Run-on and Run-off Control System Plan

Rosebud Power Plant Landfill

Rosebud County, MT

October 17, 2016

Presented by:

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Bozeman, MT 59718
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1. INTRODUCTION

This run-on and run-off control plan presents the hydrology and hydraulics of the stormwater system for the Coal Combustion Residuals (CCR) landfill of the Rosebud Power Plant in Rosebud County, Montana owned by Colstrip Energy Limited Partnership (CELP) in order to fulfill the requirements of the CCR rule as published in the Federal Register on April 17, 2015 and July 2, 2015 and its effective date of October 17, 2016. This document fulfills the requirements of 40 CFR § 257.81(c). The landfill in this report holds hydrated ash, which is solid and practically impermeable to water, similar to concrete.

The project site is located approximately seven miles north of the town of Colstrip, Montana in the southwest quarter of Section 29 and the northwest quarter of Section 32 Township 3 North, Range 41 East (Latitude 45.978859°, Longitude -106.663772° (WGS 84)). A vicinity map is included on Sheet C0-1 of the plan set included in Appendix A. The landfill serves an on-site Power Plant owned by the Colstrip Energy Limited Partnership. The Power Plant and the landfill is operated by Rosebud Operating Services, Inc.

The landfill areas covered by this report are an active and closed landfill located on the subject property. The closed landfill, last used in October, 2005, has since been reclaimed in general accordance with applicable permits and regulations at closure. In accordance with 40 CFR § 257.50(d), this closed landfill is not subject to regulation by the above referenced rules. The active landfill includes Phase I and Phase II of a contiguous landfill permitted in 1997 and placed in service in October, 2005. This active landfill is subject to regulation by the above referenced CCR rules.

The information contained herein is based on an investigation and analysis of the property's topographical and subsurface conditions, a review of existing permits, regulatory requirements, and maps and literature for the project area as related to the landfilling operations of combusted coal residuals (CCR), more commonly referred to as fly ash and bottom ash. The purpose of this report is to quantify, mitigate and convey stormwater run-off and run-on for the project site.

In general, the CCR rules define run-on as water that drains overland onto the active landfill (§257.53). For this project, run-on will generally come from the west and flowing west to east across the project site to Armells Creek. Armells Creek flows generally north to the Yellowstone River. As demonstrated in this report, the specified run-on controls are adequate for the required 24-hour, 25 year storm event. Run-off refers to water that drains from the CCR landfill directly and includes the soil cap and containment berms. No rainfall that falls directly on the active CCR placement area will be allowed to flow from the confines of the landfill. This is accomplished with containment berms completely around the active ash placement areas. During the active life of the landfill, incipient precipitation onto the ash placement area is consumed by ash hydration of the on-going ash placement. This configuration will change upon final closure when ash placement ceases and more runoff will be generated from the landfill cap area. For clarity, excess rainfall refers to all water that is not infiltrated, retained or otherwise held in place for a given area during a storm event.

2. DRAINAGE BASIN DELINEATION

The delineation of the drainage basins resulted in eleven drainage basins for the active life of the landfill and eight drainage basins for the post-closure time period. All areas with a portion draining a soil covered CCR landfill were included for both the active and closed landfill. No excess rainfall with direct contact to placed CCR will leave the site. For the operational life of the landfill, the drainage pipes will convey run-off and run-on under the landfills to existing drainages downstream. The active drainage basins are numbered 1 through 11 (see sheet C2-1 in Appendix A).

To avoid reliance upon the buried pipelines and any they might otherwise present, once ash placement is complete, the drainage basins will change with the construction of surface drainage ways to replace the underground conveyance systems. All underground piping will be plugged and abandoned in-place. For specifics on abandonment of piping see the Rosebud Power Plant CCR Landfill Closure Plan. In general, the piping will be blocked at the inlet to stop any flow from entering the pipe. The post-closure drainage basins will be numbered 1 through 9 (see sheet C2-2 in Appendix A).

Active Drainage Basins

Active Drainage Basin 1 will contribute the majority of run-on onto the active landfill and into Pipe 2 with an area of 103 acres. For reference, Pipe 2 is the 36-inch Duromaxx pipe located on the west end of Phase 2 of the active landfill. Pipe 2 drains directly to Pipe 1. Pipe 1 is the original 48-inch, High Density Polyethylene (HDPE) pipe, which accepts run-off from both Active Drainage Basins 1 and 2. The area in this basin is mostly undisturbed grasslands with sagebrush and snowberry. A small area near the inlet to Pipe 2 will contribute run-off from the side slopes created by the containment berms. This run-off will not be in direct contact with the CCR, but will come from the established final cover system that makes up the side slopes. The top soil and seeding will be included for the berms as they are constructed, thereby reducing the amount of run-off and expediting the reclamation process.

Active Drainage Basin 2 is a smaller basin receiving run-on from 14.6 acres of mostly off-site, and a small amount of run-off from the containment berms near the Pipe 3 inlet. This area has similar land cover to Active Drainage Basin 1. Pipe 3 is a 30-inch Duromaxx pipe that tees into Pipe 2, which in turn connects to the existing Pipe 1.

Active Drainage Basin 3 is the top of the active CCR landfill surface that is contained on all sides by a berm. This area will not contribute any run-off as all precipitation will be used to hydrate the ash or will evaporate over the course of the water year. The basin sizes will change over the lifetime of the power plant as ash placement moves vertically. Enough freeboard will be present within the contained area to hold all rain events by maintaining a minimum of two-feet of freeboard on the berms. Once ash placement is complete, this area will be capped with a subtle concave sub-soil and vegetated top soil cap directing run-off to an armored channel as described below. This sequence will provide opportunity to establish, observe and if necessary maintain the reclaimed side slopes during the active life of the landfill, without the risk of suddenly adding considerably more drainage area to them upon closure.

The Active Drainage Basin 4, 5, and 6 will all drain run-off from the active landfill's side slopes. These slope areas are fairly small to start with and will grow as the landfill grows vertically, but will not receive run-off from the capped top even during post closure conditions. Run-off from these drainage basins will flow into existing swales and drainage pathways once they reach the bottom of the engineered slope.

The Active Drainage Basin 7 accepts run-on from the area west of the existing closed landfill into a 42-inch corrugated metal pipe (CMP). Some run-off coming from the west side of the existing landfill will flow off of the side slopes to the existing drainage pipe. All areas on the existing closed landfill are vegetated and protected with a soil cap. The drainage area for this basin is 67.4 acres of mostly undeveloped grass lands with some home sites. A small existing stock pond near the outlet of the basin is typically full and does not affect the peak flows of the drainage basin. The CMP has an obtuse angle in the middle of the pile that directs run-off to the north and into the historic drainage swale of the underlying basin.

Currently the existing closed landfill has a concave top that retains rainfall. This area is referred to as Active Drainage Basin 8. As part of the post-closure plan, this area will be graded to drain to an armored channel that will direct flow off of the top of the existing landfill. During the operation of the power plant, this area was used periodically to store excess wastewater that would have been used to hydrate ash. When fly ash sales reached their peak, ash was no longer being placed on the landfill and all the wastewater had to be retained on-site and allowed to evaporate or infiltrate. All plant process wastewater was stored in this area during that time period. This function can now be achieved in the bermed active ash placement area.

The remaining Active Drainage Basins are 9, 10, and 11. They consist of smaller areas draining the side slopes of the existing closed landfill. The existing closed landfill drainage basins have stabilized conditions with good to excellent vegetation cover. Table 1 and Table 2 provide drainage basin information. The time to concentration is most amount of time it takes the farthest hydraulic point of a watershed to reach the outlet. The Soil Conservation Service (SCS) Curve number is a parameter used for predicting run off or infiltration from a storm event that takes into account several variables including soil type and vegetation.

Active Drainage Basin	Total Area	Time to Concentration	SCS* Curve Number
1	103 acres	52 min.	72
2	14.6 acres	42 min.	72
3	4.3 acres	28 min.	72
4	13.6 acres	81 min.	72
5	16.3 acres	56 min.	72
6	4 acres	12 min.	72
7	67.4 acres	42 min.	72
8	3.2 acres	38 min.	72
9	10.5 acres	36 min.	72
10	5.6 acres	25 min.	72
11	5.8 acres	17 min.	72

Table 1 – Active Landfill Drainage Basin General Information

Post-Closure Drainage Basins

Post Drainage Basin 1 is resultant of the filling/grading of the Pipe 2 inlet area and directing all excess rainfall into Drainage Way 1. Drainage Way 1 is a swale that will be constructed to flow from the inlet area of Pipe 2 around the southern border of the active landfill to the existing outlet swale. This drainage way accepts excess rainfall directly from 118 acres and indirectly from 23 acres. The indirect excess rainfall comes from Drainage Ways 2 and 3 which will be constructed to flow into the inlet of Drainage Way 1. This was intentionally done in order to reduce the amount of cut needed to convey flow around the north side of the active landfill. These swales will have 12-foot wide bottoms, which can be used as access roads if needed. Any run-off coming from the southern half of the landfill will be intercepted by Drainage Way 1.

As noted above, Post Drainage Basin 2 drains to the inlet of Drainage Way 1. The inlet of Drainage Way 2 is the inlet area to existing Pipe 3. The inlet area to existing Pipe 3 will be filled in order to raise the inlet elevation of the existing drainage up to the elevation needed for the drainage way to be constructed. All excess rainfall into the Post Drainage Basin 2 will flow down Drainage Way 2 and enter the Drainage Way 1 inlet fill area. The run-off from the top of the landfill will flow into the Pipe 3 fill area and out the drainage way. By allowing the majority of the excess rainfall to flow into the swale through the filled inlet areas, the filled inlet areas effectively act as stilling basins to help remove any accumulated sediment from upstream drainage. These filled inlet areas also slow velocities of excess rainfall before entering the constructed drainage ways.

Post Drainage Basin 7 will be the Phase 2 landfill run-off that doesn't drain to Drainage Way 1 or 2. The majority of run-off from this drainage basin will sheet flow to an existing swale running along the northern side of the landfill. This swale will route any excess rainfall back toward the historic discharge point of the watershed near the outlet of Pipe 1. This area is similar to the Active Drainage Basin 5 during the active portion of the project.

Once ash storage is completed, a soil cap will be constructed over the hydrated ash top surface. This cap will utilize a concave geometry to direct run-off toward the north and into Drainage Way 3, an armored channel outfall. Run-off will exit the channel into an armored plunge pool that will drain out via a gentle vegetated swale to Drainage Basin 2.

Post Drainage Basin 3 will drain an area of 71.2 acres of approximately the same area as Active Drainage Basin 7. In order for this swale to be feasible, the inlet area to the existing CMP pipe will need to be filled and a drainage way cut into the existing ground. Drainage Way 4 will be constructed using a trapezoidal channel with 3H:1V side slopes and a 4-foot bottom width. Excess rainfall will flow in Drainage Way 4 and under the existing haul road in a proposed 36-inch diameter by 72 feet long Duromaxx culvert. Below the culvert, all excess rainfall from the landfill will flow from Post Drainage Basin 4. This lower area drains the northern slope of the existing closed landfill into Drainage Way 4. Drainage Way 4's discharge point will be near the outlet of the original drainage pipe under the existing closed landfill.

The top of the existing closed landfill will be filled and graded to drain to an armored channel, thus eliminating any retained excess rainfall in the existing depression. Active Drainage Basin 8 will become Post Drainage Basin 9 that drains into Drainage Way 5 (a rock armored channel). No changes are proposed to Active Drainage Basin 10 except that it becomes Post Drainage Basin 6.

Post Drainage Basin	Total Area	Time to Concentration	SCS* Curve Number
1	118 acres	54 min.	72
2	18.6 acres	44 min.	72
3	70.2 acres	48 min.	72
4	2.9 acres	26 min.	72
5	13 acres	74 min.	72
6	8.6 acres	29 min.	72
7	16.3 acres	38 min.	72
8	4.3 acres	38 min.	72
9	3 acres	32 min.	72

Table 2 – Post-Closure Landfill Drainage Basin General Information

3. DRAINAGE BASIN STORM FLOW CALCULATION

Following the delineation of the drainage basins, the Soil Conservation Service (SCS) curve number method was utilized to calculate volumes and flow rates for the basins. The curve number used for the native ground was estimated at 72. This curve number assumed a land use type of sagebrush with grass understory rangeland for all existing and reclaimed areas. The hydrologic condition was estimated between fair and good with a Hydrologic Soil Group of mostly D. All areas were assumed to have this curve number, which should be considered conservative given that better vegetation and more porous soil areas exist within the reclaimed drainage basins. Soil porosity outside the project area was estimated using the Web Soil Survey.

The CCR rules require all stormwater conveyance systems be designed to handle the 25-year 24-hour event. The conveyance system for this site was modeled using the 25-year, 100-year and 500-year events. Precipitation for the 25-year and 100-year events was taken from the NOAA Atlas 2, Volume 1-Montana. The 500-year event was extrapolated from higher frequency storms.

Design Storm	**Precipitation (inches)**
25-Year, 24-Hour	2.90
100-Year, 24-Hour	3.82
500-Year, 24-Hour	4.66

Table 3 – Precipitation Depths Summary

	Peak Discharge During Event			
Active Drainage Basin	25-Year, 24-Hour	100-Year, 24-Hour	500-Year, 24-Hour	**Units**
1	40.9	79.4	119.1	cfs
2	6.7	13	19.5	cfs
3	0	0	0	cfs
4	3.9	7.5	11.3	cfs
5	6.13	11.9	17.9	cfs
6	3.7	7.0	10.3	cfs
7	22.4	43.5	65.1	cfs
8	1.6	3.0	4.6	cfs
9	5.4	10.4	15.5	cfs
10	3.7	7.0	10.4	cfs
11	4.7	9.0	13.2	cfs

Table 4 - Active Landfill Basins Peak Discharge

	Peak Discharge During Event			
Post Drainage Basin	25-Year, 24-Hour	100-Year, 24-Hour	500-Year, 24-Hour	**Units**
1	45.0	87.6	131.5	cfs
2	8.3	16.2	24.3	cfs
3	29.8	57.0	85.6	cfs
4	2.0	3.6	5.4	cfs
5	5.2	8.6	14.9	cfs
6	4.1	8.0	12	cfs
7	8.1	15.8	23.6	cfs
8	2.1	4.2	6.2	cfs
9	1.7	3.3	4.9	cfs

Table 5 - Post-Closure Basins Peak Discharge

5. PIPE CONVEYANCE SYSTEM DESIGN

The drainage pipe system under the landfills was modeled using the program AutoCAD Storm and Sanitary Analysis 2016 (SSA). The main pipes for this project are as follows:

Pipe 1 - 48” HDPE Pipe (Phase 1)
Pipe 2 - 36” Duromaxx Pipe (Phase 2)
Pipe 3 - 30” Duromaxx Pipe (Phase 2)
Pipe 4 - 42” CMP (Existing Landfill)
Pipe 5 - 18” CMP (Existing Haul Road Culvert)
Pipe 6 - 36” Duromaxx Pipe (Haul Road Culvert Replacement)

SSA allows for modeling of any storm event routed through swales, reservoirs, pipes, culverts, and junctions. Using the 25-year event as the minimum standard for the performance of the pipes, the larger storms were routed through the system to identify long term adequacy of the system. During the 25-year 24-hour event, the existing and newly constructed piping under the landfills was found to be more than adequate to handle the design storm event.

Conveyance Element	**Peak Flow (cfs) 25-YR 24-HR Event**	**Peak Flow (cfs) 100-YR 24-HR Event**	**Peak Flow (cfs) 500-YR 24-HR Event**	**Design Flow Capacity (cfs)**
Pipe 1	47.6	92.4	138.6	197.2
Pipe 2	40.9	79.4	119.1	115.1
Pipe 3	6.7	13.0	19.5	97.1
Pipe 4	22.4	55.7	83.8	150.8
Pipe 5	4.7	9.0	13.3	9.5
Pipe 6	30.3	54.5	88.6	60.2*
*This is for the pipe only. During larger flows water will overtop the road which is acceptable				

Table 6 - Peak Flows in Piping

During less frequent, larger storms, the piping system will work well with some ponding at the inlets. Ponding is not an issue as pipe dams have been constructed downstream of the inlets to stop ponded water from entering the ash storage areas. Also, ponding will help slow velocities near the inlet and minimize erosion. Under these larger flows, the system will experience high velocities, which will aid in flushing out any accumulated sediment.

The proposed Pipe 6 a 36 inch culvert to replace the existing haul road culvert for Drainage Way 4 will pass a 100 year event and is intended for the active life of the landfill. After closure, this culvert can either be removed and regraded as a ford or left in place realizing it may not pass extreme events above 100 years without overtopping the road, which we consider acceptable both because it is well over the 25 year design event standard and should not cause significant damage and since this area is away from CCR storage and there is no threat of exposing hydrated fly ash.

6. DRAINAGE WAY FACILITIES

As stated above, the piping conveyance under the landfills will be plugged and abandoned and the inlet areas filled during the post-closure process in order to avoid long term issues related to eventual pipe deterioration/failure. To facilitate surface drainage around the ash landfills, the drainage ways will need to be excavated into the existing ground. The drainage ways will be located outside of the fly ash footprint and placed so as to not pose a risk of future exposure of fly ash. All drainage ways will be excavated at 3H:1V side slopes. All channels will be reclaimed, and managed with appropriate BMPs to mitigate sediment run-off and sediment transport. Rock grade controls will be placed in the channels where slopes exceed 2%. A rock grade control will consist of a 2-feet wide by 4-feet deep strip of rock riprap excavated into the channel bottom and partially into the side slopes (See Sheet C3-2). The grade controls are designed to create an equilibrium slope of 2% between the grade controls by allowing for 3-feet of drop between structures. The equilibrium slope is defined in the National Engineering Handbook as “the channel slope that is required to transport the bed material supplied through the reach, without significant aggradation or degradation of the channel”. Equilibrium slope was estimated by comparing existing drainage swale grades on and around the project site. A 2% slope was used as it is less than most of the natural drainage way slopes currently on or around the site. Additional protection will be available given that the grade control structures are 4-feet deep that provides an additional 1-foot of buried rock to help equalize the slope and prevent undermining.

For Drainage Way 1, 11 rock grade-control structures will be needed for a total of approximately 66 cubic yards of rock. Drainage Way 4 will require 12 rock grade-control structures with an estimated volume of 43.7 cubic yards of rock. The rock used in the drop structures should have an average diameter or D50 of 8 inches. The steeper drainage ways 3 and 4 will require the use of rock riprap with a D50 of 12-inches and a riprap thickness of 2-feet. The bottom of the channel and 6-feet on either side will be armored to protect against erosion.

The drainage ways were evaluated using the 25-, 100-, and 500-year 24-hour storm events (the same parameters that were used for the piping conveyance system). All drainage ways were found to be more than adequate for all storm events. Slopes for the drainage ways were mostly averaged and the peak design flow capacity is given for the most constrictive portion of the channel. The bottom widths and descriptions of the drainage ways are as follows:

Drainage Way 1 - 12’ bottom width, vegetated swale with rock grade controls
Drainage Way 2 - 12’ bottom width, vegetated swale
Drainage Way 3 – 4’ bottom width into V-ditch, armored channel into plunge pool and vegetated swale
Drainage Way 4 – 4’ bottom width, vegetated swale with rock grade control

Drainage Way 5 – 4’ bottom width, armored channel into plunge pool and vegetated swale

Drainage Way 1 will run from its inlet fill area to the existing outlet swale of Pipe 1. Drainage Way 2 drains the Drainage Way 2 Inlet Fill Area to the Drainage Way 1 Inlet Fill Area. Drainage Way 3 is the armored channel from the top of the completed Phase 2 landfill to the Drainage Way 2 Inlet Fill Area. For drainage at the existing closed landfill, Drainage Way 4 will convey drainage from the existing pipe inlet to the existing drainage swale on the northern side of the existing landfill. Once the existing closed landfill top has been graded and filled to direct run-off to the west, Drainage Way 5 will convey the water to the Drainage Way 4 Inlet Fill Area.

Conveyance Element	Peak Flow (cfs) 25-YR 24-HR Event	Peak Flow (cfs) 100-YR 24-HR Event	Peak Flow (cfs) 500-YR 24-HR Event	Design Flow Capacity (cfs)
Drainage Way 1	42	86.2	119.7	152
Drainage Way 2	8.8	18.1	28.1	201
Drainage Way 3	2.1	4.1	6.2	563
Drainage Way 4	30.3	54.5	88.6	186
Drainage Way 5	1.7	3.2	4.8	540

Table 7 - Peak Flows in Drainage Ways

As outlined in Table 7 above, the design capacity of the surface drainage ways greatly exceeds the calculated peak flows during the 25-year event. The reason that the drainage ways are so large on the Phase 2 Landfill is because of the anticipated use as access roads during the post-closure period. This use is assumed to be light and/or occasional enough in post closure to prevent significant damage to vegetation.

7. SURFACE RUN-OFF

In order to control any surface run-off at the project site, BMPs will be used on disturbed ground. Shallow slopes of 3H:1V or flatter have been used on all landfill features and channel side walls. These shallow slopes are used to limit erosion from higher velocities and promote sheet flow on vegetated slopes. The design of the landfill itself utilizes a 10-foot bench located at the 3170-foot elevation or roughly halfway up the Phase 2 slope. This bench helps to slow run-off velocities on the side slope of the landfill and encourages vegetation uptake. The top of the landfill will have a soil cap that will be seeded for vegetative cover.

8. CONCLUSION

All requirements of CCR 257.81 have been meet as shown below:

(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate and maintain:

> *(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and*

As discussed above, the landfill will have two systems for controlling run-on. During the active life of the landfill, internal piping will carry run-on under the landfill. For post-closure a series of drainage ways will be created that will direct flow around the CCR unit.

(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

As discussed above, the excess rainfall created by the active portion of the landfill will be controlled using shallow slopes, benching, and vegetative cover. The flows of water created in the design event will be conveyed in existing and constructed swales or piping to stabilized outlets.

(b) Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.

Per the surface water section of the Federal Register, no discharge of pollutants is expected to waters of the United States. All disturbed ground is to be vegetated and surface roughened as necessary to reduce run-off from excess rainfall, thus reducing sediment transport. Additional BMPs such as rock riprap, erosion control blankets, and grade controls will be used in areas of concentrated flow to reduce velocities, pond excess rainfall, and settle out sediment. BMPs such as this are already in-place at the inlets to Pipe 2 and Pipe 3.

(c) Run-on and run-off control system plan—(1) Content of the Plan. The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified…These plans must document how the run-on and run-off control systems has been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by appropriate engineering calculations.

This document constitutes the control systems needed to handle all run-on and run-off for the active and post-closure lifecycles of the CCR landfills. This plan will be updated every 5 years. In each update, the plan will be modified to address the current state of the control system.

(5) The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section.

This plan was created by a qualified professional engineer and meets all requirements of the CCR rule 257.81.

Any expected run-on and run-off will be either mitigated using existing vegetation or directed to protected swales and/or piping. Most of the run-on will be handled at the property boundary through inlet areas that direct flow into either the existing piping or into the proposed surface drainage ways. This report shows that the stormwater conveyance systems for the project are more than adequate to handle the required storm event and also larger, less frequent storms that may occur during the active and post-closure time period of the landfill areas.

9. CERTIFICATION

This report was prepared by Allied Engineering Services, Inc., under the direction of Douglas S. Chandler, PhD, PE, with assistance from Andrew Graham, PE, and Ronald Orton, Environmental Scientist, and QC review by Brock Athman, PE.

