

Dugout Canyon Mine
Degassification Amendment
Wells G-18, G-31 and Access Road

August 29 and September 4, 2007

Dugout Canyon Mine
Canyon Fuel Company, LLC
C/007/039

File in:
 Confidential
 Shelf
 Expandable
Refer to Record No. 0055, Date 9/4/07
In C/ 007039, 2007, Incoming
For additional information

Canyon Fuel Company, LLC
Dugout Canyon Mine
P.O. Box 1029
Wellington, Utah 84542



September 4, 2007

Ms. Pamela Grubaugh-Littig
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
Salt Lake City, UT 84114-5801

RE: Revisions to Add Degas Wells G-18, G-31 and AMV Road, Task ID# 2828 - Dugout Canyon Mine, Canyon Fuel Company, LLC, C/007/039, Carbon County, Utah

Dear Ms. Grubaugh-Littig:

Attached please find four copies of revision to the Methane Degassification Amendment to address deficiencies associated with the addition of Degas Wells G-18, G-31 and AMV Road to the permit. To the best of our knowledge the deficiencies have been addressed in this amendment.

A copy of this submittal has been delivered to the Price field office, BLM Price field office, BLM Salt Lake office and SITLA.

Please call with questions as they may arise in your review (435) 636-2869. Thank you.

Sincerely yours,

Vicky S. Miller

cc: Dave Spillman

RECEIVED

SEP 05 2007

DIV. OF OIL, GAS & MINING

APPLICATION FOR COAL PERMIT PROCESSING

Permit Change New Permit Renewal Exploration Bond Release Transfer

Permittee: Canyon Fuel Company, LLC

Name: Dugout Canyon Mine

Permit Number: C/007/039

Title: Revisions to Degas Wells Amendment to Add Wells G-18, G-31 and the AMV Road, Task ID # 2828

Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

- | | | |
|---|--|---|
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: <u>20.63</u> <input checked="" type="checkbox"/> increase <input type="checkbox"/> decrease. |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 2. Is the application submitted as a result of a Division Order? DO# _____ |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 4. Does the application include operations in hydrologic basins other than as currently approved? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 6. Does the application require or include public notice publication? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 7. Does the application require or include ownership, control, right-of-entry, or compliance information? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 9. Is the application submitted as a result of a Violation? NOV # _____ |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 10. Is the application submitted as a result of other laws or regulations or policies? |
- Explain:* _____
- | | | |
|---|--|--|
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 11. Does the application affect the surface landowner or change the post mining land use? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2) |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 13. Does the application require or include collection and reporting of any baseline information? |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area? |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 15. Does the application require or include soil removal, storage or placement? |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 16. Does the application require or include vegetation monitoring, removal or revegetation activities? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 17. Does the application require or include construction, modification, or removal of surface facilities? |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | 18. Does the application require or include water monitoring, sediment or drainage control measures? |
| <input type="checkbox"/> Yes | <input type="checkbox"/> No | 19. Does the application require or include certified designs, maps or calculation? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 20. Does the application require or include subsidence control or monitoring? |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 21. Have reclamation costs for bonding been provided? |
| <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No | 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream? |
| <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No | 23. Does the application affect permits issued by other agencies or permits issued to other entities? |

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

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.

David Spillman
Print Name

David Spillman, Engineering Manager
Sign Name, Position, Date 9/4/07

Subscribed and sworn to before me this 4 day of September, 2007

Cheryl Sue Miller
Notary Public

My commission Expires: 1-5, 2008
Attest: State of UTAH } ss:
County of CARBON



For Office Use Only: 	Assigned Tracking Number:	Received by Oil, Gas & Mining <div style="text-align: center; color: red; font-weight: bold; font-size: 1.2em;">RECEIVED</div> <div style="text-align: center; color: black; font-weight: bold; font-size: 1.2em;">SEP 05 2007</div> <div style="text-align: center; color: red; font-weight: bold; font-size: 1.2em;">DIV. OF OIL, GAS & MINING</div>
---	---------------------------	---

CHAPTER 1

LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

M&RP

T13 S., R13 E., SLBM, Utah (Added to Permit Area in 2005, approximately 2,360 acres)

- Section 17: E1/2SW1/4, SW1/4SE1/4, E1/2E1/2W1/2SW1/4
- Section 20: E1/2W1/2, E1/2, E1/2E1/2W1/2W1/2
- Section 21: SW1/4NW1/4, SW1/4
- Section 28: NW1/4, N1/2SW1/4, SW1/4SW1/4
- Section 29: All
- Section 30: E1/2, E1/2W1/2

Waste Rock Storage Facility

T. 14 S., R. 12 E., SLBM, Utah (Approximately 26.8 acres)

- Section 18: Portions of NE1/4, SW1/4 and SE1/4 of the NE1/4

All of Lease ML-42648, except the E1/2 of Section 8 and the NE1/4 of Section 17, is included within the Dugout Canyon Mine permit boundary. However, only the S1/2 SE1/4 of Section 9 from Lease ML-42649 is within the permit boundary. The ten acres described in UTU-76601 are also described in UTU-77985. The U.S. Department of Interior, Bureau of Land Management (BLM) right-of-way application UTU-76601 is included in Appendix 1-3.

The disturbed area encompasses 20.80 acres (Mine Facility area, including Gilson well pad and small substation), 30.4 ~~24.85~~ acres (G-2, G-3, G-4, G-5, G-6, G-7, G-9, G-10, G-11, G-12, G-13, G-14, G-15, G-16, G-17, G-18, G-19 and G-31 Degas Well), 14.25 acres (AMV Road) 0.85 (Topsoil Stockpile), 1.8 acres (Leach field/pipeline area), 2.7 acres (Pace Canyon Fan Facility) and 26.8 acres (Refuse Pile area) totaling approximately 97.6 acres. That acreage includes a pre- and post mining road with an area of 1.6 acres and 2.03 acres of undisturbed land within the mine facilities disturbed area and 11.2 acres within the refuse pile disturbed area.

The permit boundary encompasses approximately 9,511 acres which includes the following surface ownership and acreage: 10 acres in the BLM right-of-way, approximately 567 acres of other federal lands, 920 acres of state lands, and fee acreage of approximately 8,014 acres (Plate 1-1 and RA Plate 1-1).

Coal ownership acreage within the permit area includes approximately 2,844 acres of federal coal, approximately 5840 acres of state coal, and 827 acres of fee coal (Plate 1-2 and RA1-1B).

Canyon Fuel Company, LLC
SCM/Dugout Canyon Mine

Mining and Reclamation Plan
August 28, 2007 ~~January 29, 2007~~

APPENDIX 1-4

Disturbed Area Legal Description

LEGAL DESCRIPTION OF BONDED AREA:

Waste Rock Storage Facility

T. 14 S., R. 12 E., SLBM, Utah (Approximately 26.8 acres)

Section 18: Portions of NW1/4NE1/4NE1/4
Portions of NE1/4NE1/4NE1/4
Portions of SW1/4NE1/4NE1/4
Portions of SE1/4NE1/4NE1/4
Portions of NW1/4SE1/4NE1/4

Leachfield and Pipeline

T. 13 S., R. 12 E., SLBM, Utah (Approximately 1.8 acres)

Section 22: Portion of SE1/4SE1/4NE1/4SE1/4
Portion of NE1/4SE1/4NE1/4SE1/4
Portion of N1/2NE1/4SE1/4SE1/4;
Portion of SW1/4NE1/4SE1/4SE1/4;
Portion of S1/2NW1/4SE1/4SE1/4;
Portion of SE1/4NE1/4SW1/4SE1/4;
Portion of N1/2SE1/4SW1/4SE1/4;
Portion of NE1/4SW1/4SW1/4SE1/4;
Portion of S1/2SW1/4SW1/4SE1/4
Section 23: Portion of SW 1/4NW1/4NW1/4SW1/4;
Portion of SE1/4NW1/4NW1/4SW1/4;
Portion of NW1/4SW1/4NW1/4SW1/4;
Section 27: Portion of W1/2NW1/4NW1/4NE1/4
Portion of SE1/4NE1/4NE1/4NW1/4
Portion of E1/2SE1/4NE1/4NW1/4
Portion of SW1/4SE1/4NE1/4NW1/4

Main Facilities Area T. 13 S., R. 12 E., SLBM, Utah (Approximately 20.80 acres)

Section 23: A Portion of the following:
NE1/4NE1/4NW1/4SW1/4; NE1/4NW1/4NW1/4SW1/4;
NW1/4NE1/4NW1/4SW1/4;SW1/4SE1/4SW1/4NW1/4;
SE1/4SE1/4SW1/4NW1/4;NW1/4SE1/4SW1/4NW1/4;
NE1/4SE1/4SW1/4NW1/4;SW1/4SW1/4SE1/4NW1/4;
SE1/4SW1/4SE1/4NW1/4;NW1/4SW1/4SE1/4NW1/4;
NE1/4SW1/4SE1/4NW1/4;SW1/4NW1/4SE1/4NW1/4;
SE1/4NW1/4SE1/4NW1/4;NE1/4NW1/4SE1/4NW1/4;
SW1/4NE1/4SE1/4NW1/4;NW1/4NE1/4SE1/4NW1/4;
NE1/4NE1/4SE1/4NW1/4;W1/2SE1/4NE1/4NW1/4;
SW1/4NE1/4NE1/4NW1/4;NW1/4NE1/4NE1/4NW1/4;
NE1/4NE1/4NE1/4NW1/4

Section 14: A Portion of the following:
SE1/4SE1/4SE1/4SW1/4;
NE1/4SE1/4SE1/4SW1/4;
NW1/4SW1/4SW1/4SE1/4

G-2 Thru G-17 Degas Well, (Approximately 24.85 acres)

G-2	Portion of N1/2SW1/4NE1/4 Section 24	Township 13 South, Range 12 East, SLBM
G-3	Portion of N1/2SW1/4NW1/4 Section 19	Township 13 South, Range 13 East, SLBM
G-4	Portion of N1/2NE1/4NW1/4 Section 24	Township 13 South, Range 12 East, SLBM
G-5	Portion of N1/2NW1/4NE1/4 Section 24	Township 13 South, Range 12 East, SLBM
G-6	Portion of S1/2SW1/4NW1/4 Section 18	Township 13 South, Range 13 East, SLBM
G-7	Portion of SW1/4NE1/4SE1/4 Section 24	Township 13 South, Range 12 East, SLBM
G-9	Portion of NW1/4NW1/4SW1/4 Section 21	Township 13 South, Range 13 East, SLBM
G-10	Portion of NE1/4NE1/4SE1/4 Section 20	Township 13 South, Range 13 East, SLBM
G-11	Portion of NE1/4SE1/4SW1/4 Section 20	Township 13 South, Range 13 East, SLBM
G-12	Portion of SE1/4NW1/4SW1/4 Section 20	Township 13 South, Range 13 East, SLBM
G-13	Portion of NW1/4NE1/4SE1/4 Section 19	Township 13 South, Range 13 East, SLBM
G-14A	Portion of SW1/4SW1/4SE1/4 Section 17	Township 13 South, Range 13 East, SLBM
G-15	Portion of NW1/4SE1/4NE1/4 Section 19	Township 13 South, Range 13 East, SLBM
G-16	Portion of SW1/4SE1/4SE1/4 Section 18	Township 13 South, Range 13 East, SLBM
G-17	Portion of SE1/4NW1/4SE1/4 Section 18	Township 13 South, Range 13 East, SLBM
G-18	Portion of NE1/4SE1/4NW1/4 Section 20	Township 13 South, Range 13 East, SLBM
G-19	Portion of SW1/4NW1/4SE1/4 Section 20	Township 13 South, Range 13 East, SLBM
G-31	Portion of NW1/4SW1/4NW1/4 Section 20	Township 13 South, Range 13 East, SLBM
AMV	Portion of S1/2NW1/4 Section 20	Township 13 South, Range 13 East, SLBM
Road	Portion of SW1/4SW1/4NE1/4 Section 20	Township 13 South, Range 13 East, SLBM

Pace Canyon Fan Facility Township 13 South, Range 13 East, SLBM (Approximately 2.7 acres)
Section 30: Portion of E1/2NW1/4NW1/4

Total Approximately 97.6 Acres

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

CHAPTER 1

LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
110 MINIMUM REQUIREMENTS FOR LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION	1-1
111 Introduction	1-1
112 Identification of Interests	1-1
112.100 Business Entity	1-1
112.200 Applicant and Operator	1-1
112.300 Officers of the Applicant	1-1
112.400 Coal Mining and Reclamation Operation Owned or Controlled	1-3
112.500 Legal or Equitable Owner of the Surface and Mineral Properties	1-3
112.600 Owners of Record of Property Contiguous to Proposed Permit Area	1-4
112.700 MSHA Numbers	1-4
112.800 Interest in Contiguous Land	1-4
112.900 Certification of Submittal Information	1-5
113 Violation Information	1-5
114 Right-of-Entry	1-5
115 Status of Unsuitability	1-5
116 Permit Term	1-5
117 Insurance, Proof of Publication, and Facilities and Structures Used in Common	1-7
118 Filing Fees	1-7
120 PERMIT APPLICATION FORMAT AND CONTENTS	1-7
130 REPORTING OF TECHNICAL DATA	1-7
140 MAPS AND PLANS	1-7
150 COMPLETENESS	1-7

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

Page

Figure 1-1 Methane Degas Bore Hole Locations 1-8

LIST OF TABLES

Table 1-1 Well Site Locations 1-2
Table 1-2 Disturbed Acres by Well Site 1-6

110 MINIMUM REQUIREMENTS FOR LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

111 Introduction

The degassification wells will be located on property owned by the Milton and Ardith Thayn Trust. The well locations are found in Table 1-1 and are shown in Figure 1-1.

112 Identification of Interests

Refer to the same section of the General Chapter 1 for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine and Banning Loadout operations.

112.100 Business Entity

Refer to the same section of the General Chapter 1 for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine and Banning Loadout operations.

112.200 Applicant and Operator

Refer to the same section of the General Chapter 1 for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine and Banning Loadout operations.

112.300 Officers of the Applicant

Refer to the same section of the General Chapter 1 for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine and Banning Loadout operations.

TABLE 1-1

Degas Well Locations
Pine Canyon, Utah Quadrangle, Salt Lake Meridian

Hole Number	Section	Township and Range
G-1	Portion of N1/2SE1/4NW1/4 Section 24	Township 13 South, Range 12 East
G-2	Portion of N1/2SW1/4NE1/4 Section 24	Township 13 South, Range 12 East
G-3	Portion of N1/2SW1/4NW1/4 Section 19	Township 13 South, Range 13 East
G-4	Portion of N1/2NE1/4NW1/4 Section 24	Township 13 South, Range 12 East
G-5	Portion of N1/2NW1/4NE1/4 Section 24	Township 13 South, Range 12 East
G-6	Portion of S1/2SW1/4NW1/4 Section 18	Township 13 South, Range 13 East
G-7	Portion of SW1/4NE1/4SE1/4 Section 24	Township 13 South, Range 12 East
G-8	Portion of NE1/4NE1/4NE1/4 Section 26	Township 13 South, Range 12 East
G-9	Portion of NW1/4NW1/4SW1/4 Section 21	Township 13 South, Range 13 East
G-10	Portion of NE1/4NE1/4SE1/4 Section 20	Township 13 South, Range 13 East
G-11	Portion of NE1/4SE1/4SW1/4 Section 20	Township 13 South, Range 13 East
G-12	Portion of SE1/4NW1/4SW1/4 Section 20	Township 13 South, Range 13 East

G-13	Portion of NW1/4NE1/4SE1/4 Section 19	Township 13 South, Range 13 East
G-14	Portion of SW1/4SW1/4SE1/4 Section 17	Township 13 South, Range 13 East
G-15	Portion of NW1/4SE1/4NE1/4 Section 19	Township 13 South, Range 13 East
G-16	Portion of SW1/4SE1/4SE1/4 Section 18	Township 13 South, Range 13 East
G-17	Portion of SE1/4NW1/4SE1/4 Section 18	Township 13 South, Range 13 East
G-18	Portion of NE1/4SE1/4NW1/4 Section 20	Township 13 South, Range 13 East
G-19	Portion of SW1/4NW1/4SE1/4 Section 20	Township 13 South, Range 13 East
G-31	Portion of NW1/4SW1/4NW1/4 Section 20	Township 13 South, Range 13 East
AMV Road	Portion of S1/2NW1/4 Section 20 Portion of SW1/4SW1/4NE1/4 Section 20	Township 13 South, Range 13 East

112.400 Coal Mining and Reclamation Operation Owned or Controlled

Refer to the same section of the General Chapter 1 for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine and Banning Loadout operations.

112.500 Legal or Equitable Owner of the Surface and Mineral Properties

The legal and equitable owner of the surface and mineral properties to be affected by this operation during the duration of the permit period are list below.

Milton & Ardith Thayn Trust

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

7730 East US Highway 6
Sunnyside Star Route
Price, Utah 84501

United States of America
State of Utah, Department of Interior
Bureau of Land Management
Price Field Office
125 South 600 West
Price, Utah 84501

State of Utah
School and Institutional
Trust Lands Administration
675 East 500 South
Salt Lake City, Utah 84102-2818

Gil L. Conover
450 So. State
Ferron, Utah 84523

112.600 Owners of Record of Property Contiguous to Proposed Permit Area

Owners of record for surface and mineral properties contiguous to the proposed permit area are list below.

United States of America
Department of Interior
Bureau of Land Management
Price Field Office
125 South 600 West

State of Utah
School and Industrial
Trust Lands Administration
675 East 500 South
Salt Lake City, Utah 84102-2818

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

Price, Utah 84501

George and Alice Conover, Et Al
2701 Georgia Way
Sandy, Utah 84092

KFJ Ranch Partnership
C/O Kerwin Jensen
Cleveland, Utah 84518

J. George Conover
275 West Main
Ferron, Utah 84523

Gil L. Conover
450 So. State
Ferron, Utah 84523

112.700 MSHA Numbers

Refer to the same section of the approved M&RP.

112.800 Interest In Contiguous Lands

Canyon Fuel Company, LLC has no interest in contiguous lands other than those currently owned as shown on Plate 1-1 of the approved M&RP.

112.900 Certification of Submittal Information

No information has changed in the approved M&RP because of this submittal. Refer to the same section of the approved M&RP.

113 Violation Information

Refer to the same section of the General Chapter 1 for Canyon Fuel Company, LLC prepared for the Dugout Canyon Mine, Soldier Canyon Mine and Banning Loadout operations.

114 Right-of-Entry Information

Refer to the same section of the approved M&RP.

See Table 1-2 for disturbed acreage for each well site. The disturbed acres will be added to the total disturbed acreage for the Dugout Mine as each site is constructed.

Additional correspondence pertaining to right-of-entry is located in Attachments 2-3, 4-2, 5-3, and 5-4.

Although notification of mining activities is required under R645.301.525.700, response when requested from landowner or others concerning right-of-entry is entirely at their discretion. The landowner agreement between the permittee and the Thayn Trust can be reviewed in Appendix 4-2 of the Methane Degassification Amendment.

115 Status of Unsuitability Claims

Refer to the same section of the approved M&RP.

116 Permit Term

Refer to the same section of the approved M&RP.

TABLE 1-2
Disturbed Acres by Well Site

Well Site	Disturbed Acres
G-1	0.6
G-2	1.21
G-3	0.97
G-4	0.85
G-5	0.75
G-6	0.32
G-7	1.25
G-8	0.9
G-9	2.2
G-10	1.7
G-11	1.6
G-12	2
G-13	2.75
G-14	2
G-15	2.5
G-16	2
G-17	1.25
G-18	1.4
G-19	2.3
G-31	1.75

The disturbed acreage for the AMV access road is approximately 14.25 acres including areas for topsoil storage and turnouts. STP-7 will add approximately 0.85 acres to the disturbed area.

117 Insurance, Proof of Publication, and Facilities and Structures Used in Common

The certificate of insurance(s) for each well will be obtained if required when the well is drilled. The certificate of insurance(s) will be included in Appendix 1-2 of the approved M&RP and General Chapter 1.

118 Filling Fees

Refer to the same section of the approved M&RP.

120 PERMIT APPLICATION FORMAT AND CONTENTS

This amendment submittal will comply with R645-301-120.

130 REPORTING OF TECHNICAL DATA

All technical data submitted in the amendment will be accompanied by the name or organization responsible for the collection and analysis of data, dates of collection and descriptions of methodology used. Technical analyses will be planned by or under the direction of a qualified professional in the subject to be analyzed.

140 MAPS AND PLANS

The maps and plans in the Mining and Reclamation Plan will correspond with the requirements in R645-301-140.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

150 COMPLETENESS

CFC believes the information in this permit application to be complete and correct.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

CHAPTER 2
SOILS

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
210 INTRODUCTION	2-1
220 ENVIRONMENTAL DESCRIPTION	2-1
221 Prime Farmland Investigation	2-1
222 Soil Survey	2-1
222.100 Soils Map	2-1
222.200 Soil Identification	2-2
222.300 Soil Description	2-3
222.400 Soil Productivity	2-3
223 Soil Characterization	2-7
224 Substitute Topsoil	2-7
230 OPERATION PLAN	2-7
231 General Requirements	2-7
231.100 Removing and Storing Topsoil Methods	2-7
231.200 Suitability of Topsoil Substituted/Supplements	2-9
231.300 Testing of Topsoil Handling and Reclamation Procedures Regrading Revegetation	2-9
231.400 Construction, Modification, Use, and Maintenance Of Topsoil Storage Pile	2-9
232 Topsoil and Subsoil Removal	2-11
232.100 Topsoil Removal and Segregation	2-11
232.200 Poor Topsoil	2-11
232.300 Thin Topsoil	2-11
232.400 Minor Disturbances Nor Requiring Topsoil Removal	2-11
232.500 Subsoil Segregation	2-11
232.600 Timing	2-11
232.700 Topsoil and Subsoil Removal Under Adverse Conditions	2-12

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
233 Topsoil Substitutes and Supplements	2-12
233.100 Overburden Materials Supplementing and/or Replacing Topsoil ..	2-12
233.200 Suitability of Topsoil Substitutes and Supplements	2-12
233.300 Physical and Chemical Analysis	2-12
233.400 Testing of Substitute Topsoil	2-12
234 Topsoil Storage	2-13
234.100 Topsoil Stockpiling	2-13
234.200 Topsoil Stockpile	2-13
234.300 Topsoil Stockpile Relocation	2-14
240 RECLAMATION PLAN	2-14
241 General Information	2-14
242 Soil Redistribution	2-14
242.100 Soil Redistribution Practices	2-14
242.200 Regrading	2-16
242.300 Topsoil Redistribution on Impoundments and Roads	2-16
243 Soil Nutrients and Amendments	2-16
244 Soil Stabilization	2-18
244.100 Protection and Stabilization of Surface Area	2-18
244.200 Mulch Application	2-18
244.300 Rills and Gullies	2-18
250 PERFORMANCE STANDARDS	2-18
251 Topsoil, Subsoil, and Topsoil Supplements Management	2-18
252 Stockpile Topsoil and Subsoil	2-19

TABLE OF CONTENTS (Continued)

LIST OF TABLES

	<u>Page</u>
Table 2-1 Topsoil Volumes	2-3
Table 2-2 Topsoil Stockpile Dimensions	2-10
Table 2-3 Topsoil Distribution Thickness	2-17

LIST OF ATTACHMENTS

Attachment 2-1	Soil Inventory and Assessment
Attachment 2-2	Topsoil Calculations
Attachment 2-3	Land Owner Correspondence

210 INTRODUCTION

This chapter and associated attachments address the pertinent data required for the addition of the degassification well sites for the Dugout Canyon Mine. Only those sections of the Division regulations that apply to the well sites have been addressed. The remainder of the regulations have already been addressed in the existing M&RP. The M&RP and this document contain pertinent information relating to the identification, management, and reclamation activities associated with the soil resources.

220 ENVIRONMENTAL DESCRIPTION

The well sites range in elevation from approximately 7400 to 9000 feet. The well sites are located in the Pace Canyon area of the Book Cliffs. General vegetation includes sagebrush, serviceberry, aspen, Douglas-fir, and snowberry.

221 Prime Farmland Investigation

Due to limiting terrain, lack of water for irrigation and no evidence of past cultivation of the sites, it is concluded that no prime farmland exists within the area of the well site disturbance.

222 Soil Survey

222.100 Soils Map

The soils have been mapped as part of the Soil Survey of the Carbon Area, Utah by the Soil Conservation Service (1988), at an Order III intensity level.

A description of the soils is included in Appendix 2-2 of the approved M&RP and in Attachment 2-1, which includes a report by Dan Larsen, Soil Scientist, entitled "Soil Inventory and Assessment Six

Methane Degassification Borehole Sites". An additional report for well site G-6 was prepared in 2004 and is incorporated into Attachment 2-1. Soil information for Well G-7 is incorporated into Attachment 2-1. A photograph of the G-7 site is included in Attachment 3-1. Well site G-3 and the access road can be seen on the photograph.

The soils report prepared by Dan Larsen, Soil Scientist for wells G-8 thru G-13 is provided in Attachment 2-1. Wells are being permitted in groups: G-8 thru G-10, G-11 thru G-12 and G-13 thru G-17.

A drawing (Plate 1) has been provided in Attachment 2-1 of the area where G-18, G-19, G-31 and the AMV Road are located. The approximate location of NRCS soil designations, with some modification per a ground truthing survey performed by Craig Clement and review of aerial photography are shown on the drawing.

222.200 Soil Identification

<u>Well No.</u>	<u>Soil Map Unit</u>	<u>Soil Components</u>
G-1	62/88	Midfork-Comodore complex, Rabbitex-Datino Varient
G-2	7	Brycan, Beje-Trag complex, 3-30% slopes
G-3	7	Beje-Trag complex, 3-30% slopes
G-4	62/103	Midfork-Comodore complex, Senchert-Toze complex
G-5	103	Senchert-Croydon
G-6	62	Midfork-Comodore complex
G-7	7	Beje-Trag complex, 3-30% slopes
G-8	21	Croydon Loam, 8 to 30% slopes
G-9	97/62	Midfork-Comodore complex, Rottulee family- Trag complex

G-10	97	Rottulee family-Trag complex
G-11	11, 26	Cabba- family, 40 to 70 percent slopes, Doney family, 50 to 70 percent slopes
G-12	47, 88	Guben-Rock outcrop complex, Rabbitex family-Datino Variant complex
G-13	23	Curecanti family
G-14A	62	Midfork family - Comodore complex
G-15	115, 62	Trag stony loam, 30 to 60 percent slopes, Midfork family - Comodore complex
G-16	26	Doney family
G-17	103	Senchert-Toze family Complex
G-18	97	Rottulee family-Trag complex
G-19	62	Midfork family - Comodore complex
G-31	97	Rottulee family-Trag complex
Access Road	97	Rottulee family-Trag complex
	62	Midfork family - Comodore complex

222.300 Soil Description

Refer to Attachment 2-1 of the submittal for soil descriptions.

222.400 Soil Productivity

The depth of topsoil at each site was measured to determine the amount of growth medium available for reclamation. The following table lists each well site and the approximate amount of growth medium available.

TABLE 2-1
Topsoil Volumes*

Well No.	Cubic Yards of Material
G-1	415
G-2	3,104
G-3	1,182
G-4	1,100
G-5	1,909
G-6	792
G-7	1251
G-8	543
G-9	1,574
G-10	2,344
G-11	254
G-12	563
G-13	2,162
G-14	1,544
G-15	1,475
G-16	1,092
G-17	797
G-18	2,195
G-19	2,037
G-31	4,624
Access Road	9,167

* These total do not include soil salvaged from short roads accessing well sites which is bladed to the side of the road.

Figure 5-1 through Figure 5-25 show the layout and approximate size of well pads for G-1 thru G-6. Figures 5-27 thru 5-29 show the layout and size for well G-7. The figures for wells G-8 thru G-19 are located in Attachment 5-1. Topsoil volume calculations can be found in Attachment 2-2.

Estimated topsoil salvage from the G-1 well site will average about 7". This site on a ridge top has previously been disturbed for exploration drilling. The site has pockets of fractured sandstone bedrock at the surface and stony subsoils, which are the limiting factors in the quantity of salvageable topsoil. The average topsoil depth at well site G-2 is 30". The average topsoil thickness for well site G-3 is 10". However, enough soil will be stripped to allow 12" of soil to be placed during reclamation. Thus some subsoils will be stripped with the topsoil to generate the required volume. The estimated topsoil salvage from well site G-4 area will be 28" except on the area of the exiting road(s). The average salvageable topsoil at well site G-5 is 22". Well site G-6 will be established on a pre-existing drill pad, with a portion of the new pad extending onto undisturbed area. Topsoil on the pre-existing drill pad ranges from 0 to 30 inches, on the north edge in from 20 to 28 inches and on the cut slope on the south edge from 6 to 30 inches. The slope will be restored to original contour with the application of topsoil, the entire site will receive at least 12 inches of topsoil. Twelve inches was used to calculate the volume of topsoil to be salvaged and to determine the size of the topsoil pile for drill site G-6. Degas well G-7 will be developed on a site with soils consistent with G-3. There is a pre-existing road to well G-3 that continues on to the G-7 proposed site. There are signs of previous vehicle disturbance at the site, however the majority of the site is undisturbed. Topsoil available for salvage has been estimated to be 10 to 12 inches. Available topsoil will be salvaged and if necessary some subsoils will be stripped with the topsoil to generate the required volume to place a minimum of 12 inches during site reclamation. Available topsoil at each site will be salvaged, stockpiled and redistributed.

Twelve inches of soil will be salvaged at well site s G-9. Well site G-9 has no topsoil over approximately half of the site, thus requiring the salvage of subsoil to generate the foot of soil proposed for reclamation. Suitable soil for salvage at site G-10 is approximately 15 inches with

some areas having 24 inches of soil. Where available soil will be salvaged to a minimum of 15 inches and approximately 18 inches will be available to cover the G-10 disturbed area at the time of reclamation. G-8 was not constructed, however the available topsoil at site was estimated at about six inches.

The majority of the area at well site G-11 has been disturbed by road construction and the major part of the undisturbed portion has shallow eroded soils, except for a small area on the west side of the site. The shallow eroded soils are approximately 5 inches deep and the soils in the small area are between 10 and 16 inches deep. Approximately fifty percent of the G-12 well site is a road with no topsoil or vegetation. Between 12 and 30 inches of soil is suitable for salvage from the other fifty percent of the pad area for site G-12. Twelve inches will be returned to the reclamation slope at G-11 and between 12 and 15 inches at G-12. Large boulders are suspected to be present at the G-12 site.

At well site G-13, parent materials for soil formation are primarily colluvial deposits derived from sandstone and shale. The surface ranges from relatively smooth and non-stoney to very stoney. Suitable soil for salvage ranges from about 8 to 28 inches, limitation are due to high rock fragment content and low organic matter. Portions along the southeast edge are too stony for soil salvage. Well site G-14 (DUG205), is relatively uniform with soils of and similar to the Midfork family. Topsoil thickness range from 12 to 24 inches, with the typical depth being 15 to 18 inches. The G-14 well site has been disturbed by logging. Between 14 and 16 inches of topsoil will be placed at well sites G-13 and G-14 during reclamation.

The road to G-13 and G-14 are existing roads, however, the soil will be bladed to the side of the road at site G-14 and replaced during reclamation.

Well site G-15 is about 50 percent disturbed by a road, slope cut and fill. The undisturbed portion of the site is a slope with a southeast aspect (35 to 45 percent gradient). The topsoil on this slope

is typically 13 to 20 inches thick, with a loam texture. Approximately 14 inches of topsoil will be replaced during reclamation.

Well site G-16 was previously the site of an exploration hole, having been disturbed and reclaimed. Approximately, 14 inches of soil will be salvaged as topsoil and replaced during reclamation. The topsoil on the access road will be bladed to one side of the road and replaced during reclamation.

At well site G-17 approximately one-third of the site is an existing road. Sufficient topsoil will be salvaged to replace 12 inches over the area of disturbance during reclamation.

The entire area of well site G-19 was previously disturbed by logging activities with two roads crossing through the area. During the soil survey it was determined that the topsoil was 8 inches in depth. Approximately 12 inches of topsoil and subsoil will be salvaged for replacement during reclamation. Although, two soil pits were samples only SP-2 is representative of the site. SP-1 is not within the G-19 site's disturbed area.

The report for sampling completed May 1 and 5, 2007 summarizes the methodology and results of the soil survey conducted by Clement Drilling & Geophysical, Inc. for the proposed access road and G-18 and G-31 wells (Attachment 2-1, May 22, 2007).

The proposed road (AMV) and drill pads for wells G-31 and G-18 were evaluated using the United States Department of Agriculture (USDA), Natural Resources Conservation Services (NRCS) WEB Soil Survey (WSS) utility. ~~Detailed soil series~~ NRCS Order III descriptions for the soil series that occur in the study area are presented in Appendix A of the May 22, 2007 report located in Attachment 2-1.

Soil test pits were excavated at the two proposed well locations. The soil test pit at well G-31 was excavated by hand on May 1, 2007. The soil test pit for well G-18 was excavated by hand on May 5, 2007. Soil test pits were also excavated in areas representative of each of the three soil map

units that occur in the vicinity of the proposed road and vent wells. The three test pits were excavated by hand on May 5, 2007. The coordinates of each test pit collected using a GPS receiver are presented in the test pit logs. The test pit logs are presented in Appendix B and photographs of the excavations in Appendix C. The soils observed in the test pits appear to generally correlate to the NRCS Order III Map Units soil series map. Soil samples were collected from each test pit from each horizon, where possible, for laboratory analysis. The analyses will be incorporated into Attachment 2-1. Two additional soils samples were taken along the road corridor, these samples were labeled AMV SP-1 and AMV SP-2. These samples were dug by hand with a shovel and pick. The lab analysis of these samples is included in Attachment 2-1.

Per the review of aerial photography taken of the area in November 2006, there does not appear to be rock outcrops along the path of the AMV access road. However, outcrops do occur in the area and may be uncovered during construction.

223 Soil Characterization

The topsoil evaluation described in this chapter was performed by Daniel M. Larsen, Professional Soil Scientist and Dean Stacy, NRCS Range Management Specialist in accordance with the standards of the National Cooperative Soil Survey. The topsoil evaluation for Wells G-18, G-19, G-31 and the Access Road were performed by Craig Clement, P.G. and Dean Stacy, NRCS Management Specialist in accordance with the standards of the National Cooperative Soil Survey and using the USDA/NRCS WEB Soil Survey utility.

224 Substitute Topsoil

Dugout Canyon does not plan to use substitute topsoil as growth media except as described in Section 222.400.

230 OPERATION PLAN

231 General Requirements

231.100 Removing and Storing Topsoil Methods

The topsoil will be removed, stockpiled and protected with a berm and/or silt fence. A qualified person will be on site during soil salvage to monitor and supervise the operation for the purpose of maximizing salvage volumes. Prior to topsoil salvage shrubs/vegetation will be removed and placed/wind rowed along the inside perimeter of the disturbed area.

After the topsoil is removed, the mud pit will be excavated and the soils from the mud pit excavation will be stored immediately adjacent to the mud pit. Mud pit excavation of subsoil will be approximately 110 CY at each well site (G-2 thru G-6).

The subsoil excavation for the mud pits at G-7 thru G-19 and G-31 was approximately 430 CY. A portable container for drilling fluids will be used if necessary, should there not be sufficient subsoil depth to excavate a mud pit.

Topsoil beneath the topsoil stockpiles will not be removed. Ribbon or a marking fabric will be placed on top of the topsoil prior to placement of the topsoil from the well pad area.

The approximate volume of subsoil to be salvaged and used to create berms around the perimeter of the well site including the topsoil stockpile perimeter is: G-1 - 161 CY; G-2 - 254 CY, G-3 - 208 CY, G-4-165 CY, G-5 - 191 CY, G-6 - 156 CY, G-7 - 107 CY, G-8 - 143 CY, G-9 - 182 CY, G-10 - 137 CY, G-11 - 185 CY, G-12 - 260 CY, G-13 - 142 CY, G-14A - 123 CY, G-15 - 101 CY, G-16 - 98 CY, G-18 - 39 CY excludes topsoil pile, G-19 - 48 CY, G-31 - 62 CY excludes topsoil pile, Topsoil Stockpiles STP-1 thru **STP 7 - 309 CY** and Access Road - 265 CY.

At the G-19 drill pad there is a variance between the disturbed area acreage and the acreage where topsoil will be salvaged. Portions of the site have no topsoil, due to previous disturbance by logging, these areas include roads, a gully and skid trails. In addition there is a perimeter buffer area that will not be disturbed and thus will not have topsoil removed from the area unless it becomes necessary due to unforeseen issues during construction, such as buried outcrops, large boulders, tree root systems, etc. An area within the northeastern portion of the disturbed area has two road forks extending from the end of the existing road, these two forks have no topsoil on them and the area between them will not be disturbed and therefore will not have topsoil salvaged. A sketch of these areas is located in Attachment 2-1.

There is a difference between the topsoil volumes totals and the estimated inches to be salvaged on pads G-18, G-31 and the AMV road. The topsoil volume totals assume that the entire disturbed area will be stripped of 12 inches of topsoil/growth medium. Any areas within the disturbed area boundary which can remain undisturbed will remain undisturbed. In addition, the soils to be salvaged are assumed to be the same depth as the test pit or 12 inches. The available soil for salvage is likely to vary throughout the areas to be salvaged. A commitment is made to salvage available topsoil or 12 inches of growth medium. Sketches of the well pads are included in the soils report, located in Attachment 2-1.

231.200 Suitability of Topsoil Substitutes/Supplements

See Section 224.

231.300 Testing of Topsoil Handling and Reclamation Procedures Regarding Revegetation

Dugout will exercise care to guard against erosion during and after application of topsoil and will employ the necessary measures to ensure the stability on graded slopes. Erosion control measures will include silt fences, berms, seeding, straw bales, soil roughening, and mulching of the soils.

Topsoil will be redistributed and the original soil surface beneath the topsoil stockpile will be roughened as presented in Section 242.100 and seeded with the seed mix described in Chapter 3, Section 352.

Methods used to evaluate success of revegetation and stabilization are discussed in Chapter 3, Section 356.

231.400 Construction, Modification, Use, and Maintenance of Topsoil Storage Pile

Topsoil removed from the drill pad sites will be stockpiled on the site, except at well site G-14 where it will be stockpiled approximately 1/10 mile away. The estimated volumes of topsoil stockpile for each site are shown in Table 2-1. The stockpiles will be sized as shown in Table 2-2.

The slopes of the stockpile will be 1H:1V or approximately 45° during the construction phase. Soils in these areas generally have an angle of repose greater than 50 degrees, making a stockpile with 1:1 slopes feasible. The steeper slope also help minimize the area to be disturbed. When space is available topsoil will be stockpiled with slopes of 2H:1V.

