Encana Oil & Gas (USA) Inc.
143 Diamond Avenue
Parachute, Colorado 81635

LIMITED IMPACT REVIEW APPLICATION

K19NE Storage Facility (Laydown Yard)

Garfield County, Colorado

February 2015

Prepared by:
Olsson Associates
760 Horizon Drive, Suite 102
Grand Junction, Colorado 81506
TEL 970.263.7800 | FAX 970.263.7456
www.olssonassociates.com

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Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Article 4-101.A Preapplication Conference Summary

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Garfield County
Community Development Department
108 8th Street, Suite 401
Glenwood Springs, CO 81601
(970) 945-8212
www.garfield-county.com

PRE-APPLICATION CONFERENCE SUMMARY

TAX PARCEL NUMBER: 2179-193-00-128 **DATE:** 8/28/14

APPLICANT'S PLANNER: Lorne Prescott, Olsson Associates

PROJECT: Encana K19NE Storage Yard

OWNER: Encana Oil and Gas (USA) Inc.

REPRESENTATIVE: Jason Eckman, Encana Oil and Gas (USA) Inc.

PRACTICAL LOCATION: Approximately 1mile southeast of the Rifle City Limits, south of the Garfield County Airport, on private roads off of County Road 333, and generally located in Section 19, T6S, R92W.

ZONING: Rural

TYPE OF APPLICATION: Limited Impact Review for a Storage Facility

I. GENERAL PROJECT DESCRIPTION

The Applicant proposes the creation of a storage facility on an existing well pad. The site is fully developed with several wells in active production on the site. The proposal is to utilize the existing disturbed area with the potential to expand the storage area up to a total of 5.172 acres. The site is located on an overall parcel of approximately 88 acres. The existing well pad and disturbed area covers approximately half of the proposed 5.1 acres. Additional grading and related improvements will be required to expand the site. The site is currently covered by existing COGCC permits/forms with reclamation covered by an existing bond.

Access roads to the site are in place and are gated. The potential for security fencing is still being considered and may be implemented for the site. The Applicant represents that the site is not located in a subdivision and given the location compatibility with adjacent land uses may be an important consideration. Existing improvements on the site include a tank area, pipelines, separator units, a communication tower and 6 well heads.

Compatibility with the existing uses will need to be addressed in the storage facility application submittal. No water or sanitation facilities are anticipated and the proposal is to operate as an unmanned facility. Staff will access the site only intermittently to pick up equipment. The Rural Zoning for the property requires a Limited Impact Review Land Use Change Permit for the proposal.

II. REGULATORY PROVISIONS APPLICANT IS REQURED TO ADDRESS

- Garfield County Comprehensive Plan 2030
- Garfield County Land Use and Development Code, as amended
  - Section 4-101, Common Review Procedures
  - Section 4-104, Limited Impact Review
  - Table 4-102, Common Review Procedures and Required Notice
  - Table 4-201, Application Submittal Requirements
  - Section 4-203, Description of Submittal Requirements
  - Table 3-403, Use Table – Storage
  - Section 7-1001, Industrial Use Standards
  - Article 15, Definitions, Storage
  - Section 4-118 (Waiver of Standards), Section 4-202 (Waiver of Submittal Requirements
  - Article VII, Standards – Divisions 1 and 2 and 3 as applicable – including roadway standards
- Colorado Department of Public Health and Environment Regulations Pertaining to Storm Water and Air Quality (site disturbance, construction, dust).
- Safety provisions pertaining to emergency procedures.
- Regulations on Noise and Nuisances
- COGCC Reclamation and Re-vegetation Requirements
- Demonstration of compliance with Section 7-107 Access and Roadway Standards including the Policy (01-14) related to submittal requirements and demonstration of compliance with Waiver Criteria for Roadway Waivers.

III. REVIEW PROCESS

1. ***Pre-application Conference***.
2. ***Preparation and Submittal of the Application***.
3. ***Determination of Completeness – Provision of Additional Application Copies, and Distribution of Referrals.***
4. ***Schedule Date for Board of County Commissioner's Public Hearing***
5. ***Completion of Public Notice Requirements***.
6. ***Staff Review – Preparation of Staff Report.***
7. ***Board of County Commissioner's Public Hearing***
8. ***Documentation of the Board's Action by Resolution - Approval, Approval with Conditions, or Denial***
9. ***Applicant addresses any Conditions of Approval within one year of the Board's Decision.***
10. ***Preparation of Land Use Change Permit as Appropriate.***

IV. APPLICABILITY OF STANDARDS AND WAIVER REQUESTS

Should the Applicant chose to request waivers from submittal requirements or standards the Application submittals will need to clearly address the review criteria contained in Sections 4-118 and 2-202 in justifying the requests. The Applicant should consult with the Roadway Standards and Waiver Policy 01-14 regarding roadway and access issues (see attached)

In lieu of waiver requests the Applicant should submit Water Supply Plans and Waste Water Plans to demonstrate the lack of demand for these services associated with the unmanned facility. Where waiver's from completion of fully developed plans are the intent of the waiver request the Application should still contain general information appropriate to demonstrate compliance with the waiver review criteria. The Application and/or waiver requests need to address screening requirements

V. SUBMITTAL REQUIREMENTS

An Application for an Administrative Review will also need to provide all standard application forms, agreement to pay form, a listing of all property owners (with addresses) within 200 ft., an excerpt from the Assessor's Office mapping showing the ownerships, a listing of any mineral rights owners on the subject property (with addresses), authorization to represent statements/letters, evidence of ownership such as a deed and/or lease agreements for the site. Other key elements of the submittal include vicinity map, site plan including details on the existing conditions and proposed use, grading and drainage plans, impact analysis, geologic hazards information, and traffic study. The areas of the site proposed for expansion will need to be addressed in the submittals including site plan and technical details (i.e. grading and drainage plans).

VI. APPLICATION REVIEW

a. Review by: Staff for completeness recommendation and referral agencies for additional technical review

b. Public Hearing:

___ Director's Decision (with notice)
___ Planning Commission
_X_ Board of County Commissioners
___ Board of Adjustment

c. Referral Agencies: May include but not limited to Garfield County Road and Bridge Department, Fire Protection Districts, Garfield County Environmental Health Manager, Garfield County Vegetation Manager, Garfield County Consulting Engineer, CDPHE, COGCC, and City of Rifle.

VII. APPLICATION REVIEW FEES

a. Planning Review Fees: $ 400

b. Referral Agency Fees: $ TBD – consulting engineer/civil engineer fees

c. Total Deposit: $ 400 (additional hours are billed at $40.50 /hour)

General Application Processing

Planner reviews case for completeness and sends to referral agencies for comments. Case planner contacts applicant and sets up a site visit. Staff reviews application to determine if it meets standards of review. Case planner makes a recommendation of approval, approval with conditions, or denial to the appropriate hearing body.

Disclaimer

The foregoing summary is advisory in nature only and is not binding on the County. The summary is based on current zoning, which is subject to change in the future, and upon factual representations that may or may not be accurate. This summary does not create a legal or vested right.

Pre-application Summary Prepared by:

Glenn Hartmann, Senior Planner

9/10/14
Date

Policy 01-14
Waivers for Roads and Demonstration of Compliance

March 3, 2014

Section 7-107, Access and Roadways, of the Garfield County Land Use and Development Code (LUDC) requires all roads to be designed to provide for "adequate and safe access" and reviewed by the designated County Engineer. The LUDC defines "road" as "a County road, State highway, public road, street or alley, or private thoroughfare which affords primary access to abutting property, excluding a driveway accessing a single property."

The LUDC defines "private road" as "a right-of-way constructed, established, owned, and maintained by a private party for access exclusively to private property." Many of the roads in Garfield County are private roads in that they are gated and do not serve the general public and they pre-existed the design currently required by the County's Road Standards as defined in Table 7-107.

The LUDC allows for the waiver of specific standards provided that the following criteria have been met: 1) an alternative design achieves the intent of the subject standard to the same or better degree and 2) the proposed alternative will impose no greater impacts on adjacent properties than would occur through compliance with the specific standard (Section 4-118).

In applications that include roads that do not meet current County road standards as outlined in Table 7-107, the County has asked that Applicants request a waiver of Section 7-107.F, Design Standards, and include in the Application submittal sufficient information, prepared by a professional qualified in the specific discipline, to demonstrate that they meet the criteria outlined in Section 4-118 for granting a waiver. In doing so, the application must include:

A Statement of Adequacy - The evaluation of the existing roadway and waiver will need to include a clear statement that finds that the road will be *adequate* for the proposed use. This statement must be signed by a professional engineer qualified in traffic engineering and licensed by the State of Colorado. To support this evaluation, the following information will be required to be provided:

- **Geometry of the road** – A description of how the private road does/does not meet the design standards in Table 7-107. This should include a chart that compares the private road design to those standards in Table 7-107, as well as a map that shows the existing road design and highlights those areas that deviate from the standards. A narrative may also be helpful in describing the characteristics of the road as they compare to Table 7-107 design standards. Unless available, this is not intended to imply construction-level drawings.

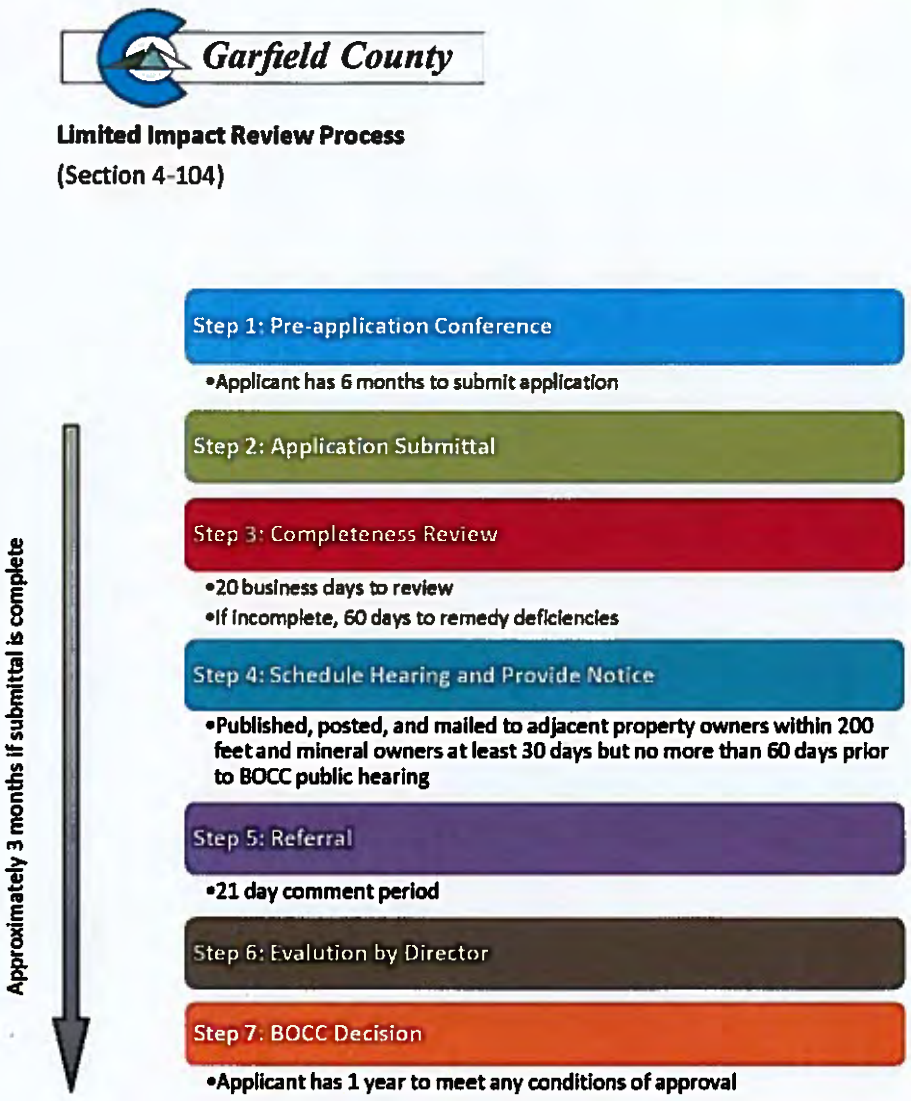
- **Safety/Structural Issues** – A description of obvious safety and/or structural issues observed and a statement about how these issues will be addressed.

- **Maintenance** – A description of how the road is and/or will be maintained. This should be supported with the submittal of any existing or proposed maintenance agreements for the road sections.

- **Travel Demand** – An accurate count of the existing peak travel demand as well as the Average Daily Traffic on the road. This should also include the types of vehicles that currently use the road as well as the additional amount and type of traffic that the proposed use will generate through all phases of its development.

Other Evidence of Compliance. In addition, Sections 7-107.A, B, C, D, and E are required to be addressed, which includes documentation about legal access. Sufficient evidence will be required to be submitted to demonstrate compliance with these sections of the Code.

A. Section 4-104 Limited Impact



Article 4-118, 4-202 Waiver Requests

Encana Oil & Gas (USA) Inc
K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2797

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Waiver Requests
Encana Oil & Gas (USA) Inc.
K19NE Storage Facility

SECTION 4-118 WAIVER OF STANDARDS

Pursuant to Section 4-118 of the Garfield County Land Use and Development Code, Encana requests a waiver for the following Access and Road Design Standards for the K19NE Storage Facility.

Section 7-107 Access & Roadways

F. Design Standards.

A waiver of standards request shall be considered based on the following criteria:

1. Achieves the intent of the subject standard to the same and better degree than the subject standard:

   Response: The intent of the design standards is to provide safe access to the project site. This road was designed for the exclusive use of Encana to access its natural gas operations. It is not designed for public use. Given the average daily traffic that this road services, it should most closely correspond to the Primitive/Driveway road standard. The private access road does not meet the design standards for road grade, cross slope, or ditches. See Road Assessment report for more information.

   The area of the road that has a grade of more than 12% is a short distance. The road has been designed to follow the natural topography of the area with minimal change to the natural grade. The road is graveled. Emergency vehicles will be able to negotiate the grade, if necessary.

   The cross slope varies from 0.6% to 7.3% along the road. In some places, the road slopes toward the side of the road without a ditch, including some areas where the road is crowned. The road geometry changes occasionally with maintenance activities. While ponding may occur in areas of shallow cross slope, the road is inspected on a regular basis for maintenance issues, which are addressed in a timely manner. Speeds are low to promote safety and reduce road damage.

   Some areas of the road do not have ditches present on either side. Where ditches are present, they range in width from 2.0 to 7.5 feet. They are fairly shallow. The road is inspected on a regular basis for maintenance issues, which are addressed in a timely manner.

2. Imposes no greater impacts on adjacent properties than would occur through compliance with the specific requirements of this Code.

   Response: This private road does not provide access to residential uses nor is it used by the general public on a regular basis. The waiver of this standard will not create greater impacts on adjacent properties than would occur if it was in full compliance.

SECTION 4-202 WAIVER OF SUBMISSION REQUIREMENTS

Pursuant to Section 4-202 of the Garfield County Land Use and Development Code, Encana Oil & Gas (USA) Inc. (Encana) requests a waiver for the submittal requirement of a Development Agreement and Improvements Agreement for the K19NE Storage Facility.

Section 4-203.J. Development Agreement

A waiver request shall be considered based on the following criteria:

1. The Applicant shows good cause for the requested waiver;

   Response: Encana wishes to neither propose a phasing schedule nor extend establishment of vested property rights.

2. The project size, complexity, anticipated impacts, or other factors support a waiver;

   Response: The facility is largely constructed and does not require additional improvements to operate as a storage facility.

3. The waiver does not compromise a proper and complete review; and

   Response: The request can be properly and completely reviewed without a development agreement.

4. The information is not material to describing the proposal or demonstrating compliance with approval criteria.

   Response: A development agreement is not material to describing the purpose, operation and maintenance of the facility or demonstrating compliance with applicable approval criteria.

Section 4-203.K. Improvements Agreement

A waiver request shall be considered based on the following criteria:

1. The Applicant shows good cause for the requested waiver;

   Response: No public improvements are being proposed that would warrant the creation of an improvements agreement.

2. The project size, complexity, anticipated impacts, or other factors support a waiver;

   Response: As stated above no public improvements are being proposed with this request.

3. The waiver does not compromise a proper and complete review; and

   Response: The application can be properly and completely reviewed without an improvements agreement.

4. The information is not material to describing the proposal or demonstrating compliance with approval criteria.

   Response: An improvements agreement is not material to describing the purpose, operation and maintenance of the facility or demonstrating compliance with applicable approval criteria.

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Article 4-203.B.1 General Application Materials

Encana Oil & Gas (USA) Inc K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2797

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Garfield County

Community Development Department
108 8th Street, Suite 401
Glenwood Springs, CO 81601
(970) 945-8212
www.garfield-county.com

LAND USE CHANGE PERMIT APPLICATION FORM

TYPE OF APPLICATION

☐ Administrative Review	☐ Development in 100-Year Floodplain
■ Limited Impact Review	☐ Development in 100-Year Floodplain Variance
☐ Major Impact Review	☐ Code Text Amendment
☐ Amendments to an Approved LUCP ☐ LIR ☐ MIR ☐ SUP	☐ Rezoning ☐ Zone District ☐ PUD ☐ PUD Amendment
☐ Minor Temporary Housing Facility	☐ Administrative Interpretation
☐ Vacation of a County Road/Public ROW	☐ Appeal of Administrative Interpretation
☐ Location and Extent Review	☐ Areas and Activities of State Interest
☐ Comprehensive Plan Amendment ☐ Major ☐ Minor	☐ Accommodation Pursuant to Fair Housing Act
☐ Pipeline Development	☐ Variance
☐ Time Extension (also check type of original application)	

INVOLVED PARTIES

Owner/Applicant

Name: Encana Oil & Gas (USA) Inc **Phone:** (970) 285.2656

Mailing Address: 143 Diamond Ave

City: Parachute **State:** CO **Zip Code:** 81635

E-mail: jason.eckman@encana.com

Representative (Authorization Required)

Name: Lorne Prescott **Phone:** (970) 263.6014

Mailing Address: 760 Horizon Drive, Suite 102

City: Grand Junction **State:** CO **Zip Code:** 81506

E-mail: lprescott@olssonassociates.com

PROJECT NAME AND LOCATION

Project Name:

K19NE Laydown Yard

Assessor's Parcel Number: 2179 - 193 - 00 - 128

Physical/Street Address:

Legal Description: Lot 3, Section 19, Township 6 South, Range 92 West, 6th PM

Zone District: Rural **Property Size (acres):** ~88.5

PROJECT DESCRIPTION

Existing Use: Natural gas well pad

Proposed Use (From Use Table 3-403): Storage

Description of Project: Provide a centralized location to store equipment and supplies in support of Encana's natural gas drilling and production activities in the area.

REQUEST FOR WAIVERS

Submission Requirements

- ☐ The Applicant requesting a Waiver of Submission Requirements per Section 4-202. List:

Section: 4-203.J Development Agreement Section: _____

Section: 4-203.K Improvements Agreement Section: _____

Waiver of Standards

- ☐ The Applicant is requesting a Waiver of Standards per Section 4-118. List:

Section: 7-107.F Access & Roadways Design Standards Section: _____

Section: _____ Section: _____

I have read the statements above and have provided the required attached information which is correct and accurate to the best of my knowledge.

Jason Eckman 2/3/15

Signature of Property Owner **Date**

OFFICIAL USE ONLY

File Number: _____-_____ **Fee Paid: $**_____

Garfield County

PAYMENT AGREEMENT FORM

GARFIELD COUNTY ("COUNTY") and Property Owner ("APPLICANT") Encana Oil & Gas (USA) Inc agree as follows:

1. The Applicant has submitted to the County an application for the following Project: K19NE Storage Facility (Laydown Yard).

2. The Applicant understands and agrees that Garfield County Resolution No. 2014-60, as amended, establishes a fee schedule for each type application, and the guidelines for the administration of the fee structure.

3. The Applicant and the County agree that because of the size, nature or scope of the proposed project, it is not possible at this time to ascertain the full extent of the costs involved in processing the application. The Applicant agrees to make payment of the Base Fee, established for the Project, and to thereafter permit additional costs to be billed to the Applicant. The Applicant agrees to make additional payments upon notification by the County, when they are necessary, as costs are incurred.

4. The Base Fee shall be in addition to and exclusive of any cost for publication or cost of consulting service determined necessary by the Board of County Commissioners for the consideration of an application or additional County staff time or expense not covered by the Base Fee. If actual recorded costs exceed the initial Base Fee, the Applicant shall pay additional billings to the County to reimburse the County for the processing of the Project. The Applicant acknowledges that all billing shall be paid prior to the final consideration by the County of any Land Use Change or Division of Land.

I hereby agree to pay all fees related to this application:

Billing Contact Person: JASON ECKMAN Phone: (970) 285-2656

Billing Contact Address: 143 DIAMOND AVE

City: PARACHUTE State: CO Zip Code: 81635

Billing Contact Email: jason.eckman@encana.com

Printed Name of Person Authorized to Sign: JASON ECKMAN

Jason Eckman (Signature) 2/3/15 (Date)

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Reception#: 821766
07/24/2012 03:04:12 PM Jean Alberico
1 of 1 Rec Fee:$11.00 Doc Fee:0.00 GARFIELD COUNTY CO

CONFORMED COPY

STATEMENT OF AUTHORITY

Pursuant to C.R.S. §38-30-172, the undersigned executes this Statement of Authority on behalf of Encana Oil & Gas (USA) Inc., a corporation (corporation, limited liability company, general partnership, registered limited liability partnership, registered limited liability limited partnership, limited partnership association, government agency, trust or other), an entity other than an individual, capable of holding title to real property (the "Entity"), and states as follows:

The name of the Entity is Encana Oil & Gas (USA) Inc. and is formed under the laws of the State of Delaware.

The mailing address for the Entity is 370 17th Street, Suite 1700 Denver, CO 80202.

The name and/or position of the person authorized to execute instruments conveying, encumbering, or otherwise affecting title to real property on behalf of the Entity is Renata Busch, Jason Eckman, Mike Herndon and Chris Putnam.

The limitations upon the authority of the person named above or holding the position described above to bind the Entity are as follows: sign permit applications and permits issued by Garfield County

(if no limitations, insert "None")

Other matters concerning the manner in which the Entity deals with any interest in real property are: _____

(if no other matter, leave this section blank)

EXECUTED this 13 day of July, 2012.

Signature: _____

Name (typed or printed: Darrin J. Henke

Title (if any): Vice-President

STATE OF Colorado)
) SS.
COUNTY OF Denver)

The foregoing instrument was acknowledged before me this 13th day of June July, 2012 by Darrin J. Henke, on behalf of Encana Oil & Gas (USA) Inc., a Delaware Corporation.

Witness my hand and official seal.

My commission expires: _____

_____
(Notary Public)

SEAL
JUDITH B SISNEROS
NOTARY PUBLIC
STATE OF COLORADO
My Commission Expires 03/17/2016

11/08

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December 8, 2014

Mr. Fred Jarman, Community Development Director
Garfield County Community Development Department
108 8th Street, Suite 401
Glenwood Springs, CO 81601

RE: Agent Authorization

Dear Mr. Jarman,

Encana Oil and Gas (USA) Inc. (Encana) authorizes Lorne Prescott and Tilda Evans, and Olsson Associates to act on behalf of and represent Encana in all matters related to land use permitting in Garfield County.

Please contact me if you have any questions.

Sincerely,

Jason Eckman
Senior Regulatory Analyst

Encana Oil & Gas (USA) Inc.
143 Diamond Avenue
Parachute,, CO 81635
t 970.285.2656
f 970.285.2691
www.encana.com

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Article 4-203.B.2 Deeds, Easements and Agreements

Encana Oil & Gas (USA) Inc K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2796

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649881 04/09/2004 03:40P B1576 P207 M ALSDORF
1 of 1 R 6.00 D 22.00 GARFIELD COUNTY CO

Filed for record the _____ day of _____, A.D. _____, at _____ o'clock ___ M. _____ RECORDER.
Reception No. _____ By _____ DEPUTY.

WARRANTY DEED

THIS DEED, Made on this day of April 07, 2004
between AIRPORT LAND PARTNERS LIMITED, A COLORADO LIMITED PARTNERSHIP

of the _____ County of GARFIELD and State of Colorado, the Grantor(s), and
ENCANA OIL & GAS (USA) INC.

whose legal address is : 950 17TH ST STE 2600, DENVER, CO 80202
of the _____ County of DENVER and State of Colorado, the Grantee(s):

WITNESS, That the Grantor(s), for and in consideration of the sum of ($220,000.00)
*** Two Hundred Twenty Thousand and 00/100 *** DOLLARS
the receipt and sufficiency of which is hereby acknowledged, has granted, bargained, sold and conveyed, and by these presents does grant, bargain, sell, convey and confirm unto the Grantee(s), his heirs and assigns forever, all the real property, together with improvements, if any, situate, lying and being in the _____ County of GARFIELD and State of Colorado, described as follows:
LOT 3 AND THE NW1/4SE1/4 OF SECTION 19, TOWNSHIP 6 SOUTH, RANGE 92 WEST OF THE 6TH P.M.

COUNTY OF GARFIELD
STATE OF COLORADO

also known as street number SECTION 18, TOWNSHIP 6 SOUTH, RANGE 92 WEST

TOGETHER with all and singular and hereditaments and appurtenances thereto belonging, or in anywise appertaining and the reversion and reversions, remainder and remainders, rents, issues and profits thereof; and all the estate, right title interest, claim and demand whatsoever of the Grantor(s), either in law or equity, of, in and to the above bargained premises, with the hereditaments and appurtenances;

TO HAVE AND TO HOLD the said premises above bargained and described with appurtenances, unto the Grantee(s), his heirs and assigns forever. The Grantor(s), for himself, his heirs and personal representatives, does covenant, grant, bargain, and agree to and with the Grantee(s), his heirs and assigns, that at the time of the ensealing and delivery of these presents, he is well seized of the premises above conveyed, has good, sure, perfect, absolute and indefeasible estate of inheritance, in law, in fee simple, and has good right, full power and lawful authority to grant, bargain, sell and convey the same in manner and form as aforesaid, and that the same are free and clear from all former and other grants, bargains, sales, liens, taxes, assessments, encumbrances and restrictions of whatever kind or nature soever, SUBJECT TO GENERAL TAXES FOR THE YEAR 2004, AND EASEMENTS, RESERVATIONS, RESTRICTIONS COVENANTS AND RIGHTS OF WAY OF RECORD, IF ANY; AND DISTRIBUTION UTILITY EASEMENTS; AND MATTERS NOT SHOWN BY THE PUBLIC RECORDS BUT OF WHICH GRANTEE HAS ACTUAL KNOWLEDGE; AND INCLUSION OF THE PROPERTY WITHIN ANY SPECIAL TAXING DISTRICT, AND THE BENEFITS AND BURDENS OF ANY DECLARATION AND PARTY WALL AGREEMENTS, IF ANY.

The Grantor(s) shall and will WARRANT AND FOREVER DEFEND the above bargained premises in the quiet and peaceable possession of the Grantee(s), his heirs and assigns, against all and every person or persons lawfully claiming the whole or any part thereof. The singular number shall include the plural, and the plural the singular, and the use of any gender shall be applicable to all genders.

IN WITNESS WHEREOF the Grantor(s) has executed this deed on the date set forth above.

AIRPORT LAND PARTNERS LIMITED, A COLORADO LIMITED PARTNERSHIP

BY: AIRPORT BUSINESS PARK CORPORATION

BY: ROBERT A. HOWARD, PRESIDENT

STATE OF Colorado)
) ss.
County of GARFIELD)

The foregoing instrument was acknowledged before me on this day of April 07 2004
by ROBERT A. HOWARD, PRESIDENT OF AIRPORT BUSINESS PARK CORPORATION, SOLE GENERAL PARTNER OF AIRPORT LAND PARTNERS LIMITED.

My commission expires 7/31/07
Witness my hand and official seal.

Notary Public

Name and Address of Person Creating Newly Created Legal Description (38-35-106 5, C.R.S.)

Approved: GM241575
Title#: GM241575

When Recorded Return to: ENCANA OIL & GAS (USA) INC.
950 17TH ST STE 2600
DENVER, CO 80202

Form No. 932 Rev 4 94, WARRANTY DEED (Photographic Record NO)

LAND TITLE

(22.00) 432 5/1 (1)

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RECEIVED AT 10 14 O'CLOCK A M. JAN 22 1990
REC'D 409298 MILDRED ALSDORF, COUNTY CLERK
GARFIELD COUNTY, COLORADO

Producers 88—Rev. 1988
Rocky Mountain (Colo. CBM)

OIL AND GAS LEASE

BOOK 771 PAGE 464

AGREEMENT, made and entered into this 7th day of December 19 89

by and between

Richard Thompson Dever, a single man
P.O. Box 636
Glenwood Springs, CO 81602

and

Dorothy Dever, formerly Dorothy Dever Fuller, now a single woman
99 South Downing Street, #502
Denver, CO 80209

Party of the first part, hereinafter called lessor (whether one or more) and Pioneer Oil & Gas, a Utah corporation, 6925 Union Park Center, Suite 145, Midvale, Utah 84047 . Party of the second part, hereinafter called lessee

WITNESSETH, that the said lessor, for and in consideration of Ten and More ($10.00 & More) Dollars cash in hand paid, receipt of which is hereby acknowledged and of the covenants and agreements hereinafter contained on the part of the lessee to be paid, kept and performed, has granted, demised, leased, and let and by these presents does grant, demise, lease, and let exclusively unto the said lessee, its successors and assigns, for the sole and only purposes of surveying, by geological, geophysical, and all other methods, exploring, mining and operating for, and producing oil, gas, and other hydrocarbons, and all other minerals or substances, whether similar or dissimilar, including, but not limited to, coalbed methane, helium, nitrogen, carbon dioxide, and all substances produced in association therewith from coal-bearing formations or elsewhere, that may be produced from any well drilled by lessee on the leased premises hereinafter described, and laying pipelines, and building tanks, power stations and structures thereon to produce, save, and take care of said products, all that certain tract of land together with any reversionary, remainderman- and springing executory rights therein, situate in the County of- Garfield , State of- Colorado , described as follows, to wit:

Township 6 South, Range 92 West, 6th PM
Sec. 17: SW¼NW¼, W½SW¼
Sec. 18: S½NE¼, N½SE¼, SW¼SE¼
Sec. 19: NW¼SE¼, Lot 3 (48.42 a.)

Township 6 South, Range 93 West, 6th PM
Sec. 25: SE¼NW¼
Sec. 26: W½SE¼
Sec. 35: S½SE¼, N½NE¼
Sec. 36: N½SW¼

Township 7 South, Range 93 West, 6th PM
Sec. 1: Lot 2, (24.00 a.) W½SW¼, NE¼SW¼, W½NW¼SE¼
Sec. 2: Lot 1, (23.65 a.) E½SE¼

together with all strips, or parcels of land, (not, however, to be construed to include parcels comprising a regular 40-acre legal subdivision or lot of approximately corresponding size) adjoining or contiguous to the above described land and owned or claimed by lessor, and containing 1036.07 acres, more or less.

1. Without reference to the commencement, prosecution or cessation at any time of drilling or other development operations and/or to the discovery, development or cessation at any time of production of oil, gas or other hydrocarbons including coalbed methane or other minerals or substances covered hereby (herein collectively referred to as "oil or gas") or either or any of them, and without further payments other than the royalties herein provided and notwithstanding anything herein contained to the contrary, it is agreed that this lease shall remain in force for a term of seven (7) years from the date hereof, and as long thereafter as oil and gas, or either or any of them, is produced from said lands or premises pooled therewith or drilling operations are continued as hereinafter provided by the lessee, its successors and assigns. During the term of this lease, lessor agrees not to enter into any oil and gas lease with any other party covering any lands covered by this lease.

2. This is a PAID-UP LEASE. In consideration of the cash down payment, lessor agrees that lessee shall not be obligated, except as otherwise provided herein, to commence or continue any operations during the primary term. Lessee may at any time or times during or after the primary term surrender this lease as to all or any portion of said land and as to any strata or stratum by delivering to lessor or by filing for record a release or releases, and be relieved of all obligation thereafter accruing as to the acreage surrendered.

3. In consideration of the premises the said lessee covenants and agrees:

First. The lessee shall deliver to the credit of lessor as royalty, free of cost in the pipeline to which lessee may connect its wells, the equal one-eighth (1/8th) part of all oil produced and saved from the leased premises, or at lessee's option, lessee may buy or sell such one-eighth (1/8th) royalty and pay lessor the market price for oil of like grade and gravity prevailing in the field on the day such oil is run into pipelines or into storage tanks.

Second. To pay lessor one-eighth (1/8th) of the net proceeds at the well from the proceeds received for gas sold from each well where gas only is found, or the market value at the well of such gas used off the premises.

Third. To pay lessor one-eighth (1/8th) of the market value at the well for gas produced from any oil well and used off the premises, or for the manufacture of casing-head gasoline or dry commercial gas.

Fourth. To pay lessor one-eighth (1/8th) of the proceeds received from the sale of any substance covered by this lease, other than oil and gas and the products thereof, which lessee may elect to produce, save, and market from the leased premises.

4. If at the expiration of the primary term of this lease, oil or gas is not being produced on the leased premises or on acreage pooled therewith but lessee is then engaged in drilling or re-working operations thereon, then this lease shall continue in force so long as operations are being continuously prosecuted on the leased premises or on acreage pooled therewith, and operations shall be considered to be continuously prosecuted if not more than ninety (90) days shall elapse between the completion or abandonment of one well and the beginning of operations for the drilling of a subsequent well. If after discovery of oil or gas on said land or on acreage pooled therewith, the production thereof should cease from any cause after the primary term, this lease shall not terminate if lessee commences additional drilling or re-working operations within ninety (90) days from date of cessation of production or from date of completion of dry hole. If oil or gas shall be discovered and produced as a result of such operations at or after the expiration of the primary term of this lease, this lease shall continue in force so long as oil or gas is produced from the leased premises or on acreage pooled therewith.

5. If a well capable of producing oil or gas is located on said land and is shut-in before production commences, or at any time thereafter, this lease shall continue in effect from the date such well is shut-in until the anniversary date (herein called "said anniversary date") of this lease next ensuing after the expiration of ninety (90) days from the date such well is shut-in. Lessee may thereafter pay, or tender to lessor as royalty, on or before said anniversary date, an amount of $100.00 per well per year, and if such payment or tender is made, such well shall continue this lease in effect for a further period of one year from said anniversary date, and in like manner and upon like payments or tenders annually made on or before the anniversary date hereof, this lease shall continue in effect for successive periods of twelve (12) months each. Notwithstanding any other provision to the contrary, this lease shall not terminate because of a failure to properly or timely make a shut-in well payment unless lessor shall have given lessee written notice of such failure to properly or timely make such shut-in well payment and lessee shall have failed for a period of thirty (30) days after receipt of such notice to tender such payment in the proper amount, together with a late or improper payment penalty of $100.00.

6. If said lessor owns a less interest in the above described land than the entire and undivided fee simple estate therein, then the royalties herein provided shall be paid the lessor only in the proportion which his interest bears to the whole and undivided fee. Any interest in the production from the above described land to which the interest of lessor may be subject shall be deducted from the royalties provided for herein.

7. Lessee shall have the right to use, free of cost, oil or gas and water produced on said land for its operations thereon, except water from wells of lessor. Lessee shall have the right at any time to remove all machinery and fixtures placed on said premises, including the right to draw and remove casing.

8. Lessee shall pay for damages caused by its operations to growing crops on said lands. When requested by the lessor, lessee shall bury his pipelines below plow depth. No well shall be drilled nearer than 200 feet to the house or barn now on said premises, without written consent of the lessor.

