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September 29, 2017

Mr. Brooks Stanfield, On-Scene Coordinator
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue, Mail Stop ECL-133
Seattle, Washington 98101

Re: Contract Number: EP-S7-13-07
Technical Direction Document Number: 14-06-0006
Final 2016 Removal Action Report, Bonanza Mine Site, Nonpariel, Oregon

Dear Mr. Stanfield:

Enclosed please find the final 2016 Removal Action Report for the Bonanza Mine Site in Nonpariel, Oregon. If you have any questions regarding this submittal, please contact Jim Petersen at (907) 257-5000 or me at (206) 624-9537.

Sincerely,

ECOLOGY AND ENVIRONMENT, INC.

Steven G. Hall
START-IV Removal Team Leader

cc: Jim Petersen, START IV Project Manager, E & E, Anchorage, Alaska

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2016 REMOVAL ACTION REPORT

Bonanza Mine Site
Nonpareil, Oregon
TDD: 14-06-0006

START IV
Region 10

Prepared for:

U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Prepared by:

Ecology and Environment, Inc.
1007 West Third Avenue, Suite 201
Anchorage, Alaska 99501

September 2017

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List of Abbreviations and Acronyms

Abbreviation	Definition
%	percent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
EQM	Environmental Quality Management, Inc.
ERRS	Emergency and Rapid Response Services
GDC	geosynthetic drainage composite
GPS	global positioning system
HDPE	high-density polyethylene
LLDPE	linear low-density polyethylene
$\mu g/m^3$	micrograms per cubic meter
MM&R	Maintenance, Monitoring and Repair
NWL	Northwest Linings & Geotextile Products, Inc.
ODEQ	Oregon Department of Environmental Quality
PPE	personal protective equipment
Site	Bonanza Mine Site
START	Superfund Technical Assessment and Response Team
TDD	Technical Direction Document
yd^3	cubic yards

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Executive Summary

The United States Environmental Protection Agency (EPA) performed a time-critical removal action at the Bonanza Mine (Site) in September and October 2016 to repair and stabilize a mine waste repository that EPA previously constructed during a removal action in 2014. During the 2014 removal action EPA consolidated contaminated mine waste material in an on-Site repository. The total area of the finished repository was approximately 196,000 square feet, or nearly four and a half acres. The waste material in the repository was covered with an impervious linear-low density polyethylene (LLDPE) geomembrane liner, a geosynthetic drainage composite drain layer, and an approximately 2-foot thick soil layer. Logs and slash material were dispersed over the repository soil cover surface. Finally, the entire repository surface was hand-seeded to establish a vegetative cover (E & E, 2015).

On January 13, 2016 the Oregon Department of Environmental Quality (ODEQ) was notified by the Site property owner, Don Smith, that a slide had occurred on the repository cover during heavy rains on or about January 12. ODEQ project manager Bryn Thoms visited the site on January 15 and observed exposed geomembrane material in two areas, including the upper slope on the southern and northeastern portions of the repository. Soil cracks and pressure ridges were also observed on the mid and lower portions of the repository slope. The slide appeared to be limited to the repository cover system, above the LLDPE layer. ODEQ informed EPA of the repository cover slide on January 28, 2016.

EPA visited the site in February 2016 along with Superfund Technical Assessment and Response Team IV (START) and Emergency and Rapid Response Services (ERRS) contractor representatives to assess Site conditions and initiate a discussion of appropriate actions to address the compromised repository cover.

START collected samples of the existing repository cover soil to evaluate potential cause(s) for the cover movement. Also, START collected samples from a local, off-site soil source to support an engineered design for slope stability and drainage improvements. START prepared a report for EPA presenting an overview of the existing site conditions, preliminary assessment of factors that led to the cover slide, and descriptions and comparisons of repair alternatives to address the compromised repository cover (E & E, 2016).

After selecting the repair alternative, EPA directed START to begin planning for the 2016 removal action by developing an engineering design to repair the exposed liner, buttress the slope with rock-filled gabion baskets for toe support, improve drainage with slope drains, and revegetate the repository surface.

With support from ERRS and START, EPA performed a second removal action at the Bonanza Mine Site in September and October, 2016 to repair the damage to the repository cover and make improvements to prevent future movement of the cover. The exposed areas of the LLDPE were visually inspected, and punctures in the LLDPE were repaired with plug welds or welded patches by the liner installation subcontractor. Exposed LLDPE was overlain with geotextile fabric which was then covered with a layer of sand to provide drainage. Finally, a layer of imported soil

was placed over the sand to provide a full 24-inches of cover material and a growth medium for vegetation.

A rock-filled gabion basket wall was constructed at the toe of the repository slope to provide resistance against cover soil movement. A subsurface drainage pipe network was installed within the repository cover system to aid drainage of cover soils. Lateral collection pipes were installed in a herringbone pattern to flow toward two centrally located downdrains. The subsurface downdrain pipes were terminated in the gabion wall to allow for rapid drainage and resistance against erosion.

In addition to the cover repairs and improvements, a row of boulders was installed along the top of the repository slope to prevent vehicle access on the cover. Prior to demobilization, the repository cover and adjacent disturbed areas received an application of hydroseed containing a mixture of soil amendments, seed blend, soil tackifier, and mulch material to stabilize the soil and promote seed germination.

The engineered design, which included cover soil and drainage layer repairs, slope drain installation, gabion basket toe slope stabilization, and revegetation, was implemented in the Fall 2016 removal action to stabilize the repository and provide resistance against cover movement.

1 Introduction

The United States Environmental Protection Agency (EPA) performed a time-critical removal action at the Bonanza Mine Site (Site) in Fall 2016 under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act. The purpose of the 2016 removal action was to repair and stabilize the protective cover system of an on-Site mercury mine waste repository that was constructed during a 2014 EPA removal action, also performed under CERCLA.

The 2016 removal action repair and stabilization work was performed by Environmental Quality Management, Inc. (EQM) under an Emergency and Rapid Response Services (ERRS) contract with EPA Region 10. EPA tasked Ecology and Environment, Inc. (E & E), under Superfund Technical Assessment and Response Team (START)-IV contract number EP-S7-13-07, Technical Direction Document (TDD) number 14-06-0006, to provide engineering, monitoring, and documentation support for the removal action.

This report documents the 2016 Site removal action repairing and improving the mine waste repository, and is organized into the following sections:

- Introduction (Section 1);
- Site Description and Background (Section 2);
- Cover Repair Design (Section 3);
- Removal Activities (Section 4);
- Health and Safety (Section 5);
- Summary and Conclusions (Section 6); and
- References (Section 7).

Photographs from the removal action are included with this report in Appendix A. Memoranda of the engineering design assumptions are included in Appendix B. The engineering record (as-built) drawing set is included in Appendix C and includes a cover sheet (Sheet C-1); the March 2016 survey depicting repository cover slide conditions (Sheet C-2); the November 2016 post-removal action survey (Sheet C-3); the underdrain, cover, and gabion wall plan view (Sheet C-4); and the underdrain, cover, and gabion wall details (Sheet C-5).

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2 Site Description and Background

2.1 Site Location and Layout

Site Name	Bonanza Mine Site
Owners / Responsible Party	Don Smith
SSID #	10NE
CERCLIS #	ORN001001174
Location	Nonpareil, Douglas County, Oregon
Latitude	43.3899870
Longitude	-123.1845630

The Bonanza Mine Site is an abandoned historical mercury mine and mill located approximately 6 miles east of Sutherlin, Douglas County, Oregon (Figures 2-1 and 2-2). The Site is located within the southwest quarter of Section 16, Township 25 South, Range 4 West, Willamette Meridian. During a 2014 EPA-lead removal action, mine waste was placed in an on-Site repository. Subsequent damage to the repository cover which occurred during an extremely heavy rain storm event in January 2016 necessitated the cover repair and improvement work described in this report.

2.2 2014 Removal Action and Repository Construction

From August 4 through December 6, 2014, EPA Region 10 performed a removal action at the Bonanza Mine Site with support from its ERRS and START contractors. The removal action was intended to mitigate human health and ecological threats from mercury and arsenic exposure. A total of 38,500 cubic yards (yd^3) of mine waste contaminated material was excavated and placed in an on-Site repository along with approximately 130,000 yd^3 of preexisting calcine and waste rock. The total area of the repository was 196,000 square feet, or nearly four and a half acres. The repository was covered with a linear low-density polyethylene (LLDPE) geomembrane, a geosynthetic drainage composite (GDC) layer, and a minimum thickness of two feet of clean fill soil from on-Site and off-Site sources. ERRS workers hand-broadcast seed and granular fertilizer onto the repository. Slash material that had been set aside from grubbing/clearing work was placed over the finished surface of the repository. Rock-lined channels were constructed in the drainages to accommodate increased volumes of surface water runoff from the repository face (E & E, 2015).

After the 2014 EPA removal action at the Site, a long-term maintenance, monitoring, and repair (MM&R) plan was prepared for the property owner, with assistance and oversight to be provided by Oregon Department of Environmental Quality (ODEQ) (EPA, 2014).

2.3 Repository Cover Damage

The Site property owner, Don Smith, notified ODEQ on January 13, 2016 that a slide had occurred on the repository in the two previous days, likely during the heavy rains on or about January 12.

ODEQ project manager Bryn Thoms visited the Site to assess the repository damage on January 15, 2016. Upon observing the slide, he estimated that approximately two-thirds of the repository cover material showed evidence of movement (E & E, June 2016). ODEQ informed EPA of the repository cover slide on January 28, 2016.

Dan Heister, EPA On-Scene Coordinator; Jake Moersen and Tom Campbell, START members; and Mark Conway with the ERRS contractor performed a site visit on February 24 and 25, 2016 to inspect the slide, document on-Site conditions, and assess repair alternatives. During the site visit, the face of the repository was inspected visually, and samples of cover material were collected for geotechnical and agronomic testing. The conditions of the cover were photo documented and the area of the slide was mapped using a hand-held global positioning system (GPS) device. EPA, START, and ERRS observed the exposed underlying LLDPE liner. There were several distinct areas where the LLDPE was exposed, which were generally concentrated in the upper (northern) portions of the repository slope and in the central and northeastern portion. The southwestern region of the repository did not exhibit indications of slope movement.

The slope movement appeared to have occurred in a southerly direction, and along the orientation of the GDC panel seams. The slide activity resulted in movement of both the cover soil and the GDC, exposing the underlying LLDPE liner. The LLDPE did not appear to have moved, based on the absence of torn, stretched, or otherwise stressed LLDPE. A zone of accumulation, where cover materials (soil, geotextile and/or vegetation) originating from higher areas of the slope built up with mounding and/or a hummocky appearance, were observed below each of the slide areas.

The rock-lined drainage swale at the toe of the repository was folded over on itself, such that the side of the channel nearest the repository was steepened, and near vertical in some locations. The channels were essentially operating as French drains in this manner. Immediately below these areas, the channels did not show recent sediment accumulation. Photographs of the Site including the slide area are located in Appendix A. Additional details of the repository slide and discussion of the cover system drainage may be found in the Draft After Action Report and Alternative Analysis for the Bonanza Mine Site (E & E, 2016).

The repository in this damaged condition was highly susceptible to continued sliding, and areas of the LLDPE liner were exposed and unprotected, increasing the risk of exposing mine waste. In addition, continued movement of the toe of the repository slope could have caused surface water to impound upstream of the impaired drainage features and saturate the toe of the repository, resulting in further movement of the cover.

During the Removal Action in September 2017, START and ERRS identified several punctures in the exposed areas of the LLDPE liner which were subsequently patched. Based on discussions with the residents living near the site, and on the discovery of an apparent home-made sled on the liner that consisted of a board attached to a skateboard with numerous exposed nails, it appeared that the local children had been sliding down the exposed LLDPE cover, which likely caused the damage.

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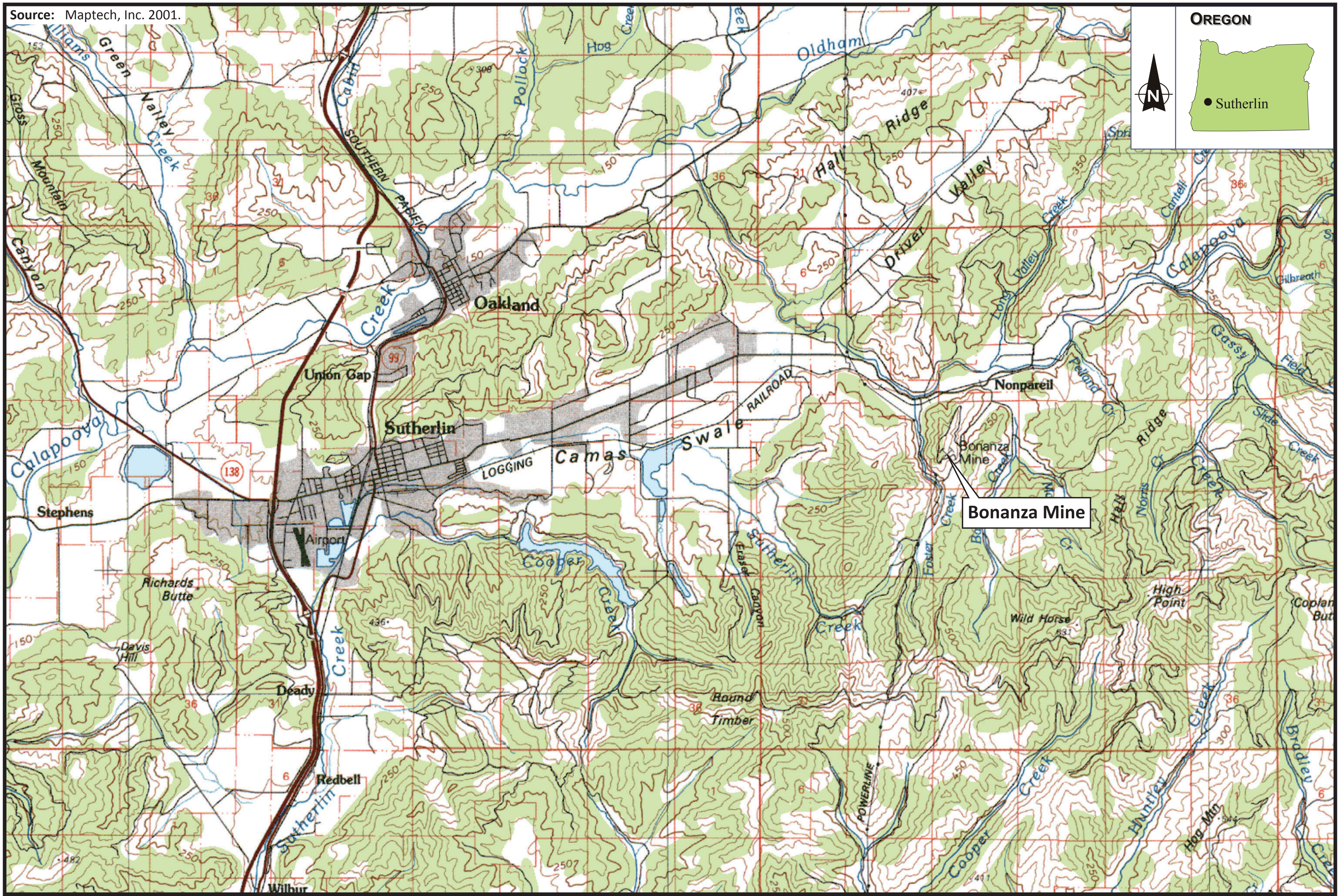

BONANZA MINE SITE
Sutherlin, Oregon

Figure 2-1
SITE LOCATION MAP

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

0 .75 1.5
Approximate Scale in Miles

Date:	Drawn by:	
7/24/17	AES	10:START-IV\14060006\fig 2-1

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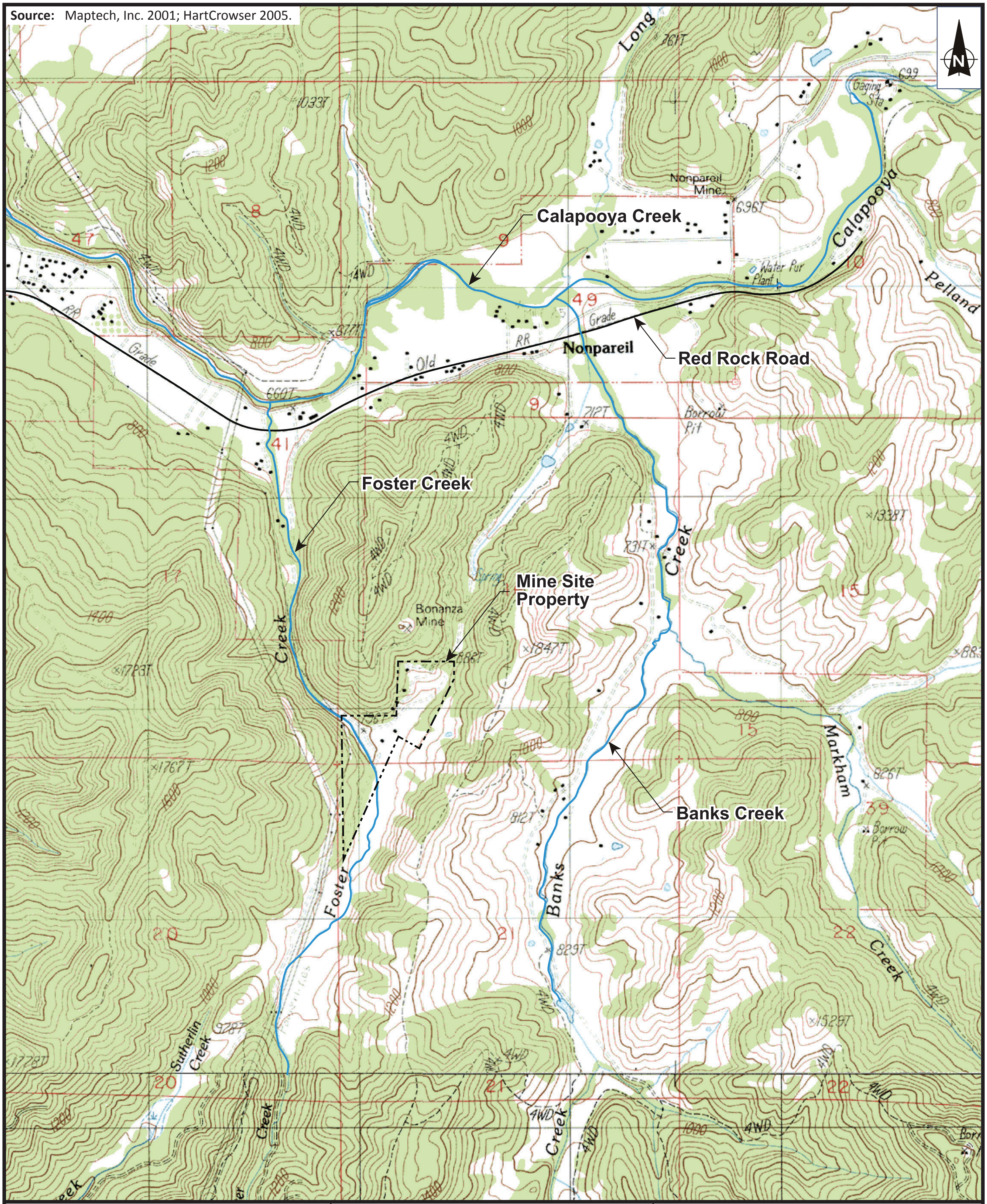

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Global Environmental Specialists
Seattle, Washington

BONANZA MINE SITE Sutherlin, Oregon			Figure 2-2 SITE VICINITY MAP
0 1000 2000 Approximate Scale in Feet	Date: 7/24/17	Drawn by: AES	10:START-IV\14060006\fig 2-2

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3 Cover Repair Design

The observed conditions, and START's assessment of the cover damage, were documented in the Draft After Action Report and Alternative Analysis (E & E, June 2016). That report also presented three options for managing the damaged repository cover. These options included a full-scale removal action (Option 1, complete replacement of the repository cover and drainage layer system), an integrated removal action (Option 2, replacing the repository cover at the exposed areas while also improving drainage and installing a rock gabion support wall), and a limited removal action (Option 3, replacing the cover system components only at the areas where the LLDPE liner was exposed). A "do-nothing" option was not considered because the damaged repository cover was highly susceptible to further movement, and the exposed areas of LLDPE liner would not provide sufficient protection for the underlying mercury-containing mine wastes.

3.1 Recommended Improvements and Selection

The Draft After Action Report and Alternative Analysis recommended Option 2, the integrated removal action (i.e., replacing geotextile drainage and cover soil at exposed LLDPE areas, improving drainage with a subsurface drainage system, and installing rock gabions to resist slope movement). START recommended this repair to mitigate further repository cover movement by adding drain lines to reduce potential for saturated cover soils and high drainage layer hydraulic pressure, and to buttress the lower slope with an engineered gabion wall system. Meanwhile the recommended repairs at the exposed LLDPE cover were designed to restore the protective properties of the cover system.

EPA selected the integrated removal action, as presented in the After Action Report, based on a variety of factors including a moderate cost of repairs resulting in long-term stability of the cover system and protection for the underlying mine waste material (EPA, August 2016).

3.2 Engineering Design

EPA tasked START to develop an engineered design for the recommended repair and stabilization approach described in Section 3.1. Engineering design assumptions and calculations are assembled in the Drainage Design and Gabion Wall Design Memoranda, which are included in Appendix B of this report.

3.2.1 Cover Repair

The stabilization plan for repairing areas of exposed liner material included clearing soil and debris from the exposed LLDPE liner and repairing punctured LLDPE, if needed; exposing intact GDC material around the periphery of the bare areas; placing non-woven geotextile and a porous sand drain layer on the exposed LLDPE liner; and, completing the repair with additional cover soil to restore the full-thickness repository cover to 24 inches.

3.2.2 Subsurface Slope Drains

The perforated high-density polyethylene (HDPE) pipe slope drains were intended to improve the repository cover system drainage by placing two subsurface pipe drains parallel to the repository slope, each with lateral branches in a herringbone pattern to collect subsurface flow, directing water off the repository to the toe drain. The pipes were positioned just above the

LLDPE layer, at the interface of the drainage layer, to collect water from the drainage layer and direct it off the repository. START performed calculations, included in the Drainage Design Memorandum in Appendix B, to assess the proposed porous sand layer drainage characteristics, to size and space the lateral drains, and to confirm that the existing toe drain system had adequate capacity with the addition of the slope drains.

3.2.3 Gabion Wall

START completed design calculations to select the minimum size and the configuration for the gabion wall, such that the gabion wall would withstand sliding and overturning forces, and resist movement at the toe of the repository. The design incorporated an approximately 400-foot section of rock-filled gabion baskets along the repository toe. See the Gabion Wall Design Memorandum in Appendix B.

3.2.4 Vegetation Cover

The final component of the repair design incorporated a hydraulically applied mulch, seed, and fertilizer mix across the entire repository surface and any surrounding, disturbed areas. The specified mulch mix was intended to cover the soil surface in a bound matrix, preventing soil erosion and providing a favorable medium for the seeds to germinate and take root in the soil. Hydraulic application of the mulch and seed mix, or “hydroseeding,” allows for an even, consistent coverage. The seed mix was a US Bureau of Land Management-recommended seed blend used regionally for timber harvest revegetation, and consisted of 30 percent (%) Blue Wildrye, 30% California Brome, 30% Native Red Fescue, and 10% Sandberg Bluegrass. The mulch and fertilizer mixture and application rate, and ratio of mulch to the seed mix, was based on the recommendation of the mulch supplier to optimize the seed growth and prevent erosion. The successful growth of the seed mix ultimately is a design requirement to provide long-term cover soil stability of the repository cover.

4 Removal Activities

This section describes removal action activities on Site between September 17 and October 26, 2016. The removal action was performed under the management and supervision of EPA On-Scene Coordinators Dan Heister and Brooks Stanfield. Removal action repository improvements were performed by EQM under the EPA Region 10 ERRS contract. E & E, under the EPA Region 10 START contract, provided on-Site technical assistance, evaluated the gabion and drain installations and the cover repairs, and documented Site activities. The description of EPA, START, and ERRS activities through the removal action are presented in chronological sequence. Photographs taken during the removal action are included in Appendix A.

4.1 Site Controls

4.1.1 Traffic Control

Signage was deployed near the turnoff from Nonpareil Road onto Bonanza Mine Road to warn of construction-related truck traffic, and information placards were installed near the Site entrance to direct visitors and subcontractors to report to the EPA office trailers. Publicly owned and operated vehicles (i.e., those not related to Site activities) were not allowed on Site with the exception of residents and visitors to the three on-Site residences that were inhabited during the removal action. Whenever possible, traffic detours and disruption were coordinated with the homeowners in advance. The movement of equipment and personnel during on-Site operations (e.g., construction equipment staging, waste and fill hauling, and Site personnel access) was limited to daylight hours.

4.1.2 Site Security

As a security measure for the command post area, a security company was subcontracted to provide site security during non-working periods including overnight hours and Sundays. During the non-working periods, the entry gate located on the road near the command post was closed and locked.

4.1.3 Communications

Hand-held 2-way radios were used for Site communications. ERRS installed a satellite dish at the command post to provide internet access in the two office trailers. Cellular telephone reception at the Site was poor. Cellular reception was available by driving approximately one-half to one mile from the site to a higher elevation. This location was on neighboring timber company property, and the timber company allowed EPA access during the removal action.

4.2 Chronological Description of Removal Action Activities

September 17 – 20, 2016

The unpaved road surface of Bonanza Mine Road was in poor condition, with potholes, ruts, and some wash-boarded segments. Prior to beginning the repository repairs, ERRS placed a thin veneer of gravel from an off-site quarry to improve an approximately one mile gravel segment of the road leading to the site. The road surface improvements were performed to improve safety and prevent further deterioration of the road surface from haul trucks and other traffic associated with the removal action. Temporary signage was installed along Bonanza Mine Road to provide notification of truck traffic and construction related activities.

The project command post was sited at the same location used during the 2014 EPA removal action, along BLM Road 25-4-8.0, southwest of the repository location. ERRS mobilized construction equipment and materials, and command post facilities including EPA and contractor office trailers, lockable Conex storage containers, and a fuel tank with a secondary containment pad. ERRS construction equipment included large and small excavators, a front end loader, a small tracked loader, an articulated off-road dump truck, a roller compactor, and various smaller pieces of equipment such as all-terrain vehicles.

START had two engineers on site during this period and marked the locations for the subsurface drainage pipe installation on the repository cover. START also deployed a Jerome J505 mercury vapor analyzer to screen ambient mercury vapor concentrations across the repository. The Jerome J505 had a mercury vapor detection level of 0.05 micrograms per cubic meter ($\mu g/m^3$) which was lower than air monitoring action levels for worker exposure (25 $\mu g/m^3$ threshold limit value—time weighted average). Based on the Jerome J505 screening results, and on the evaluation that the mercury-containing mine wastes were confined beneath the LLDPE membrane in the repository, site operations were performed in Level D personal protective equipment (PPE).

September 21 – 24, 2016

ERRS crew members began clearing slash and excavating trenches in the repository soil cover using a small tracked excavator in preparation for the drain system installation. ERRS used an excavator to excavate a level base on which to install the gabion wall. Laborers assembled wire gabion baskets which were then placed on the prepared base. A nonwoven geotextile fabric was placed on the ground beneath the gabions and on the up-slope or repository side of the gabions to minimize sediment infiltration into the gabions while still allowing for drainage. Gabions were filled with imported 6- to 8-inch rock. Additional ERRS crew members cleared the culverts in the drainage channels downstream from the repository of debris and sediment which had likely accumulated during the heavy precipitation the previous winter. START's on-Site engineer used a Trimble GPS unit to record the locations of the gabions, drain trenches, and other Site improvements.

START placed two DataRAM portable particle monitors on the site, at locations in the upper, northeastern corner of the repository, and in the level area immediately southwest of the repository used for material and equipment staging. ERRS used a water truck to control dust emissions. The weather during this period was warm and dry; however, START did not observe visible dust emissions leaving the work areas, and based on the DataRAM readings particulate levels were well under the 2.5 $\mu g/m^3$ Site action level. The action level (established during the 2014 EPA Removal Action) was selected to be protective for mercury salts, arsenic particulates, and nuisance dust.

September 26 to October 8, 2017

Installation of the gabion wall continued during this period. Except for backfilling the soil upslope of the gabions, the first tier of the gabions wall was largely completed by October 4, and the second tier was installed on October 6. A short segment near the center of the wall, wide enough to accommodate heavy equipment onto the repository, was left open and would be completed later toward the end of the removal action. Site work was temporarily halted on October 5 due to heavy rain.

ERRS and START personnel identified several punctures in the LLDPE liner in exposed areas after loose soil was cleared from the surface. ERRS subcontracted with Northwest Linings & Geotextile Products, Inc. (NWL), the liner installation subcontractor in 2014, to perform heat fusion weld field repairs. A crew of two NWL technicians were on site on October 7 and 8, 2017. At each of the identified punctures the technicians cleaned and lightly abraded an area around the hole, then applied a heat-fused plug weld to seal the geomembrane. Tears larger than two to three inches were repaired with patches laid on the LLDPE and welded in place. Prior to repair, START used the Jerome J505 to measure ambient mercury concentrations in the air immediately adjacent to each hole. Although elevated mercury concentrations were measured when the Jerome probe was placed into the holes, thus measuring mercury vapor concentrations beneath the geomembrane, mercury vapor concentrations higher than background were not observed above the geomembrane. START recorded the locations of the puncture repairs using a Trimble GPS. The NWL technicians used a vacuum box with a soap solution to test each of the repairs. The testing apparatus allowed the technicians to visually observe a stream of bubbles at any tested repair that was not air-tight. All of the repair locations were air-tight, passing the test criteria.

Based on discussions with the local residents, EPA concluded that the punctures in the exposed liner were most likely caused by the local children sliding down the exposed liner. During the removal action, EPA discussed with the Site owner and local children the need to restrict access onto the repository and the importance of maintaining the integrity of the repository cover system to prevent exposure to the mine waste. In addition, EPA informed Bryn Thoms of Oregon Department of Environmental Quality of the damage to the LLDPE liner.

During this time ERRS continued the repository cover repairs by hand-shoveling soil to expose several inches of the GDC around the perimeters of each exposed LLDPE area, and then placing geotextile followed by 6 to 12 inches of freely draining sand on the LLDPE geomembrane. Clean, imported cover soil was placed on top of the sand to a depth creating a minimum cover of 24 inches on top of the geomembrane.

Dust monitoring and ambient mercury vapor monitoring continued to show levels well under Site action levels.

October 9 to 15, 2016

ERRS finished installing the subsurface drain system and repairing the exposed LLDPE geomembrane areas. The ERRS crew redistributed slash material on the repository that had been previously moved aside during Site preparation. ERRS obtained additional slash material from the Lone Rock Timber Company, which allowed ERRS to collect the slash from their recently harvested timberlands near the Site. ERRS personnel secured straw bale check dams in the drainage channels downstream of the repository. The repository slope above the gabions was filled and blended back to the existing repository soil cover, creating a smooth slope to allow surface drainage off the repository toward the gabions.

Additional wire gabion baskets were placed in the gabion wall gap that was left open for repository slope access. The baskets were filled with 6- to 8-inch gabion rock. The slope behind the gabions was filled using granular backfill material and blended to the repository slope for positive drainage off the repository. This completed the gabion wall.

ERRS hand-broadcasted weed-free straw on the repository slopes and other areas of the Site that were disturbed during the removal action to facilitate stabilization of the bare soils. Site work was temporarily paused for part of October 15 and all of October 16 due to rainy weather and wet Site conditions.

October 17 to 24, 2016
ERRS performed additional slope grading behind the gabion wall. Several truckloads of 2-foot diameter boulders were brought on site and placed in an evenly spaced row along the top of the repository to prevent on-road and off-road vehicles from accessing and damaging the repository cover. The boulder row installation was a site control measure agreed upon by EPA and ODEQ as better alternative to a fence. ODEQ had requested the installation of a fence or similar access restriction on the top of the repository due to past evidence of vehicles driving on the soil cover. Boulders were selected in lieu of fencing due to concerns that fence posts installed off the road in the repository cover may potentially breach the LLDPE geomembrane, while any fence posts placed north/upslope of the repository cover to avoid the LLDPE geomembrane could encroach on the roadway and present a safety hazard. If, based on future site activities, it becomes evident that a fence is necessary, ODEQ may consider the option of installing a fence that does not require penetration below the ground surface, such as a snake rail fence or a jack leg (or buck) fence.

October 21 to 26, 2016
Hydroseeding was conducted on October 21, 22, and 24 by Heard Excavation of Roseburg, Oregon, as a subcontractor to ERRS. Heard Excavating used a truck-mounted hydraulic sprayer with an on-board tank. The START-specified mulch mix included a fertilizer, applied at 2,000 pounds per acre, and FlexTerra FGM Bonded Fiber Matrix, a proprietary mulch fiber material with strong adhesion qualities applied at 3,000 pounds per acre. A manufacturer's representative from Profile Products, marketer of the FlexTerra material, was on site during the application, and provided guidance to the Heard Excavating crew on the application of FlexTerra FGM.

The hydroseed mix was spray-applied to the entire repository surface and the staging area southwest of the repository. A small area to the north of the repository used by trucks to turn around and to stage straw bales and other materials was also seeded. ERRS demobilized the last of their equipment from the site on October 26, 2016.

November 4, 2016
A final topographical survey was performed on November 4 by Centerline Concepts, Inc. of Oregon City, Oregon, a licensed surveying firm subcontracted by START. The survey documented the removal action Site improvements, including the gabion wall, the boulder row at

the crest of the repository, rocked ditches surrounding the repository, and the area southwest of the repository used for material staging during the removal action. The survey also included topographical surface measurements of the repository. The underdrain system was not included in the survey because the entire system is below the ground surface. However, the downdrain and lateral drain pipe locations were recorded by the START on-Site engineer using a Trimble GPS. START incorporated the drainage system measurements into the November 4, 2016 survey to create a record drawing set (Appendix C).

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5 Health and Safety

EPA maintained Site safety authority during the removal activities. Both ERRS and START developed a health and safety plan. Daily safety meetings were conducted at the beginning of each day of Site work and attended by all personnel present, including EPA, START, and ERRS. Daily safety meeting agendas included the planned daily removal activities, material deliveries and other traffic issues, communications, and general Site hazard awareness. At each safety meeting personnel from EPA, START, and ERRS were invited to share any safety concerns.

The primary physical hazards present at the Site were vehicle traffic, heavy equipment operation, and uneven terrain and slip/trip hazards. The primary chemical hazards present at the Site were mercury vapor in air and mercury-contaminated soil. However, since mine waste materials were encapsulated in the repository during the 2014 removal, the chemical hazard was largely mitigated. Although damage had occurred to the repository soil cover, the LLDPE geomembrane remained intact with the exception of a limited number of small punctures and tears. Mercury vapor screening above the compromised sections of liner indicated mercury vapor concentrations less than site action levels. The site safety plan included a contingency to perform additional air monitoring with the Jerome mercury vapor monitor and upgrade to level C PPE as necessary in the event that a significant LLDPE geomembrane liner breach were to occur exposing the mine waste, or if known or suspected mine waste was encountered.

The minimum level of PPE for the Site was Level D, including safety glasses, hard hat, high visibility safety vest, and steel-toed safety shoes. Other safety equipment, such as gloves and hearing protection, were required as work tasks and Site conditions warranted.

There were no worker injuries or other health and safety-related incidents on the Site during the removal action.

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6 Summary and Conclusions

EPA performed a time-critical removal action at the Bonanza Mine Site in September and October 2016. The purpose of the removal action was to repair damage to the on-Site mine waste repository by repairing exposed liner areas, buttressing the slope against future movement with rock-filled gabion baskets along the slope toe, and installing a slope underdrain pipe network to improve drainage in order to stabilize the repository and provide resistance against future cover soil movement.

Exposed areas of the LLDPE liner were restored by placing geotextile fabric, a porous sand drainage layer, and cover soil from on- and off-site sources to provide a full 24 inches of cover material and a growth medium for vegetation. A rock-filled gabion basket wall was installed at the toe of the repository slope to provide resistance to cover soil movement. A subsurface drainage pipe network was installed in the repository cover for improved drainage. The downdrain pipes were terminated at the gabion wall. A row of boulders was installed along the top of the repository slope to prevent vehicle access onto the cover. The repository cover and adjacent disturbed areas were hydroseeded with a mixture of soil amendments, a seed blend, soil tackifier, and a mulch material to stabilize the soil and promote seed germination.

After the 2014 EPA removal action at the Site, a long-term MM&R plan (EPA, 2014) was prepared for the property owner, with assistance and oversight to be provided by ODEQ. The 2016 removal action modifications to the repository do not change the monitoring and inspection frequency requirements outlined in the MM&R plan. The subsurface drainpipe network is not expected to require routine maintenance. However, individuals inspecting or monitoring the site should be aware of the presence of the drainage system, and should note any unusual occurrence of localized erosion, sink holes, or areas where it appears water is emerging from or draining into the subsurface on the repository cover, as that may indicate a clog or separation of a drainpipe and warrant further investigation and repair. Copies of the new record drawings should be attached to the MM&R plan to reflect the added gabion wall and subsurface drainage system.

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7 References

Ecology and Environment, Inc. (E & E), June 2016, *After Action Report and Alternative Analysis, Bonanza Mine Site,* prepared for the U.S Environmental Protection Agency, TDD 14-06-0006, Contract Number EP-S7-13-07.

______, November 2015, *Removal Action Report, Bonanza Mine Site*, prepared for the U.S Environmental Protection Agency, TDD 14-06-0006, Contract Number EP-S7-13-07.

United State Environmental Protection Agency (EPA), August 2016, *Bonanza Mine Site Action Memorandum Addendum*.

______, December 2014, *Bonanza Mine Site Maintenance, Monitoring, and Repair Plan.*

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A Photographic Documentation

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Photo 1 View of repository, showing areas cleared for subsurface drain installation.

Direction: *Northwest* *Date: 9/30/16* *Time: 13:22* *Taken by: TC*

Photo 2 Exposed LLDPE.

Direction: West Date: 10/6/16 Time: 13:35 Taken by: JP

Photo 3 Exposed LLDPE.

Direction: Southwest Date: 10/6/16 Time: 13:35 Taken by: JP

Photo 4 Gabion installation.

Direction: East-Northeast Date: 10/6/16 Time: 15:30 Taken by: JP

Photo 5 Gabion installation.

Direction: Northeast Date: 10/6/16 Time: 15:31 Taken by: JP

Photo 6 Installing drain trenches.

Direction: *Northwest* *Date: 10/6/16* *Time: 17:05* *Taken by: JP*

Photo 7 Placing sand layer on exposed LLDPE.

Direction: *West-Southwest* *Date: 10/7/16* *Time: 14:06* *Taken by: JP*

Photo 8 Preparing for sand placement.

Direction: *West-Southwest* *Date: 10/7/16* *Time: 14:06* *Taken by: JP*

Photo 9 Placing sand layer on LLDPE.

Direction: *Southwest* *Date: 10/7/16* *Time: 15:33* *Taken by: JP*

Photo 10 Geotextile placement.

Direction: South Date: 10/7/16 Time: 15:33 Taken by: JP

Photo 11 Southwestern end of gabion wall.

Direction: Northeast Date: 10/7/16 Time: 16:59 Taken by: JP

Photo 12 Tear in LLDPE, prior to repair.

Direction: South Date: 10/8/16 Time: 09:26 Taken by: JP

Photo 13 Backfilling behind gabions.

Direction: South Date: 10/8/16 Time: 11:15 Taken by: JP

Photo 14 Installing lateral drain.

Direction: Northeast Date: 10/8/16 Time: 16:23 Taken by: JP

Photo 15 Placing geotextile.

Direction: South Date: 10/10/16 Time: 10:18 Taken by: JP

Photo 16 Installing lateral drain across area of exposed LLDPE.

Direction: East Date: 10/11/16 Time: 11:04 Taken by: JP

Photo 17 Lateral drain installation.

Direction: West Date: 10/11/16 Time: 14:31 Taken by: JP

Photo 18 Completing lower end of down-drain.

Direction: *Northwest* *Date: 10/12/16* *Time: 10:07* *Taken by: JP*

Photo 19 Backfilling behind gabions.

Direction: *East-Northeast* *Date: 10/13/16* *Time: 14:33* *Taken by: JP*

Photo 20 Replacing slash material on restored cover soil.

Direction: *West* *Date: 10/13/16* *Time: 14:34* *Taken by: JP*

Photo 21 Restoring rock-lined run-on control ditch.

Direction: *Northeast* *Date: 10/14/16* *Time: 11:13* *Taken by: JP*

Photo 22 Restored cover soil on upper slope of repository.

Direction: *Southwest* *Date: 10/14/16* *Time: 11:17* *Taken by: JP*

Photo 23 Boulder row on top of repository.

Direction: *Southwest* *Date: 10/18/16* *Time: 14:57* *Taken by: JP*

Photo 24 Boulder row on top of repository.

Direction: *Northeast* *Date: 10/18/16* *Time: 14:57* *Taken by: JP*

Photo 25 Placing riprap boulders below southwestern end of gabion wall.

Direction: *Northeast* *Date: 10/18/16* *Time: 15:05* *Taken by: JP*

Photo 26 Upper slope of repository, after spreading straw and slash.

Direction: Southwest Date: 10/19/16 Time: 16:25 Taken by: JP

Photo 27 Flexterra.

Direction: NA Date: 10/21/16 Time: 08:24 Taken by: TC

Photo 28 Cover vegetation seed mix.

Direction: NA Date: 10/21/16 Time: 08:25 Taken by: TC

Photo 29 Preparing for hydraulic mulch and seed mix application.

Direction: North Date: 10/21/16 Time: 08:57 Taken by: TC

Photo 30 Hydraulic mulch and seed application.

Direction: *Northeast* *Date: 10/21/16* *Time: 09:09* *Taken by: TC*

Photo 31 Hydraulic mulch and seed application.

Direction: *Northeast* *Date: 10/21/16* *Time: 09:36* *Taken by: TC*

Photo 32 Restored repository cover.

Direction: *Northwest* *Date: 10/22/16* *Time: 15:22* *Taken by: TC*

Photo 33 View of revegetated repository, Spring 2017.

Direction: *North* *Date: 4/17/17* *Time: 13:34* *Taken by: BC*

Photo 34 View of revegetated repository, Spring 2017.

Direction: Southeast Date: 4/17/17 Time: 13:37 Taken by: BC

Photo 35 View of revegetated repository, Spring 2017.

Direction: Northwest Date: 4/17/17 Time: 13:39 Taken by: BC

Photo 36 View of revegetated repository, Spring 2017.

Direction: Northeast Date: 4/17/17 Time: 13:57 Taken by: BC

B Design Memoranda

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ecology and environment, inc.

Design Memorandum

Date: 8/17/2017

To: Design File

From: Tom Campbell, P.E.