TABLE 2-2
Topsoil Stockpile Dimensions*

Well No.	Length (ft)	Width (ft)	Height (ft)
G-1	55	35	16
G-2	156	50	20
G-3	70	60	17
G-4	110	35	17
G-5	90	65	21
G-6	105	30	13
G-7	80	70	6 to 12
G-8	168	60	6
G-9	160	90	30
G-10	170	80	65
G-11	40	50	12
G-12	60	80	18
G-13	120	100	17
G-14A	120	60	11
G-15	90	90	19
G-16	100	80	12
G-17	85	55	10

TABLE 2-2 (Continued)
Topsoil Stockpile Dimensions*

Well No.	Description	Length (ft)	Width (ft)	Height (ft)
G-18	STP-6	200	50	22
G-19	Lower Road	235	8	5
	Pad	140	52	35
G-31	STP-4	150	110	25
	STP-5	150	70	25
Access Road	STP-1	85	50	20
	STP-2	90	40	22
	STP-3	205	120	25
	STP-7	125	62	15

* These are approximate dimensions of the topsoil stockpile and construction dimensions may vary. The height represents the elevation difference between the lowest point and highest point of the topsoil stockpile. The topsoil thickness will vary with the slope of the native ground surface. When stored on steep slopes the topsoil thickness will be much less than the estimated height of the stockpile.

See Section 234.200 for detailed information on the topsoil stockpile(s).

232 Topsoil and Subsoil Removal

232.100 Topsoil Removal and Segregation

All topsoil will be removed as a single layer with no segregation. Topsoil will be removed using a dozer and/or loader. Refer to Section 231.100 for additional details.

232.200 Poor Topsoil

No poor soils exist at the well sites see Attachment 2-1.

232.300 Thin Topsoil

Not applicable see Attachment 2-1.

232.400 Minor Disturbances Not Requiring Topsoil Removal

Topsoil will not be removed along the fence line at the wells sites.

232.500 Subsoil Segregation

The B and C soil horizons will not be removed. Any small quantity of subsoil removed with the topsoil will not be segregated.

232.600 Timing

Topsoil removal will take place after all vegetation that could interfere with salvaging the topsoil has been grubbed.

232.700 Topsoil and Subsoil Removal Under Adverse Conditions

The topsoil will be removed first and stockpiled and the remaining soil horizons will be left in place, except where natural conditions render removal operations hazardous or detrimental to soils outside the disturbed area then topsoil will not be removed.

Conventional Machines - In locations where steep grades, adverse terrains, severe rockiness, limited depth of soils, or other adverse conditions exist that render soil removal activities using

conventional machines hazardous, soils will not be salvaged and stockpiled. Such conditions are not likely to occur in these areas.

Substitute Topsoil - Importing of substitute topsoil is not anticipated (Section 224).

233 Topsoil Substitutes and Supplements

233.100 Overburden Materials Supplementing and/or Replacing Topsoil

No overburden material will be used.

233.200 Suitability of Topsoil Substitutes and Supplements

No substitute topsoil is planned.

233.300 Physical and Chemical Analysis

See Section 243.

233.400 Testing of Substitute Topsoil

No substitute topsoil is planned.

234 Topsoil Storage

234.100 Topsoil Stockpiling

Topsoil will be stockpiled for later use in reclamation operations. The topsoil will be stored and treated as outlined in Section 234 of this amendment. Refer to Sections 231 through 234 of the M&RP for additional information pertaining to the topsoil at the Pace Canyon Fan site.

234.200 Topsoil Stockpile

Stable Stockpile Site - Stockpiled material will be placed on a stable site.

Protection from Contaminants and Compaction - To protect the topsoil from contaminants and unnecessary compaction that could interfere with vegetation, the stockpile will be isolated from the main surface area by a berm and/or silt fence. A sign designating "topsoil" will be installed on the stockpile.

The topsoil stockpile will be constructed in such a manner as to allow access for repair of the pile surfaces and diversion structures.

Wind and Water Erosion Protection - The topsoil stockpile will be protected from water erosion by berms, which trap sediment runoff from the stockpile. The berms have been designed to completely contain the 10-year 24-hour storm event (see Attachment 7-1). The stockpile will be surface pitted, gouged and/or roughened and revegetated using the grass seeds listed in Table 3-2 to prevent wind erosion.

Topsoil Redistribution - Stockpile soil will not be moved until redistribution during contemporaneous or final reclamation operations unless approved by the Division.

At well pad G-19 a portion of the salvaged topsoil will be stored on a fork of the existing road. There is no topsoil remaining on the road and the road will remain following reclamation of the G-19 pad site. Wide flagging will be used as a marker to identify the separate between the road surface and the stored topsoil. Landowner correspondence pertaining to topsoil storage on the existing road is contained in Attachment 2-3.

Cross-sections of topsoil piles STP-1 thru STP-7 are shown on Plates 2 and 3, in Attachment 5-4.

234.300 Topsoil Stockpile Relocation

Stockpiled soil in jeopardy of being detrimentally affected in terms of its quantity and quality by drilling operations may be temporarily redistributed or relocated on approval by the Division and modification of this M&RP.

240 RECLAMATION PLAN

241 General Information

Reclamation of the degassification sites (topsoil redistribution, amendments, and stabilization) is discussed in Sections 242, 243, and 244 respectively.

242 Soil Redistribution

242.100 Soil Redistribution Practices

The topsoil will be placed after recontouring of the site has occurred. Topsoil will be handled when they are loose or in a friable condition. The moisture content will be visually monitored and water will be added as needed to enhance the soil's condition for handling. The approximate amount of topsoil available for each site is shown in Table 2-1. The reclamation time line can be found on Figure 5-15 for sites G-2 and G-3 and on Figure 5-26 for sites G-4 thru G-19 and G-31. Figure 5-26 has been revised to include the access road (AMV).

The topsoil will be distributed in two phases at well site G-2, the first phase will be the contemporaneous reclamation of a portion of the pad area used during well construction (see Figures 5-4, 5-8 and 5-12). During contemporaneous reclamation topsoil from the stockpile will be distributed in the depths shown in Table 2-3.

Final reclamation will occur at all well sites after venting of the methane gas is complete, venting equipment has been removed and the well has been plugged. Well plugging will be delayed at well sites G-2, G-5 and G-7, to allow additional time for venting of the gob behind the sealed panels and to provide surface access to the mine. The surface at well sites G-2 and G-5 will be reclaimed in 2007/2008, however the wells will not be plugged. The surface at well site G-7 will be reclaimed in 2008, but the wells will not be plugged. The topsoil stockpile storage area and access road (G-2 and G-5) will be reclaimed during this final phase. The access roads to G-3, G-4, G-6, G-7, G-8, G-9, G-10, G-11 and G-12 are pre-existing and will not be reclaimed.

The topsoil stockpile storage area and access road (G-2 and G-5) will be reclaimed following the plugging of the wells. The access roads to , G-3, G-4, G-6, G-7, G-8, G-9, G-10, G-11, G-12, G-13, G-15, G-17 and G-19 are pre-existing and will not be reclaimed. The access road joining the pre-existing road to G-16 and the portion of the access road between the topsoil stockpile and the well site at G-14 will be pocked/gouged and seeded during final reclamation of the site.

The AMV access road will be reclaimed using the technology discussed in Section 240 of this amendment following the sealing and reclamation of well pads G-18 and G-31.

Refer to Section 341 for additional information.

Soil Thickness - The topsoil will be distributed during contemporaneous and final reclamation in the thickness shown in Table 2-3.

Compaction - Prior to the application of topsoil, compacted subsoils will be roughened or loosened for a depth of 18 to 24 inches. To prevent compaction of topsoil, soil moving equipment will refrain from unnecessary operation over spread topsoil. The topsoil will be in a loosened condition prior to seeding.

Following the drying of the mud pit materials, the dirt excavated to create the mud pit will be mixed with the drill cutting and returned to the pit to prevent a boundary of hard material from forming in the mud pit area that would hamper root penetration and then compacted to minimize settling.

Erosion - Care will be exercised to ensure the stability of topsoil on graded slopes to guard against erosion during and after topsoil application. Post reclamation (contemporaneous and final) erosion control measures will be surface roughing, mulching and seeding.

242.200 Regrading

The areas will be graded to their approximate original topographic configuration, except as approved by the Division.

242.300 Topsoil Redistribution on Impoundments and Roads

The mud pits will be dismantled and filled following completion of drilling. See Section 242.100, Compaction for additional information. Mud pits will be covered with the same amount of topsoil as the rest of the site. The roads existing prior to starting the drilling program will not be reclaimed. Access roads built to allow entrance to the drilling pads will be reclaimed and will receive topsoil in the same depth as their corresponding pad areas, unless specified otherwise .

243 Soil Nutrients and Amendments

The soils will be analyzed directly following salvage to determine if amendments are needed. Testing of the topsoil will be done according to Table 6 of the Division's Topsoil and Overburden Guidelines. The topsoil will be tested at a minimum for the following parameters: pH, electrical conductivity, total carbon, SAR, water holding capacity, plant available nitrogen, and phosphorus. Results of these analyses will be incorporated into Attachment **2-1 and 2-2**.

TABLE 2-3

Approximate Topsoil Distribution Thickness

Well Site No.	Topsoil Thickness (Inches)
G-1*	7
G-2	30
G-3	12
G-4	28
G-5	22
G-6	12
G-7	12
G-8*	12
G-9	12
G-10	18
G-11	12
G-12	15
G-13	14 - 16
G-14A	14 - 16
G-15	14
G-16	14
G-17	12
G-18	12
G-19	12
G-31	15
AMV Access Road	12

* Wells G-1 and G-8 were never constructed.

244 Soil Stabilization

244.100 Protection and Stabilization of Surface Area

All reclaimed areas will be stabilized to control erosion by application of mulch, tackifier, and roughening of the surface. The areas will be graded to the approximately original topographic configuration. Seeding will be accomplished with the application of seeds and mulch with a long fiber tackifier or broadcast. Methods of protection and stabilization are further discussed in Chapter 3, Section 341.

244.200 Mulch Application

Mulch/tackifier will be applied to stabilize the soil on all areas that have been regraded and covered with growth media. For further discussion of revegetation practices to be utilized, see Chapter 3, Section 341.

244.300 Rills and Gullies

Postmining Land Use and Revegetation - Rills and gullies that are approximately nine (9) inches in depth and disrupt the postmining land use or reestablishment of vegetative cover will be regraded and seeded. In addition, the repair of rills and gullies will assist in the maintenance of water quality standards.

250 PERFORMANCE STANDARDS

251 Topsoil, Subsoil, and Topsoil Supplements Management

All topsoil, subsoil, and topsoil supplements will be managed as outlined in Sections 230 and 240.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

252 Stockpiled Topsoil and Subsoil

All stockpiled topsoil and subsoil will be managed according to plans outlined in Sections 230 and 240.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
~~August 28, 2007~~ July 9, 2007

ATTACHMENT 2-1
SOIL INVENTORY AND ASSESSMENT

add to the back of existing information



4114 West 9950 North
Cedar Hills, Utah 84062
Phone 801-372-3685
Fax 801-785-5748

July 29, 2007

Ms. Vicky Miller,
Dugout Canyon Mine
PO Box 1029
Wellington, Utah 84542

Dear Ms. Miller,

This letter report summarizes the methodology and results of the soil survey conducted by Clement Drilling & Geophysical, Inc. for the proposed AMV Road and vent well locations in Pace Canyon, Carbon County, Utah.

NRCS Soil Data

The proposed AMV Road and drill pads for vent well G31 and G18 were evaluated using the United States Department of Agriculture (USDA), Natural Resources Conservation Services' (NRCS) WEB Soil Survey (WSS) utility. Figure 1 presents the map generated by the utility with annotation added showing the approximate location of the soil test pits. In addition, modifications to the soil map units are shown on Figure 1 based on field observations. Detailed soil series descriptions for the soil series that occur in the study area are presented in Appendix A.

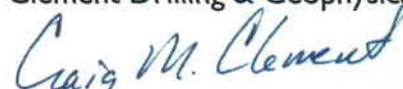
Soil Test Pits

Soil test pits were excavated at the two proposed vent well locations. The soil test pit at vent well G31 was excavated by hand on May 1, 2007. The soil test pit for vent well G19 was excavated by hand on May 5, 2007. Soil test pits were also on excavated July 29, 2007 in areas representative of each of the two soil map units that occur in the vicinity of the proposed road and vent wells. The locations of the test pits are approximately located on Figure 1 and coordinates of each test pit collected using a GPS receiver are presented in the test pit logs. The test pit logs are presented in Appendix B and photographs of the excavations in Appendix C. The soils observed in the test pits appear to generally correlate to the NRCS soil series map.

Soil samples were collected from each test pit from each horizon, where possible, for laboratory analysis.

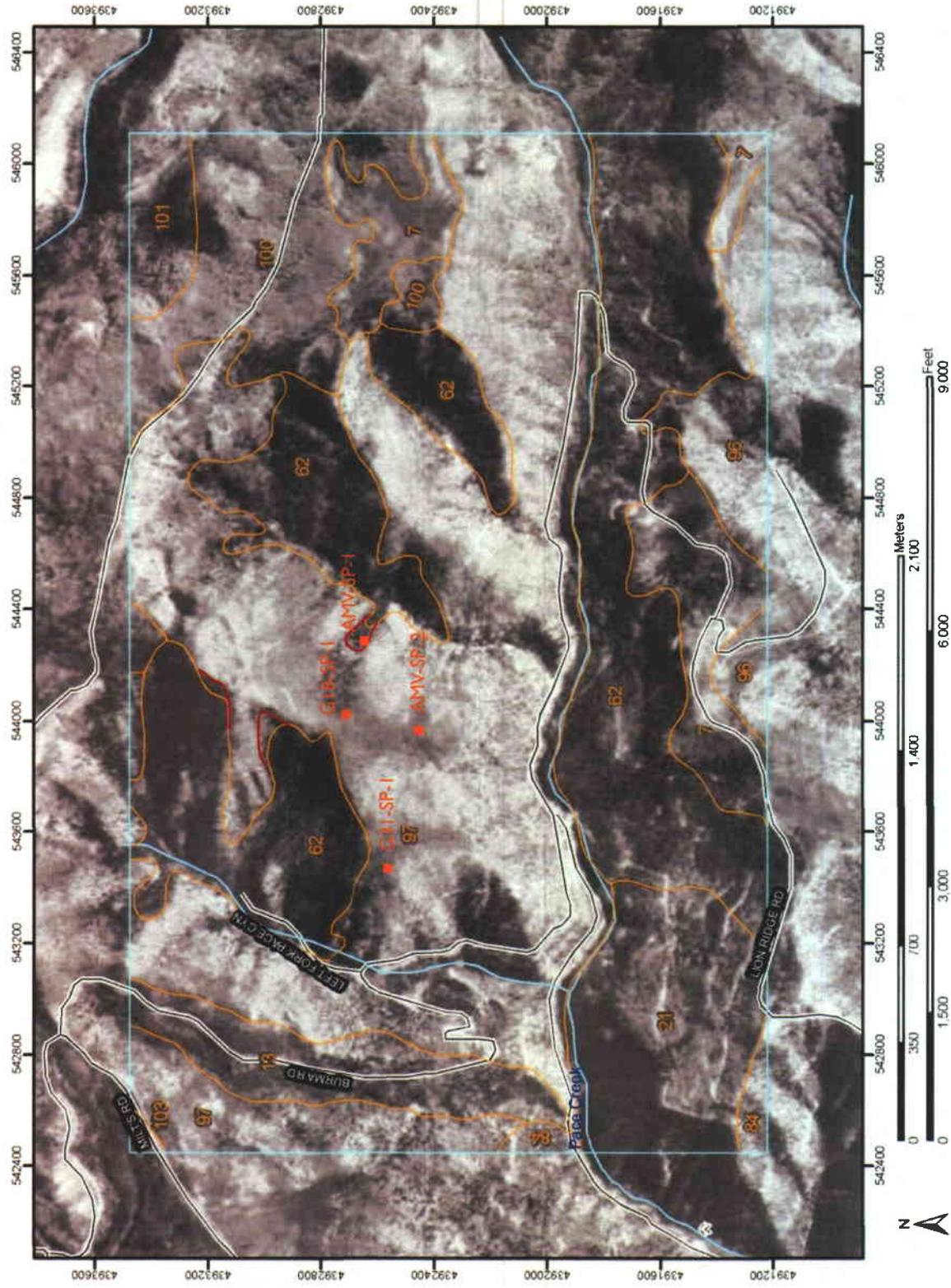
Please feel free to contact me if you have any questions regarding the results of the soil survey. I appreciate the opportunity to work with you on this project.

Sincerely,
Clement Drilling & Geophysical, Inc.


Craig M. Clement, P.G.

Figures

Soil Map-Carbon Area, Utah, Parts of Carbon and Emery Counties (AMV)



Natural Resources Conservation Service
Web Soil Survey 2.0
National Cooperative Soil Survey

7/29/2007
Page 1 of 3

Figure 1
Soil Map and Location of Test Pits

MAP LEGEND

- Area of Interest (AOI)
 - Area of Interest (AOI)
- Soils
 - Very Stony Spot
 - Wet Spot
 - Other
- Soil Map Units
 - Very Stony Spot
 - Wet Spot
 - Other
- Special Point Features
 - Blowout
 - Borrow Pit
 - Clay Spot
 - Closed Depression
 - Gravel Pit
 - Gravelly Spot
 - Landfill
 - Lava Flow
 - Marsh
 - Mine or Quarry
 - Miscellaneous Water
 - Perennial Water
 - Rock Outcrop
 - Saline Spot
 - Sandy Spot
 - Severely Eroded Spot
 - Sinkhole
 - Slide or Slip
 - Sodic Spot
 - Spoil Area
 - Stony Spot
- Special Line Features
 - Gully
 - Short Steep Slope
 - Other
- Political Features
 - Municipalities
 - Cities
 - Urban Areas
- Water Features
 - Oceans
 - Streams and Canals
- Transportation
 - Rails
 - Interstate Highways
 - US Routes
 - State Highways
 - Local Roads
 - Other Roads
- Roads
 - Soil Test Pit Location
 - Soil Map Unit modification based on field observations

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
 Coordinate System: UTM Zone 12N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Carbon Area, Utah, Parts of Carbon and Emery Counties

Survey Area Date: Version 3, Dec 14, 2006

Date(s) aerial images were photographed: 10/8/1998; 11/2/1998

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Figure 2
 Soil Map Legend

Map Unit Legend

Carbon Area, Utah, Parts of Carbon and Emery Counties (UT616)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7	Beje-Trag complex	131.7	6.4%
13	Cabba family-Guben-Rock outcrop complex	85.5	4.2%
21	Croydon loam, 8 to 30 percent slopes	140.0	6.9%
62	Midfork family-Comodore complex	525.6	25.7%
84	Podo-Rock outcrop complex	14.5	0.7%
96	Rock outcrop-Rubbleland-Travessilla complex	77.9	3.8%
97	Rottulee family-Trag complex	873.3	42.8%
100	Senchert loam, 3 to 15 percent slopes	155.3	7.6%
101	Senchert loam, 30 to 50 percent slopes	35.3	1.7%
103	Senchert-Toze family complex	3.0	0.1%
Totals for Area of Interest (AOI)		2,042.1	100.0%

Figure 3
Soil Map Map Unit Legend

G-31

WEST

BRUSH IS VERY TALL OBSTRUCTING VISION

DF - DOUGLAS FIR

MB - MOUNTAIN BRUSH

SB - SAGE BRUSH

DF

DF

DF

12-14" TOPSOIL

SB

DF

DF

MB

MB

DF LOGGED AREA

DF

MAPLE

MB

MB

6-8" TOPSOIL

MB

SB

DF

LARGE DF

MB

00 Builders

DF

DF

DF

MB

TOPSOIL TEST PIT 7-23"

SB

SB

DF

7-9" TOPSOIL

SB

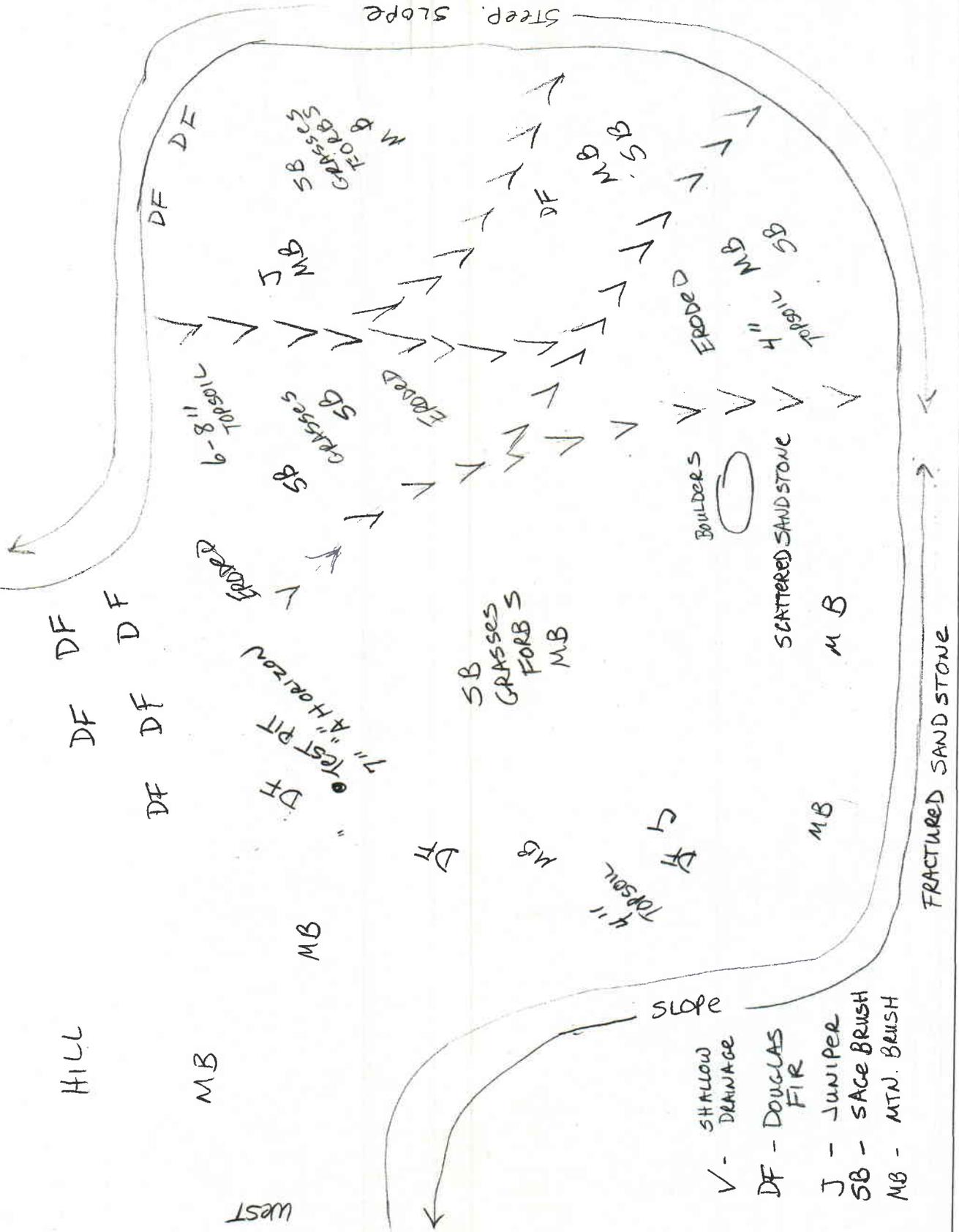
MB

MB

42-381 80 SHEETS RELEASE 9 SQUARE
42-382 100 SHEETS RELEASE 9 SQUARE
42-389 200 SHEETS RELEASE 9 SQUARE
42-392 100 RECYCLED WHITE 5 SQUARE
42-399 200 RECYCLED WHITE 5 SQUARE
Made in the U.S.A.



G-18



V - SHALLOW DRAINAGE

DF - DOUGLAS FIR

J - JUNIPER

SB - SAGE BRUSH

MB - MTN. BRUSH

42,380 50 SHEETS PER CASE 9 SQUARE
 42,380 100 SHEETS PER CASE 18 SQUARE
 42,382 200 SHEETS PER CASE 36 SQUARE
 42,398 200 RECYCLED WHITE 36 SQUARE
 42,399 200 RECYCLED WHITE 5 SQUARE
 Made in U.S.A.



Appendix A
Map Unit Descriptions

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

7 Beje-Trag complex

Setting

Elevation: 6980 to 9670 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 38 to 45 degrees F
Frost-free period: 60 to 100 days

Composition

Beje and similar soils: 55 percent
Trag and similar soils: 20 percent

Description of Beje

Setting

Landform: Ridges
Landform position (two-dimensional): Summit
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium and/or colluvium over residuum weathered from sandstone and shale

Properties and Qualities

Slope: 3 to 15 percent
Depth to restrictive feature: 10 to 20 inches to Lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 5 percent
Gypsum maximum: 0 percent
Available water capacity: Very low (about 2.4 inches)

Interpretive Groups

Land capability (non irrigated): 6s
Ecological site: Mountain Shallow Loam (Mountai (R047XA446UT)

Typical Profile

0 to 6 inches: loam
6 to 14 inches: clay loam
14 to 18 inches: unweathered bedrock

Description of Trag

Setting

Landform: Draws
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium and/or colluvium derived from sandstone and shale

Properties and Qualities

Slope: 3 to 30 percent
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 10 percent
Gypsum maximum: 0 percent
Available water capacity: High (about 10.8 inches)

Interpretive Groups

Land capability (non irrigated): 6e
Ecological site: MOUNTAIN LOAM (SALINA WILDRYE) (R048AY409UT)

Typical Profile

0 to 5 inches: clay loam
5 to 39 inches: clay loam
39 to 60 inches: clay loam

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

13 Cabba family-Guben-Rock outcrop complex

Setting

Elevation: 5980 to 8180 feet
Mean annual precipitation: 14 to 16 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 60 to 120 days

Composition

Cabba and similar soils: 50 percent
Guben and similar soils: 20 percent
Rock outcrop: 15 percent

Description of Cabba

Setting

Landform: Canyons
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and/or slope alluvium over residuum weathered from shale and siltstone

Properties and Qualities

Slope: 40 to 70 percent
Surface area covered with stones and boulders: 13.0 percent
Depth to restrictive feature: 8 to 20 inches to Paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 10 percent
Gypsum maximum: 0 percent
Available water capacity: Very low (about 2.3 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: Upland Very Steep Shallow Loam (R034XY342UT)

Typical Profile

0 to 3 inches: bouldery loam
3 to 15 inches: loam
15 to 19 inches: weathered bedrock

Description of Guben

Setting

Landform: Hillslopes
Landform position (two-dimensional): Toeslope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium derived from sandstone and shale

Properties and Qualities

Slope: 40 to 75 percent
Surface area covered with stones and boulders: 33.0 percent
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high or high (0.60 to 6.00 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 40 percent
Gypsum maximum: 0 percent
Sodium adsorption ratio maximum: 5.0
Available water capacity: Low (about 4.6 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: Upland Very Steep Shallow Loam (R034XY342UT)

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

Typical Profile

0 to 7 inches: extremely bouldery loam
7 to 15 inches: very stony loam
15 to 30 inches: very stony loam
30 to 60 inches: very stony loam

Description of Rock outcrop

Setting

Landform: Canyons
Down-slope shape: Linear
Across-slope shape: Linear

Properties and Qualities

Slope: 40 to 75 percent
Depth to restrictive feature: 0 to 0 inches to Lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Very low or moderately low (0.00 to 0.06 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 0.0 inches)

Interpretive Groups

Land capability (non irrigated): 8s

Typical Profile

0 to 60 inches: unweathered bedrock

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

62 Midfork family-Comodore complex

Setting

Elevation: 7880 to 9470 feet
Mean annual precipitation: 16 to 25 inches
Mean annual air temperature: 34 to 45 degrees F
Frost-free period: 40 to 80 days

Composition

Midfork and similar soils: 50 percent
Comodore and similar soils: 20 percent

Description of Midfork

Setting

Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium derived from sedimentary rock

Properties and Qualities

Slope: 50 to 70 percent
Surface area covered with stones and boulders: 13.0 percent
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high or high (0.60 to 2.00 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 5 percent
Gypsum maximum: 0 percent
Available water capacity: Low (about 5.1 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: High Mountain Very Steep Loam (R048AY530UT)

Typical Profile

0 to 4 inches: bouldery loam
4 to 7 inches: bouldery loam
7 to 17 inches: very channery loam
17 to 60 inches: very gravelly loam

Description of Comodore

Setting

Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium derived from sandstone

Properties and Qualities

Slope: 50 to 70 percent
Surface area covered with stones and boulders: 13.0 percent
Depth to restrictive feature: 10 to 20 inches to Lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 0 percent
Gypsum maximum: 0 percent
Available water capacity: Very low (about 1.7 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: High Mountain Very Steep Loam (R048AY530UT)

Typical Profile

0 to 6 inches: bouldery loam

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

6 to 19 inches: very stony loam

19 to 23 inches: unweathered bedrock

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

97 Rottulee family-Trag complex

Setting

Elevation: 7080 to 8670 feet
Mean annual precipitation: 16 to 20 inches
Mean annual air temperature: 38 to 45 degrees F
Frost-free period: 60 to 100 days

Composition

Rottulee and similar soils: 60 percent
Trag and similar soils: 20 percent

Description of Rottulee

Setting

Landform: Mountain slopes, canyons
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Colluvium over residuum weathered from sandstone and shale

Properties and Qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 20 to 40 inches to Lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 15 percent
Gypsum maximum: 0 percent
Available water capacity: Low (about 5.2 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: MOUNTAIN VERY STEEP STONY LOAM (R047XA473UT)

Typical Profile

0 to 8 inches: loam
8 to 15 inches: clay loam
15 to 23 inches: gravelly silty clay loam
23 to 34 inches: gravelly silt loam
34 to 38 inches: unweathered bedrock

Description of Trag

Setting

Landform: Canyons, mountain slopes
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Alluvium and/or colluvium derived from sandstone and shale

Properties and Qualities

Slope: 30 to 60 percent
Surface area covered with stones and boulders: 13.0 percent
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 10 percent
Gypsum maximum: 0 percent
Available water capacity: High (about 10.2 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: MOUNTAIN LOAM (SALINA WILDRIE) (R048AY409UT)

Typical Profile

0 to 10 inches: stony loam

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

10 to 36 inches: clay loam
36 to 60 inches: clay loam

100 Senchert loam, 3 to 15 percent slopes

Setting

Elevation: 8670 to 9470 feet
Mean annual precipitation: 20 to 30 inches
Mean annual air temperature: 36 to 38 degrees F
Frost-free period: 40 to 60 days

Composition

Senchert and similar soils: 80 percent

Description of Senchert

Setting

Landform: Ridges, plateaus
Landform position (two-dimensional): Summit
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Colluvium and/or slope alluvium over residuum weathered from sandstone and shale

Properties and Qualities

Slope: 3 to 15 percent
Depth to restrictive feature: 20 to 40 inches to Lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 0 percent
Gypsum maximum: 0 percent
Sodium adsorption ratio maximum: 5.0
Available water capacity: Moderate (about 6.2 inches)

Interpretive Groups

Land capability (non irrigated): 6e
Ecological site: High Mountain Loam (Aspen) (R047XA508UT)

Typical Profile

0 to 4 inches: loam
4 to 16 inches: loam
16 to 35 inches: clay loam
35 to 39 inches: unweathered bedrock

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

101 Senchert loam, 30 to 50 percent slopes

Setting

Elevation: 8580 to 9370 feet
Mean annual precipitation: 20 to 30 inches
Mean annual air temperature: 36 to 38 degrees F
Frost-free period: 40 to 60 days

Composition

Senchert and similar soils: 80 percent

Description of Senchert

Setting

Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or slope alluvium over residuum weathered from sandstone and shale

Properties and Qualities

Slope: 30 to 50 percent
Depth to restrictive feature: 20 to 40 inches to Lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 0 percent
Gypsum maximum: 0 percent
Sodium adsorption ratio maximum: 5.0
Available water capacity: Moderate (about 6.2 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: High Mountain Loam (Aspen) (R047XA508UT)

Typical Profile

0 to 4 inches: loam
4 to 16 inches: loam
16 to 35 inches: clay loam
35 to 39 inches: unweathered bedrock

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

103 Senchert-Toze family complex

Setting

Elevation: 7480 to 9470 feet
Mean annual precipitation: 20 to 25 inches
Mean annual air temperature: 36 to 38 degrees F
Frost-free period: 40 to 60 days

Composition

Senchert and similar soils: 50 percent
Toze and similar soils: 30 percent

Description of Senchert

Setting

Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or slope alluvium over residuum weathered from sandstone and shale

Properties and Qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to Lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low or moderately high (0.06 to 0.20 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 0 percent
Gypsum maximum: 0 percent
Available water capacity: Low (about 4.5 inches)

Interpretive Groups

Land capability (non irrigated): 7e
Ecological site: High Mountain Loam (Douglas Fi (R047XA512UT)

Typical Profile

0 to 4 inches: loam
4 to 18 inches: clay loam
18 to 25 inches: silty clay
25 to 29 inches: unweathered bedrock

Description of Toze

Setting

Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium derived from sandstone, shale and siltstone

Properties and Qualities

Slope: 15 to 35 percent
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high or high (0.60 to 2.00 in/hr)
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate maximum: 30 percent
Gypsum maximum: 0 percent
Available water capacity: Moderate (about 6.5 inches)

Interpretive Groups

Land capability (non irrigated): 6e
Ecological site: High Mountain Loam (Douglas Fi (R047XA512UT)

Typical Profile

0 to 3 inches: loam
3 to 33 inches: gravelly silt loam
33 to 60 inches: very gravelly fine sandy loam

Map Unit Description

Carbon Area, Utah, Parts of Carbon and Emery Counties

Map Unit Description

Detailed Soil Map Units

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description indicates the composition of the map unit and selected properties of the components of the unit.

Soils that have profiles that are almost alike make up a "soil series." Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into "soil phases." Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A "complex" consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An "association" is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An "undifferentiated group" is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include "miscellaneous areas." Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other Soil Data Mart reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the Soil Data Mart reports define some of the properties included in the map unit descriptions.