9. Lessee, at its option, is hereby given the right and power at any time and from time to time as a recurring right, either before or after production as to all or any part of the land described herein and as to any one or more of the formations hereunder, to pool or unitize the leasehold estate and the mineral estate covered by this lease with other land, lease or leases in the immediate vicinity for the production of oil or gas, or both, when in lessee's judgment it is necessary or advisable to do so, and irrespective of whether authority similar to this exists with respect to such other land, lease or leases. Likewise, units previously formed to include formations not producing oil or gas, may be reformed to exclude such non-producing formations. The forming or reforming of any unit shall be accomplished by lessee executing and filing of record a declaration of such unitization or reformation, which declaration shall describe the unit. Any unit may include land upon which a well has theretofore been completed or upon which operations for drilling have theretofore been commenced. Production, drilling or reworking operations, or a well shut in anywhere on a unit which includes all or part of this lease shall be treated as if it were production, drilling or reworking operations, or a well shut in under this lease. In lieu of the royalties elsewhere herein specified, excluding shut-in royalties, lessor shall receive on production from the unit so pooled royalties only on the portion of such production allocated to this lease; such allocation shall be that proportion of the unit production that the total number of surface acres covered by this lease and included in the unit bears to the total number of surface acres in such unit. In addition to the foregoing, lessee shall have the right to unitize, pool, or combine all or any part of the above described lands as to one or more of the formations thereunder with other lands in the same general area by entering into a cooperative or unit plan of development or operation approved by any governmental authority and, from time to time, with like approval, to modify, change or terminate any such plan or agreement and, in such event, the terms, conditions and provisions of this lease shall be deemed modified to conform to the terms, conditions, and provisions of such approved cooperative or unit plan of development or operation and, particularly, all drilling and development requirements of this lease, express or implied, shall be satisfied by compliance with the drilling and development requirements of such plan or agreement, and this lease shall not terminate or expire during the life of such plan or agreement. In the event that said above described lands or any part thereof, shall hereafter be operated under any such cooperative or unit plan of development or operation whereby the production therefrom is allocated to different portions of the land covered by said plan, then the production allocated to any particular tract of land shall, for the purpose of computing the royalties to be paid hereunder to lessor, be regarded as having been produced from the particular tract of land to which it is allocated and not to any other tract of land; and the royalty payments to be made hereunder to lessor shall be based upon production only as so allocated. Lessor shall formally express lessee's consent to any cooperative or unit plan of development or operation adopted by lessee and approved by any governmental agency by executing the same upon request of lessee.

10. If the estate of either party hereto is assigned or sublet, and the privilege of assigning or subletting in whole or in part is expressly allowed, the express and implied covenants hereof shall extend to the sublessees, successors, and assigns of the parties, and in the event of an assignment or subletting by lessee, lessee shall be relieved and discharged as to the leasehold rights so assigned or sublet from any liability to lessor thereafter accruing upon any of the covenants or conditions of this lease, either express or implied. No change in the ownership of the land or royalties, however accomplished, shall operate to enlarge the obligations or diminish the rights of lessee or require separate measuring or installation of separate tanks by lessee. Notwithstanding any actual or constructive knowledge of or notice to lessee, no change in the ownership of said land or of the right to receive royalties hereunder, or of any interest therein, whether by reason of death, conveyance, or any other matter, shall be binding on lessee (except at lessee's option in any particular case) until sixty (60) days after lessee has been furnished with either the original recorded instrument of conveyance or a duly certified copy thereof or a certified copy of the will of any deceased owner and of the probate thereof, or certified copy of the proceeding showing appointment of an administrator for the estate of any deceased owner, whichever is appropriate, together with all original recorded instruments of conveyance or duly certified copies thereof necessary in showing a complete chain of title back to lessor, to the full interest claimed; and all advance payments of shut-in royalties made hereunder before receipt of said documents shall be binding on any direct or indirect assignee, grantee, devisee, administrator, executor, or heir of lessor. It is hereby agreed in the event this lease shall be assigned as to a part or parts of the above described lands and the assignee or assignees of such part or parts shall fail or make default in the payment of the proportionate part of the shut-in royalties due from him or them, such default shall not operate to defeat or affect this lease insofar as it covers a part or parts of said lands upon which the said lessee or any assignee thereof shall make due payment of said shut-in royalties.

11. All provisions hereof, express or implied, shall be subject to all applicable laws, governmental orders, rules and regulations. This lease shall not be terminated in whole or in part, nor lessee held liable in damages, because of a cessation of production or of drilling operations due to the application of such laws, governmental orders, rules and regulations or breakdown of equipment or the repairing of a well or wells, or because of such a cessation or a failure to comply with any of the express or implied provisions of this lease if such cessation or failure is the result of the exercise of governmental authority, war, lack of market, act of God, strike, fire, explosion, flood, or any other cause reasonably beyond the control of lessee. If lessee shall be prevented during the last six months of the primary term hereof from drilling a well hereunder by the order of any constituted authority having jurisdiction thereover, or if lessee should be unable during said period to drill a well hereunder due to equipment necessary in the drilling thereof not being available on account of any cause beyond the control of lessee, the primary term of this lease shall continue until six months after said order is suspended and/or said equipment is available.

12. In the event lessor considers that the lessee has failed to comply with any obligations hereunder, express or implied, lessor shall notify lessee in writing, specifying in what respect lessor claims lessee has breached this lease. Lessee shall then have sixty (60) days after receipt of said notice within which to meet or commence to meet all or any part of the breaches alleged by lessor. The service of said notice shall be precedent to the bringing of any action by lessor on said lease for any cause, and no such action shall be brought until the lapse of sixty (60) days after service of such notice on lessee. Neither the service of said notice nor the doing of any acts by lessee aimed to meet all or any of the alleged breaches shall be deemed an admission or presumption that lessee has failed to perform all its obligations hereunder.

13. Lessor hereby releases and relinquishes any right of homestead, dower or curtesy they or either of them may have in or to the leased land.

14. Lessor hereby warrants and agrees to defend the title to the lands herein described, and agrees that the lessee shall have the right at any time to redeem for lessor, by payment, any mortgage, taxes, or other liens on the above described lands in the event of default of payment by lessor, and be subrogated to the rights of the holder thereof, and such payments may be deducted from any royalties which may be payable to lessor hereunder.

15. This lease and all its terms, conditions, and stipulations binds each executing lessor and shall extend to and be binding on his assigns, heirs, devisees and successors, and those of the lessee, though unsigned by other lessors named herein.

IN WITNESS WHEREOF, We sign the day and year first above written.

1000

By: Richard Thompson Dever
Richard Thompson Dever
(S.S. #521-60-5425)

By: Dorothy Dever, formerly
Dorothy Dever, formerly Dorothy Dever Fuller (S.S. #522-48-6139)

Dorothy Dever Fuller

STATE OF COLORADO)
) ss.
COUNTY OF GARFIELD)

BEFORE ME, the undersigned authority, on this day personally appeared Richard Thompson Dever, a single man, known to me to be the person whose name is subscribed to the foregoing instrument and acknowledged to me that he executed the same for the purposes and consideration therein expressed.

GIVEN UNDER MY HAND AND SEAL OF OFFICE THIS 11th day of December, 198 9.

My commission expires:
My commission expires December 19, 1989.
901 Grand Avenue
Glenwood Springs, CO 81601

Elaine Duers
Notary Public

STATE OF COLORADO)
) ss.
COUNTY OF DENVER)

now a single woman

BEFORE ME, the undersigned authority, on this day personally appeared Dorothy Dever, formerly Dorothy Dever Fuller, known to me to be the person whose name is subscribed to the foregoing instrument and acknowledged to me that she executed the same for the purposes and consideration therein expressed.

GIVEN UNDER MY HAND AND SEAL OF OFFICE THIS 22nd day of December, 198 9.

My commission expires:
My Commission Expires Nov. 4, 1991

Robert E. Swanton
Notary Public

STATE OF _____)
) ss.
COUNTY OF _____)

BEFORE ME, the undersigned authority, on this day personally appeared _____, known to me to be the person whose name is subscribed to the foregoing instrument as _____ of _____, a corporation, and acknowledged to me that he executed the same for the purposes and consideration therein expressed, in the capacity stated, and as the act and deed of said corporation.

GIVEN UNDER MY HAND AND SEAL OF OFFICE THIS _____ day of _____, 198 _____.

My commission expires:

_____
Notary Public

RETURN TO: Pioneer Oil & Gas, 6925 Union Park Center, #145, Midvale, UT 84047

DP

Contract Documents

Contract Number: 28057

Document Date: 06.04.2013 State: CO

Contract File/Contract Document Types:

■ ***Contract***

- ☐ Area of Mutual Interest
- ☐ Communitization Agreement
- ☐ Development Contract
- ☐ Divestiture
- ☐ Encumbrance Documents
- ☐ Environmental Contract
- ☐ Exchange Agreement
- ☐ Farmout
- ☐ Farmout Option
- ☐ Joint Operating Agreement
- ☐ Joint Exploration Agreement
- ☐ Letter Agreement
- ☐ Participating Area
- ☐ Participation Agreement
- ■ Pooling Agreement
- ☐ Purchase & Sale Agreement
- ☐ Segregation Agreement
- ☐ Unit Agreement
- ☐ Unit Operating Agreement
- ☐ Misc.

☐ ***General***

- ☐ Amendment
- ☐ Assignment
- ☐ BLM Notification
- ☐ Contract Brief
- ☐ Correspondence
- ☐ Data Sheet
- ☐ Draft Agreements
- ☐ Due Diligence Documentation
- ☐ Paying Well Determination
- ☐ Plan of Development
- ☐ Ratification/Joinders
- ☐ Termination/Release Documentation
- ☐ Title Opinion

Submitted by: EBryan

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07/01/2013 02:29:30 PM Jean Alberico
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DECLARATION OF POOLING
K19CNE UNIT
(305.25 ACRE POOLED UNIT)

STATE OF COLORADO §
§
COUNTY OF GARFIELD §

WHEREAS, Encana Oil & Gas (USA) Inc., a Delaware corporation, whose address is 370 17TH Street, Suite 1700, Denver, CO 80202 (hereinafter referred to as "Lessee"), is the owner of the oil, gas and mineral leases, as extended and/or amended, and ratifications thereto described in Exhibit "A" (the "Leases"), which cover certain lands in Garfield County, Colorado, as depicted on a plat marked as Exhibit "B"; said Exhibits "A" and "B" are attached hereto and made a part hereof for all purposes; and

WHEREAS, each of the Leases provides the Lessee the right to unitize or pool the Leases and the lands covered thereby, in whole or in part, so as to create a unit or pool as may or may not be required to conform with applicable rules and orders of the Colorado Oil and Gas Conservation Commission.

WHEREAS, in the judgment of the Lessee, it is necessary and desirable to pool and combine the Leases described in Exhibit "A," insofar as such Leases extend to and cover the lands depicted in Exhibit "B," in order to promote conservation and properly develop and operate those lands for the production of oil and/or gas, condensate, and all other hydrocarbons.

NOW THEREFORE, in consideration of the premises, Lessee, acting under and by virtue of the power and authority granted to it by the terms and provisions of the Leases, does hereby pool and combine the Leases described in Exhibit "A," and the leasehold rights, mineral and royalty interests therein, as well as all other interests which may be covered by any agreement or amendment affecting said lands now held by Lessee, or which Lessee may hereinafter acquire, insofar and only insofar, as such Leases, rights, and interests extend to and cover the lands depicted in Exhibit "B" (the "Unit Area"), and further, insofar, and only insofar, as said Leases, rights and interest cover the depths from the surface down to one hundred feet (100') below the base of the stratigraphic equivalent of the Mesa Verde Formation, for the purpose of forming and creating a pooled unit for the drilling for, development of, and production of oil and/or gas, condensate and all other hydrocarbons.

The pooled unit created hereby shall be known as the "**K19CNE** Unit," containing 305.25 acres, more or less.

The production of oil, gas, condensate, and all other hydrocarbons (after any authorized deductions) shall be allocated on a pro rata acreage basis to and among separate tracts within the Unit Area having any difference in mineral or royalty ownership; that is, the percentage of production allocated to each tract shall be equal to the percentage the tract's surface acreage comprises of the overall surface acreage of the Unit Area, and all working interests, royalties, overriding royalties, or other interest in the oil and/or gas, condensate, and all other hydrocarbons produced from such pooled unit shall be computed and paid on the basis of their respective interest in the pooled substances allocated to the tract or tracts in which they own and interest.

Lessee reserves the continuing right to amend, correct, or alter this instrument and the pooled unit created hereby to the extent permitted by law and the authority granted in the Leases, including, without limitation, the power to (i) change the size, area, and formations covered by the pooled unit; (ii) to successively amend, reform, divide, alter, or revise the configuration of or rearrange any then existing Unit Area, to diminish or expand any Unit Area, and or to dissolve and terminate any then existing unit and create another unit or several units; (iii) to include in the pooled unit designated herein any subsequent oil, gas and mineral leases, amendments, extensions and/or ratifications thereof, covering interest in the Unit Area; and (iv) to include in the pooled unit any undivided interest in the Unit Area which is not otherwise included herein by the respective owner of such undivided interest. Further, by execution of this Declaration of Pooling ("Declaration"), Lessee does not exhaust its right to pool the Leases and lands hereinabove described with other leases and lands as to any other horizon, strata, or substances covered thereby and not pooled herein. Any amendment to this Declaration shall be in writing, signed by Lessee, or its successors in interest or title, filed for record in the office of the Clerk and Recorder of Garfield County, Colorado.

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This pooled unit shall be effective as of the date set forth below and shall remain in full force and effect as long as oil and/or gas, condensate or other hydrocarbons are being produced from the pooled unit, drilling or reworking operations are being conducted, delay rentals or shut-in payments are being paid to maintain the Leases or any other provisions of the Leases are being satisfied to maintain the Leases in full force and effect.

The terms of this instrument shall inure to the benefit of and be binding upon the respective parties hereto, the owners or royalty or other interests upon whose behalf the parties are acting, and their heirs, successors, legal representative, and assigns.

IN WITNESS WHEREOF, this instrument is dated and effective the 4th day of ~~May~~ June, 2013.

ENCANA OIL & GAS (USA) INC.

By: _____
Helen M. Capps
Attorney-in-Fact

ACKNOWLEDGEMENT

STATE OF COLORADO §

CITY AND COUNTY OF DENVER §

On this 4th day of ~~May~~ June, 2013, before me personally appeared Helen M. Capps, known to me to be an Attorney-in-Fact for Encana Oil & Gas (USA) Inc. and that she executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein set forth.

WITNESS my hand and official seal.

My Commission Expires: _____

APRIL JACKSON
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094010261
MY COMMISSION EXPIRES MARCH 25, 2017

April Jackson
Notary Public

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EXHIBIT "A"

Attached to and made a part of that certain Declaration of Pooling for the K19CNE Unit, containing 305.25 acres, more or less, and dated ~~May~~ 4th June, 2013.

INSOFAR AND ONLY INSOFAR AS TO LOTS 2, 3, 4, AND THE N/2NE/4, SW/4NE/4 AND NW/4SE/4 OF SECTION 19, TOWNSHIP 6 SOUTH, RANGE 92 WEST, 6TH P.M., CONTAINING 305.25 ACRES, MORE OR LESS
GARFIELD COUNTY, COLORADO

Lessor:	Catherine Sweeny, a/k/a Catherine J. Sweeny, Individually and As Attorney in Fact for Alfred Sweeny, a/k/a Alfred A. Sweeny, her husband, under that certain P-O-A, dated April 1988, and recorded in Bk. 754, Pg. 757 of the records of Garfield County, Colorado
Original Lessee:	Mobil Oil Corporation
Present Lessee:	Encana Oil & Gas (USA) Inc.
Lease Date:	July 14, 1989
Recorded:	Book 779, Page 726, Garfield County, Colorado
Description of Lands:	Township 6 South, Range 92 West, 6th P.M. Section 8: SE/4SW/4 Section 16: SW/4SW/4, W/2NW/4NE/4, Westerly 30 feet of the E/2NW/4NE/4, NE/4NW/4, less and except that portion lying Northerly of the Rising Sun Ditch. Section 17: SW/4NE/4, E/2NW/4, E/2SW/4, SE/4 Section 18: SE/4SE/4 Section 19: Lot 2 (SW/4NW/4 48.48 ac), N/2NE/4, SW/4NE/4 Also Section 8: SW/4SW/4 and Section 17: NW/4NW/4, less and except that part conveyed to George Yule recorded in Bk. 32, Pg. 425 of the offices of County Clerk, Garfield County, Colorado, containing 56.75 acres, more or less. Township 7 South, Range 92 West, 6th P.M. Section 17: W/2NW/4, NW/4SW/4 Section 18: NE/4SE/4 Garfield County, Colorado, containing 891.73 acres.

Lessor:	J. Gentry and Carol L. Gentry, husband and wife
Original Lessee:	Mobil Oil Corporation
Present Lessee:	Encana Oil & Gas (USA) Inc.
Lease Date:	May 9, 1989
Recorded:	Book 779, Page 765, Garfield County, Colorado
Description of Lands:	Township 6 South, Range 92 West, 6th P.M. Section 8: SE/4SW/4 Section 16: SW/4SW/4 Section 17: SW/4NE/4, E/2NW/4, E/2SW/4, SE/4 Section 18: SE/4SE/4 Section 19: Lot 2 (SW/4NW/4 48.48 ac), N/2NE/4, SW/4NE/4 Also Section 8: SW/4SW/4 and Section 17: NW/4NW/4, less and except that part conveyed to George Yule recorded in Bk. 32, Pg. 425 of the offices of County Clerk, Garfield County, Colorado, containing 56.75 acres, more or less. Township 7 South, Range 92 West, 6th P.M. Section 17: W/2NW/4, NW/4SW/4 Section 1S: NE/4SE/4 Garfield County, Colorado, containing 831.73 acres.

Lessor:	Richard Thompson Dever, a single man, and Dorothy Dever, formerly Dorothy Dever Fuller, now a single woman
Original Lessee:	Pioneer Oil & Gas, a Utah corporation
Present Lessee:	Encana Oil & Gas (USA) Inc.
Lease Date:	December 7, 1989
Recorded:	Book 771, Page 464, Garfield County, Colorado
Description of Lands:	Township 6 South, Range 92 West, 6th P.M. Section 17: SW/4NW/4, S/2SW/4 Section 18: S/2NE/4, N/2SE/4, SW/4SE/4 Section 19: NW/4SE/4, Lot 3 (48.42 a.) Township 7 South, Range 93 West, 6th P.M. Section 1: Lot 2 (24.00 a.), W/2SW/4, NE/4SW/4, W/2NW/4SE/4 Section 2: Lot 1 (23.65 a.), E/2SE/4 Township 6 South, Range 93 West, 6th P.M. Section 25: SE/4NW/4 Section 26: W/2SE/4 Section 35: S/2SE/4, N/2NE/4 Section 36: N/2SW/4 Garfield County, Colorado, containing 1036.07 acres, more or less.

Lessor:	Larry R. Wiskirchen, aka Lawrence R. Wiskirchen, a married man dealing in his sole and separate property
Original Lessee:	Ballard Petroleum LLC
Present Lessee:	Encana Oil & Gas (USA) Inc.
Lease Date:	May 4, 1999
Recorded:	Book 1136, Page 763, Garfield County, Colorado
Description of Lands:	Township 6 South, Range 92 West, 6th P.M. Section 19: Lot 4 Section 30: Lot 1, Lot 2 Garfield County, Colorado, containing 144.93 acres, more or less.

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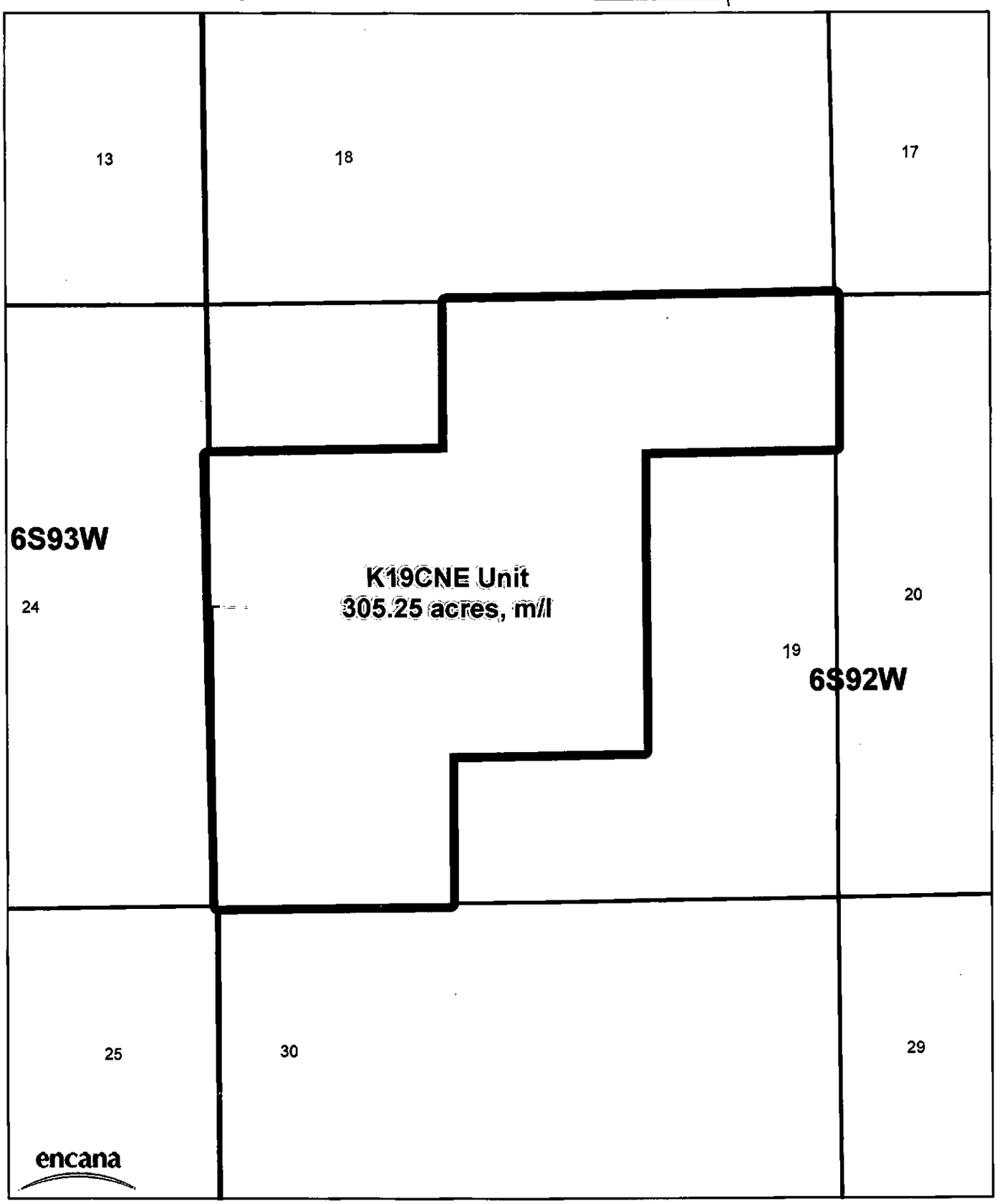
Exhibit "B"

Attached to and made part of that certain Declaration of Pooling for K19CNE Unit, containing 305.25 acres, more or less, and dated June 4th, 2013.



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EASEMENT AND RIGHT-OF-WAY AGREEMENT

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THIS EASEMENT AND RIGHT-OF-WAY AGREEMENT, dated effective April 2, 2004, is made by and between Airport Land Partners Limited, located at 312 Aspen Airport Business Center, Suite A, Aspen, CO 81611-2568 ("GRANTOR") and EnCana Oil & Gas (USA) Inc , located at 950 17th Street, Suite 2600, Denver, Colorado 80202 ("GRANTEE").

WITNESSETH·

For and in consideration of the sum of Ten Dollars ($10 00) in hand paid, and other valuable consideration, the receipt and sufficiency of which is hereby acknowledged, Grantor does hereby grant, bargain, convey and confirm unto Grantee, the following.

A. ACCESS EASEMENT: A non-exclusive easement and right-of-way to construct, maintain, and remove an access road for ingress and egress across the lands identified on Exhibit "A" attached hereto and made a part hereof for the purpose of drilling and completing one or more wells on leasehold owned by Grantee Said access easement shall be approximately forty feet (45') in width, with a sixteen (16') foot travel surface Grantee has the right to use an additional thirty feet (30') of land as temporary workspace as Grantee determines necessary to the exercise of the rights granted herein

B PIPELINE RIGHT-OF-WAY· An easement and right-of-way to construct, lay, maintain operate, alter, replace remove one gas pipeline and one water pipeline including but not limited to valves, regulators, meters, separators, purification equipment and pipeline with fittings, appliances, and appurtenant facilities. The pipeline shall be used for the transportation and processing of oil, natural gas, petroleum products or any other liquids, gases or substances which can be transported through a pipeline and for other purpose. The approximate pipeline route is depicted on Exhibit "B", attached hereto and made a part hereof Said easement and right of way shall be fifteen feet (15') in width, being seven and one half feet (7 5') on each side of a center line of the right-of-way. During the period of pipeline construction, Grantee shall have the right to use an additional strip of land forty feet (40') in width along and on either side of the easement and right of way described in this paragraph, except where Grantee's activities will interfere with irrigation ditches, streams or creeks Grantee shall bury the pipeline with a minimum of 36 inches (36") of soil from the top of the pipeline to the normal surface of the ground. The affected areas shall be recontoured and reseeded with species which are consistent to adjacent, undisturbed areas upon completion of pipeline construction to prevent erosion Grantee shall be permitted to cut all undergrowth and other obstructions that may injure, endanger or interfere with the use of said pipeline

The lands that are the subject of the above described access easement, pipeline easement and right-of-way are hereinafter referred to as "Subject Lands" Grantor reserves the right to the full use and enjoyment of the Subject Lands except for the purposes herein granted

The foregoing rights and privileges of Grantee are further conditioned upon the following

1. DAMAGES Grantee shall either repair and/or pay Grantor for damages (if any) caused by its operations on the Subject Lands relative to growing crops, buildings, ditches, fences and livestock of Grantor or Grantor's surface lessees Grantee shall not alter the natural flow of any creeks, streams, or irrigation ditches relative to the Subject Lands

2. MAINTENANCE The access road shall be maintained by Grantee in accordance with Bureau of Land Management standards.

3 GRANTOR'S DUTIES AND OBLIGATIONS Grantor shall have the right to use and enjoy the above-described premises, subject to the rights herein granted Grantor shall not interfere with or impair or permit others to interfere with or impair in any way the exercise of the rights herein granted to Grantee, and Grantor shall not build, construct, or permit to be built or constructed, any structure or obstruction, or impound water or other substance, or change the grade on or over said road, provided, however, at such time as Grantor undertakes development of the property adjacent to and including the Subject Lands, Grantor shall have the right, at Grantor's expense, to provide Grantee with an alternate legal access, equivalent in grade and surface, in which event the access provided in this Agreement shall be abandoned.

4 LIABILITY OF THE PARTIES. Grantee covenants and agrees to fully defend, protect, indemnify, and hold harmless Grantor, its partners, employees and agents, from and against each and every claim, demand or cause of action and liability, cost and/or expense (including but not limited to reasonable attorney's fees and costs incurred in defense of Grantor, its officers, directors, employees and/or agents), for damage or loss in connection therewith, which may be made or asserted by Grantee, Grantee's partners, employees and/or agents, or which may be asserted by any third party, on account of personal injury or death or property damage caused by, arising out of, or in any way incidental to, or in connection with Grantee's use of the Subject Lands or the rights granted hereunder, except to the extent such damage or injury results from the actions of Grantor, its partners, employees, contractors, or agents Where personal injury, death, or loss of or damage to property is the result of the joint actions of Grantor or its partners, employees, contractors, agents and Grantee, Grantee's duty of indemnification shall be in proportion to its allocable share of such action.

5 DRUGS, ALCOHOL AND FIREARMS: Grantee shall not allow the use or possession of illegal drugs or other unlawful substances or alcohol or firearms by Grantee or its contractors, sub-contractors, agents, business invitees or other visitors while on the Subject Lands or adjacent lands.

6 HUNTING AND FISHING: No hunting, trapping or fishing is permitted on the Subject Lands or adjacent lands and no such rights are granted by this Agreement

7 GOVERNING LAW: This Agreement and all matters pertaining hereto, including, but not limited to, matters of performance, non-performance, breach, remedies, procedures, rights, duties and interpretation or construction, shall be governed and determined by the laws of the State of Colorado

8 MISCELLANEOUS: This Agreement contains the entire agreement between Grantor and Grantee and any prior oral representations or understanding concerning this Agreement or its subject matter shall be of no force and effect

This Agreement is subject to all contracts, leases, liens, easements and encumbrances or claims of title which may affect the Subject Lands and nothing contained herein shall be construed as a covenant or warranty against the existence of any thereof.

The terms and provisions of this Agreement shall extend to and be binding upon the parties and their successors and assigns

IN WITNESS WHEREOF, the parties have executed this Easement and Right-of-Way Agreement the day and year indicated below but effective on the date first set forth above.

GRANTOR.
Airport Land Partners Limited
By Airport Business Park Corporation, General Partner

By _____
Robert Howard, President

Date 4/2/04

GRANTEE
ENCANA OIL & GAS(USA) INC.

By _____
Joel S Fox
Attorney-in-Fact

Date 3/30/04

650315 04/16/2004 03:17P B1578 P392 M ALSDORF
4 of 6 R 31.00 D 0.00 GARFIELD COUNTY CO

ACKNOWLEDGEMENTS

STATE OF COLORADO)
Pitkin)
COUNTY OF ~~GARFIELD~~)

The foregoing instrument was acknowledged before me on this 2nd day of April 2004 by Robert A. Howard, President of Airport Business Park Corporation, the general partner of Airport Land Partners Limited, on behalf of said limited partnership.

Notary Public

My Commission Expires: 7/31/07

STATE OF COLORADO)
)
CITY AND COUNTY OF DENVER)

The foregoing instrument was acknowledged before me on this 30th day of March 2004 by Joel S. Fox, Attorney-in-Fact for ENCANA OIL & GAS (USA) Inc., a Delaware corporation, on behalf of said corporation

Notary Public

My Commission Expires Jan 26, 2007

EXHIBIT A

650315 04/16/2004 03:17P B1578 P393 M ALSDORF
5 of 6 R 31.00 D 0.00 GARFIELD COUNTY CO

GM NE

GM

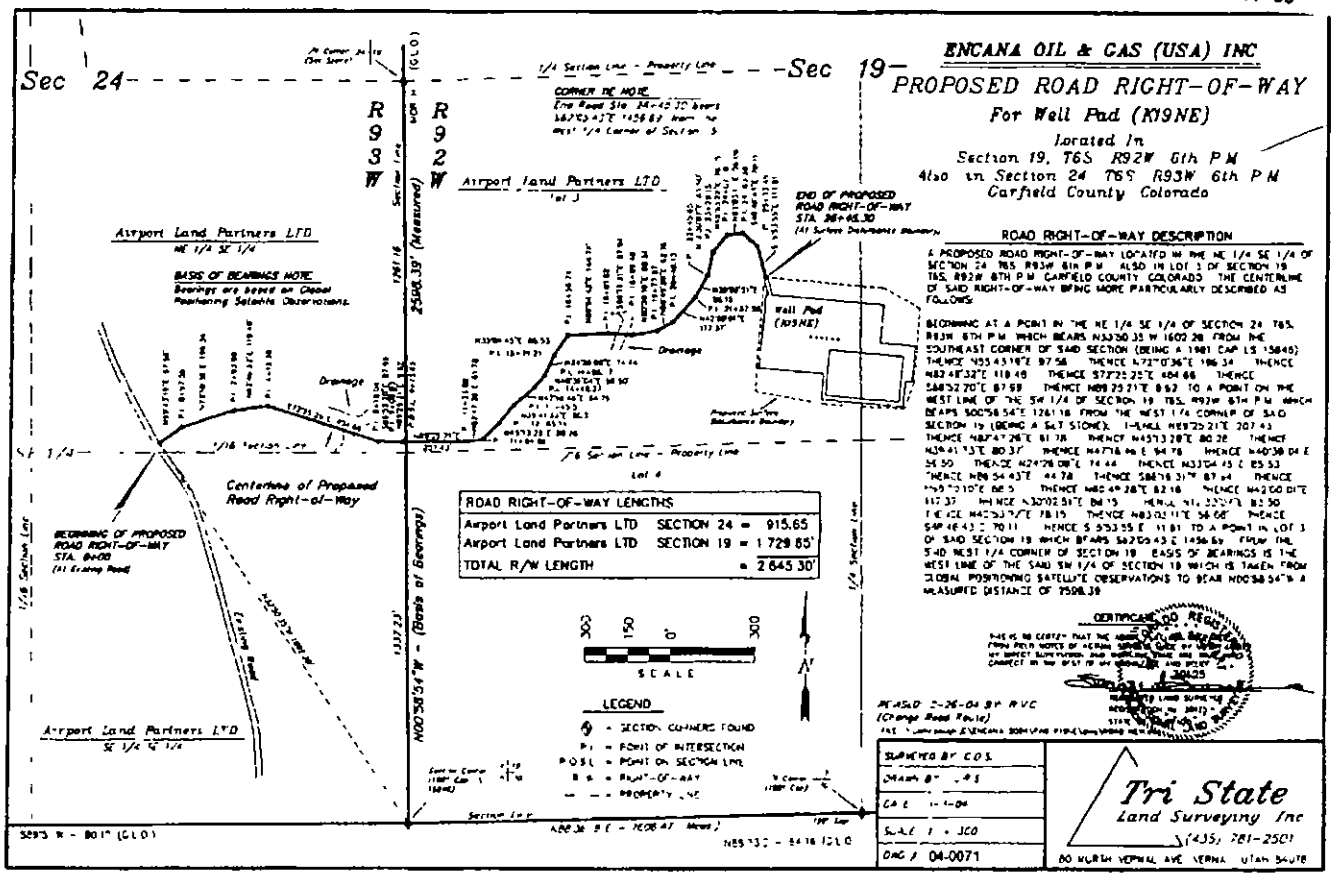
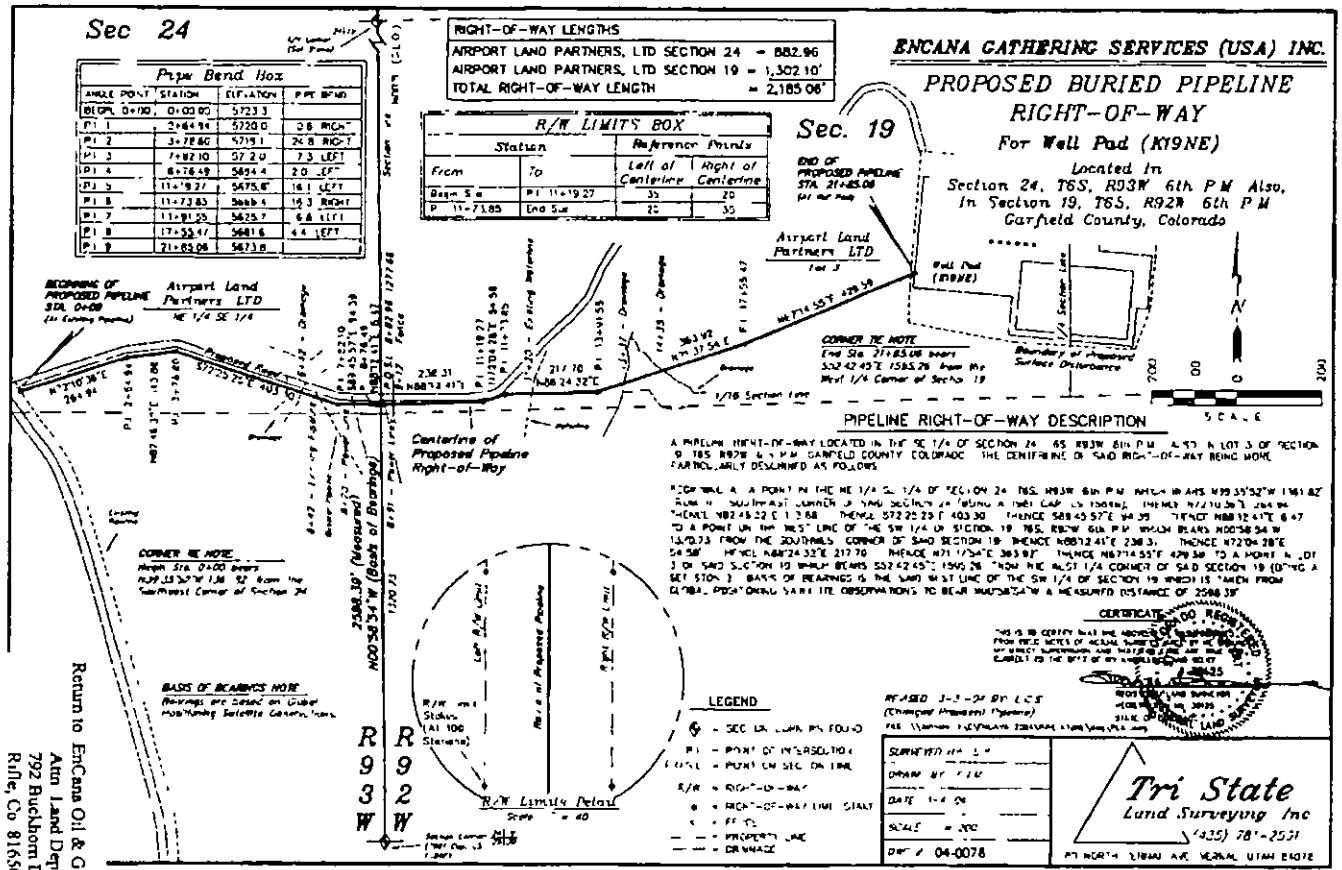