ALLIED ENGINEERING SERVICES, INC

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10. REFERENCES

AASHTO Model Drainage Manual. “Chapter 7, Hydrology.” October 3, 1995

Autodesk, Storm and Sanitary Analysis 2016. Version 10.1.53.1

National Oceanic and Atmospheric Administration. “NOAA Atlas 2 – Precipitation Frequency Atlas of the Western United States-Volume I – Montana.” 1973

National Engineering Handbook Part 654, “Technical Supplement 14- Grade Stabilization Techniques”. 2007

Urban Drainage And Flood Control District Criteria Manual, “Volume 2 Structures, Storage and Recreation”. 2016

Natural Resources Conservation Service. Web Soil Survey http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. 2016

APPENDIX A

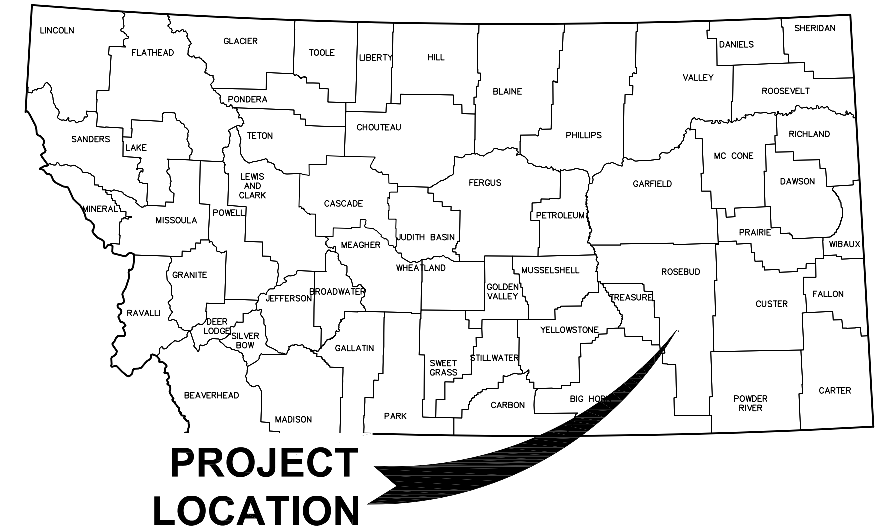
Rosebud Power Plant
Fly Ash Landfill Post-Closure Design

ROSEBUD POWER PLANT

FLY ASH LANDFILL POST-CLOSURE DESIGN

PROJECT LOCATION: 6.5 MILES NORTH OF COLSTRIP, MT ON HIGHWAY 39

LEGAL DESCRIPTION: NW $\frac{1}{4}$, SECTION 32, TOWNSHIP 3N, RANGE 41E, P.M.M., ROSEBUD COUNTY, MT



OWNER: COLSTRIP ENERGY LIMITED PARTNERSHIP (CELP)
1087 W. RIVER STREET, SUITE 200
BOISE, ID 83702

CLIENT: ROSEBUD OPERATING SERVICES, INC.
1087 W. RIVER STREET, SUITE 200
BOISE, ID 83702

SEPTEMBER 15, 2016

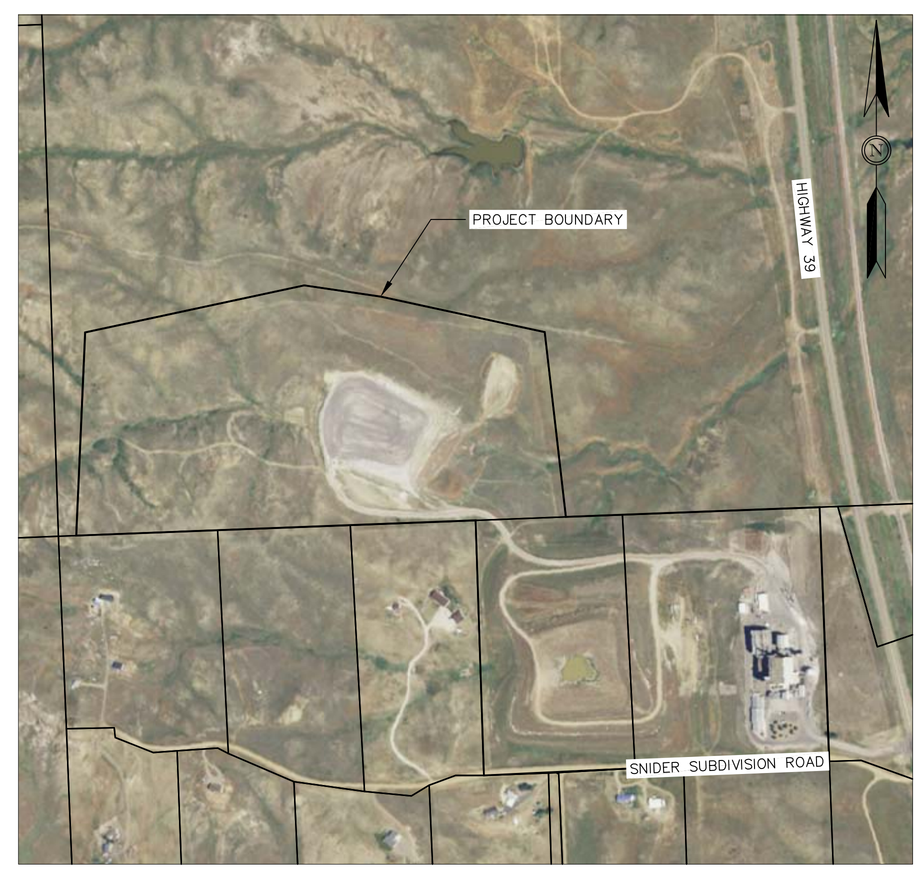
SET NO. ________

PRINCIPAL-IN-CHARGE: DOUG CHANDLER, PE, Ph.D

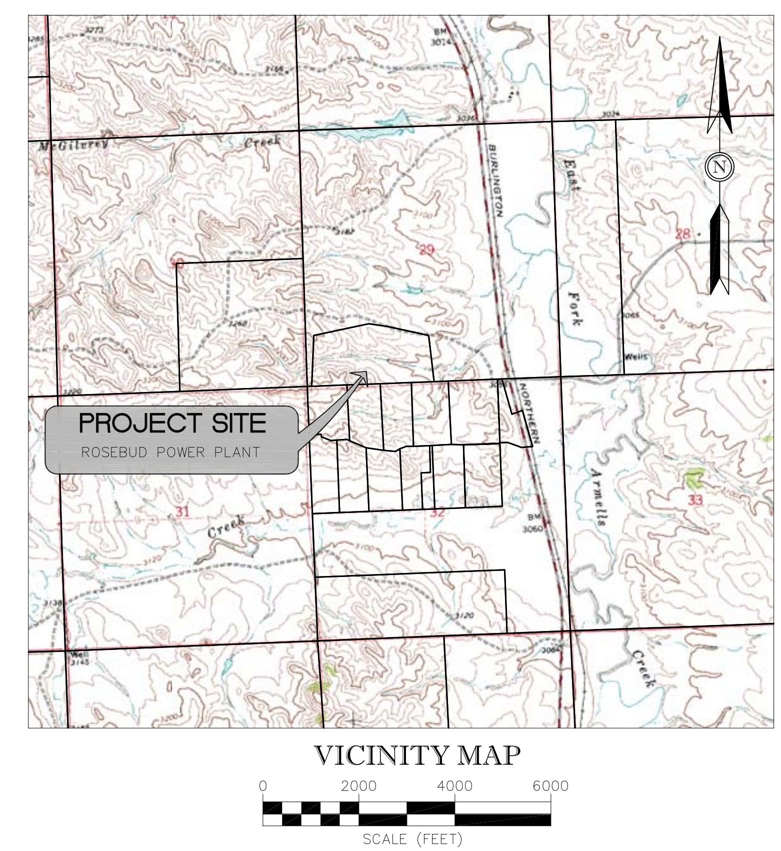
PROJECT ENGINEER: ANDREW S. GRAHAM, PE

QC REVIEW: BROCK D. ATHMAN, PE

PROJECT SURVEYOR: KYLE THOMPSON, PLS
GREG FINCK, PLS



LOCATION MAP



VICINITY MAP

32 DISCOVERY DRIVE
BOZEMAN, MT 59718
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ROSEBUD POWER PLANT
ROSEBUD COUNTY, MONTANA

NO.	REVISIONS	DATE

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\POST-CLOSURE COVER & NOTES.dwg

ROSEBUD POWER PLANT
CO-1 COVER SHEET

SHEET INDEX

SHEET NO.	
GENERAL SHEETS	
C0-1	COVER SHEET
C0-2	SHEET INDEX, LEGEND, & GENERAL NOTES
C0-3	EXISTING CONDITIONS (AS-BUILT)
C0-4	EXISTING CONDITIONS
DRAINAGE SHEETS	
C1-1	DESIGN PLAN – DRAINAGE WAY 1 & 2
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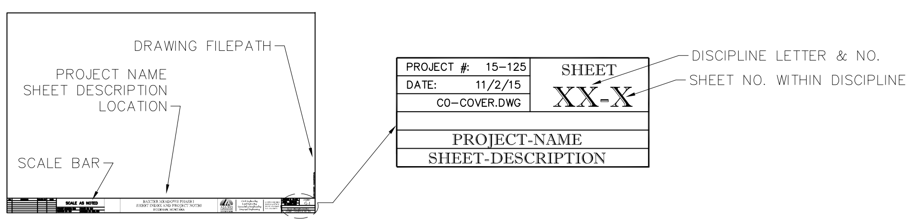
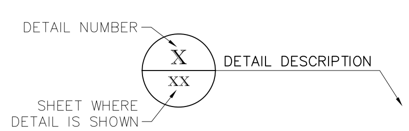
AESI STANDARD BORDER FORMAT



PLAN SHEET DETAIL CALLOUTS



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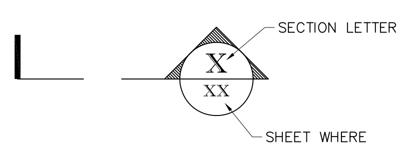

GENERAL NOTES:

1. THESE PLANS PRESENT FIELD AND DESIGN CHANGES TO THE ORIGINAL PLAN SET, ROSEBUD FLYASH DISPOSAL – DATED MAY, 1996. THESE ORIGINAL PLANS WERE CREATED BY CHANDLER GEOTECHNICAL, INC. FOR THE DESIGN OF PHASE 1 AND PHASE 2 OF THE FLYASH LANDFILL. ASH PLACEMENT IN PHASE 1 BEGAN IN 2005 AND CONSTRUCTION OF PHASE 2 BEGAN IN AUGUST, 2015. THESE PLANS ARE A CONTINUATION TO THE ROSEBUD POWER PLANT, FLY ASH LANDFILL DESIGN MODIFICATIONS – DATED JANUARY 7, 2016.
2. THIS PROJECT SHALL BE CONSTRUCTED IN ACCORDANCE WITH ALLIED ENGINEERING'S PLAN SET; ALONG WITH THE MONTANA PUBLIC WORKS STANDARD SPECIFICATIONS (MPWSS), SIXTH EDITION.
3. ALL DuroMaxx PIPE IS TO BE INSTALLED PER ALLIED ENGINEERING'S PLANS AND SPECIFICATIONS; ALONG WITH CONTECH'S DuroMaxx STEEL REINFORCED PE TECHNOLOGY INSTALLATION GUIDE.

LEGEND

- 4770 — MAJOR CONTOUR – FG
- 4771 — MINOR CONTOUR – FG
- 4770 — MAJOR CONTOUR – EG
- 4771 — MINOR CONTOUR – EG
- FOUND MONUMENT AS NOTED
- SET MONUMENT
- CONTROL POINT
- X — X FENCE – EXISTING
- OHP OVERHEAD POWER – EXISTING
- G — G UTILITY GAS – EXISTING
- TEL UTILITY PHONE – EXISTING
- E — E UTILITY ELECTRIC – EXISTING
- UTILITY POWER POLE – EXISTING
- LIGHT POLE – EXISTING
- ELECTRICAL PEDESTAL – EXISTING
- ELECTRICAL METER – EXISTING
- TELEPHONE PEDESTAL – EXISTING
- GAS METER – EXISTING
- GAS VALVE – EXISTING
- GUY ANCHOR – EXISTING
- EASEMENT LINE
- BOUNDARY/ LOT LINE
- ROAD CENTERLINE
- ROAD – CURB
- CONCRETE SIDEWALK
- STREET SIGN
- S — SEWER MAIN
- S — SEWER MAIN – EXISTING
- SS — SEWER SERVICE
- SANITARY SEWER MANHOLE
- SEWER CLEANOUT
- W — WATER MAIN
- W — WATER MAIN – EXISTING
- WS — WATER SERVICE
- FIRE HYDRANT
- BLOW-OFF HYDRANT
- WATER VALVE
- WELL
- MONITORING WELL
- SD — STORM MAIN
- CULVERT – EXISTING
- DITCH–CENTERLINE – EXISTING
- STORM MAIN JOINT,BEND, OR STRUCTURE

CIVIL ABBREVIATIONS:

AESI	ALLIED ENGINEERING SERVICES, INC.
AC	ACRE
AVE	AVENUE
BLDG	BUILDING
BM	BENCHMARK
BOG	BACK OF GRATE (GUTTER)
CI	CAST IRON
CL	CENTERLINE
CMP	CORRUGATED METAL PIPE
CO	CLEAN OUT
COB	CITY OF BOZEMAN
CONC	CONCRETE
CY	CUBIC YARD
DI	DUCTILE IRON
DIA	DIAMETER
DWG	DRAWING
E	EAST
EA	EACH
EG	EXISTING GRADE
ELEV	ELEVATION
EOG	EDGE OF GRAVEL
EOP	EDGE OF PAVEMENT
EX	EXISTING
FETS	FLARED END TERMINAL SECTION
FG	FINISHED GRADE
FHYD	FIRE HYDRANT
FL	FLANGE
FL	FLOWLINE
FM	SEWER FORCE MAIN
FT	FEET
GPM	GALLONS PER MINUTE
GV	GATE VALVE
HDPE	HIGH DENSITY POLYETHYLENE
HORZ	HORIZONTAL
HP	HIGH POINT
HWY	HIGHWAY
IE	INVERT ELEVATION
IN	INCH
INV	INVERT
LF	LINEAR FEET
LP	LOW POINT
LT	LEFT
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
MJ	MECHANICAL JOINT
MP	MID POINT
MPWSS	MONTANA PUBLIC WORKS STANDARD SPECIFICATIONS
MSU	MONTANA STATE UNIVERSITY
N	NORTH
PC	POINT OF CURVATURE
PE	PLAIN END
PE	POLYETHYLENE
PI	POINT OF INTERSECTION
PL	PROPERTY LINE
PSI	POUNDS PER SQUARE INCH
PT	POINT OF TANGENCY
PVC	POLYVINYL CHLORIDE
R	RADIUS
RP	RADIUS POINT
RCP	REINFORCED CONCRETE PIPE
ROW	RIGHT-OF-WAY
RT	RIGHT
S	SOUTH
SCH	SCHEDULE
SD	STORM DRAIN
SECT	SECTION
SG	SUBGRADE
S	SANITARY SEWER MAIN
SS	SANITARY SEWER SERVICE
ST	STREET
STA	STATION
STD	STANDARD
SY	SQUARE YARD
TBM	TEMPORARY BENCH MARK
TBC	TOP BACK OF CURB
TDH	TOTAL DYNAMIC HEAD
TYP	TYPICAL
UG	UNDERGROUND
VC	VITRIFIED CLAY
VERT	VERTICAL
W	WATER MAIN
W	WEST
W/	WITH
W/O	WITHOUT
WS	WATER SERVICE

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\POST-CLOSURE COVER & NOTES.dwg

NO.	REVISIONS	DRAWN BY	DATE

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG, BDA | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
SHEET INDEX, LEGEND, & GENERAL NOTES
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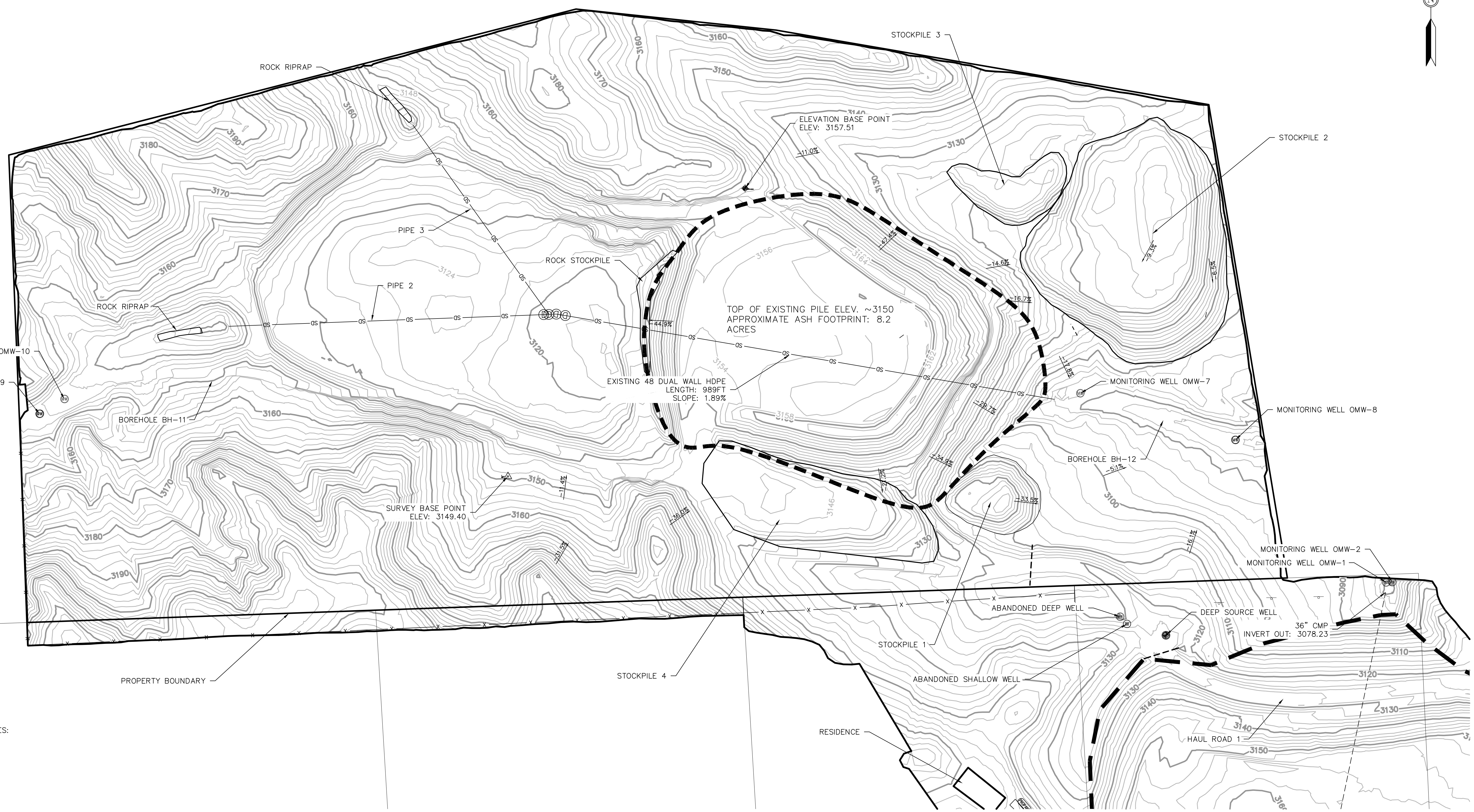
PROJECT #: 15-125
DATE: 9/15/2016

SHEET
C0-2

INDEX, LEGEND, & NOTES

SURVEY OF PHASE 1 LANDFILL AND SURROUNDING AREA
BASED ON TOPOGRAPHIC SURVEYS COMPLETED ON:
9/14/15 BY GREG FINCK OF AESI
1/27/16 BY GREG FINCK AND KYLE THOMPSON OF AESI



BASE POINT COORDINATES:
SURVEY BASE POINT
ELEV: 314940
LAT: 45.978219
LONG: 106.665945

ELEVATION BASE POINT
ELEV: 3157.51
LAT: 45.979748
LONG: 106.664004

NO.	REVISIONS	DRAWN BY	DATE

0 100 200 300
SCALE (FEET)

PROJECT ENGINEER: DSC	DRAWN BY: ASG
DESIGNED BY: ASG	REVIEWED BY: DSC, BDA

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EXISTING CONDITIONS (AS-BUILT)
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SHEET
C0-3

EXISTING CONDITIONS

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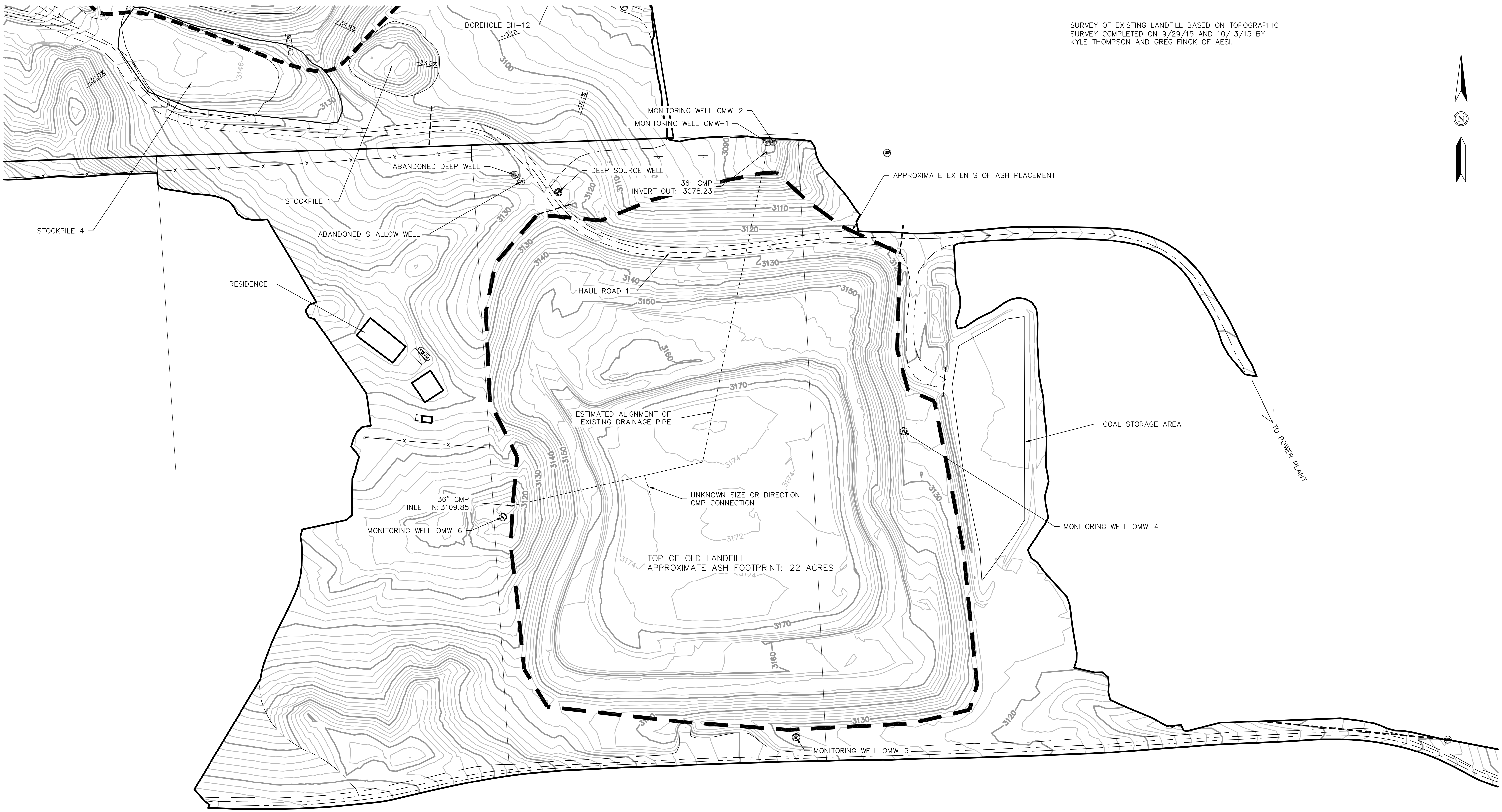

NO.	REVISIONS	DRAWN BY	DATE

0 100 200 300

SCALE (FEET)

PROJECT ENGINEER: DSC | DRAWN BY: ASG

DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

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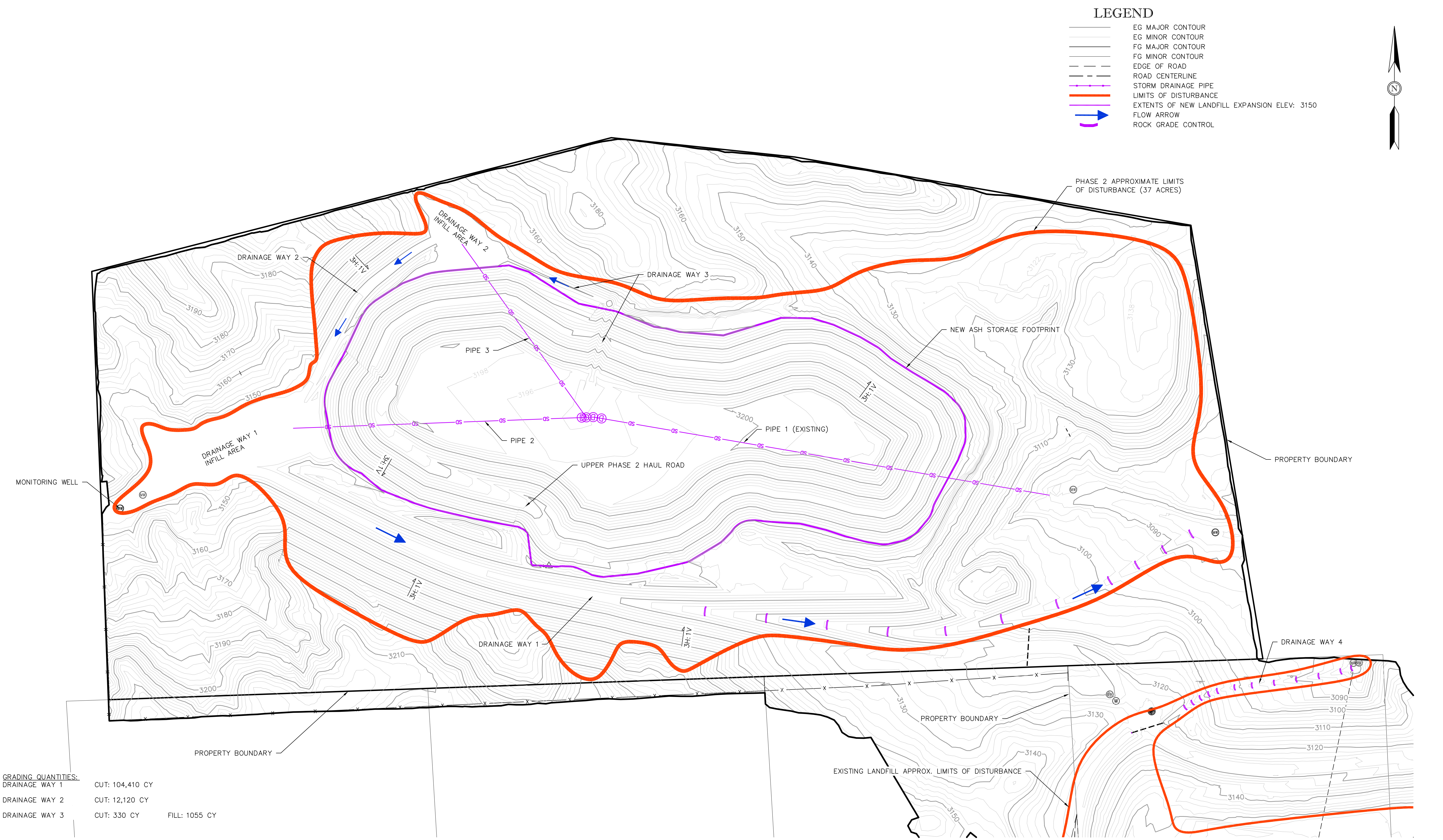
SHEET

C0-4

EXISTING CONDITIONS



GRADING QUANTITIES:

DRAINAGE WAY 1	CUT: 104,410 CY	
DRAINAGE WAY 2	CUT: 12,120 CY	
DRAINAGE WAY 3	CUT: 330 CY	FILL: 1055 CY

NO.	REVISIONS	DRAWN BY	DATE

SCALE (FEET) 0 100 200 300

PROJECT ENGINEER: DSC
DRAWN BY: ASG
DESIGNED BY: ASG
REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DESIGN PLAN - DRAINAGE WAY 1 & 2
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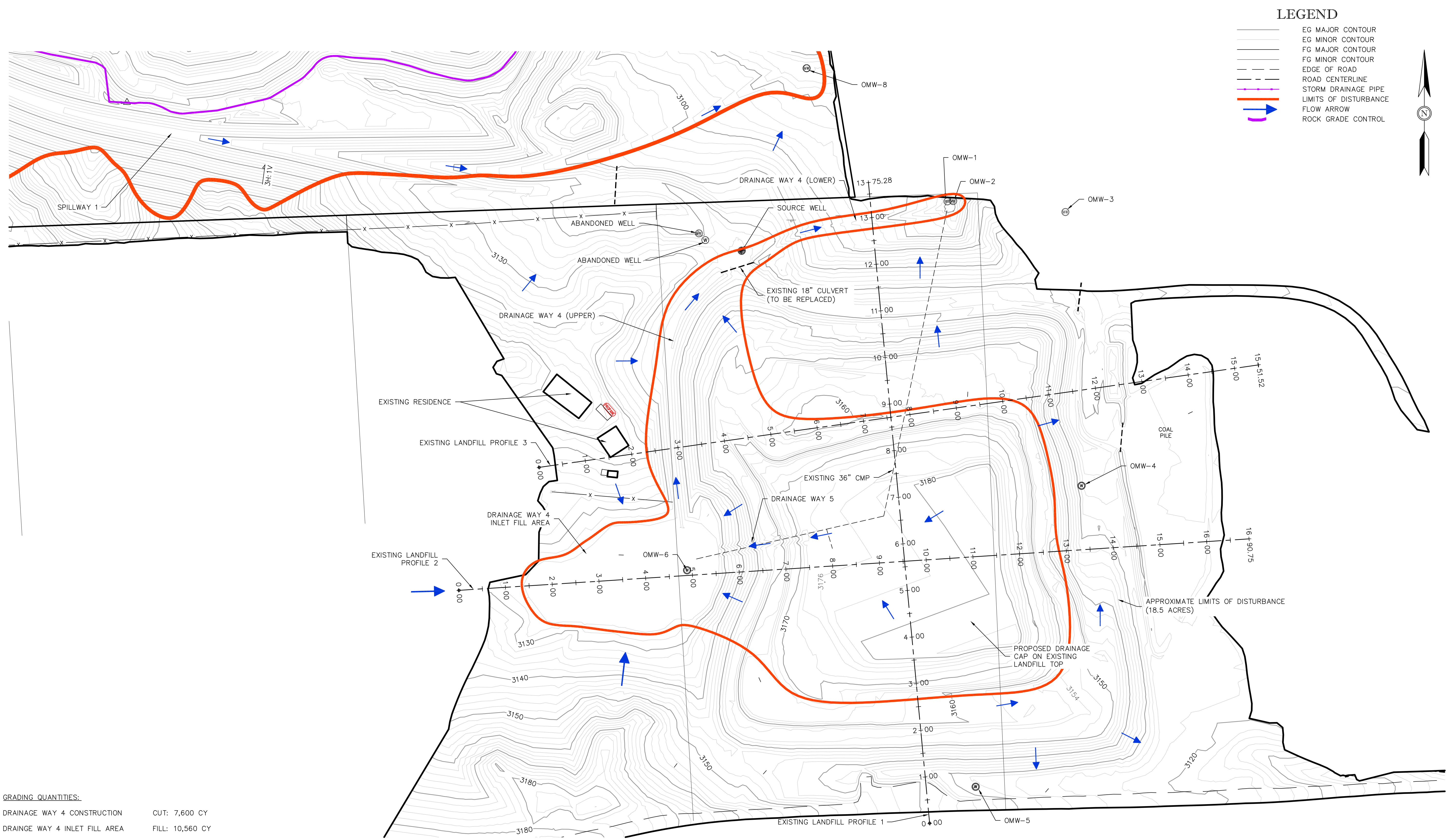
DATE: 9/15/2016

SHEET C1-1

DESIGN PLAN -DRAINAGE



GRADING QUANTITIES:

DRAINAGE WAY 4 CONSTRUCTION	CUT: 7,600 CY
DRAINGE WAY 4 INLET FILL AREA	FILL: 10,560 CY
DRAINAGE WAY 5 CONSTRUCTION:	CUT: 70 CY FILL: 817 CY
EXISTING LANDFILL TOP FILL	FILL: 25,480 CY

NO.	REVISIONS	DRAWN BY	DATE

0 100 200 300
SCALE (FEET)

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DESIGN PLAN - EXISTING LANDFILL
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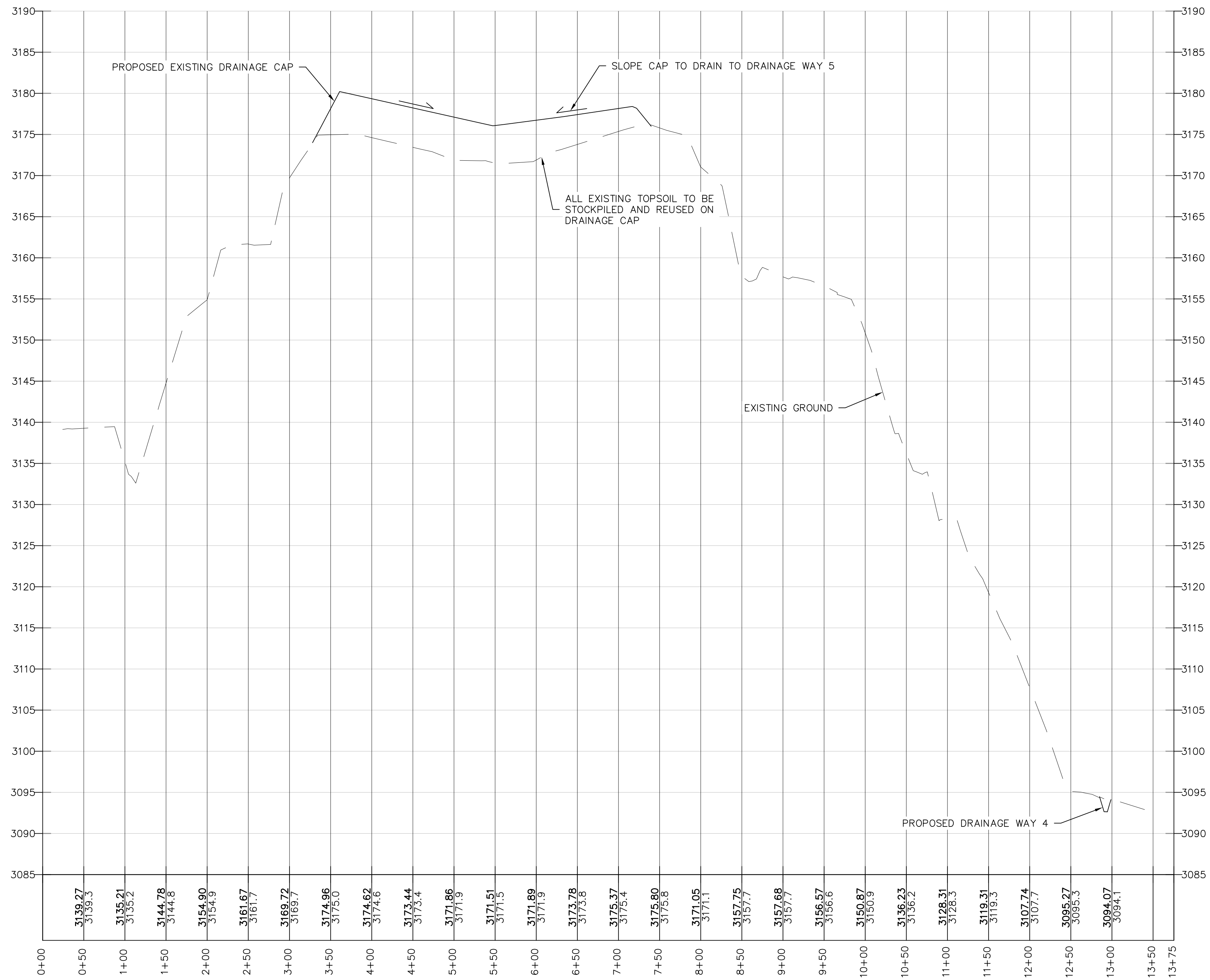
DATE: 9/15/2016

SHEET
C1-2

DESIGN PLAN - EXISTING

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DESIGN PLAN- EXISTING LANDFILL.dwg



PROFILE VIEW - EXISTING LANDFILL PROFILE 1

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DESIGN PLAN- EXISTING LANDFILL.dwg

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 80 160
VERTICAL SCALE FEET 0 8 16

PROJECT ENGINEER: DSC
DRAWN BY: ASG
DESIGNED BY: ASG
REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PROFILE VIEW - EXISTING LANDFILL PROFILE 1
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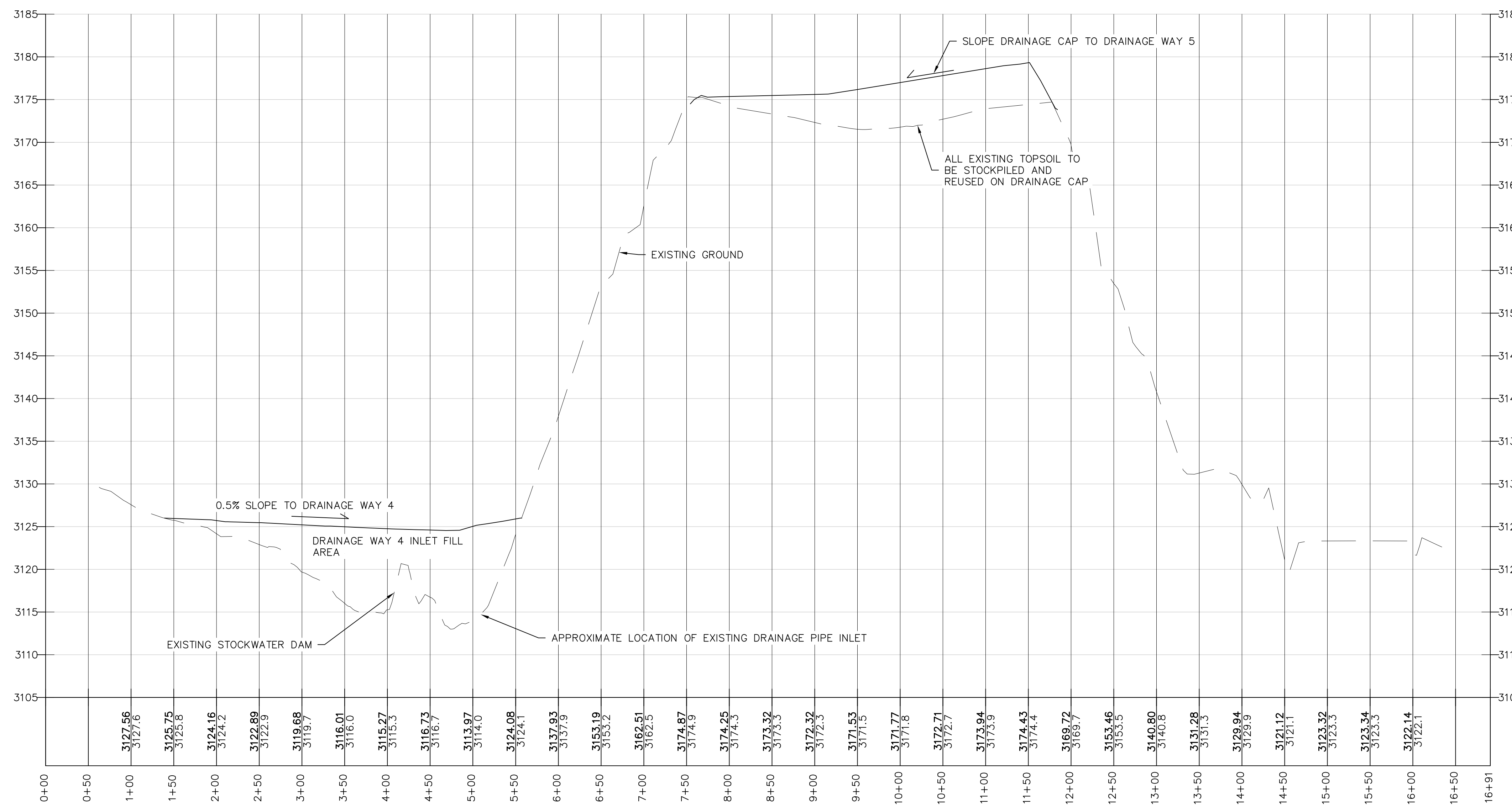
DATE: 9/15/2016
SHEET C1-3

DESIGN PLAN - EXISTING



PROFILE VIEW - PROFILE 2

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET: 0 80 160

VERTICAL SCALE FEET: 0 8 16

PROJECT ENGINEER: DSC | DRAWN BY: ASG

DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PROFILE VIEW - EXISTING LANDFILL PROFILE 2
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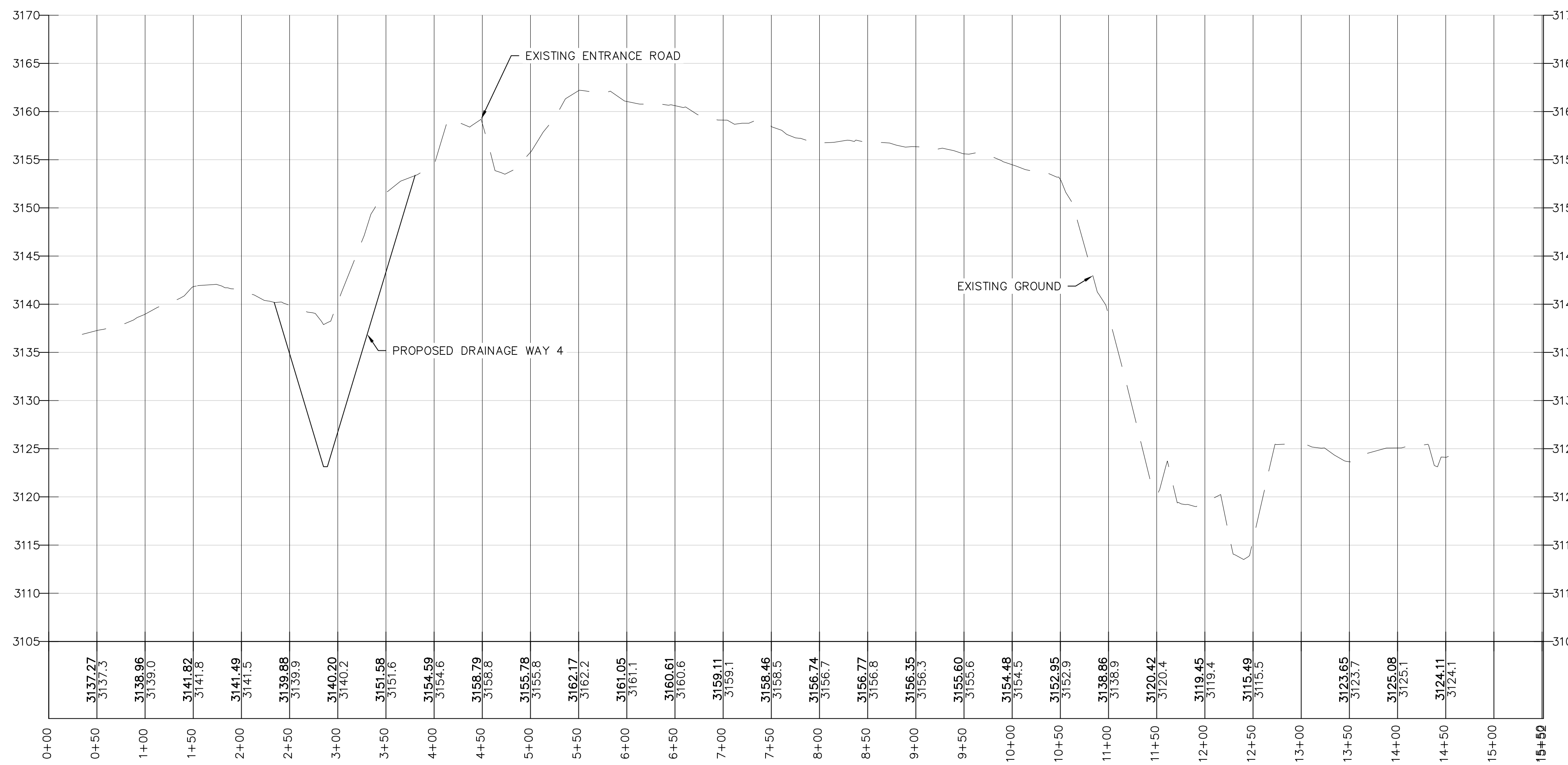
SHEET C1-4

DESIGN PLAN - EXISTING

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DESIGN PLAN\DESIGN PLAN- EXISTING LANDFILL.dwg



PROFILE VIEW - PROFILE 3

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DESIGN PLAN - EXISTING LANDFILL.dwg

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET: 0 80 160
VERTICAL SCALE FEET: 0 8 16

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PROFILE VIEW - EXISTING LANDFILL PROFILE 3
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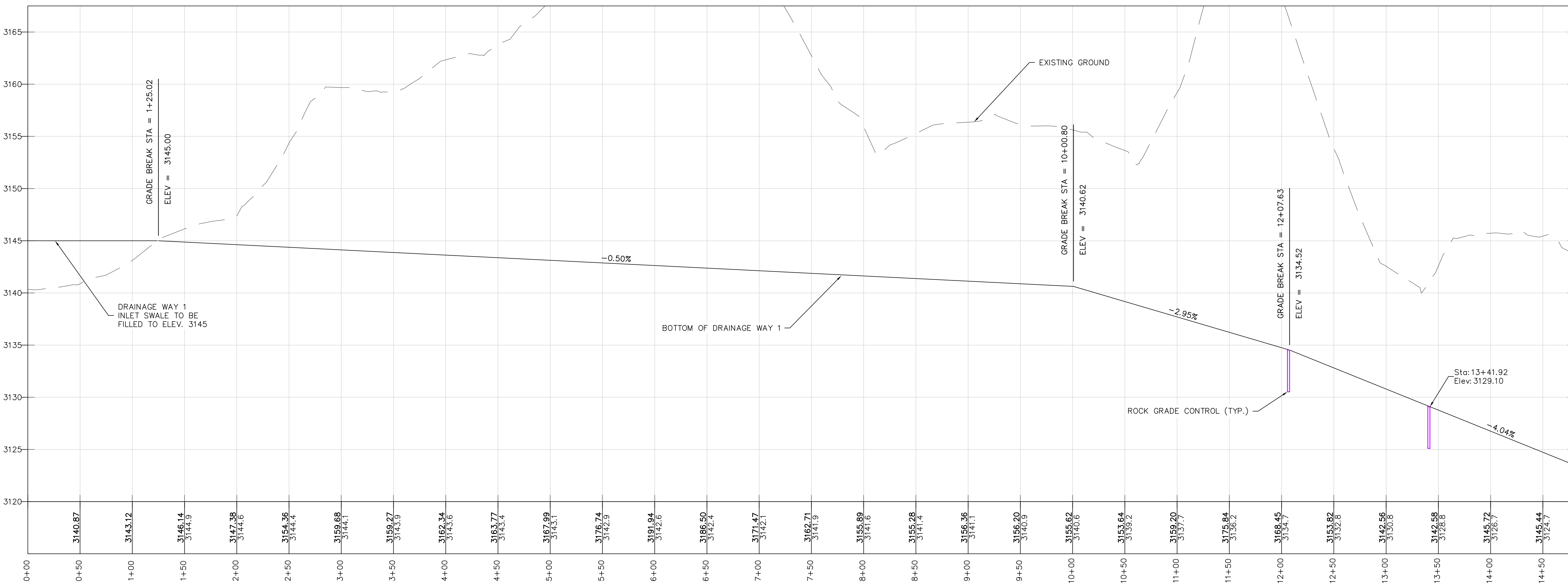
SHEET
C1-5

DESIGN PLAN - EXISTING

PLAN VIEW - DRAINAGE WAY 1 (STA 0+00 - STA 14+80)



PROFILE VIEW - DRAINAGE WAY 1 (STA 0+00 - STA 14+80)

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 50 100

VERTICAL SCALE FEET 0 5 10

PROJECT ENGINEER: DSC — DRAWN BY: ASG

DESIGNED BY: ASG — REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PLAN & PROFILE - DRAINAGE WAY 1
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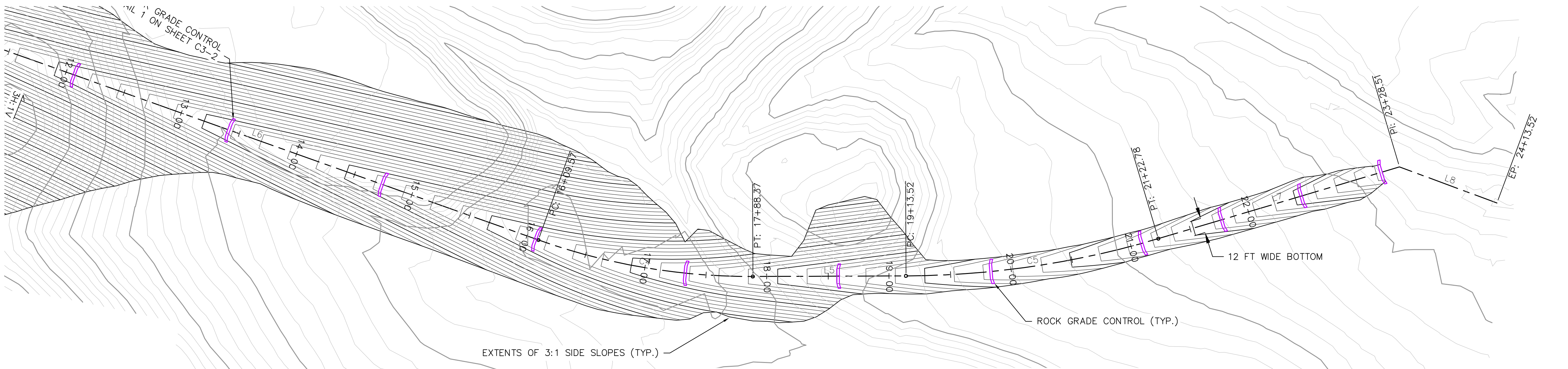
DATE: 9/15/2016

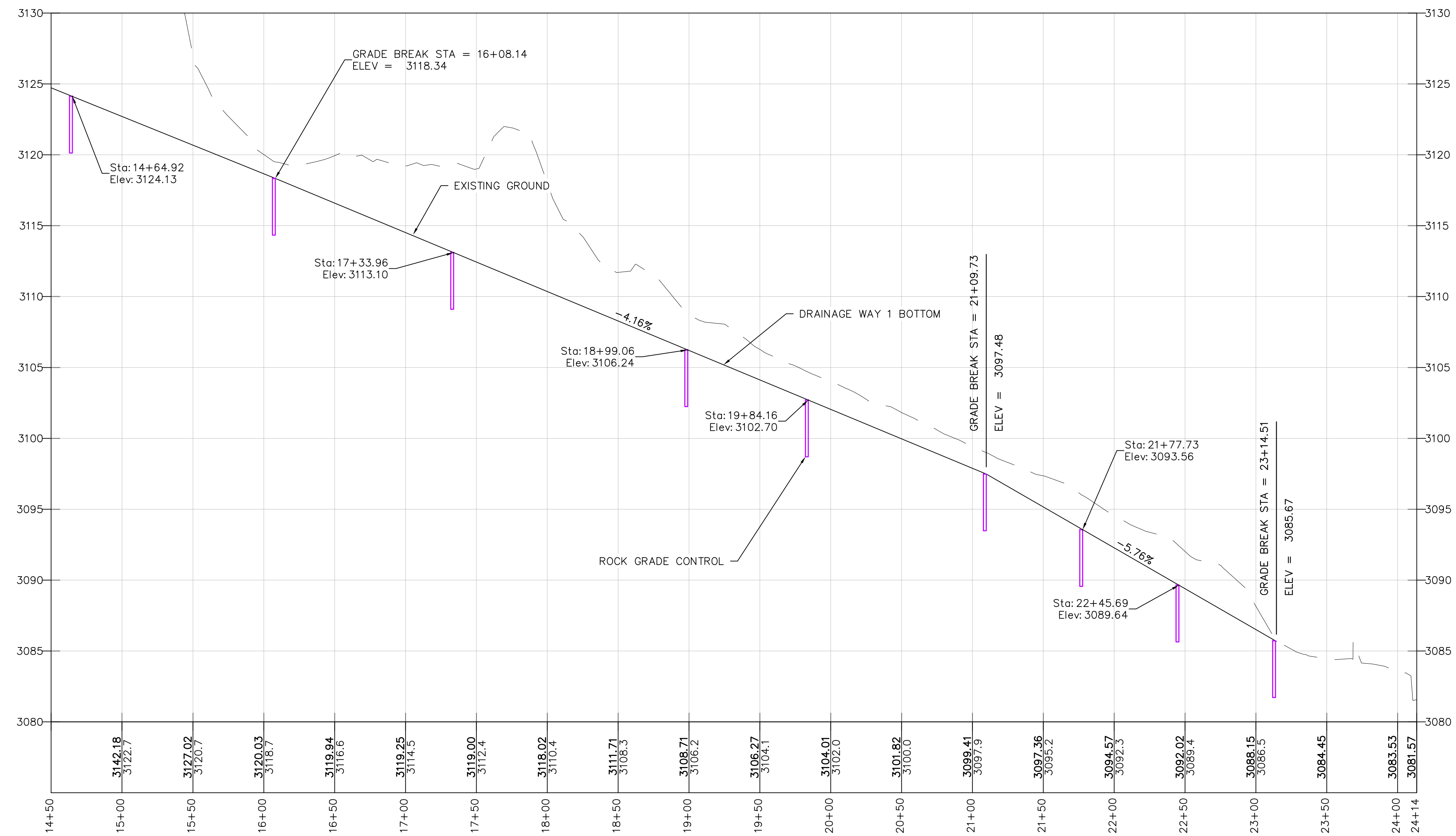
SHEET C1-6

P & P - DRAINAGE WAY 1



PLAN VIEW - DRAINAGE WAY 1 (STA 14+50 - STA 22+10)

NOTE:
SEE SHEET C3-3 FOR ALIGNMENT TABLE.