Subject: **Bonanza Mine Repository Repair – Gabion Sizing**

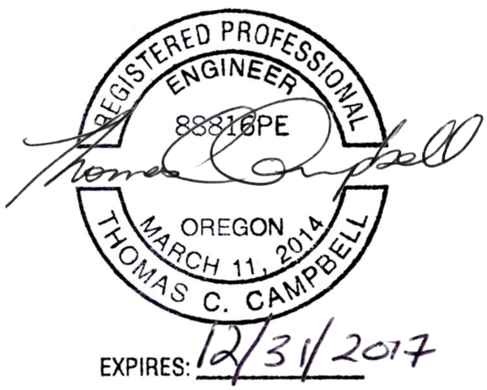
PROFESSIONAL ENGINEER CERTIFICATION

Repository Repair Gabion Sizing
Bonanza Mine Site
Sutherlin, Oregon
TDD: 14-06-0006

I hereby certify that this document was prepared by me or under my direct personal supervision and I am a duly licensed Professional Engineer under the laws of the State of Oregon. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

REGISTRATION NUMBER: 88816PE
STATE: Oregon



OBJECTIVE:

Conduct stability analysis of gabion retaining wall in order to determine the proper size and placement of rock-filled gabion baskets used for repository toe ballast.

REFERENCES:

1. Maccaferri Group, GAWAC Release 2.0 User's Manual, used with GawacWin 2003 web-based design software.

ASSUMPTIONS:

1. Standard manufactured sizes of gabion baskets was used in the analysis as manufactured by Maccaferri, Inc. and Terra Aqua gabion providers. Design software of each manufacturer was used to cross-verify design (References 1 and 2).

2. Unit weights of materials was based off geotechnical analyses from onsite and borrow sources. Rock fill 135 lbs/ft^2

3. Cohesion was ignored in calculations in order to be conservative.

Program released in license to: MACCAFERRI WEB VERSION

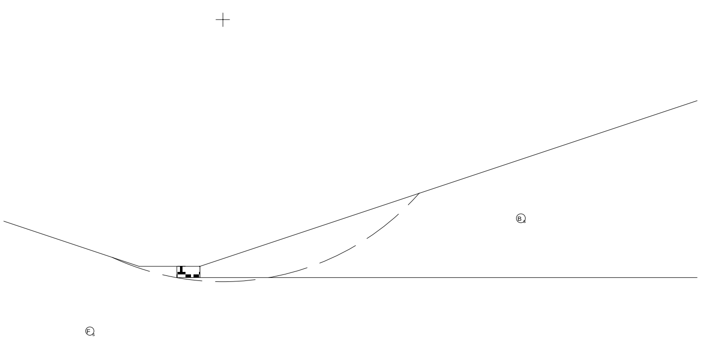
Project: Bonanza1
File: Bonanza1 Date: 9/14/2016

INPUT DATA

Wall data

Wall batter : 0.00 deg
Rockfill unit weight : 135.00 lb/ft³
Porosity of gabions : 30.00 %
Geotextile in the backfill : Yes
Friction reduction : 20.00 %
Geotextile on the base : No
Friction reduction : %
Mesh and the wire diam.: : 8x10, ø 2.70 mm

Layer	Length ft	Width ft	Offset ft
1	6.00	3.00	-



Backfill soil data

Inclination of Stretch 1 : 18.40 deg
Length of stretch 1 : 250.00 ft
Inclination of Stretch 2 : 0.00 deg
Soil unit weight : 125.00 lb/ft³
Soil friction angle : 16.20 deg
Soil cohesion : 14.00 lb/ft²

Additional Backfill Layers

Layer	Initial height ft	Incl. angle deg	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Foundation data

Top surface height	:	3.00 ft
Top surface init. length	:	10.00 ft
Top surface incl. angle	:	-18.40 deg
Soil unit weight	:	115.00 lb/ft³
Soil friction angle	:	38.10 deg
Soil cohesion	:	19.90 lb/ft²
Foundation allowable pressure	:	lb/ft²
Water table height	:	ft

Additional Foundation Layers

Layer	Depth ft	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Water profile data

Initial height	:	ft
Inclination of the 1st stretch	:	deg
Length of the 1st stretch	:	ft
Inclination of the 2nd stretch	:	deg
Length of the 2nd stretch	:	ft

Loads data

Distributed loads on backfill			First stretch	:	0.00 lb/ft²
			Second stretch	:	lb/ft²
Distributed loads on wall			Load	:	lb/ft²
Line loads on backfill					
Load 1	:	lb/ft	Distance from wall face	:	ft
Load 2	:	lb/ft	Distance from wall face	:	ft
Load 3	:	lb/ft	Distance from wall face	:	ft
Line load on wall					
Load	:	lb/ft	Distance from wall face	:	ft

Seismic action data

Horizontal coefficient	:	Vertical coefficient	:

STABILITY ANALYSIS RESULTS

Active and Passive Thrust

Active Thrust	: 375.54 lb/ft
Point of application ref. to X axis	: 6.00 ft
Point of application ref. to Y axis	: 1.00 ft
Direction of the thrust ref. to X axis	: 12.96 deg
Passive Thrust	: 2430.45 lb/ft
Point of application ref. to X axis	: 0.00 ft
Point of application ref. to Y axis	: 0.86 ft
Direction of the thrust ref. to X axis	: 0.00 deg

Sliding

Normal force on the base	: 1785.22 lb/ft
Point of application ref. to X axis	: 4.11 ft
Point of application ref. to Y axis	: 0.00 ft
Shear force on the base	: -2064.48 lb/ft
Resisting force on the base	: 3889.95 lb/ft
Sliding Safety Coefficient	**: 10.63**

Overturning

Overturning Moment	: 365.97 lb/ft x ft
Restoring Moment	: 7699.07 lb/ft x ft
Overturning Safety Coefficient	**: 21.04**

Stresses Acting on Foundation

Eccentricity	: -1.11 ft
Normal stress on outer border	: 289.74 lb/ft²
Normal stress on inner border	: 0.00 lb/ft²
Max. allowable stress on the foundation	:12848.94 lb/ft²

Warning. Not all base is used!

Project: Bonanza1
File: Bonanza1 Date: 9/14/2016

Overall Stability

Initial distance at pivot leftside	:	ft
Initial distance at pivot rightside	:	ft
Initial depth referred to base	:	ft
Max depth allowed in calculation	:	ft
Center of the arch referred to X axis	:	12.10 ft
Center of the arch referred to Y axis	:	67.79 ft
Radius of the arch	:	68.92 ft
Number of search surfaces	:	70
Overall Stability Safety Coefficient	**:**	**1.88**

Internal Stability

Layer	H ft	N lb/ft	T lb/ft	M lb/ft x ft	τ_{Max} lb/ft²	τ_{All} lb/ft²	σ_{Max} lb/ft²	σ_{All} lb/ft²

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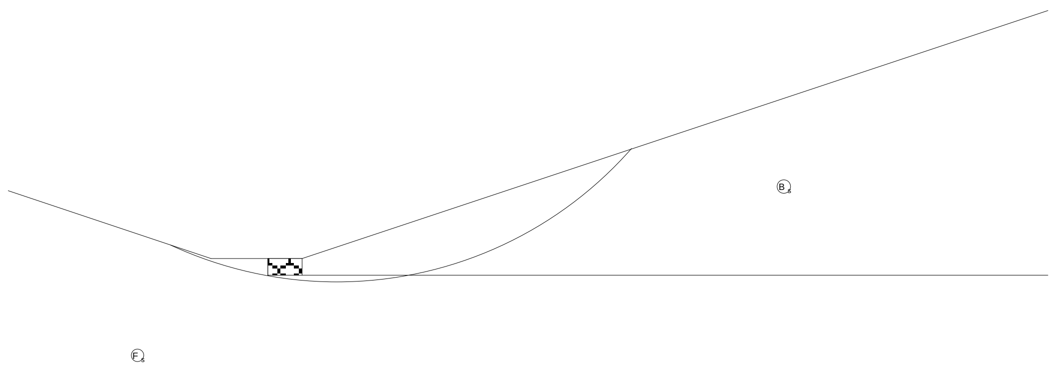
Project: Bonanza1
File: Bonanza1 Date: 9/14/2016



SOIL DATA

Soil	γ lb/ft³	c lb/ft²	ϕ deg	Soil	γ lb/ft³	c lb/ft²	ϕ deg
B_S	125.00	14.00	16.20	F_S	115.00	19.90	38.10

LOADS

Load	Value lb/ft²	Load	Value lb/ft

STABILITY CHECKS

Sliding Safety Coefficient	10.63	Base normal stress (left)	289.74lb/ft²
Overturning Safety Coefficient	21.04	Base normal stress (right)	0.00lb/ft²
Overall Stability Safety Coefficient	1.88	Max. allowable stress	12848.94lb/ft²

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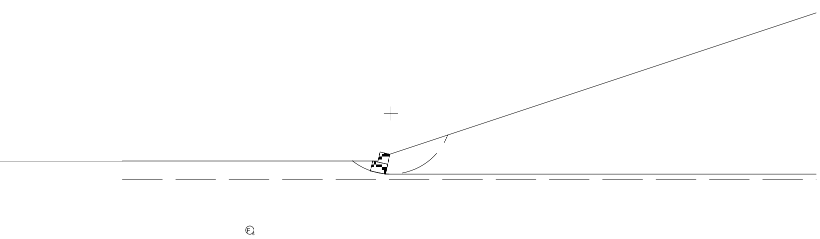
Project: Bonanza2
File: Bonanza2 Date: 9/14/2016

INPUT DATA

Wall data

Wall batter	:	12.50 deg
Rockfill unit weight	:	135.00 lb/ft³
Porosity of gabions	:	30.00 %
Geotextile in the backfill	:	Yes
Friction reduction	:	20.00 %
Geotextile on the base	:	No
Friction reduction	:	%
Mesh and the wire diam.:	:	8x10, ø 2.70 mm

Layer	Length ft	Width ft	Offset ft
1	4.50	3.00	-
2	3.00	3.00	1.50



Backfill soil data

Inclination of Stretch 1	:	18.40 deg
Length of stretch 1	:	250.00 ft
Inclination of Stretch 2	:	deg
Soil unit weight	:	125.00 lb/ft³
Soil friction angle	:	16.20 deg
Soil cohesion	:	14.00 lb/ft²

Additional Backfill Layers

Layer	Initial height ft	Incl. angle deg	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Foundation data

Top surface height	: 3.00 ft
Top surface init. length	: 150.00 ft
Top surface incl. angle	: 0.00 deg
Soil unit weight	: 115.00 lb/ft³
Soil friction angle	: 38.10 deg
Soil cohesion	: 19.90 lb/ft²
Foundation allowable pressure	:1250.00 lb/ft²
Water table height	: -2.50 ft

Additional Foundation Layers

Layer	Depth ft	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Water profile data

Initial height	: ft
Inclination of the 1st stretch	: deg
Length of the 1st stretch	: ft
Inclination of the 2nd stretch	: deg
Length of the 2nd stretch	: ft

Loads data

Distributed loads on backfill			First stretch	: 0.00 lb/ft²
			Second stretch	: lb/ft²
Distributed loads on wall			Load	: lb/ft²
Line loads on backfill				
Load 1	:	lb/ft	Distance from wall face	: ft
Load 2	:	lb/ft	Distance from wall face	: ft
Load 3	:	lb/ft	Distance from wall face	: ft
Line load on wall				
Load	:	lb/ft	Distance from wall face	: ft

Seismic action data

Horizontal coefficient : Vertical coefficient :

STABILITY ANALYSIS RESULTS

Active and Passive Thrust

Active Thrust	: 1404.59 lb/ft
Point of application ref. to X axis	: 4.83 ft
Point of application ref. to Y axis	: 0.98 ft
Direction of the thrust ref. to X axis	: 0.46 deg
Passive Thrust	: 2430.45 lb/ft
Point of application ref. to X axis	: 0.23 ft
Point of application ref. to Y axis	: 1.05 ft
Direction of the thrust ref. to X axis	: 0.00 deg

Sliding

Normal force on the base	: 1864.81 lb/ft
Point of application ref. to X axis	: 2.66 ft
Point of application ref. to Y axis	: -0.59 ft
Shear force on the base	: -1464.23 lb/ft
Resisting force on the base	: 4704.76 lb/ft
Sliding Safety Coefficient	**: 3.77**

Overturning

Overturning Moment	: 1374.51 lb/ft x ft
Restoring Moment	: 9143.52 lb/ft x ft
Overturning Safety Coefficient	**: 6.65**

Stresses Acting on Foundation

Eccentricity	: -0.48 ft
Normal stress on outer border	: 290.88 lb/ft²
Normal stress on inner border	: 1005.53 lb/ft²
Max. allowable stress on the foundation	: 1250.00 lb/ft²

Project: Bonanza2
File: Bonanza2 Date: 9/14/2016

Overall Stability

Initial distance at pivot leftside	:	ft
Initial distance at pivot rightside	:	ft
Initial depth referred to base	:	ft
Max depth allowed in calculation	:	ft
Center of the arch referred to X axis	:	5.95 ft
Center of the arch referred to Y axis	:	17.02 ft
Radius of the arch	:	18.08 ft
Number of search surfaces	:	68
Overall Stability Safety Coefficient	**:**	**2.18**

Internal Stability

Layer	H ft	N lb/ft	T lb/ft	M lb/ft x ft	τ_{Max} lb/ft²	τ_{All} lb/ft²	σ_{Max} lb/ft²	σ_{All} lb/ft²
1	2.93	892.00	83.84	1438.68	27.95	570.79	276.52	

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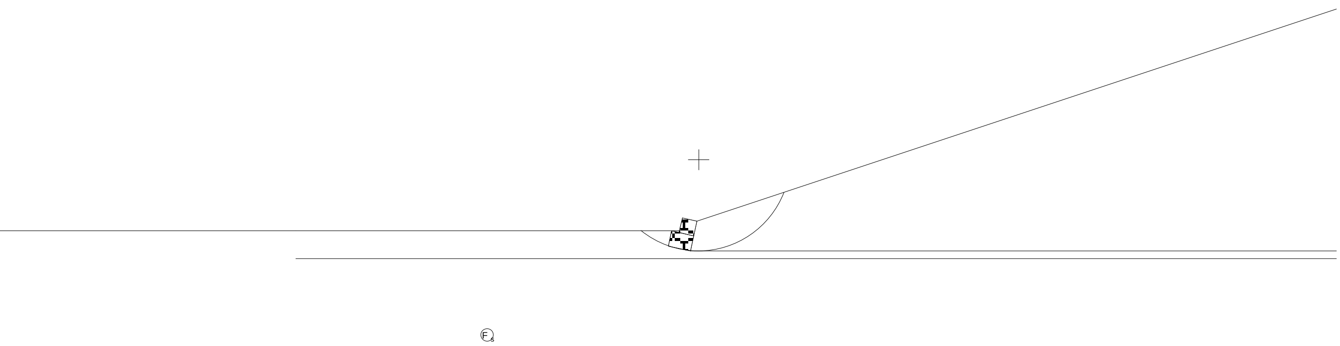
Project: Bonanza2
File: Bonanza2 Date: 9/14/2016



SOIL DATA

Soil	γ lb/ft³	c lb/ft²	φ deg	Soil	γ lb/ft³	c lb/ft²	φ deg
B_S	125.00	14.00	16.20	F_S	115.00	19.90	38.10

LOADS

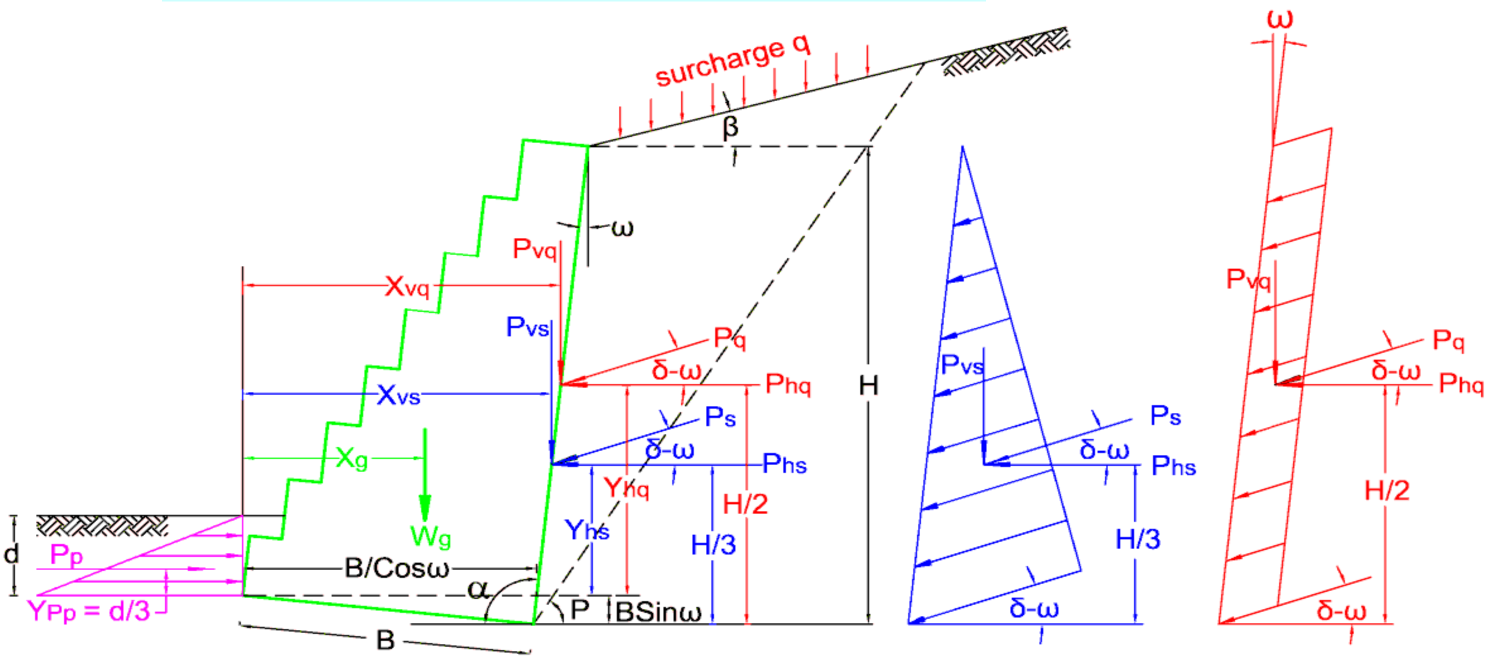
Load	Value lb/ft²	Load	Value lb/ft

STABILITY CHECKS

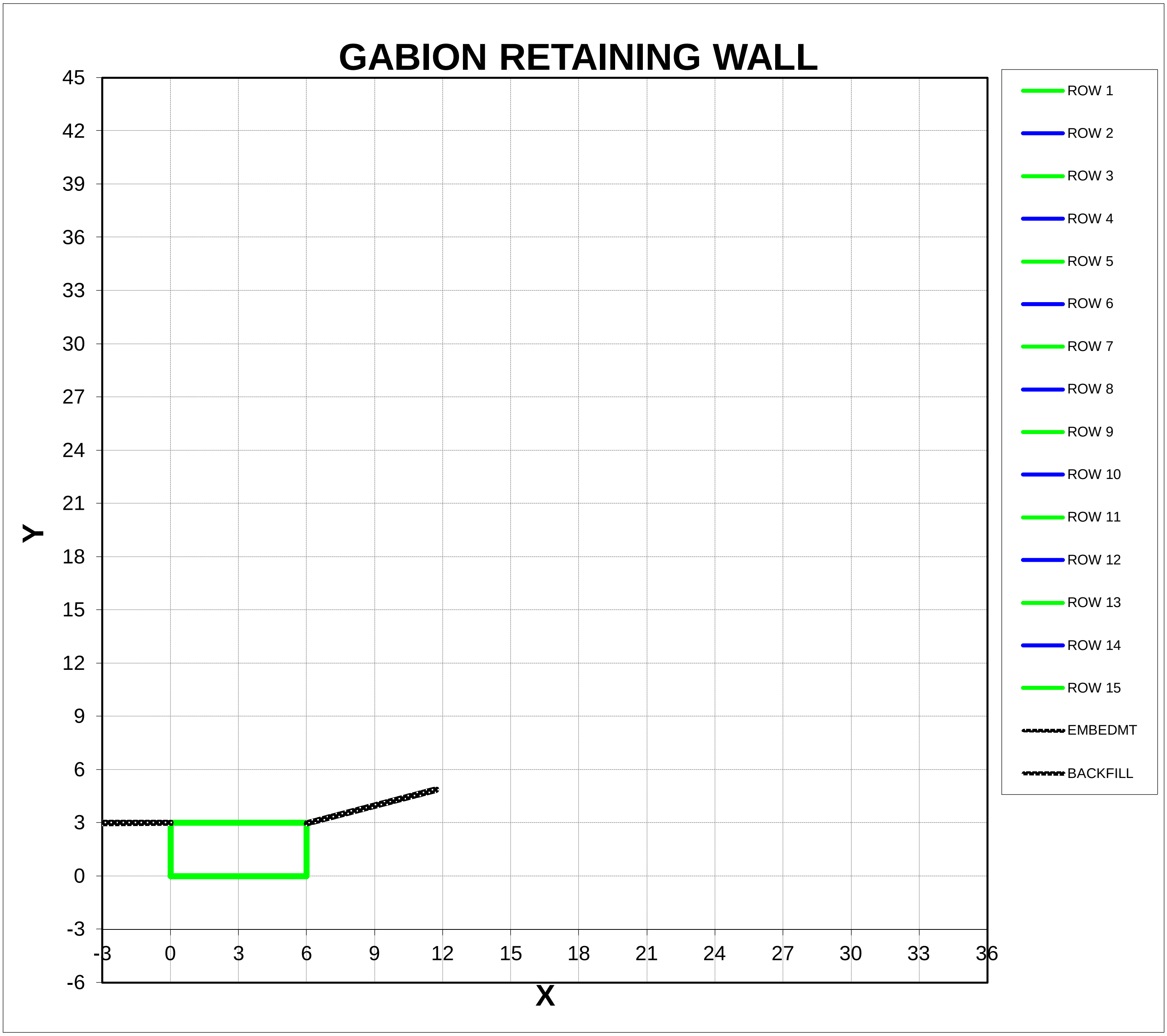
Sliding Safety Coefficient	3.77	Base normal stress (left)	290.88lb/ft²
Overturning Safety Coefficient	6.65	Base normal stress (right)	1005.53lb/ft²
Overall Stability Safety Coefficient	2.18	Max. allowable stress	1250.00lb/ft²

TERRA AQUA GABIONS GRAVITY RETAINING WALL CALCULATIONS
(STRAIGHT LINE BACK)

PROJECT NAME:	Bonanza Mine Repository Repair	**PROJECT #:**	
LOCATION:	Sutherlin, Oregon	**SECTION:**	
GEOTECHNICAL ENGINEER:		**REPORT #:**	
NOTES:	Check of Maccaferri Calculations.	**DRAWING #:**	
		DATE:	8/31/2016



Descriptions	symbols	Input Values	Units	Notes
Backfill slope angle above wall	β	18.400	º	< Φ
Angle of internal friction	Φ	30.000	º	
Wall friction reduction by geotextile	fr	20.000	%	Back of wall
Angle of wall friction	δ	24.000	º	Φ(100-fr)/100
Inclination angle to vertical plane	ω	0.000	º	for wall with straight back (no offsets)
Back of wall angle to horizontal	α	90.000	º	90+ω
Cohesion	c	0	psf	Ignore cohesion
Surcharge	q	150.000	psf	
Soil density	γs	135.000	pcf	
Rock density	γr	135.000	pcf	
Void in gabion	v	30.000	%	
Gabion density	γg	94.500	pcf	γr(100-v)/100
Actual height of wall	H	3.000	ft	(hCosω) Corrected for inclination
Embedment	d	3.000	ft	0 ft to ignore passive thrust
Width of base	B	6	ft	
Allowable soil bearing capacity	qa	**1250.000**	psf	**determined by Geotechnical Engineer**



Row #	Width (ft)	Height (ft)	offset (from toe) (ft)	Area (ft²)	X (ft)	Moment (ft³)	Y (ft)	Moment (ft³)
15				0.000	0.000	0.000	0.000	0.000
14				0.000	0.000	0.000	0.000	0.000
13				0.000	0.000	0.000	0.000	0.000
12				0.000	0.000	0.000	0.000	0.000
11				0.000	0.000	0.000	0.000	0.000
10				0.000	0.000	0.000	0.000	0.000
9				0.000	0.000	0.000	0.000	0.000
8				0.000	0.000	0.000	0.000	0.000
7				0.000	0.000	0.000	0.000	0.000
6				0.000	0.000	0.000	0.000	0.000
5				0.000	0.000	0.000	0.000	0.000
4				0.000	0.000	0.000	0.000	0.000
3				0.000	0.000	0.000	0.000	0.000
2				0.000	0.000	0.000	0.000	0.000
1	6.0	3.0	0.00	18.000	3.000	54.000	1.500	27.000
	h=	3.0		18.000	3.000	54.000	1.500	27.000

1 **COULOMB'S THEORY**

BACK

Active earth pressure coefficient K_a =

$$K_a = \frac{\sin^2(\alpha+\Phi)}{\sin^2\alpha \; \sin(\alpha-\delta)\left[1+\sqrt{\dfrac{\sin(\Phi+\delta)\;\sin(\Phi-\beta)}{\sin(\alpha-\delta)\;\sin(\alpha+\beta)}}\right]^2}$$

$$= \frac{0.750}{1.000 \;\; 0.914\left[1+\sqrt{\dfrac{0.809 \;\; 0.201}{0.914 \;\; 0.949}}\right]^2}$$

$$= \frac{0.750}{1.876}$$

$$= 0.400$$

Active soil thrust P_s = $0.5K_a\gamma_s$ H^2

= 242.808 lb/ft

Active surcharge thrust P_q = $\dfrac{\sin\alpha}{\sin(\alpha+\beta)}$ K_aqH

= $\dfrac{1.000}{0.949}$ 179.857

= 189.548 lb/ft

Horizontal active soil thrust P_{hs} = $P_s\cos(\delta-\omega)$

= 221.816 lb/ft

Horizontal active surcharge thrust P_{hq} = $P_q\cos(\delta-\omega)$

= 173.161 lb/ft

Vertical active soil thrust P_{vs} = $P_s\sin(\delta-\omega)$

= 98.759 lb/ft

Vertical active surcharge thrust P_{vq} = $P_q\sin(\delta-\omega)$

= 77.096 lb/ft

FRONT

Inclination angle to vertical ω_p = 0.000

Front face angle to horizontal α_p = $90-\omega_p$

= 90.000

Backfill slope β_p = 0.000

Angle of wall friction δ_p = 0.000

Passive earth pressure coefficient K_p =

$$K_p = \frac{\sin^2(\alpha-\Phi)}{\sin^2\alpha \; \sin(\alpha+\delta)\left[1-\sqrt{\dfrac{\sin(\Phi+\delta)\;\sin(\Phi+\beta)}{\sin(\alpha+\delta)\;\sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \quad 1.000 \left[1-\sqrt{\frac{0.500}{1.000}\quad\frac{0.500}{1.000}}\right]^2}$$

$$\frac{0.750}{0.250}$$

3.000

Passive soil thrust P_p = $0.5K_p\gamma_s$ d^2

= 1822.500 lb/ft

2 Check Overturning:

Vertical distance to P_{hs} Y_{hs} = H/3-BSinω

= 1.000 ft

Vertical distance to P_{hq} Y_{hq} = H/2-BSinω

= 1.500 ft

Overturning moment $\sum M_o$ = $Y_{hs}P_{hs}$ + $Y_{hq}P_{hq}$

= 481.557 ft-lb / ft

Weight of Gabion W_g = $\sum A\,\gamma_g$

= 1701.000 lb / ft

Horizontal distance to W_g X_g = Ysinω + XCosω

= 3.000 ft

Horizontal distance to P_{vs} X_{vs} = B/Cosω + (H/3-BSinω)Tanω

6.000

Horizontal distance to P_{vq} X_{vq} = B/Cosω + (H/2-BSinω)Tanω

6.000

Vertical distance to P_p Y_{Pp} = d/3

= 1.000

Resisting moment $\sum M_r$ = $W_g X_g$ + $P_{vs} X_{vs}$ + $P_{vq} X_{vq}$ + $P_p Y_{Pp}$

= 7980.629 ft-lb / ft

Overturning factor of safety SF_o = $\frac{\sum M_r}{\sum M_o}$

16.573 ≥ 2.000 **O.K**

3 Check Sliding

Total Normal forces	$\sum W$ =	$W_g Cos\omega$ +	$P_s Sin\delta$ +	$P_q Sin\delta$ -	$P_p Sin\omega$	
	=	1876.855	lb/ft			
Frictional force	F_f =	$\sum W$	$Tan\Phi$			
	=	1876.855	0.577			
	=	1083.603				
Total Resisting Forces	$\sum F_r$ =	$F_f + Cos\omega P_p$				
	=	2906.103				
Total Driving Forces at base	$\sum F_d$ =	$P_s Cos\delta$ +	$P_q Cos\delta$ -	$W_g Sin\omega$		
		394.976				
Siding factor of safety	SF_s =	$\frac{\sum F_r}{\sum F_d}$				
		7.358	≥	1.500	**O.K**	

4 Check the Eccentricity of Resultant Force

(Resultant is in middle one third)

Eccentricity	e =	0.5 B	-	$\frac{(\sum M_r - M_o)}{\sum W}$		
	=	3.000	-	3.996		
	=	-B/6	≤	e	≤	+B/6
		-1.000	≤	-0.996	≤	1.000
			O.K		**O.K**	

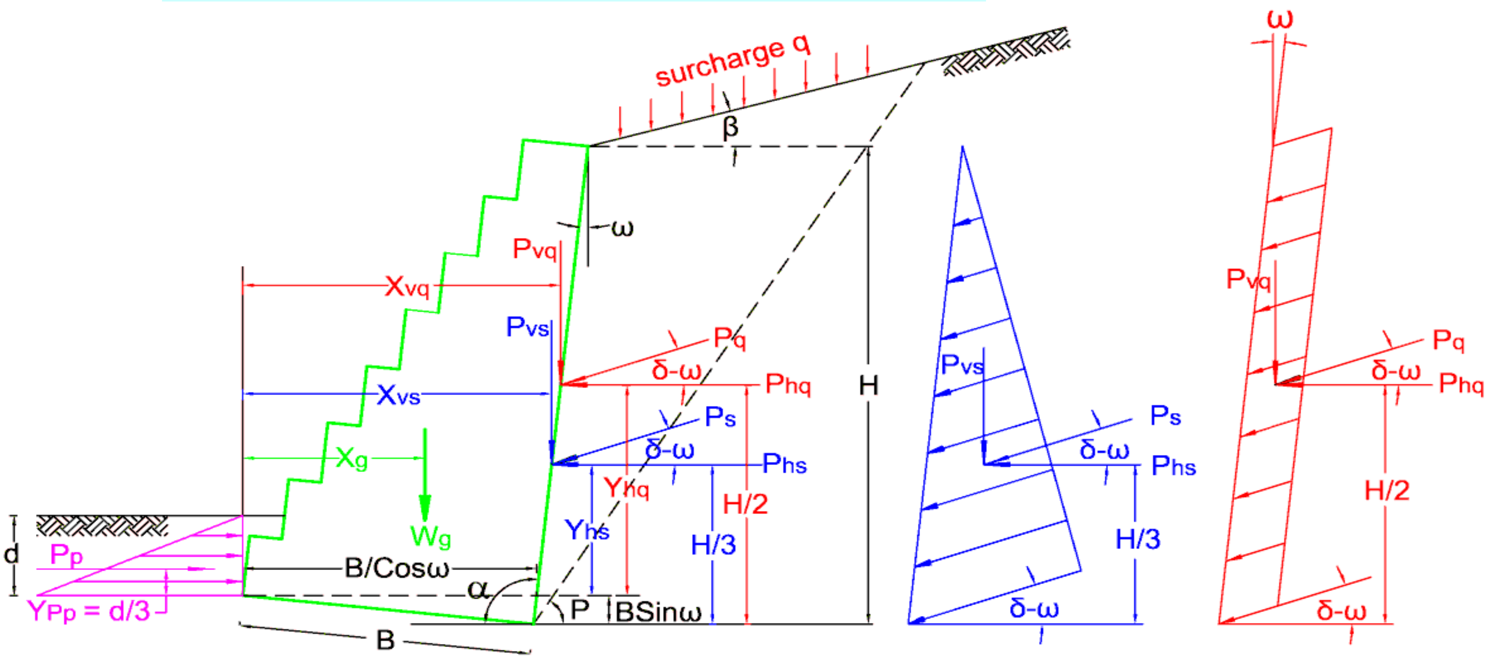
5 Check Bearing

Applied bearing pressure	P =	$\frac{\sum W}{B}$	(1±	6e/B)		
	=	312.809	(1±	0.996	)	
Right	=	624.227	psf	≤	1250.000	**O.K**
Left	=	1.391	psf	≤	1250.000	**O.K**

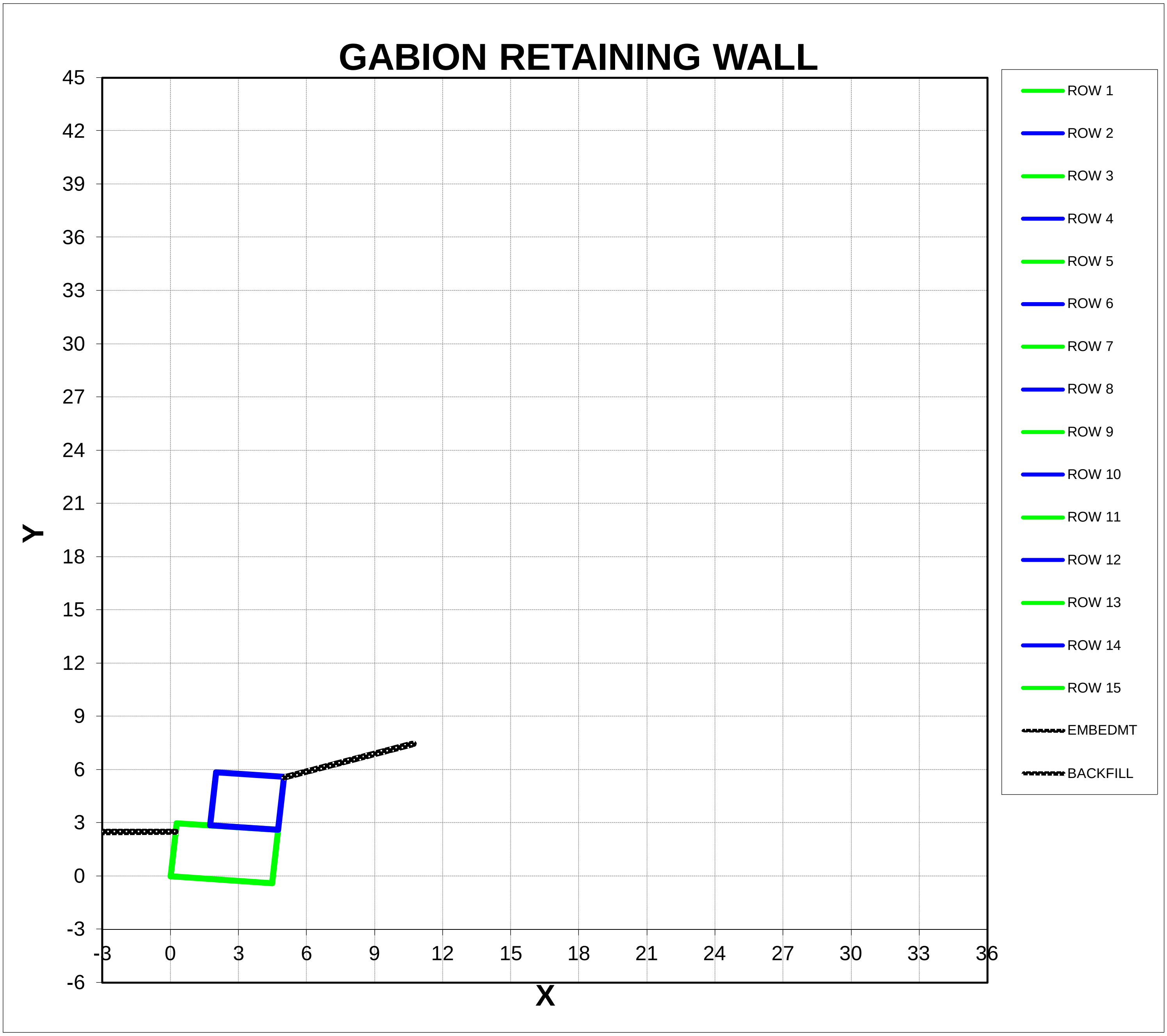
Additional calculations may have to be performed including and not limiting to global stability analysis (by (Geotechnical Engineer), seismic forces (by Seismic Engineer) and hydraulic forces (by Hydraulic Engineer). Please check local, State and Federal requirements. The calculator assumes drained uniformed retained and foundation soil properties. The calculations should be reviewed, checked and certified by a Professional Engineer. To the best of our knowledge, the calculator and information was prepared accurately. Terra Aqua is not responsible for the reliability and validity of the geotechnical parameters assumed in the calculations. The calculator is intended to provided design design assistance to the engineer for the purpose of designing with Terra Aqua products.

