GENWAL™ RESOURCES, INC.

P.O. Box 910, East Carbon, Utah 84520   794 North "C" Canyon Rd, East Carbon, Utah 84520
Telephone (435) 888-4000   Fax (435) 888-4002

Utah Division of Oil, Gas & Mining
Utah Coal Program
1594 West North Temple, Suite 1210
Salt Lake City, UT 84114-5801

August 14, 2019

Attn: Steve Christensen
Permit Supervisor

Re: Genwal Resources, Inc. C/015/032
C19-003 NOV #21216 Response: Drainage Revision, Task ID#5938

Dear Mr. Christensen,

In response to NOV #21216 GENWAL RESOURCES, INC. has made the following changes to correct the drainage above the sediment pond to prevent future failure of the slope inside the pond: Slotted culvert C-15 will be replaced with a swale that will cross the road and direct water North to drop into culvert C-3, that will carry water South under the road and into the pond as previously designed. This minor change is described on Plate 7-5.

The Trail Mountain Fire that moved through Crandall Canyon in the summer of 2018 burned the existing vegetation in the North slopes of Crandall Canyon. This has caused a major runoff problem in the undisturbed drainages behind the shop building. As a result of this, in the Fall of 2018 massive a rain storm caused the ash and debris from the fire to quickly move down the undisturbed drainage and overwhelm the culvert in UD-1, diverting a massive debris-flow down the undisturbed hillside which washed out a wall of our shop and filled the entire bottom of the building with mud and debris over 2 feet deep. This was not a result of the existing drainage and culvert being under-designed, but a result of the fire damage eliminating all of the vegetation within the drainage. As this was an emergency situation needed to further protect our building, to protect the culvert from clogging, and since the weather was too wet to do proper excavation, we temporarily diverted undisturbed drainage to flow west of the designed culvert to get us through the winter. Now that the hillside is starting to dry out enough to get equipment up the hill, we plan on removing the temporary emergency berm and correcting the existing undisturbed drainage flow as designed, however, we will creating a small emergency overflow in case the culvert inlet becomes overwhelmed by runoff from the burn area again. This way, if or when the culvert becomes overwhelmed due to lack of vegetation in the burn scar, the water will flow west down the hill and into the parking area, instead of directly into our building, causing more damage and cost to the company. This emergency overflow plan is shown on Plate 7-5. The berm will be removed after vegetation in the burn scar has been re-established.

If you have any questions regarding this submittal, please feel free to call me directly at: 435-888-4000.

Karin Madsen
Environmental Engineering Technician
Genwal Resources, Inc.

APPLICATION FOR PERMIT PROCESSING

Permit Change X	New Permit ☐	Renewal ☐	Transfer ☐	Exploration ☐	Bond Release ☐	Permit Number: ACT/015/032
Title of Proposal: C19-003 Drainage Revision						Mine: Crandall Canyon Mine
						Permittee: Genwal Resources, Inc.

Description, include reason for application and timing required to implement

Instructions: *If you answer yes to any of the first 8 questions (gray), submit the application to the Salt Lake Office. Otherwise, you may submit it to your reclamation*

☐ Yes	☐ No	1. Change in the size of the Permit Area? _____ acres Disturbed Area? _____ acres ☐ increase ☐ decrease.
☐ Yes	☐ No	2. Is the application submitted as a result of a Division Order? DO #
☐ Yes	☐ No	3. Does application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes	☐ No	4. Does application include operations in hydrologic basins other than as currently approved?
☐ Yes	☐ No	5. Does application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes	☐ No	6. Does the application require or include public notice/publication?
☐ Yes	☐ No	7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes	☐ No	8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes	☐ No	9. Is the application submitted as a result of a Violation? NOV # 21216
☐ Yes	☐ No	10. Is the application submitted as a result of other laws or regulations or policies? Explain:
☐ Yes	☐ No	11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes	☐ No	12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2?)
☐ Yes	☐ No	13. Does the application require or include collection and reporting of any baseline information?
☐ Yes	☐ No	14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes	☐ No	15. Does application require or include soil removal, storage or placement?
☐ Yes	☐ No	16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes	☐ No	17. Does the application require or include construction, modification, or removal of surface facilities?
☐ Yes	☐ No	18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes	☐ No	19. Does the application require or include certified designs, maps, or calculations?
☐ Yes	☐ No	20. Does the application require or include subsidence control or monitoring?
☐ Yes	☐ No	21. Have reclamation costs for bonding been provided for?
☐ Yes	☐ No	22. Does application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes	☐ No	23. Does the application affect permits issued by other agencies or permits issued to other entities?

X Attach 1 complete digital copy of the application and maps.

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

[signature] Karin Madsen - Engineering Tech - 8-14-19

Signed - Name - Position - Date

Subscribed and sworn to before me this 14 day of Aug, 2019.

[signature]
Notary Public

My Commission Expires: 5/8, 2021)
Attest: STATE OF Utah
COUNTY OF Carbon) ss:

GINGER BASSO
NOTARY PUBLIC-STATE OF UTAH
COMMISSION# 695360
COMM. EXP. 05-08-2021

Received by Oil, Gas & Mining

ASSIGNED TRACKING NUMBER

Application for Permit Processing
Detailed Schedule of Changes to the MRP

C19-003 Drainage Revision	Permit Number: ACT/015/032 Mine: Crandall Canyon Mine Permittee: Genwal Resources, Inc.

Provide a detailed listing of all changes to the mining and reclamation plan which will be required as a result of this proposed permit application. Individually list all maps and drawings which are to be added, replaced, or removed from the plan. Include changes of the table of contents, section of the plan, pages, or other information as needed to specifically locate, identify and revise the existing mining and reclamation plan. **Include page, section and drawing numbers as part of the description.**

			DESCRIPTION OF MAP, TEXT, OR MATERIALS TO BE CHANGED
☐ ADD	☐ REPLACE	☐ REMOVE	Plate 7-5
☐ ADD	☐ REPLACE	☐ REMOVE	Appendix 7-4 pages: 11, 22, 23, & 27.
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	
☐ ADD	☐ REPLACE	☐ REMOVE	

Any other specific or special instructions required for insertion of this proposal into the Mining and Reclamation Plan?

WordPerfect Document Compare Summary

Original document: K:\Crandall\2019\C19-003 Drainage Revision\Appe
Revised document: K:\Crandall\2019\C19-003 Drainage Revision\Appe
Deletions are shown with the following attributes and color:
~~Strikeout~~, Blue RGB(0,0,255).
Deleted text is shown as full text.
Insertions are shown with the following attributes and color:
Double Underline, Redline, Red RGB(255,0,0).

The document was marked with 6 Deletions, 8 Insertions, 0 Moves.

APPENDIX 7-4

CRANDALL CANYON MINE
SEDIMENTATION AND DRAINAGE CONTROL PLAN

~~*PREPARED BY: DAN W. GUY, P.E.*~~
~~*BLACKHAWK ENGINEERING, INC.*~~
~~*1056 WEST 2060 NORTH HELPER, UT. 84526*~~

~~*REVISED: July 2013*~~

REVISED: June 2019

CRANDALL CANYON MINE
SEDIMENTATION AND DRAINAGE CONTROL PLAN

TABLE OF CONTENTS

SECTION PAGE NUMBER

Tables:

Figures:

1. <u>Introduction</u>

The Sedimentation and Drainage Control Plan for the Crandall Canyon Mine has been designed according to the State of Utah R645- Coal Mining Rules, November 1, 1996. All design criteria and construction will be certified by a Utah Registered Professional Engineer.

This plan has been divided into the following three sections:

1) Design of Drainage Control Structures for the Proposed Construction
2) Design of Sediment Control Structures
3) Design of Drainage Control Structures for Reclamation

The general surface water control plan for this project will consist of the following:

(a) The proposed pad expansion will necessitate modifications of a number of existing hydrologic structures on the site. In an effort to clarify the new plan, the entire sedimentation and drainage control plan has been re-evaluated for the site and presented in this Appendix.

(b) The general plan for the pad expansion is to divert undisturbed drainage from Crandall Canyon above the minesite through a 6' diameter CMP culvert beneath the expansion area and discharge below the disturbed area. As a result of the expansion, existing culverts C-2, C-8, C-10 and Ditch DD-9 will be removed. 2 new ditches (DD-12 & DD-13) and 3 new culverts (Main Canyon, C-11 and C-11A) will be added to provide for drainage control for the expanded facility. The existing sediment pond will also be expanded to contain additional runoff from the expansion area. All other existing drainage controls will remain unchanged. All minesite drainage controls are shown on Plate 7-5 “Drainage Map”.

(c) The main canyon culvert is sized to safely pass the runoff from a 100 year - 6 hour precipitation event. All other undisturbed diversions, disturbed ditches and culverts are sized to safely convey runoff from a 10 year - 24 hour precipitation event. The sediment pond is sized to contain runoff from a 10 year - 24 hour precipitation event, as required.