PROFILE VIEW - DRAINAGE WAY 1 (STA 14+50 - STA 22+10)

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 50 100
VERTICAL SCALE FEET 0 5 10

PROJECT ENGINEER: DSC
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REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PLAN & PROFILE - DRAINAGE WAY 1
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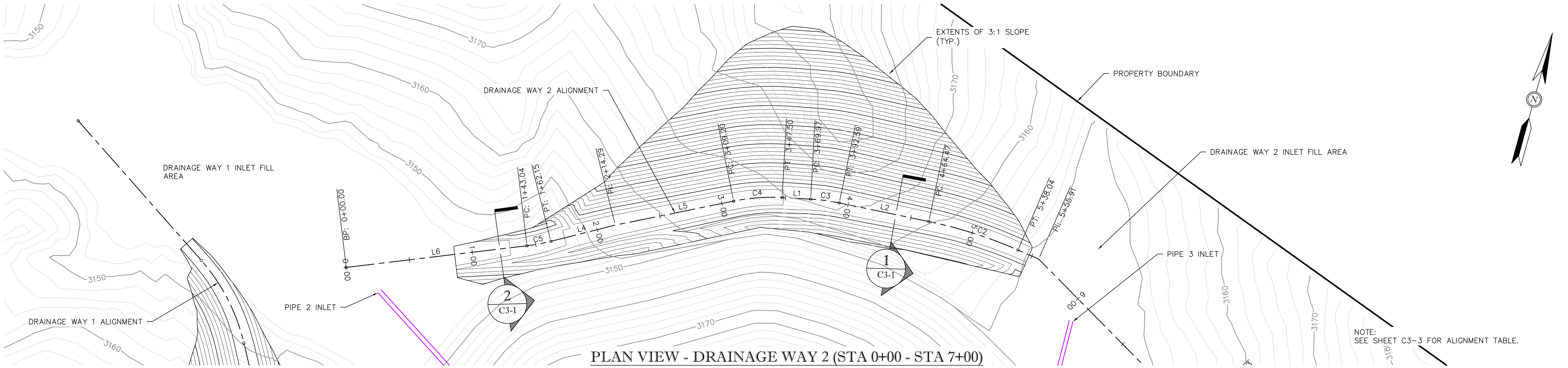
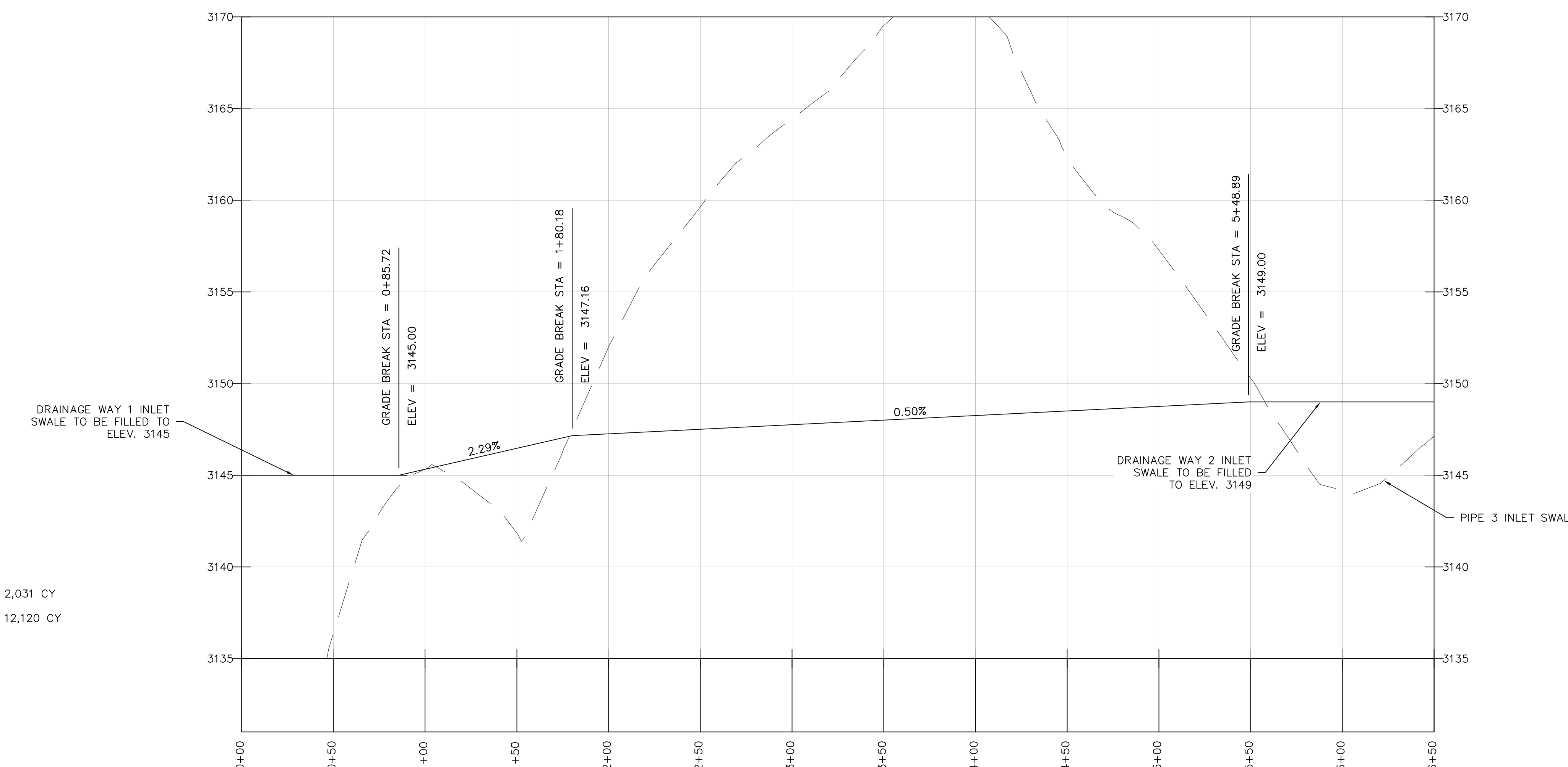
DATE: 9/15/2016
SHEET C1-7

P & P - SPILLLWAY 1



PLAN VIEW - DRAINAGE WAY 2 (STA 0+00 - STA 7+00)



GRADING QUANTITIES:

DRAINAGE WAY 2 INLET FILL VOLUME: 2,031 CY

DRAINAGE WAY 2 CUT VOLUME: 12,120 CY

PROFILE VIEW - DRAINAGE WAY 2 (STA 0+00 - STA 7+00)

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 40 80 — VERTICAL SCALE FEET 0 4 8

PROJECT ENGINEER: DSC — DRAWN BY: ASG

DESIGNED BY: ASG — REVIEWED BY: DSC, BDA

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PLAN & PROFILE - DRAINAGE WAY 2
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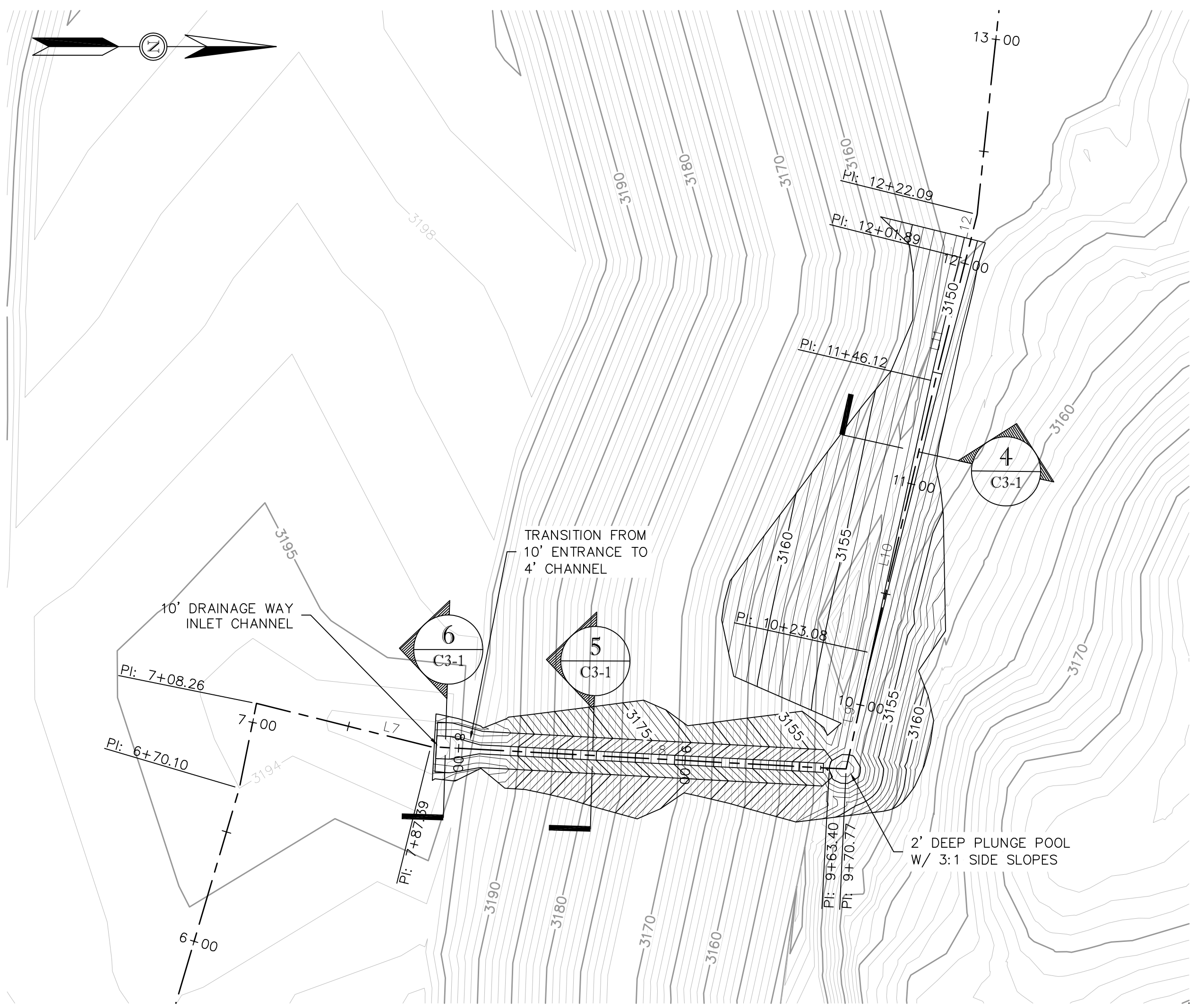
PROJECT #: 15-125

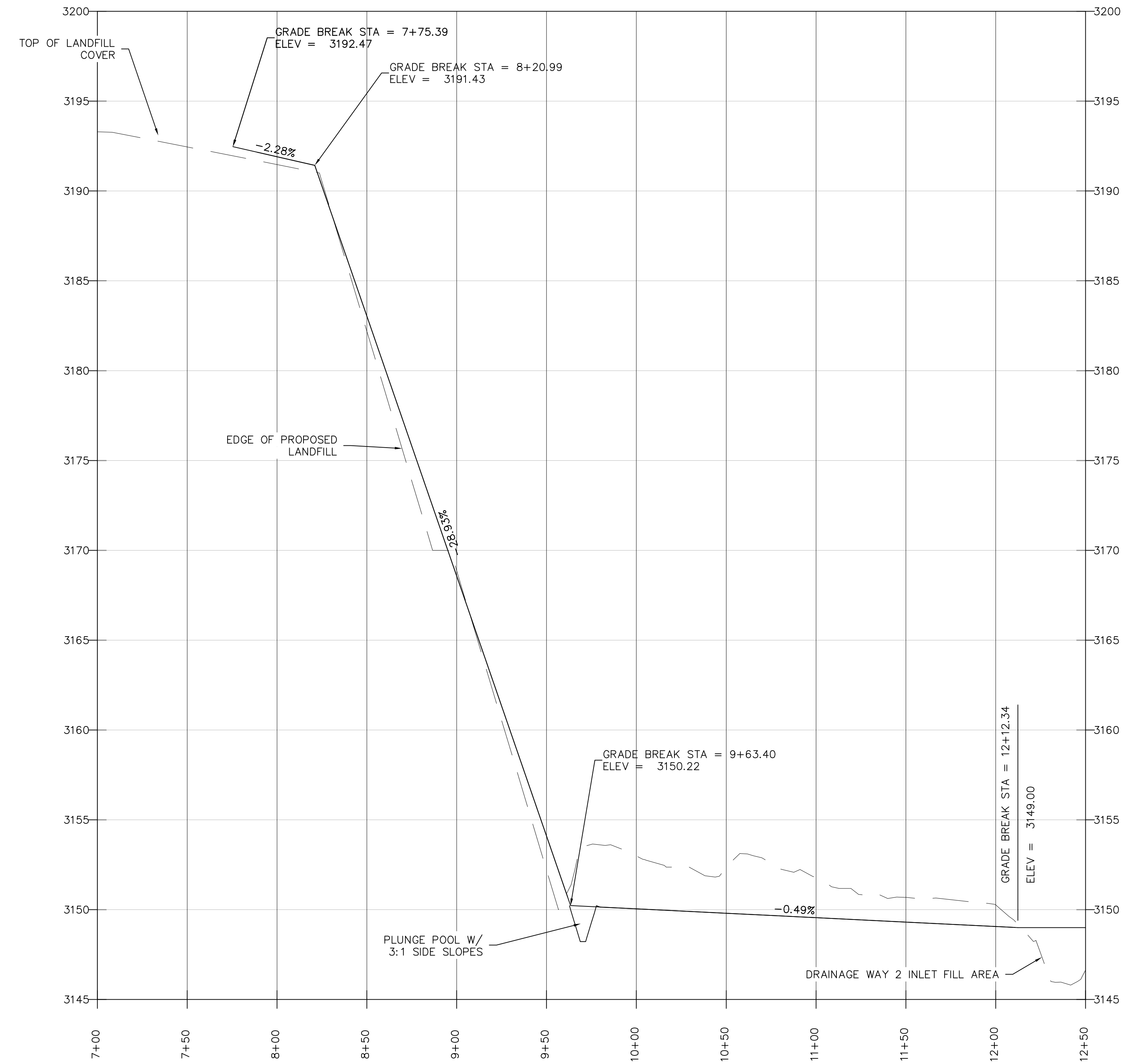
DATE: 9/15/2016

SHEET C1-8

P & P - DRAINAGE WAY 2



PLAN VIEW - DRAINAGE WAY 3 (STA 7+00 - STA 10+00)



PROFILE VIEW - DRAINAGE WAY 3 (STA 7+00 - STA 10+00)

CONSTRUCTION NOTES:
ALIGNMENT TABLE: SEE SHEET C3-3

EROSION CONTROL: SEE SHEET C4-1

FOR CHANNEL TYPICAL CROSS-SECTIONS OF DRAINAGE WAY 3 ON SHEET C3-1.

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DRAINAGE WAY 3.dwg

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET: 0 40 80
VERTICAL SCALE FEET: 0 4 8

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PLAN & PROFILE - DRAINAGE WAY 3
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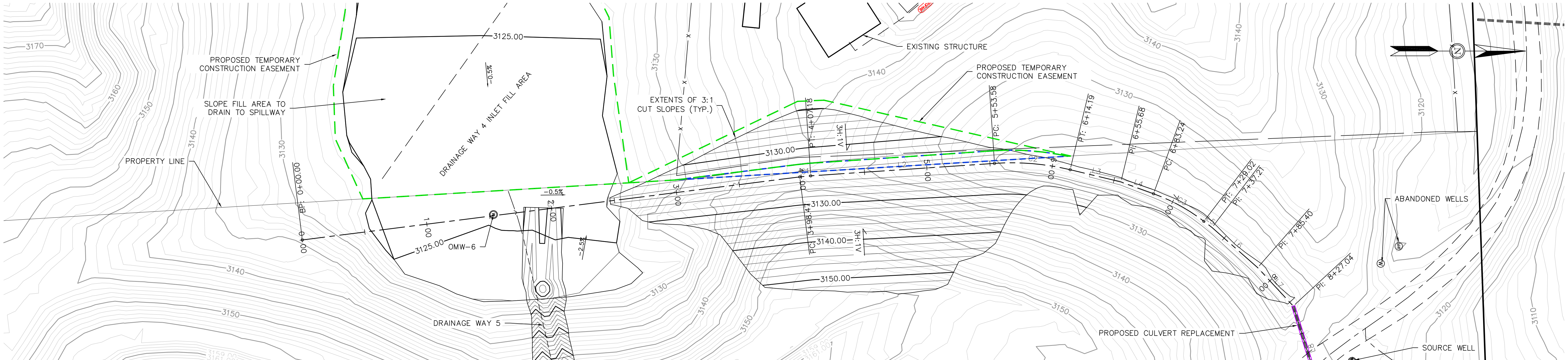
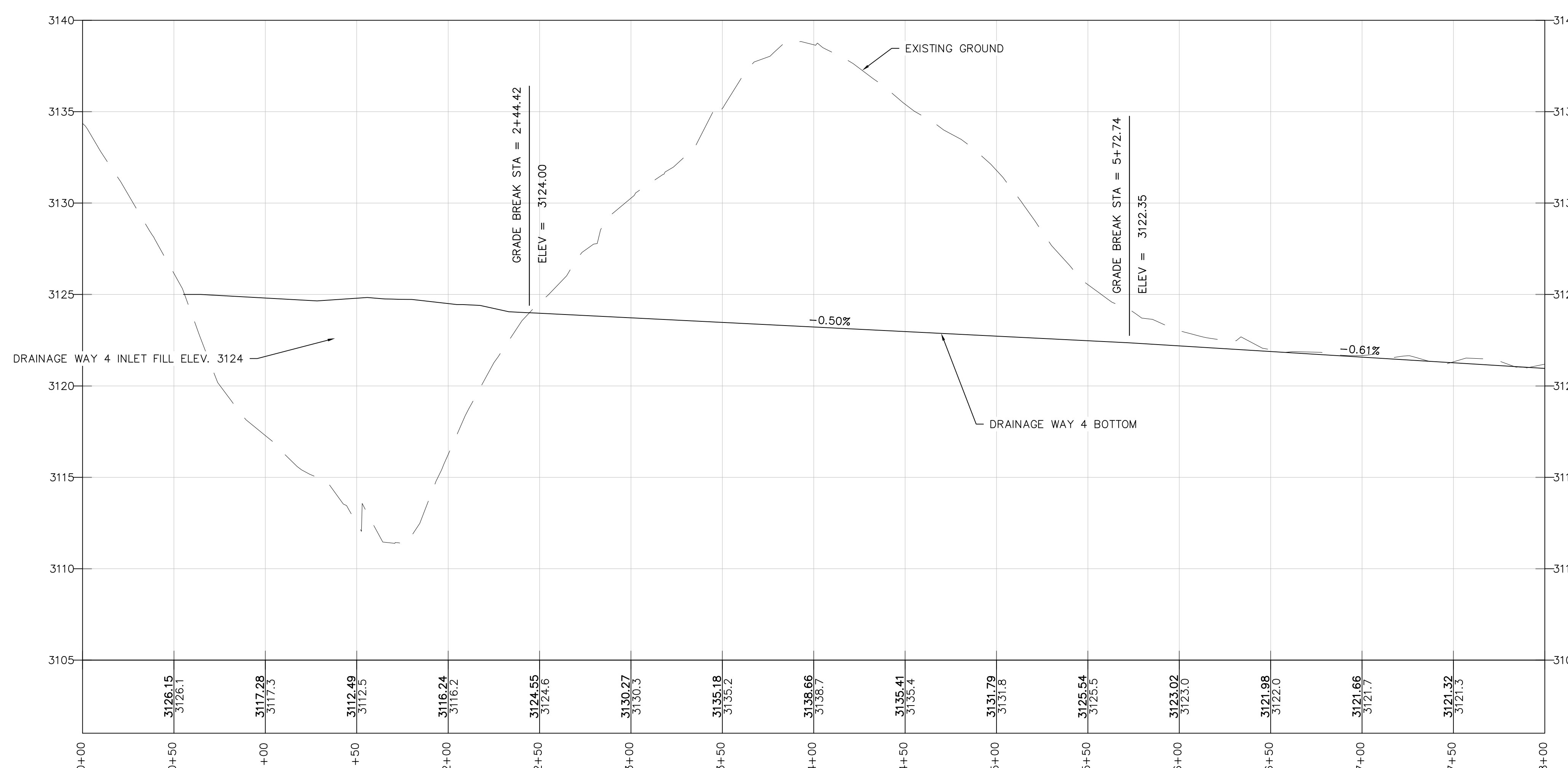
SHEET C1-9

P & P - DRAINAGE WAY 3



PLAN VIEW - DRAINAGE WAY 4 (STA 0+00 - STA 8+00)



PROFILE VIEW - DRAINAGE WAY 4 (STA 0+00 - STA 8+00)

NOTE:
SEE SHEET C4-9 FOR ALIGNMENT TABLE.
SEE SHEET C1-8 FOR EASEMENT TABLE.

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DRAINAGE WAY 4.dwg

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 40 80	VERTICAL SCALE FEET 0 4 8
PROJECT ENGINEER: DSC	DRAWN BY: ASG
DESIGNED BY: ASG	REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PLAN & PROFILE - DRAINAGE WAY 4
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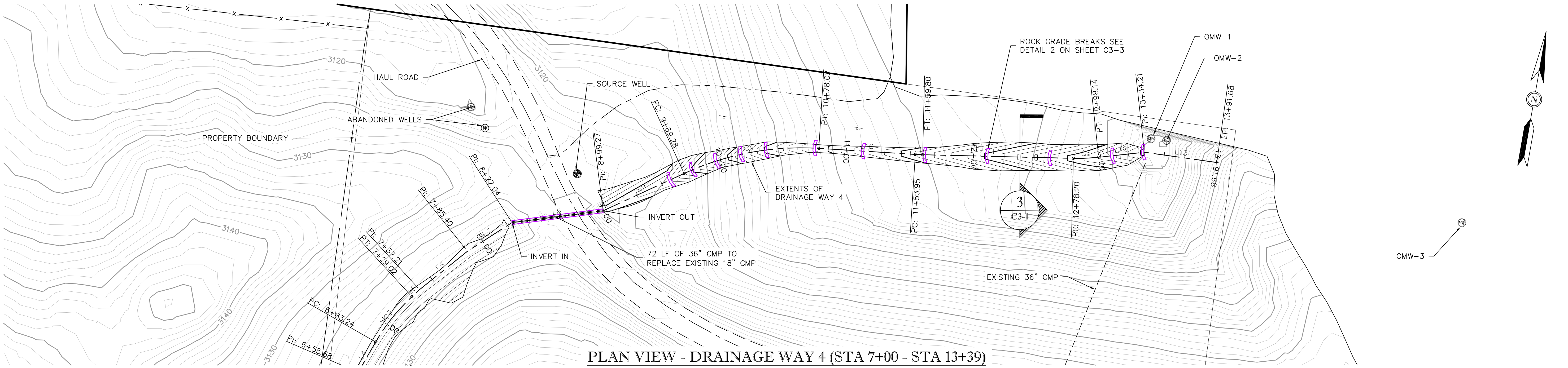
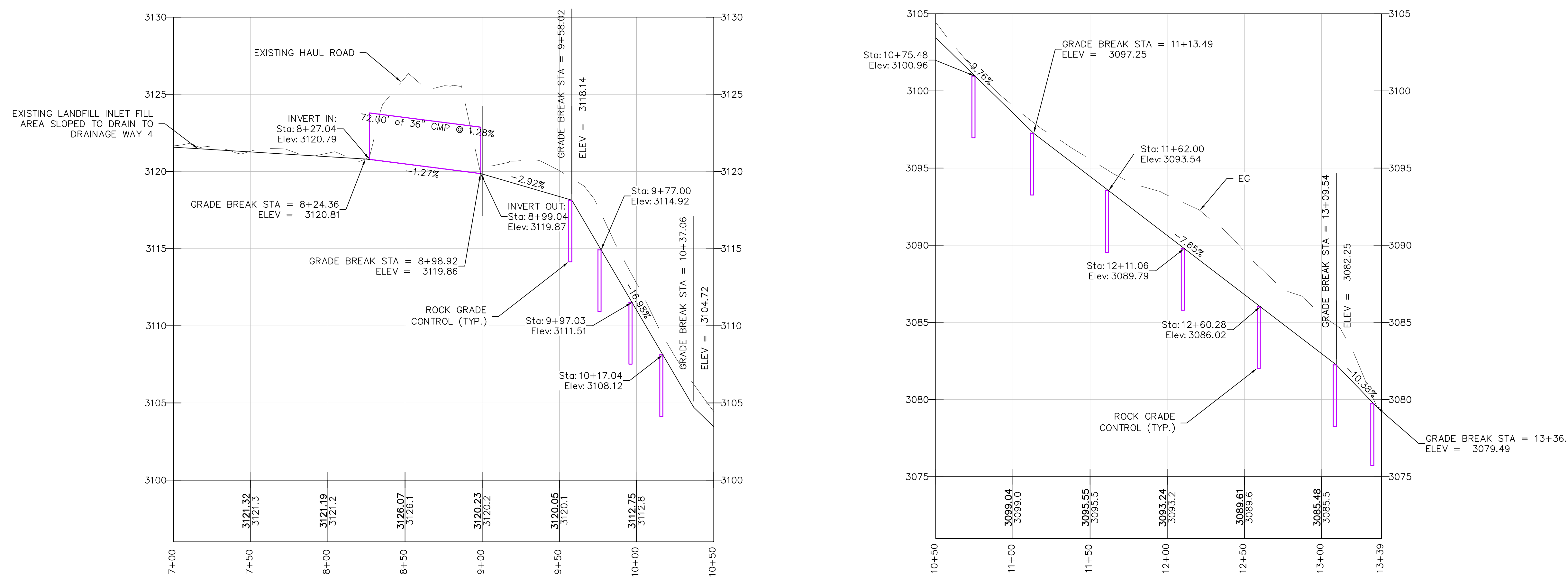
DATE: 9/15/2016

SHEET
C1-10

P & P - DRAINAGE WAY 4



PLAN VIEW - DRAINAGE WAY 4 (STA 7+00 - STA 13+39)



PROFILE VIEW - DRAINAGE WAY 4 (STA 7+00 - STA 13+39)

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET: 0 40 80
VERTICAL SCALE FEET: 0 4 8

PROJECT ENGINEER: DSC
DRAWN BY: ASG
DESIGNED BY: ASG
REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PLAN & PROFILE - DRAINAGE WAY 4
ROSEBUD COUNTY, MT