Appendix B

Soil Test Pit Logs

Site G18-SP-1 AMV Road

Name	Craig Clement	WD	Well Drained					
Date	5/5/2007	none						
Weather	Clear, 75°F	none						
Location	N 39.68265°, W 110.48699°	Unknown						
Datum	NAD 83	SOS	primarily sagebrush & serviceberry					
Topographic Map	Mount Bartles, UT; 1:24,000; 1972	COL	colluvium					
Slope Aspect	SSW	SST, SIS, SHA	Interbedded sandstone, siltstone and shale					
Slope Gradient	45%							
Slope Complexity	Complex	MO	Moderate					
Slope Shape	LV	66 cm						
Hillslope Profile Position	SH	R	rill					
Geomorphic Component	CT	1	>0 up to 25%					
Microrelief	MH	VH	Very High					
Drainage Pattern	dendritic	Stony						
Diagnostic Horizons	Observation Method	Depth (cm)	Color (moist)	Structure	Reaction (HCI)	% Rock Fragments & Size	% Roots, Size & Location	
		From To						Distinctness Topography
A	SP	0 18	Gradual Wavy	Moderate yellowish brown		5%, GR to CB	5% VF to F, T	
		18 53	Gradual Wavy	Moderate olive brown		5%, GR to CB	2% VF to F, T	
		53 66	Gradual Wavy	Light olive gray		5%, GR to CB	>2% VF to F, T	
BC		Weathered bedrock at 66 cm						

Depth (cm)	Description
From To	
0 18	Silt with fine sand, moderate amount of root material, sandstone clasts, slightly moist
18 53	Silt with trace fine sand, moderate root material decreasing with depth, slightly moist, sandstone clasts
53 66	Fine sand with trace silt, minor root material, hard @ 66cm, may be weathered bedrock

Site AMV-SP-1 AMV Road

Name	Craig Clement	WD	Well Drained					
Date	7/23/2007	none						
Weather	Clear, 85 F	none						
Location	N 39.68271 ° W 110.48338 °	Unknown						
Datum	NAD 83	SOS	Douglas fir, Mtn maple, sagebrush, Gambel oak					
Topographic Map	Mount Bartles, UT; 1:24,000; 1972	COL	colluvium					
Slope Aspect	N	SST, SIS, SHA	Interbedded sandstone, siltstone and shale					
Slope Gradient	75%							
Slope Complexity	Complex	MO	Moderate					
Slope Shape	LV Linear, Convex	120 cm	estimated					
Hillslope Profile Position	BS back slope	G	gully					
Geomorphic Component	NS nose slope	1	>0 up to 25%					
Microrelief	MH microhigh	VH	Very High					
Drainage Pattern	dendritic	Stony						
Diagnostic Horizons	Observation Method	Depth (cm)	Color (dry)	Texture	Structure	Reaction (HCI)	% Rock Fragments & Size	% Roots, Size & Location
		From To						
AO	SP	0 76	Gradual	Wavy				
BC	SP	76 120	Gradual	Wavy				
Penetration with pick became very difficult at 120 cm.								
Depth (cm)	Description							
	From To							
0	76	clayey loamy silt, sandstone gravel to boulders on surface, dry						
76	120	clayey silt, sandstone & siltstone clasts, dry						

AMV-SP-2 AMV Road

Craig Clement		WD		Well Drained						
7/23/2007		none								
Clear, 90 °F		none								
N 39.67975°, W 110.48692°		Unknown								
NAD 83		SOS		Other shrub cover, sagebrush, serviceberry, bunch grasses						
Mount Bartles, UT; 1:24,000; 1972		COL		colluvium						
SW		SST, SIS, SHA		Interbedded sandstone, siltstone and shale						
60%		-								
Complex		MO		Moderate						
LL Linear, Linear		200 cm		estimated						
BS backslope		G		Gully						
SS side slope		1		>0 up to 25%						
MH microhigh		VH		Very High						
dendritic		Stony								
		Surface Fragments								
Observation Method	Depth (cm)	Boundary		Color (dry)	Texture	Structure	Reaction (HG)	% Rock Fragments & Size	% Roots, Size & Location	
		From	To							Distinctness
SP	0	15	Gradual	Wavy	Moderate yellowish brown	SI	1, VF, GR	VE	5%, GR to CB	5% VF to F, T
SP	15	91	Gradual	Wavy	Pale yellowish brown	SI	1, VF, GR	VE	<2%, GR to CB	2% VF to M, T
SP	91 +		Gradual	Wavy	Pale yellowish brown				weathered siltstone bedrock	
Depth (cm)		Description								
From	To									
0	15	Silt, gravelly on surface (~20%) less below surface (5%), dry, moderate amount of roots								
15	91	Silt with sandstone clasts (5%), minor amount of roots, dry								
91 +		Siltstone bedrock, weathered, dry								



Appendix C
Photographs



G31-SP-1 - Photograph 1
Looking NW at SP-1



G31-SP-1 - Photograph 2
0 to 25 cm



G31-SP-1 - Photograph 3
25 to 48 cm



G31-SP-1 - Photograph 4
48 to 76 cm



G18-SP-1 - Photograph 1
Looking north at SP-1



G18-SP-1 - Photograph 2
0 to 30 cm



G18-SP-1 - Photograph 3
30 to 66 cm



AMV-SP-1 - Photograph 1
Looking south at SP-1



AMV-SP-1 – Photograph 2
0 to 53 cm



AMV-SP-1 – Photograph 3
53 to 83 cm



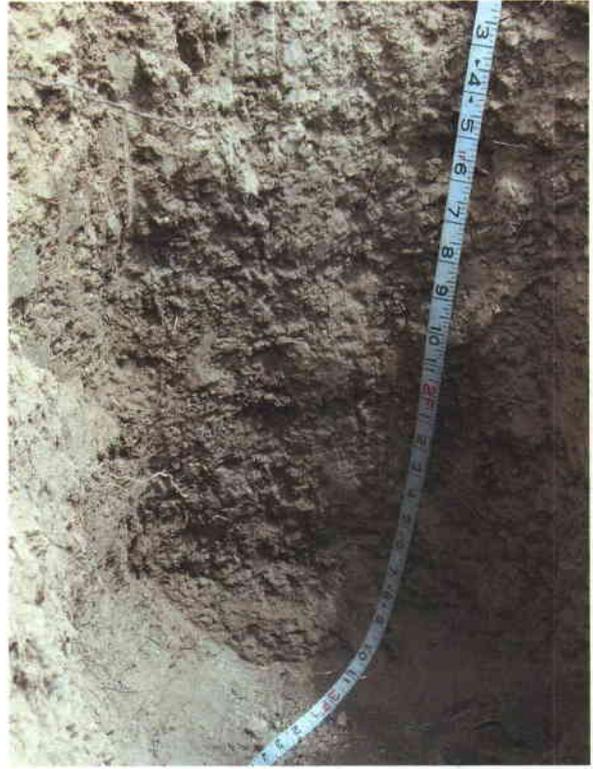
AMV-SP-1 – Photograph 4
83 to 120 cm



AMV-SP-2 – Photograph 1
Looking northeast at SP-1



AMV-SP-2 – Photograph 2
0 to 55 cm



AMV-SP-2 – Photograph 3
40 to 90 cm



Soil Analysis Report

Canyon Fuel Company
 Dugout Canyon Mine
 P.O. Box 1029
 Wellington, UT 84542

Report ID: S0707453001

Project: Dugout Canyon Mine

Date: 8/6/2007

Date Received: 7/26/2007

Work Order: S0707453

Lab ID	Sample ID	Depths cm	pH s.u.	Saturation %	Electrical		Field Capacity %	Wilt Point %
					Conductivity dS/m			
S0707453-001	G-20 SP1	0-30	7.4	34.3	0.42	14	10	
S0707453-002	G-20 SP1	30-	7.5	39.7	0.42	17	12	
S0707453-003	AMV Road SP1	0-30	7.3	48.6	0.40	20	17	
S0707453-004	AMV Road SP1	30-48	7.6	45.9	0.31	20	16	
S0707453-005	AMV Road SP2	0-6	7.6	41.3	0.31	17	14	
S0707453-006	AMV Road SP2	6-36	7.7	43.4	0.23	19	15	

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2Osol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
 Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PysS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral, Pot.= Neutralization Potential
 Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A. Secor
 Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company
Dugout Canyon Mine
P.O. Box 1029
Wellington, UT 84542

Report ID: S0707453001

Project: Dugout Canyon Mine

Date Received: 7/26/2007

Date: 8/6/2007
Work Order: S0707453

Lab ID	Sample ID	Depths cm	Calcium meq/L	Magnesium meq/L	Sodium meq/L	Potassium meq/L	SAR
S0707453-001	G-20 SP1	0-30	3.20	0.97	0.28	0.36	0.20
S0707453-002	G-20 SP1	30-	3.87	1.00	0.19	0.30	0.12
S0707453-003	AMV Road SP1	0-30	3.28	0.99	0.11	0.18	0.08
S0707453-004	AMV Road SP1	30-48	2.43	0.78	0.11	0.16	0.09
S0707453-005	AMV Road SP2	0-6	2.97	0.50	0.21	0.16	0.16
S0707453-006	AMV Road SP2	6-36	2.52	0.51	0.11	0.09	0.09

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor

Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company

Dugout Canyon Mine

P.O. Box 1029

Wellington, UT 84542

Report ID: S0707453001

Date: 8/6/2007

Work Order: S0707453

Project: Dugout Canyon Mine

Date Received: 7/26/2007

Lab ID	Sample ID	Depths cm	Total		T.S.		Neut.		T.S.		Total Carbon	TOC	Available Sodium	Exchangeable Sodium
			Sulfur	AB	Pot.	ABP	%	%	meq/100g	meq/100g				
S0707453-001	G-20 SP1	0-30	0.04	1.23	11.0	9.73	1.8	1.6	0.03	0.02				
S0707453-002	G-20 SP1	30-	0.01	0.40	107	107	2.8	1.5	0.03	0.03				
S0707453-003	AMV Road SP1	0-30	0.04	1.09	146	145	4.2	2.5	0.02	0.01				
S0707453-004	AMV Road SP1	30-48	<0.01	<0.01	189	189	3.9	1.6	0.02	0.02				
S0707453-005	AMV Road SP2	0-6	<0.01	<0.01	207	207	3.8	1.3	0.02	<0.01				
S0707453-006	AMV Road SP2	6-36	<0.01	<0.01	286	286	4.2	0.8	0.02	0.01				

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2Osoil= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyRS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by:

Karen A. Secor

Secor, Soil Lab Supervisor



Soil Analysis Report
Canyon Fuel Company
Dugout Canyon Mine
P.O. Box 1029
Wellington, UT 84542

Report ID: S0707453001

Project: Dugout Canyon Mine

Date: 8/6/2007

Date Received: 7/26/2007

Work Order: S0707453

Lab ID	Sample ID	Depths cm	Sand			Silt			Clay			Texture	Coarse Fragment %
			%	%	%	%	%	%	%	%			
S0707453-001	G-20 SP1	0-30	49.0	28.0	23.0	Loam	0.03						
S0707453-002	G-20 SP1	30-	35.0	41.0	24.0	Loam	0.02						
S0707453-003	AMV Road SP1	0-30	20.0	46.0	34.0	Clay Loam	0.06						
S0707453-004	AMV Road SP1	30-48	17.0	48.0	35.0	Silty Clay Loam	0.24						
S0707453-005	AMV Road SP2	0-6	15.0	53.0	32.0	Silty Clay Loam	5.71						
S0707453-006	AMV Road SP2	6-36	6.0	66.0	28.0	Silty Clay Loam	3.41						

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, Py/S= Pyritic Sulfur, Py+Org= Pyritic Sulfur + Organic Sulfur, Neutral Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor

Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company

Dugout Canyon Mine

P.O. Box 1029

Wellington, UT 84542

Report ID: S0707453001

Date: 8/6/2007

Work Order: S0707453

Project: Dugout Canyon Mine

Date Received: 7/26/2007

Lab ID	Sample ID	Depths cm	Nitrogen				
			Boron ppm	TKN %	Nitrate ppm	Phosphorus ppm	Selenium ppm
S0707453-001	G-20 SP1	0-30	0.40	0.10	1.88	8.45	<0.02
S0707453-002	G-20 SP1	30-	0.52	0.19	5.10	20.0	<0.02
S0707453-003	AMV Road SP1	0-30	0.40	0.21	0.66	2.41	<0.02
S0707453-004	AMV Road SP1	30-48	0.33	0.14	0.50	1.29	<0.02
S0707453-005	AMV Road SP2	0-6	0.32	0.13	0.21	1.14	<0.02
S0707453-006	AMV Road SP2	6-36	0.21	0.08	0.29	<0.01	<0.02

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyRS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral, Pot= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by:

Karen A Secor

Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company

Dugout Canyon Mine
P.O. Box 1029
Wellington, UT 84542

Report ID: S0707379001

Date: 8/7/2007

Work Order: S0707379

Project: Dugout Canyon Mine

Date Received: 7/23/2007

Lab ID	Sample ID	Depths cm	Electrical				Field Capacity %	Willt Point %
			pH s.u.	Saturation %	Conductivity dS/m	Capacity %		
S0707379-001	G-19 SP1	0-90	7.5	33.8	0.46	15	10	
S0707379-002	G-19 SP1	90-150	8.0	37.6	0.20	15	11	
S0707379-003	G-19 SP2	0-20	7.6	57.3	0.44	24	18	
S0707379-004	G-19 SP2	20-80	7.8	37.7	0.31	16	11	

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S. = Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot = Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by:

Karen A Secor

Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company

Dugout Canyon Mine

P.O. Box 1029

Wellington, UT 84542

Report ID: S0707379001

Date: 8/7/2007

Work Order: S0707379

Project: Dugout Canyon Mine

Date Received: 7/23/2007

Lab ID	Sample ID	Depths cm	Calcium	Magnesium	Sodium	Potassium	SAR
			meq/L	meq/L	meq/L	meq/L	
S0707379-001	G-19 SP1	0-90	4.31	1.46	0.34	0.20	0.20
S0707379-002	G-19 SP1	90-150	2.05	1.08	0.16	0.12	0.13
S0707379-003	G-19 SP2	0-20	3.87	0.74	0.25	0.23	0.16
S0707379-004	G-19 SP2	20-80	2.74	0.61	0.23	0.28	0.18

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, Pyr/S= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor

Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company

Dugout Canyon Mine

P.O. Box 1029

Wellington, UT 84542

Report ID: S0707379001

Date: 8/7/2007

Work Order: S0707379

Project: Dugout Canyon Mine

Date Received: 7/23/2007

Lab ID	Sample ID	Depths cm	Total		T.S.		Neut.		T.S.		Total Carbon %	TOC %	Available Sodium meq/100g	Exchangeable Sodium meq/100g
			Sulfur %	AB /1000t	Pot. /1000t	ABP /1000t	Carbon %	TOC %						
S0707379-001	G-19 SP1	0-90	0.02	0.68	442	441	6.6	1.3	0.03	0.02				
S0707379-002	G-19 SP1	90-150	<0.01	<0.01	463	463	5.9	0.4	0.03	0.02				
S0707379-003	G-19 SP2	0-20	0.01	0.43	162	162	5.8	3.9	0.03	0.01				
S0707379-004	G-19 SP2	20-80	<0.01	<0.01	185	185	3.4	1.2	0.03	0.02				

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2OSol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by:

Karen A Secor

Secor, Soil Lab Supervisor



Soil Analysis Report
Canyon Fuel Company
Dugout Canyon Mine
P.O. Box 1029
Wellington, UT 84542

Report ID: S0707379001

Project: Dugout Canyon Mine

Date: 8/7/2007

Date Received: 7/23/2007

Work Order: S0707379

Lab ID	Sample ID	Depths cm	Sand		Silt		Clay		Texture	Coarse Fragment	
			%	%	%	%	%	%			
S0707379-001	G-19 SP1	0-90	36.0	44.0	20.0	Loam	19.8				
S0707379-002	G-19 SP1	90-150	8.0	56.0	36.0	Silty Clay Loam	22.1				
S0707379-003	G-19 SP2	0-20	36.0	39.0	25.0	Loam	11.2				
S0707379-004	G-19 SP2	20-80	37.0	38.0	25.0	Loam	12.8				

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2Osol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S. = Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A. Secor
Secor, Soil Lab Supervisor



Soil Analysis Report

Canyon Fuel Company

Dugout Canyon Mine

P.O. Box 1029

Wellington, UT 84542

Report ID: S0707379001

Date: 8/7/2007

Work Order: S0707379

Project: Dugout Canyon Mine

Date Received: 7/23/2007

Lab ID	Sample ID	Depths cm	Nitrogen				
			Boron ppm	TKN %	Nitrate ppm	Phosphorus ppm	Selenium ppm
S0707379-001	G-19 SP1	0-90	0.40	0.13	1.72	3.88	<0.02
S0707379-002	G-19 SP1	90-150	0.18	0.07	0.35	<0.01	<0.02
S0707379-003	G-19 SP2	0-20	0.70	0.20	1.71	26.3	<0.02
S0707379-004	G-19 SP2	20-80	0.42	0.11	1.46	6.80	<0.02

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H2Osol= water soluble, AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, Pyrs= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral, Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by:

Karen A Secor

Secor, Soil Lab Supervisor

**ATTACHMENT 2-2
TOPSOIL CALCULATIONS**



Stockpile Dimensions and Volumes

Stockpile	Length (ft)	Width (ft)	Height (ft)	Volume (yd ³)
STP-1	85	50	20	765
STP-2	90	40	22	625
STP-3	205	120	25	5,120
STP-4	150	110	25	6,000
STP-5	150	70	25	1,820
STP-6	200	50	22	1,085
STP-7	125	62	15	4,305
				19,720

Notes

Stockpile locations are shown on the map.

Stockpile dimensions are approximate, and site conditions may affect their sizes and locations.

Stockpile volumes were calculated using AutoCAD Land Desktop Design 2008 software.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
~~September 4, 2007~~ July 9, 2007

CHAPTER 3
BIOLOGY

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
310 INTRODUCTION	3-1
311 Vegetative, Fish and Wildlife Resources	3-1
312 Potential Impacts to Vegetative, Fish and Wildlife Resources	3-1
313 Description of Reclamation Plan	3-1
320 ENVIRONMENTAL DESCRIPTION	3-1
321 Vegetation Information	3-1
321.100 Plant Communities Within the Proposed Permit Area	3-2
321.200 Land Productivity Prior to Mining	3-3
322 Fish and Wildlife Information	3-4
322.100 Level of Detail	3-5
322.200 Site-Specific Resource Information	3-5
322.300 Fish and Wildlife Service Review	3-10
323 Maps and Aerial Photographs	3-11
323.100 Location and Boundary of Proposed Reference Area	3-11
323.200 Elevation and Locations of Monitoring Stations	3-11
323.300 Facilities for Protection and Enhancement	3-11
323.400 Vegetation Type and Plant Communities	3-11
330 OPERATION PLAN	3-12
331 Measures Taken to Disturb the Smallest Area	3-12
332 Description of Anticipated Impacts of Subsidence	3-12
333 Plan to Minimize Disturbances and Adverse Impacts	3-12
333.100 Minimize Disturbance to Endangered or Threatened Species	3-13
333.200 Species and Habitats	3-13
333.300 Protective Measures	3-13

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
340 RECLAMATION PLAN	3-13
341 Revegetation	3-13
341.100 Schedule and Timetable	3-14
341.200 Descriptions	3-14
341.300 Greenhouse Studies, Field Trials or Other Equivalent Studies	3-15
342 Fish and Wildlife	3-15
342.100 Enhancement Measures	3-15
342.200 Plants Used for Wildlife Habitat	3-16
342.300 Cropland	3-16
342.400 Residential, Public Service, and Industrial Land Use	3-16
350 PERFORMANCE STANDARDS	3-16
351 General Requirements	3-16
352 Contemporaneous Reclamation	3-16
353 Revegetation: General Requirements	3-17
353.100 Vegetative Cover	3-17
353.200 Reestablished Plant Species	3-17
353.300 Vegetative Exception	3-18
353.400 Cropland	3-18
354 Revegetative: Timing	3-18
355 Revegetation: Mulching and Other Soil Stabilizing Practices	3-18
356 Revegetation: Standards for Success	3-20
356.100 Success of Revegetation	3-20
356.200 Standards for Success	3-20
356.300 Siltation Structures	3-21
356.400 Removal of Siltation Structures	3-21

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
357 Revegetation: Extended Responsibility Period	3-21
357.100 Extended Period Begins	3-22
357.200 Vegetation Parameters	3-22
357.300 Husbandry Practices	3-22
358 Protection of Fish, Wildlife, and Related Environmental Values	3-22
358.100 Existence of Endangered or Threatened Species	3-22
358.200 Bald and Golden Eagles	3-23
358.300 Taking of Endangered or Threatened Species	3-23
358.400 Replacement of Wetland or Riparian Vegetation	3-23
358.500 Manmade Wildlife Protection Measures	3-23

LIST OF FIGURES

Figure 3-1 Vegetation Reference Areas	3-24
Figure 3-2 Adjacent Vegetation	3-25

LIST OF TABLES

Table 3-1 Productivity and Percent Over Story	3-3
Table 3-2 Reclamation Seed Mix	3-19

LIST OF ATTACHMENTS

Attachment 3-1	Vegetation Inventory
Attachment 3-2	Threatened, Endangered, and Sensitive Species Information
Attachment 3-3	Information Moved to Confidential Folder in 2005

310 INTRODUCTION

This chapter presents a description of the biological resources found on the Dugout Canyon degas well site areas and the AMV road.

311 Vegetative, Fish and Wildlife Resources

Vegetative, fish, and wildlife resource conditions in and adjacent to the proposed degassification wells are discussed in Section 320 of this submittal and the approved M&RP.

312 Potential Impacts to Vegetative, Fish, and Wildlife Resources

Potential impacts to vegetative, fish, and wildlife resources and the associated mitigation plan is presented in Sections 330 and 340 of this chapter.

313 Description of Reclamation Plan

The reclamation plan used to restore the vegetative, fish, and wildlife resources to a condition suitable for the post mining land use is presented in Section 340.

320 ENVIRONMENTAL DESCRIPTION

321 Vegetation Information

This section and the approved M&RP contain the environmental descriptions of the vegetation for the permit and adjacent areas.

321.100 Plant Communities Within the Proposed Permit Area

During June 2003, the degassification well sites were surveyed by Patrick Collins, Mt. Nebo Scientific. The report and survey for the areas are included in Attachment 3-1. The site for G-6 was moved to a pre-disturbed exploration well pad, the plant communities described in Mr. Collins report reflect the undisturbed portions on the north and south edges of the well pad. Vegetation information for G-7 was obtained from a report prepared by the NRCS Range Management Specialist, Dean Stacy (refer to Attachment 2-1 and 3-1) and the Patrick Collins survey prepared for well site G-3. A photograph of the G-7 site is included in Attachment 3-1. Well site G-3 and the access road can be seen on the photograph.

A vegetation survey of well sites G-8 thru G-12 was completed in July 2005 by Patrick Collins, Mt. Nebo Scientific. These sites have all been pre-disturbed, with a road running through the center of G-8 and remnants of logging activity at both G-9 and G-10. Approximately fifty percent of the well pads at sites G-11 and G-12 are existing roads which have no topsoil or vegetation. The remaining area at site G-11 has been disturbed, except for a small portion on the west side of the site. Well site G-12 has evidence of disturbance above the road cut however both soil and vegetation are intact. The reports and surveys for the areas will be included in Attachment 3-1.

The vegetation survey of well sites G-13 thru G-17 were completed between July and September 2005. The reports and surveys for the areas are included in Attachment 3-1. At well site G-13, the surface ranges from relatively smooth and non-stoney to very stoney. Portions along the southeast edge are too stoney for soil salvage. The G-14 well site has been disturbed by logging. The road to G-13 and G-14 are existing roads, however, the soil will be bladed to the side of the road at site G-14 and replaced during reclamation.

Well site G-15 is about 50 percent disturbed by a road, slope cut and fill. The undisturbed portion of the site is a slope with a southeast aspect (35 to 45 percent gradient). Well site G-16 was previously the site of an exploration hole, having been disturbed and reclaimed. The topsoil on

the access road to G-16 will be bladed to one side of the road and replaced during reclamation. At well site G-17 approximately one-third of the site is an existing road.

The entire area of well site G-19 was previously disturbed by logging activities with two roads crossing through the area. Well site G-18 appears to be undisturbed, while G-31 has evidence of disturbance by logging and evidence of use by cattle. The AMV access road to pad G-31 has been used by cattle and hunters to access the top of the ridge. The portion of the AMV road which accesses well site G-18 appears to be undisturbed.

Per an exception granted by the Division during a meeting on April 16, 2007, vegetation on the AMV is being compared to quantitative vegetative analysis information surveyed for degassification well pads. Qualitative data recorded on the access road is discussed in "Vegetation of the De-Gas Sites G-18, G-31 & Reference Area", located in Attachment 3-1. The reference area for the AMV road is the same area as G-16, G-17, G-18 and G-31. The path of the AMV road is a trail used by livestock, hunters, wildlife and a length was disturbed by logging activities, as well as the other activities.

The vegetation on the AMV is similar if not identical to the vegetation analysis presented for degas wells pads G-18, G-19 and G-31. Segment A (approximately 1100 feet) of the road parallels a drainage, the road is on the west side of the drainage and drill pad G-19 is on the east side of the same drainage. The vegetation on Segment A is similar to the vegetation surveyed on Degas pads G-18 and G-31. Segment B approximately 700 feet mimics the soil type and vegetation on the G-19 pad site. A second similarity to the G-19 pad is that Segment B of the road has also been disturbed by logging, containing slash piles and skid trails, this area has experienced natural recovery, except for the width of the trail. Segment C, includes the remainder of the road. Segment C mimics the vegetation on drill pads G-18 and G-31. A drawing of the road, being included to show the segments described above, is provided in Attachment 3-1.

An area approximately 100 x 100 feet on drill pad G-18 was disturbed by logging activity and has experienced natural recovery.

321.200 Land Productivity Prior to Mining

Productivity of the well site lands and the AMV road prior to mining are shown in Table 3-1. Refer to Appendix 3-1 for a copy of the NRCS letter pertaining to productivity.

TABLE 3-1
Land Productivity

Well No.	Productivity (lbs.) Per Acre
G-1 (Previously Disturbed)	100
G-2	1,500*
G-3	1,500*
G-4 (Previously Disturbed)	150
G-5	1500*
G-6 (Majority Previously Disturbed)	300*
G-7	1200*
G-8 (Previously Disturbed)	1200
G-9 (Previously Disturbed)	1000*
G-10 (Previously Disturbed)	1000*
G-11 (Previously Disturbed)	1000*
G-12 (Previously Disturbed)	1000*
G-13	1000*
G-14 (Previously Disturbed)	1000*
G-15 (Previously Disturbed)	1000*
G-16 (Previously Disturbed)	1000*

G-17 (Previously Disturbed)	1000*
G-18	900 - 1200*
G-19 (Previously Disturbed)	500 - 800*
G-31 (Previously Disturbed)	900 - 1200*
Access Road - AMV (Previously Disturbed)	900 - 1200*
Reference Areas	
Sagebrush/Snowberry/Grass (G-2, G-3, G-4, G-5, and G-7)	1,500*
Aspen/Maple/Douglas Fir (G-1, G-6, and G-8)	300*
Mountain Brush/Conifer (G-9 thru G-11)	1200
Conifer/Mountain Brush/Pinyon Juniper (G-12, G-13 and G-15)	1100
Aspen/Conifer (G-14 and G-19)	300
Mountain Brush/Snowberry (G-16, G-17, G-18 and G-31, AMV Access Road)	1400

* Community composition is experiencing a declining trend, with decrease in herbaceous production, increase in shrub/tree production.

322 Fish and Wildlife Information

Fish and wildlife information associated with the degas wells is provided in this chapter. A summary of the fish and wildlife resource information for the permit and adjacent areas is contained in Sections 322.100 through 322.200 of the approved M&RP.

322.100 Level of Detail

The scope and level of detail within the "Methane Degassification Amendment" are sufficient to design the protection and enhancement plan for wildlife and fish associated with the degas wells. Additional information pertaining to fish and wildlife in the permit area is located in the M&RP.

322.200 Site-Specific Resource Information

Raptors - An aerial raptor nest survey was done of the area by the Utah Division of Wildlife Resource (DWR, Chris Colt, Leroy Mead) and CFC personnel in May of 2003, refer to the Confidential Folder. Surveys were completed in May of 2004 and 2005, the information has been incorporated into the Confidential Folder.

No raptor nests were recorded during the survey (2003) in the area (portions of N1/2SE1/4NW1/4 and N1/2SW1/4NE1/4 of Section 24; a portions of N1/2SW1/4NW1/4 Section 19, Township 13 South, Range 13 East) of the degas wells. Refer to Figure 1-1 for mapped well locations.

During the 2004 raptor survey, there were no active or tended nests identified in the vicinity of the degas wells. During the 2005 raptor survey (May 12 & 20), there were no active or tended nests identified in the vicinity of degas wells G-9 and G-10. Two golden eagles nests were observed in the cliffs adjacent to degas well G-8 (Nest 9, DWR 2005 Raptor Survey). A single young eagle was observed, but habitually vacates the nest within 45 days of birth. A raptor survey will be conducted of the well site areas, each year that the wells are in operation.

A raptor survey was performed by Division of Wildlife Resources personnel in May 2006, a copy of the written log is included with deficiencies for Task ID #2456 (located in the confidential folder). Nest 424 when inventoried during the 1998 annual raptor survey was determined to be an inactive raven nest and was not found or inventoried again until 2004 when it was listed as inactive. Nest 424 was not inventoried or found during the annual raptor surveys in 2005 and 2006 by the Division of Wildlife Resources.

During a ground-truthing by Leroy Mead of the Division of Wildlife Resources on July 11, 2006, the two well sites with potential habitat for NSO and northern goshawks were G-14 and G-17. A calling survey will be performed if drilling at either of these sites will begin prior to the end of the exclusionary period, described as July 15.

Well G-14 will be drilled in 2006 after July 15. Well G-17 is to be drilled in 2009, the date for drilling will be scheduled according to the availability of drilling companies and a calling survey if needed will be performed at that time. If a calling survey is performed, the results will be incorporated into the confidential folder.

A Northern Goshawk calling survey was performed in July of 2003 for four weeks in the area of well site G-17. According to the survey there was no response from a northern goshawk. A copy of this survey is located in the confidential binder.

On July 12, 2006, Nest 9 a golden eagle nest was inventoried on the ground by Leroy Mead, although there is evidence of disturbance associated with subsidence in the area, the nest was not disturbed. The 2006 raptor survey lists Nest 9 as being tended.

The G-19 well site was inventoried by Leroy Mead in November 2006 and on June 11, 2007, no wildlife concerns were noted. The area was part of the annual raptor survey, no nest are located in the area.

Well sites G-18, G-31 and the AMV access road were inventoried by Leroy Mead on June 11, 2007, no wildlife concerns were noted. Cattle were observed along the road and on the G-31 well pad site. The area was part of the annual raptor survey, no nests are located in the area.

Bats - No known open mine shafts, caves, adits or other man made structures that might provide habitats for bats are known to exist in the degas project area. The sites are open and the lack of a food source would force the bats to seek habitat and nourishment elsewhere.

During June of 2005 a bat survey was performed by JBR Environmental Consultants, Inc, on Pace Creek. Site/stop #6 was in the W1/2SE1/4 of Section 20, Appendix 3-3 of M&RP, Confidential Folder, Figure 1, this stop was the closest to the proposed AMV road and drill pads G-18 and G-19. In the summary of the report it states "the nearly constant bat activity at the Stop #7 pond suggests that this water feature is an important resource for bats in terms of both water and feeding." The Stop #7 pond is approximately one mile east of Site/stop #6, drill sites G-18, G-19 and the AMV road and will not be disturbed in association with these mining activities. The same pond is approximately 1.5 miles from drill pad G-31 and the portion of the AMV road which connects the G-31 and G-18 pads. According to the JBR consultants the pond surveyed at Site/stop #7 which is at a minimum one mile east of the road and drill sites is likely the water source used by the bats in the area.

According to the 2005 survey only the Fringed Myotis is listed as a bat species of concern when compared with the Utah Sensitive Species list dated October 17, 2006. "Concerning the fringed myotis, of the 3,246 recordings, 10 were identified as showing nearly conclusive patterns to that known for the species. The 10 good recordings occurred over 3 consecutive nights at Station 7, located at the east edge of the Inventory Area. It is unknown if the species actually utilizes the Inventory Area for roosting or if it just visits the pond for foraging (JBR, 2005)." The remainder of the 3,236 bat calls recorded during the survey were not identified as being from Utah Sensitive Species.

On the nights of May 21 and 22, 2007 JBR Environmental Consultants, Inc conducted bat surveys along the northern cliffs of Pace Creek Canyon. The inventory area of the survey included portions of Sections 16, 17, 18, 19, 20 and 21 T13SR13E. Pad G-19 was within the area inventoried. During the two night of recording bat calls, no bat call files were produced. A copy of the inventory report cover and page one have been included, once the complete final report is received it will be incorporated into Attachment 3-2. The survey was requested by Division personnel to address the potential for bat habitat in the cliffs adjacent to degas well pads, the AMV road and the permit area expansion to add Federal and SITLA leased acreage.

Mexican Spotted Owl - In the Summer of 2003, a calling point survey was conducted in the degas well area by EIS Environmental and Engineering Consulting. The survey report concluded that “within the project area, a thorough search did not reveal the presence of any Mexican spotted owls”. The report is included in Attachment 3-2. A second survey was completed in May of 2004, the information is incorporated into Appendix 3-3 of the M&RP .

Threatened and Endangered Plant and Wildlife Species - There are no known federally or state listed threatened and endangered plant and wildlife species within the sites planned for degassification wells **or for the AMV road.**

Bureau of Land Management Environmental Assessment No. UT-070-2001-83 and UT-070-2004-49 contain determination in accordance with the United States Fish and Wildlife Service’s protocols, for sites G-11, G-15, G-16 and G-17. The sites were inventoried for the presence of threatened, endangered, and sensitive faunal, and floral species in June of 2001, April, May and June of 2004, no species were found. In the assessment the sites were being used for exploration holes and were referenced by a different number which is in parenthesis following the degas well number G-11 (DT-2), G-15(DUG0204), G-16 (E) and G-17 (DUG0304).

Mt. Nebo Scientific, Inc. conducted a survey of Pad G-18, G-19, G-31 and the AMV access road no rare, endemic, threatened or endangered or otherwise sensitive species were found in the study area (Attachment 3-1).

There are no known groundwater or surface water flows to the Colorado or Green Rivers with

There are no known groundwater or surface water flows to the Colorado or Green Rivers with potential for impact by the drilling of the degas wells. Potential adverse affects to the four Colorado River endangered fish species (refer to table below) would not be likely since there is no direct route to the Colorado River or Green River from the proposed well locations. Per the Windy Gap Process (referenced by personal communication Jerriann Ernstsens, 8/19/03) consumption estimates for the degas wells: evaporation from ventilation - zero, drill holes will not intersect the coal seam being mined, therefore no access to mine ventilation until after area is sealed; coal

18.1 in/yr (high estimate based on HCI Technical Memo, August 22, 2002)
0.16 ac/ft
7030 gallons/yr
Refuse Pile Pond
0.41 acres (surface area)
9 in/yr
0.31 ac/ft
5612 gallons/yr (high estimate)

Spring and Seeps Effects From Subsidence - Not Applicable

Alluvial Aquifer Abstractions into Mines - Not Applicable

Alluvial Well Pumpage - Not Applicable

Deep Aquifer Pumpage - Not Applicable

Postmining Inflow to Workings - Not Applicable

Direct Diversions: - Not Applicable

Dust Suppression - 1,000 gallons per truck load, 3 load per day, for 335 days = 1,005,000 gallons plus 1,000 per truck load, 1 load per day, for 193 days = 193,000. Total: 1,198,000 gallons per year.

Mine Discharge: 6 Month Average 420,537gpd = 155,260,050 gal/yr

Calculation estimates for water use in 2005 were necessary since we are using 2005 purchases and usage and the year is 2 months short.

**Utah's Federally (US F&WS) Listed
Carbon County, Utah - County of Occurrence
08/27/07**

<u>Common Name</u>	<u>Scientific Name</u>	<u>Status</u>	<u>Habitat Present*</u>
Plants Species			
Uinta Basin Hookless Cactus	Sclerocactus glaucus T		No habitat available
Fish Species			
Humpback Chub	Gila cypha	E	No habitat available
Bonytail	Gila elegans	E	No habitat available
Colorado Pikeminnow	Ptychocheilus lucius	E	No habitat available
Razorback Sucker	Xyrauchen texanus	E	No habitat available
Birds			
Yellow-billed Cuckoo	Coccyzus americanus	C	No habitat available
Mammals			

Black-footed Ferret *Mustela nigripes*

E/EXP No habitat available

* Habitat availability in Carbon County/Dugout Mine/Degas Well Sites and AMV road.

E = A taxon that is listed by the U.S. Fish and Wildlife Service as "endangered" with the possibility of worldwide extinction.

E/EXP = E Experimental - An endangered taxon that is considered by the U.S. Fish and Wildlife Service to be experimental and non-essential in its designated use areas in Utah.

T = A taxon that is listed by the U.S. Fish and Wildlife Service as "threatened" with becoming endangered.

C = A taxon for which the U.S. Fish and Wildlife Service has on file sufficient information on biological vulnerability and threats to justify it being a "candidate" for listing as and endangered or threatened.

Source: Utah Division of Wildlife Resources - created 8/27/2007(Attachment 3-2)

Utah Sensitive Species List

October 17, 2006

State of Utah, Department of Natural Resources, Division of Wildlife Resources

Federally Threatened Species

Bird Species

Bald Eagle	<i>Haliaeetus leucocephalus</i>	T	No habitat available See Confidential Folder
Mexican Spotted Owl	<i>Strix occidentalis lucida</i>	T	No habitat available See Attachment 3-2 and Appendix 3-3 (M&RP)

Refer to Attachment 3-2 for a listing of Federal and State Listed, Threatened, Endangered and Candidate Species., ~~Plants and Wildlife of Carbon County, Utah (2003).~~

322.300 Fish and Wildlife Service Review

If requested, Dugout Canyon authorizes the release of information pertaining to Section 322 and 333 to the U. S. Fish and Wildlife Service Regional and Field Office for their review. On the 25th of May 2005, Leroy Mead of the DWR toured degas well sites G-8, G-9, G-10, G-11 thru G-14. During the tour no wildlife concerns were noted.

The G-18, G-19 and G-31 well sites, as well as, the AMV access road was inventoried by Leroy Mead on June 11, 2007 and no concerns were noted.

323 Maps and Aerial Photographs

Location of the well sites can be seen in Figure 1-1 of this submittal. The AMV road is shown on Plate , in Attachment 5-4.

323.100 Location and Boundary of Proposed Reference Area

Reference areas for the degassification wells were established during the vegetative study conducted in the Summer of 2003. Well sites G-2, G-3, G-4, G-5, and G-7 will be compared to the Sagebrush/Snowberry/Grass reference area and G-1, G-6, and G-8 to the Aspen/Maple/Douglas Fir reference area. Mountain Brush and Conifer is the reference area for well sites G-9 thru G-11. The reference area for Degas Well G-12 , G-13 and G-15 is Conifer, Mountain Brush and Pinyon Juniper. The reference area for Degas Well G-14 and G-19 is Aspen/Conifer, the reference area for G-16 thru G-18, G-31 and the AMV access road is Mountain Brush/Snowberry. Refer to Attachment 3-1 and Figure 3-1 for the location of the reference areas associated specifically with the degas wells. Reference areas are also shown on Plate 3-1 and 3-1E in the M&RP.

323.200 Elevation and Locations of Monitoring Stations

Refer to Section 323.200 of the approved M&RP.

323.300 Facilities for Protection and Enhancement

Section 333.300 and 358.500 of the approved M&RP contain additional discussion pertaining to protective measures to be taken by Dugout Canyon on behalf of wildlife.

323.400 Vegetation Type and Plant Communities

Vegetative types and plant communities are outlined in the vegetative report in Attachment 3-1. Figure 3-2 and the vegetation drawing in Attachment 3-1 (Vegetation, Sections 19 and 20, Township 13 S R13 E) give details of the vegetation types located adjacent to the well sites and the AMV road.

330 OPERATION PLAN

331 Measures Taken to Disturb the Smallest Particle Area

The well sites will be sized to disturb the smallest acreage possible and still meet the requirements for the drilling equipment. The AMV road will be constructed disturbing the small area possible. The drainage control required will be built to satisfy the environmental requirements.

332 Description of Anticipated Impacts of Subsidence

Refer to Section 525.

333 Plan to Minimize Disturbances and Adverse Impacts

General control and mitigation measures addressing potential related biological impacts will include the following:

- Minimizing the total area of disturbance,
- Design, construction, and operation of the well sites and AMV road to minimize impacts
- Establishment of stream buffer zones
- Control of surface discharges
- Exclusion of wildlife from potentially hazardous areas, and

- Reclamation of disturbed areas when they are no longer needed.

All water associated with the drilling of these wells will be appropriated and hauled and/or pumped to the sites by a licensed contractor. Since the drilling of degas wells does not involve the mining of coal, the USWFS consumption requirements for underground operations do not apply (i.e., evaporation from ventilation, coal preparation, sediment pond evaporation, subsidence of springs, alluvial aquifer abstractions into the mine, postmining inflow to workings, coal moisture loss, direct diversions).

As inventoried by the Division of Wildlife Resources in 2003, 2004, 2005 and 2006, Nest 424 was determined to be a raven's nest, which was either inactive, not inventoried or found. Wells G-13, G-14 were drilled post July 15th. Wells G-18, G-19 and G-31 will be drilled post September 1st. ~~after the exclusionary period for NSO and northern goshawks.~~

333.100 Minimize Disturbance to Endangered or Threatened Species

Dugout Canyon will apply all methods necessary to minimize disturbances or any adverse effects to threatened or endangered species. See Section 322.200.

333.200 Species and Habitats

All species and habitats within the permit area will be protected to the best of Dugout Canyon's ability.

333.300 Protective Measures

Refer to Section 333.300 of the approved M&RP.

[AMV Road - Protection of Upper Channel](#)

Probable Hydrologic Consequences within the area associated with the road is discussed in Section 728.300 and Attachment 7-1, buffer zone designation is discussed in Section 731.600, road drainage is further discussed in Sections 732.400 and 742.400.

Silt fencing will be used at the down hill toe of the slope of the road fill during road construction and reclamation to capture loose soils and rocks. A diagram of the AMV road is provided in Attachment 7-1, during the operation phase the road will have a ditch, berm and culverts with rip rapped outlets to collect and treat road runoff. Outslopes and ditches associated with the road will be seeded during operations to encourage the establishment of vegetation and for erosion control.

A spring designated at SC-96 on Plate 7-1 (M&RP) was not flowing during the months of permitting preparations for the AMV road. Employees of Dugout Canyon Mine were traversing the area in May thru August, during that time no flow from the spring was observed.

340 RECLAMATION PLAN

341 Revegetation

Revegetation of the sites will occur in two phases at drill site G-2. The first phase is to redistribute topsoil and seed the well area not needed for access and operation of the gas exhaust blower. The second phase will consist of plugging the well and distributing the remaining topsoil and seeding on the remaining pad area. Complete final reclamation at well sites G-2, G-5 and G-7 will be delayed, refer to Section 242.100 for additional detail and Attachment 5-2. Sites G-3, G-4, G-6, G-8 (never constructed), G-9, G-10, G-11 thru G-19 and G-31 will be reclaimed in one phase. A separate reclamation schedule has been proposed for the AMV road, it will be needed to access the degas wells during and following reclamation (Figure 5-26).

The short-term goal of this revegetation plan is the immediate stabilization of the disturbed sites through erosion control. This objective will be achieved through controlled grading practices, proper seedbed preparation to encourage rapid plant establishment, inclusion of rapidly establishing species in the seed mixture to be planted, and mulch application.

The long-term goals are to establish useful, and productive range. These goals will be attained through the selection and placement of desirable and productive plant species and a commitment to monitor and maintain revegetated areas throughout the bond liability period.

The well sites will be fenced to discourage wildlife and livestock from grazing the reclaimed areas until bond release.

341.100 Schedule and Timetable

The reclamation timetable is shown in Figures 5-15 (G-2) and 5-26 (G-3 thru G-19, G-31 and AMV access road) of this submittal and the reclamation monitoring schedule is found in Chapter 3, Table 3-3 of the approved M&RP.

341.200 Descriptions

Species and Amounts of Seed - The well sites and AMV road will be planted with the seed mix listed on Table 3-2. The seed mix will be used in both contemporaneous and final reclamation phases. The seed will be incorporated with a small amount of wood fiber mulch and applied by hydroseeding equipment or broadcast. Refer to Section 234.200 for topsoil stockpile seeding description.