(d) The cresent-shaped area below the portals will be utilized as a water treatment facility for the mine water discharging from the mine and seeping from the slope below the portals. The plan is to divert all mine water into this area, where it will be treated with an aeration system and settling pond to reduce the iron content. Once treated, the mine water will flow into the main canyon culvert at the UPDES #002 discharge location. Calculations show a minimum 12" pipeline at a minimum grade of 3 % is more than adequate to carry the expected maximum discharge of 800 gpm or 1.78 cfs. A larger pipeline may be used. This system will be isolated from the rest of the minesite drainage by topography and jersey-barriers, and will no longer flow to the sediment pond. The location and drainage plans are shown on Plate 7-5. As a result of constructing this facility, the volume of runoff reporting to the sediment pond actually decreases by a small amount, estimated at about 0.05 ac/ft. However, since the facility may not be permanent and could be removed in the future, the runoff calculations for the affected ditches, culverts and sediment pond have not been changed to reflect any resulting decrease.

(e) When the Crandall Canyon Mine Portals were sealed as a result of the 2007 disaster, culvert system UD-3 which diverts undisturbed drainage area WSUD-3, was damaged beyond repair. Therefore it was decided to re-route UD-3 as shown on Figures 13A and 13B. Culvert UD-3 now reports to Disturbed Ditch DD-8, Culvert C-1, Disturbed Ditch DD-5, Culvert C-12 and ultimately into the Sediment Pond. Calculations show that all affected ditches, culverts and the Sediment Pond are adequately sized to handle the increased flow from WSUD-3 (See Tables 3, 5, 6, 7 and 11).

DESIGN OF DRAINAGE CONTROL STRUCTURES

Design Parameters:

Tables:

Design Parameters:

2.1 Precipitation

The precipitation-frequency values for the area were taken from the existing plan which lists Miller, et.al. (1973) as the sources.

Frequency - Duration	Precipitation
10 year-6 hour	1.55"
10 year-24 hour	2.50"
25 year-6 hour	1.90"
100 year-6 hour	2.40"
100 year-24 hour	3.70"

2.2 Flow

Peak flows, flow depths, areas and velocities were calculated using the computer program "Office of Surface Mining Watershed Model", Storm Version 6.21 by Gary E. McIntosh. All flow is based on the SCS - TR55 Method for Type II storms.

Time of concentration of storm events was calculated for each drainage area using the following formula:

$$t_L = \frac{L^{0.8} (S+1)^{0.7}}{1900\, Y^{0.5}}$$

where:

t_C	=	Time of Concentration (hrs.)
t_L	=	Lag Time (hrs.) = 0.6 t_C
L	=	Hydraulic Length of Watershed (ft.)
Y	=	Average Land Slope (%)
S	=	$\frac{1000}{CN} - 10$

2.3 Velocity

Flow velocities for each ditch structure were calculated using the Storm computer program with Manning's Formula:

$$V = \frac{1.49}{n} R^{2/3} S^{1/3}$$

where:			
	V	=	Velocity (fps)
	R	=	Hydraulic Radius (ft.)
	S	=	Slope (ft. per ft.)
	n	=	Manning's n; Table 3.1, p. 159,

"Applied Hydrology and Sedimentology for Disturbed Areas", Barfield, Warner & Haan, 1983.

Note: The following Manning's n were used in the calculations:

Structure	Manning's n
Culverts (cmp)	0.020
Unlined Disturbed Area Ditches	0.035

2.4 Drainage Areas

All drainage areas were planimetered directly from Plate 7-5, Drainage Map, and Plate 7-5C, Watershed Boundaries.

2.5 Slopes, Lengths

All slopes and lengths were measured directly from the topography on Plate 7-5, Drainage Map, and Plate 7-5C, Watershed Boundaries.

2.6 Runoff

Runoff was calculated using the SCS Formula for Type II Storms; using the Storm Version 6.21 computer program:

$$Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S}$$

where:

CN	=	Runoff Curve Number
Q	=	Runoff in inches
P	=	Precipitation in inches
S	=	$\frac{1000}{CN} - 10$

2.7 Runoff Curve Numbers

Two curve numbers were utilized for the undisturbed areas. Average curve numbers for the north facing and south facing slopes were determined from curves presented in Figure 7-3 (Chapter 7), using measured cover densities as reported in Chapter 3 and the northern half of lease area SL 062648, assuming a hydrologic soil group of C. Curve numbers of 60 and 69 were obtained for the north facing and south facing undisturbed areas, respectively, using Chart A for Oak-Aspen and ground cover densities of 45 and 26 for north facing and south facing areas, respectively. The above referenced Figure 7-3 (Chapter 7) is included in this Appendix as Figure 9.

Runoff curve numbers for reclaimed, disturbed and paved areas were selected based on comparison with Table 2.20 (p. 82, Barfield, et al, 1983) and numbers previously approved in the M.R.P. A conservative number of 75 was used for reclaimed areas within the disturbed boundary. Curve numbers of 90 and 95 were used for all disturbed areas and paved areas, respectively. See Plates 7-5 and 7-5C for referenced areas.

The following is a summary of runoff curve numbers used in these calculations:

Watershed	Runoff CN
Undisturbed (North Facing):	60
Undisturbed (South Facing):	69
Reclaimed:	75
Disturbed:	90
Paved:	95

2.8 Culvert Sizing

Minimum culvert sizing is based on the following Manning's Equation; using the Haestad Methods, Flowmaster I, Version 3.42 computer program:

$$D = \left(\frac{2.16\ Q\ n}{\sqrt{S}}\right)^{0.35}$$

where:	D	=	Required Diameter (feet)
	Q	=	QP = Peak Discharge (cfs)
	n	=	Roughness Factor (0.020 for cmp)
	S	=	Slope (ft. Per ft.)

Using the above formula, minimum required culvert sizes were calculated for each applicable area. Culverts were then selected above the required minimum, and these sizes were checked for adequacy against the Culvert Nomograph included as Figure 1 of this report.

2.9 Culverts

As indicated in Section 1, the proposed pad expansion will necessitate modifications of a number of existing hydrologic structures on the site, including culverts. As a result of the expansion, existing culverts C-2, C-8 and C-10 will be removed. Two new culverts (Main Canyon, C-11) were added to provide drainage control for the expanded facility during phase I of the surface expansion. One more (C-11A) will be added during the phase II south portal construction. All other existing culverts on the site will remain unchanged.

Culverts have been sized according to the calculations previously described, and are summarized on the following tables. The culverts are shown on Plate 7-5, Drainage Map.

All undisturbed diversions are labeled with a UD number (i.e. UD-1). One of these diversions is a culvert (UD-1), and is clearly marked on Plate 7-5. Contributing watersheds for undisturbed diversions are labeled with a WSUD number, (i.e. WSUD-1) as shown on Plates 7-5 and 7-5C. All undisturbed diversion culverts will be fitted with trash racks to minimize plugging by rocks or other debris.

The proposed Main Canyon culvert is sized to carry runoff from a 100 year - 6 hour precipitation event for the Crandall Canyon area above the minesite. A 6' diameter C.M.P. culvert is proposed to carry the Crandall Canyon runoff beneath the expanded pad area and discharge below the minesite. Calculations in Table 10 show the proposed 6' diameter culvert to be more than adequate to carry the expected peak flow. The culvert will be equipped with an inlet headwall and trash rack and a properly sized outlet apron and energy dissipator for erosion protection. Runoff characteristics, flow and culvert design are presented in this Appendix.

The remaining undisturbed culverts on the site (UD-1 and UD-3) are existing. These culverts are adequate for the required 10 year - 6 hour precipitation event, as shown on Table 10 of this Appendix.

Culverts carrying disturbed drainage are designed with a C number (i.e. C-1). Contributing watersheds for disturbed area culverts (and ditches) are designated with a WSDD number (i.e. WSDD-1) shown on Plate 7-5. All disturbed area drainage culverts have been designed to carry the runoff from a 10 year - 24 hour precipitation event. All calculations and design criteria are included in this Appendix.

Existing culverts C-2, C-8 and C-10 will be removed during the pad extension, and therefore are not included in this Appendix. These culverts are shown on Plate 7-5C, dated 03/21/91.

All culverts will be inspected regularly, and cleaned as necessary to provide for passage of design flows. Inlets and outlets shall also be maintained to prevent plugging, undue restriction of water flow and erosion. Culvert outlets will be
rip-rapped where necessary to protect from erosion.

One culvert, UD-1, is considered a permanent diversion, and will remain in place after reclamation. This culvert is sized to carry runoff in-excess of a 100 year - 6 hour storm. Justification for leaving it in place is provided in the Reclamation Hydrology Section 4.1, of this Appendix.

