameter (D_I + 2z or D_O – t), in

(3-15) $$P_{WC} = \frac{5.65}{N}\sqrt{RB'E'\frac{E}{12(DR-1)^3}}$$

WHERE
P_{WC} = allowable constrained buckling pressure, lb/in²
N = safety factor

Reference Information:
Plastic Pipe Institute, 2012. *Handbook of Polyethlyene Pipe,* 2nd Edition, June 6. Retrieved from: https://plasticpipe.org/publications/pe-handbook.html. Retrieved on April 17, 2018.
Plastic Pipe Institute, 2010. *Large Scale Constrained Modulus Test,* February 8. Retrieved from https://plasticpipe.org/pdf/ms-study-report.pdf. Retrieved on April 17, 2018.

STRUCTURAL PIPE CALCULATION WORKSHEET

Geo-Logic ASSOCIATES

Project Name: Washington County Landfill
Master Plan
Project Number: AU19.1274.00
Calculation By: ASO
Calculation Date: June 4, 2020

Description: Establish if the LCRS piping components will be structurally adequate given the waste filling planned for WCL Master Planning: Phases 5-12 Sump/Riser Pipes

Compressive Stress

Description	Units	Phase 5/11/12 Sump/Riser Pipes	Phases 6/7 Sump/Riser Pipes	Phases 8/9/10 Sump/Riser Pipes
Unit Weight of Waste	pcf	90	90	90
Maximum Waste Fill Height	ft	90	200	150
Final Cover Unit Weight	pcf	120	120	120
Final Cover Height	ft	4	4	4
Overburden Stress	psf	8580	18480	13980
Overburden Stress	psi	60	128	97
Outer Diameter of Pipe	in	18	18	18
Dimension Ratio (DR)	--	17	11	13.5
Pipe Wall Thickness (t)	in	1.06	1.64	1.33
Mean Radius of Pipe (r_m)	in	8.47	8.18	8.33
Perforation Diameter	in	0.625	0.5	0.625
Perforation Spacing	in	6	6	6
Number of Perforations Around Pipe	--	4	4	4
Reduced Pipe Length Accounting for Perforations (L_p)	in	5	4	5
Length Based on Overburden Correction	in	1.714	1.500	1.714
Reduced Pipe Area to Account for Perforations (L_a)	in²	2.45	1.57	2.45
Area Based Overburden Correction	--	1.008	1.005	1.008
Design Overburden Stress	psf	14709	27720	23966
Design Overburden Stress	psi	102	193	166
Constrained Modulus of Soil (M_s) Assumes medium compacted rock (PPI, 2010)	psi	5000	5000	5000
Assumed Pipe Temperature	°F	100	100	100
Assumed Load Duration	years	100	100	100
Pipe Apparent Elastic Modulus (E)	psi	28000	28000	28000
Temperature Multiplier	--	0.73	0.73	0.73
Long Term Pipe Modulus of Elasticity (E)	psi	20440	20440	20440
Hoop Thrust Stiffness (S_A)	--	2.80	1.75	2.19
Vertical Arching Factor (VAF)	--	0.64	0.75	0.70
Pressure Due to Soil (P_{RD})	psf	9399	20924	16783
Ring Compressive Stress (S)	psi	554.8	799.2	786.7
Allowable Compressive Stress at 100°F	psi	897	897	897
Compressive Stress OK?	--	YES	YES	YES

Ring Deflection Using the Watkins-Gaube Graph

Description		Phase 5/11/12 Sump/Riser Pipes	Phases 6/7 Sump/Riser Pipes	Phases 8/9/10 Sump/Riser Pipes
Poisson's Ratio of Backfill Material (μ)	--	0.3	0.3	0.3
Secant Modulus of Soil (E_S)	psi	3714	3714	3714
Ridgitity Factor (R_F)	--	8932	2181	4259
Deformation Factor (D_F)	--	1.85	1.41	1.6
Soil Strain (ε_s)	%	2.8	5.2	4.5
Deflection	%	5.1	7.3	7.2
Acceptable Deflection	%	7.5	7.5	7.5
Defelction OK?	--	YES	YES	YES

Moore-Selig Constrained Pipe Wall Buckling (for dry soil)

Description	Units	Phase 5/11/12 Sump/Riser Pipes	Phases 6/7 Sump/Riser Pipes	Phases 8/9/10 Sump/Riser Pipes
Calibration Factor (φ)	--	0.55	0.55	0.55
Geometry Factor (R_H)	--	1.0	1.0	1.0
Pipe Wall Moment of Inertia (I)	in⁴/in	0.099	0.365	0.198
Mod Secant Modulus of Soil (E_S*)	--	5306	5306	5306
Moore-Selig Critical Buckling Pressure (P_{CR})	psi	299.7	479.6	383.7
Acceptable Factor of Safety	--	2	2	2
Factor of Safety	--	2.93	2.49	2.31
Buckling OK?	--	YES	YES	YES

Luscher Constrained Pipe Wall Buckling

Description	Units	Phase 5/11/12 Sump/Riser Pipes	Phases 6/7 Sump/Riser Pipes	Phases 8/9/10 Sump/Riser Pipes
Height of Fill (H)	ft	90	200	150
Height of Groundwater (H_{GW})	ft	0	0	0
Elastic Support Coefficient (B')	--	1.0	1.0	1.0
Buoyancy Reduction Factor (R)	--	1.0	1.0	1.0
Luscher's Critical Buckling Pressure (P_{CR} @ N=1)	psi	256.2	521.4	373.1
Acceptable Factor of Safety	--	2	2	2
Factor of Safety	--	2.5	2.7	2.2
Buckling OK?	--	YES	YES	YES

Pipe calculations are as presented by the Plastic Pipe Institute in the Second Edition Handbook of PE Pipe

(3-21)
$$VAF = 0.88 - 0.71\frac{S_A - 1}{S_A + 2.5}$$

WHERE
VAF = Vertical Arching Factor
S_A = Hoop Thrust Stiffness Ratio

(3-22)
$$S_A = \frac{1.43\, M_S\, r_{CENT}}{EA}$$

WHERE
r_{CENT} = radius to centroidal axis of pipe, in
M_s = one-dimensional modulus of soil, psi
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A = profile wall average cross-sectional area, in²/in, or wall thickness (in) for DR pipe

(3-23)
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WHERE
P_{RD} = radial directed earth pressure, lb/ft²
W = unit weight of soil, pcf
H = depth of cover, ft

(3-13)
$$S = \frac{(P_E + P_L)\,DR}{288}$$

WHERE
P_E = vertical soil pressure due to earth load, psf
P_L = vertical soil pressure due to live-load, psf
S = pipe wall compressive stress, lb/in²
DR = Dimension Ratio, D_O/t
D_O = pipe outside diameter (for profile pipe $D_O = D_I + 2H_P$), in
D_I = pipe inside diameter, in
H_P = profile wall height, in
A = profile wall average cross-sectional area, in²/in
(Obtain the profile wall area from the manufacturer of the profile pipe.)

(3-26)
$$E_S = M_S\frac{(1+\mu)(1-2\mu)}{(1-\mu)}$$

TABLE 3-13
Typical range of Poisson's Ratio for Soil (Bowles [21])

Soil Type	Poisson's Ratio, μ
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Sandy Clay	0.2-0.3
Silt	0.3-0.35
Sand (Dense)	0.2-0.4
Coarse Sand (Void Ratio 0.4-0.7)	0.15
Fine-grained Sand (Void Ratio 0.4-0.7)	0.25

(3-24)
$$R_F = \frac{12\,E_S\,(DR-1)^3}{E}$$

WHERE
DR = Dimension Ratio
E_S = Secant modulus of the soil, psi
E = Apparent modulus of elasticity of pipe material, psi
I = Pipe wall moment of inertia of pipe, in⁴/in
D_m = Mean diameter (D_I + 2z or D_O – t), in

(3-27)
$$\varepsilon_S = \frac{wH}{144E_S}$$

WHERE
w = unit weight of soil, pcf
H = depth of cover (height of fill above pipe crown), ft
E_S = secant modulus of the soil, psi

The designer can find the pipe deflection as a percent of the diameter by multiplying the soil strain, in percent, by the deformation factor:

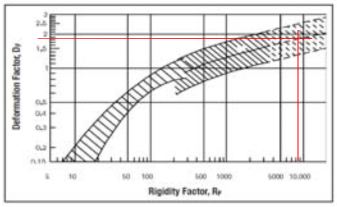


Figure 3-6 Watkins-Gaube Graph

(3-28)
$$\frac{\Delta X}{D_M}(100) = D_F\varepsilon_S$$

(3-29)
$$P_{CR} = \frac{2.4\,\varphi\,R_H}{D_M}(EI)^{\frac{1}{3}}(E_S^{*})^{\frac{2}{3}}$$

WHERE
P_{CR} = Critical constrained buckling pressure, psi
φ = Calibration Factor, 0.55 for granular soils
R_H = Geometry Factor
E = Apparent modulus of elasticity of pipe material, psi
I = Pipe wall moment of Inertia, in⁴/in (t³/12, if solid wall construction)
E_S^{*} = E_S /(1-μ)
E_S = Secant modulus of the soil, psi
μ_S = Poisson's Ratio of Soil (Consult a textbook on soil for values. Bowles (1982) gives typical values for sand and rock ranging from 0.1 to 0.4.)

(3-17)
$$R = 1 - 0.33\frac{H_{GW}}{H}$$

WHERE
R = buoyancy reduction factor
H_{GW} = height of ground water above pipe, ft
H = depth of cover, ft

(3-18)
$$B' = \frac{1}{1+4e^{(-0.065H)}}$$

WHERE
e = natural log base number, 2.71828
E' = soil reaction modulus, psi
E = apparent modulus of elasticity, psi
DR = Dimension Ratio
I = pipe wall moment of inertia, in⁴/in (t³/12, if solid wall construction)
D_M = Mean diameter (D_I + 2z or D_O – t), in

(3-15)
$$P_{WC} = \frac{5.65}{N}\sqrt{RB'E'\frac{E}{12(DR-1)^3}}$$

WHERE
P_{WC} = allowable constrained buckling pressure, lb/in²
N = safety factor

Reference Information:
Plastic Pipe Institute, 2012. *Handbook of Polyethlyene Pipe,* 2nd Edition, June 6. Retrieved from: https://plasticpipe.org/publications/pe-handbook.html. Retrieved on April 17, 2018.
Plastic Pipe Institute, 2010. *Large Scale Constrained Modulus Test,* February 8. Retrieved from https://plasticpipe.org/pdf/ms-study-report.pdf. Retrieved on April 17, 2018.

APPENDIX C

SLOPE STABILITY CALCULATIONS

APPENDIX C.1

SEISMIC HAZARD ANALYSIS

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Dynamic: Conterminous U.S. 2014 (upd

Latitude

Decimal degrees

37.14107

Longitude

Decimal degrees, negative values for western longitudes

-113.44769

Site Class

760 m/s (B/C boundary)

Spectral Period

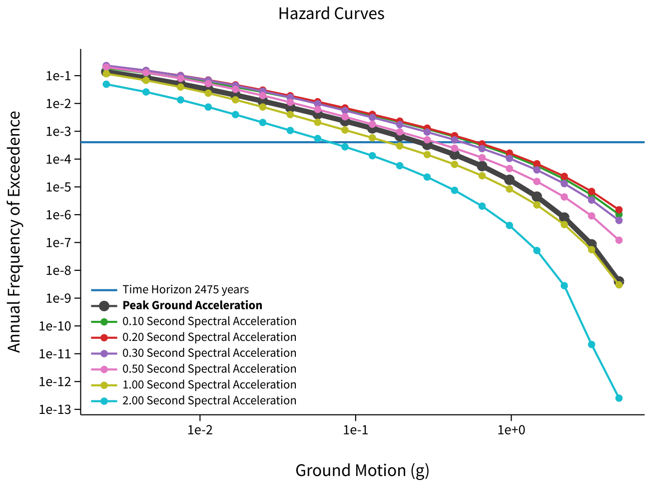
Peak Ground Acceleration

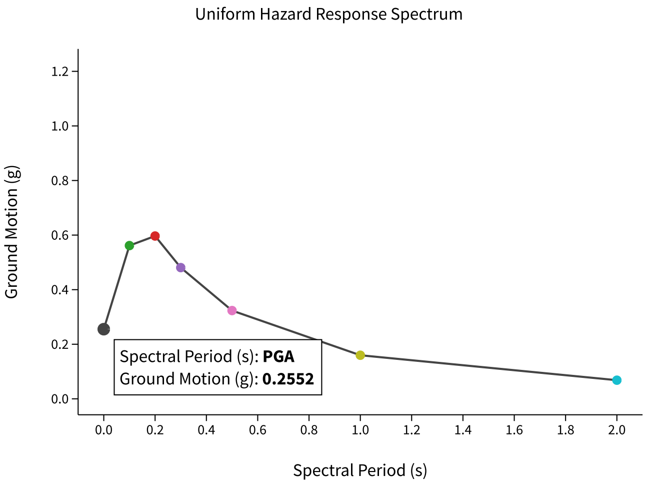
Time Horizon

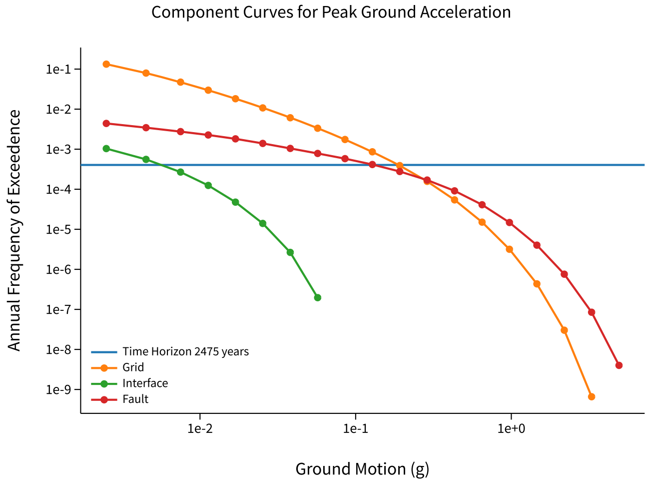
Return period in years

2475

Hazard Curve





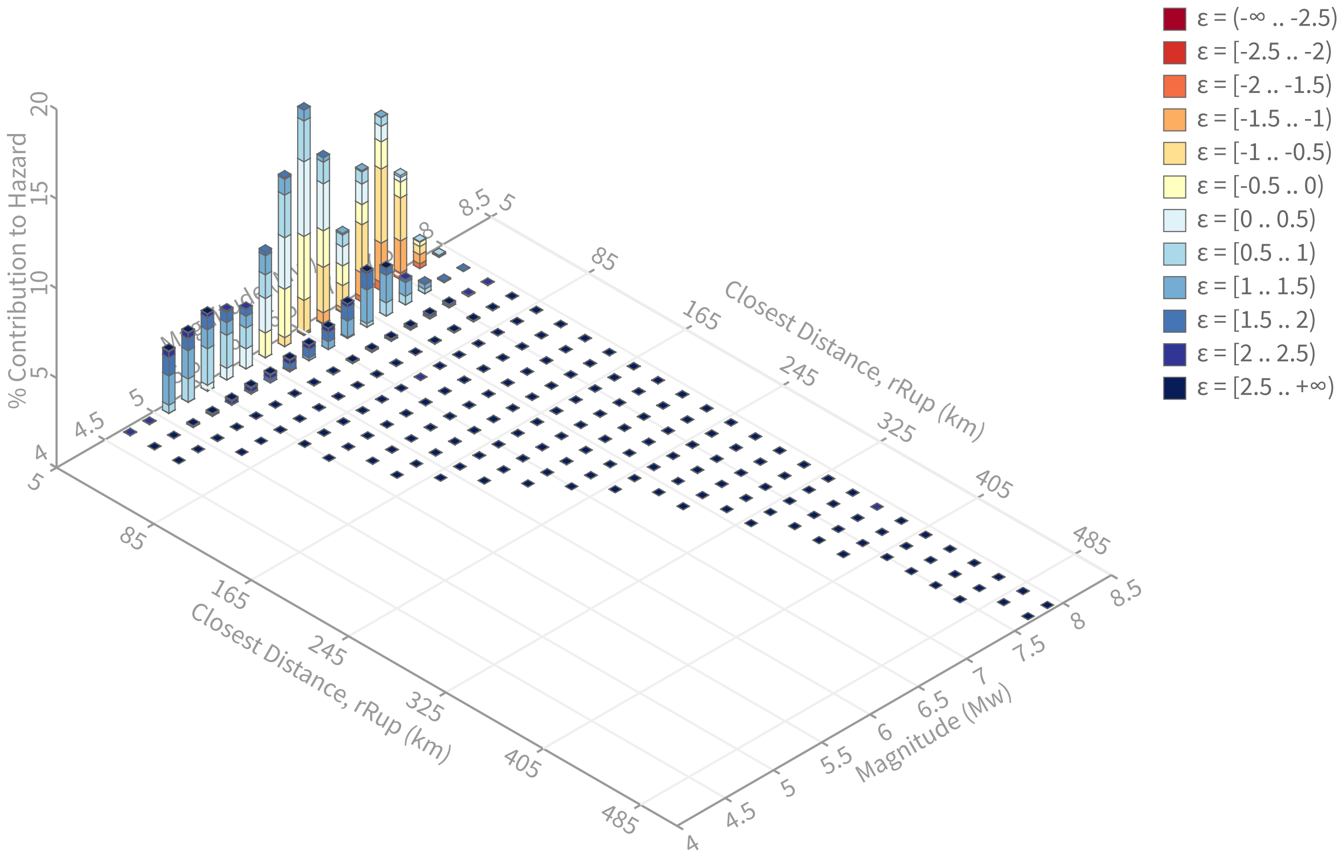


View Raw Data

Deaggregation

Component

Total



Summary statistics for, Deaggregation: Total

Deaggregation targets

Return period: 2475 yrs
Exceedance rate: 0.0004040404 yr^{-1}
PGA ground motion: 0.25518583 g

Recovered targets

Return period: 2545.4022 yrs
Exceedance rate: 0.00039286522 yr^{-1}

Totals

Binned: 100 %
Residual: 0 %
Trace: 0.32 %

Mean (over all sources)

m: 6.55
r: 13.5 km
ε_0: 0.32 σ

Mode (largest m-r bin)

m: 6.51
r: 11.78 km
ε_0: 0.03 σ
Contribution: 12.59 %

Mode (largest m-r-ε_0 bin)

m: 6.51
r: 12.99 km
ε_0: 0.2 σ
Contribution: 4.17 %

Discretization

r: min = 0.0, max = 1000.0, Δ = 20.0 km
m: min = 4.4, max = 9.4, Δ = 0.2
ε: min = -3.0, max = 3.0, Δ = 0.5 σ

Epsilon keys

ε0: [-∞ .. -2.5)
ε1: [-2.5 .. -2.0)
ε2: [-2.0 .. -1.5)
ε3: [-1.5 .. -1.0)
ε4: [-1.0 .. -0.5)
ε5: [-0.5 .. 0.0)
ε6: [0.0 .. 0.5)
ε7: [0.5 .. 1.0)
ε8: [1.0 .. 1.5)
ε9: [1.5 .. 2.0)
ε10: [2.0 .. 2.5)
ε11: [2.5 .. +∞]

Deaggregation Contributors

Source Set ↳ Source	Type	r	m	ε_0	lon	lat	az	%
EXTmap_2014_fixSm.ch.in (opt)	Grid							18.12
PointSourceFinite: -113.448, 37.200		7.89	5.87	0.40	113.448°W	37.200°N	0.00	4.50
PointSourceFinite: -113.448, 37.209		8.52	5.90	0.48	113.448°W	37.209°N	0.00	2.33
PointSourceFinite: -113.448, 37.218		9.14	5.95	0.53	113.448°W	37.218°N	0.00	2.01
PointSourceFinite: -113.448, 37.271		13.09	6.20	0.86	113.448°W	37.271°N	0.00	1.47
PointSourceFinite: -113.448, 37.307		15.77	6.36	1.02	113.448°W	37.307°N	0.00	1.05
Geologic Model Full Rupture	Fault							13.55
Hurricane (central) 50		9.78	7.39	-0.91	113.306°W	37.129°N	96.11	6.88
Hurricane (central) 35		7.36	7.39	-1.34	113.306°W	37.129°N	96.11	2.51
Hurricane (central) 65		11.56	7.40	-0.12	113.306°W	37.129°N	96.11	1.55
Hurricane (northern) 50		22.40	7.00	1.23	113.283°W	37.297°N	40.01	1.51
Geologic Model Partial Rupture	Fault							12.51
Hurricane (central) 50		11.33	6.92	-0.39	113.306°W	37.129°N	96.11	7.24
Hurricane (central) 35		9.09	6.91	-0.72	113.306°W	37.129°N	96.11	2.72
Hurricane (central) 65		13.29	6.93	0.28	113.306°W	37.129°N	96.11	1.58
EXTmap_2014_adSm.ch.in (opt)	Grid							12.24
PointSourceFinite: -113.448, 37.200		7.89	5.87	0.40	113.448°W	37.200°N	0.00	2.89
PointSourceFinite: -113.448, 37.209		8.52	5.90	0.48	113.448°W	37.209°N	0.00	1.66
PointSourceFinite: -113.448, 37.218		9.14	5.95	0.53	113.448°W	37.218°N	0.00	1.30
PointSourceFinite: -113.448, 37.271		13.09	6.20	0.86	113.448°W	37.271°N	0.00	1.03
Geologic Model Small Mag	Fault							11.81
Dutchman Draw 50		13.77	6.46	0.34	113.349°W	37.000°N	150.64	6.65
Dutchman Draw 35		10.35	6.45	-0.45	113.349°W	37.000°N	150.64	4.22
EXTmap_2014_fixSm.gr.in (opt)	Grid							8.11
PointSourceFinite: -113.448, 37.200		8.04	5.78	0.48	113.448°W	37.200°N	0.00	2.07
PointSourceFinite: -113.448, 37.218		9.14	5.95	0.53	113.448°W	37.218°N	0.00	1.00
EXTmap_2014_adSm.gr.in (opt)	Grid							5.44
PointSourceFinite: -113.448, 37.200		8.04	5.78	0.48	113.448°W	37.200°N	0.00	1.33
EXTmap_2014_fixSm_M8.in (opt)	Grid							3.45
EXTmap_2014_adSm_M8.in (opt)	Grid							2.34
Bird Model Full Rupture	Fault							2.34
Zeng Model Full Rupture	Fault							2.31
Hurricane (central) 50		9.78	7.39	-0.91	113.306°W	37.129°N	96.11	1.19
Zeng Model Partial Rupture	Fault							2.14
Hurricane (central) 50		11.33	6.92	-0.39	113.306°W	37.129°N	96.11	1.25
Zeng Model Small Mag	Fault							1.96
Dutchman Draw 50		13.77	6.46	0.34	113.349°W	37.000°N	150.64	1.10

Source Set ↳ Source	Type	r	m	ε_0	lon	lat	az	%
Bird Model Partial Rupture	Fault							1.94
Hurricane (central) 50		11.33	6.92	-0.39	113.306°W	37.129°N	96.11	1.04
Bird Model Small Mag	Fault							1.51

Search Results

63 of 63 earthquakes in map area.

^ Click for more information

Last Updated	2020-05-19 21:38:14 (UTC)

Download

Search Parameters

starttime	1850-05-12 00:00:00
endtime	2020-05-19 23:59:59
latitude	37.14107
longitude	-113.44769
maxradiuskm	160.9
minmagnitude	4
eventtype	earthquake
orderby	time

Modify Search

4.2	19km SE of Pioche, Nevada 2019-06-30 23:43:36 (UTC)	3.1 km
4.3	22km WSW of Enterprise, Utah 2016-01-15 22:37:26 (UTC)	1.0 km
4.1	3km NW of Panguitch, Utah 2015-07-04 16:00:03 (UTC)	3.4 km
5.3	**37km SSW of Caliente, Nevada** 2015-05-22 18:47:42 (UTC)	4.0 km

	2014-01-29 01:30:27 (UTC)	7.0 km
4.1	42km WNW of Ivins, Utah 2014-01-28 16:20:11 (UTC)	7.2 km
4.2	209km ENE of Mesquite, NV 2012-04-12 03:29:22 (UTC)	8.8 km
4.2	Utah 2012-04-12 03:29:22 (UTC)	14.8 km
4.6	**Utah** 2011-01-03 12:06:36 (UTC)	11.1 km
4.1	Utah 2010-01-04 16:24:02 (UTC)	9.1 km
4.1	30km SSE of Caliente, Nevada 2009-11-08 18:34:33 (UTC)	0.0 km
4.3	36km SSE of Caliente, Nevada 2008-06-30 22:49:58 (UTC)	0.0 km
4.5	**22km NE of Caliente, NV** 2007-08-06 05:59:45 (UTC)	3.4 km
4.4	45km SSW of Caliente, Nevada 2006-06-20 04:16:25 (UTC)	0.0 km
4.5	**Nevada** 2004-05-16 01:29:39 (UTC)	0.0 km
4.3	Nevada 2002-03-24 10:44:07 (UTC)	9.0 km
4.1	Utah 1999-10-22 17:51:15 (UTC)	5.6 km
4.4	Utah 1998-01-02 07:28:29 (UTC)	12.0 km

4.2	Nevada 1998-01-02 00:05:58 (UTC)	5.0 km
4.0	Utah 1994-09-06 03:48:37 (UTC)	6.3 km
5.6	**63km ENE of Mesquite, Nevada** 1992-09-02 10:26:20 (UTC)	13.7 km
5.9	**Utah** 1992-09-02 10:26:20 (UTC)	13.9 km
4.6	**Nevada** 1992-08-04 13:37:27 (UTC)	5.0 km
4.2	Utah 1992-06-29 01:59:05 (UTC)	-3.2 km
4.2	Utah 1992-06-29 01:12:56 (UTC)	7.5 km
4.6	**Utah** 1991-04-20 12:56:51 (UTC)	9.6 km
4.1	Nevada 1982-07-06 02:10:43 (UTC)	3.2 km
4.0	Nevada 1982-05-12 19:29:24 (UTC)	10.0 km
4.2	Utah 1981-04-05 05:40:39 (UTC)	5.9 km
4.1	64km NNE of Caliente, NV 1979-08-13 18:23:29 (UTC)	6.0 km
4.1	31km N of Caliente, NV 1977-07-21 16:06:14 (UTC)	6.0 km
4.0	52km SSE of Alamo, NV	

4.0	52km SSE of Alamo, NV 1970-03-19 16:29:04 (UTC)	6.0 km
4.1	48km N of Caliente, NV 1969-07-26 17:18:56 (UTC)	6.0 km
4.7	**Nevada** 1967-05-07 18:01:35 (UTC)	15.0 km
4.8	**Nevada** 1967-02-16 15:05:54 (UTC)	33.0 km
4.3	Nevada 1966-10-26 15:17:38 (UTC)	33.0 km
4.4	Nevada 1966-10-25 16:39:32 (UTC)	33.0 km
4.5	**Nevada** 1966-10-02 15:39:41 (UTC)	33.0 km
4.5	**Nevada** 1966-09-23 11:56:09 (UTC)	33.0 km
4.4	Nevada 1966-09-22 19:59:39 (UTC)	33.0 km
5.3	**Nevada** 1966-09-22 18:57:36 (UTC)	33.0 km
4.5	**Nevada** 1966-09-22 18:56:41 (UTC)	33.0 km
4.2	Nevada 1966-09-04 11:23:18 (UTC)	33.0 km
4.3	Nevada 1966-08-22 08:27:30 (UTC)	33.0 km
4.2	Nevada	

4.2	Nevada 1966-08-19 10:51:37 (UTC)	7.0 km
5.2	**Nevada** 1966-08-18 17:35:06 (UTC)	33.0 km
4.6	**Nevada** 1966-08-18 09:15:37 (UTC)	33.0 km
4.2	Nevada 1966-08-18 06:15:01 (UTC)	34.0 km
4.9	**Nevada** 1966-08-17 23:07:58 (UTC)	33.0 km
4.6	**Nevada** 1966-08-16 19:50:09 (UTC)	33.0 km
5.7	**Nevada** 1966-08-16 18:02:36 (UTC)	10.0 km
4.0	44km SW of Mesquite, NV 1965-05-03 03:30:48 (UTC)	6.0 km
4.4	24km NE of Boulder City, NV 1964-09-23 18:09:36 (UTC)	6.0 km
4.5	**Utah** 1962-06-05 22:29:45 (UTC)	33.0 km
4.5	**Arizona** 1962-02-15 07:12:42 (UTC)	26.0 km
5.6	**Arizona** 1959-07-21 17:39:29 (UTC)	–
4.5	**Nevada** 1953-08-09 22:00:02 (UTC)	–
4.8	**39km ENE of Boulder City, NV**	

		1965-05-03 03:30:48 (UTC)	6.0 km
4.4	24km NE of Boulder City, NV	1964-09-23 18:09:36 (UTC)	6.0 km
4.5	**Utah**	1962-06-05 22:29:45 (UTC)	33.0 km
4.5	**Arizona**	1962-02-15 07:12:42 (UTC)	26.0 km
5.6	**Arizona**	1959-07-21 17:39:29 (UTC)	–
4.5	**Nevada**	1953-08-09 22:00:02 (UTC)	–
4.8	**39km ENE of Boulder City, NV**	1952-05-24 04:15:12 (UTC)	6.0 km
4.7	**Arizona**	1949-11-02 02:29:38 (UTC)	–
4.5	**Nevada**	1940-04-07 08:42:00 (UTC)	16.0 km
4.5	**Nevada**	1940-03-11 00:06:30 (UTC)	16.0 km
5.0	**Nevada**	1940-03-10 18:01:54 (UTC)	16.0 km
4.7	**Utah**	1936-09-21 06:20:00 (UTC)	–

Didn't find what you were looking for?