Methods Used for Planting and Seeding - The degassification sites will be graded to final contour, then ripped to relieve compaction. The depth of ripping will be from 18 to 24 inches. Following ripping, topsoil will be applied to the ripped surface and left in a gouged and roughened state.

Mulching Techniques - Wood fiber mulch will be applied on top of the seed with hydroseeding equipment at the rate of 2,000 pounds per acre and anchored with a tackifier in amounts specified by the manufacturer.

Irrigation, Pest, and Disease Control - No irrigation is planned and pesticides will not be used unless previously approved by the Division.

Measures Proposed for Revegetation Success - Refer to Section 356.

341.300 Greenhouse Studies, Field Trials or Other Equivalent Studies

Refer to the Section 341.300 of the approved M&RP.

342 Fish and Wildlife

342.100 Enhancement Measures

Post bond release enhancement measure will include the establishment of vegetation for wildlife food, cover, and the break up of large blocks of monoculture to diversify habitat. The current blocks of monoculture include large area of sagebrush and mixed brush. According to Dean Stacy, Range Management Specialist, USDA-NRCS "past management practices have allowed the shrub (mainly mountain sage brush) to surpass the 25-35%, while the herbaceous production has declined". By planting reclamation seed mixes with grasses and forbs the planted areas will breakup the monocultures and provide a future seed source.

In consultation with UDWR (Tony Wright, July 6, 2004) and UDOGM (Jerriann Ernstsens, July 6, 2004) a mitigation project was designated for the Northern Saw Whet Owl to compensate for drilling during the exclusionary period. The project will be completed prior to October 1, 2004. The project will include the construction and installation of 6 to 10 nest boxes on property owned by Canyon Fuel Company, LLC. Because of the UDWR knowledge and experience their personnel will choose the location and install the boxes. Information (goals, procedures, agencies, dates, box locations - township, range, section) concerning the owl mitigation project will be included in the annual report for 2004.

342.200 Plants Used for Wildlife Habitat

Nutritional Value - The nutritional value will be consistent with that of vegetation in the surrounding areas.

Cover - Cover will be comparable to the cover on the associated reference area.

342.300 Cropland

Cropland is not a postmining land use.

342.400 Residential, Public Service, and Industrial Land Use

No residential, industrial or public service use is planned.

350 PERFORMANCE STANDARDS

351 General Requirements

Dugout Canyon commits to conduct all operations in accordance with the plans submitted in Sections R645-301-330 through R645-301-340 of the permit application.

352 Contemporaneous Reclamation

Reclamation activities prior to final reclamation will to the extent feasible, be preformed contemporaneously. Contemporaneous reclamation will be performed at the well sites following construction of the wells. Refer to Section 341 for additional details.

353 Revegetation: General Requirements

A vegetative cover will be established on all reclaimed areas to allow for the designated postmining land use of grazing. Refer to Section 411 for additional information.

353.100 Vegetative Cover

The seed mix proposed for revegetation is intended to provide vegetative cover that will be diverse, effective, and permanent. The seed mixture was selected with respect to the climate, potential seedbed quality, erosion control, drought tolerance, and the mixture's ability for quick establishment and spreading.

Native Species - The reclamation vegetation mixture will be comprised of species indigenous to the area and capable of achieving the postmining land use. Diversity of species should allow utilization of plants by wildlife and domestic livestock. The recommended seed mix is comprised of native species.

Extent of Cover - The vegetative cover will be at least equal in extent to the cover at the designated reference areas.

Stabilizing - The vegetative cover mixture is capable of stabilizing the soil surfaces from erosion.

353.200 Reestablished Plant Species

Compatible - The reestablished plant species have been selected to insure their compatibility with the approved postmining use.

Seasonal Characteristics - The revegetation plant species will have the same growing season as the adjacent areas.

Self-Generation - The reestablished plants are species capable of self-generation and plant succession.

Compatibility - The seed mix suggested for revegetation contains plants native to the area and compatible with the plant and animal species of the permit area.

Federal and Utah Laws or Regulations - The seed mix purchased to revegetate the degassification well sites and **AMV road** will contain no poisonous or noxious plant (see Section 234.200). No species will be introduced in the area without being approved by the Division.

353.300 Vegetative Exception

Dugout Canyon does not require vegetative exception at this time.

353.400 Cropland

The permit area contains no land designated as cropland.

354 Revegetative: Timing

Dugout Canyon will follow the recommended guidelines for revegetation and planting during the first normal period for favorable planting conditions after replacement of the topsoil. In Utah the planting period is usually Fall due to the precipitation events.

355 Revegetation: Mulching and Other Soil Stabilizing Practices

Mulch and/or other soil stabilizing practices (roughing, etc.) will be used on all areas that have been regraded and covered by topsoil (Section 341.200). Dugout Canyon Mine will exercise care to guard against erosion during and after application of topsoil.

Table 3-2
Reclamation Seed Mix

<u>SPECIES</u>	<u># pls/acre</u>	<u># pls/sq. ft.**</u>
Grasses, Forbs, and Shrubs		
Kentucky Bluegrass (1,390,000 seeds/lb)*	0.5	16
Mountain Brome (64,000 seeds/lb)*	2.0	3
Sandberg Bluegrass (1,100,000 seeds/lb)*	1.0	25
Bluebunch Wheatgrass (126,000 seeds/lb)*	4.0	12
Bottlebrush Squirreltail (192,000 seeds/lb)*	1.0	4
Rocky Mountain Penstemon (478,000 seeds/lb)*	1.0	11
Mountain Lupine (12,000 seeds/lb)*	3.0	1
Mtn. Snowberry (54,000 seeds/lb)*	4.0	5
Wyoming Big Sage (2,500,000 seeds/lb)*	<u>0.5</u>	<u>29</u>
TOTAL	17	106

* Native Plants

** Rounded nearest whole seed

Grass seed quantities will be doubled if the area is broadcast seeded.

356 Revegetation: Standards for Success

356.100 Success of Revegetation

The success of revegetation will be judged on the effectiveness of the vegetation for postmining land use, the extent of cover on each degassification well site and the AMV road compared to their respective reference areas.

Sampling Techniques - Dugout Canyon will comply with the standards for success, statistically valid sampling techniques for measuring success, and the approved methods outline in the Division's "Vegetation Information Guidelines, Appendix A" for sampling.

The sampling methods to be used during reclamation will be specific to the requirements at the time of reclamation. Nonetheless, according to the currently approved UDOGM guidelines, these sampling methods would be used: sample adequacy, cover (line interception), density (belt transects or plots) and productivity (clipping). The Jaccard's Community Coefficient will be used to calculate acceptable plant similarity and diversity.

Standards for Success - The standards for success will include criteria representative of undisturbed lands in the area of the degas wells as means to evaluate ground cover, production and stocking of the reclaimed site.

356.200 Standards for Success

Standards of success will be applied in accordance with the approved postmining land use as described in this section.

Grazing Land and Pasture Land - The ground cover and production of living plants on the revegetated area will be at least equal to the reference area.

Cropland - There is no area designated as cropland within the degassification well sites or the area of the AMV road.

Fish and Wildlife Habitat - The postmining land use for the degas well sites and AMV road will be grazing, except on pre-existing roads or trails. Pre-existing roads will be returned to their approximate original contour and compacted.

Industrial, Commercial or Residential - The postmining land use for the permit area is not designated for industrial, commercial, or residential use.

Previously Disturbed Areas - Site G-1 (never constructed), G-4, G-6, G-7, G-8 (never constructed), G-9, G-10, G-11, G-12, G-14, G-15, G-16, G-17, G-19, G-31 and AMV access road have been previously disturbed. The AMV access road was previously used for logging, as a trail for hunting and for cattle to access the site of degas well G-31, the road from G-31 to G-18 has not been disturbed. Sites G-2, G-3, G-5, G-13 and G-18 have not been previously disturbed. Standards of success for all sites will be applied in accordance with the postmining land use of grazing as described in this section.

356.300 Siltation Structures

Siltation structures will be maintained until the disturbed areas have been stabilized and revegetated. For additional details on siltation structures, see Sections 542 and 763 of this amendment.

356.400 Removal of Siltation Structures

The land on which siltation structures are located will be revegetated in accordance with the reclamation plan discussed in Section 353 and 357. Refer to Section 763 for addition information pertaining to the removal of siltation structures.

357 Revegetation: Extended Responsibility Period

Dugout Canyon will be responsible for the success of revegetation for a period of 10 years following seeding of the reclaimed area or upon Division bond release.

357.100 Extended Period Begins

The period of extended responsibility will begin after disturbed areas have been reseeded.

357.200 Vegetation Parameters

Vegetation parameters will equal or exceed the approved success standard during the last 2 years of the responsibility period. The success standards are outline in Section 356 of this application.

357.300 Husbandry Practices

The use of husbandry practices are not being requested by Dugout Canyon for the degas well sites ~~and the AMV road~~.

358 Protection of Fish, Wildlife, and Related Environmental Values

Dugout Canyon will minimize disturbances and adverse impacts on wildlife and their related environments as outline in Section 333 of the approved M&RP and ~~Sections 333~~ and 342 of this submittal. See Chapter 7, Section 731.100 of the approved M&RP for methods to protect water sources in the area.

358.100 Existence of Endangered or Threatened Species

The well sites ~~and the AMV road~~ will not be constructed or operated where they might jeopardize the existence of any endangered or threatened species. Refer to Section 322.200 and

Attachments 3-1, 3-2 and 3-3 for additional information pertaining to threatened, endangered, and sensitive species.

State or federally listed endangered or threatened species will be reported to the Division upon its discovery.

358.200 Bald and Golden Eagles

Dugout Canyon understands that there is no permission implied by these regulations for taking of bald or golden eagles, their nests, or eggs. If found, nests will be reported to the Division.

358.300 Taking of Endangered or Threatened Species

Dugout Canyon understands that there is no permission implied by these regulations for taking of endangered or threatened species, their nests, or eggs.

358.400 Replacement of Wetland or Riparian Vegetation

The sites contain no wetland or riparian vegetation, unless specifically noted in the vegetation survey. **The disturbed area of the AMV road, outlined on Plate 1 (Attachment 5-4) contains no wetland or riparian vegetation.**

358.500 Manmade Wildlife Protection Measure

Electric Power Lines - No utilities will exist at the well sites **or on the AMV road.**

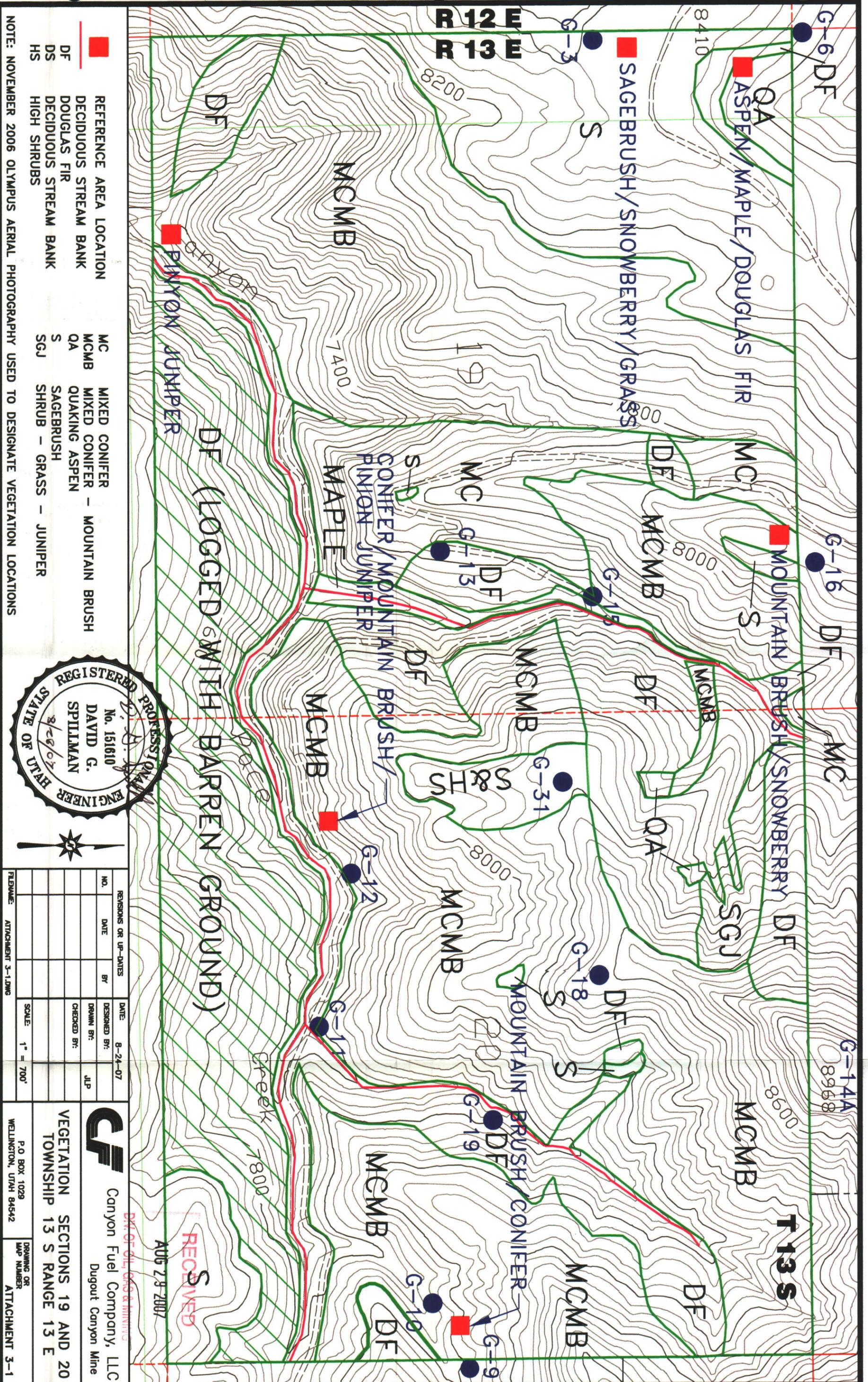
Potential Barriers - No potential barriers will exist at any of the well sites **or on the AMV road**, except for the perimeter fence **at the well sites**. No ponds exist at the well sites **or on the AMV road**. Refer to Sections 231.100 and 242 for information pertaining to the mud pit.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
~~September 4, 2007~~ July 9, 2007

**ATTACHMENT 3-1
VEGETATION INVENTORY
NRCS LETTER**

add to the back of existing information



NOTE: NOVEMBER 2006 OLYMPUS AERIAL PHOTOGRAPHY USED TO DESIGNATE VEGETATION LOCATIONS

- | | | | |
|----|-------------------------|------|--------------------------------|
| ■ | REFERENCE AREA LOCATION | MC | MIXED CONIFER |
| — | DECIDUOUS STREAM BANK | MCMB | MIXED CONIFER - MOUNTAIN BRUSH |
| DF | DOUGLAS FIR | QA | QUAKING ASPEN |
| DS | DECIDUOUS STREAM BANK | S | SAGEBRUSH |
| HS | HIGH SHRUBS | SGJ | SHRUB - GRASS - JUNIPER |



REVISIONS OR UP-DATES		DATE:		
NO.	DATE	BY	DESIGNED BY:	8-24-07
			DRAWN BY:	JLP
			CHECKED BY:	

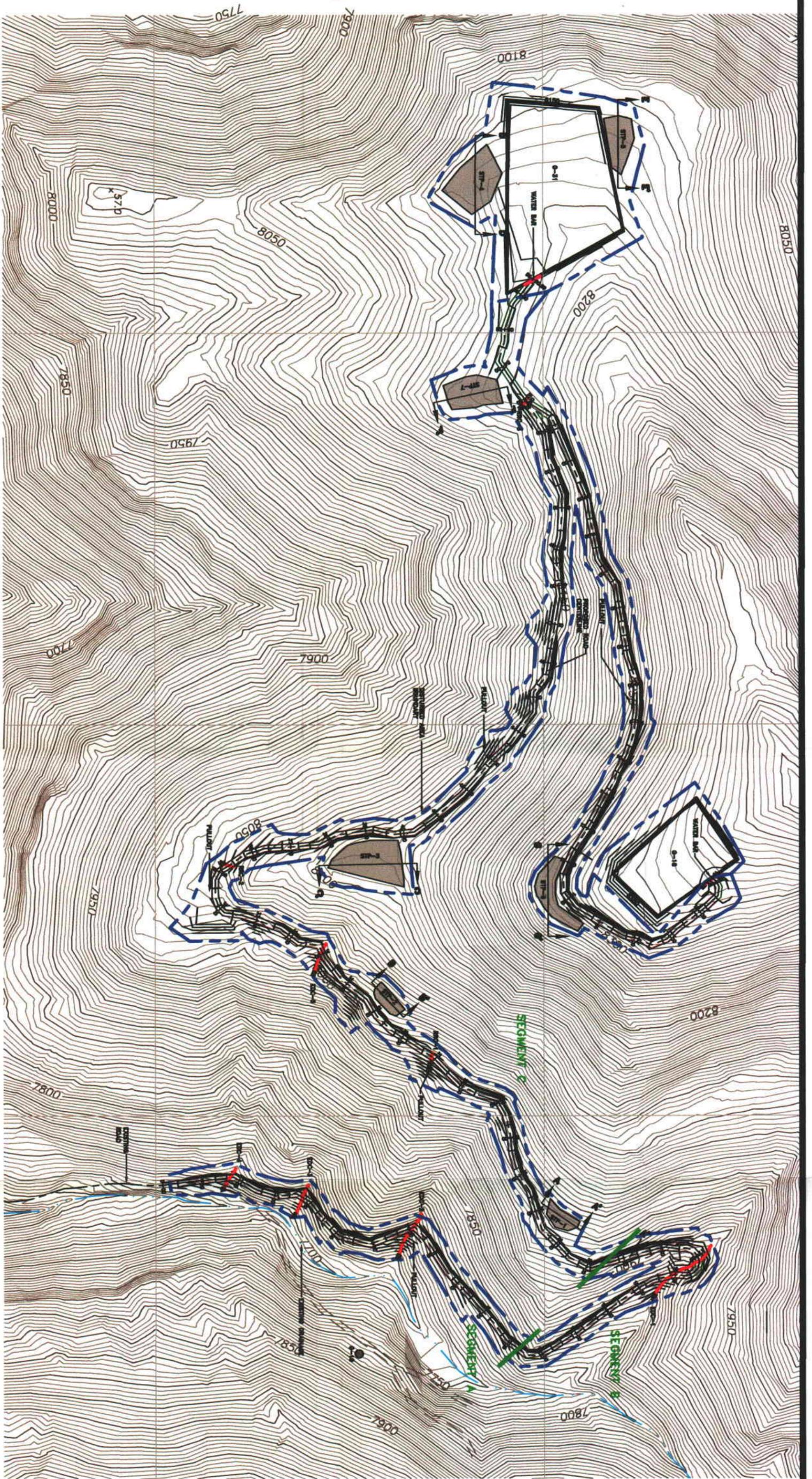
CF Canyon Fuel Company, LLC
Dugout Canyon Mine

VEGETATION SECTIONS 19 AND 20
TOWNSHIP 13 S RANGE 13 E

P.O. BOX 1029
WELLINGTON, UTAH 84542

DRAWING OR MAP NUMBER
ATTACHMENT 3-1

RECEIVED
AUG 29 2007



REVISIONS OR UP-DATES		DATE:
NO.	DATE	BY
		DESIGNED BY:
		DRAWN BY:
		CHECKED BY:


Canyon Fuel Company, LLC
 Dugout Canyon Mine

ROAD SEGMENTS
 P.O. BOX 1028
 WELLINGTON, UTAH 84542
 DRAWING OR MAP NUMBER
ATTACHMENT 3-1



SCALE: 1" = 250'
 FILENAME: ATTACHMENT 3-1.DWG

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
September 4, 2007 ~~July 9, 2007~~

ATTACHMENT 3-2
THREATENED, ENDANGERED, AND SENSITIVE SPECIES INFORMATION

Add to the back of existing information

**Utah's Federally (US F&WS) Listed
Threatened (T), Endangered (E), and Candidate (C) Plant Species**

<u>Common Name</u>	<u>Scientific Name</u>	<u>Status</u>	<u>County of Occurrence</u>
Monocot Plants:			
	Family Cyperaceae		
Navajo Sedge	<i>Carex specuicola</i>	T	San Juan & Kane.
	Family Orchidaceae		
Ute Ladies'-tresses	<i>Spiranthes diluvialis</i>	T	Daggett, Duchesne, Garfield, Tooele, Uintah, Utah, Wasatch, & Wayne. Possibly Juab. Formerly Salt Lake & Weber.
Dicot Plants:			
	Family Apocynaceae		
Jones Cycladenia	<i>Cycladenia humilis var jonesii</i>	T	Emery, Garfield, Grand, & Kane.
	Family Asclepiadaceae		
Welsh's Milkweed	<i>Asclepias welshii</i>	T	Kane.
	Family Asteraceae		
Maguire Daisy	<i>Erigeron maguirei</i>	T	Emery, Garfield, & Wayne.
Last Chance Townsendia	<i>Townsendia aprica</i>	T	Emery, Sevier, & Wayne.
	Family Brassicaceae		
Barneby Ridge-cress	<i>Lepidium barnebyanum</i>	E	Duchesne.
Kodachrome Bladderpod	<i>Lesquerella tumulosa</i>	E	Kane.
Clay Reed-mustard	<i>Schoenocrambe argillacea</i>	T	Uintah.
Barneby Reed-mustard	<i>Schoenocrambe barnebyi</i>	E	Emery & Wayne.
Shrubby Reed-mustard	<i>Glaucocarpum suffrutescens</i>	E	Duchesne & Uintah.
	Family Cactaceae		
San Rafael Cactus	<i>Pediocactus despainii</i>	E	Emery & Wayne.
Siler Pincushion Cactus	<i>Pediocactus sileri</i>	T	Kane & Washington.
Winkler Pincushion Cactus	<i>Pediocactus winkleri</i>	T	Emery & Wayne.
Uinta Basin Hookless Cactus	<i>Sclerocactus glaucus</i>	T	Carbon, Duchesne, & Uintah.
Wright Fishhook Cactus	<i>Sclerocactus wrightiae</i>	E	Emery, Sevier, & Wayne.
	Family Fabaceae		
Deseret Milkvetch	<i>Astragalus desereticus</i>	T	Utah.
Shivwits or Shem Milkvetch	<i>Astragalus ampullarioides</i>	E	Washington.
Holmgren Milkvetch	<i>Astragalus holmgreniorum</i>	E	Washington.
Heliotrope Milkvetch	<i>Astragalus montii</i>	T	Sanpete & Sevier.
	Family Hydrophyllaceae		
Clay Phacelia	<i>Phacelia argillacea</i>	E	Utah.
	Family Ophloglossaceae		
Slender Moonwort	<i>Botrychium lineare</i>	C	Salt Lake.
	Family Papaveraceae		
Dwarf Bearclaw-poppy	<i>Arctomecon humilis</i>	E	Washington.
	Family Primulaceae		
Maguire Primrose	<i>Primula maguirei</i>	T	Cache.
	Family Ranunculaceae		
Autumn Buttercup	<i>Ranunculus aestivalis</i>	E	Garfield.
	Family Scrophulariaceae		
White River Beardtongue	<i>Penstemon scariosus var albifluvis</i>	C	Uintah.

**Utah's Federally Listed
Threatened (T), Endangered (E), and Candidate (C) Invertebrate Species**

<u>Common Name</u>	<u>Scientific Name</u>	<u>Status</u>	<u>County of Occurrence</u>
Mollusks:			
Ogden Rocky Mountainsnail	<i>Oreohelix peripherica wasatchensis</i>	C	Weber.
Kanab Ambersnail	<i>Oxyloma kanabense</i>	E	Kane.
Utah Valvata Snail	<i>Valvata utahensis</i>	E Extirpated	Formerly found in Utah.
Fat-whorled Pondsnaill	<i>Stagnicola bonnevillensis</i>	C	Box Elder.
Insects:			
Coral Pink Sand Dunes Tiger Beetle	<i>Cicindela limbata albissima</i>	C	Kane.

**Utah's Federally Listed
Threatened (T), Endangered (E), and Candidate (C) Vertebrate Species**

<u>Common Name</u>	<u>Scientific Name</u>	<u>Status</u>	<u>County of Occurrence</u>
Amphibians:			
Relict Leopard Frog	<i>Rana onca</i>	C Extirpated	Formerly Washington.
Fishes:			
Lahontan Cutthroat Trout	<i>Oncorhynchus clarkii henshawi</i>	T	Introduced in Box Elder.
Humpback Chub	<i>Gila cypha</i>	E	Carbon, Emery, Garfield, Grand, San Juan, Uintah, & Wayne. Possibly Duchesne. Formerly Daggett & Kane.
Bonytail	<i>Gila elegans</i>	E	Carbon, Emery, Garfield, Grand, San Juan, Uintah, & Wayne. Possibly Duchesne. Formerly Daggett & Kane.
Virgin Chub	<i>Gila seminuda</i>	E	Washington.
Colorado Pikeminnow	<i>Ptychocheilus lucius</i> E		Carbon, Daggett, Emery, Garfield, Grand, San Juan, Uintah, & Wayne. Possibly Duchesne. Formerly Kane.
Woundfin	<i>Plagopterus argentissimus</i>	E	Washington.
June Sucker	<i>Chasmistes liorus</i>	E	Utah. Introduced in Box Elder, Salt Lake, & Weber.
Razorback Sucker	<i>Xyrauchen texanus</i>	E	Carbon, Emery, Garfield, Grand, San Juan, Uintah, & Wayne. Possibly Duchesne. Formerly Daggett & Kane.
Reptiles:			
Desert Tortoise	<i>Gopherus agassizii</i>	T	Washington.
Birds:			
California Condor	<i>Gymnogyps californianus</i>	E Experimental	Visits Southern Utah from Northern Arizona. Formerly Beaver & Iron.
Whooping Crane	<i>Grus americana</i>	E Extirpated	Formerly passed through E Utah.
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	C	Occurs or possible in all counties except Rich.
Mexican Spotted Owl	<i>Strix occidentalis lucida</i>	T	Emery, Garfield, Iron, Kane, San Juan, Uintah, Washington, & Wayne. Possibly Carbon & Grand.
Southwestern Willow Flycatcher	<i>Empidonax traillii extimus</i>	E	Emery, Garfield, Grand, Iron, Kane, San Juan, Washington, & Wayne.

Mammals:

Utah Prairie-dog	<i>Cynomys parvidens</i>	T	Beaver, Garfield, Iron, Kane, Millard, Piute, Sanpete, Sevier, & Wayne.
Gray Wolf	<i>Canis lupus</i>	E Extirpated	Formerly found throughout Utah.
Brown (Grizzly) Bear	<i>Ursus arctos</i>	T Extirpated	Formerly found throughout Utah.
Black-footed Ferret	<i>Mustela nigripes</i>	E Experimental	Unconfirmed sightings persist from Carbon, Daggett, Duchesne, Emery, Grand, Rich, San Juan, & Summit. Introduced as experimental non-essential in Uintah.
Canada Lynx	<i>Lynx canadensis</i>	T	Daggett, Duchesne, Summit, Uintah, & Wasatch. Formerly Sanpete. Possibly Cache, Morgan, Rich, Salt Lake, Utah, & Weber.

DEFINITIONS

E	A taxon that is listed by the U.S. Fish and Wildlife Service as "endangered" with the possibility of worldwide extinction.
E Experimental	An "endangered" taxon that is considered by the U.S. Fish and Wildlife Service to be "experimental and non-essential" in its designated use areas in Utah.
E, T, or C Extirpated	An "endangered," "threatened," or "candidate" taxon that is "extirpated" and considered by the U.S. Fish and Wildlife Service to no longer occur in Utah.
E or T Proposed	A taxon "proposed" to be listed as "endangered" or "threatened" by the U.S. Fish and Wildlife Service.
T	A taxon that is listed by the U.S. Fish and Wildlife Service as "threatened" with becoming endangered.
C	A taxon for which the U.S. Fish and Wildlife Service has on file sufficient information on biological vulnerability and threats to justify it being a "candidate" for listing as endangered or threatened.

Note: Please contact the U.S. Fish and Wildlife Service (801-975-3330) for the purpose of consultation under the Endangered Species Act.



State of Utah
Department of Natural Resources
Division of Wildlife Resources

Utah Sensitive Species List

October 17, 2006

This list has been prepared pursuant to Utah Division of Wildlife Resources Administrative Rule R657-48. By rule, wildlife species that are federally listed, candidates for federal listing, or for which a conservation agreement is in place automatically qualify for the *Utah Sensitive Species List*. The additional species on the *Utah Sensitive Species List*, "wildlife species of concern," are those species for which there is credible scientific evidence to substantiate a threat to continued population viability. It is anticipated that wildlife species of concern designations will identify species for which conservation actions are needed, and that timely and appropriate conservation actions implemented on their behalf will preclude the need to list these species under the provisions of the federal Endangered Species Act. Please see Appendix A for the rationale behind each wildlife species of concern designation.

Utah Sensitive Species List

Fishes

Federal Candidate Species
(None)

Federally Threatened Species
Lahontan cutthroat trout (introduced)

Oncorhynchus clarkii henshawi

Federally Endangered Species
humpback chub
bonytail
Virgin chub
Colorado pikeminnow
woundfin
June sucker
razorback sucker

Gila cypha
Gila elegans
Gila seminuda
Ptychocheilus lucius
Plagopterus argentissimus
Chasmistes liorus
Xyrauchen texanus

Conservation Agreement Species
Bonneville cutthroat trout
Colorado River cutthroat trout
Virgin spinedace
least chub
roundtail chub
bluehead sucker
flannelmouth sucker

Oncorhynchus clarkii utah
Oncorhynchus clarkii pleuriticus
Lepidomeda mollispinis mollispinis
Itichthys phlegethontis
Gila robusta
Catostomus discobolus
Catostomus latipinnis

Wildlife Species of Concern
leatherside chub
desert sucker
Yellowstone cutthroat trout
Bear Lake whitefish
Bonneville cisco
Bonneville whitefish
Bear Lake sculpin

Gila copei
Catostomus clarkii
Oncorhynchus clarkii bouvieri
Prosopium abyssicola
Prosopium gemmifer
Prosopium spilonotus
Cottus extensus

Utah Sensitive Species List

Amphibians

Federal Candidate Species
relict leopard frog (extirpated)

Rana onca

Federally Threatened Species
(None)

Federally Endangered Species
(None)

Conservation Agreement Species
Columbia spotted frog

Rana luteiventris

Wildlife Species of Concern
western toad
Arizona toad

Bufo boreas
Bufo microscaphus

Utah Sensitive Species List

Reptiles

Federal Candidate Species
(None)

Federally Threatened Species
desert tortoise

Gopherus agassizii

Federally Endangered Species
(None)

Conservation Agreement Species
(None)

Wildlife Species of Concern

zebra-tailed lizard
western banded gecko
desert iguana
Gila monster
common chuckwalla
desert night lizard
sidewinder
speckled rattlesnake
Mojave rattlesnake
cornsnake
smooth greensnake
western threadsnake

Callisaurus draconoides
Coleonyx variegatus
Dipsosaurus dorsalis
Heloderma suspectum
Sauromalus ater
Xantusia vigilis
Crotalus cerastes
Crotalus mitchellii
Crotalus scutulatus
Elaphe guttata
Opheodrys vernalis
Leptotyphlops humilis

Utah Sensitive Species List

Birds

Federal Candidate Species

Yellow-billed Cuckoo

Coccyzus americanus

Federally Threatened Species

Bald Eagle

Haliaeetus leucocephalus

Mexican Spotted Owl

Strix occidentalis lucida

Federally Endangered Species

California Condor (experimental)

Gymnogyps californianus

Whooping Crane (extirpated)

Grus americana

Southwestern Willow Flycatcher

Empidonax traillii extimus

Conservation Agreement Species

Northern Goshawk

Accipiter gentilis

Wildlife Species of Concern

Grasshopper Sparrow

Ammodramus savannarum

Short-eared Owl

Asio flammeus

Burrowing Owl

Athene cunicularia

Ferruginous Hawk

Buteo regalis

Greater Sage-grouse

Centrocercus urophasianus

Black Swift

Cypseloides niger

Bobolink

Dolichonyx oryzivorus

Lewis's Woodpecker

Melanerpes lewis

Long-billed Curlew

Numenius americanus

American White Pelican

Pelecanus erythrorhynchos

Three-toed Woodpecker

Picoides tridactylus

Sharp-tailed Grouse

Tympanuchus phasianellus

Utah Sensitive Species List

Mammals

Federal Candidate Species
(None)

Federally Threatened Species
Utah prairie-dog
brown/grizzly bear (extirpated)
Canada lynx

Cynomys parvidens
Ursus arctos
Lynx canadensis

Federally Endangered Species
black-footed ferret (experimental, non-essential
in Duchesne and Uintah counties)
gray wolf (extirpated)

Mustela nigripes
Canis lupus

Conservation Agreement Species
(None)

Wildlife Species of Concern

Preble's shrew
Townsend's big-eared bat
spotted bat
Allen's big-eared bat
western red bat
fringed myotis
big free-tailed bat
pygmy rabbit
Gunnison's prairie-dog
white-tailed prairie-dog
silky pocket mouse
dark kangaroo mouse
Mexican vole
kit fox

Sorex preblei
Corynorhinus townsendii
Euderma maculatum
Idionycteris phyllotis
Lasiurus blossevillii
Myotis thysanodes
Nyctinomops macrotis
Brachylagus idahoensis
Cynomys gunnisoni
Cynomys leucurus
Perognathus flavus
Microdipodops megacephalus
Microtus mexicanus
Vulpes macrotis

Utah Sensitive Species List

Mollusks

Federal Candidate Species

Ogden rocky mountainsnail
fat-whorled pondsnail

Oreohelix peripherica wasatchensis
Stagnicola bonnevillensis

Federally Threatened Species

(None)

Federally Endangered Species

Kanab ambersnail
desert valvata (extirpated)

Oxyloma kanabense
Valvata utahensis

Conservation Agreement Species

(None)

Wildlife Species of Concern

southern tightcoil
Eureka mountainsnail
lyrate mountainsnail
Brian Head mountainsnail
Deseret mountainsnail
Yavapai mountainsnail
cloaked physa
Utah physa
wet-rock physa
longitudinal gland pyrg
smooth Glenwood pyrg
desert springsnail
Otter Creek pyrg
Hamlin Valley pyrg
carinate Glenwood pyrg
Ninemile pyrg
bifid duct pyrg
Bear Lake springsnail
Black Canyon pyrg
sub-globose Snake pyrg
southern Bonneville pyrg
northwest Bonneville pyrg
California floater
western pearlshell

Ogaridiscus subrupicola
Oreohelix eurekaensis
Oreohelix haydeni
Oreohelix parawanensis
Oreohelix peripherica
Oreohelix yavapai
Physa megalochlamys
Physella utahensis
Physella zionis
Pyrgulopsis anguina
Pyrgulopsis chamberlini
Pyrgulopsis deserta
Pyrgulopsis fusca
Pyrgulopsis hamlinensis
Pyrgulopsis inopinata
Pyrgulopsis nonaria
Pyrgulopsis peculiaris
Pyrgulopsis pilsbryana
Pyrgulopsis plicata
Pyrgulopsis saxatilis
Pyrgulopsis transversa
Pyrgulopsis variegata
Anodonta californiensis
Margaritifera falcata

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

**CHAPTER 5
ENGINEERING**

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
510 INTRODUCTION	5-1
511 General Requirements	5-1
512 Certification	5-1
512.100 Cross Sections and Maps	5-1
512.200 Plans and Engineering Designs	5-2
513 Compliance With MSHA Regulations and MSHA Approval	5-2
513.100 Coal Processing Waste Dams and Embankments	5-2
513.200 Impoundments and Sedimentation Ponds	5-3
513.300 Underground Development Waste, Coal Processing Waste, and Excess Spoil	5-3
513.400 Refuse Piles	5-3
513.500 Underground Openings to the Surface	5-3
513.600 Discharge to Underground Mine	5-3
513.700 Surface Coal Mining and Reclamation Activities	5-3
513.800 Coal Mine Waste Fire	5-4
514 Inspection	5-4
514.100 Excess Spoil	5-4
514.200 Refuse Piles	5-4
514.300 Impoundments	5-4
515 Reporting and Emergency Procedures	5-4
515.100 Slides	5-4
515.200 Impoundments Hazards	5-4
515.300 Temporary Cessation of Operations	5-5
520 OPERATION PLAN	5-5
521 General	5-5
521.100 Cross Sections and Maps	5-5
521.200 Signs and Markers	5-6

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
522 Coal Recovery	5-7
523 Mining Methods	5-7
524 Blasting and Explosives	5-7
525 Subsidence	5-8
526 Mine Facilities	5-8
526.100 Mine Structures and Facilities	5-8
526.200 Utility Installation and Support Facilities	5-8
527 Transportation Facilities	5-8
527.100 Road Classification	5-8
527.200 Description of Transportation Facilities	5-9
528 Handling and Disposal of Coal, Excess Spoil, and Coal Mine Waste	5-9
529 Management of Mine Openings	5-9
530 OPERATIONAL DESIGN CRITERIA AND PLANS	5-10
531 General	5-10
532 Sediment Control	5-10
533 Impoundments	5-11
534 Roads	5-11
535 Spoil	5-11

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
536 Coal Mine Waste	5-11
537 Regraded Slopes	5-11
537.100 Division Approval	5-11
537.200 Regrading of Settled and Revegetative Fills	5-12
540 RECLAMATION PLAN	5-12
541 General	5-12
541.100 Commitment	5-12
541.200 Surface Coal Mining and Reclamation Activities	5-12
541.300 Underground Coal Mining and Reclamation Activities	5-12
541.400 Environmental Protection Performance Standards	5-12
542 Narratives, Maps, and Plans	5-13
542.100 Reclamation Timetable	5-13
542.200 Plan for Backfilling, Soil Stabilization, Compacting, and Grading ..	5-13
542.300 Final Surface Configuration Maps and Cross Sections	5-13
542.400 Removal of Temporary Structures	5-14
542.500 Removal of Sedimentation Pond	5-14
542.600 Roads	5-14
542.700 Final Abandonment of Mine Openings and Disposal Areas	5-14
542.800 Estimated Cost of Reclamation	5-15
550 RECLAMATION DESIGN CRITERIA AND PLANS	5-15
551 Casing and Sealing of Underground Openings	5-15
552 Permanent Features	5-15
552.100 Small Depressions	5-15
552.200 Permanent Impoundments	5-15
553 Backfilling and Grading	5-15
553.100 Disturbed Area Backfilling and Grading	5-15

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
553.200 Spoil and Waste	5-16
553.250 Refuse Piles	5-16
553.300 Exposed Coal Seams, Acid and Toxic Forming Materials and Combustible	5-16
553.400 Cut and Fill Terraces	5-16
553.500 Highwall From Previously Mined Areas	5-16
553.600 Previously Mined Areas	5-17
553.700 Backfilling and Grading - Thin Overburden	5-17
553.800 Backfilling and Grading - Thick Overburden	5-17
553.900 Regrading of Settled and Revegetated Fills	5-17
560 PERFORMANCE STANDARDS	5-17

LIST OF ATTACHMENTS

Attachment 5-1	Degas Wells G-8, G-9, G-10, G-11 thru G-19 and G-31
Attachment 5-2	Methane Degassification
Attachment 5-3	Land Owner Correspondence
Attachment 5-4	Degas Wells Access Road

LIST OF FIGURES

Figures follow the text, unless noted otherwise

- Figure 5-1** Contour Map For G-1
- Figure 5-2** Typical Cross Sections For G-1
- Figure 5-3** Approximate Drilling Layout For G-1
- Figure 5-4** Approximate Operational Layout For G-1
- Figure 5-5** Contour Map For G-2
- Figure 5-6** Typical Cross Sections For G-2
- Figure 5-7** Approximate Drilling Layout For G-2
- Figure 5-8** Approximate Operational Layout For G-2
- Figure 5-9** Contour Map For G-3
- Figure 5-10** Typical Cross Sections For G-3
- Figure 5-11** Approximate Drilling Layout For G-3
- Figure 5-12** Approximate Operational Layout For G-3
- Figure 5-13** Typical Road Cross Section
- Figure 5-14** Typical Access Road Cross Section
- Figure 5-15** Reclamation Time Table
- Figure 5-16** Typical Well Design
- Figure 5-17** Contour Map For G-4
- Figure 5-18** Typical Cross Sections For G-4
- Figure 5-19** Approximate Drilling Layout For G-4
- Figure 5-20** Contour Map For G-5
- Figure 5-21** Typical Cross Sections For G-5
- Figure 5-22** Approximate Drilling Layout For G-5
- Figure 5-23** Contour Map For G-6
- Figure 5-24** Typical Cross Sections For G-6
- Figure 5-25** Approximate Drilling Layout For G-6
- Figure 5-26** Reclamation Schedule - Wells G-3, G-4, G-6 thru G-19, G-31 and
AMV Access Road
- Figure 5-27** Contour Map For G-7
- Figure 5-28** Typical Cross Sections For G-7
- Figure 5-29** Approximate Drilling Layout For G-7

510 INTRODUCTION

This chapter provides a discussion of general engineering aspects, an operation plan, a reclamation plan, design criteria, and performance standards related to the degassification well sites. The activities associated with the construction and reclamation of the well sites have been or will be designed, located, constructed, maintained, and reclaimed in accordance with the operation and reclamation plans.