Historical Note Concerning UD-1

As a result of the Trail Mountain Fire that moved through Crandall Canyon in the summer of 2018, the existing vegetation on the North slopes of Crandall Canyon were completely burned. This caused a major runoff problem in the undisturbed drainage behind the shop building. In the Fall of 2018, a rain storm caused the ash and debris from the fire to quickly move down the undisturbed drainage and overwhelm the culvert in UD-1, diverting the massive debris-flow down the undisturbed hillside which washed out a wall of the shop resulting in filling the bottom of the building with mud and debris over 2 feet deep. This was not a result of the existing drainage and culvert being under-designed, but a result of the fire damage eliminating all of the vegetation within the drainage and de-stabilizing the slope. As this was an emergency situation needed to further protect the structures and to protect the culvert from clogging, a small emergency overflow was constructed in case the culvert inlet becomes overwhelmed by runoff from the burn area again. This way, if or when the culvert becomes overwhelmed due to lack of vegetation in the burn scar, the water will flow west down the hill and into the parking area, instead of directly into our building, causing more damage and cost to the company. This emergency overflow plan is shown on Plate 7-5. The small berm near the UD-1 inlet will be removed as soon as vegetation on the burn scar has been re-established.

All other culverts are considered temporary, and will be removed upon final reclamation, with the exception of the lower 300' of the Main Canyon Culvert. This portion of the culvert will be left in place until the sediment pond is removed during Phase II Reclamation. The remaining portion of the culvert will be removed at that time.

2.10 Ditches

The proposed pad expansion will necessitate modifications to hydrologic structures, including ditches. As a result of the expansion, existing ditch DD-9 will be eliminated. Two new ditches (DD-12 and DD-13) will be added to provide drainage control for the expanded facility. All other existing ditches on the site will remain unchanged.

Undisturbed diversions are designated with a UD number (i.e. UD-2). There is only one undisturbed diversion ditch - (UD-2). This ditch is existing. Contributing watersheds for the undisturbed diversion are labelled with a WSUD number (i.e. WSUD-2), and are shown on Plate 7-5C.

Disturbed diversions (ditches) are designated with a DD number (i.e. DD-1). Contributing watersheds for disturbed diversions are labelled with a WSDD number (i.e. WSDD-1) as shown on Plates 7-5 and 7-5C. All disturbed diversions carry runoff which ultimately goes to the sediment pond.

All ditches are designed to carry the expected runoff from respective watersheds from a 10 year - 6 hour precipitation event, with a minimum freeboard of 0.3'. Ditches were assumed to be unlined with a Manning's No. of 0.035. All ditches have been conservatively evaluated for size using the computer program "Office of Surface Mining Watershed Model," Storm, Version 6.21, by Gary E. McIntosh, to calculate peak flows, which were then routed into triangular shaped channels with 1:1 side slopes. This evaluation shows conditions which are not uncommon at minesites and which tend to maximize required flow depths. All ditches are designed with the steeper (1:1) side slopes to allow for maintenance by road grading or other equipment. Actual side slopes may vary in the field; however, as long as the ditch has the required depth and cross-sectional area to carry the flow with required freeboard, the ditch is adequate.

Ditches with flow velocities of 5 fps or greater will be lined with properly sized rip-rap or other controls to protect from erosion.

All ditch slopes and lengths were taken from Plate 7-5, “Drainage Map”.

A typical ditch section, as well as a summary of flow depths and sizes is provided in Figure 3 of this Appendix.

All ditches will be inspected regularly, constructed and maintained to the minimum dimensions to provide adequate capacity for the design flow. All ditches are temporary and will be removed during final reclamation.
Note: Ditches were also evaluated for adequacy to carry runoff from the 10 year - 24 hour precipitation event.

2.11 Main Canyon Culvert

The proposed main canyon culvert will be placed to closely approximate the existing stream alignment. In an effort to protect the natural channel, the area will be covered with a filter fabric (geotextile material). An underdrain will then be installed on the fabric, consisting of an 18" perforated drain pipe surrounded by a bed of clean 2" drain drainrock. The underdrain will be covered by a second layer of fabric which in turn will be covered with a layer of marker material used to facilitate visibility during final reclamation. A layer of bedding material will then be placed over the marker material. The proposed 72" cmp culvert will then be installed on the bedding material and backfilled and compacted throughout the length of the mine site - approximately 1500'.

The culvert has been sized to safely carry the runoff from a 100 year - 6 hour precipitation event for all of Crandall Canyon above the minesite. The 100 year - 6 hour flow has been calculated at 222.79 cfs, as shown on Table 3. This flow can be carried by a 3.75' minimum diameter culvert, as calculated by the Manning's Equation and shown in Table 10; therefore, the proposed 6' diameter culvert is more than adequate.

There have been some questions raised as to previous main canyon flow calculations which showed the expected runoff from the 100 year - 6 hour storm to be as high as 431 cfs. It appears this number was generated by using a computer program called "Peak", using slightly different parameters than those used in this report.

The runoff numbers in this Appendix were calculated using the "Office of Surface Mining Watershed Model", Storm Version 6.21, by Gary E. McIntosh. All flows were based on the SCS-TR55 Method for Type II storms. This program has been supplied to the operators by the Division, and results have been consistently accepted by the agencies.

In an effort to make the runoff values more conservative, yet realistic, for design purposes, some parameters, such as concentration time and SCS Upland Curve numbers were placed on the conservative side in the program. Based on these numbers, a very conservative flow of 222.79 cfs was obtained. It should be noted that this flow agrees closely with a previous calculation using the equation of Thomas and Lindskov (1983), which estimates the 100 year - 6 hour flow for the main canyon at 272 cfs.

Summary: It is obvious that the final number on the main channel flow is entirely dependent upon which computer program or method is used. Since the OSM Storm program has been used throughout calculations for this plan, and since it is a widely accepted method, the more conservative figure of 222.79 cfs has been used in design calculations for this plan.

2.12 Main Canyon Culvert Inlet Structure

The culvert inlet will be protected by an inlet section and trash rack, along with a rip-rapped headwall. An additional trash rack will be installed upstream of the inlet at a location convenient for maintenance and cleanout, as shown on Figure 10. Based on the Culvert Nomograph, Figure 1, the expected flow will enter the culvert at slightly over 1 diameter of head; therefore, additional headwall protection will be provided for a minimum of 5' above and around the inlet structure. Headwall protection will be of 18" D_{50} rip-rap, as shown on Figure 10.

A small side drainage enters Crandall Creek just west of the bypass culvert inlet. As the drainage calculations took into consideration the runoff from this side canyon, the bypass culvert and inlet riprap are adequately sized to handle drainage from this side canyon. The riprap has been extended up this drainage for a short distance (see Map 5-3) in order to protect the culvert inlet.

2.13 Main Canyon Culvert - Outlet Structure

The outlet of the 6' diameter main canyon culvert has been designed to flow into a rip-rap apron to protect against scouring and for energy dissipation. The rip-rap apron is designed to fit the natural channel configuration as closely as possible, and will allow runoff to re-enter the natural channel at a reduced velocity which is no greater than natural flow conditions. Runoff from the 100 year - 6 hour precipitation event in the canyon above the minesite has been calculated at 222.79 cfs.

The rip-rap apron design is based on Figure 7-26, Design of Outlet Protection - Maximum Tailwater Condition, “Applied Hydrology and Sedimentology for Disturbed Areas”, Barfield, Warner and Haan, 1983. Based on the figure, the apron should be a minimum of 22' in length, widening from 6' to 15', with a 0% slope. The proposed length has been increased to 30', with an 18' width, to ensure adequate time for velocity reduction. The slope is kept at 0%. Rip-rap size is conservatively placed at 30" D_{50} . Rip-rap will be placed to a depth of 1.5 D_{50} and will be embedded in a 12" layer of 2" drain rock filter. Rip-rap will also be placed on 1:1 side slopes to the height of the culvert (6') at the culvert outlet tapering to 3' at the outlet of the apron. This rip rap apron has been sized and designed to adequately dissipate energy from flow velocities of a 100 year, 24 hour precipitation event and resist dislodgement. The drain rock filter bed will also serve to secure the rip rap boulders firmly in place, to add an additional element of stability, and prevent scouring underneath the boulder bed.

The natural channel below the proposed outlet has been measured from field surveys to have a bottom width of approximately 17' at the proposed apron outlet, with side slopes approximately 1:1. When the flow is routed from the culvert across the apron to the natural channel, the velocity is reduced from 21.70 fps at the culvert outlet to 10.83 fps at the outlet of the apron. Refer to 72" Culvert Outlet Rip-Rap Apron Flow Velocity Calculations in Section 4.6. Based on actual field measurements, the natural channel flow velocity would be approximately 11.02 fps at this location with the same flow of 222.79 cfs. Therefore, the velocity of the stream flow exiting the rip rap apron will be less than the velocity in the naturally existing stream bed, at that location, under similar conditions.