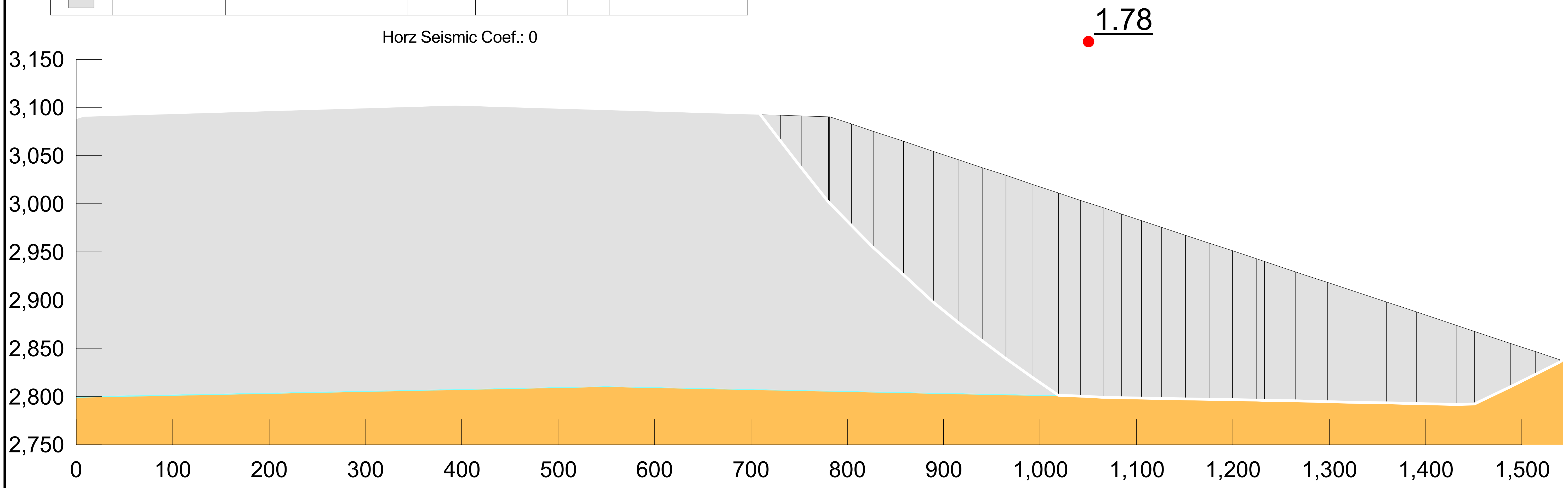
- Check your Settings.
- Which earthquakes are included on the map and list?
- Felt something not shown – report it here.

APPENDIX C.2

SLOPE/W OUTPUT

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Strength Function
🟦	Liner - Floor	Shear/Normal Fn.	100			Wash Co Master Plan (Peak)
🟪	Liner - Slopes	Shear/Normal Fn.	100			Wash Co Master Plan (Residual)
🟧	Subgrade	Bedrock (Impenetrable)				
⬜	Waste	Mohr-Coulomb	90	900	31	

Horz Seismic Coef.: 0



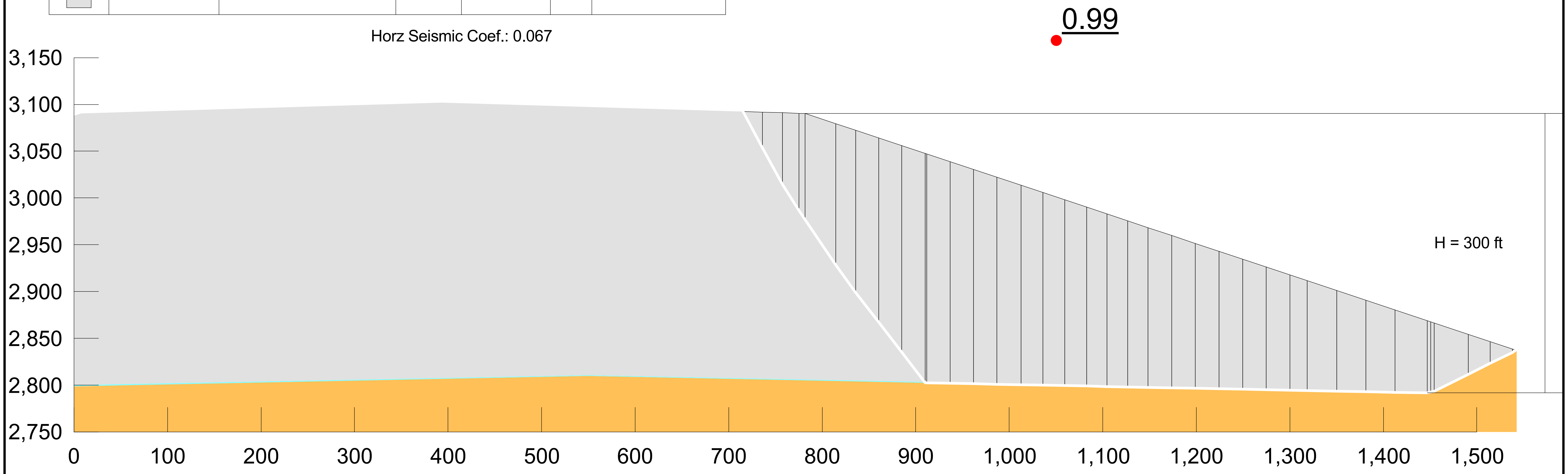
Section A-A, Description: Static

WCL_Master Plan_Section A_04.gsz

09/18/2020 1:1,250

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Strength Function
🟦	Liner - Floor	Shear/Normal Fn.	100			Wash Co Master Plan (Residual)
🟪	Liner - Slopes	Shear/Normal Fn.	100			Wash Co Master Plan (Residual)
🟧	Subgrade	Bedrock (Impenetrable)				
⬜	Waste	Mohr-Coulomb	90	900	31	

Horz Seismic Coef.: 0.067



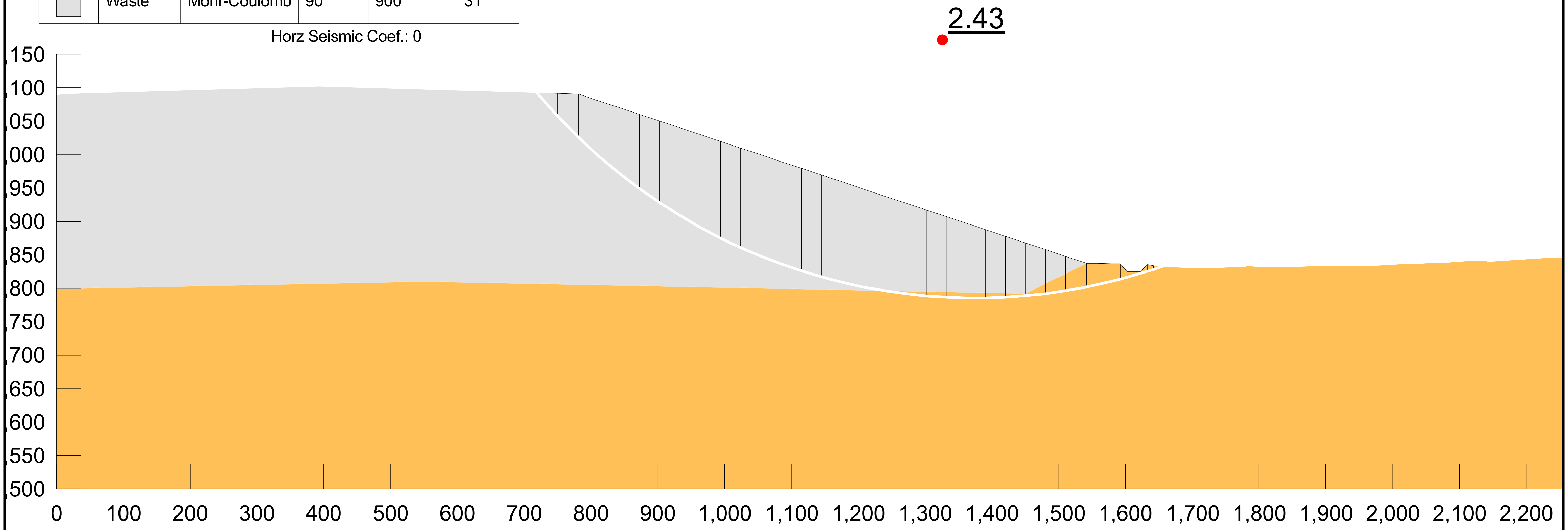
Section A-A, Description: Seismic Yield

WCL_Master Plan_Section A_04_seismic.gsz

05/20/2020 1:1,250

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟧	Subgrade	Mohr-Coulomb	120	0	30
⬜	Waste	Mohr-Coulomb	90	900	31

Horz Seismic Coef.: 0



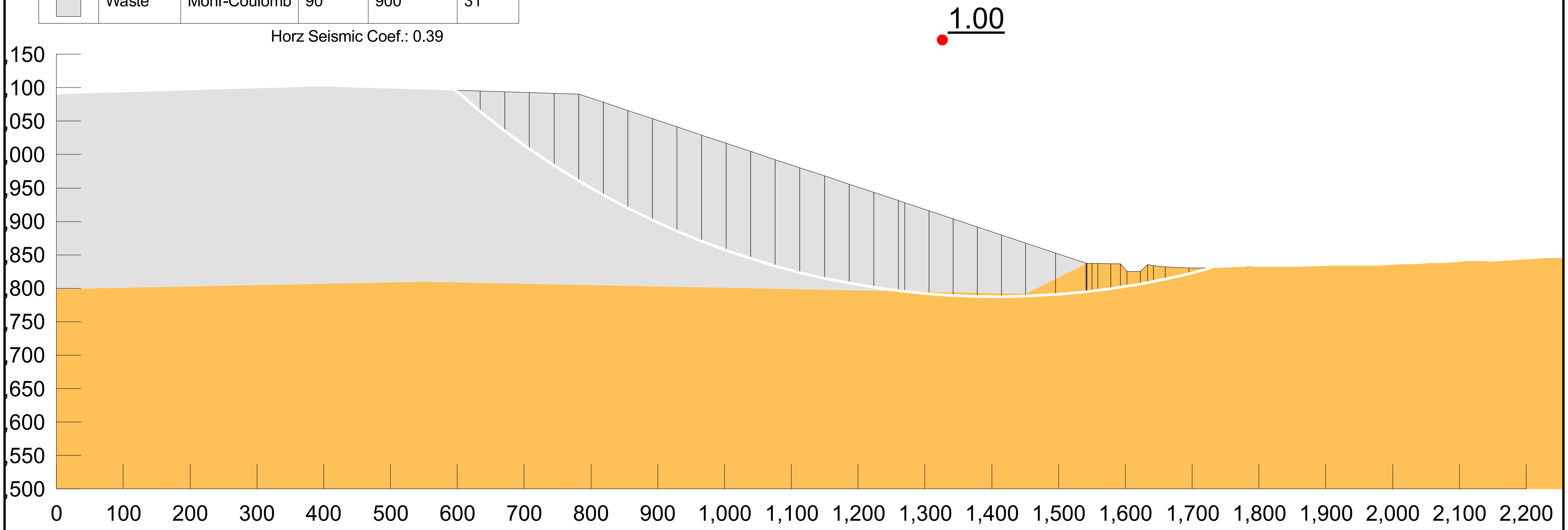
Section A-A, Description: Static- Rotational (Subgrade)

WCL_Master Plan_Section A_10.gsz

05/21/2020 1:1,750

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟧	Subgrade	Mohr-Coulomb	120	0	30
⬜	Waste	Mohr-Coulomb	90	900	31

Horz Seismic Coef.: 0.39



Section A-A, Description: Seismic- Rotational (Subgrade)

WCL_Master Plan_Section A_10_seismic.gsz

05/21/2020 1:1,750

APPENDIX C.3

SEISMIC DISPLACEMENT CALCULATIONS

5/20/2020 Washington Co Landfill Master Plan Stability
AU19.1274.00 ASO

Calculate Estimated Seismically-Induced Permanent Displacement
Section A-A'

Source Parameters

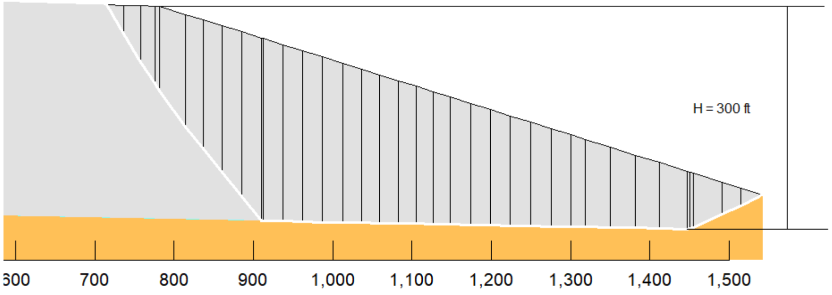
Fault or Source Distance: 13.5 km (mean for all sources)
Reutrn Period: 2,475 yrs
EQ mag, Mw = 6.6 = Mean Mag. from Deaggregation Analysis
Spectral Acceleration (Sa(1.5Ts)) = 0.11 g Sa for Ts = 1.41 sec.
PGA = 0.26 g PGA for info only: NOT USED

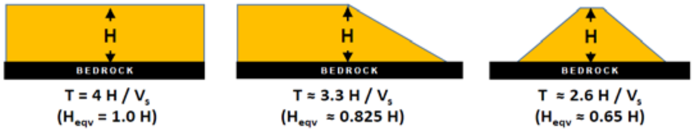
Slope Parameters

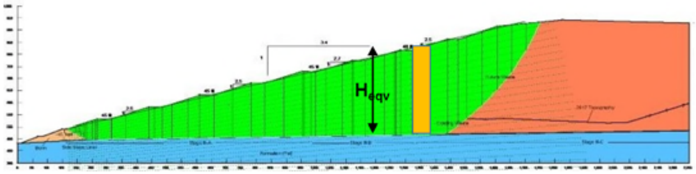
Heqv = 0.825 H = 247.5 ft ft = 75.4 m
Ky = 0.067 from limit equilibrium analysis (file=WCL_Master Plan_Section A_04_seismic.gsz)
Vs,avg = Vs @ Heqv = 265 m/s (avg)
V0 = 150 m/s (@ top of waste)
V1 = 380 m/s (@ base of 75.4 m of waste)
Kavazanjian et al. (2013)

Representative Slide Mass Height:

0.99







Use: Ts = 3.3 H/Vs,avg
Ts = **0.939 sec.**
1.5Ts = **1.409 sec.**

Results

*Note: results calc'd per Bray and Travasarou (2007)** using spreadsheet developed by these authors.*
*** Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007*

Bray & Traverssou (2007) Non-Zero Seismic Displacement Estimate: **1.5 cm**
0.6 inches

5/21/2020 Washington Co Landfill Master Plan Stability
AU19.1274.00 ASO

Calculate Estimated Seismically-Induced Permanent Displacement
Section A-A'_Rotational

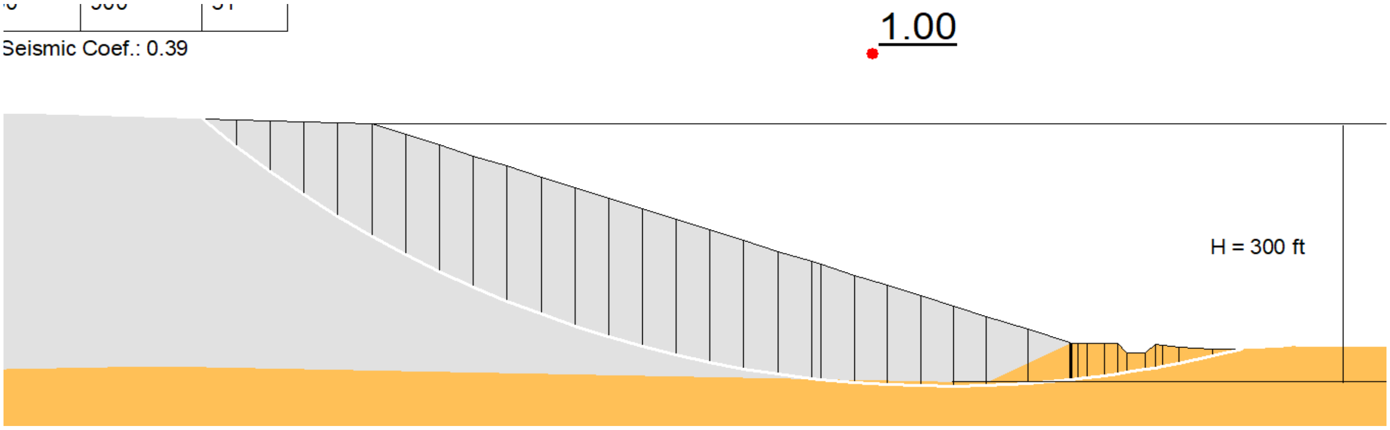
Source Parameters

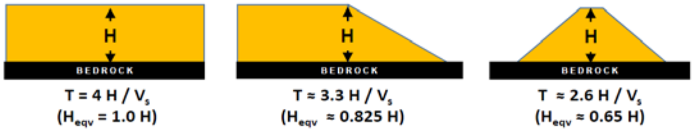
Fault or Source Distance: 13.5 km (mean for all sources)
Reutrn Period: 2,475 yrs
EQ mag, Mw = 6.6 = Mean Mag. from Deaggregation Analysis
Spectral Acceleration (Sa(1.5Ts)) = 0.11 g Sa for Ts = 1.41 sec.
PGA = 0.26 g PGA for info only: NOT USED

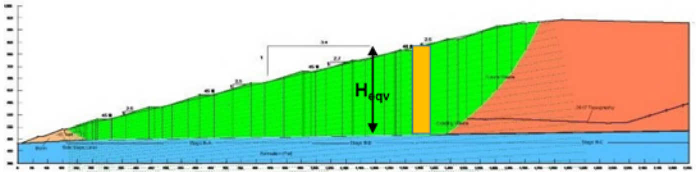
Slope Parameters

Heqv = 0.825 H = 247.5 ft ft = 75.4 m
Ky = 0.39 from limit equilibrium analysis (file=WCL_Master Plan_Section A_10_seismic.gsz)
Vs,avg = Vs @ Heqv = 265 m/s (avg)
V0 = 150 m/s (@ top of waste)
V1 = 380 m/s (@ base of 75.4 m of waste)
Kavazanjian et al. (2013)

Representative Slide Mass Height:





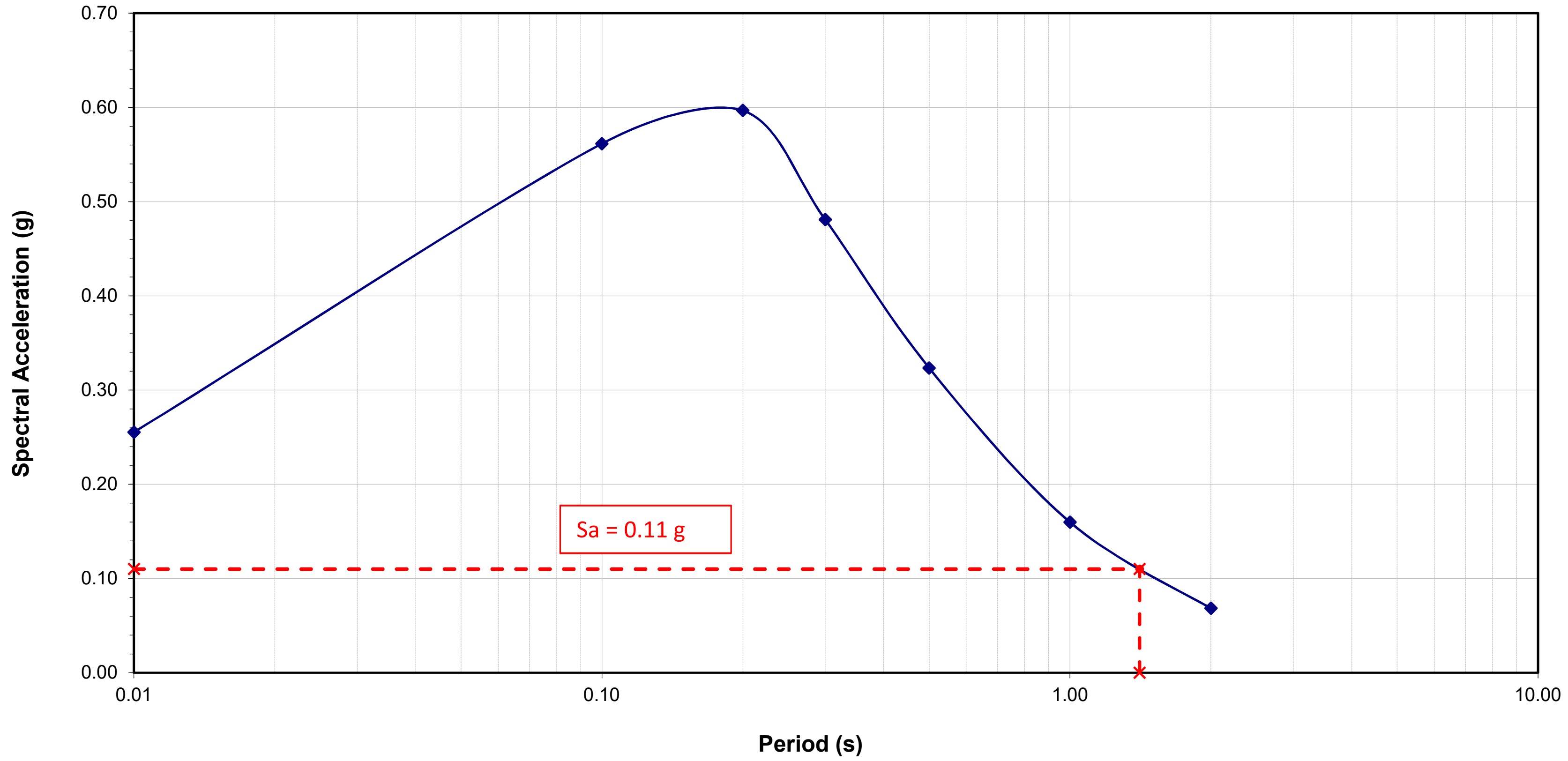


Use: Ts = 3.3 H/Vs,avg
Ts = 0.939 sec.
1.5Ts = 1.409 sec.

Results

*Note: results calc'd per Bray and Travasarou (2007)** using spreadsheet developed by these authors.*
*** Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007*

Bray & Traverssou (2007) Non-Zero Seismic Displacement Estimate: **<1 cm**



Site-Specific Probabilistic Horizontal Bedrock Acceleration Response Spectra for Return Period 2,474 years; Mw 6.6

Avg. PGA =	0.26 g
Avg. Sa(t=0.2s) =	0.6 g
Avg. Sa(t=1.0s) =	0.16 g

ARS Curve

Washington Co LF
Master Plan Slope Stability
Section A-A'

Geo-Logic
ASSOCIATES

DRAWN BY: **ASO**	DATE: MAY **2020**	AU19.1274.00

APPENDIX D

SURFACE WATER ANALYSIS

APPENDIX D.1

DESIGN STORM DATA

NOAA Atlas 14, Volume 1, Version 5
Location name: Washington, Utah, USA*
Latitude: 37.1372°, Longitude: -113.4509°
Elevation: 2777.77 ft**

* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1000**
5-min	**0.125** (0.107-0.148)	**0.160** (0.138-0.190)	**0.219** (0.187-0.258)	**0.270** (0.230-0.321)	**0.351** (0.293-0.414)	**0.420** (0.345-0.498)	**0.501** (0.403-0.596)	**0.593** (0.463-0.709)	**0.734** (0.550-0.892)	**0.857** (0.624-1.05)
10-min	**0.190** (0.163-0.225)	**0.244** (0.211-0.289)	**0.333** (0.285-0.393)	**0.411** (0.349-0.488)	**0.533** (0.445-0.631)	**0.639** (0.526-0.757)	**0.763** (0.613-0.907)	**0.902** (0.704-1.08)	**1.12** (0.837-1.36)	**1.30** (0.949-1.60)
15-min	**0.236** (0.202-0.278)	**0.302** (0.261-0.359)	**0.412** (0.353-0.488)	**0.509** (0.433-0.605)	**0.661** (0.552-0.782)	**0.793** (0.651-0.938)	**0.946** (0.760-1.13)	**1.12** (0.872-1.34)	**1.39** (1.04-1.68)	**1.62** (1.18-1.98)
30-min	**0.317** (0.271-0.375)	**0.407** (0.351-0.483)	**0.555** (0.475-0.657)	**0.686** (0.583-0.815)	**0.890** (0.743-1.05)	**1.07** (0.877-1.26)	**1.27** (1.02-1.52)	**1.51** (1.18-1.80)	**1.87** (1.40-2.27)	**2.18** (1.58-2.67)
60-min	**0.393** (0.336-0.464)	**0.504** (0.434-0.598)	**0.687** (0.588-0.813)	**0.849** (0.721-1.01)	**1.10** (0.920-1.30)	**1.32** (1.09-1.56)	**1.58** (1.27-1.87)	**1.86** (1.45-2.23)	**2.31** (1.73-2.81)	**2.69** (1.96-3.30)
2-hr	**0.476** (0.416-0.551)	**0.598** (0.523-0.694)	**0.788** (0.688-0.911)	**0.958** (0.829-1.11)	**1.22** (1.04-1.40)	**1.44** (1.21-1.66)	**1.69** (1.39-1.96)	**1.98** (1.58-2.32)	**2.41** (1.86-2.87)	**2.79** (2.09-3.36)
3-hr	**0.529** (0.470-0.604)	**0.662** (0.589-0.758)	**0.857** (0.761-0.978)	**1.02** (0.902-1.16)	**1.27** (1.11-1.45)	**1.48** (1.27-1.69)	**1.72** (1.45-1.98)	**1.99** (1.64-2.34)	**2.42** (1.93-2.90)	**2.81** (2.17-3.40)
6-hr	**0.660** (0.589-0.748)	**0.827** (0.742-0.938)	**1.06** (0.943-1.19)	**1.25** (1.10-1.41)	**1.52** (1.33-1.72)	**1.75** (1.51-1.99)	**1.99** (1.70-2.28)	**2.27** (1.90-2.62)	**2.71** (2.21-3.18)	**3.08** (2.45-3.66)
12-hr	**0.790** (0.712-0.883)	**0.992** (0.892-1.11)	**1.25** (1.12-1.40)	**1.46** (1.30-1.63)	**1.74** (1.55-1.95)	**1.97** (1.72-2.21)	**2.19** (1.90-2.48)	**2.44** (2.09-2.78)	**2.79** (2.34-3.22)	**3.12** (2.57-3.69)
24-hr	**0.914** (0.848-0.984)	**1.14** (1.06-1.23)	**1.42** (1.32-1.52)	**1.64** (1.52-1.76)	**1.94** (1.79-2.08)	**2.17** (2.00-2.33)	**2.41** (2.21-2.58)	**2.65** (2.41-2.85)	**2.97** (2.68-3.24)	**3.21** (2.88-3.73)
2-day	**1.00** (0.937-1.07)	**1.24** (1.16-1.33)	**1.54** (1.44-1.64)	**1.77** (1.66-1.89)	**2.08** (1.95-2.22)	**2.32** (2.16-2.47)	**2.56** (2.38-2.73)	**2.81** (2.59-3.00)	**3.13** (2.86-3.35)	**3.37** (3.07-3.77)
3-day	**1.06** (0.998-1.14)	**1.32** (1.24-1.41)	**1.63** (1.53-1.73)	**1.87** (1.76-1.98)	**2.19** (2.06-2.32)	**2.44** (2.29-2.59)	**2.69** (2.51-2.86)	**2.95** (2.73-3.13)	**3.27** (3.02-3.50)	**3.52** (3.23-3.85)
4-day	**1.13** (1.06-1.20)	**1.40** (1.32-1.49)	**1.72** (1.62-1.82)	**1.97** (1.86-2.08)	**2.31** (2.18-2.43)	**2.57** (2.42-2.71)	**2.83** (2.65-2.99)	**3.09** (2.87-3.27)	**3.42** (3.17-3.65)	**3.68** (3.38-3.94)