EXHIBIT B

650315 04/16/2004 03:17P B1578 P394 M ALSDORF
6 of 6 R 31.00 D 0.00 GARFIELD COUNTY CO



Return to EnCana Oil & Gas (USA) Inc
Attn Land Dept
792 Buckhorn Drive
Rifle, Co 81650

Article 4-203.B.3
Adjacent Land Owners and Mineral Rights Owners Information

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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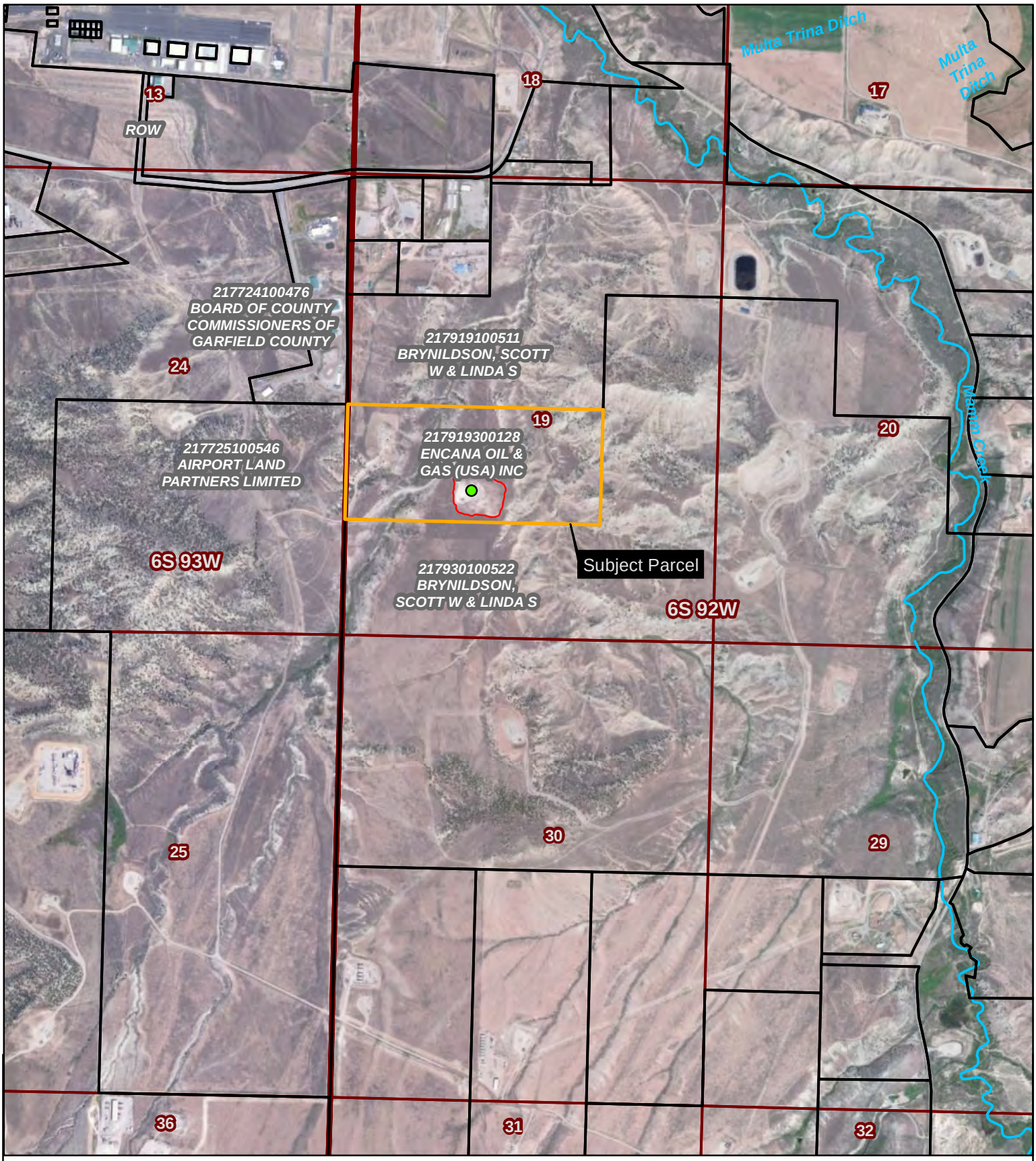

K19NE Storage Yard
K19NE Storage Yard Boundary
Parcels
Subject Parcel
Perennial Stream

N
W
E
S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

ADJACENT LAND OWNERS MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

ALO-1

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Adjacent Land Owners and Mineral Rights Owners
Encana Oil & Gas (USA) Inc.
K19NE Storage Facility (Laydown Yard)
January 13, 2015

Adjacent Land Owners

Parcel Number: 217724100476
Board of County Commissioners
Garfield County
108 8th Street, Suite 213
Glenwood Springs, CO 81601

Parcel Number: 217725100546
Airport Land Partners Limited
312 AABC, Suite A
Aspen, CO 81611-2568

Parcel Number: 217919100511
Scott W & Linda S Brynildson
1831 Railroad Avenue
Rifle, CO 81650-3203

Parcel Number: 217919300128
Encana Oil & Gas (USA) Inc
c/o Merit Appraisal & Tax Consulting
PO Box 330
Gainesville, TX 76241

Parcel Number: 217930100522
Scott W & Linda S Brynildson
1831 Railroad Avenue
Rifle, CO 81650-3203

Mineral Rights Owners

Richard Thompson Dever
PO Box 636
Glenwood Springs, CO 81602

Dorothy Dever
99 S Downing Street, #502
Denver, CO 80209

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Article 4-203.B.4
Project Description

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Project Description
Encana Oil & Gas (USA) Inc.
K19NE Storage Facility (Laydown Yard)

As detailed in this application, Encana Oil & Gas (USA) Inc. (Encana) is requesting a Limited Impact Review (LIR) to allow a Storage Facility (Laydown Yard). The property is zoned Rural by Garfield County. Table 3-403 of the Garfield County Land Use and Development Code identifies storage use as requiring a Limited Impact Review (LIR) in this zone.

The facility will be at an elevation of approximately 5,689 feet. The proposed project area is in a location that provides convenient field access for Encana operations. In addition, this land use will take advantage of a previously permitted surface disturbance and stay within the boundaries of the existing disturbance. The project site is located is approximately one mile south of the Garfield County Regional Airport in Lot 3 of Section 19, Township 6 South, Range 92 West of the 6th Prime Meridian in Garfield County. The total project area is approximately 5.17 acres.

The proposed laydown yard will utilize an existing disturbance. The current use is a Colorado Oil and Gas Conservation Commission (COGCC) approved natural gas well pad. The proposed additional use is intended to accommodate storage of equipment and supplies on-site for convenient access related to Encana's natural gas drilling and production activities. The proposed use is compatible with surrounding properties which are similar and are host to natural gas operations.

This property is located within the Rural (R) zone district and is not within a platted subdivision. Storage Areas are an allowed use in the subject zone district provided the LIR is approved. The proposed facility meets all applicable standards for the Rural zoning district. The adjacent properties are primarily undergoing oil and gas development and have limited residential and agricultural operations. Due to the location of the facility, the proposed use will have minimal impact, if any, to the surrounding area. Project activities will generate little or no noise impacts, thus sound impacts will be easily accommodated by the Garfield County and Colorado Revised Statue noise standards.

The site is covered by Encana's Mamm Creek Unit Stormwater Management Plan (SWMP), which details the use of site-specific Best Management Practices (BMPs). Implementation of the SWMP will ensure that activities conducted at the site comply with stormwater management regulations as required by Garfield County, the State of Colorado, and the United States Environmental Protection Agency. Through this plan, disturbed soils will be reseeded to regain stability as soon as practical and BMPs will be utilized to mitigate sediment erosion and transportation. Implementation of these plans also ensures that installation and operation of this facility will not impact surface runoff, stream flow, or groundwater.

760 Horizon Drive, Suite 102
Grand Junction, CO 81506
TEL 970.263.7800
FAX 970.263.7456
www.olssonassociates.com

This site is not covered by a Spill Prevention Control and Countermeasures (SPCC) Plan. Nothing will be stored on site that requires an SPCC.

This facility will be in operation for approximately thirty (30) years, the expected lifespan of the associated gas wells in the area. When the facility is no longer needed to support operation of the wells in the area, this site will be reclaimed by removing all surface equipment and structures, grading to restore original contours, replacing any topsoil that may have been removed, and revegetating the reclaimed area with the applicable seed mix. See Reclamation Plan for further information.

Hazardous materials will not be stored at this location. The proposed use may require minor additional surface disturbance to accommodate the Grading and Drainage Plan. Encana employees and contractors will be on-site for short intervals picking up or dropping off supplies. Sanitation facilities, potable water and office space are not proposed. Portable toilets are provided throughout the area for use by field employees. The site will not be fenced.

Access to the laydown yard is via Garfield County Road (CR) 315 (Mamm Creek Road) for approximately 4 miles from I-70 exit 94 to CR 333 (Hunter Mesa Road) for approximately 2.8 miles to a private access road (see Access Road Map). The K19NE Laydown Yard location is approximately 0.5 miles east of CR 333 on this private access road. There is no historic public access through the proposed site. See Traffic Analysis for further information.

A secondary access route uses CR 346 (Rifle-Silt Rd) west for approximately 2 miles from I-70 exit 94 to CR 352 (Airport Road). Vehicles will then head east for approximately 1.3 miles to CR 333, then head south for approximately 0.8 miles to the private access road.

No significant natural or geological hazards are found at the project site. Because this is a previously disturbed location with minor additional disturbance anticipated, impacts on wildlife and native vegetation will be negligible. No smoke, vibration, heat, radiation or fumes will be produced as a result of the operation of this facility. Adjacent properties will not be affected by the operations. A public nuisance or hazard will not be created. Traffic impacts to public roads will be minimal and will not require additional improvements or permits.

Potential impacts to wildlife, natural environment, and the surrounding properties are expected to be minimal, if any. The proposed facility will be located on an existing disturbed area. The topography surrounding the facility acts as a visual and sound barrier in most directions. The facility may be partially visible from surrounding properties and public roads.

The following table summarizes the required permitting for this facility.

Table 1: Permits Required

Permit Required	Responsible Regulatory Agency	Status
Land Use Change Permit – Limited Impact Review	Garfield County	Application submitted TBD
Stormwater Permit	CDPHE	Permit COR034840 issued 7/1/2002, renewed 6/20/2007, and administratively continued 6/21/2012, included in this permit application.
Air Quality	CDPHE	Not Required
Access/Driveway Permit	Garfield County	Permit GRB05-D-38 included in this permit application.

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Article 4-203.C
Vicinity Map

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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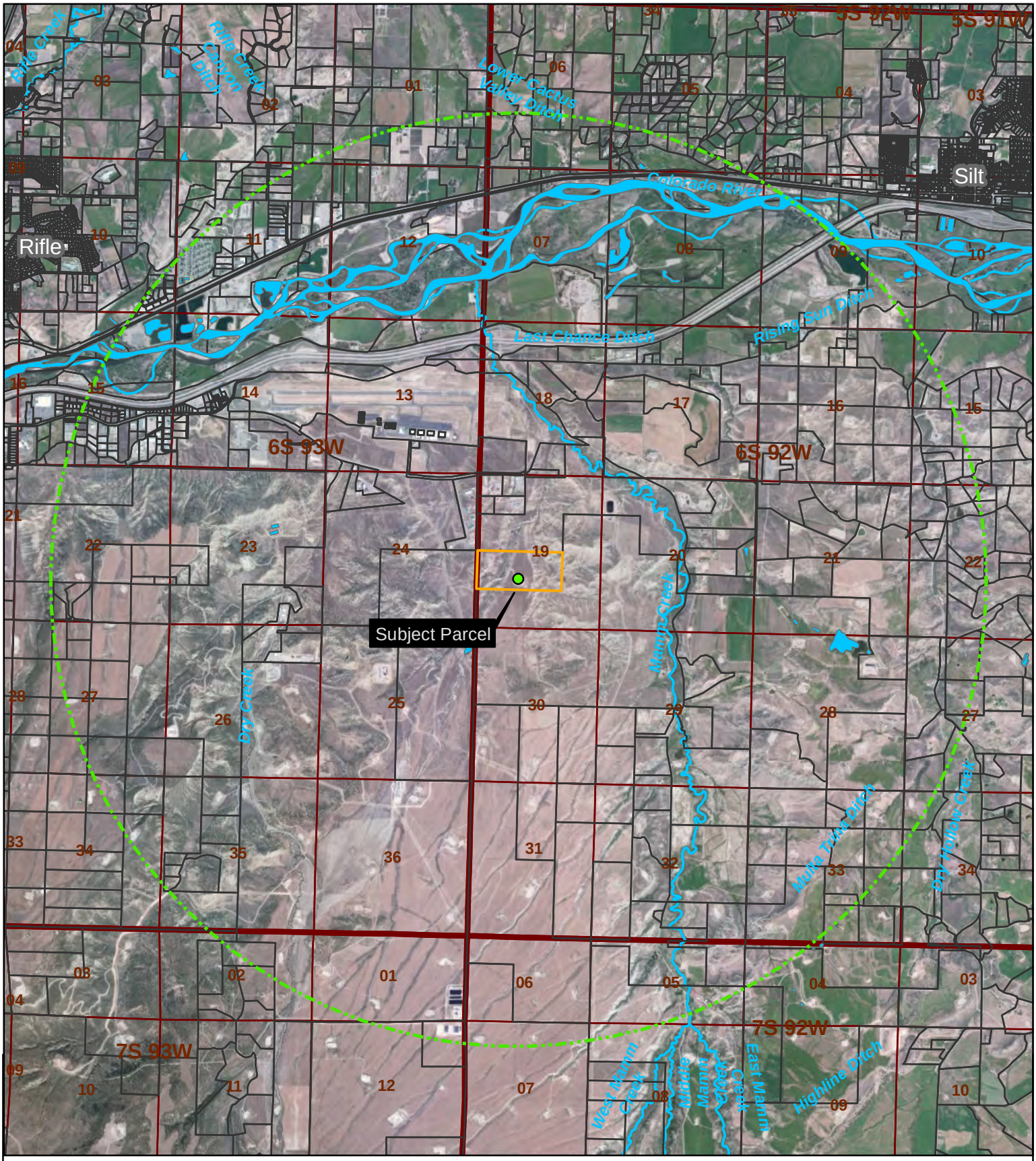

PROJECT NO: 014-2797	VICINITY MAP	OLSSON ASSOCIATES	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO			V-1
DATE: 11/25/2014				

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Article 4-203.D
Site Plan

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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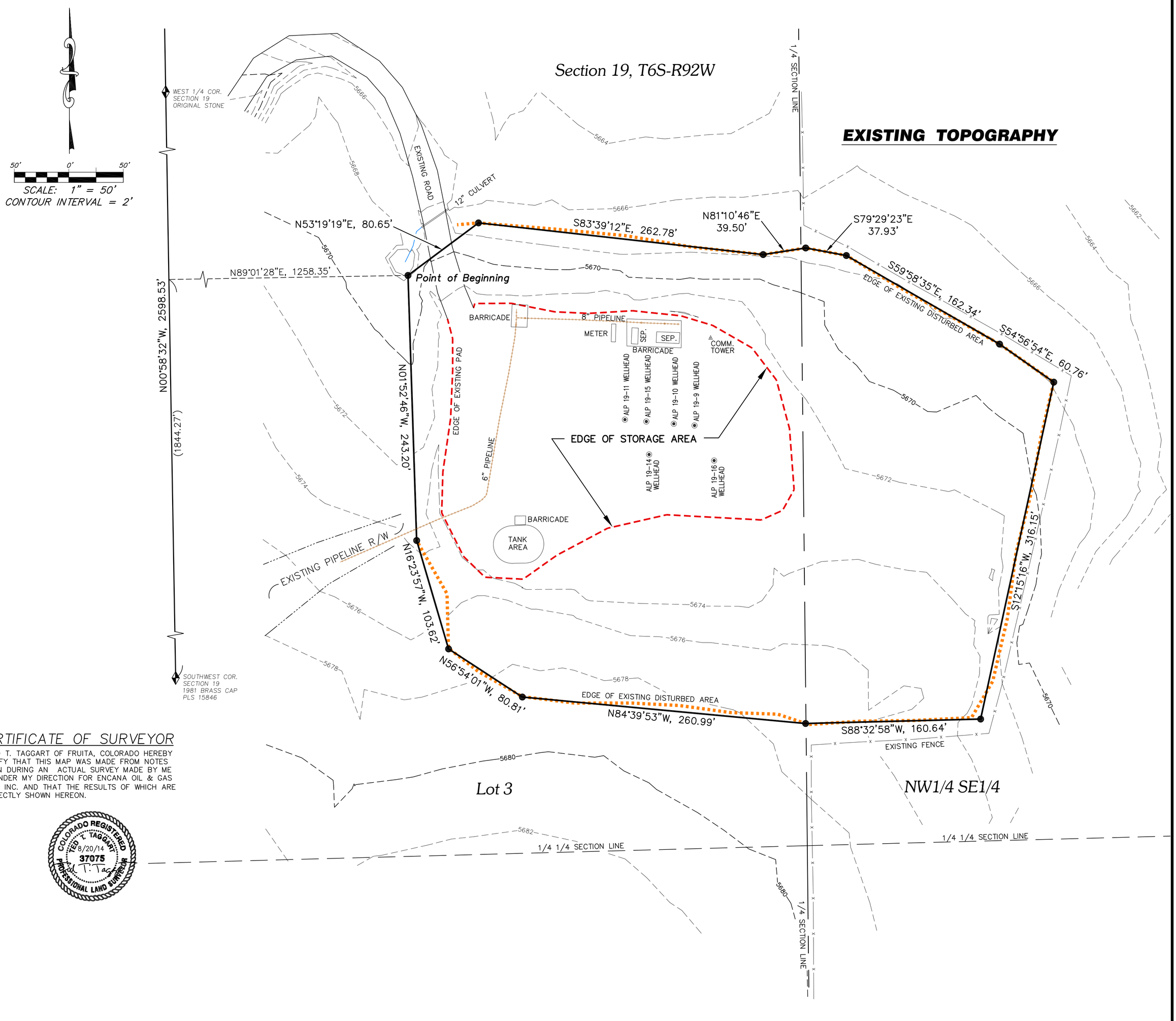
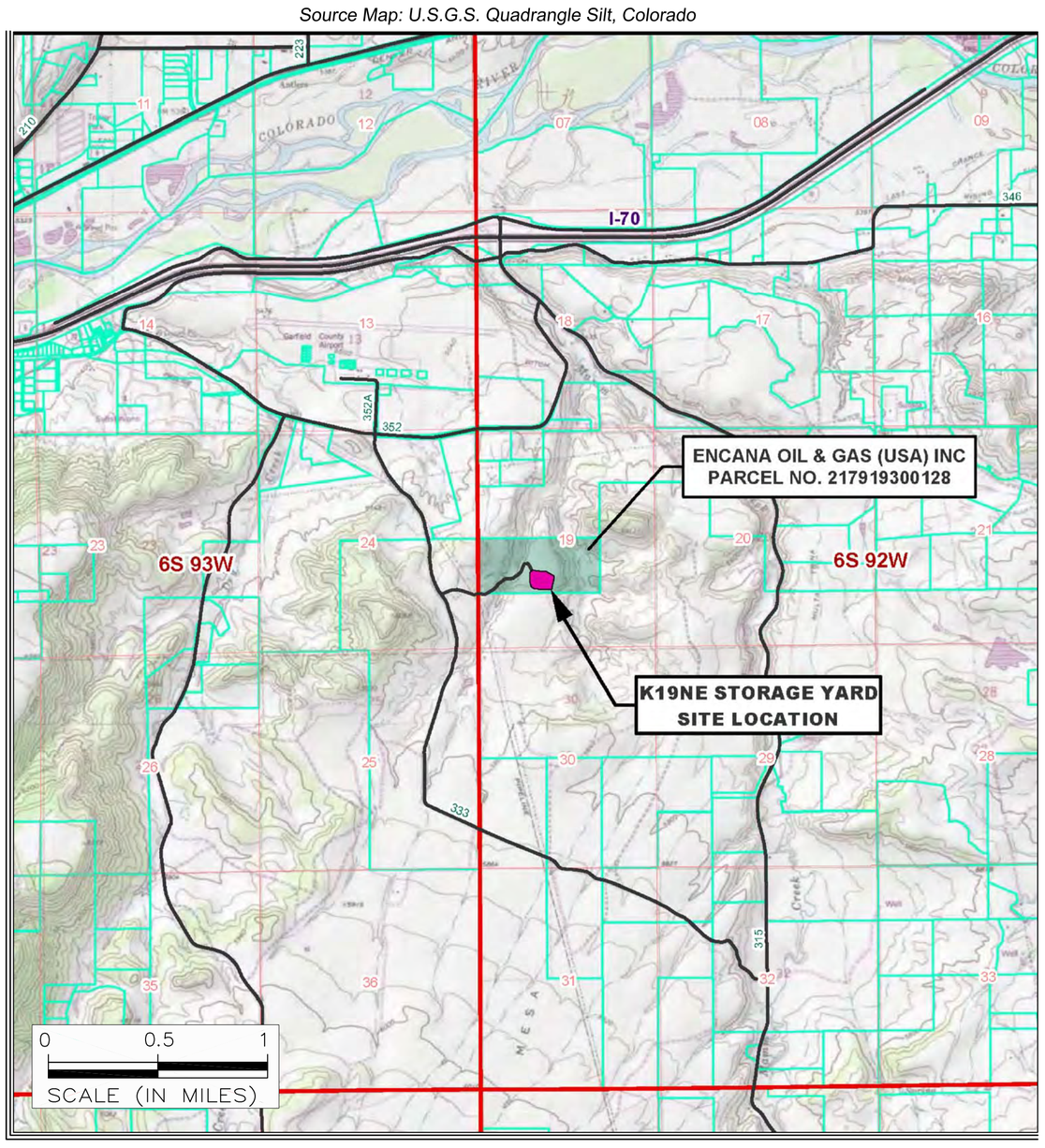


CERTIFICATE OF SURVEYOR

I, TED T. TAGGART OF FRUITA, COLORADO HEREBY CERTIFY THAT THIS MAP WAS MADE FROM NOTES TAKEN DURING AN ACTUAL SURVEY MADE BY ME OR UNDER MY DIRECTION FOR ENCANA OIL & GAS (USA) INC. AND THAT THE RESULTS OF WHICH ARE CORRECTLY SHOWN HEREON.

COLORADO REGISTERED TED T. TAGGART 8/20/14 37075 PROFESSIONAL LAND SURVEYOR

Source Map: U.S.G.S. Quadrangle Silt, Colorado



INFORMATION TABLE
TOTAL SITE AREA: 5.172 ACRES
ZONING: RURAL
FLOOD ZONE DESIGNATION: UNDETERMINED BY FEMA
TOTAL AREA OF EXISTING BUILDINGS = 0 SQ. FT. NO PROPOSED BUILDINGS
WASTE WATER SYSTEM: NONE
CULINARY WATER SUPPLY: NONE
GENERAL NOTES
THE SITE SURFACE IS GRADED NATIVE SOIL OR GRAVEL.
NO PLANNED SURFACE GRADING
NO RECORDED EASEMENTS WERE FOUND

PROJECT LOCATION DESCRIPTION

A TRACT OF LAND LOCATED IN LOT 3 AND THE NW1/4 SE1/4 OF SECTION 19, T6S, R92W, 6th P.M., GARFIELD COUNTY, COLORADO, SAID TRACT BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS:

COMMENCING AT THE SOUTHWEST CORNER OF SAID SECTION 19 AND RUNNING
THENCE N00°58'32"W, 1844.27 FEET ALONG THE WEST LINE THEREOF;
THENCE N89°01'28"E, 1258.35 FEET TO THE POINT OF BEGINNING;
THENCE N53°19'19"E, 80.65 FEET; THENCE S83°39'12"E, 262.78 FEET;
THENCE N81°10'46"E, 39.50 FEET; THENCE S79°29'23"E, 37.93 FEET;
THENCE S59°58'35"E, 162.34 FEET; THENCE S54°56'54"E, 60.76 FEET;
THENCE S12°15'16"W, 316.15 FEET; THENCE S88°32'58"W, 160.64 FEET;
THENCE N84°39'53"W, 260.99 FEET; THENCE N56°54'01"W, 80.81 FEET;
THENCE N16°23'57"W, 103.62 FEET; THENCE N01°52'46"W, 243.20 FEET
TO THE POINT OF BEGINNING.

SAID TRACT CONTAINING 5.172 ACRES, MORE OR LESS.

THE BASIS OF BEARING FOR THIS SURVEY IS N00°58'32"W, 2598.53 FEET BETWEEN FOUND MONUMENTS AT THE SOUTHWEST CORNER AND THE WEST ONE-QUARTER CORNER OF SECTION 19, T6S, R92W, 6TH P.M.

MAP LEGEND

- = PUBLIC LAND SURVEY CORNER
- = SITE BOUNDARY CORNER
- = EXISTING PIPELINE
- = EDGE OF EXISTING DISTURBANCE
- = SITE BOUNDARY LINE

REVISIONS			
0	Issued for Preliminary Review	sgt	8/20/14

REFERENCES
USGS QUADRANGLE: SILT, CO.

PREPARED FOR: Encana Oil & Gas (USA) Inc.

PREPARED BY:
Wasatch Surveying Associates
906 Main Street
Evanston, Wyoming 82930
Phone No. (307) 789-4545

TITLE: **K19NE Storage Yard Existing Site Plan**

Located in Lot 3 and the NW1/4 SE1/4 of Section 19 T6S, R92W, 6th P.M. Garfield County, Colorado

DATE: 8/20/14
SCALE: 1" = 50'
PROJECT NO.: 14-04-12
DRAWING NAME: Site Plan
SHEET NO.: 1 of 1

Article 4-203.E
Grading and Drainage Plan

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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FINAL DRAINAGE REPORT

ENCANA OIL AND GAS - K19NE STORAGE YARD
GARFIELD COUNTY, COLORADO

PREPARED FOR:
ENCANA OIL AND GAS
143 DIAMOND AVENUE
PARACHUTE, CO 81635
PH: (970) 285-2600
CONTACT: JASON ECKMAN

PREPARED BY:
OLSSON ASSOCIATES
760 HORIZON DRIVE, SUITE 102
GRAND JUNCTION, CO 81506
PH: (970) 263-7800
CONTACT: LORNE C. PRESCOTT
WYATT E. POPP, PE, LEED AP

JANUARY 16, 2015

OLSSON ASSOCIATES
PROJECT NO. 014-2797

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ENGINEER'S STATEMENT

I hereby certify that this *Final Drainage Report* for the design of Encana Oil and Gas, K19NE Storage Yard was prepared by me, or under my direct supervision, in accordance with sound engineering practices for the owners thereof. I understand that Garfield County does not and will not assume liability for drainage facilities designed by others.

Wyatt E. Popp, PE
Registered Professional Engineer
State of Colorado No. 38514

1/23/15
Date

OWNER'S STATEMENT

I, _____, hereby certify that the drainage facilities for Encana Oil and Gas, K19NE Storage Yard shall be constructed according to the design presented in this report. I understand that Garfield County does not and will not assume liability for the drainage facilities designed and/or certified by my engineer. I understand that Garfield County reviews drainage plans but cannot, on behalf of Encana Oil and Gas, K19NE Storage Yard, guarantee that final drainage design review will absolve _____ and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the Final Plat and/or Final Development Plan does not imply approval of my engineer's drainage design.

_____
Owner/Developer

_____
Authorized Signature Date

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TABLE OF CONTENTS

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I. INTRODUCTION

A. Background

This Final Drainage Report has been prepared for Encana Oil and Gas, K19NE Storage Yard (the SITE) by Olsson Associates. This report evaluates the SITE's drainage patterns, analyzes the change in stormwater quantity/quality associated with existing development, and provides design to alleviate the impacts of stormwater runoff due to the proposed use.

B. Project Location

The SITE is located in Lot 3 and the NW1/4 of the SE1/4 of Section 19, Township 6 South, Range 92 West of the Sixth Principal Meridian, County of Garfield, State of Colorado. Refer to Appendix A for the General Project Map.

The SITE is approximately 4.3 miles southeast of the City of Rifle, Colorado. The SITE is located on County Road 333 approximately 0.8 miles south of Airport Road.

C. Property Description

The SITE consists of a modification to a previously developed well pad of approximately 1.73 acres. Prior to the initial development, the SITE was covered by native vegetation, and sheet-flowed from south to north. The existing site pad is a gravel surface.

According to the NRCS Web Soil Survey, soils in the area of the SITE consist of Potts loam on 3 to 6% slopes, which is classified as hydrologic group Type C. A soil map and description of NRCS soil groups from NRCS is included within Appendix A.

D. Previous Investigations

To the best of our knowledge, no previous drainage investigations have been conducted in regards to this site

II. DRAINAGE SYSTEM DESCRIPTION

A. Existing Drainage Conditions

The SITE drains to an unnamed tributary to the northeast which eventually empties into Mamm Creek to the north. Refer to the General Location Map in Appendix A for the SITE location relative to major tributary drainage ways.

The SITE generally slopes from south to north at approximately 3%. The SITE generally drains via overland flow to an unnamed tributary mentioned above. Refer to the Drainage Plan Exhibit in Appendix B for the SITE's historic drainage conditions. The Rational Method for determining runoff has been applied resulting in site peak flow rates listed in Table 1, and calculations of each flow rate are presented in Appendix B – Hydrologic Calculations.

Table 1: Site Peak Runoff

Drainage Basin	Area (Ac)	10-YR Peak Flow (cfs)	100-YR Peak Flow (cfs)
OS-1 – Offsite Run-On	1.52	0.70	2.35
OS-2 – Offsite Run-On	2.99	0.97	3.28
A - SITE Storage Yard	1.73	0.66	1.60

B. Master Drainage Plan

To our knowledge, no master drainage studies have analyzed the SITE.

C. Offsite Tributary Area

The SITE will not be adversely affected by stormwater from adjacent land. The offsite run-on will be diverted around the site by existing grass lined drainage swales. For the purposes of this study, all adjacent land was assumed to remain undeveloped in the foreseeable future.

During construction, runoff from the SITE storage yard should be treated prior to leaving the SITE using methods described in Vol. 3 of the Urban Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual*, including use of straw bales and/or other methods to provide temporary water quality.

D. Proposed Drainage System Description

The site consists of three drainage basins, Basin A, Basin OS-1, and Basin OS-2. Refer to the Drainage Plan Exhibit in Appendix B.

Drainage Basin A comprises 1.73 acres of an existing pad and drains via sheet flow and pad perimeter swales into a detention basin located in the northwest corner of the pad. The pad as it exists does not provide enough slope to drain into the proposed detention basin. The proposed changes to the pad will not change the dimensions of the existing pad but will only modify the grades to provide positive drainage to the detention basin. The grades within the secondary containment of the existing tanks on the pad will not be modified.

Drainage Basin OS-1 consists of 1.52 acres of undeveloped area on the south side of the existing pad. This basin drains via sheet flow towards the pad and will be conveyed around the pad using an existing swale and discharged to the east of the pad towards an existing natural drainage way. The swales that are currently in place will be sufficient to intercept the offsite flow anticipated.

Drainage Basin OS-2 consists of 2.99 acres of undeveloped area on the west side of the existing pad. This basin drains via sheet flow and a natural drainage way parallel to the pad and will be conveyed around the detention basin by a swale formed by the detention basin itself. The swale will discharge to the north of the detention basin into the existing road ditch. The existing road ditch will need to be modified slightly to convey the offsite runoff to convey any emergency overflow from the detention basin released through the proposed weir.

The proposed detention basin will replace an existing basin that is undersized for the drainage requirements. The proposed detention basin will be an ellipse 57 feet long and 41 wide with 3:1 slopes and a depth of 4.5'. The proposed detention basin outlet will replace an existing culvert under the existing access road with a new culvert graded for appropriate outflow into an existing natural drainage way. The release rates from the proposed detention basin are calculated based on common engineering practices and are detailed below.

Mesa County *Storm Water Management Manual*
Table 1402 - Allowable Release Rates for Detention Ponds (cfs/acre)

CONTROL FREQUENCY	SOIL GROUP		
	A	B	C/D
10-year	0.05	0.09	0.12
100-year	0.25	0.43	0.50

For soil group C, the allowable release rate for the 10-year event in Basin A is 0.12 cfs/acre x 1.73 acres = 0.21 cfs and the allowable release rate for the 100-year event in Basin A is 0.50 cfs/acre x 1.73 acres = 0.87 cfs. These release rates are reflected in the Hydraulics Calculations in Appendix C.

Refer to Appendix B for Hydrologic Calculations and Appendix C for Hydraulic Calculations.

E. Drainage Facility Maintenance

The owner shall be responsible for maintaining all on-site drainage facilities. A minor amount of continuous maintenance will be necessary to keep vegetation established and stormwater structures working at their original designed capacity. The detention pond bottom should be scraped and regraded at least once every 1-3 years to remove sediment build-up. The detention pond and outlet structure should be examined after any significant rainfall event to ensure proper functionality.

III. DRAINAGE ANALYSIS AND DESIGN CRITERIA

A. Regulations

This report has been prepared in accordance with common engineering practices, Mesa County's *Storm Water Management Manual*, the Urban Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual,* and Garfield County Standards.

B. Development Criteria

There are no known constraints placed on the SITE due to floodplain studies, master studies or adjacent property drainage studies. Flows from upstream land will be diverted around the SITE.

C. Hydrologic Criteria

Hydrologic calculations have been prepared in accordance with common engineering practices and criteria set forth in Mesa County's *Storm Water Management Manual* and Urban

Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual*. Rainfall intensities used are sourced from the NOAA Atlas 14, Volume 8, Version 2. Refer to Appendix B for all hydrologic calculations.

D. Hydraulic Criteria

Hydraulic calculations have been prepared in accordance with criteria set forth in Mesa County's *Storm Water Management Manual,* the Urban Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual,* and Garfield County Land Use and Development Code, Article 7, Section 204. Refer to Appendix C for all hydraulic calculations.