511 General Requirements

The permit application includes descriptions of construction, maintenance, and reclamation operations of the proposed well sites with maps and plans. Potential environmental impact as well as methods and calculations utilized to achieve compliance with the design criteria are also presented.

512 Certification

Where required by the regulations, cross sections and maps in this permit application have been prepared by or under the direction of, and certified by, qualified registered professional engineers or land surveyors. As appropriate, these persons were assisted by experts in the fields of hydrology, geology, biology, etc.

512.100 Cross Sections and Maps

Cross sections for the degassification well pads are shown on Figures 5-2, 5-6, 5-10, 5-18, 5-21, 5-24 and typical road cross sections are shown on Figures 5-13 and 5-14. Cross sections for the degassification well pads G-8, G-9, G-10, G-11 thru G-19 and G-31 are shown on figures located in Attachment 5-1.

512.200 Plans and Engineering Designs

Excess Spoil - No excess spoil will be generated from the well sites.

Durable Rock Fills - No durable rock fills will exist at the well sites.

Coal Mine Waste - No coal mine waste will exist at the well sites.

Impoundments - Refer to Section 733.200 of this submittal.

Primary Roads - Short sections of road are required to access well sites G-2, G-5, and G-16. These access roads are classified as primary roads. Well sites G-1 and G-8 (not drilled), G-3 thru G-15 and G-19, are on existing roads, no **primary** access roads will be constructed. Refer to Section 527.200 for additional information.

Variance from Approximate Original Contour - No variance from approximate original contour is required for the well sites.

513 Compliance with MSHA Regulations and MSHA Approval

513.100 Coal Processing Waste Dams and Embankments

No coal processing waste dams and embankments will exist at the well sites.

513.200 Impoundments and Sedimentation Ponds

Refer to Section 733.200 of this submittal.

513.300 Underground Development Waste, Coal Processing Waste, and Excess Spoil

No underground waste, coal processing waste, and excess spoil will exist at the well sites.

513.400 Refuse Piles

No refuse piles will exist at the well sites.

513.500 Underground Openings to the Surface

The well will be equipped with a valve that will be closed and locked when not in use. A typical well head is shown in Figure 5-16.

513.600 Discharge to Underground Mine

No discharge to the underground mine will occur at the well sites.

513.700 Surface Coal Mining and Reclamation Activities

No surface coal mining, or reclamation activities associated with surface coal mining will occur at the well sites.

513.800 Coal Mine Waste Fire

No coal waste will be developed, therefore, no coal waste fires will occur at the well sites.

514 Inspection

514.100 Excess Spoil

No excess spoil will be stored at the well sites.

514.200 Refuse Piles

No refuse piles will exist at the well sites.

514.300 Impoundments

Refer to Section 733.200 of this submittal.

515 Reporting and Emergency Procedures

515.100 Slides

Refer to Section 515.100 in the approved M&RP.

515.200 Impoundments Hazards

No impoundments will exist at the well sites.

515.300 Temporary Cessation of Operations

If temporary cessation of the mining operations does occur, the wells will remain open. Once liberation of the methane gas is completed, the wells will be sealed as discussed in Section 542.700 of this submittal.

520 OPERATION PLAN

521 General

See Figures 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1 (G-8 thru G-19 and G-31) for the contour map showing pre-disturbance and drilling phase contours. These figures also show the disturbed area boundary and the new access road contours. Figures 5-3, 5-7, 5-11, 5-19, 5-22, 5-25, 5-29 and Attachment 5-1 (G-8 thru G-19 and G-31) show the layout of the well sites during the drilling phase. Figures 5-4, 5-8, 5-12 show the layout of the well sites during the operational phase and the area to be reclaimed at the completion of drilling. Cross sections for each site can be found on Figures 5-2, 5-6, 5-10, 5-18, 5-21, 5-24, 5-28 and Attachment 5-1 (G-8 thru G-19 and G-31).

521.100 Cross Sections and Maps

Existing Surface and Subsurface Facilities Features - No buildings are located on or within 1,000 feet of any of the well sites.

Landowner, Right-of-Entry, and Public Interest - The land which the wells will be drilled on is owned by the Milton and Ardith Thayn Trust. Canyon Fuels, LLC has reached an agreement with the Thayn trustees to allow access for the construction and drilling of the wells (see Attachment 4-2).

Mining Sequence and Planned Subsidence - Refer to Section 525. Mining sequence maps showing the location of drilled degas wells are submitted to the BLM and UDOGM as part of their annual reports. A drawing representing the drill holes previously permitted for drilling and those currently proposed for drilling in 2007 are shown on a drawing included in Attachment 5-4. The drawing shows the pad locations not the location where the drill hole will be completed. Drill holes from the G-9 pad were or are being drilled to release gas from the Gil-5 and Gil-6 panels. Drill holes from the G-10, G-11, G-12, and G-13 pads were drilled to release gas from the Gil-5 panel. Drill holes from the G-15, G-18, G-19, and G-31 pads will be drilled to release gas from the Gil-6 panel.

Land Surface Configuration - Surface contours of undisturbed well sites are included in Figures 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1 (G-8 thru G-19 and G-31).

Surface Facilities - No permanent surface facilities will exist at the well sites.

521.200 Signs and Markers

Mine and Permit Identification Signs - A mine and permit identification sign will be displayed at each well site. This sign will be a design that can be easily seen and read, will be made of durable material, will conform to local regulations, and will be maintained until after the release of all bonds for the well site areas. The sign will contain the following information:

- Mine name,
- Company name,
- Company address and telephone number
- MSHA identification number, and
- Permanent program permit identification number

Perimeter Markers - The perimeter of all areas affected will be clearly marked before beginning mining activities. The markers will be a design that can be easily seen and read, will be made of

durable material, will conform to local regulations, and will be maintained until after the release of all bonds for the permit area.

Buffer Zone Markers - Stream buffer zone markers will not be required at the G-2 thru G-10, G-13, G-14, G-16 and G-17 well sites. Stream buffer zone markers will be placed at G-11, G-12, G-15, G-19 and on the AMV road where required by regulation.

Topsoil Markers - Markers will be placed on all topsoil stockpiles. These markers will be a design that can be easily seen and read, will be made of durable material, will conform to local regulations, and will be maintained until topsoil is redistributed on the well sites.

Construction Markers - Not applicable.

Hazard Signs - Signs will be placed at the degas wells with open degas holes, declaring danger, no smoking, etc.

522 Coal Recovery

No coal recovery will be performed at the well sites. The operator has been contacted by the BLM, in reference to changes in Operator's R2P2 associated with Federal Regulation 43 CFR Chapter 11, Subpart 3484. Degas wells G-11, G-12, G-18, G-19 and G-31 are on the SITLA lease and not on a federal lease, therefore changes in the R2P2 are not required.

523 Mining Methods

No mining will be performed at the well sites.

524 Blasting and Explosives

No explosives are to be used at the well sites.

525 Subsidence

No subsidence will occur at the well sites, as a result of drilling and development of the degassification well sites. Subsidence could occur at the well site because of underground mining see Section 525 of the approved M&RP.

526 Mine Facilities

526.100 Mine Structures and Facilities

No buildings exist or are proposed at the well sites; therefore, no existing building will be used in connection with or to facilitate this proposed coal mining and reclamation plan.

526.200 Utility Installation and Support Facilities

No utilities are to be installed at the well sites. A portable methane exhaust unit will be temporarily installed to draw methane to the surface from the mined panel. The exhaust blower will be started by using propane from portable tanks. Once started and running, the unit will be powered by burning the extracted methane gas. The level of extracted methane required to operate the exhaust blower is greater than 30%. Excess methane will be vented to the atmosphere. The blower is approximately 12-feet long by 6-feet wide and about 10-feet tall. It is not known how long the degassification of the longwall panel will take.

527 Transportation Facilities

527.100 Road Classification

Well sites will be developed near existing private roads as shown on Figures 1-1, 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1 (G-8 thru G-17 and G-19). The new short segments of access roads will be classified as primary roads and will be maintained by the permittee (see Figure

5-14). The AMV access road will be classified as an ancillary road per a discussion with Wayne Western during a meeting at the UDOGM offices on April 16, 2007. The road is improving a trail used for hunting, cattle and for logging. There are small slash piles along segments of the trail.

527.200 Description of Transportation Facilities

The well sites were chosen close to existing roads in the area to limit surface disturbance. The existing roads were constructed and are maintained by the land owner. The existing roads are approximately 20 feet wide and are shown on Figures 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1 (G-8 thru G-17 and G-19). See Figure 5-13 for a typical cross section of the existing roads.

The access road to the G-16 well site follows an existing road which has been reclaimed. The incised road is approximately 500 feet long, 15 to 20 feet wide and will be constructed on compacted subsoil. Topsoil will be stripped from the road alignment and either wind rowed adjacent to the road or stored with the topsoil stripped from the pad area. The access road will have a maximum grade of 10% and an average grade of 5%. The road will be constructed as shown on Figure 5-14 in the approved methane degassification amendment. As needed, water bars will be used to direct flow off the road and either silt fences or strawbales will be used to treat runoff. Refer to Chapter 5, Attachment 5-1 for drawings of well site. The access road to G-16 is also discussed in Chapter 7, Section 732.400.

The AMV access road will be classified as an ancillary road per a discussion with Wayne Western during a meeting at the UDOGM offices on April 16, 2007. The road is improving a trail used for hunting, cattle and for logging. A drawing showing the alignment of the road can be found in Attachment 5-4, as Plate 1. The drawing outlines the disturbed area and shows the road center line, ~~water bars~~ **culvert locations**, turnouts and topsoil stockpile locations. Topsoil will be removed from the road and stockpiled along the road as shown on Plate 1. The cut and fill volumes for the road have been determined to be close, making it unlikely that subsoil will need to be stored. However, should it be necessary to store subsoil a pile will be created on one of the proposed turnouts. The

subsoil pile will be bermed, pocked, gouged and seeded. The topsoil piles will be treated as described in Chapters 2 and 3 of the Methane Degassification Amendment.

A typical road cross section is found in Attachment 5-4 as Figure 1. The road will be at a minimum 12 feet wide, with two additional feet of the road width being added as a berm and two feet being used as a ditch, making the road approximately 16 feet wide. Additional descriptive information for the road is located in Attachment 5-4, including cross-sections of the road on Plates 2 and 3 within the attachment.

The steepness of access road cut slopes will depend on the stability of the exposed subsurface material. Cuts into competent material such as bedrock will be sloped at angles of approximately 0.5H:1V (63.4 degrees). Cut into unconsolidated material such as soils will be sloped at angles of approximately 1H:1V (45 degrees). The steepness of these slopes is justified by the presence of several near-vertical bedrock outcrops and naturally steep (approximately 1H:1V) colluvial slopes along road cuts in the vicinity of the proposed access road. Furthermore, the nearby cut slopes along access roads have maintained such slopes for several years. Cut slopes will be maintained along the length of the proposed access road. Area determined to be unstable will be regraded to a stable configuration.

When necessary during the normal use of the AMV road, it will be graded, berms will be repaired, culverts inlets/outlets and ditches will be cleaned. The materials excavated during road maintenance will be stockpiled to be used for either repair or during reclamation. The AMV road is not likely to be used during winter due to the access from below the road being impassable, therefore snow removal and storage has not been discussed. Damage to the AMV access road will be repaired as soon as practical following a catastrophic event.

On the AMV road silt fences will be placed in the ditch upstream of the approach to the culverts to treat road runoff during construction. Silt fences will be placed at the toe of fill slopes during

construction to reduce the amount of loose soil material and sediment laden runoff from entering the drainage. Outslopes and ditches associated with the road will be seeded during operations to encourage the establishment of vegetation and erosion control.

528 Handling and Disposal of Coal, Excess Spoil, and Coal Mine Waste

No disposal of coal, excess spoil, and coal mine waste will occur at the well sites.

529 Management of Mine Openings

The perimeter of the sites, including the topsoil stockpiles will be fenced with gates on the access roads. The well casing will have a valve that is closed and locked. The valve will also prevent access by animals or other material. Mine openings will be monitored in accordance with Federal and State Regulations.

During the life of the methane wells, the sites will be inspected as needed by mine personnel to verify the continued operation of the pumping equipment and general site conditions. Motorized vehicles to access the methane wells may include trucks, four-wheelers, a snow cat, snowmobiles and etc.

530 OPERATIONAL DESIGN CRITERIA AND PLANS

531 General

This section contains the general plans for the construction of sediment controls and general construction and maintenance of the well sites.

The decision to construct each well will be based on the amount of methane encountered during mining. If small amounts of methane are encountered and the mine's ventilation system can dilute the methane, no well will be drilled. The proposed well site locations are shown on Figure 1-1.

The topography above the Dugout Canyon Mine severely limits the selection of methane drainage drill sites (degas wells). Various other factors also affect the drill site locations. These include proximity to the mining area, existing access verses new access, site slope, meeting reclamation success standards, etc. Sites with exiting access are given preference over sites without, where possible sites are located along existing roads and at other pre-disturbed areas. In addition, drill methods are often modified (using directional drilling methods vs. conventional vertical drilling methods) to allow drilling along existing access and to reduce environmental impacts. Directional drilling methods allow the surface site to be located as described yet allow the bottom of the hole to be completed in the required mining area.

532 Sediment Control

Sediment control measures for the well sites are described in Sections 732 and 742 of this submittal. Runoff control structures at the well sites have been designed to convey runoff in a non-erosive manner. Sediment yields in the well permit area are minimized by:

- Disturbing the smallest practicable area during the construction of the well site and
- Contemporaneously reclaiming areas suitable for such reclamation.

The runoff control measures for the AMV access road are discussed in Attachment 5-4 , **Attachment 7-1, Sections 732.400 and 742.**

533 Impoundments

No impoundments will exist at the well sites **or on the AMV road.**

534 Roads

Refer to Section 527 **and 532** of this submittal.

535 Spoil

No spoil will be generated at the well sites.

536 Coal Mine Waste

No coal mine waste will be stored at the well sites.

537 Regraded Slopes

537.100 Division Approval

No mining or reclamation activities will be conducted in the permit area that requires approval of the Division for alternative specifications or for steep cut slopes.

537.200 Regrading of Settled and Revegetated Fills

Upon completion of the well site, the areas not required for the exhaust blower will be regraded to approximate original contour. Because of the nature of the well site, settling is not anticipated. However, if settlement does occur, these areas will be regraded.

540 RECLAMATION PLAN

541 General

541.100 Commitment

Upon the permanent cessation of methane venting, Dugout Canyon Mine will seal the wells and permanently reclaim all affected areas in accordance with the R645 regulations and this reclamation plan.

541.200 Surface Coal Mining and Reclamation Activities

Not applicable.

541.300 Underground Coal Mining and Reclamation Activities

Upon completion of the methane venting activities the wells will be reclaimed.

541.400 Environmental Protection Performance Standards

The plan presented is designed to meet the requirements of R645-301 and the environmental protection performance standards of the State Program.

542 Narratives, Maps, and Plans

542.100 Reclamation Timetable

A timetable for the completion of each major step in the reclamation plan is presented in Figure 5-15 (G-2 and G-5) and 5-26 (G-3, G-4, G-6 thru G-19, G-31 and the AMV access road). Per Task ID #2408, "the Division requires notification and a reasonably specific time to initiate the

reclamation activities associated with degassification well sites.” In addition to the two figures referenced above, information pertaining to reclamation timing for methane degas wells is provided in Attachment 5-2 of this amendment.

542.200 Plan for Backfilling, Soil Stabilization, Compacting, and Grading

Following completion of the venting activities, the well site will be prepared for contouring and soil distribution. Details regarding topsoil placement and revegetation are provided in Section 242 and Section 353, respectively.

Sedimentation Pond Removal and Interim Sediment Control - See Section 542.500 of this submittal.

542.300 Final Surface Configuration Maps and Cross Sections

The sites will be regraded to the approximate original contour, the contours representing the pre-disturbance topography also represent the reclamation topography. Refer to Figures 5-2, 5-6, 5-10, 5-18, 5-21, 5-24, 5-28 and Attachment 5-1 (G-8 thru G-19 and G-31) to see cross sections representing the final surface configuration. Refer to Attachment 5-4, Plates 1 thru 3 for the surface configuration of the road and cross sections showing pre-mining, operational and post-mining contours.

542.400 Removal of Temporary Structures

The well sites will not have surface structures.

542.500 Removal of Sedimentation Pond

No sediment pond will be constructed at the well sites.

542.600 Roads

The roads which existed prior to the drilling program will be retained after reclamation. The access roads established during the drilling program will be reclaimed after methane extraction has been completed. See Section 242 for additional detail concerning the reclamation plan.

The road to well site G-16 is pre-existing however it has been reclaimed, the road to access well sites G-13, G-14, G-15, G-17 and G-19 are existing roads. Subsoil being cut in order to construction the pad for well G-15 will be placed on the existing road, causing it to be elevated. Refer to Section 527.200 and Attachment 5-4 for a description of the AMV access road.

Once the degassification is completed at wells G-18 and G-31 the AMV road will be reclaimed. To begin, the segment of the road will be reclaimed which joins pad G-18 to G-31, then reclamation of the road will continue on downhill until the road rejoins the existing road connecting the Pace Canyon road and degas pad G-19. The area of the road will be returned to approximate original contour, pocked and gouged and seeded (Section 350).

542.700 Final Abandonment of Mine Openings and Disposal Areas

Degas drill holes G-9 thru G-19 and G-31 will be sealed in accordance with Federal Regulations 43 CFR Ch. 11, Subpart 3484, (3) per a decision by the BLM and UDOGM.

The casings on degas well sites G-2 thru G-7 will be plugged at the bottom to hold concrete. A lean concrete mixture will be poured into the casing until the concrete is within five (5) feet of the surface. At that time the casing will be cut off at ground level and the rest of the casing will be filled with lean concrete. The concrete will be allowed to harden before final reclamation is completed.

A copy of 43 CFR Ch. 11, Subpart 3484, (3) and a discussion of how methane is removed from mines is contained in Attachment 5-2.

542.800 Estimated Cost of Reclamation

Refer to the Appendix 5-6 of the existing M&RP. It is anticipated that the cost of reclamation of the well sites and AMV road are adequately covered by the Dugout Canyon Reclamation Bond, refer to Chapter 8 for additional detail.

550 RECLAMATION DESIGN CRITERIA AND PLANS

551 Casing and Sealing of Underground Openings

Permanent sealing is described in Section 542.700.

552 Permanent Features

552.100 Small Depressions

No permanent small depressions will be created as part of the well site or AMV road construction and reclamation.

552.200 Permanent Impoundments

See Section 515.200 of this submittal.

553 Backfilling and Grading

553.100 Disturbed Area Backfilling and Grading

Approximate Original Contour - The well sites and AMV road will be returned to their approximate original contour after reclamation is completed.

Erosion and Water Pollution - Sediment controls will consist of gouging the surface to create depressions and mounds which store and impede the movement of water. As vegetation becomes established on the reclaimed surface, erosion potential will be further minimized.

Post-Mining Land Use - The disturbed area will be reclaimed in a manner that supports the approved post-mining land use. Refer to Sections 411 and 412 for additional detail.

553.200 Spoil and Waste

Spoil - No spoil will be generated within the well sites.

Coal Processing Waste - No coal processing waste will be generated within the well sites.

553.250 Refuse Piles

No refuse piles will exist at the well sites.

553.300 Exposed Coal Seams, Acid and Toxic Forming Materials and Combustible Materials

No coal seams will be left exposed at the well sites. All wells will be sealed according to Federal and State regulations.

553.400 Cut and Fill Terraces

No cut and fill terraces will be constructed at the well sites **or on AMV road.**

553.500 Highwall From Previously Mined Areas

No highwalls exist or will be built at the well sites **or on AMV road.**

553.600 Previously Mined Area

No previously mined areas exist at the well sites **or on AMV road.**

553.700 Backfilling and Grading - Thin Overburden

No surface mining and reclamation activities involving thin overburden will occur at the well sites **or on AMV road.**

553.800 Backfilling and Grading - Thick Overburden

No surface mining and reclamation activities involving thick overburden will occur at the well sites **or on AMV road.**

553.900 Regrading of Settled and Revegetated Rills

If settlement or rills occur at the well sites **or on AMV road**, they will be regraded and revegetated. Refer to Section 244.300.

560 PERFORMANCE STANDARDS

Dugout Canyon Mine well sites will be conducted in accordance with the approved permit and the requirements of R645-301-510 through R645-301-553.

**ATTACHMENT 5-4
DEGAS WELLS ACCESS ROAD**



Reclamation – AMV Road

The road will be reclaimed following the reclamation of drill pads for the G-18 and G-31 degas wells. The reclamation schedule is shown on Figure 5-26 of this amendment.

The AMV road will be returned to approximate original contour during reclamation, drainages will be restored following the removal of culverts and any associated structures. The reclaimed segments of the drainages will be tied into the existing segments of the drainage. The restored drainages will be rip rapped with native rock, which has been stockpiled during the initial construction of the road, when possible. If additional rock is required it will be secured to complete the restoration of the drainages. The size of the rip rap used for the operational culvert outlets will be the size used during reclamation to restore the natural drainages. When necessary, the filter blanket material will also mimic the material used during the operational phase of the road. Refer to Attachment 7-1 for rip rap and filter blanket information. The reclaimed drainages will be seeded with the approved seed mix.

The return to approximate original contour of the road slopes may require them to be concave, the plan is that they will not need to be concave, but if required they will be concave. The restored road slopes will be seeded using the methods discussed in Section 341.200 and meeting the performance standards in Section 350.

The road surface will be ripped a minimum of 12 inches prior to the placement of subsoil and topsoil. If it becomes necessary to add gravel to the road surface during the operational phase, it will be left in place and ripped to relieve compaction. Subsoil fill material and topsoil will be placed on top of the ripped surface.

Following reclamation of the road slopes, settling/rills are not anticipated, but should they occur the small areas would be reworked with hand tools, if settling/rills occur in a large area it may become necessary to regard the area.

At the time of reclamation, a determination will be made between the permittee and the Division as to the “best current technology” for the placement or use of silt fence/strawbales for sediment control along the path of the reclaimed road.

Cut/Fill Volumetrics

Area	Road	Pad 31	Pad 18	TOTAL
Disturbed Acreage	5.68	2.87	1.36	9.91
Disturbed Area Acreage within Boundary	14.23	4.66	1.74	20.63
Topsoil Volume (cyd)	9,167	4,624	2,195	15,986
Subsoil Cut Volume (cyd)	15,207	8,470	6,962	30,639
Cut Volume Total (cyd)	24,374	13,094	9,157	46,625
Fill Volume Required (cyd)	11,954	11,781	5,938	29,673
Net Cut(+)/Fill(-) Subsoil Only (cyd)	3,253	-3,311	1,024	966

Notes

Proposed road is 7,155 feet long.

Topsoil Volume assumes that the Disturbed Area will have 1 foot (avg) thickness topsoil to be stockpiled.

The Subsoil Cut Volume is the Cut Volume Total minus the Topsoil Volume.

The Net Cut Volume (966 cyd) does not include the volume of subsoil required to construct berms along the proposed road (265 cyd), around the proposed topsoil stockpiles (309 cyd), or around the proposed degas well pads G-31 (62 cyd) and G-18 (39 cyd). The net cut is thus $966 - 309 - 265 - 62 - 39 = 291$ cyd. The road and pad berm volumes were calculated assuming that they will be 1 ft tall with 1H:1V side slopes. The lengths of the berms for the road, G-31, and G-18 were taken as 7155, 1670, and 1023 feet long, respectively. Stockpile berm volumes are calculated on the Stockpile Runoff Containment Volume Calculations table.

All acreages and cut/fill volumes were calculated with AutoCAD software.

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

CHAPTER 7
HYDROLOGY

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
710 INTRODUCTION	7-1
711 General Requirements	7-1
712 Certification	7-1
713 Inspection	7-1
720 ENVIRONMENTAL DESCRIPTION	7-1
721 General Requirements	7-1
722 Cross Sections and Maps	7-2
722.100 Location and Extent of Subsurface Water	7-2
722.200 Location of Surface Water Bodies	7-2
722.300 Locations of Monitoring Stations	7-2
722.400 Locations and Depth of Water Wells	7-2
722.500 Surface Topography	7-3
723 Sampling and Analysis	7-3
724 Baseline Information	7-3
724.100 Groundwater Information	7-3
724.200 Surface Water Information	7-3
724.300 Geologic Information	7-3
724.400 Climatological Information	7-4
724.500 Supplemental Information	7-4
724.600 Survey of Renewable Resource Lands	7-4
724.700 Alluvial Valley Floor Requirements	7-4
725 Baseline Cumulative Impact Area Information	7-4

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
726 Modeling	7-4
727 Alternative Water Source Information	7-5
728 Probable Hydrologic Consequences	7-5
728.100 Potential Impacts of Surface and Groundwater	7-5
728.200 Baseline Hydrologic and Geologic Information	7-5
728.300 PHC Determination	7-5
729 Cumulative Hydrologic Impact Assessment (CHIA)	7-7
730 OPERATION PLAN	7-7
731 General Requirements	7-7
731.100 Hydrologic - Balance Protection	7-7
731.200 Water Monitoring	7-8
731.300 Acid or Toxic Forming Materials	7-8
731.400 Transfer of Wells	7-8
731.500 Discharge	7-9
731.600 Stream Buffer Zone	7-9
731.700 Cross Section and Maps	7-9
731.800 Water Rights and Replacement	7-9
732 Sediment Control Measures	7-9
732.100 Siltation Structures	7-10
732.200 Sedimentation Pond	7-10
732.300 Diversions	7-10
732.400 Road Drainage	7-10
733 Impoundments	7-11
733.100 General Plans	7-11
733.200 Permanent and Temporary Impoundments	7-11
734 Discharge Structures	7-11

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
735 Disposal of Excess Spoil	7-11
736 Coal Mine Waste	7-11
737 Non-Coal Mine Waste	7-11
738 Temporary Casing and Sealing of Wells	7-12
740 DESIGN CRITERIA AND PLANS	7-12
741 General Requirements	7-12
742 Sediment Control Measures	7-12
742.100 General Requirements	7-12
742.200 Siltation Structures	7-12
742.300 Diversions	7-13
742.400 Road Drainage	7-13
743 Impoundments	7-13
744 Discharge Structures	7-13
745 Disposal of Excess Spoil	7-13
746 Coal Mine Waste	7-14
746.100 General Requirements	7-14
746.200 Refuse Piles	7-14
746.300 Impounding Structures	7-14
746.400 Return of Coal Processing Waste to Abandoned Underground Workings	7-14
747 Disposal of Non-Coal Waste	7-14
748 Casing and Sealing Wells	7-14

TABLE OF CONTENTS(Continued)

<u>Section</u>	<u>Page</u>
750 PERFORMANCE STANDARDS	7-15
751 Water Quality Standards and Effluent Limitations	7-15
752 Sediment Control Measures	7-15
752.100 Siltation Structures and Diversions	7-15
752.200 Road Drainage	7-15
753 Impoundments and Discharge Structures	7-15
754 Disposal of Excess Spoil, Coal Mine Waste and Non-Coal Mine Waste ...	7-16
755 Casing and Sealing	7-16
760 RECLAMATION	7-16
761 General Requirements	7-16
762 Roads	7-16
762.100 Restoring the Natural Drainage Patterns	7-16
762.200 Reshaping Cut and Fill Slopes	7-16
763 Siltation Structures	7-17
763.100 Maintenance of Siltation Structures	7-17
763.200 Removal of Siltation Structures	7-17
764 Structure Removal	7-17
765 Permanent Casing and Sealing of Wells	7-17

Canyon Fuel Company, LLC
Dugout Canyon Mine

Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

LIST OF ATTACHMENTS

Attachment 7-1 Hydrology Calculations

710 INTRODUCTION

711 General Requirements

This chapter presents a description of the following:

- Proposed operations and the potential impacts to the hydrologic balance;
- Methods of compliance with design criteria and the calculations utilized to show compliance; and
- Applicable hydrologic performance standards.

712 Certification

All maps, plans, and cross sections presented in this chapter have been certified by a qualified, registered professional engineer.

713 Inspection

Inspections are not required since no permanent impoundments will exist at the well sites.

720 ENVIRONMENTAL DESCRIPTION

721 General Requirements

The application will include a description of the existing premining hydrologic resources with the proposed permit and adjacent areas that may be affected or impacted by the proposed coal mining and reclamation operations.

722 Cross Sections and Maps

722.100 Location and Extent of Subsurface Water

Figure 7-1 in the approved M&RP shows a generalized hydrostratigraphic cross section of the permit and adjacent areas including the well sites. Section 724.100 of the approved M&RP provides baseline groundwater conditions.

722.200 Location of Surface Water Bodies

Plate 7-2 in the approved M&RP shows the locations of surface-water bodies and existing or pending water rights. Section 724.200 of the approved M&RP provides baseline surface water conditions.

722.300 Locations of Monitoring Stations

Plate 7-1 in the approved M&RP shows the location of surface water and groundwater monitoring stations.

722.400 Locations and Depth of Water Wells

Refer to Section 722.400 and Plate 7-1 of the approved M&RP for information pertaining to the groundwater monitoring wells. Refer to Appendix 7-9 of approved M&RP for details pertaining to the Gilson well.

722.500 Surface Topography

Surface topography features at the well sites and adjacent areas are shown on Figures 1-1, 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and in Attachment 5-1 for Degas Wells G-8 thru G-19 and G-31. Refer to Plate 1-4 in the M&RP for well locations.

The surface topography for the AMV access road is shown on Plate 1 included in Attachment 5-4.

723 Sampling and Analysis

Refer to Section 723 of the approved M&RP.

724 Baseline Information

Refer to Section 724 of the approved M&RP.

724.100 Groundwater Information

Refer to Section 724.100 of the approved M&RP.

724.200 Surface Water Information

Refer to Section 724.200 of the approved M&RP.

724.300 Geologic Information

Geologic information related to the well sites and adjacent areas is presented in Chapter 6 of this submittal and in the approved M&RP.

724.400 Climatological Information

Climatological data are summarized in Appendix 4-1 behind the Air Quality Permit of the approved M&RP and RA Attachment 7-5 of the Refuse Pile Amendment.

724.500 Supplemental Information

Refer to Section 724.500 of the approved M&RP.

724.600 Survey of Renewable Resource Lands

Refer to Section 724.600 of the approved M&RP.

724.700 Alluvial Valley Floor Requirements

Information regarding the presence or absence of alluvial valley floors in the well sites and adjacent areas is presented in Chapter 9 of this submittal and the approved M&RP.

725 Baseline Cumulative Impact Area Information

The CHIA currently in place for the Dugout Canyon Mine covers the well sites. The hydrologic and geologic information required for the Division to develop a Cumulative Hydrologic Impact Assessment (CHIA) is presented in the approved M&RP.

726 Modeling

No groundwater or surface water modeling was conducted in support of this submittal.

727 Alternative Water Source Information

Not applicable.

728 Probable Hydrologic Consequences

This section addresses the probable hydrologic consequences of construction and reclamation operations at the well sites. Mitigation measures are discussed generally in this section and in detail in Section 730 of the approved M&RP.

728.100 Potential Impacts of Surface and Groundwater

Potential impacts of the well sites in this area on the quality and quantity of surface and groundwater flow may include contamination from materials associated with the drilling of the wells. Once installed, the wells are designed as an ambient vent of methane gas, having no affect on the surface or groundwater. The potential impact is addressed in Section 728.300 of this submittal and the approved M&RP.

728.200 Baseline Hydrologic and Geologic Information

Baseline geologic information is presented in Chapter 6 of the approved M&RP. Baseline hydrologic information is presented in Section 724.100 and 724.200 of the approved M&RP.

728.300 PHC Determination

Potential Impacts to the Hydrologic Balance - Potential impacts of the Dugout Canyon Mine on the hydrologic balance of the well sites and adjacent areas are addressed in the subsections of this submittal and the approved M&RP. The PHC prepared by Mayo and Associates for the Dugout Canyon Mine is located in Appendix 7-3, Section 3 , of the approved M&RP. Refer to Chapter 3,

Section 322.200 for information addressing water usage for degas well drilling, as well as mining. Little to no impacts to the Hydrologic Balance are anticipated since 1) the potential impacts are limited to the drilling and construction of the wells; 2) BTCA techniques for sediment control are implemented for the surface disturbance of the well pad; 3) hydrogeologic information from in-mine observations, Degas wells G-1 through G-9, and PHC information included in the approved M&RP support that minimal groundwater is encountered in the geologic formations being drilled; and 4) any water encountered during drilling and construction of the well will need to be sealed for the well to function as an ambient vent of methane gas.

Acid and Toxic Forming Materials - No acid or toxic forming materials have been identified in the soils or strata of the Dugout Canyon Mine (Chapter 6, Section 623 of this submittal). Additional information is located in Appendix 6-2 of the approved M&RP.

Groundwater - When encountered during drilling groundwater aquifers will be sealed using drilling mud. At completion, the casing will be grouted and cement placed inside the well casing during reclamation.

Once drilling is completed, the casing is grouted in the well hole, sealing aquifers to prevent groundwater migration, including groundwater migrating down the outside of the casing into the mine. Should water inflow greater than 15 gallon per minute be encountered during the drilling of the degas wells the depth and volume will be recorded and included in Attachment 7-1. No measurable inflows of water have been encountered during the drilling of degas wells G-1 thru G-9.

The development and construction of degas wells does not have the potential to decrease creek flow or spring discharges, the wells are not designed to capture water, dewater aquifers or cause subsidence. Methane gas, not liquid (water) is pumped from the wells following construction.

Surface Water - Degas wells are not used to access water to be discharged to the surface. As mentioned above, no measureable water has been encountered during the drilling, construction

and operation of degas wells G-1 thru G-9. Also, the well cannot function as a degas well if significant water is encountered, and will need to be abandoned.

Potential Hydrocarbon Contamination - Hydrocarbon products will not be stored at the well sites, however fuels, greases, and other oils may leak from equipment during drilling operations. Absorbent materials will be used for the collection of leaked fuels, greases, and other oils. The saturated absorbent materials will be disposed of at an appropriate landfill facility.

G-18, G-31 and AMV Access Road

728.300 The PHC Determination:

728.310 - The construction and operation of the G-18, G-31 well pads and associated access road is not anticipated to cause adverse impacts to the hydrologic balance. No underground aquifers or springs are located in the area of the road and well pads. Sediment control structures will be used to reduce the likelihood of erosion and increased sediment loads to the ephemeral and intermittent drainage areas. Sediment controls have been designed to adequately address treatment of runoff from the steep hillsides and grades associated with the access road. The locations, designs, and descriptions of the sediment control structures to be implemented during road and pad construction, operation, and reclamation are contained in Attachments 5-4 and 7-1.

Examples of construction and operational sediment and erosion control on the road include building appropriately sized water bars or the canting of the road surface toward the uphill side of the road to divert runoff into the roadside ditch. When necessary the water bar outlets will be rip rapped with native rock. Native rock will be collected during the construction of the road to be used as rip rap. Culverts will be located at appropriate sites (Attachment 5-4, Plate 1) to direct flow from the ditch to drainage areas that would normally contain the area runoff. Where required appropriately sized rip-rap will be placed at the outlet of the culverts used to divert water into the existing ephemeral drainages.

According to calculations, culvert inlet velocities should be less than approximately 5 fps, therefore no inlet protection is required. Silt fences will also be placed upstream from the approach to the culverts to treat road runoff during construction. Silt fences will be placed at the toe of fill slopes during construction to reduce the amount of loose soil material and sediment laden runoff from entering the drainage. Outslopes and ditches associated with the road will be seeded during operations to encourage the establishment of vegetation and erosion control.

Erosion, runoff and sediment control at pads G-18 and G-31 during construction, operation, and reclamation may include, but not necessarily be limited to, construction of berms around the disturbed areas and the use of silt fence to treat runoff.

Reclamation of the road and well pads is described in Sections 340 and 760. As part of the reclamation activities the reclaimed and resoiled surfaces will be deep gouged to reduce the length of surface flow paths and trap runoff. The reclamation plan described in these sections have been designed to minimize erosion and runoff by encouraging timely revegetation of the disturbed areas. Where necessary, silt fencing will be used during reclamation activities to contain loose soils and reduce sediment laden runoff.

728.320 - Soil samples have been obtained from selected sites in the road and pad areas. Results of the soil analyses indicate the samples did not contain acid-forming or toxic-forming materials. Thus, the soils moved or exposed as a result of the construction of the road and pad will not result in the contamination of the surface or ground-water supplies. Refer to Section 231 and Attachment 2-1.

728.330 - The sediment control structures to be constructed as part of the access road and G-18 and G -31 well pads project should minimize the sediment yield from disturbed areas during runoff events. As described in Section 527 and above in Section 728.310, silt fencing will be used at the downhill toe of the slope of the road fill during road construction and reclamation to capture loose soils and rock. This will prevent loose material from entering the channels.