TABLE 1
WATERSHED SUMMARY

Watershed	Type	CN	Acres	Drains To		Final
Crandall	Undisturbed	69	3480.00	Main Culvert		-
				Crandall Creek		
WSUD-1	Undisturbed	69	84.88	Culvert UD-1		-
				Crandall Creek		
WSUD-2	Undisturbed	69	1.39	Ditch UD-2	-	Culvert UD-1
WSUD-3	Undisturbed	69	8.66	Culvert UD-3		-
						Sediment Pond
WSDD-1	Undisturbed	69	0.14	Ditch DD-1	-	Sediment Pond
WSDD-1	Reclaimed	75	0.08	Ditch DD-1	-	Sediment Pond
WSDD-2	Reclaimed	75	0.15	Ditch DD-1	-	Sediment Pond
WSDD-3	Undisturbed	69	0.13	Ditch DD-3	-	Sediment Pond
WSDD-3	Reclaimed	75	0.15	Ditch DD-3	-	Sediment Pond
WSDD-3	Disturbed	90	0.26	Ditch DD-3	-	Sediment Pond
WSDD-3	Paved	95	0.33	Ditch DD-3	-	Sediment Pond
WSDD-4	Paved Road	95	0.11	Ditch DD-4	-	Sediment Pond
WSDD-4	Disturbed	90	0.08	Ditch DD-4	-	Sediment Pond
WSDD-5	Undisturbed	69	0.12	Ditch DD-5	-	Sediment Pond
WSDD-5	Reclaimed	75	0.33	Ditch DD-5	-	Sediment Pond
WSDD-5	Paved Road	95	0.33	Ditch DD-5	-	Sediment Pond
WSDD-7	Undisturbed	69	0.18	Ditch DD-7	-	Sediment Pond
WSDD-7	Disturbed	90	0.17	Ditch DD-7	-	Sediment Pond
WSDD-7	Paved Road	95	0.09	Ditch DD-7	-	Sediment Pond
WSDD-8	Undisturbed	69	3.59	Ditch DD-8	-	Sediment Pond
WSDD-8	Reclaimed	75	0.15	Ditch DD-8	-	Sediment Pond
WSDD-8	Disturbed	90	0.37	Ditch DD-8	-	Sediment Pond
WSDD-8	Paved Road	95	0.25	Ditch DD-8	-	Sediment Pond
WSDD-10	Undisturbed	69	0.07	Ditch DD-10	-	Sediment Pond
WSDD-10	Reclaimed	75	0.12	Ditch DD-10	-	Sediment Pond
WSDD-10	Disturbed	90	0.61	Ditch DD-10	-	Sediment Pond
WSDD-10	Paved Road	95	0.27	Ditch DD-10	-	Sediment Pond
WSDD-11	Undisturbed	69	2.09	Ditch DD-11	-	Sediment Pond
WSDD-11	Reclaimed	75	0.15	Ditch DD-11	-	Sediment Pond
WSDD-11	Disturbed	90	0.04	Ditch DD-11	-	Sediment Pond
WSDD-12	Undisturbed	60	8.82	Ditch DD-12	-	Sediment Pond
WSDD-12	Disturbed	90	2.29	Ditch DD-12	-	Sediment Pond
WSDD-13	Undisturbed	60	17.72	Ditch DD-13	-	Sediment Pond
WSDD-13	Disturbed	90	3.70	Ditch DD-13	-	Sediment Pond
WSDD-13	Paved	95	0.27	Ditch DD-13	-	Sediment Pond
WSDD-14	Disturbed	90	0.89	Sediment Pond	-	Sediment Pond
WSDD-14	Undisturbed	60	0.78	Sediment Pond	-	Sediment Pond

WSDD-14	Paved	95	0.02	Sediment Pond	-	Sediment Pond
WSDD-15	Paved	95	0.09	Ditch DD-7	-	Sediment Pond

TABLE 2
WATERSHED PARAMETERS

Watershed	Type	CN	Acres	Hyd. Length(ft.)	Land Slope(%)	Elev.Change(ft.)
Crandall	Und.	69	3480.00	16,500	17.58	2900
WSUD-1	Und.	69	84.88	3,100	53.55	1660
WSUD-2	Und.	69	1.39	320	78.13	250
WSUD-3	Und.	69	8.66	1300	70.77	920
WSDD-1	Und.	69	0.14	100	40.00	40
WSDD-1	Recl.	75	0.08	120	25.00	30
WSDD-2	Recl.	75	0.15	200	25.00	50
WSDD-3	Und.	69	0.13	80	50.00	40
WSDD-3	Recl.	75	0.15	100	48.00	48
WSDD-3	Dist.	90	0.26	125	56.00	70
WSDD-3	Paved	95	0.33	100	3.00	3
WSDD-4	Paved	95	0.11	250	8.33	20
WSDD-4	Dist.	90	0.08	100	10.00	10
WSDD-5	Und.	69	0.12	60	50.00	30
WSDD-5	Recl.	75	0.33	80	50.00	40
WSDD-5	Paved	95	0.33	300	8.33	25
WSDD-7	Und.	69	0.18	100	78.00	78
WSDD-7	Dist.	90	0.17	120	66.67	80
WSDD-8	Und.	69	3.59	700	65.71	460
WSDD-8	Recl.	75	0.15	80	62.50	50
WSDD-8	Dist.	90	0.37	60	65.71	39

WSDD-8	Paved	95	0.25	560	5.36	30
WSDD-10	Und.	69	0.07	45	62.22	28
WSDD-10	Recl.	75	0.12	50	72.00	36
WSDD-10	Dist.	90	0.61	120	62.50	75
WSDD-10	Paved	95	0.27	335	5.37	18
WSDD-11	Und.	69	2.09	570	64.91	370
WSDD-11	Recl.	75	0.15	30	66.67	20
WSDD-11	Dist.	90	0.04	35	66.67	23
WSDD-12	Und.	60	8.82	1600	42.50	680
WSDD-12	Dist.	90	2.29	80	72.73	58
WSDD-13	Und.	60	17.72	2100	53.81	1130
WSDD-13	Dist.	90	3.70	650	9.09	59
WSDD-13	Paved	95	0.27	40	4.00	2
WSDD-14	Dist.	90	0.89	140	16.11	23
WSDD-14	Und.	60	0.78	380	64.41	245
WSDD-14	Paved	95	0.02	30	3.00	1
WSDD-15	Paved	95	0.09	150	3.33	5

TABLE 3
RUNOFF SUMMARY
UNDISTURBED DIVERSIONS

Diversion	Main Culvert	UD-1	UD-2	UD-3
Watershed	Crandall Canyon	WSUD-1	WSUD-2	WSUD-3
Area (Acres)	3480.0	84.88	1.39	8.66
Runoff CN	69	69	69	69
10 year/6 hour				

Rainfall (in.)	1.55	1.55	1.55	1.55
Peak Flow 10/6 (cfs)	N/A	1.91	0.04	0.23
25 year/6 hour Rainfall (in.)	1.90	1.90	1.90	1.90
Peak Flow 25/6 (cfs)	N/A	3.68	0.08	0.43
100 year/6 hour Rainfall (in.)	2.40	2.40	2.40	2.40
Peak Flow 100/6 (cfs)	222.79	6.81	0.21	0.89
10 year/24 hour Rainfall (in.)	N/A	2.50	2.50	2.50
Runoff Volume 10/24 (ac.ft.)	N/A	2.98	0.05	0.30

TABLE 4
RUNOFF SUMMARY
DRAINAGE TO SEDIMENT POND

Watershed	Type	10 year/24 hour Volume-ac.ft.	10 year/24 hour Peak Flow-cfs	10 year/6 hour Peak Flow-cfs	25 year/6 hour Peak Flow-cfs
WSDD-1	Undisturbed	0.02	0.10	0.04	0.06
WSDD-1	Reclaimed	0.01	0.04	0.01	0.01
WSDD-2	Reclaimed	0.01	0.06	0.01	0.03
WSDD-3	Undisturbed	0.00	0.03	0.00	0.01
WSDD-3	Reclaimed	0.01	0.05	0.01	0.02
WSDD-3	Disturbed	0.03	0.18	0.08	0.12
WSDD-3	Paved	0.05	0.32	0.17	0.22
WSDD-4	Paved	0.02	0.12	0.07	0.09

WSDD-4	Disturbed	0.01	0.08	0.04	0.05
WSDD-5	Undisturbed	0.00	0.03	0.00	0.01
WSDD-5	Reclaimed	0.02	0.10	0.02	0.04
WSDD-5	Paved	0.05	0.39	0.21	0.27
WSDD-7	Undisturbed	0.01	0.05	0.00	0.01
WSDD-7	Disturbed	0.02	0.12	0.05	0.07
WSUD-3	Undisturbed	0.30	1.40	0.23	0.43
WSDD-8	Undisturbed	0.13	0.75	0.10	0.20
WSDD-8	Reclaimed	0.01	0.05	0.01	0.02
WSDD-8	Disturbed	0.05	0.23	0.10	0.14
WSDD-8	Paved	0.04	0.37	0.20	0.26
WSDD-10	Undisturbed	0.00	0.03	0.00	0.01
WSDD-10	Reclaimed	0.01	0.03	0.01	0.01
WSDD-10	Disturbed	0.08	0.42	0.19	0.27
WSDD-10	Paved	0.04	0.35	0.19	0.24
WSDD-11	Undisturbed	0.07	0.47	0.06	0.12
WSDD-11	Reclaimed	0.01	0.04	0.01	0.02
WSDD-11	Disturbed	0.01	0.06	0.03	0.04
WSDD-12	Undisturbed	0.13	0.25	0.04	0.16
WSDD-12	Disturbed	0.29	3.33	1.51	2.10
WSDD-13	Undisturbed	0.26	0.49	0.07	0.30
WSDD-13	Disturbed	0.47	5.39	2.44	3.39
WSDD-13	Paved	0.04	0.20	0.11	0.14
WSDD-14	Disturbed	0.11	0.78	0.35	0.49
WSDD-14	Undisturbed	0.01	0.03	0.00	0.02
WSDD-14	Paved	0.02	0.07	0.04	0.05
WSDD-15	Paved	0.02	0.11	0.06	0.08
Totals		2.36	16.53	6.46	9.50