E. Variance from Criteria

No variances from criteria set forth in the above noted regulations are requested at this time.

IV. POST-CONSTRUCTION STORMWATER MANAGEMENT

A. Stormwater Quality Control Measures

The existing grass lined drainage swale will provide a means for offsite run-on stormwater to be routed around the SITE during all post-construction storm events. The proposed detention pond will temporarily detain and slowly release the runoff from a 100-year precipitation event from the SITE storage yard area to allow sediment to settle to the bottom of the pond, therefore providing stormwater quality for the SITE.

B. Calculations

All Hydrologic Calculations can be found in Appendix B.

All Hydraulic Calculations can be found in Appendix C.

V. CONCLUSIONS

A. Compliance with Manual

This report has been prepared in accordance with common engineering practices and the criteria set forth in Mesa County's *Storm Water Management Manual* and the Urban Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual,* and Garfield County Land Use and Development Code, Article 7, Section 204.

B. Compliance with Colorado Oil and Gas Conservation Commission Criteria

<u>100-Year Run-on Diversions</u>

Along the south and west sides of the SITE, existing swales will convey the run-on flow. The swale on the south side will discharge into an existing natural drainage way. The swale on the west side will be routed around the detention basin and discharged into the existing road ditch.

25-Year Runoff Control

Runoff from the site will be captured in a detention pond at the northwest corner of the SITE which was designed to capture the 100 year runoff for the SITE.

C. Design Effectiveness

Proper implementation of the proposed measures outlined in this report will alleviate the direct impacts of stormwater runoff on adjacent, downstream lands. The quantity of stormwater released from the SITE will not exceed the current conditions.

A registered licensed engineer in the state of Colorado has been consulted for the preparation of construction plans related to the recommendations outlined within this report.

D. Areas in Flood Hazard Zone

The SITE is within FEMA Panel 0802051360B, which has not been printed. Based on the relative elevation above the nearest major river (approximately 200 feet), the flood risk has been determined to be minimal. Refer to Appendix A for the FEMA map information.

E. Variance from Manual

No variances from the criteria set forth in the references listed below are requested at this time.

VI. REFERENCES

1) *Stormwater Management Manual*, City of Grand Junction and Mesa County
2) Urban Drainage and Flood Control District *Urban Storm Drainage and Criteria Manual, Vols. 1-3*
3) Garfield County Land Use and Development Code, Article 7, Section 204
4) NRCE Web Soil Survey - http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
5) FEMA Flood Map Service Center - https://msc.fema.gov/portal

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APPENDIX A: MAPS AND EXHIBITS

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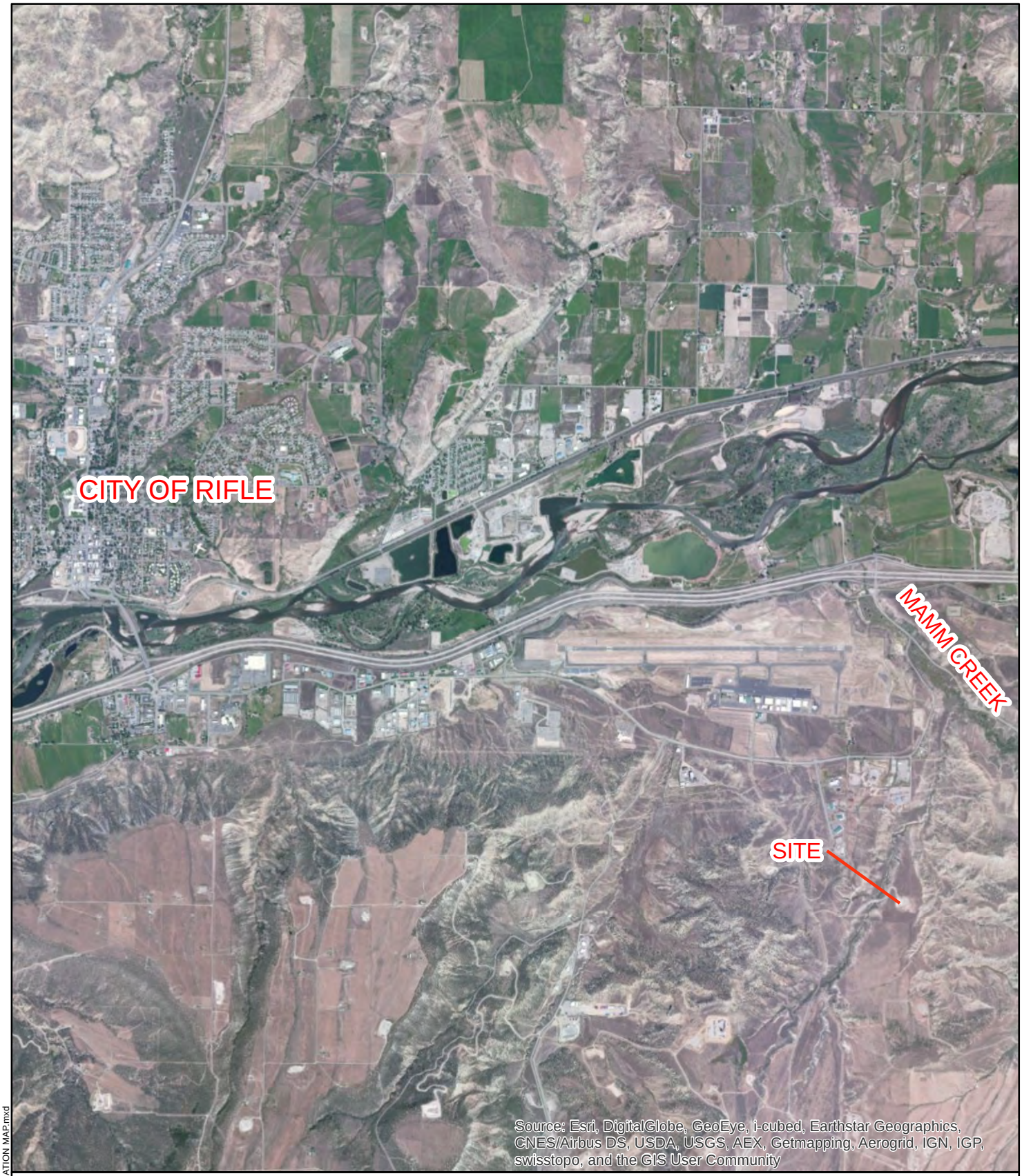

N

F:\Projects\014-2797_LDVP\Drainage Report\LOCATION MAP.mxd

Project Number: 014-2797	**General Location Map** Encana Oil and Gas K19NE Storage Facility Garfield County, CO Lot 3, Sec 19, T6S, R92W, 6th PM	OLSSON ASSOCIATES 760 Horizon Drive, Suite 102 Grand Junction, CO 81506 P: 970.263.7800 F: 970.263.7456	Figure **1**
Drawn By: ABL			
Revision Date: 1/14/2015			

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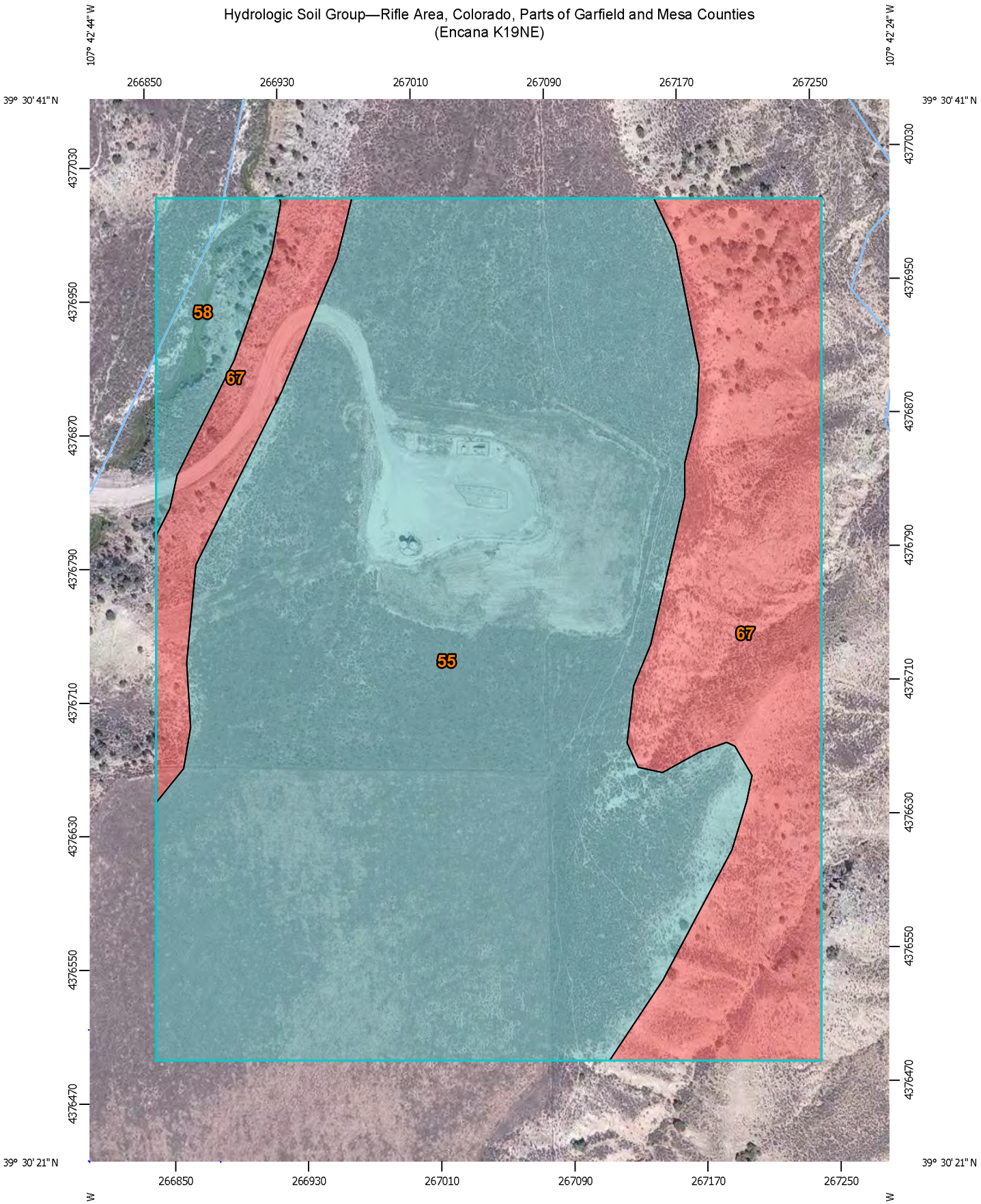
Hydrologic Soil Group—Rifle Area, Colorado, Parts of Garfield and Mesa Counties
(Encana K19NE)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Rifle Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 8, Sep 22, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 7, 2011—Sep 3, 2011

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
55	Potts loam, 3 to 6 percent slopes	C	35.5	69.3%
58	Potts-Ildefonso complex, 12 to 25 percent slopes	C	2.1	4.1%
67	Torriorthents-Rock outcrop complex, steep	D	13.6	26.6%
Totals for Area of Interest			**51.2**	**100.0%**

Description

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.

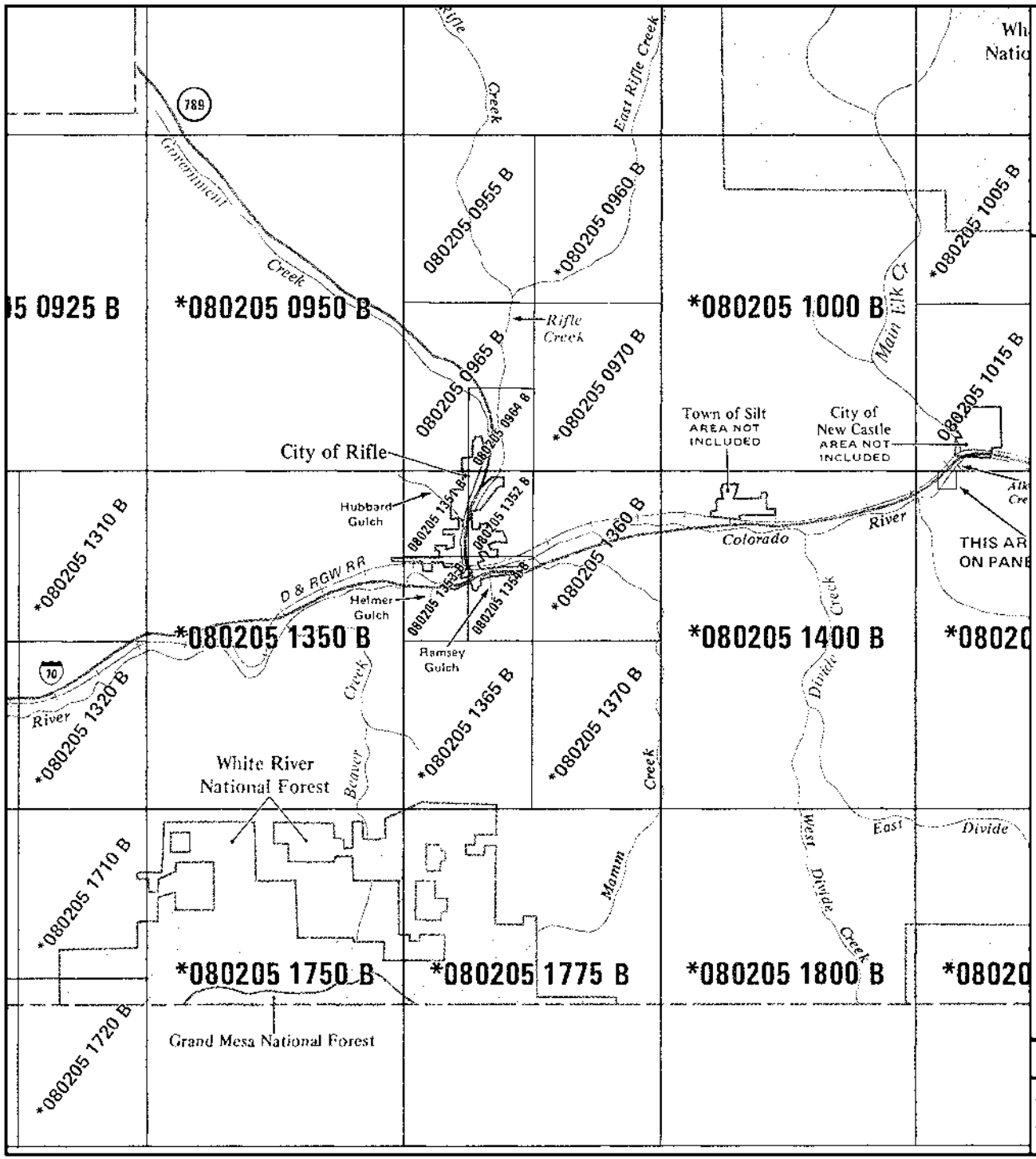
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher



*PANEL NOT PRINTED - AREA IN ZONE D

**PANEL NOT PRINTED - THIS AREA IS SHOWN ON 080205 1885 B IS SHO

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

GARFIELD COUNTY, COLORADO
(UNINCORPORATED AREAS)

MAP INDEX

PANELS PRINTED: 955, 964, 965, 1015, 1043, 1045, 1054, 1431, 1432, 1434, 1442, 1453, 1455, 1470, 1705, 1855, 1856–1859, 1870, 1880

COMMUNITY PANEL NUMBERS
080205 0001-1900

MAP REVISED:
JANUARY 3, 1986

Federal Emergency Management Agency

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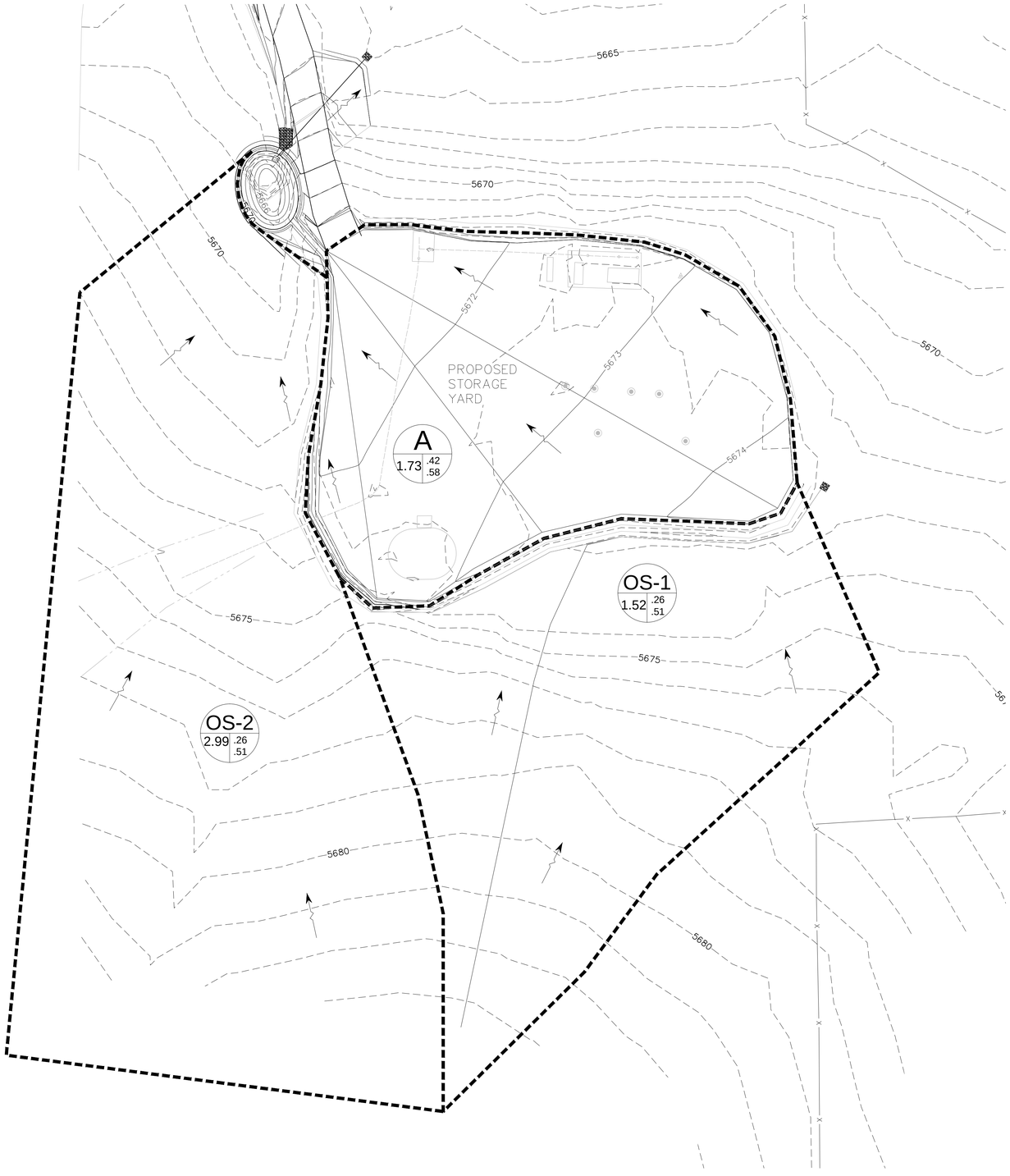

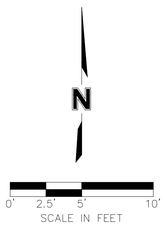

DRAINAGE BOUNDARY
5670 PROPOSED MAJOR CONTOUR
5666 PROPOSED MAJOR CONTOUR
5670 PROPOSED MAJOR CONTOUR
PROPOSED MAJOR CONTOUR
PROPOSED DRAINAGE FLOW DIRECTION

XX BASIN DESIGNATION
.XX 10-YR RUNOFF COEFF.
X.XX .XX 100-YR RUNOFF COEFF.
BASIN AREA IN AC.

DWG: F:\Projects\014-2797_LDVP\Final_Plans\014-2797 DRAINAGE.dwg USER: alheritier
DATE: Jan 15, 2015 8:09am XREFS: 014-2797 PTOPO 014-2797 XTOPO

OLSSON ASSOCIATES
5285 McWhinney Boulevard, Suite 160
Loveland, CO 80538
TEL 970.461.7733 www.olssonassociates.com

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811 Know what's below. Call before you dig.
CALL 811 SEVENTY-TWO HOURS PRIOR TO DIGGING, GRADING OR EXCAVATING FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES

REV. NO.	DATE	REVISIONS DESCRIPTION
		REVISIONS

ENCANA K19NE STORAGE YARD
LOT 3, SECTION 19, T6S, R92W, 6TH P.M.

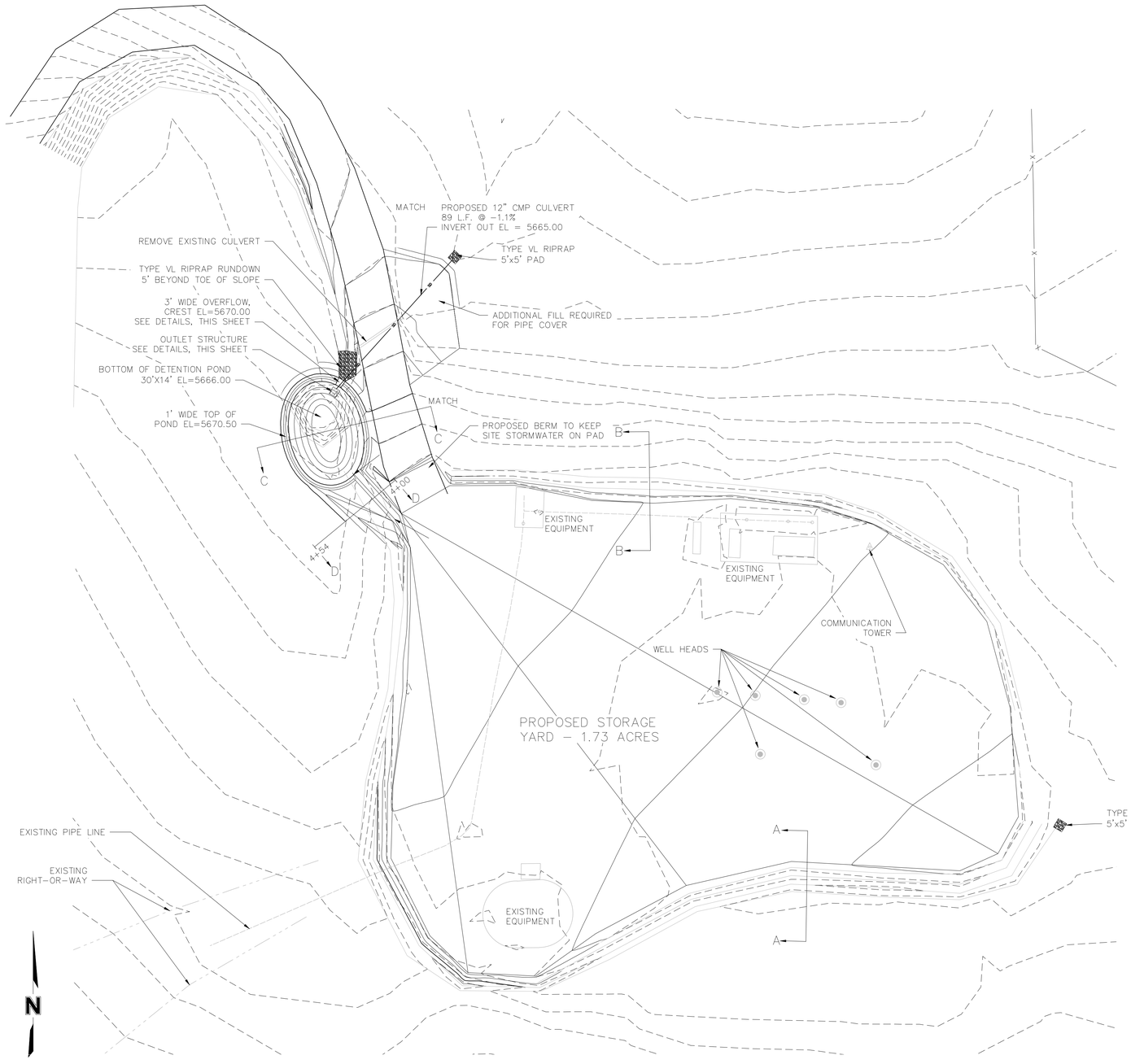
DRAINAGE PLAN SHEET
ENCANA K19NE STORAGE YARD

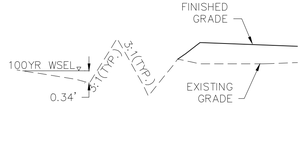
GARFIELD COUNTY, COLORADO

2015

drawn by:	ABL
checked by:	WEP
approved by:	WEP
QA/QC by:	WEP
project no.:	014-2797
drawing no.:	
date:	01-16-2015

SHEET
1





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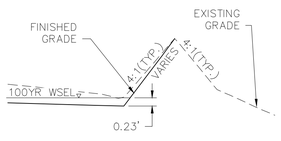

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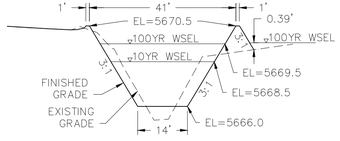

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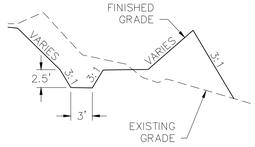

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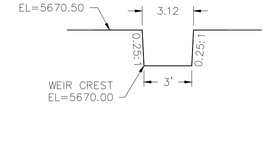


WEIR DETAIL
NOT TO SCALE

GRADING LEGEND

EXISTING		PROPOSED
	PROPERTY LINE	
5670	MAJOR CONTOURS	5670
	MINOR CONTOURS	5666
	BREAKLINE	
x	FENCE	
	SPOT ELEVATIONS	x ELEV
	WATER SURFACE ELEVATION	WSEL

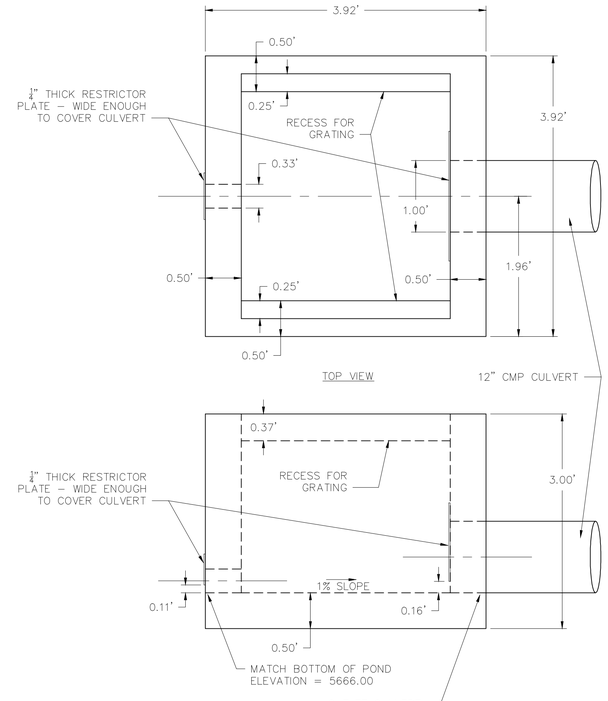
EXCAVATION QUANTITIES

SITE QUANTITIES
CUT: 935 CY
FILL: 565 CY
NET: 370 CY (CUT)

THE ABOVE ESTIMATES OF EARTHWORK QUANTITIES ARE NET QUANTITIES ONLY FOR THE PURPOSES OF PERMITTING AND ARE NOT TO BE USED FOR PAY QUANTITIES. THE EARTHWORK CONTRACTOR SHALL DETERMINE HIS OWN QUANTITIES FOR BIDDING PURPOSES.

STAGE STORAGE TABLE

ELEVATION	DEPTH	AREA	INCREMENTAL VOLUME (CUBIC FEET)	TOTAL VOLUME (CUBIC FEET)
5666	--	329	--	--
5667	1.0	566	443	443
5668	2.0	856	707	1150
5669	3.0	1206	1028	2178
5670	4.0	1612	1405	3583
5670.5	4.5	1836	861	4444



SIDE VIEW

NOTES:
1. CONCRETE STRUCTURE DESIGN ADOPTED FROM CDOT INLET TYPE C (M-604-10).
2. REFER TO CDOT INLET TYPE C FOR STEEL GRATE DETAILS - STADARD INLET GRATE.
3. REFER TO CDOT INLET TYPE C FOR REINFORCING BAR DETAILS.

OUTLET STRUCTURE DETAIL
NOT TO SCALE

OLSSON ASSOCIATES
5285 McWhinney Boulevard, Suite 160
Loveland, CO 80538
TEL 970.461.7733
www.olssonassociates.com

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ENCANA K19NE STORAGE YARD
LOT 3, SECTION 19, T6S, R92W, 6TH P.M.

ENCANA K19NE STORAGE YARD
GRADING PLAN SHEET

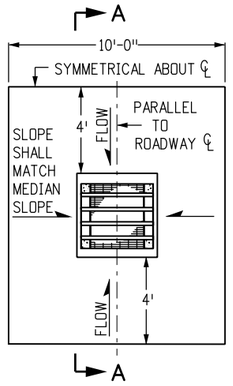
GARFIELD COUNTY, COLORADO

2015

drawn by: ABL
checked by: WEP
approved by: WEP
QA/QC by: WEP
project no.: 014-2797
drawing no.: 014-2797 GRADING.dwg
date: 01-16-2015

SHEET
2

DWG: F:\Projects\014-2797_LDVP\Final_Plans\014-2797 GRADING.dwg USER: alheritier
DATE: Jan 15, 2015 9:19am XREFS: 014-2797 PTOPO 014-2797 XTOPO

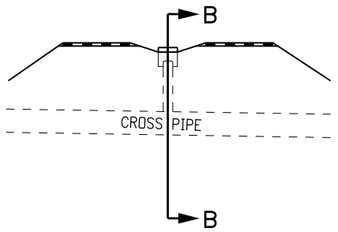


INLET WITH DITCH PAVING

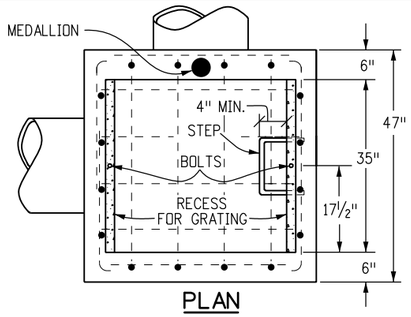
STEEL GRATE QUANTITIES

NO. PIECES	DESCRIPTION	LENGTH	LBS PER FT.	WEIGHT (LBS.)
4	S4 x 7.7 BEAM	40"	7.70	103
2	3½" x ¼" FLAT	26⅝"	2.98	13
2	3" x ¼" FLAT	26⅝"	2.55	12

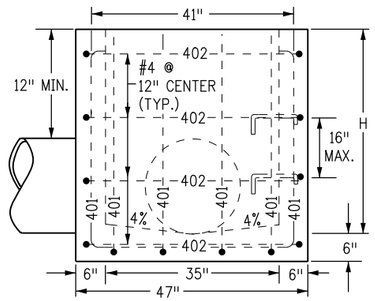
TOTAL LBS. - 128



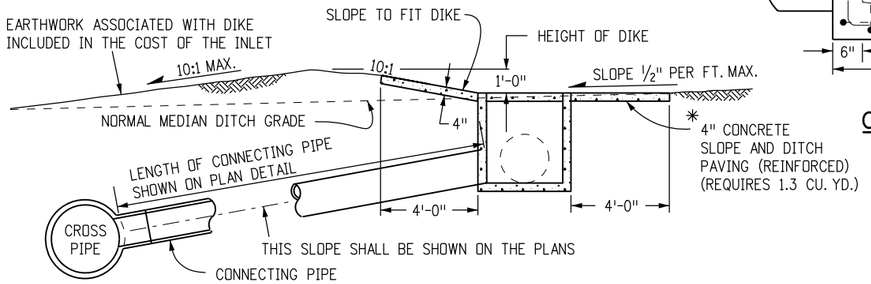
SECTION VIEW



PLAN



ELEVATION CONCRETE INLET

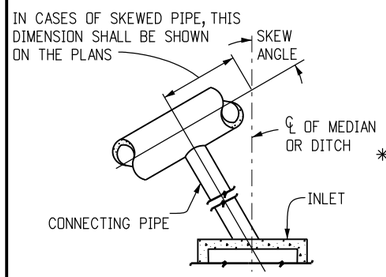


SECTION B-B

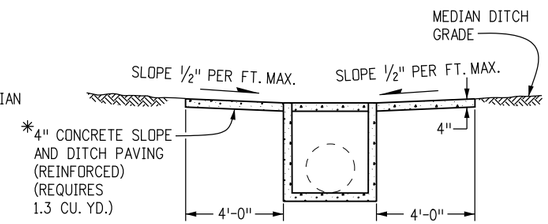
INLET CONNECTED TO A CROSS PIPE

SECTION A-A

INLET ON GRADE (FLOW FROM ONE DIRECTION)



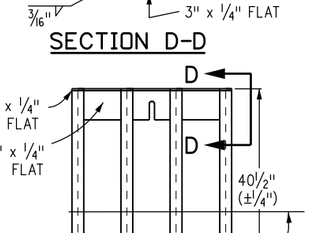
INLET CONNECTED TO A SKEWED CROSS PIPE



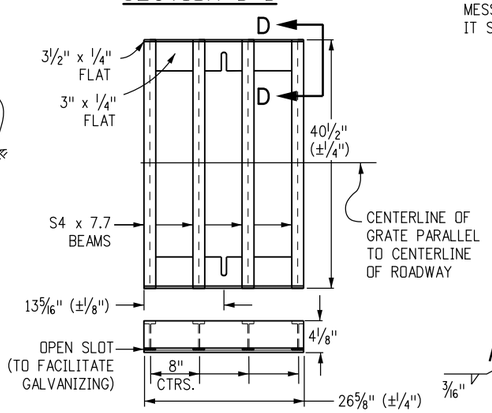
SECTION A-A

*CONCRETE SLOPE AND DITCH PAVING WILL BE REQUIRED WHEN SHOWN ON THE PLANS.