7-day	**1.30** (1.21-1.38)	**1.61** (1.51-1.71)	**1.97** (1.85-2.09)	**2.25** (2.12-2.38)	**2.62** (2.46-2.77)	**2.89** (2.72-3.06)	**3.16** (2.96-3.35)	**3.42** (3.19-3.63)	**3.75** (3.48-3.99)	**3.98** (3.69-4.25)
10-day	**1.43** (1.33-1.53)	**1.78** (1.66-1.90)	**2.19** (2.05-2.33)	**2.50** (2.35-2.66)	**2.92** (2.73-3.09)	**3.22** (3.01-3.42)	**3.52** (3.28-3.75)	**3.81** (3.55-4.07)	**4.18** (3.87-4.47)	**4.44** (4.10-4.78)
20-day	**1.77** (1.65-1.90)	**2.21** (2.06-2.37)	**2.70** (2.53-2.88)	**3.06** (2.87-3.26)	**3.51** (3.28-3.72)	**3.82** (3.57-4.06)	**4.11** (3.84-4.37)	**4.38** (4.08-4.66)	**4.69** (4.36-5.00)	**4.89** (4.54-5.22)
30-day	**2.10** (1.96-2.25)	**2.62** (2.44-2.81)	**3.21** (2.99-3.43)	**3.63** (3.40-3.88)	**4.17** (3.90-4.44)	**4.54** (4.24-4.84)	**4.90** (4.57-5.22)	**5.23** (4.86-5.58)	**5.61** (5.20-6.01)	**5.87** (5.43-6.30)
45-day	**2.50** (2.32-2.71)	**3.12** (2.90-3.37)	**3.85** (3.58-4.14)	**4.38** (4.07-4.69)	**5.03** (4.68-5.37)	**5.49** (5.11-5.85)	**5.91** (5.50-6.31)	**6.29** (5.86-6.72)	**6.72** (6.26-7.17)	**6.98** (6.51-7.46)
60-day	**2.84** (2.62-3.07)	**3.54** (3.27-3.82)	**4.35** (4.03-4.68)	**4.95** (4.58-5.31)	**5.69** (5.27-6.10)	**6.21** (5.75-6.66)	**6.70** (6.19-7.18)	**7.14** (6.59-7.66)	**7.64** (7.05-8.22)	**7.95** (7.33-8.57)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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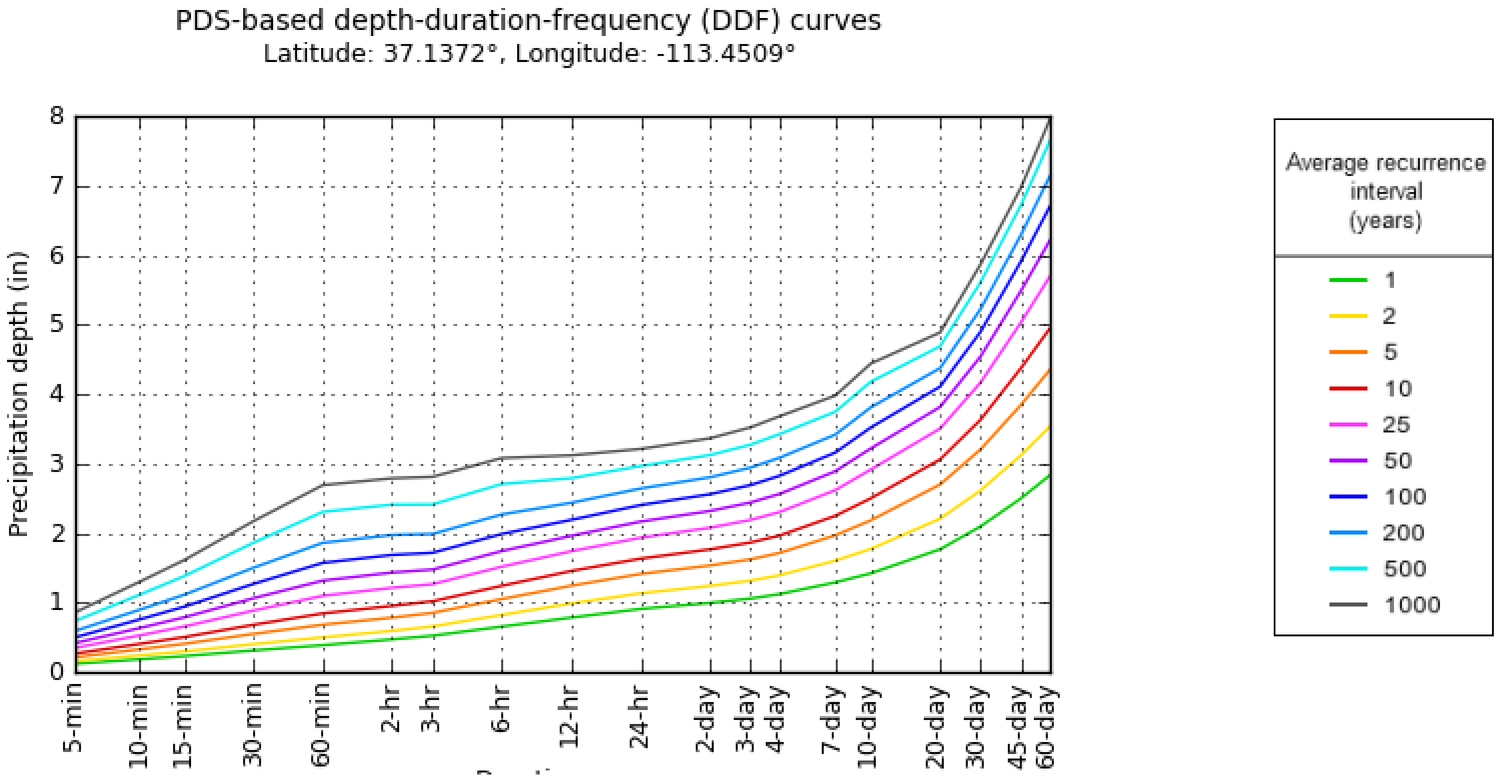
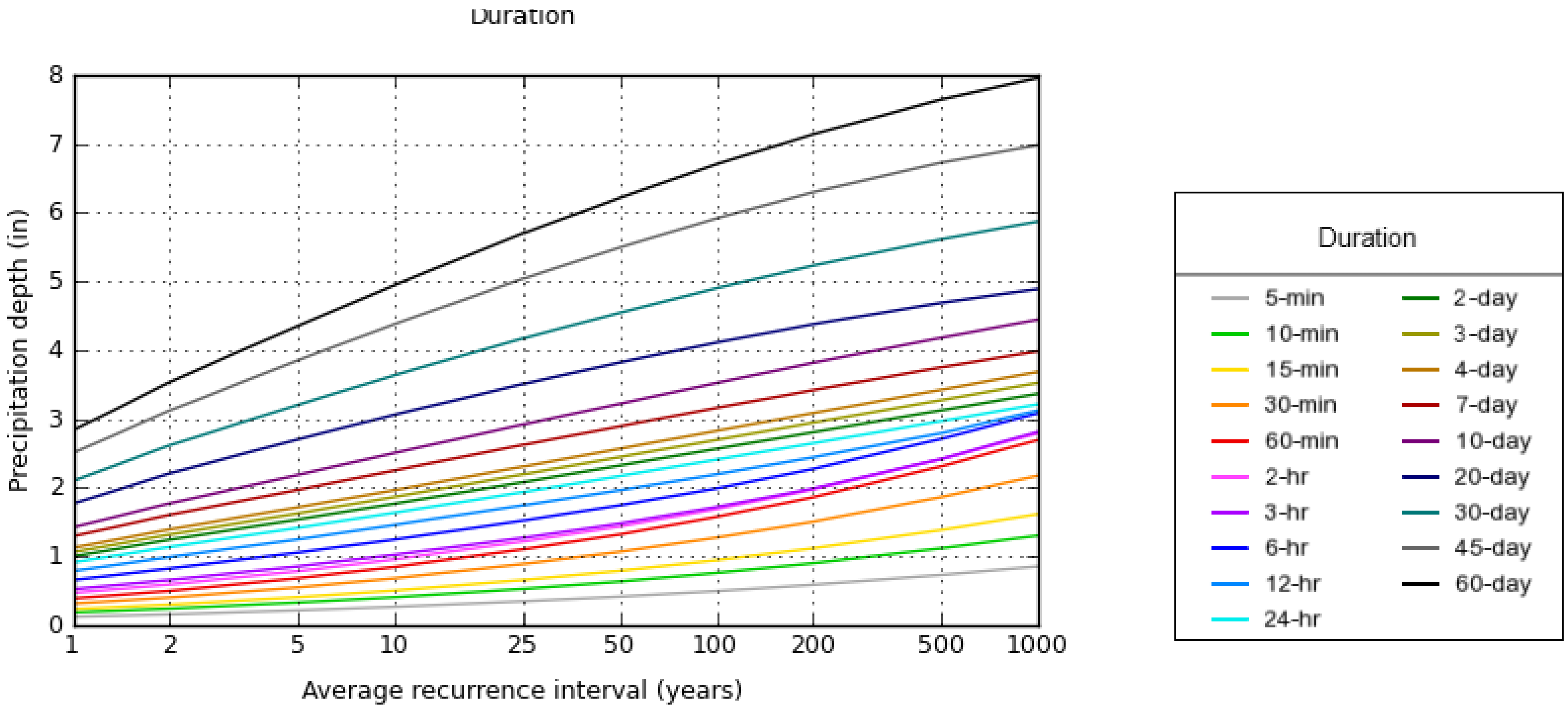
PF graphical





NOAA Atlas 14, Volume 1, Version 5

Created (GMT): Wed Aug 5 15:00:43 2020

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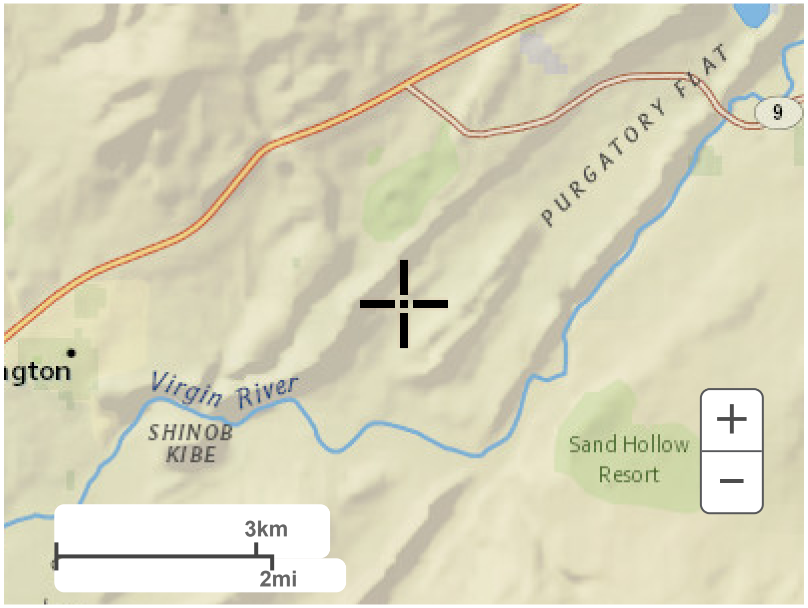
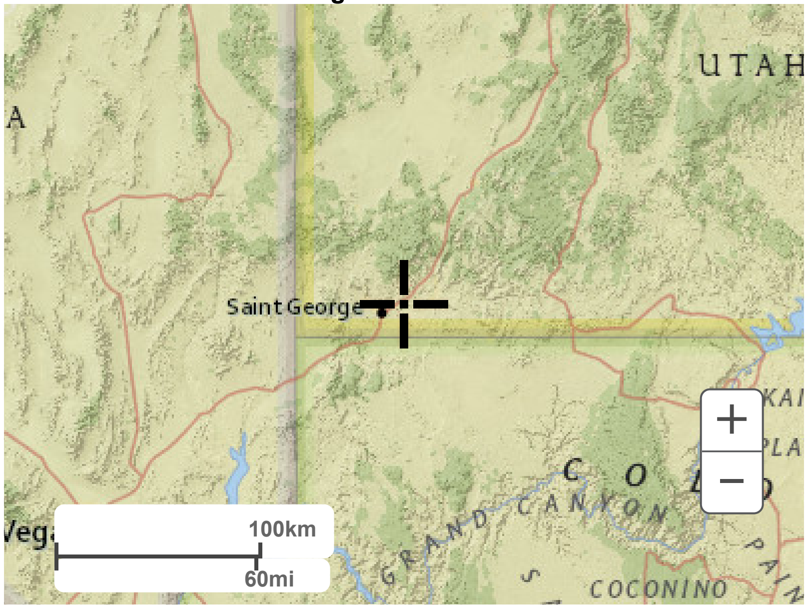
Maps & aerials

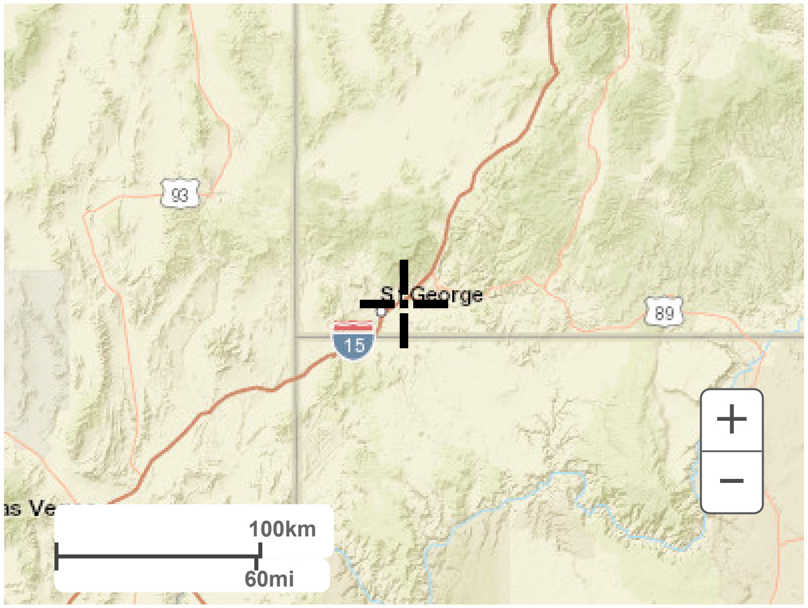
Small scale terrain



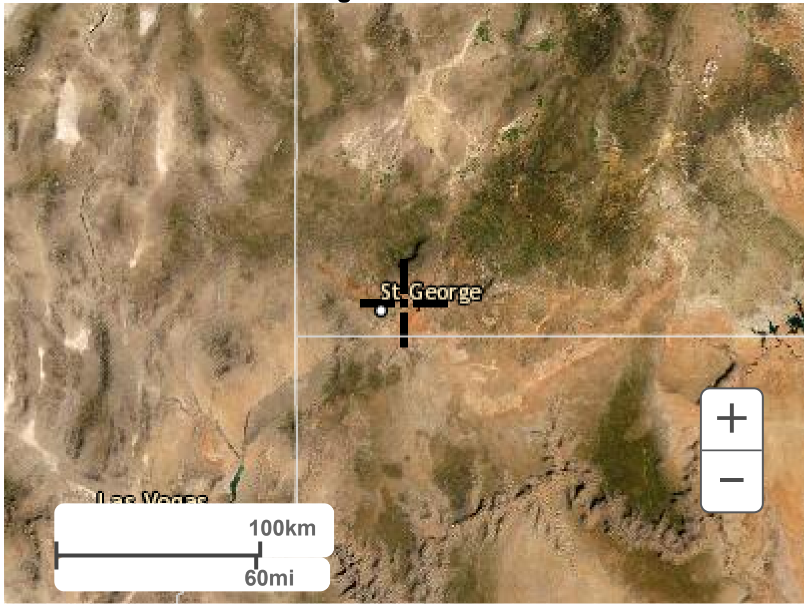
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX D.2