TERRA AQUA GABIONS GRAVITY RETAINING WALL CALCULATIONS
(STRAIGHT LINE BACK)

PROJECT NAME:	Bonanza Mine Repository Repair	**PROJECT #:**	
LOCATION:	Sutherlin, Oregon	**SECTION:**	
GEOTECHNICAL ENGINEER:		**REPORT #:**	
NOTES:	Check of Maccaferri calculations.	**DRAWING #:**	
		DATE:	8/31/2016



Descriptions	**symbols**	**Input Values**	**Units**	**Notes**
Backfill slope angle above wall	β	18.400	º	< Φ
Angle of internal friction	Φ	30.000	º	
Wall friction reduction by geotextile	fr	20.000	%	Back of wall
Angle of wall friction	δ	24.000	º	Φ(100-fr)/100
Inclination angle to vertical plane	ω	5.000	º	for wall with straight back (no offsets)
Back of wall angle to horizontal	α	95.000	º	90+ω
Cohesion	c	0	psf	Ignore cohesion
Surcharge	q	150.000	psf	
Soil density	γs	135.000	pcf	
Rock density	γr	135.000	pcf	
Void in gabion	v	30.000	%	
Gabion density	γg	94.500	pcf	γr(100-v)/100
Actual height of wall	H	5.977	ft	(hCosω) Corrected for inclination
Embedment	d	2.500	ft	0 ft to ignore passive thrust
Width of base	B	4.5	ft	
Allowable soil bearing capacity	qa	**1250.000**	psf	**determined by Geotechnical Engineer**



Row #	Width (ft)	Height (ft)	offset (from toe) (ft)	Area (ft²)	X (ft)	Moment (ft³)	Y (ft)	Moment (ft³)
15				0.000	0.000	0.000	0.000	0.000
14				0.000	0.000	0.000	0.000	0.000
13				0.000	0.000	0.000	0.000	0.000
12				0.000	0.000	0.000	0.000	0.000
11				0.000	0.000	0.000	0.000	0.000
10				0.000	0.000	0.000	0.000	0.000
9				0.000	0.000	0.000	0.000	0.000
8				0.000	0.000	0.000	0.000	0.000
7				0.000	0.000	0.000	0.000	0.000
6				0.000	0.000	0.000	0.000	0.000
5				0.000	0.000	0.000	0.000	0.000
4				0.000	0.000	0.000	0.000	0.000
3				0.000	0.000	0.000	0.000	0.000
2	3.0	3.0	1.50	9.000	3.000	27.000	4.500	40.500
1	4.5	3.0	0.00	13.500	2.250	30.375	1.500	20.250
	h=	6.0		22.500	2.550	57.375	2.700	60.750

1 **COULOMB'S THEORY**

BACK

Active earth pressure coefficient

$$K_a = \frac{\sin^2(\alpha+\Phi)}{\sin^2\alpha \quad \sin(\alpha-\delta)\left[1+\sqrt{\dfrac{\sin(\Phi+\delta)\quad \sin(\Phi-\beta)}{\sin(\alpha-\delta)\quad \sin(\alpha+\beta)}}\right]^2}$$

$$= \frac{0.671}{0.992 \quad 0.946\left[1+\sqrt{\dfrac{0.809 \quad 0.201}{0.946 \quad 0.918}}\right]^2}$$

$$= \frac{0.671}{1.927}$$

$$= 0.348$$

Active soil thrust $P_s = 0.5K_a\gamma_s \quad H^2$

$= 839.824$ lb/ft

Active surcharge thrust $P_q = \dfrac{\sin\alpha}{\sin(\alpha+\beta)} \quad K_a qH$

$= \dfrac{0.996}{0.918} \quad 312.234$

$= 338.920$ lb/ft

Horizontal active soil thrust $P_{hs} = P_s\cos(\delta-\omega)$

$= 794.069$ lb/ft

Horizontal active surcharge thrust $P_{hq} = P_q\cos(\delta-\omega)$

$= 320.456$ lb/ft

Vertical active soil thrust $P_{vs} = P_s\sin(\delta-\omega)$

$= 273.420$ lb/ft

Vertical active surcharge thrust $P_{vq} = P_q\sin(\delta-\omega)$

$= 110.342$ lb/ft

FRONT

Inclination angle to vertical $\omega_p = 0.000$

Front face angle to horizontal $\alpha_p = 90-\omega_p$

$= 90.000$

Backfill slope $\beta_p = 0.000$

Angle of wall friction $\delta_p = 0.000$

Passive earth pressure coefficient

$$K_p = \frac{\sin^2(\alpha-\Phi)}{\sin^2\alpha \quad \sin(\alpha+\delta)\left[1-\sqrt{\dfrac{\sin(\Phi+\delta)\quad \sin(\Phi+\beta)}{\sin(\alpha+\delta)\quad \sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \qquad 1.000 \left[1- \sqrt{\frac{0.500}{1.000} \quad \frac{0.500}{1.000}} \right]^2}$$

$$\frac{0.750}{0.250}$$

3.000

Passive soil thrust P_p = $0.5K_p\gamma_s$ d^2

= 1265.625 lb/ft

2 Check Overturning:

Vertical distance to P_{hs} Y_{hs} = $H/3-BSin\omega$

= 1.600 ft

Vertical distance to P_{hq} Y_{hq} = $H/2-BSin\omega$

= 2.596 ft

Overturning moment $\sum M_o$ = $Y_{hs}P_{hs}$ + $Y_{hq}P_{hq}$

= 2102.685 ft-lb / ft

Weight of Gabion W_g = $\sum A\ \gamma_g$

= 2126.250 lb / ft

Horizontal distance to W_g X_g = $Ysin\omega$ + $XCos\omega$

= 2.776 ft

Horizontal distance to P_{vs} X_{vs} = $B/Cos\omega$ + $(H/3-BSin\omega)Tan\omega$

4.657

Horizontal distance to P_{vq} X_{vq} = $B/Cos\omega$ + $(H/2-BSin\omega)Tan\omega$

4.744

Vertical distance to P_p Y_{Pp} = $d/3$

= 0.833

Resisting moment $\sum M_r$ = $W_g\ X_g$ + $P_{vs}\ X_{vs}$ + $P_{vq}\ X_{vq}$ + P_pY_{Pp}

= 8753.209 ft-lb / ft

Overturning factor of safety SF_o = $\frac{\sum M_r}{\sum M_o}$

4.163 ≥ 2.000 **O.K**

3 Check Sliding

Total Normal forces $\sum W = W_g Cos\omega + P_s Sin\delta + P_q Sin\delta - P_p Sin\omega$

$= 2487.291$ lb/ft

Frictional force $F_f = \sum W \; Tan\Phi$

$= 2487.291 \quad 0.577$

$= 1436.038$

Total Resisting Forces $\sum F_r = F_f + Cos\omega P_p$

$= 2696.847$

Total Driving Forces at base $\sum F_d = P_s Cos\delta + P_q Cos\delta - W_g Sin\omega$

891.521

Siding factor of safety $SF_s = \dfrac{\sum F_r}{\sum F_d}$

3.025 ≥ 1.500 **O.K**

4 Check the Eccentricity of Resultant Force
(Resultant is in middle one third)

Eccentricity $e = 0.5\,B - \dfrac{(\sum M_r - M_o)}{\sum W}$

$= 2.250 - 2.674$

$= -B/6 \le e \le +B/6$

$-0.750 \le -0.424 \le 0.750$
O.K **O.K**

5 Check Bearing

Applied bearing pressure $P = \dfrac{\sum W}{B}(1 \pm 6e/B)$

$= 552.731\,(1 \pm 0.565\;)$

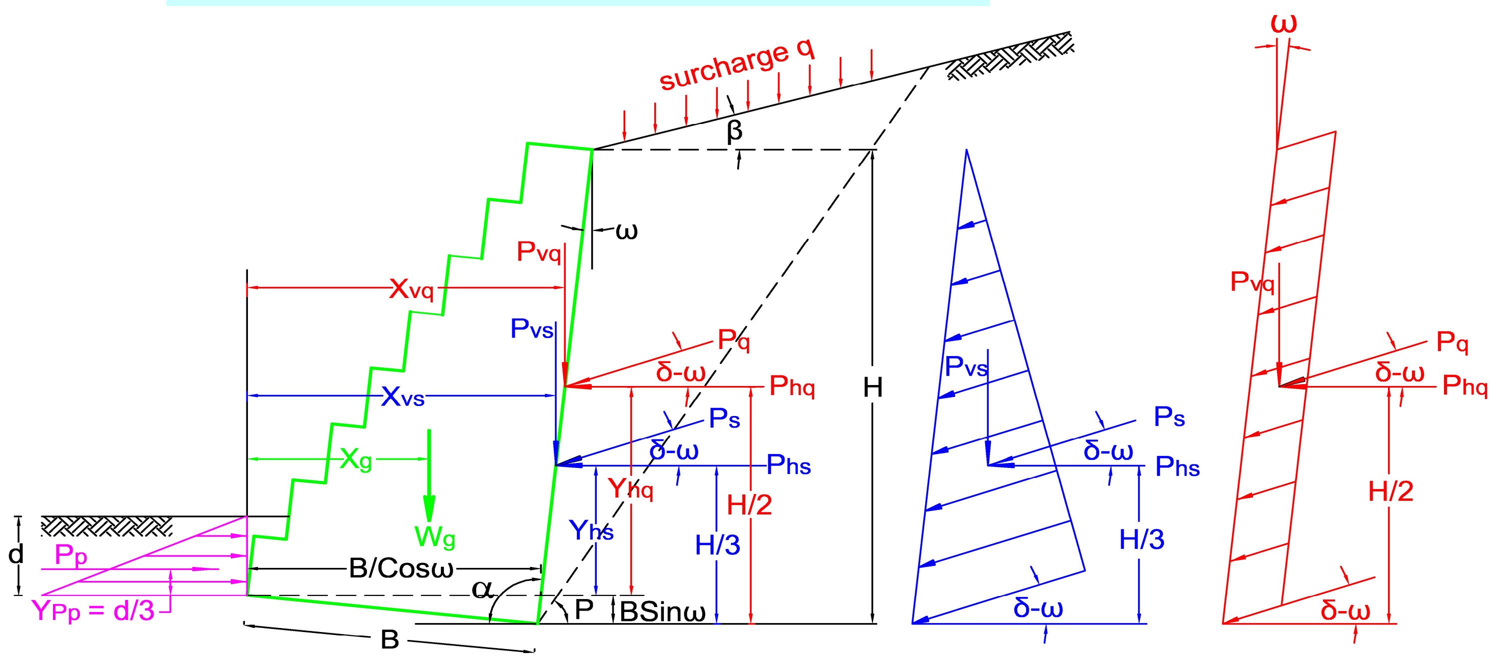
Right = 865.063 psf ≤ 1250.000 **O.K**

Left = 240.400 psf ≤ 1250.000 **O.K**

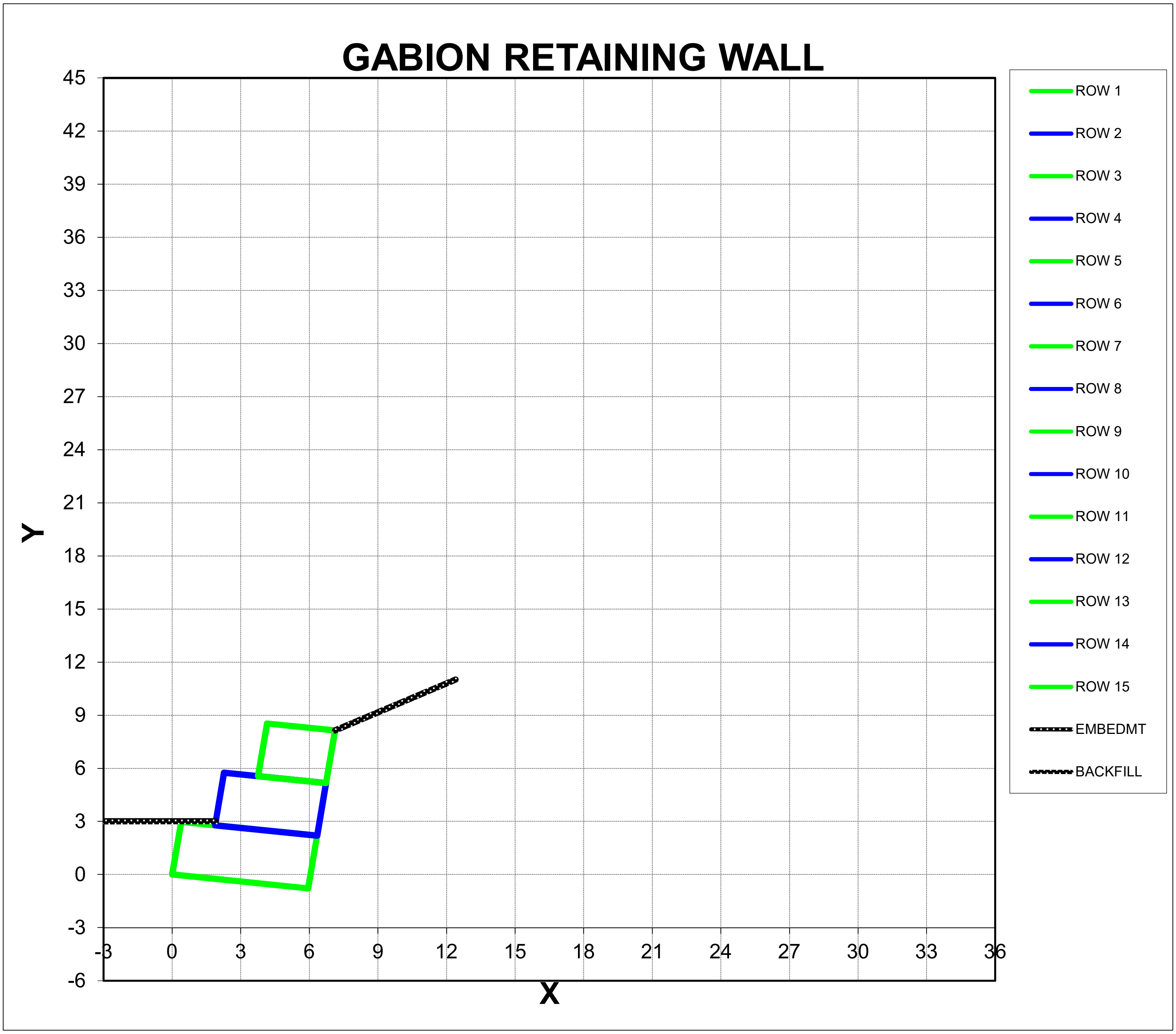
Additional calculations may have to be performed including and not limiting to global stability analysis (by (Geotechnical Engineer), seismic forces (by Seismic Engineer) and hydraulic forces (by Hydraulic Engineer). Please check local, State and Federal requirements. The calculator assumes drained uniformed retained and foundation soil properties. The calculations should be reviewed, checked and certified by a Professional Engineer. To the best of our knowledge, the calculator and information was prepared accurately. Terra Aqua is not responsible for the reliability and validity of the geotechnical parameters assumed in the calculations. The calculator is intended to provided design design assistance to the engineer for the purpose of designing with Terra Aqua products.

TERRA AQUA GABIONS GRAVITY RETAINING WALL CALCULATIONS
(STRAIGHT LINE BACK)

PROJECT NAME:	Bonanza Mine Repository Repair	**PROJECT #:**	
LOCATION:	Sutherlin, Oregon	**SECTION:**	
GEOTECHNICAL ENGINEER:		**REPORT #:**	
NOTES:	Check of Maccaferri calculations.	**DRAWING #:**	
		DATE:	9/21/2016



Descriptions	**symbols**	**Input Values**	**Units**	**Notes**
Backfill slope angle above wall	β	28.648	°	< Φ
Angle of internal friction	Φ	30.000	°	
Wall friction reduction by geotextile	fr	20.000	%	Back of wall
Angle of wall friction	δ	24.000	°	Φ(100-fr)/100
Inclination angle to vertical plane	ω	7.500	°	for wall with straight back (no offsets)
Back of wall angle to horizontal	α	97.500	°	90+ω
Cohesion	c	0	psf	Ignore cohesion
Surcharge	q	150.000	psf	
Soil density	γ_s	135.000	pcf	
Rock density	γ_r	135.000	pcf	
Void in gabion	v	30.000	%	
Gabion density	γ_g	94.500	pcf	γ_r(100-v)/100
Actual height of wall	H	8.923	ft	(hCosω) Corrected for inclination
Embedment	d	3.000	ft	0 ft to ignore passive thrust
Width of base	B	6	ft	
Allowable soil bearing capacity	q_a	**1250.000**	psf	**determined by Geotechnical Engineer**



Row #	Width (ft)	Height (ft)	offset (from toe) (ft)	Area (ft²)	X (ft)	Moment (ft³)	Y (ft)	Moment (ft³)
15				0.000	0.000	0.000	0.000	0.000
14				0.000	0.000	0.000	0.000	0.000
13				0.000	0.000	0.000	0.000	0.000
12				0.000	0.000	0.000	0.000	0.000
11				0.000	0.000	0.000	0.000	0.000
10				0.000	0.000	0.000	0.000	0.000
9				0.000	0.000	0.000	0.000	0.000
8				0.000	0.000	0.000	0.000	0.000
7				0.000	0.000	0.000	0.000	0.000
6				0.000	0.000	0.000	0.000	0.000
5				0.000	0.000	0.000	0.000	0.000
4				0.000	0.000	0.000	0.000	0.000
3	3.0	3.0	3.00	9.000	4.500	40.500	7.500	67.500
2	4.5	3.0	1.50	13.500	3.750	50.625	4.500	60.750
1	6.0	3.0	0.00	18.000	3.000	54.000	1.500	27.000
	h=	9.0		40.500	3.583	145.125	3.833	155.250

1 **COULOMB'S THEORY**

BACK

Active earth pressure coefficient

$$K_a = \frac{\sin^2(\alpha+\Phi)}{\sin^2\alpha \; \sin(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\Phi+\delta)\;\sin(\Phi-\beta)}{\sin(\alpha-\delta)\;\sin(\alpha+\beta)}}\right]^2}$$

$$= \frac{0.629}{0.983 \quad 0.959\left[1+\sqrt{\frac{0.809 \quad 0.024}{0.959 \quad 0.807}}\right]^2}$$

$$= \frac{0.629}{1.262}$$

$$= 0.499$$

Active soil thrust $P_s = 0.5K_a\gamma_s \; H^2$

$= 2681.025$ lb/ft

Active surcharge thrust $P_q = \frac{\sin\alpha}{\sin(\alpha+\beta)} \; K_a qH$

$= \frac{0.991}{0.807} \; 667.694$

$= 819.794$ lb/ft

Horizontal active soil thrust $P_{hs} = P_s\cos(\delta-\omega)$

$= 2570.620$ lb/ft

Horizontal active surcharge thrust $P_{hq} = P_q\cos(\delta-\omega)$

$= 786.035$ lb/ft

Vertical active soil thrust $P_{vs} = P_s\sin(\delta-\omega)$

$= 761.452$ lb/ft

Vertical active surcharge thrust $P_{vq} = P_q\sin(\delta-\omega)$

$= 232.834$ lb/ft

FRONT

Inclination angle to vertical $\omega_p = 0.000$

Front face angle to horizontal $\alpha_p = 90-\omega_p$

$= 90.000$

Backfill slope $\beta_p = 0.000$

Angle of wall friction $\delta_p = 0.000$

Passive earth pressure coefficient

$$K_p = \frac{\sin^2(\alpha-\Phi)}{\sin^2\alpha \; \sin(\alpha+\delta)\left[1-\sqrt{\frac{\sin(\Phi+\delta)\;\sin(\Phi+\beta)}{\sin(\alpha+\delta)\;\sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \quad 1.000 \left[1- \sqrt{\frac{0.500 \quad 0.500}{1.000 \quad 1.000}} \right]^2}$$

$$\frac{0.750}{0.250}$$

3.000

Passive soil thrust P_p = $0.5K_p\gamma_s$ d^2

= 1822.500 lb/ft

2 Check Overturning:

Vertical distance to P_{hs} Y_{hs} = $H/3-BSin\omega$

= 2.191 ft

Vertical distance to P_{hq} Y_{hq} = $H/2-BSin\omega$

= 3.678 ft

Overturning moment $\sum M_o$ = $Y_{hs}P_{hs}$ + $Y_{hq}P_{hq}$

= 8523.991 ft-lb / ft

Weight of Gabion W_g = $\sum A\ \gamma_g$

= 3827.250 lb / ft

Horizontal distance to W_g X_g = $Ysin\omega$ + $XCos\omega$

= 4.053 ft

Horizontal distance to P_{vs} X_{vs} = $B/Cos\omega$ + $(H/3-BSin\omega)Tan\omega$

6.340

Horizontal distance to P_{vq} X_{vq} = $B/Cos\omega$ + $(H/2-BSin\omega)Tan\omega$

6.536

Vertical distance to P_p Y_{Pp} = $d/3$

= 1.000

Resisting moment $\sum M_r$ = $W_g X_g$ + $P_{vs} X_{vs}$ + $P_{vq} X_{vq}$ + P_pY_{Pp}

= 23684.059 ft-lb / ft

Overturning factor of safety SF_o = $\frac{\sum M_r}{\sum M_o}$

2.779 ≥ 2.000 **O.K**

3 Check Sliding

Total Normal forces	$\sum W$ =	$W_g \cos\omega$ +	$P_s \sin\delta$ +	$P_q \sin\delta$ -	$P_p \sin\omega$	
	=	4980.535	lb/ft			
Frictional force	F_f =	$\sum W$	$\tan\Phi$			
	=	4980.535	0.577			
	=	2875.513				
Total Resisting Forces	$\sum F_r$ =	$F_f + \cos\omega P_p$				
	=	4682.421				
Total Driving Forces at base	$\sum F_d$ =	$P_s \cos\delta$ +	$P_q \cos\delta$ -	$W_g \sin\omega$		
		2698.601				
Siding factor of safety	SF_s =	$\frac{\sum F_r}{\sum F_d}$				
		1.735	≥	1.500	**O.K**	

4 Check the Eccentricity of Resultant Force
(Resultant is in middle one third)

Eccentricity	e =	0.5 B	-	$\frac{(\sum M_r - M_o)}{\sum W}$		
	=	3.000	-	3.044		
	=	-B/6	≤	e	≤	+B/6
		-1.000	≤	-0.044	≤	1.000
			O.K		**O.K**	

5 Check Bearing

Applied bearing pressure	P =	$\frac{\sum W}{B}$	(1±	6e/B)		
	=	830.089	(1±	0.044	)	
Right	=	866.500	psf	≤	1250.000	**O.K**
Left	=	793.678	psf	≤	1250.000	**O.K**

Additional calculations may have to be performed including and not limiting to global stability analysis (by (Geotechnical Engineer), seismic forces (by Seismic Engineer) and hydraulic forces (by Hydraulic Engineer). Please check local, State and Federal requirements. The calculator assumes drained uniformed retained and foundation soil properties. The calculations should be reviewed, checked and certified by a Professional Engineer. To the best of our knowledge, the calculator and information was prepared accurately. Terra Aqua is not responsible for the reliability and validity of the geotechnical parameters assumed in the calculations. The calculator is intended to provided design design assistance to the engineer for the purpose of designing with Terra Aqua products.

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	04/15/16	Tested By:	dln
End Date:	04/18/16	Checked By:	jdt
Boring ID:	Bonanza		
Sample ID:	16031005		
Depth, ft:	Bottom Repos		
Soil Description:	Moist, light olive brown sandy clay		

Direct Shear Test Series by ASTM D3080

Soil Preparation: Target Compaction: 90% of Maximum Dry Density at Optimum Moisture Content

Compaction Characteristics:

- Maximum Dry Density: 106.8 pcf
- Optimum Moisture Content: 19.1 %
- Compaction Test Method: ASTM D698

Test Equipment: Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2

Maximum Particle Size Used, in:	0.5	Horizontal Displacement, in/min:	0.02
Soil Height, in:	3	Test Condition:	inundated
Gap Between Boxes, in:	0.25		

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	18.7	18.4	18.8	---	---	---
Initial Dry Density, pcf	96.2	96.5	96.2	---	---	---
Percent Compaction, %	90.1	90.4	90.0	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	113	386	817	---	---	---
Final Moisture Content, %	29.6	25.4	23.8	---	---	---

Notes:

Peak Friction Angle: 38.1 degrees

Peak Cohesion: 19.9 psf

Figure a. Shear Force vs. Horizontal Displacement

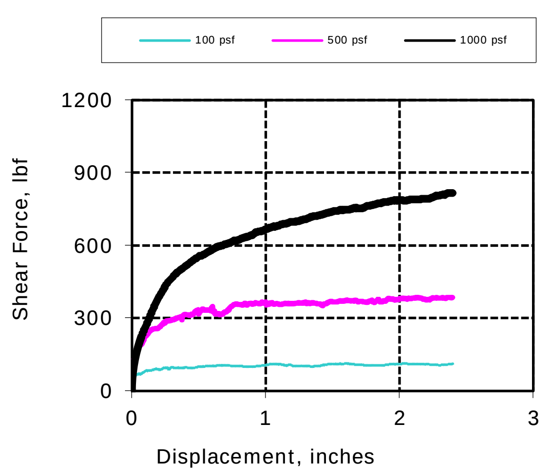
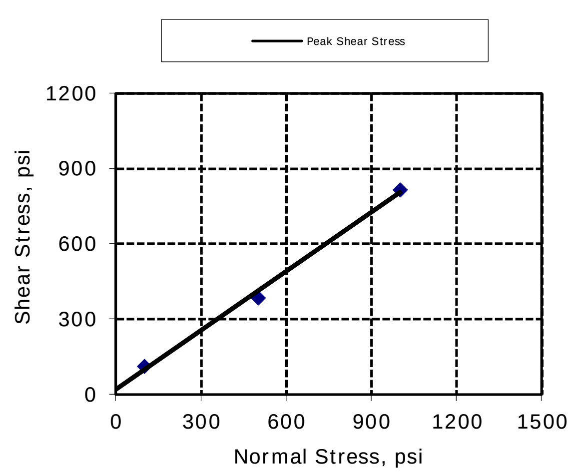


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Landfill		
Project Location:	---		
GTX #:	304536		
Start Date:	04/12/16	Tested By:	dln
End Date:	04/15/16	Checked By:	emm
Soil ID:	Bonanza, 16031005, Bottom Repos		
Soil Description:	Moist, light olive brown sandy clay		
Geomembrane ID:	Roll 3/24/16 (Roll # not provided)		
Geomembrane Description:	Black, 40 mil Agru textured LLDPE geomembrane		

Interface Shear Test Series by ASTM D5321

Test Series #:	1		
Test Profile - Top to Bottom:	steel plate / SOIL / GEOMEMBRANE / textured gripping surface		
Soil Preparation:	Soil compacted to 90% of Maximum Dry Density at Optimum Moisture Content.		
Compaction Characteristics:	Maximum Dry Density	106.8 pcf	
	Optimum Moisture Content	19.1 %	
	Compaction Test Method	ASTM D698	
Geosynthetic Preparation:	Test set-up saturated at normal load for 1 hour prior to shear		
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2		
Horizontal Displacement, in/min:	0.04	Test Condition:	inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	20.0	19.9	20.0	---	---	---
Initial Dry Density, pcf	97.2	97.3	97.2	---	---	---
Percent Compaction, %	91.0	91.1	91.0	---	---	---
Final Moisture Content, %	30.0	26.1	25.4	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	125	364	732	---	---	---
Post Peak Shear Stress, psf	125	325	722	---	---	---
Peak Secant Friction Angle, °	51.3	36.1	36.2	---	---	---
Post-Peak Secant Friction Angle, °	51.3	33.0	35.8	---	---	---
Pre-Test: Average Asperity, mils	37.0	38.1	41.1	---	---	---
Post-Test: Average Asperity, mils	36.3	37.8	39.1	---	---	---

NOTES: Asperity measurements taken on side of membrane involved in shear plane in general accordance with ASTM D7466. Six measurements taken at the same locations before and after test.

Peak Friction Angle:	**34.1**	**degrees**
Peak Adhesion:	**46**	**psf**
Post Peak Friction Angle:	**33.8**	**degrees**
Post Peak Adhesion:	**34**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

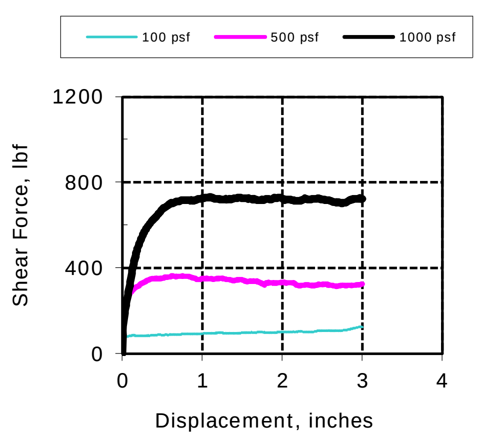
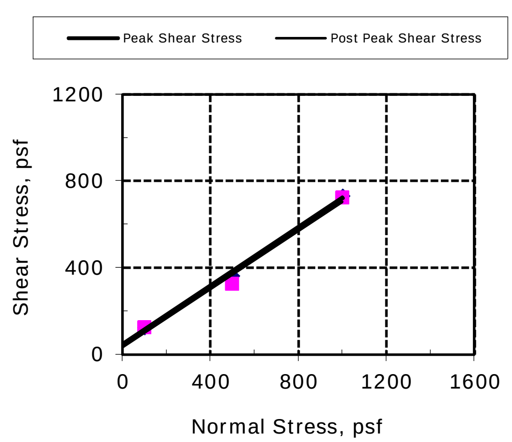


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

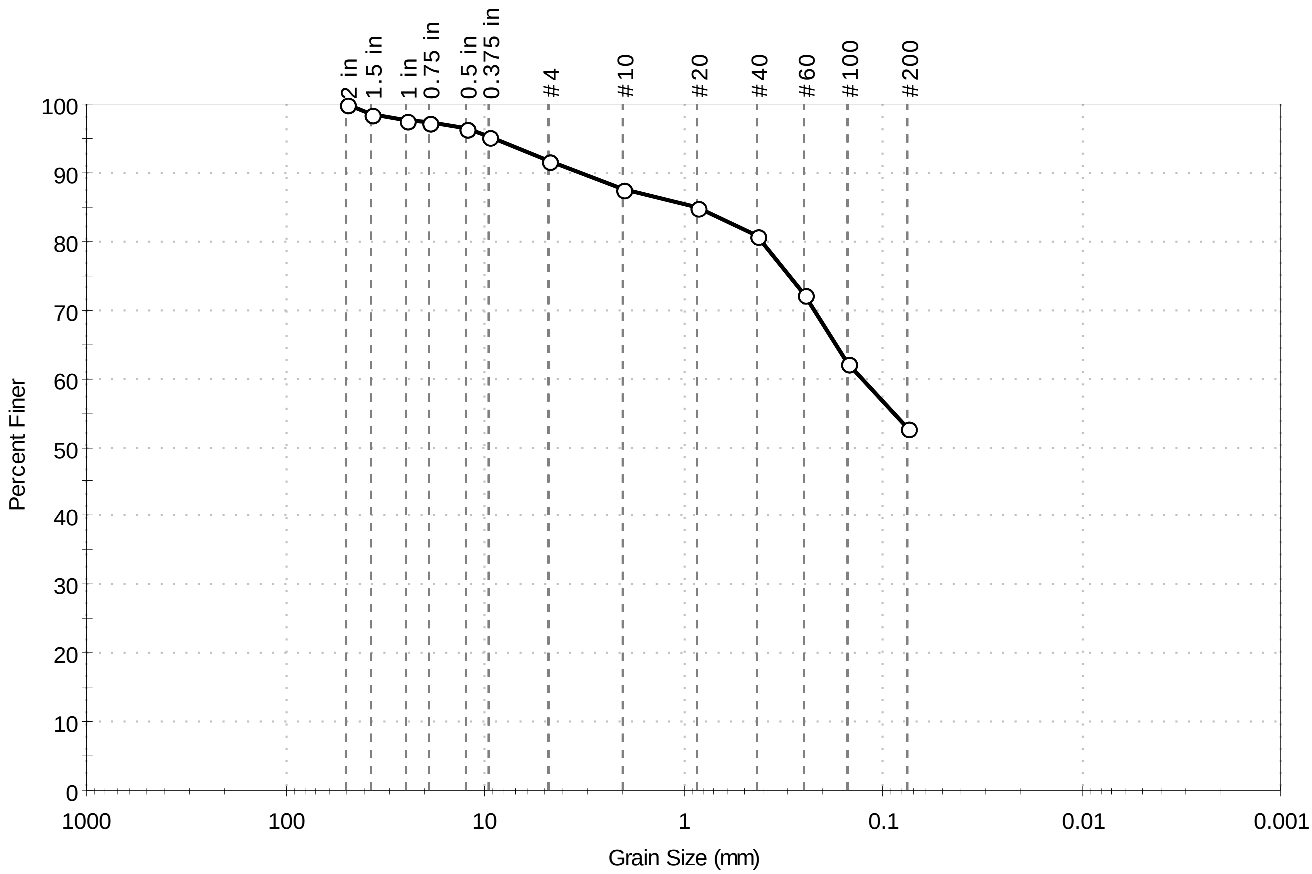
Form D5321, version 2

GeoTesting EXPRESS

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	jbr
Sample ID:	16031005	Test Date:	04/04/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370686		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	8.2	38.9	52.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	98		
1 in	25.00	98		
0.75 in	19.00	97		
0.5 in	12.50	97		
0.375 in	9.50	95		
#4	4.75	92		
#10	2.00	88		
#20	0.85	85		
#40	0.42	81		
#60	0.25	72		
#100	0.15	62		
#200	0.075	53		

Coefficients

D_{85} = 0.8573 mm D_{30} = N/A
D_{60} = 0.1268 mm D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM Sandy Lean clay (CL)

AASHTO Clayey Soils (A-6 (6))

Sample/Test Description

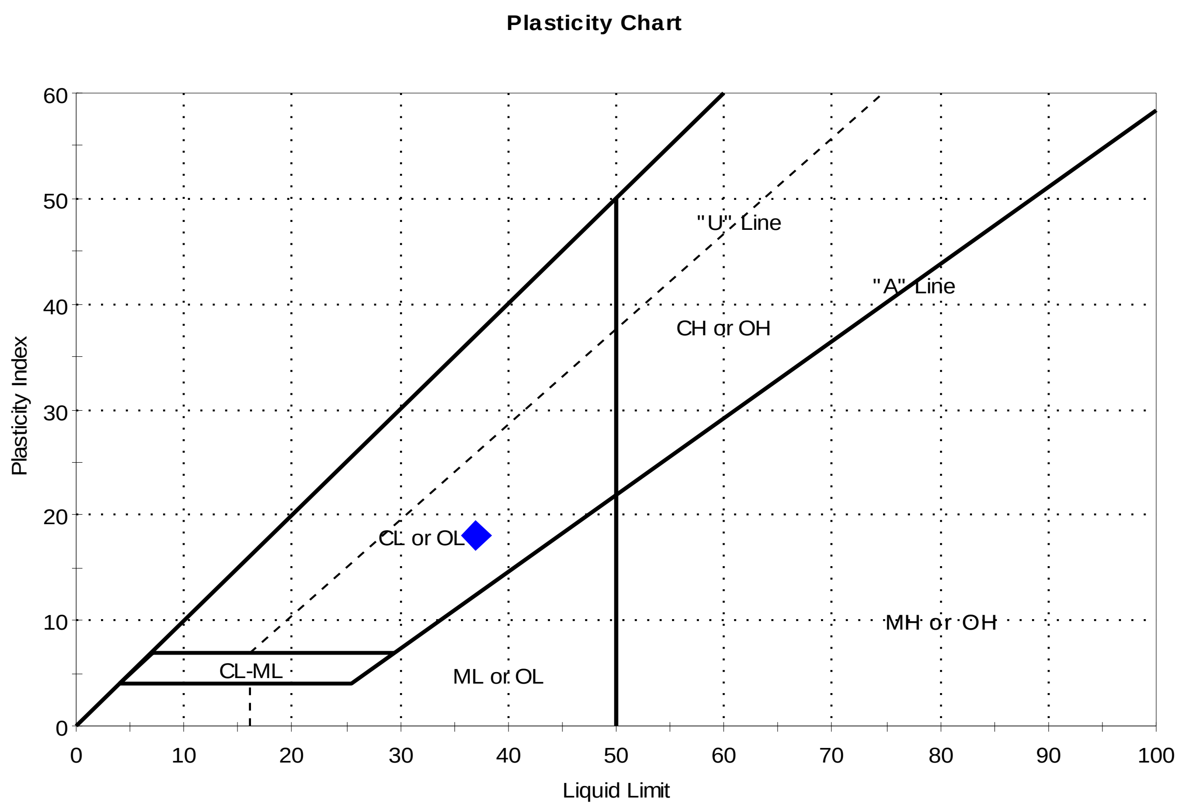
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

GeoTesting EXPRESS

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	cam
Sample ID:	16031005	Test Date:	04/05/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370691		
Test Comment:	---				
Visual Description:	Moist, light olive brown sandy clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	16031005	Bonanza	Bottom Repos	24	37	19	18	0.3	Sandy Lean clay (CL)

Sample Prepared using the WET method

19% Retained on #40 Sieve

Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

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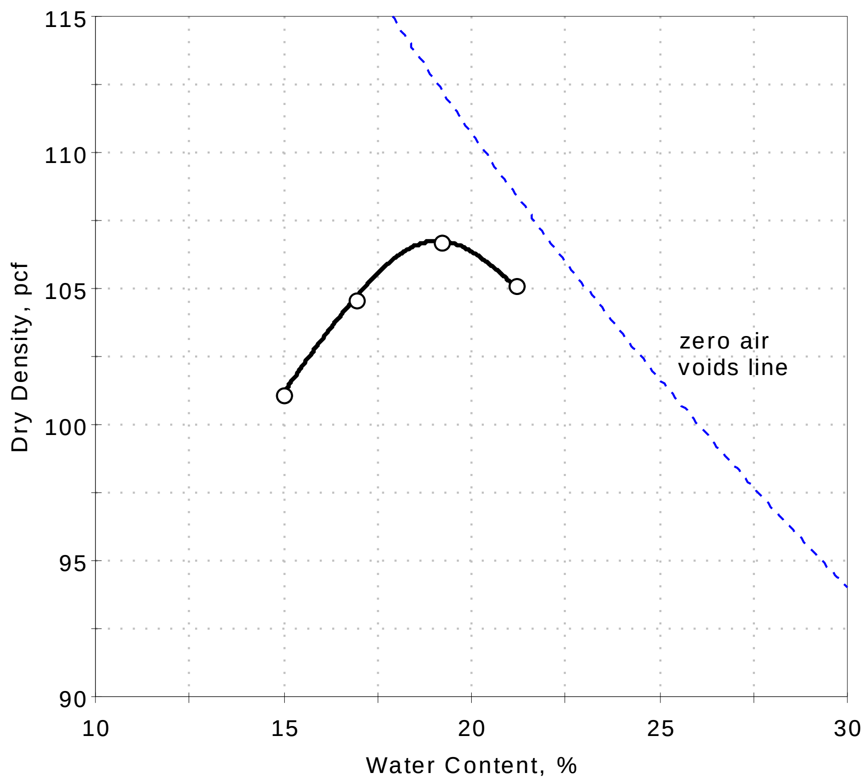
Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	pmh
Sample ID:	16031005	Test Date:	04/04/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370701		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay
Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	101.1	104.6	106.8	105.1
Moisture Content, %	15.0	16.9	19.2	21.1

Method : B

Preparation : DRY

As received Moisture :24 %

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.75

Maximum Dry Density= 106.8 pcf
Optimum Moisture= 19.1 %

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GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	4/6/2016	Tested By:	jcw
End Date:	4/8/2016	Checked By:	emm
Boring #:	Bonanza		
Sample #:	16031005		
Depth:	Bottom Repo		
Visual Description:	Moist, light olive brown sandy clay		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084
Constant Gradient

Sample Type:	Remolded	Permeant Fluid:	De-aired Distilled water
Orientation:	Vertical	Cell #:	2/5

Sample Preparation: Target Compaction: 90% of maximum dry density (106.8 pcf) at the optimum moisture content (19.1%). Values specified by client. Material >3/8-inch removed from sample prior to testing (5% of sample). Trimmings moisture content = 19.3%

Assumed Specific Gravity: 2.65

Parameter	Initial	Final
Height, in	3.00	2.98
Diameter, in	2.86	2.86
Area, in^2	6.42	6.42
Volume, in^3	19.3	19.1
Mass, g	579	610
Bulk Density, pcf	114.2	121.1
Moisture Content, %	19.3	25.6
Dry Density, pcf	95.8	96.4
Degree of Saturation, %	70	95

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.00	Increased Cell Pressure, psi:	94.97	Cell Pressure Increment, ps	4.97
Sample Pressure, psi:	84.99	Corresponding Sample Pressure, psi:	89.70	Sample Pressure Increment	4.71
				B Coefficient:	0.95

FLOW DATA

Date	Time, sec	Pressure, psi Cell	Inlet	Outlet	Gradient	Flow Volume, cc In	Out	Δ In	Δ Out	Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
4/7	---	90.0	85.3	84.8	4.6	12.50	13.00	---	---	---	---	---
4/7	136	90.0	85.3	84.8	4.6	12.80	12.70	0.30	0.30	20.5	0.988	1.1E-05
4/7	----	90.0	85.3	84.8	4.6	12.40	13.10	---	---	---	---	---
4/7	122	90.0	85.3	84.8	4.6	12.70	12.80	0.30	0.30	20.5	0.988	1.3E-05
4/7	----	90.0	85.3	84.8	4.6	13.00	13.30	---	---	---	---	---
4/7	152	90.0	85.3	84.8	4.6	13.30	13.00	0.30	0.30	20.5	0.988	1.0E-05
4/7	----	90.0	85.3	84.8	4.6	12.90	12.90	---	---	---	---	---
4/7	120	90.0	85.3	84.8	4.6	13.20	12.60	0.30	0.30	20.5	0.988	1.3E-05

PERMEABILITY AT 20° C: 1.2 x 10^{-5} cm/sec (@ 5 psi effective stress)

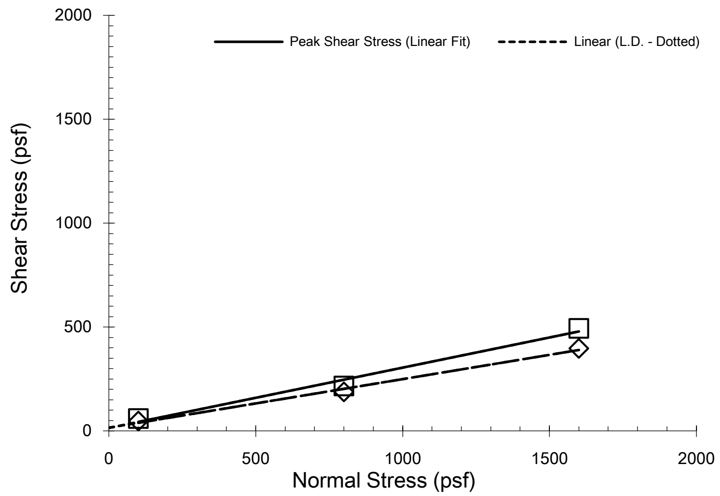
Interface Friction Test Report

Client: **Northwest Liners**
Project: **Bonanza Mine**
Date: 10-08-2014 to 10-08-2014

TRI Log#: E2388-46-05
Test Method: ASTM D5321

John M. Allen, P.E., 10/08/2014
Quality Review/Date

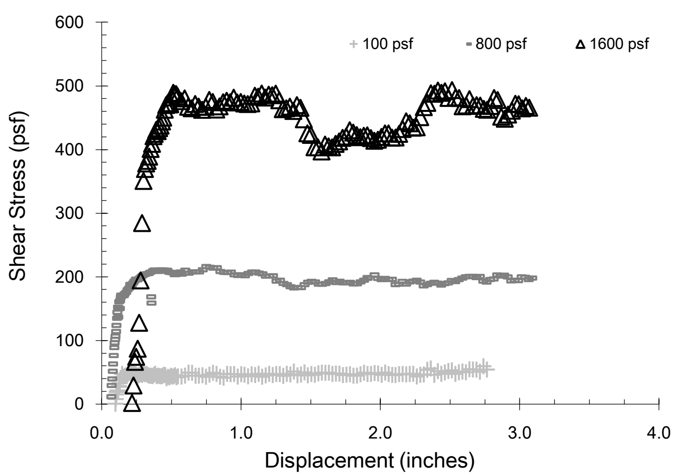
Tested Interface: Agru 200-1-6 Single-sided Geocomposite (529216-11) vs. Agru 40 mil LLDPE Microspike Geomembrane (F14A391005)



Test Results

	Peak	Large Displacement (@ 3.0 in.)
Friction Angle (degrees):	16.2	13.2
Y-intercept or Adhesion (psf):	14	16

Shearing occurred at the interface.



Test Conditions

Upper Box &	Agru 200-1-6 single-sided geocomposite (net side down)
Lower Box	Agru 40 mil LLDPE Microspike geomembrane (dull side up)
Box Dimensions: 12"x12"x4"	
Interface Conditioning:	Interface loading applied for a minimum of 15 hours prior to shear.
Test Condition: Dry	
Shearing Rate: 0.2 inches/minute	

Test Data

Specimen No.	1	2	3
Bearing Slide Resistance (lbs)	9	16	23
Normal Stress (psf)	100	800	1600
Corrected Peak Shear Stress (psf)	59	216	493
Corrected Large Displacement Shear Stress (psf)	47	188	397
Peak Secant Angle (degrees)	30.7	15.1	17.1
Large Displacement Secant Angle (degrees)	25.4	13.2	13.9
Asperity (mils)	26.6	26.6	26.8

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

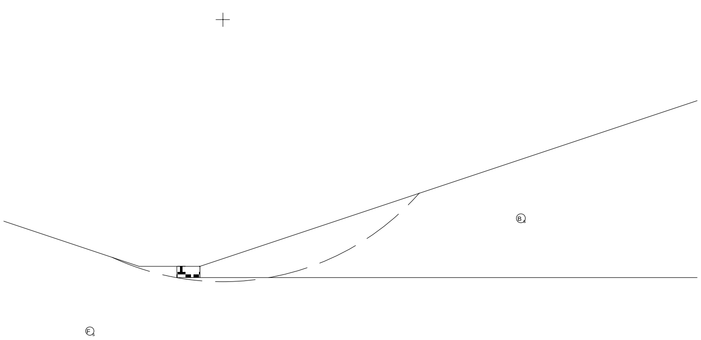
Project: Bonanza1
File: Bonanza1 Date: 9/14/2016

INPUT DATA

Wall data

Wall batter	:	0.00 deg
Rockfill unit weight	:	135.00 lb/ft³
Porosity of gabions	:	30.00 %
Geotextile in the backfill	:	Yes
Friction reduction	:	20.00 %
Geotextile on the base	:	No
Friction reduction	:	%
Mesh and the wire diam.:	:	8x10, ø 2.70 mm

Layer	Length ft	Width ft	Offset ft
1	6.00	3.00	-



Backfill soil data

Inclination of Stretch 1	:	18.40 deg
Length of stretch 1	:	250.00 ft
Inclination of Stretch 2	:	0.00 deg
Soil unit weight	:	125.00 lb/ft³
Soil friction angle	:	16.20 deg
Soil cohesion	:	14.00 lb/ft²

Additional Backfill Layers

Layer	Initial height ft	Incl. angle deg	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Project: Bonanza1
File: Bonanza1 Date: 9/14/2016

Foundation data

Top surface height	:	3.00 ft
Top surface init. length	:	10.00 ft
Top surface incl. angle	:	-18.40 deg
Soil unit weight	:	115.00 lb/ft³
Soil friction angle	:	38.10 deg
Soil cohesion	:	19.90 lb/ft²
Foundation allowable pressure	:	lb/ft²
Water table height	:	ft

Additional Foundation Layers

Layer	Depth ft	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Water profile data

Initial height	:	ft
Inclination of the 1st stretch	:	deg
Length of the 1st stretch	:	ft
Inclination of the 2nd stretch	:	deg
Length of the 2nd stretch	:	ft

Loads data

Distributed loads on backfill			First stretch	:	0.00 lb/ft²
			Second stretch	:	lb/ft²
Distributed loads on wall			Load	:	lb/ft²
Line loads on backfill					
Load 1	:	lb/ft	Distance from wall face	:	ft
Load 2	:	lb/ft	Distance from wall face	:	ft
Load 3	:	lb/ft	Distance from wall face	:	ft
Line load on wall					
Load	:	lb/ft	Distance from wall face	:	ft

Seismic action data

Horizontal coefficient	:	Vertical coefficient	:

STABILITY ANALYSIS RESULTS

Active and Passive Thrust

Active Thrust	: 375.54 lb/ft
Point of application ref. to X axis	: 6.00 ft
Point of application ref. to Y axis	: 1.00 ft
Direction of the thrust ref. to X axis	: 12.96 deg
Passive Thrust	: 2430.45 lb/ft
Point of application ref. to X axis	: 0.00 ft
Point of application ref. to Y axis	: 0.86 ft
Direction of the thrust ref. to X axis	: 0.00 deg

Sliding

Normal force on the base	: 1785.22 lb/ft
Point of application ref. to X axis	: 4.11 ft
Point of application ref. to Y axis	: 0.00 ft
Shear force on the base	: -2064.48 lb/ft
Resisting force on the base	: 3889.95 lb/ft
Sliding Safety Coefficient	**: 10.63**

Overturning

Overturning Moment	: 365.97 lb/ft x ft
Restoring Moment	: 7699.07 lb/ft x ft
Overturning Safety Coefficient	**: 21.04**

Stresses Acting on Foundation

Eccentricity	: -1.11 ft
Normal stress on outer border	: 289.74 lb/ft²
Normal stress on inner border	: 0.00 lb/ft²
Max. allowable stress on the foundation	:12848.94 lb/ft²

Warning. Not all base is used!