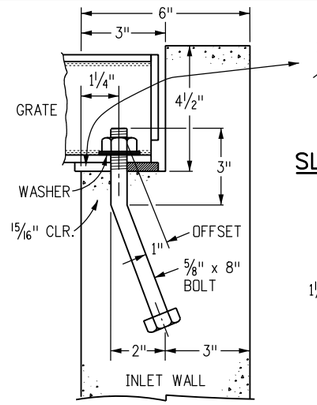
INLET AT BOTTOM OF VERTICAL CURVE (FLOW FROM TWO DIRECTIONS)



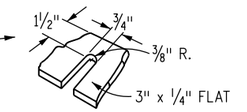
SECTION D-D



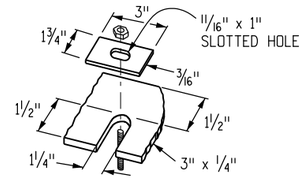
STANDARD INLET GRATE



GRATE INSTALLATION DETAIL



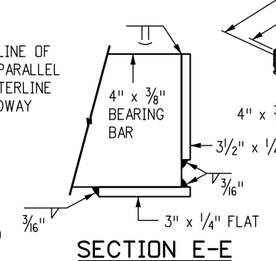
SLOT DETAIL



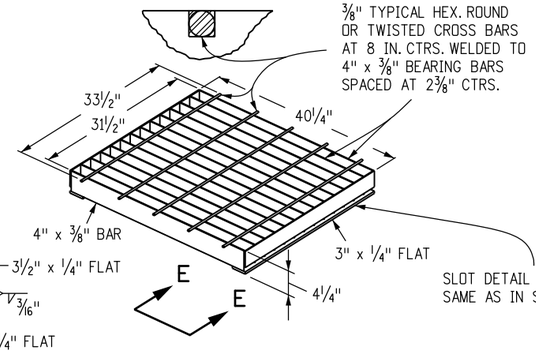
ALTERNATE SLOT AND HOLD DOWN PLATE DETAIL

GENERAL NOTES

1. INLET TYPE C IS NOT HS-20 RATED AND SHALL NOT BE PLACED IN PAVED ROADWAYS. THIS INLET SHALL BE USED ONLY OUTSIDE PAVED ROADWAYS.
2. CONCRETE SHALL BE CLASS B. INLET MAY BE CAST-IN-PLACE OR PRECAST.
3. REINFORCING BARS SHALL BE EPOXY COATED AND DEFORMED #4, AND SHALL HAVE A MINIMUM 2 IN. CLEARANCE. CUT OR BEND AROUND PIPES AS REQUIRED.
4. CONCRETE SLOPE AND DITCH PAVING SHALL BE IN ACCORDANCE WITH SECTION 507. REINFORCEMENT FOR CONCRETE SLOPE PAVING SHALL BE 6 X 6 - W1.4 X W1.4 OR 6 X 6 - W2.1 X W2.1.
5. STRUCTURAL STEEL FOR GRATES AND GRATE INSTALLATION HARDWARE SHALL BE GALVANIZED, AND SHALL BE IN ACCORDANCE WITH SUBSECTION 712.06.
6. THE STANDARD INLET GRATES SHALL BE USED ON ALL TYPE C INLETS UNLESS CLOSE MESH GRATES ARE SPECIFIED ON THE PLANS.
7. CLOSE MESH GRATES ARE RECOMMENDED WHERE FOOT TRAFFIC OR BICYCLE ROUTES ARE IN CLOSE PROXIMITY TO GRATE. THIS GRATE IS NOT ADA COMPLIANT OR BICYCLE FRIENDLY AND SHALL NOT BE PLACED DIRECTLY IN SIDEWALKS, CROSSWALKS OR BIKE PATHS.
8. STEPS SHALL BE PROVIDED WHEN INLET DIMENSION "H" IS EQUAL TO OR GREATER THAN 3 FT. - 6 IN., AND SHALL CONFORM TO AASHTO M 199.
9. SEE STANDARD PLAN M-604-11, FOR REINFORCEMENT AROUND THE PIPE OPENING.
10. ALL INLETS SHALL HAVE A 4 IN. DIA. METAL MEDALLION WITH A "NO DUMPING DRAINS TO STREAM" MESSAGE ON IT. THE MEDALLION SHALL HAVE A FISH SYMBOL WITH A BLUE BACKGROUND. IT SHALL BE FIRMLY ATTACHED TO THE TOP OF THE INLET WITH A PERMANENT FASTENER.



SECTION E-E



CLOSE MESH GRATE

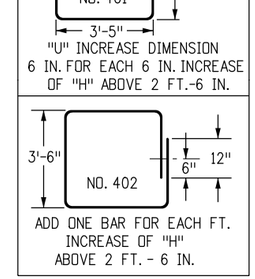
QUANTITIES FOR ONE INLET

H	CONCRETE (CU. YDS.) ▼	STEEL (LBS.) ▼	NO. STEPS REQ'D.
2'-6"	0.9	75	0
3'-0"	1.0	80	0
3'-6"	1.2	96	0
4'-0"	1.3	101	1
4'-6"	1.4	116	2
5'-0"	1.5	122	2
5'-6"	1.7	137	2
6'-0"	1.8	142	3
6'-6"	1.9	158	3
7'-0"	2.0	163	3
7'-6"	2.2	179	4
8'-0"	2.3	184	4
8'-6"	2.4	199	4
9'-0"	2.5	205	5
9'-6"	2.7	220	5
10'-0"	3.0	235	6
11'-6"	3.4	251	6

▼ PIPE INSIDE DIAMETER SHALL BE 30 IN. OR LESS. CONCRETE AND STEEL QUANTITIES ARE FOR ONE ENTIRE INLET BEFORE DEDUCTION FOR VOLUME OCCUPIED BY PIPE. WEIGHT OF STEEL INCLUDES A RING FOR THE MAXIMUM PIPE DIAMETER.

BAR LIST FOR H = 2 FT.-6 IN. AND BENDING DIAGRAM

MARK	NO. REQ'D.	HEIGHT	LENGTH
401	2	2'-3"	7'-11"
401	6	2'-7"	8'-7"
402	3	"U"	15'-0"



402 BARS SHALL BE EQUALLY SPACED FROM EACH OTHER.

Computer File Information		Sheet Revisions	
Creation Date: 07/04/12 Initials: DD		Date:	Comments
Last Modification Date: 07/04/12 Initials: LTA	R-X		
Full Path: www.coloradodot.info/business/designsupport	R-X		
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CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English	R-X		

Colorado Department of Transportation
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Project Development Branch DD/LTA

INLET, TYPE C

Issued By: Project Development Branch July 4, 2012

STANDARD PLAN NO.
M-604-10
Sheet No. 1 of 1

APPENDIX B: HYDROLOGIC CALCULATIONS

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NOAA Atlas 14, Volume 8, Version 2
Location name: Rifle, Colorado, US*
Latitude: 39.5104°, Longitude: -107.7098°
Elevation: 5669 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	1.38 (1.08–1.74)	1.74 (1.36–2.20)	2.38 (1.85–3.02)	2.96 (2.29–3.79)	3.86 (2.92–5.24)	4.61 (3.38–6.35)	5.42 (3.84–7.68)	6.30 (4.28–9.20)	7.55 (4.92–11.4)	8.56 (5.41–13.0)
10-min	1.01 (0.786–1.28)	1.27 (0.990–1.61)	1.74 (1.36–2.21)	2.17 (1.68–2.78)	2.83 (2.14–3.84)	3.38 (2.48–4.64)	3.97 (2.81–5.62)	4.61 (3.13–6.74)	5.52 (3.61–8.33)	6.26 (3.97–9.55)
15-min	0.820 (0.640–1.04)	1.03 (0.804–1.31)	1.42 (1.10–1.80)	1.76 (1.36–2.26)	2.30 (1.74–3.12)	2.74 (2.02–3.78)	3.22 (2.29–4.57)	3.75 (2.55–5.48)	4.49 (2.93–6.78)	5.09 (3.22–7.76)
30-min	0.530 (0.414–0.672)	0.682 (0.532–0.864)	0.944 (0.734–1.20)	1.18 (0.912–1.51)	1.53 (1.15–2.07)	1.82 (1.33–2.49)	2.12 (1.50–3.00)	2.45 (1.66–3.58)	2.91 (1.90–4.39)	3.28 (2.08–5.00)
60-min	0.345 (0.270–0.437)	0.429 (0.335–0.544)	0.576 (0.448–0.733)	0.707 (0.546–0.904)	0.900 (0.677–1.21)	1.06 (0.775–1.45)	1.23 (0.867–1.73)	1.41 (0.953–2.05)	1.66 (1.08–2.49)	1.86 (1.18–2.83)
2-hr	0.212 (0.168–0.267)	0.259 (0.204–0.326)	0.340 (0.266–0.429)	0.412 (0.321–0.522)	0.518 (0.392–0.690)	0.604 (0.446–0.816)	0.695 (0.496–0.967)	0.792 (0.542–1.14)	0.928 (0.610–1.37)	1.04 (0.662–1.55)
3-hr	0.164 (0.130–0.205)	0.194 (0.153–0.242)	0.245 (0.193–0.308)	0.291 (0.228–0.368)	0.360 (0.275–0.477)	0.417 (0.310–0.559)	0.477 (0.342–0.658)	0.541 (0.373–0.771)	0.631 (0.418–0.928)	0.704 (0.453–1.05)
6-hr	0.102 (0.081–0.126)	0.118 (0.094–0.146)	0.146 (0.116–0.181)	0.170 (0.134–0.212)	0.204 (0.157–0.266)	0.232 (0.174–0.307)	0.262 (0.189–0.355)	0.292 (0.203–0.409)	0.335 (0.224–0.483)	0.369 (0.240–0.539)
12-hr	0.061 (0.049–0.075)	0.071 (0.057–0.087)	0.087 (0.070–0.107)	0.101 (0.080–0.125)	0.120 (0.093–0.155)	0.136 (0.103–0.177)	0.152 (0.111–0.204)	0.169 (0.118–0.233)	0.192 (0.130–0.273)	0.210 (0.138–0.302)
24-hr	0.037 (0.030–0.045)	0.042 (0.034–0.051)	0.051 (0.042–0.063)	0.059 (0.048–0.073)	0.071 (0.055–0.090)	0.080 (0.061–0.103)	0.089 (0.066–0.118)	0.099 (0.070–0.135)	0.113 (0.077–0.158)	0.123 (0.082–0.175)
2-day	0.021 (0.017–0.026)	0.024 (0.020–0.029)	0.030 (0.024–0.036)	0.034 (0.028–0.041)	0.041 (0.032–0.051)	0.046 (0.035–0.058)	0.051 (0.038–0.067)	0.057 (0.041–0.076)	0.064 (0.044–0.089)	0.070 (0.047–0.098)
3-day	0.015 (0.012–0.018)	0.018 (0.014–0.021)	0.022 (0.018–0.026)	0.025 (0.020–0.030)	0.030 (0.024–0.037)	0.034 (0.026–0.043)	0.038 (0.028–0.049)	0.042 (0.030–0.055)	0.047 (0.032–0.064)	0.051 (0.035–0.070)
4-day	0.012 (0.010–0.014)	0.014 (0.012–0.017)	0.017 (0.014–0.021)	0.020 (0.016–0.024)	0.024 (0.019–0.030)	0.027 (0.021–0.034)	0.030 (0.022–0.038)	0.033 (0.024–0.043)	0.037 (0.026–0.050)	0.040 (0.027–0.055)
7-day	0.008 (0.007–0.010)	0.009 (0.008–0.011)	0.011 (0.009–0.013)	0.013 (0.011–0.015)	0.015 (0.012–0.019)	0.017 (0.013–0.021)	0.019 (0.014–0.024)	0.020 (0.015–0.027)	0.023 (0.016–0.030)	0.025 (0.017–0.033)
10-day	0.006 (0.005–0.008)	0.007 (0.006–0.009)	0.009 (0.007–0.010)	0.010 (0.008–0.012)	0.011 (0.009–0.014)	0.013 (0.010–0.016)	0.014 (0.010–0.017)	0.015 (0.011–0.019)	0.017 (0.012–0.022)	0.018 (0.012–0.024)
20-day	0.004 (0.004–0.005)	0.005 (0.004–0.005)	0.005 (0.005–0.006)	0.006 (0.005–0.007)	0.007 (0.006–0.008)	0.008 (0.006–0.009)	0.008 (0.006–0.010)	0.009 (0.007–0.011)	0.010 (0.007–0.013)	0.011 (0.007–0.014)
30-day	0.003 (0.003–0.004)	0.004 (0.003–0.004)	0.004 (0.004–0.005)	0.005 (0.004–0.006)	0.005 (0.004–0.007)	0.006 (0.005–0.007)	0.006 (0.005–0.008)	0.007 (0.005–0.009)	0.008 (0.005–0.010)	0.008 (0.006–0.010)
45-day	0.003 (0.002–0.003)	0.003 (0.003–0.003)	0.003 (0.003–0.004)	0.004 (0.003–0.005)	0.004 (0.004–0.005)	0.005 (0.004–0.006)	0.005 (0.004–0.006)	0.006 (0.004–0.007)	0.006 (0.004–0.008)	0.006 (0.004–0.008)
60-day	0.002 (0.002–0.003)	0.003 (0.002–0.003)	0.003 (0.003–0.004)	0.003 (0.003–0.004)	0.004 (0.003–0.005)	0.004 (0.003–0.005)	0.004 (0.003–0.005)	0.005 (0.004–0.006)	0.005 (0.004–0.007)	0.005 (0.004–0.007)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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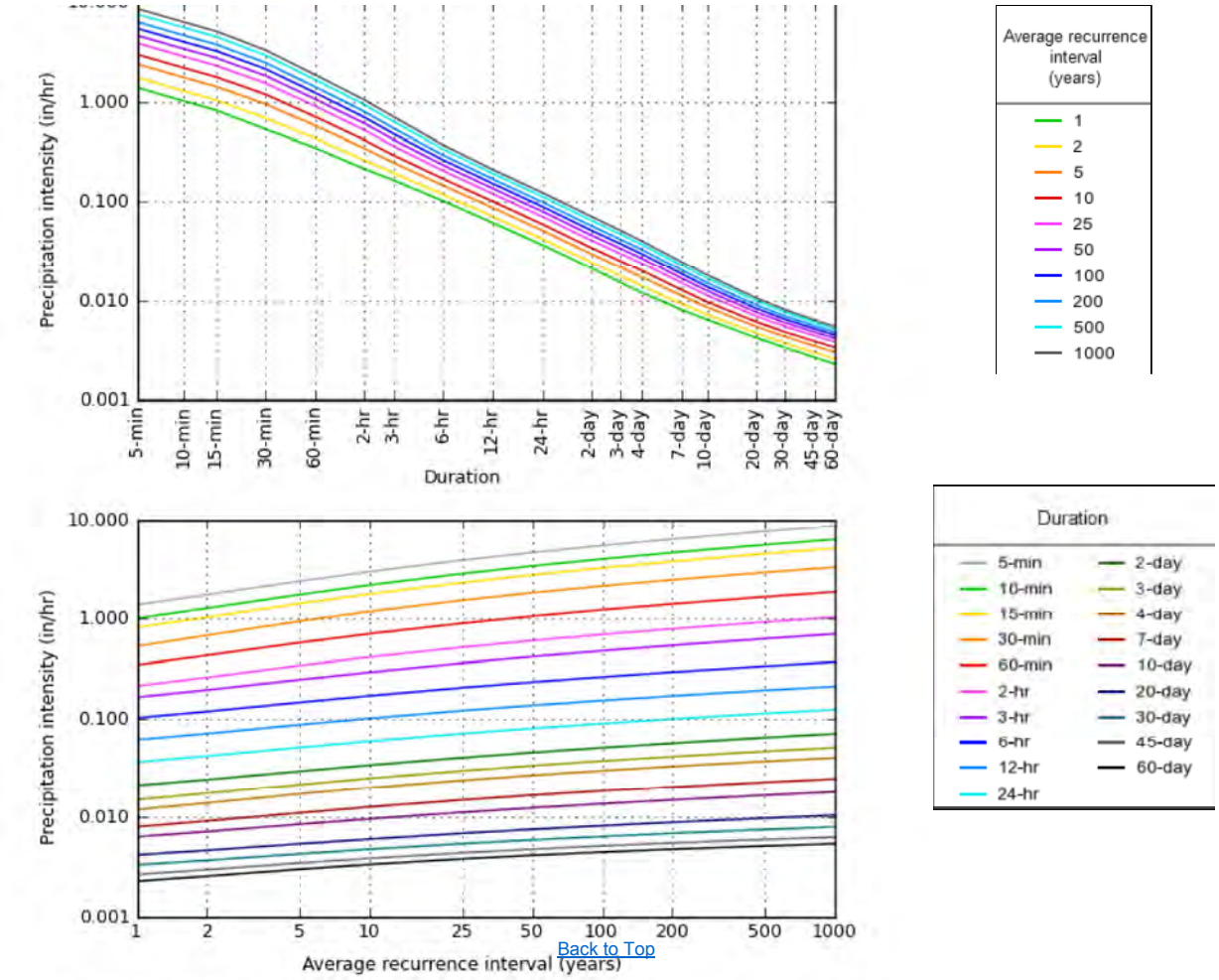
PF graphical



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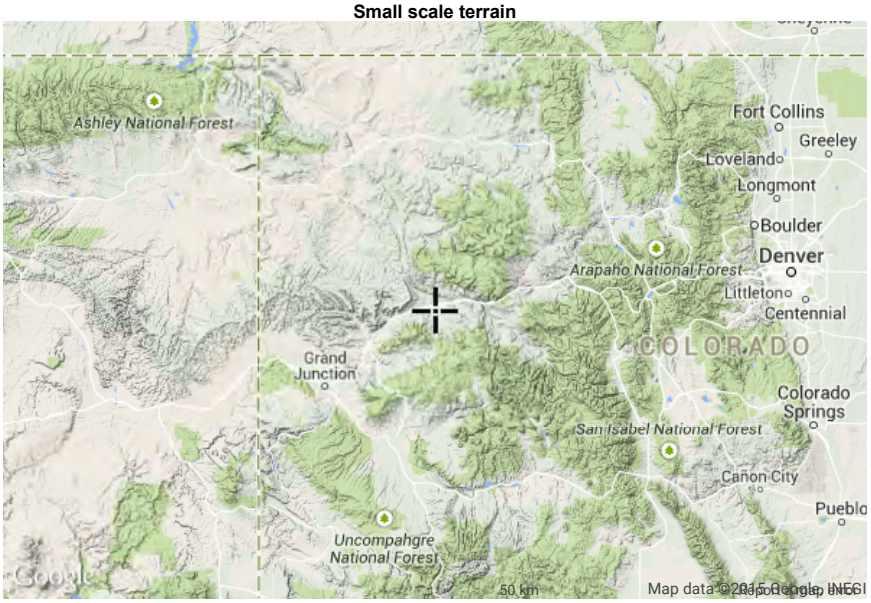
Maps & aerials

NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Thu Jan 15 16:33:38 2015

Small scale terrain



Large scale terrain

Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

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CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Encana K19NE Storage Yard
Catchment ID: A

I. Catchment Hydrologic Data

Catchment ID = A
Area = 1.73 Acres
Percent Imperviousness = 40.00 %
NRCS Soil Type = C A, B, C, or D

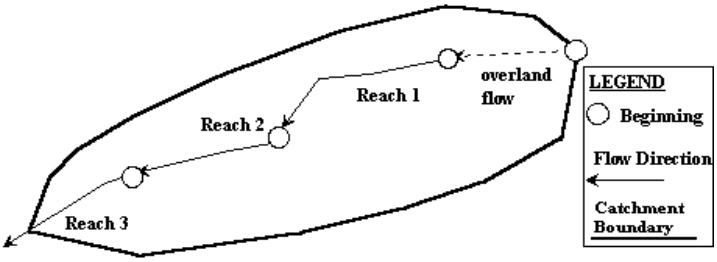
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 10 years (input return period for design storm)
C1 = 28.90 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 0.71 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.42
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.35
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0020	300	0.35	N/A	0.13	39.96
1	0.0020	57		10.00	0.45	2.12
2						
3						
4						
5						
	Sum	357			Computed Tc =	42.08
					Regional Tc =	11.98
					User-Entered Tc =	42.08

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 0.92 inch/hr — Peak Flowrate, Qp = 0.66 cfs
Rainfall Intensity at Regional Tc, I = 1.81 inch/hr — Peak Flowrate, Qp = 1.30 cfs
Rainfall Intensity at User-Defined Tc, I = 0.92 inch/hr — Peak Flowrate, Qp = 0.66 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Encana K19NE Storage Yard
Catchment ID: A

I. Catchment Hydrologic Data

Catchment ID = A
Area = 1.73 Acres
Percent Imperviousness = 40.00 %
NRCS Soil Type = C A, B, C, or D

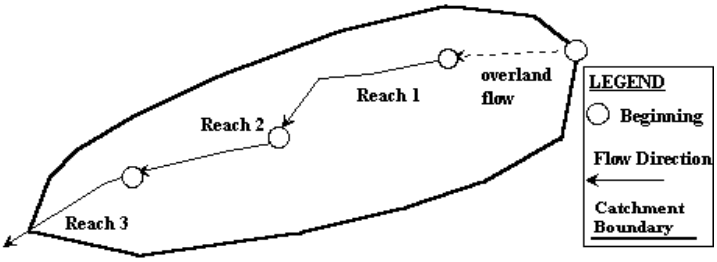
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.90 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 1.23 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.58
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.35
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0020	300	0.35	N/A	0.13	39.96
1	0.0020	57		10.00	0.45	2.12
2						
3						
4						
5						
	Sum	357				

Computed Tc = 42.08
Regional Tc = 11.98
User-Entered Tc = 42.08

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 1.59 inch/hr — Peak Flowrate, Qp = 1.60 cfs
Rainfall Intensity at Regional Tc, I = 3.13 inch/hr — Peak Flowrate, Qp = 3.16 cfs
Rainfall Intensity at User-Defined Tc, I = 1.59 inch/hr — Peak Flowrate, Qp = 1.60 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Encana K19NE Storage Yard
Catchment ID: OS-1

I. Catchment Hydrologic Data

Catchment ID = OS-1
Area = 1.52 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = C A, B, C, or D

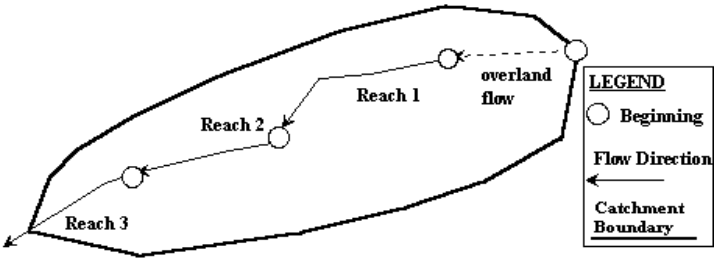
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 10 years (input return period for design storm)
C1 = 28.90 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 0.71 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.26
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.16
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0270	300	0.16	N/A	0.24	21.11
1	0.0780	40		10.00	2.79	0.24
2	0.0150	60		10.00	1.22	0.82
3	0.0030	100		10.00	0.55	3.04
4						
5						
	Sum	500				

Computed Tc = 25.21
Regional Tc = 12.78
User-Entered Tc = 12.78

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 1.25 inch/hr — Peak Flowrate, Qp = 0.50 cfs
Rainfall Intensity at Regional Tc, I = 1.76 inch/hr — Peak Flowrate, Qp = 0.70 cfs
Rainfall Intensity at User-Defined Tc, I = 1.76 inch/hr — Peak Flowrate, Qp = 0.70 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Encana K19NE Storage Yard
Catchment ID: OS-1

I. Catchment Hydrologic Data

Catchment ID = OS-1
Area = 1.52 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = C A, B, C, or D

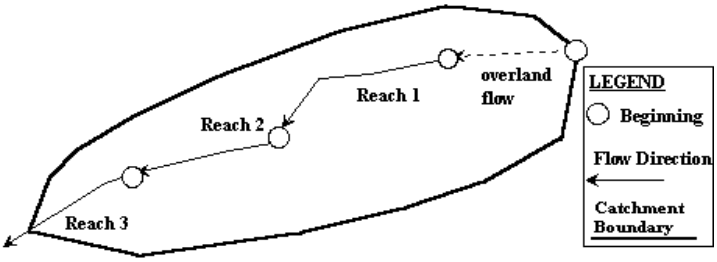
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.90 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 1.23 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.51
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.16
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0270	300	0.16	N/A	0.24	21.11
1	0.0780	40		10.00	2.79	0.24
2	0.0150	60		10.00	1.22	0.82
3	0.0030	100		10.00	0.55	3.04
4						
5						
	Sum	500		Computed Tc =		25.21
				Regional Tc =		12.78
				User-Entered Tc =		12.78

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 2.16 inch/hr — Peak Flowrate, Qp = 1.67 cfs
Rainfall Intensity at Regional Tc, I = 3.05 inch/hr — Peak Flowrate, Qp = 2.35 cfs
Rainfall Intensity at User-Defined Tc, I = 3.05 inch/hr — Peak Flowrate, Qp = 2.35 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Encana K19NE Storage Yard
Catchment ID: OS-2

I. Catchment Hydrologic Data

Catchment ID = OS-2
Area = 2.99 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = C A, B, C, or D

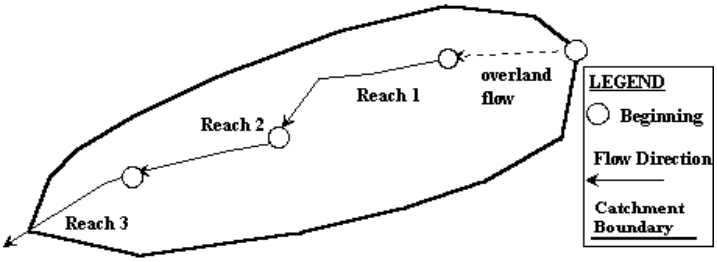
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 10 years (input return period for design storm)
C1 = 28.90 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 0.71 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.26
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.16
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0240	300	0.16	N/A	0.23	21.95
1	0.0270	330		10.00	1.64	3.35
2						
3						
4						
5						
	Sum	630				

Computed Tc = 25.29
Regional Tc = 13.50
User-Entered Tc = 25.29

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 1.25 inch/hr — Peak Flowrate, Qp = 0.97 cfs
Rainfall Intensity at Regional Tc, I = 1.72 inch/hr — Peak Flowrate, Qp = 1.34 cfs
Rainfall Intensity at User-Defined Tc, I = 1.25 inch/hr — Peak Flowrate, Qp = 0.97 cfs

CALCULATION OF A PEAK RUNOFF USING RATIONAL METHOD

Project Title: Encana K19NE Storage Yard
Catchment ID: OS-2

I. Catchment Hydrologic Data

Catchment ID = OS-2
Area = 2.99 Acres
Percent Imperviousness = 2.00 %
NRCS Soil Type = C A, B, C, or D

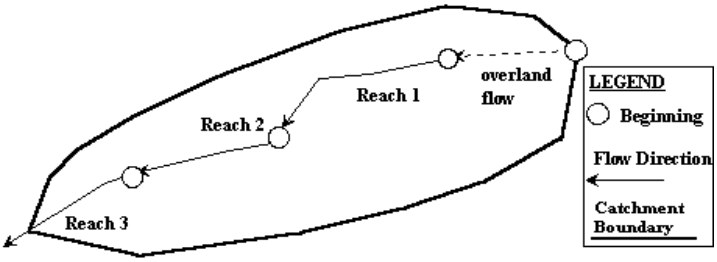
II. Rainfall Information I (inch/hr) = C1 * P1 /(C2 + Td)^C3

Design Storm Return Period, Tr = 100 years (input return period for design storm)
C1 = 28.90 (input the value of C1)
C2= 10.00 (input the value of C2)
C3= 0.786 (input the value of C3)
P1= 1.23 inches (input one-hr precipitation--see Sheet "Design Info")

III. Analysis of Flow Time (Time of Concentration) for a Catchment

Runoff Coefficient, C = 0.51
Overide Runoff Coefficient, C = (enter an overide C value if desired, or leave blank to accept calculated C.)
5-yr. Runoff Coefficient, C-5 = 0.16
Overide 5-yr. Runoff Coefficient, C = (enter an overide C-5 value if desired, or leave blank to accept calculated C-5.)

Illustration



NRCS Land Type	Heavy Meadow	Tillage/ Field	Short Pasture/ Lawns	Nearly Bare Ground	Grassed Swales/ Waterways	Paved Areas & Shallow Paved Swales (Sheet Flow)
Conveyance	2.5	5	7	10	15	20

Calculations:

Reach ID	Slope S ft/ft input	Length L ft input	5-yr Runoff Coeff C-5 output	NRCS Convey-ance input	Flow Velocity V fps output	Flow Time Tf minutes output
Overland	0.0240	300	0.16	N/A	0.23	21.95
1	0.0270	330		10.00	1.64	3.35
2						
3						
4						
5						
	Sum	630			Computed Tc =	25.29
					Regional Tc =	13.50
					User-Entered Tc =	25.29

IV. Peak Runoff Prediction

Rainfall Intensity at Computed Tc, I = 2.16 inch/hr — Peak Flowrate, Qp = 3.28 cfs
Rainfall Intensity at Regional Tc, I = 2.97 inch/hr — Peak Flowrate, Qp = 4.51 cfs
Rainfall Intensity at User-Defined Tc, I = 2.16 inch/hr — Peak Flowrate, Qp = 3.28 cfs

APPENDIX C: HYDRAULIC CALCULATIONS

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DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: Encana K19NE

Basin ID: A

(For catchments less than 160 acres only. For larger catchments, use hydrograph routing method)
(NOTE: for catchments larger than 90 acres, CUHP hydrograph and routing are recommended)

Determination of MINOR Detention Volume Using Modified FAA Method

Design Information (Input):

Catchment Drainage Imperviousness	I_a =	40.00	percent
Catchment Drainage Area	A =	1.730	acres
Predevelopment NRCS Soil Group	Type =	C	A, B, C, or D
Return Period for Detention Control	T =	10	years (2, 5, 10, 25, 50, or 100)
Time of Concentration of Watershed	Tc =	12	minutes
Allowable Unit Release Rate	q =	0.12	cfs/acre
One-hour Precipitation	P_1 =	0.71	inches
Design Rainfall IDF Formula $i = C_1 * P_1/(C_2+T_c)^{C_3}$			
Coefficient One	C_1 =	28.50	
Coefficient Two	C_2 =	10	
Coefficient Three	C_3 =	0.789	

Determination of Average Outflow from the Basin (Calculated):

Runoff Coefficient	C =	0.42	
Inflow Peak Runoff	Qp-in =	1.28	cfs
Allowable Peak Outflow Rate	Qp-out =	**0.21**	cfs
Mod. FAA Minor Storage Volume =		1,465	**cubic feet**
Mod. FAA Minor Storage Volume =		**0.034**	**acre-ft**

5 <- Enter Rainfall Duration Incremental Increase Value Here (e.g. 5 for 5-Minutes)

Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)
0	0.00	0.000	0.00	0.00	0.000	0.000
5	2.39	0.012	1.00	0.21	0.001	0.011
10	1.90	0.019	1.00	0.21	0.003	0.016
15	1.60	0.024	0.90	0.19	0.004	0.020
20	1.38	0.028	0.80	0.17	0.005	0.023
25	1.22	0.031	0.74	0.15	0.005	0.025
30	1.10	0.033	0.70	0.15	0.006	0.027
35	1.00	0.035	0.67	0.14	0.007	0.028
40	0.92	0.037	0.65	0.13	0.007	0.030
45	0.86	0.039	0.63	0.13	0.008	0.030
50	0.80	0.040	0.62	0.13	0.009	0.031
55	0.75	0.041	0.61	0.13	0.010	0.032
60	0.71	0.043	0.60	0.12	0.010	0.032
65	0.67	0.044	0.59	0.12	0.011	0.033
70	0.64	0.045	0.59	0.12	0.012	0.033
75	0.61	0.046	0.58	0.12	0.012	0.033
80	0.58	0.047	0.58	0.12	0.013	0.033
85	0.56	0.047	0.57	0.12	0.014	0.033
90	0.53	0.048	0.57	0.12	0.015	0.034
95	0.51	0.049	0.56	0.12	0.015	0.034
100	0.50	0.050	0.56	0.12	0.016	0.034
105	0.48	0.050	0.56	0.12	0.017	0.034
110	0.46	0.051	0.55	0.12	0.017	0.034
115	0.45	0.052	0.55	0.11	0.018	0.033
120	0.43	0.052	0.55	0.11	0.019	0.033
125	0.42	0.053	0.55	0.11	0.020	0.033
130	0.41	0.053	0.55	0.11	0.020	0.033
135	0.40	0.054	0.54	0.11	0.021	0.033
140	0.39	0.054	0.54	0.11	0.022	0.033
145	0.38	0.055	0.54	0.11	0.022	0.032
150	0.37	0.055	0.54	0.11	0.023	0.032
155	0.36	0.056	0.54	0.11	0.024	0.032
160	0.35	0.056	0.54	0.11	0.025	0.032
165	0.34	0.057	0.54	0.11	0.025	0.031
170	0.34	0.057	0.54	0.11	0.026	0.031
175	0.33	0.058	0.53	0.11	0.027	0.031
180	0.32	0.058	0.53	0.11	0.027	0.031
185	0.32	0.058	0.53	0.11	0.028	0.030
190	0.31	0.059	0.53	0.11	0.029	0.030
195	0.30	0.059	0.53	0.11	0.030	0.030
200	0.30	0.060	0.53	0.11	0.030	0.029
205	0.29	0.060	0.53	0.11	0.031	0.029
210	0.29	0.060	0.53	0.11	0.032	0.029
215	0.28	0.061	0.53	0.11	0.032	0.028
220	0.28	0.061	0.53	0.11	0.033	0.028
225	0.27	0.061	0.53	0.11	0.034	0.027
230	0.27	0.062	0.53	0.11	0.035	0.027
235	0.26	0.062	0.53	0.11	0.035	0.027
240	0.26	0.062	0.53	0.11	0.036	0.026
245	0.26	0.063	0.52	0.11	0.037	0.026
250	0.25	0.063	0.52	0.11	0.037	0.025
255	0.25	0.063	0.52	0.11	0.038	0.025
260	0.24	0.064	0.52	0.11	0.039	0.025
265	0.24	0.064	0.52	0.11	0.040	0.024
270	0.24	0.064	0.52	0.11	0.040	0.024
275	0.23	0.064	0.52	0.11	0.041	0.023
280	0.23	0.065	0.52	0.11	0.042	0.023
285	0.23	0.065	0.52	0.11	0.042	0.022
290	0.22	0.065	0.52	0.11	0.043	0.022
295	0.22	0.065	0.52	0.11	0.044	0.022
300	0.22	0.066	0.52	0.11	0.045	0.021

Mod. FAA Minor Storage Volume (cubic ft.) = 1,465
Mod. FAA Minor Storage Volume (acre-ft.) = 0.0336

Determination of MAJOR Detention Volume Using Modified FAA Method

Design Information (Input):

Catchment Drainage Imperviousness	I_a =	40.00	percent
Catchment Drainage Area	A =	1.730	acres
Predevelopment NRCS Soil Group	Type =	C	A, B, C, or D
Return Period for Detention Control	T =	100	years (2, 5, 10, 25, 50, or 100)
Time of Concentration of Watershed	Tc =	12	minutes
Allowable Unit Release Rate	q =	0.50	cfs/acre
One-hour Precipitation	P_1 =	1.23	inches
Design Rainfall IDF Formula $i = C_1 * P_1/(C_2+T_c)^{C_3}$			
Coefficient One	C_1 =	28.50	
Coefficient Two	C_2 =	10	
Coefficient Three	C_3 =	0.789	

Determination of Average Outflow from the Basin (Calculated):

Runoff Coefficient	C =	0.58	
Inflow Peak Runoff	Qp-in =	3.07	cfs
Allowable Peak Outflow Rate	Qp-out =	**0.87**	cfs
Mod. FAA Major Storage Volume =		2,570	**cubic feet**
Mod. FAA Major Storage Volume =		**0.059**	**acre-ft**