TR-55 OUTPUT

```
                         WinTR-55 Current Data Description

                          --- Identification Data ---

User:      JG                                          Date:        9/4/2020
Project:   WCL Master Plan                             Units:       English
SubTitle:  Master Plan SW Calcs                        Areal Units: Acres
State:     Utah
County:    Washington
Filename:  N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                              --- Sub-Area Data ---

Name            Description             Reach          Area(ac)     RCN     Tc
-------------------------------------------------------------------------------
SA-1                                   Outlet           20.87       87     .1
SA-2                                   Outlet           93.69       87     .153
SA-3                                   Outlet           0.2         87     0.1
SA-4                                   Outlet           1.56        87     0.1
SA-5                                   Outlet           2.96        87     0.1
SA-6                                   Outlet           3.45        87     0.1
SA-7                                   Outlet           2.65        87     0.1
SA-8                                   Outlet           2.44        87     0.1
SA-9                                   Outlet           0.12        87     0.1
SA-10                                  Outlet           2.2         87     0.1

Total area: 130.14 (ac)


                              --- Storm Data  --

                      Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0


Storm Data Source:             User-provided custom storm data
Rainfall Distribution Type:    Type II
Dimensionless Unit Hydrograph: <standard>
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                                   Storm Data

                     Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0


Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                              Watershed Peak Table


 Sub-Area           Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
-----------------------------------------------------------------------------------
SUBAREAS
SA-1           27.50

SA-2          113.22

SA-3            0.26

SA-4            2.06

SA-5            3.90

SA-6            4.55

SA-7            3.49

SA-8            3.21

SA-9            0.16

SA-10           2.90


REACHES

OUTLET        158.38
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                       Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-1           27.50
           11.94

SA-2          113.22
           11.98

SA-3            0.26
           11.94

SA-4            2.06
           11.94

SA-5            3.90
           11.94

SA-6            4.55
           11.94

SA-7            3.49
           11.94

SA-8            3.21
           11.94

SA-9            0.16
           11.94

SA-10           2.90
           11.94


REACHES

OUTLET        158.38
```

```
JG                            WCL Master Plan
                            Master Plan SW Calcs
                          Washington County, Utah

                             Sub-Area Summary Table

 Sub-Area   Drainage    Time of     Curve  Receiving     Sub-Area
Identifier   Area    Concentration  Number   Reach      Description
             (ac)        (hr)
--------------------------------------------------------------------------------

SA-1          20.87     0.100        87     Outlet
SA-2          93.69     0.153        87     Outlet
SA-3            .20     0.100        87     Outlet
SA-4           1.56     0.100        87     Outlet
SA-5           2.96     0.100        87     Outlet
SA-6           3.45     0.100        87     Outlet
SA-7           2.65     0.100        87     Outlet
SA-8           2.44     0.100        87     Outlet
SA-9            .12     0.100        87     Outlet
SA-10          2.20     0.100        87     Outlet

Total Area:   130.14 (ac)
```

```
JG                        WCL Master Plan
                        Master Plan SW Calcs
                      Washington County, Utah

                 Sub-Area Time of Concentration Details

 Sub-Area      Flow              Mannings's    End     Wetted               Travel
Identifier/   Length    Slope       n          Area   Perimeter   Velocity   Time
               (ft)    (ft/ft)                (sq ft)    (ft)     (ft/sec)   (hr)
--------------------------------------------------------------------------------
SA-1
  SHEET          100   0.4920      0.050                                     0.032
  SHALLOW        303   0.4920      0.050                                     0.007
  CHANNEL       3071                                                14.000   0.061

                                            Time of Concentration           .1
                                                                      ========

SA-2
  SHEET          100   0.4920      0.050                                     0.032
  SHALLOW        303   0.4920      0.050                                     0.007
  CHANNEL       5757                                                14.000   0.114

                                            Time of Concentration         .153
                                                                      ========

SA-3
  SHEET           66   0.3330      0.050                                     0.026

                                            Time of Concentration          0.1
                                                                      ========

SA-4
  SHEET          100   0.3300      0.050                                     0.037
  SHALLOW         51   0.3330      0.050                                     0.002
  CHANNEL        192                                                8.000    0.007

                                            Time of Concentration          0.1
                                                                      ========

SA-5
  SHEET          100   0.3330      0.050                                     0.037
  SHALLOW         50   0.3330      0.050                                     0.001
  CHANNEL        663                                                8.000    0.023

                                            Time of Concentration          0.1
                                                                      ========

SA-6
  SHEET          100   0.3330      0.050                                     0.037
  SHALLOW         50   0.3330      0.050                                     0.001
  CHANNEL        985                                                8.000    0.034

                                            Time of Concentration          0.1
                                                                      ========

SA-7
  SHEET          100   0.3330      0.050                                     0.037
  SHALLOW         50   0.3333      0.050                                     0.001
  CHANNEL       1542                                                8.000    0.054

                                            Time of Concentration          0.1
                                                                      ========

SA-8
  SHEET          100   0.3333      0.050                                     0.037
  SHALLOW         50   0.3330      0.050                                     0.001
  CHANNEL        980                                                8.000    0.034

                                            Time of Concentration          0.1
                                                                      ========

SA-9
  CHANNEL        216                                                8.000    0.008
```

```
              Sub-Area Time of Concentration Details (continued)


 Sub-Area     Flow             Mannings's    End     Wetted                Travel
Identifier/  Length    Slope       n         Area   Perimeter   Velocity    Time
              (ft)    (ft/ft)              (sq ft)    (ft)      (ft/sec)    (hr)
-------------------------------------------------------------------------------

                                                  Time of Concentration      0.1
                                                                        ========


SA-10
  SHEET        100    0.3330     0.050                                     0.037
  SHALLOW       50    0.3330     0.050                                     0.001
  CHANNEL     1115                                             8.000       0.039

                                                  Time of Concentration      0.1
                                                                        ========
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                   Sub-Area Land Use and Curve Number Details


 Sub-Area                                                 Hydrologic   Sub-Area    Curve
Identifier           Land Use                                Soil        Area      Number
                                                             Group       (ac)
-----------------------------------------------------------------------------------
SA-1          Desert shrub                         (poor)      C          4.174       85
              Desert shrub                         (poor)      D         16.699       88

              Total Area / Weighted Curve Number                          20.87       87
                                                                          =====       ==

SA-2          Desert shrub                         (poor)      C         18.738       85
              Desert shrub                         (poor)      D         74.951       88

              Total Area / Weighted Curve Number                          93.69       87
                                                                          =====       ==

SA-3          Desert shrub                         (poor)      C           .04        85
              Desert shrub                         (poor)      D          .161        88

              Total Area / Weighted Curve Number                            .2        87
                                                                            ==        ==

SA-4          Desert shrub                         (poor)      C          .311        85
              Desert shrub                         (poor)      D         1.245        88

              Total Area / Weighted Curve Number                          1.56        87
                                                                          ====        ==

SA-5          Desert shrub                         (poor)      C          .591        85
              Desert shrub                         (poor)      D         2.365        88

              Total Area / Weighted Curve Number                          2.96        87
                                                                          ====        ==

SA-6          Desert shrub                         (poor)      C          .691        85
              Desert shrub                         (poor)      D         2.763        88

              Total Area / Weighted Curve Number                          3.45        87
                                                                          ====        ==

SA-7          Desert shrub                         (poor)      C           .53        85
              Desert shrub                         (poor)      D          2.12        88

              Total Area / Weighted Curve Number                          2.65        87
                                                                          ====        ==

SA-8          Desert shrub                         (poor)      C          .489        85
              Desert shrub                         (poor)      D         1.956        88

              Total Area / Weighted Curve Number                          2.44        87
                                                                          ====        ==

SA-9          Desert shrub                         (poor)      C          .025        85
              Desert shrub                         (poor)      D          .098        88

              Total Area / Weighted Curve Number                           .12        87
                                                                           ===        ==

SA-10         Desert shrub                         (poor)      C           .44        85
              Desert shrub                         (poor)      D         1.759        88

              Total Area / Weighted Curve Number                           2.2        87
                                                                           ===        ==
```

```
                    WinTR-55 Current Data Description

                        --- Identification Data ---

User:     JG                                         Date:       9/4/2020
Project:  WCL Master Plan                            Units:      English
SubTitle: Master Plan SW Calcs                       Areal Units: Acres
State:    Utah
County:   Washington
Filename: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                          --- Sub-Area Data ---

Name            Description            Reach        Area(ac)     RCN     Tc
------------------------------------------------------------------------------
SA-11                                 Outlet         0.6          87    0.1
SA-12                                 Outlet         2.96         87    0.1
SA-13                                 Outlet         1.52         87    0.1
SA-14                                 Outlet         2.91         87    0.1
SA-15                                 Outlet         2.43         87    0.1
SA-16                                 Outlet         3.97         87    .109
SA-17                                 Outlet         6.03         87    .106
SA-18                                 Outlet         4.82         87    .104
SA-19                                 Outlet         0.77         87    0.1
SA-20                                 Outlet         5.61         87    0.1

Total area: 31.62 (ac)


                          --- Storm Data  --

                  Rainfall Depth by Rainfall Return Period

   2-Yr       5-Yr       10-Yr      25-Yr      50-Yr      100-Yr     1-Yr
   (in)       (in)       (in)       (in)       (in)       (in)       (in)
--------------------------------------------------------------------------------
   1.14       .0         .0         1.94       .0         2.41       .0


Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                                WCL Master Plan
                                Master Plan SW Calcs
                              Washington County, Utah

                                     Storm Data

                      Rainfall Depth by Rainfall Return Period

    2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
    (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
    1.14        .0          .0          1.94        .0          2.41        .0


Storm Data Source:                User-provided custom storm data
Rainfall Distribution Type:       Type II
Dimensionless Unit Hydrograph:    <standard>
```

```
JG                            WCL Master Plan
                            Master Plan SW Calcs
                          Washington County, Utah

                            Watershed Peak Table


 Sub-Area            Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
-------------------------------------------------------------------------------------
SUBAREAS
SA-11           0.79

SA-12           3.90

SA-13           2.01

SA-14           3.84

SA-15           3.20

SA-16           5.14

SA-17           7.85

SA-18           6.31

SA-19           1.01

SA-20           7.40


REACHES

OUTLET         41.41
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                       Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-11           0.79
           11.94

SA-12           3.90
           11.94

SA-13           2.01
           11.94

SA-14           3.84
           11.94

SA-15           3.20
           11.94

SA-16           5.14
           11.95

SA-17           7.85
           11.94

SA-18           6.31
           11.94

SA-19           1.01
           11.94

SA-20           7.40
           11.94


REACHES

OUTLET         41.41
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                             Sub-Area Summary Table

 Sub-Area   Drainage     Time of      Curve  Receiving      Sub-Area
Identifier    Area    Concentration  Number    Reach       Description
              (ac)        (hr)
--------------------------------------------------------------------------------
SA-11            .60    0.100          87     Outlet
SA-12           2.96    0.100          87     Outlet
SA-13           1.52    0.100          87     Outlet
SA-14           2.91    0.100          87     Outlet
SA-15           2.43    0.100          87     Outlet
SA-16           3.97    0.109          87     Outlet
SA-17           6.03    0.106          87     Outlet
SA-18           4.82    0.104          87     Outlet
SA-19            .77    0.100          87     Outlet
SA-20           5.61    0.100          87     Outlet

Total Area:   31.62 (ac)
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                     Sub-Area Time of Concentration Details

 Sub-Area     Flow              Mannings's    End     Wetted              Travel
Identifier/  Length    Slope      n          Area    Perimeter  Velocity   Time
              (ft)    (ft/ft)               (sq ft)    (ft)     (ft/sec)   (hr)
--------------------------------------------------------------------------------
SA-11
  CHANNEL      225                                               8.000     0.008

                                                 Time of Concentration       0.1
                                                                        ========

SA-12
  SHEET        100   0.3333     0.050                                      0.037
  SHALLOW       50   0.3333     0.050                                      0.001
  CHANNEL     1116                                               8.000     0.039

                                                 Time of Concentration       0.1
                                                                        ========

SA-13
  SHEET        100   0.3330     0.050                                      0.037
  SHALLOW       50   0.3330     0.050                                      0.001
  CHANNEL     1060                                               8.000     0.037

                                                 Time of Concentration       0.1
                                                                        ========

SA-14
  SHEET        100   0.3300     0.050                                      0.037
  SHALLOW       51   0.3330     0.050                                      0.002
  CHANNEL      999                                               8.000     0.035

                                                 Time of Concentration       0.1
                                                                        ========

SA-15
  SHEET        100   0.3330     0.050                                      0.037
  SHALLOW       50   0.3330     0.050                                      0.001
  CHANNEL      945                                               8.000     0.033

                                                 Time of Concentration       0.1
                                                                        ========

SA-16
  SHEET        100   0.3330     0.050                                      0.037
  SHALLOW       50   0.3330     0.050                                      0.001
  CHANNEL     2037                                               8.000     0.071

                                                 Time of Concentration      .109
                                                                        ========

SA-17
  SHEET        100   0.3330     0.050                                      0.037
  SHALLOW       50   0.3333     0.050                                      0.001
  CHANNEL     1954                                               8.000     0.068

                                                 Time of Concentration      .106
                                                                        ========

SA-18
  SHEET        100   0.3333     0.050                                      0.037
  SHALLOW       50   0.3330     0.050                                      0.001
  CHANNEL     1906                                               8.000     0.066

                                                 Time of Concentration      .104
                                                                        ========

SA-19
  SHEET         70   0.3330     0.050                                      0.028
```

```
              Sub-Area Time of Concentration Details (continued)

 Sub-Area     Flow              Mannings's    End     Wetted               Travel
Identifier/  Length    Slope        n         Area   Perimeter   Velocity   Time
              (ft)    (ft/ft)               (sq ft)    (ft)      (ft/sec)   (hr)
--------------------------------------------------------------------------------
  CHANNEL     1852                                               8.000     0.064

                                        Time of Concentration              0.1
                                                                         ========

SA-20
  CHANNEL     1453                                               8.000     0.050

                                        Time of Concentration              0.1
                                                                         ========
```

```
JG                       WCL Master Plan
                       Master Plan SW Calcs
                     Washington County, Utah

               Sub-Area Land Use and Curve Number Details

 Sub-Area                                         Hydrologic  Sub-Area   Curve
Identifier          Land Use                         Soil       Area     Number
                                                    Group       (ac)
---------------------------------------------------------------------------------
SA-11      Desert shrub                      (poor)    C          .12       85
           Desert shrub                      (poor)    D          .478      88

           Total Area / Weighted Curve Number                     .6        87
                                                                  ==        ==

SA-12      Desert shrub                      (poor)    C          .592      85
           Desert shrub                      (poor)    D         2.369      88

           Total Area / Weighted Curve Number                    2.96       87
                                                                 ====       ==

SA-13      Desert shrub                      (poor)    C          .304      85
           Desert shrub                      (poor)    D         1.217      88

           Total Area / Weighted Curve Number                    1.52       87
                                                                 ====       ==

SA-14      Desert shrub                      (poor)    C          .539      85
           Desert shrub                      (poor)    D         2.369      88

           Total Area / Weighted Curve Number                    2.91       87
                                                                 ====       ==

SA-15      Desert shrub                      (poor)    C          .486      85
           Desert shrub                      (poor)    D         1.944      88

           Total Area / Weighted Curve Number                    2.43       87
                                                                 ====       ==

SA-16      Desert shrub                      (poor)    C          .793      85
           Desert shrub                      (poor)    D         3.172      88

           Total Area / Weighted Curve Number                    3.97       87
                                                                 ====       ==

SA-17      Desert shrub                      (poor)    C         1.207      85
           Desert shrub                      (poor)    D         4.827      88

           Total Area / Weighted Curve Number                    6.03       87
                                                                 ====       ==

SA-18      Desert shrub                      (poor)    C          .965      85
           Desert shrub                      (poor)    D         3.858      88

           Total Area / Weighted Curve Number                    4.82       87
                                                                 ====       ==

SA-19      Desert shrub                      (poor)    C          .155      85
           Desert shrub                      (poor)    D          .618      88

           Total Area / Weighted Curve Number                     .77       87
                                                                  ===       ==

SA-20      Desert shrub                      (poor)    C         1.123      85
           Desert shrub                      (poor)    D         4.491      88

           Total Area / Weighted Curve Number                    5.61       87
                                                                 ====       ==
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                        Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
---------------------------------------------------------------------------------
SUBAREAS
SA-21            5.68
           11.94

SA-22            5.32
           11.94

SA-23            5.19
           11.94

SA-24            5.60
           11.94

SA-25            6.10
           11.94

SA-26            1.08
           11.94

SA-27            1.17
           11.94

SA-28            3.23
           11.94

SA-29            3.79
           11.94

SA-30            3.42
           11.94


REACHES

OUTLET          40.59
```

```
                    WinTR-55 Current Data Description

                        --- Identification Data ---

User:      JG                                     Date:        9/4/2020
Project:   WCL Master Plan                        Units:       English
SubTitle:  Master Plan SW Calcs                   Areal Units: Acres
State:     Utah
County:    Washington
Filename:  N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                            --- Sub-Area Data ---

Name            Description            Reach        Area(ac)      RCN     Tc
--------------------------------------------------------------------------------
SA-21                                 Outlet          4.31         87    0.1
SA-22                                 Outlet          4.04         87    0.1
SA-23                                 Outlet          3.94         87    0.1
SA-24                                 Outlet          4.25         87    0.1
SA-25                                 Outlet          4.63         87    0.1
SA-26                                 Outlet          0.82         87    0.1
SA-27                                 Outlet          0.89         87    0.1
SA-28                                 Outlet          2.45         87    0.1
SA-29                                 Outlet          2.88         87    0.1
SA-30                                 Outlet          2.6          87    0.1

Total area: 30.81 (ac)


                            --- Storm Data  --

                  Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
-----------------------------------------------------------------------------------
   1.14         .0          .0         1.94         .0         2.41         .0

Storm Data Source:             User-provided custom storm data
Rainfall Distribution Type:    Type II
Dimensionless Unit Hydrograph: <standard>
```

```
JG                               WCL Master Plan
                               Master Plan SW Calcs
                             Washington County, Utah

                                   Storm Data

                       Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0


Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                              Watershed Peak Table

 Sub-Area           Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
--------------------------------------------------------------------------------
SUBAREAS
SA-21            5.68

SA-22            5.32

SA-23            5.19

SA-24            5.60

SA-25            6.10

SA-26            1.08

SA-27            1.17

SA-28            3.23

SA-29            3.79

SA-30            3.42


REACHES

OUTLET          40.59
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                       Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-21           5.68
           11.94

SA-22           5.32
           11.94

SA-23           5.19
           11.94

SA-24           5.60
           11.94

SA-25           6.10
           11.94

SA-26           1.08
           11.94

SA-27           1.17
           11.94

SA-28           3.23
           11.94

SA-29           3.79
           11.94

SA-30           3.42
           11.94


REACHES

OUTLET         40.59
```

```
JG                            WCL Master Plan
                            Master Plan SW Calcs
                          Washington County, Utah

                           Sub-Area Summary Table

 Sub-Area   Drainage     Time of      Curve   Receiving     Sub-Area
Identifier    Area    Concentration  Number     Reach      Description
              (ac)         (hr)
--------------------------------------------------------------------------------
SA-21           4.31       0.100         87     Outlet
SA-22           4.04       0.100         87     Outlet
SA-23           3.94       0.100         87     Outlet
SA-24           4.25       0.100         87     Outlet
SA-25           4.63       0.100         87     Outlet
SA-26            .82       0.100         87     Outlet
SA-27            .89       0.100         87     Outlet
SA-28           2.45       0.100         87     Outlet
SA-29           2.88       0.100         87     Outlet
SA-30           2.60       0.100         87     Outlet

Total Area:   30.81 (ac)
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                     Sub-Area Time of Concentration Details

 Sub-Area       Flow              Mannings's    End      Wetted              Travel
Identifier/    Length    Slope        n         Area    Perimeter  Velocity   Time
                (ft)    (ft/ft)               (sq ft)     (ft)     (ft/sec)   (hr)
--------------------------------------------------------------------------------
SA-21
  CHANNEL       1473                                                8.000    0.051

                                                  Time of Concentration        0.1
                                                                          ========

SA-22
  SHEET          100    0.3333      0.050                                    0.037
  SHALLOW         50    0.3333      0.050                                    0.001
  CHANNEL       1240                                                8.000    0.043

                                                  Time of Concentration        0.1
                                                                          ========

SA-23
  SHEET          100    0.3330      0.050                                    0.037
  SHALLOW         50    0.3330      0.050                                    0.001
  CHANNEL       1180                                                8.000    0.041

                                                  Time of Concentration        0.1
                                                                          ========

SA-24
  SHEET          100    0.3300      0.050                                    0.037
  SHALLOW         51    0.3330      0.050                                    0.002
  CHANNEL       1378                                                8.000    0.048

                                                  Time of Concentration        0.1
                                                                          ========

SA-25
  SHEET          100    0.3330      0.050                                    0.037
  SHALLOW         50    0.3330      0.050                                    0.001
  CHANNEL       1375                                                8.000    0.048

                                                  Time of Concentration        0.1
                                                                          ========

SA-26
  SHEET          100    0.3330      0.050                                    0.037
  SHALLOW         50    0.3330      0.050                                    0.001
  CHANNEL        273                                                8.000    0.009

                                                  Time of Concentration        0.1
                                                                          ========

SA-27
  SHEET          100    0.3330      0.050                                    0.037
  SHALLOW         50    0.3333      0.050                                    0.001
  CHANNEL        273                                                8.000    0.009

                                                  Time of Concentration        0.1
                                                                          ========

SA-28
  SHEET          100    0.3333      0.050                                    0.037
  SHALLOW         50    0.3330      0.050                                    0.001
  CHANNEL        810                                                8.000    0.028

                                                  Time of Concentration        0.1
                                                                          ========

SA-29
  SHEET          100    0.3330      0.050                                    0.037
```

```
              Sub-Area Time of Concentration Details (continued)

 Sub-Area     Flow              Mannings's    End     Wetted               Travel
Identifier/  Length    Slope        n         Area   Perimeter   Velocity   Time
              (ft)    (ft/ft)               (sq ft)    (ft)      (ft/sec)   (hr)
--------------------------------------------------------------------------------
  SHALLOW        50   0.3333     0.050                                     0.001
  CHANNEL       874                                              8.000     0.030

                                           Time of Concentration            0.1
                                                                       ========

SA-30
  CHANNEL      1453                                              8.000     0.050

                                           Time of Concentration            0.1
                                                                       ========
```

```
JG                         WCL Master Plan
                         Master Plan SW Calcs
                       Washington County, Utah

                 Sub-Area Land Use and Curve Number Details

 Sub-Area                                        Hydrologic   Sub-Area    Curve
Identifier           Land Use                       Soil        Area      Number
                                                   Group        (ac)
---------------------------------------------------------------------------------
SA-21      Desert shrub                     (poor)    C          .863       85
           Desert shrub                     (poor)    D         3.451       88

           Total Area / Weighted Curve Number                    4.31       87
                                                                 ====       ==

SA-22      Desert shrub                     (poor)    C          .808       85
           Desert shrub                     (poor)    D         3.233       88

           Total Area / Weighted Curve Number                    4.04       87
                                                                 ====       ==

SA-23      Desert shrub                     (poor)    C          .788       85
           Desert shrub                     (poor)    D         3.152       88

           Total Area / Weighted Curve Number                    3.94       87
                                                                 ====       ==

SA-24      Desert shrub                     (poor)    C          .851       85
           Desert shrub                     (poor)    D         3.403       88

           Total Area / Weighted Curve Number                    4.25       87
                                                                 ====       ==

SA-25      Desert shrub                     (poor)    C          .925       85
           Desert shrub                     (poor)    D           3.7       88

           Total Area / Weighted Curve Number                    4.63       87
                                                                 ====       ==

SA-26      Desert shrub                     (poor)    C          .163       85
           Desert shrub                     (poor)    D          .653       88

           Total Area / Weighted Curve Number                     .82       87
                                                                  ===       ==

SA-27      Desert shrub                     (poor)    C          .178       85
           Desert shrub                     (poor)    D          .713       88

           Total Area / Weighted Curve Number                     .89       87
                                                                  ===       ==

SA-28      Desert shrub                     (poor)    C           .49       85
           Desert shrub                     (poor)    D         1.958       88

           Total Area / Weighted Curve Number                    2.45       87
                                                                 ====       ==

SA-29      Desert shrub                     (poor)    C          .576       85
           Desert shrub                     (poor)    D         2.304       88

           Total Area / Weighted Curve Number                    2.88       87
                                                                 ====       ==

SA-30      Desert shrub                     (poor)    C          .519       85
           Desert shrub                     (poor)    D         2.077       88

           Total Area / Weighted Curve Number                     2.6       87
                                                                  ===       ==
```

```
                    WinTR-55 Current Data Description

                       --- Identification Data ---

User:     JG                                        Date:        9/4/2020
Project:  WCL Master Plan                           Units:       English
SubTitle: Master Plan SW Calcs                      Areal Units: Acres
State:    Utah
County:   Washington
Filename: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                         --- Sub-Area Data ---

Name           Description            Reach         Area(ac)     RCN     Tc
-------------------------------------------------------------------------------
SA-31                                Outlet          0.96        87     0.1
SA-32                                Outlet          1.66        87     0.1
SA-33                                Outlet          0.54        87     0.1
SA-34                                Outlet          2.57        87     0.1
SA-35                                Outlet          0.35        87     0.1
SA-36                                Outlet          2.36        87     0.1
SA-37                                Outlet          2.51        87     0.1
SA-38                                Outlet          2.13        87     0.1
SA-39                                Outlet          2.38        87     0.1
SA-40                                Outlet          1.16        87     0.1

Total area: 16.62 (ac)


                         --- Storm Data --

                   Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
---------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0

Storm Data Source:             User-provided custom storm data
Rainfall Distribution Type:    Type II
Dimensionless Unit Hydrograph: <standard>
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                                  Storm Data

                   Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14         .0          .0         1.94         .0         2.41         .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                          Watershed Peak Table

 Sub-Area          Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
--------------------------------------------------------------------------------
SUBAREAS
SA-31           1.26

SA-32           2.18

SA-33           0.71

SA-34           3.39

SA-35           0.46

SA-36           3.11

SA-37           3.31

SA-38           2.81

SA-39           3.14

SA-40           1.53


REACHES

OUTLET         21.90
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                       Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-31           1.26
           11.94

SA-32           2.18
           11.94

SA-33           0.71
           11.94

SA-34           3.39
           11.94

SA-35           0.46
           11.94

SA-36           3.11
           11.94

SA-37           3.31
           11.94

SA-38           2.81
           11.94

SA-39           3.14
           11.94

SA-40           1.53
           11.94


REACHES

OUTLET         21.90
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                          Sub-Area Summary Table

 Sub-Area   Drainage    Time of     Curve   Receiving     Sub-Area
Identifier    Area    Concentration Number    Reach      Description
              (ac)        (hr)
--------------------------------------------------------------------------------
SA-31          .96      0.100        87     Outlet
SA-32         1.66      0.100        87     Outlet
SA-33          .54      0.100        87     Outlet
SA-34         2.57      0.100        87     Outlet
SA-35          .35      0.100        87     Outlet
SA-36         2.36      0.100        87     Outlet
SA-37         2.51      0.100        87     Outlet
SA-38         2.13      0.100        87     Outlet
SA-39         2.38      0.100        87     Outlet
SA-40         1.16      0.100        87     Outlet

Total Area:   16.62 (ac)
```

```
JG                         WCL Master Plan
                         Master Plan SW Calcs
                       Washington County, Utah

                  Sub-Area Time of Concentration Details

 Sub-Area      Flow             Mannings's     End      Wetted                Travel
Identifier/   Length    Slope       n          Area    Perimeter   Velocity    Time
               (ft)    (ft/ft)               (sq ft)     (ft)      (ft/sec)    (hr)
-------------------------------------------------------------------------------------
SA-31
  SHEET         100    0.3333     0.050                                        0.037
  SHALLOW        50    0.3333     0.050                                        0.001
  CHANNEL       681                                                8.000       0.024

                                              Time of Concentration             0.1
                                                                             ========

SA-32
  CHANNEL      1550                                                12.000      0.036

                                              Time of Concentration             0.1
                                                                             ========

SA-33
  SHEET          85    0.3330     0.050                                        0.032

                                              Time of Concentration             0.1
                                                                             ========

SA-34
  SHEET         100    0.3300     0.050                                        0.037
  SHALLOW        51    0.3330     0.050                                        0.002
  CHANNEL       465                                                8.000       0.016

                                              Time of Concentration             0.1
                                                                             ========

SA-35
  SHEET          67    0.3330     0.050                                        0.027

                                              Time of Concentration             0.1
                                                                             ========

SA-36
  SHEET         100    0.3330     0.050                                        0.037
  SHALLOW        50    0.3330     0.050                                        0.001
  CHANNEL       286                                                8.000       0.010

                                              Time of Concentration             0.1
                                                                             ========

SA-37
  SHEET         100    0.3330     0.050                                        0.037
  SHALLOW        50    0.3333     0.050                                        0.001
  CHANNEL       798                                                8.000       0.028

                                              Time of Concentration             0.1
                                                                             ========

SA-38
  SHEET         100    0.3333     0.050                                        0.037
  SHALLOW        50    0.3330     0.050                                        0.001
  CHANNEL       677                                                8.000       0.024

                                              Time of Concentration             0.1
                                                                             ========
SA-39
  SHEET         100    0.3330     0.050                                        0.037
  SHALLOW        50    0.3333     0.050                                        0.001
  CHANNEL       710                                                8.000       0.025

                                              Time of Concentration             0.1
```

```
              Sub-Area Time of Concentration Details (continued)

 Sub-Area     Flow               Mannings's    End     Wetted              Travel
Identifier/  Length     Slope        n         Area   Perimeter  Velocity   Time
              (ft)     (ft/ft)               (sq ft)    (ft)     (ft/sec)   (hr)
-------------------------------------------------------------------------------
                                                                          ========

SA-40
  SHEET        100    0.3330     0.050                                     0.037
  SHALLOW       50    0.3330     0.050                                     0.001
  CHANNEL      574                                             8.000       0.020

                                                Time of Concentration       0.1
                                                                          ========
```

```
                    Sub-Area Land Use and Curve Number Details

 Sub-Area                                              Hydrologic  Sub-Area   Curve
Identifier          Land Use                              Soil       Area     Number
                                                          Group      (ac)
-------------------------------------------------------------------------------------
SA-31      Desert shrub                         (poor)      C         .192      85
           Desert shrub                         (poor)      D         .769      88

           Total Area / Weighted Curve Number                          .96      87
                                                                       ===      ==

SA-32      Desert shrub                         (poor)      C         .331      85
           Desert shrub                         (poor)      D        1.324      88

           Total Area / Weighted Curve Number                         1.66      87
                                                                      ====      ==

SA-33      Desert shrub                         (poor)      C         .108      85
           Desert shrub                         (poor)      D         .432      88

           Total Area / Weighted Curve Number                          .54      87
                                                                       ===      ==

SA-34      Desert shrub                         (poor)      C         .514      85
           Desert shrub                         (poor)      D        2.056      88

           Total Area / Weighted Curve Number                         2.57      87
                                                                      ====      ==

SA-35      Desert shrub                         (poor)      C         .069      85
           Desert shrub                         (poor)      D         .276      88

           Total Area / Weighted Curve Number                          .35      87
                                                                       ===      ==

SA-36      Desert shrub                         (poor)      C         .473      85
           Desert shrub                         (poor)      D        1.892      88

           Total Area / Weighted Curve Number                         2.36      87
                                                                      ====      ==

SA-37      Desert shrub                         (poor)      C         .502      85
           Desert shrub                         (poor)      D        2.006      88

           Total Area / Weighted Curve Number                         2.51      87
                                                                      ====      ==

SA-38      Desert shrub                         (poor)      C         .426      85
           Desert shrub                         (poor)      D        1.703      88

           Total Area / Weighted Curve Number                         2.13      87
                                                                      ====      ==

SA-39      Desert shrub                         (poor)      C         .476      85
           Desert shrub                         (poor)      D        1.906      88

           Total Area / Weighted Curve Number                         2.38      87
                                                                      ====      ==

SA-40      Desert shrub                         (poor)      C         .233      85
           Desert shrub                         (poor)      D         .931      88

           Total Area / Weighted Curve Number                         1.16      87
                                                                      ====      ==
```

```
                    WinTR-55 Current Data Description

                        --- Identification Data ---

User:      JG                                       Date:         9/4/2020
Project:   WCL Master Plan                          Units:        English
SubTitle:  Master Plan SW Calcs                     Areal Units:  Acres
State:     Utah
County:    Washington
Filename:  N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                            --- Sub-Area Data ---

Name            Description            Reach        Area(ac)     RCN     Tc
------------------------------------------------------------------------------
SA-41                                 Outlet          2.35       87    0.1
SA-42                                 Outlet          1.27       87    0.1
SA-43                                 Outlet          4.72       87    0.1
SA-44                                 Outlet          1.23       87    0.1
SA-45                                 Outlet          2.89       87    0.1
SA-46                                 Outlet          0.61       87    0.1
SA-47                                 Outlet          3.06       87    0.1
SA-48                                 Outlet          3.84       87    0.1
SA-49                                 Outlet          0.79       87    0.1
SA-50                                 Outlet          2.4        87    0.1

Total area: 23.16 (ac)


                            --- Storm Data --

                   Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14         .0          .0         1.94         .0         2.41         .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                         WCL Master Plan
                         Master Plan SW Calcs
                       Washington County, Utah

                              Storm Data

                 Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                           WCL Master Plan
                           Master Plan SW Calcs
                         Washington County, Utah

                           Watershed Peak Table

 Sub-Area          Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
-----------------------------------------------------------------------------------
SUBAREAS
SA-41           3.09

SA-42           1.67

SA-43           6.22

SA-44           1.62

SA-45           3.81

SA-46           0.80

SA-47           4.03

SA-48           5.06

SA-49           1.04

SA-50           3.16


REACHES

OUTLET         30.51
```

```
JG                                WCL Master Plan
                                Master Plan SW Calcs
                              Washington County, Utah

                          Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
-----------------------------------------------------------------------------------
SUBAREAS
SA-41           3.09
           11.94

SA-42           1.67
           11.94

SA-43           6.22
           11.94

SA-44           1.62
           11.94

SA-45           3.81
           11.94

SA-46           0.80
           11.94

SA-47           4.03
           11.94

SA-48           5.06
           11.94

SA-49           1.04
           11.94

SA-50           3.16
           11.94


REACHES

OUTLET         30.51
```

```
JG                        WCL Master Plan
                        Master Plan SW Calcs
                      Washington County, Utah

                       Sub-Area Summary Table

 Sub-Area   Drainage    Time of      Curve   Receiving     Sub-Area
Identifier    Area   Concentration  Number     Reach      Description
              (ac)        (hr)
--------------------------------------------------------------------------------
SA-41          2.35     0.100          87     Outlet
SA-42          1.27     0.100          87     Outlet
SA-43          4.72     0.100          87     Outlet
SA-44          1.23     0.100          87     Outlet
SA-45          2.89     0.100          87     Outlet
SA-46           .61     0.100          87     Outlet
SA-47          3.06     0.100          87     Outlet
SA-48          3.84     0.100          87     Outlet
SA-49           .79     0.100          87     Outlet
SA-50          2.40     0.100          87     Outlet

Total Area:   23.16 (ac)
```

```
                  Sub-Area Time of Concentration Details

 Sub-Area      Flow             Mannings's    End     Wetted             Travel
Identifier/   Length    Slope       n         Area   Perimeter  Velocity  Time
               (ft)    (ft/ft)              (sq ft)    (ft)    (ft/sec)  (hr)
--------------------------------------------------------------------------------
SA-41
  SHEET         100   0.3333     0.050                                    0.037
  SHALLOW        50   0.3333     0.050                                    0.001
  CHANNEL       772                                            8.000     0.027

                                           Time of Concentration          0.1
                                                                     ========

SA-42
  SHEET         100   0.3333     0.050                                    0.037
  SHALLOW         7   0.3333     0.050                                    0.000
  CHANNEL       624                                            8.000     0.022

                                           Time of Concentration          0.1
                                                                     ========

SA-43
  SHEET         100   0.3330     0.050                                    0.037
  SHALLOW        50   0.3330     0.050                                    0.001
  CHANNEL      1443                                            8.000     0.050

                                           Time of Concentration          0.1
                                                                     ========

SA-44
  CHANNEL      1274                                            8.000     0.044

                                           Time of Concentration          0.1
                                                                     ========

SA-45
  SHEET         100   0.3330     0.050                                    0.037
  CHANNEL       977                                            8.000     0.034

                                           Time of Concentration          0.1
                                                                     ========

SA-46
  SHEET         100   0.3330     0.050                                    0.037
  CHANNEL       224                                            8.000     0.008

                                           Time of Concentration          0.1
                                                                     ========

SA-47
  SHEET         100   0.3330     0.050                                    0.037
  SHALLOW        50   0.3333     0.050                                    0.001
  CHANNEL      1113                                            8.000     0.039

                                           Time of Concentration          0.1
                                                                     ========

SA-48
  SHEET         100   0.3333     0.050                                    0.037
  SHALLOW        50   0.3330     0.050                                    0.001
  CHANNEL      1110                                            8.000     0.039

                                           Time of Concentration          0.1
                                                                     ========

SA-49
  CHANNEL      1024                                            8.000     0.036

                                           Time of Concentration          0.1
```

```
                 Sub-Area Time of Concentration Details (continued)


 Sub-Area      Flow              Mannings's     End     Wetted                Travel
Identifier/   Length    Slope       n          Area    Perimeter   Velocity    Time
               (ft)    (ft/ft)                (sq ft)    (ft)      (ft/sec)    (hr)
--------------------------------------------------------------------------------
                                                                             ========


SA-50
  SHEET          100   0.3330     0.050                                        0.037
  SHALLOW         50   0.3330     0.050                                        0.001
  CHANNEL        894                                              8.000        0.031

                                                 Time of Concentration           0.1
                                                                             ========
```

```
JG                               WCL Master Plan
                               Master Plan SW Calcs
                             Washington County, Utah

                      Sub-Area Land Use and Curve Number Details

 Sub-Area                                                   Hydrologic   Sub-Area    Curve
Identifier            Land Use                                 Soil        Area      Number
                                                               Group       (ac)
--------------------------------------------------------------------------------
SA-41       Desert shrub                           (poor)      C          .469        85
            Desert shrub                           (poor)      D         1.877        88

            Total Area / Weighted Curve Number                            2.35        87
                                                                          ====        ==

SA-42       Desert shrub                           (poor)      C          .255        85
            Desert shrub                           (poor)      D          1.02        88

            Total Area / Weighted Curve Number                            1.27        87
                                                                          ====        ==

SA-43       Desert shrub                           (poor)      C          .945        85
            Desert shrub                           (poor)      D         3.779        88

            Total Area / Weighted Curve Number                            4.72        87
                                                                          ====        ==

SA-44       Desert shrub                           (poor)      C          .245        85
            Desert shrub                           (poor)      D          .981        88

            Total Area / Weighted Curve Number                            1.23        87
                                                                          ====        ==

SA-45       Desert shrub                           (poor)      C          .578        85
            Desert shrub                           (poor)      D         2.312        88

            Total Area / Weighted Curve Number                            2.89        87
                                                                          ====        ==

SA-46       Desert shrub                           (poor)      C          .121        85
            Desert shrub                           (poor)      D          .486        88

            Total Area / Weighted Curve Number                             .61        87
                                                                           ===        ==

SA-47       Desert shrub                           (poor)      C          .611        85
            Desert shrub                           (poor)      D         2.445        88

            Total Area / Weighted Curve Number                            3.06        87
                                                                          ====        ==

SA-48       Desert shrub                           (poor)      C          .767        85
            Desert shrub                           (poor)      D         3.069        88

            Total Area / Weighted Curve Number                            3.84        87
                                                                          ====        ==

SA-49       Desert shrub                           (poor)      C          .158        85
            Desert shrub                           (poor)      D          .631        88

            Total Area / Weighted Curve Number                             .79        87
                                                                           ===        ==

SA-50       Desert shrub                           (poor)      C           .48        85
            Desert shrub                           (poor)      D          1.92        88

            Total Area / Weighted Curve Number                             2.4        87
                                                                           ===        ==
```

```
                    WinTR-55 Current Data Description

                        --- Identification Data ---

User:      JG                                        Date:         9/4/2020
Project:   WCL Master Plan                           Units:        English
SubTitle:  Master Plan SW Calcs                      Areal Units:  Acres
State:     Utah
County:    Washington
Filename:  N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                          --- Sub-Area Data ---

Name           Description              Reach        Area(ac)     RCN    Tc
-------------------------------------------------------------------------------
SA-51                                  Outlet          2.2        87    0.1
SA-52                                  Outlet          4.3        87    0.1
SA-53                                  Outlet          3.75       87    .103
SA-54                                  Outlet          3.45       87    0.1
SA-55                                  Outlet          2.53       87    0.1
SA-56                                  Outlet          0.83       87    0.1
SA-57                                  Outlet          3.76       87    0.1
SA-58                                  Outlet          3.46       87    0.1
SA-59                                  Outlet          2.34       87    0.1
SA-60                                  Outlet          4.74       87    0.1

Total area: 31.36 (ac)


                          --- Storm Data --

                 Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
---------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0

Storm Data Source:             User-provided custom storm data
Rainfall Distribution Type:    Type II
Dimensionless Unit Hydrograph: <standard>
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                               Storm Data

                 Rainfall Depth by Rainfall Return Period

   2-Yr       5-Yr       10-Yr      25-Yr      50-Yr      100-Yr     1-Yr
   (in)       (in)       (in)       (in)       (in)       (in)       (in)
--------------------------------------------------------------------------------
   1.14       .0         .0         1.94       .0         2.41       .0

Storm Data Source:               User-provided custom storm data
Rainfall Distribution Type:      Type II
Dimensionless Unit Hydrograph:   <standard>
```