Overall Stability

Initial distance at pivot leftside	:	ft
Initial distance at pivot rightside	:	ft
Initial depth referred to base	:	ft
Max depth allowed in calculation	:	ft
Center of the arch referred to X axis	:	12.10 ft
Center of the arch referred to Y axis	:	67.79 ft
Radius of the arch	:	68.92 ft
Number of search surfaces	:	70
Overall Stability Safety Coefficient	**:**	**1.88**

Internal Stability

Layer	H	N	T	M	τ_{Max}	τ_{All}	σ_{Max}	σ_{All}
	ft	lb/ft	lb/ft	lb/ft x ft	lb/ft²	lb/ft²	lb/ft²	lb/ft²

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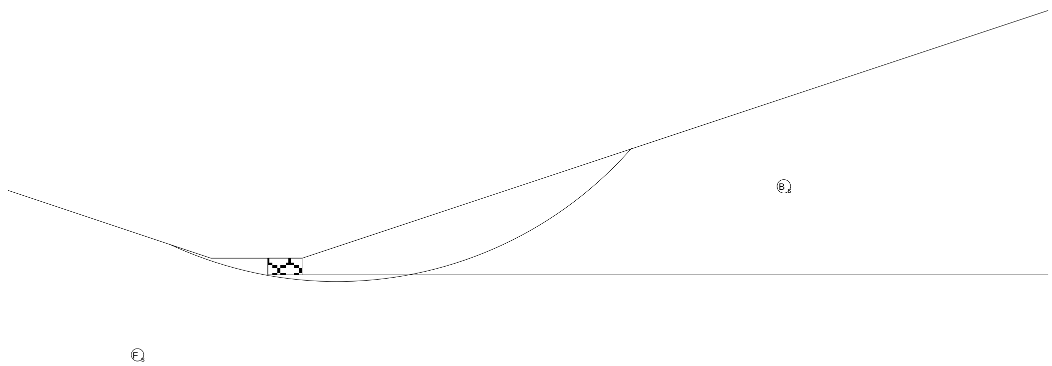
Project: Bonanza1
File: Bonanza1 Date: 9/14/2016



SOIL DATA

Soil	γ lb/ft³	c lb/ft²	ϕ deg	Soil	γ lb/ft³	c lb/ft²	ϕ deg
B_s	125.00	14.00	16.20	F_s	115.00	19.90	38.10

LOADS

Load	Value lb/ft²	Load	Value lb/ft

STABILITY CHECKS

Sliding Safety Coefficient	10.63	Base normal stress (left)	289.74lb/ft²
Overturning Safety Coefficient	21.04	Base normal stress (right)	0.00lb/ft²
Overall Stability Safety Coefficient	1.88	Max. allowable stress	12848.94lb/ft²

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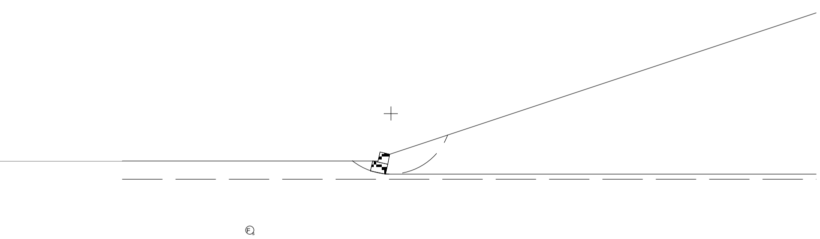
Project: Bonanza2
File: Bonanza2 Date: 9/14/2016

INPUT DATA

Wall data

Wall batter : 12.50 deg
Rockfill unit weight : 135.00 lb/ft³
Porosity of gabions : 30.00 %
Geotextile in the backfill : Yes
Friction reduction : 20.00 %
Geotextile on the base : No
Friction reduction : %
Mesh and the wire diam.: : 8x10, ø 2.70 mm

Layer	Length ft	Width ft	Offset ft
1	4.50	3.00	-
2	3.00	3.00	1.50



Backfill soil data

Inclination of Stretch 1 : 18.40 deg
Length of stretch 1 : 250.00 ft
Inclination of Stretch 2 : deg
Soil unit weight : 125.00 lb/ft³
Soil friction angle : 16.20 deg
Soil cohesion : 14.00 lb/ft²

Additional Backfill Layers

Layer	Initial height ft	Incl. angle deg	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Project: Bonanza2
File: Bonanza2 Date: 9/14/2016

Foundation data

Top surface height	:	3.00 ft
Top surface init. length	:	150.00 ft
Top surface incl. angle	:	0.00 deg
Soil unit weight	:	115.00 lb/ft³
Soil friction angle	:	38.10 deg
Soil cohesion	:	19.90 lb/ft²
Foundation allowable pressure	:	1250.00 lb/ft²
Water table height	:	-2.50 ft

Additional Foundation Layers

Layer	Depth ft	Unit weight lb/ft³	Cohesion lb/ft²	Friction angle deg

Water profile data

Initial height	:	ft
Inclination of the 1st stretch	:	deg
Length of the 1st stretch	:	ft
Inclination of the 2nd stretch	:	deg
Length of the 2nd stretch	:	ft

Loads data

Distributed loads on backfill			First stretch	:	0.00 lb/ft²
			Second stretch	:	lb/ft²
Distributed loads on wall			Load	:	lb/ft²
Line loads on backfill					
Load 1	:	lb/ft	Distance from wall face	:	ft
Load 2	:	lb/ft	Distance from wall face	:	ft
Load 3	:	lb/ft	Distance from wall face	:	ft
Line load on wall					
Load	:	lb/ft	Distance from wall face	:	ft

Seismic action data

Horizontal coefficient	:	Vertical coefficient	:

STABILITY ANALYSIS RESULTS

Active and Passive Thrust

Active Thrust	: 1404.59 lb/ft
Point of application ref. to X axis	: 4.83 ft
Point of application ref. to Y axis	: 0.98 ft
Direction of the thrust ref. to X axis	: 0.46 deg
Passive Thrust	: 2430.45 lb/ft
Point of application ref. to X axis	: 0.23 ft
Point of application ref. to Y axis	: 1.05 ft
Direction of the thrust ref. to X axis	: 0.00 deg

Sliding

Normal force on the base	: 1864.81 lb/ft
Point of application ref. to X axis	: 2.66 ft
Point of application ref. to Y axis	: -0.59 ft
Shear force on the base	: -1464.23 lb/ft
Resisting force on the base	: 4704.76 lb/ft
Sliding Safety Coefficient	**: 3.77**

Overturning

Overturning Moment	: 1374.51 lb/ft x ft
Restoring Moment	: 9143.52 lb/ft x ft
Overturning Safety Coefficient	**: 6.65**

Stresses Acting on Foundation

Eccentricity	: -0.48 ft
Normal stress on outer border	: 290.88 lb/ft²
Normal stress on inner border	: 1005.53 lb/ft²
Max. allowable stress on the foundation	: 1250.00 lb/ft²

Overall Stability

Initial distance at pivot leftside	:	ft
Initial distance at pivot rightside	:	ft
Initial depth referred to base	:	ft
Max depth allowed in calculation	:	ft
Center of the arch referred to X axis	:	5.95 ft
Center of the arch referred to Y axis	:	17.02 ft
Radius of the arch	:	18.08 ft
Number of search surfaces	:	68
Overall Stability Safety Coefficient	**:**	**2.18**

Internal Stability

Layer	H ft	N lb/ft	T lb/ft	M lb/ft x ft	τ_{Max} lb/ft²	τ_{All} lb/ft²	σ_{Max} lb/ft²	σ_{All} lb/ft²
1	2.93	892.00	83.84	1438.68	27.95	570.79	276.52	

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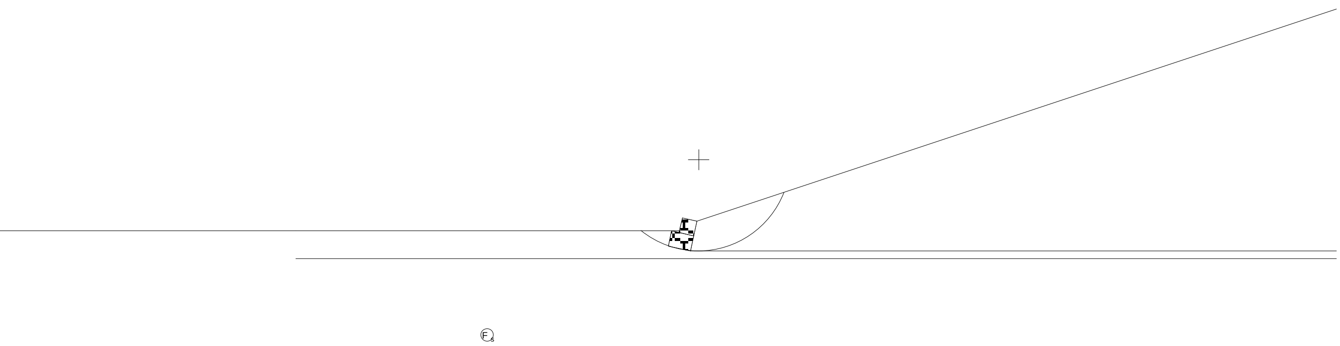
Project: Bonanza2
File: Bonanza2 Date: 9/14/2016



SOIL DATA

Soil	γ lb/ft³	c lb/ft²	ϕ deg	Soil	γ lb/ft³	c lb/ft²	ϕ deg
B_S	125.00	14.00	16.20	F_S	115.00	19.90	38.10

LOADS

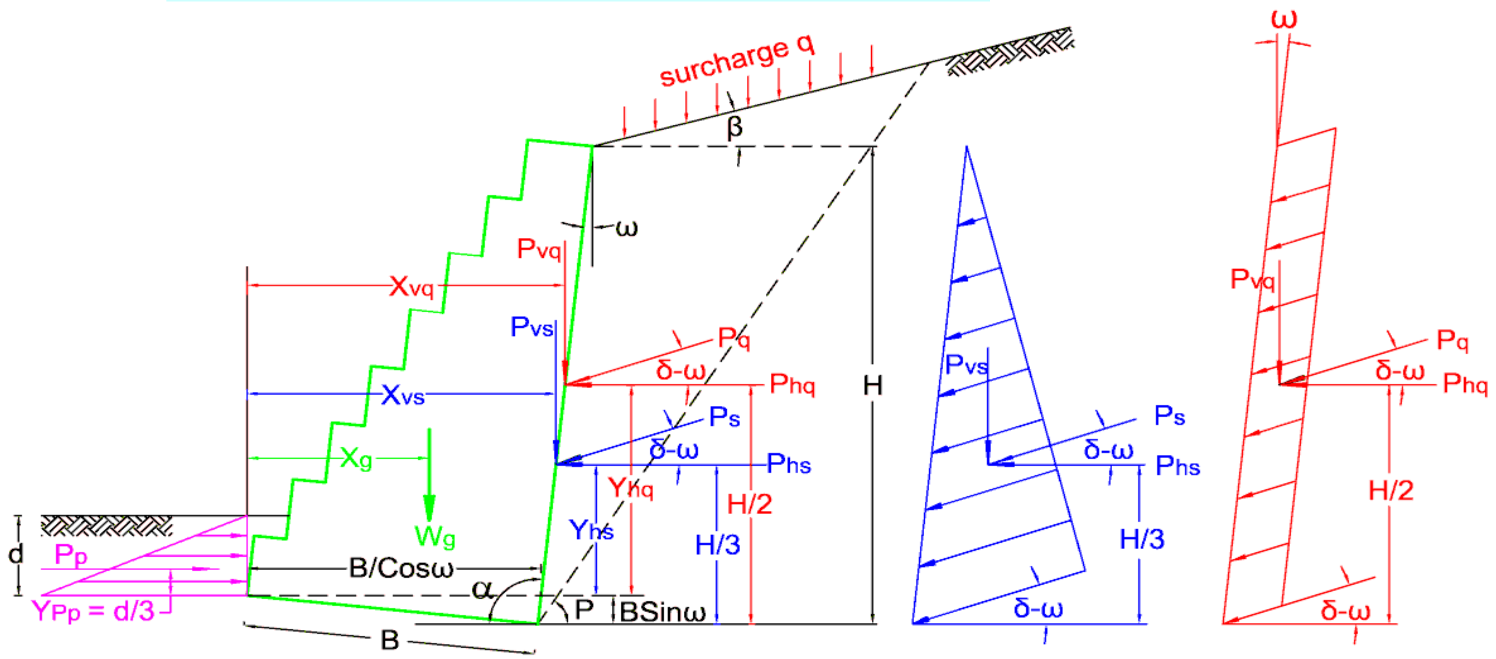
Load	Value lb/ft²	Load	Value lb/ft

STABILITY CHECKS

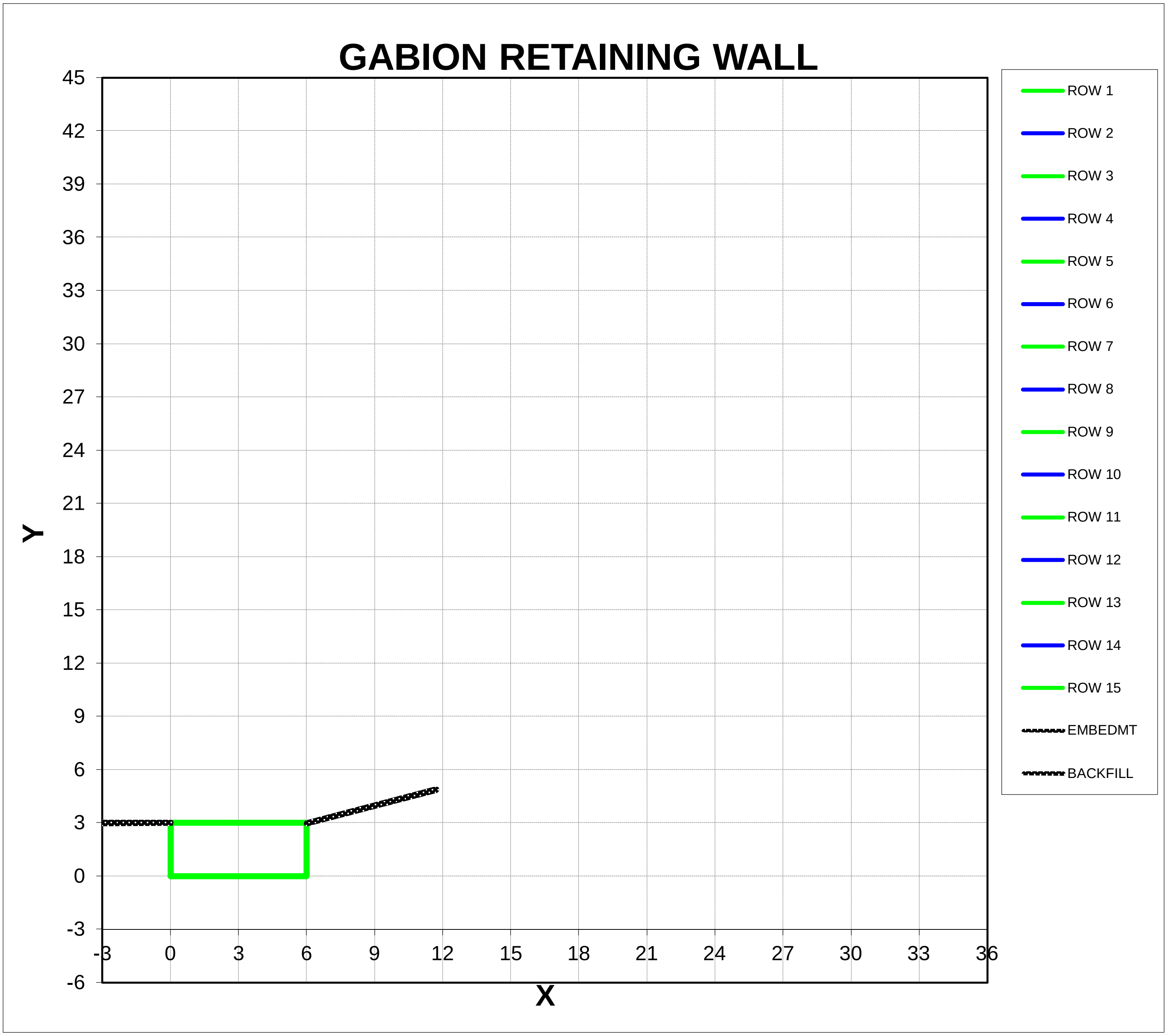
Sliding Safety Coefficient	3.77	Base normal stress (left)	290.88lb/ft²
Overturning Safety Coefficient	6.65	Base normal stress (right)	1005.53lb/ft²
Overall Stability Safety Coefficient	2.18	Max. allowable stress	1250.00lb/ft²

TERRA AQUA GABIONS GRAVITY RETAINING WALL CALCULATIONS
(STRAIGHT LINE BACK)

PROJECT NAME:	Bonanza Mine Repository Repair	**PROJECT #:**	
LOCATION:	Sutherlin, Oregon	**SECTION:**	
GEOTECHNICAL ENGINEER:		**REPORT #:**	
NOTES:	Check of Maccaferri Calculations.	**DRAWING #:**	
		DATE:	8/31/2016



Descriptions	**symbols**	**Input Values**	**Units**	**Notes**
Backfill slope angle above wall	β	18.400	º	< Φ
Angle of internal friction	Φ	30.000	º	
Wall friction reduction by geotextile	fr	20.000	%	Back of wall
Angle of wall friction	δ	24.000	º	Φ(100-fr)/100
Inclination angle to vertical plane	ω	0.000	º	for wall with straight back (no offsets)
Back of wall angle to horizontal	α	90.000	º	90+ω
Cohesion	c	0	psf	Ignore cohesion
Surcharge	q	150.000	psf	
Soil density	γs	135.000	pcf	
Rock density	γr	135.000	pcf	
Void in gabion	v	30.000	%	
Gabion density	γg	94.500	pcf	γr(100-v)/100
Actual height of wall	H	3.000	ft	(hCosω) Corrected for inclination
Embedment	d	3.000	ft	0 ft to ignore passive thrust
Width of base	B	6	ft	
Allowable soil bearing capacity	qa	**1250.000**	psf	**determined by Geotechnical Engineer**



Row #	Width (ft)	Height (ft)	offset (from toe) (ft)	Area (ft²)	X (ft)	Moment (ft³)	Y (ft)	Moment (ft³)
15				0.000	0.000	0.000	0.000	0.000
14				0.000	0.000	0.000	0.000	0.000
13				0.000	0.000	0.000	0.000	0.000
12				0.000	0.000	0.000	0.000	0.000
11				0.000	0.000	0.000	0.000	0.000
10				0.000	0.000	0.000	0.000	0.000
9				0.000	0.000	0.000	0.000	0.000
8				0.000	0.000	0.000	0.000	0.000
7				0.000	0.000	0.000	0.000	0.000
6				0.000	0.000	0.000	0.000	0.000
5				0.000	0.000	0.000	0.000	0.000
4				0.000	0.000	0.000	0.000	0.000
3				0.000	0.000	0.000	0.000	0.000
2				0.000	0.000	0.000	0.000	0.000
1	6.0	3.0	0.00	18.000	3.000	54.000	1.500	27.000
	h=	3.0		18.000	3.000	54.000	1.500	27.000

1 **COULOMB'S THEORY**

BACK

Active earth pressure coefficient K_a = $$\frac{\sin^2(\alpha+\Phi)}{\sin^2\alpha \quad \sin(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\Phi+\delta)\quad \sin(\Phi-\beta)}{\sin(\alpha-\delta)\quad \sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \quad 0.914\left[1+\sqrt{\frac{0.809\quad 0.201}{0.914\quad 0.949}}\right]^2}$$

$$\frac{0.750}{1.876}$$

0.400

Active soil thrust P_s = $0.5K_a\gamma_s \quad H^2$

= 242.808 lb/ft

Active surcharge thrust P_q = $\frac{\sin\alpha}{\sin(\alpha+\beta)} \quad K_aqH$

= $\frac{1.000}{0.949}$ 179.857

= 189.548 lb/ft

Horizontal active soil thrust P_{hs} = $P_s\cos(\delta-\omega)$

= 221.816 lb/ft

Horizontal active surcharge thrust P_{hq} = $P_q\cos(\delta-\omega)$

= 173.161 lb/ft

Vertical active soil thrust P_{vs} = $P_s\sin(\delta-\omega)$

= 98.759 lb/ft

Vertical active surcharge thrust P_{vq} = $P_q\sin(\delta-\omega)$

= 77.096 lb/ft

FRONT

Inclination angle to vertical	ω_p	=	0.000
Front face angle to horizontal	α_p	=	$90-\omega_p$
		=	90.000
Backfill slope	β_p	=	0.000
Angle of wall friction	δ_p	=	0.000

Passive earth pressure coefficient K_p = $$\frac{\sin^2(\alpha-\Phi)}{\sin^2\alpha \quad \sin(\alpha+\delta)\left[1-\sqrt{\frac{\sin(\Phi+\delta)\quad \sin(\Phi+\beta)}{\sin(\alpha+\delta)\quad \sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \quad 1.000 \left[1 - \sqrt{\frac{0.500 \quad 0.500}{1.000 \quad 1.000}} \right]^2}$$

$$\frac{0.750}{0.250}$$

3.000

Passive soil thrust P_p = $0.5K_p\gamma_s$ d^2

= 1822.500 lb/ft

2 Check Overturning:

Vertical distance to P_{hs} Y_{hs} = $H/3 - B\sin\omega$

= 1.000 ft

Vertical distance to P_{hq} Y_{hq} = $H/2 - B\sin\omega$

= 1.500 ft

Overturning moment $\sum M_o$ = $Y_{hs}P_{hs}$ + $Y_{hq}P_{hq}$

= 481.557 ft-lb / ft

Weight of Gabion W_g = $\sum A \gamma_g$

= 1701.000 lb / ft

Horizontal distance to W_g X_g = $Y\sin\omega$ + $X\cos\omega$

= 3.000 ft

Horizontal distance to P_{vs} X_{vs} = $B/\cos\omega$ + $(H/3 - B\sin\omega)\tan\omega$

6.000

Horizontal distance to P_{vq} X_{vq} = $B/\cos\omega$ + $(H/2 - B\sin\omega)\tan\omega$

6.000

Vertical distance to P_p Y_{Pp} = $d/3$

= 1.000

Resisting moment $\sum M_r$ = $W_g X_g$ + $P_{vs} X_{vs}$ + $P_{vq} X_{vq}$ + $P_p Y_{Pp}$

= 7980.629 ft-lb / ft

Overturning factor of safety SF_o = $\frac{\sum M_r}{\sum M_o}$

16.573 ≥ 2.000 **O.K**

3 Check Sliding

Total Normal forces	$\sum W$	=	$W_g \cos\omega$ +	$P_s \sin\delta$ +	$P_q \sin\delta$ -	$P_p \sin\omega$	
		=	1876.855	lb/ft			
Frictional force	F_f	=	$\sum W$	$\tan\Phi$			
		=	1876.855	0.577			
		=	1083.603				
Total Resisting Forces	$\sum F_r$	=	$F_f + \cos\omega P_p$				
		=	2906.103				
Total Driving Forces at base	$\sum F_d$	=	$P_s \cos\delta$ +	$P_q \cos\delta$ -	$W_g \sin\omega$		
			394.976				
Siding factor of safety	SF_s	=	$\frac{\sum F_r}{\sum F_d}$				
			7.358	≥	1.500	**O.K**	

4 Check the Eccentricity of Resultant Force
(Resultant is in middle one third)

Eccentricity	e	=	0.5 B	-	$\frac{(\sum M_r - M_o)}{\sum W}$		
		=	3.000	-	3.996		
		=	-B/6	≤	e	≤	+B/6
			-1.000	≤ **O.K**	-0.996	≤ **O.K**	1.000

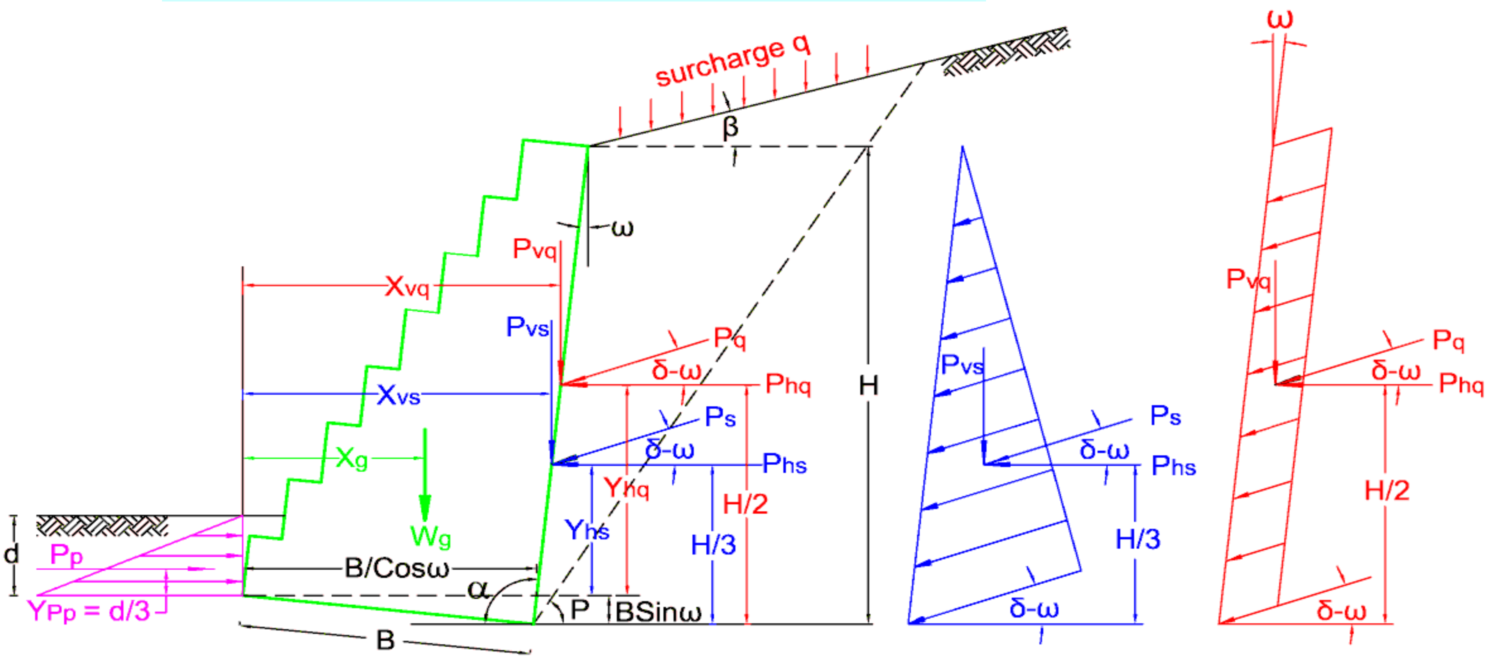
5 Check Bearing

Applied bearing pressure	P	=	$\frac{\sum W}{B}$	(1±	6e/B)		
		=	312.809	(1±	0.996	)	
	Right	=	624.227	psf	≤	1250.000	**O.K**
	Left	=	1.391	psf	≤	1250.000	**O.K**

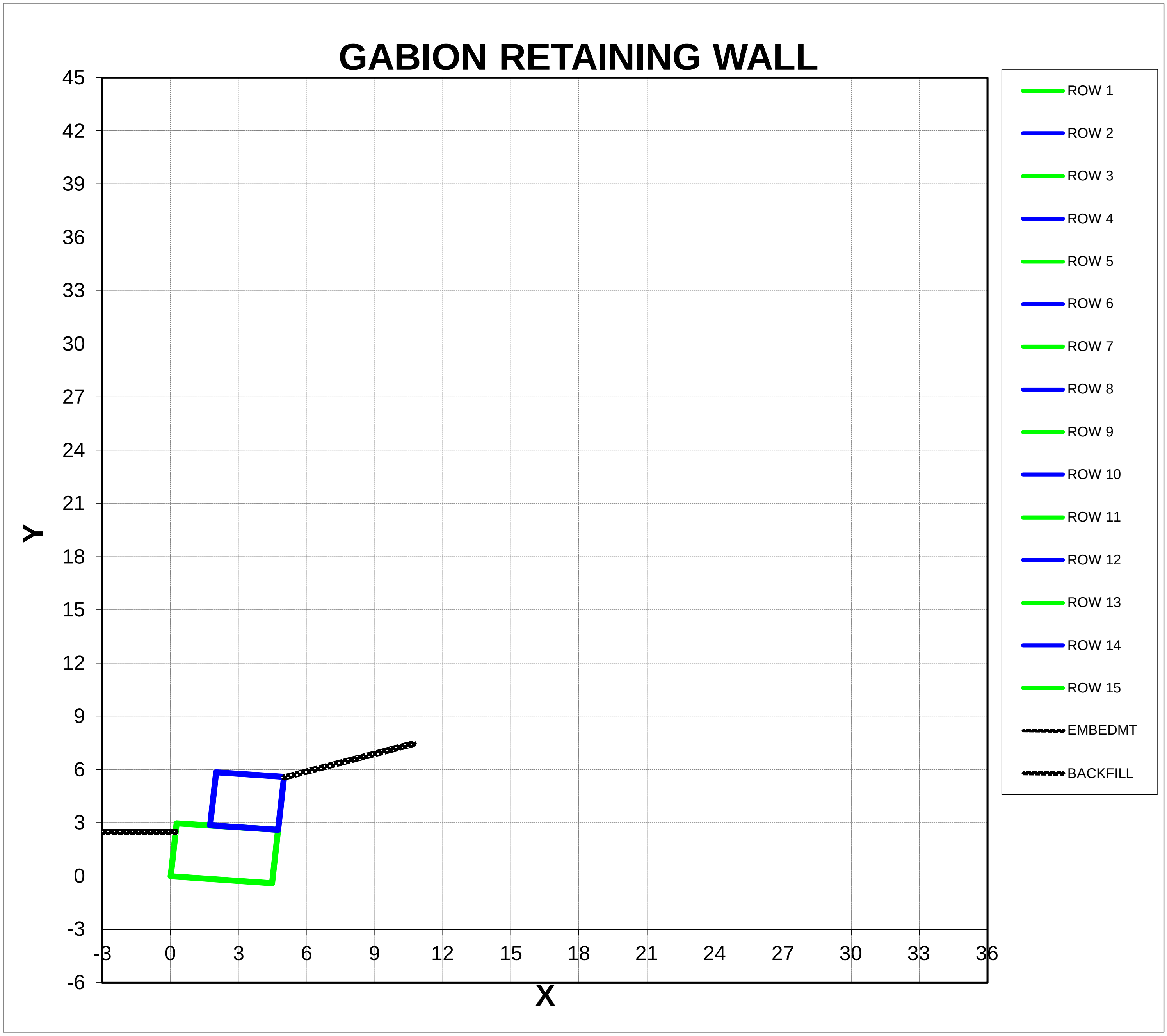
Additional calculations may have to be performed including and not limiting to global stability analysis (by (Geotechnical Engineer), seismic forces (by Seismic Engineer) and hydraulic forces (by Hydraulic Engineer). Please check local, State and Federal requirements. The calculator assumes drained uniformed retained and foundation soil properties. The calculations should be reviewed, checked and certified by a Professional Engineer. To the best of our knowledge, the calculator and information was prepared accurately. Terra Aqua is not responsible for the reliability and validity of the geotechnical parameters assumed in the calculations. The calculator is intended to provided design design assistance to the engineer for the purpose of designing with Terra Aqua products.

TERRA AQUA GABIONS GRAVITY RETAINING WALL CALCULATIONS
(STRAIGHT LINE BACK)

PROJECT NAME:	Bonanza Mine Repository Repair	**PROJECT #:**	
LOCATION:	Sutherlin, Oregon	**SECTION:**	
GEOTECHNICAL ENGINEER:		**REPORT #:**	
NOTES:	Check of Maccaferri calculations.	**DRAWING #:**	
		DATE:	8/31/2016



Descriptions	symbols	Input Values	Units	Notes
Backfill slope angle above wall	β	18.400	o	< Φ
Angle of internal friction	Φ	30.000	o	
Wall friction reduction by geotextile	fr	20.000	%	Back of wall
Angle of wall friction	δ	24.000	o	Φ(100-fr)/100
Inclination angle to vertical plane	ω	5.000	o	for wall with straight back (no offsets)
Back of wall angle to horizontal	α	95.000	o	90+ω
Cohesion	c	0	psf	Ignore cohesion
Surcharge	q	150.000	psf	
Soil density	γs	135.000	pcf	
Rock density	γr	135.000	pcf	
Void in gabion	v	30.000	%	
Gabion density	γg	94.500	pcf	γr(100-v)/100
Actual height of wall	H	5.977	ft	(hCosω) Corrected for inclination
Embedment	d	2.500	ft	0 ft to ignore passive thrust
Width of base	B	4.5	ft	
Allowable soil bearing capacity	qa	**1250.000**	psf	**determined by Geotechnical Engineer**



Row #	Width (ft)	Height (ft)	offset (from toe) (ft)	Area (ft²)	X (ft)	Moment (ft³)	Y (ft)	Moment (ft³)
15				0.000	0.000	0.000	0.000	0.000
14				0.000	0.000	0.000	0.000	0.000
13				0.000	0.000	0.000	0.000	0.000
12				0.000	0.000	0.000	0.000	0.000
11				0.000	0.000	0.000	0.000	0.000
10				0.000	0.000	0.000	0.000	0.000
9				0.000	0.000	0.000	0.000	0.000
8				0.000	0.000	0.000	0.000	0.000
7				0.000	0.000	0.000	0.000	0.000
6				0.000	0.000	0.000	0.000	0.000
5				0.000	0.000	0.000	0.000	0.000
4				0.000	0.000	0.000	0.000	0.000
3				0.000	0.000	0.000	0.000	0.000
2	3.0	3.0	1.50	9.000	3.000	27.000	4.500	40.500
1	4.5	3.0	0.00	13.500	2.250	30.375	1.500	20.250
	h=	6.0		22.500	2.550	57.375	2.700	60.750

1 COULOMB'S THEORY

BACK

Active earth pressure coefficient

$$K_a = \frac{\sin^2(\alpha+\Phi)}{\sin^2\alpha \;\; \sin(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\Phi+\delta)\;\;\sin(\Phi-\beta)}{\sin(\alpha-\delta)\;\;\sin(\alpha+\beta)}}\right]^2}$$

$$= \frac{0.671}{0.992 \;\; 0.946\left[1+\sqrt{\frac{0.809 \;\; 0.201}{0.946 \;\; 0.918}}\right]^2}$$

$$= \frac{0.671}{1.927}$$

$$= 0.348$$

Active soil thrust $P_s = 0.5K_a\gamma_s \;\; H^2$

$= 839.824$ lb/ft

Active surcharge thrust $P_q = \frac{\sin\alpha}{\sin(\alpha+\beta)} \;\; K_a qH$

$= \frac{0.996}{0.918} \;\; 312.234$

$= 338.920$ lb/ft

Horizontal active soil thrust $P_{hs} = P_s\cos(\delta-\omega)$

$= 794.069$ lb/ft

Horizontal active surcharge thrust $P_{hq} = P_q\cos(\delta-\omega)$

$= 320.456$ lb/ft

Vertical active soil thrust $P_{vs} = P_s\sin(\delta-\omega)$

$= 273.420$ lb/ft

Vertical active surcharge thrust $P_{vq} = P_q\sin(\delta-\omega)$

$= 110.342$ lb/ft

FRONT

Inclination angle to vertical $\omega_p = 0.000$

Front face angle to horizontal $\alpha_p = 90-\omega_p$

$= 90.000$

Backfill slope $\beta_p = 0.000$

Angle of wall friction $\delta_p = 0.000$

Passive earth pressure coefficient

$$K_p = \frac{\sin^2(\alpha-\Phi)}{\sin^2\alpha \;\; \sin(\alpha+\delta)\left[1-\sqrt{\frac{\sin(\Phi+\delta)\;\;\sin(\Phi+\beta)}{\sin(\alpha+\delta)\;\;\sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \quad 1.000\left[1-\sqrt{\frac{0.500}{1.000}\quad\frac{0.500}{1.000}}\right]^{2}}$$

$$\frac{0.750}{0.250}$$

3.000

Passive soil thrust P_p = $0.5K_p\gamma_s$ d^2

= 1265.625 lb/ft

2 Check Overturning:

Vertical distance to P_{hs} Y_{hs} = $H/3-B\sin\omega$

= 1.600 ft

Vertical distance to P_{hq} Y_{hq} = $H/2-B\sin\omega$

= 2.596 ft

Overturning moment $\sum M_o$ = $Y_{hs}P_{hs}$ + $Y_{hq}P_{hq}$

= 2102.685 ft-lb / ft

Weight of Gabion W_g = $\sum A\,\gamma_g$

= 2126.250 lb / ft

Horizontal distance to W_g X_g = $Y\sin\omega$ + $X\cos\omega$

= 2.776 ft

Horizontal distance to P_{vs} X_{vs} = $B/\cos\omega$ + $(H/3-B\sin\omega)\tan\omega$

4.657

Horizontal distance to P_{vq} X_{vq} = $B/\cos\omega$ + $(H/2-B\sin\omega)\tan\omega$

4.744

Vertical distance to P_p Y_{Pp} = $d/3$

= 0.833

Resisting moment $\sum M_r$ = $W_g X_g$ + $P_{vs} X_{vs}$ + $P_{vq} X_{vq}$ + $P_p Y_{Pp}$

= 8753.209 ft-lb / ft

Overturning factor of safety SF_o = $\frac{\sum M_r}{\sum M_o}$

4.163 ≥ 2.000 **O.K**

3 Check Sliding

Total Normal forces	$\sum W$	=	$W_g \cos\omega$ +	$P_s \sin\delta$ +	$P_q \sin\delta$ -	$P_p \sin\omega$	
		=	2487.291	lb/ft			
Frictional force	F_f	=	$\sum W$	$\tan\Phi$			
		=	2487.291	0.577			
		=	1436.038				
Total Resisting Forces	$\sum F_r$	=	$F_f + \cos\omega P_p$				
		=	2696.847				
Total Driving Forces at base	$\sum F_d$	=	$P_s \cos\delta$ +	$P_q \cos\delta$ -	$W_g \sin\omega$		
			891.521				
Siding factor of safety	SF_s	=	$\frac{\sum F_r}{\sum F_d}$				
			3.025	≥	1.500	**O.K**	

4 Check the Eccentricity of Resultant Force
(Resultant is in middle one third)

Eccentricity	e	=	0.5 B	-	$\frac{(\sum M_r - M_o)}{\sum W}$		
		=	2.250	-	2.674		
		=	-B/6	≤	e	≤	+B/6
			-0.750	≤	-0.424	≤	0.750
				O.K		**O.K**	

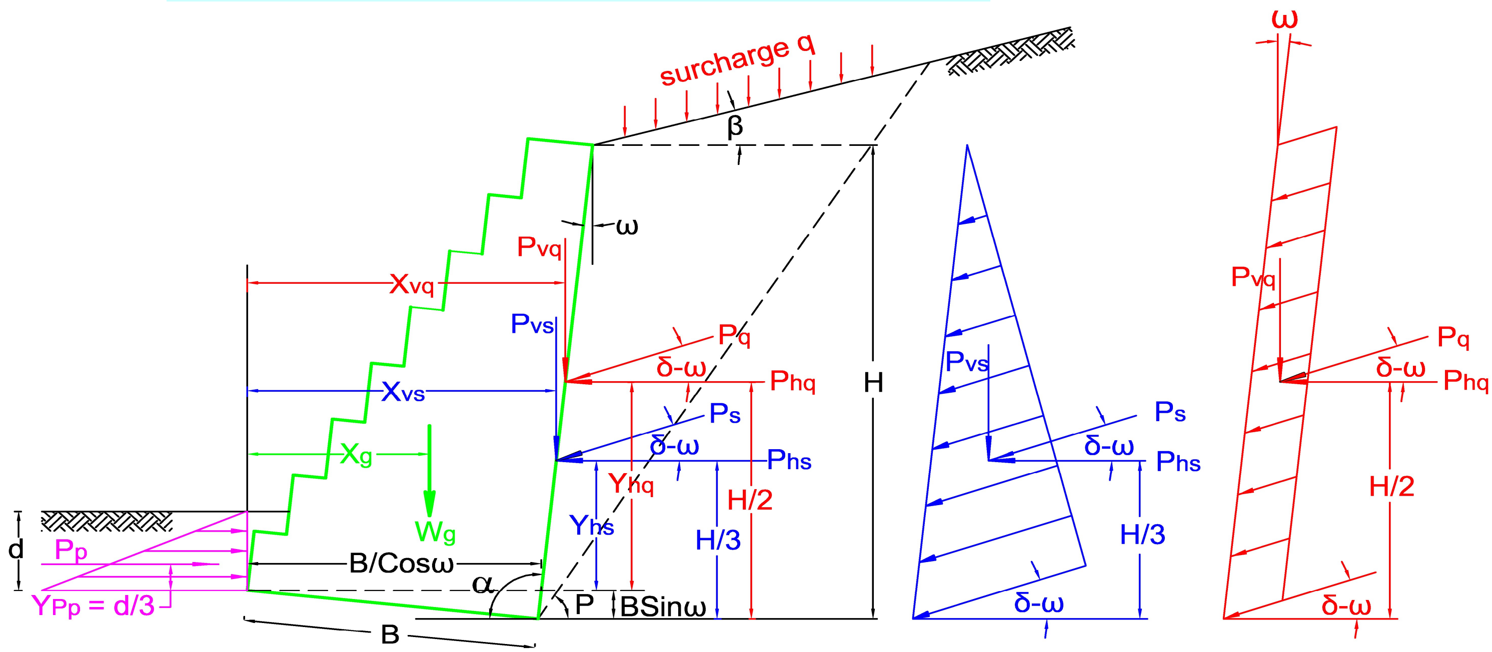
5 Check Bearing

Applied bearing pressure	P	=	$\frac{\sum W}{B}$	(1±	6e/B)		
		=	552.731	(1±	0.565	)	
	Right	=	865.063	psf	≤	1250.000	**O.K**
	Left	=	240.400	psf	≤	1250.000	**O.K**

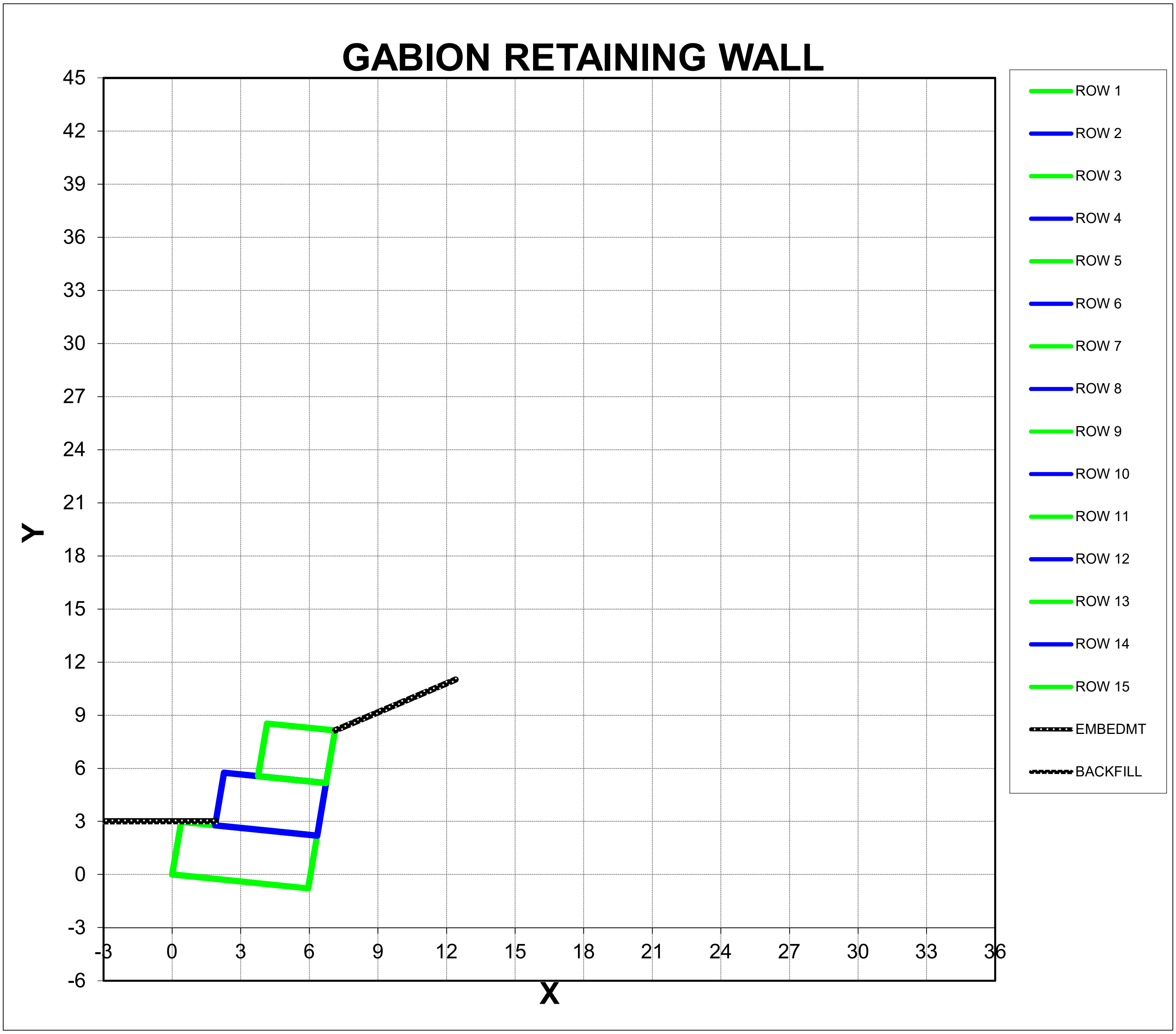
Additional calculations may have to be performed including and not limiting to global stability analysis (by (Geotechnical Engineer), seismic forces (by Seismic Engineer) and hydraulic forces (by Hydraulic Engineer).
Please check local, State and Federal requirements. The calculator assumes drained uniformed retained and foundation soil properties. The calculations should be reviewed, checked and certified by a Professional Engineer. To the best of our knowledge, the calculator and information was prepared accurately. Terra Aqua is not responsible for the reliability and validity of the geotechnical parameters assumed in the calculations. The calculator is intended to provided design design assistance to the engineer for the purpose of designing with Terra Aqua products.