Rainfall Duration minutes (input)	Rainfall Intensity inches / hr (output)	Inflow Volume acre-feet (output)	Adjustment Factor "m" (output)	Average Outflow cfs (output)	Outflow Volume acre-feet (output)	Storage Volume acre-feet (output)
0	0.00	0.000	0.00	0.00	0.000	0.000
5	4.14	0.029	1.00	0.87	0.006	0.023
10	3.30	0.046	1.00	0.87	0.012	0.034
15	2.77	0.057	0.90	0.78	0.016	0.041
20	2.39	0.066	0.80	0.69	0.019	0.047
25	2.12	0.073	0.74	0.64	0.022	0.051
30	1.91	0.079	0.70	0.61	0.025	0.054
35	1.74	0.084	0.67	0.58	0.028	0.056
40	1.60	0.088	0.65	0.56	0.031	0.058
45	1.48	0.092	0.63	0.55	0.034	0.058
50	1.39	0.096	0.62	0.54	0.037	0.059
55	1.30	0.099	0.61	0.53	0.040	0.059
60	1.23	0.102	0.60	0.52	0.043	0.059
65	1.16	0.104	0.59	0.51	0.046	0.059
70	1.10	0.107	0.59	0.51	0.049	0.058
75	1.05	0.109	0.58	0.50	0.052	0.057
80	1.01	0.111	0.58	0.50	0.055	0.056
85	0.96	0.113	0.57	0.49	0.058	0.056
90	0.93	0.115	0.57	0.49	0.061	0.054
95	0.89	0.117	0.56	0.49	0.064	0.053
100	0.86	0.119	0.56	0.48	0.067	0.052
105	0.83	0.120	0.56	0.48	0.070	0.051
110	0.80	0.122	0.55	0.48	0.073	0.049
115	0.78	0.123	0.55	0.48	0.076	0.048
120	0.75	0.125	0.55	0.48	0.079	0.046
125	0.73	0.126	0.55	0.47	0.082	0.045
130	0.71	0.128	0.55	0.47	0.085	0.043
135	0.69	0.129	0.54	0.47	0.088	0.041
140	0.67	0.130	0.54	0.47	0.091	0.040
145	0.66	0.131	0.54	0.47	0.094	0.038
150	0.64	0.133	0.54	0.47	0.097	0.036
155	0.62	0.134	0.54	0.47	0.099	0.034
160	0.61	0.135	0.54	0.46	0.102	0.032
165	0.60	0.136	0.54	0.46	0.105	0.030
170	0.58	0.137	0.54	0.46	0.108	0.028
175	0.57	0.138	0.53	0.46	0.111	0.026
180	0.56	0.139	0.53	0.46	0.114	0.024
185	0.55	0.140	0.53	0.46	0.117	0.022
190	0.54	0.141	0.53	0.46	0.120	0.020
195	0.53	0.142	0.53	0.46	0.123	0.018
200	0.52	0.143	0.53	0.46	0.126	0.016
205	0.51	0.143	0.53	0.46	0.129	0.014
210	0.50	0.144	0.53	0.46	0.132	0.012
215	0.49	0.145	0.53	0.46	0.135	0.010
220	0.48	0.146	0.53	0.46	0.138	0.008
225	0.47	0.147	0.53	0.46	0.141	0.006
230	0.46	0.148	0.53	0.46	0.144	0.003
235	0.46	0.148	0.53	0.45	0.147	0.001
240	0.45	0.149	0.53	0.45	0.150	-0.001
245	0.44	0.150	0.52	0.45	0.153	-0.003
250	0.44	0.151	0.52	0.45	0.156	-0.005
255	0.43	0.151	0.52	0.45	0.159	-0.008
260	0.42	0.152	0.52	0.45	0.162	-0.010
265	0.42	0.153	0.52	0.45	0.165	-0.012
270	0.41	0.153	0.52	0.45	0.168	-0.015
275	0.41	0.154	0.52	0.45	0.171	-0.017
280	0.40	0.155	0.52	0.45	0.174	-0.019
285	0.39	0.155	0.52	0.45	0.177	-0.022
290	0.39	0.156	0.52	0.45	0.180	-0.024
295	0.38	0.157	0.52	0.45	0.183	-0.026
300	0.38	0.157	0.52	0.45	0.186	-0.029

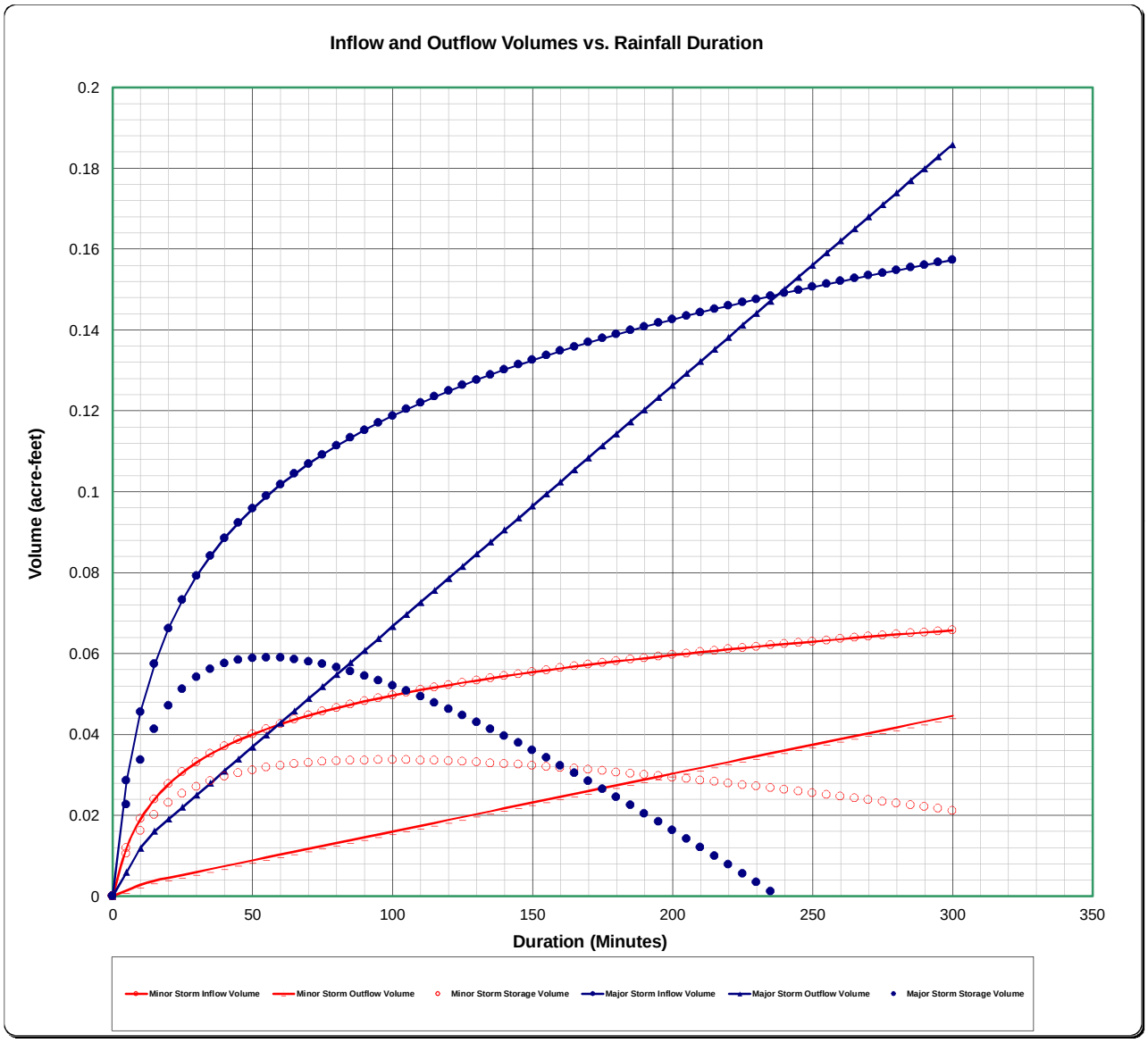
Mod. FAA Major Storage Volume (cubic ft.) = 2,570
Mod. FAA Major Storage Volume (acre-ft.) = 0.0590

UDFCD DETENTION BASIN VOLUME ESTIMATING WORKBOOK Version 2.34, Released November 2013

DETENTION VOLUME BY THE MODIFIED FAA METHOD

Project: Encana K19NE

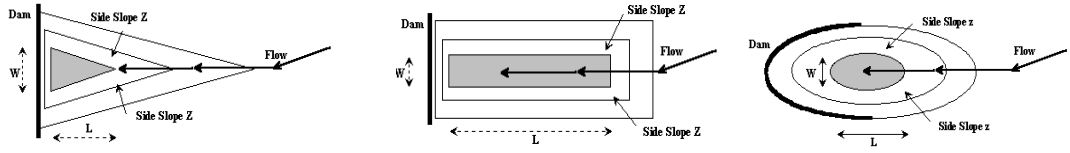
Basin ID: A



STAGE-STORAGE SIZING FOR DETENTION BASINS

Project: Encana K19NE Storage Yard

Basin ID: A



Design Information (Input):

Width of Basin Bottom, W	=	14.00	ft
Length of Basin Bottom, L	=	30.00	ft
Dam Side-slope (H:V), Z_d	=	3.00	ft/ft

Check Basin Shape

Right Triangle		OR…
Isosceles Triangle		OR…
Rectangle		OR…
Circle / Ellipse	X	OR…
Irregular		(Use Overide values in cells G32:G52)

Stage-Storage Relationship:

	MINOR	MAJOR	
Storage Requirement from Sheet 'Modified FAA':	0.03	0.06	acre-ft.
Storage Requirement from Sheet 'Hydrograph':			acre-ft.
Storage Requirement from Sheet 'Full-Spectrum':			acre-ft.

Labels for WQCV, Minor, & Major Storage Stages (input)	Water Surface Elevation ft (input)	Side Slope (H:V) ft/ft Below El.	Basin Width at Stage ft (output)	Basin Length at Stage ft (output)	Surface Area at Stage ft^2 (output)	Surface Area at Stage ft^2 User Overide	Volume Below Stage ft^3 (output)	Surface Area at Stage acres (output)	Volume Below Stage acre-ft (output)	Target Volumes for WQCV, Minor, & Major Storage Volumes (for goal seek)
	5666.00	(input)	14.00	30.00	329.9			0.008	0.000	
	5666.25	3.00	15.50	31.50	383.5		89	0.009	0.002	
	5666.50	3.00	17.00	33.00	440.6		192	0.010	0.004	
	5666.75	3.00	18.50	34.50	501.3		310	0.012	0.007	
	5667.00	3.00	20.00	36.00	565.5		443	0.013	0.010	
	5667.25	3.00	21.50	37.50	633.2		593	0.015	0.014	
	5667.50	3.00	23.00	39.00	704.5		760	0.016	0.017	
	5667.75	3.00	24.50	40.50	779.3		946	0.018	0.022	
	5668.00	3.00	26.00	42.00	857.7		1,150	0.020	0.026	
MINOR	5668.25	3.00	27.50	43.50	939.5		1,375	0.022	0.032	
	5668.50	3.00	29.00	45.00	1,024.9		1,621	0.024	0.037	
	5668.75	3.00	30.50	46.50	1,113.9		1,888	0.026	0.043	
	5669.00	3.00	32.00	48.00	1,206.4		2,178	0.028	0.050	
	5669.25	3.00	33.50	49.50	1,302.4		2,492	0.030	0.057	
MAJOR	5669.50	3.00	35.00	51.00	1,401.9		2,830	0.032	0.065	
	5669.75	3.00	36.50	52.50	1,505.0		3,193	0.035	0.073	
WEIR CREST	5670.00	3.00	38.00	54.00	1,611.6		3,583	0.037	0.082	
	5670.25	3.00	39.50	55.50	1,721.8		3,999	0.040	0.092	
TOP	5670.50	3.00	41.00	57.00	1,835.5		4,444	0.042	0.102	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
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							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
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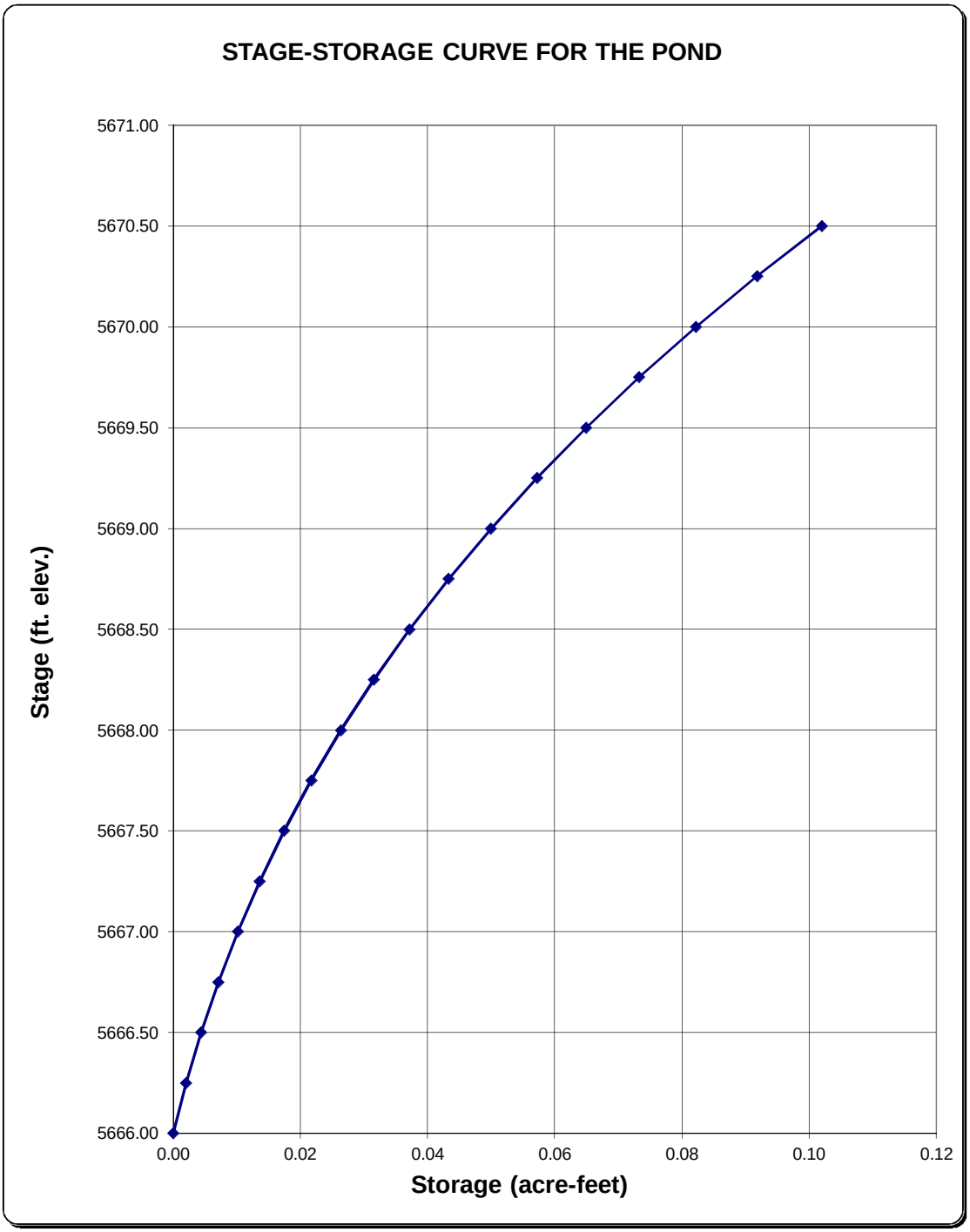
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	
							#N/A		#N/A	

STAGE-STORAGE SIZING FOR DETENTION BASINS

Project: _____

Basin ID: _____

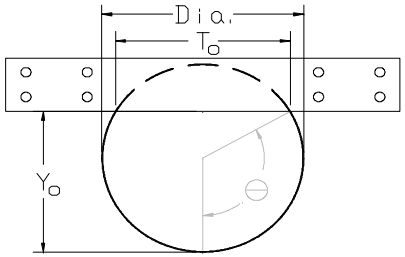


RESTRICTOR PLATE SIZING FOR CIRCULAR VERTICAL ORIFICES

Project: Encana K19NE Storage Yard

Basin ID: A - 100 YR RELEASE RATE CULVERT FROM POND STRUCTURE

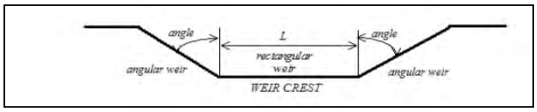
X



		#1 Vertical Orifice	#2 Vertical Orifice	
Sizing the Restrictor Plate for Circular Vertical Orifices or Pipes (Input)				
Water Surface Elevation at Design Depth	Elev: WS =	5,670.00		feet
Pipe/Vertical Orifice Entrance Invert Elevation	Elev: Invert =	5,666.00		feet
Required Peak Flow through Orifice at Design Depth	Q =	0.87		cfs
Pipe/Vertical Orifice Diameter (inches)	Dia =	12.0		inches
Orifice Coefficient	C_o =	0.65		
Full-flow Capacity (Calculated)				
Full-flow area	Af =	0.79		sq ft
Half Central Angle in Radians	Theta =	3.14		rad
Full-flow capacity	Qf =	7.7		cfs
	Percent of Design Flow =	880%		
Calculation of Orifice Flow Condition				
Half Central Angle (0<Theta<3.1416)	Theta =	0.84		rad
Flow area	A_o =	0.08		sq ft
Top width of Orifice (inches)	T_o =	8.90		inches
Height from Invert of Orifice to Bottom of Plate (feet)	Y_o =	0.16		feet
Elevation of Bottom of Plate	Elev Plate Bottom Edge =	5,666.16		feet
Resultant Peak Flow Through Orifice at Design Depth	Q_o =	0.9		cfs
Width of Equivalent Rectangular Vertical Orifice	**Equivalent Width =**	**0.50**		**feet**

STAGE-DISCHARGE SIZING OF THE SPILLWAY

Project: Encana K19NE
Basin ID: A



Design Information (input):

Bottom Length of Weir	L =	3.00	feet
Angle of Side Slope Weir	Angle =	14.04	degrees
Elev. for Weir Crest	EL. Crest =	5,670.00	feet
Coef. for Rectangular Weir	C_w =	3.34	
Coef. for Trapezoidal Weir	C_t =	3.34	

Calculation of Spillway Capacity (output):

Water Surface Elevation ft. (linked)	Rect. Weir Flowrate cfs (output)	Triangle Weir Flowrate cfs (output)	Total Spillway Release cfs (output)	Total Pond Release cfs (output)
5666.00	0.00	0.00	0.00	#N/A
5666.25	0.00	0.00	0.00	#N/A
5666.50	0.00	0.00	0.00	#N/A
5666.75	0.00	0.00	0.00	#N/A
5667.00	0.00	0.00	0.00	#N/A
5667.25	0.00	0.00	0.00	#N/A
5667.50	0.00	0.00	0.00	#N/A
5667.75	0.00	0.00	0.00	#N/A
5668.00	0.00	0.00	0.00	#N/A
5668.25	0.00	0.00	0.00	#N/A
5668.50	0.00	0.00	0.00	#N/A
5668.75	0.00	0.00	0.00	#N/A
5669.00	0.00	0.00	0.00	#N/A
5669.25	0.00	0.00	0.00	#N/A
5669.50	0.00	0.00	0.00	#N/A
5669.75	0.00	0.00	0.00	#N/A
5670.00	0.00	0.00	0.00	#N/A
5670.25	1.25	0.03	1.28	#N/A
5670.50	3.54	0.15	3.69	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
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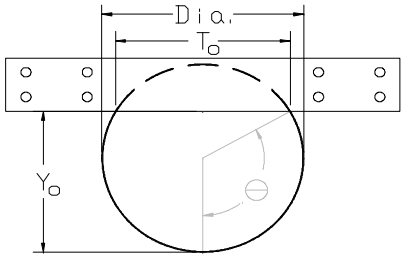
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A

RESTRICTOR PLATE SIZING FOR CIRCULAR VERTICAL ORIFICES

Project: **Encana K19NE Storage Yard**

Basin ID: **A**

X



		#1 Vertical Orifice	#2 Vertical Orifice	
Sizing the Restrictor Plate for Circular Vertical Orifices or Pipes (Input)				
Water Surface Elevation at Design Depth	Elev: WS =	5,668.50		feet
Pipe/Vertical Orifice Entrance Invert Elevation	Elev: Invert =	5,666.00		feet
Required Peak Flow through Orifice at Design Depth	Q =	0.21		cfs
Pipe/Vertical Orifice Diameter (inches)	Dia =	4.0		inches
Orifice Coefficient	C_o =	0.65		
Full-flow Capacity (Calculated)				
Full-flow area	Af =	0.09		sq ft
Half Central Angle in Radians	Theta =	3.14		rad
Full-flow capacity	Qf =	0.7		cfs
	Percent of Design Flow =	333%		
Calculation of Orifice Flow Condition				
Half Central Angle (0<Theta<3.1416)	Theta =	1.24		rad
Flow area	A_o =	0.03		sq ft
Top width of Orifice (inches)	T_o =	3.78		inches
Height from Invert of Orifice to Bottom of Plate (feet)	Y_o =	0.11		feet
Elevation of Bottom of Plate	Elev Plate Bottom Edge =	5,666.11		feet
Resultant Peak Flow Through Orifice at Design Depth	Q_o =	0.2		cfs
Width of Equivalent Rectangular Vertical Orifice	**Equivalent Width =**	**0.27**		**feet**

SECTION A-A RUN-ON BERM

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00150	ft/ft
Left Side Slope	2.40	ft/ft (H:V)
Right Side Slope	67.00	ft/ft (H:V)
Discharge	2.35	ft^3/s

Results

Normal Depth	0.34	ft
Flow Area	4.00	ft^2
Wetted Perimeter	23.64	ft
Hydraulic Radius	0.17	ft
Top Width	23.57	ft
Critical Depth	0.20	ft
Critical Slope	0.02859	ft/ft
Velocity	0.59	ft/s
Velocity Head	0.01	ft
Specific Energy	0.34	ft
Froude Number	0.25	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.34	ft
Critical Depth	0.20	ft
Channel Slope	0.00150	ft/ft
Critical Slope	0.02859	ft/ft

SECTION B-B PAD BERM

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.033	
Channel Slope	0.00300	ft/ft
Left Side Slope	200.00	ft/ft (H:V)
Right Side Slope	2.30	ft/ft (H:V)
Discharge	3.16	ft^3/s

Results

Normal Depth	0.23	ft
Flow Area	5.40	ft^2
Wetted Perimeter	46.78	ft
Hydraulic Radius	0.12	ft
Top Width	46.73	ft
Critical Depth	0.14	ft
Critical Slope	0.03823	ft/ft
Velocity	0.59	ft/s
Velocity Head	0.01	ft
Specific Energy	0.24	ft
Froude Number	0.30	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.23	ft
Critical Depth	0.14	ft
Channel Slope	0.00300	ft/ft
Critical Slope	0.03823	ft/ft

SECTION C-C RUN-ON BERM

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00500	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	33.00	ft/ft (H:V)
Discharge	3.28	ft^3/s

Results

Normal Depth	0.39	ft
Flow Area	2.78	ft^2
Wetted Perimeter	14.22	ft
Hydraulic Radius	0.20	ft
Top Width	14.15	ft
Critical Depth	0.29	ft
Critical Slope	0.02512	ft/ft
Velocity	1.18	ft/s
Velocity Head	0.02	ft
Specific Energy	0.41	ft
Froude Number	0.47	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.39	ft
Critical Depth	0.29	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.02512	ft/ft

SECTION D-D SWALE TO POND

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.01500	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	3.00	ft
Discharge	3.16	ft^3/s

Results

Normal Depth	0.33	ft
Flow Area	1.29	ft^2
Wetted Perimeter	5.06	ft
Hydraulic Radius	0.26	ft
Top Width	4.95	ft
Critical Depth	0.29	ft
Critical Slope	0.02169	ft/ft
Velocity	2.44	ft/s
Velocity Head	0.09	ft
Specific Energy	0.42	ft
Froude Number	0.84	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.33	ft
Critical Depth	0.29	ft
Channel Slope	0.01500	ft/ft

SECTION D-D SWALE TO POND

GVF Output Data

Critical Slope	0.02169	ft/ft

DETENTION POND OUTLET WEIR

Project Description

Solve For	Discharge

Input Data

Headwater Elevation	1.00	ft
Crest Elevation	0.50	ft
Tailwater Elevation	0.00	ft
Weir Coefficient	3.34	US
Crest Length	3.00	ft

Results

Discharge	3.54	ft^3/s
Headwater Height Above Crest	0.50	ft
Tailwater Height Above Crest	-0.50	ft
Equal Side Slopes	0.25	ft/ft (H:V)
Flow Area	1.56	ft^2
Velocity	2.27	ft/s
Wetted Perimeter	4.03	ft
Top Width	3.25	ft

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Article 4-203.E.16 Stormwater Management Permit and Plan

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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STATE OF COLORADO

John W. Hickenlooper, Governor
Christopher E. Urbina, MD, MPH
Executive Director and Chief Medical Officer

Dedicated to protecting and improving the health and environment of the people of Colorado

4300 Cherry Creek Dr. S.
Denver, Colorado 80246-1530
Phone (303) 692-2000
Located in Glendale, Colorado

Laboratory Services Division
8100 Lowry Blvd.
Denver, Colorado 80230-6928
(303) 692-3090

http://www.cdphe.state.co.us

Colorado Department
of Public Health
and Environment

June 21, 2012

Cindy Allen, EHS Team Lead
Encana Oil & Gas (USA) Inc
370 17 St Ste 1700
Denver, CO 80202

RE: Renewal of Permit/Certification
Administrative Continuation
For: Mamm Creek
Located at: See Map In File, Uninc, Garfield County
Permit No.: COR034840

Dear Mr. Allen;

The Division has received an application to renew the above permit/certification. It has been determined that there is sufficient information to make this permit/certification eligible for renewal. More information may be requested by the Division as progress is made in developing a new permit/certification for the above listed facility. This information must be made available to the Division when requested to complete the permit process.

The Division is currently in the process of developing a new permit or master general permit and associated certification for the above permitted facility. The development and review procedures required by law have not yet been completed. When the discharge permit issued to you for your facility expired on **June 30, 2012** your permit is administratively continued and remains in effect under Section 104(7) of the Administrative Procedures Act, C.R.S. 1973, 24-4-101, et seq (1982 repl. vol. 10) until the new permit/certification is issued and effective.

All effluent permit terms and conditions in your current permit will remain in effect until your new permit/certification is issued and effective.

PLEASE KEEP THIS LETTER WITH YOUR PERMIT AND SWMP TO SHOW CONTINUATION OF PERMIT COVERAGE.

Sincerely,

Debbie Jessop
Permits Section
WATER QUALITY CONTROL DIVISION

xc: Permit File

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Master Stormwater Management Plan

Mamm Creek

Volume 1

COR-034840

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encana™ natural gas

Permit Area	Permit Number
Mamm Creek	COR-034840

SWMP REVISIONS

Date	Description	Initials
11/24/2010	Update Legal and Local Contacts	KK
11/24/2010	Updated company name from EnCana to Encana	KK
11/24/2010	Inserted Oil and Gas Construction Field Permit Certification NOTICE OF AMENDMENT OF PERMIT COVERAGE in the place of the Final Stabilization Certification - Appendix F	KK

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Prepared by:
EnCana Oil & Gas (USA) Inc.
Parachute, Colorado

Volume 1
Master Stormwater Management Plan
Mamm Creek
COR-034840

EnCana Oil & Gas (USA) Inc.
Updated June 2009

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Prepared by:
EnCana Oil & Gas (USA) Inc.
Parachute, Colorado

Volume 1
Master Stormwater Management Plan
Mamm Creek
COR-034840

_____
Prepared By Lindsey Kruckenberg, Environmental Field Coordinator

_____
Reviewed By Ryan Meath, Environmental Field Coordinator

EnCana Oil & Gas (USA) Inc.
Updated June 2009

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Contents

List of Appendices

1.0 Introduction

This Master Stormwater Management Plan (Master SWMP) satisfies the Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD) General Permit No. COR-030000 issued on May 31, 2007 for Stormwater Discharges Associated with Construction Activities (the Stormwater Construction Permit). EnCana Oil & Gas (USA) Inc. (EnCana) has submitted a General Permit Application to WQCD, a copy of which is provided as Appendix A.

This Master SWMP has been prepared in compliance with CDPHE WQCD, the Federal Clean Water Act (CWA), and the National Pollutant Discharge Elimination Permit (NPDES) regulations found in 40 CFR, Part 122.26 for stormwater discharges.

The objectives of this Master SWMP are to:

1. Identify all potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges associated with construction activity within this Master SWMP permit area at each project site;
2. Describe the practices to be used to reduce the pollutants in stormwater discharges associated with construction activity within this Master SWMP permit area at each project site (also known as Best Management Practices (BMPs)); and ensure the practices are selected and described in accordance with good engineering practices, including the installation, implementation and maintenance requirements;
3. Be properly prepared and updated to ensure compliance with the terms and conditions of the Stormwater Construction Permit;
4. Work hand in hand with the Site Specific Records, as described in the following section; and
5. Serve as an education tool and comprehensive reference/guide to stormwater management for inspectors, surveyors, engineers, and EnCana employees and contractors.

EnCana construction activities fall under one of two types. Exploration and Production (E&P) sites involve the construction of well pads, roads, and other facilities. Midstream Services (also referred to as Gas Gathering) sites involve the construction of pipelines and compressor, treatment, and other facilities. This Master SWMP is intended to address stormwater management for any and all of these sites within this Master SWMP's Permit Coverage Area.

1.1 Site Specific Records

While Volume 1 of the Master SWMP contains all of the general permit area information, Volume 2 of the Master SWMP contains all of the Site Specific Records including all Individual Stormwater Site Plans (Site Plans), as discussed in Section 2.8, and all Inspection and Maintenance Reports (discussed in Section 5.4). These Site Specific Records contain information specific to each site (each well pad, compressor station, section of road/pipeline, etc.), including information on areas of disturbance, ecosystems and vegetation, soil types, percent pre-disturbance vegetation, etc. Any changes to the design of individual sites or the BMPs used at those sites will be noted on the Site Plans as those changes occur, and kept with the Site Specific Records.

The Site Specific Records (Volume 2 of the Master SWMP) are bound separately from the body of this Master SWMP; however, both are readily available during any inspection. Both the body of this SWMP (Volume 1) and the Site Specific Records (Volume 2) comprise the entire SWMP, and go hand in hand in keeping EnCana in compliance with stormwater regulations. The Site Specific Records will be kept at the EnCana field office in

Parachute during active construction and site inspections to ensure accurate implementation, inspections, and maintenance of BMPs, as well as timely revisions to the Site Specific Records.

1.2 SWMP Administrator

The SWMP Administrator is responsible for the process of developing, implementing, maintaining, and revising this SWMP as well as serving as the comprehensive point of contact for all aspects of the facility's SWMP.

SWMP Administrators:

- Local Contact: Kathy Kiloh, Surface Management Lead
  2717 County Road 215, Suite 100, Parachute, CO 81635
  (970) 285-2626

- Legal Contact: Brant Gimmeson, Group Lead EH&S South Rockies
  370 17th St. Suite 1700, Denver, CO 80202
  (720) 876-5030

2.0 Narrative Description of Master SWMP Permit Coverage Area

Name of Permit Coverage Area: Mamm Creek Unit

Permit Number: COR-034840

Location of the Permit Coverage Area:

- County: Garfield and Mesa County.
- City: Located in Colorado approximately 1 mile south of Rifle and south of the Colorado River within the southern portion of the Piceance Basin.
- Township/Section/Range: Township 6S, 7S, & 8S, Range 92W, 93W, & 94W, portions or all of 113 sections, Sixth Principal Meridian.

Activities at the Permit Coverage Area will likely involve the construction of:

- Well pads
- Access roads
- Pipelines
- Compressor stations
- Water Treatment Facility
- Fresh Water Storage Pond
- Evaporation Facility

The above construction activities are only typical and may vary once construction begins. Up-to-date information on the construction of well pads, roads, pipelines, etc. will be kept with the Site Specific Records (Volume 2 of the Master SWMP).

2.1 Sequence of Major Activities

Site specific, scheduling, surface use agreements, and/or other constraints can and/or may dictate changes in construction sequences. Significant sequence changes are addressed in the Site Specific Records (Volume 2 of the Master SWMP). Specific details on the construction and maintenance of BMPs mentioned below are provided in the Stormwater Manual of Best Management Practices (BMP Manual) as discussed in Section 3.3.

2.1.1 Well Pads and Roads

Construction activities for well pads and roads are generally completed in the following sequence:

Preconstruction:

1. **Surveys.** Topographic, vegetation, wildlife and archeology, as dictated.
2. **Temporary BMP's.** Where physical access is available, installation of terminal perimeter and temporary sediment controls, such as wattles, silt fence and/or other as necessary. Actual BMPs used for each site are shown on the Site Plans (discussed in Section 2.8) and kept with the Site Specific Records (Volume 2 of the Master SWMP).

Construction:

3. **Vegetation Clearing.** Vegetation will be cleared/grubbed and placed along the perimeter at the terminal discharge edges/points in a windrow and/or dam beyond the edge of excavation and at any run-on-protection discharge points, and/or chipped or other depending on landowner requirements.
4. **Diversions and Retention Reservoirs.** After vegetation clearing and prior to topsoil stockpiling, diversions are to be placed for run-on-protection (ROP) to prevent the greater landscape from discharging onto the planned disturbance. Temporary sediment control BMPs shall be placed at the discharge points of the ROP until permanent erosion controls can be installed along the entire length of the ROP. Diversions are to be installed along the terminal discharge edge inside of the vegetation windrows to convey site water/sediment to terminal discharge points where rough retention reservoirs are to be installed. The retention reservoir outlets are to receive temporary sediment control BMPs until permanent retention reservoirs and erosion, drainage, and sediment BMPs can be installed.
5. **Topsoil Stripping/Conservation.** All ACCESSIBLE TOPSOIL is to be removed from areas that are to be excavated, covered in subsoils, or turned into stabilized unpaved surfaces. If initial topsoil stockpile areas are insufficient to accommodate the quantities of topsoil being generated, the excess is to be placed at either end of the subsoil stockpile and segregated as much as possible. After major earthwork, grading, and erosion/drainage/sediment controls are complete, any areas that can be identified for immediate interim reclamation shall receive topsoil.
6. **General Rough Grading.** The site location will be graded to provide suitable surfaces for vehicle traffic and/or building sites, and may be graded to establish surface drainage patterns, such as berms or roadside ditches as necessary.
7. **Facility Specific Grading.** Individual facilities may require additional excavation to allow for construction of foundations. Excess soil will typically be used in general site grading.
8. **Foundation Construction.** To support facilities (such as tanks, processing equipment, etc), foundations will be constructed. Foundations may consist of select backfill, concrete spread footings, or piles. Finished support elevations are to be installed twelve to eighteen inches (12-18") above finished grade or the lowest point of the facility.
9. **Facility Construction.** Tanks, processing equipment, etc. will be constructed.

Interim Reclamation:

10. **Gravel Surfacing.** Areas used for access, parking, or materials staging will typically be gravel surfaced.
11. **Reclamation of Unused Areas.** Areas not needed for facilities, roads, parking, or materials staging will generally be reclaimed. Salvaged topsoil will be spread and the vegetative seed mix will be applied.
12. **Application of Erosion Stabilization.** Depending on terrain (e.g. steep slopes and drainage crossings) additional measures may be applied to increase stability of the reclaimed area.

Final Reclamation:

13. **Reclamation of Post-Operation Areas.** When operation of well pad or road is no longer necessary, the area will be decommissioned and all newly disturbed areas will be reclaimed. Any remaining topsoil will be spread and the vegetative seed mix will be applied. This may occur after termination of this permit and under the coverage of a new construction permit.

2.1.2 Pipelines

Construction activities for pipelines are generally completed in the following sequence:

Preconstruction:

1. **Surveys.** Topographic, vegetation, wildlife and archeology, as dictated.

2. **Mark Right-Of-Way.** The construction right-of-way (ROW) will be marked prior to construction with laths and/or flagging. Laths/flagging will be maintained throughout construction and will not be removed until after reclamation activities have been completed.

3. **Temporary BMPs.** EnCana's stormwater inspectors will determine locations to install preconstruction temporary erosion control devices, per site specific BMP installation plans and as necessary. EnCana's contractor will maintain the erosion control structures as directed by the stormwater inspectors throughout all phases of construction, or until permanent erosion control measures are installed. Actual BMPs used for each site are shown on the Site Plans, which are kept with the Site Specific Records (Volume 2 of the Master SWMP).

Construction:

4. **Vegetation Clearing.** If necessary, vegetation will be cleared and placed in a windrow at the edge of the work area to be used later in reclamation activities, removed from the construction site, or burned/chipped depending on landowner requirements. Details for windrows are provided within the Stockpiling BMP of the BMP Manual (discussed in Section 3.3).

5. **Topsoil Stripping.** All ACCESSIBLE TOPSOIL (from the entire width of the right-of-way) will be removed and temporarily stockpiled along the up-hill side of the right-of-way (if terrain grades will allow) for later use in reclamation activities.