TABLE 5
RUNOFF CONTROL STRUCTURE
WATERSHED SUMMARY

Structure	Type	Contributing Watersheds
Main Culvert	Culvert	Crandall Canyon Above Mine
UD-1	Culvert	WSUD-1
UD-2	Culvert	WSUD-2
UD-3	Culvert	WSUD-3
DD-1	Ditch	WSDD-1, WSDD-2
DD-3	Ditch	WSDD-1, WSDD-2, WSDD-3
DD-4	Ditch	WSDD-1, WSDD-2, WSDD-3, WSDD-4, WSDD-8, WSDD-12

DD-5	Ditch	WSDD-1, WSDD-2, WSDD-3, WSDD-4, WSDD-5, WSDD-8, WSDD-12
DD-7	Ditch	WSDD-7, WSDD-11
DD-8	Ditch	WSDD-8, WSUD-3
DD-10	Ditch	WSDD-10 + Mine Water
DD-10A	Ditch	½ WSDD-10 (Disturbed)
DD-11	Ditch	WSDD-11
DD-12	Ditch	WSDD-12
DD-13	Ditch	WSDD-13
DD-14	Sheet Flow	WSDD-14
C-1	Culvert	WSDD-1, WSDD-2, WSDD-3, WSDD-8
C-3	Culvert	WSDD-7, WSDD-11, WSDD-15
C-4	Culvert	WSDD-10 + Mine Water
C-5	Culvert	WSDD-11
C-6	Culvert	WSUD-2
C-7	Culvert	WSDD-1, WSDD-2, WSDD-3
C-9	Culvert	WSDD-4, WSDD-12
C-11	Culvert	WSDD-12
C-11A	Culvert	WSDD-12
C-12	Culvert	WSDD-1, 2, 3, 4, 5, 8, 12
C-13	Culvert	WSDD-13
C-14	Slot Culvert	WSDD-4
~~C-15~~Swale	~~Slot Culvert~~Swale	WSDD-15
C-16	Culvert	WSDD-13
C-17	Culvert	WSDD-13
Sediment Pond	Pond	WSDD-1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14, WSUD-3

TABLE 6
RUNOFF CONTROL STRUCTURE
FLOW SUMMARY

Structure	Type	10 year/6 hour Peak Flow-cfs	10 year/24 hour Peak Flow-cfs	25 year/6 hour Peak Flow-cfs	100 year/6 hour Peak Flow-cfs
Main Culvert	Culvert	-	-	-	222.79
UD-1	Culvert	1.91	-	3.68	6.81
UD-2	Ditch	0.04	-	0.08	0.21
UD-3	Culvert	0.23	-	0.43	0.89
DD-1	Ditch	0.06	0.20	0.10	-
DD-3	Ditch	0.32	0.78	0.47	-
DD-4	Ditch	2.39	5.96	3.49	-
DD-5	Ditch	2.85	7.88	4.24	-
DD-7	Ditch	0.21	0.85	0.34	-
DD-8	Ditch	0.64	2.80	1.05	-
DD-10A	Ditch	0.10	0.21	0.14	-
DD-10	Ditch	2.62	3.06	2.76	-
DD-11	Ditch	0.10	0.57	0.18	-
DD-12	Ditch	1.55	3.58	2.26	-
DD-13	Ditch	2.62	6.08	3.83	-
DD-14	Sht Flw	0.39	0.88	0.56	-
C-1	Culvert	0.96	3.58	1.52	-
C-3	Culvert	0.21	0.85	0.34	-
C-4	Culvert	2.62	3.06	2.76	-
C-5	Culvert	0.10	0.57	0.18	-
C-6	Culvert	0.04	-	0.08	-
C-7	Culvert	0.32	0.78	0.47	-
C-9	Culvert	0.11	0.20	0.14	-
C-11	Culvert	1.55	3.58	2.26	-
C-11A	Culvert	1.55	3.58	2.26	-
C-12	Culvert	2.85	7.36	3.92	-
C-13	Culvert	2.62	6.08	3.83	-
C-14	Slot Cul.	0.11	0.20	0.14	-
~~C-15~~	~~Slot Cul.~~Swale		Swale	0.06	0.110.08-
C-16	Culvert	2.62	6.08	3.83	-
C-17	Culvert	2.62	6.08	3.83	-
Sediment Pond	Pond	6.46	16.53	9.50	-

TABLE 7
DISTURBED DITCH DESIGN SUMMARY

Ditch	DD-1	DD-3	DD-4	DD-5	DD-7	DD-8	DD-10A
Slope (%)	30.77	3.00	11.91	4.50	3.33	3.59	5.00
Length (ft.)	130	75	168	628	142	557	50
Manning's No.	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Side Slope (H:V)	1:1	1:1	1:1	1:1	1:1	1:1	1:1
*Bottom Width (ft.)	0	0	0	0	0	0	0
Peak Flow 10/6 (cfs)	0.06	0.32	2.39	2.85	0.21	0.64	0.10
Peak Flow 10/24 (cfs)	0.21	0.20	0.78	5.96	7.88	0.85	2.80
Flow Depth (ft.) 10/6	0.14	0.40	0.66	0.84	0.33	0.50	0.23
Flow Depth (ft.) 10/24	0.31	0.22	0.56	0.92	1.23	0.57	0.87
Flow Area (ft^2)10/6	0.02	0.16	0.43	0.71	0.11	0.25	0.06
Flow Area (ft^2)10/24	0.05	0.31	0.85	1.52	0.32	0.76	0.10
Velocity (fps)10/6	3.15	2.00	5.55	4.02	1.87	2.55	1.81
Velocity (fps) 10/24	4.26	2.50	6.97	5.19	2.66	3.68	2.18
Rip-Rap Req'd (Y/N)	N	N	Y	N	N	N	N
Rip-Rap D_{50}	-	-	6"	-	-	-	-

* All ditches are triangular.
** Flows include 1000 gpm (2.23 cfs) Mine Water Flow.
Note: Slope/Lengths from Plate 7-5.

TABLE 7 (Continued)
DISTURBED DITCH DESIGN SUMMARY

Ditch	DD-10	DD-11	DD-12	DD-13	DD-13	
					(MIN.)	(MAX.)
Slope (%)	3.33	3.00	3.29	1.79	50.00	
Length (ft.)	70	173	50	280	80	
Manning's No.	0.035	0.035	0.035	0.035	0.035	
Side Slope (H:V)	1:1	1:1	1:1	1:1	2:1	
Bottom Width (ft.)	0	0	0	0	2	
Peak Flow 10/6 (cfs)	2.62**	0.10	1.55	2.62	2.62	
Peak Flow 10/24 (cfs)		3.06**	0.57	3.58	6.08	6.08
Flow Depth (ft.) 10/6	0.86	0.26	0.71	0.97	0.15	
Flow Depth (ft.) 10/24		0.92	0.50	0.97	1.33	0.24
Flow Area (ft^2) 10/6	0.75	0.07	0.50	0.94	0.34	
Flow Area (ft^2) 10/24	0.84	0.25	0.94	1.77	0.60	
Velocity (fps) 10/6	3.51	1.50	3.07	2.79	7.66	
Velocity (fps) 10/24	3.65	2.31	3.79	3.44	10.12	
Rip-Rap Req'd (Y/N)	N	N	N	N	Y	
Rip-Rap D_{50}	-	-	-	-	9"	

*All ditches are triangular.
Note: Slope/Lengths from Plate 7-5.
Note: DD-12 is shortened due to construction of the south portal access ramp/fan pad.

TABLE 8
UNDISTURBED DITCH DESIGN SUMMARY

Ditch	UD-2
Slope (%)	12.5
Length (ft.)	400
Manning's No.	0.035
Side Slope (H:V)	1:1
Bottom Width (ft.)	0
Peak Flow-10/6 (cfs)	0.04
Flow Depth (ft.)	0.14
Flow Area (ft^2)	0.02
Velocity (fps)	2.03
Lined (Y/N)	N
Rip-Rap Req'd (Y/N)	N

Note: Slope/Lengths from Plate 7-5.