As described in the preceding sections, acid forming materials will not be exposed or created as part of the construction, operation, or reclamation of the road and pad areas. Total suspended solids will be controlled through the use of sediment control structures. Dissolved solids within the runoff from the disturbed areas is not likely to noticeably increase above background levels since the disturbance is generally occurring within weathered soils and bedrock surfaces. Much of the soluble material will have naturally leached from the shallow soils prior to the proposed disturbance. The soil samples obtained and analyzed are located in Attachment 2-1 and referenced in Section 728.320 above do not contain significant volumes of highly soluble minerals. Therefore, it is unlikely exposing these soils to increased moisture will result in increased total dissolved solids in the surface water relative to known background levels. No significant volumes of highly soluble materials are proposed to be imported as part of the construction, operation, and reclamation of the road and pads.

No impoundments or restriction of stream flows are anticipated as part of the road and pad project, making it unlikely that unnatural flooding will occur as a result of this project. No additional or new perennial or intermittent stream channel alterations are anticipated as part of this project. Culverts are to be placed in ephemeral channels at road crossings. The culverts are adequately sized such that flooding due to the placement of the culverts should not occur. Only minimal alteration to the ephemeral channels will occur during the placement of the culverts.

No groundwater is anticipated to be encountered during construction of the road or pads, therefore no change in groundwater availability is anticipated. Minimal amounts of surface water will be used for dust suppression during construction and operation of the road and pads.

728.340 - The sediment controls installed during construction, operation, and reclamation of the road and pad will not proximately result in contamination, diminution or interruption of an underground or surface source of water within the proposed permit or adjacent areas which is used for domestic, agricultural, industrial or other legitimate purpose.

728.350 - Because of the installation of the sediment controls and since no surface or ground water will be diverted as a result of this project, the road and pad construction will not result in contamination, diminution or interruption of State-appropriated water in existence within the proposed permit or adjacent areas at the time the application is submitted.

729 Cumulative Hydrologic Impact Assessment (CHIA)

The Cumulative Hydrologic Impact Assessment currently in place for the Dugout Canyon Mine includes the well sites and adjacent areas.

730 OPERATION PLAN

731 General Requirements

731.100 Hydrologic - Balance Protection

Groundwater Protection - The effect on groundwater at the well sites is expected to be minimal. Groundwater encountered during drilling will be sealed off, refer to Section 728.300.

Surface Water Protection - To protect the hydrologic balance, construction, maintenance, and reclamation operations will be conducted to handle earth materials and runoff in a manner that prevents, to the extent possible, additional contributions of suspended solids to stream flow outside the permit area, and otherwise prevent water pollution.

During initial drilling, the sites will be graded to ensure that storm runoff will flow towards the berms surrounding the drilling pad area. The berms will direct the runoff to the lowest point(s) within the pad area where a silt fence and/or straw bale dike(s) will treat the runoff (see Figures 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1). The berm placed at the top of the drilling pad cut

slopes will divert runoff around the drilling pad. Thus reducing the runoff affected by the drilling pad.

The pad will be re-graded to cause the storm runoff to sheet flow towards a silt fence and/or straw bale dike. A berm will be placed at the top of the fill slope to direct any runoff from the operational pad to the silt fence and/or straw bale dike (see Figures 5-4, 5-8, 5-12, 5-19, 5-22, 5-25, 5-29 and Attachment 5-1). The silt fences and/or straw bale dikes will be periodically inspected, and accumulated sediment will be removed as needed to maintain functionality. The sediment from the silt fence and/or straw bale dikes will be piled on the pad and will be used for fill during final reclamation of the well site. During the drilling phase a berm and silt fence will be installed at the toe of the fill slope as shown on Figures 5-1, 5-5, 5-9, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1 to treat any runoff from the drilling pad.

731.200 Water Monitoring

No water monitoring will be conducted at the degas well sites. Refer to approved M&RP for a description of water monitoring.

731.300 Acid or Toxic Forming Materials

No acid or toxic forming materials are anticipated at the well sites (see Section 728.300).

731.400 Transfer of Wells

Refer to Section 731.400 of the approved M&RP.

731.500 Discharge

No discharges to underground workings.

731.600 Stream Buffer Zones

Stream Channel Diversions - No stream channel diversions are planned at the well sites, **unless specified in the runoff controls specific to each well site.**

Buffer Zone Designation - When drilling sites are adjacent to a perennial or an intermittent stream, a stream buffer zone will be established. Well sites G-11, G-12, G-15 and G-19 require buffer zone designation. Refer to Chapter 5, Attachment 5-1 for drawings of well sites G-8 through G-17 and G-19. **A buffer zone designation will be required on approximately the first 1100 feet of the AMV road, signs will be placed along the road at intervals so that the previous sign is visible at the location of the current sign.**

731.700 Cross Section and Maps

Not applicable.

731.800 Water Rights and Replacement

Refer to Sections 728.300 and 731.800 of the approved M&RP.

732 Sediment Control Measures

The sediment control measures within the well sites have been designed to prevent additional contributions of sediment to stream flow or to runoff outside the well sites. In addition, the well sites have been designed to minimize erosion to the extent possible.

The structures to be used for runoff control at the well sites are berms, silt fences and/or straw bale dikes.

732.100 Siltation Structures

Berms, silt fences and straw bales dikes will be used to treat runoff.

732.200 Sedimentation Pond

The drilling sites will not have sedimentation ponds.

732.300 Diversions

Refer to Section 731.100 of this submittal.

732.400 Road Drainage

No diversion ditches will be constructed along the primary roads leading to the well sites. See Figures 5-13 and 5-14 for typical road cross sections. Where needed roads accessing the drill sites will have a water bar constructed at the base of the road to divert water off the road prior to the runoff reaching the drilling pad.

The incised road to well site G-16 will be constructed as shown on Figure 5-14 in the approved permit, water bars will be used to direct flow off the road and either silt fences or strawbales will be used to treat runoff. Refer to Chapter 5, Attachment 5-1 for drawings of well site G-16 showing the location of a single water bar, additional water bar(s) will be constructed as required to direct water from the road. Refer to Section 527.200 for road construction information.

Subsoil being cut in order to construction the pad for well G-15 will be placed on the existing road, causing it to be elevated, no new access road will be constructed to well site G-15.

The AMV access road will be classified as an ancillary road per a discussion with Wayne Western during a meeting at the UDOGM offices on April 16, 2007. The road is improving a trail used for hunting, cattle and for logging. Drawings showing the alignment and cross-sections of the road can be found in Attachment 5-4, as Plate 1 thru 3. A typical road cross section is found in Attachment 5-4 as Figure 1. The drawing outlines the disturbed area and shows the road center line, water bars, culverts, turnouts and topsoil stockpile locations.

The steepness of access road cut slopes will depend on the stability of the exposed subsurface material. Cuts into competent material such as bedrock will be sloped at angles of approximately 0.5H:1V (63.4 degrees). Cut into unconsolidated material such as soils will be sloped at angles of approximately 1H:1V (45 degrees). The steepness of these slopes is justified by the presence of several near-vertical bedrock outcrops and naturally steep (approximately 1H:1V) colluvial slopes in the vicinity of the proposed access road.

~~Water on the roads will be directed off the road with water bars, placed at intervals along the road. The road berm will be broken at the water bars to allow the runoff to drain. The water bar outlets will be rip-rapped with native rock, collected during the construction of the road. As required, siltation structures will be installed prior to beginning road construction, refer to Section 728 for additional information.~~

733 Impoundments

733.100 General Plans

Not applicable.

733.200 Permanent and Temporary Impoundments

No permanent impoundments will exist at the well sites.

734 Discharge Structures

A berm will surround the entire drill pad at each well site during the drilling phase (excepted as noted). The berm will divert undisturbed runoff around the drilling pad and direct runoff from the pad to a silt fence/straw bale dike at the lowest point within the well pad disturbed area. A silt fence and/or straw bale dike will be the discharge structure for each of the well sites during the operational phase.

735 Disposal of Excess Spoil

There will be no excess spoil generated at the well sites.

736 Coal Mine Waste

There will be no coal mine waste generated or stored at the well sites.

737 Non-Coal Mine Waste

There will be no non-coal mine waste disposed at the well sites.

738 Temporary Casing and Sealing of Wells

Refer to Section 542.700 of this submittal.

740 DESIGN CRITERIA AND PLANS

741 General Requirements

This submittal includes general well site plans and AMV road that incorporate design criteria for the control of drainage. A description and explanation for designs and components are located in Attachments 5-4 and 7-1.

742 Sediment Control Measures

742.100 General Requirements

Design - Sediment control measures have been formulated to prevent additional contributions of sediment to stream flow or to runoff outside the well site area; and minimize erosion to the extent possible.

Measures and Methods - Sediment control methods will include silt fences, berms, and straw bales to reduce runoff and trap sediment.

742.200 Siltation Structures

General Requirements - Additional contributions of suspended solids and sediment or runoff outside the well site area, including access roads will be prevented to the extent possible using silt fences, berms, and straw bale dikes. Construction activities will not occur during major precipitation events. As required, siltation structures will be installed prior to beginning site construction.

Design - All hydrology calculations were made using the 10-year, 24-hour precipitation event. Hydrology calculations are in Attachment 7-1. Locations of the berms and silt fences are shown on Figures 5-1, 5-4, 5-5, 5-8, 5-9, 5-12, 5-17, 5-20, 5-23, 5-27 and Attachment 5-1.

742.300 Diversions

No diversion ditches will be constructed as part of the drilling or operational phases, **with the exception of the AMV road.**

742.400 Road Drainage

Refer to Section 732.400 of this submittal. The road design for G-16 is shown on drawings located in Chapter 5, Attachment 5-1 and Figure 5-16. The road design for the AMV access road is shown in Attachment 5-4.

Hydrocad, a computer modeling program was used to determine the runoff from contributing watersheds. The program modeled runoff for the area and routed the runoff through the associated drainage structures. The results of the hydrocad models determined the peak flow, depth, and flow velocities of runoff through the drainage control system. The result are located in Attachment 7-1.

743 Impoundments

No impoundments will exist at the well sites.

744 Discharge Structures

No discharge structures have been planned or designed.

745 Disposal of Excess Spoil

There will be no excess spoil generated at the well sites.

746 Coal Mine Waste

746.100 General Requirements

There will be no coal mine waste used at the well sites.

746.200 Refuse Piles

There will be no refuse piles at the well sites.

746.300 Impounding Structures

Refer to Section 733.200 of this submittal.

746.400 Return of Coal Processing Waste to Abandoned Underground Workings

No coal processing waste will be generated at the well sites.

747 Disposal of Non-Coal Mine Waste

All non-coal mine waste will be disposed of at an approved landfill.

748 Casing and Sealing Wells

Refer to Section 542.700 of this submittal.

750 PERFORMANCE STANDARDS

751 Water Quality Standards and Effluent Limitations

Water encountered during drilling and runoff water will be treated using silt fence and/or straw bale dikes prior to leaving the site. Should it become necessary the water encountered during drilling will be pumped into a tank and hauled from the site for disposal at a licensed facility.

752 Sediment Control Measures

All sediment control measures will be located, maintained, constructed and reclaimed according to plans and designs presented in Section 732, 742, and 760 of this submittal.

752.100 Siltation Structures and Diversions

Siltation structures will be located, maintained, constructed and reclaimed according to plans and designs presented in Section 732, 742, and 763 of the submittal.

752.200 Road Drainage

Refer to Section 732.400 of this submittal.

753 Impoundments and Discharge Structures

Refer to Section 733.200 of this submittal.

754 Disposal of Excess Spoil, Coal Mine Waste and Non-Coal Mine Waste

There will be no excess spoil or coal mine waste generated at the well sites. Refer to Section 747 of this submittal regarding non-coal waste disposal.

755 Casing and Sealing

Refer to Section 542.700 of this submittal.

760 RECLAMATION

761 General Requirements

A detailed reclamation plan for the well sites is presented in Section 540. No structures will exist at the well sites.

762 Roads

Refer to Section 542.600.

762.100 Restoring the Natural Drainage Patterns

The natural drainage patterns will be restored after degassification is completed. **The natural drainage patterns associated with the constructed AMV road will be restored.**

762.200 Reshaping Cut and Fill Slopes

Cut and fill slopes will be reshaped at the well sites **and on the AMV road.**

763 Siltation Structures

763.100 Maintenance of Siltation Structures

All siltation structures will be maintained until removed in accordance with the approved reclamation plan.

763.200 Removal of Siltation Structures

When a siltation structure is removed, the land on which the siltation structure was located will be regraded and revegetated in accordance with the reclamation plan presented in Section 540.

764 Structure Removal

A timetable for the reclamation of the sites is presented in Figures 5-15 (G-2 and G-5) and 5-26 (G-3, G-4, G-6 thru G-19, G-31 and AMV access road).

765 Permanent Casing and Sealing of Wells

Refer to Section 542.700 of this submittal.

Canyon Fuel Company, LLC
Dugout Canyon Mine

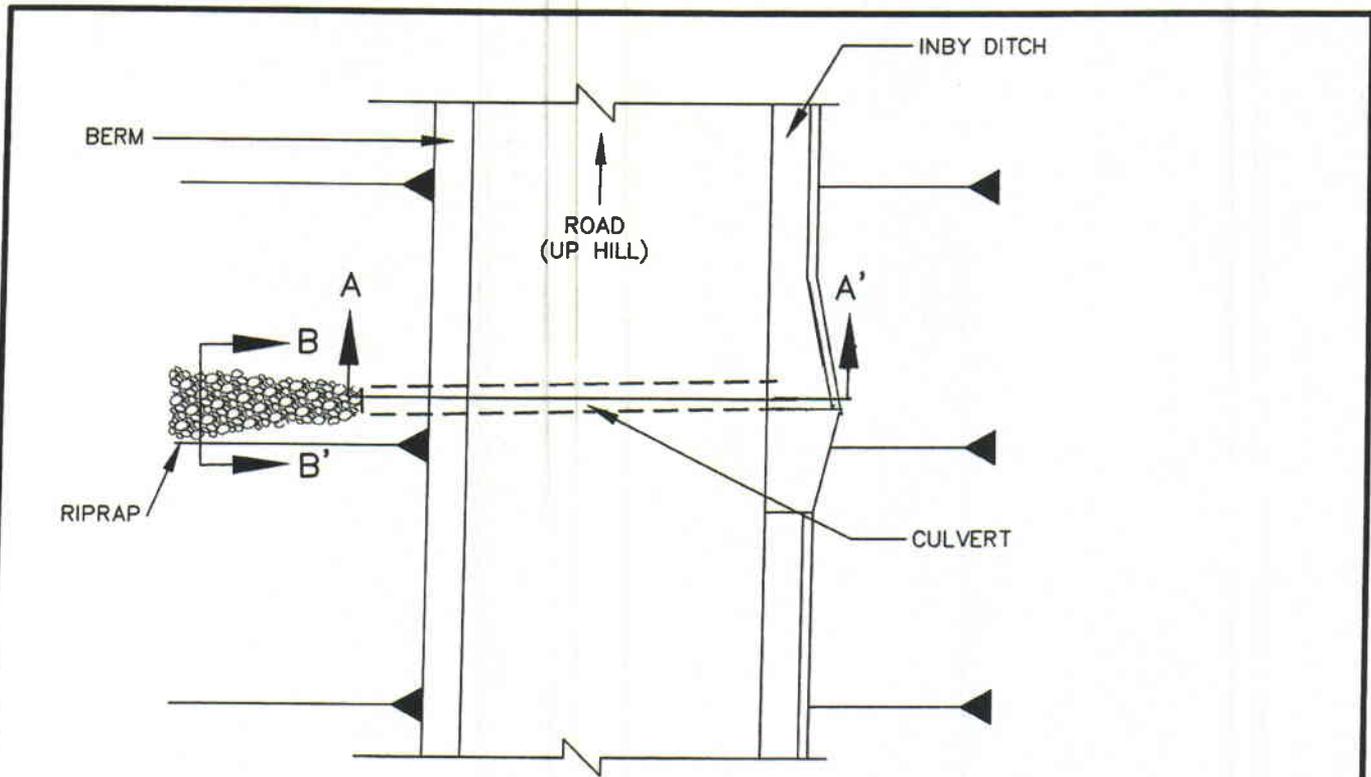
Methane Degassification Amendment
August 28, 2007 ~~July 9, 2007~~

**ATTACHMENT 7-1
HYDROLOGY CALCULATIONS**

add to the back of existing information

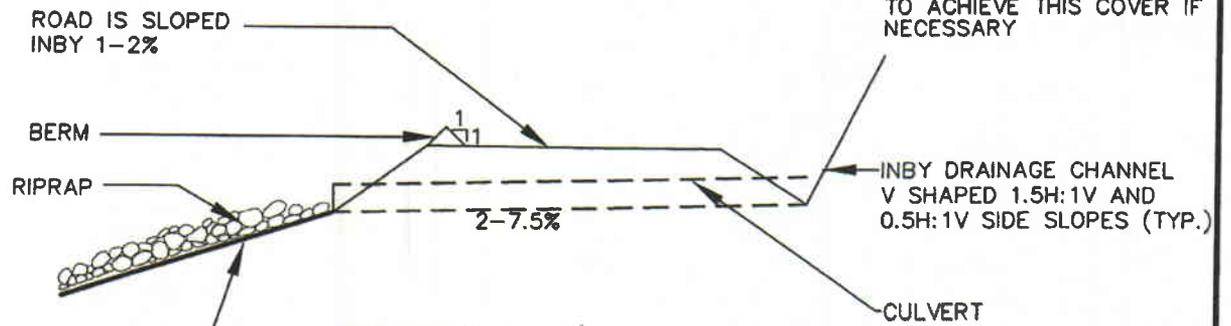
The components and design considerations for controlling the drainage during construction, operational.

Construction - Refer to text in Chapter 7, Attachment 5-4, Attachment 7-1		
Component	Section(s)	Drawing
Silt Fence	728.300, 731.100, 732, 732.400, 734, 742.100, 742.200, 751	Attachment 7-1
Berms	728.300, 731, 732, 742	Attachments 5-4 & 7-1
Culverts	728, 732.400	Attachments 5-4 & 7-1
Operation - Refer to text in Chapter 7, Attachment 5-4, Attachment 5-4 (Plates 1 thru 3), Attachment 7-1		
Component	Section	Drawing
Silt Fence	731.100, 732, 732.400, 734,	Attachment 7-1
Berms	731, 732	Attachments 5-4 & 7-1
Culverts	732.400	Attachments 5-4 & 7-1

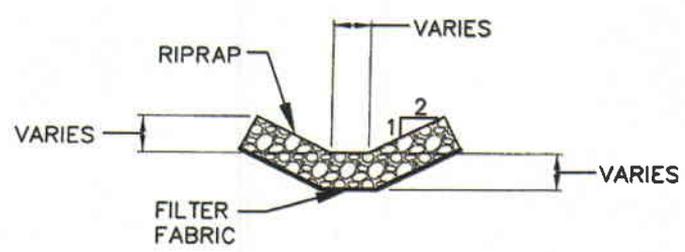


PLAN
NOT TO SCALE

CULVERT MUST HAVE 1 FT. MIN. COVER. CHANNEL MAY BE WIDENED AND DEEPEMED TO ACHIEVE THIS COVER IF NECESSARY



SECTION A-A'
NOT TO SCALE

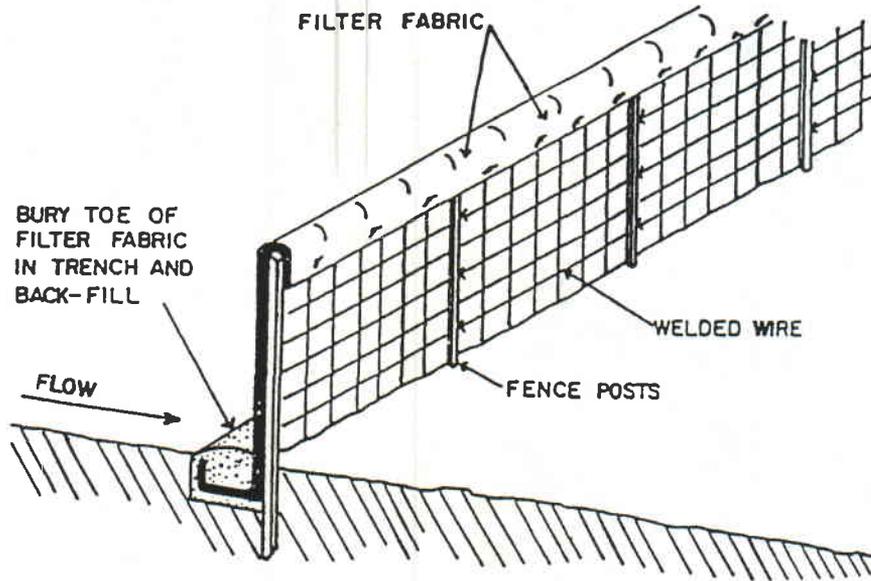


SECTION B-B'
NOT TO SCALE

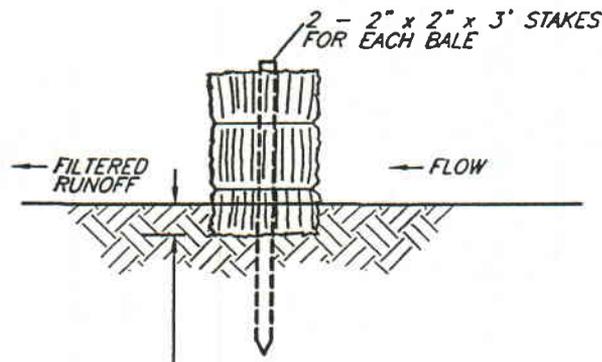


FIGURE 3. ROAD RUNOFF CULVERT PLAN





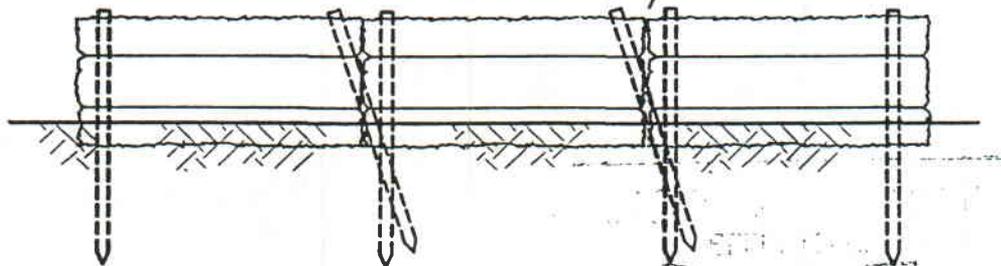
SILT FENCE



FIRST STAKE IN EACH BALE TO BE ANGLED TOWARD PREVIOUSLY LAID BALE TO FORCE BALES TOGETHER

EMBED STRAW BALE 4" MINIMUM INTO SOIL

BALES TO BUTT TIGHTLY TOGETHER



STRAW-BALE DIKE

OCT 19 1998

18-1

SOURCE: Barfield, et al. (1981)
McCULLAH (1994)

**ATTACHMENT 7-1
HYDROLOGY CALCULATIONS - AMV Road**



Stockpile Runoff Volume Calculations

Stockpile	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. - <i>P</i> (in)	Curve Number (<i>CN</i>)	Potential Max. Retention - <i>S</i> (in.)	Runoff - <i>Q</i> (in)	Runoff Volume - <i>V</i> (ft ³)
STP-1	3,282	0.08	2.05	87	1.49	0.94	258
STP-2	3,312	0.08	2.05	87	1.49	0.94	261
STP-3	15,690	0.36	2.05	87	1.49	0.94	1,235
STP-4	14,734	0.34	2.05	87	1.49	0.94	1,160
STP-5	7,895	0.18	2.05	87	1.49	0.94	622
STP-6	8,417	0.19	2.05	87	1.49	0.94	663
STP-7	9,982	0.23	2.05	87	1.49	0.94	786

Notes

Calculations have been performed for the 10-year, 24-hour design storm event.

Topsoil is derived from the Midfork Family - Comodore Complex, as described in the NRCS Soil Survey for Carbon Area, Parts of Carbon and Emery Counties.

Calculations based on Soil Conservation Service (SCS) Method, National Engineering Handbook Section 4, Chapters 9 & 10 by Victor Mockus, 1972

Precipitation for 10-year, 24-hour event taken from National Weather Service web site (http://hdsc.nws.noaa.gov/hdsc/pfds/sa/ut_pfds.html)

CN = 87, based on Table 9.1, NEH s4 ch9. Assume Hyd. Soil Gp. C (as given for Rottulee family - Trag complex in NRCS survey). Assume road, dirt surface (non-vegetated, conservative case).

$$S = (1000/CN) - 10$$

$$L = [(I^{0.8} (S+1)^{0.7}) / (1900Y^{0.5})]$$

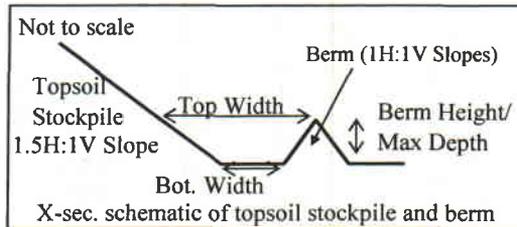
$$T_c = 1.67L$$

$$Q = (P - 0.2*S)^2 / (P + 0.8*S)$$

$$V = \text{Area} * Q$$

Stockpile Runoff Containment Volume Calculations

Stockpile	Bottom Width (ft)	Top Width (ft)	Max Depth (ft)	Impounding Length of Berm (ft)	Total Length of Berm (ft)	Fill Req'd for Berm (yd ³)	Cntmnt Vol. (ft ³)	Contain Vol > Runoff Vol ?
STP-1	2	4.5	1	78	268	10	254	Yes
STP-2	2	4.5	1	89	257	10	289	Yes
STP-3	2	7	2	250	510	76	2,250	Yes
STP-4	2	7	2	227	509	75	2,043	Yes
STP-5	2	7	2	76	402	60	684	Yes
STP-6	2	4.5	1	262	513	19	852	Yes
STP-7	2	7	2	183	404	60	1,647	Yes
309							Total fill for berms (yd³)	



Notes

The bottom width is the distance between the toe of the topsoil stockpile and the base of the berm. (see schematic)

The top width is the horizontal distance between the crest of the berm and the topsoil stockpile. (see schematic)

The max depth is the height of the berm.

The Impounding Length of the berm accounts for the slope of the ground, and is the portion of the berm that will impound runoff.

The Total Length of Berm is its entire length around the topsoil stockpile.

The Fill Required for Berm is the volume of subsoil required to construct each berm, and is based on the length, height, and width of each berm. Berms shall be constructed with 1H:1V slopes.

The Containment Volume = Length * Cross sectional area of the space between the topsoil stockpile and the inby side of the berm.

Watershed Hydrology - Culvert Design

Watershed	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. P (in)	Hydraulic Length - L (ft)	Avg Watershed Slope - Y (%)	Duration of Storm (hr)	Curve Number (CN)	Potential Max. Retention S (in.)	Lag - L (hr)	Time of Concentration - T _c (hr)	Runoff - Q (in)	Runoff Volume - V (ft ³)	Peak Discharge (cfs)
EDWS1	1,532,383	35.2	2.05	2,262	60.5	24	77	2.99	0.09	0.14	0.48	60,692	24.68
EDWS2	276,566	6.3	2.05	1,502	60.1	24	77	2.99	0.06	0.10	0.48	10,954	4.94
EDWS3	205,995	4.7	2.05	1,151	57.7	24	77	2.99	0.05	0.09	0.48	8,159	3.79
EDWS4	395,010	9.1	2.05	1,100	49.8	24	77	2.99	0.05	0.09	0.48	15,645	7.25
EDWS5	74,016	1.7	2.05	589	45.7	24	82	2.20	0.03	0.05	0.68	4,206	2.25
RRWS-1	438,378	10.1	1.38	1,930	42.4	6	77	2.99	0.09	0.15	0.16	5,935	2.83
RRWS-2	237,126	5.4	1.38	1,695	61.7	6	77	2.99	0.07	0.11	0.16	3,211	1.84
RRWS-3	282,656	6.5	1.38	985	60.2	6	77	2.99	0.04	0.07	0.16	3,827	2.97

Notes

Calculations have been performed for the 10-year, 24-hour storm event for ephemeral drainage channel culverts and the 10-year, 6-hour design storm event road runoff culverts. Refer to attached Figures 1 and 2 for locations of watersheds and NRCS soils units

Calculations based on Soil Conservation Service (SCS) Method, National Engineering Handbook Section 4, Chapters 9 & 10 by Victor Mockus, 1972

CN determined based on NRCS soils map, which shows that each watershed (except WS5) contains soils of which half are in Hydrologic Soils Group B and half are in Group C. According to the UDOT Manual of Instruction, Table 7-14, woods-grass combination, poor condition has a CN of 73 for Group B and 82 for Group C. The weighted average CN is thus approximately 77. EDWS5 is comprised entirely of soils in Group C.

$$S = (1000/CN) - 10$$

$$L = [t^{0.8} (S+1)^{0.7}] / (1900Y^{0.5})$$

$$T_c = 1.67L$$

$$Q = (P - 0.2*S)^2 / (P + 0.8*S)$$

$$V = \text{Area} * Q$$

Peak discharge calculated using HydroCad 8.00 software (see attached sheets for output).

Average Watershed Slope Calculation (Sum of lengths of contour lines X contour interval / Area)

EDWS1

Contour (ft)	Length (ft)
7,900	825
8,000	1,021
8,100	1,353
8,200	1,483
8,300	1,481
8,400	1,327
8,500	843
8,600	546
8,700	256
8,800	131
TOTAL	9,266
AvgSlope	60.5%

EDWS2

Contour (ft)	Length (ft)
7,800	142
7,900	298
8,000	251
8,100	328
8,200	245
8,300	398
TOTAL	1,662
AvgSlope	60.1%

EDWS3

Contour (ft)	Length (ft)
7,800	246
7,900	231
8,000	294
8,100	202
8,200	156
8,300	60
TOTAL	1,189
AvgSlope	57.7%

EDWS4

Contour (ft)	Length (ft)
7,800	284
7,900	380
8,000	624
8,100	451
8,200	170
8,300	60
TOTAL	1,969
AvgSlope	49.8%

EDWS5

Contour (ft)	Length (ft)
8,100	282
8,200	56
TOTAL	338
AvgSlope	45.7%

RRWS3

Contour (ft)	Length (ft)
8,000	333
8,050	635
8,100	606
8,150	600
8,200	511
8,250	421
8,300	295
TOTAL	3,401
AvgSlope	60.2%

RRWS2

Contour (ft)	Length (ft)
8,075	60
8,125	485
8,175	1,242
8,225	802
8,275	337
TOTAL	2,926
AvgSlope	61.7%

RRWS1

Contour (ft)	Length (ft)
8,225	450
8,275	887
8,325	1,305
8,375	974
8,425	103
TOTAL	3,719
AvgSlope	42.4%

Culvert Sizing

Ephemeral Drainage Culvert No.	Minimum Diameter (in)	Length (ft)	Inlet Elevation (ft)	Outlet Elevation (ft)	Average Slope (ft/ft)	Peak Discharge (cfs)	Peak Stage in Road Ditch (ft)	Peak Velocity in Road Ditch (fps)	Culvert Peak Inlet Depth (ft)	Culvert Peak Inside Depth (ft)	Peak Flow Velocity from Culvert (fps)
EDC-1	36	203	7,890	7,845	0.22	24.3	0.54	4.72	2.46	0.78	16.60
EDC-2	24	117	7,735	7,730	0.04	6.62	0.45	4.29	1.38	0.40	14.97
EDC-3	18	89	7,735	7,700	0.39	4.30	0.41	3.98	1.23	0.36	13.25
EDC-4	18	64	7,712	7,690	0.34	3.67	0.35	3.02	1.04	0.34	12.06
EDC-5	18	80	8,020	7,997	0.29	2.27	0.32	3.41	0.86	0.29	9.90
RRC-1	18	20	NA	NA	0.02-0.075	2.26	0.68	4.95	0.86	0.39	6.10
RRC-2	18	20	NA	NA	0.02-0.075	1.00	0.53	3.51	0.45	0.26	4.80
RRC-3	18	20	NA	NA	0.02-0.075	2.31	0.63	5.84	0.86	0.40	6.14

Notes

Culvert No. corresponds to Watershed No. on Ephemeral Drainage Watershed Hydrology - Culvert Design Table. i.e. Culvert EDC-1 will be located where EDWS-1 crosses the road.

Culverts were conservatively assumed to be corrugated metal pipe. Polyethylene pipe may also be used.

Since their precise locations are subject to change, inlet and outlet elevations were not specified for the Road Runoff Culverts. It was assumed that they would slope at a grade of 7.5%.

The peak flows and stages in each culvert and ditch were calculated using HydroCad 8.00 software using the Soil Conservation Service (SCS) method, as shown in the Watershed Hydrology - Culvert Design Table. The design storm was the 10-year, 24-hour precipitation event for the ephemeral drainage culverts and the 10-year, 6-hour precipitation event for the road runoff ditches and culverts.

Since the peak design flow velocities within each ditch are less than 5 fps, they are considered non-erosive. Thus, no channel or culvert inlet protection is required. The peak inlet depth is measured from the bottom of the culvert and was determined using Hydraulic Engineering Circular No. 5 Chart 5 (U.S. Department of Transportation, 1977). As a conservative measure, the projecting condition was assumed. See the attached nomograph for additional information. The peak inside depth is measured from the bottom of the culvert and was calculated using HydroCad 8.00 software. See attached output sheets for additional information.

Culvert Outlet Protection

Culvert Outlet	Rip Rap Outlet Protection D_{50} (in)	Min. Length of Slope Protected Below Culvert Outlet (ft)	Min. Width of Slope Protected Below Culvert Outlet (ft)	Min. Depth of Rip Rap (ft)	Slope at Culvert Outlet (ft/ft)	Manning's Roughness (n)	Design Event Peak Culvert Flow (cfs)	Peak Design Culvert Velocity (fps)	Steady State Flow Velocity in Rip Rap Structure (fps)
EDC1	24	24	9	4	0.22	0.059	24.3	16.6	7.6
EDC2	24	16	6	4	0.30	0.062	6.6	15.0	6.3
EDC3	15	10.5	4.5	2.5	0.36	0.060	4.3	13.3	5.6
EDC4	15	12	4.5	2.5	0.27	0.057	7.8	12.1	5.9
EDC5	6	9	4.5	1.2	0.23	0.048	2.3	9.9	4.6
RRC1	15	9	4.5	4.1	0.50	0.063	2.3	6.1	5.0
RRC2	None	None	None	None	0.67	0.060	1.0	4.8	4.2
RRC3	6	9	4.5	1.7	0.29	0.050	2.3	6.1	4.8

Notes

Refer to Figure 3 for a typical drawing of road culverts and outlet protection

Sizing of rip rap intended to withstand culvert outlet flow velocities predicted in Culvert Sizing Table as per USDOT FHWA HEC 11 Fig. 2. Since the design event peak flow velocity in RRC2 < 5 fps, it is not considered erosive and thus no rip rap is specified.

Minimum lengths, widths, and depths of rip rap taken from FHWA HEC 11 (USDOT, 1989). Outlet protection structures may flare at a 3:1 angle from the culvert outlet. Filter fabric will be placed underneath the rip rap. Outlet protection will be monitored after precipitation events to ensure that the armored area is sufficient to reduce the erosive power of discharges.

Manning's Roughness calculated as $n = 0.0456(D_{50} X S)^{0.159}$, where D_{50} is the median rip rap diameter in inches and S is the channel slope (Abt et al, 1987). Note that n for RRC2 was taken as 0.060 (overland flow through brush).

Peak culvert flows and velocities were calculated for the 10-year, 24-hour event for ephemeral drainage culverts and the 10-year, 6-hour event for road runoff culverts using HydroCAD 8.00

Steady state flow velocities calculated using Flowmaster 6.0 (Haestad Methods, Inc.) They have been calculated to show that the rip rap protection will sufficiently reduce flow velocities so that the design discharge is non-erosive when it is discharged. Velocities less than 5.0 fps are considered nonerosive. Rip rap structure discharges with velocities higher than 5.0 fps are assumed to be nonerosive because they empty into existing drainage channels which are self-armoring.