TERRA AQUA GABIONS GRAVITY RETAINING WALL CALCULATIONS (STRAIGHT LINE BACK)

PROJECT NAME:	Bonanza Mine Repository Repair	**PROJECT #:**	
LOCATION:	Sutherlin, Oregon	**SECTION:**	
GEOTECHNICAL ENGINEER:		**REPORT #:**	
NOTES:	Check of Maccaferri calculations.	**DRAWING #:**	
		DATE:	9/21/2016



Descriptions	**symbols**	**Input Values**	**Units**	**Notes**
Backfill slope angle above wall	β	28.648	°	< Φ
Angle of internal friction	Φ	30.000	°	
Wall friction reduction by geotextile	fr	20.000	%	Back of wall
Angle of wall friction	δ	24.000	°	Φ(100-fr)/100
Inclination angle to vertical plane	ω	7.500	°	for wall with straight back (no offsets)
Back of wall angle to horizontal	α	97.500	°	90+ω
Cohesion	c	0	psf	Ignore cohesion
Surcharge	q	150.000	psf	
Soil density	γ_s	135.000	pcf	
Rock density	γ_r	135.000	pcf	
Void in gabion	v	30.000	%	
Gabion density	γ_g	94.500	pcf	γ_r(100-v)/100
Actual height of wall	H	8.923	ft	(hCosω) Corrected for inclination
Embedment	d	3.000	ft	0 ft to ignore passive thrust
Width of base	B	6	ft	
Allowable soil bearing capacity	q_a	**1250.000**	psf	**determined by Geotechnical Engineer**



Row #	Width (ft)	Height (ft)	offset (from toe) (ft)	Area (ft²)	X (ft)	Moment (ft³)	Y (ft)	Moment (ft³)
15				0.000	0.000	0.000	0.000	0.000
14				0.000	0.000	0.000	0.000	0.000
13				0.000	0.000	0.000	0.000	0.000
12				0.000	0.000	0.000	0.000	0.000
11				0.000	0.000	0.000	0.000	0.000
10				0.000	0.000	0.000	0.000	0.000
9				0.000	0.000	0.000	0.000	0.000
8				0.000	0.000	0.000	0.000	0.000
7				0.000	0.000	0.000	0.000	0.000
6				0.000	0.000	0.000	0.000	0.000
5				0.000	0.000	0.000	0.000	0.000
4				0.000	0.000	0.000	0.000	0.000
3	3.0	3.0	3.00	9.000	4.500	40.500	7.500	67.500
2	4.5	3.0	1.50	13.500	3.750	50.625	4.500	60.750
1	6.0	3.0	0.00	18.000	3.000	54.000	1.500	27.000
	h=	9.0		40.500	3.583	145.125	3.833	155.250

1 **COULOMB'S THEORY**

BACK

Active earth pressure coefficient

$$K_a = \frac{\sin^2(\alpha+\Phi)}{\sin^2\alpha \; \sin(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\Phi+\delta)\;\sin(\Phi-\beta)}{\sin(\alpha-\delta)\;\sin(\alpha+\beta)}}\right]^2}$$

$$= \frac{0.629}{0.983 \;\; 0.959\left[1+\sqrt{\frac{0.809\;\;0.024}{0.959\;\;0.807}}\right]^2}$$

$$= \frac{0.629}{1.262}$$

$$= 0.499$$

Active soil thrust $P_s = 0.5K_a\gamma_s \; H^2$

$= 2681.025$ lb/ft

Active surcharge thrust $P_q = \frac{\sin\alpha}{\sin(\alpha+\beta)} \; K_a qH$

$= \frac{0.991}{0.807} \; 667.694$

$= 819.794$ lb/ft

Horizontal active soil thrust $P_{hs} = P_s\cos(\delta-\omega)$

$= 2570.620$ lb/ft

Horizontal active surcharge thrust $P_{hq} = P_q\cos(\delta-\omega)$

$= 786.035$ lb/ft

Vertical active soil thrust $P_{vs} = P_s\sin(\delta-\omega)$

$= 761.452$ lb/ft

Vertical active surcharge thrust $P_{vq} = P_q\sin(\delta-\omega)$

$= 232.834$ lb/ft

FRONT

Inclination angle to vertical $\omega_p = 0.000$

Front face angle to horizontal $\alpha_p = 90-\omega_p$

$= 90.000$

Backfill slope $\beta_p = 0.000$

Angle of wall friction $\delta_p = 0.000$

Passive earth pressure coefficient

$$K_p = \frac{\sin^2(\alpha-\Phi)}{\sin^2\alpha \; \sin(\alpha+\delta)\left[1-\sqrt{\frac{\sin(\Phi+\delta)\;\sin(\Phi+\beta)}{\sin(\alpha+\delta)\;\sin(\alpha+\beta)}}\right]^2}$$

$$\frac{0.750}{1.000 \quad 1.000 \left[1- \sqrt{\frac{0.500 \quad 0.500}{1.000 \quad 1.000}} \right]^2}$$

$$\frac{0.750}{0.250}$$

3.000

Passive soil thrust $P_p = 0.5K_p\gamma_s \quad d^2$

$= 1822.500$ lb/ft

2 Check Overturning:

Vertical distance to P_{hs} $\quad Y_{hs} = H/3-BSin\omega$

$= 2.191$ ft

Vertical distance to P_{hq} $\quad Y_{hq} = H/2-BSin\omega$

$= 3.678$ ft

Overturning moment $\quad \sum M_o = Y_{hs}P_{hs} + Y_{hq}P_{hq}$

$= 8523.991$ ft-lb / ft

Weight of Gabion $\quad W_g = \sum A \gamma_g$

$= 3827.250$ lb / ft

Horizontal distance to W_g $\quad X_g = Ysin\omega + XCos\omega$

$= 4.053$ ft

Horizontal distance to P_{vs} $\quad X_{vs} = B/Cos\omega + (H/3-BSin\omega)Tan\omega$

6.340

Horizontal distance to P_{vq} $\quad X_{vq} = B/Cos\omega + (H/2-BSin\omega)Tan\omega$

6.536

Vertical distance to P_p $\quad Y_{Pp} = d/3$

$= 1.000$

Resisting moment $\quad \sum M_r = W_g X_g + P_{vs} X_{vs} + P_{vq} X_{vq} + P_pY_{Pp}$

$= 23684.059$ ft-lb / ft

Overturning factor of safety $\quad SF_o = \frac{\sum M_r}{\sum M_o}$

2.779 $\geq$ 2.000 **O.K**

3 Check Sliding

Total Normal forces	$\sum W$	=	$W_g Cos\omega$ +	$P_s Sin\delta$ +	$P_q Sin\delta$ -	$P_p Sin\omega$
		=	4980.535	lb/ft		
Frictional force	F_f	=	$\sum W$	$Tan\Phi$		
		=	4980.535	0.577		
		=	2875.513			
Total Resisting Forces	$\sum F_r$	=	$F_f + Cos\omega P_p$			
		=	4682.421			
Total Driving Forces at base	$\sum F_d$	=	$P_s Cos\delta$ +	$P_q Cos\delta$ -	$W_g Sin\omega$	
			2698.601			
Siding factor of safety	SF_s	=	$\frac{\sum F_r}{\sum F_d}$			
			1.735	≥	1.500	**O.K**

4 Check the Eccentricity of Resultant Force

(Resultant is in middle one third)

Eccentricity	e	=	0.5 B	-	$\frac{(\sum M_r - M_o)}{\sum W}$		
		=	3.000	-	3.044		
		=	-B/6	≤	e	≤	+B/6
			-1.000	≤ **O.K**	-0.044	≤ **O.K**	1.000

5 Check Bearing

Applied bearing pressure	P	=	$\frac{\sum W}{B}$	(1±	6e/B)		
		=	830.089	(1±	0.044)		
	Right	=	866.500	psf	≤	1250.000	**O.K**
	Left	=	793.678	psf	≤	1250.000	**O.K**

Additional calculations may have to be performed including and not limiting to global stability analysis (by (Geotechnical Engineer), seismic forces (by Seismic Engineer) and hydraulic forces (by Hydraulic Engineer). Please check local, State and Federal requirements. The calculator assumes drained uniformed retained and foundation soil properties. The calculations should be reviewed, checked and certified by a Professional Engineer. To the best of our knowledge, the calculator and information was prepared accurately. Terra Aqua is not responsible for the reliability and validity of the geotechnical parameters assumed in the calculations. The calculator is intended to provided design design assistance to the engineer for the purpose of designing with Terra Aqua products.

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	04/15/16	Tested By:	dln
End Date:	04/18/16	Checked By:	jdt
Boring ID:	Bonanza		
Sample ID:	16031005		
Depth, ft:	Bottom Repos		
Soil Description:	Moist, light olive brown sandy clay		

Direct Shear Test Series by ASTM D3080

Soil Preparation:	Target Compaction: 90% of Maximum Dry Density at Optimum Moisture Content		
Compaction Characteristics:	Maximum Dry Density	106.8 pcf	
	Optimum Moisture Content	19.1 %	
	Compaction Test Method	ASTM D698	
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2		
Maximum Particle Size Used, in:	0.5	Horizontal Displacement, in/min:	0.02
Soil Height, in:	3	Test Condition:	inundated
Gap Between Boxes, in:	0.25		

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	18.7	18.4	18.8	---	---	---
Initial Dry Density, pcf	96.2	96.5	96.2	---	---	---
Percent Compaction, %	90.1	90.4	90.0	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	113	386	817	---	---	---
Final Moisture Content, %	29.6	25.4	23.8	---	---	---

Notes:

Peak Friction Angle:	**38.1**	**degrees**
Peak Cohesion:	**19.9**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

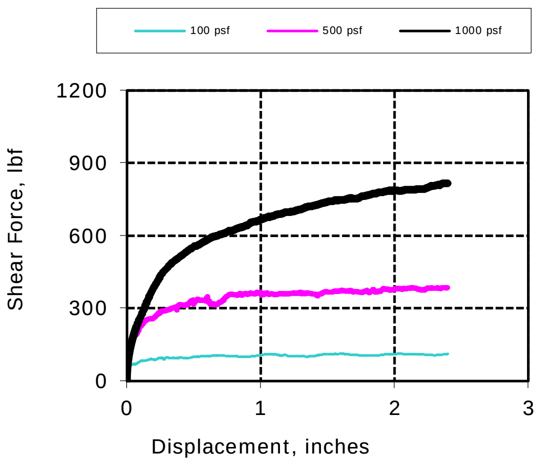
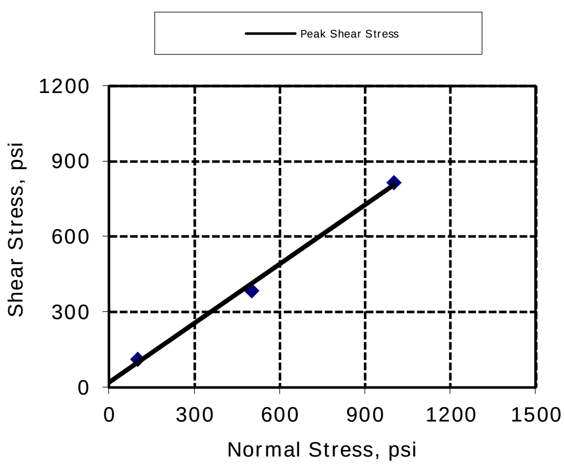


Figure b. Shear Stress vs. Normal Stress



Client:	Test America		
Project Name:	Bonanza Landfill		
Project Location:	---		
GTX #:	304536		
Start Date:	04/12/16	Tested By:	dln
End Date:	04/15/16	Checked By:	emm
Soil ID:	Bonanza, 16031005, Bottom Repos		
Soil Description:	Moist, light olive brown sandy clay		
Geomembrane ID:	Roll 3/24/16 (Roll # not provided)		
Geomembrane Description:	Black, 40 mil Agru textured LLDPE geomembrane		

Interface Shear Test Series by ASTM D5321

Test Series #:	1
Test Profile - Top to Bottom:	steel plate / SOIL / GEOMEMBRANE / textured gripping surface
Soil Preparation:	Soil compacted to 90% of Maximum Dry Density at Optimum Moisture Content.
Compaction Characteristics:	Maximum Dry Density 106.8 pcf
	Optimum Moisture Content 19.1 %
	Compaction Test Method ASTM D698
Geosynthetic Preparation:	Test set-up saturated at normal load for 1 hour prior to shear
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2
Horizontal Displacement, in/min:	0.04 Test Condition: inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	20.0	19.9	20.0	---	---	---
Initial Dry Density, pcf	97.2	97.3	97.2	---	---	---
Percent Compaction, %	91.0	91.1	91.0	---	---	---
Final Moisture Content, %	30.0	26.1	25.4	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	125	364	732	---	---	---
Post Peak Shear Stress, psf	125	325	722	---	---	---
Peak Secant Friction Angle, °	51.3	36.1	36.2	---	---	---
Post-Peak Secant Friction Angle, °	51.3	33.0	35.8	---	---	---
Pre-Test: Average Asperity, mils	37.0	38.1	41.1	---	---	---
Post-Test: Average Asperity, mils	36.3	37.8	39.1	---	---	---

NOTES: Asperity measurements taken on side of membrane involved in shear plane in general accordance with ASTM D7466. Six measurements taken at the same locations before and after test.

Peak Friction Angle:	**34.1**	**degrees**
Peak Adhesion:	**46**	**psf**
Post Peak Friction Angle:	**33.8**	**degrees**
Post Peak Adhesion:	**34**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

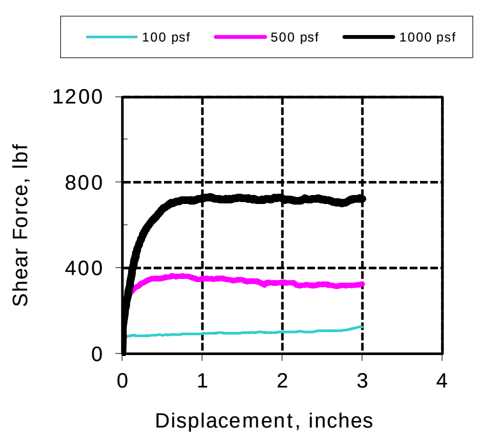
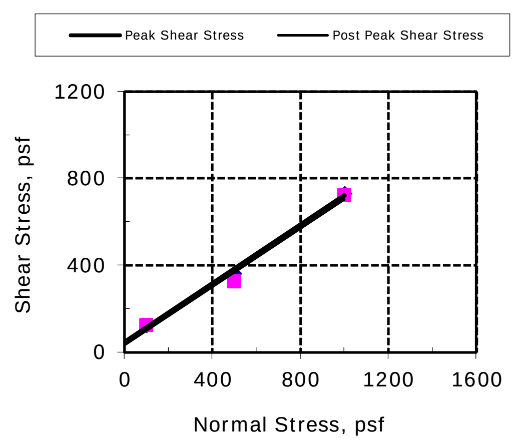


Figure b. Shear Stress vs. Normal Stress



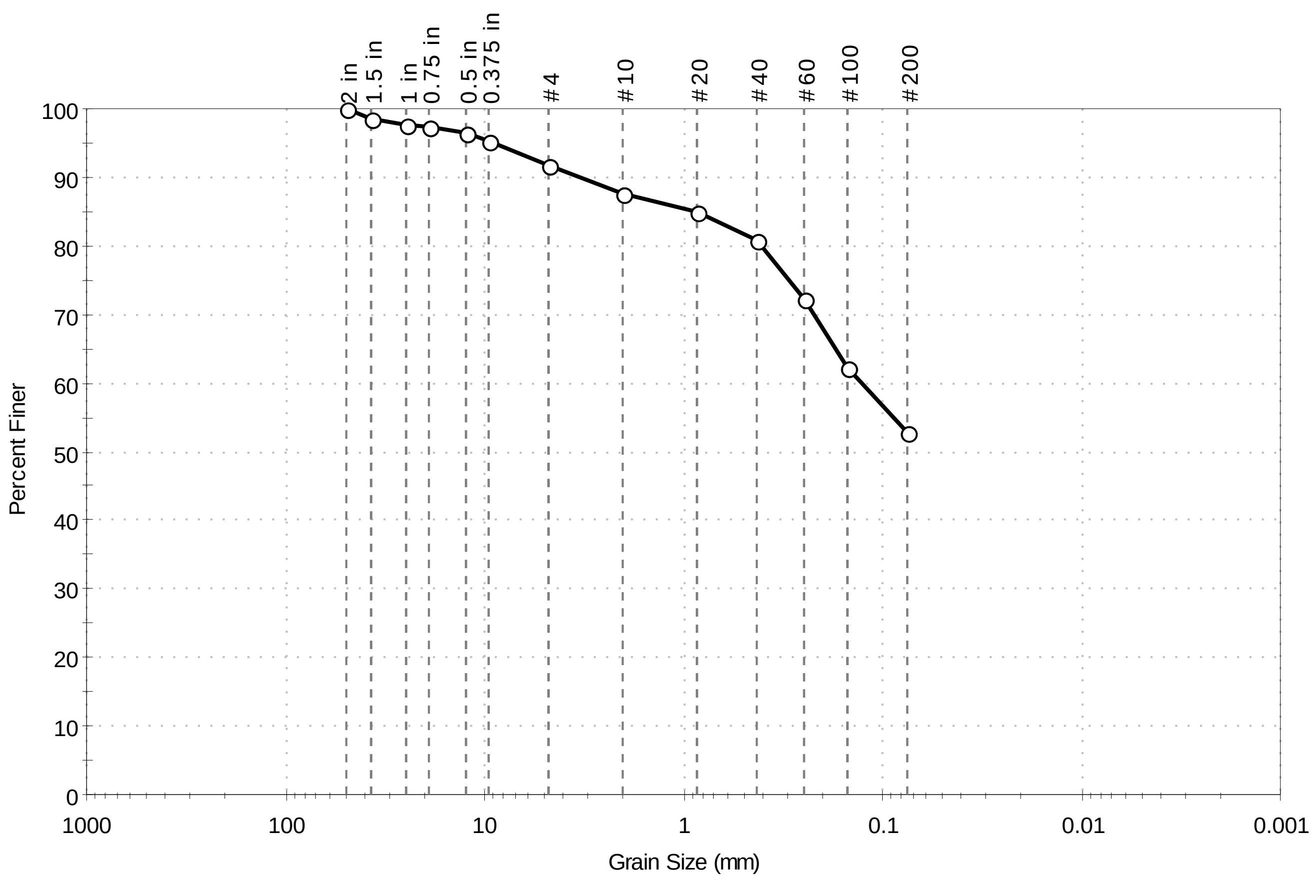
Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Form D5321, version 2

GeoTesting EXPRESS

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	jbr
Sample ID:	16031005	Test Date:	04/04/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370686		
Test Comment:	---				
Visual Description:	Moist, light olive brown sandy clay				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	8.2	38.9	52.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	98		
1 in	25.00	98		
0.75 in	19.00	97		
0.5 in	12.50	97		
0.375 in	9.50	95		
#4	4.75	92		
#10	2.00	88		
#20	0.85	85		
#40	0.42	81		
#60	0.25	72		
#100	0.15	62		
#200	0.075	53		

Coefficients

D_{85} = 0.8573 mm	D_{30} = N/A
D_{60} = 0.1268 mm	D_{15} = N/A
D_{50} = N/A	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM Sandy Lean clay (CL)

AASHTO Clayey Soils (A-6 (6))

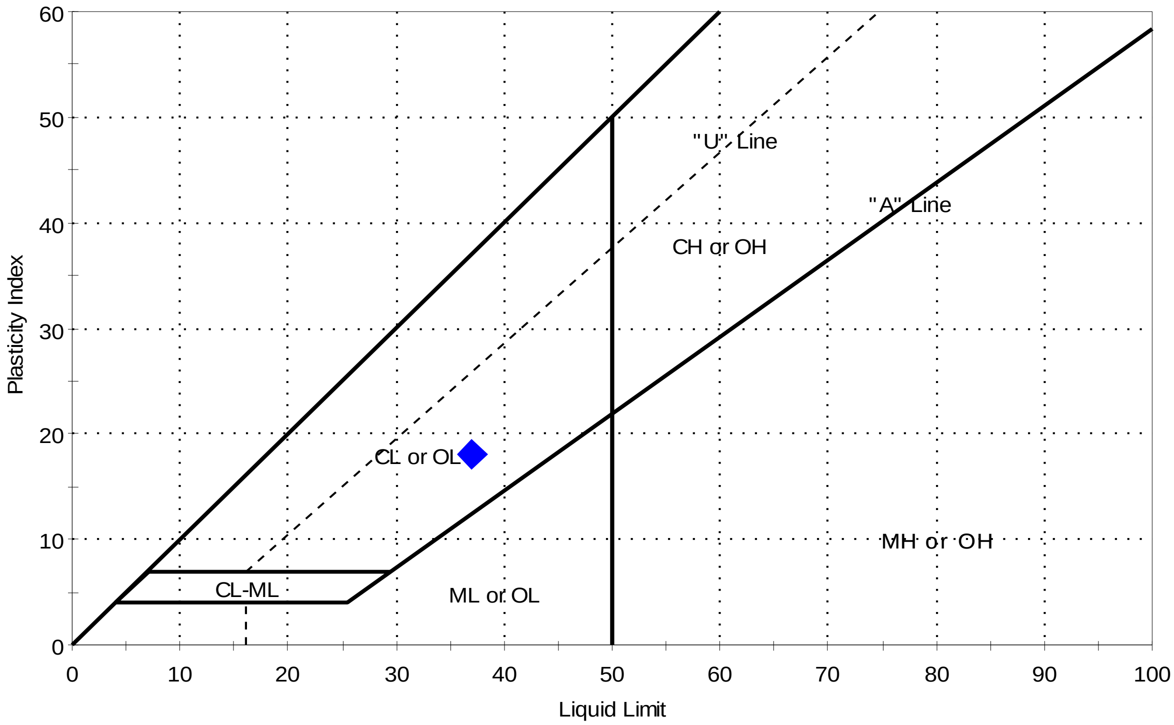
Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Test America
Project:	Bonanza Mine
Location:	---
Project No:	GTX-304536
Boring ID:	Bonanza
Sample Type:	bucket
Tested By:	cam
Sample ID:	16031005
Test Date:	04/05/16
Checked By:	emm
Depth :	Bottom Repos
Test Id:	370691
Test Comment:	---
Visual Description:	Moist, light olive brown sandy clay
Sample Comment:	---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	16031005	Bonanza	Bottom Repos	24	37	19	18	0.3	Sandy Lean clay (CL)

Sample Prepared using the WET method

19% Retained on #40 Sieve

Dry Strength: VERY HIGH

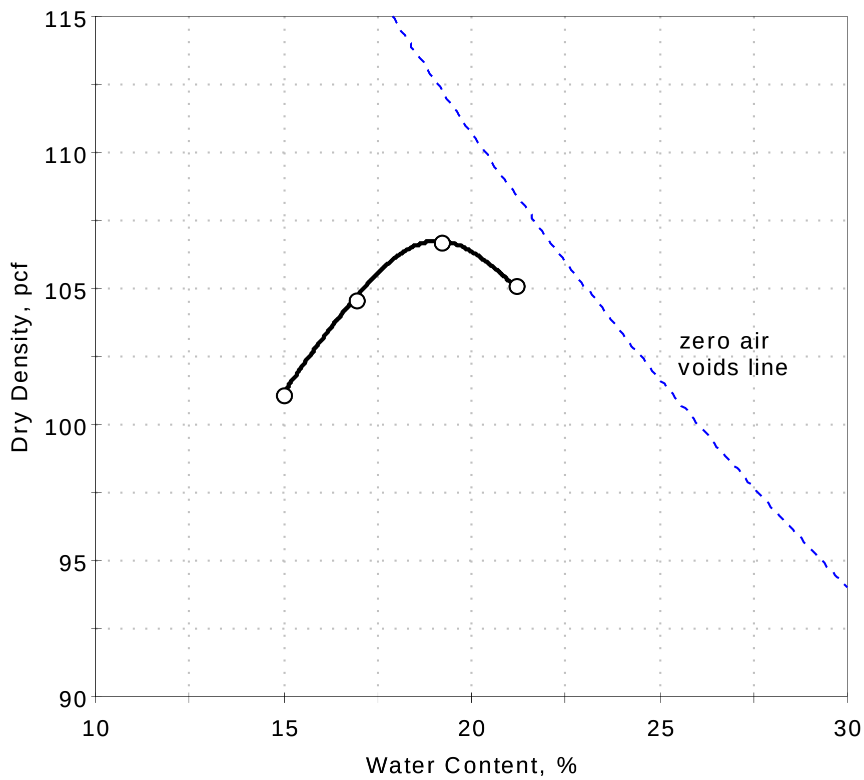
Dilatancy: SLOW

Toughness: LOW

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	pmh
Sample ID:	16031005	Test Date:	04/04/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370701		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay
Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	101.1	104.6	106.8	105.1
Moisture Content, %	15.0	16.9	19.2	21.1

Method : B

Preparation : DRY

As received Moisture :24 %

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.75

Maximum Dry Density= 106.8 pcf
Optimum Moisture= 19.1 %

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Client:	Test America
Project Name:	Bonanza Mine
Project Location:	---
GTX #:	304536
Start Date:	4/6/2016	Tested By:	jcw
End Date:	4/8/2016	Checked By:	emm
Boring #:	Bonanza
Sample #:	16031005
Depth:	Bottom Repo
Visual Description:	Moist, light olive brown sandy clay

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084

Constant Gradient

Sample Type: Remolded
Permeant Fluid: De-aired Distilled water
Orientation: Vertical
Cell #: 2/5

Sample Preparation: Target Compaction: 90% of maximum dry density (106.8 pcf) at the optimum moisture content (19.1%). Values specified by client. Material >3/8-inch removed from sample prior to testing (5% of sample). Trimmings moisture content = 19.3%

Assumed Specific Gravity: 2.65

Parameter	Initial	Final
Height, in	3.00	2.98
Diameter, in	2.86	2.86
Area, in^2	6.42	6.42
Volume, in^3	19.3	19.1
Mass, g	579	610
Bulk Density, pcf	114.2	121.1
Moisture Content, %	19.3	25.6
Dry Density, pcf	95.8	96.4
Degree of Saturation, %	70	95

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.00	Increased Cell Pressure, psi:	94.97	Cell Pressure Increment, ps	4.97
Sample Pressure, psi:	84.99	Corresponding Sample Pressure, psi:	89.70	Sample Pressure Increment	4.71
				B Coefficient:	0.95

FLOW DATA

Date	Time, sec	Pressure, psi Cell	Inlet	Outlet	Gradient	Flow Volume, cc In	Out	Δ In	Δ Out	Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
4/7	---	90.0	85.3	84.8	4.6	12.50	13.00	---	---	---	---	---
4/7	136	90.0	85.3	84.8	4.6	12.80	12.70	0.30	0.30	20.5	0.988	1.1E-05
4/7	----	90.0	85.3	84.8	4.6	12.40	13.10	---	---	---	---	---
4/7	122	90.0	85.3	84.8	4.6	12.70	12.80	0.30	0.30	20.5	0.988	1.3E-05
4/7	----	90.0	85.3	84.8	4.6	13.00	13.30	---	---	---	---	---
4/7	152	90.0	85.3	84.8	4.6	13.30	13.00	0.30	0.30	20.5	0.988	1.0E-05
4/7	----	90.0	85.3	84.8	4.6	12.90	12.90	---	---	---	---	---
4/7	120	90.0	85.3	84.8	4.6	13.20	12.60	0.30	0.30	20.5	0.988	1.3E-05

PERMEABILITY AT 20° C: 1.2 x 10^{-5} cm/sec (@ 5 psi effective stress)

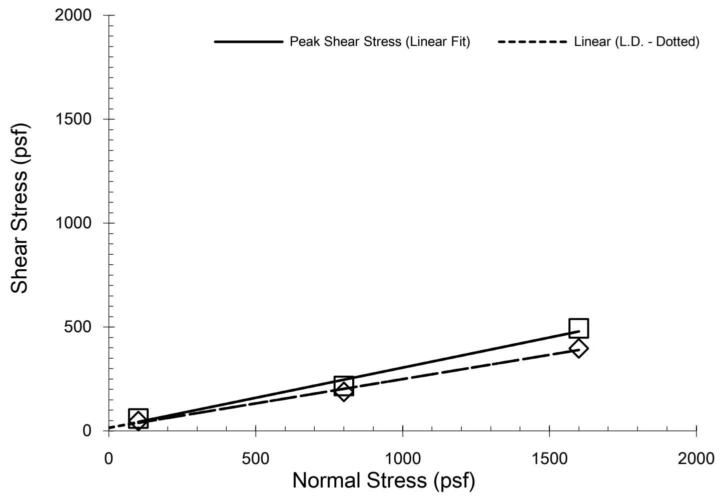
Interface Friction Test Report

Client: **Northwest Liners**
Project: **Bonanza Mine**
Date: 10-08-2014 to 10-08-2014

TRI Log#: E2388-46-05
Test Method: ASTM D5321

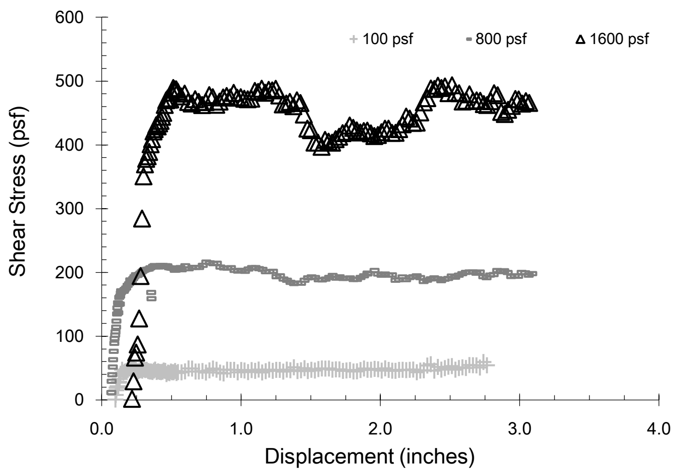
John M. Allen, P.E., 10/08/2014
Quality Review/Date

Tested Interface: Agru 200-1-6 Single-sided Geocomposite (529216-11) vs. Agru 40 mil LLDPE Microspike Geomembrane (F14A391005)



Test Results		
	Peak	Large Displacement (@ 3.0 in.)
Friction Angle (degrees):	16.2	13.2
Y-intercept or Adhesion (psf):	14	16

Shearing occurred at the interface.



Test Conditions	
Upper Box &	Agru 200-1-6 single-sided geocomposite (net side down)
Lower Box	Agru 40 mil LLDPE Microspike geomembrane (dull side up)
Box Dimensions: 12"x12"x4"	
Interface Conditioning:	Interface loading applied for a minimum of 15 hours prior to shear.
Test Condition: Dry	
Shearing Rate: 0.2 inches/minute	

Test Data

Specimen No.	1	2	3
Bearing Slide Resistance (lbs)	9	16	23
Normal Stress (psf)	100	800	1600
Corrected Peak Shear Stress (psf)	59	216	493
Corrected Large Displacement Shear Stress (psf)	47	188	397
Peak Secant Angle (degrees)	30.7	15.1	17.1
Large Displacement Secant Angle (degrees)	25.4	13.2	13.9
Asperity (mils)	26.6	26.6	26.8

ecology and environment, inc.

Design Memorandum

Date: 8/17/2017

To: Design File

From: Tom Campbell, P.E.

Subject: **Bonanza Mine Repository Repair - Underdrain Sizing**

PROFESSIONAL ENGINEER CERTIFICATION

Repository Repair Underdrain Sizing
Bonanza Mine Site
Sutherlin, Oregon
TDD: 14-06-0006

I hereby certify that this document was prepared by me or under my direct personal supervision and I am a duly licensed Professional Engineer under the laws of the State of Oregon. All engineering calculations and recommendations included therein are in accordance with standard and appropriate engineering practices.

REGISTERED PROFESSIONAL
ENGINEER: Thomas C. Campbell

REGISTRATION NUMBER: 88816PE
STATE: Oregon

REGISTERED PROFESSIONAL ENGINEER
88816PE
OREGON
MARCH 11, 2014
THOMAS C. CAMPBELL
EXPIRES: 12/31/2017

OBJECTIVE:

Determine the maximum allowable drainage area to any single underdrain pipe. Confirm the size of high-density polyethylene (HDPE) perforated pipe for use as underdrain and HDPE solid wall pipe used for downslope drainage.

REFERENCES:

1. ADS, Inc. Drainage Handbook. “Chapter 3 – Hydraulics,” ADS, Inc. July 2010.

2. Geotechnical Analysis, attached.

3. Repair Geosynthetic Drainage Composite Analysis, Ecology and Environment, 2016.

ASSUMPTIONS:

1. Final cover underdrain pipes must have sufficient capacity to accommodate the maximum rate of flow delivered to the pipes.

2. The maximum capacity of the underdrains are determined using Manning’s equation (see calculations), based on the diameter of the pipe, the slope of the pipe, the roughness of the pipe, and assuming that the pipe is flowing full.

3. The underdrains are smooth interior high-density polyethylene (HDPE) pipe with a Manning’s “n” value of 0.012 (Reference 1).

4. Underdrain pipe slopes will be set at 1%.

5. The maximum rate of flow that can be delivered to a pipe is conservatively assumed to be equal to the hydraulic conductivity of the cover soils multiplied by the contributing drainage area (i.e., no account is made for evaporation, transpiration, moisture held by the soil cover, etc.).

6. The hydraulic conductivity (k) of the cover is 1.8x10-4 cm/s (Reference 2).

7. The maximum slope length draining to an underdrain cannot exceed 75 feet as determined in the Repair Geosynthetic Drainage Composite Analysis (Reference 3).

1. Underdrain Pipe Capacity (Pipe-Full Capacity)

Manning’s equation is used to calculate the pipe-full flow rate for the smooth interior HDPE pipe. ADS, Inc. manufactures a 4”-slotted pipe as the smallest corrugated outer/smooth inner wall pipe:

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

Q_{full} = pipe-full flow rate, ft^3/sec (unknown)
D = pipe diameter = 0.67 feet (Assumption 3)
n = Manning’s “n” = 0.012 (Assumption 3)
A = cross-sectional area of pipe flowing full $Pi/4*D^2$
R = hydraulic radius = D/4 (ft)
S = longitudinal slope of pipe = 0.01 ft/ft (Assumption 4)

For the 4” diameter underdrains, maximum hydraulic capacity is 0.21 cubic feet per second.

2. Maximum Pipe Catchment Area

The maximum drainage area to any single 4" underdrain is governed by the equation:

$Q_{in} = A * k$, where:

Q_{in} = maximum rate of flow to drainage pipe (ft^3/sec)
= Q_{full} when determining maximum allowable drainage area
= 0.21 ft^3/sec (calculated above)
A = contributing drainage area, ft^2 (unknown)
k = hydraulic conductivity of cover soils, $1.8x10^{-4}$ cm/s ($5.9x10^{-8}$ ft/sec, Assumption 6)

Thus,

$0.21\ ft^3/sec = A * 5.9x10^{-8}\ ft/sec$

$A = 35{,}015\ ft^2$

The maximum drainage area to any single underdrain pipe (4-inch diameter at 0.01 gradient) shall be limited to no more than 35,015 square feet (0.8 acres). Since the upslope drain length cannot exceed 75 feet (Assumption 7), the width of the drainage area cannot exceed 467 feet.

3. Down Slope Conveyance Pipe Capacity (4-inch Pipe at Full Capacity)

Manning's equation is used to calculate the pipe-full flow rate for smooth interior HDPE conveyance pipe and comparing it to the underdrain size and quantity to ensure that it is adequately sized:

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

$Q_{full-4inch}$= pipe-full flow rate, ft^3/sec (unknown)
D = pipe diameter = 0.67 feet (Assumption 3)
n = Manning's "n" = 0.012 (Assumption 3)
A = cross-sectional area of pipe flowing full = Pi/4*D^2
R = hydraulic radius = D/4 (ft)
S = longitudinal slope of pipe = 0.01 ft/ft (Assumption 4)

Thus, $Q_{full-4inch}$ = 0.85 cf/s

The 4-inch down slope conveyance pipe will have capacity for the crest underdrains (0.41 cfs) and the upper midslope underdrain (0.83 cfs). The lower midslope (1.24 cfs) and toe of slope (1.65 cfs) underdrains will require a larger pipe diameter.

4. Down Slope Conveyance Pipe Capacity (6-inch Pipe at Full Capacity)

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

$Q_{full-6inch}$= pipe-full flow rate, ft^3/sec (unknown)
D = pipe diameter = 0.50 feet (Assumption 3)
n = Manning's "n" = 0.012 (Assumption 3)
A = cross-sectional area of pipe flowing full = Pi/4*D^2
R = hydraulic radius = D/4 (ft)
S = longitudinal slope of pipe = 0.01 ft/ft (Assumption 4)

Thus, $Q_{full-6inch}$ = 2.51 cf/s

The 6-inch down slope conveyance pipe will have capacity for the lower midslope (1.24 cfs) and toe of slope (1.65 cfs) underdrains.

SUMMARY:

On the repository, the maximum drainage area to any single underdrain (sloped at 1%) shall be limited to no more than 35,015 square feet (0.8 Acres). The down slope conveyance pipes shall be smooth interior HDPE pipe (sloped at no less than 17%) sized 4” diameter between the top of slope and toe of slope underdrains and 6” diameter between the toe of slope underdrain and repository toe drain.