32 DISCOVERY DRIVE
BOZEMAN, MT 59718
PHONE (406) 582-0221
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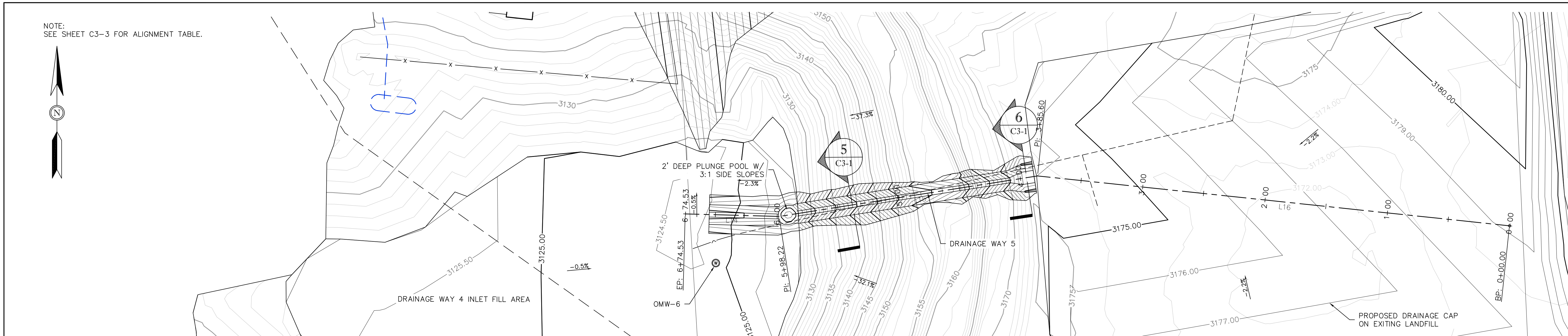
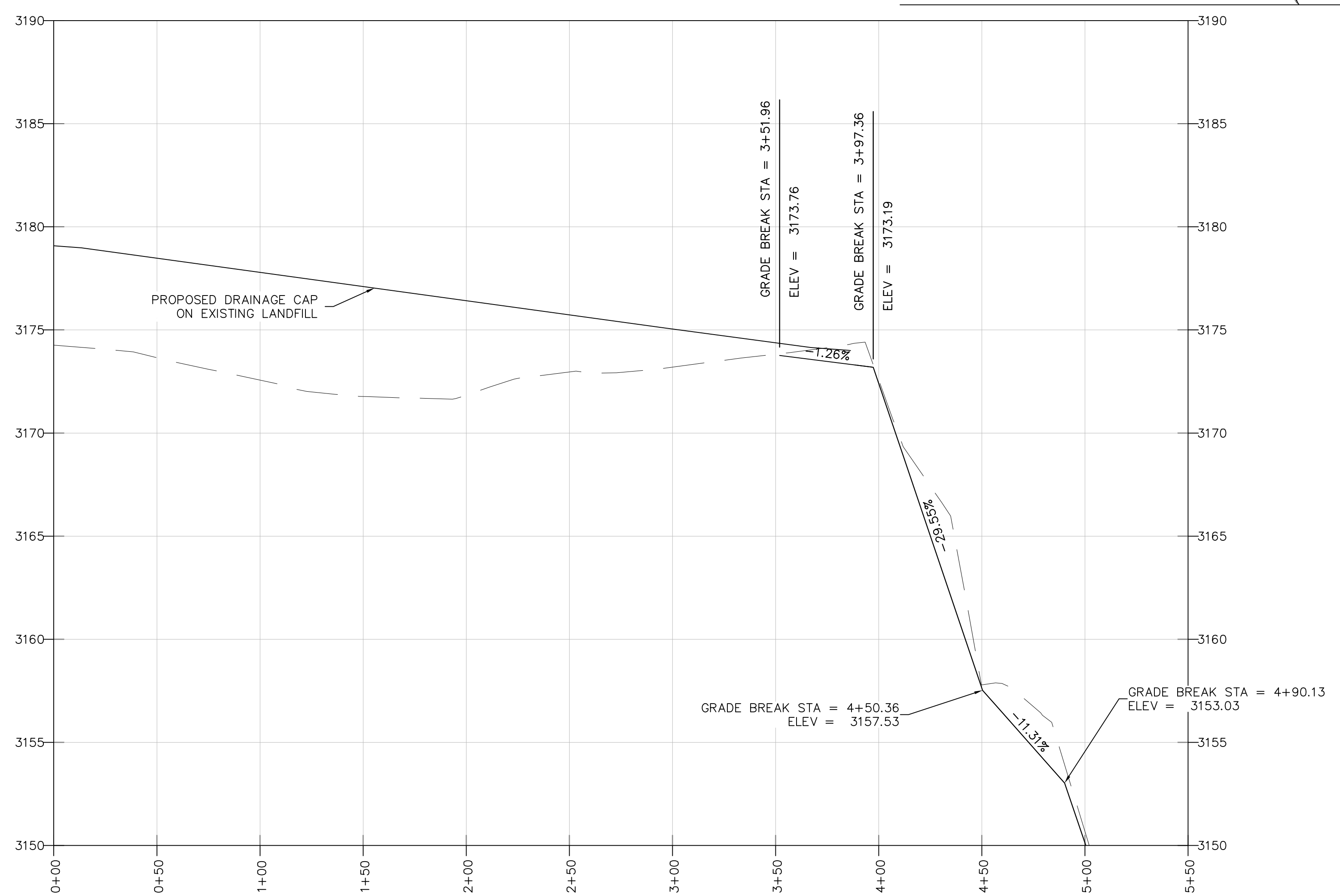
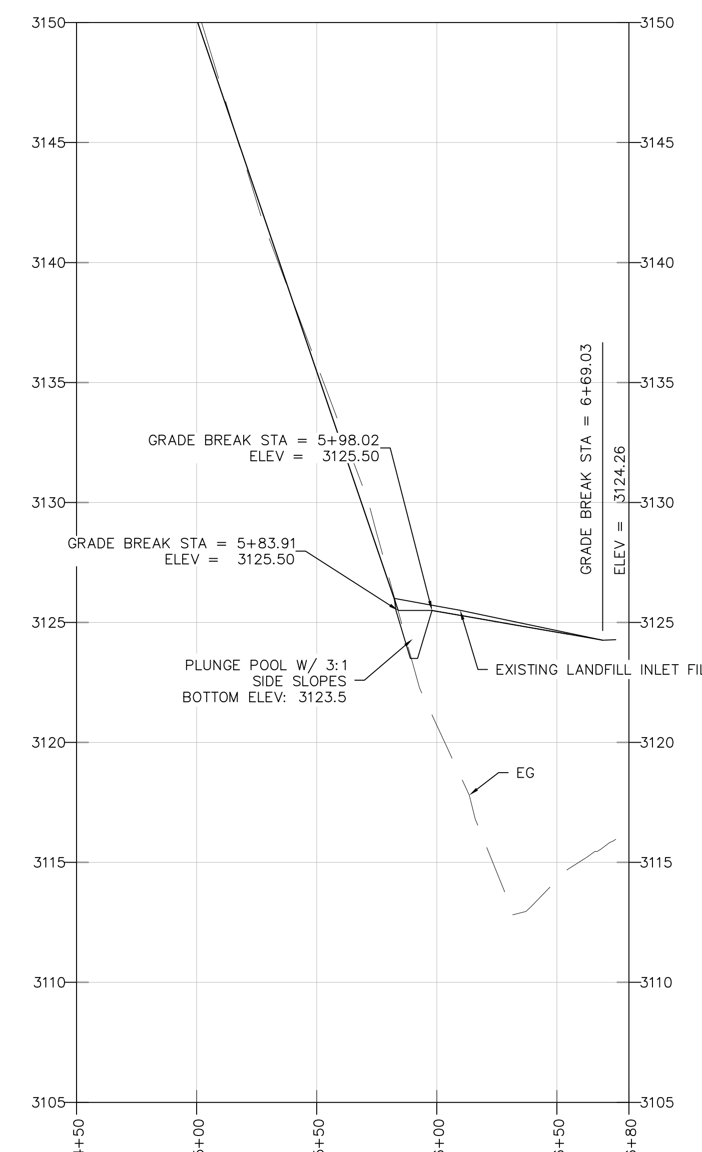
PROJECT #: 15-125
DATE: 9/15/2016
SHEET C1-11
P & P - DRAINAGE WAY 4

NOTE:
SEE SHEET C3-3 FOR ALIGNMENT TABLE.



PLAN VIEW - DRAINAGE WAY 5 (STA 0+00 - STA 6+75)





PROFILE VIEW - DRAINAGE WAY 5 (STA 0+00 - STA 6+75)

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 40 80
VERTICAL SCALE FEET 0 4 8
PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PLAN & PROFILE - DRAINAGE WAY 5
ROSEBUD COUNTY, MT

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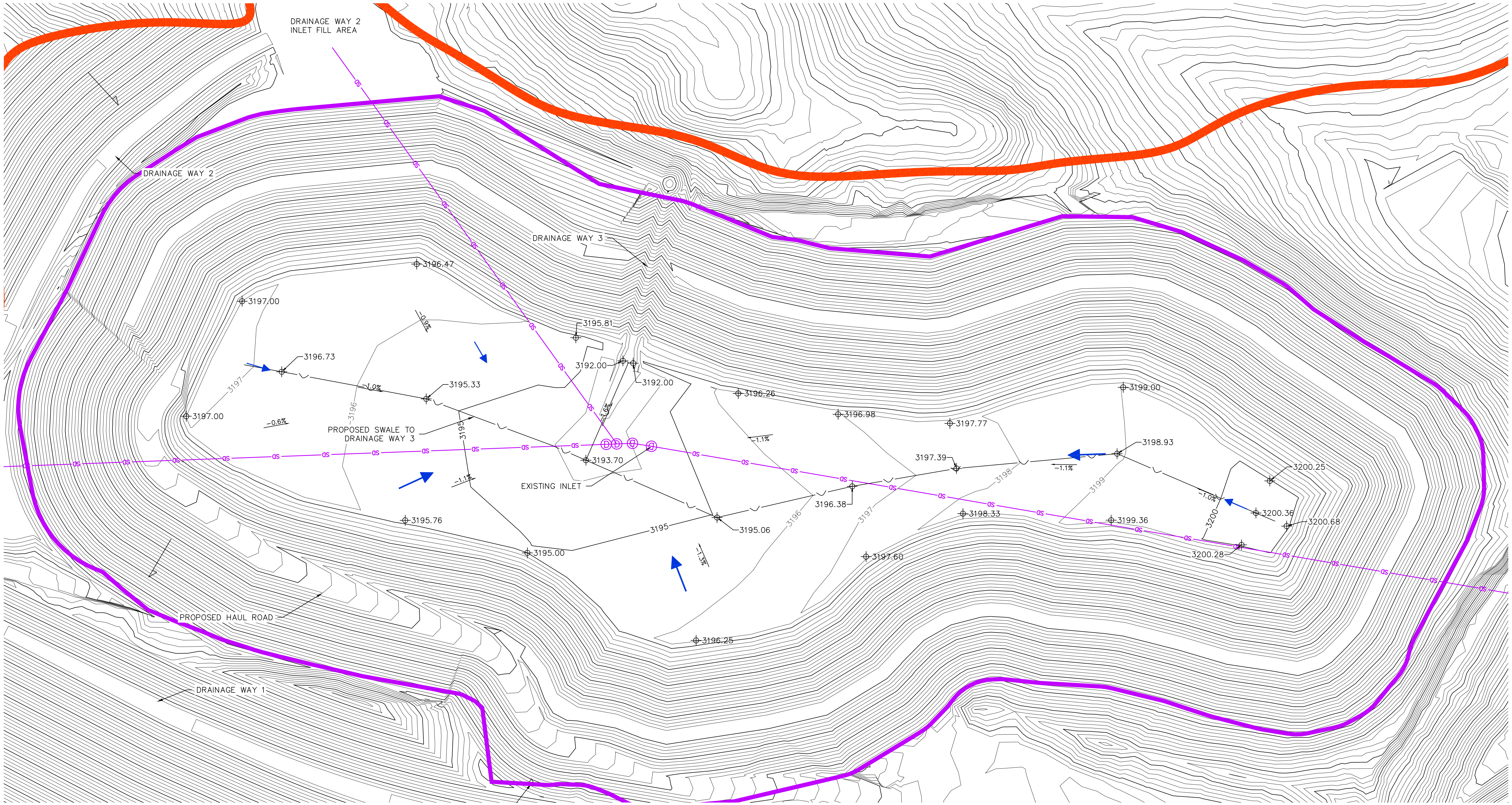
PROJECT #: 15-125
DATE: 9/15/2016
SHEET C1-12
P & P - DRAINAGE WAY 4

LEGEND

- FG MAJOR CONTOUR
- FG MINOR CONTOUR
- EDGE OF ROAD
- ROAD CENTERLINE
- STORM DRAINAGE PIPE
- LIMITS OF DISTURBANCE
- EXTENTS OF NEW LANDFILL EXPANSION ELEV: 3150
- FLOW ARROW
- ROCK GRADE CONTROL



CONSTRUCTION NOTES:
ALL ELEVATIONS SHOWN ARE FOR SUB-SOIL. ON TOP OF THIS SUB-SOIL WILL BE PLACED A MINIMUM OF 6 INCHES OF TOP SOIL.

THE FIRST 18 INCHES OF SUB-SOIL IS TO BE COMPACTED TO 95% OF PROCTOR DENSITY. REMAINING SUB-SOIL AND TOP SOIL IS ONLY TO BE COMPACTED TO 80% PROCTOR DENSITY TO PROMOTE PLANT GROWTH.

NO.	REVISIONS	DRAWN BY	DATE

0 100 200 300
SCALE (FEET)

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DESIGN PLAN - PHASE 1 & 2 DRAINAGE CAP
ROSEBUD COUNTY, MT

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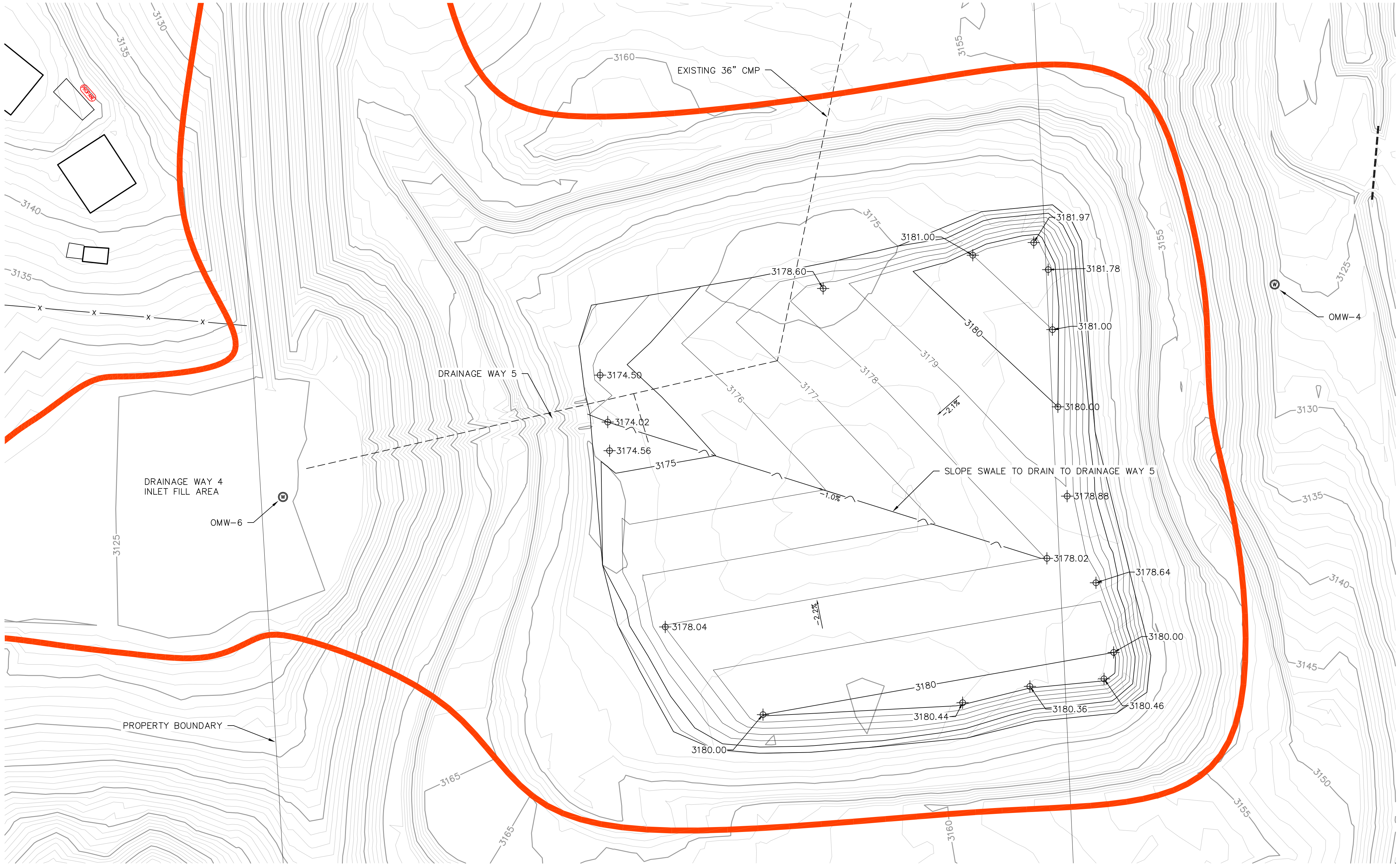
PROJECT #: 15-125
DATE: 9/15/2016

SHEET
C1-13

DESIGN PLAN -DRAINAGE



LEGEND

	EG MAJOR CONTOUR
	EG MINOR CONTOUR
	FG MAJOR CONTOUR
	FG MINOR CONTOUR
	EDGE OF ROAD
	ROAD CENTERLINE
	STORM DRAINAGE PIPE
	LIMITS OF DISTURBANCE
	FLOW ARROW
	ROCK GRADE CONTROL

N

CONSTRUCTION NOTES:
ALL AREAS TO BE FILLED ARE TO BE STRIPPED OF ALL TOP SOIL.

ALL ELEVATIONS SHOWN ARE FOR SUB-SOIL. ON TOP OF THIS SUB-SOIL WILL BE PLACED A MINIMUM OF 6 INCHES OF TOP SOIL.

THE FIRST 18 INCHES OF SUB-SOIL IS TO BE COMPACTED TO 95% OF PROCTOR DENSITY. REMAINING SUB-SOIL AND TOP SOIL IS ONLY TO BE COMPACTED TO 80% PROCTOR DENSITY TO PROMOTE PLANT GROWTH.

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DESIGN PLAN- EXISTING DRAINAGE CAP.dwg

NO.	REVISIONS	DRAWN BY	DATE

0 100 200 300
SCALE (FEET)

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DESIGN PLAN - EXISTING LANDFILL DRAINAGE CAP
ROSEBUD COUNTY, MT

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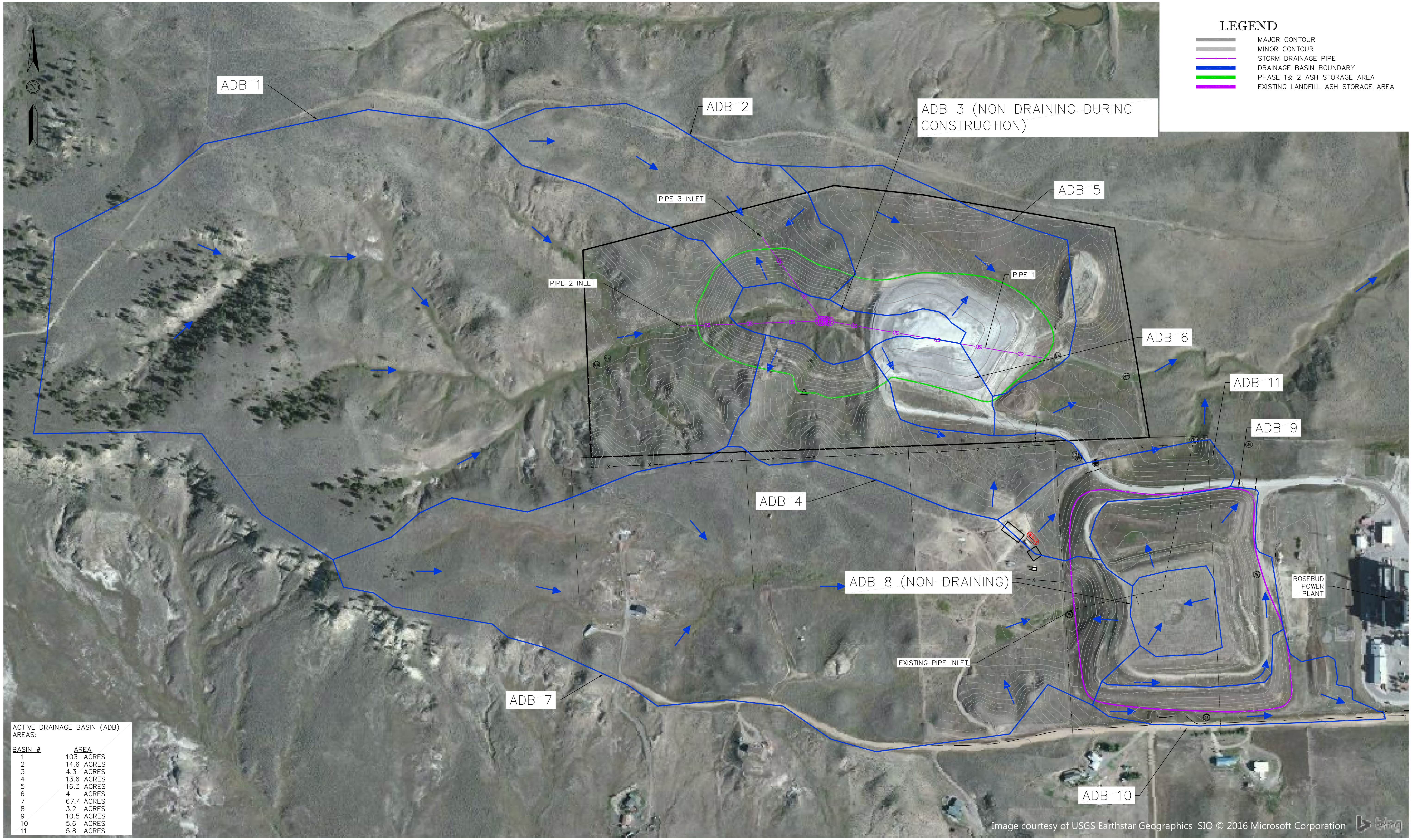
PROJECT #: 15-125
DATE: 9/15/2016

SHEET
C1-14

DESIGN PLAN - EXISTING



ACTIVE DRAINAGE BASIN (ADB) AREAS:

BASIN #	AREA
1	103 ACRES
2	14.6 ACRES
3	4.3 ACRES
4	13.6 ACRES
5	16.3 ACRES
6	4 ACRES
7	67.4 ACRES
8	3.2 ACRES
9	10.5 ACRES
10	5.6 ACRES
11	5.8 ACRES

NO.	REVISIONS	DRAWN BY	DATE

0 200 400 600
SCALE (FEET)

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
ACTIVE LANDFILL DRAINAGE BASINS
ROSEBUD COUNTY, MT

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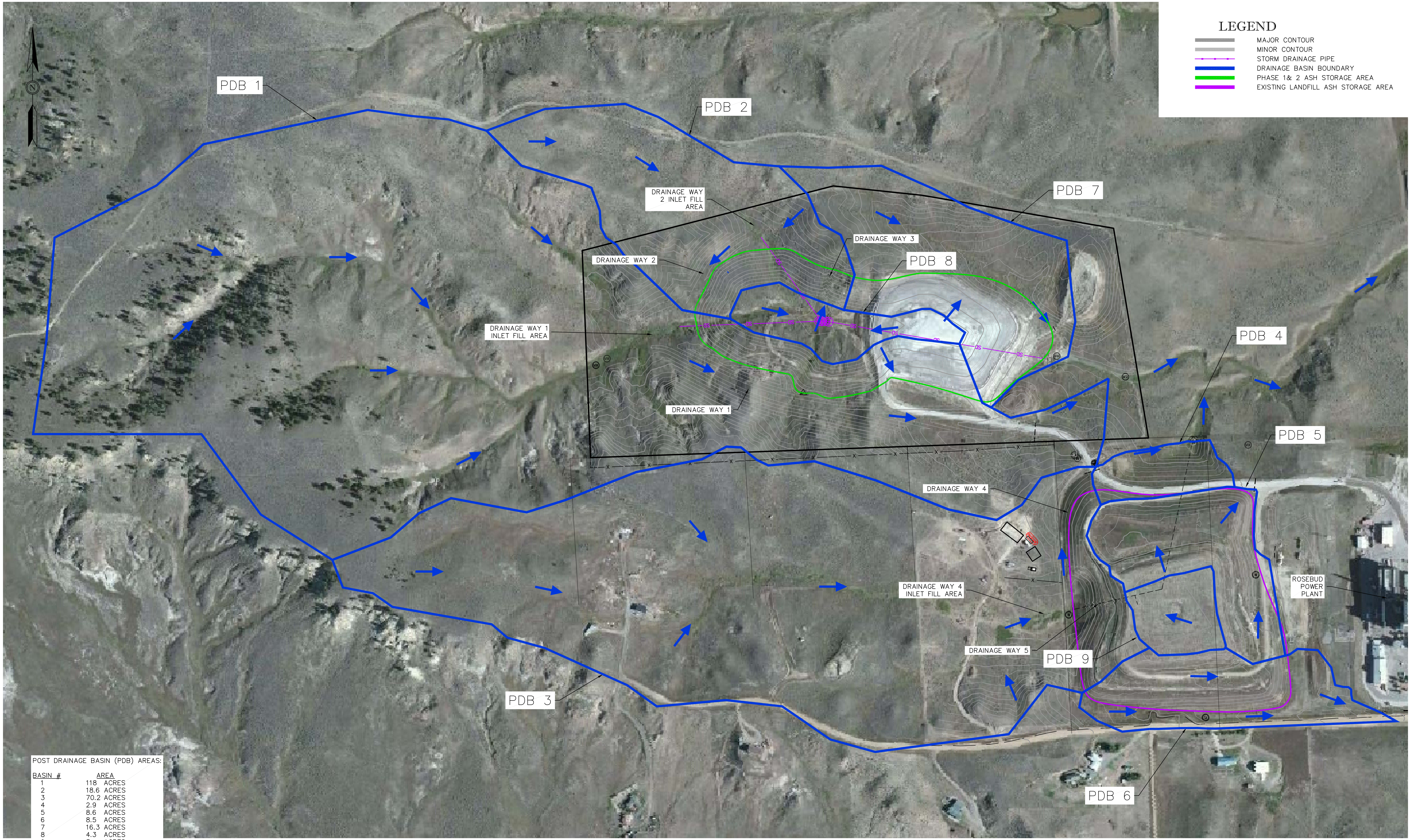
PROJECT #: 15-125
DATE: 9/15/2016

SHEET
C2-1

ACTIVE DRAINAGE BASINS



POST DRAINAGE BASIN (PDB) AREAS:

BASIN #	AREA
1	118 ACRES
2	18.6 ACRES
3	70.2 ACRES
4	2.9 ACRES
5	8.6 ACRES
6	8.5 ACRES
7	16.3 ACRES
8	4.3 ACRES
9	3 ACRES

NO.	REVISIONS	DRAWN BY	DATE

SCALE (FEET): 0 200 400 600

PROJECT ENGINEER: DSC
DRAWN BY: ASG
DESIGNED BY: ASG
REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
POST-CLOSURE DRAINAGE BASINS
ROSEBUD COUNTY, MT

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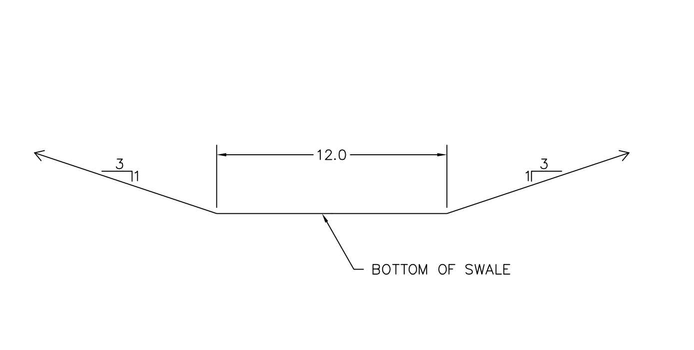
PROJECT #: 15-125
DATE: 9/15/2016

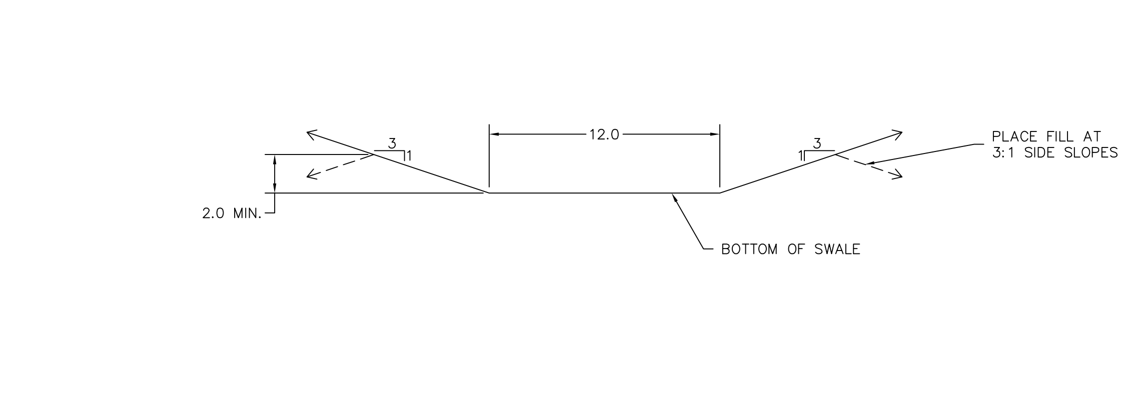
SHEET
C2-2

POST DRAINAGE BASINS

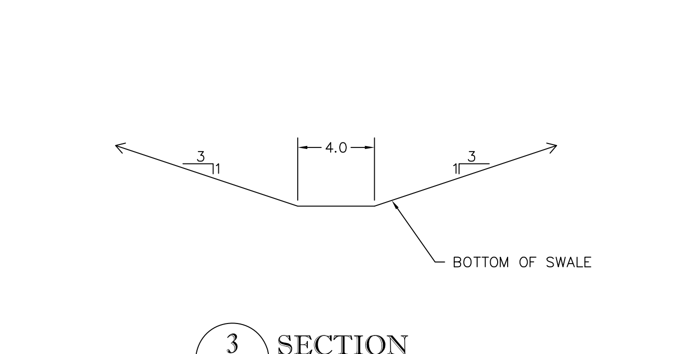
C:\aesi_wf\Designs\2015\15-125 Rosebud Power Plant Ash Disposal Site\29 CAD-Production\Storm\POST H&H FIGURES.dwg



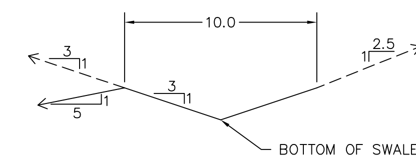
1 SECTION
C1-3 12' DRAINAGE SWALE
1" = 5'



2 SECTION
C1-5 12' DRAINAGE SWALE W/ RIGHT BERM
1" = 5'



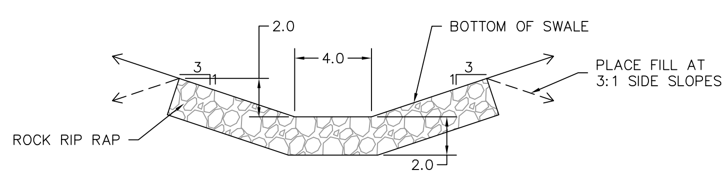
3 SECTION
C1-7 4' DRAINAGE SWALE
1" = 5'



NOTES:
1. PLACE LEFT SIDE DAYLIGHT FILL AT 5:1 SLOPES FILLING ANY DEPRESSIONS, AND DIRECTING DRAINAGE INTO SWALE.