JG

WCL Master Plan
Master Plan SW Calcs
Washington County, Utah

Watershed Peak Table

```
 Sub-Area           Peak Flow by Rainfall Return Period
  or Reach      25-Yr
 Identifier     (cfs)
--------------------------------------------------------------------------------
SUBAREAS
SA-51            2.90

SA-52            5.67

SA-53            4.92

SA-54            4.55

SA-55            3.33

SA-56            1.10

SA-57            4.96

SA-58            4.56

SA-59            3.09

SA-60            6.25


REACHES

OUTLET          41.31
```

```
JG                               WCL Master Plan
                               Master Plan SW Calcs
                             Washington County, Utah

                         Hydrograph Peak/Peak Time Table

 Sub-Area        Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach       25-Yr
Identifier      (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-51            2.90
           11.94

SA-52            5.67
           11.94

SA-53            4.92
           11.94

SA-54            4.55
           11.94

SA-55            3.33
           11.94

SA-56            1.10
           11.94

SA-57            4.96
           11.94

SA-58            4.56
           11.94

SA-59            3.09
           11.94

SA-60            6.25
           11.94


REACHES

OUTLET          41.31
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                          Sub-Area Summary Table

 Sub-Area  Drainage      Time of     Curve  Receiving      Sub-Area
Identifier   Area    Concentration  Number   Reach       Description
             (ac)         (hr)
--------------------------------------------------------------------------------
SA-51         2.20      0.100         87     Outlet
SA-52         4.30      0.100         87     Outlet
SA-53         3.75      0.103         87     Outlet
SA-54         3.45      0.100         87     Outlet
SA-55         2.53      0.100         87     Outlet
SA-56          .83      0.100         87     Outlet
SA-57         3.76      0.100         87     Outlet
SA-58         3.46      0.100         87     Outlet
SA-59         2.34      0.100         87     Outlet
SA-60         4.74      0.100         87     Outlet

Total Area:   31.36 (ac)
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                  Sub-Area Time of Concentration Details

 Sub-Area      Flow            Mannings's    End     Wetted              Travel
Identifier/   Length    Slope      n         Area   Perimeter  Velocity   Time
               (ft)    (ft/ft)             (sq ft)    (ft)     (ft/sec)   (hr)
---------------------------------------------------------------------------------
SA-51
  SHEET         100    0.3330    0.050                                    0.037
  SHALLOW        50    0.3333    0.050                                    0.001
  CHANNEL       841                                              8.000    0.029

                                         Time of Concentration              0.1
                                                                       ========

SA-52
  SHEET         100    0.3333    0.050                                    0.037
  SHALLOW        50    0.3333    0.050                                    0.001
  CHANNEL      1471                                              8.000    0.051

                                         Time of Concentration              0.1
                                                                       ========

SA-53
  SHEET         100    0.3330    0.050                                    0.037
  SHALLOW        50    0.3330    0.050                                    0.001
  CHANNEL      1882                                              8.000    0.065

                                         Time of Concentration             .103
                                                                       ========

SA-54
  SHEET         100    0.3300    0.050                                    0.037
  SHALLOW        50    0.3330    0.050                                    0.001
  CHANNEL      1186

                                         Time of Concentration              0.1
                                                                       ========

SA-55
  SHEET         100    0.3330    0.050                                    0.037
  SHALLOW        50    0.3330    0.050                                    0.001
  CHANNEL       888                                              8.000    0.031

                                         Time of Concentration              0.1
                                                                       ========

SA-56
  SHEET         100    0.3330    0.050                                    0.037
  CHANNEL       581                                              8.000    0.020

                                         Time of Concentration              0.1
                                                                       ========

SA-57
  SHEET         100    0.3330    0.050                                    0.037
  SHALLOW        50    0.3333    0.050                                    0.001
  CHANNEL      1118                                              8.000    0.039

                                         Time of Concentration              0.1
                                                                       ========

SA-58
  SHEET         100    0.3333    0.050                                    0.037
  SHALLOW        50    0.3330    0.050                                    0.001
  CHANNEL      1056                                              8.000    0.037

                                         Time of Concentration              0.1
                                                                       ========

SA-59
```

```
               Sub-Area Time of Concentration Details (continued)

 Sub-Area      Flow              Mannings's   End     Wetted              Travel
Identifier/   Length    Slope        n        Area   Perimeter  Velocity   Time
               (ft)    (ft/ft)              (sq ft)    (ft)     (ft/sec)   (hr)
--------------------------------------------------------------------------------
  SHEET         100    0.3330      0.050                                   0.037
  SHALLOW       150    0.3333      0.050                                   0.004
  CHANNEL       986                                              8.000     0.034

                                           Time of Concentration             0.1
                                                                        ========

SA-60
  SHEET         100    0.3330      0.050                                   0.037
  SHALLOW        50    0.3330      0.050                                   0.001
  CHANNEL      1371                                              8.000     0.048

                                           Time of Concentration             0.1
                                                                        ========
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                     Sub-Area Land Use and Curve Number Details

 Sub-Area                                                  Hydrologic   Sub-Area    Curve
Identifier            Land Use                                Soil        Area      Number
                                                              Group       (ac)
---------------------------------------------------------------------------------------
SA-51     Desert shrub                          (poor)     C          .441       85
          Desert shrub                          (poor)     D         1.763       88

          Total Area / Weighted Curve Number                           2.2       87
                                                                       ===       ==

SA-52     Desert shrub                          (poor)     C           .86       85
          Desert shrub                          (poor)     D          3.44       88

          Total Area / Weighted Curve Number                           4.3       87
                                                                       ===       ==

SA-53     Desert shrub                          (poor)     C           .75       85
          Desert shrub                          (poor)     D             3       88

          Total Area / Weighted Curve Number                          3.75       87
                                                                      ====       ==

SA-54     Desert shrub                          (poor)     C           .69       85
          Desert shrub                          (poor)     D          2.76       88

          Total Area / Weighted Curve Number                          3.45       87
                                                                      ====       ==

SA-55     Desert shrub                          (poor)     C          .506       85
          Desert shrub                          (poor)     D         2.023       88

          Total Area / Weighted Curve Number                          2.53       87
                                                                      ====       ==

SA-56     Desert shrub                          (poor)     C          .165       85
          Desert shrub                          (poor)     D          .662       88

          Total Area / Weighted Curve Number                           .83       87
                                                                       ===       ==

SA-57     Desert shrub                          (poor)     C          .752       85
          Desert shrub                          (poor)     D         3.009       88

          Total Area / Weighted Curve Number                          3.76       87
                                                                      ====       ==

SA-58     Desert shrub                          (poor)     C          .693       85
          Desert shrub                          (poor)     D         2.771       88

          Total Area / Weighted Curve Number                          3.46       87
                                                                      ====       ==

SA-59     Desert shrub                          (poor)     C          .467       85
          Desert shrub                          (poor)     D          1.87       88

          Total Area / Weighted Curve Number                          2.34       87
                                                                      ====       ==

SA-60     Desert shrub                          (poor)     C          .948       85
          Desert shrub                          (poor)     D         3.791       88

          Total Area / Weighted Curve Number                          4.74       87
                                                                      ====       ==
```

```
                    WinTR-55 Current Data Description

                       --- Identification Data ---

User:     JG                                        Date:         9/4/2020
Project:  WCL Master Plan                           Units:        English
SubTitle: Master Plan SW Calcs                      Areal Units: Acres
State:    Utah
County:   Washington
Filename: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                           --- Sub-Area Data ---

Name            Description              Reach       Area(ac)     RCN     Tc
--------------------------------------------------------------------------------
SA-61                                   Outlet          3.77       87    0.1
SA-62                                   Outlet          1.17       87    0.1
SA-63                                   Outlet          0.88       87    0.1
SA-64                                   Outlet          1.24       87    0.1
SA-65                                   Outlet          1.06       87    0.1
SA-66                                   Outlet          0.92       87    0.1
SA-67                                   Outlet          2.81       87    0.1
SA-68                                   Outlet          0.13       87    0.1
SA-69                                   Outlet          4.21       87    0.1
SA-70                                   Outlet          3.86       87    0.1

Total area: 20.05 (ac)


                           --- Storm Data --

                 Rainfall Depth by Rainfall Return Period

   2-Yr       5-Yr       10-Yr      25-Yr      50-Yr      100-Yr      1-Yr
   (in)       (in)       (in)       (in)       (in)       (in)        (in)
---------------------------------------------------------------------------------
   1.14       .0         .0         1.94       .0         2.41        .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                                  WCL Master Plan
                                  Master Plan SW Calcs
                                Washington County, Utah

                                      Storm Data

                        Rainfall Depth by Rainfall Return Period

     2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
     (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
     1.14        .0          .0          1.94        .0          2.41        .0

Storm Data Source:                User-provided custom storm data
Rainfall Distribution Type:       Type II
Dimensionless Unit Hydrograph:    <standard>
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                              Watershed Peak Table


 Sub-Area           Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
----------------------------------------------------------------------------------
SUBAREAS
SA-61           4.97

SA-62           1.54

SA-63           1.16

SA-64           1.64

SA-65           1.40

SA-66           1.21

SA-67           3.70

SA-68           0.17

SA-69           5.55

SA-70           5.09


REACHES

OUTLET         26.43
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                        Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
-----------------------------------------------------------------------------------
SUBAREAS
SA-61            4.97
           11.94

SA-62            1.54
           11.94

SA-63            1.16
           11.94

SA-64            1.64
           11.94

SA-65            1.40
           11.94

SA-66            1.21
           11.94

SA-67            3.70
           11.94

SA-68            0.17
           11.94

SA-69            5.55
           11.94

SA-70            5.09
           11.94


REACHES

OUTLET          26.43
```

JG

WCL Master Plan
Master Plan SW Calcs
Washington County, Utah

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
SA-61	3.77	0.100	87	Outlet	
SA-62	1.17	0.100	87	Outlet	
SA-63	.88	0.100	87	Outlet	
SA-64	1.24	0.100	87	Outlet	
SA-65	1.06	0.100	87	Outlet	
SA-66	.92	0.100	87	Outlet	
SA-67	2.81	0.100	87	Outlet	
SA-68	.13	0.100	87	Outlet	
SA-69	4.21	0.100	87	Outlet	
SA-70	3.86	0.100	87	Outlet	

Total Area: 20.05 (ac)

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                    Sub-Area Time of Concentration Details

 Sub-Area     Flow               Mannings's    End      Wetted               Travel
Identifier/  Length     Slope        n         Area    Perimeter   Velocity   Time
              (ft)     (ft/ft)               (sq ft)     (ft)      (ft/sec)   (hr)
--------------------------------------------------------------------------------
SA-61
  SHEET        100    0.3330     0.050                                        0.037
  SHALLOW       50    0.3333     0.050                                        0.001
  CHANNEL     1366                                                8.000       0.047

                                         Time of Concentration                0.1
                                                                         ========

SA-62
  SHEET        100    0.3333     0.050                                        0.037
  SHALLOW       50    0.3333     0.050                                        0.001
  CHANNEL      772                                                8.000       0.027

                                         Time of Concentration                0.1
                                                                         ========

SA-63
  SHEET        100    0.3330     0.050                                        0.037
  SHALLOW       50    0.3330     0.050                                        0.001
  CHANNEL      262                                                8.000       0.009

                                         Time of Concentration                0.1
                                                                         ========

SA-64
  SHEET        100    0.3300     0.050                                        0.037
  SHALLOW       50    0.3330     0.050                                        0.001
  CHANNEL      773                                                8.000       0.027

                                         Time of Concentration                0.1
                                                                         ========

SA-65
  CHANNEL      922                                               12.000       0.021

                                         Time of Concentration                0.1
                                                                         ========

SA-66
  SHEET        100    0.3330     0.050                                        0.037
  SHALLOW       20    0.3330     0.050                                        0.001

                                         Time of Concentration                0.1
                                                                         ========

SA-67
  SHEET        100    0.3330     0.050                                        0.037
  SHALLOW       50    0.3333     0.050                                        0.001
  CHANNEL      670                                                8.000       0.023

                                         Time of Concentration                0.1
                                                                         ========

SA-68
  CHANNEL     1435                                                8.000       0.050

                                         Time of Concentration                0.1
                                                                         ========
```

```
SA-69
  SHEET        100    0.3330     0.050                                        0.037
  SHALLOW      150    0.3333     0.050                                        0.004
  CHANNEL     1122                                                8.000       0.039
```

```
               Sub-Area Time of Concentration Details (continued)

 Sub-Area      Flow            Mannings's    End     Wetted                Travel
Identifier/   Length    Slope      n        Area    Perimeter   Velocity    Time
               (ft)    (ft/ft)             (sq ft)    (ft)      (ft/sec)    (hr)
--------------------------------------------------------------------------------
                                                 Time of Concentration        0.1
                                                                        ========

SA-70
  SHEET          100   0.3330     0.050                                    0.037
  SHALLOW         50   0.3330     0.050                                    0.001
  CHANNEL       1159                                            8.000      0.040

                                                 Time of Concentration        0.1
                                                                        ========
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                    Sub-Area Land Use and Curve Number Details

 Sub-Area                                                Hydrologic  Sub-Area   Curve
Identifier           Land Use                               Soil       Area     Number
                                                            Group      (ac)
-------------------------------------------------------------------------------------
SA-61     Desert shrub                           (poor)     C          .754      85
          Desert shrub                           (poor)     D         3.014      88

          Total Area / Weighted Curve Number                           3.77      87
                                                                       ====      ==

SA-62     Desert shrub                           (poor)     C          .235      85
          Desert shrub                           (poor)     D          .939      88

          Total Area / Weighted Curve Number                           1.17      87
                                                                       ====      ==

SA-63     Desert shrub                           (poor)     C          .176      85
          Desert shrub                           (poor)     D          .704      88

          Total Area / Weighted Curve Number                            .88      87
                                                                        ===      ==

SA-64     Desert shrub                           (poor)     C          .249      85
          Desert shrub                           (poor)     D          .994      88

          Total Area / Weighted Curve Number                           1.24      87
                                                                       ====      ==

SA-65     Desert shrub                           (poor)     C          .212      85
          Desert shrub                           (poor)     D          .848      88

          Total Area / Weighted Curve Number                           1.06      87
                                                                       ====      ==

SA-66     Desert shrub                           (poor)     C          .184      85
          Desert shrub                           (poor)     D          .737      88

          Total Area / Weighted Curve Number                            .92      87
                                                                        ===      ==

SA-67     Desert shrub                           (poor)     C          .563      85
          Desert shrub                           (poor)     D         2.252      88

          Total Area / Weighted Curve Number                           2.81      87
                                                                       ====      ==

SA-68     Desert shrub                           (poor)     C          .025      85
          Desert shrub                           (poor)     D            .1      88

          Total Area / Weighted Curve Number                            .13      87
                                                                        ===      ==

SA-69     Desert shrub                           (poor)     C          .841      85
          Desert shrub                           (poor)     D         3.364      88

          Total Area / Weighted Curve Number                           4.21      87
                                                                       ====      ==

SA-70     Desert shrub                           (poor)     C          .772      85
          Desert shrub                           (poor)     D         3.086      88

          Total Area / Weighted Curve Number                           3.86      87
                                                                       ====      ==
```

```
                    WinTR-55 Current Data Description

                     --- Identification Data ---

User:      JG                                       Date:        9/4/2020
Project:   WCL Master Plan                          Units:       English
SubTitle:  Master Plan SW Calcs                     Areal Units: Acres
State:     Utah
County:    Washington
Filename:  N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                       --- Sub-Area Data ---

Name            Description             Reach         Area(ac)    RCN     Tc
--------------------------------------------------------------------------------
SA-71                                  Outlet           1.27       87     0.1
SA-72                                  Outlet           5.55       87     .184
SA-73                                  Outlet           7.08       87     .194
SA-74                                  Outlet           6.72       87     .202
SA-75                                  Outlet           7.39       87     .198
SA-76                                  Outlet           12.99      87     .238
SA-77                                  Outlet           12.62      87     .235
SA-78                                  Outlet           0.29       87     0.1
SA-79                                  Outlet           0.42       87     0.1
SA-80                                  Outlet           1.43       87     0.1

Total area: 55.76 (ac)


                       --- Storm Data  --

              Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
                                    Storm Data
-------------------------------------------------------------------------------
                      Rainfall Depth by Rainfall Return Period

     2-Yr       5-Yr       10-Yr      25-Yr      50-Yr      100-Yr     1-Yr
     (in)       (in)       (in)       (in)       (in)       (in)       (in)
--------------------------------------------------------------------------------
     1.14       .0         .0         1.94       .0         2.41       .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                          Watershed Peak Table

 Sub-Area           Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
--------------------------------------------------------------------------------
SUBAREAS
SA-71           1.67

SA-72           6.46

SA-73           8.14

SA-74           7.64

SA-75           8.45

SA-76          14.06

SA-77          13.72

SA-78           0.38

SA-79           0.56

SA-80           1.88


REACHES

OUTLET         62.00
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                       Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-71           1.67
           11.94

SA-72           6.46
           12.01

SA-73           8.14
           12.01

SA-74           7.64
           12.03

SA-75           8.45
           12.02

SA-76          14.06
           12.05

SA-77          13.72
           12.04

SA-78           0.38
           11.94

SA-79           0.56
           11.94

SA-80           1.88
           11.94


REACHES

OUTLET         62.00
```

```
JG                         WCL Master Plan
                         Master Plan SW Calcs
                       Washington County, Utah

                          Sub-Area Summary Table

 Sub-Area   Drainage    Time of     Curve  Receiving     Sub-Area
Identifier    Area   Concentration Number    Reach      Description
              (ac)       (hr)
--------------------------------------------------------------------------------
SA-71           1.27     0.100       87     Outlet
SA-72           5.55     0.184       87     Outlet
SA-73           7.08     0.194       87     Outlet
SA-74           6.72     0.202       87     Outlet
SA-75           7.39     0.198       87     Outlet
SA-76          12.99     0.238       87     Outlet
SA-77          12.62     0.235       87     Outlet
SA-78            .29     0.100       87     Outlet
SA-79            .42     0.100       87     Outlet
SA-80           1.43     0.100       87     Outlet

Total Area:   55.76 (ac)
```

```
JG                          WCL Master Plan
                           Master Plan SW Calcs
                         Washington County, Utah

                     Sub-Area Time of Concentration Details

 Sub-Area     Flow              Mannings's    End     Wetted              Travel
Identifier/  Length    Slope       n         Area    Perimeter  Velocity   Time
              (ft)    (ft/ft)               (sq ft)    (ft)     (ft/sec)   (hr)
---------------------------------------------------------------------------------
SA-71
  CHANNEL     1435                                                8.000    0.050

                                                Time of Concentration        0.1
                                                                        ========

SA-72
  SHEET        100    0.0300     0.050                                     0.097
  SHALLOW      878    0.0300     0.050                                     0.087

                                                Time of Concentration       .184
                                                                        ========

SA-73
  SHEET        100    0.0300     0.050                                     0.097
  SHALLOW      973    0.0300     0.050                                     0.097

                                                Time of Concentration       .194
                                                                        ========

SA-74
  SHEET        100    0.0300     0.050                                     0.097
  SHALLOW     1060    0.0300     0.050                                     0.105

                                                Time of Concentration       .202
                                                                        ========

SA-75
  SHEET        100    0.0300     0.050                                     0.097
  SHALLOW     1020    0.0300     0.050                                     0.101

                                                Time of Concentration       .198
                                                                        ========

SA-76
  SHEET        100    0.0300     0.050                                     0.097
  SHALLOW     1419    0.0300     0.050                                     0.141

                                                Time of Concentration       .238
                                                                        ========

SA-77
  SHEET        100    0.0300     0.050                                     0.097
  SHALLOW     1390    0.0300     0.050                                     0.138

                                                Time of Concentration       .235
                                                                        ========

SA-78
  CHANNEL      247                                               12.000    0.006

                                                Time of Concentration        0.1
                                                                        ========

SA-79
  SHEET        100    0.3330     0.050                                     0.037

                                                Time of Concentration        0.1
                                                                        ========

SA-80
  CHANNEL     1133                                               12.000    0.026

                                                Time of Concentration        0.1
```

WCL Master Plan
Master Plan SW Calcs
Washington County, Utah

Sub-Area Time of Concentration Details (continued)

```
 Sub-Area      Flow              Mannings's    End     Wetted               Travel
Identifier/   Length     Slope      n          Area    Perimeter  Velocity   Time
               (ft)     (ft/ft)               (sq ft)    (ft)     (ft/sec)   (hr)
--------------------------------------------------------------------------------
                                                                        ========
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                             Washington County, Utah

                      Sub-Area Land Use and Curve Number Details

 Sub-Area                                              Hydrologic   Sub-Area    Curve
Identifier           Land Use                             Soil        Area      Number
                                                          Group       (ac)
-------------------------------------------------------------------------------------
SA-71       Desert shrub                        (poor)     C          .254        85
            Desert shrub                        (poor)     D         1.016        88

            Total Area / Weighted Curve Number                        1.27        87
                                                                      ====        ==

SA-72       Desert shrub                        (poor)     C          1.11        85
            Desert shrub                        (poor)     D          4.44        88

            Total Area / Weighted Curve Number                        5.55        87
                                                                      ====        ==

SA-73       Desert shrub                        (poor)     C         1.415        85
            Desert shrub                        (poor)     D         5.661        88

            Total Area / Weighted Curve Number                        7.08        87
                                                                      ====        ==

SA-74       Desert shrub                        (poor)     C         1.343        85
            Desert shrub                        (poor)     D         5.373        88

            Total Area / Weighted Curve Number                        6.72        87
                                                                      ====        ==

SA-75       Desert shrub                        (poor)     C         1.478        85
            Desert shrub                        (poor)     D         5.911        88

            Total Area / Weighted Curve Number                        7.39        87
                                                                      ====        ==

SA-76       Desert shrub                        (poor)     C         2.598        85
            Desert shrub                        (poor)     D        10.392        88

            Total Area / Weighted Curve Number                       12.99        87
                                                                     =====        ==

SA-77       Desert shrub                        (poor)     C         2.525        85
            Desert shrub                        (poor)     D        10.099        88

            Total Area / Weighted Curve Number                       12.62        87
                                                                     =====        ==

SA-78       Desert shrub                        (poor)     C          .059        85
            Desert shrub                        (poor)     D          .235        88

            Total Area / Weighted Curve Number                         .29        87
                                                                       ===        ==

SA-79       Desert shrub                        (poor)     C          .083        85
            Desert shrub                        (poor)     D          .333        88

            Total Area / Weighted Curve Number                         .42        87
                                                                       ===        ==

SA-80       Desert shrub                        (poor)     C          .285        85
            Desert shrub                        (poor)     D         1.141        88

            Total Area / Weighted Curve Number                        1.43        87
                                                                      ====        ==
```

```
                        WinTR-55 Current Data Description

                         --- Identification Data ---

User:     JG                                     Date:        9/4/2020
Project:  WCL Master Plan                        Units:       English
SubTitle: Master Plan SW Calcs                   Areal Units: Acres
State:    Utah
County:   Washington
Filename: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                             --- Sub-Area Data ---

Name           Description              Reach        Area(ac)     RCN     Tc
------------------------------------------------------------------------------
SA-81                                  Outlet          0.17        87    0.1
SA-82                                  Outlet          1.38        87    0.1
SA-83                                  Outlet          0.94        87    0.1
SA-84                                  Outlet          0.96        87    0.1
SA-85                                  Outlet          0.8         87    0.1
SA-86                                  Outlet          0.67        87    0.1
SA-87                                  Outlet          1.15        87    0.1
SA-88                                  Outlet          0.86        87    0.1
SA-89                                  Outlet          0.13        87    0.1
SA-90                                  Outlet          1.74        87    0.1

Total area: 8.80 (ac)


                             --- Storm Data --

                   Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14         .0          .0         1.94         .0         2.41         .0

Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                               WCL Master Plan
                               Master Plan SW Calcs
                             Washington County, Utah

                                   Storm Data

                      Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0


Storm Data Source:               User-provided custom storm data
Rainfall Distribution Type:      Type II
Dimensionless Unit Hydrograph:   <standard>
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                             Watershed Peak Table


 Sub-Area           Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
----------------------------------------------------------------------------------
SUBAREAS
SA-81           0.23

SA-82           1.82

SA-83           1.24

SA-84           1.26

SA-85           1.05

SA-86           0.89

SA-87           1.52

SA-88           1.13

SA-89           0.17

SA-90           2.29


REACHES

OUTLET         11.60
```

```
JG                               WCL Master Plan
                               Master Plan SW Calcs
                             Washington County, Utah

                         Hydrograph Peak/Peak Time Table

 Sub-Area        Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
----------------------------------------------------------------------------------
SUBAREAS
SA-81            0.23
            11.94

SA-82            1.82
            11.94

SA-83            1.24
            11.94

SA-84            1.26
            11.94

SA-85            1.05
            11.94

SA-86            0.89
            11.94

SA-87            1.52
            11.94

SA-88            1.13
            11.94

SA-89            0.17
            11.94

SA-90            2.29
            11.94


REACHES

OUTLET          11.60
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                            Sub-Area Summary Table

 Sub-Area   Drainage    Time of     Curve   Receiving     Sub-Area
Identifier    Area   Concentration Number     Reach      Description
              (ac)        (hr)

--------------------------------------------------------------------------------
SA-81              .17     0.100      87     Outlet
SA-82             1.38     0.100      87     Outlet
SA-83              .94     0.100      87     Outlet
SA-84              .96     0.100      87     Outlet
SA-85              .80     0.100      87     Outlet
SA-86              .67     0.100      87     Outlet
SA-87             1.15     0.100      87     Outlet
SA-88              .86     0.100      87     Outlet
SA-89              .13     0.100      87     Outlet
SA-90             1.74     0.100      87     Outlet

Total Area:   8.80 (ac)
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                             Washington County, Utah

                        Sub-Area Time of Concentration Details

 Sub-Area     Flow               Mannings's     End      Wetted              Travel
Identifier/  Length     Slope        n          Area    Perimeter  Velocity   Time
              (ft)     (ft/ft)                (sq ft)     (ft)    (ft/sec)    (hr)
---------------------------------------------------------------------------------
SA-81
  SHEET          51   0.3330      0.050                                       0.022

                                                  Time of Concentration        0.1
                                                                          ========

SA-82
  CHANNEL       831                                                12.000     0.019

                                                  Time of Concentration        0.1
                                                                          ========

SA-83
  SHEET         100   0.3333      0.050                                       0.037
  SHALLOW        50   0.3333      0.050                                       0.001
  CHANNEL       292                                                 8.000     0.010

                                                  Time of Concentration        0.1
                                                                          ========

SA-84
  SHEET         100   0.3333      0.050                                       0.037
  SHALLOW        50   0.3333      0.050                                       0.001
  CHANNEL       398                                                 8.000     0.014

                                                  Time of Concentration        0.1
                                                                          ========

SA-85
  CHANNEL      1003                                                 8.000     0.035

                                                  Time of Concentration        0.1
                                                                          ========

SA-86
  CHANNEL       467                                                 8.000     0.016

                                                  Time of Concentration        0.1
                                                                          ========

SA-87
  SHEET         100   0.3333      0.050                                       0.037
  SHALLOW        50   0.3333      0.050                                       0.001

                                                  Time of Concentration        0.1
                                                                          ========

SA-88
  SHEET         100   0.3333      0.050                                       0.037
  SHALLOW        20   0.3330      0.050                                       0.001

                                                  Time of Concentration        0.1
                                                                          ========

SA-89
  CHANNEL       160                                                 8.000     0.006

                                                  Time of Concentration        0.1
                                                                          ========
```

```
SA-90
  SHEET          92   0.3330      0.050                                       0.035

                                                  Time of Concentration        0.1
```

Sub-Area Time of Concentration Details (continued)

```
 Sub-Area     Flow              Mannings's    End     Wetted                Travel
Identifier/  Length    Slope       n         Area    Perimeter   Velocity   Time
              (ft)    (ft/ft)               (sq ft)    (ft)      (ft/sec)    (hr)
---------------------------------------------------------------------------------
                                                                         ========
```

```
JG                              WCL Master Plan
                              Master Plan SW Calcs
                            Washington County, Utah

                   Sub-Area Land Use and Curve Number Details

 Sub-Area                                                 Hydrologic  Sub-Area   Curve
Identifier           Land Use                                Soil       Area     Number
                                                             Group      (ac)
-------------------------------------------------------------------------------------
SA-81     Desert shrub                              (poor)     C         .034      85
          Desert shrub                              (poor)     D         .136      88

          Total Area / Weighted Curve Number                              .17      87
                                                                          ===      ==

SA-82     Desert shrub                              (poor)     C         .276      85
          Desert shrub                              (poor)     D        1.102      88

          Total Area / Weighted Curve Number                             1.38      87
                                                                         ====      ==

SA-83     Desert shrub                              (poor)     C         .188      85
          Desert shrub                              (poor)     D         .751      88

          Total Area / Weighted Curve Number                              .94      87
                                                                          ===      ==

SA-84     Desert shrub                              (poor)     C         .192      85
          Desert shrub                              (poor)     D         .767      88

          Total Area / Weighted Curve Number                              .96      87
                                                                          ===      ==

SA-85     Desert shrub                              (poor)     C          .16      85
          Desert shrub                              (poor)     D         .642      88

          Total Area / Weighted Curve Number                               .8      87
                                                                           ==      ==

SA-86     Desert shrub                              (poor)     C         .134      85
          Desert shrub                              (poor)     D         .537      88

          Total Area / Weighted Curve Number                              .67      87
                                                                          ===      ==

SA-87     Desert shrub                              (poor)     C         .231      85
          Desert shrub                              (poor)     D         .922      88

          Total Area / Weighted Curve Number                             1.15      87
                                                                         ====      ==

SA-88     Desert shrub                              (poor)     C         .171      85
          Desert shrub                              (poor)     D         .685      88

          Total Area / Weighted Curve Number                              .86      87
                                                                          ===      ==

SA-89     Desert shrub                              (poor)     C         .027      85
          Desert shrub                              (poor)     D         .107      88

          Total Area / Weighted Curve Number                              .13      87
                                                                          ===      ==

SA-90     Desert shrub                              (poor)     C         .347      85
          Desert shrub                              (poor)     D         1.39      88

          Total Area / Weighted Curve Number                             1.74      87
                                                                         ====      ==
```

```
                    WinTR-55 Current Data Description

                     --- Identification Data ---

User:     JG                                      Date:         9/4/2020
Project:  WCL Master Plan                         Units:        English
SubTitle: Master Plan SW Calcs                    Areal Units: Acres
State:    Utah
County:   Washington
Filename: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\4_Hydrolc