Date: **8/31/2016**
To: **Design File**
From: **Tom Campbell, P.E.**
Reviewer:
Subject: **Bonanza Mine Repository Repair - Underdrain Sizing**

Underdrain Pipe Capacity (Pipe-Full Capacity)

Manning's equation is used to calculate the pipe-full flow rate:

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

Q_{full} = pipe-full flow rate, ft^3/sec (unknown)			
D = pipe diameter, ft	4 inch	0.33	ft
n = Manning's "n", dimensionless		0.012	
A = cross-sectional area of pipe flowing full, ft^2		0.087	ft^2
R = hydraulic radius = D/4, ft		0.083	ft
S = longitudinal slope of pipe, ft/ft		0.01	ft/ft

Q_{full} = 0.21 ft3/sec

Maximum Pipe Catchment Area

The maximum drainage area to any single 4" underdrain is governed by the equation:

$Q_{in} = A * k$, where:

Q_{in} = rate of flow to drainage pipe (ft^3/sec)
= Q_{full} when determining maximum allowable drainage area
= 0.21 ft^3/sec (calculated above)
A = contributing drainage area, ft^2 (unknown)
k = hydraulic conductivity of cover soils, 1.80E-4 cm/s (5.90E-6 ft/sec)

A =	35,015	ft^2	feet in upslope height
A =	0.80	acres	feet in width

Down Slope Conveyance Pipe Capacity (4-inch Pipe at Full Capacity)

Manning's equation is used to calculate the pipe-full flow rate for the conveyance pipe and comparing it to the underdrain size and quantity to ensure that it is adequately sized:

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

Q_{full} = pipe-full flow rate, ft^3/sec (unknown)			
D = pipe diameter, ft	4 inch	0.33	ft
n = Manning's "n", dimensionless		0.012	
A = cross-sectional area of pipe flowing full, ft^2		0.087	ft^2

R	= hydraulic radius = D/4, ft	0.083	ft
S	= longitudinal slope of pipe, ft/ft	0.17	ft/ft

Q_{full} = 0.85 ft3/sec

	No. Pipes	Flow		
Top of slope - 2 underdrains at 0.21 cfs	2	0.41 <	Qfull = 0.85 cfs	4 inch pipe okay
Midslope - 4 underdrains at 0.21 cfs	4	0.83 <	Qfull = 0.85 cfs	4 inch pipe okay
Toe of slope - 6 underdrains at 0.21 cfs	6	1.24 <	Qfull = 0.85 cfs	Larger pipe required

Down Slope Conveyance Pipe Capacity (6-inch Pipe at Full Capacity)

Manning's equation is run again to calculate the pipe-full flow rate for a larger smooth interior HDPE

$Q_{full} = 1.49/n * A * R^{2/3} * S^{1/2}$, where:

Q_{full}	= pipe-full flow rate, ft^3/sec (unknown)			
D	= pipe diameter, ft	6 inch	0.50	ft
n	= Manning's "n", dimensionless		0.012	
A	= cross-sectional area of pipe flowing full, ft^2		0.196	ft^2
R	= hydraulic radius = D/4, ft		0.125	ft
S	= longitudinal slope of pipe, ft/ft		0.17	ft/ft

Q_{full} = 2.51 ft3/sec

	No. Pipes			
Toe of slope - 6 underdrains at 0.21 cfs	6	1.24 <	Qfull = 2.51 cfs	6 inch pipe okay

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

ANALYTICAL REPORT

Job Number: 580-58737-1

Job Description: EE-004439-Laboratory BOA 14-06-0006

For:
Ecology and Environment, Inc.
Pacific Building
720 Third Avenue
Suite 1700
Seattle, WA 98104

Attention: Mr. Mark Woodke

Kristine D. Allen

Approved for release.
Kristine D Allen
Manager of Project Management
4/27/2016 12:50 PM

Kristine D Allen, Manager of Project Management
5755 8th Street East, Tacoma, WA, 98424
(253)248-4970
kristine.allen@testamericainc.com

04/27/2016

TestAmerica Seattle is a part of TestAmerica Laboratories, Inc.

The results included in this report have been reviewed for compliance with the laboratory QA/QC plan and meet all requirements of NELAC. All data have been found to be compliant with laboratory protocol, with the exception of any items noted in the case narrative.

Table of Contents

Job Narrative
580-58737-1

Comments
No additional comments.

Receipt
The samples were received on 3/24/2016 8:57 AM; the samples arrived in good condition, properly preserved and, where required, on ice.

Subcontract Work
Methods ASTM D-2487 Visual Classification, ASTM D-3080 Direct Shear, ASTM D4318 Atterberg Limits, ASTM D-5084 Hydraulic Conductivity, ASTM D-5321 Interface Shear Strength, ASTM D-698 Compaction, ASTM Methods D-421/422 Grain Size Sieve: These methods were subcontracted to GeoTesting - Boxboro. The subcontract laboratory certifications are different from that of the facility issuing the final report.

SAMPLE SUMMARY

Client: Ecology and Environment, Inc. Job Number: 580-58737-1

Lab Sample ID	Client Sample ID	Client Matrix	Date/Time Sampled	Date/Time Received
580-58737-1	16031001	Solid	03/11/2016 0001	03/24/2016 0857
580-58737-2	16031002	Solid	03/11/2016 0001	03/24/2016 0857
580-58737-3	16031003	Solid	03/11/2016 0001	03/24/2016 0857
580-58737-4	16031004	Solid	03/11/2016 0001	03/24/2016 0857
580-58737-5	16031005	Solid	03/11/2016 0001	03/24/2016 0857

METHOD SUMMARY

Client: Ecology and Environment, Inc. Job Number: 580-58737-1

Description	Lab Location	Method	Preparation Method
Matrix: Solid			
General Sub Contract Method	GeoTesting	Subcontract	

Lab References:

GeoTesting = GeoTesting - Boxboro

Method References:

DATA REPORTING QUALIFIERS

Lab Section	Qualifier	Description

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	---	Sample Type:	---	Tested By:	cam
Sample ID:	---	Test Date:	04/15/16	Checked By:	emm
Depth :	---	Test Id:	370696		

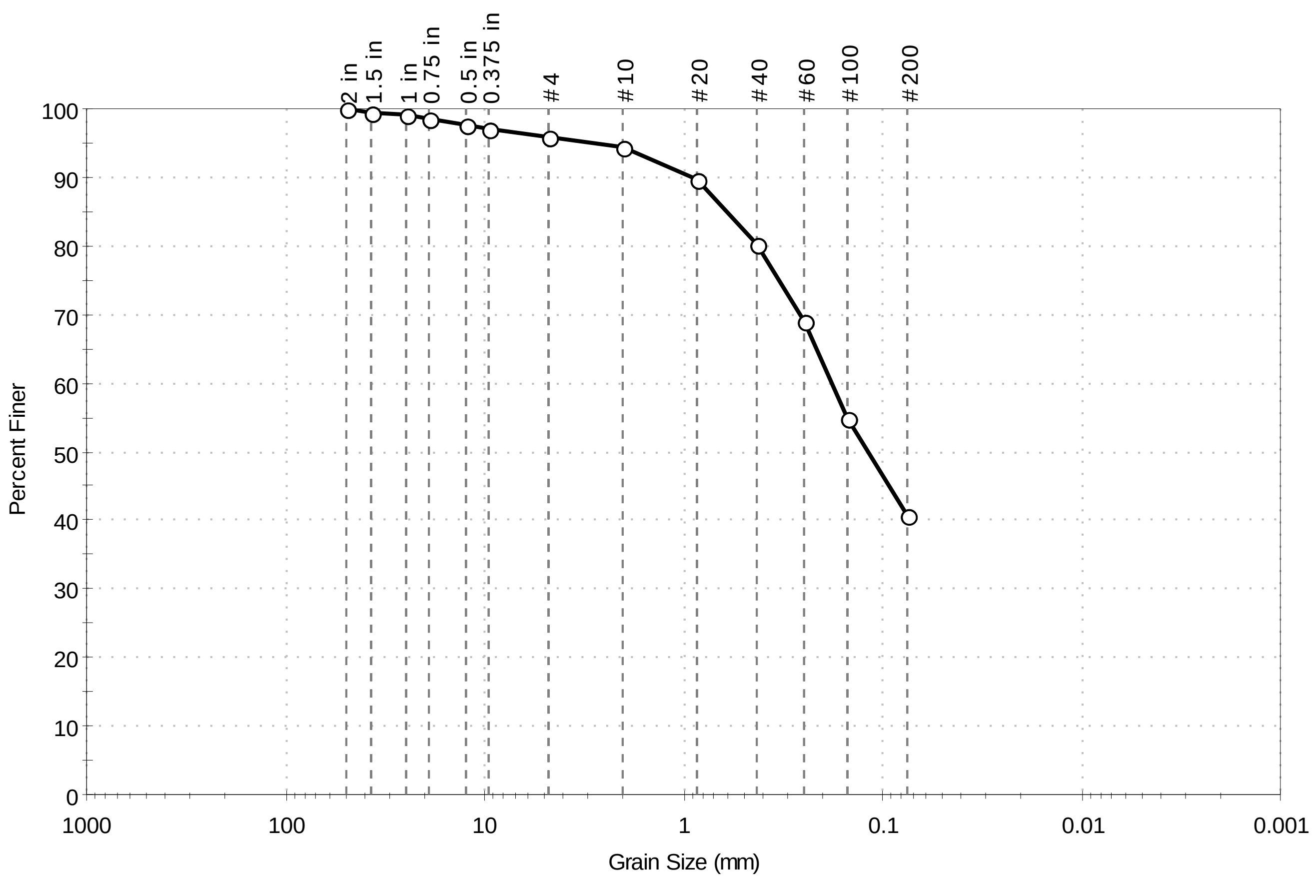
USCS Classification - ASTM D2487

Boring ID	Sample ID	Depth	Group Name	Group Symbol	Gravel, %	Sand, %	Fines, %
Umpqua	16031001	Unscreened Topsoil	Clayey sand	SC	4.2	55.1	40.7
Umpqua	16031002	Washed Sand	Poorly graded sand	SP	1.5	95.1	3.4
Umpqua	16031003	3 Inch Minus	Well-graded gravel with sand	GW	75.2	21.3	3.5
Bonanza	16031004	Top Repos	Sandy Lean clay with gravel	CL	16.2	33.0	50.8
Bonanza	16031005	Bottom Repos	Sandy Lean clay	CL	8.2	38.9	52.9

Remarks: Grain Size analysis performed by ASTM D422 results enclosed
Atterberg Limits performed by ASTM D4318, results enclosed

Client:	Test America		
Project:	Bonanza Mine		
Location:	---	Project No:	GTX-304536
Boring ID: Umpqua	Sample Type: bucket	Tested By:	jbr
Sample ID: 16031001	Test Date: 04/04/16	Checked By:	emm
Depth : Unscreened Topsoil	Test Id: 370682		
Test Comment:	---		
Visual Description:	Moist, dark brown clayey sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	4.2	55.1	40.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	99		
1 in	25.00	99		
0.75 in	19.00	98		
0.5 in	12.50	98		
0.375 in	9.50	97		
#4	4.75	96		
#10	2.00	94		
#20	0.85	90		
#40	0.42	80		
#60	0.25	69		
#100	0.15	55		
#200	0.075	41		

Coefficients

D_{85} = 0.6040 mm D_{30} = N/A

D_{60} = 0.1813 mm D_{15} = N/A

D_{50} = 0.1187 mm D_{10} = N/A

C_u = N/A C_c = N/A

Classification

ASTM Clayey sand (SC)

AASHTO Clayey Soils (A-6 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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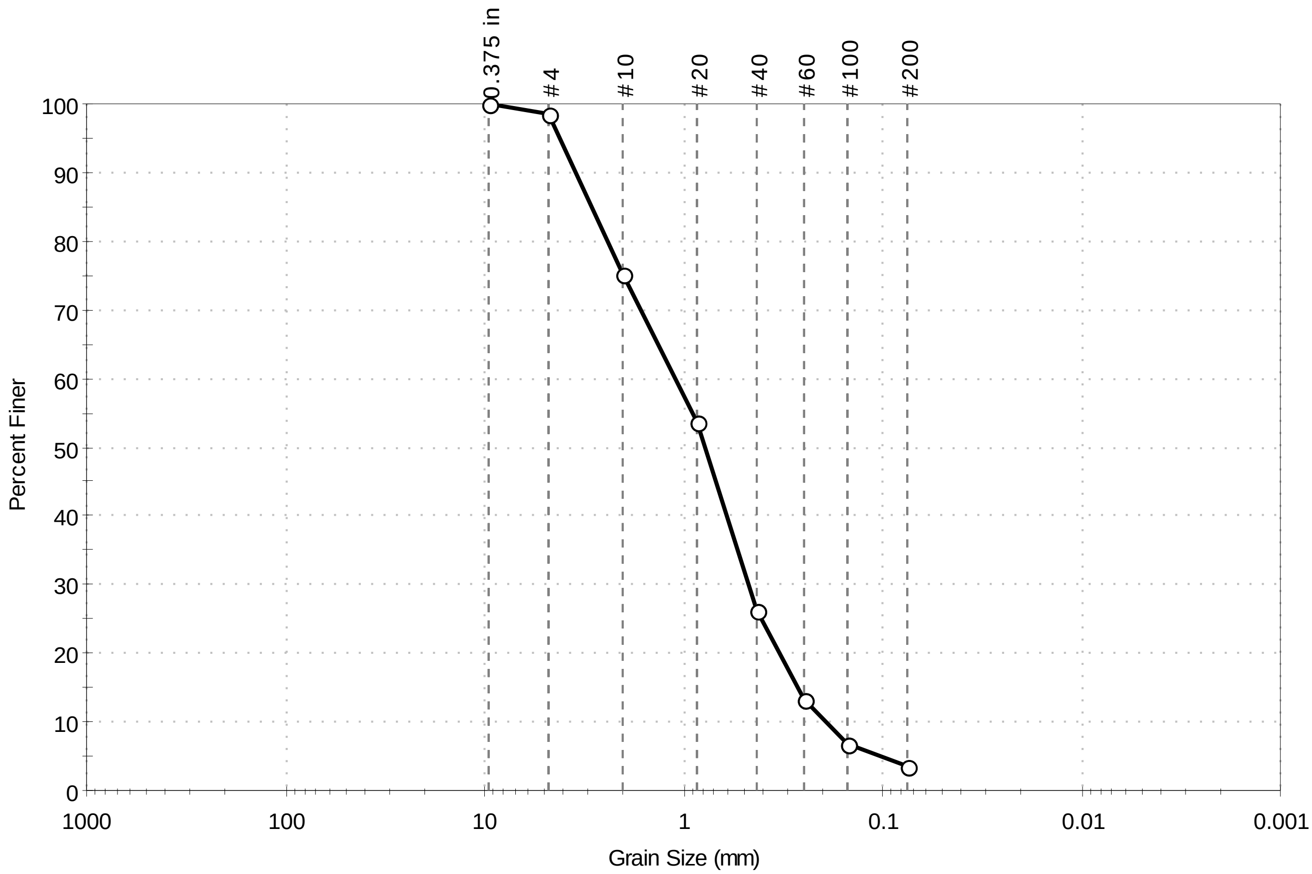
04/27/2016

Client:	Test America		
Project:	Bonanza Mine		
Location:	---	Project No:	GTX-304536
Boring ID: Umpqua	Sample Type: bucket	Tested By:	jbr
Sample ID: 16031002	Test Date: 04/01/16	Checked By:	emm
Depth : Washed Sand	Test Id: 370683		
Test Comment:	---		
Visual Description:	Moist, dark olive brown sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	1.5	95.1	3.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	98		
#10	2.00	75		
#20	0.85	54		
#40	0.42	26		
#60	0.25	13		
#100	0.15	7		
#200	0.075	3.4		

Coefficients

D_{85} = 2.8783 mm　　D_{30} = 0.4673 mm

D_{60} = 1.0965 mm　　D_{15} = 0.2695 mm

D_{50} = 0.7765 mm　　D_{10} = 0.1934 mm

C_u = 5.670　　C_c = 1.030

Classification

ASTM　Poorly graded sand (SP)

AASHTO　Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

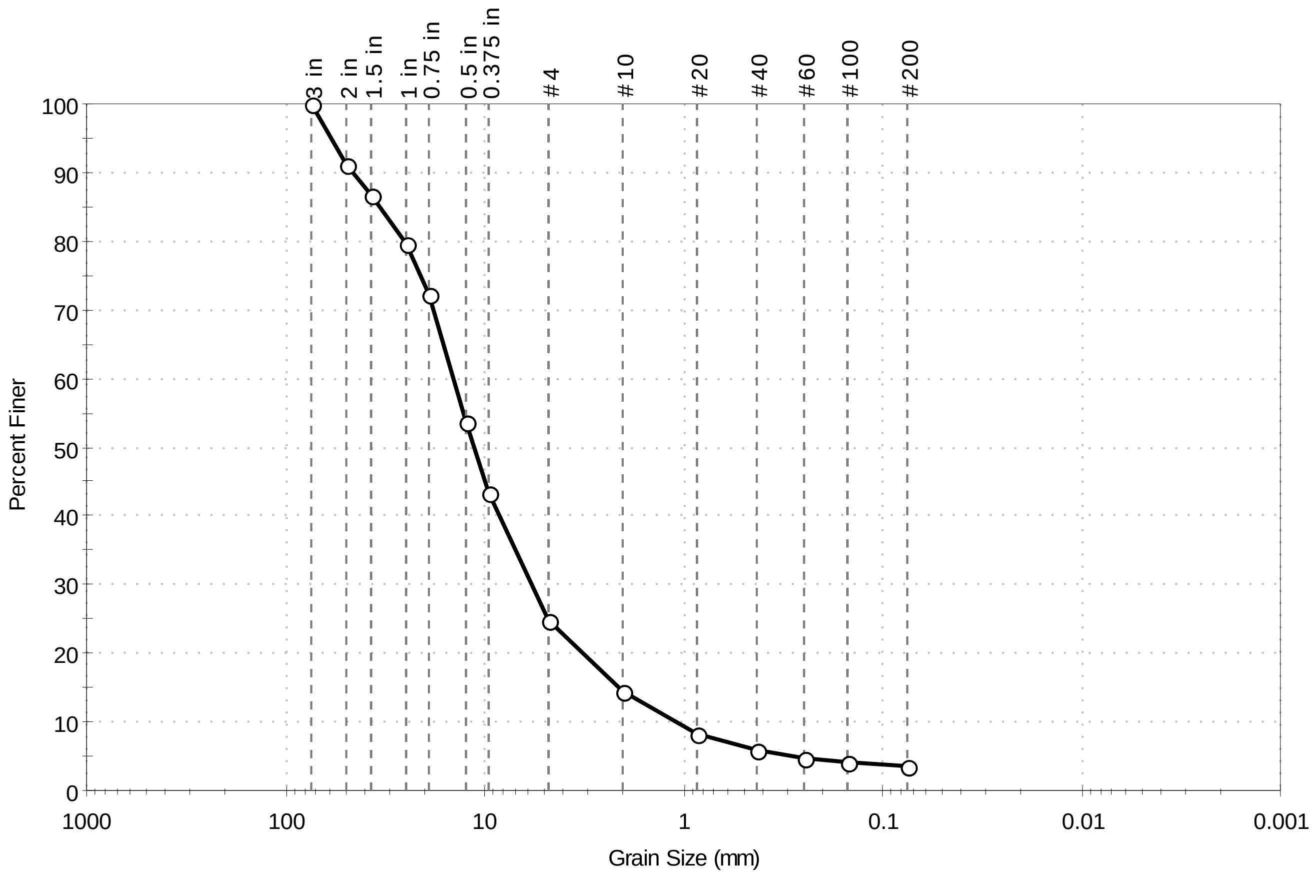
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Umpqua	Sample Type:	bucket	Tested By:	jbr
Sample ID:	16031003	Test Date:	04/01/16	Checked By:	emm
Depth :	3 Inch Minus	Test Id:	370684		

Test Comment: ---
Visual Description: Moist, dark olive gray gravel with sand
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	75.2	21.3	3.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3 in	75.00	100		
2 in	50.00	91		
1.5 in	37.50	87		
1 in	25.00	80		
0.75 in	19.00	72		
0.5 in	12.50	54		
0.375 in	9.50	43		
#4	4.75	25		
#10	2.00	14		
#20	0.85	8		
#40	0.42	6		
#60	0.25	5		
#100	0.15	4		
#200	0.075	3.5		

Coefficients

D_{85} = 33.9764 mm — D_{30} = 5.7633 mm
D_{60} = 14.3957 mm — D_{15} = 2.1146 mm
D_{50} = 11.3291 mm — D_{10} = 1.1009 mm
C_u = 13.076 — C_c = 2.096

Classification

ASTM Well-graded gravel with sand (GW)

AASHTO Clayey Gravel and Sand (A-2-6 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

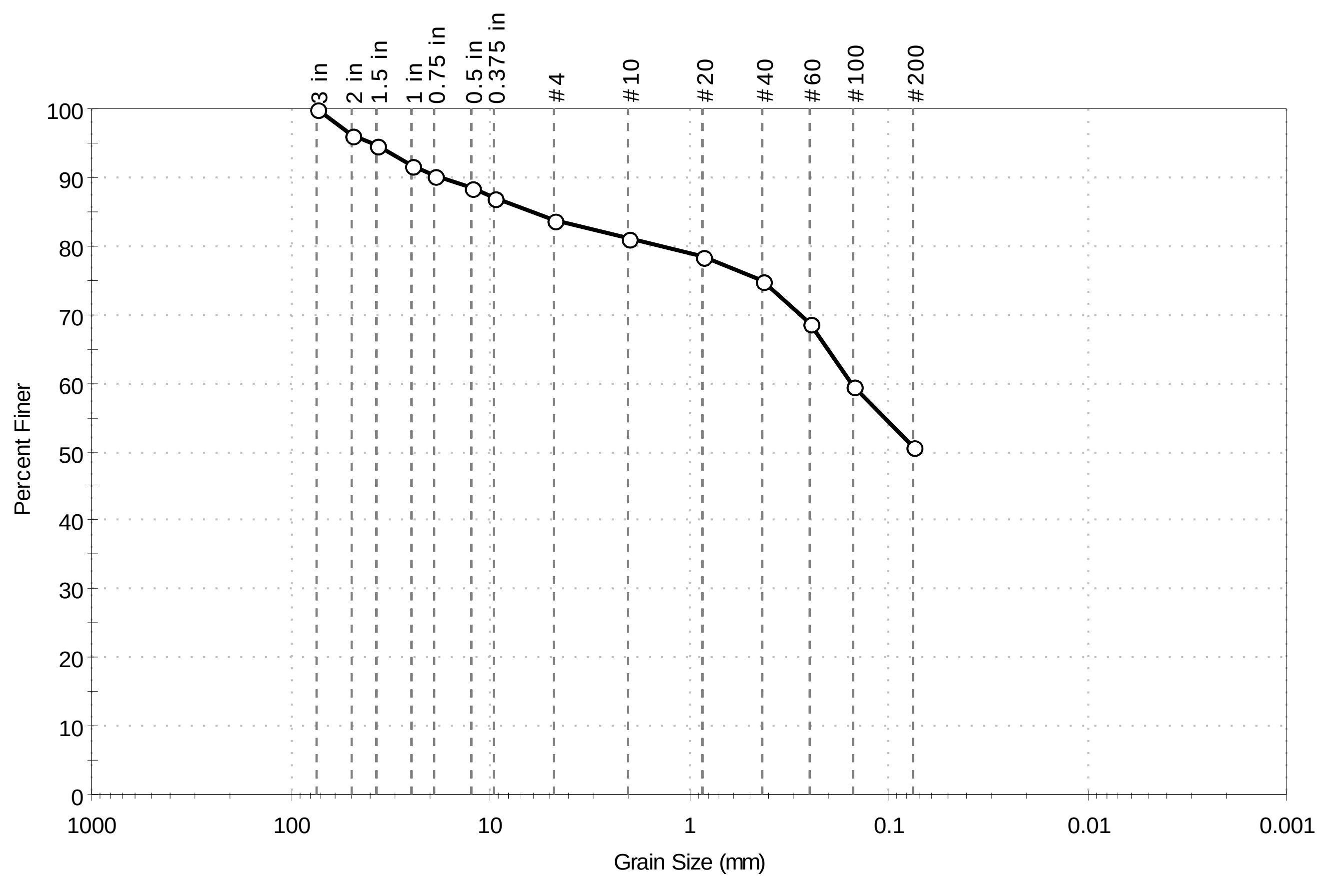
Sand/Gravel Hardness : HARD

GeoTesting EXPRESS

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	jbr
Sample ID:	16031004	Test Date:	04/04/16	Checked By:	emm
Depth :	Top Repos	Test Id:	370685		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	16.2	33.0	50.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3 in	75.00	100		
2 in	50.00	96		
1.5 in	37.50	95		
1 in	25.00	92		
0.75 in	19.00	90		
0.5 in	12.50	88		
0.375 in	9.50	87		
#4	4.75	84		
#10	2.00	81		
#20	0.85	79		
#40	0.42	75		
#60	0.25	69		
#100	0.15	60		
#200	0.075	51		

Coefficients

D_{85} = 6.1631 mm D_{30} = N/A
D_{60} = 0.1532 mm D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM   Sandy Lean clay with gravel (CL)

AASHTO   Clayey Soils (A-7-6 (8))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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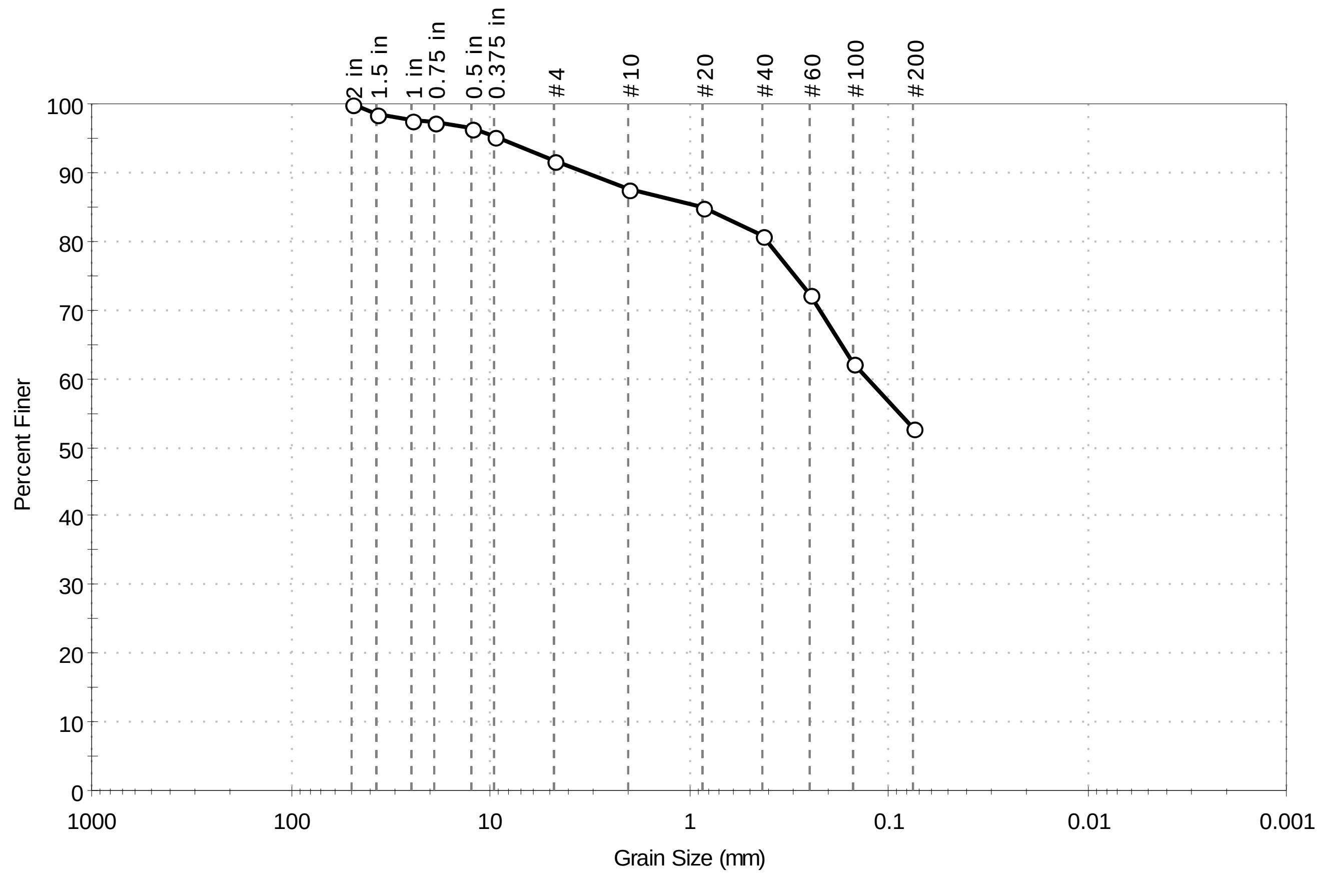
Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	jbr
Sample ID:	16031005	Test Date:	04/04/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370686		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	8.2	38.9	52.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1.5 in	37.50	98		
1 in	25.00	98		
0.75 in	19.00	97		
0.5 in	12.50	97		
0.375 in	9.50	95		
#4	4.75	92		
#10	2.00	88		
#20	0.85	85		
#40	0.42	81		
#60	0.25	72		
#100	0.15	62		
#200	0.075	53		

Coefficients

D_{85} = 0.8573 mm D_{30} = N/A
D_{60} = 0.1268 mm D_{15} = N/A
D_{50} = N/A D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM   Sandy Lean clay (CL)

AASHTO   Clayey Soils (A-6 (6))

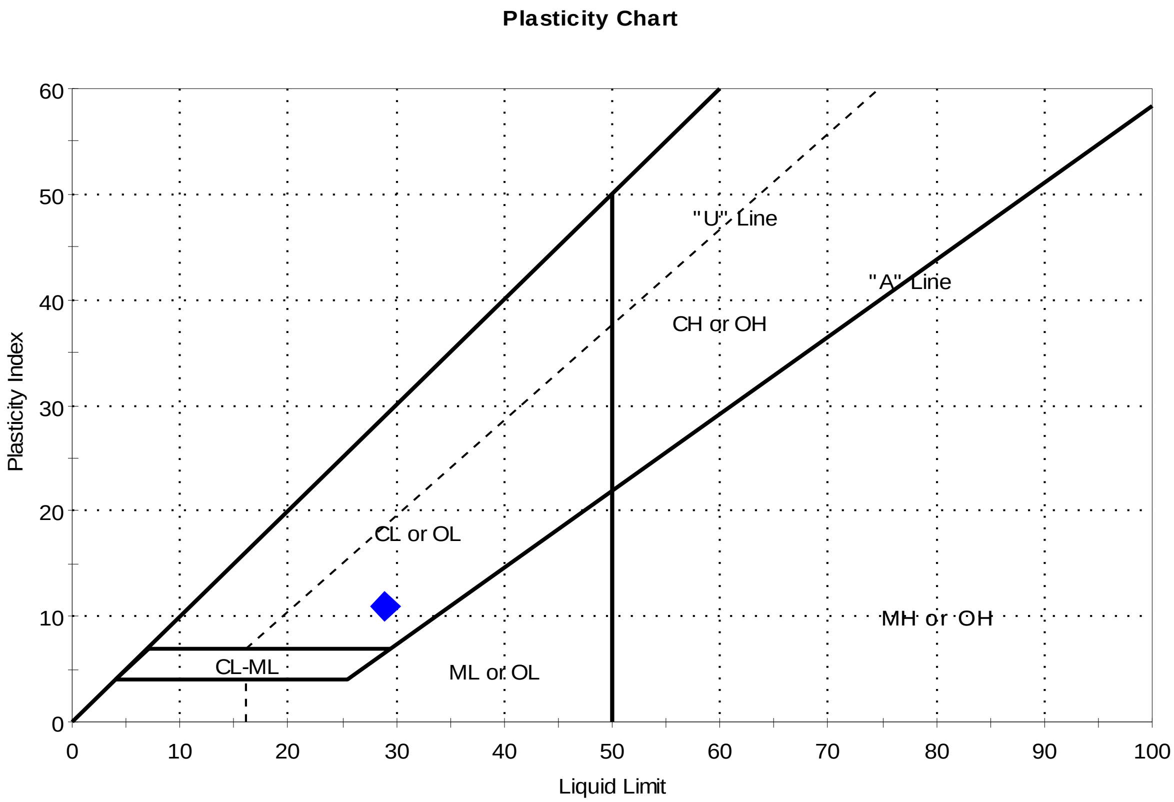
Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Umpqua	Sample Type:	bucket	Tested By:	cam
Sample ID:	16031001	Test Date:	04/01/16	Checked By:	emm
Depth :	Unscreened Topsoil	Test Id:	370687		
Test Comment:	---				
Visual Description:	Moist, dark brown clayey sand				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	16031001	Umpqua	Unscreened Topsoil	15	29	18	11	-0.2	Clayey sand (SC)

Sample Prepared using the WET method

20% Retained on #40 Sieve

Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

GeoTesting EXPRESS

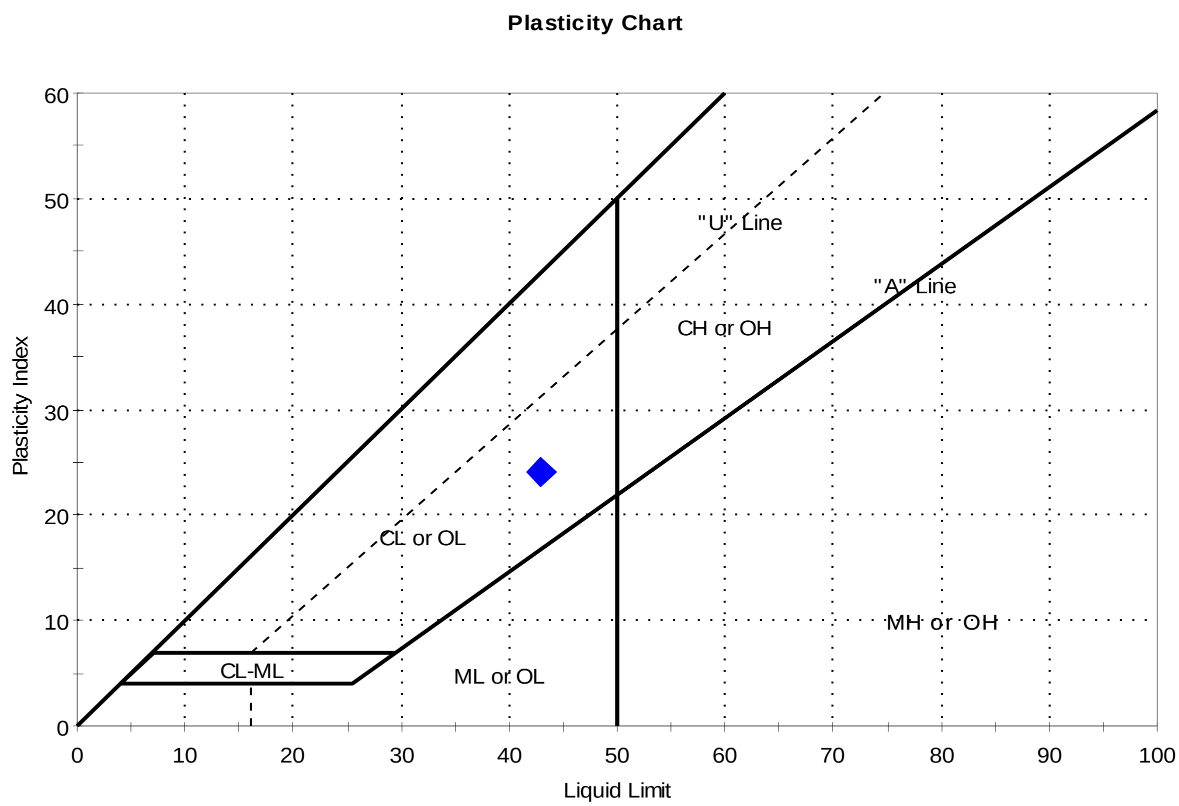
Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	cam
Sample ID:	16031004	Test Date:	04/04/16	Checked By:	emm
Depth :	Top Repos	Test Id:	370690		

Test Comment: ---

Visual Description: Moist, light olive brown sandy clay with gravel

Sample Comment: ---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	16031004	Bonanza	Top Repos	22	43	19	24	0.1	Sandy Lean clay with gravel (CL)

Sample Prepared using the WET method

25% Retained on #40 Sieve

Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

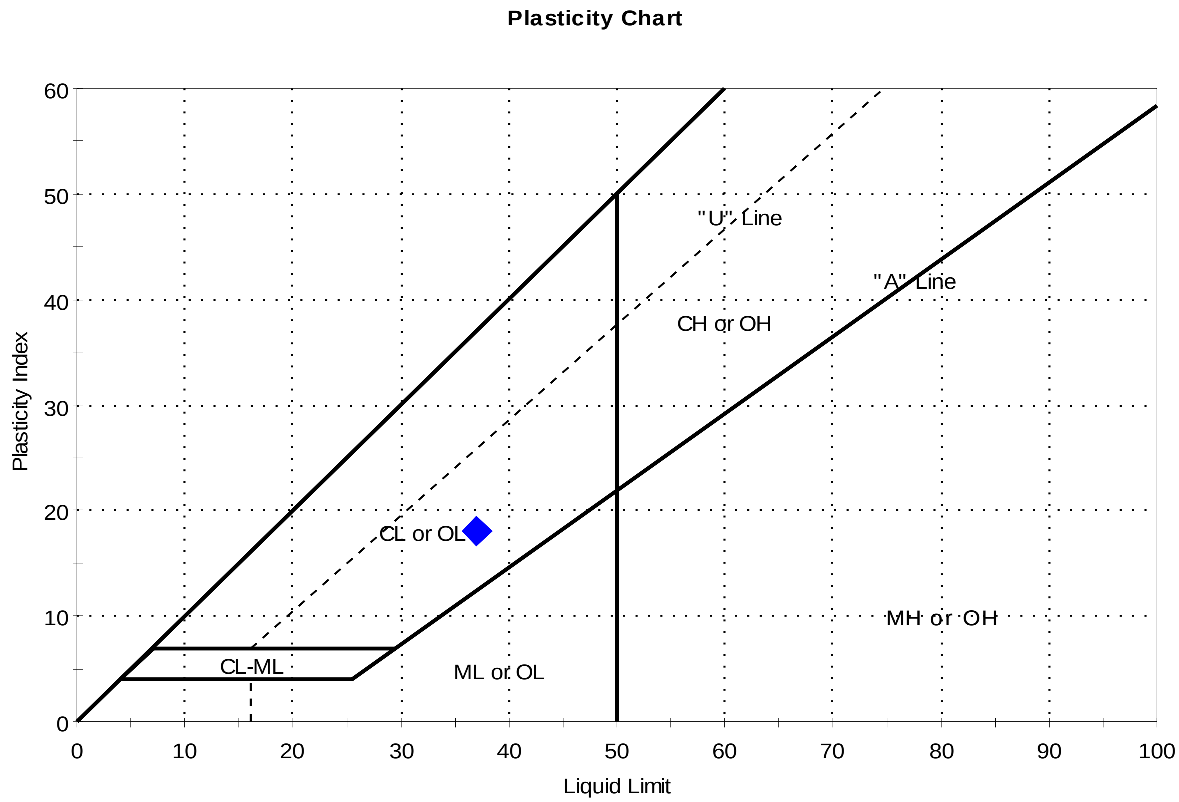
Client: Test America			
Project: Bonanza Mine			
Location: ---		Project No:	GTX-304536
Boring ID: Bonanza	Sample Type: bucket	Tested By:	cam
Sample ID: 16031005	Test Date: 04/05/16	Checked By:	emm
Depth : Bottom Repos	Test Id: 370691		

Test Comment: ---

Visual Description: Moist, light olive brown sandy clay

Sample Comment: ---

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	16031005	Bonanza	Bottom Repos	24	37	19	18	0.3	Sandy Lean clay (CL)

Sample Prepared using the WET method

19% Retained on #40 Sieve

Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

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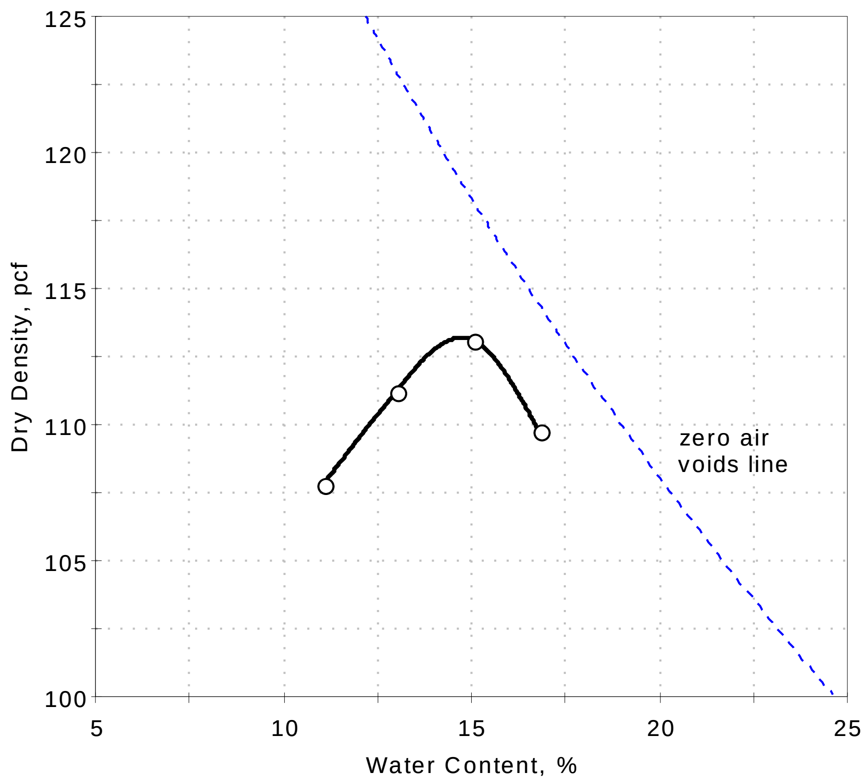
Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Umpqua	Sample Type:	bucket	Tested By:	pmh
Sample ID:	16031002	Test Date:	03/31/16	Checked By:	emm
Depth :	Washed Sand	Test Id:	370698		
Test Comment:	---				
Visual Description:	Moist, dark olive brown sand				
Sample Comment:	---				

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	107.8	111.2	113.1	109.7
Moisture Content, %	11.1	13.0	15.0	16.8

Method : A

Preparation : DRY

As received Moisture :8 %

Rammer : Manual

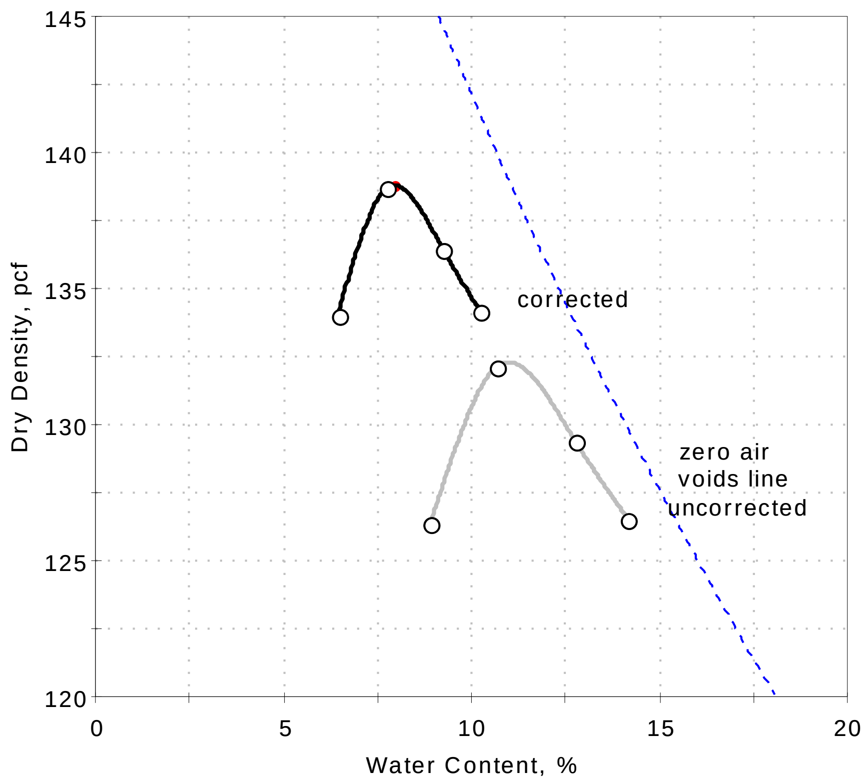
Zero voids line based on assumed specific gravity of 2.65