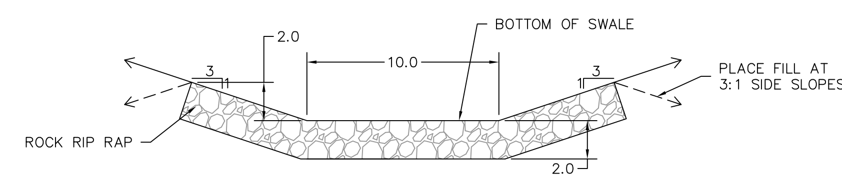
2. CUT RIGHT SIDE DAYLIGHT TO A 2.5:1 OR GREATER DEPENDING ON SOIL CONDITIONS ENCOUNTERED.

4 SECTION
C1-9 SPILLWAY 4
1" = 5'



NOTES:
1. ROCK RIPRAP IS TO BE ANGULAR ROCK WITH A D50 OF 12 INCHES.

5 SECTION
C1-6 4' DRAINAGE SWALE
1" = 5'



NOTES:
1. ROCK RIPRAP IS TO BE ANGULAR ROCK WITH A D50 OF 12 INCHES.

6 SECTION
C1-6 10' DRAINAGE SWALE
1" = 5'

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DETAILS POST.dwg

NO.	REVISIONS	DRAWN BY	DATE

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DETAILS - SWALE SECTIONS
ROSEBUD COUNTY, MT

32 DISCOVERY DRIVE
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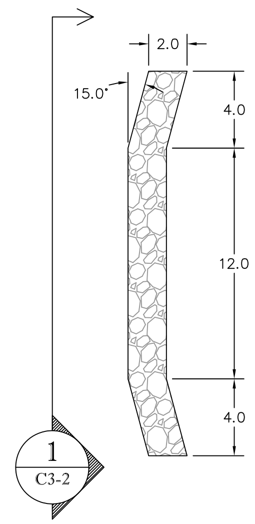
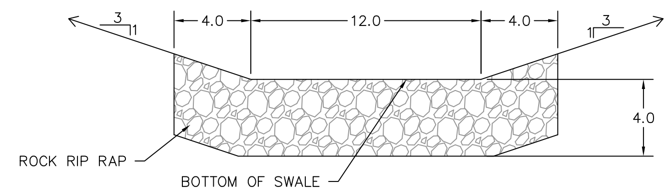
PROJECT #: 15-125
DATE: 9/15/2016

SHEET
C3-1

DETAILS - SWALE SECTIONS

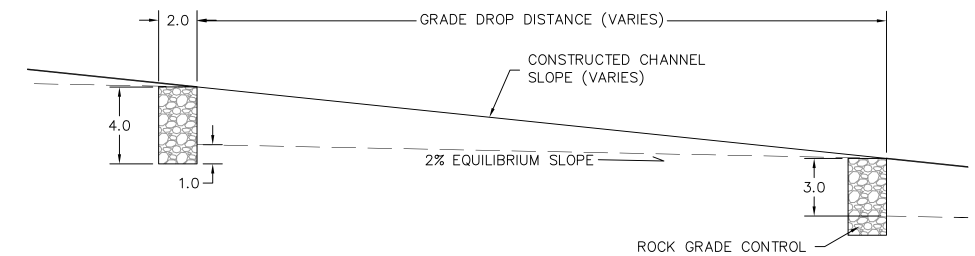


1 DETAIL
C2-2
SPILLWAY 1 GRADE CONTROL - PLAN VIEW
1 " = 5'



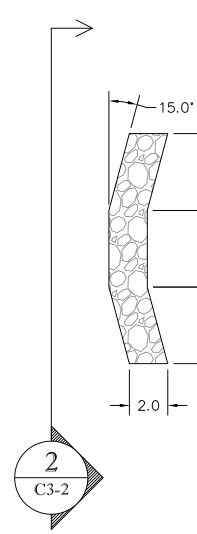
NOTES:
1. ROCK RIPRAP IS TO BE ANGULAR ROCK WITH A D50 OF 8 INCHES.

1 SECTION
C3-2
SPILLWAY 1 GRADE CONTROL
1" = 5'

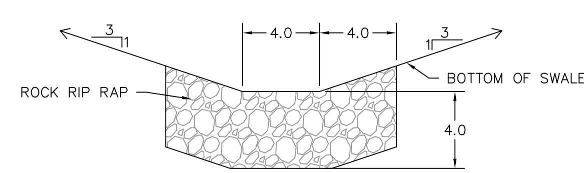


NOTES:
1. ROCK RIPRAP IS TO BE ANGULAR ROCK WITH A D50 OF 8 INCHES.
2. DISTANCE BETWEEN GRADE DROPS IS SHOWN ON PLANS. IT VARIES WITH CHANNEL SLOPE.
3. EQUILIBRIUM SLOPE WAS DETERMINED BY COMPARISON OF EXISTING SLOPES.

3 DETAIL
C3-2
TYPICAL GRADE CONTROL PROFILE
1 " = 5'



2 DETAIL
S3-3
SPILLWAY 3 GRADE CONTROL - PLAN VIEW
1 " = 5'



NOTES:
1. ROCK RIPRAP IS TO BE ANGULAR ROCK WITH A D50 OF 8 INCHES.

2 SECTION
C3-2
SPILLWAY 3 GRADE CONTROL
1" = 5'

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DETAILS POST.dwg

NO.	REVISIONS	DRAWN BY	DATE

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DETAILS - ROCK GRADE CONTROLS
ROSEBUD COUNTY, MT

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PROJECT #: 15-125
DATE: 9/15/2016
SHEET
C3-2
DETAILS - ROCK CONTROL

DRAINAGE WAY 1 ALIGNMENT

Number	Radius	Length	Line/Chord Direction	Start Station	End Station	Start Northing, Easting
L3		146.31	N88° 36' 59.04"E	0+00.00	1+46.31	643344.5741, 2687756.5228
C6	150.00	73.86	S77° 16' 41.83"E	1+46.31	2+20.16	643348.1068, 2687902.7880
L4		271.68	S63° 10' 22.69"E	2+20.16	4+91.85	643332.0065, 2687974.1047
C1	312.15	17.89	S64° 48' 54.31"E	4+91.85	5+09.74	643209.3966, 2688216.5469
L1		77.78	S66° 27' 25.94"E	5+09.74	5+87.52	643201.7835, 2688232.7365
C2	1084.22	246.98	S72° 58' 58.71"E	5+87.52	8+34.50	643170.7161, 2688304.0411
L2		166.70	S79° 30' 31.48"E	8+34.50	10+01.19	643098.5926, 2688539.6957
C3	1614.37	117.37	S81° 35' 29.84"E	10+01.19	11+18.57	643068.2396, 2688703.6054
L6		491.00	S83° 40' 28.20"E	11+18.57	16+09.57	643051.0800, 2688819.6928
C4	516.43	178.80	N86° 24' 25.40"E	16+09.57	17+88.37	642996.9829, 2689307.7071
L5		125.15	N76° 29' 19.00"E	17+88.37	19+13.52	643008.1319, 2689485.2646
C5	732.50	209.26	N68° 18' 16.74"E	19+13.52	21+22.78	643037.3726, 2689606.9542
L7		205.73	N60° 07' 14.48"E	21+22.78	23+28.51	643114.4664, 2689800.7281
L8		85.01	S82° 55' 28.98"E	23+28.51	24+13.52	643216.9581, 2689979.1158

DRAINAGE WAY 2 ALIGNMENT

Number	Radius	Length	Line/Chord Direction	Start Station	End Station	Start Northing, Easting
L6		143.04	N33° 10' 00.74"E	0+00.00	1+43.04	643431.7828, 2687980.2610
C5	150.00	19.11	N29° 31' 01.66"E	1+43.04	1+62.15	643551.5167, 2688058.5138
L4		52.14	N25° 52' 02.59"E	1+62.15	2+14.29	643568.1351, 2688067.9226
L5		94.91	N28° 30' 48.36"E	2+14.29	3+09.20	643615.0533, 2688090.6719
C4	150.00	38.30	N35° 49' 38.90"E	3+09.20	3+47.50	643698.4554, 2688135.9809
L1		22.47	N43° 08' 29.44"E	3+47.50	3+69.97	643729.4211, 2688158.3366
C3	150.00	22.62	N47° 27' 42.66"E	3+69.97	3+92.59	643745.8146, 2688173.6997
L2		71.88	N51° 46' 55.89"E	3+92.59	4+64.47	643761.0939, 2688190.3518
C2	355.54	73.57	N57° 42' 36.31"E	4+64.47	5+38.04	643805.5653, 2688246.8288

DRAINAGE WAY 3 ALIGNMENT

Number	Radius	Length	Line/Chord Direction	Start Station	End Station	Start Northing, Easting
L7		79.14	N23° 58' 15.77"E	7+08.26	7+87.39	643460.8902, 2688626.0039
L8		176.01	N13° 05' 01.79"E	7+87.39	9+63.40	643533.2022, 2688658.1555
L9		52.31	N67° 32' 36.83"W	9+70.77	10+23.08	643711.8326, 2688699.6038
L10		123.04	N66° 51' 54.52"W	10+23.08	11+46.12	643731.8139, 2688651.2609
L11		55.76	N65° 51' 12.83"W	11+46.12	12+01.89	643780.1573, 2688538.1121
L12		20.20	N66° 02' 56.78"W	12+01.89	12+22.09	643802.9681, 2688487.2288

DRAINAGE WAY 4 ALIGNMENT

Number	Radius	Length	Line/Chord Direction	Start Station	End Station	Start Northing, Easting
L1		398.47	N7° 12' 41.64"W	0+00.00	3+98.47	641989.0819, 2689783.7761
C1	150.00	8.71	N5° 32' 52.52"W	3+98.47	4+07.18	642384.3984, 2689733.7549
L2		146.40	N3° 53' 03.40"W	4+07.18	5+53.58	642393.0672, 2689732.9129
C2	200.00	60.61	N4° 47' 51.97"E	5+53.58	6+14.19	642539.1338, 2689722.9953
L3		41.48	N13° 28' 47.34"E	6+14.19	6+55.68	642599.3026, 2689728.0455
L4		27.57	N19° 55' 02.83"E	6+55.68	6+83.24	642639.6409, 2689737.7148
C3	150.00	45.78	N28° 39' 40.33"E	6+83.24	7+29.02	642665.5578, 2689747.1055
L5		8.19	N37° 24' 17.83"E	7+29.02	7+37.21	642705.5746, 2689768.9789
L6		48.18	N41° 16' 43.16"E	7+37.21	7+85.40	642712.0804, 2689773.9539
L7		41.65	N47° 12' 05.16"E	7+85.40	8+27.04	642748.2914, 2689805.7420
L8		72.23	N72° 35' 03.58"E	8+27.04	8+99.27	642776.5860, 2689836.2990
L9		70.01	N55° 15' 38.42"E	8+99.27	9+69.28	642798.2050, 2689905.2192
C4	219.87	108.74	N69° 25' 41.66"E	9+69.28	10+78.02	642838.0991, 2689962.7492
L10		75.94	N83° 35' 44.90"E	10+78.02	11+53.95	642875.9183, 2690063.5164
C5	150.00	5.84	N82° 28' 49.16"E	11+53.95	11+59.80	642884.3884, 2690138.9792
L11		118.41	N81° 21' 53.41"E	11+59.80	12+78.20	642885.1527, 2690144.7693
C6	150.00	19.94	N77° 33' 23.89"E	12+78.20	12+98.14	642902.9304, 2690261.8327
L12		36.07	N73° 44' 54.38"E	12+98.14	13+34.21	642907.2237, 2690281.2896
L13		57.47	N88° 02' 50.21"E	13+34.21	13+91.68	642917.3186, 2690315.9202

DRAINAGE WAY 5 ALIGNMENT

Number	Radius	Length	Line/Chord Direction	Start Station	End Station	Start Northing, Easting
L14		76.31	N88° 27' 10.46"W	5+98.22	6+74.53	642178.8475, 2689815.0061
L15		212.62	S81° 05' 30.77"W	3+85.60	5+98.22	642211.7723, 2690025.0646
L16		385.60	N83° 58' 06.39"W	0+00.00	3+85.60	642171.2554, 2690408.5251

NO.	REVISIONS	DRAWN BY	DATE

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DETAILS - ALIGNMENT TABLES
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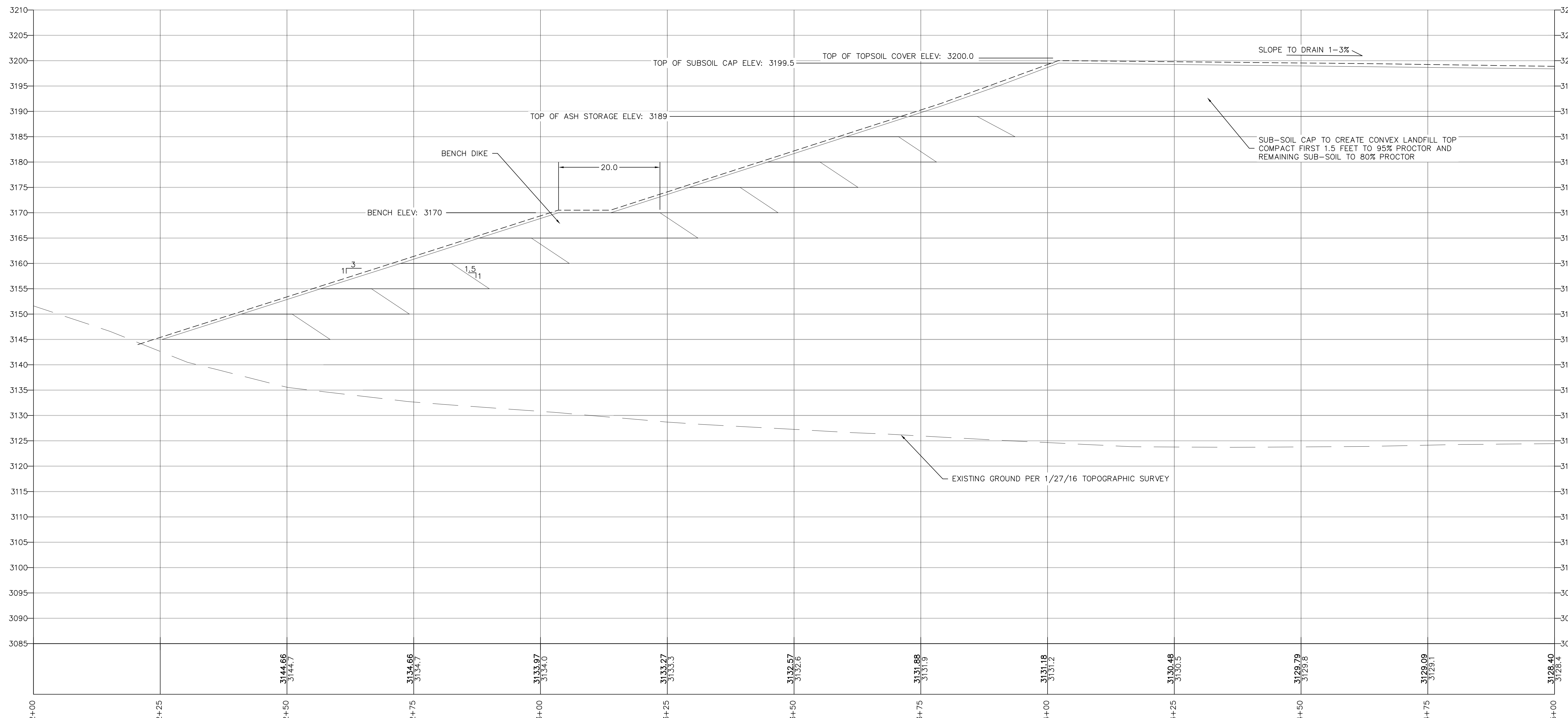
PROJECT #: 15-125
DATE: 9/15/2016

SHEET
C3-3

DETAILS - TABLES



PROFILE VIEW - LANDFILL CONTAINMENT BERMS AND TOP

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 10 20

VERTICAL SCALE FEET 0 10 20

PROJECT ENGINEER: DSC | DRAWN BY: ASG

DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
DETAILS - LANDFILL TOP
ROSEBUD COUNTY, MT

32 DISCOVERY DRIVE
BOZEMAN, MT 59718
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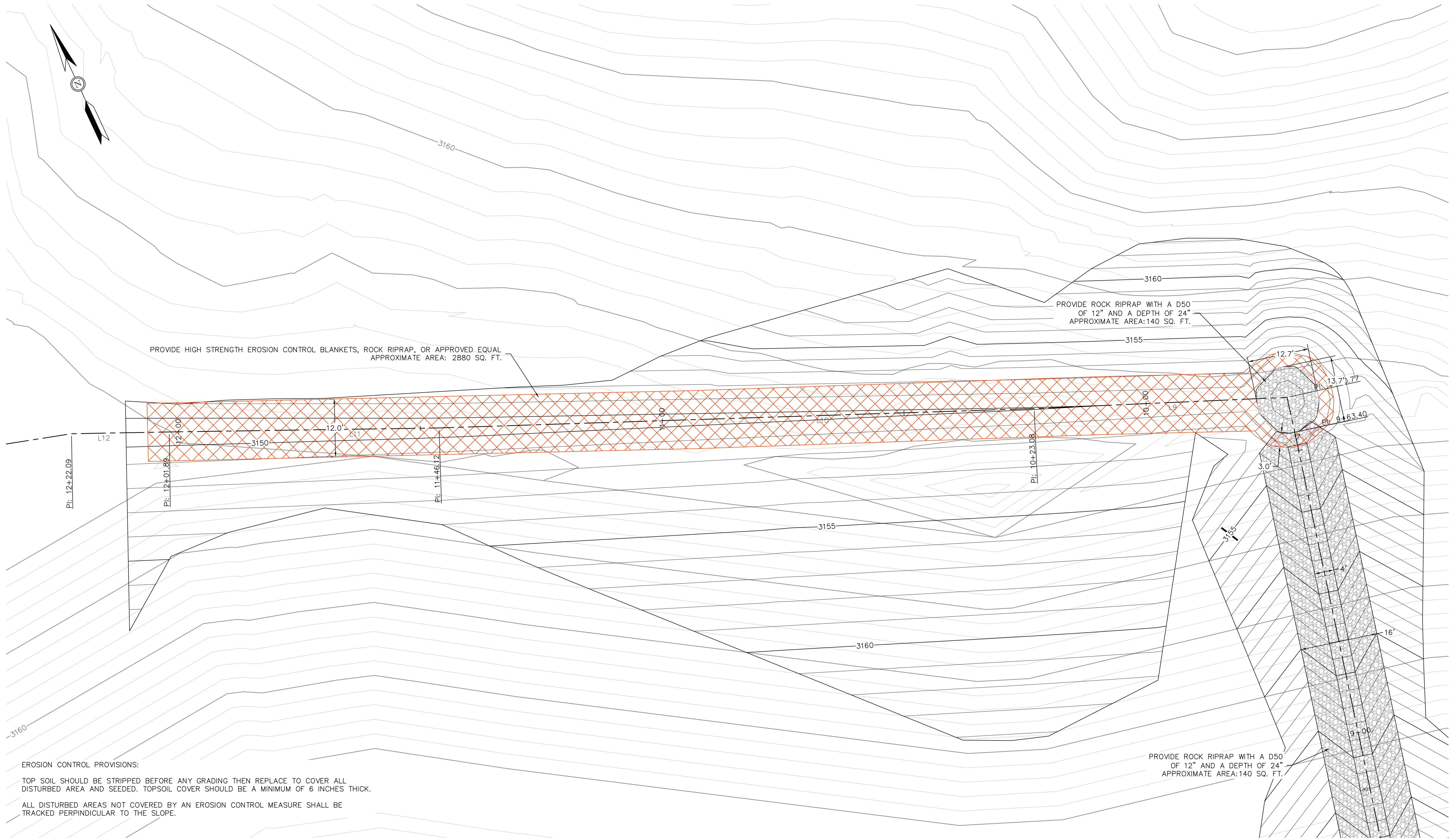
PROJECT #: 15-125

DATE: 9/15/2016

SHEET C3-4

DETAILS - LANDFILL TOP

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DETAILS POST.dwg



EROSION CONTROL PROVISIONS:

TOP SOIL SHOULD BE STRIPPED BEFORE ANY GRADING THEN REPLACE TO COVER ALL DISTURBED AREA AND SEEDED. TOPSOIL COVER SHOULD BE A MINIMUM OF 6 INCHES THICK.

ALL DISTURBED AREAS NOT COVERED BY AN EROSION CONTROL MEASURE SHALL BE TRACKED PERPENDICULAR TO THE SLOPE.

NO.	REVISIONS	DRAWN BY	DATE

SCALE (FEET): 0, 10, 20, 30

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
EROSION CONTROL - DRAINAGE WAY 3
ROSEBUD COUNTY, MT

32 DISCOVERY DRIVE
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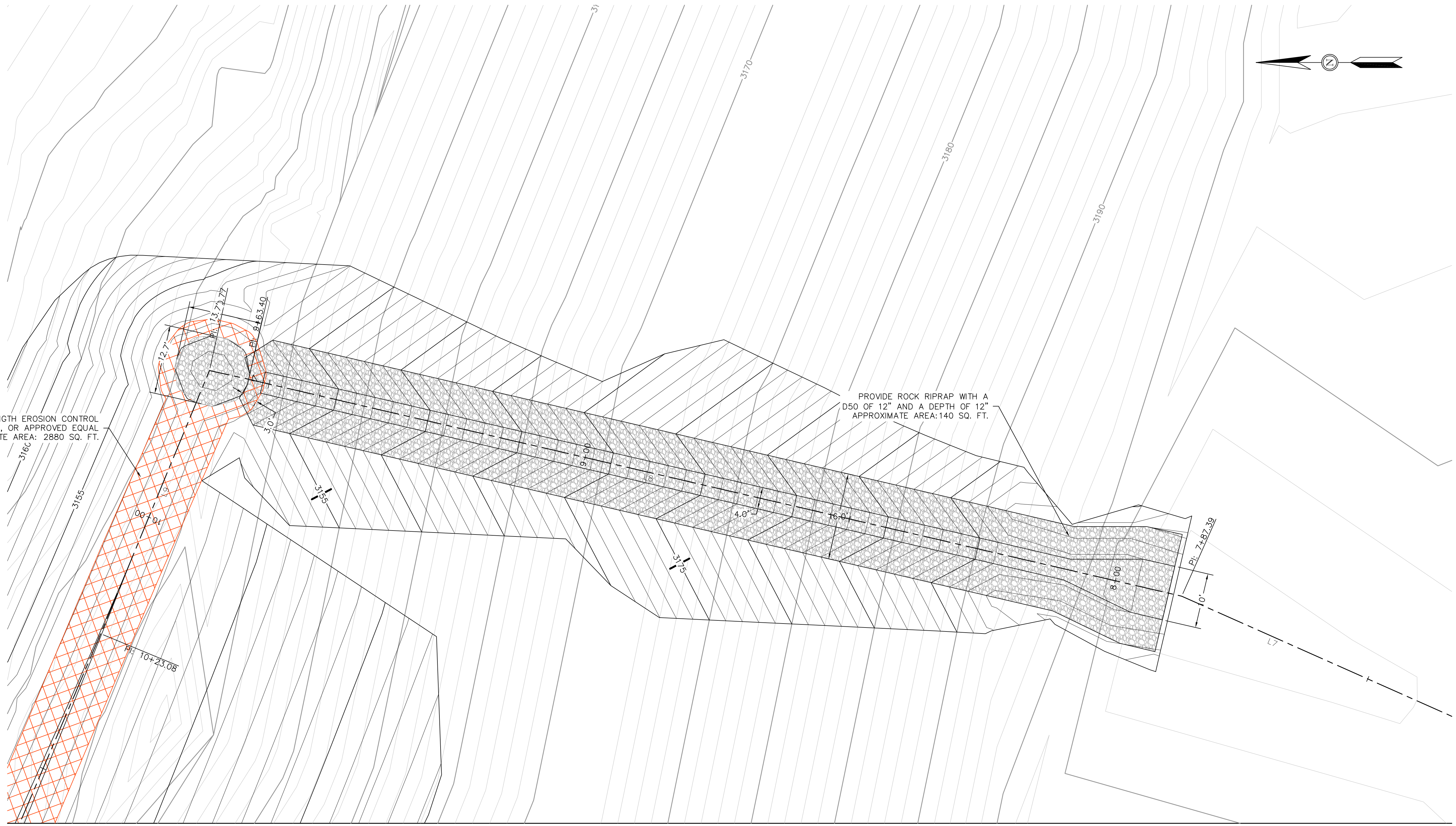
PROJECT #: 15-125
DATE: 9/15/2016

SHEET C4-1

EROSION CONTROL

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\DRAINAGE WAY 3.dwg



EROSION CONTROL PROVISIONS:

TOP SOIL SHOULD BE STRIPPED BEFORE ANY GRADING THEN REPLACE TO COVER ALL DISTURBED AREA AND SEEDED. TOPSOIL COVER SHOULD BE A MINIMUM OF 6 INCHES THICK.