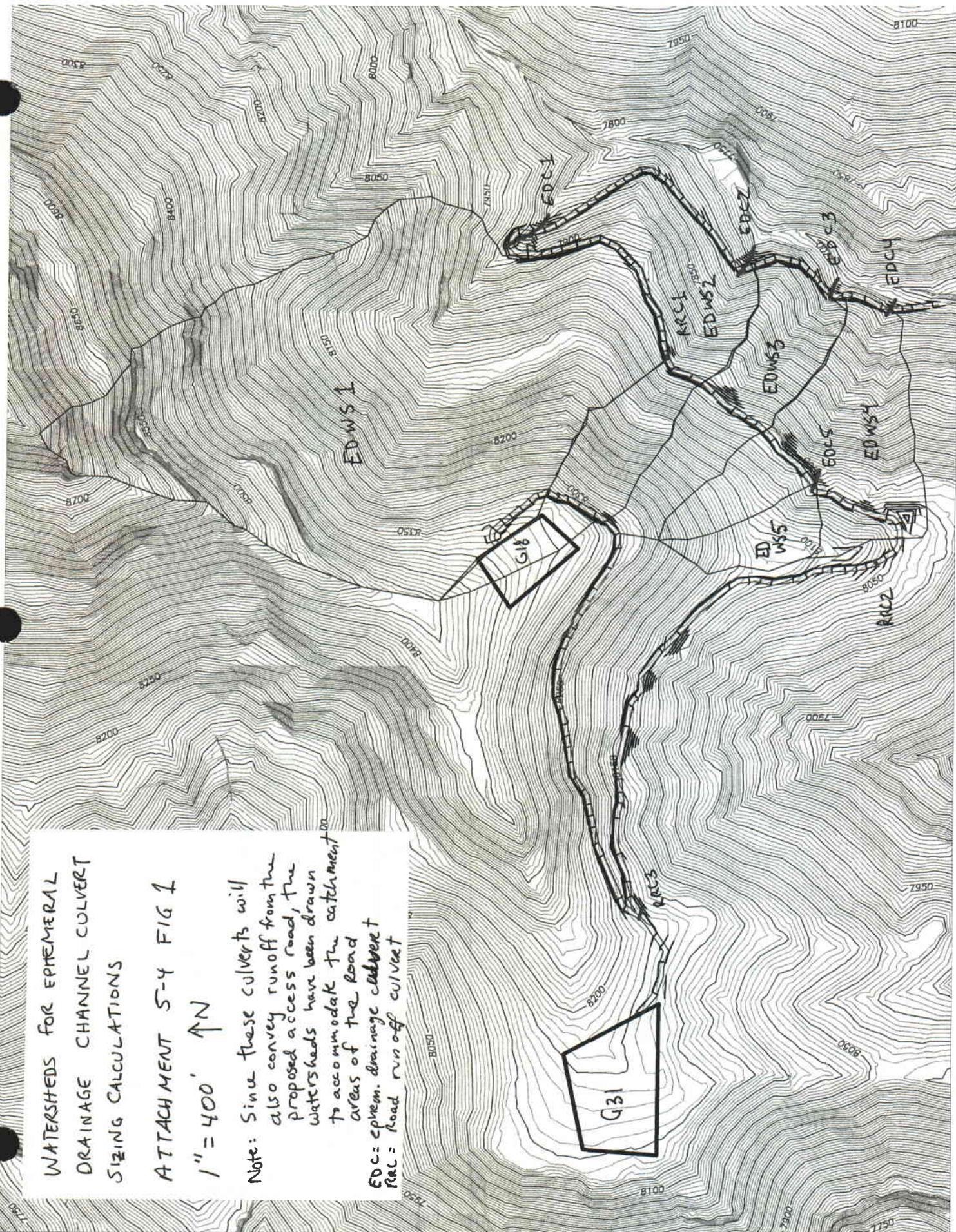
WATERSHEDS FOR EPHEMERAL
DRAINAGE CHANNEL CULVERT
SIZING CALCULATIONS

ATTACHMENT S-4 FIG 1

1" = 400' ↑ N

Note: Since these culverts will also convey runoff from the proposed access road, the watersheds have been drawn to accommodate the catchment areas of the road

EDC = ephem. drainage culvert
RAC = road run off culvert



WATERSHEDS FOR ROAD RUNOFF
CULVERT SIZING CALCULATIONS

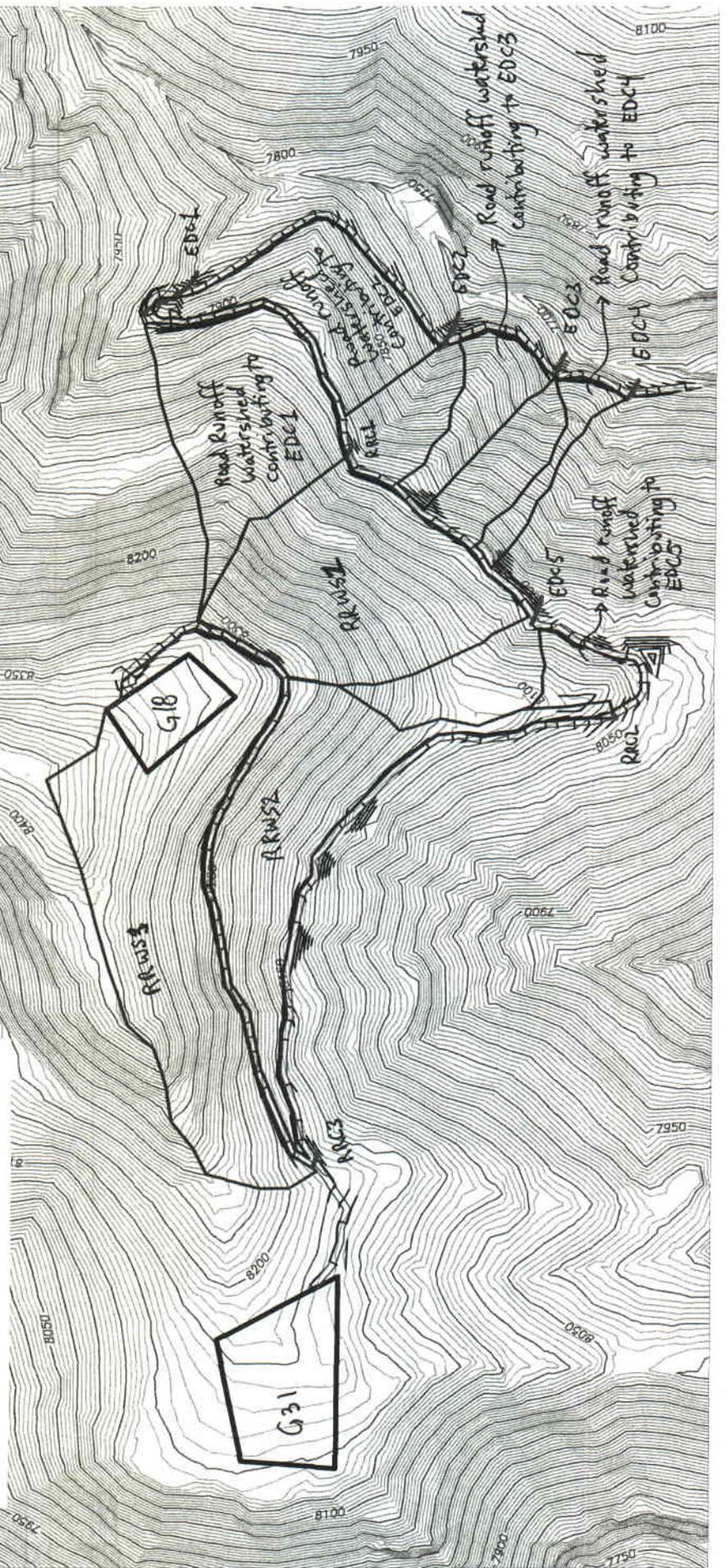
ATTACHMENT 5-4 FIG 2

1" = 400' ↑ N

Note: Watersheds are drawn as
the area contributing to each
culvert.

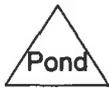
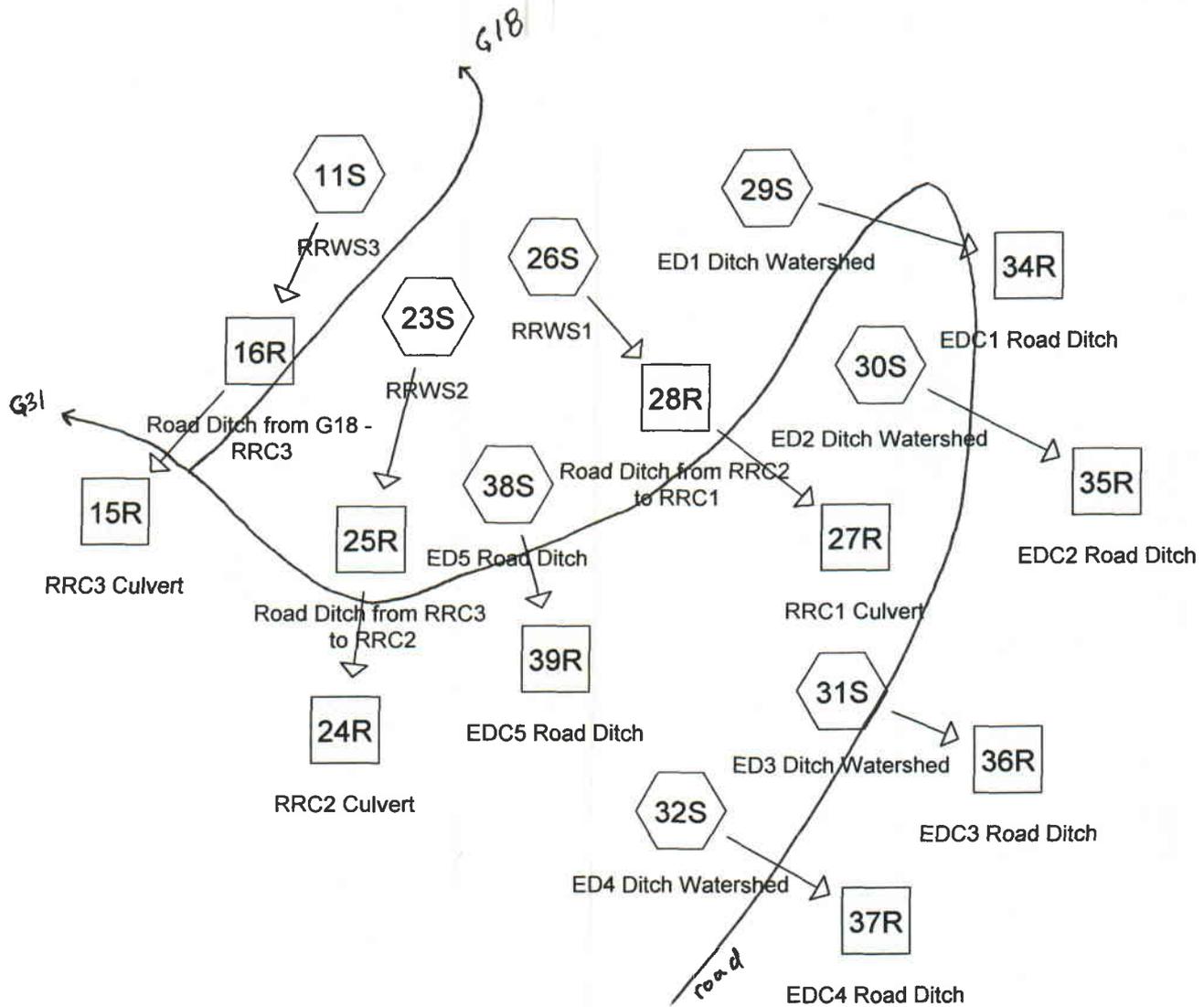
EDC = Ephemeral Drainage Culvert

RRC = Road Runoff Culvert



BACKUP INFORMATION

ROAD RUNOFF DITCH AND CULVERT HYDROLOGY SCHEMATIC



Drainage Diagram for 10yr - 6hr Road Runoff Culverts
 Prepared by {enter your company name here} 8/27/2007
 HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 2

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Time span=0.00-30.00 hrs, dt=0.01 hrs, 3001 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 11S: RRWS3 Runoff Area=438,378 sf Runoff Depth=0.16"
Flow Length=1,930' Slope=0.4240 '/ Tc=9.0 min CN=77 Runoff=2.83 cfs 5,935 cf

Subcatchment 23S: RRWS2 Runoff Area=237,126 sf Runoff Depth=0.16"
Flow Length=1,695' Slope=0.6170 '/ Tc=6.8 min CN=77 Runoff=1.84 cfs 3,211 cf

Subcatchment 26S: RRWS1 Runoff Area=282,656 sf Runoff Depth=0.16"
Flow Length=985' Slope=0.6020 '/ Tc=4.4 min CN=77 Runoff=2.97 cfs 3,827 cf

Subcatchment 29S: ED1 Ditch Watershed Runoff Area=202,641 sf Runoff Depth=0.16"
Flow Length=1,348' Slope=0.6050 '/ Tc=5.7 min CN=77 Runoff=1.78 cfs 2,744 cf

Subcatchment 30S: ED2 Ditch Watershed Runoff Area=135,524 sf Runoff Depth=0.16"
Flow Length=941' Slope=0.6010 '/ Tc=4.3 min CN=77 Runoff=1.44 cfs 1,835 cf

Subcatchment 31S: ED3 Ditch Watershed Runoff Area=65,082 sf Runoff Depth=0.16"
Flow Length=721' Slope=0.5770 '/ Tc=3.5 min CN=77 Runoff=0.79 cfs 881 cf

Subcatchment 32S: ED4 Ditch Watershed Runoff Area=33,833 sf Runoff Depth=0.16"
Flow Length=686' Slope=0.4980 '/ Tc=3.6 min CN=77 Runoff=0.41 cfs 458 cf

Subcatchment 38S: ED5 Road Ditch Runoff Area=36,179 sf Runoff Depth=0.16"
Flow Length=644' Slope=0.4570 '/ Tc=3.6 min CN=77 Runoff=0.43 cfs 490 cf

Reach 15R: RRC3 Culvert Avg. Depth=0.40' Max Vel=6.14 fps Inflow=2.31 cfs 5,935 cf
D=18.0" n=0.025 L=20.0' S=0.0750 '/ Capacity=14.96 cfs Outflow=2.31 cfs 5,935 cf

Reach 16R: Road Ditch from G18 - RRC3 Avg. Depth=0.63' Max Vel=5.84 fps Inflow=2.83 cfs 5,935 cf
n=0.035 L=1,266.0' S=0.1461 '/ Capacity=7.94 cfs Outflow=2.31 cfs 5,935 cf

Reach 24R: RRC2 Culvert Avg. Depth=0.26' Max Vel=4.80 fps Inflow=1.00 cfs 3,211 cf
D=18.0" n=0.025 L=20.0' S=0.0750 '/ Capacity=14.96 cfs Outflow=1.00 cfs 3,211 cf

Reach 25R: Road Ditch from RRC3 to RRC2 Avg. Depth=0.53' Max Vel=3.51 fps Inflow=1.84 cfs 3,211 cf
n=0.035 L=1,665.0' S=0.0661 '/ Capacity=5.34 cfs Outflow=1.00 cfs 3,211 cf

Reach 27R: RRC1 Culvert Avg. Depth=0.39' Max Vel=6.10 fps Inflow=2.27 cfs 3,827 cf
D=18.0" n=0.025 L=20.0' S=0.0750 '/ Capacity=14.96 cfs Outflow=2.26 cfs 3,827 cf

Reach 28R: Road Ditch from RRC2 to RRC1 Avg. Depth=0.68' Max Vel=4.95 fps Inflow=2.97 cfs 3,827 cf
n=0.035 L=628.0' S=0.0955 '/ Capacity=6.42 cfs Outflow=2.27 cfs 3,827 cf

Reach 34R: EDC1 Road Ditch Avg. Depth=0.54' Max Vel=4.72 fps Inflow=1.78 cfs 2,744 cf
n=0.035 L=765.0' S=0.1176 '/ Capacity=7.13 cfs Outflow=1.37 cfs 2,744 cf

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 3

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Reach 35R: EDC2 Road Ditch Avg. Depth=0.45' Max Vel=4.29 fps Inflow=1.44 cfs 1,835 cf
n=0.035 L=941.0' S=0.1222 '/' Capacity=7.26 cfs Outflow=0.89 cfs 1,835 cf

Reach 36R: EDC3 Road Ditch Avg. Depth=0.41' Max Vel=3.98 fps Inflow=0.79 cfs 881 cf
n=0.035 L=292.0' S=0.1199 '/' Capacity=7.19 cfs Outflow=0.67 cfs 881 cf

Reach 37R: EDC4 Road Ditch Avg. Depth=0.35' Max Vel=3.02 fps Inflow=0.41 cfs 458 cf
n=0.035 L=173.0' S=0.0867 '/' Capacity=6.12 cfs Outflow=0.36 cfs 458 cf

Reach 39R: EDC5 Road Ditch Avg. Depth=0.32' Max Vel=3.41 fps Inflow=0.43 cfs 490 cf
n=0.035 L=323.0' S=0.1238 '/' Capacity=7.31 cfs Outflow=0.34 cfs 490 cf

Total Runoff Area = 1,431,419 sf Runoff Volume = 19,381 cf Average Runoff Depth = 0.16"
100.00% Pervious Area = 1,431,419 sf 0.00% Impervious Area = 0 sf

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 4

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Subcatchment 11S: RRWS3

Runoff = 2.83 cfs @ 3.11 hrs, Volume= 5,935 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
438,378	77	
438,378		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	1,930	0.4240	3.56		Lag/CN Method,

Subcatchment 23S: RRWS2

Runoff = 1.84 cfs @ 3.07 hrs, Volume= 3,211 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
237,126	77	
237,126		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.8	1,695	0.6170	4.18		Lag/CN Method,

Subcatchment 26S: RRWS1

Runoff = 2.97 cfs @ 3.04 hrs, Volume= 3,827 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
282,656	77	
282,656		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.4	985	0.6020	3.70		Lag/CN Method,

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 5

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Subcatchment 29S: ED1 Ditch Watershed

Runoff = 1.78 cfs @ 3.06 hrs, Volume= 2,744 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
202,641	77	
202,641		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	1,348	0.6050	3.95		Lag/CN Method,

Subcatchment 30S: ED2 Ditch Watershed

Runoff = 1.44 cfs @ 3.04 hrs, Volume= 1,835 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
135,524	77	
135,524		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	941	0.6010	3.67		Lag/CN Method,

Subcatchment 31S: ED3 Ditch Watershed

Runoff = 0.79 cfs @ 3.03 hrs, Volume= 881 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
65,082	77	
65,082		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	721	0.5770	3.41		Lag/CN Method,

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 6

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Subcatchment 32S: ED4 Ditch Watershed

Runoff = 0.41 cfs @ 3.03 hrs, Volume= 458 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
33,833	77	
33,833		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	686	0.4980	3.13		Lag/CN Method,

Subcatchment 38S: ED5 Road Ditch

Runoff = 0.43 cfs @ 3.03 hrs, Volume= 490 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type II 24-hr 6.00 hrs Rainfall=1.38"

Area (sf)	CN	Description
36,179	77	
36,179		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	644	0.4570	2.96		Lag/CN Method,

Reach 15R: RRC3 Culvert

Inflow Area = 438,378 sf, Inflow Depth = 0.16"

Inflow = 2.31 cfs @ 3.22 hrs, Volume= 5,935 cf

Outflow = 2.31 cfs @ 3.22 hrs, Volume= 5,935 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Max. Velocity= 6.14 fps, Min. Travel Time= 0.1 min

Avg. Velocity = 2.64 fps, Avg. Travel Time= 0.1 min

Peak Storage= 8 cf @ 3.22 hrs, Average Depth at Peak Storage= 0.40'

Bank-Full Depth= 1.50', Capacity at Bank-Full= 14.96 cfs

18.0" Diameter Pipe, n= 0.025 Corrugated metal

Length= 20.0' Slope= 0.0750 '/'

Inlet Invert= 8,175.00', Outlet Invert= 8,173.50'

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 7

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 16R: Road Ditch from G18 - RRC3

Inflow Area =	438,378 sf,	Inflow Depth =	0.16"	
Inflow =	2.83 cfs @	3.11 hrs,	Volume=	5,935 cf
Outflow =	2.31 cfs @	3.22 hrs,	Volume=	5,935 cf, Atten= 18%, Lag= 6.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
 Max. Velocity= 5.84 fps, Min. Travel Time= 3.6 min
 Avg. Velocity = 2.55 fps, Avg. Travel Time= 8.3 min

Peak Storage= 502 cf @ 3.16 hrs, Average Depth at Peak Storage= 0.63'
 Bank-Full Depth= 1.00', Capacity at Bank-Full= 7.94 cfs

0.00' x 1.00' deep channel, n= 0.035
 Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
 Length= 1,266.0' Slope= 0.1461 ' / '
 Inlet Invert= 8,360.00', Outlet Invert= 8,175.00'



Reach 24R: RRC2 Culvert

Inflow Area =	237,126 sf,	Inflow Depth =	0.16"	
Inflow =	1.00 cfs @	3.30 hrs,	Volume=	3,211 cf
Outflow =	1.00 cfs @	3.30 hrs,	Volume=	3,211 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
 Max. Velocity= 4.80 fps, Min. Travel Time= 0.1 min
 Avg. Velocity = 1.96 fps, Avg. Travel Time= 0.2 min

Peak Storage= 4 cf @ 3.30 hrs, Average Depth at Peak Storage= 0.26'
 Bank-Full Depth= 1.50', Capacity at Bank-Full= 14.96 cfs

18.0" Diameter Pipe, n= 0.025 Corrugated metal
 Length= 20.0' Slope= 0.0750 ' / '
 Inlet Invert= 8,060.00', Outlet Invert= 8,058.50'

10yr - 6hr Road Runoff Culverts

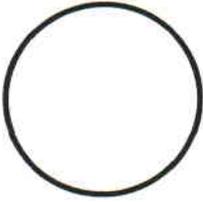
Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 8

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 25R: Road Ditch from RRC3 to RRC2

Inflow Area = 237,126 sf, Inflow Depth = 0.16"
Inflow = 1.84 cfs @ 3.07 hrs, Volume= 3,211 cf
Outflow = 1.00 cfs @ 3.30 hrs, Volume= 3,211 cf, Atten= 46%, Lag= 13.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.51 fps, Min. Travel Time= 7.9 min
Avg. Velocity= 1.34 fps, Avg. Travel Time= 20.7 min

Peak Storage= 473 cf @ 3.17 hrs, Average Depth at Peak Storage= 0.53'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 5.34 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 1,665.0' Slope= 0.0661 ' / '
Inlet Invert= 8,170.00', Outlet Invert= 8,060.00'



Reach 27R: RRC1 Culvert

Inflow Area = 282,656 sf, Inflow Depth = 0.16"
Inflow = 2.27 cfs @ 3.10 hrs, Volume= 3,827 cf
Outflow = 2.26 cfs @ 3.10 hrs, Volume= 3,827 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 6.10 fps, Min. Travel Time= 0.1 min
Avg. Velocity= 2.63 fps, Avg. Travel Time= 0.1 min

Peak Storage= 7 cf @ 3.10 hrs, Average Depth at Peak Storage= 0.39'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 14.96 cfs

18.0" Diameter Pipe, n= 0.025 Corrugated metal
Length= 20.0' Slope= 0.0750 ' / '
Inlet Invert= 7,965.00', Outlet Invert= 7,963.50'

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 9

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 28R: Road Ditch from RRC2 to RRC1

Inflow Area = 282,656 sf, Inflow Depth = 0.16"
Inflow = 2.97 cfs @ 3.04 hrs, Volume= 3,827 cf
Outflow = 2.27 cfs @ 3.10 hrs, Volume= 3,827 cf, Atten= 24%, Lag= 3.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.95 fps, Min. Travel Time= 2.1 min
Avg. Velocity = 2.21 fps, Avg. Travel Time= 4.7 min

Peak Storage= 288 cf @ 3.07 hrs, Average Depth at Peak Storage= 0.68'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 6.42 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 628.0' Slope= 0.0955 ' / '
Inlet Invert= 8,025.00', Outlet Invert= 7,965.00'



Reach 34R: EDC1 Road Ditch

Inflow Area = 202,641 sf, Inflow Depth = 0.16"
Inflow = 1.78 cfs @ 3.06 hrs, Volume= 2,744 cf
Outflow = 1.37 cfs @ 3.14 hrs, Volume= 2,744 cf, Atten= 23%, Lag= 4.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.72 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 2.18 fps, Avg. Travel Time= 5.8 min

Peak Storage= 223 cf @ 3.09 hrs, Average Depth at Peak Storage= 0.54'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 7.13 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 765.0' Slope= 0.1176 ' / '
Inlet Invert= 7,975.00', Outlet Invert= 7,885.00'

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 10

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 35R: EDC2 Road Ditch

Inflow Area = 135,524 sf, Inflow Depth = 0.16"
Inflow = 1.44 cfs @ 3.04 hrs, Volume= 1,835 cf
Outflow = 0.89 cfs @ 3.14 hrs, Volume= 1,835 cf, Atten= 39%, Lag= 6.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 4.29 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 1.95 fps, Avg. Travel Time= 8.1 min

Peak Storage= 194 cf @ 3.08 hrs, Average Depth at Peak Storage= 0.45'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 7.26 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 941.0' Slope= 0.1222 ' / '
Inlet Invert= 7,885.00', Outlet Invert= 7,770.00'



Reach 36R: EDC3 Road Ditch

Inflow Area = 65,082 sf, Inflow Depth = 0.16"
Inflow = 0.79 cfs @ 3.03 hrs, Volume= 881 cf
Outflow = 0.67 cfs @ 3.06 hrs, Volume= 881 cf, Atten= 15%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.98 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.96 fps, Avg. Travel Time= 2.5 min

Peak Storage= 50 cf @ 3.04 hrs, Average Depth at Peak Storage= 0.41'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 7.19 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 292.0' Slope= 0.1199 ' / '
Inlet Invert= 7,765.00', Outlet Invert= 7,730.00'

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

Page 11

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 37R: EDC4 Road Ditch

Inflow Area = 33,833 sf, Inflow Depth = 0.16"
Inflow = 0.41 cfs @ 3.03 hrs, Volume= 458 cf
Outflow = 0.36 cfs @ 3.06 hrs, Volume= 458 cf, Atten= 11%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.02 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 1.53 fps, Avg. Travel Time= 1.9 min

Peak Storage= 21 cf @ 3.04 hrs, Average Depth at Peak Storage= 0.35'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 6.12 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 173.0' Slope= 0.0867 ' / '
Inlet Invert= 7,725.00', Outlet Invert= 7,710.00'



Reach 39R: EDC5 Road Ditch

Inflow Area = 36,179 sf, Inflow Depth = 0.16"
Inflow = 0.43 cfs @ 3.03 hrs, Volume= 490 cf
Outflow = 0.34 cfs @ 3.08 hrs, Volume= 490 cf, Atten= 21%, Lag= 2.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.41 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 1.72 fps, Avg. Travel Time= 3.1 min

Peak Storage= 33 cf @ 3.05 hrs, Average Depth at Peak Storage= 0.32'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 7.31 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 0.5 1.5 ' / ' Top Width= 2.00'
Length= 323.0' Slope= 0.1238 ' / '
Inlet Invert= 8,065.00', Outlet Invert= 8,025.00'

10yr - 6hr Road Runoff Culverts

Type II 24-hr 6.00 hrs Rainfall=1.38"

Prepared by {enter your company name here}

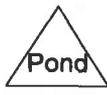
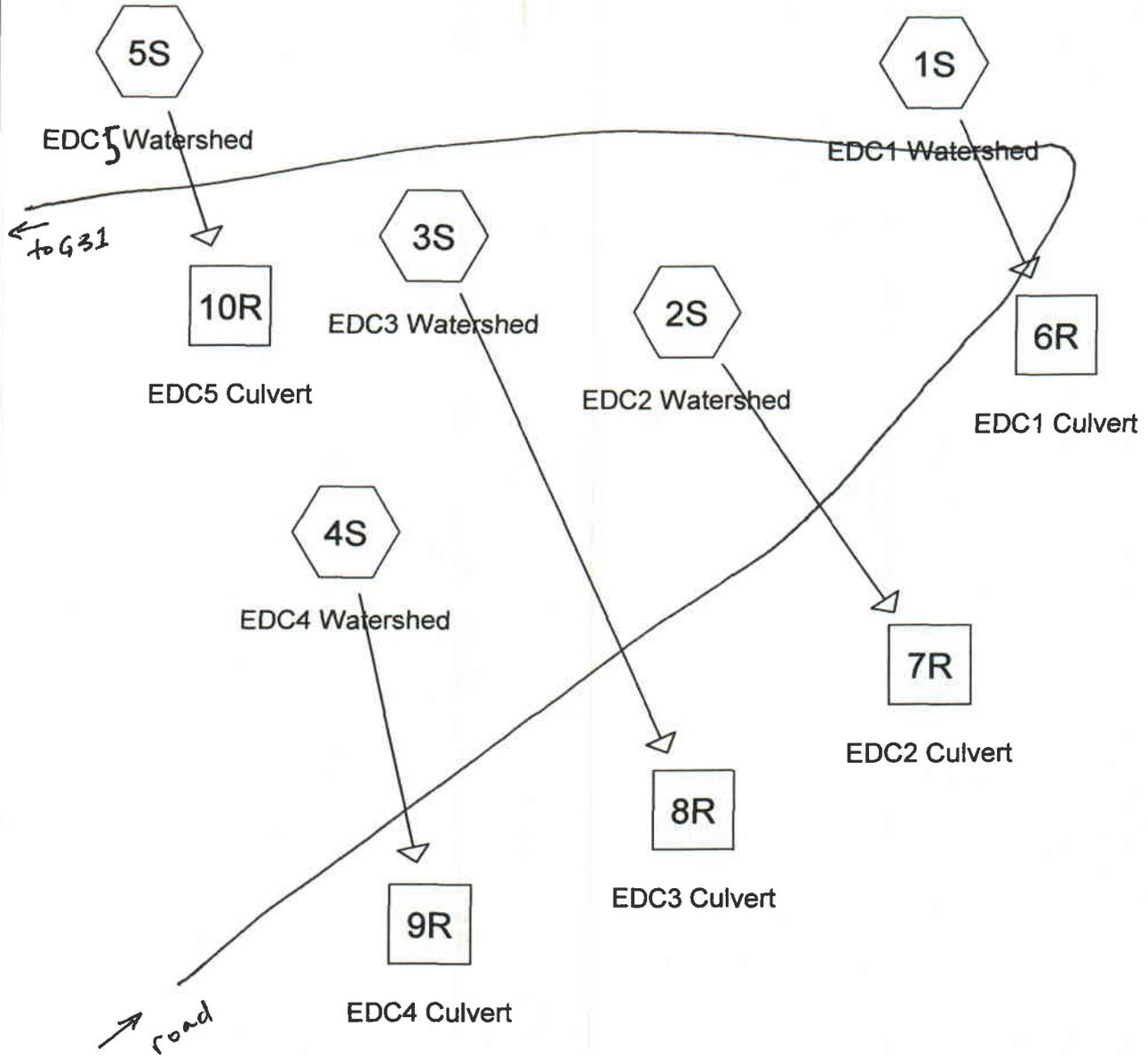
Page 12

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



EPHEMERAL DRAINAGE CULVERT HYDROLOGY SCHEMATIC



10-24Ephemeral Drainage Culverts

Type II 24-hr Rainfall=2.05"

Prepared by {enter your company name here}

Page 2

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Time span=0.00-30.00 hrs, dt=0.02 hrs, 1501 points

Runoff by SCS TR-20 method, UH=SCS

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: EDC1 Watershed Runoff Area=1,487,270 sf Runoff Depth=0.48"
Flow Length=2,262' Slope=0.6050 '/ Tc=8.6 min CN=77 Runoff=24.42 cfs 58,905 cf

Subcatchment 2S: EDC2 Watershed Runoff Area=363,860 sf Runoff Depth=0.48"
Flow Length=1,502' Slope=0.6010 '/ Tc=6.2 min CN=77 Runoff=6.65 cfs 14,411 cf

Subcatchment 3S: EDC3 Watershed Runoff Area=225,090 sf Runoff Depth=0.48"
Flow Length=1,151' Slope=0.5770 '/ Tc=5.1 min CN=77 Runoff=4.32 cfs 8,915 cf

Subcatchment 4S: EDC4 Watershed Runoff Area=407,357 sf Runoff Depth=0.48"
Flow Length=1,100' Slope=0.4980 '/ Tc=5.3 min CN=77 Runoff=7.75 cfs 16,134 cf

Subcatchment 5S: EDC5 Watershed Runoff Area=74,015 sf Runoff Depth=0.68"
Flow Length=589' Slope=0.4570 '/ Tc=2.9 min CN=82 Runoff=2.32 cfs 4,206 cf

Reach 6R: EDC1 Culvert Avg. Depth=0.78' Max Vel=16.60 fps Inflow=24.42 cfs 58,905 cf
D=36.0" n=0.025 L=203.0' S=0.2217 '/ Capacity=163.30 cfs Outflow=24.30 cfs 58,905 cf

Reach 7R: EDC2 Culvert Avg. Depth=0.40' Max Vel=14.97 fps Inflow=6.65 cfs 14,411 cf
D=24.0" n=0.025 L=117.0' S=0.4274 '/ Capacity=76.90 cfs Outflow=6.62 cfs 14,411 cf

Reach 8R: EDC3 Culvert Avg. Depth=0.36' Max Vel=13.25 fps Inflow=4.32 cfs 8,915 cf
D=18.0" n=0.025 L=89.0' S=0.3933 '/ Capacity=34.25 cfs Outflow=4.30 cfs 8,915 cf

Reach 9R: EDC4 Culvert Avg. Depth=0.45' Max Vel=14.52 fps Inflow=7.75 cfs 16,134 cf
D=24.0" n=0.025 L=64.0' S=0.3438 '/ Capacity=68.97 cfs Outflow=7.73 cfs 16,134 cf

Reach 10R: EDC5 Culvert Avg. Depth=0.29' Max Vel=9.89 fps Inflow=2.32 cfs 4,206 cf
D=18.0" n=0.025 L=80.0' S=0.2875 '/ Capacity=29.29 cfs Outflow=2.30 cfs 4,206 cf

Total Runoff Area = 2,557,592 sf Runoff Volume = 102,571 cf Average Runoff Depth = 0.48"
100.00% Pervious Area = 2,557,592 sf 0.00% Impervious Area = 0 sf

10-24Ephemeral Drainage Culverts

Type II 24-hr Rainfall=2.05"

Prepared by {enter your company name here}

Page 3

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Subcatchment 1S: EDC1 Watershed

Runoff = 24.42 cfs @ 12.02 hrs, Volume= 58,905 cf, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=2.05"

Area (sf)	CN	Description
1,487,270	77	
1,487,270		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.6	2,262	0.6050	4.38		Lag/CN Method,

Subcatchment 2S: EDC2 Watershed

Runoff = 6.65 cfs @ 11.99 hrs, Volume= 14,411 cf, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=2.05"

Area (sf)	CN	Description
363,860	77	
363,860		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	1,502	0.6010	4.03		Lag/CN Method,

Subcatchment 3S: EDC3 Watershed

Runoff = 4.32 cfs @ 11.97 hrs, Volume= 8,915 cf, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=2.05"

Area (sf)	CN	Description
225,090	77	
225,090		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.1	1,151	0.5770	3.74		Lag/CN Method,

10-24Ephemeral Drainage Culverts

Type II 24-hr Rainfall=2.05"

Prepared by {enter your company name here}

Page 4

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007

Subcatchment 4S: EDC4 Watershed

Runoff = 7.75 cfs @ 11.98 hrs, Volume= 16,134 cf, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=2.05"

Area (sf)	CN	Description
407,357	77	
407,357		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	1,100	0.4980	3.44		Lag/CN Method,

Subcatchment 5S: EDC5 Watershed

Runoff = 2.32 cfs @ 11.94 hrs, Volume= 4,206 cf, Depth= 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=2.05"

Area (sf)	CN	Description
74,015	82	
74,015		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.9	589	0.4570	3.40		Lag/CN Method,

Reach 6R: EDC1 Culvert

Inflow Area = 1,487,270 sf, Inflow Depth = 0.48"

Inflow = 24.42 cfs @ 12.02 hrs, Volume= 58,905 cf

Outflow = 24.30 cfs @ 12.02 hrs, Volume= 58,905 cf, Atten= 0%, Lag= 0.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs

Max. Velocity= 16.60 fps, Min. Travel Time= 0.2 min

Avg. Velocity = 6.06 fps, Avg. Travel Time= 0.6 min

Peak Storage= 299 cf @ 12.02 hrs, Average Depth at Peak Storage= 0.78'

Bank-Full Depth= 3.00', Capacity at Bank-Full= 163.30 cfs

36.0" Diameter Pipe, n= 0.025 Corrugated metal

Length= 203.0' Slope= 0.2217 '/'

Inlet Invert= 7,890.00', Outlet Invert= 7,845.00'

10-24Ephemeral Drainage Culverts

Type II 24-hr Rainfall=2.05"

Prepared by {enter your company name here}

Page 5

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 7R: EDC2 Culvert

Inflow Area = 363,860 sf, Inflow Depth = 0.48"
Inflow = 6.65 cfs @ 11.99 hrs, Volume= 14,411 cf
Outflow = 6.62 cfs @ 11.99 hrs, Volume= 14,411 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 14.97 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 5.32 fps, Avg. Travel Time= 0.4 min

Peak Storage= 52 cf @ 11.99 hrs, Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 76.90 cfs

24.0" Diameter Pipe, n= 0.025
Length= 117.0' Slope= 0.4274 '/'
Inlet Invert= 7,780.00', Outlet Invert= 7,730.00'



Reach 8R: EDC3 Culvert

Inflow Area = 225,090 sf, Inflow Depth = 0.48"
Inflow = 4.32 cfs @ 11.97 hrs, Volume= 8,915 cf
Outflow = 4.30 cfs @ 11.98 hrs, Volume= 8,915 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 13.25 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.66 fps, Avg. Travel Time= 0.3 min

Peak Storage= 29 cf @ 11.98 hrs, Average Depth at Peak Storage= 0.36'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 34.25 cfs

18.0" Diameter Pipe, n= 0.025
Length= 89.0' Slope= 0.3933 '/'
Inlet Invert= 7,735.00', Outlet Invert= 7,700.00'

10-24 Ephemeral Drainage Culverts

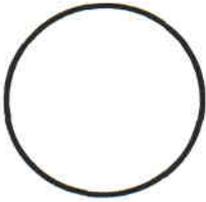
Type II 24-hr Rainfall=2.05"

Prepared by {enter your company name here}

Page 6

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

8/27/2007



Reach 9R: EDC4 Culvert

Inflow Area = 407,357 sf, Inflow Depth = 0.48"
Inflow = 7.75 cfs @ 11.98 hrs, Volume= 16,134 cf
Outflow = 7.73 cfs @ 11.98 hrs, Volume= 16,134 cf, Atten= 0%, Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 14.52 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 5.10 fps, Avg. Travel Time= 0.2 min

Peak Storage= 34 cf @ 11.98 hrs, Average Depth at Peak Storage= 0.45'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 68.97 cfs

24.0" Diameter Pipe, n= 0.025
Length= 64.0' Slope= 0.3438 '/
Inlet Invert= 7,712.00', Outlet Invert= 7,690.00'



Reach 10R: EDC5 Culvert

Inflow Area = 74,015 sf, Inflow Depth = 0.68"
Inflow = 2.32 cfs @ 11.94 hrs, Volume= 4,206 cf
Outflow = 2.30 cfs @ 11.94 hrs, Volume= 4,206 cf, Atten= 1%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 9.89 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.20 fps, Avg. Travel Time= 0.4 min

Peak Storage= 19 cf @ 11.94 hrs, Average Depth at Peak Storage= 0.29'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 29.29 cfs

18.0" Diameter Pipe, n= 0.025
Length= 80.0' Slope= 0.2875 '/
Inlet Invert= 8,020.00', Outlet Invert= 7,997.00'

10-24Ephemeral Drainage Culverts

Prepared by {enter your company name here}

HydroCAD® 8.00 s/n 003900 © 2006 HydroCAD Software Solutions LLC

Type II 24-hr Rainfall=2.05"

Page 7

8/27/2007



Hydraulic Charts for the Selection of Highway Culverts

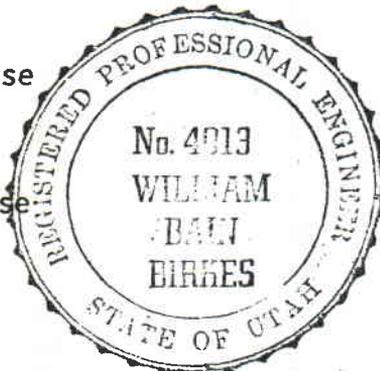
Hydraulic Engineering Circular No. 5

December 1965*

Prepared by the Hydraulics Branch, Bridge Division, Office of Engineering, Federal Highway Administration, Washington, D.C. 20590

CONTENTS

Section	Page
I Introduction	5-1
II Culvert Hydraulics	5-1
A. Culverts Flowing with Inlet Control	5-3
B. Culverts Flowing with outlet Control	5-5
C. Computing Depth of Tailwater	5-11
D. Velocity of Culvert Flow	5-11
E. Performance Curves	5-12
F. Inlets and Culvert Capacity	5-12
III Procedure for Selection of Culvert Size	5-15
IV Inlet-Control Nomographs	5-19
A. Instructions for Use	5-19
B. Charts 1-7	5-21 5-27
V Outlet-Control Nomographs	5-29
A. Instructions for Use	5-29
B. Charts 8-20	5-31 5-43
VI Appendix	
A. Performance Curves	5-45
B. Tables	
1. Entrance Loss Coefficients	5-49
2. Manning's n for Natural Stream Channels	5-50
C. Illustrative Problems	5-51