TABLE 9
DISTURBED CULVERT DESIGN SUMMARY

Culvert	C-1	C-3	C-4	C-5	C-6	C-7	C-9	C-11	C-11A	C-12	C-13	C
Slope (%)	16.67	8.00	25.07	57.14	17.20	3.00	3.50	3.50	1.50	4.50	3.00	1.
Length (ft.)	60	360	69	120	12	80	18	30	60	330	100	40
Manning's No.	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.
Peak Flow 10/6 (cfs)	0.96	0.21	2.62*	0.10	0.04	0.32	0.11	1.55	1.55	2.85	2.62	0.
Peak Flow 10/24 (cfs)	3.58	0.85	3.06*	0.57	N/A	0.78	0.20	3.58	3.58	7.36	6.08	0.
Min. Diam. Req'd (ft.) 10/6	0.42	0.28	0.57	0.14	0.13	0.39	0.25	0.68	0.80	0.82	0.85	0.
Min. Diam. Req'd (ft.) 10/24	0.69	0.46	0.61	0.28	N/A	0.54	0.32	0.93	1.09	1.16	1.17	0.
Diam. Installed (ft.)	1.50	2.00	2.00	1.00	1.00	1.00	1.00	1.50	1.50	2.00	2.00	1.
Velocity (fps) 10/6	6.80	3.53	10.18	6.13	3.11	2.71	2.20	4.27	3.10	5.46	4.59	1.
Velocity (fps) 10/24	9.44	5.01	10.58	9.47	N/A	3.39	2.56	5.26	3.83	6.92	5.67	1.
Rip-Rap D_{50}	12"	-	12"	6"	-	-	-	-	-	6"	-	-

* Includes 1000 gpm (2.23 cfs) Mine Water Flow.
Note: Slope/Lengths from Plate 7-5.
Source: (Haestad Methods, Flowmaster I, Version 3.42)

TABLE 10
UNDISTURBED CULVERT DESIGN SUMMARY

Culvert	*Main Canyon	UD-1	UD-3
Slope (%)	8.00	23.33	30.00
Length (ft.)	1500	270	50'
Manning's No.	0.02	0.02	0.02
Peak Flow 100/6 (cfs)	222.79	-	-
Peak Flow 10/6 (cfs)	-	1.91	0.23
Min. Diam. Req'd (ft.)	3.75	0.52	0.22
Diam. Installed (ft.)	6.00	3.50	1.00
Velocity (fps)	20.14	9.16	5.93

* Culvert to be installed under expansion plan.
All other undisturbed culverts are existing.

Note: Slope/Lengths from Plate 7-5.

Source: (Haestad Methods, Flowmaster I, Version 3.43)

DESIGN OF SEDIMENT CONTROL STRUCTURES

Design Specifications:

3.1 Design Specification for Expanded Sedimentation Pond
3.2 Sediment Yield
3.3 Sediment Pond Volume

Tables:

Table 11 Sediment Pond Design
Table 12 Sediment Pond Stage Volume Data
Table 13 Sediment Pond Stage Discharge Data

3.4 Sediment Pond Summary

Figures:

Figure 4 Soil Erodibility Chart - Disturbed Areas
Figure 5 Soil Erodibility Chart - Undisturbed/Reclaimed Areas
Figure 6 Sediment Pond Stage-Volume Curve
Figure 7 Sediment Pond Stage-Discharge Curve

3.1 Design Specification for Expanded Sediment Pond

The sedimentation pond located in Crandall Canyon has been redesigned and reconstructed to control the additional storm runoff from the pad extension and from the undisturbed drainage areas above the pad extension. The "As-Constructed" topography and cross sections of the pond design are shown on Plate 7-3.

The pond has been sized to meet the requirements of R645-301-742.221.33 (DOGM), which stipulates that sedimentation ponds be capable of containing or treating the 10-year 24-hour precipitation event. According to Miller, et al (1973), the 10-year, 24-hour design storm for Crandall Canyon is 2.5 inches. The design storm calculations for the sedimentation pond are presented in Table 4 of this Appendix. These calculations include the proposed pad extension, the additional watersheds above the pad extension, the existing pad and reclaimed areas, and the undisturbed watersheds above the existing pad.

As required by R645-301-742.223, the 25 year-6 hour precipitation event was routed through the sedimentation pond to determine the adequacy of the spillway. Overflow from the pond is discharged to Crandall Creek. Total precipitation from the 25 year-6 hour storm is 1.9 inches (Miller, et al, 1973). The 25 year-6 hour flow is calculated at 9.07 cfs. Based on the calculations, the primary spillway is more than adequate to carry the expected runoff from a 25 year-6 hour event.

3.2 Sediment Yield

The Universal Soil Equation (USLE) was used to estimate sediment yield from all drainage areas contributing to the pond. All soil loss from this area was assumed to be delivered to, and deposited in the sedimentation pond.

Erosion rate (A) in tons-per-acre-per-year is determined using the USLE as follows:

$$A = (R)\,(K)\,(LS)\,(CP)$$

Where the variables R, K, LS, and CP are defined as follows:

Variable “R” is the rainfall factor which can be estimated from $R = 27P^{2.2}$; where P is the 2-year, 6-hour precipitation value. P for the Crandall Canyon area is estimated at 1.00" based on Figure 5.4, page 315, Barfield, et.al. 1983. Therefore, the estimated value of “R” for this area is 27.00.

Variable “K” is the soil erodibility factor. For disturbed areas, the “K” value is taken as 0.06 as determined from soils samples and shown on the soil erodibility chart, Figure 4. K is estimated to be 0.15 for undisturbed and reclaimed areas, based on soils data and the soil erodibility chart, Figure 5.

Variable “LS” is the length-slope factor. This figure was determined by calculating a weighted average slope length and percentage for the undisturbed, reclaimed and disturbed areas, respectively. The slope length and percentage were then substituted into the following equation to determine the LS Factor:

[illegible]

where:			
	π	=	Field slope length in feet;
	m	=	0.5 if S is 5% or greater;
	x	=	sin θ;
	θ	=	Angle of slope in degrees.

Variable "CP" is the control practice factor, which can be divided into a cover and practice factor. Values were determined from Appendix 5A, Barfield, et.al., 1983.

Site	CP Factor
Disturbed Areas	1.20
Reclaimed Areas	0.100
Undisturbed Areas	0.003

The sediment volume is based on a density of 100 pounds per cubic foot of sediment.

SEDIMENT YIELD CALCULATIONS - USLE

Drainage	R	K	Acres	Slope Length Feet	%	LS	CP	A*	Yield**

Undisturbed	27.00	0.15	42.25	1700	53	79.60	0.003	00.967	0.019
Reclaimed	27.00	0.15	1.22	90	52	17.81	0.10	07.213	0.004
Disturbed	27.00	0.06	8.92	350	26	11.69	1.200	22.725	0.093

Total Sediment 1 year (ac.ft.) 0.116

Total Sediment 3 years (ac. ft.). 0.348

* A = tons/acre-year
** Yield = acre-ft/year

3.3 Sediment Pond Volume

The volumes shown in Table 11 are from the volumes calculated from the precipitation, runoff and sediment yield for a 10 year-24 hour precipitation event. The volumes were calculated based on the disturbed areas (and contributing undisturbed areas) runoff values, developed using the design parameters described in this section.

The sediment pond has been reconstructed, and the sediment pond volumes on Table 11, Table 12 and Figure 6 all represent the "As-Constructed" pond.

Mine Water

There may be times that the mine water oxidizer must be shut down for repair or cleaning, at which time the mine discharge water will need to bypass the treatment system. In such a case, the water will be directed to temporarily run down the road around the outside of the basin, and into the sediment pond through ditch DD-10 and existing culvert C-4 located below the treatment facility. Assuming the sediment level in the pond is below the approved clean-out level (7769'), and assuming the pond has been previously decanted under approved UPDES discharge criteria, the remaining capacity in the sediment pond is 3.22 ac. ft., as described in Table 12. The required freeboard for a 10 year -24 hour event is 2.452 ac. ft. (2.36 ac. ft. runoff + 0.092 ac. ft. direct precipitation) leaving a usable volume of 0.771 ac. ft. for the purpose of the above bypass. This equates to approximately 251,000 gallons. At an average flow rate of 500 gpm from the mine, the sediment pond could theoretically contain 8.37 hours worth of by-passed mine water in addition to the required 10 year

- 24 hour storm event. The maximum amount of by-passed mine water storage would occur at a volume of 1.061 ac. ft. (0.290 acre-feet sediment level plus 0.771 acre-feet of mine water). As shown on Table 12, this volume would occur at elevation of 7773.2.

Expanded Area Pond Requirement
3 Year Sediment Storage

TABLE 11
SEDIMENT POND DESIGN

1. Use 2.50" for 10 year-24 hour event.

2. Runoff Volume (from Table 4, 10 yr/24 hr) = 2.360 ac. ft.

3. Sediment Storage Volume

   USLE 0.116 ac.ft./yr. x 3 yrs. = 0.348 ac. ft.

4. Direct Precipitation into Pond

   0.441 acres x 2.50" / 12 in./ft. = 0.092 ac. ft.

5. Total Required Pond Volume

   2.360 + 0.348 + 0.092 = 2.800 ac. ft.

6.* Peak Flow (25 yr. - 6 hr. event) = 9.500 cfs

7. Pond Design Volume @ Principle Spillway =
   (See Table 12) 3.513 ac. ft.

* Peak Flow values from Table 4.