                       --- Sub-Area Data ---

Name           Description              Reach        Area(ac)    RCN    Tc
------------------------------------------------------------------------------
SA-91                                  Outlet          0.48       87    0.1
SA-92                                  Outlet          0.47       87    0.1
SA-93                                  Outlet          9.52       87    .231
SA-94                                  Outlet          9.72       87    .234
SA-95                                  Outlet          6.78       87    .171
SA-96                                  Outlet          9.47       87    .211
SA-97                                  Outlet          6.04       87    .179
SA-98                                  Outlet          0.18       87    0.1
SA-99                                  Outlet          11.4       87    .113

Total area: 54.06 (ac)


                       --- Storm Data --

              Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14         .0          .0         1.94         .0         2.41         .0


Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                            WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                                 Storm Data

                   Rainfall Depth by Rainfall Return Period

   2-Yr        5-Yr        10-Yr       25-Yr       50-Yr       100-Yr      1-Yr
   (in)        (in)        (in)        (in)        (in)        (in)        (in)
--------------------------------------------------------------------------------
   1.14        .0          .0          1.94        .0          2.41        .0


Storm Data Source:              User-provided custom storm data
Rainfall Distribution Type:     Type II
Dimensionless Unit Hydrograph:  <standard>
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                          Watershed Peak Table

 Sub-Area          Peak Flow by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
--------------------------------------------------------------------------------
SUBAREAS
SA-91           0.63

SA-92           0.62

SA-93          10.41

SA-94          10.58

SA-95           8.01

SA-96          10.64

SA-97           7.08

SA-98           0.24

SA-99          14.66


REACHES

OUTLET         60.91
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                       Hydrograph Peak/Peak Time Table

 Sub-Area       Peak Flow and Peak Time (hr) by Rainfall Return Period
 or Reach      25-Yr
Identifier     (cfs)
            (hr)
--------------------------------------------------------------------------------
SUBAREAS
SA-91            0.63
           11.94

SA-92            0.62
           11.94

SA-93           10.41
           12.04

SA-94           10.58
           12.04

SA-95            8.01
           12.01

SA-96           10.64
           12.03

SA-97            7.08
           12.01

SA-98            0.24
           11.94

SA-99           14.66
           11.95


REACHES

OUTLET          60.91
```

```
JG                             WCL Master Plan
                             Master Plan SW Calcs
                           Washington County, Utah

                            Sub-Area Summary Table

 Sub-Area   Drainage     Time of     Curve  Receiving      Sub-Area
Identifier    Area    Concentration  Number   Reach       Description
              (ac)        (hr)
--------------------------------------------------------------------------------
SA-91           .48     0.100        87     Outlet
SA-92           .47     0.100        87     Outlet
SA-93          9.52     0.231        87     Outlet
SA-94          9.72     0.234        87     Outlet
SA-95          6.78     0.171        87     Outlet
SA-96          9.47     0.211        87     Outlet
SA-97          6.04     0.179        87     Outlet
SA-98           .18     0.100        87     Outlet
SA-99         11.40     0.113        87     Outlet

Total Area:   54.06 (ac)
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                  Sub-Area Time of Concentration Details

 Sub-Area     Flow              Mannings's    End     Wetted               Travel
Identifier/  Length    Slope        n         Area   Perimeter  Velocity    Time
              (ft)    (ft/ft)               (sq ft)    (ft)     (ft/sec)    (hr)
--------------------------------------------------------------------------------
SA-91
  SHEET         70    0.3330      0.050                                     0.028
  CHANNEL      282                                              8.000       0.010

                                           Time of Concentration            0.1
                                                                         ========

SA-92
  SHEET        100    0.3333      0.050                                     0.037
  SHALLOW       50    0.3333      0.050                                     0.001
  CHANNEL      208                                              8.000       0.007

                                           Time of Concentration            0.1
                                                                         ========

SA-93
  SHEET        100    0.0300      0.050                                     0.097
  SHALLOW     1353    0.0300      0.050                                     0.134

                                           Time of Concentration            .231
                                                                         ========

SA-94
  SHEET        100    0.0300      0.050                                     0.097
  SHALLOW     1378    0.0300      0.050                                     0.137

                                           Time of Concentration            .234
                                                                         ========

SA-95
  SHEET        100    0.0300      0.050                                     0.097
  SHALLOW      749    0.0300      0.050                                     0.074

                                           Time of Concentration            .171
                                                                         ========

SA-96
  SHEET        100    0.0300      0.050                                     0.097
  SHALLOW     1151    0.0300      0.050                                     0.114

                                           Time of Concentration            .211
                                                                         ========

SA-97
  SHEET        100    0.0300      0.050                                     0.097
  SHALLOW      822    0.0300      0.050                                     0.082

                                           Time of Concentration            .179
                                                                         ========

SA-98
  CHANNEL      611                                              8.000       0.021

                                           Time of Concentration            0.1
                                                                         ========

SA-99
  CHANNEL     5675                                             14.000       0.113

                                           Time of Concentration            .113
                                                                         ========
```

```
JG                          WCL Master Plan
                          Master Plan SW Calcs
                        Washington County, Utah

                  Sub-Area Land Use and Curve Number Details

 Sub-Area                                        Hydrologic  Sub-Area  Curve
Identifier          Land Use                        Soil       Area    Number
                                                    Group      (ac)
------------------------------------------------------------------------------
SA-91      Desert shrub                    (poor)    C         .095      85
           Desert shrub                    (poor)    D         .381      88

           Total Area / Weighted Curve Number                   .48      87
                                                                ===      ==

SA-92      Desert shrub                    (poor)    C         .094      85
           Desert shrub                    (poor)    D         .379      88

           Total Area / Weighted Curve Number                   .47      87
                                                                ===      ==

SA-93      Desert shrub                    (poor)    C        1.904      85
           Desert shrub                    (poor)    D        7.616      88

           Total Area / Weighted Curve Number                  9.52      87
                                                               ====      ==

SA-94      Desert shrub                    (poor)    C        1.944      85
           Desert shrub                    (poor)    D        7.776      88

           Total Area / Weighted Curve Number                  9.72      87
                                                               ====      ==

SA-95      Desert shrub                    (poor)    C        1.357      85
           Desert shrub                    (poor)    D        5.426      88

           Total Area / Weighted Curve Number                  6.78      87
                                                               ====      ==

SA-96      Desert shrub                    (poor)    C        1.894      85
           Desert shrub                    (poor)    D        7.576      88

           Total Area / Weighted Curve Number                  9.47      87
                                                               ====      ==

SA-97      Desert shrub                    (poor)    C        1.207      85
           Desert shrub                    (poor)    D        4.829      88

           Total Area / Weighted Curve Number                  6.04      87
                                                               ====      ==

SA-98      Desert shrub                    (poor)    C         .035      85
           Desert shrub                    (poor)    D         .142      88

           Total Area / Weighted Curve Number                   .18      87
                                                                ===      ==

SA-99      Desert shrub                    (poor)    C         2.28      85
           Desert shrub                    (poor)    D        9.121      88