ALL DISTURBED AREAS NOT COVERED BY AN EROSION CONTROL MEASURE SHALL BE TRACKED PERPENDICULAR TO THE SLOPE.

ALL DISTURBED AREAS ARE TO BE SEEDED.

NO.	REVISIONS	DRAWN BY	DATE

SCALE (FEET): 0 10 20 30

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
EROSION CONTROL - DRAINAGE WAY 3
ROSEBUD COUNTY, MT

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PROJECT #: 15-125
DATE: 9/15/2016

SHEET C4-2

EROSION CONTROL

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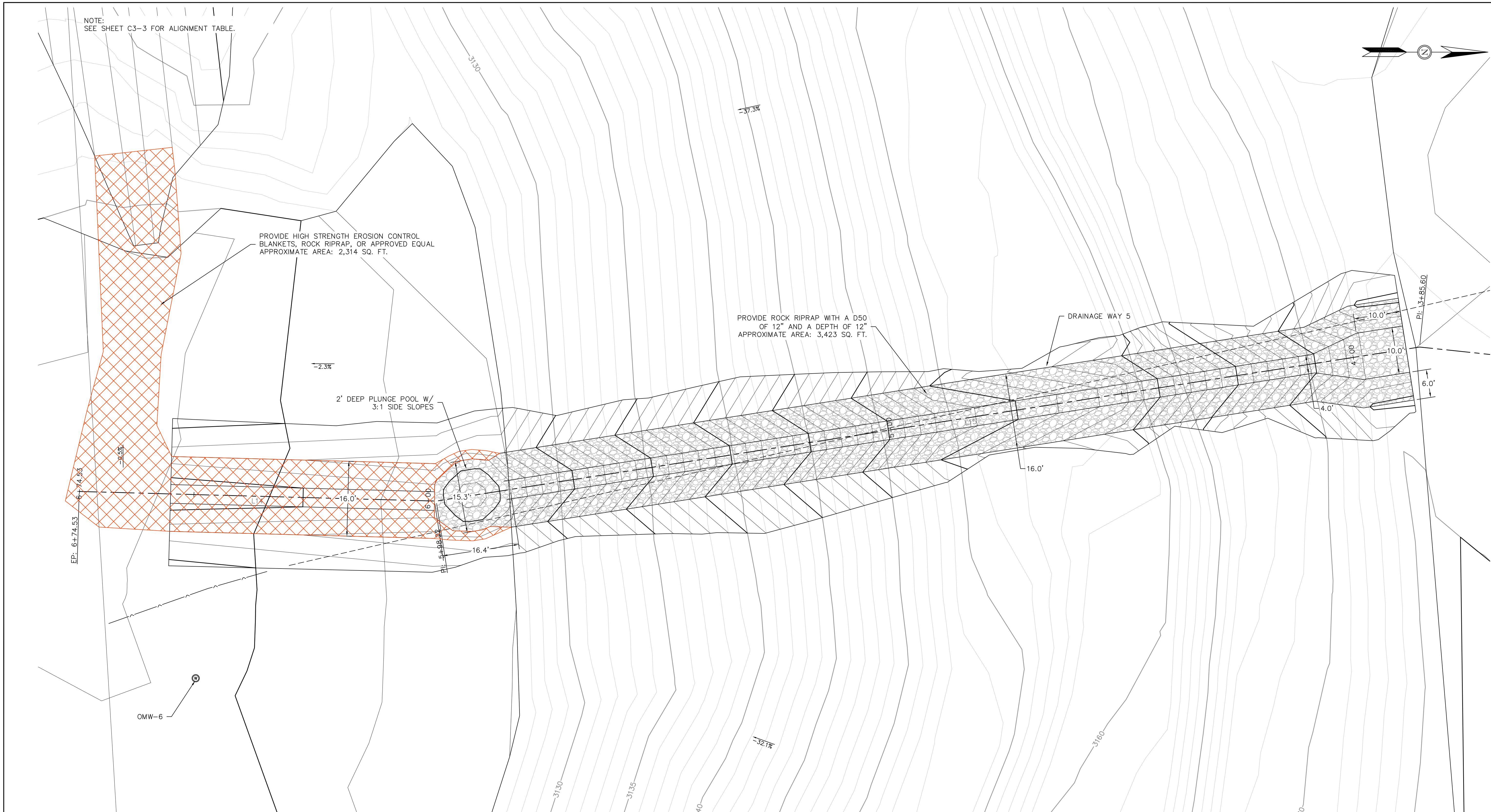

PLAN VIEW - DRAINAGE WAY 5 (STA 3+60 - STA 6+75)

NO.	REVISIONS	DRAWN BY	DATE

HORIZONTAL SCALE FEET 0 40 80
VERTICAL SCALE FEET 0 4 8

PROJECT ENGINEER: DSC
DRAWN BY: ASG
DESIGNED BY: ASG
REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
EROSION CONTROL - DRAINAGE WAY 5
ROSEBUD COUNTY, MT

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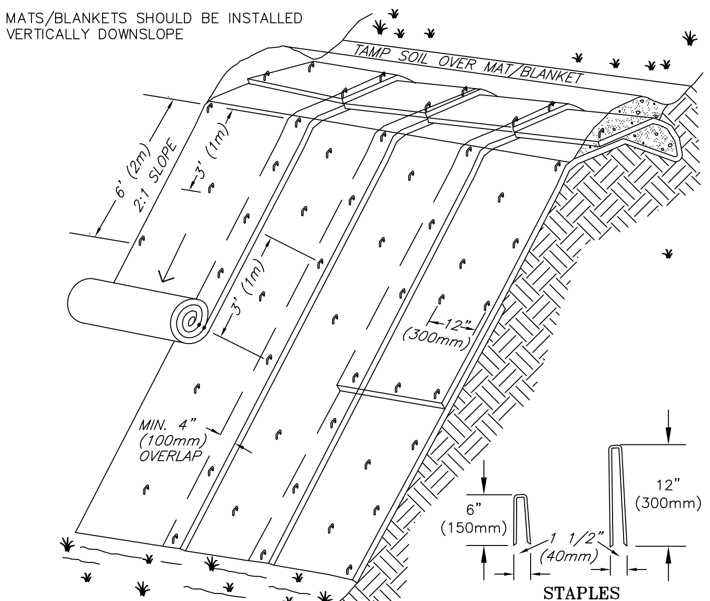
PROJECT #: 15-125
DATE: 9/15/2016

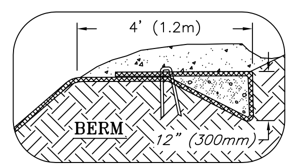
SHEET C4-3

P & P - DRAINAGE WAY 4



ISOMETRIC VIEW

STAPLES

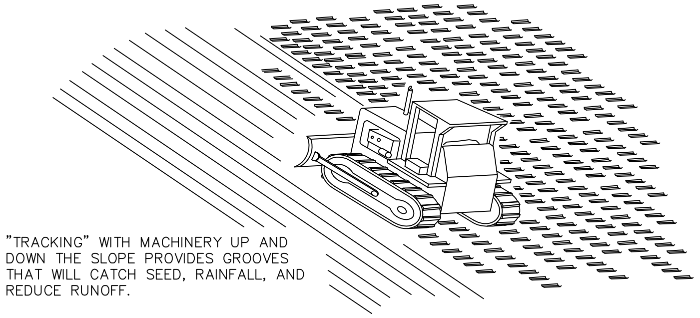


TYPICAL SLOPE SOIL STABILIZATION

NOTES:
1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH SOIL. DO NOT STRETCH.

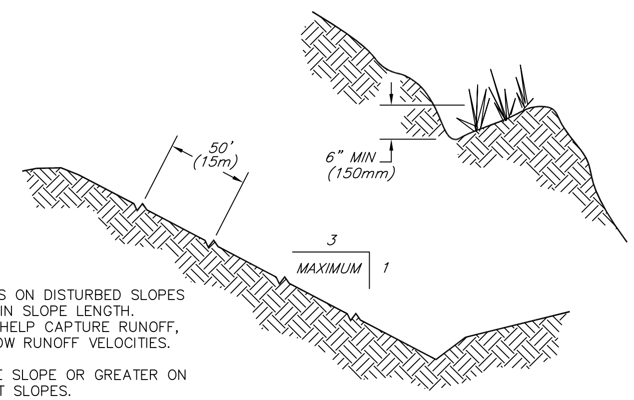
NOT TO SCALE

1 DETAIL
EROSION CONTROL BLANKETS ON A SLOPE
NTS



"TRACKING" WITH MACHINERY UP AND DOWN THE SLOPE PROVIDES GROOVES THAT WILL CATCH SEED, RAINFALL, AND REDUCE RUNOFF.

TRACKING

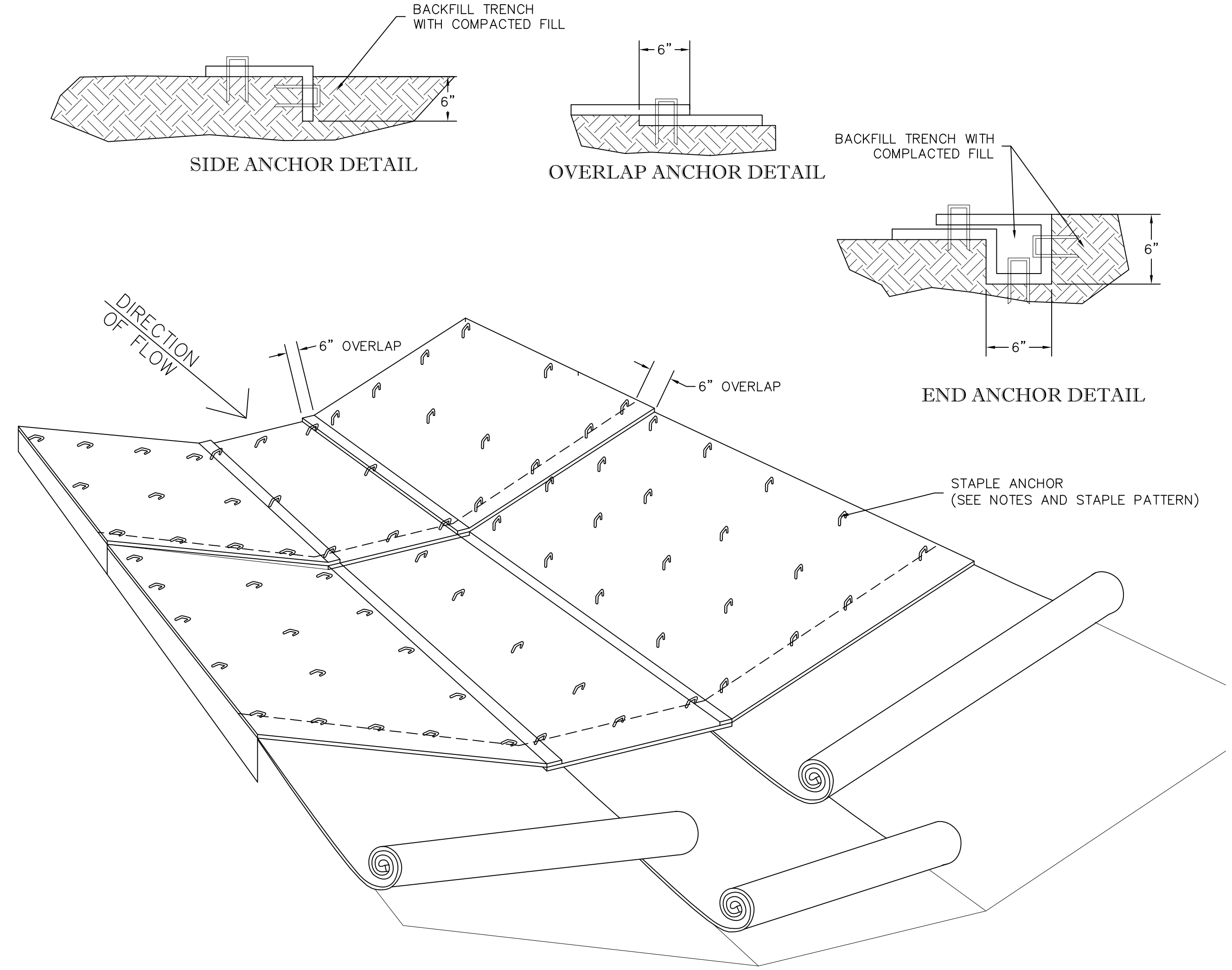


PLACE FURROWS ON DISTURBED SLOPES OVER 50 FEET IN SLOPE LENGTH. FURROWS WILL HELP CAPTURE RUNOFF, SEEDS AND SLOW RUNOFF VELOCITIES.

USE 3H:1V SIDE SLOPE OR GREATER ON ALL PERMANENT SLOPES.

CONTOUR FURROWS

2 DETAIL
SLOPE TEXTURING
NTS



ISOMETRIC VIEW

3 DETAIL
EROSION BLANKETS IN A CHANNEL
NTS

CONSTRUCTION NOTES:

1. PREPARE SOIL SO THAT AREA IS SMOOTH, THEN ADD SEED. AND FERTILIZER AS NEEDED.
2. START BY STAPLING THE BLANKET AT THE TOP OF THE CHANNEL IN A 6" DEEP X 6" WIDE TRENCH. BACKFILL AND COMPACT TRENCH SO THAT THE WATER WILL FLOW EVENLY ONTO THE BLANKET.
3. ROLL CENTER BLANKET IN THE BOTTOM OF THE CHANNEL AND PLACE 4 STAPLES EVENLY SPACED PER SQUARE YARD.
4. PLACE ADJOINING ENDS (SHINGLE STYLE) OVERLAPPING 6" SECURING THE OVERLAP WITH A DOUBLE ROW OF STAPLES STAGGERED 4" APART. OVERLAP EDGES OF BLANKET A MINIMUM OF 6" WITH PARALLEL BLANKETS.
5. THE FULL LENGTH OF THE BLANKET AT THE TOP OF THE CHANNEL MUST BE ANCHORED IN A 6"X6" TRENCH THEN BACKFILLED AND COMPACTED AFTER PLACING STAPLES IN THE TRENCH 3 FEET APART. INSURE COMPACTION SO THAT WATER CAN FLOW EVENLY ONTO THE BLANKETS FROM THE SIDES OF THE CHANNEL.
6. PLACE A DOUBLE ROW OF STAGGERED STAPLES 4" APART EVERY 33 FEET.
7. INSURE BLANKET IS PLACED ON SIDE BANKS OF CHANNEL 1 FOOT ABOVE FLOW LINE.
8. AT THE TERMINAL END OF THE CHANNEL, THE BLANKET MUST BE ANCHORED SUCH THAT THE WATER WILL FLOW TO THE DESIRED AREA. IF THE END OF THE CHANNEL IS A CULVERT, THE BLANKET BUST BE PLACED UNDER THE CULVERT AND SECURED WITH STAPLES 4" APART IN A STAGGERED PATTER. IF THE TERMINAL END IS A ROCK OUTFALL, THE BLANKET BUST BE PLACED IN A 6" WIDE X6" DEEP TRENCH STAPLED THE BACKFILLED, COMPACTED THE ROCKS PLACED ON THE TRENCH TO CREATE A SMOOTH TRANSITION.

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\EROSION CONTROL POST.dwg

NO.	REVISIONS	DRAWN BY	DATE

PROJECT ENGINEER: DSC	DRAWN BY: ASG
DESIGNED BY: ASG	REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
EROSION CONTROL DETAILS
ROSEBUD COUNTY, MT

32 DISCOVERY DRIVE
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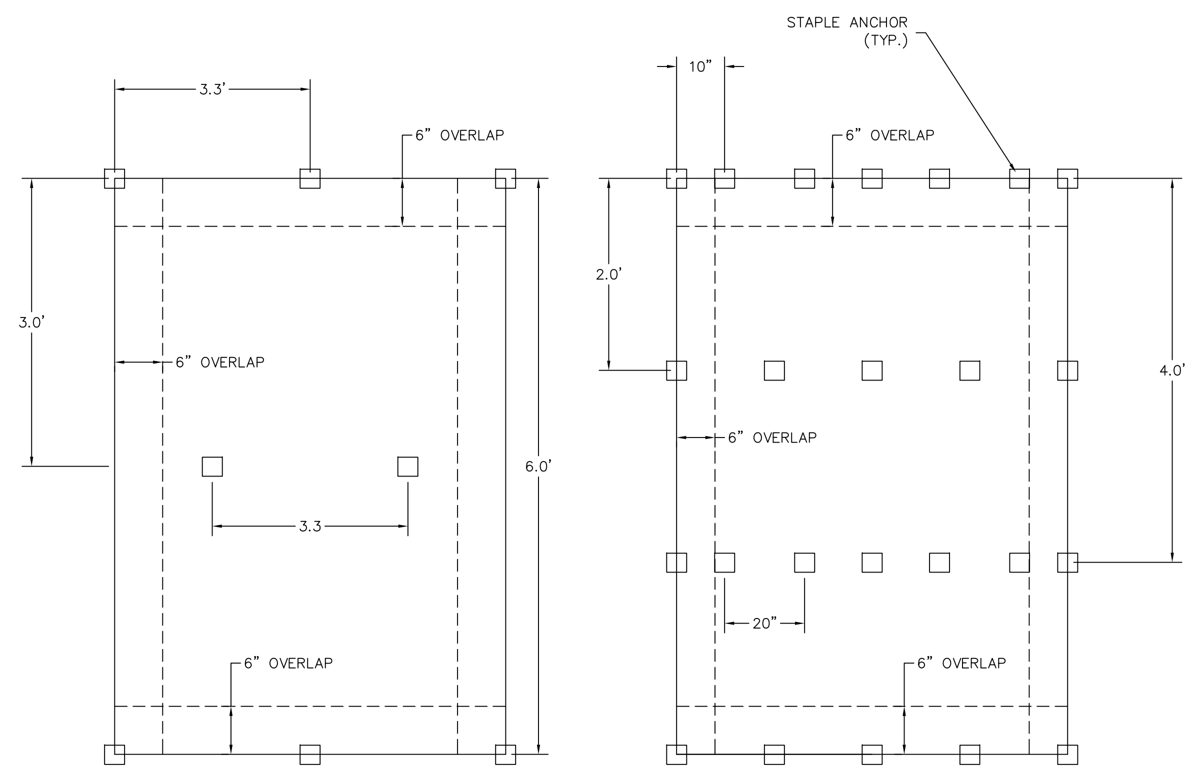
PROJECT #: 15-125
DATE: 9/15/2016
SHEET C4-4
EROSION CONTROL

EROSION BLANKET ANCHORING PATTERNS



3:1 SIDE SLOPES

CHANNEL BOTTOM/HIGH FLOW AREAS

ANCHORING NOTES:

CHOICE OF STAPLES WILL DEPEND ON SOIL TYPE AND COMPACTION. STAPLES PLACED IN SOIL SHOULD NOT COME OUT EASILY BY HAND. STANDARD 6" STAPLES WILL BE USED IN MOST CONDITIONS. LONGER STAPLES 8"–12" MAY BE NEEDED IN SANDY SOILS. FOR VERY LOOSE SOILS A LONG PIN WITH WASHER MAY BE USED TO ANCHOR BLANKET.

BLANKET SHALL BE OVERLAPPED A MINIMUM OF 6" WITH THE UPSTREAM BLANKET COMING OVER THE DOWNSTREAM BLANKET (SHINGLE STYLE).

1 DETAIL
EROSION BLANKETS ANCHORING PATTERNS
NTS

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SHEET SET\POST-CLOSURE PLAN SET\EROSION CONTROL POST.dwg

NO.	REVISIONS	DRAWN BY	DATE

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
EROSION CONTROL DETAILS
ROSEBUD COUNTY, MT

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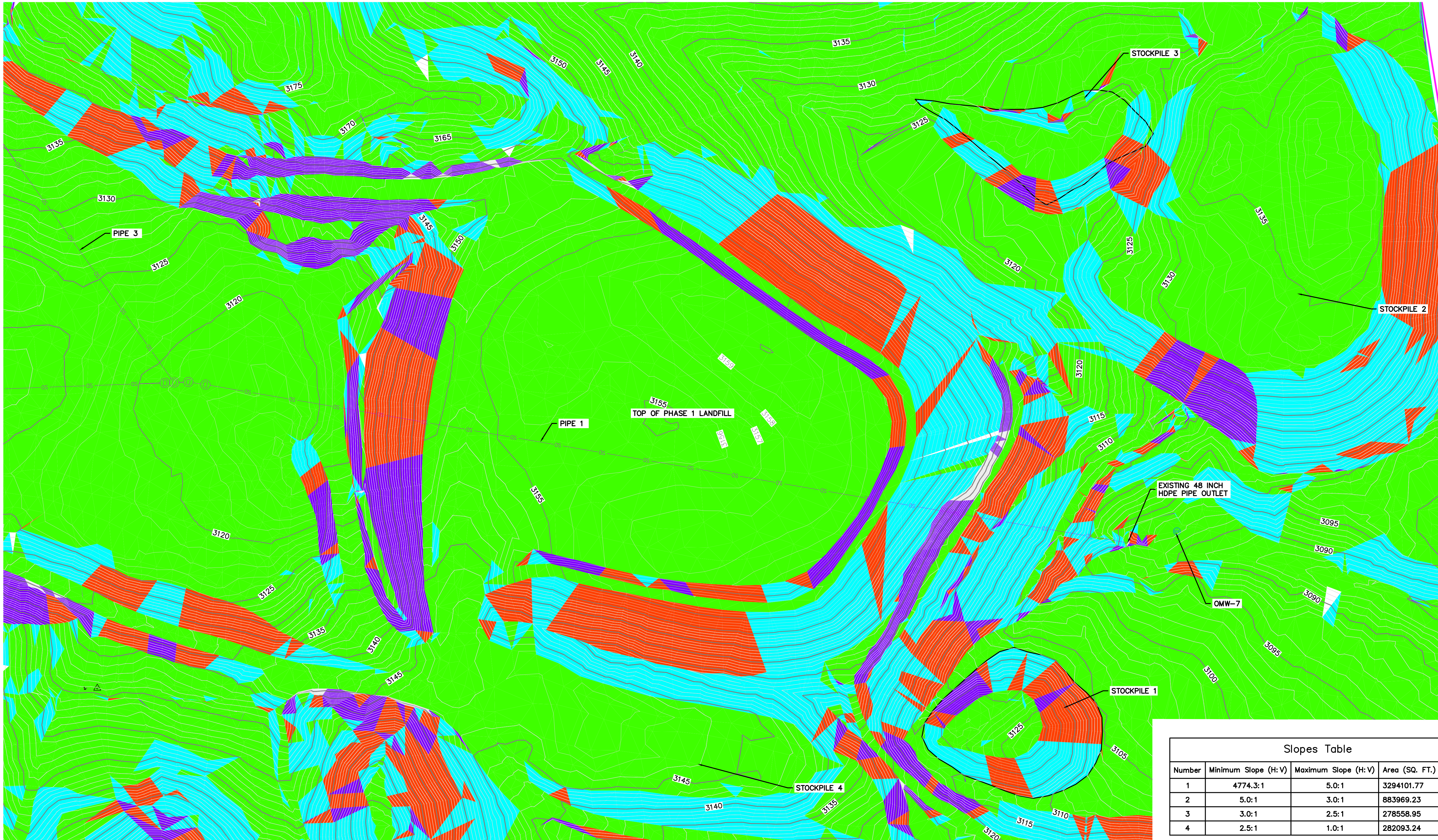
PROJECT #: 15–125
DATE: 9/15/2016
SHEET C4-5
EROSION CONTROL



Slopes Table				
Number	Minimum Slope (H:V)	Maximum Slope (H:V)	Area (SQ. FT.)	Color
1	4774.3:1	5.0:1	3294101.77	
2	5.0:1	3.0:1	883969.23	
3	3.0:1	2.5:1	278558.95	
4	2.5:1	1.0:1	282093.24	

NO.	REVISIONS	DRAWN BY	DATE

0 50 100 150
SCALE (FEET)

PROJECT ENGINEER: DSC | DRAWN BY: ASG
DESIGNED BY: ASG | REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
PHASE 1 LANDFILL SLOPES
ROSEBUD COUNTY, MT