TABLE 12
SEDIMENT POND
STAGE / VOLUME DATA

Elev.	Area	Volume	Acc. Volume (ac.ft.)	Remarks
7766	1756.67	.0000	.0000	Bottom of Pond
7767	3706.92	2731.80	0.063	
7768	5119.14	4413.03	0.164	
7769	5857.00	5488.07	0.290	Sediment Cleanout Level
7770	6949.54	6403.32	0.437	Maximum Sediment Level
7771	7806.54	7378.14	0.606	
7772	8894.51	8350.53	0.798	
7773	9905.02	9399.77	1.014	
7773.2	-	-	1.061	Max. Elev. of Mine Water
7774	11055.91	10480.47	1.254	
7775	12153.06	11604.49	1.520	
7776	13120.22	12636.64	1.810	
7777	14084.05	13602.14	2.123	
7778	15043.33	14563.69	2.457	
7779	15984.66	15514.00	2.813	
7780	16934.94	16459.15	3.191	

7780.81	17669.26	14014.70	3.513	Principal Spillway
7781	17868.13	3376.05	3.591	
7781.81	18661.53	15028.20	3.936	Emergency Spillway
7782	18848.42	3430.08	4.012	
7783	19886.14	19367.28	4.457	
7784	21113.55	20499.85	4.927	
7785	22110.39	21611.97	5.423	Top of Embankment

TABLE 13
SEDIMENT POND
STAGE / DISCHARGE DATA

Head (ft.)	Q (cfs) Weir Controlled	Q (cfs) Orfice Controlled	Q (cfs) Pipe Flow Controlled
0.0	-	-	-
0.2	1.69	6.77	17.14
0.4	4.77	9.57	17.32
0.6	8.76	11.72	17.50
0.8	13.49	13.53	17.68
1.0	18.85	15.13	17.86

Note: 1- 25 year-6 hour flow = 9.500 cfs.

2- Flow will be weir controlled at a head of 0.64' over riser inlet.

<u>Weir Controlled</u>

$Q = CLH^{1.5}$; where : C = 3.0, L = Circumference of Riser = 6.2832'

<u>Orifice Controlled</u>

$Q = C'a\,(2gH)^{0.5}$; where : C = 0.6, a =Area of Riser = 3.1416 ft^2, g = 32.2 ft/sec^2

Pipe Flow Controlled

$$Q = \frac{a\,(2gH')0.5}{(1+Ke+Kb+KcL)^{0.5}}$$

where a = Area of Pipe = 1.77 ft^2

H' = Head = H + 9.1 (At outlet of Riser)

Ke = 1.0

Kb = 0.5

Kc = 0.043

L = 90'

3.4 Sediment Pond Summary

a) The sedimentation pond has been designed to contain the disturbed area (and contributing undisturbed area) runoff from a 10 year-24 hour precipitation event, along with 3 years of sediment storage capacity. Runoff to the pond will be directed by various ditches and culverts as described in the plan.

b) The required volume for the sediment pond is calculated at 2.800 acre feet, including 3 years of sediment storage. The existing sediment pond size is 3.513 acre feet (at the principle spillway), which is more than adequate.

c) The pond will meet a theoretical detention time of 24 hours. It is equipped with a decant, a culvert principle spillway and an open-channel emergency spillway. Any discharge from the pond will be in accordance with the approved UPDES Permit.

d) The pond inlets will be protected from erosion, and the spillway will discharge into the main Crandall Canyon drainage.

e) The pond is temporary, and will be removed upon final reclamation of the property.

f) The pond expansion will be constructed according to the regulations and under supervision of a Registered, Professional Engineer.

g) The pond volume has been increased at the request of the Forest Service to provide a greater level of protection for forest resources located down stream from the minesite. The enlarged pond capacity (3.513 acre ft.) is over-designed by nearly 25% to contain the 10 year-24 hour design evert.

h) Clean-out operations will be initiated at the sediment pond based upon inspection of the sediment markers. Cleanout operations will be initiated when the sediment level is between the 60% and maximum level. At no time will the sediment level be allowed to exceed the 100% level as determined by Table 12. The water level of the pond will not be allowed to exceed 7773.2 which still allows for a 10 Year 24 hour event.

Storm Event	Pond Volume Required	Pond Capacity Provided
10 yr./24 hr.	2.800 acre ft.	125%

3.5 <u>Alternate Sediment Control Areas (ASCA's)</u>

ASCA-2 (consisting of 0.34 acre) exists at the northwest corner of the site. This area was initially constructed as a substation pad but was never utilized as such. A 12-inch CMP culvert was installed to act as a discharge into UD-1. A silt fence and strawbale dike have been placed to trap the sediment and prevent erosion. (Refer to Plates 7-5)

ASCA-5, ASCA-6, ASCA-7 and ASCA-11 consist of the topsoil stockpiles #1, #2, #3, and #4 respectfully. These stockpiles are located on the north and south side of the access road as shown on Plate 2-3. Disturbed areas associated with the topsoil stockpiles are 0.20 acres, 0.22 acres, 0.62 acres and 0.65 acres for ASCA-5, ASCA-6, ASCA-7, and ASCA-11, respectively. All topsoil stockpiles have been protected from erosion by a combination of dikes, silt-fencing, berms, and a vegetative cover. (Refer to Plate 2-3)

ASCA-9 (0.15 acres) is the outslope of the sediment pond; ASCA-10 (0.02 acres) is the headwall of the inlet of the main by-pass culvert. The drainage from these areas can not be directed to the sediment pond and are too close to the creek to construct separate sediment ponds. Therefore GENWAL has used alternate sediment control methods such as silt fences, straw bale dikes and vegetation. (Refer to Plate 7-5)

Note: ASCA's 1, 3, 4 and 8 have been eliminated through previous permitting actions.

A 0.30 acre water treatment facility is located within WSDD-10. This facility contains a settling basin for treating mine discharge water. The treated water is then piped directly to a UPDES outfall into Crandall Creek. Therefore, surface runoff from this facility does not report to the sediment pond.

DESIGN OF DRAINAGE CONTROL STRUCTURES FOR RECLAMATION

Reclamation Hydrology

4.1 General (Phase I)

During Phase I of reclamation, all disturbed area culverts and ditches will be removed except as shown on Plate 5-16. Undisturbed diversion UD-2 will also be removed, and the drainage from that area will be directed to the sediment pond. Undisturbed diversion UD-1 will remain in place as a permanent structure for the following reasons:

(1) The diversion is necessary to continue to divert runoff from the reclaimed site, the U.S. Forest Service turnaround area and beneath the U.S. Forest Service Road;
(2) The 10 year-24 hour storm runoff from WSUD-1 is approximately 2.98 acre feet, which combined with runoff from the reclaimed site, exceeds the holding capacity of the sediment pond;
(3) The existing diversion is a 42" full-round C.M.P. pipe, which is well in excess of the size required to carry runoff from a 100 year-6 hour storm event for the area (See Table 10).

The main canyon 72" culvert will also be removed during Phase I reclamation, except for the lower approximately 300', which will be left in place to divert undisturbed and treated runoff beneath the sediment pond. Once the main canyon culvert is removed, Crandall Creek will be directed back to the original drainage channel through the area. Silt fences will be installed on both sides of the restored channel to treat runoff from the reclaimed pad areas, as shown on Plate 5-16.

The U.S. Forest Service Road will be left as a permanent feature. A berm and ditch (RD-1) will be established along the road. This ditch will direct all runoff from areas above the road to the sediment pond. The sediment pond will remain in place until Phase II of reclamation.

Watersheds are shown on Plates 7-5 and 7-5C. Reclamation drainage details are shown on Plates 5-16 and 5-17.

4.2 General (Phase II)

Once the criteria for Phase II Bond Release are met, the sediment pond will be removed and, the area recontoured and reseeded according to the plan. The remaining 300' of the main canyon 72" culvert will also be removed at this time. At the discretion of the U.S. Forest Service, the berm along the road can also be removed at this time, or left in place. If the berm if left in place, reclaimed ditch RD-1 will be extended through the reclaimed pond area to the main channel.

4.3 Reclamation - Disturbed Drainage Control

Drainage from all contributing watersheds above the U.S. Forest Service Road, except WSUD-1, will be collected in a reclamation ditch (RD-1) and diverted into the sediment pond during Phase I reclamation. Drainage from the reclaimed areas and contributing watersheds below the road, will be treated through silt fences along the restored natural main channel, during Phase I reclamation.

Approximately 300' of the main canyon culvert will remain in place beneath the sediment pond area during Phase I.

Upon Phase II reclamation, the sediment pond will be removed and the area restored. The remaining portion of the main canyon culvert will also be removed at this time. Silt fences along the previously reclaimed channel section may also be removed during Phase II; however, additional silt fences will be installed along the 300' section of culvert removal channel restoration.