6. **General Grading.** For pipeline segments that occur in relatively rough terrain, general grading will be conducted to create a safe and workable ground surface. This is generally done to form a relatively level work surface on steep cross slopes and to reduce slopes in undulating terrain (arroyo and wash crossings). The site location will be graded to provide suitable surfaces for vehicle traffic and/or building sites, and may be graded to establish surface drainage patterns, such as berms or roadside ditches as necessary.

7. **Trench Excavation.** The trench needed for pipeline installation is almost always off-set in the ROW. The surveyors may indicate the location of the trench on their pipeline lateral. Generally, the trench will be located in the first third of the ROW. The remaining two thirds of the ROW will be used for working space. The trench depth and width will vary with the number of pipes to be installed and the pipe diameter. Generally, a 4-foot deep trench will be excavated by track-mounted excavators. The ditch will be excavated and sloped in accordance with OSHA specifications. The cover from top of pipe to ground level will be a minimum of 36 inches. Where rock is encountered, tractor-mounted mechanical rippers or rock trenching equipment may be used to facilitate excavation. The trench will be excavated and subsoil material stockpiled within the confines of the approved right-of-way limits. Trench spoil will be stored in a separate location from the previously segregated topsoil.

8. **Pipe Installation.** Pipe installation will include stringing, bending for horizontal or vertical angles in the alignment, welding the pipe segments together, coating the joint areas to prevent corrosion, and then lowering-in and padding.

9. **Stringing.** Pipe will be hauled by truck to the pipeline ROW. Each joint of pipe will be unloaded and placed parallel to the ditch.

10. **Bending.** After the joints of pipe are strung along the ditch, individual joints of pipe may need to be bent to accommodate horizontal and vertical changes in direction. Field bends will be made utilizing a hydraulically operated bending machine. Where the deflection of a bend exceeds the allowable limits for a field-bent pipe, factory (induction) bends will be installed.

11. **Welding.** After the pipe joints are bent, the pipe is lined up end-to-end and clamped into position. The pipe is then welded in conformance with 49 CFR Part 192, Subpart E. "Welding of Steel Pipelines" and API 1104, "Standard for Welding Pipelines and Related Facilities".

12. **Welding Inspection.** Welds will be visually inspected by a qualified inspector. Any defects will be repaired or cut out as required under the specified regulations and standards.

13. **Coating.** To prevent corrosion, the pipe will be externally coated with fusion bonded epoxy coating prior to delivery. After welding, field joints will be coated with fusion bond epoxy coating, tape and

primer, or shrink sleeves. Before the pipe is lowered into the ditch, the pipeline coating will be visually inspected and tested with an electronic detector, and any faults or scratches will be repaired.

14. **Lowering-In and Padding.** Once the pipe coating operation has been completed, a section of the pipe will be lowered into the ditch. Side-boom tractors may be used to simultaneously lift the pipe, position it over the ditch, and lower it in place. Inspection will be conducted to verify: that minimum cover is provided; the trench bottom is free of rocks, debris, etc.; external pipe coating is not damaged; and the pipe is properly fitted and installed into the ditch. Specialized padding machines will be used to sift soil fines from the excavated subsoil to provide rock-free pipeline padding and bedding. In rocky areas, padding material or a rock shield will be used to protect the pipe. Topsoil will not be used to pad the pipe. At the completion of lowering-in and padding activities the contractor may install trench breakers around the pipelines to minimize subsurface water flow. Details for trench breakers are provided within the BMP Manual (discussed in Section 3.3).
15. **Backfilling.** Backfilling will begin after a section of the pipe has been successfully placed in the ditch and final inspection has been completed. Backfilling will be conducted using a bulldozer, rotary auger backfill, padding machine or other suitable equipment. Backfilling the trench will use the subsoil previously excavated from the trench. Backfill will be graded and compacted, where necessary for ground stability, by being tamped or walked in with a wheeled or track vehicle. Compaction will be performed to the extent that there are no voids in the trench. Any excavated materials or materials unfit for backfill will be utilized or properly disposed of in conformance with applicable laws or regulations.
16. **General Grading.** If general grading was conducted to facilitate pipeline construction, these materials will be replaced and graded to recreate the preconstruction topography.

Final Reclamation:

17. **Cleanup.** Cleanup activities will be initiated as soon as practicable after backfilling activities have been completed. All construction-related debris will be removed and disposed of at an approved disposal facility.
18. **Subsoil and Topsoil Placement.** Subsoil will be evenly re-contoured across the right-of-way to pre-construction conditions. After the subsoil has been re-spread the contractor will spread the previously segregated topsoil back across the right-of-way. The topsoil will be evenly spread to original contours.
19. **Vegetation.** After any remaining topsoil is spread, the vegetative seed mix will be applied. The area will be revegetated according to private landowner Surface Use Agreements and/or according to the BLM/Forest Service reclamation requirements. Details for revegetation are provided within the BMP Manual (discussed in Section 3.3) and the Revegetation Manual (provided as Appendix B).
20. **Application of Erosion Stabilization.** Depending on terrain (e.g. steep slopes and drainage crossings) additional measures may be applied to increase stability of the reclaimed area. Possible erosion stabilization methods are provided within the BMP Manual (discussed in Section 3.3). Actual locations and measures used are shown on the Site Plans, which are kept with the Site Specific Records (Volume 2 of the Master SWMP).

2.1.3 Compressor Stations, Treatment Facilities, or Other Facilities.

Construction activities for compressor stations, treatment facilities, and other facilities are generally completed in the following sequence:

Preconstruction:

1. **Surveys.** Topographic, vegetation, wildlife and archeology, as dictated.
2. **Temporary BMP's.** Where physical access is available, installation of terminal perimeter and temporary sediment controls, such as wattles, silt fence and/or other as necessary. Actual BMPs

used for each site are shown on the Site Plans, which are kept with the Site Specific Records (Volume 2 of the Master SWMP).

Construction:

3. **Vegetation Clearing.** Vegetation will be cleared/grubbed and placed along the perimeter at the terminal discharge edges/points in a windrow and/or dam beyond the edge of excavation and at any run-on-protection discharge points, and/or chipped or other depending on landowner requirements.
4. **Diversions and Retention Reservoirs.** After vegetation clearing and prior to topsoil stockpiling, diversion are to be placed for ROP to prevent the greater landscape from discharging onto the planned disturbance. Temporary sediment control BMP's shall be placed at the discharge points of the ROP until permanent erosion controls can be installed along the entire length of the ROP. Diversions are to be installed along the terminal discharge edge inside of the vegetation windrows to convey site water/sediment to terminal discharge points where rough retention reservoirs are to be installed. The retention reservoir outlets are to receive temporary sediment control BMP's until permanent retention reservoirs and erosion, drainage, and sediment BMP's can be installed.
5. **Topsoil Stripping/Conservation.** All ACCESSIBLE TOPSOIL is to be removed from areas that are to be excavated, covered in subsoils, or turned into stabilized unpaved surfaces. If initial topsoil stockpile areas are insufficient to accommodate the quantities of topsoil being generated, the excess is to be placed at either end of the subsoil stockpile and segregated as much as possible. After major earthwork, grading, and erosion/drainage/sediment controls are complete, any areas that can be identified for immediate interim reclamation shall receive topsoil.
6. **General Rough Grading.** The site location will be graded to provide suitable surfaces for building sites and vehicle traffic, and may be graded to establish surface drainage patterns, such as berms or roadside ditches as necessary.
7. **Excavation.** Soil will be excavated to allow for the construction of foundations. Trenches will be excavated for all underground piping and conduit. Excess soil will typically be used in general site grading.
8. **Foundation Construction.** Foundations will be constructed to support facility buildings. Foundations may consist of select backfill, concrete spread footings, piles, etc. Finished support elevations are to be installed twelve to eighteen inches (12-18") above finished grade or the lowest point of the facility.
9. **Facility Construction.** Buildings, tanks, processing equipment, etc. will be constructed. Utilities will be installed.

Interim Reclamation:

10. **Landscaping.** If necessary, certain areas will be spread with topsoil and landscaped.
11. **Gravel Surfacing.** Areas used for access, parking, or materials staging will typically be gravel surfaced.
12. **Reclamation of Unused Areas.** Areas not needed for facilities, roads, parking, or materials staging will generally be reclaimed. Salvaged topsoil will be spread and the vegetative seed mix will be applied.
13. **Application of Erosion Stabilization.** Depending on terrain (e.g. steep slopes and drainage crossings) additional measures may be applied to increase stability of the reclaimed area. Possible erosion stabilization methods are provided within the BMP Manual (discussed in Section 3.3). Actual locations and measures used are shown on the Site Plans, which are kept with the Site Specific Records (Volume 2 of the Master SWMP).

Final Reclamation:

14. **Reclamation of Closed Facilities.** When facilities are no longer necessary, the buildings may be demolished, according to approved procedures. All construction materials will be removed and the newly disturbed areas will be reclaimed. Any remaining topsoil will be spread and the vegetative seed

mix will be applied. This may occur after termination of this permit and under the coverage of a new construction permit.

2.2 Area Estimates

The Permit Coverage Area encompasses portions or all of 113 sections of surface land (approximately 72,273 acres) in Township 6, 7, and 8 South, Range 92, 93, and 94 West. Development of the natural gas resource and related facilities within the area is estimated to result in a total disturbance area of 999+ acres. Because the area will vary over time, these are only approximate estimates. This information is used to help determine the extent of control measures (BMPs) needed.

2.3 Description of Existing Topography and Soils

The Permit Coverage Area consists of relatively flat mesas and ridge crests, alluvial terraces, steep slopes, mountainsides, intermittent drainage swells, and valley bottoms. The Mamm Creek Unit is located south of the Colorado River, within the southern portion of the Piceance Basin. The Piceance Basin is a broad, asymmetric, southeast-northwest trending structural basin that contains sedimentary rocks up to 20,000 feet thick and lies between the White River uplift to the northeast, the Gunnison uplift to the south, and the Uncompahgre swell to the west (George 1927; Weiner and Haun 1960).

Elevations within the Permit Coverage Area range from approximately 5,000 feet above mean sea level (amsl) along the Colorado River to 8,900 feet on Grass Mesa near the western edge of the unit area. Annual precipitation within the Permit Coverage Area ranges from 10 to 40 inches. Soils surrounding the Permit Coverage Area are distributed according to the major soil forming factors including climate (effective moisture and temperature), parent material, topographic position, and slope. The soils table within Appendix C provides a summary of the soil types found within the Permit Coverage Area (including permeability, available water capacity, surface runoff, erosion hazard, and others). Most of these soil types are considered to possess moderate to very severe potential for water erosion.

2.4 Description of Existing Vegetation

The existing percent vegetative ground cover for each well pad, section of roadway/pipeline, etc. within the Permit Coverage Area is estimated on each inspection and maintenance report form (discussed in Section 5.4), which are kept with the Site Specific Records (Volume 2 of the Master SWMP). A map indicating the existing ecosystem types within the Permit Coverage Area is provided in Appendix C.

A description of the existing vegetation within each ecosystem (Mutel, 1992) is as follows:

1. **Grasslands**

   a. **Plains Grasslands.** Plains grasslands are dominated by a mixture of blue grama *(Chondrosum gracile)* and buffalograss *(Buchloe dactyloides)*. Interspersed are occasional shrubs and bright flowered forbs, most of which are members of the pea and sunflower families. Taller grass species cover 10 to 25 percent of the ground of little-grazed, moist sites. Most are perennial bunch-grasses up to three feet tall. Needle-and-thread *(Stipa comata)*, sand dropseed *(Sporobolus cryptandrus)*, side-oats grama *(Bouteloua curtipendula)*, western wheatgrass *(Pascopyrum smithii)*, Junegrass *(Koeleria macrantha)*, and red three-awn *(Aristida purpurea)* are other common species. Common forbs consist of prickly pear *(Opuntia polyacantha),* pasture sage *(Artemisia frigida)*, and yucca *(Yucca glauca).*

   b. **Mountain Grasslands and Meadows.** Natural wet meadows and fens are dominated by moisture-loving species, primarily members of the sedge and rush families. Spike-rush *(Eleocharis palustris)*, sedges, Canadian reedgrass *(Calamagrostis canadensis)*, and tufted hairgrass *(Deschampsia cespitosa)* are common. Natural dry meadows are filled with members of the grass family. Bunchgrasses dominate at low elevations. Needle-and-thread, mountain muhly *(Muhlenbergia montana)*, Junegrass, blue grama, and species of wheatgrass and bluegrass are common. Successional meadows contain a combination of weedy, introduced plants and plants

typical of dry, rocky slopes, such as common dandelion *(Taraxacum officinale)*, golden banner *(Thermopsis divaricarpa)*, Colorado locoweed *(Oxytropic sericea)*, mountain pussytoes *(Antennaria parvifolia)*, showy daisies *(Erigeron speciosus)*, stonecrop *(Sedum lanceolatum)*, and some sedges *(Carex* ssp.). Mountain grasslands, where Thurber fescue *(Festuca thurberi)* and mountain muhly were once the dominant grasses, are now largely dominated by blue grama, Canada bluegrass *(Poa compressa)*, foxtail barley *(Critesion jubatum)*, and other species as a result of grazing.

2. **Riparian Ecosystems**

   a. **Lowland Riparian Ecosystems.** The lowland riparian ecosystem is dominated by the plains cottonwood *(Populus deltoidea* ssp. *occidentalis),* the valley cottonwood *(Populus deltoidea* ssp. *wislizenii)* and the peach-leaved willow *(Salix amygdaloides).* Common shrubs and herbaceous plants include snowberry *(Symphoricarpos occidentalis)*, sandbar willow *(Salix exigua),* bulrush *(Schoenoplectus lacustris),* broad-leaved cat-tail *(Typha latifolia),* prairie cord-grass *(Spartina pectinata),* and western wheatgrass.

   b. **Mountain Riparian Ecosystems.** The mountain riparian ecosystem is dominated by quaking aspen *(Populus tremuloides*), lanceleaf cottonwood *(Populus X acuminata)*, narrowleaf cottonwood (*Populus angustifolia*), and Colorado blue spruce *(Picea pungens)*. Common shrubs include alder *(Alnus incana)*, river birch *(Betula fontinalis)*, chokecherry *(Padus virginiana)*, common gooseberry *(Ribes inerme)*, bush honeysuckle *(Distegia involucrata)*, and mountain maple *(Acer glabrum)*. The lush riparian herbaceous understory includes forbs, grasses, sedges, rushes, climbing vines, mosses, lichens, and liverworts. Weedy invaders are also common.

3. **Shrublands.** Shrub communities include semidesert shrublands found in dry lowlands, sagebrush shrublands that occupy a wide range of elevation from the Colorado Plateau to high mountain valleys, and montane shrublands other than sagebrush, characteristic of foothills and mountain regions.

   a. **Semidesert Shrublands.** Common shrubs include Great Basin big sagebrush (*Seriphidium tridentatum*), greasewood *(Sarcobatus vermiculatus)*, rabbitbrush *(Chrysothamnus)*, four-winged saltbush *(Atriplex canescens)*, and shadscale *(Atriplex confertifolia)*. Common grasses and forbs include galletagrass (*Hilaria jamesii*), blue grama, alkali sacaton (*Sporobolus airoides*), nodding eriogonum (*Eriogonum cernuum*), copper mallow (*Sphaeralcea coccinea*), and prince's plume (*Stanleya pinnata*).

   b. **Sagebrush Shrublands.** Common shrubs include Great Basin big sagebrush, mountain big sagebrush (*Seriphidium vaseyanum)*, rabbitbrush, and serviceberry *(Amelanchier alnifolia)*. Common grasses and forbs include nodding eriogonum, copper mallow, and Indian Paintbrush (*Castilleja* spp.).

   c. **Montane Shrublands.** Common shrubs include mountain mahogany (*Cercocarpus*), Gamble oak (*Quercus gambelii*), rabbitbrush, serviceberry, and skunkbrush *(Rhus aromatica)*. Common grasses and forbs include needle-and-thread, western wheatgrass, copper mallow, and Indian Paintbrush.

4. **Pinyon-Juniper Woodlands.** Pinyon-juniper woodlands consist of scattered Utah juniper interspersed with big sagebrush. Pinyon pine is a minor component. Several other shrub species also occur in this community, including snowberry, bitterbrush *(Purshia tridentata)*, snakeweed *(Gutierrezia sarothrae)*, and serviceberry. In general, the sparse herbaceous layer consists of graminoids such as cheatgrass *(Anisantha tectorum)*, Kentucky bluegrass *(Poa pratensis)*, western wheatgrass, Indian ricegrass *(Oryzopsis hymenoides)*, and squirreltail *(Elymus elymoides)*. Forbs include Tracy's thistle *(Cirsium tracyi)*, mariposa lily *(Calochortus nuttallii)*, western wallflower *(Erysimum capitatum)*, tapertip onion *(Allium acuminatum)*, yarrow *(Achillea lanulosa)*, stemless four-nerve daisy *(Tetraneuris acaulis)*, and sharpleaf twinpod *(Physaria acutifolia)*. All of these are native species, except for cheatgrass (an invasive, non-native annual species) and Kentucky bluegrass (a widely naturalized non-native perennial species).

5. **Montane Forests**

   a. **Ponderosa Pine Forests.** These forests are dominated by the ponderosa pine (Pinus ponderosa) and the Rocky Mountain juniper (Savina scopulorum). Common shrubs and herbaceous plants include the wax currant (*Ribes cereum*), blue grama, side-oats grama, Junegrass, needle-and-thread, spike fescue (*Leucopoa kingii*), and sulphur flower (*Eriogonum umbellatum*).

   b. **Douglas Fir Forests.** These forests are dominated by the Douglas fir (*Pseudotsuga menziesii*). Common shrubs and herbaceous plants include common juniper (*Juniperus communis*), kinnikinnik (*Arctostaphylos*), mountain maple (*Acer glabrum*), mountain lover (*Paxistima myrsinites*), heart-leaved arnica *(Arnica cordifolia)*, and false Solomon's seal (*Maianthemum* spp.)

   c. **Aspen forests.** Quaking aspen generally occur on north-facing slopes, and along drainage swales. The aspen forest generally has an understory of Wood's rose (*Rosa woodsii*), Colorado blue columbine (*Aquilegia caerulea*), showy daisy, Thurber fescue, white geranium (*Geranium richardsonii*), common lupine *(Lupinus argenteus*), Fendler meadowrue (*Thalictrum fendleri*), and American vetch (*Vicia americana*).

   d. **Lodgepole Pine Forests.** These forests are dominated by the lodgepile pine *(Pinus contorta*). Common shrubs and herbaceous plants include broom huckleberry *(Vaccinium scoparium)*, common juniper, kinnikinnik, sticky-laurel *(Ceanothus velutinus)*, and heart-leaved arnica.

6. **Subalpine Forests**

   a. **Engelmann Spruce and Subalpine Fir.** Engelmann spruce *(Picea engelmannii)* and subalpine fir *(Abies bifolia)* trees are the dominant species in this type of forest, however lodgepole pine, aspen, and sedge-bluegrass have been known to invade in areas which have been severely burned. Understory growth is patchy and consists primarily of dense, low-growing blueberry *(Vaccinium myrtillus)* and broom huckleberry bushes. Moisture-loving shrubs and herbs such as broad-leaved arnica *(Arnica latifolia)* and heart-leaved arnica, Jacob's ladder *(Polemonium pulcherrimum),* curled lousewort *(Pedicularis racemosa)*, elk sedge *(Carex geyeri)*, and lesser wintergreen *(Pyrola minor)* are interspersed among the huckleberry.

   b. **Limber and Bristlecone Pine Woodlands.** Limber pine *(Pinus flexilis)* and bristlecone pine *(Pinus aristata)* trees are the only tree species that can invade this harsh ecosystem. Common species among the sparse understory consist of common juniper, kinnikinnik*,* sticky-laurel, Junegrass, stonecrop, Colorado locoweed, and whitlow-wort *(Draba* spp.). Lichens cover exposed rock surfaces.

7. **Alpine Tundra.** Tundra vegetation consists of a low growth of shrubs, cushion plants, and small forbs with brilliantly colored flowers, and of lush meadows of narrow-leaved sedges and grasses. These plants cover gentle slopes and rock crevices filled with soil. Rock surfaces are partially covered with more primitive plants – lichens and mosses. Shrubs consist of arctic willow *(Salix arctica)*, barrenground *(Salix brachycarpa)*, planeleaf *(Salix planifolia)*, and snow *(Salix reticulate* ssp. *nivalis)*. Common grasses are alpine bluegrass *(Poa arctica)*, tufted hairgrass *(Deschampsia cespitosa)*, and kobresia *(Kobresia myosuroides)*. The most common forbs are alpine avens *(Acomastylis rossii)*, American bistort *(Bistorta bistortoides)*, marsh marigold *(Psychrophila leptosepala)*, old-man-on-the-mountain *(Rydbergia grandiflora)*, moss pink *(Silene acualis)*, rock selaginella *(Selaginella densa)*, and alpine sandwort *(Lidia obtusiloba)*. All plant species are slow-growing perennials except for the rare annual koenigia, a tiny member of the buckwheat family.

8. **Urban Areas.** Urban areas contain an increased density of human-created structures in comparison to the areas surrounding it. Depending on the area, vegetation may account for anywhere between 20 and 70 percent of the total land cover, with the remaining portion being constructed materials. Types of vegetation within urban areas may be any combination of the above ecosystems, and may include areas of blue grass yards and parks.

9. **Cropland**. Cropland vegetation may consist of wheat, corn, soybeans, or a variety of many other crops. Cropland may either lie fallow (bare of any crops) or contain crops at any stage of growth from seedlings to mature plants.

Detailed Description of Existing Vegetation

The existing percent vegetative ground cover for each well pad, section of roadway/pipeline, etc. within the Permit Coverage Area is estimated on each inspection and maintenance report form (discussed in Section 5.4), which are kept with the Site Specific Records (Volume 2 of the Master SWMP). The primary vegetation types in the Mamm Creek Unit are sagebrush shrublands (*Artemisia tridentata*), pinyon-juniper woodlands (*Pinus edulis-Juniperus osteosperma*), and Gambel oak shrublands (*Quercus gambelii*). A small amount of aspen is present at the southern and eastern edge of the Project Area. The riparian vegetation includes narrowleaf cottonwood (*Populus angustifolia*), mountain maple (*Acer glabrum*), river birch (*Betula occidentalis*), alder (*Alnus incana spp. tenuifolia*), dogwood (*Cornus sereciea*), and Woods' rose (*Rosa woodsii*). Snowberry occurs in the shrublayer, and orange sneezeweed (*Dugaldia hoopesii*), tailcup lupine (*Lupinus caudatus*), field horsetail (*Equisetum arvense*), American vetch (*Vicia americana*), orchardgrass (*Dactylis gloverata*), northern bedstraw, geranium (*Geranium caespitosum*), and yarrow (*Achillea lanulosa*) occur in the understory. Further to the southwest, numerous blue spruce (*Picea pungens*) occur along the creek (BLM 2005).

Vegetation within the Grass Mesa area primarily consists of hillsides dominated by pinyon-juniper woodlands (Juniperus osteosperma and Pinus edulis) and the mesa top dominated by mixed mountain shrubs, mostly big sagebrush (Artemisia tridentata), Gambel oak (Quercus gambelii), and serviceberry (Amelanchier alnifolia). Several of the proposed locations fall within areas dominated by sagebrush-steppe. Herbaceous and succulent species commonly found in the project area include arrow-leaf balsamroot (Balsamorhiza sagittata), prickly pear cactus (Opuntia polyacantha), prairie lupine (Lupinus wyethii), orange globemallow (Sphaeralcea munroana), and several species of penstemon (Penstemon spp.) and paintbrush (Castilleja spp.) (BLM 2004).

The entire Mamm Creek Unit has, to some extent, been affected by cheatgrass (downy brome) (*Bromus tectorum*) (see Invasive, Non-Native Species). It is often associated with sagebrush communities and disturbed areas, especially two-track roads. In the pinyon/juniper woodlands, this species may be found as the understory.

Stressed by the recent drought, many pinyon pine trees in the Colorado Plateau have succumbed to an engraver beetle (*Ips confusus*) infestation. However, in the Mamm Creek Unit, the scattered pinyon pine trees have shown few signs of infestation.

2.5 Identification of Potential Pollution Sources

Potential sources of pollution are associated with all phases of the project from the start of construction though interim reclamation and up until final stabilization has occurred. Final stabilization occurs when construction activities have been completed and all disturbed areas have been either built on, paved, or a uniform vegetative cover has been established with a density of at least 70 percent of pre-disturbance levels, or equivalent permanent, physical erosion reduction methods have been employed.

The most common source of pollution during construction is sediment resulting from the erosion of recently cleared and/or graded areas, such as cut/fill slopes and soil stockpiles. However, there may be many potential pollution sources at any given site. The following types of conditions that might affect the potential for a pollutant source to contribute pollutants to stormwater (CDPHE, 2007B) shall be evaluated:

- The frequency of the activity (i.e., does it occur every day or just once a month? can it be scheduled to occur only during dry weather?);
- Characteristics of the area where the activity takes place (i.e., surface type (pavement, gravel, vegetation, etc.), physical characteristics [site gradients, slope lengths, etc.]);
- Ability of primary and secondary containment (fuel tanks, drum storage, etc.) at product storage and loading/unloading facilities to prevent and contain spills and leaks;
- Proximity of product storage and loading/unloading facilities to waterways or drainage facilities;
- Concentration and toxicity of materials which may to be found in the site's stormwater runoff; and
- Contamination of storage facilities/containment with stored materials (i.e., used oil drums or tanks coated with spilled oil).

The following items are potential sources of pollutants at the Mamm Creek Unit. Each of the potential sources of pollutants will be controlled using one or more of the following types of BMPs: Erosion Controls, Drainage Controls, Sediment Controls or Non-Stormwater Controls. Descriptions and details for each of these types of BMPs are provided in the BMP Manual (discussed in Section 3.3). Actual BMPs used at each site are shown on the Site Plans (discussed in Section 5.4).

Construction:

- All Disturbed and Stored Soils: Erosion Controls, Drainage Controls, Sediment Controls.
- Vehicle Tracking of Sediments: Sediment Controls, Non-Stormwater Controls.
- Management of Contaminated Soils: Non-Stormwater Controls.
- Loading and Unloading Operations: Non-Stormwater Controls.
- Outdoor Storage Activities (Building Materials, Fertilizers, Chemicals, etc.): Non-Stormwater Controls.
- Vehicle and Equipment Maintenance and Fueling: Non-Stormwater Controls.
- Significant Dust or Particulate Generating Processes: Non-Stormwater Controls.
- Routine Maintenance Activities Involving Fertilizers, Pesticides, Detergents, Fuels, Solvents, Oils, etc.: Non-Stormwater Controls.
- On-Site Waste Management Practices (Waste Piles, Liquid Wastes, Dumpsters, etc.): Non-Stormwater Controls.
- Concrete Truck/Equipment Washing, Including the Concrete Truck Chute and Associated Fixtures and Equipment: Non-Stormwater Controls.
- Dedicated Asphalt and Concrete Batch Plants: There will be no asphalt or concrete batch plants located within the Permit Coverage Area of this SWMP.
- Non-Industrial Waste Sources Such as Worker Trash and Portable Toilets: Non-Stormwater Controls.

Interim/Final Reclamation:

- All Disturbed and Stored Soils: Erosion Controls, Drainage Controls, Sediment Controls.
- Vehicle Tracking of Sediments: Sediment Controls, Non-Stormwater Controls.
- Vehicle and Equipment Maintenance and Fueling: Non-Stormwater Controls.
- Significant Dust or Particulate Generating Processes: Non-Stormwater Controls.
- Non-Industrial Waste Sources such as Worker Trash and Portable Toilets: Non-Stormwater Controls.

2.6 Allowable Sources of Non-Stormwater Discharge

Allowable sources of non-stormwater discharge within the Permit Coverage Area include the following:

- **Uncontaminated Springs**. Although there are several springs within the Permit Coverage Areas, none of these springs are currently located in areas where soil disturbance will occur. If this changes in the future, the controls used at any such location will be noted with the Site Specific Records.

- **Landscape Irrigation Return Flow.** There are several locations where pipelines cross through irrigated fields. These locations will be treated similarly to any water crossing with the use of an appropriate control which will be noted in the Site Specific Records.

- **Construction Dewatering.** Construction dewatering is described and discussed in Section 3.2.5.
- **Concrete Washout.** Concrete washout is described and discussed in Section 3.2.4.
- **Emergency Fire Fighting Water.** Water used to put out any type of fire is considered an allowable source of non-stormwater discharge.

No other non-stormwater discharges are allowed under the Stormwater Construction Permit. Other types of non-stormwater discharges must be addressed in a separate permit issued for that discharge.

2.7 Receiving Water

Runoff from disturbed areas during construction will be controlled and/or routed through the use of one or more BMPs, as described later in this plan, prior to being discharged to receiving waters. However, it may be expected that runoff from certain areas will infiltrate into the earth and is not expected to contribute to receiving waters.

All streams in the Mamm Creek Unit are tributary to the Colorado River. The project area is located in the Mamm Creek watershed, and drained by Gant Gulch, Middle Mamm Creek, and an unnamed tributary to Middle Mamm Creek. Gant Gulch is tributary to West Mamm Creek. These drainages flow to the northeast into the mainstream portion of Mamm Creek. Mamm Creek is a perennial tributary to the Colorado River. Floodplain habitat occurs along Middle Mamm Creek and East Mamm Creek, which are perennial streams within the Gant Gulch Area. Dry Hollow Creek is also within the Project Area. Riparian habitat is found along the banks of these streams. The riparian vegetation along Middle Mamm creek extends up to 100 feet on either side of the creek. The riparian habitats associated with Middle Mamm, East Mamm and Dry Hollow Creeks, have been determined to be “non-functional” or “functioning at risk” (M. Kinser, BLM, personal communication, September 2005) (BLM 2005).

The Grass Mesa area is located within the watersheds of Dry Creek and Ramsey Gulch. Both of these creeks are tributaries to the Colorado River. Stream flows in the drainages within the Grass Mesa area are generally ephemeral and dependent on seasonal storm and snowmelt runoff. Floodplain habitats occur along the intermittent drainages within Dry Creek and Ramsey Gulch but no floodplain habitat would be impacted by the proposed action. Intermittent drainages occur along Dry Creek and Ramsey Gulch. However, no wetland habitats or riparian vegetation have been documented along these drainages (BLM 2004)

2.8 Master SWMP Permit Area Map and Individual Stormwater Site Plans

An overall Master SWMP Permit Area Map is provided as Appendix D. This map is likely to change constantly and will be updated at least annually. The Master SWMP Permit Area Map includes:

- Contours and elevations (topography) with existing drainage patterns;

- Locations and names of major surface waters such as streams, wetlands, irrigation ditches, canals, etc.;
- Master SWMP permit area boundaries;
- Construction area locations including roads, pipelines, well pads, compressor station facilities, treatment facilities, water parks, and all other facilities.

Individual Stormwater Site Plans (Site Plans) of each site (well pad, access road, section of pipeline, etc.) are provided with the Site Specific Records (Volume 2 of the Master SWMP) Separate Site Plans will be developed for each phase of construction: preconstruction, construction, interim reclamation (if applicable), final stabilization (if applicable) and final reclamation (if applicable). These Site Plans include:

- Construction site boundaries (this is the area expected to be disturbed by clearing, excavating, grading, or other construction activities);
- Contours and elevations (topography) with existing and proposed drainage patterns;
- Limits of well pads and locations of reserve pits and well heads (if applicable);
- All areas of ground surface disturbance, including areas of cut and fill;
- Locations of all potential pollutant sources listed in Section 2.5 (including areas used for vehicle fueling, the storage of materials, equipment, soil, or waste, etc…);
- Locations of all minor surface waters and all anticipated allowable sources of non-stormwater discharge (including springs, dewatering, concrete washout, etc…);
- Locations of all existing and planned BMPs (including erosion, drainage, and sediment controls);
- Locations, names, distances to streams, wetlands, irrigation ditches, canals, other surface waters, etc;
- The size, type and location of any outfall(s). If the stormwater discharge is to a municipal separate stormwater system, name that system, the location of the storm sewer discharge, and the ultimate receiving water(s).

Figures showing typical BMP locations along roadways and pipelines are provided as part of the BMP Manual (discussed in Section 3.3).

3.0 Best Management Practices (BMPs)

A key component of this Master SWMP is employing BMPs to improve stormwater quality. Local factors will be evaluated to determine what BMPs are suitable and practical at different locations. BMPs will be employed in different combinations during construction activities and phases as conditions warrant. Due to the fact that this Master SWMP is likely to cover more than one ecosystem (as described in Section 2.4), the selection of BMPs (including type, quantity, sequence/combination, etc.) will vary at each site within the Master SWMP Permit Area. Specific BMPs to be employed at each well pad, road, pipeline, or other facility are identified on the Site Plans, which are kept with the Site Specific Records (Volume 2 of the Master SWMP).

3.1 Erosion, Drainage, and Sediment Control BMPs

The primary method for controlling erosion, drainage, and sediment transport consists of minimizing initial disturbance of the soil and ground cover. However, many other methods can also be used. All stormwater-related BMPs will fall under at least one of the following three types of controls:

- **Erosion Control.** Any source control practice that protects the soil surface and/or strengthens the subsurface in order to prevent soil particles from being detached by rain or wind, thus controlling raindrop, sheet, and/or rill erosion.

- **Runoff Control.** Any practice that reduces or eliminates gully, channel, and stream erosion by minimizing, diverting, or conveying runoff.

- **Sediment Control.** Any practice that traps the soil particles after they have been detached and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them prior to leaving the site boundary.

BMPs may also be classified as either structural or non-structural controls:

- **Structural Control.** Handles sediment-laden stormwater prior to it leaving each site. Structural BMPs are used to delay, capture, store, treat, or infiltrate stormwater runoff. Some examples of structural BMPs include sediment traps, diversions, and silt fences. Most Runoff Controls and Sediment Controls can also be classified as Structural Controls.

- **Non-structural Control.** Reduces the generation and accumulation of pollutants, including sediment, from a construction site by stabilizing disturbed areas and preventing the occurrence of erosion. Some examples of non-structural BMPs include revegetation, mulching, and surface roughening. These types of stabilization techniques are not only the most effective method for reducing soil loss, but they are also normally the most cost effective due to low initial cost and reduced maintenance requirements. Most, but not all, Erosion Controls can also be classified as Non-structural Controls.

The Site Plans, as mentioned previously and kept with the Site Specific Records (Volume 2 of the Master SWMP), show the proposed locations of all erosion, drainage, and sediment control BMPs (both structural and non-structural). Detailed descriptions, design criteria, construction specifications, and maintenance information for all BMPs are provided in the BMP Manual (discussed in Section 3.3).

3.2 Non-Stormwater Control BMPs

Non-stormwater controls include general site and materials management measures that indirectly aid in the minimization of water pollution. Types of pollution sources include, but are not limited to, litter, oil and grease, hazardous material spills, and sediment.

3.2.1 Materials Delivery and Storage

The good housekeeping practices listed below will be followed on site during construction and operation:

- An effort will be made to store only enough product required for task completion.
- All materials stored on site will be stored in a neat and orderly manner in appropriate containers and, where possible, under a roof or other enclosure, and/or within secondary containment areas to avoid contact with stormwater.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Whenever possible, all of the product will be used before disposing of the container.
- Manufacturer's recommendations for proper use and disposal will be followed.

Additional information on material delivery and storage is available in the BMP Manual (discussed in Section 3.3).

3.2.2 Material Handling and Spill Prevention

In addition to the material storage practices (listed in the previous section) that will be used to reduce the risk of spills or other accidental exposure of materials and substance, the BMP Manual (discussed in Section 3.3) will provide more detailed information on spill prevention and control. Furthermore, the Spill Prevention, Control and Countermeasure (SPCC) Plan will be followed for the control of hydrocarbons. In general, spill prevention and response procedures will include notification (CDPHE 24-hour spill reporting line – 877-518-5608), clean-up with the use of spill kits and absorbents, and ensuring that materials and wash water can not discharge from the site, and never into a storm drain system or stream.