Maximum Dry Density= 113.2 pcf
Optimum Moisture= 14.7 %

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Umpqua	Sample Type:	bucket	Tested By:	pmh
Sample ID:	16031003	Test Date:	04/04/16	Checked By:	emm
Depth :	3 Inch Minus	Test Id:	370699		

Test Comment: ---
Visual Description: Moist, dark olive gray gravel with sand
Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	126.4	132.1	129.4	126.5
Moisture Content, %	8.9	10.7	12.8	14.2

Method : C
Preparation : DRY
As received Moisture :6 %
Rammer : Manual
Zero voids line based on assumed specific gravity of 2.95

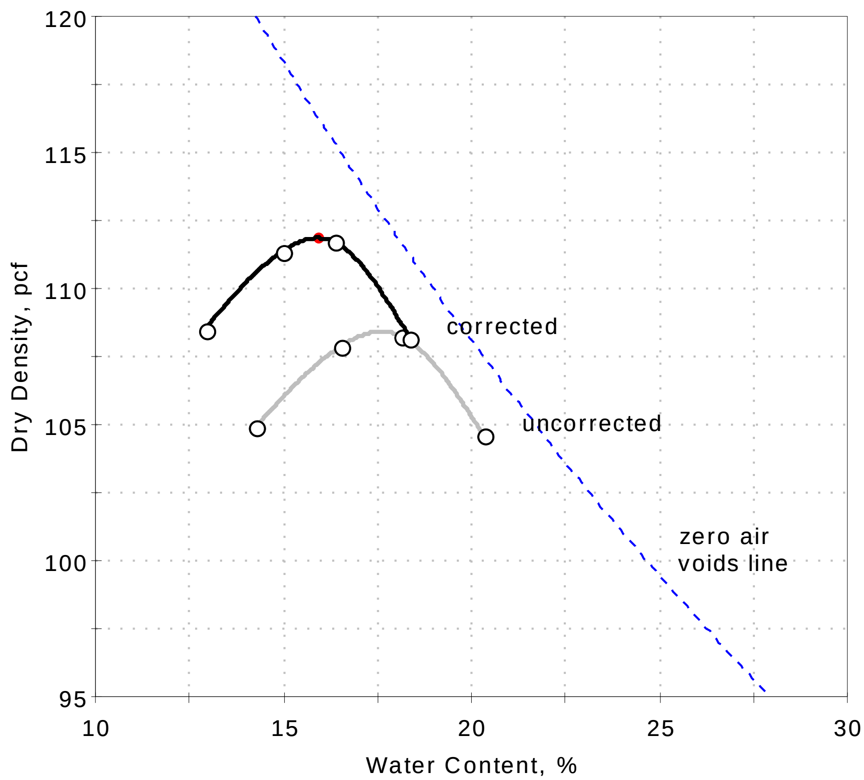
Maximum Dry Density= 132.3 pcf
Optimum Moisture= 11.0 %

Oversize Correction (27.7% > 3/4 inch Sieve)
Corrected Maximum Dry Density= 138.8 pcf
Corrected Optimum Moisture= 8.0 %
Assumed Average Bulk Specific Gravity = 2.55

Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	pmh
Sample ID:	16031004	Test Date:	04/04/16	Checked By:	emm
Depth :	Top Repos	Test Id:	370700		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay with gravel
Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	104.9	107.9	108.3	104.6
Moisture Content, %	14.3	16.5	18.1	20.3

Method : C

Preparation : DRY

As received Moisture :22 %

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.65

Maximum Dry Density= 108.4 pcf
Optimum Moisture= 17.6 %

Oversize Correction (9.6% > 3/4 inch Sieve)

Corrected Maximum Dry Density= 111.9 pcf
Corrected Optimum Moisture= 15.9 %
Assumed Average Bulk Specific Gravity = 2.55

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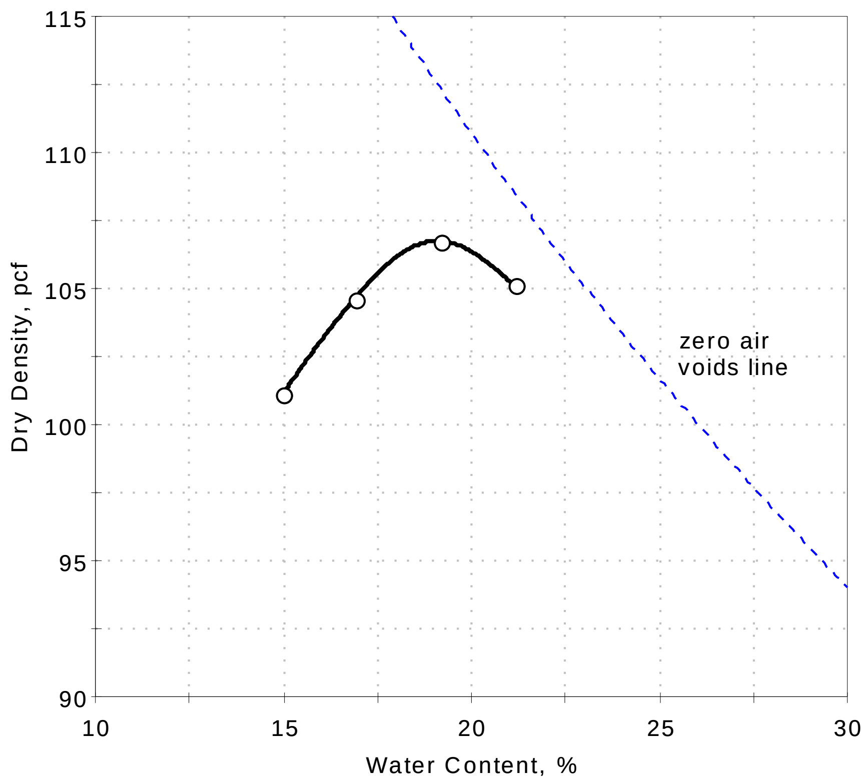
Client:	Test America				
Project:	Bonanza Mine				
Location:	---			Project No:	GTX-304536
Boring ID:	Bonanza	Sample Type:	bucket	Tested By:	pmh
Sample ID:	16031005	Test Date:	04/04/16	Checked By:	emm
Depth :	Bottom Repos	Test Id:	370701		

Test Comment: ---
Visual Description: Moist, light olive brown sandy clay
Sample Comment: ---

Compaction Report - ASTM D698



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	101.1	104.6	106.8	105.1
Moisture Content, %	15.0	16.9	19.2	21.1

Method : B

Preparation : DRY

As received Moisture :24 %

Rammer : Manual

Zero voids line based on assumed specific gravity of 2.75

Maximum Dry Density= 106.8 pcf
Optimum Moisture= 19.1 %

Client:	Test America
Project Name:	Bonanza Mine
Project Location:	---
GTX #:	304536
Start Date:	4/5/2016
End Date:	4/7/2016
Tested By:	jcw
Checked By:	emm
Boring #:	Umpqua
Sample #:	16031001
Depth:	Unscreened Topsoil
Visual Description:	Moist, dark brown clayey sand

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084
Constant Gradient

Sample Type: Remolded
Orientation: Vertical
Permeant Fluid: De-aired Distilled water
Cell #: 9/15

Sample Preparation: Test specimen compacted with moderate effort at the as-recieved moisture content. Values specified by client. Material >3/8-inch removed from sample prior to testing (3% of sample). Trimmings moisture content = 15.4%

Assumed Specific Gravity: 2.65

Parameter	Initial	Final
Height, in	2.98	2.98
Diameter, in	2.86	2.86
Area, in^2	6.42	6.42
Volume, in^3	19.1	19.1
Mass, g	599	632
Bulk Density, pcf	119.0	125.5
Moisture Content, %	15.1	21.4
Dry Density, pcf	103.3	103.3
Degree of Saturation, %	67	95

B COEFFICIENT DETERMINATION

Cell Pressure, psi: 92.03
Sample Pressure, psi: 87.03
Increased Cell Pressure, psi: 96.96
Corresponding Sample Pressure, psi: 91.49
Cell Pressure Increment, ps 4.93
Sample Pressure Increment 4.46
B Coefficient: 0.90
*B value did not increase with increase in pressure. Final degree of saturation >95%.

FLOW DATA

Date	Time, sec	Pressure, psi			Gradient	Flow Volume, cc				Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
		Cell	Inlet	Outlet		In	Out	Δ In	Δ Out			
4/6	---	92.0	87.1	86.9	1.9	12.30	13.50	---	---	---	---	---
4/6	73	92.0	87.1	86.9	1.9	13.30	12.50	1.00	1.00	20.4	0.991	1.8E-04
4/6	----	92.0	87.1	86.9	1.9	12.50	13.60	---	---	---	---	---
4/6	49	92.0	87.1	86.9	1.9	13.10	13.00	0.60	0.60	20.4	0.991	1.6E-04
4/6	----	92.0	87.1	86.9	1.9	12.50	13.20	---	---	---	---	---
4/6	58	92.0	87.1	86.9	1.9	13.20	12.50	0.70	0.70	20.4	0.991	1.6E-04
4/6	----	92.0	87.1	86.9	1.9	12.60	13.50	---	---	---	---	---
4/6	40	92.0	87.1	86.9	1.9	13.10	13.00	0.50	0.50	20.4	0.991	1.6E-04

PERMEABILITY AT 20° C: 1.6 x 10^{-4} cm/sec (@ 5 psi effective stress)

Client:	Test America
Project Name:	Bonanza Mine
Project Location:	---
GTX #:	304536
Start Date:	04/07/16	Tested By:	jcw
End Date:	04/07/16	Checked By:	emm
Boring #:	Umpqua
Sample #:	16031002
Depth:	Washed Sand
Visual Description:	Moist, dark olive brown sand

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

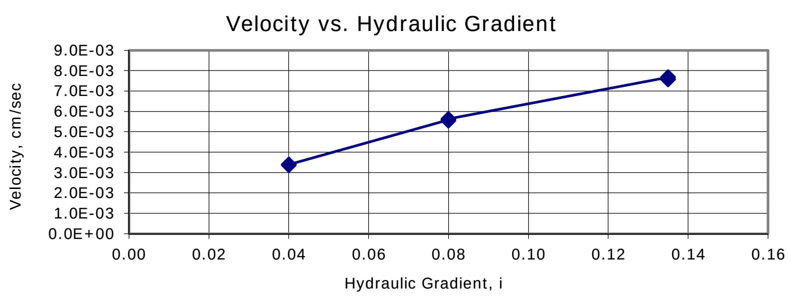
Sample Information:

- Maximum Dry Density: 113.2 pcf
- Optimum Moisture Content: 14.7 %
- Compaction Test Method: D698
- Classification (ASTM D2487): SP
- Assumed Specific Gravity: 2.65

Sample Preparation / Test Setup: Target Compaction: 90% of maximum dry density (113.2 pcf) at air-dried moisture content. Values specified by client. Material >3/8-inch removed from sample prior to testing (0% of sample).

Parameter	Initial	Final
Height, in	4.03	4.03
Diameter, in	3.98	3.98
Area, in^2	12.4	12.4
Volume, in^3	50.1	50.1
Mass, g	1344	1637
Bulk Density, pcf	102.1	124.4
Moisture Content, %	0.8	22.8
Dry Density, pcf	101.3	101.3
Degree of Saturation, %	---	95.3
Void Ratio, e	---	0.63

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., ^oC	Correction Factor	Permeability @ 20 ^oC, cm/sec
4/7	1	2.7	10	0.27	0.04	8.5E-02	19.1	1.023	8.7E-02
4/7	2	2.7	10	0.27	0.04	8.4E-02	19.1	1.023	8.6E-02
4/7	3	2.7	10	0.27	0.04	8.5E-02	19.1	1.023	8.6E-02
4/7	4	4.5	10	0.45	0.08	7.0E-02	19.1	1.023	7.1E-02
4/7	5	4.4	10	0.44	0.08	6.9E-02	19.1	1.023	7.1E-02
4/7	6	4.5	10	0.45	0.08	7.0E-02	19.1	1.023	7.2E-02
4/7	7	6.2	10	0.62	0.14	5.7E-02	19.1	1.023	5.8E-02
4/7	8	6.1	10	0.61	0.14	5.6E-02	19.1	1.023	5.7E-02
4/7	9	6.1	10	0.61	0.14	5.6E-02	19.1	1.023	5.7E-02



PERMEABILITY @ 20 ^oC =

7.2×10^{-2} cm / sec

Note: This standard has been withdrawn by ASTM with no replacement.

Client:	Test America
Project Name:	Bonanza Mine
Project Location:	---
GTX #:	304536
Start Date:	4/6/2016	Tested By:	jcw
End Date:	4/8/2016	Checked By:	emm
Boring #:	Bonanza
Sample #:	16031004
Depth:	Top Repos
Visual Description:	Moist, light olive brown sandy clay with gravel

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084

Constant Gradient

Sample Type: Remolded
Permeant Fluid: De-aired Distilled water
Orientation: Vertical
Cell #: 6/7

Sample Preparation: Target Compaction: 90% of maximum dry density (108.5 pcf) at the optimum moisture content (17.6%). Values specified by client. Material >3/8-inch removed from sample prior to testing (13% of sample). Trimmings moisture content = 17.5%

Assumed Specific Gravity: 2.65

Parameter	Initial	Final
Height, in	3.00	2.99
Diameter, in	2.86	2.86
Area, in^2	6.42	6.42
Volume, in^3	19.3	19.2
Mass, g	581	616
Bulk Density, pcf	114.6	121.9
Moisture Content, %	17.9	24.9
Dry Density, pcf	97.2	97.6
Degree of Saturation, %	68	95

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.03	Increased Cell Pressure, psi:	95.00	Cell Pressure Increment, ps	4.97
Sample Pressure, psi:	85.00	Corresponding Sample Pressure, psi:	89.70	Sample Pressure Increment	4.70
				B Coefficient:	0.95

FLOW DATA

Date	Time, sec	Pressure, psi			Gradient	Flow Volume, cc				Temp,	R_t	Permeability K @ 20 ^oC,
		Cell	Inlet	Outlet		In	Out	Δ In	Δ Out	^oC		cm/sec
4/7	---	90.0	85.1	84.9	1.9	12.50	13.40	---	---	---	---	---
4/7	31	90.0	85.1	84.9	1.9	12.90	13.00	0.40	0.40	20.5	0.988	1.7E-04
4/7	----	90.0	85.1	84.9	1.9	12.80	13.50	---	---	---	---	---
4/7	49	90.0	85.1	84.9	1.9	13.50	12.80	0.70	0.70	20.5	0.988	1.8E-04
4/7	----	90.0	85.1	84.9	1.9	12.20	13.20	---	---	---	---	---
4/7	50	90.0	85.1	84.9	1.9	12.90	12.50	0.70	0.70	20.5	0.988	1.8E-04
4/7	----	90.0	85.1	84.9	1.9	12.50	13.30	---	---	---	---	---
4/7	55	90.0	85.1	84.9	1.9	13.30	12.50	0.80	0.80	20.5	0.988	1.9E-04

PERMEABILITY AT 20^o C: 1.8 x 10^{-4} cm/sec (@ 5 psi effective stress)

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	4/6/2016	Tested By:	jcw
End Date:	4/8/2016	Checked By:	emm
Boring #:	Bonanza		
Sample #:	16031005		
Depth:	Bottom Repo		
Visual Description:	Moist, light olive brown sandy clay		

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084
Constant Gradient

Sample Type:	Remolded	Permeant Fluid:	De-aired Distilled water
Orientation:	Vertical	Cell #:	2/5

Sample Preparation: Target Compaction: 90% of maximum dry density (106.8 pcf) at the optimum moisture content (19.1%). Values specified by client. Material >3/8-inch removed from sample prior to testing (5% of sample). Trimmings moisture content = 19.3%

Assumed Specific Gravity: 2.65

Parameter	Initial	Final
Height, in	3.00	2.98
Diameter, in	2.86	2.86
Area, in^2	6.42	6.42
Volume, in^3	19.3	19.1
Mass, g	579	610
Bulk Density, pcf	114.2	121.1
Moisture Content, %	19.3	25.6
Dry Density, pcf	95.8	96.4
Degree of Saturation, %	70	95

B COEFFICIENT DETERMINATION

Cell Pressure, psi:	90.00	Increased Cell Pressure, psi:	94.97	Cell Pressure Increment, ps	4.97
Sample Pressure, psi:	84.99	Corresponding Sample Pressure, psi:	89.70	Sample Pressure Increment	4.71
				B Coefficient:	0.95

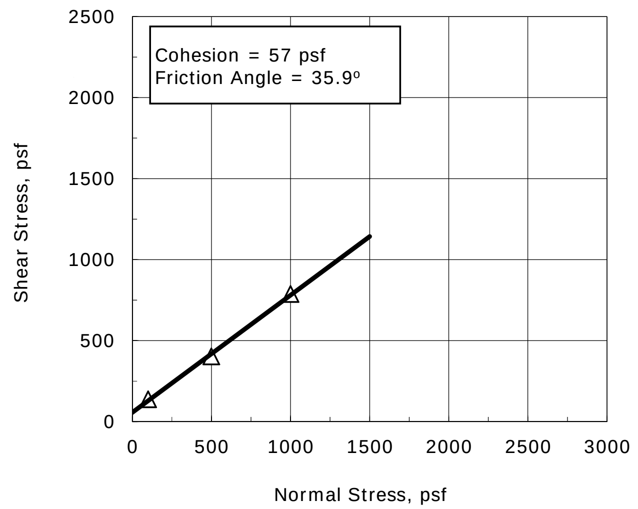
FLOW DATA

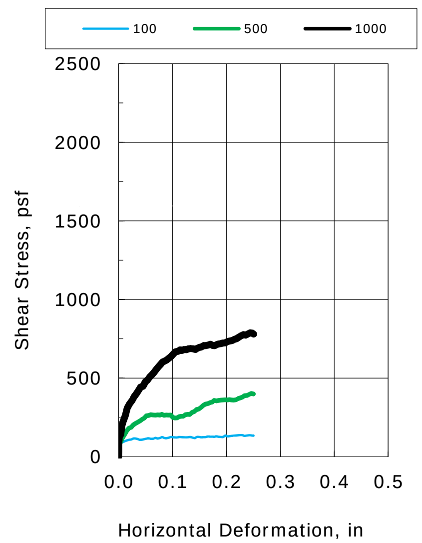
Date	Time, sec	Pressure, psi Cell	Inlet	Outlet	Gradient	Flow Volume, cc In	Out	Δ In	Δ Out	Temp, °C	R_t	Permeability K @ 20 °C, cm/sec
4/7	---	90.0	85.3	84.8	4.6	12.50	13.00	---	---	---	---	---
4/7	136	90.0	85.3	84.8	4.6	12.80	12.70	0.30	0.30	20.5	0.988	1.1E-05
4/7	----	90.0	85.3	84.8	4.6	12.40	13.10	---	---	---	---	---
4/7	122	90.0	85.3	84.8	4.6	12.70	12.80	0.30	0.30	20.5	0.988	1.3E-05
4/7	----	90.0	85.3	84.8	4.6	13.00	13.30	---	---	---	---	---
4/7	152	90.0	85.3	84.8	4.6	13.30	13.00	0.30	0.30	20.5	0.988	1.0E-05
4/7	----	90.0	85.3	84.8	4.6	12.90	12.90	---	---	---	---	---
4/7	120	90.0	85.3	84.8	4.6	13.20	12.60	0.30	0.30	20.5	0.988	1.3E-05

PERMEABILITY AT 20° C: 1.2 x 10^{-5} cm/sec (@ 5 psi effective stress)

Client:	Test America
Project Name:	Bonanza Mine
Project Location:	---
GTX #:	304536
Test Date:	04/12/16
Tested By:	md
Checked By:	njh
Boring ID:	Umpqua
Sample ID:	16031002
Depth, ft:	Washed Sand
Visual Description:	Moist, dark olive brown sand

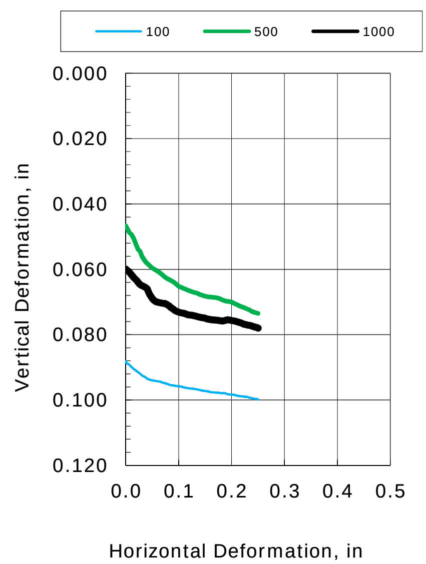
Direct Shear Test of Soils Under Consolidated Drained Conditions by ASTM D3080





Test No.:	DS-1	DS-2	DS-3
Initial Diameter, in:	2.5	2.5	2.5
Initial Height, in:	1.0	1.0	1.0
Initial Mass, grams:	151	151	151
Initial Dry Density, pcf:	102.9	102.9	102.9
Initial Moisture Content, %:	13.6	13.6	13.6
Initial Bulk Density, pcf:	116.9	116.9	116.9
Initial Degree of Saturation:	59.2	59.2	59.2
Initial Void Ratio:	0.61	0.61	0.61
Final Dry Density, pcf:	114.3	111.1	111.6
Final Moisture Content, %:	20.2	19.8	19.1
Final Bulk Density, pcf:	137.3	133.0	132.9
Normal Stress, psf:	100	500	1000
Maximum Shear Stress, psf:	138	403	788.0
Shear Rate, in/min:	0.001	0.001	0.001

Sample Type:	reconstituted
Estimated Specific Gravity:	2.65
Liquid Limit:	Non-Plastic
Plastic Limit:	Non-Plastic
Plasticity Index:	Non-Plastic
% Passing #200 sieve:	3.4
Soil Classification:	Poorly Graded Sand
Group Symbol:	SP



Notes:
Material greater than #5 sieve screened out of sample prior to testing
Moisture content obtained before shear from sample trimmings
Moisture Content determined by ASTM D2216
Percent passing #200 sieve determined by ASTM D422
Target Compaction: 90% of the maximum dry density (113.2 pcf) at the optimum moisture content (14.7%). Values specified by client.
Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.
"---" indicates testing required to determine these values was not requested.

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	04/16/16	Tested By:	dln
End Date:	04/19/16	Checked By:	jdt
Boring ID:	Umpqua		
Sample ID:	16031003		
Depth, ft:	3 inch minus		
Soil Description:	Moist, dark olive gray gravel with sand		

Direct Shear Test Series by ASTM D3080

Soil Preparation: Target Compaction: 90% of Maximum Dry Density at Optimum Moisture Content

Compaction Characteristics:
- Corrected Maximum Dry Density: 138.8 pcf
- Corrected Optimum Moisture Content: 8.0 %
- Compaction Test Method: ASTM D698

Test Equipment: Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2

Maximum Particle Size Used, in: 0.5
Soil Height, in: 3
Gap Between Boxes, in: 0.25
Horizontal Displacement, in/min: 0.02
Test Condition: inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	8.3	8.3	8.6	---	---	---
Initial Dry Density, pcf	124.3	124.4	124.0	---	---	---
Percent Compaction, %	89.6	89.6	89.3	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	141	485	1049	---	---	---
Final Moisture Content, %	14.6	12.9	14.3	---	---	---

Notes:

Peak Friction Angle: 45.4 degrees
Peak Cohesion: 17.8 psf

Figure a. Shear Force vs. Horizontal Displacement

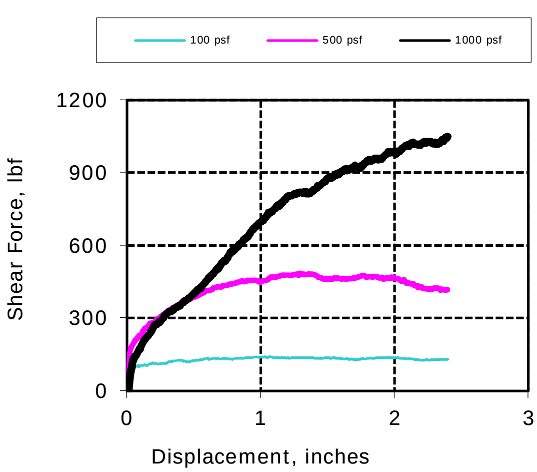
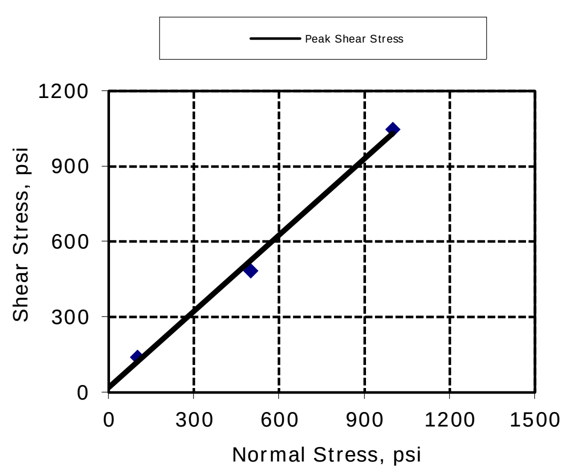


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	04/15/16	Tested By:	dln
End Date:	04/18/16	Checked By:	jdt
Boring ID:	Bonanza		
Sample ID:	16031005		
Depth, ft:	Bottom Repos		
Soil Description:	Moist, light olive brown sandy clay		

Direct Shear Test Series by ASTM D3080

Soil Preparation: Target Compaction: 90% of Maximum Dry Density at Optimum Moisture Content

Compaction Characteristics:
- Maximum Dry Density: 106.8 pcf
- Optimum Moisture Content: 19.1 %
- Compaction Test Method: ASTM D698

Test Equipment: Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2

Maximum Particle Size Used, in:	0.5	Horizontal Displacement, in/min:	0.02
Soil Height, in:	3	Test Condition:	inundated
Gap Between Boxes, in:	0.25		

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	18.7	18.4	18.8	---	---	---
Initial Dry Density, pcf	96.2	96.5	96.2	---	---	---
Percent Compaction, %	90.1	90.4	90.0	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	113	386	817	---	---	---
Final Moisture Content, %	29.6	25.4	23.8	---	---	---

Notes:

Peak Friction Angle: **38.1** **degrees**

Peak Cohesion: **19.9** **psf**

Figure a. Shear Force vs. Horizontal Displacement

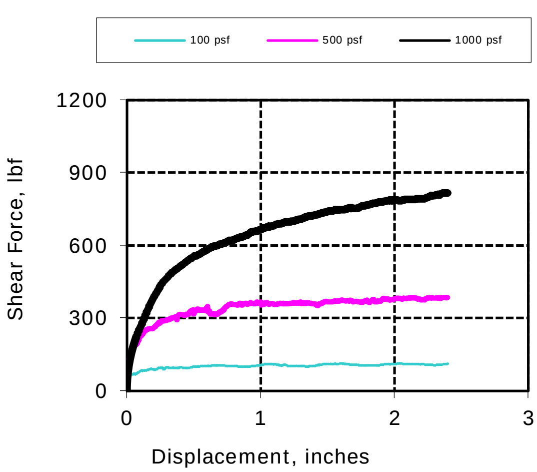
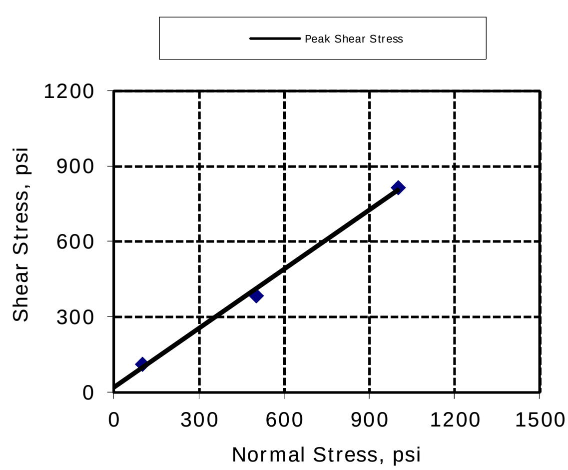


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Client:	Test America		
Project Name:	Bonanza Mine		
Project Location:	---		
GTX #:	304536		
Start Date:	04/15/16	Tested By:	dln
End Date:	04/21/16	Checked By:	jdt
Boring ID:	Bonanza		
Sample ID:	16031004		
Depth, ft:	Top Repos		
Soil Description:	Moist, light olive brown sandy clay with gravel		

Direct Shear Test Series by ASTM D3080

Soil Preparation: Target Compaction: 90% of Maximum Dry Density at Optimum Moisture Content

Compaction Characteristics:
- Corrected Maximum Dry Density: 111.9 pcf
- Corrected Optimum Moisture Content: 15.9 %
- Compaction Test Method: ASTM D698

Test Equipment: Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; surface area = 144 in^2

Maximum Particle Size Used, in:	0.5	Horizontal Displacement, in/min:	0.02
Soil Height, in:	3	Test Condition:	inundated
Gap Between Boxes, in:	0.25		

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	16.1	14.1	14.3	---	---	---
Initial Dry Density, pcf	100.3	102.1	101.9	---	---	---
Percent Compaction, %	89.6	91.2	91.1	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	121	378	902	---	---	---
Final Moisture Content, %	28.5	28.6	27.7	---	---	---

Notes:

Peak Friction Angle: 41.2 degrees

Peak Cohesion: 0.2 psf

Figure a. Shear Force vs. Horizontal Displacement

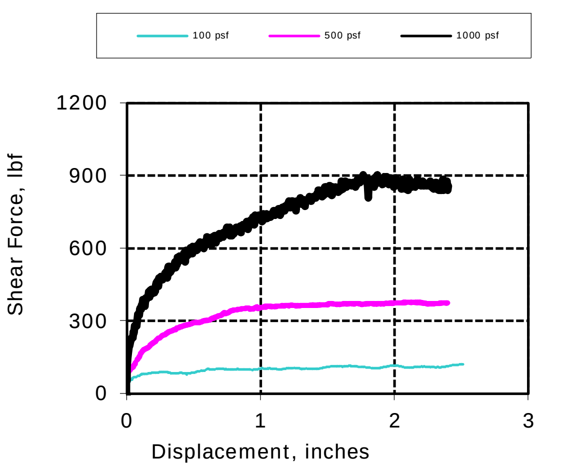
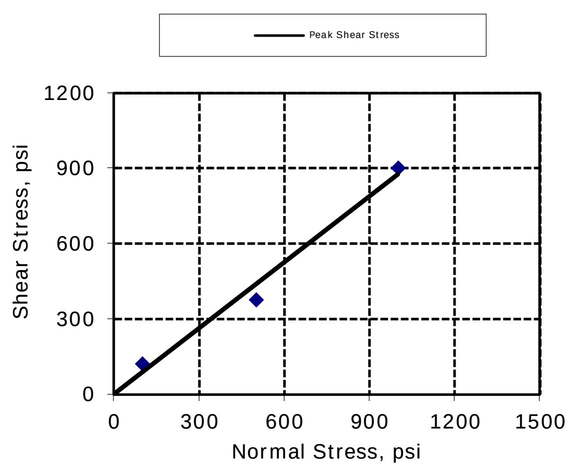


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Landfill		
Project Location:	---		
GTX #:	304536		
Start Date:	04/12/16	Tested By:	dln
End Date:	04/15/16	Checked By:	emm
Soil ID:	Umpqua, 16031003, 3 inch minus		
Soil Description:	Moist, dark olive gray clayey gravel with sand		
Geosynthetic ID:	Geocomposite: Roll #G14E407251		
Geosynthetic Description:	Black, single sided nonwoven biplanar geocomposite		

Interface Shear Test Series by ASTM D5321

Test Series #:	4
Test Profile - Top to Bottom:	steel plate / SOIL/ GEOCOMPOSITE / textured gripping surface
Soil Preparation:	Soil compacted to 90% of Maximum Dry Density at Optimum Moisture Content
Compaction Characteristics:	Corrected Maximum Dry Density 138.8 pcf Corrected Optimum Moisture Content 8.0 % Compaction Test Method ASTM D698
Geosynthetic Preparation:	Test set-up saturated at normal load for 1 hour prior to shear
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2
Horizontal Displacement, in/min:	0.04 Test Condition: inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	8.7	8.6	8.8	---	---	---
Initial Dry Density, pcf	123.8	124.0	123.7	---	---	---
Percent Compaction, %	89.2	89.3	89.1	---	---	---
Final Moisture Content, %	17.0	14.6	14.9	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	121	435	935	---	---	---
Post Peak Shear Stress, psf	115	392	753	---	---	---
Peak Secant Friction Angle, °	50.5	41.0	43.1	---	---	---
Post-Peak Secant Friction Angle, °	49.0	38.1	37.0	---	---	---

NOTES:

Peak Friction Angle:	**42.3**	**degrees**
Peak Adhesion:	**13**	**psf**
Post Peak Friction Angle:	**35.3**	**degrees**
Post Peak Adhesion:	**42**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

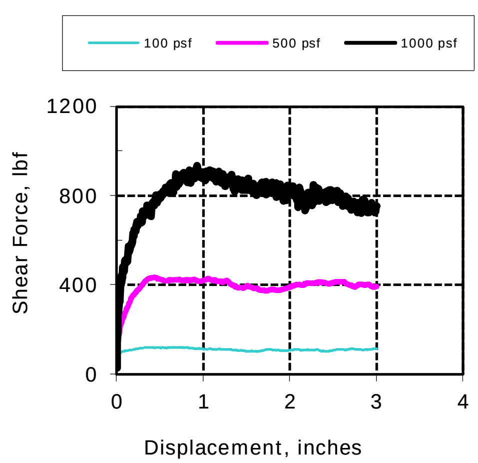
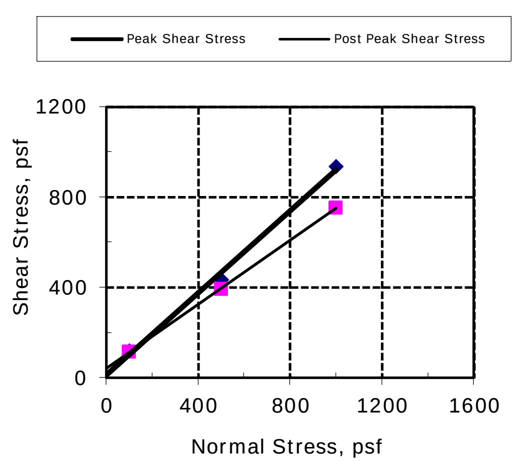


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Form D5321, version 2

Client:	Test America		
Project Name:	Bonanza Landfill		
Project Location:	---		
GTX #:	304536		
Start Date:	04/12/16	Tested By:	dln
End Date:	04/15/16	Checked By:	emm
Soil ID:	Bonanza, 16031005, Bottom Repos		
Soil Description:	Moist, light olive brown sandy clay		
Geomembrane ID:	Roll 3/24/16 (Roll # not provided)		
Geomembrane Description:	Black, 40 mil Agru textured LLDPE geomembrane		

Interface Shear Test Series by ASTM D5321

Test Series #:	1		
Test Profile - Top to Bottom:	steel plate / SOIL / GEOMEMBRANE / textured gripping surface		
Soil Preparation:	Soil compacted to 90% of Maximum Dry Density at Optimum Moisture Content.		
Compaction Characteristics:	Maximum Dry Density	106.8 pcf	
	Optimum Moisture Content	19.1 %	
	Compaction Test Method	ASTM D698	
Geosynthetic Preparation:	Test set-up saturated at normal load for 1 hour prior to shear		
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2		
Horizontal Displacement, in/min:	0.04	Test Condition:	inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	20.0	19.9	20.0	---	---	---
Initial Dry Density, pcf	97.2	97.3	97.2	---	---	---
Percent Compaction, %	91.0	91.1	91.0	---	---	---
Final Moisture Content, %	30.0	26.1	25.4	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	125	364	732	---	---	---
Post Peak Shear Stress, psf	125	325	722	---	---	---
Peak Secant Friction Angle, °	51.3	36.1	36.2	---	---	---
Post-Peak Secant Friction Angle, °	51.3	33.0	35.8	---	---	---
Pre-Test: Average Asperity, mils	37.0	38.1	41.1	---	---	---
Post-Test: Average Asperity, mils	36.3	37.8	39.1	---	---	---

NOTES: Asperity measurements taken on side of membrane involved in shear plane in general accordance with ASTM D7466. Six measurements taken at the same locations before and after test.

Peak Friction Angle:	**34.1**	**degrees**
Peak Adhesion:	**46**	**psf**
Post Peak Friction Angle:	**33.8**	**degrees**
Post Peak Adhesion:	**34**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

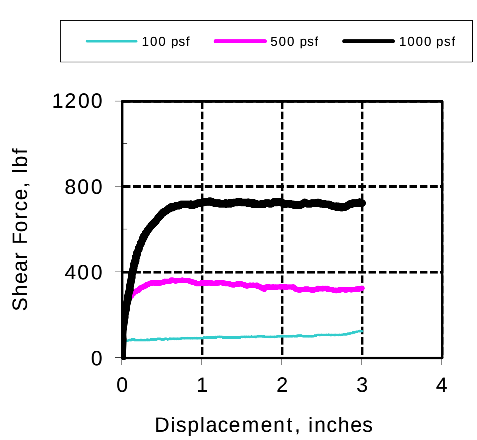
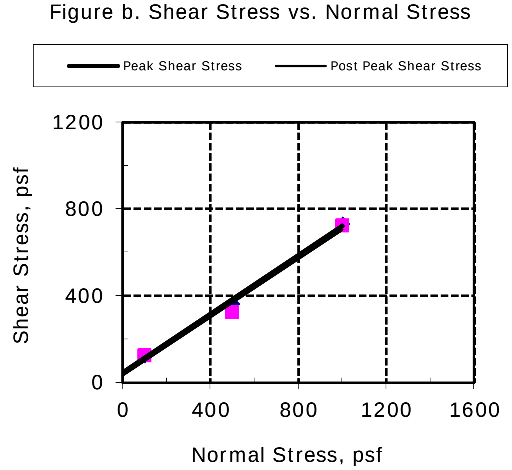


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Form D5321, version 2

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Landfill		
Project Location:	---		
GTX #:	304536		
Start Date:	04/12/16	Tested By:	dln
End Date:	04/15/16	Checked By:	jdt
Soil ID:	Bonanza, 16031004, Top Repos		
Soil Description:	Moist, light olive brown sandy clay wih gravel		
Geosynthetic ID:	Geocomposite: Roll #G14E407251		
Geosynthetic Description:	Black, single sided nonwoven biplanar geocomposite		

Interface Shear Test Series by ASTM D5321

Test Series #:	2
Test Profile - Top to Bottom:	steel plate / SOIL / GEOCOMPOSITE / textured gripping surface
Soil Preparation:	Soil compacted to 90% of Maximum Dry Density at Optimum Moisture Content.
Compaction Characteristics:	Corrected Maximum Dry Density 111.9 pcf Corrected Optimum Moisture Content 15.9 % Compaction Test Method ASTM D698
Geosynthetic Preparation:	Test set-up saturated at normal load for 1 hour prior to shear
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2
Horizontal Displacement, in/min:	0.04 Test Condition: inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	15.8	17.2	16.7	---	---	---
Initial Dry Density, pcf	101	99	100	---	---	---
Percent Compaction, %	89.9	88.8	89.2	---	---	---
Final Moisture Content, %	27.7	24.0	22.8	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	127	423	953	---	---	---
Post Peak Shear Stress, psf	127	402	904	---	---	---
Peak Secant Friction Angle, °	51.8	40.2	43.6	---	---	---
Post-Peak Secant Friction Angle, °	51.8	38.8	42.1	---	---	---

NOTES:

Peak Friction Angle:	**42.7**	**degrees**
Peak Adhesion:	**9**	**psf**
Post Peak Friction Angle:	**41.0**	**degrees**
Post Peak Adhesion:	**14**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

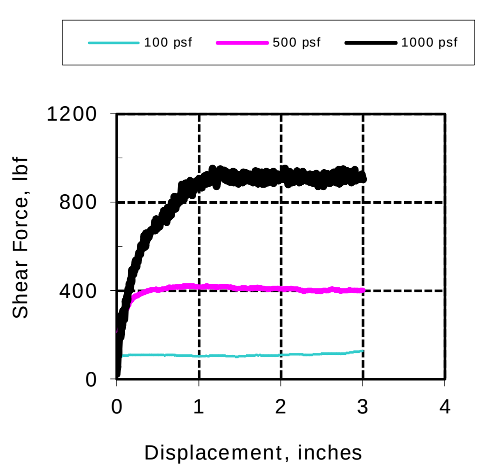
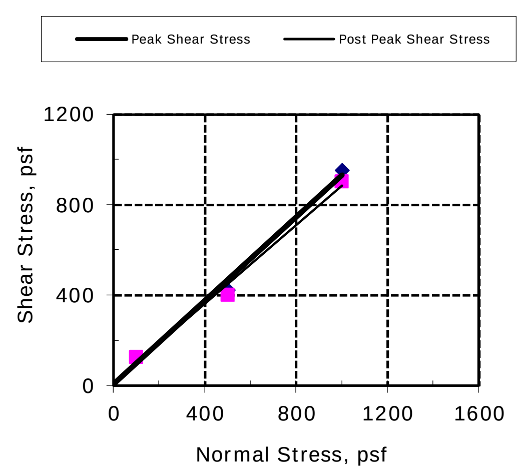


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Form D5321, version 2

GeoTesting EXPRESS

Client:	Test America		
Project Name:	Bonanza Landfill		
Project Location:	---		
GTX #:	304536		
Start Date:	04/12/16	Tested By:	dln
End Date:	04/15/16	Checked By:	jdt
Soil ID:	Umpqua, 16031002, Washed Sand		
Soil Description:	Moist, dark olive brown sand		
Geomembrane ID:	Roll 3/24/16 (Roll # not provided)		
Geomembrane Description:	Black, 40 mil Agru textured LLDPE geomembrane		

Interface Shear Test Series by ASTM D5321

Test Series #:	3		
Test Profile - Top to Bottom:	steel plate / SOIL / GEOMEMBRANE / textured gripping surface		
Soil Preparation:	Soil compacted to 90% of Maximum Dry Density at Optimum Moisture Content.		
Compaction Characteristics:	Maximum Dry Density	113.2 pcf	
	Optimum Moisture Content	14.7 %	
	Compaction Test Method	ASTM D698	
Geosynthetic Preparation:	Test set-up saturated at normal load for 1 hour prior to shear		
Test Equipment:	Top box = 12 in x 12 in; Bottom box = 12 in x 12 in; Load cells and LVDTs connected to data acquisition system for shear force, normal load and horizontal displacement readings; Flat plate clamping device; surface area = 144 in^2		
Horizontal Displacement, in/min:	0.04	Test Condition:	inundated

Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Initial Moisture Content, %	13.5	13.8	13.6	---	---	---
Initial Dry Density, pcf	102.8	102.5	102.6	---	---	---
Percent Compaction, %	90.8	90.6	90.7	---	---	---
Final Moisture Content, %	20.7	19.7	19.6	---	---	---
Normal Compressive Stress, psf	100	500	1000	---	---	---
Peak Shear Stress, psf	106	364	811	---	---	---
Post Peak Shear Stress, psf	95.8	326	762	---	---	---
Peak Secant Friction Angle, °	46.6	36.1	39.0	---	---	---
Post-Peak Secant Friction Angle, °	43.8	33.1	37.3	---	---	---
Pre-Test: Average Asperity, mils	40.1	41.7	40.3	---	---	---
Post-Test: Average Asperity, mils	39.6	41.3	39.7	---	---	---

NOTES: Asperity measurements taken on side of membrane involved in shear plane in general accordance with ASTM D7466. Six measurements taken at the same locations before and after test.