*Reprinted April 1977

**U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration**

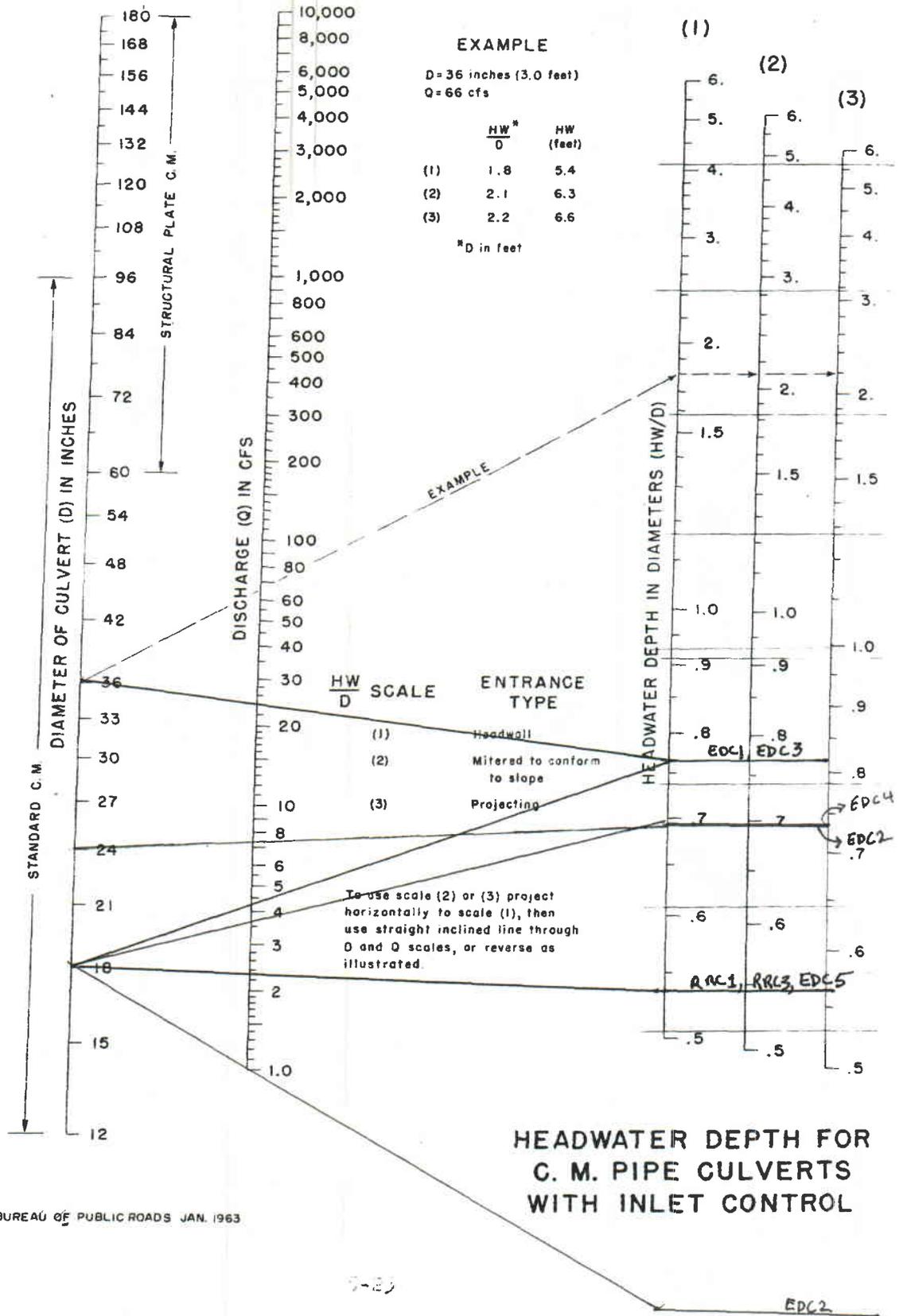
For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 90 cents

Stock No. 050-002-00010-1

There is a minimum charge of \$1.00 for each mail order

CULVERT INLET CONDITIONS

CHART 5



EDC1 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.059
Slope	0.220000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	3.00 ft
Discharge	24.30 cfs

$$n = 0.0456 (D_{50} \times S)^{0.159}$$

where D_{50} is in inches
 S is channel slope
 after Abt et al, 1987

Results	
Depth	0.72 ft
Flow Area	3.2 ft ²
Wetted Perimeter	6.22 ft
Top Width	5.88 ft
Critical Depth	1.01 ft
Critical Slope	0.061793 ft/ft
Velocity	7.59 ft/s
Velocity Head	0.89 ft
Specific Energy	1.62 ft
Froude Number	1.81
Flow Type	Supercritical

$$D_{50} = 24''$$

$$S = 0.22$$

→ OK for discharge into naturally armored channel

EDC2 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.062
Slope	0.300000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	6.60 cfs

$D_{50} = 24''$
 $S = 0.30 \text{ ft/ft}$

Results	
Depth	0.40 ft
Flow Area	1.1 ft ²
Wetted Perimeter	3.80 ft
Top Width	3.61 ft
Critical Depth	0.57 ft
Critical Slope	0.081191 ft/ft
Velocity	5.85 ft/s
Velocity Head	0.53 ft
Specific Energy	0.93 ft
Froude Number	1.84
Flow Type	Supercritical

→ OK for discharge into naturally armored channel

EDC3 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.060
Slope	0.360000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	4.30 cfs

$D_{50} = 15''$
 $S = 0.36$

Results	
Depth	0.30 ft
Flow Area	0.8 ft ²
Wetted Perimeter	3.33 ft
Top Width	3.19 ft
Critical Depth	0.45 ft
Critical Slope	0.080645 ft/ft
Velocity	5.60 ft/s
Velocity Head	0.49 ft
Specific Energy	0.78 ft
Froude Number	2.01
Flow Type	Supercritical

OK for discharge into naturally armored channel

EDC4 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.057 → $D_{50} = 15''$
Slope	0.270000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	7.80 cfs

Results	
Depth	0.43 ft
Flow Area	1.2 ft ²
Wetted Perimeter	3.94 ft
Top Width	3.73 ft
Critical Depth	0.63 ft
Critical Slope	0.067104 ft/ft
Velocity	6.28 ft/s → OK for discharge into naturally armored channel
Velocity Head	0.61 ft
Specific Energy	1.05 ft
Froude Number	1.92
Flow Type	Supercritical

EDC5 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.048
Slope	0.230000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	2.30 cfs

→ $D_{50} = 6''$

Results	
Depth	0.21 ft
Flow Area	0.5 ft ²
Wetted Perimeter	2.93 ft
Top Width	2.83 ft
Critical Depth	0.31 ft
Critical Slope	0.056502 ft/ft
Velocity	4.58 ft/s
Velocity Head	0.33 ft
Specific Energy	0.53 ft
Froude Number	1.92
Flow Type	Supercritical

→ OK for discharge. peak flow < 5 f/s - nonerosive

RRC1 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.063
Slope	0.500000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	2.30 cfs

$D_{50} = 15''$

Results	
Depth	0.19 ft
Flow Area	0.5 ft ²
Wetted Perimeter	2.87 ft
Top Width	2.78 ft
Critical Depth	0.31 ft
Critical Slope	0.097333 ft/ft
Velocity	4.95 ft/s
Velocity Head	0.38 ft
Specific Energy	0.58 ft
Froude Number	2.14
Flow Type	Supercritical

< 5 fps, nonerosive

RRC2 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.060
Slope	0.670000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	1.00 cfs

→ No rip rap req'd
n for overland flow through brush

Results	
Depth	0.11 ft
Flow Area	0.2 ft ²
Wetted Perimeter	2.48 ft
Top Width	2.43 ft
Critical Depth	0.19 ft
Critical Slope	0.100668 ft/ft
Velocity	4.23 ft/s
Velocity Head	0.28 ft
Specific Energy	0.39 ft
Froude Number	2.39
Flow Type	Supercritical

→ < 5 fps, nonerosive velocity

RRC3 Outlet Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Road Runoff Culvert Outlet
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data	
Mannings Coefficient	0.050
Slope	0.290000 ft/ft
Left Side Slope	2.00 H : V
Right Side Slope	2.00 H : V
Bottom Width	2.00 ft
Discharge	2.30 cfs

→ $D_{50} = 6''$

Results	
Depth	0.20 ft
Flow Area	0.5 ft ²
Wetted Perimeter	2.89 ft
Top Width	2.80 ft
Critical Depth	0.31 ft
Critical Slope	0.061308 ft/ft
Velocity	4.82 ft/s
Velocity Head	0.36 ft
Specific Energy	0.56 ft
Froude Number	2.06
Flow Type	Supercritical

→ < 5 fps, nonerosive velocity

SOIL SURVEY OF CARBON AREA, UTAH, PARTS OF CARBON AND EMERY COUNTIES



Tables - Hydrologic Soil Group

Summary by Map Unit - Carbon Area, Utah, Parts of Carbon and Emery Counties

Soil Survey Area Map Unit Symbol	Map Unit Name	Rating	Total Acres in AOI	Percent of AOI
62	Midfork family-Comodore complex	B	81.7	25.3
97	Rottulee family-Trag complex	C	230.8	71.3
100	Senchert loam, 3 to 15 percent slopes	C	11.0	3.4

Description - Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Parameter Summary - Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff:

Tie-break Rule: Lower

TABLE 7-14 — Other Agricultural Lands¹

Cover Description	Hydrologic Condition	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Pasture, grassland, or range — continuous forage for graving ²	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow — continuous grass — protected from grazing and generally mowed for hay		30	58	71	78
Brush — brush-weed-grass mixture with brush the major element ³	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 ⁴	48	65	73
Woods — grass combination (orchard or tree farm) ⁵	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods ⁶	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 ⁴	55	70	77
Farmsteads — buildings, land, driveways and surrounding lots	—	59	74	82	86

¹ Average runoff condition and $I_a = 0.2S$.

² Poor: < 50% ground cover or heavily grazed with no mulch
 Fair: 50% to 75% ground cover and not heavily grazed
 Good: > 75% ground cover and lightly or only occasionally grazed

³ Poor: < 50% ground cover
 Fair: 50% to 75% ground cover
 Good: > 75% ground cover

⁴ Actual Curve Number is less than 30; use CN = 30 for runoff computations.

⁵ CNs shown were computed for areas with 50% grass (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture.

⁶ Poor: Forest litter, small trees and brush are destroyed by heavy grazing or regular burning.
 Fair: Woods grazed but not burned, and some forest litter covers the soil.
 Good: Woods protected from grazing; litter and brush adequately cover soil.



POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14



Utah 39.68175 N 110.48129 W 7946 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4

G M Bonnin, D Martin, B Lin, T Parzybok, M Yekta, and D Riley

NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Tue Jun 26 2007

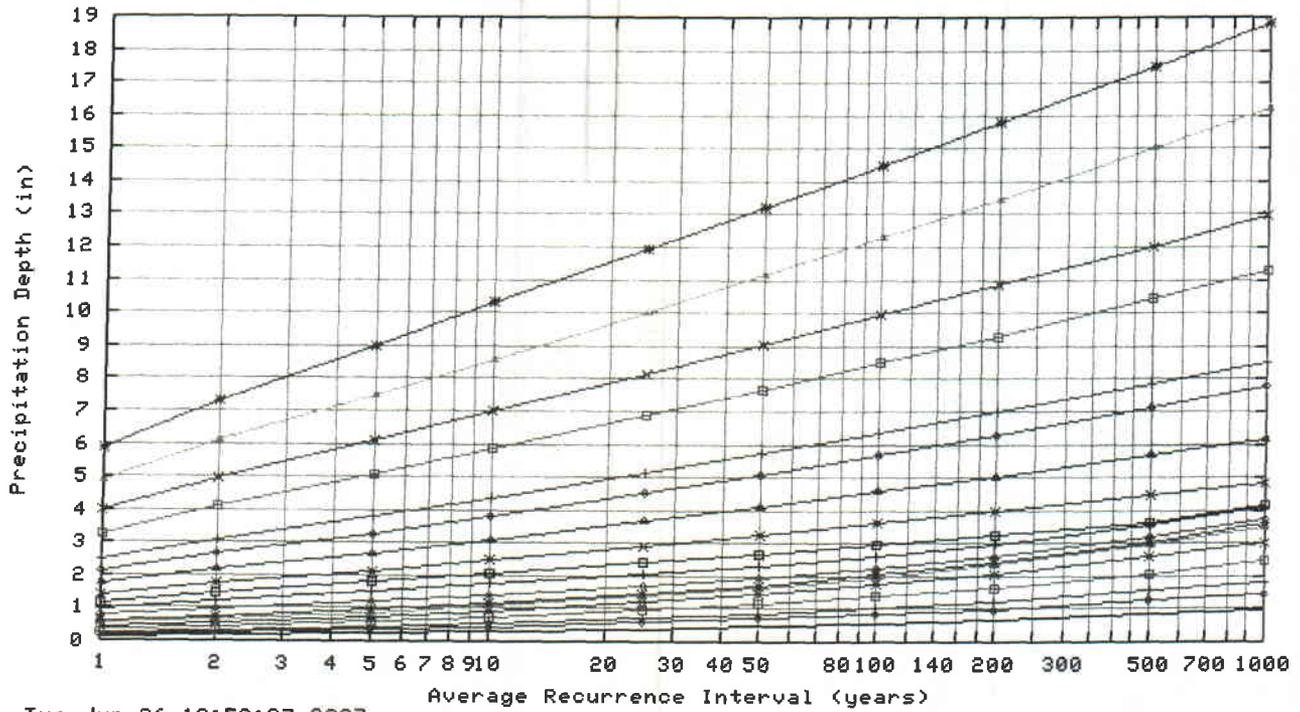
Confidence Limits	Seasonality	Location Maps	Other Info.	GIS data	Maps	Help	D
-------------------	-------------	---------------	-------------	----------	------	------	---

Precipitation Frequency Estimates (inches)																		
ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.20	0.25	0.34	0.42	0.52	0.59	0.77	0.99	1.18	1.40	1.74	2.12	2.44	3.26	3.97	4.88	5.83
2	0.17	0.26	0.33	0.44	0.55	0.65	0.74	0.96	1.23	1.46	1.74	2.16	2.65	3.06	4.08	4.95	6.10	7.31
5	0.24	0.36	0.45	0.60	0.74	0.86	0.95	1.19	1.50	1.78	2.13	2.67	3.29	3.78	5.05	6.09	7.50	9.00
10	0.29	0.45	0.55	0.74	0.92	1.06	1.15	1.38	1.73	2.05	2.46	3.08	3.80	4.36	5.82	6.98	8.59	10.29
25	0.38	0.58	0.72	0.97	1.20	1.36	1.45	1.67	2.05	2.40	2.89	3.65	4.52	5.14	6.86	8.15	10.04	11.96
50	0.46	0.70	0.86	1.16	1.44	1.64	1.72	1.92	2.32	2.68	3.24	4.09	5.08	5.74	7.66	9.04	11.15	13.22
100	0.55	0.83	1.03	1.39	1.72	1.96	2.04	2.22	2.60	2.96	3.60	4.55	5.67	6.36	8.48	9.94	12.29	14.50
200	0.65	0.99	1.23	1.66	2.05	2.33	2.41	2.57	2.94	3.25	3.96	5.03	6.28	7.00	9.31	10.84	13.44	15.78
500	0.82	1.24	1.54	2.08	2.57	2.93	3.03	3.18	3.53	3.64	4.45	5.67	7.11	7.86	10.44	12.03	14.99	17.48
1000	0.97	1.47	1.83	2.46	3.04	3.49	3.59	3.74	4.09	4.13	4.84	6.17	7.77	8.53	11.30	12.94	16.22	18.80

Text version of table

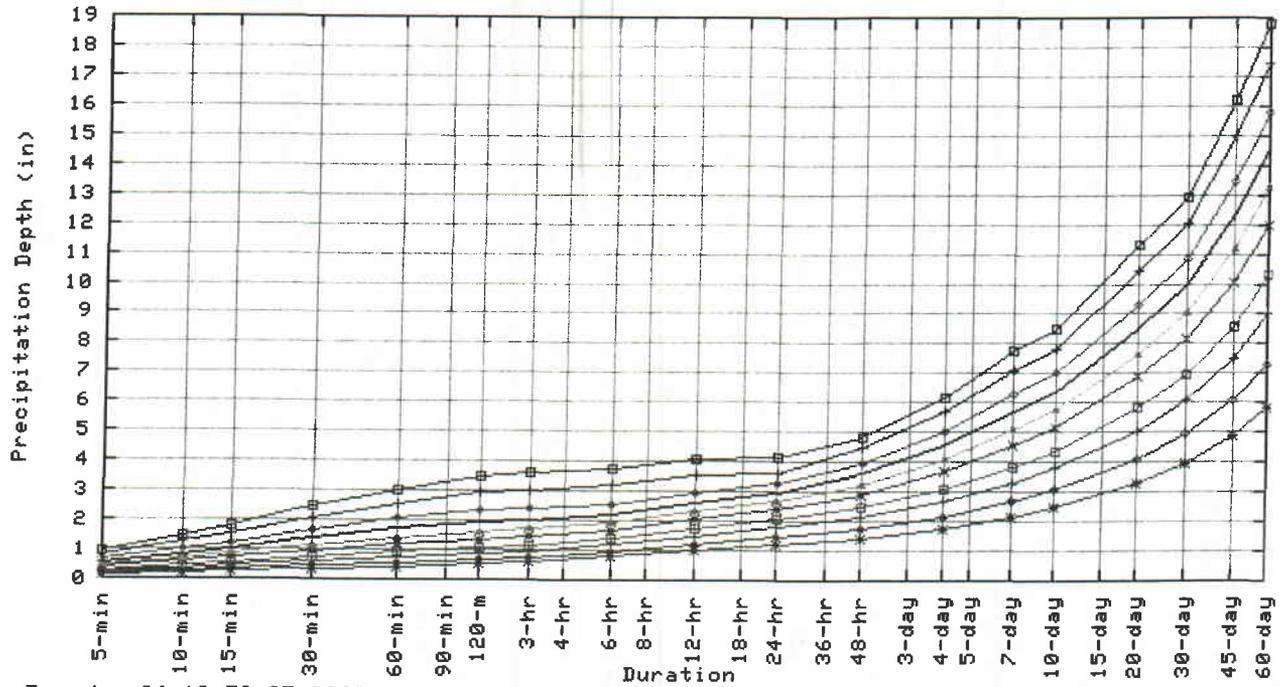
* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Partial duration based Point Precipitation Frequency Estimates Version: 4
 39.68175 N 110.48129 W 7946 ft



Duration			
5-min	—	120-min	—
10-min	◆	3-hr	*
15-min	+	6-hr	◆
30-min	⊖	12-hr	+
60-min	*	24-hr	⊖
		48-hr	*—
		4-day	▲
		7-day	◆
		10-day	+
		20-day	⊖
		30-day	*—
		45-day	—
		60-day	*—

Partial duration based Point Precipitation Frequency Estimates Version: 4
 39.68175 N 110.48129 W 7946 ft



Tue Jun 26 12:59:37 2007

Average Recurrence Interval (years)	
1	*
2	+
5	+
10	+
25	*
50	+
100	+
200	+
500	+
1000	+

Confidence Limits -

*** Upper bound of the 90% confidence interval
 Precipitation Frequency Estimates (inches)**

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.16	0.24	0.30	0.41	0.51	0.60	0.69	0.88	1.11	1.31	1.56	1.94	2.41	2.74	3.65	4.43	5.44	6.49
2	0.21	0.32	0.39	0.53	0.65	0.76	0.86	1.09	1.38	1.63	1.94	2.42	3.01	3.42	4.56	5.54	6.80	8.12
5	0.28	0.43	0.53	0.72	0.89	1.01	1.11	1.35	1.68	2.00	2.38	2.98	3.73	4.24	5.66	6.80	8.37	10.00
10	0.35	0.53	0.66	0.89	1.10	1.24	1.33	1.58	1.94	2.29	2.74	3.44	4.33	4.89	6.53	7.79	9.60	11.44
25	0.46	0.69	0.86	1.16	1.43	1.60	1.69	1.91	2.32	2.69	3.23	4.08	5.15	5.76	7.70	9.12	11.24	13.33
50	0.55	0.83	1.04	1.40	1.73	1.93	2.01	2.21	2.63	3.00	3.62	4.58	5.80	6.45	8.61	10.14	12.51	14.77
100	0.66	1.00	1.24	1.67	2.07	2.33	2.40	2.58	2.97	3.33	4.03	5.11	6.50	7.17	9.55	11.18	13.80	16.25
200	0.79	1.20	1.49	2.01	2.49	2.79	2.87	3.01	3.38	3.66	4.45	5.65	7.22	7.91	10.53	12.23	15.15	17.77
500	1.01	1.54	1.90	2.56	3.17	3.59	3.67	3.79	4.13	4.17	5.04	6.42	8.24	8.93	11.88	13.66	17.01	19.80
1000	1.22	1.85	2.30	3.09	3.83	4.35	4.43	4.52	4.85	4.90	5.51	7.04	9.06	9.75	12.94	14.77	18.49	21.43

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.

** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

*** Lower bound of the 90% confidence interval**

Precipitation Frequency Estimates (inches)

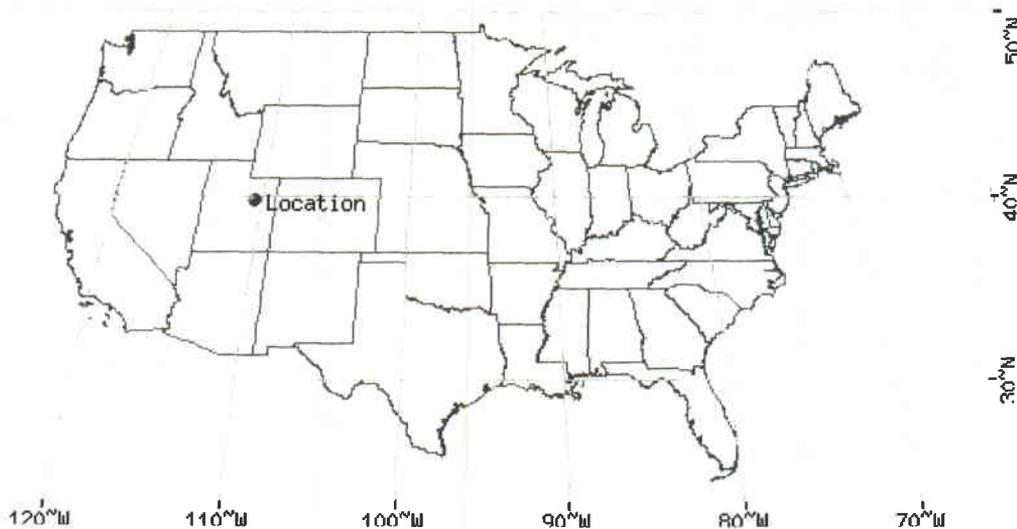
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.12	0.18	0.22	0.29	0.36	0.45	0.52	0.69	0.90	1.07	1.26	1.56	1.89	2.19	2.94	3.59	4.41	5.28
2	0.15	0.23	0.28	0.38	0.47	0.57	0.65	0.85	1.11	1.32	1.57	1.95	2.36	2.75	3.68	4.48	5.51	6.61
5	0.20	0.31	0.38	0.52	0.64	0.75	0.84	1.05	1.34	1.61	1.92	2.39	2.92	3.38	4.53	5.49	6.75	8.10
10	0.25	0.38	0.47	0.63	0.79	0.90	1.00	1.22	1.54	1.84	2.20	2.75	3.37	3.88	5.22	6.26	7.69	9.22
25	0.32	0.48	0.59	0.80	0.99	1.14	1.24	1.45	1.81	2.15	2.58	3.23	3.97	4.55	6.10	7.27	8.94	10.66
50	0.37	0.56	0.70	0.94	1.17	1.34	1.44	1.65	2.02	2.39	2.86	3.60	4.43	5.05	6.76	8.02	9.86	11.71
100	0.43	0.66	0.82	1.10	1.36	1.56	1.67	1.88	2.23	2.62	3.15	3.97	4.90	5.55	7.41	8.75	10.78	12.73
200	0.50	0.76	0.94	1.27	1.57	1.81	1.93	2.13	2.48	2.85	3.44	4.34	5.36	6.06	8.07	9.47	11.69	13.73
500	0.60	0.91	1.13	1.52	1.88	2.17	2.32	2.56	2.93	3.15	3.81	4.82	5.99	6.71	8.90	10.36	12.86	15.01
1000	0.68	1.04	1.29	1.73	2.15	2.48	2.65	2.94	3.34	3.38	4.10	5.18	6.46	7.19	9.53	11.03	13.76	15.97

* The lower bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are less than.

** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.

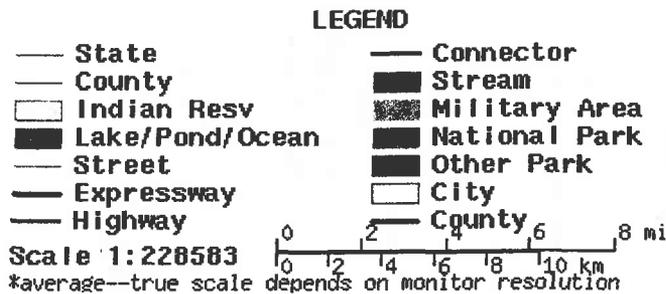
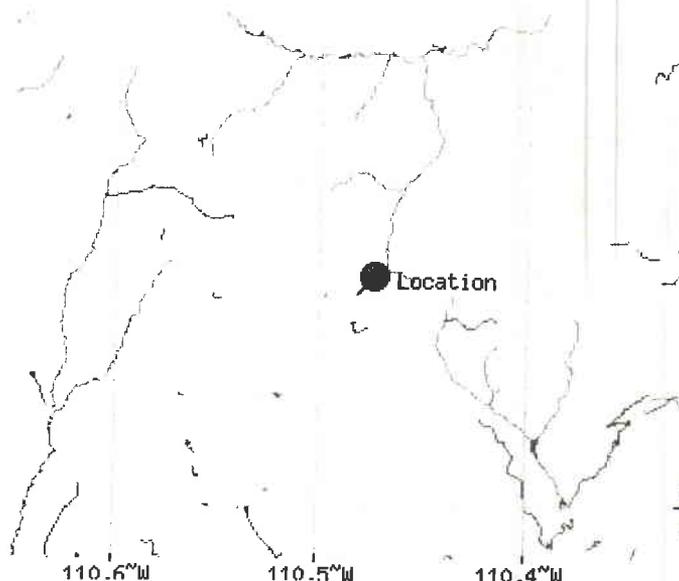
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Maps -



These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server.

Please read [disclaimer](#) for more information.



Other Maps/Photographs -

View [USGS digital orthophoto quadrangle \(DOQ\)](#) covering this location from TerraServer; [USGS Aerial Photograph](#) may also be available from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the [USGS](#) for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to our documentation.

Using the [National Climatic Data Center's \(NCDC\)](#) station search engine, locate other climate stations within:

...OR... of this location (39.68175/-110.48129). Digital ASCII data can be obtained directly from [NCDC](#).

Find [Natural Resources Conservation Service \(NRCS\) SNOTEL \(SNOWpack TELEmetry\)](#) stations by visiting the [Western Regional Climate Center's state-specific SNOTEL station maps](#).

Hydrometeorological Design Studies Center
 DOC/NOAA/National Weather Service
 1325 East-West Highway
 Silver Spring, MD 20910

(301) 713-1669
 Questions? HDSC.Questions@noaa.gov

Disclaimer

Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase I

Prepared by S. R. Abt, M. S. Khattak, J. D. Nelson,
J. F. Ruff, A. Shaikh, R. J. Wittler/CSU
D. W. Lee, N. E. Hinkle/ORNL

Colorado State University

Oak Ridge National Laboratory

**Prepared for
U.S. Nuclear Regulatory
Commission**

4.3.1 Estimating Manning's n for Cascading Flow

The average Manning's roughness value, n , was computed for each failure test based on flow velocities and depths measured prior to failure, and are plotted versus the median stone size, D_{50} , in Fig. 4.7. It is observed in Fig. 4.7 that the n values for 1% and 2% slopes fall closely to the solid line representing a relationship developed by Anderson et al. (see Section 4.3.2). However, the n value for each stone size increased as the slope of the embankment increased, and the n value is over 40% higher when $\text{Depth}/D_{50} < 2$ (cascading flow conditions) than when Depth/D_{50} is greater than 2 (Table 4.8).

A median stone size-slope parameter ($D_{50} \times S$) was correlated to the Manning's n value for the CSU data as presented in Fig. 4.8. Combining the median stone size and slope in one parameter appears to have reduced the data scatter. The relationship can be expressed as:

$$n = 0.0456 (D_{50} \times S)^{0.159} \quad (4.8)$$

where D_{50} is in inches. The correlation coefficient, r^2 , is 0.90. Therefore, a Manning's n value can be estimated for a riprapped surface in cascading flow as a function of the median stone size and slope.

4.3.2 Comparison of Procedures

A commonly used expression for determining Manning's n for riprap was presented by Anderson et al. (1970) as

$$n = 0.0395 (D_{50})^{1/6} \quad (4.9)$$

where D_{50} is the median stone size in feet. This relationship, which was developed from natural streams with slopes less than 2% for uniform flow conditions over submerged riprap is shown as the solid line in Fig. 4.7. However, the Anderson et al. (1970) relationship is commonly used and extrapolated to estimate roughness on steep slopes. Anderson et al. did not consider the resistance to be a function of slope.

The U.S. Army Corps of Engineers (COE, 1970) have also developed a procedure for estimating Manning's n value. Although the COE procedure was formulated for flat slopes and deep flow depths (1-60 ft), it is routinely applied to estimate flow resistance of steep slopes. The Manning's n is calculated as

$$n = \frac{R^{1/6}}{23.85 + 21.95 \log_{10} (R/K)} \quad (4.10)$$

where R is the hydraulic radius and K is the equivalent roughness height in ft. The equivalent roughness for stone lined channels is the theoretical spherical diameter of the median stone size. The hydraulic radius is approximated with the depth of flow in wide channels.

The CSU and Anderson et al. (1970) equations were compared to demonstrate the effect that slope has on the Manning's n . The Manning's n values were approximated by applying Eq. 4.8 and Eq. 4.9 for median stone sizes of 2.2 inches and 5.1 inches on slopes of 1%, 2%, 5%, 10% and 20%.

The results of the analysis (Table 4.9) indicate that at slopes below 2%, the Anderson et al. equation yields slightly greater n values (approximately 10%) than does the CSU equation. The CSU and Anderson et al. relations coincide at a slope between 2% and 5%.

The CSU and Anderson et al. relations yield significantly different Manning's n values at steep slopes ($\geq 10\%$). The Anderson et al. n value remains constant at 0.034 for a 5.1-inch stone (D_{50}) for all slopes. However, the CSU equation yields an n value of 0.046 for a 5.1-inch stone (D_{50}) at 20% slope, a value 35% greater than predicted by Anderson et al. It is evident that the Anderson et al. formulation can lead to erroneous designs if applied to slopes greater than 2%.

An attempt was also made to compare the Manning's n value from the U.S. Army Corps of Engineers procedure (COE, 1970) with the CSU results presented in Fig. 4.8. As observed in Table 4.9, the COE n values are less than the Anderson et al. and CSU values at slopes less than 10%. However, the COE value meets or exceeds the Anderson et al. and CSU n values for slopes of 10% or greater.

It should be noted that the CSU equation was based on computed average n values and does not indicate the upper range of localized n values which extended from 0.06 to 0.08. Appendix C, Summary of Hydraulic Data, presents the localized n values resulting from each test of the testing program.

4.3.3 Bed Critical Shields' Coefficient

The bed critical Shields' coefficient, C_c , was computed for each test as presented in Table 4.6 and Table 4.7. The Shields' coefficient of each

Reference: Use of Riprap for Bank Protection
 Hydraulic Engineering Circular No. 11
 US DOT Federal Highway Admin 1978

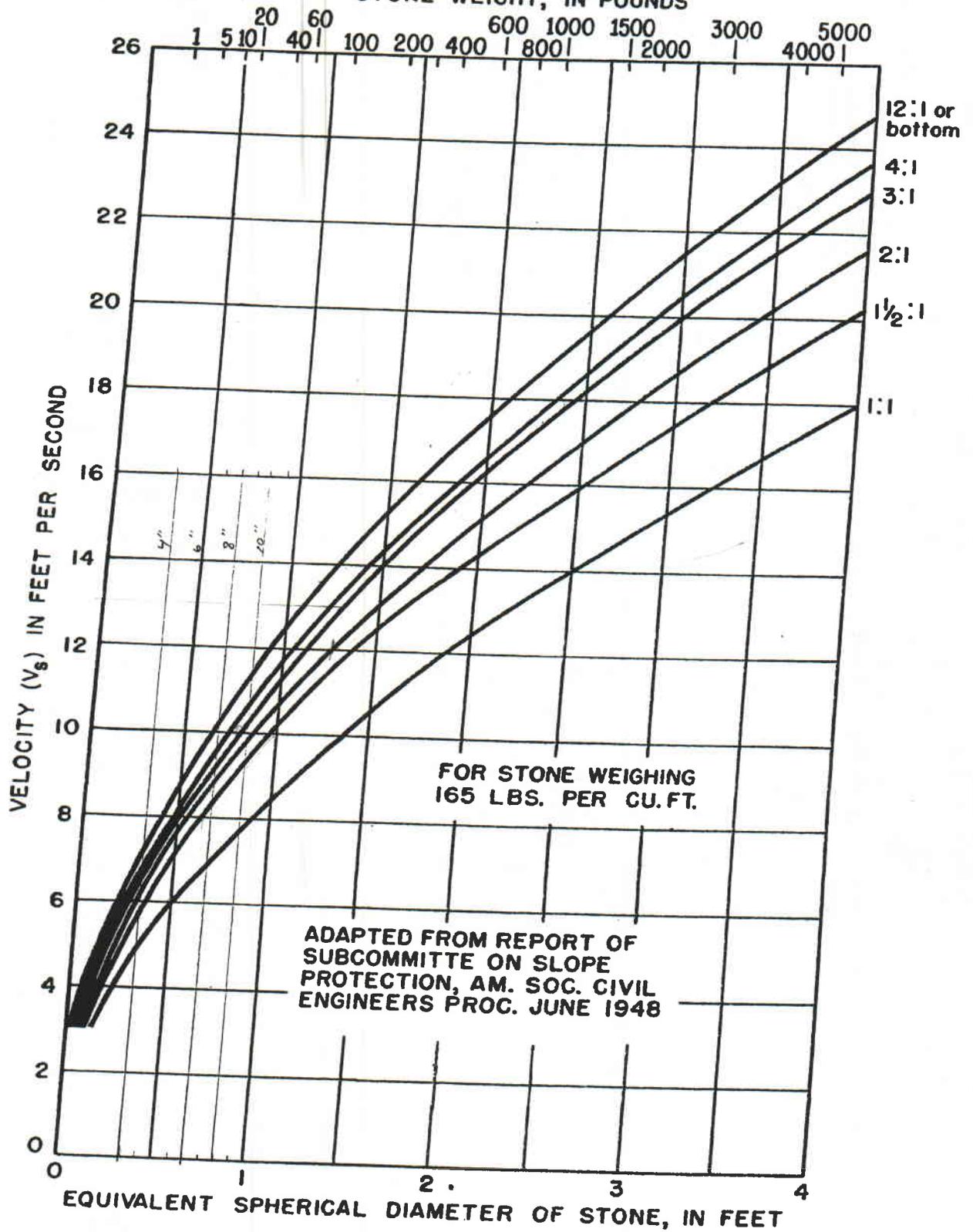


FIG. 2 - SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

Table 4.13 Calculations for Example Problem 4.19

D_{50}^a	Manning's n	Depth to convey flow (ft)	Maximum tractive force on channel bed (lb/ft ²)	Channel bed stability factor (η_b)	Safety factor for channel bed (SF_b)	Maximum tractive force on walls (lb/ft ²)	Channel wall stability factor (η')	Channel wall safety factor (SF)
1.7	0.043	0.72	4.49	0.541	1.53	3.41	0.308	1.36
2.0	0.044	0.73	4.58	0.467	1.72	3.48	0.268	1.45
2.5	0.046	0.75	4.68	0.382	2.02	3.56	0.220	1.56
2.2	0.045	0.74	4.62	0.429	1.84	3.51	0.247	1.50

^aUse a riprap with a D_{50} of 2.2 ft for both channel sides and bottom.

From Eq. (4.46),

$$\beta = \tan^{-1} \left[\frac{\cos \lambda}{2 \sin \alpha / \eta \tan \phi + \sin \lambda} \right]$$

$$= \tan^{-1} \left[\frac{\cos(5.71)}{2 \sin(21.8) / (0.408 \tan(42)) + \sin(5.71)} \right]$$

$$\beta = 25.1^\circ$$

From Eq. (4.48),

$$\eta' = \eta \left[\frac{1 + \sin(\lambda + \beta)}{2} \right] = 0.408 \left[\frac{1 + \sin(5.71 + 25.10)}{2} \right]$$

$$\eta' = 0.308.$$

From Eq. (4.45),

$$SF = \frac{\cos \alpha \tan \phi}{\eta' \tan \phi + \sin \alpha \cos \beta}$$

$$= \frac{\cos(21.8) \tan(42)}{0.308(\tan(42)) + \sin(21.8) \cos(25.1)}$$

$$SF = 1.36.$$

Thus the riprap is stable, but does not have the required safety factor of 1.5. The selection of an acceptable riprap for the channel side slopes will be made using trial and error. The calculations are in Table 4.13. It is assumed that the riprap on the channel bed will be the same as that used on the side slopes. It would obviously be possible to vary the side slopes and channel width to obtain a smaller D_{50} . The final selection of channel dimensions and riprap size would have to be based on economics.

Selecting Proper Gradation

It is important for a riprap to have a gradation such that the voids between the larger particles are filled with smaller particles to reduce flow beneath the riprap and the formation of open pockets. A suggested gradation for riprap has been made by Simons and Senturk

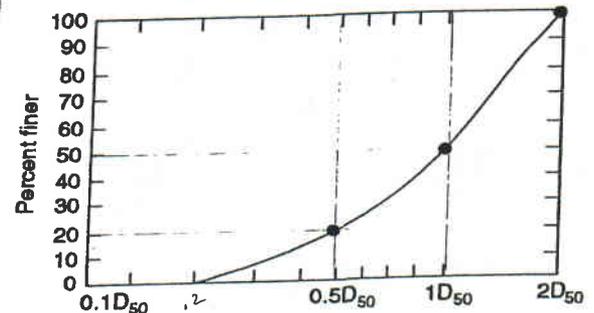


Figure 4.19 Suggested size distribution of riprap (after Simons and Senturk, 1977, 1992).

(1977, 1992) based on studies at Colorado State University. The proposed gradation is shown in Fig. 4.19.

Selecting an Underlying Filter

The placement of a properly designed filter blanket underneath the riprap is necessary when the particle size of the riprap is much larger than that of the base material. The following criteria have been established for sizing the filter, based on the size distribution of the riprap and the base material:

- (1) $\frac{D_{50}(\text{filter})}{D_{50}(\text{base})} < 40$ also $\frac{D_{50}(\text{riprap})}{D_{50}(\text{filter})} < 40$
- (2) $5 < \frac{D_{15}(\text{filter})}{D_{15}(\text{base})} < 40$ also $5 < \frac{D_{15}(\text{riprap})}{D_{15}(\text{filter})} < 40$
- (3) $\frac{D_{15}(\text{filter})}{D_{85}(\text{base})} < 5$ also $\frac{D_{15}(\text{riprap})}{D_{85}(\text{filter})} < 5.$

These criteria were developed for sizing filters around drain pipe to prevent piping of the soil into the