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BOZEMAN, MT 59718
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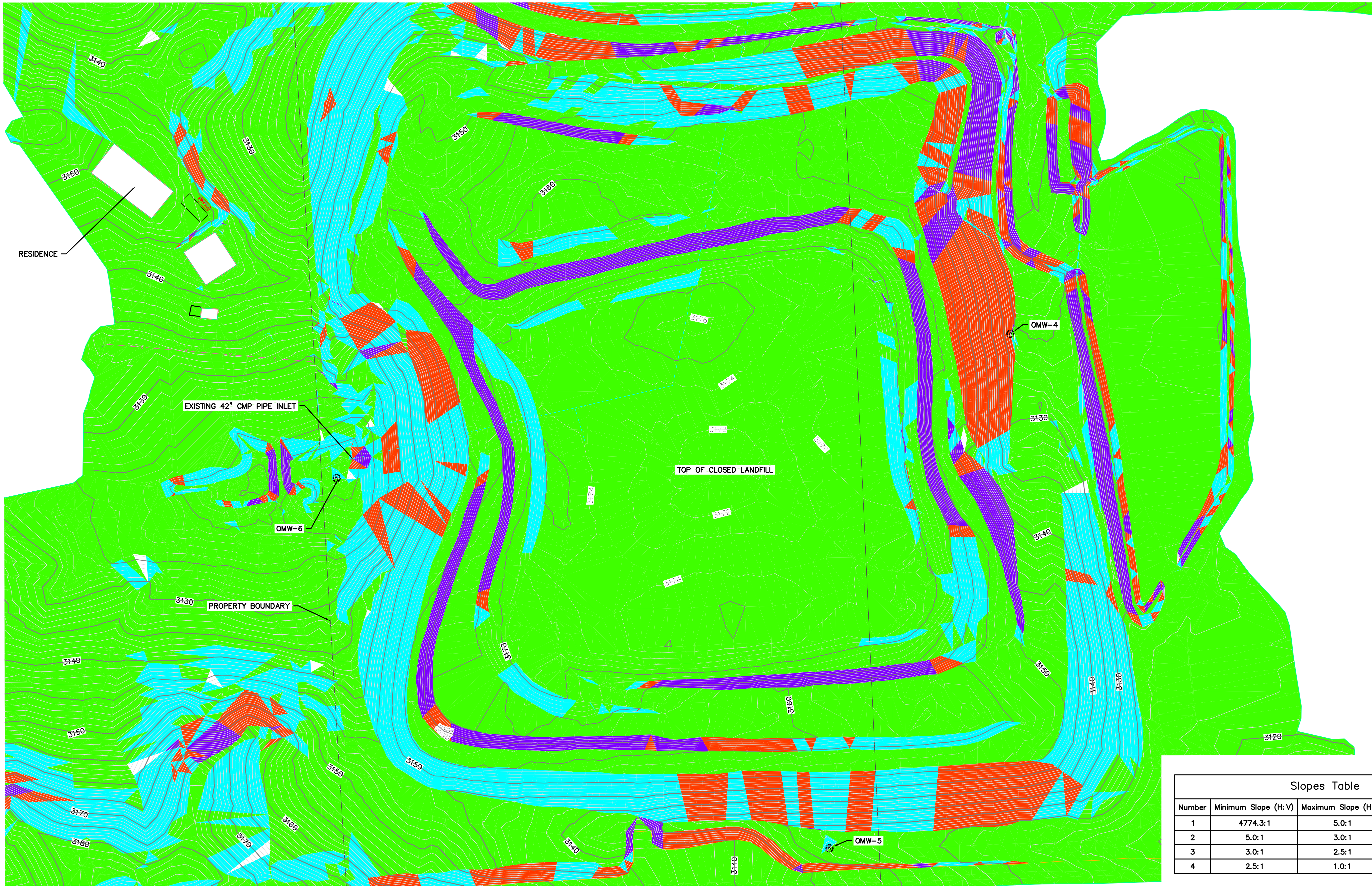
PROJECT #: 15–125
DATE: 09/15/16

SHEET
S-1



Slopes Table				
Number	Minimum Slope (H:V)	Maximum Slope (H:V)	Area (SQ. FT.)	Color
1	4774.3:1	5.0:1	3294101.77	green
2	5.0:1	3.0:1	883969.23	cyan
3	3.0:1	2.5:1	278558.95	red-orange
4	2.5:1	1.0:1	282093.24	purple

P:\2015\15-125 Rosebud Power Plant Ash Disposal Site\09 CAD Data\SLOPE FIGURE.dwg

NO.	REVISIONS	DRAWN BY	DATE

0 60 120 180

SCALE (FEET)

PROJECT ENGINEER: DSC
DRAWN BY: ASG
DESIGNED BY: ASG
REVIEWED BY: DSC, BDA

ROSEBUD POST-CLOSURE DESIGN
EXISTING CLOSED LANDFILL SLOPES
ROSEBUD COUNTY, MT

32 DISCOVERY DRIVE
BOZEMAN, MT 59718
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PROJECT #: 15-125
DATE: 09/15/2016

SHEET S-2

APPENDIX B

SSA 25, 50, and 100Year Storm Event Output
Active Landfill Drainage Basins
Post-Closure Drainage Basins
Rainfall Hyetograph and Hydrograph

Active Landfill

Autodesk Storm and Sanitary Analysis - 25 Year Event Output

25 Year 24 Hour Rainfall Event

Pipes

Element ID	Pipe Material	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
42" Fittings	Duromaxx	35	3112.90	3112.23	0.67	1.91	42	0.012	46.76	9.6	150.8	1.8
42" to 36" Section	Duromaxx	10	3113.09	3112.90	0.19	1.90	42	0.012	40.61	5.7	150.2	2.4
Pipe 1	HDPE	990	3111.78	3093.13	18.65	1.88	48	0.013	46.78	14.0	197.2	1.3
Pipe 2	Duromaxx	628	3129.52	3113.59	15.93	2.54	36	0.012	40.57	10.4	115.1	1.7
Pipe 3	Duromaxx	465	3136.12	3113.90	22.22	4.78	30	0.012	6.66	9.8	97.1	0.8
Pipe 4	CMP	1055	3110.13	3078.58	31.55	2.99	42	0.015	22.22	11.0	150.8	0.9

Channels

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Channel Type	Channel Height (ft)	Channel Width (ft)	Channel Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Outlet Swale from Pipe 1	440.00	3090.50	3082.00	8.50	1.93	Trapezoidal	3	26	0.05	46.7	4.0	368.60	1.05

Reservoirs

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)
Pipe Dam 2	3129.50	3135.00	5.50	40.6	40.6	3130.75	1.25	3129.64	0.14
Pipe Dam 3	3136.00	3141.00	5.00	6.70	6.70	3136.56	0.56	3136.14	0.14

Rainfall Information

Element ID	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
Rain Gage-01	25 Year	Cumulative	inches	Montana	Rosebud	25	2.9	SCS Type II 24-hr

Drainage Basin Information

Active Drainage Basin ID	Area (acres)	Drainage Node ID	Weighted Curve Number	Rain Gage ID	Total Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Time of Concentration (min)
1	103.0	PipeDam2	72	Rain Gage-01	2.90	0.75	40.9	52
2	14.6	PipeDam3	72	Rain Gage-01	2.90	0.75	6.7	42
3	4.3	Out-04	72	Rain Gage-01	2.90	0.75	2.6	27
4	13.6	Out-02	72	Rain Gage-01	2.90	0.75	3.9	80
5	16.3	Out-05	72	Rain Gage-01	2.90	0.75	6.1	55
6	4.0	Out-09	72	Rain Gage-01	2.90	0.75	3.7	12
7	67.4	Jun-07	72	Rain Gage-01	2.90	0.75	22.4	66
8	3.2	Out-07	72	Rain Gage-01	2.90	0.75	1.6	38
9	10.5	Out-08	72	Rain Gage-01	2.90	0.75	5.4	36
10	5.6	Out-06	72	Rain Gage-01	2.90	0.75	3.7	25
11	5.8	Out-01	72	Rain Gage-01	2.90	0.75	4.7	16

Active Landfill

Autodesk Storm and Sanitary Analysis - 100 Year Event Output

100 Year 24 Hour Rainfall Event

Pipes

Element ID	Pipe Material	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
42" Fittings	Duromaxx	35	3112.90	3112.23	0.67	1.91	42	0.012	91.5	11.3	150.8	2.7
42" to 36" Section	Duromaxx	10	3113.09	3112.90	0.19	1.90	42	0.012	79.1	8.2	150.2	3.5
Pipe 1	HDPE	990	3111.78	3093.13	18.65	1.88	48	0.013	91.5	16.4	197.2	1.8
Pipe 2	Duromaxx	628	3129.52	3113.59	15.93	2.54	36	0.012	79.1	12.7	115.1	2.5
Pipe 3	Duromaxx	465	3136.12	3113.90	22.22	4.78	30	0.012	13.0	9.8	97.1	1.6
Pipe 4	CMP	1055	3110.13	3078.58	31.55	2.99	42	0.015	43.4	13.2	150.8	1.3

Channels

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Channel Type	Channel Height (ft)	Channel Width (ft)	Channel Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Outlet Swale from Pipe 1	440.00	3090.50	3082.00	8.5	1.93	Trapezoidal	3	26	0.05	91.00	4.90	368.60	1.50

Reservoirs

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)
Pipe Dam 2	3129.50	3135.00	5.50	79.2	79.1	3131.47	1.97	3129.71	0.21
Pipe Dam 3	3136.00	3141.00	5.00	13.0	13.0	3136.74	0.74	3136.16	0.16

Rainfall Information

Element ID	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
Rain Gage-01	100 Year	Cumulative	inches	Montana	Rosebud	100	3.82	SCS Type II 24-hr

Drainage Basin Information

Active Drainage Basin ID	Area (acres)	Drainage Node ID	Weighted Curve Number	Rain Gage ID	Total Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Time of Concentration (min)
1	103.0	PipeDam2	72	Rain Gage-01	3.82	1.34	79.4	52
2	14.6	PipeDam3	72	Rain Gage-01	3.82	1.34	13.0	42
3	4.3	Out-04	72	Rain Gage-01	3.82	1.34	5.1	27
4	13.6	Out-02	72	Rain Gage-01	3.82	1.34	7.5	80
5	16.3	Out-05	72	Rain Gage-01	3.82	1.34	11.9	55
6	4.0	Out-09	72	Rain Gage-01	3.82	1.34	7.0	12
7	67.4	Jun-07	72	Rain Gage-01	3.82	1.34	43.5	66
8	3.2	Out-07	72	Rain Gage-01	3.82	1.34	3.0	38
9	10.5	Out-08	72	Rain Gage-01	3.82	1.34	10.4	36
10	5.6	Out-06	72	Rain Gage-01	3.82	1.34	7.0	25
11	5.8	Out-01	72	Rain Gage-01	3.82	1.34	9.0	16

Active Landfill

Autodesk Storm and Sanitary Analysis - 500 Year Event Output

500 Year 24 Hour Rainfall Event

Pipes

Element ID	Pipe Material	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
42" Fittings	Duromaxx	35	3112.90	3112.23	0.67	1.91	42	0.0120	118.4	13.81	150.80	2.92
42" to 36" Section	Duromaxx	10	3113.09	3112.90	0.19	1.90	42	0.0120	100.7	10.47	150.24	3.50
Pipe 1	HDPE	990	3111.78	3093.13	18.65	1.88	48	0.0130	118.4	17.35	197.20	2.14
Pipe 2	Duromaxx	628	3129.52	3113.59	15.93	2.54	36	0.0120	100.7	14.24	115.08	3.00
Pipe 3	Duromaxx	465	3136.12	3113.90	22.22	4.78	30	0.0120	19.4	9.59	97.13	1.63
Pipe 4	CMP	1055	3110.13	3078.58	31.55	2.99	42	0.0150	65.1	14.61	150.79	1.65

Channels

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Channel Type	Channel Height (ft)	Channel Width (ft)	Channel Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Outlet Swale from Pipe 1	440	3090.50	3082.00	8.50	1.93	Trapezoidal	3	26	0.05	118.30	5.25	368.60	1.72

Reservoirs

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)
Pipe Dam 2	3129.50	3135.00	5.50	119.1	100.5	3135.00	5.50	3129.85	0.35
Pipe Dam 3	3136.00	3141.00	5.00	19.5	19.5	3136.88	0.88	3136.18	0.18

Rainfall Information

Element ID	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
Rain Gage-01	Extrapolated	Cumulative	inches	Montana	Rosebud	500	4.66	SCS Type II 24-hr

Drainage Basin Information

Active Drainage Basin ID	Area (acres)	Drainage Node ID	Weighted Curve Number	Rain Gage ID	Total Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Time of Concentration (min)
1	103.0	PipeDam2	72	Rain Gage-01	4.66	1.94	119.1	52
2	14.6	PipeDam3	72	Rain Gage-01	4.66	1.94	19.5	42
3	4.3	Out-04	72	Rain Gage-01	4.66	1.94	7.6	27
4	13.6	Out-02	72	Rain Gage-01	4.66	1.94	11.3	80
5	16.3	Out-05	72	Rain Gage-01	4.66	1.94	17.9	55
6	4.0	Out-09	72	Rain Gage-01	4.66	1.94	10.3	12
7	67.4	Jun-07	72	Rain Gage-01	4.66	1.94	65.1	66
8	3.2	Out-07	72	Rain Gage-01	4.66	1.94	4.6	38
9	10.5	Out-08	72	Rain Gage-01	4.66	1.94	15.5	36
10	5.6	Out-06	72	Rain Gage-01	4.66	1.94	10.4	25
11	5.8	Out-01	72	Rain Gage-01	4.66	1.94	13.3	16

Post-Closure

Autodesk Storm and Sanitary Analysis - 25 Year Event Output

25 Year 24 Hour Rainfall Event

Pipes

Element ID	Pipe Material	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Culvert Under Haul Road	Duromaxx	72	3120.97	3119.72	1.25	1.74	36	0.019	29.3	8.0	60.1	1.6

Channels

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Channel Type	Channel Height (ft)	Channel Width (ft)	Channel Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Drainage Way 1 Upper	875	3145.00	3140.62	4.38	0.50	Trapezoidal	2	24	0.032	41.90	3.20	152.26	0.89
Drainage Way 1 Lower	1295	3140.62	3088.97	51.65	3.99	Trapezoidal	2	21	0.032	41.53	5.65	252.22	0.54
Drainage Way 2	459	3149.00	3145.00	4.00	0.87	Trapezoidal	2	24	0.032	8.84	0.83	200.89	0.78
Drainage Way 3 Upper	143	3191.40	3150.22	41.18	28.80	Trapezoidal	2	16	0.032	2.12	1.32	563.21	0.61
Drainage Way 3 Lower	250	3150.22	3149.00	1.22	0.49	Triangular	2	6	0.032	2.89	3.67	17.22	0.73
Drainage Way 4 Upper	581	3124.00	3120.97	3.03	0.52	Trapezoidal	3	22	0.032	30.30	1.95	186.12	1.96
Drainage Way 4 Lower	438	3119.72	3079.44	40.28	9.20	Trapezoidal	2	16	0.032	29.97	8.29	318.27	0.62
Drainage Way 5	186	3173.20	3124.00	49.20	26.45	Trapezoidal	2	16	0.032	1.68	0.55	539.78	0.68
Existing Outlet Swale	216	3090.00	3088.00	2.00	0.93	Trapezoidal	2	22	0.035	8.22	2.07	164.61	0.45
Existing Outlet Swale	710	3085.00	3082.00	3.00	0.42	Trapezoidal	2	32	0.032	44.72	3.03	302.64	0.67

Reservoirs

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)
Inlet Fill Area 1	3145.00	3150.00	5	45.0	38.4	3146.20	1.2	3145.18	0.18
Inlet Fill Area 2	3149.00	3152.00	3	8.3	8.3	3149.33	0.3	3149.04	0.04

Rainfall Information

Element ID	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
Rain Gage-01	25 Year	Cumulative	inches	Montana	Rosebud	25	2.9	SCS Type II 24-hr

Drainage Basin Information

Post Drainage Basin ID	Area (acres)	Drainage Node ID	Weighted Curve Number	Rain Gage ID	Total Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Time of Concentration (min)
1	118.0	PipeDam2	72.00	Rain Gage-01	2.90	0.75	45.0	55
2	18.6	PipeDam3	72.00	Rain Gage-01	2.90	0.75	8.3	44
3	70.2	ExtInletFill	72.00	Rain Gage-01	2.90	0.75	29.4	48
4	2.9	Jun-16	72.00	Rain Gage-01	2.90	0.75	1.9	25
5	8.6	Out-04	72.00	Rain Gage-01	2.90	0.75	5.2	29
6	8.5	Out-03	72.00	Rain Gage-01	2.90	0.75	4.1	39
7	16.3	Jun-19	72.00	Rain Gage-01	2.90	0.75	8.1	38
8	4.3	DW-3	72.00	Rain Gage-01	2.90	0.75	2.1	38
9	3.0	Jun-21	72.00	Rain Gage-01	2.90	0.75	1.7	31

Post-Closure

Autodesk Storm and Sanitary Analysis - 100 Year Event Output

100 Year 24 Hour Rainfall Event

Pipes

Element ID	Pipe Material	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Culvert Under Haul Road	Duromaxx	72	3120.97	3119.72	1.25	1.74	36	0.019	50.9	10.7	60.1	1.9

Channels

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Channel Type	Channel Height (ft)	Channel Width (ft)	Channel Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Drainage Way 1 Upper	875	3145	3140.62	4.38	0.5	Trapezoidal	2	24	0.032	86.26	4.20	152.26	1.29
Drainage Way 1 Lower	1295	3140.62	3088.97	51.65	3.99	Trapezoidal	1.5	21	0.032	85.68	7.21	252.22	0.82
Drainage Way 2	459	3149	3145	4	0.87	Trapezoidal	2	24	0.032	18.07	1.21	200.89	1.12
Drainage Way 3 Upper	143	3191.4	3150.22	41.18	28.8	Trapezoidal	2	16	0.032	4.10	1.87	563.21	0.73
Drainage Way 3 Lower	250	3150.22	3149	1.22	0.49	Triangular	2	6	0.032	4.13	3.94	17.22	0.92
Drainage Way 4 Upper	581	3124	3120.97	3.03	0.52	Trapezoidal	3	22	0.032	57.77	2.18	186.12	2.54
Drainage Way 4 Lower	438	3119.72	3079.44	40.28	9.2	Trapezoidal	2	16	0.032	52.04	9.70	318.27	0.83
Drainage Way 5	186	3173.2	3124	49.2	26.45	Trapezoidal	2	16	0.032	3.22	0.64	539.78	1.05
Existing Outlet Swale	216	3090	3088	2	0.93	Trapezoidal	2	22	0.035	15.91	2.47	164.61	0.69
Existing Outlet Swale	710	3085	3082	3	0.42	Trapezoidal	2	32	0.032	92.38	3.90	302.64	1.03

Reservoirs

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)
Inlet Fill Area 1	3145.00	3150.00	5.0	105.3	86.26	3146.77	1.77	3145.25	0.25
Inlet Fill Area 2	3149.00	3152.00	3.0	20.2	18.07	3149.52	0.52	3149.06	0.06

Rainfall Information

Element ID	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
Rain Gage-01	100 Year	Cumulative	inches	Montana	Rosebud	100	3.82	SCS Type II 24-hr

Drainage Basin Information

Drainage Basin ID	Area (acres)	Drainage Node ID	Weighted Curve Number	Rain Gage ID	Total Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Time of Concentration (min)
1	118.0	PipeDam2	72	Rain Gage-01	3.82	1.34	87.6	55
2	18.6	PipeDam3	72	Rain Gage-01	3.82	1.34	16.2	44
3	70.2	ExtInletFill	72	Rain Gage-01	3.82	1.34	57.0	48
4	2.9	Jun-16	72	Rain Gage-01	3.82	1.34	3.6	25
5	8.6	Out-04	72	Rain Gage-01	3.82	1.34	10.0	29
6	8.5	Out-03	72	Rain Gage-01	3.82	1.34	8.0	39
7	16.3	Jun-19	72	Rain Gage-01	3.82	1.34	15.8	38
8	4.3	DW-3	72	Rain Gage-01	3.82	1.34	4.2	38
9	3.0	Jun-21	72	Rain Gage-01	3.82	1.34	3.3	31

Post-Closure

Autodesk Storm and Sanitary Analysis - 500 Year Event Output

500 Year 24 Hour Rainfall Event

Pipes

Element ID	Pipe Material	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Culvert Under Haul Road	Duromaxx	72	3120.97	3119.72	1.25	1.74	36	0.019	58.2	11.52	60.13	2.05

Channels

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Channel Type	Channel Height (ft)	Channel Width (ft)	Channel Manning's Roughness	Peak Flow (cfs)	Max Flow Velocity (ft/sec)	Design Flow Capacity (cfs)	Max Flow Depth (ft)
Drainage Way 1 Upper	875	3145.00	3140.62	4.38	0.50	Trapezoidal	2	24	0.032	119.7	4.85	152.26	1.50
Drainage Way 1 Lower	1295	3140.62	3088.97	51.65	3.99	Trapezoidal	2	21	0.032	119.6	8.04	252.22	0.99
Drainage Way 2	459	3149.00	3145.00	4.00	0.87	Trapezoidal	2	24	0.032	28.1	1.42	200.89	1.33
Drainage Way 3 Upper	143	3191.40	3150.22	41.18	28.80	Trapezoidal	2	16	0.032	6.2	1.22	563.21	0.85
Drainage Way 3 Lower	250	3150.22	3149.00	1.22	0.49	Triangular	2	6	0.032	5.6	4.02	17.22	1.09
Drainage Way 4 Upper	581	3124.00	3120.97	3.03	0.52	Trapezoidal	3	22	0.032	86.8	2.44	186.12	3.00
Drainage Way 4 Lower	438	3119.72	3079.44	40.28	9.20	Trapezoidal	2	16	0.032	88.4	11.20	318.27	1.08
Drainage Way 5	186	3173.20	3124.00	49.20	26.45	Trapezoidal	2	16	0.032	4.8	0.71	539.78	1.08
Existing Outlet Swale	216	3090.00	3088.00	2.00	0.93	Trapezoidal	2	22	0.035	23.4	2.71	164.61	0.90
Existing Outlet Swale	710	3085.00	3082.00	3.00	0.42	Trapezoidal	2	32	0.032	129.7	4.37	302.64	1.25

Reservoirs

Element ID	Invert Elevation (ft)	Max (Rim) Elevation (ft)	Max (Rim) Offset (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Maximum HGL Elevation (ft)	Maximum HGL Depth (ft)	Average HGL Elevation (ft)	Average HGL Depth (ft)
Inlet Fill Area 1	3145.00	3150.00	5.0	158.7	119.71	3147.33	2.33	3145.33	0.33
Inlet Fill Area 2	3149.00	3152.00	3.0	29.8	28.11	3149.67	0.67	3149.07	0.07

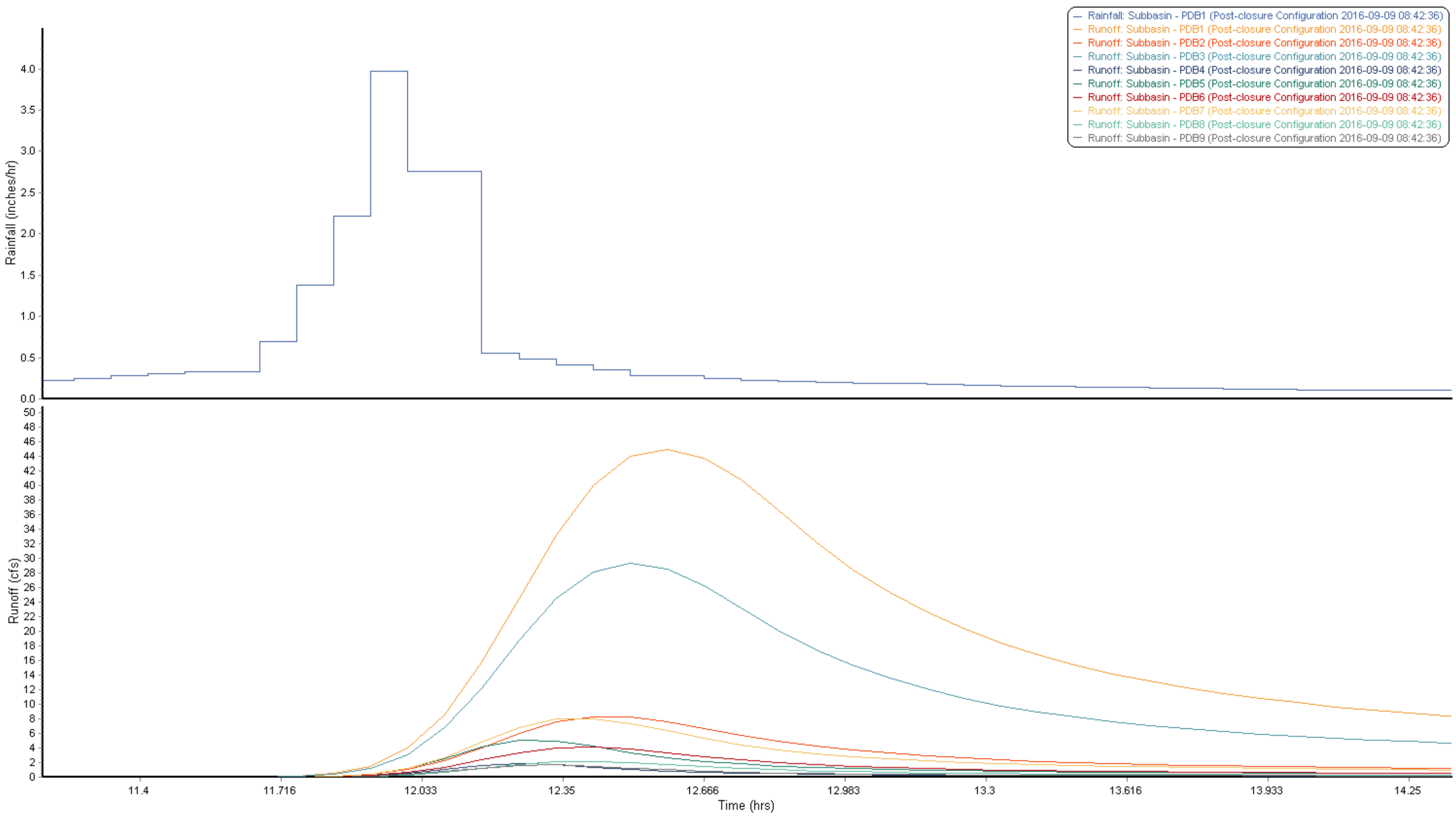
Rainfall Information

Element ID	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
Rain Gage-01	Extrapolated	Cumulative	inches	Montana	Rosebud	500	4.66	SCS Type II 24-hr

Drainage Basin Information

Drainage Basin ID	Area (acres)	Drainage Node ID	Weighted Curve Number	Rain Gage ID	Total Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Time of Concentration (min)
1	118.0	PipeDam2	72	Rain Gage-01	4.66	1.94	131.5	55
2	18.6	PipeDam3	72	Rain Gage-01	4.66	1.94	24.3	44
3	70.2	ExtInletFill	72	Rain Gage-01	4.66	1.94	85.6	48
4	2.9	Jun-16	72	Rain Gage-01	4.66	1.94	5.4	25
5	8.6	Out-04	72	Rain Gage-01	4.66	1.94	14.9	29
6	8.5	Out-03	72	Rain Gage-01	4.66	1.94	12.0	39
7	16.3	Jun-19	72	Rain Gage-01	4.66	1.94	23.6	38
8	4.3	DW-3	72	Rain Gage-01	4.66	1.94	6.2	38
9	3.0	Jun-21	72	Rain Gage-01	4.66	1.94	4.9	31

Rosebud Power Plant
Rainfall Hyetograph and Hydrograph
Post-Closure Drainage Basins



Autodesk Storm and Sanitary Analysis

9/9/16