           Total Area / Weighted Curve Number                  11.4      87
                                                               ====      ==
```

APPENDIX D.3

CALCULATIONS

HYDRAULIC DRAINAGE STRUCTURES

Project Name: *Washington County Landfill*
Client: *Allied Waste*
Job No.: *AU19.1274*
Date: *09/04/2020*
Calculated By: *JMG*

Channel Section	Channel Slope (%)	Left Side Slope (H:1)	Right Side Slope (H:1)	Bottom Width (feet)	Calculated Channel Depth (feet)	Total Channel Depth (feet)	Total Channel Width (feet)	Available Freeboard (feet)	Flow Velocity (fps)	Erosion Control Protection	Median Rip-Rap Size, D_{50} (in)	Required Rip-Rap Thickness (in)	Rip-Rap Thickness Provided (in)	Rip-Rap Size, D_{50} Provided (in)
Top Deck Berm Channel Contributing subarea: SA-76	2.00%	**2**	**33.333**	**0**	0.37	**1.00**	35.33	0.63	5.70	**Erosion Mat**	N/A	N/A	**N/A**	**N/A**
Bench Drainage Channel Contributing subarea: SA-17	2.00%	**2**	**2**	**0**	1.11	**1.50**	6.00	0.39	3.21	**Rip-Rap**	4.0	8.0	**8.0**	**4.0**
Access Road Drainage Channel Contributing subareas: SA-31,32,64	8.00%	**2**	**2**	**0**	0.72	**2.50**	10.00	1.78	4.84	**Rip-Rap**	10.0	22.0	**22.0**	**10.0**
Run-On Channel Contributing subarea: SA-2, 10, 12-34, 37-40, 47-73, 76-87, 91-99	1.30%	**0.5**	**1**	**20**	2.44	**10.00**	35.00	7.56	7.77	**Rock-cut**	N/A	N/A	**N/A**	**N/A**
Run-off Channel Contributing subareas: SA-16	1.30%	**2**	**2**	**0**	0.94	**2.00**	8.00	1.06	7.93	**Erosion Mat**	N/A	N/A	**N/A**	**N/A**

Culvert Sections	Entrance Type	Culvert Type	Culvert Size (inches)	Entrance Invert Elevation (feet)	Max Headwater Elevation (feet)	Surcharge Over Pipe (feet)	Exit Invert Elevation (feet)	Max Tailwater Elevation (feet)	Culvert Slope (ft/ft)	Flow Into Culvert (cfs)	% of Culvert Capacity	Culvert Max Capacity (cfs)
Culvert Across Perimeter Access Road Contributing subareas: SA-3-98	Drop Inlet	HDPE	**24**	100.00	104.00	2.00	99.00	102.00	0.030	14	55%	25.78
Bench to Access Road Channel Culvert Contributing subareas: SA-17	Drop Inlet	HDPE	**12**	100.00	105.00	4.00	99.00	100.00	0.020	8	96%	8.20
Downdrain Contributing subareas: SA-34, 37, 38, 39, 40, 69, 70, 71, 72	Headwall	HDPE	**24**	100.00	105.00	3.00	98.50	100.50	0.030	33	89%	37.00

Culvert Calculator Report
BENCH TO ACCESS ROAD CHANNEL CULVERT

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	105.00 ft	Headwater Depth/Height	5.00
Computed Headwater Elevation	105.00 ft	Discharge	8.20 cfs
Inlet Control HW Elev.	105.00 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	104.79 ft	Control Type	Inlet Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	99.00 ft
Length	50.00 ft	Constructed Slope	0.020000 ft/ft

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	0.99 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	0.99 ft
Velocity Downstream	10.47 ft/s	Critical Slope	0.041147 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Corrugated HDPE (Smooth Interior)	Span	1.00 ft
Section Size	12 inch	Rise	1.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	104.79 ft	Upstream Velocity Head	1.69 ft
Ke	0.50	Entrance Loss	0.85 ft

Inlet Control Properties

Inlet Control HW Elev.	105.00 ft	Flow Control	N/A
Inlet Type	Square edge w/headwall	Area Full	0.8 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
CULVERT ACROSS PERIMTER ROAD DROP INLET

Solve For: Section Size

Culvert Summary

Allowable HW Elevation	104.00	ft	Headwater Depth/Height	2.39	
Computed Headwater Elevation	103.58	ft	Discharge	14.06	cfs
Inlet Control HW Elev.	103.51	ft	Tailwater Elevation	101.34	ft
Outlet Control HW Elev.	103.58	ft	Control Type	Outlet Control	

Grades

Upstream Invert	100.00	ft	Downstream Invert	99.00	ft
Length	50.00	ft	Constructed Slope	0.020000	ft/ft

Hydraulic Profile

Profile	PressureProfile		Depth, Downstream	2.34	ft
Slope Type	N/A		Normal Depth	1.09	ft
Flow Regime	N/A		Critical Depth	1.38	ft
Velocity Downstream	7.96	ft/s	Critical Slope	0.013242	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	1.50	ft
Section Size	18 inch		Rise	1.50	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	103.58	ft	Upstream Velocity Head	0.98	ft
Ke	0.50		Entrance Loss	0.49	ft

Inlet Control Properties

Inlet Control HW Elev.	103.51	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall		Area Full	1.8	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Calculator Report
DOWNDRAIN DROP INLET

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	104.00 ft	Headwater Depth/Height	1.13
Computed Headwater Elevation	102.25 ft	Discharge	14.06 cfs
Inlet Control HW Elev.	102.13 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	102.25 ft	Control Type	Entrance Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	99.00 ft
Length	50.00 ft	Constructed Slope	0.020000 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	0.95 ft
Slope Type	Steep	Normal Depth	0.89 ft
Flow Regime	Supercritical	Critical Depth	1.35 ft
Velocity Downstream	9.52 ft/s	Critical Slope	0.005171 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Corrugated HDPE (Smooth Interior)	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	102.25 ft	Upstream Velocity Head	0.60 ft
Ke	0.50	Entrance Loss	0.30 ft

Inlet Control Properties

Inlet Control HW Elev.	102.13 ft	Flow Control	Unsubmerged
Inlet Type	Square edge w/headwall	Area Full	3.1 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
DOWNDRAIN ENTRANCE

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	104.00 ft	Headwater Depth/Height	1.04
Computed Headwater Elevation	102.07 ft	Discharge	14.06 cfs
Inlet Control HW Elev.	101.99 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	102.07 ft	Control Type	Entrance Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	98.50 ft
Length	50.00 ft	Constructed Slope	0.030000 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	0.87 ft
Slope Type	Steep	Normal Depth	0.79 ft
Flow Regime	Supercritical	Critical Depth	1.35 ft
Velocity Downstream	10.79 ft/s	Critical Slope	0.005171 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.012
Section Material	Corrugated HDPE (Smooth Interior)	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	102.07 ft	Upstream Velocity Head	0.60 ft
Ke	0.20	Entrance Loss	0.12 ft

Inlet Control Properties

Inlet Control HW Elev.	101.99 ft	Flow Control	Unsubmerged
Inlet Type	Beveled ring, 33.7° bevels	Area Full	3.1 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Culvert Calculator Report
RUN-OFF CULVERT

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	2,777.65 ft	Headwater Depth/Height	1.05
Computed Headwater Elevation	2,781.49 ft	Discharge	340.00 cfs
Inlet Control HW Elev.	2,780.92 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	2,781.49 ft	Control Type	Entrance Control

Grades

Upstream Invert	2,773.65 ft	Downstream Invert	2,765.00 ft
Length	253.50 ft	Constructed Slope	0.034122 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	2.72 ft
Slope Type	Steep	Normal Depth	2.50 ft
Flow Regime	Supercritical	Critical Depth	4.76 ft
Velocity Downstream	23.49 ft/s	Critical Slope	0.003662 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	7.50 ft
Section Size	90 inch	Rise	7.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	2,781.49 ft	Upstream Velocity Head	2.05 ft
Ke	0.50	Entrance Loss	1.02 ft

Inlet Control Properties

Inlet Control HW Elev.	2,780.92 ft	Flow Control	N/A
Inlet Type	Square edge w/headwall	Area Full	44.2 ft²
K	0.00980	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	1
C	0.03980	Equation Form	1
Y	0.67000		

Culvert Calculator Report
RUN-ON CULVERT

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	2,771.00	ft	Headwater Depth/Height	1.10	
Computed Headwater Elevation	2,770.93	ft	Discharge	102.10	cfs
Inlet Control HW Elev.	2,770.57	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	2,770.93	ft	Control Type	Entrance Control	

Grades

Upstream Invert	2,766.00	ft	Downstream Invert	2,759.85	ft
Length	131.00	ft	Constructed Slope	0.046947	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	1.64	ft
Slope Type	Steep		Normal Depth	1.50	ft
Flow Regime	Supercritical		Critical Depth	2.97	ft
Velocity Downstream	19.50	ft/s	Critical Slope	0.004512	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	4.50	ft
Section Size	54 inch		Rise	4.50	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	2,770.93	ft	Upstream Velocity Head	1.31	ft
Ke	0.50		Entrance Loss	0.65	ft

Inlet Control Properties

Inlet Control HW Elev.	2,770.57	ft	Flow Control	N/A	
Inlet Type	Square edge w/headwall		Area Full	15.9	ft²
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Worksheet for BENCH DRAINAGE CHANNEL

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.041	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Discharge	7.85	ft³/s

Results

Normal Depth	1.11	ft
Flow Area	2.45	ft²
Wetted Perimeter	4.95	ft
Hydraulic Radius	0.49	ft
Top Width	4.43	ft
Critical Depth	0.99	ft
Critical Slope	0.03592	ft/ft
Velocity	3.21	ft/s
Velocity Head	0.16	ft
Specific Energy	1.27	ft
Froude Number	0.76	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.11	ft
Critical Depth	0.99	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.03592	ft/ft

Worksheet for CULVERT ACROSS PERIMETER ACCESS ROAD

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.010	
Channel Slope	0.03000	ft/ft
Diameter	2.00	ft
Discharge	47.01	ft³/s

Results

Normal Depth	1.52	ft
Flow Area	2.55	ft²
Wetted Perimeter	4.23	ft
Hydraulic Radius	0.60	ft
Top Width	1.71	ft
Critical Depth	1.97	ft
Percent Full	75.8	%
Critical Slope	0.02332	ft/ft
Velocity	18.40	ft/s
Velocity Head	5.26	ft
Specific Energy	6.78	ft
Froude Number	2.66	
Maximum Discharge	54.79	ft³/s
Discharge Full	50.94	ft³/s
Slope Full	0.02555	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	75.79	%
Downstream Velocity	Infinity	ft/s

Worksheet for CULVERT ACROSS PERIMETER ACCESS ROAD

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.52	ft
Critical Depth	1.97	ft
Channel Slope	0.03000	ft/ft
Critical Slope	0.02332	ft/ft

Worksheet for ACCESS ROAD DRAINAGE CHANNEL

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.041	
Channel Slope	0.08000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Discharge	5.08	ft³/s

Results

Normal Depth	0.72	ft
Flow Area	1.05	ft²
Wetted Perimeter	3.24	ft
Hydraulic Radius	0.32	ft
Top Width	2.90	ft
Critical Depth	0.83	ft
Critical Slope	0.03806	ft/ft
Velocity	4.84	ft/s
Velocity Head	0.36	ft
Specific Energy	1.09	ft
Froude Number	1.42	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.72	ft
Critical Depth	0.83	ft
Channel Slope	0.08000	ft/ft
Critical Slope	0.03806	ft/ft

Worksheet for RUN-OFF CHANNEL

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.01300	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Discharge	14.06	ft³/s

Results

Normal Depth	0.94	ft
Flow Area	1.77	ft²
Wetted Perimeter	4.21	ft
Hydraulic Radius	0.42	ft
Top Width	3.77	ft
Critical Depth	1.25	ft
Critical Slope	0.00285	ft/ft
Velocity	7.93	ft/s
Velocity Head	0.98	ft
Specific Energy	1.92	ft
Froude Number	2.04	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.94	ft
Critical Depth	1.25	ft
Channel Slope	0.01300	ft/ft
Critical Slope	0.00285	ft/ft

Worksheet for RUN-ON CHANNEL

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01300	ft/ft
Left Side Slope	0.50	ft/ft (H:V)
Right Side Slope	1.00	ft/ft (H:V)
Bottom Width	20.00	ft
Discharge	413.79	ft³/s

Results

Normal Depth	2.44	ft
Flow Area	53.25	ft²
Wetted Perimeter	26.18	ft
Hydraulic Radius	2.03	ft
Top Width	23.66	ft
Critical Depth	2.30	ft
Critical Slope	0.01578	ft/ft
Velocity	7.77	ft/s
Velocity Head	0.94	ft
Specific Energy	3.38	ft
Froude Number	0.91	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.44	ft
Critical Depth	2.30	ft
Channel Slope	0.01300	ft/ft

Worksheet for RUN-ON CHANNEL

GVF Output Data

Critical Slope	0.01578	ft/ft

Worksheet for TOP DECK BERM CHANNEL

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	33.33	ft/ft (H:V)
Discharge	14.06	ft³/s

Results

Normal Depth	0.37	ft
Flow Area	2.47	ft²
Wetted Perimeter	13.30	ft
Hydraulic Radius	0.19	ft
Top Width	13.21	ft
Critical Depth	0.52	ft
Critical Slope	0.00331	ft/ft
Velocity	5.70	ft/s
Velocity Head	0.50	ft
Specific Energy	0.88	ft
Froude Number	2.32	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.37	ft
Critical Depth	0.52	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.00331	ft/ft

Worksheet for DOWNDRAIN

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.010	
Channel Slope	0.02000	ft/ft
Diameter	2.00	ft
Discharge	32.95	ft³/s

Results

Normal Depth	1.34	ft
Flow Area	2.24	ft²
Wetted Perimeter	3.84	ft
Hydraulic Radius	0.58	ft
Top Width	1.88	ft
Critical Depth	1.90	ft
Percent Full	67.2	%
Critical Slope	0.01087	ft/ft
Velocity	14.68	ft/s
Velocity Head	3.35	ft
Specific Energy	4.69	ft
Froude Number	2.37	
Maximum Discharge	44.74	ft³/s
Discharge Full	41.59	ft³/s
Slope Full	0.01255	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	67.18	%
Downstream Velocity	Infinity	ft/s

Worksheet for DOWNDRAIN

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.34	ft
Critical Depth	1.90	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.01087	ft/ft

Worksheet for CULVERT ACROSS PERIMETER ACCESS ROAD

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.010	
Channel Slope	0.03000	ft/ft
Diameter	2.00	ft
Discharge	47.01	ft³/s

Results

Normal Depth	1.52	ft
Flow Area	2.55	ft²
Wetted Perimeter	4.23	ft
Hydraulic Radius	0.60	ft
Top Width	1.71	ft
Critical Depth	1.97	ft
Percent Full	75.8	%
Critical Slope	0.02332	ft/ft
Velocity	18.40	ft/s
Velocity Head	5.26	ft
Specific Energy	6.78	ft
Froude Number	2.66	
Maximum Discharge	54.79	ft³/s
Discharge Full	50.94	ft³/s
Slope Full	0.02555	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	75.79	%
Downstream Velocity	Infinity	ft/s

Worksheet for CULVERT ACROSS PERIMETER ACCESS ROAD

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	1.52	ft
Critical Depth	1.97	ft
Channel Slope	0.03000	ft/ft
Critical Slope	0.02332	ft/ft

Project Name: *Washington County Landfill*
Client: *Allied Waste*
Job No.: *AU19.1274*
Date: *09/04/2020*
Calculated By: *JMG*

RIP-RAP APRON SIZING[3]								
Channel Section	Culvert Size (inches)	Discharge (cfs)	Median Stone Diameter (inches)	Max Stone Diameter (inches)	Required Rip-Rap Thickness (inches)	Minimum Length of Apron (feet)	Minimum Width at Outlet (feet)	Minimum Width at Apron End (feet)
Run-on Channel Outlet	60.0	413.8	6.0	9.0	13.5	10.0	15.0	15.0

3) Rip-rap apron sized using Figure 7.45 or Figure 7.46 in the "Erosion and Sediment Control Handbook".

Project Name: *Washington County Landfill*
Client: *Allied Waste*
Job No.: *AU19.1274*
Date: *09/04/2020*
Calculated By: *JMG*

RIP-RAP SIZING[1]

Channel Section	Sideslope (z_1:1)	Sideslope (z_2:1)	Bottom Width (ft)	Normal Depth (ft)	Discharge (Q) (cfs)	Slope (S) (ft/ft)	Median Stone Diameter (inches)	Max Stone Diameter (inches)	Required Rip-Rap Thickness (inches)
Bench Drainage Channel	2.0	2.0	0.0	1.11	7.9	0.0200	3.4	5.1	7.6
Access Road Drainage Channel	2.0	2.0	0.0	0.72	5.1	0.0800	9.4	14.2	21.3

Notes:
1) Rip-rap sized using the following equation for v-notch channels [12(64.4QS13/6(z/(z2+1))]2/5 shown on Figure 7.34 and the equation [12(118QS13/6(R/P)]2/5 for trapezoidal channels shown on Figure 7.31 in the "Erosion and.Sediment Control Handbook", which has been modified to account for varying sidedslopes

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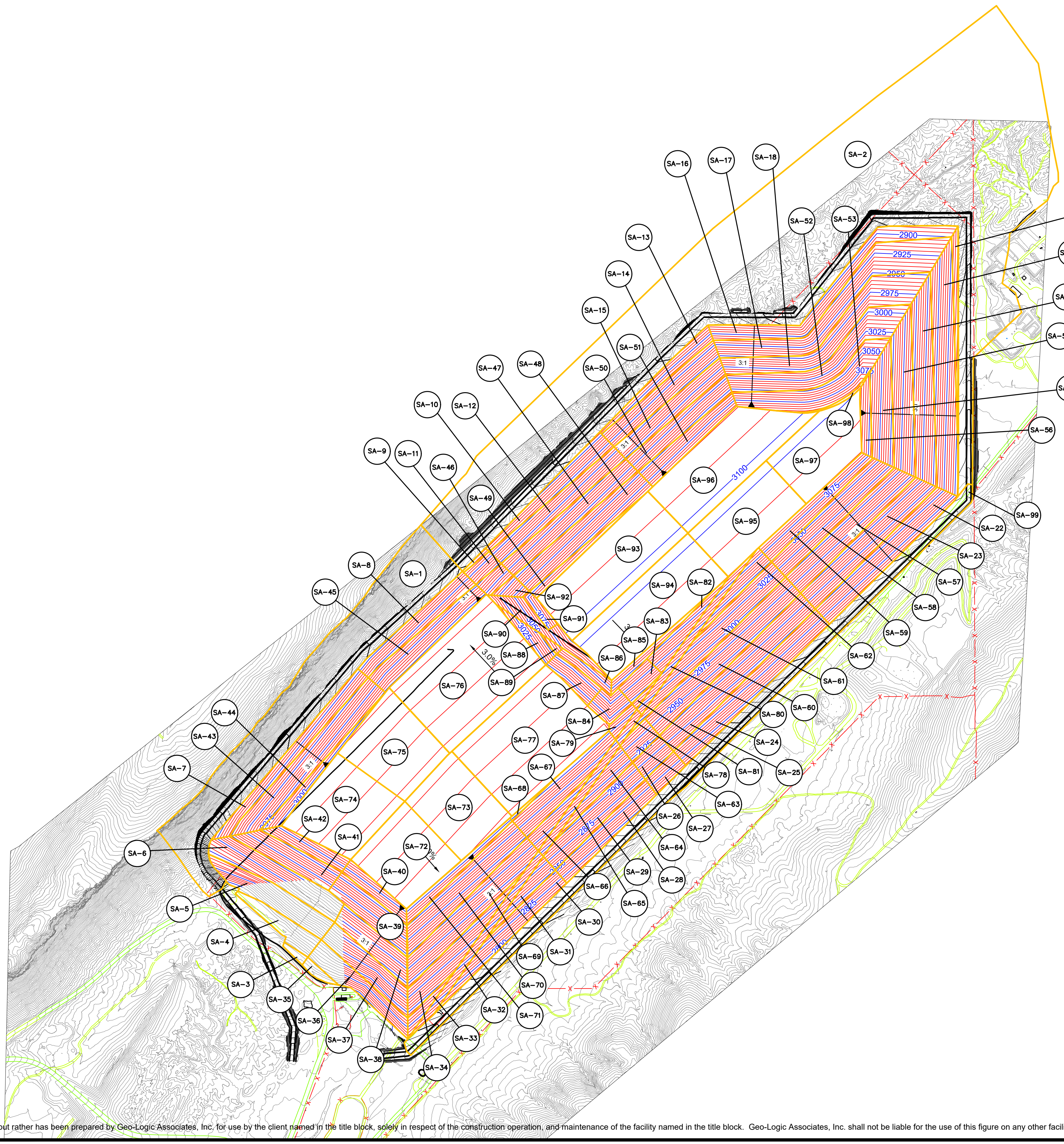
Sources:
Brown, Scott A., and Eric S. Clyde, (1989), "Design of Rip-rap Revetment, FHWA-IP-89-016, HEC-11",
Office of Implementation, HRT-10, Federal Highway Administration.

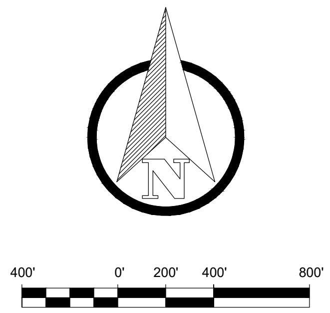
Goldman, Steven J., et al., (1986), "Erosion and Sediment Control Handbook", McGraw-Hill, Inc.

APPENDIX D.4

FIGURES

LOCATION: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\1_Civil\Drawings\Figures\Stormwater Figures\FIGURE 1 - DRAINAGE AREAS.dwg DATE: 10/2/2020 11:20 AM PLOT SCALE = 1:2 PLOTTED BY: GLA USER





LEGEND

1000 EXISTING 25' CONTOUR(1)
EXISTING 5' CONTOUR(1)
1000 PROPOSED GRADING 10' CONTOUR
PROPOSED GRADING 2' CONTOUR
1000 PROPOSED FILL 25' CONTOUR
PROPOSED FILL 5' CONTOUR
HYDROLOGIC SUBAREA BOUNDARY

SA–1 HYDROLOGIC SUBAREA

NOTES

1. REFERENCE AERIAL TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

WASHINGTON COUNTY LANDFILL

2020 MASTER PLAN DRAWINGS

WASHINGTON, UTAH

HYDROLOGIC SUBAREAS

FIGURE NO.
1

PROJECT NO.
AU19.1274.00

DATE OF ISSUE: 08/26/2020 **DRAWN BY:** JMG **APPROVED BY:** SAH

Geo-Logic
ASSOCIATES

143E Spring Hill Dr, Grass Valley, California 95945
geo-logic.com | 530.272.2448

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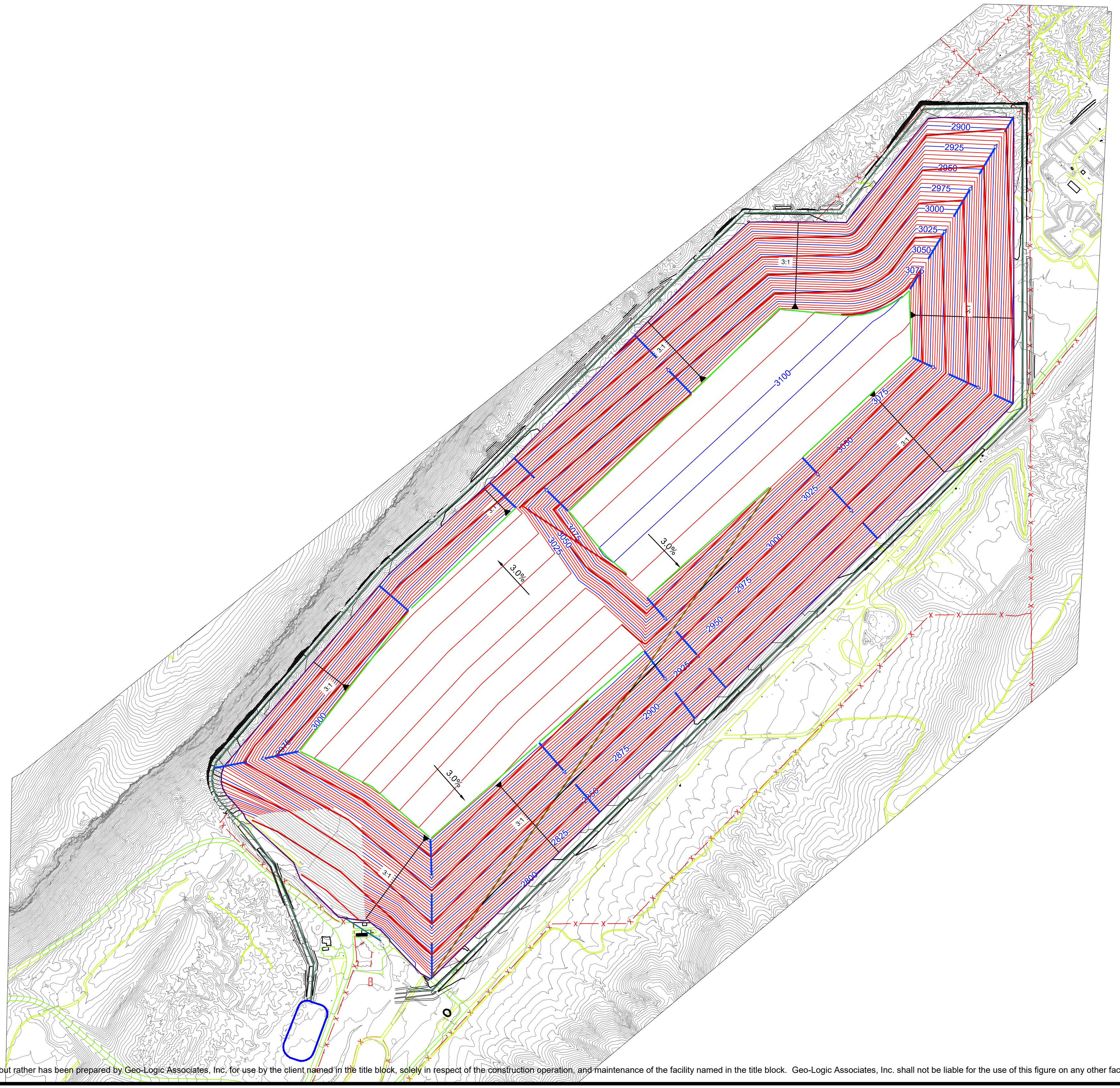

LEGEND

—— 1000 ——	EXISTING 25' CONTOUR$^{(1)}$
————	EXISTING 5' CONTOUR$^{(1)}$
—— 1000 ——	PROPOSED GRADING 25' CONTOUR
————	PROPOSED GRADING 5' CONTOUR
—— 1000 ——	PROPOSED FILL 25' CONTOUR
————	PROPOSED FILL 5' CONTOUR
	PROPOSED ACCESS ROAD HINGELINE
————	PROPOSED BENCH TO ACCESS ROAD CULVERT
————	PROPOSED BENCH DRAINAGE CHANNEL
————	PROPOSED ACCESS ROAD DRAINAGE CHANNEL
————	PROPOSED TOP DECK BERM CHANNEL
— ◁—	PROPOSED CULVERT/DOWNDRAINS
————	PROPOSED PERIMETER RUN-OFF CHANNEL
————	PROPOSED PERIMETER RUN-ON CHANNEL
————	PROPOSED RUN-ON CHANNEL CULVERT
————	PROPOSED RUN-OFF CHANNEL CULVERT
————	PROPOSED ENTRANCE FACILITY DETENTION POND

NOTES

1. REFERENCE AERIAL TOPOGRAPHY BASED ON MARCH 3, 2020 AERIAL SURVEY PERFORMED BY COOPER AERIAL SURVEYS COMPANY.

WASHINGTON COUNTY LANDFILL

2020 MASTER PLAN DRAWINGS

WASHINGTON, UTAH

STORMWATER IMPROVMENTS

FIGURE NO.

2

PROJECT NO.
AU19.1274.00

DATE OF ISSUE: 08/26/2020 **DRAWN BY:** JMG **APPROVED BY:** SAH

Geo-Logic
ASSOCIATES

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LOCATION: N:\Washington County Landfill\AU19.1274.00 WCSW 2020 Master Plan\5_Engineering\1_Civil\Drawings\Figures\Stormwater Figures\FIGURE 2 - DRAINAGE STRUCTURES.dwg DATE: 10/2/2020 9:49 AM PLOT SCALE = 1:2 PLOTTED BY: GLA USER

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APPENDIX E

SITE LIFE CALCULATIONS

WASHINGTON COUNTY LANDFILL

LANDFILL SITE LIFE PROJECTION
Operational Density: 1,824 lbs/cy, Cover Soil Estimated at 15% Soil to Waste
Loading Rate: Waste 960 tons/day and 286 days/yr
2020 Master Plan Configuration (Waste Fill_Phases 5 through 12)

Operational Density (lb/cy)	1824	0.912	tons/cy
Waste accepted (days)	286		
Waste tons per day	960		
Soil to waste (%)	0.15		
% growth	**1.020**	2.00%	

Year	Waste (tons/yr)	Waste (cy/yr)	Daily Soil Cover @15% (cy)	Total Waste and Cover Soil Landfilled (cy/yr)	Cumulative Airspace Used (cy)	Remaining Airspace (cy) **1,087,388**	**(based on 2021 ABM, remaining airspace from Phase 4D fill plan based on 3/3/2020 top**	
2020	226,560	211,158	37,263	248,421	248,421	838,967	(partial year beginning 3/3/2020)	
2021	274,560	255,895	45,158	301,053	549,474	537,914		
2022	280,051	261,013	46,061	307,074	856,547	230,841		
2023	285,652	266,233	46,982	313,215	1,169,763	7,574,625	Construct Phase 5	7,657,000 cy added
2024	291,365	271,558	47,922	319,479	1,489,242	7,255,146		
2025	297,193	276,989	48,880	325,869	1,815,111	6,929,277		
2026	303,136	282,528	49,858	332,386	2,147,497	6,596,891		
2027	309,199	288,179	50,855	339,034	2,486,532	6,257,856		
2028	315,383	293,943	51,872	345,815	2,832,346	5,912,042		
2029	321,691	299,821	52,910	352,731	3,185,078	5,559,310		
2030	328,125	305,818	53,968	359,786	3,544,863	5,199,525		
2031	334,687	311,934	55,047	366,981	3,911,845	4,832,543		
2032	341,381	318,173	56,148	374,321	4,286,166	4,458,222		
2033	348,208	324,536	57,271	381,808	4,667,973	4,076,415		
2034	355,173	331,027	58,417	389,444	5,057,417	3,686,971		
2035	362,276	337,648	59,585	397,233	5,454,650	3,289,738		
2036	369,522	344,401	60,777	405,177	5,859,827	2,884,561		
2037	376,912	351,289	61,992	413,281	6,273,108	2,471,280		
2038	384,450	358,314	63,232	421,546	6,694,654	2,049,734		
2039	392,139	365,481	64,497	429,977	7,124,631	1,619,757		
2040	399,982	372,790	65,787	438,577	7,563,208	1,181,180		
2041	407,982	380,246	67,102	447,348	8,010,557	733,831		
2042	416,141	387,851	68,444	456,295	8,466,852	277,536		
2043	424,464	395,608	69,813	465,421	8,932,273	5,343,715	Construct Phase 6	5,531,600 cy added
2044	432,953	403,520	71,209	474,730	9,407,003	4,868,985		
2045	441,613	411,591	72,634	484,224	9,891,227	4,384,761		
2046	450,445	419,822	74,086	493,909	10,385,136	3,890,852		
2047	459,454	428,219	75,568	503,787	10,888,923	3,387,065		
2048	468,643	436,783	77,079	513,863	11,402,785	2,873,203		
2049	478,016	445,519	78,621	524,140	11,926,925	2,349,063		
2050	487,576	454,429	80,193	534,623	12,461,548	1,814,440		
2051	497,327	463,518	81,797	545,315	13,006,863	1,269,125		
2052	507,274	472,788	83,433	556,221	13,563,085	712,903		
2053	517,419	482,244	85,102	567,346	14,130,431	145,557		
2054	527,768	491,889	86,804	578,693	14,709,123	5,105,665	Construct Phase 7	5,538,800 cy added
2055	538,323	501,727	88,540	590,267	15,299,390	4,515,398		
2056	549,090	511,761	90,311	602,072	15,901,462	3,913,326		
2057	560,071	521,996	92,117	614,113	16,515,576	3,299,212		
2058	571,273	532,436	93,959	626,396	17,141,971	2,672,817		
2059	582,698	543,085	95,839	638,924	17,780,895	2,033,893		
2060	594,352	553,947	97,755	651,702	18,432,597	1,382,191		
2061	606,239	565,026	99,710	664,736	19,097,333	717,455		
2062	618,364	576,326	101,705	678,031	19,775,364	39,424		
2063	630,731	587,853	103,739	691,591	20,466,956	1,960,732	Construct Phase 8	2,612,900 cy added
2064	643,346	599,610	105,813	705,423	21,172,379	1,255,309		
2065	656,213	611,602	107,930	719,532	21,891,911	535,777		
2066	669,337	623,834	110,088	733,922	22,625,833	4,334,355	Construct Phase 9	4,532,500 cy added
2067	682,724	636,311	112,290	748,601	23,374,434	3,585,754		
2068	696,378	649,037	114,536	763,573	24,138,007	2,822,181		
2069	710,306	662,018	116,827	778,844	24,916,851	2,043,337		
2070	724,512	675,258	119,163	794,421	25,711,272	1,248,916		
2071	739,002	688,763	121,546	810,310	26,521,582	438,606		
2072	753,782	702,538	123,977	826,516	27,348,098	11,481,090	Construct Phase 10	11,869,000 cy added
2073	768,858	716,589	126,457	843,046	28,191,144	10,638,044		
2074	784,235	730,921	128,986	859,907	29,051,051	9,778,137		
2075	799,920	745,539	131,566	877,105	29,928,156	8,901,032		
2076	815,918	760,450	134,197	894,647	30,822,804	8,006,384		
2077	832,237	775,659	136,881	912,540	31,735,344	7,093,844		

WASHINGTON COUNTY LANDFILL

LANDFILL SITE LIFE PROJECTION
Operational Density: 1,824 lbs/cy, Cover Soil Estimated at 15% Soil to Waste
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Waste accepted (days)	286		
Waste tons per day	960		
Soil to waste (%)	0.15		
% growth	**1.020**	2.00%	

Year	**Waste (tons/yr)**	**Waste (cy/yr)**	**Daily Soil Cover @15% (cy)**	**Total Waste and Cover Soil Landfilled (cy/yr)**	**Cumulative Airspace Used (cy)**	**Remaining Airspace (cy)**		
						1,087,388	**(based on 2021 ABM, remaining airspace from Phase 4D fill plan based on 3/3/2020 top**	
2078	848,881	791,172	139,619	930,791	32,666,135	6,163,053		
2079	865,859	806,996	142,411	949,407	33,615,542	5,213,646		
2080	883,176	823,136	145,259	968,395	34,583,937	4,245,251		
2081	900,840	839,599	148,164	987,763	35,571,700	3,257,488		
2082	918,857	856,390	151,128	1,007,518	36,579,218	2,249,970		
2083	937,234	873,518	154,150	1,027,669	37,606,887	1,222,301		
2084	955,978	890,989	157,233	1,048,222	38,655,109	174,079		
2085	975,098	908,808	160,378	1,069,186	39,724,295	16,994,893	Construct Phase 11	17,890,000 cy added
2086	994,600	926,985	163,586	1,090,570	40,814,865	15,904,323		
2087	1,014,492	945,524	166,857	1,112,382	41,927,247	14,791,941		
2088	1,034,782	964,435	170,194	1,134,629	43,061,876	13,657,312		
2089	1,055,477	983,723	173,598	1,157,322	44,219,198	12,499,990		
2090	1,076,587	1,003,398	177,070	1,180,468	45,399,666	11,319,522		
2091	1,098,119	1,023,466	180,612	1,204,078	46,603,743	10,115,445		
2092	1,120,081	1,043,935	184,224	1,228,159	47,831,902	8,887,286		
2093	1,142,483	1,064,814	187,908	1,252,722	49,084,625	7,634,563		
2094	1,165,332	1,086,110	191,667	1,277,777	50,362,401	6,356,787		
2095	1,188,639	1,107,832	195,500	1,303,332	51,665,734	5,053,454		
2096	1,212,412	1,129,989	199,410	1,329,399	52,995,133	3,724,055		
2097	1,236,660	1,152,589	203,398	1,355,987	54,351,119	2,368,069		
2098	1,261,393	1,175,641	207,466	1,383,107	55,734,226	984,962		
2099	1,286,621	1,199,153	211,615	1,410,769	57,144,995	17,721,493	Construct Phase 12	18,147,300 cy added
2100	1,312,354	1,223,136	215,848	1,438,984	58,583,979	16,282,509		
2101	1,338,601	1,247,599	220,165	1,467,764	60,051,743	14,814,745		
2102	1,365,373	1,272,551	224,568	1,497,119	61,548,862	13,317,626		
2103	1,392,680	1,298,002	229,059	1,527,061	63,075,923	11,790,565		
2104	1,420,534	1,323,962	233,640	1,557,603	64,633,526	10,232,962		
2105	1,448,944	1,350,442	238,313	1,588,755	66,222,281	8,644,207		
2106	1,477,923	1,377,450	243,079	1,620,530	67,842,810	7,023,678		
2107	1,507,482	1,404,999	247,941	1,652,940	69,495,751	5,370,737		
2108	1,537,631	1,433,099	252,900	1,685,999	71,181,750	3,684,738		
2109	1,568,384	1,461,761	257,958	1,719,719	72,901,469	1,965,019		
2110	1,599,752	1,490,997	263,117	1,754,114	74,655,583	210,905		
Total:	**68,085,892**	**63,457,245**	**11,198,337**	**74,655,583**				

APPENDIX F

CONSTRUCTION COST ESTIMATES

PHASE 5 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 5 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$149,042.50	$149,043
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	423,900	$5.00	$2,119,500
6	Rock Blasting	Cubic Yard	63,600	$10.00	$636,000
7	Placement and compaction of engineered fill	Cubic Yard	210,300	$5.00	$1,051,500
8	Liner Foundation Preparation	Square Foot	1,078,400	$0.25	$269,600
9	Permanent Liner Termination	Lineal Foot	3,000	$20.00	$60,000
10	Temporary Sideslope Liner Termination	Lineal Foot	190	$7.50	$1,425
11	GCL	Square Foot	1,078,400	$0.90	$970,560
12	60-mil double-sided Geomembrane texture	Square Foot	1,078,400	$0.70	$754,880
13	Double-Sided Geocomposite	Square Foot	1,078,400	$0.85	$916,640
14	Geotextile	Square Foot	33,600	$0.35	$11,760
15	Placement and grading of the Operations layer	Cubic Yard	60,000	$7.50	$450,000
16	Existing Waste Liner Termination	Lineal Foot	0	$5.00	$0
17	Liner Tie in	Lineal Foot	2,700	$15.00	$40,500
18	Temporary Liner Termination	Lineal Foot	230	$12.00	$2,760
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	2,600	$20.00	$52,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$1,117,819	$1,117,819
22	Overhead and Profit	15% of Construction	1	$1,117,819	$1,117,819
				Total	**$9,836,805**

PHASE 6 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 6 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$387,104.70	$387,105
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	1,870,100	$5.00	$9,350,500
6	Rock Blasting	Cubic Yard	280,600	$10.00	$2,806,000
7	Placement and compaction of engineered fill	Cubic Yard	493,100	$5.00	$2,465,500
8	Liner Foundation Preparation	Square Foot	983,300	$0.25	$245,825
9	Permanent Liner Termination	Lineal Foot	1,400	$20.00	$28,000
10	Temporary Sideslope Liner Termination	Lineal Foot	290	$7.50	$2,175
11	GCL	Square Foot	1,456,200	$0.90	$1,310,580
12	60-mil double-sided Geomembrane texture	Square Foot	1,456,200	$0.70	$1,019,340
13	Double-Sided Geocomposite	Square Foot	1,456,200	$0.85	$1,237,770
14	Geotextile	Square Foot	51,700	$0.35	$18,095
15	Placement and grading of the Operations layer	Cubic Yard	80,900	$7.50	$606,750
16	Existing Waste Liner Termination	Lineal Foot	200	$5.00	$1,000
17	Liner Tie in	Lineal Foot	2,900	$15.00	$43,500
18	Temporary Liner Termination	Lineal Foot	2,100	$12.00	$25,200
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	4,000	$20.00	$80,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$2,903,285	$2,903,285
22	Overhead and Profit	15% of Construction	1	$2,903,285	$2,903,285
				Total	**$25,548,910**

PHASE 7 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 7 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$467,364.80	$467,365
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	2,815,700	$5.00	$14,078,500
6	Rock Blasting	Cubic Yard	422,400	$10.00	$4,224,000
7	Placement and compaction of engineered fill	Cubic Yard	119,700	$5.00	$598,500
8	Liner Foundation Preparation	Square Foot	952,400	$0.25	$238,100
9	Permanent Liner Termination	Lineal Foot	1,600	$20.00	$32,000
10	Temporary Sideslope Liner Termination	Lineal Foot	250	$7.50	$1,875
11	GCL	Square Foot	1,346,800	$0.90	$1,212,120
12	60-mil double-sided Geomembrane texture	Square Foot	1,346,800	$0.70	$942,760
13	Double-Sided Geocomposite	Square Foot	1,346,800	$0.85	$1,144,780
14	Geotextile	Square Foot	39,300	$0.35	$13,755
15	Placement and grading of the Operations layer	Cubic Yard	74,900	$7.50	$561,750
16	Existing Waste Liner Termination	Lineal Foot	0	$5.00	$0
17	Liner Tie in	Lineal Foot	8,100	$15.00	$121,500
18	Temporary Liner Termination	Lineal Foot	1,800	$12.00	$21,600
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	3,100	$20.00	$62,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$3,505,236	$3,505,236
22	Overhead and Profit	15% of Construction	1	$3,505,236	$3,505,236
				Total	**$30,846,077**

PHASE 8 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 8 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$363,778.39	$363,778
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	2,334,400	$5.00	$11,672,000
6	Rock Blasting	Cubic Yard	350,200	$10.00	$3,502,000
7	Placement and compaction of engineered fill	Cubic Yard	16,100	$5.00	$80,500
8	Liner Foundation Preparation	Square Foot	506,300	$0.25	$126,575
9	Permanent Liner Termination	Lineal Foot	2,106	$20.00	$42,115
10	Temporary Sideslope Liner Termination	Lineal Foot	200	$7.50	$1,500
11	GCL	Square Foot	897,600	$0.90	$807,840
12	60-mil double-sided Geomembrane texture	Square Foot	897,600	$0.70	$628,320
13	Double-Sided Geocomposite	Square Foot	897,600	$0.85	$762,960
14	Geotextile	Square Foot	29,000	$0.35	$10,150
15	Placement and grading of the Operations layer	Cubic Yard	49,900	$7.50	$374,250