Peak Friction Angle:	**38.2**	**degrees**
Peak Adhesion:	**7**	**psf**
Post Peak Friction Angle:	**36.7**	**degrees**
Post Peak Adhesion:	**0**	**psf**

Figure a. Shear Force vs. Horizontal Displacement

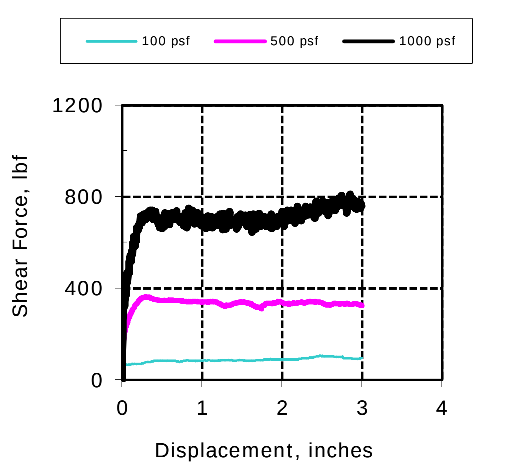
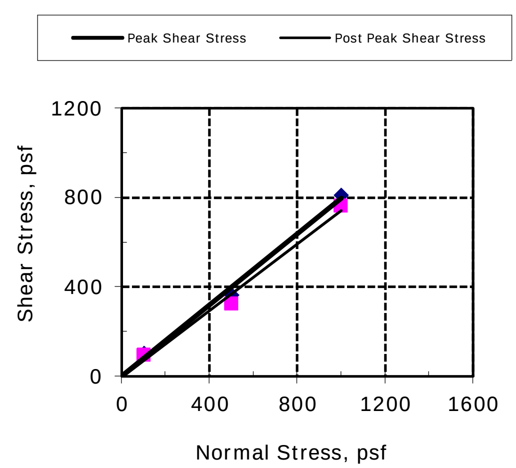


Figure b. Shear Stress vs. Normal Stress



Notes: These results apply only to the sample tested for the specific test conditions. The test procedures employed follow accepted industry practice and the indicated test method. GeoTesting Express has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material. Values for cohesion and friction angle determined from best-fit straight line to the data for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site-specific conditions.

Form D5321, version 2

Subcontract Data

Shipping and Receiving Documents

CHAIN OF CUSTODY RECORD

No: 2016-A

Lab: GeoTesting Express
Lab Phone: 978-635-0424
AirbillNo: 3168125

Site #: 10NE
Project Code:
Cooler #:

FedEx Account 2006-6560-0
Contact Name: Jacob Moersen
Contact Phone: 206-920-9566

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	Lab QC
	16031001	Umpqua - Unscreened Topsoil	ASTM D 421/422 (TAT 2 Weeks)	Topsoil	3/11/2016	3	5 gal bucket	None	N
	16031001	Umpqua - Unscreened Topsoil	ATSM D 5084	Topsoil	3/11/2016	3	5 gal bucket	None	N
	16031001	Umpqua - Unscreened Topsoil	ATSM D 2487	Topsoil	3/11/2016	3	5 gal bucket	None	N
	16031001	Umpqua - Unscreened Topsoil	ASTM D 4318	Topsoil	3/11/2016	3	5 gal bucket	None	N

580-58737 Chain of Custody

Special Instructions: Request 2 week TAT for ASTM D421/422, D4318, D5084, and D2487.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
shipping	E & E	3/17/16			

CHAIN OF CUSTODY RECORD

No: 2016-B

Lab: GeoTesting Express
Lab Phone: 978-635-0424
AirbillNo: 3168127

Site #: 10NE
Project Code:
Cooler #:

FedEx Account 2006-6560-0
Contact Name: Jacob Moersen
Contact Phone: 206-920-9566

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	Lab QC
	16031002	Umpqua - Washed Sand	ASTM D 421/422 (TAT 2 Weeks)	Sand	3/11/2016	3	5 gal bucket	None	N
	16031002	Umpqua - Washed Sand	ASTM D 698	Sand	3/11/2016	3	5 gal bucket	None	N
	16031002	Umpqua - Washed Sand	ATSM D 2487	Sand	3/11/2016	3	5 gal bucket	None	N
	16031002	Umpqua - Washed Sand	ATSM D 3080	Sand	3/11/2016	3	5 gal bucket	None	N
	16031002	Umpqua - Washed Sand	ATSM D 5084	Sand	3/11/2016	3	5 gal bucket	None	N
	16031002	Umpqua - Washed Sand	ATSM D 5321	Sand	3/11/2016	3	5 gal bucket	None	N

Special Instructions	SAMPLES TRANSFERRED FROM CHAIN OF CUSTODY #
Special Instructions: Request 2 week TAT for ASTM D421/422, D698, D3080, D5084, D2487, and D5321.	

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
Shipping	[signature] E & E	3/17/16			

CHAIN OF CUSTODY RECORD

No: 2016-C

Lab: GeoTesting Express
Lab Phone: 978-635-0424
AirbillNo: 9976850

Site #: 10NE
Project Code:
Cooler #:

FedEx Account 2006-6560-0
Contact Name: Jacob Moersen
Contact Phone: 206-920-9566

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	Lab QC
	16031003	Umpqua - 3 Inch Minus	ASTM D 421/422 (TAT 2 Weeks)	Gravel	3/11/2016	3	5 gal bucket	None	N
	16031003	Umpqua - 3 Inch Minus	ASTM D 698	Gravel	3/11/2016	3	5 gal bucket	None	N
	16031003	Umpqua - 3 Inch Minus	ATSM D 2487	Gravel	3/11/2016	3	5 gal bucket	None	N
	16031003	Umpqua - 3 Inch Minus	ATSM D 3080	Gravel	3/11/2016	3	5 gal bucket	None	N
	16031003	Umpqua - 3 Inch Minus	ATSM D 5084	Gravel	3/11/2016	3	5 gal bucket	None	N
	16031003	Umpqua - 3 Inch Minus	ATSM D 5321	Gravel	3/11/2016	3	5 gal bucket	None	N

Special Instructions: Request 2 week TAT for ASTM D421/422, D698, D3080, D5084, D2487, and D5321.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
Shipping	[signature] E & E	3/17/16			

CHAIN OF CUSTODY RECORD

No: 2016-D

Lab: GeoTesting Express
Lab Phone: 978-635-0424
AirbillNo: 9976997

Site #: 10NE
Project Code:
Cooler #:

FedEx Account 2006-6560-0
Contact Name: Jacob Moersen
Contact Phone: 206-920-9566

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	Lab QC
	16031004	Bonanza - Top Repos	ASTM D 421/422 (TAT 2 Weeks)	Soil	3/11/2016	3	5 gal bucket	None	N
	16031004	Bonanza - Top Repos	ASTM D 4318	Soil	3/11/2016	3	5 gal bucket	None	N
	16031004	Bonanza - Top Repos	ASTM D 698	Soil	3/11/2016	3	5 gal bucket	None	N
	16031004	Bonanza - Top Repos	ATSM D 2487	Soil	3/11/2016	3	5 gal bucket	None	N
	16031004	Bonanza - Top Repos	ATSM D 3080	Soil	3/11/2016	3	5 gal bucket	None	N
	16031004	Bonanza - Top Repos	ATSM D 5084	Soil	3/11/2016	3	5 gal bucket	None	N
	16031004	Bonanza - Top Repos	ATSM D 5321	Soil	3/11/2016	3	5 gal bucket	None	N

Special Instructions: Request 2 week TAT for ASTM D421/422, D698, D4318, D3080, D5084, D2487, and D5321.

SAMPLES TRANSFERRED FROM CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
shipping	[signature] E & E	3/17/16			

CHAIN OF CUSTODY RECORD

No: 2016-E

Lab: GeoTesting Express
Lab Phone: 978-635-0424
AirbillNo: 9976999

Site #: 10NE
Project Code:
Cooler #:

FedEx Account 2006-6560-0
Contact Name: Jacob Moersen
Contact Phone: 206-920-9566

Lab #	Sample #	Location	Analyses	Matrix	Collected	Numb Cont	Container	Preservative	Lab QC
	16031005	Bonanza - Bottom Repos	ASTM D 421/422 (TAT 2 Weeks)	Soil	3/11/2016	3	5 gal bucket	None	N
	16031005	Bonanza - Bottom Repos	ASTM D 4318	Soil	3/11/2016	3	5 gal bucket	None	N
	16031005	Bonanza - Bottom Repos	ASTM D 698	Soil	3/11/2016	3	5 gal bucket	None	N
	16031005	Bonanza - Bottom Repos	ATSM D 2487	Soil	3/11/2016	3	5 gal bucket	None	N
	16031005	Bonanza - Bottom Repos	ATSM D 3080	Soil	3/11/2016	3	5 gal bucket	None	N
	16031005	Bonanza - Bottom Repos	ATSM D 5084	Soil	3/11/2016	3	5 gal bucket	None	N
	16031005	Bonanza - Bottom Repos	ATSM D 5321	Soil	3/11/2016	3	5 gal bucket	None	N

Special Instructions: Request 2 week TAT for ASTM D421/422, D698, D4318, D3080, D5084, D2487, and D5321.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
shipping	[signature] E & E	3/17/16			

Login Sample Receipt Checklist

Client: Ecology and Environment, Inc.

Job Number: 580-58737-1

Login Number: 58737
List Number: 1
Creator: Gamble, Cathy L

List Source: TestAmerica Seattle

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

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C Record Drawings

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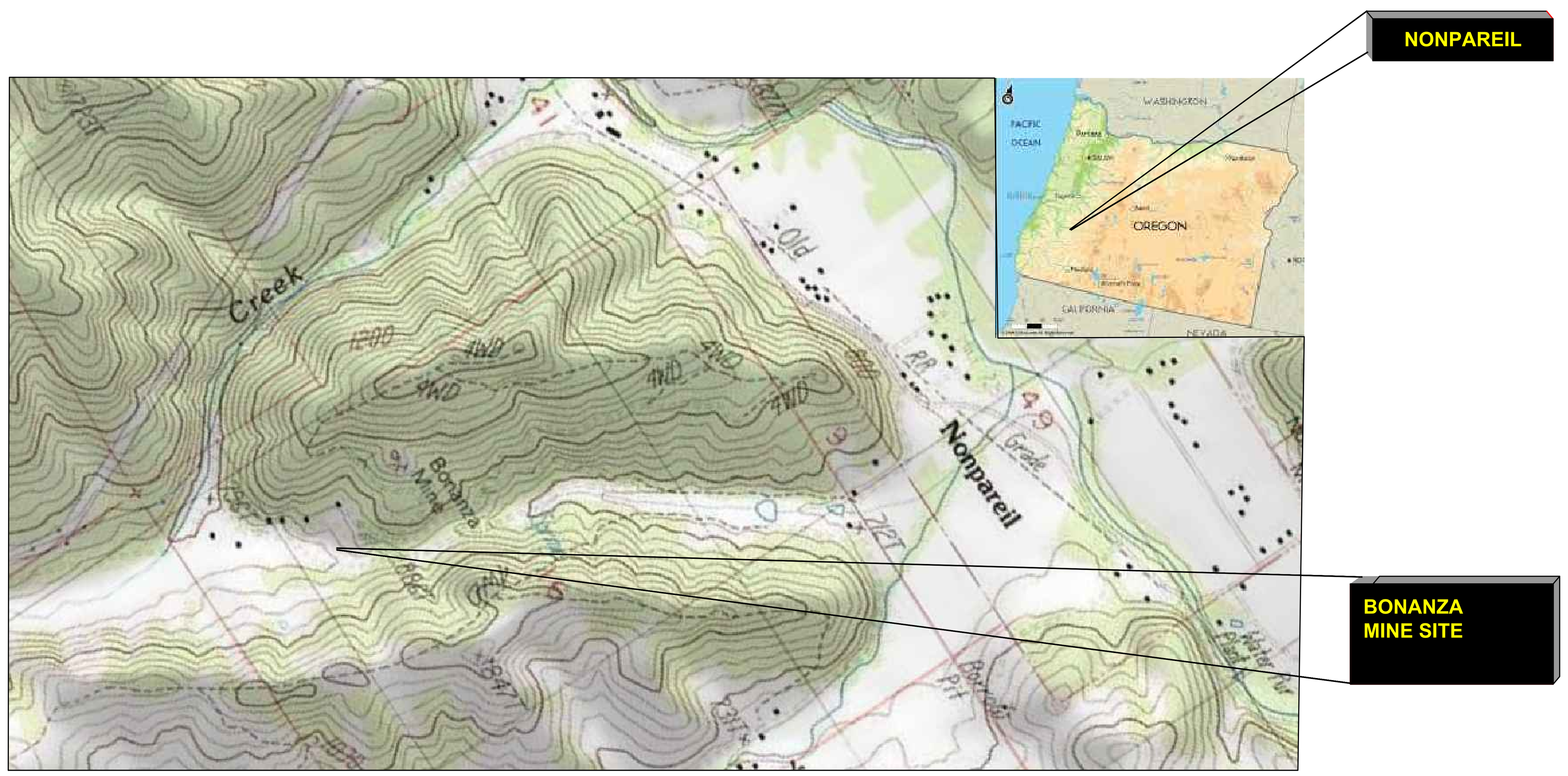
REPOSITORY COVER REPAIR

BONANZA MINE SITE
NONPAREIL, DOUGLAS COUNTY, OREGON
TDD NO.: 14-06-0006
PAN NO.: 1004530.0004.064.02



SOURCE: ERSI INC. 2015

VICINITY MAP
1" = 1000'

SOURCE: ERSI INC. 2015

SITE LOCATION MAP
NOT TO SCALE

LEGEND (SOME SYMBOLS MAY NOT BE USED IN THE SHEETS)

DECIDUOUS TREE	UTILITY AND LIGHT POLE
EVERGREEN TREE	GUY WIRE
STORM SEWER MANHOLE	TRAFFIC SIGNAL POLE
SANITARY SEWER CLEANOUT	ELECTRICAL POWER PEDESTAL
DITCH INLET	COMMUNICATIONS PEDESTAL
SANITARY SEWER MANHOLE	COMMUNICATIONS MANHOLE
IRRIGATION CONTROL VALVE	OVERHEAD LINE
WATER METER	GAS LINE
FIRE HYDRANT	ELECTRICAL LINE
BOLLARD	COMMUNICATIONS LINE
GAS VALVE	SANITARY SEWER LINE
GAS METER	STORM DRAIN LINE
SIGN	WATER LINE
MAILBOX	FENCELINE
UTILITY POLE	ELECTRIC RISER
LIGHT POLE	UTILITY RISER
ELECTRIC METER	STORM PIPE
WELL STORAGE TANK	SANITARY JUNCTION BOX

LIST OF ABBREVIATIONS

APPROX	APPROXIMATE	MH	MANHOLE
℄	CENTER LINE	N	NORTH
CFS	CUBIC FOOT PER SECOND	NO., #	NUMBER
CY	CUBIC YARD	NTS	NOT TO SCALE
D, DIA, ø	DIAMETER	NAD83	NORTH AMERICAN DATUM, 1983
EL	ELEVATION	NAVD88	NORTH AMERICAN VERTICAL DATUM, 1988
FT, '	FEET, FOOT	OC	ON CENTER
GW	GROUNDWATER	OD	OUTSIDE DIAMETER
H, HORIZ	HORIZONTAL	OZ/SQ YD	OUNCE PER SQUARE YARD
HR	HOUR	PVC	POLYVINYL CHLORIDE
I.E.	INVERT ELEVATION	RCP	REINFORCED CONCRETE PIPE
IN, "	INCH	TYP	TYPICAL
MAX	MAXIMUM	V	VERTICAL
MIN	MINIMUM		

SHEET NO.	DESCRIPTION OF DRAWINGS
C-1	VICINITY MAP, SITE LOCATION, AND SHEET INDEX
C-2	SLIDE CONDITIONS SURVEY – MARCH 2016
C-3	FINAL CONDITIONS SURVEY – NOVEMBER 2016
C-4	UNDERDRAIN, COVER, AND GABION WALL PLAN VIEW
C-5	UNDERDRAIN, COVER, AND GABION WALL DETAILS

SHEET INDEX

REGISTERED PROFESSIONAL ENGINEER
88816PE
OREGON
MARCH 11, 2014
THOMAS C. CAMPBELL
EXPIRES 12/31/2017

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Symbol	Description	Date	Approved
1	RECORD DRAWINGS	08-16-2017	TCC

SIZE D
IF SHEET IS LESS THAN 22"X34" IT IS REDUCED PRINT– SCALE REDUCED ACCORDINGLY
ONE INCH

Designed by: T. CAMPBELL, P.E.		Date: 08/16/2017
Drawn by: VG/ TJC	Spec No.:	TDD #: 14-06-0006
Reviewed by: J. PETERSEN, P.E.		PAN #: 1004530.0004.064.02
Approved by: T. CAMPBELL, P.E. OREGON_PE_LICENSE#88816PE		DWG Scale: AS SHOWN

ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
(206) 624-9537 ene.com

DOUGLAS COUNTY OREGON
BONANZA MINE SITE
VICINITY MAP, SITE LOCATION, AND SHEET INDEX

Sheet reference number:
C-1
SHEET 1 OF 5

SITE CONDITIONS – MARCH 2016

NOTES

1. SLIDE CONDITIONS SURVEY WAS PERFORMED ON MARCH 21, 2016 BY CENTERLINE CONCEPTS LAND SURVEYING, INC. HORIZONTAL DATUM IS NAD83 OREGON STATE PLANE, SOUTH ZONE, US FEET. VERTICAL DATUM IS NAVD 88, US FEET.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Symbol	Description	Date	Approved
1	RECORD DRAWINGS	08-16-2017	TCC

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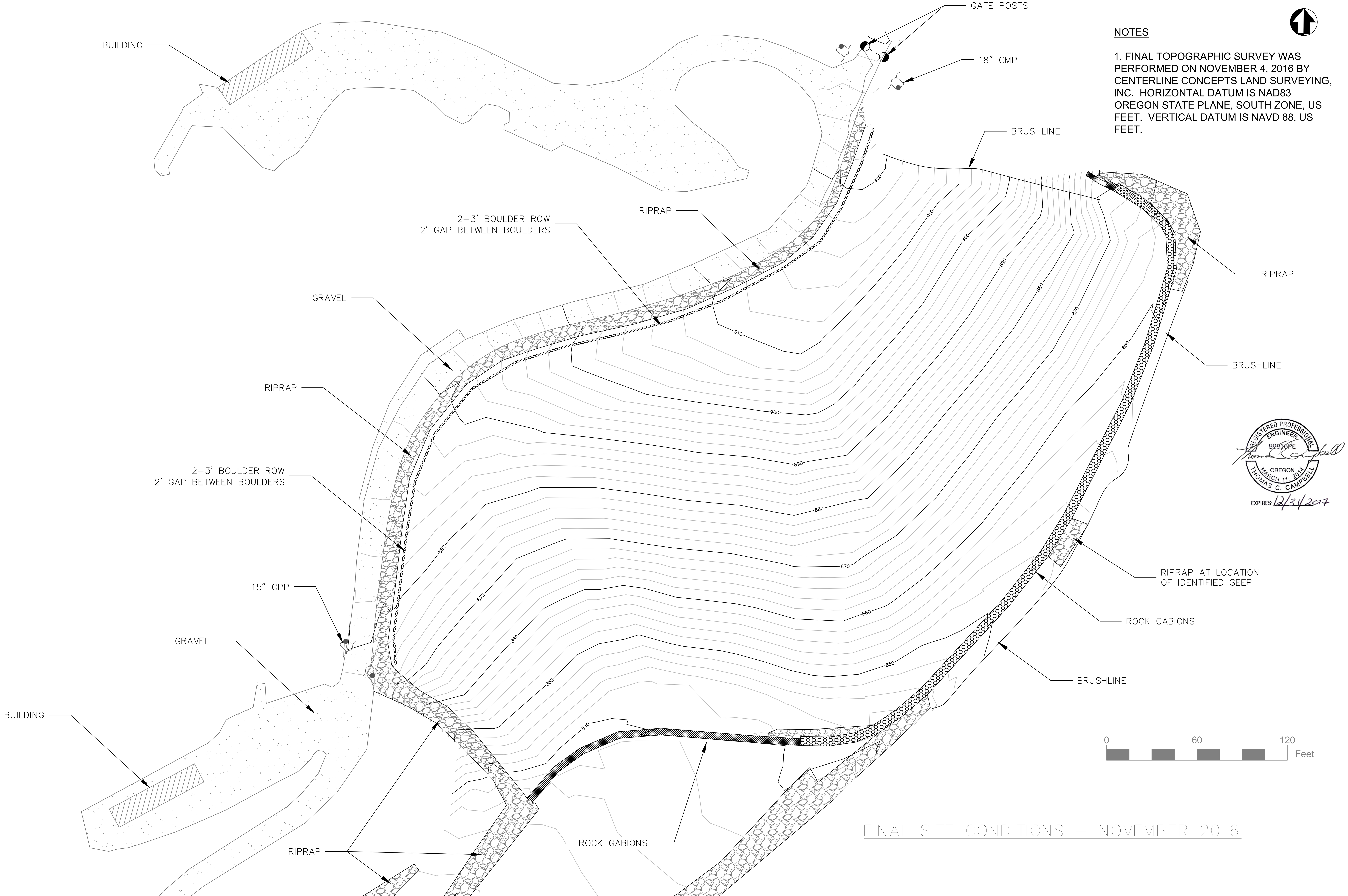
Approved by: T. CAMPBELL, P.E. OREGON_PE_LICENSE#88816PE		DWG Scale: AS SHOWN

REGISTERED PROFESSIONAL ENGINEER 88816PE OREGON MARCH 11, 2014 THOMAS C. CAMPBELL
EXPIRES 12/31/2017

ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
(206) 624-9537 ene.com

DOUGLAS COUNTY OREGON
BONANZA MINE SITE
SLIDE CONDITIONS SURVEY
MARCH 2016

Sheet reference number:
C-2
SHEET 2 OF 5



NOTES

1. FINAL TOPOGRAPHIC SURVEY WAS PERFORMED ON NOVEMBER 4, 2016 BY CENTERLINE CONCEPTS LAND SURVEYING, INC. HORIZONTAL DATUM IS NAD83 OREGON STATE PLANE, SOUTH ZONE, US FEET. VERTICAL DATUM IS NAVD 88, US FEET.

REGISTERED PROFESSIONAL ENGINEER 88816PE OREGON MARCH 11, 2014 THOMAS C. CAMPBELL

EXPIRES: 12/31/2017

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Symbol	Description	Date	Approved
1	RECORD DRAWINGS	08-16-2017	TCC

SIZE D
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ONE INCH

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Drawn by: VG/ TJC	Spec No.:	TDD #: 14-06-0006
Reviewed by: J. PETERSEN, P.E.		PAN #: 1004530.0004.064.02
Approved by: T. CAMPBELL, P.E.		DWG Scale: AS SHOWN

OREGON_PE_LICENSE#88816PE

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720 Third Avenue, Suite 1700
Seattle, Washington 98104
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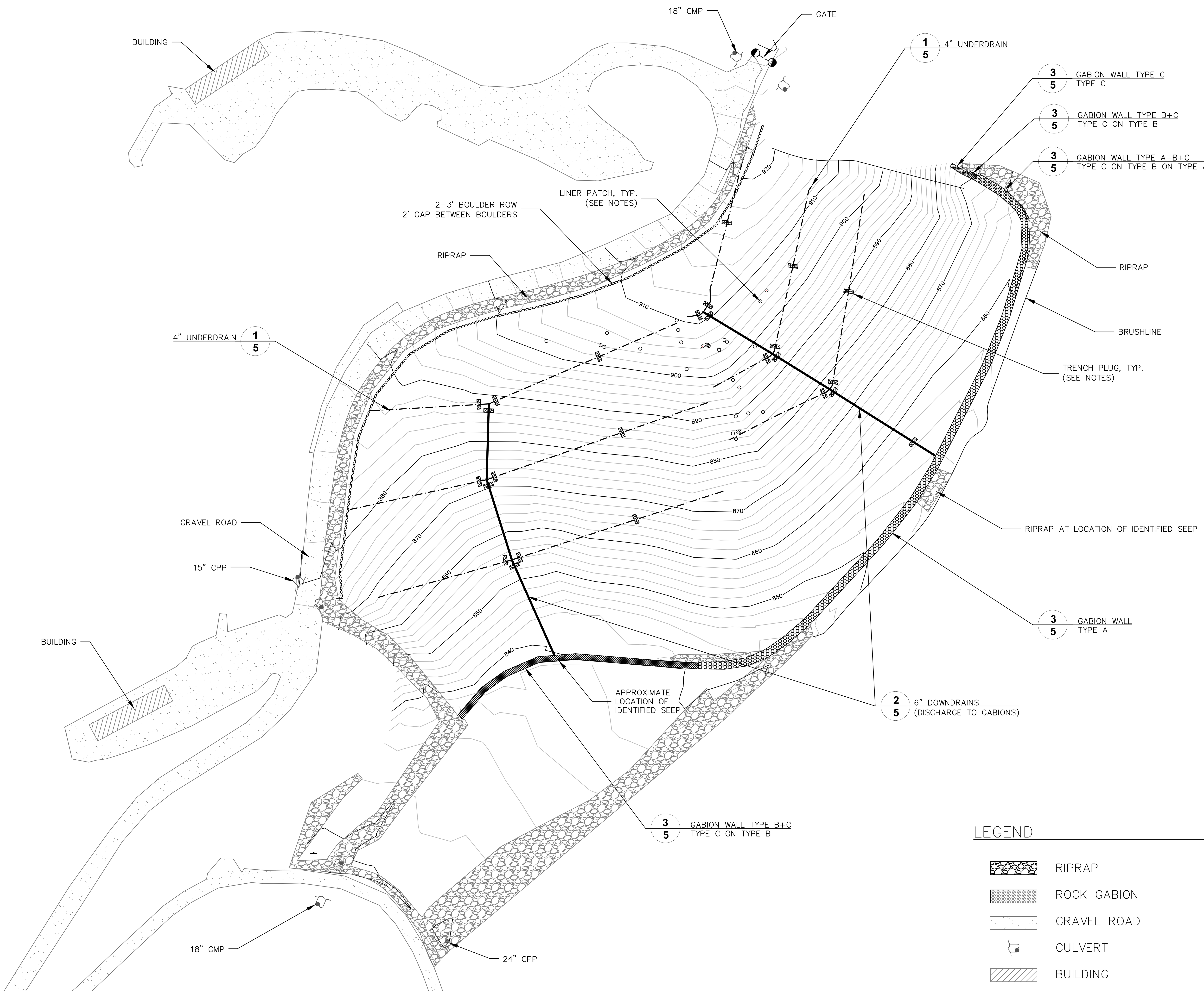
DOUGLAS COUNTY OREGON
BONANZA MINE SITE

FINAL CONDITION SURVEY
NOVEMBER 2016

Sheet reference number:
C-3
SHEET 3 OF 5



NOTES

1. COVER REPAIR CONSTRUCTION ACTIVITIES BEGAN ON SEPTEMBER 19, 2016 AND WERE COMPLETED ON OCTOBER 25, 2016.

2. FINAL TOPOGRAPHIC SURVEY WAS PERFORMED ON NOVEMBER 4, 2016 BY CENTERLINE CONCEPTS LAND SURVEYING, INC. HORIZONTAL DATUM IS NAD83 OREGON STATE PLANE, SOUTH ZONE, US FEET. VERTICAL DATUM IS NAVD 88, US FEET.

3. HOLES IN THE LINER WERE PATCHED BY NORTHWEST LININGS & GEOTEXTILE PRODUCTS, INC.

4. TRENCH PLUGS WERE CONSTRUCTED USING TIGHTLY PACKED SANDBAGS ACROSS THE EXCAVATED TRENCH PLACED AT THE FOLLOWING MINIMUM FREQUENCY:

SLOPE %	SPACING (FT)
0 - 5	NOT REQUIRED
5 - 15	300
15 - 30	200
>30	100

REGISTERED PROFESSIONAL ENGINEER 88816PE OREGON MARCH 11, 2014 THOMAS C. CAMPBELL
EXPIRES: 12/31/2017

0 80 160 Feet

LEGEND

- RIPRAP
- ROCK GABION
- GRAVEL ROAD
- CULVERT
- BUILDING
- 4" HDPE LATERAL UNDERDRAIN
- 6" HDPE DOWNDRAIN
- LINER HOLE PATCH
- TRENCH PLUG
- BOULDER WALL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Symbol	Description	Date	Approved
1	RECORD DRAWINGS	08-16-2017	TCC

SIZE D
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ONE INCH

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Date: 08/16/2017
Drawn by: VG/ TJC
Spec No.:
TDD #: 14-06-0006
Reviewed by: J. PETERSEN, P.E.
PAN #: 104530.0004.064.02
Approved by: T. CAMPBELL, P.E.
OREGON_PE_LICENSE_#88816PE
DWG Scale: 1-INCH = 40 FEET

ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
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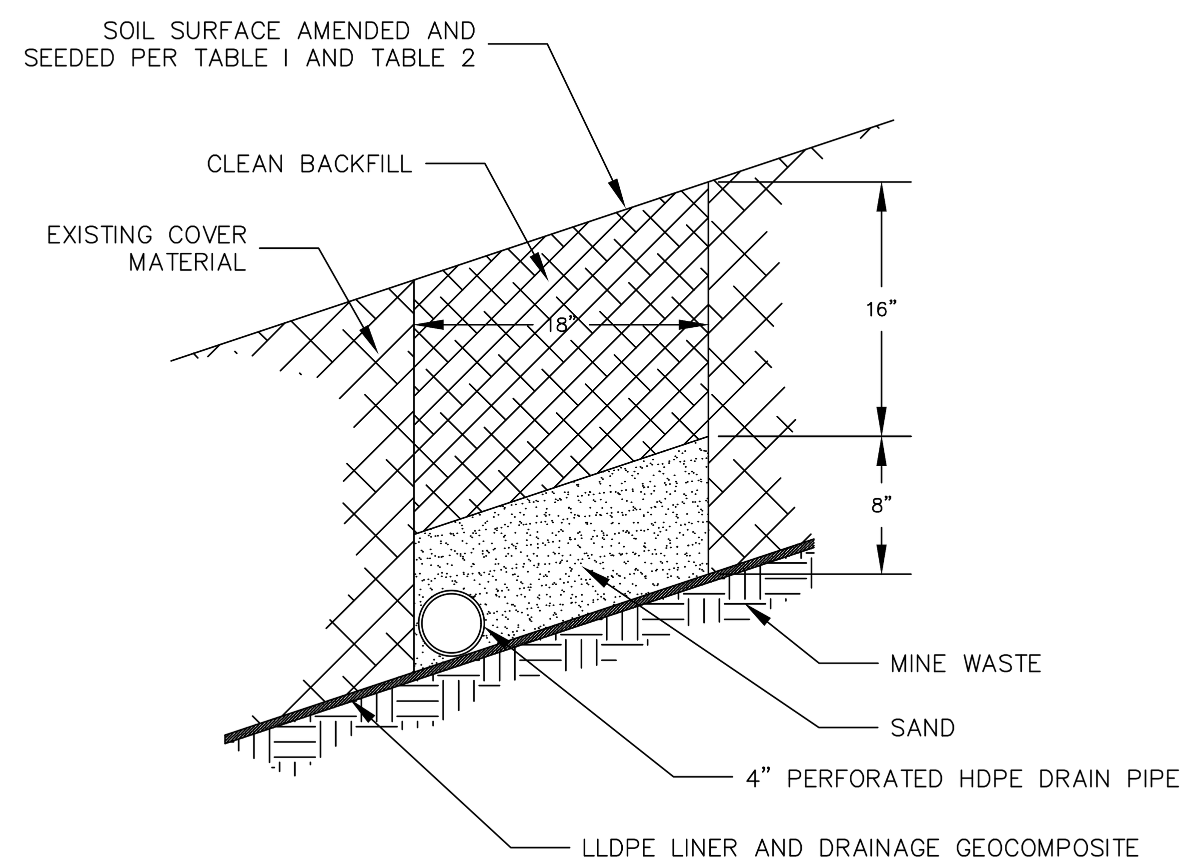
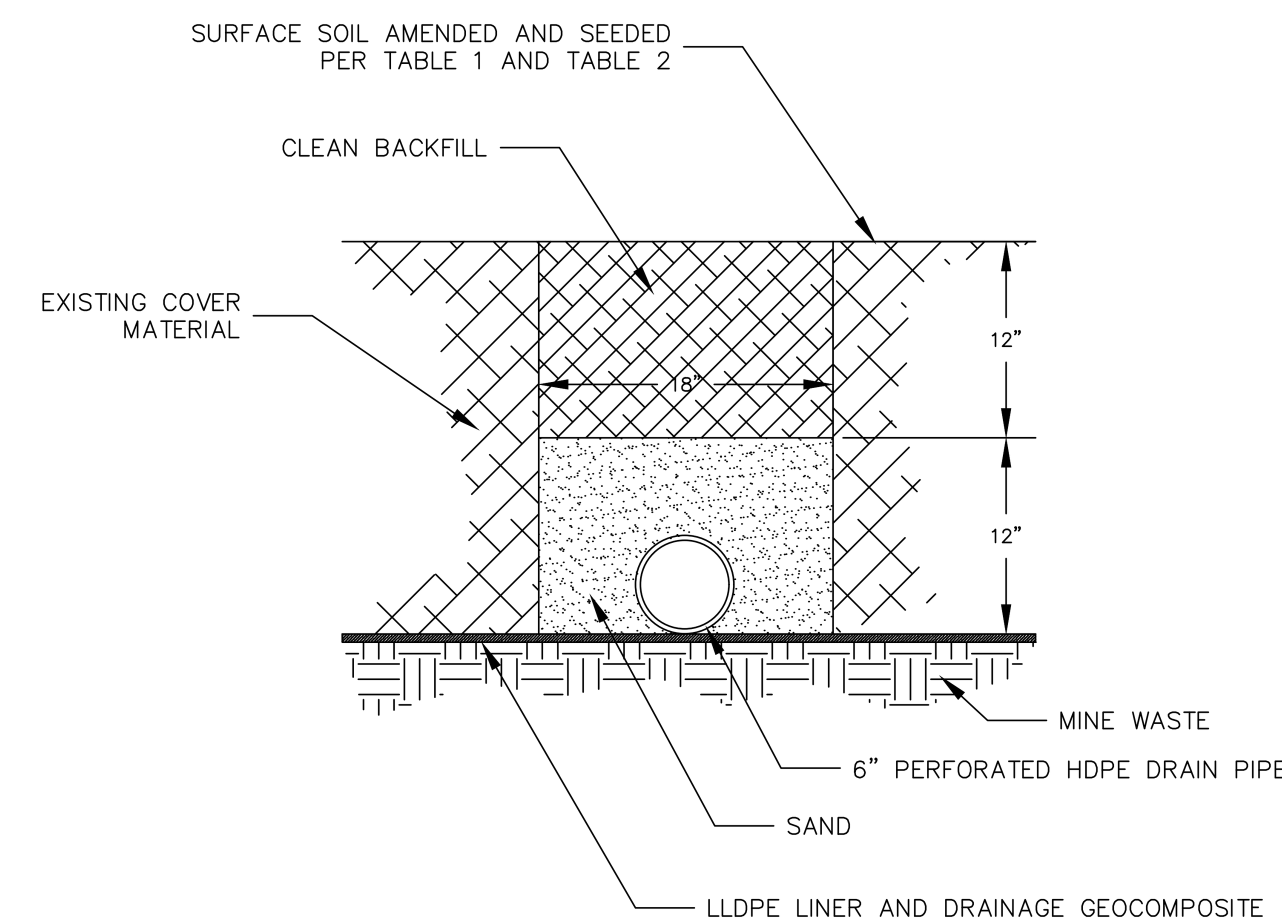
DOUGLAS COUNTY OREGON
BONANZA MINE SITE
UNDERDRAIN, COVER, AND GABION WALL PLAN VIEW

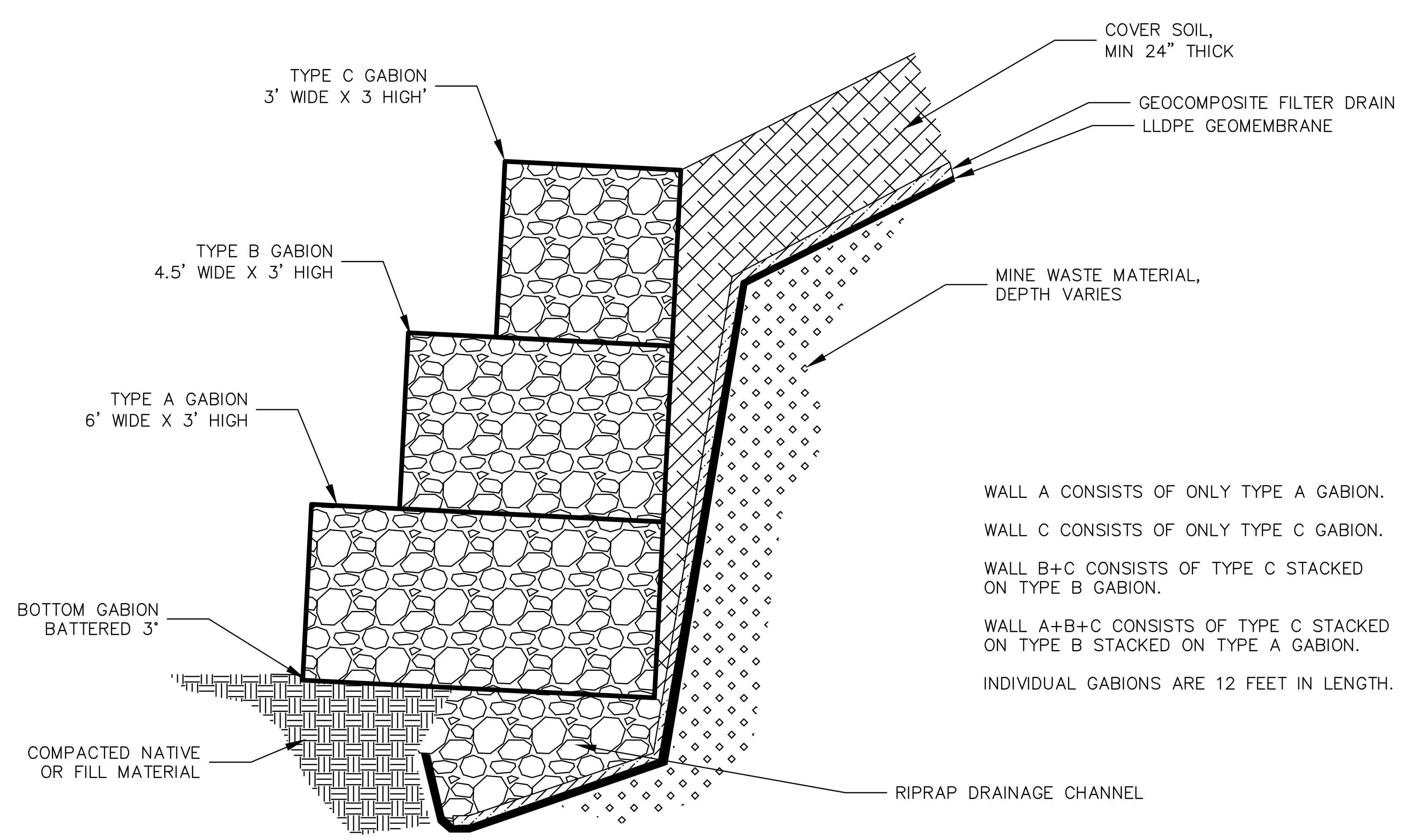
Sheet reference number:
C-4
SHEET 4 OF 5



1/5 4" UNDERDRAIN DETAIL
AS SHOWN



2/5 6" DOWNDRAIN DETAIL
AS SHOWN



WALL A CONSISTS OF ONLY TYPE A GABION.

WALL C CONSISTS OF ONLY TYPE C GABION.

WALL B+C CONSISTS OF TYPE C STACKED ON TYPE B GABION.

WALL A+B+C CONSISTS OF TYPE C STACKED ON TYPE B STACKED ON TYPE A GABION.

INDIVIDUAL GABIONS ARE 12 FEET IN LENGTH.

3/5 ROCK GABION WALL DETAIL
AS SHOWN

Table 1. Soil Stabilization Seed Mix

Seed	Percent Mix
Blue Wildrye	30%
California Brome	30%
Native Red Fescue	30%
Sandberg Bluegrass	10%
Application Rate	*35 lbs/acre*

Table 2. Soil Amendments

Amendments	Description	Rate
Fertilizer	Sustane 3-7-2, Medium Grade	2,000 lbs/ac
Bonded Fiber Matrix	FlexTerra FGM	3,000 lbs/ac

REGISTERED PROFESSIONAL ENGINEER 88916PE OREGON MARCH 11, 2014 THOMAS C. CAMPBELL
EXPIRES 12/31/2017

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Symbol	Description	Date	Approved
1	RECORD DRAWINGS	08-16-2017	TCC

SIZE D
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ONE INCH

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Reviewed by: J. PETERSEN, P.E.
Approved by: T. CAMPBELL, P.E.
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PAN #: 1002459.0004.064.02
DWG Scale: AS SHOWN

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DOUGLAS COUNTY OREGON
BONANZA MINE SITE
UNDERDRAIN, COVER, AND GABION WALL DETAILS

Sheet reference number: C-5
SHEET 5 OF 5