4.4 Restored Channels

Upon final reclamation, the main canyon drainage will be returned to the natural channel. During construction, this channel is to be covered by filter fabric and an underdrain system. The culvert will then be placed over the protected channel. Upon removal of the culvert, filter fabric will also be removed, exposing the natural channel. Construction in this manner will have a temporary effect on the riparian vegetation; however, this can readily be restored upon reclamation. Flow characteristics, bedding and other natural features of the natural channel will not be changed appreciably; therefore, no actual channel reconstruction or reclamation (beyond revegetation) is proposed.

No other channels are proposed to be restored within the reclaimed minesite.

4.5 Sediment Pond

The sediment pond will remain in place during Phase I reclamation. The pond will be removed during Phase II and all drainage will be returned to the Main Crandall Canyon channel at that time.

Calculations show the sediment pond to be adequately sized to contain the runoff from contributing watersheds from a 10 year-24 hour precipitation event, along with a minimum of 3 years of sediment storage. The principle and emergency spillways are each capable of passing the runoff from a 25 year-6 hour event, as required.

4.6 Calculations

For ease of calculation and to ensure a conservative runoff requirement for sediment pond adequacy, no curve numbers for contributing watersheds were changed for reclamation purposes. Contributing watershed characteristics and flows were taken from Tables 1 through 4 of this report. Watersheds and pre-reclamation drainage control are shown on Plates 7-5 and 7-5C. Phase I and Phase II drainage control are shown on Plates 5-16 and 5-17, respectively.

TABLE 14

RECLAMATION - PHASE I
RUNOFF SUMMARY
DRAINAGE TO SEDIMENT POND

Watershed	10 year/24 hour Volume-ac.ft.	10 year/ 6 hour Peak Flow-cfs	25 year/6 hour Peak Flow-cfs
WSUD-2	0.05	0.04	0.08
WSUD-3	0.30	0.23	0.43
WSDD-1	0.03	0.05	0.07
WSDD-2	0.01	0.01	0.03
WSDD-3	0.09	0.26	0.37
WSDD-4	0.03	0.11	0.14
WSDD-5	0.07	0.23	0.32
WSDD-7	0.05	0.11	0.16
WSDD-8	0.23	0.41	0.62
WSDD-10	0.13	0.39	0.53
WSDD-11	0.09	0.10	0.18
WSDD-14	0.13	0.39	0.56

Totals	1.21	2.33	3.49

Note: Volumes and flows are totals from respective watersheds on Tables 3 and 4 of this report.

TABLE 15

RECLAMATION - PHASE I
RUNOFF CONTROL STRUCTURE
WATERSHED SUMMARY

Structure	Type	Contributing Watersheds
Main Channel	Silt Fence	WSDD-12, WSDD-13
UD-1	Culvert	WSUD-1
RD-1	Ditch	WSUD-2, WSUD-3, WSDD-1 thru WSDD-11
Sediment Pond	Pond	WSUD-2, WSUD-3, WSDD-1 thru WSDD-11 and WSDD-14

TABLE 16

RECLAMATION - PHASE I
RUNOFF CONTROL STRUCTURE
FLOW SUMMARY

Structure	Type	10 year/6 hour Peak Flow (cfs)	25 year/6 hour Peak Flow (cfs)	100 year/6 hour Peak Flow (cfs)	
Main Channel	Silt Fence		3.73	5.44	-
UD-1	Culvert	1.91	3.68	6.81	
RD-1	Ditch	1.94	2.93	-	
Sediment Pond	Pond	2.33	3.49	-	

TABLE 17

RECLAMATION - PHASE 1
RECLAIMED DITCH/CULVERT DESIGN SUMMARY

Ditch	RD-1
Slope (%)	10.10
Length (ft.)	990
Manning's No.	0.035
Side Slope (H:V)	1.5:1
Bottom Width (ft.)	0
Peak Flow 10/6 (cfs)	1.94
Flow Depth (ft.)	0.52
Flow Area (ft^2)	0.40
Velocity (fps)	4.85
Lined (Y/N)	N
Rip Rap Req'd (Y/N)	N

Note: Slope / Length from Plate 5-16

WATERSHED RUNOFF CALCULATIONS

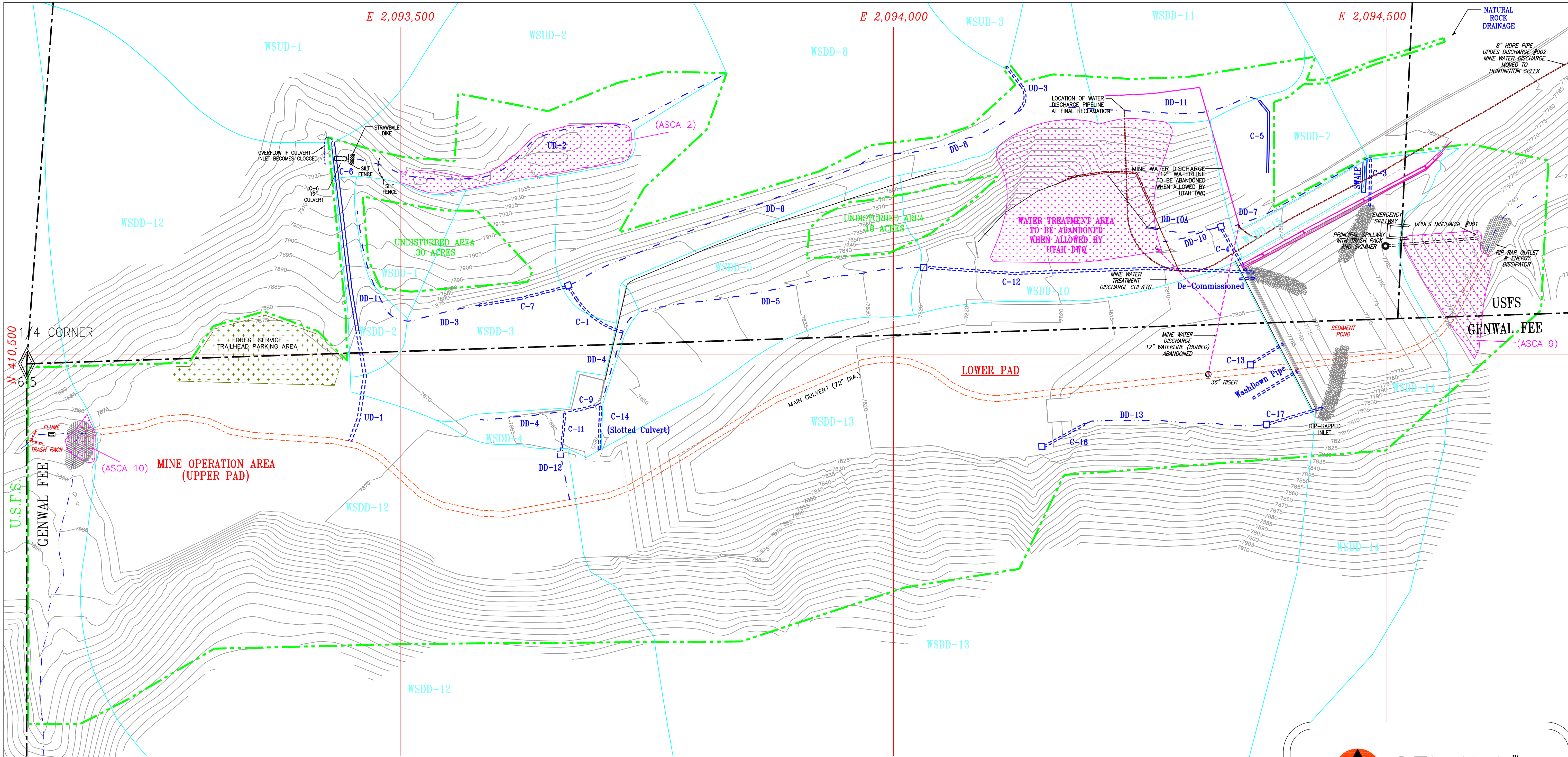
DITCH FLOW CALCULATIONS

CULVERT FLOW CALCULATIONS

72" CULVERT OUTLET

RIP-RAP APRON

FLOW VELOCITY CALCULATIONS



LEGEND:

POTENTIAL EXTENT OF DISTURBANCE	
10' CONTOUR	
JERSEY BARRIERS	
WATERSHED BOUNDARY	
UNDISTURBED/DISTURBED WATERSHED	WSUD-1 WSDD-10
DIVERSION DITCH	DD-4
CULVERT (Solid-Above Grd/Dashed-Buried)	C-8
6' DIAMETER CULVERT	
ASCA AREA:	

CONTOUR INTERVAL = 5'

GENWAL™ RESOURCES, INC.
P.O. Box 1077, 794 North "C" Canyon Rd, Price Utah
Telephone: (435) 888-4000

CRANDALL CANYON MINE
DRAINAGE MAP

REV: 21	ACAD: 7-5
DATE: 8-13-19	BY: PJJ
SCALE: 1" = 100'	PLATE #: 7-5

G:\Current Drawings\MRP Maps\Crandall Canyon\Pipe Mine Water to Huntington Creek\ACAD-7-5 Rev 21.dwg, Layout1, 8/13/2019 8:41:47 AM