16	Existing Waste Liner Termination	Lineal Foot	0	$5.00	$0
17	Liner Tie in	Lineal Foot	530	$15.00	$7,950
18	Temporary Liner Termination	Lineal Foot	980	$12.00	$11,760
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	2,300	$20.00	$46,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$2,728,338	$2,728,338
22	Overhead and Profit	15% of Construction	1	$2,728,338	$2,728,338
				Total	**$24,009,374**

PHASE 9 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 9 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$184,547.40	$184,547
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	1,000,300	$5.00	$5,001,500
6	Rock Blasting	Cubic Yard	150,100	$10.00	$1,501,000
7	Placement and compaction of engineered fill	Cubic Yard	82,200	$5.00	$411,000
8	Liner Foundation Preparation	Square Foot	466,200	$0.25	$116,550
9	Permanent Liner Termination	Lineal Foot	1,500	$20.00	$30,000
10	Temporary Sideslope Liner Termination	Lineal Foot	160	$7.50	$1,200
11	GCL	Square Foot	686,000	$0.90	$617,400
12	60-mil double-sided Geomembrane texture	Square Foot	686,000	$0.70	$480,200
13	Double-Sided Geocomposite	Square Foot	686,000	$0.85	$583,100
14	Geotextile	Square Foot	30,800	$0.35	$10,780
15	Placement and grading of the Operations layer	Cubic Yard	38,200	$7.50	$286,500
16	Existing Waste Liner Termination	Lineal Foot	0	$5.00	$0
17	Liner Tie in	Lineal Foot	980	$15.00	$14,700
18	Temporary Liner Termination	Lineal Foot	870	$12.00	$10,440
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	2,400	$20.00	$48,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$1,384,106	$1,384,106
22	Overhead and Profit	15% of Construction	1	$1,384,106	$1,384,106
				Total	**$12,180,128**

PHASE 10 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 10 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$261,209.80	$261,210
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	1,320,000	$5.00	$6,600,000
6	Rock Blasting	Cubic Yard	198,000	$10.00	$1,980,000
7	Placement and compaction of engineered fill	Cubic Yard	53,200	$5.00	$266,000
8	Liner Foundation Preparation	Square Foot	1,094,700	$0.25	$273,675
9	Permanent Liner Termination	Lineal Foot	1,300	$20.00	$26,000
10	Temporary Sideslope Liner Termination	Lineal Foot	130	$7.50	$975
11	GCL	Square Foot	1,272,200	$0.90	$1,144,980
12	60-mil double-sided Geomembrane texture	Square Foot	1,272,200	$0.70	$890,540
13	Double-Sided Geocomposite	Square Foot	1,272,200	$0.85	$1,081,370
14	Geotextile	Square Foot	57,200	$0.35	$20,020
15	Placement and grading of the Operations layer	Cubic Yard	70,700	$7.50	$530,250
16	Existing Waste Liner Termination	Lineal Foot	0	$5.00	$0
17	Liner Tie in	Lineal Foot	2,200	$15.00	$33,000
18	Temporary Liner Termination	Lineal Foot	890	$12.00	$10,680
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	4,400	$20.00	$88,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$1,959,074	$1,959,074
22	Overhead and Profit	15% of Construction	1	$1,959,074	$1,959,074
				Total	**$17,239,847**

PHASE 11 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 11 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$147,120.40	$147,120
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	453,500	$5.00	$2,267,500
6	Rock Blasting	Cubic Yard	68,100	$10.00	$681,000
7	Placement and compaction of engineered fill	Cubic Yard	37,400	$5.00	$187,000
8	Liner Foundation Preparation	Square Foot	1,139,300	$0.25	$284,825
9	Permanent Liner Termination	Lineal Foot	1,300	$20.00	$26,000
10	Temporary Sideslope Liner Termination	Lineal Foot	80	$7.50	$600
11	GCL	Square Foot	1,269,800	$0.90	$1,142,820
12	60-mil double-sided Geomembrane texture	Square Foot	1,269,800	$0.70	$888,860
13	Double-Sided Geocomposite	Square Foot	1,269,800	$0.85	$1,079,330
14	Geotextile	Square Foot	58,500	$0.35	$20,475
15	Placement and grading of the Operations layer	Cubic Yard	70,600	$7.50	$529,500
16	Existing Waste Liner Termination	Lineal Foot	150	$5.00	$750
17	Liner Tie in	Lineal Foot	2,200	$15.00	$33,000
18	Temporary Liner Termination	Lineal Foot	780	$12.00	$9,360
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	4,500	$20.00	$90,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$1,103,403	$1,103,403
22	Overhead and Profit	15% of Construction	1	$1,103,403	$1,103,403
				Total	**$9,709,946**

PHASE 12 CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL PHASE 12 EXPANSION					
1	Mobilization/Demobilization	Lump Sum	1	$35,000.00	$35,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$149,064.50	$149,065
3	NPDES	Lump Sum	1	$10,000.00	$10,000
4	Surveying and As-Built Drawings	Lump Sum	1	$20,000.00	$20,000
5	Excavation/Stockpiling	Cubic Yard	359,300	$5.00	$1,796,500
6	Rock Blasting	Cubic Yard	53,900	$10.00	$539,000
7	Placement and compaction of engineered fill	Cubic Yard	154,800	$5.00	$774,000
8	Liner Foundation Preparation	Square Foot	1,099,500	$0.25	$274,875
9	Permanent Liner Termination	Lineal Foot	3,100	$20.00	$62,000
10	Temporary Sideslope Liner Termination	Lineal Foot	0	$7.50	$0
11	GCL	Square Foot	1,284,300	$0.90	$1,155,870
12	60-mil double-sided Geomembrane texture	Square Foot	1,284,300	$0.70	$899,010
13	Double-Sided Geocomposite	Square Foot	1,284,300	$0.85	$1,091,655
14	Geotextile	Square Foot	96,900	$0.35	$33,915
15	Placement and grading of the Operations layer	Cubic Yard	71,400	$7.50	$535,500
16	Existing Waste Liner Termination	Lineal Foot	2,900	$5.00	$14,500
17	Liner Tie in	Lineal Foot	760	$15.00	$11,400
18	Temporary Liner Termination	Lineal Foot	0	$12.00	$0
19	Leachate Collection Pipe, Gravel and Install Geotextile	Lineal Foot	7,500	$20.00	$150,000
20	Sump Construction	Lump Sum	1	$50,000.00	$50,000
21	Design & Construction Quality Assurance	15% of Construction	1	$1,117,984	$1,117,984
22	Overhead and Profit	15% of Construction	1	$1,117,984	$1,117,984
				Total	**$9,838,257**

CLOSURE CONSTRUCTION COST ESTIMATE

item no.	item description	unit	qty.	unit price in figures	total in figures
WCL CLOSURE					
1	Mobilization/Demobilization	Lump Sum	1	$125,000.00	$125,000
2	Insurance and Bonds (2% of Construction Costs)	Lump Sum	1	$591,550.30	$591,550
3	NPDES	Lump sum	1	$10,000.00	$10,000
4	Surveying and as-built drawings	Lump sum	1	$50,000.00	$50,000
5	Placement and Compaction of the Drainage Benches	Cubic Yard	2,000	$5.00	$10,000
6	Placement and Grading of the Foundation Layer	Cubic Yard	459,700	$3.50	$1,608,950
7	60-mil double-sided Geomembrane texture	Square Foot	12,410,300	$0.70	$8,687,210
8	Double-Sided Geocomposite	Square Foot	12,410,300	$0.85	$10,548,755
9	Liner Termination	Lineal Foot	16,100	$15.00	$241,500
10	Placement and Grading of the Protective Cover Soil	Cubic Yard	689,500	$7.50	$5,171,250
11	Placement and grading of the Vegetative Soil	Cubic Yard	229,900	$3.50	$804,650
12	Stormwater Diversion Berms	Lineal Foot	12,600	$7.00	$88,200
13	Downdrains	Lineal Foot	9,200	$50.00	$460,000
14	Stormwater Channels	Lineal Foot	66,800	$25.00	$1,670,000
15	Fencing	Lineal Foot	6,800	$15.00	$102,000
16	Design & Construction Quality Assurance	10% of Construction	1	$2,957,752	$2,957,752
17	Overhead and Profit	15% of Construction	1	$4,436,627	$4,436,627
				Total	**$37,563,444**

ATTACHMENT P

CLOSURE AND POST-CLOSURE MAINTENANCE COST ESTIMATES

Geo-Logic
ASSOCIATES

February 5, 2021

Mr. Darin Olson
Republic Services
1111 West Hwy 123
East Carbon, UT 84520

Re: 2021 Closure Post-Closure Cost Estimate for the Washington County Landfill

Dear Darin,

Per your request, Geo-Logic Associates (GLA) has revised the Closure and Post-Closure Cost Estimate for the Washington County Landfill operated by Republic Services, Inc. (Republic). This letter is provided to certify that the attached estimates (Tables 1 through 3) were prepared in accordance with generally accepted civil engineering and waste management practices and in accordance with the requirements of 40 CFR 258.60, Subpart F. It should be noted that no corrective action is anticipated for the site and therefore, no costs for corrective action are provided in the estimates.

The 2021 Closure and Post-Closure Costs were derived after reviewing the previous cost estimates and adjusting the cost spreadsheets, where applicable, by the Utah Department of Environmental Quality (UDEQ) Inflation Adjustment of 1.012 for the Year 2021. Please note that there was a cost increase from the 2020 to 2021 Closure Cost due to an increase in the landfill area from expansion construction of approximately 3.0 acres lined area.

We hope this provides you with the information you requested. If you have any question regarding the cost estimate, please contact me at your earliest convenience at (530) 272-2448.
Sincerely,

Geo-Logic Associates, Inc.

Jake Russell, P.E.
Senior Project Manager

Enclosure - Tables 1 through 3

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
3-31-2023
State of Utah

TABLE 1
WASHINGTON COUNTY LANDFILL
FINAL CAPPING COST ESTIMATES SUMMARY

AREA OF UNLINED LANDFILL: 2,051,310 SQUARE FEET

AREA OF LINED LANDFILL: 1,195,093 SQUARE FEET

SIZE OF CLOSURE AREA[(5)]: 74.5 ACRES

CLOSURE COSTS	**MEASURE**	**UNIT COST (1)**	**QUANTITY**	**TOTAL**
Grading of Waste/Surface Preparation	Acre	$ 3,710.79	75	**$ 276,454.14**
Surveying	Acre	$ 1,236.93	75	**$ 92,151.38**
Supply & Placement of Cover Soil (2)(3)				
Contractor Mobilization/Demobilization	Lump Sum	$ 80,400.53	1	$ 80,400.53
Final Cover Borrow Source Identification (Testing and Labor)	Lump Sum	$ 12,869.03	1	$ 12,869.03
Low-Permeability Infiltration Layer (18")	Cubic Yard	$ 12.87	114,000	$ 1,467,069.77
Protective Soil Cover for Geomembrane (12")	Cubic Yard	$ 9.40	44,300	$ 416,450.03
Topsoil Layer (6")	Cubic Yard	$ 3.65	60,100	$ 219,301.73
Subtotal - Supply and Placement of Cover Soil				**$ 2,196,091.10**
Supply & Placement of Geosynthetics				
40-mil Double-Textured LLDPE Geomembrane Cap	Square Feet	$ 0.23	1,195,093	$ 269,041.12
Geomembrane Cap Installation	Square Feet	$ 0.13	1,195,093	$ 155,216.03
Geocomposite (250 mil Drainage Net, Double-Sided 8 oz. Geotextile)	Square Feet	$ 0.51	1,195,093	$ 613,472.89
Geocomposite Drainage Layer Installation	Square Feet	$ 0.11	1,195,093	$ 125,651.07
Subtotal - Supply and Placement of Geosynthetics				**$ 1,163,381.11**
Supply & Application of Seed				
Seed Purchase	Acre	$ 482.59	75	$ 35,952.86
Seed Application	Acre	$ 477.17	75	$ 35,549.02
Subtotal - Supply and Application of Seed				**$ 71,501.88**
Earthwork for Stormwater Management				
Drainage Improvements	Lump Sum	$ 225,121.49	1	$ 225,121.49
Subtotal - Earthwork and Stormwater Management				**$ 225,121.49**
Landfill Gas Control System Installation				
Complete Gas Collection & Control System (GCCS)	Lump Sum	$ 175,246.57	1	$ 175,246.57
Subtotal - Landfill Gas Control System Installation				**$ 175,246.57**
Other: (List)				
Project Mgmt. & QC/QA (Construction Oversight, QC/QA Testing during Installation, & CQA Report)	Acre	$ 2,523.34	75	$ 187,988.82
Engineering & Construction Drawings	Lump Sum	$ 44,158.45	1	$ 44,158.45
Subtotal - Other				**$ 232,147.26**
TOTAL				**$ 4,432,094.94**

NOTES:

1 - Unit rates are reported in 2021 third-party dollars.

2 - Final cover system (top to bottom): 6" topsoil layer, 18" of low-perm soil (unlined area); 6" topsoil layer, 12" soil cover, 40 mil LLDPE (lined area).

3 - Initial 12" of foundation layer is placed as part of daily/intermediate cover.

4 - Corrective actions are currently not occurring on-site or anticipated on-site.

5 - Size of Closure Area is based on landfill footprint and adjusted for slope correction.

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
3-31-2023
State of Utah

2/5/2021

TABLE 2
WASHINGTON COUNTY LANDFILL
POST-CLOSURE COST ESTIMATES SUMMARY

LENGTH OF CLOSURE ACTIVITIES: 30 YEARS

FINAL CLOSURE COSTS					**COST/ YEAR**	**30-YEAR TOTAL**
Closure Certification(1)(4)					$ 1,890.26	**$ 56,707.87**
MAINTENANCE COSTS(1)(4)						
Security, fencing, gates, signs, access, etc.					$ 2,219.91	$ 66,597.25
Erosion repair, settlement repair, revegetation					$ 6,434.52	$ 193,035.50
Surface water control maintenance (run-on/run-off)					$ 3,217.26	$ 96,517.75
Monitoring system maintenance, repair, replacement					$ 1,286.90	$ 38,607.10
Leachate collection system, repair, replacement					$ 1,286.90	$ 38,607.10
Subtotal - Maintenance Costs					**$ 14,445.49**	**$ 433,364.69**
MONITORING COSTS (2)(3)(4)	**# OF WELL/PTS**	**# OF SAMPLES**	**FREQ/ YEAR**	**COST/ SAMPLE**	**COST/ YEAR**	
Groundwater						
3rd Party/Sample Collection(3)	3	1	2	$ 210.28	$ 1,261.70	
3rd Party/Statistical Analysis(3)	1	1	2	$ 946.25	$ 1,892.50	
Lab Analysis	3	1	2	$ 462.62	$ 2,775.70	
Subtotal - Groundwater					**$ 5,929.90**	**$ 177,896.97**
Leachate Analysis						
3rd Party/Sample Collection(3)	2	2	2	$ -	$ -	
Lab Analysis (Bi-Annual for 10 years)	2	2	2	$ 378.50	$ 3,028.01	
Subtotal - Leachate Analysis					**$ 3,028.01**	**$ 90,840.23**
Landfill Gas						
3rd Party/Operation and Maintenance(3)(5)	25	1	12	$ 192.96	$ 57,888.38	
Subtotal - Landfill Gas					**$ 57,888.38**	**$ 868,325.76**
Oversite Inspection		**HRS/ INSPECT.**	**FREQ/ YEAR**	**COST/ SAMPLE**	**COST/ YEAR**	
3rd Party Oversite Inspections		4	4	$ 118.61	$ 1,897.73	
Subtotal - Oversite Inspection					**$ 1,897.73**	**$ 56,932.03**
Total					**$ 85,079.78**	**$ 1,684,067.57**

NOTES:

1 - Rates are reported in 2021 third-party dollars.

2 - Surface water monitoring costs are not included due to no local surface water sources.

3 - Estimate reflects third-party semi-annual sample collection, lab analysis, and statistical evaluation, monitoring and facility inspection, conducted together, when appropriate.

4 - All overhead for oversight and record keeping included within unit rates.

5 - The landfill gas operation and maintenance total cost is based on operating the system for 15 years.

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
3-31-2023
State of Utah

2/5/2021

TABLE 3
WASHINGTON COUNTY LANDFILL
CLOSURE/POST-CLOSURE CARE COST SUMMARY

SIZE OF CLOSURE AREA(4):	**74.5 ACRES**	
TOTAL CLOSURE COSTS:	**$**	**4,432,095**
TOTAL POST-CLOSURE COSTS:	**$**	**1,684,068**
TOTAL CORRECTIVE ACTION COSTS:	**$**	**-**
TOTAL COST ESTIMATE:	**$**	**6,116,163**

NOTES:

1 - Total Costs are reported in 2021 third-party dollars.

2 - Includes a complete gas collection & control system (GCCS).

3 - Corrective actions are currently not anticipated at the site.

4 - Size of Closure Area is based on landfill footprint and adjusted for slope correction.

REGISTERED PROFESSIONAL ENGINEER
5881834-2202
JACOB V. RUSSELL
3-31-2023
State of Utah

ATTACHMENT Q

FINANCIAL ASSURANCE FUND BALANCE

STATEMENT OF ACCOUNT

PTIF

UTAH PUBLIC TREASURERS' INVESTMENT FUND

Marlo M. Oaks, Utah State Treasurer, Fund Manager
PO Box 142315
350 N State Street, Suite 180
Salt Lake City, Utah 84114-2315
Local Call (801) 538-1042 Toll Free (800) 395-7665
www.treasurer.utah.gov

WCSW - CELL PREP
CARLY A. MERRILL
325 N LANDFILL RD
WASHINGTON UT 84780

Account	**Account Period**
2102	July 01, 2021 through July 31, 2021

Summary

Beginning Balance	$ 3,118,699.74	Average Daily Balance	$ 3,118,699.74
Deposits	$ 954.09	Interest Earned	$ 954.09
Withdrawals	$ 0.00	360 Day Rate	0.3553
Ending Balance	$ 3,119,653.83	365 Day Rate	0.3602

Date	Activity	Deposits	Withdrawals	Balance
07/01/2021	FORWARD BALANCE	$ 0.00	$ 0.00	$ 3,118,699.74
07/31/2021	REINVESTMENT	$ 954.09	$ 0.00	$ 3,119,653.83
07/31/2021	ENDING BALANCE	$ 0.00	$ 0.00	$ 3,119,653.83

{Effective: 07/31/2021} *The GASB Fair Value factor at June 30, 2021 is 1.00335237*

STATEMENT OF ACCOUNT

PTIF

UTAH PUBLIC TREASURERS' INVESTMENT FUND

Marlo M. Oaks, Utah State Treasurer, Fund Manager
PO Box 142315
350 N State Street, Suite 180
Salt Lake City, Utah 84114-2315
Local Call (801) 538-1042 Toll Free (800) 395-7665
www.treasurer.utah.gov

ESC-WASHINGTON CO-LANDFILL
CARLY A. MERRILL
325 N LANDFILL RD
WASHINGTON, UT 84780-1995

Account	**Account Period**
2103	July 01, 2021 through July 31, 2021

Summary

Beginning Balance	$ 3,296,638.16	Average Daily Balance	$ 3,296,638.16
Deposits	$ 1,008.52	Interest Earned	$ 1,008.52
Withdrawals	$ 0.00	360 Day Rate	0.3553
Ending Balance	$ 3,297,646.68	365 Day Rate	0.3602

Date	Activity	Deposits	Withdrawals	Balance
07/01/2021	FORWARD BALANCE	$ 0.00	$ 0.00	$ 3,296,638.16
07/31/2021	REINVESTMENT	$ 1,008.52	$ 0.00	$ 3,297,646.68
07/31/2021	ENDING BALANCE	$ 0.00	$ 0.00	$ 3,297,646.68

{Effective: 07/31/2021} *The GASB Fair Value factor at June 30, 2021 is 1.00335237*

STATEMENT OF ACCOUNT

PTIF

UTAH PUBLIC TREASURERS' INVESTMENT FUND

Marlo M. Oaks, Utah State Treasurer, Fund Manager
PO Box 142315
350 N State Street, Suite 180
Salt Lake City, Utah 84114-2315
Local Call (801) 538-1042 Toll Free (800) 395-7665
www.treasurer.utah.gov

WASHINGTON CO SP SERV DIST
CARLY A MERRIL
325 N LANDFILL RD
WASHINGTON UT 84780

Account	**Account Period**
620	July 01, 2021 through July 31, 2021

Summary

Beginning Balance	$ 1,440,147.87	Average Daily Balance	$ 1,440,147.87
Deposits	$ 440.58	Interest Earned	$ 440.58
Withdrawals	$ 0.00	360 Day Rate	0.3553
Ending Balance	$ 1,440,588.45	365 Day Rate	0.3602

Date	**Activity**	**Deposits**	**Withdrawals**	**Balance**
07/01/2021	FORWARD BALANCE	$ 0.00	$ 0.00	$ 1,440,147.87
07/31/2021	REINVESTMENT	$ 440.58	$ 0.00	$ 1,440,588.45
07/31/2021	ENDING BALANCE	$ 0.00	$ 0.00	$ 1,440,588.45

{Effective: 07/31/2021} *The GASB Fair Value factor at June 30, 2021 is 1.00335237*

ATTACHMENT R

HISTORIC PRESERVATION SURVEY

Utah Division of State History

Case No.

SHORT CULTURAL RESOURCES INVENTORY REPO

State Project No. U21TW0582

Report Title: Cultural Heritage Inventory for Washington County Landfill Expansion, Washington County, Utah

State Project No.: U21TW0582 Organization Project No.: 21-07

Report Date: 24 August 2021 County(ies): Washington

Report Author(s): Hannah Russell and Mark Richter

Principal Investigator: Hannah Russell Field Supervisor(s): Hannah Russell

Records search date(s): 3 August 2021 Preservation Pro Used?: ● Yes ○ No

Acres Surveyed: Intensive (≤15 m intervals): 49.3 Recon/Intuitive (>15 m intervals): 11.7

USGS 7.5' Series

Map Reference(s): Harrisburg Junction, Utah (2020)

SITES REPORTED	COUNT	SMITHSONIAN SITE NUMBERS
Revisits (no site form updates)	0	
Updates (updated site forms attached)	0	
New recordings (site forms attached)	0	
Total Count of Archaeological Sites in APE	0	
Historic Structures (structure forms attached)	0	
Total National Register Eligible Sites	0	

CHECKLIST OF REQUIRED ITEMS FOR SUBMITTAL TO SHPO

1. ☒ **Copy of the Final Report**
2. ☒ **Copy of USGS 7.5' Series basemap with investigated area clearly Identified**
3. ☐ **Completed site forms**
   - ☐ **IMACS Encoding Forms**
   - ☐ **Site Sketch Map**
   - ☐ **Photographs adhering to UDSH standards**
   - ☐ **Copy of USGS 7.5' Series basemap with site location and Smithsonian site number clearly labeled**
4. ☒ **CD of digital report and site documents, including shapefiles (optional)**

For UDSH office use only

SHORT CULTURAL RESOURCES INVENTORY REPORT FORM

State Project Number: U21TW0582

Report Title: Cultural Heritage Inventory for Washington County Landfill Expansion, Washington County, Utah

Report Date: 24 August 2021

Report Authors: Hannah Russell and Mark Richter

Principal Investigator: Hannah Russell

Person-Days for Survey: 3

Acreage: APE: 61.0
Intensive: 49.3
Recon/Intuitive: 11.7

Project Background:

Hannah Russell of Cottonwood Archaeology was contacted by Stephanie Hamilton of Geo-Logic Associates on behalf of the Washington County Landfill to conduct a cultural heritage survey in compliance with Utah Code 9-8-404 and R315-302-1(2)(f). The Area of Potential Effect total 61 acres on lands owned by Washington County Special Services District No, 1. The property was purchased from the Bureau of Land Management in 2016. The purpose of the land purchase and the cultural compliance survey is to expand the existing landfill to extend the life of the landfill. The parcels are northwest and parallel to the existing landfill. The legal description is Township 32S, Range 14W, Sec. 8.

Area of Potential Effect Definition:

The area of potential effect is defined by the lands acquired by the Washington County Special Services District No. 1 for the purposes of the lateral landfill expansion.

Identification Strategies (*archaeological, historical, and ethnographic*):

Prior to fieldwork, a file search was conducted through Utah SHPO's SEGO and UDAM online databases to identify previous archaeological projects and sites that occur within and within half a mile of the project areas. The search identified 17 previously conducted archaeological projects (Table 1) and 35 previously recorded archaeological sites (Table 2) within and within a half-mile of the proposed project area. Of the 17 projects in the file search area, projects U77IG0076, U95BL0797, U95BL0798, U95BL0819, and U95BL0829 occur within the current APE. None of the previously recorded sites occur in the APE of the current project.

The project areas are located on a steep slope cut through by a cliff. As a result, areas that were too dangerous to properly survey at the intensive level (slopes of 40 degrees or greater with loose scree) were subject to reconnaissance level survey with special attention paid to cliff faces and large talus boulders. All other areas were surveyed with the archaeologist traversing the project areas at no greater than 15 meter intervals.

Archaeological sites are defined as 50 years old or older, two or more temporally associated cultural features without artifacts, a cultural feature with at least one temporally associated artifact, and/or a cluster of ten or more associated cultural materials in a ten meter square area or 15 or more unassociated artifacts within a ten meter square area (Utah State Historic Preservation Office and Antiquities Section 2019: 13-14). Potential sites would have been documented using the Utah Archaeological Site Form, mapped with a Trimble Juno 3B GPS, and photographed with a digital camera. Trimble collected GIS data were post-processed. No archaeological materials were collected in the course of the inventory. All archaeological sites were evaluated for National Register of Historic Places (NRHP) inclusion. Isolated finds, finds of cultural places or materials that do not meet the minimum standard of a site, were inventoried, photographed with a digital camera, and a GPS point was collected at the location of the isolate.

Location(s) and Date(s) of Pre-Field Records Search:

1. **Utah Division of State History:** 3 August 2021
2. **Federal/State Office:**
3. **Historic Records/Maps:** 3 August 2021 (Utah Historic Aerial Imagery)
4. **Other:**

Results of Pre-Field Records Search (*sites & projects within agency-defined APE buffer and/or site leads from research*):

Table 1: Previous Archaeological Projects

Project No.	**Report Title**	**Author**	**Date**
U77IG0076	(Not on Record)		
U80BL0139	Harrisburg Quantity Grant Archaeology	Gardiner F. Dalley	1980
U86BL0064	Rock Sale Vic County Landfill	Gardiner F. Dalley	1986
U88NP0024	A Cultural Resource Inventory of the Proposed Mt. Fuel Supply Company Natural Gas Pipeline from Cedar City in Iron County to Ivins in Washington County, Utah	Asa S. Nielson	1988
U88PD0524	Cultural Resource Inventory along State Road 9, I-15 to Virgin River, milepost 0 to 5, Washington County, Utah	Betsy L. Tipps, K Renee Barlow, and Gary M. Popek	1989
U93IG0064	Alpha Engineering-Harrisburg Junction Development Project Addendum	Richard A. Thompson and Barbara A. Walling	1993
U93IG0508	US West Washington to Hurricane fiber optic line, Washington County, Utah	Richard A. Thompson and Barbara A. Walling	1993
U94NP0152	A Cultural Resource Inventory of the Proposed Uamps Quail Creek 69Kv power line east of St. George, Washington County, Utah	Asa S. Nielson, V. Garth Norman	1994
U95ST0498	Cultural Resource Inventory of Telegraph Road in Washington County, Utah	Elizabeth Skinner; Lynn Neal; Jill Caouette	1995
U95BL0796	Desert Tortoise exchange (DTX) Tract 15	Gardiner F. Dalley	1995
U95BL0797	Desert Tortoise exchange (DTX) Tract 16	Gardiner F. Dalley	1995
U95BL0798	Desert Tortoise exchange (DTX) Tract 17	Gardiner F. Dalley	1996
U95BL0799	Desert Tortoise exchange (DTX) Tract 28	Gardiner F. Dalley	1996
U95BL0819	Desert Tortoise exchange (DTX) Tract 18	Gardiner F. Dalley	1996
U95BL0829	Desert Tortoise exchange (DTX) Tract 61 c,d,e	Gardiner F. Dalley	1996
U98UM0703	An Archaeological Survey of a Trust Land Development Parcel near Harrisburg Junction, Washington County, Utah	Chris Horting, Kristine Curry, and Kenneth L. Wintch	1999
U06HO0024	A Cultural Resource Inventory of the Proposed Gateway to Quail Creek Powerline, Washington County, Utah	Jon R. Baxter and Dale R. Gourley	2006

Table 2: Previously Recorded Archaeological Sites

Site No.	**Site Type**	**Eligibility**	**Date Recorded**

42WS782	Precontact Artifact Scatter	Recommended Ineligible	1977
42WS783	Precontact Artifact Scatter	Recommended Ineligible	1977
42WS797	Precontact Artifact Scatter	Recommended Ineligible	1977
42WS1219	Precontact Artifact Scatter	Recommended Eligible	1999
42WS1224	Precontact Artifact Scatter/ Quarry	Recommended Eligible	1999
42WS1227	Precontact Artifact Scatter/ Quarry	Determined Eligible	1993
42WS1228	Precontact Temporary Camp	Unevaluated	1980
42WS1229	Precontact Temporary Camp	Destroyed	2019
42WS1230	Precontact Temporary Camp	Recommended Ineligible	1999
42WS1231	Precontact Rock Shelter	Recommended Ineligible	1999
42WS1232	Precontact Artifact Scatter/ Quarry	Recommended Ineligible	1999
42WS1233	Precontact Temporary Camp	Recommended Ineligible	2002
42WS1234	Precontact Rock Shelter	Recommended Ineligible	1999
42WS2290	Precontact Rock Marking	Recommended Ineligible	1988
42WS2349	Precontact Artifact Scatter	Determined Ineligible	2019
42WS2352	Precontact Artifact Scatter	Determined Ineligible	2019
42WS3083	Precontact Artifact Scatter/ Quarry	Recommended Ineligible	1999
42WS3084	Precontact Artifact Scatter/ Quarry	Recommended Eligible	1995
42WS3630	Historic Road	Recommended Ineligible	2013
42WS3662	Precontact Stone Cluster	Recommended Ineligible	1999
42WS3663	Precontact Rock Piles	Recommended Ineligible	1999
42WS3709	Historic Road	Determined Eligible	2020
42WS3747	Multicomponent Artifact Scatter and Structures	Determined Eligible	1998
42WS3748	Precontact Artifact Scatter	Determined Ineligible	1998
42WS3749	Precontact Artifact Scatter/ Quarry	Determined Ineligible	1998
42WS3750	Precontact Artifact Scatter/ Quarry	Determined Ineligible	1998
42WS3751	Historic Artifact Scatter	Determined Ineligible	1998
42WS3752	Historic Mining Complex	Determined Eligible	1998
42WS3753	Precontact Artifact Scatter/ Quarry	Recommended Ineligible	1999
42WS3754	Precontact Artifact Scatter/ Quarry	Recommended Ineligible	1999
42WS3755	Precontact Artifact Scatter/ Quarry	Recommended Ineligible	1999
42WS3756	Multicomponent Lithic Scatter and Mining Claim	Determined Eligible	1998
42WS3757	Precontact Artifact Scatter	Determined Eligible	1998
42WS3758	Precontact Artifact Scatter	Recommended Ineligible	1998
42WS4457	Precontact Trail	Determined Ineligible	2004

Date(s) of Survey: 5-7 August 2021

Description of Findings:

The APE of the project area had been previously surveyed by multiple Bureau of Land Management projects in 1995. Because of the previous 100% survey coverage no cultural materials were expected in the project area. Portions of the project area were difficult or dangerous to access due to steep slopes and cliffs and loose scree slopes. These areas were inventoried at the reconnaissance level with special attention paid to cliff faces and large talus boulders. The survey yielded a single isolated find (IF-21-07-01). It consisted of broken pieces of a large aqua glass insulator. It was likely made in Provo and the find likely represents all the shards of the insulator. The find is located on a light reddish-brown sandy loam residual colluvium surrounded by ephedra and sagebrush. Because of the project area's proximity to an active landfill, large amounts of modern trash are also found throughout the project area as was modern KKK related graffiti, and bolted climbing routes.

Conclusion & Management Recommendations:

Cottonwood Archaeology conducted a cultural heritage inventory of 61 acres of land owned by the Washington County Special Services District No. 1 for the Washington County Landfill expansion. The purpose of the survey was to provide compliance with Utah Code 9-8-404 and R315-302-1(2)(f). The survey identified a single isolated find of historic cultural material, a broken glass insulator which is not eligible for National Register of Historic Places inclusion. A determination of "no historic properties affected" is recommended.

If cultural materials including, but not limited to precontact deposits, features, or human remains, or historic deposits, features, or burials are encountered in the course of the undertaking, work must be halted within 50 feet of the discovery and the responsible agency must be notified. While work is halted, the agency or qualified archaeologist will assess the discovery and contact the Utah State Historic Preservation Office to determine a mitigation strategy for the discovery.

Required Materials:
☒ 7.5 Quadrangle Base Map(s) for Project Area
☐ 7.5 Quadrangle Base Map(s) for Surveyed Area (if different than #1)

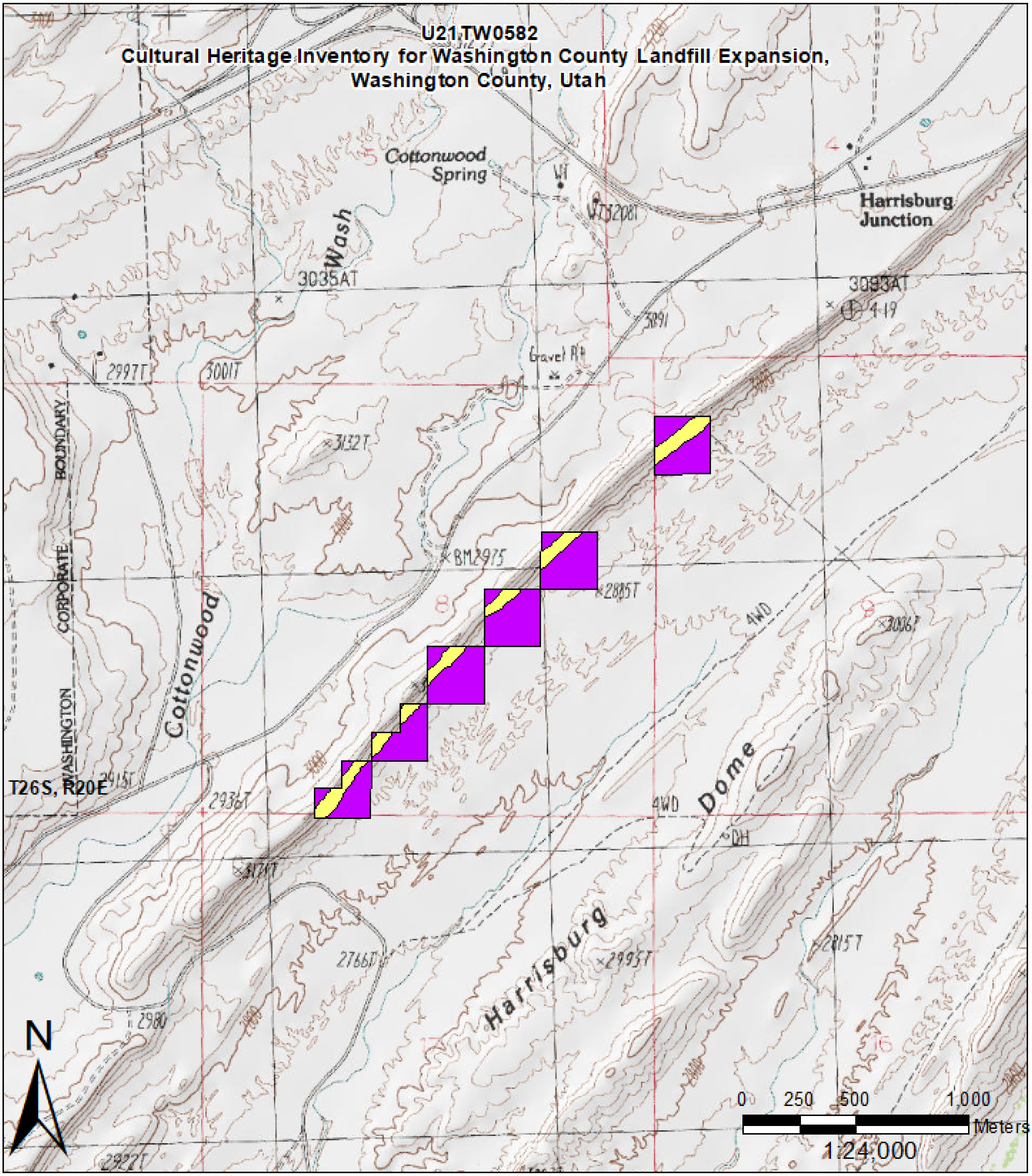
Figure 1: Overview of the project area facing 240 degrees.

Figure 2: Overview of Isolate find facing 110 degrees.

Utah Division of State History

SHORT CULTURAL RESOURCES INVENTORY REPORT FORM

U21TW0582
Cultural Heritage Inventory for Washington County Landfill Expansion, Washington County, Utah



USGS Topographic Map 7.5' Harrisburg Junction, Utah (2020)

Legend

- 🟪 U21TW0582 APE
- 🟨 Reconnaissance Level Survey

Cottonwood Archaeology

19 August 2021