3.2.3 Vehicle Cleaning, Fueling, Maintenance, and Tracking Controls

As required by EnCana Oil & Gas (USA), Inc. master service agreement(s) and drilling contract(s), contracting companies and/or vendors are required to service all vehicles and equipment prior to entering EnCana facilities. However, in the event maintenance procedures are required at EnCana facilities, all fluids transferred must utilize secondary containment and drip pans to minimize a release of materials and properly dispose or recycle spent materials in compliance with local, state, and federal guidelines.

While on site, equipment will be parked, serviced, and fueled within designated areas. Equipment fueling on pipeline rights-of-way will be mobile during active construction. Periodic inspections of equipment and control procedures will be implemented. Selected equipment may be fueled in place using fuel trucks. When necessary, equipment and machinery will be decontaminated at an on-site decontamination area prior to removal from the construction area. Areas will be provided with adequate waste disposal receptacles for liquid as well as solid waste.

Vehicle tracking of sediments is not expected to be a problem due to construction scheduling. Construction vehicles will remain on site throughout earth-moving activities. All other vehicles remain in stabilized areas and do not enter the construction area until that area is stabilized. However, applicable BMPs (such as scheduling (to minimize site access), stabilized construction entrances, vehicle cleaning, etc.) will be utilized if sediment tracking does become a problem.

In addition to the typical practices listed above, the BMP Manual (discussed in Section 3.3) provides more detailed information on vehicle cleaning, fueling, maintenance, and tracking controls.

3.2.4 Waste Management and Disposal

As required by EnCana Oil & Gas (USA), Inc. master service agreement(s) and drilling contract(s), contracting companies and/or vendors are required to manage all waste generated by their activities at EnCana facilities in compliance with local, state, and federal guidelines. EnCana Oil & Gas (USA) utilizes a periodic inspection program to ensure waste management requirements are fulfilled and inspections are documented.

A few of the waste management procedures that will be followed include the following:

- Proper bins will be provided for trash collection and disposal in compliance with local, state, and federal guidelines.
- Contaminated soils will be placed into a lined and bermed area. Samples of the impacted soil will be collected and a complete characterization analysis will be performed. When applicable, the impacted soil will be sent to a licensed disposal facility.
- The contractor will provide portable toilets. Sanitary waste will be regularly collected by a licensed sanitary waste management contractor and disposed of in an approved manner.
- In the event that sediment is inadvertently transported off the construction site, it will be collected and returned to the site and placed on the soil stockpile or spread over the construction pad area and compacted.

On well pads and access roads concrete washout is used as an interior conductor pipe ballast. Concrete washout water can NOT be discharged to surface waters or to storm sewer systems without separate permit coverage. However, discharge to the ground of concrete washout water from washing of tools and concrete mixer chutes may be authorized by this permit, provided that (CDPHE, 2007a):

1. The source is identified in the SWMP;
2. BMPs are included in the SWMP to prevent pollution of groundwater; and
3. These discharges do not leave the site as surface runoff or to surface waters.

Locations where concrete washout activities take place are shown on the Site Plans.

Additional waste management procedures, including solid waste, hazardous waste, contaminated soil, concrete washout, and septic and sanitary waste, are included in the BMP Manual (discussed in Section 3.3).

3.2.5 Dewatering

Dewatering refers to the mechanical removal of water from an excavation or other structure. Both groundwater and stormwater may require dewatering during construction. Dewatering of pipelines at the completion of hydrostatic testing will be required for most pipeline installations.

3.2.5.1 Groundwater Dewatering

Groundwater is very rarely encountered during the construction activities associated with either E&P sites or Midstream Services sites. If groundwater is encountered, it is typically during construction of a pipeline across a stream crossing. These pipelines are either bored under the stream or a flume is utilized.

Non-stormwater construction dewatering of groundwater can NOT be discharged to surface waters or to storm sewer systems without separate permit coverage. However, discharges to the ground of water from construction dewatering activities may be authorized by this permit, provided that (CDPHE, 2007a):

1. The source is groundwater and/or groundwater combined with stormwater that does not contain pollutants in concentrations exceeding the State groundwater standards in Regulations 5 CCR 1002-41 and 42;
2. The source is identified in the SWMP;
3. BMPs are included in the SWMP; and
4. These discharges do not leave the site as surface runoff or to surface waters.

Dewatered groundwater shall be pumped or diverted to a sediment control BMP prior to discharge to the ground. Locations of groundwater dewatering, as well as any BMPs utilized, will be noted on the Site Plans as soon as such dewatering occurs. Additional information on groundwater dewatering is provided in the BMP Manual, discussed in Section 3.3.

3.2.5.2 Stormwater Dewatering

The discharge of pumped stormwater (not including groundwater or other non-stormwater sources) from excavations, ponds, depressions, etc., to surface water, or to a municipal separate storm-sewer system is allowed by the Stormwater Construction Permit, as long as the dewatering activity and associated BMPs are identified in the SWMP (including location of the activity), and BMPs are implemented in accordance with the BMP Manual, discussed in Section 3.3 (CDPHE, 2007c).

Stormwater that collects in open depressions or trenches during construction activities will be dewatered into an existing sediment control, such as a detention pond, a sediment trap, or simply into a well-vegetated area to percolate into the ground and catch suspended sediment. The quality, source, and location of dewatering, as well as any BMPs utilized, will be noted on the Site Plans as soon as such dewatering occurs. Additional information on stormwater dewatering is provided in the BMP Manual, discussed in Section 3.3.

3.2.5.3 Pipeline Dewatering

New Department of Transportation (DOT) pipelines are hydrostatically tested with water upon completion of construction. Once the hydrostatic testing has been completed, dewatering of the pipeline must occur. This will involve the insertion of a displacer, commonly referred to as a pig, in the pipeline. The discharge rate will be regulated, and energy dissipation devices, and/or sediment controls will be used, as necessary, to prevent erosion, streambed scour, suspension of sediments, or excessive streamflow. Locations on pipeline dewatering, as well as any BMPs utilized, will be noted on the Site Plans as soon as such dewatering occurs. Additional information on stormwater dewatering is provided in the BMP Manual, discussed in Section 3.3.

3.3 Stormwater Manual of BMPs

A Stormwater Manual of Best Management Practices (BMP Manual) is provided as Appendix E. The BMP Manual has been prepared to provide EnCana personnel, contractors, and subcontractors with information on the proper selection, design, installation, and maintenance of BMPs to manage oil and gas related stormwater and to meet federal and state SWMP implementation requirements. The main objectives of the BMP manual are to:

- Serve as an easy-to-use guide for selecting, designing, installing, and maintaining BMPs.
- Function as a reference for construction plans and specifications.
- Ultimately lead to the avoidance of any net increase in off-site erosion and sedimentation of waters of the U.S.

The BMPs within this BMP Manual are organized into four main types of controls for easy reference: Erosion Controls, Runoff Controls, Sediment Controls, and Non-stormwater Controls. Each of these types of controls has been discussed earlier in this section of the SWMP.

3.4 Phased BMP Implementation

Various BMPs will be implemented and maintained during different phases of the project. A description of each phase is as follows:

- **Preconstruction.** The preconstruction phase involves the installation of BMPs (temporary and/or permanent) around each site perimeter and at discharge points (such as vegetation buffers (no installation required for this BMP), slash, wattles, diversions, sediment basins and reservoirs, etc…).
- **Construction.** The construction phase involves the stripping and stockpiling of topsoil, the excavation and backfill for access roads, pipelines, and well pads, and the installation of additional BMPs (preferably permanent BMPs) to control erosion and sedimentation (such as tracking topsoil piles and the installation of roadside channels, culverts, diversions, etc…).
- **Interim Reclamation.** The interim reclamation phase primarily involves seeding of all disturbed areas not needed during operation of the well pads. However, this phase also involves the installation of any additional permanent BMPs that may be needed, as well as the continued maintenance and inspections of all BMPs until final stabilization occurs. Final stabilization occurs once all surfaces are built on, paved or graveled, and/or a uniform stabilized vegetative cover with a density of 70 percent of pre-disturbance levels has been established or when an equivalent permanent, physical erosion reduction method has been employed. A further explanation of final stabilization is provided as section 4 of this plan.
- **Final Reclamation.** For pipelines, this phase involves seeding of all disturbed areas, and the installation of any additional permanent BMPs that may be needed, as well as the continued maintenance and inspections of all BMPs until final stabilization occurs. For other areas (roads, well pads, facilities, etc…), this phase (which may occur after termination of this permit and under the coverage of a new construction permit) occurs when operation of the area is no longer necessary. In these cases, this phase will include the installation of any additional BMPs required during facility decommissioning as well as the spreading of any remaining topsoil, the application of seed, and the inspection/maintenance of all BMPs until final stabilization occurs.

Temporary controls, such as silt fencing, may be used to control sediment and erosion during preconstruction and construction activities. Permanent controls, such as diversions and sediment traps, may also be used during the initial phases of the project. However, only permanent controls will be used during interim reclamation and final stabilization. Temporary controls may be converted into permanent controls (such as revegetating a diversion) if needed. The primary control used during interim and final stabilization will be revegetation. Seeding will occur as soon as possible after disturbance of an area is complete. If the seeding is not successful, the area will either be reseeded or other controls will be put in place until reseeding can occur.

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4.0 Interim Reclamation and Final Stabilization

As soon as practicable after construction activities have been completed in a disturbed area, interim (for well pads, or other facilities) or final (for roads and pipelines) reclamation will be started to prevent further erosion of soil from that area. This typically occurs immediately upon completion of earthwork activities. All disturbed areas (except for the surface of dirt roads, those portions covered by pavement or a structure, and those areas used during operation of a well) will be stabilized with permanent controls. The most common measure used to achieve final stabilization is revegetation. Mulching, erosion control blankets, surfacing with gravel or slash, and/or other methods may also be used. Structural controls (such as diversions, berms, and sediment traps) may be revegetated and used as permanent measures to control pollutants in stormwater discharges that will occur after construction operations have been completed. Appendix E includes detailed information on each of the previously discussed BMPs. In addition, a revegetation manual is provided as Appendix B, which provides guidance as to possible methods and materials needed to accomplish revegetation on differing site conditions. The specific BMPs used at each site are shown on the Site Plans which are kept with the Site Specific Records (Volume 2 of the Master SWMP).

Final stabilization means that all ground surface disturbing activities at the site have been completed, and all disturbed areas have been either built on, paved, or a uniform vegetative cover has been established with an individual plant density of at least 70 percent of pre-disturbance levels, or equivalent permanent, physical erosion reduction methods have been employed. For purposes of this permit, establishment of a vegetative cover capable of providing erosion control equivalent to pre-existing conditions at the site will be considered final stabilization. Areas developed as stabilized unpaved surfaces as needed for operation of the facility after interim reclamation, will also qualify as “finally stabilized.” This includes dirt road surfaces and the portions of the well pad surfaces that cannot be revegetated due to operational necessity, but does not include slopes, ditches, and other areas where revegetation is necessary. Stabilized unpaved surfaces will be prepared in such a way as to prevent ongoing erosion issues.

Coverage under the Stormwater Construction Permit may be inactivated for any individual site or a portion/section of that site (i.e. the access road to a well pad) when the area has attained final stabilization and all temporary erosion and sediment control measures associated with that area have been removed. An area will be considered finally stabilized when construction and interim reclamation is complete and when the above final stabilization criteria have been met, even though the site may be disturbed again in the future for final reclamation. However, future land disturbances that follow final stabilization and result in disturbance of one acre or greater (such as final reclamation) will require new permit coverage at that time.

Upon final stabilization of any site or portion/section of a site, Oil and Gas Construction Field Permit Certification NOTICE OF AMENDMENT OF PERMIT COVERAGE and/or Final Stabilization Certification (provided in Appendix F) will be placed into the Site Specific Records binder to replace the Site Plans and the inspection and maintenance records for that area. However, the Site Plans and inspection reports shall be retained in a separate location for a period of three years following final stabilization of the Permit Coverage Area. These documents will be made available to WQCD or EPA upon request and at the time of inspection.

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5.0 Inspection and Maintenance

Inspections and maintenance is an extremely important part of the Stormwater Construction Permit. The Construction Manager will ensure that all stormwater management controls are constructed or applied in accordance with governing specifications or good engineering practices. Experienced teams will be used for construction. A first inspection will occur upon installation of the controls. In addition, all workers on the site will be trained as to the location and use of the controls, especially those controls that will be disturbed as construction proceeds across the site. The goal is to minimize the potential for inadvertent removal or disturbance of BMPs and to prevent the off site transport of sediment and other pollutants.

5.1 Inspection Schedule

Inspections are required as soon as the first soil disturbance occurs at the site. Once final stabilization of the site has occurred and the EnCana inspector has filled out the final stabilization certification sheet (see Section 4), inspections are no longer necessary. Specific information regarding inspection schedules are provided in the following sections.

5.1.1 Minimum Inspection Schedule for active sites

The minimum inspection schedule applies to those sites under active construction, which includes the period from when the ground is initially disturbed to when construction activity is completed, and also includes the preparation of areas that will be revegetated for interim reclamation. During the Active Site period, a thorough inspection of the site stormwater management system (which includes all utilized BMPs) must be conducted at least every 14 calendar days. Also, post-storm event inspections must be conducted within 24 hours after the end of any precipitation or snowmelt event that causes surface erosion.

There are three exceptions to the minimum inspection schedule which are described in detail within the next three sections: post-storm event inspections at temporarily idle sites (inspections required within 72 hours after a storm), inspections at completed sites (inspections required monthly), and inspections during certain winter conditions (inspections may not be required). Any use of an exception is temporary, and does not eliminate the requirement to perform routine maintenance due to the effects of a storm event or other conditions that may impact BMP performance, including maintaining vehicle tracking controls and removing sediment from impervious areas. Inspections, as described above, are required at all other times.

5.1.2 Post-Storm Event Inspections at Temporarily Idle Sites

Temporarily idle sites are those where there are no construction activities occurring following a storm event. At such sites, post-storm event inspections must be conducted prior to restarting construction activities at the site, but no later than 72 hours following the storm event, and the delay noted in the inspection report. Routine inspections still must be conducted at least every 14 calendar days.

5.1.3 Completed Sites

Once construction is completed and the site has been prepared for interim or final stabilization (including completion of appropriate soil preparation, amendments and stabilization practices), the site (or portion of the site) is considered a Completed Site (for purposes of the stormwater permit). Note: only construction activities that result in a disturbance of the ground surface must be completed. Construction activities that can be conducted without disturbance of the ground surface, such as certain well completion activities, would not prohibit a site from otherwise qualifying as a Completed Site. (Completed Sites still require permit coverage until the final stabilization criteria have been met)

Completed Sites qualify for a reduced inspection schedule, as the potential for pollution is reduced if the site has been adequately prepared and/or seeded. However, because slopes and other disturbed areas may not

be fully vegetated, erosion in these areas still occurs which requires maintenance activities such as regrading and seeding of problem areas. As such, inspections must continue in order to address these situations. During the Completed Site period, a thorough inspection of the site stormwater management system (which included all utilized BMPs) is required at least once every month. The SWMP must be amended to indicate those areas that will be inspected at this reduced frequency.

5.1.4 Winter Conditions Inspections Exclusion

Inspections are not required at sites where construction activities are temporarily halted, snow cover exists over the entire site for an extended period, ***and*** melting conditions posing a risk of soil erosion ***do not exist***. This temporary exclusion is applicable only during the period where melting conditions do not exist, and applies to the routine 14-day and monthly inspections, as well as the post-storm-event inspections. It is typical that when snow cover exists, even at a Completed Site, significant potential for erosion and BMP failure exists when melting does finally occur. Therefore, the site should prepared prior to snow cover to ensure it is as stabilized as possible, and be prepared to perform site maintenance when melt-off occurs, to alleviate any potential problems. Inspection records (see Section 5.4) will document that winter conditions exist and that inspections will be excluded.

5.2 Performing Inspections

Inspections will be conducted by qualified personnel on the following areas:

- All vegetated areas until 70% of pre-disturbance vegetation levels are reached.
- All BMP measures identified in this document.
- Construction site perimeter and discharge points.
- All disturbed areas.
- Areas used for storage of material/waste that are exposed to precipitation.
- Other areas determined to have a significant potential for stormwater pollution, such as demolition areas or concrete washout locations, or locations where vehicles enter or exit the site.

These areas will be inspected to determine if there is evidence of, or the potential for, pollutants leaving the construction site boundaries, entering the stormwater drainage system, or discharging to state waters. All BMPs will be evaluated to determine if they still meet the design and operational criteria in the SWMP and if they continue to adequately control pollutants at the site. Any BMPs not operating in accordance with Appendix E of this SWMP will be addressed as soon as possible, immediately in most cases, to minimize the discharge of pollutants, and the Site Specific Records will be updated.

5.3 Maintenance

Maintenance activities will ensure that all control measures are functioning at optimum levels and that all procedures and techniques will be in proper working order during a runoff event or spill condition. Any maintenance, repairs, or replacements deemed necessary after required inspections will be corrected as soon as possible (if not immediately), to minimize the discharge of pollutants. Certain maintenance procedures may take a short period of time to make sure that all the proper safety precautions are in place, such as a “one call” for utilities, if the maintenance involves excavation of sediment located above a buried pipeline.

Maintenance will include, but is not limited to:

- Pickup or otherwise prevention of litter, construction debris, and construction chemicals from becoming a pollutant source prior to anticipated storm events.
- Removal of sediment from silt fences, sediment traps, and other sediment controls.

- Reseeding of any bare spots where vegetation has failed to establish.
- Repairs and/or adjustments to any erosion and sediment control that is deteriorating or found to be performing inadequately.

Detailed maintenance requirements for each BMP are identified in Appendix E.

When maintenance is required, the following process will typically be followed:

1. Perform inspections according to the minimum inspection schedule discussed in Section 5.1.
2. Note the need for maintenance on the inspection and maintenance report form.
3. If necessary, collect the additional materials and/or resources needed to perform the maintenance activity.
4. Perform maintenance and note the date performed on the inspection and maintenance report form.
5. Re-inspect the area to ensure compliance.

5.4 Documenting Inspections and Maintenance

The permittee must document inspection results, maintenance activities, and maintain a record of the results for a period of 3 years following expiration or inactivation of permit coverage. A typical inspection and maintenance report form is provided in Appendix G. Although the site may have a phased construction schedule, all construction areas may be inspected at the same time and on one form. Each well pad, road, pipeline, or other facility which is inspected shall be clearly written on the inspection form. Inspection reports will include the following:

- Date of inspection, name of inspector, and title of inspector
- The area inspected (Site ID), type of area (well pad, access road, pipeline, etc.), phase of construction (preconstruction, construction, etc.), and type of inspection (active, completed, etc.)
- Site specific information including disturbed area, soil type(s), ecosystem/vegetation type(s), receiving waters, etc.
- Vegetation observations including the percent pre-disturbance vegetation and whether or not vegetation growth has reached 70% of pre-disturbance levels
- Specific inspection requirements (all BMPs and areas of potential pollutant sources)
- Observed conditions including:
  - Location(s) of discharges of sediment or other pollutants from the site
  - Location(s) of BMPs that need to be maintained
  - Location(s) of BMPs that failed to operate as designed or proved inadequate for a particular location
  - Location(s) where additional BMPs are needed that were not in place at the time of inspection
- Description and date(s) of corrective action(s) taken, and measures taken to prevent future violations
- Changes necessary to the SWMP

A hand drawn Site Plan shall be included, if necessary, to show the location(s) of any observed condition (as listed above).

After adequate corrective action(s) has been taken and recorded, or where a report does not identify any incidents requiring corrective action, the report will contain a signed statement indicating the site is in compliance with the permit to the best of the signer's knowledge and belief.

All completed inspection and maintenance report forms (a blank copy of which is included in Appendix G) are kept with the Site Specific Records (Volume 2 of the Master SWMP).

6.0 Plan Revisions and Retention

When BMPs or site conditions change, the Master SWMP (Volume 1) and/or the Site Specific Records (Volume 2) will be amended to accurately reflect the actual field conditions. Examples include, but are not limited to, removal of BMPs, identification of new potential pollutant sources, addition of BMPs, modification of BMP installation/implementation specifications or maintenance procedures, and changes in items included in the Site Plans. Changes to the Master SWMP (Volume 1) shall be noted on the SWMP Revisions log at the front of this plan. Changes to individual site conditions will be noted in the Site Specific Records (Volume 2) on the applicable inspection and maintenance report form. All changes in Volume 1 and Volume 2 shall be made prior to actual changes in the site conditions, except for responsive SWMP changes, which shall be made immediately after changes are made in the field or as soon as practical, but in no case more than 72 hours after the change(s) in BMP installation and/or implementation occur at the site that require development of materials to modify the SWMP. At a minimum, the Master SWMP will be updated annually.

The Master SWMP and the Site Specific Records will be retained at the EnCana field office in Parachute during active construction and site inspections to ensure accurate implementation and maintenance of BMPs, and required revisions. These documents will be retained for a period of three years following final stabilization of the Permit Coverage Area. These reports will be made available to WQCD or EPA upon request and at the time of inspection.

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7.0 Inactivation Notice

When all disturbed areas associated with the Stormwater Construction Permit have reached “final stabilization" (as described in Section 4), all temporary erosion and sediment control measures have been removed, and all components of the SWMP are complete, the area no longer requires coverage under the permit terms. At that time, EnCana will submit an Inactivation Notice that closes this permit to the WQCD upon final stabilization of all areas covered by the permit. A blank copy of this form is included in Appendix H of this document.

Upon receipt of the Inactivation Notice, the WQCD will provide written confirmation that coverage under this permit has been terminated. This historical documentation will be maintained at the EnCana field office in Parachute for a period of at least three years following termination of permit coverage.

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8.0 Signature

The signature page will not be signed unless the SWMP is requested by an agency as a legal document. At that time, the supervisor will review the most updated version of the SWMP and sign it before submitting to an agency.

"*I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted, to the best of my knowledge and belief, is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment or knowing violations.*"

Printed name	Title
Signature	Date
Printed name	Title
Signature	Date

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Appendix A

General Permit Application

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STATE OF COLORADO

Bill Ritter, Jr., Governor
James B. Martin, Executive Director

Dedicated to protecting and improving the health and environment of the people of Colorado

4300 Cherry Creek Dr. S.
Denver, Colorado 80246-1530
Phone (303) 692-2000
TDD Line (303) 691-7700
Located in Glendale, Colorado

http://www.cdphe.state.co.us

Laboratory Services Division
8100 Lowry Blvd.
Denver, Colorado 80230-6928
(303) 692-3090

Colorado Department
of Public Health
and Environment

June 20, 2007

Terry C. Gosney, Envir. Coord.
EnCana Oil & Gas (USA) Inc.,
2717 County Road 215 Ste. 100
Parachute, CO 81635
970/285-2687

RE: Final Permit, Colorado Discharge Permit System – Stormwater
Certification No: COR-034840
Mamm Creek
Garfield County

Local Contact: Terry Gosney, Envir. Coordinator
970/309-8155

Dear Sir or Madam:

Enclosed please find a copy of the new permit and certification which have been re-issued to you under the Colorado Water Quality Control Act.

Your old permit expires on June 30, 2007. This is a renewal to the permit, and replaces the old one. See page 2 of the Rationale (the pages in italics) for a summary of the changes to the permit.

Your Certification under the permit requires that specific actions be performed at designated times. You are legally obligated to comply with all terms and conditions of the permit.

Please read the permit and certification. If you have any questions please visit our website at : www.cdphe.state.co.us/wq/permitsunit/stormwater or contact Matt Czahor at (303) 692-3517.

Sincerely,

Kathryn Dolan
Stormwater Program Coordinator
Permits Unit
WATER QUALITY CONTROL DIVISION
xc: Regional Council of Governments
Local County Health Department
District Engineer, Technical Services, WQCD
Permit File

STATE OF COLORADO

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
WATER QUALITY CONTROL DIVISION
TELEPHONE: (303) 692-3500

CERTIFICATION TO DISCHARGE
UNDER
CDPS GENERAL PERMIT COR-030000
STORMWATER DISCHARGES ASSOCIATED WITH CONSTRUCTION

Certification Number **COR034840**

This Certification to Discharge specifically authorizes:

EnCana Oil & Gas (USA) Inc.

LEGAL CONTACT:
Terry C. Gosney, Envir. Coord.
EnCana Oil & Gas (USA) Inc.
2717 County Road 215 Ste. 100
Parachute, CO 81635
Phone # 970/285-2687
terry.gosney@encana.com

LOCAL CONTACT:
Terry Gosney, Envir. Coordinator,
Phone # 970/309-8155
terry.gosney@encana.com

During the Construction Activity: **Gas/Oil Field Exploration and/or Development**
to discharge stormwater from the facility identified as **Mamm Creek**
which is located at:

Various locations
Various locations, Co 81650

Latitude **39/25/00,** Longitude **107/50/00**
In **Garfield County**

to: -- Colorado River

Anticipated Activity begins **07/01/2002** continuing through **06/30/2010**
On **999** acres (**999** acres disturbed)

Certification is effective: **07/01/2007** Certification Expires: **06/30/2012**

Annual Fee: $245.00 **(DO NOT PAY NOW** – A prorated bill will be sent shortly.)

Appendix B

Revegetation Manual

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EnCana Oil & Gas (USA), Inc. Revegetation Manual

Table of Contents

EnCana Oil & Gas (USA), Inc. Revegetation Manual

Introduction

The objective of a revegetation program is to establish a diverse self sustaining vegetative cover that provides for erosion control and a productive land use. There is not a single best method to revegetation practices. This is why revegetation is considered "an Art and a Science". As many revegetation practitioners have said in the past it is better to be lucky than good. Meaning that the most critical ingredient needed to complete the cycle of revegetation is adequate and timely rainfall. Achieving successful revegetation of a disturbed area is even more complicated than a successful crop from dry land farming. Farming practices are normally completed on land that has prime soil for plant growth and consist of cereal grain crops that are easier to grow than native grasses.

This manual is for the layman who needs to understand revegetation as part of their job duties with EnCana Oil & Gas (USA), Inc., but does not necessarily have the college degree or hands on experience to complete this type of work. This manual will present steps and options that will help increase the chances of successful revegetation. There are sections

that outline methods and materials needed to accomplish revegetation on differing site conditions.

1.0 Fertilization

Fertilization of areas to be revegetated is often times a consideration. Soil test of the areas to be seeded are the best way to determine if fertilizer is needed. The major nutrients needed by native vegetation for growth is Nitrogen, Phosphorus, and Potassium. Nitrogen is for top growth of plants, Phosphorus is for root growth, and Potassium is for the overall health and vigor of plants. All fertilizer will list the nutrients in the order of Nitrogen, Phosphorus, and Potassium or N-P-K. For example a product listed as 18-46-0 will contain 18 % Nitrogen, 46% Phosphorus, and 0% Potassium.

Nitrogen may not be at desirable levels in the soil at the time of seeding. However, research has shown that adding nitrogen at the time of seeding can often times increase the growth and cover of weed species at the expense of the desirable seeded species. Also, nitrogen can not be metabolized by native grasses until they are approximately one year old. For these reasons, most experienced revegetation specialists will not recommend the use of nitrogen at the time of seeding. Instead, they will tend to place nitrogen fixing legumes in the seed mixture. These legumes will pull nitrogen from the atmosphere and provide it later to other plants such as grasses.

Phosphorus most likely will be the limiting nutrient in the soil. It is advisable to add phosphorus prior to soil tillage and work it into the soil to a depth of 6 to 8 inches.

Most native soils in Colorado contain optimum levels of potassium. Therefore, potassium should very seldom if ever be needed in the Colorado Fields.

Fertilizer is typically applied using a Three Point Hitch Tractor Mounted Spreader or Fertilizer Buggy Wagon Implement (See photo #'s 1 and 2: Three Point Spreader and Fertilizer Buggy Wagon). Both of these styles of spreaders are considered broadcast spreaders. Their width of application is typically between 10 and 30 feet. The amount of fertilizer applied per acre is controlled by a slide gate opening on the bottom of the spreader.

2.0 Soil Preparation

Soil Preparation is a critical first step to revegetation. The objective is to have the surface 8 inches of soil loose enough to allow for root growth and firm enough on the surface for good seed to soil contact. The soil surface should also be relatively free of rocks, debris, and dirt clods greater than 3 inches in diameter. Too much debris, rock, and clods will prohibit proper seed placement.

There are several types of implements that can be pulled behind farm tractors or small dozers to till the soil. These consist of disk, chisel plows, subsoilers, and harrows. The working widths commercially available for soil preparation implements typically vary 6 feet to over 20 feet. The working width of implements used by contractors is typically based on site access and size. Also, smaller contractors may have a limited number and size of tillage implements in their equipment fleet.

2a. Disking

Disks are normally used where there is significant surface compaction and the soil needs to be tilled to loosen and large soil clods need to be broken down. Disks also are used where there is a concern of bringing more rock up to the soil surface as will occur with chisels,

rippers, and subsoilers. Disks should not be used alone where extreme subsoil compaction exist. There are offset disks and tandem disks available on the market. Tandem disks turn the soil twice and offset disks move the soil in opposing directions and help level the surface (See photo #'s 3 and 4: Tandem Disk and Rhome Offset Construction Disk). On very rough sites a Rhome brand construction type disk is recommended because of the weight of the disk and its ability to withstand rough conditions (See photo #4: Rhome Offset Construction Disk). A heavy construction disk normally needs to be pulled behind a mid-size dozer or large 4WD tractor because of its weight and soil penetration ability.

2b. Chisel Plowing

A chisel plow cuts through the soil and helps to eliminate soil compaction to a depth of approximately 8 inches (See photo #'s 5 and 6: Chisel Plow). Chisel plowing to a shallower depth can help cut off and kill weeds. Some rock and clod material can be brought to the soil surface during this operation. If a significant amount of clods are brought up to the soil surface then a cultipacker (See Section 2e.) should be utilized to break clods back down prior to seeding.

2c. Subsoiling

Subsoiling is used to break up compacted soil layers 6 to 24 inches in depth (See photo #7: Subsoiler). Subsoiling helps to improve water infiltration and aerates subsoil layers to encourage root penetration. Subsoiling can bring up significant large clods in zones with heavy clays and compacted zones. Cultipacking (See Section 2e.) will need to follow subsoiling when large volumes of clods greater than 3 inches are brought to the soil surface.

2d. Harrowing

Harrows lightly scratch the ground to loosen a shallow layer of soil (4 inches or shallower). The three styles of harrows consist of a spike tooth harrow (See photo #8), flex-tine tooth harrow (See photo #9), and spring tooth harrow (See photo #10). Harrows should only be used on loose friable soils that do not require deep tillage. Harrows can be used to remove undesirable vegetation such as weeds that will interfere with seeding operations. Harrows will break up surface crust and generally break up clods of topsoil material, but not hard and massive subsoil material. Harrows are excellent for preparing a seedbed for small seeds such as forbs and some shrub seeds.

2e. Cultipacking

Cultipackers consist of front rollers that are an open mesh, a middle set of rippers, and a back set of rollers with knurled edges (See photo #11: Cultipacker). The front set of rollers crushes clods, the rippers bring additional clod material to the soil surface, and the rear roller crushes remaining clods and firms the soil surface.

3.0 Drill Seeding

3a. Equipment

Drill seeders are implements that are towed behind an agricultural seeder or small crawler dozer (See photo #'s 12 and 13: Truax and Horizon Brand Drills). Drill seeding is considered the optimum means of planting grasses, forbs, and most shrub seed. Rangeland type drill seeders used for planting native vegetation should have several critical features or components. This includes three seed boxes, double disk furrow openers equipped with depth bands, press wheels or drag chains (See photo #'s 14, 15, and 16: Close-up of Double Disk Furrow Openers and Depth Bands, Press Wheels, and Drag Chains in Transport Position).

The drill seeder should be equipped with three different seed boxes: A legume box is needed for small seed such as wildflowers, alfalfa, sweet clover, etc., a trashy seed box with aggressive picker wheels for handling trashy seed such as bluestems and gramas (See photo #17: Trashy Seed Box Picker Wheels), and a standard seed box used for flowable seeds such as wheat grasses and small grains (See photo #18: Small Grain Standard Seed Box/Seed Cups). Most native grass drill seeders come in 8 to 10 foot planting widths.

The seed drill is activated by a series of gears and chains that are attached to one of the drill wheels on the drill (See photo #19: Seed Drill Gear Assembly). When the drive wheel is activated it turns the gears which turn the shafts that run through the seed boxes. The seed gravity feeds into seed cups that are attached to the shaft (See photo #18: Small Grain Standard Seed Box/Seed Cups). The trashy seed box has an extra shaft that runs above the seed cup shaft and has an aggressive picker spiral agitator wheel which forces the seed down to the seed cup so it does not simply float in the seed box (See photo #17: Trashy Seed Box Picker Wheels). The seed from all seed boxes falls through a hole in the seed box where a flexible rubber tube is connected between the bottom of the seed box and the double disk furrow openers (See photo #20: Seed Tubes). The double disk furrow openers, as the name implies, opens a small trench in the soil that the seed falls into. As the drill moves forward the seed is covered with soil and pressed into the ground by the press wheels or drag chains (See photo #'s 15 and 16: Press Wheels and Drag Chains in Transport Position). It is very important that the seed is planted to the right depth and the seed is pressed into the soil firmly to press out air and allow the seed to absorb moisture as it becomes available to help germinate the seed. The double disk is attached to a lift arm assembly that allows it to roll and float over minor obstacles in the ground such as small rocks tree branches, and dirt clods. The drill should be lifted up by using the hydraulic cylinder when large rocks and debris are encountered in the drills path. While rangeland type drill seeders are built to handle tough conditions they can be high maintenance and require a supply of extra parts in the field when breakdowns occur.

3b. Methods of Use

Drill seeders should be calibrated for use on a small area before all seeding is completed. Most manufacturers of drill seeding equipment can provide general guidelines as to the amount of seed output by seed box for flowable seeds versus trashy seeds. Calibration will help ensure that the proper amount of Pure Live Seed (PLS) is planted. PLS of any given vegetation species is determined by a registered seed testing laboratory. Individual seeds from individual species are normally placed in a growth chamber to determine the percentage of seeds that will germinate, For example, if 100 seeds are placed in a growth chamber and forced to germinate and only 90 germinate, the germination percentage is considered 90%. Purity is the measure of viable seed and separates out inert material, weed seed (not more than 1% according to federal regulations) and other crop seed. Therefore, the total viable seed is the percent by count that will germinate. The following example provides an illustration of a method of calculating an amount of seed to be planted which takes into account the variation of seed germination and purity of the seed source:

Example of a Pure Live Seed (PLS) Calculation:

A recommended seed mixture requires that 5 lbs. (PLS) of intermediate wheatgrass be planted:

Intermediate wheatgrass germination = 80%
Intermediate wheatgrass purity = 90%

80% X 90% (PLS) = 0.72

$$\frac{\text{5 lbs (PLS) to be planted}}{\text{0.72 (PLS factor)}}$$ = Approximately 7 lbs of bagged seed should be included in the mixture so that 5 lbs of PLS will be planted.

Thus, a seed species PLS factor is based on germination X purity. In order to plant one PLS pound of a species you may end up planting 1.6 to 2.0 times more seed which is considered the bulk seed amount.

The operator should first decide whether to have the seed mixture divided by trashy vs. flowable species or to combine the species and utilize both seed boxes to achieve proper seed output. It is best to consult with your seed dealer to determine just how trashy or fluffy the seed will be. There are several different opinions in the industry as to how to calibrate a native grass seed drill. The most elaborate method of calibration involves jacking up the drill and spinning the drive wheel the number of revolutions that represent an acre. Seed is caught from one of the seed tubes and weighed after spinning the gauge wheel and the seed weight for one tube is converted into the fraction of an acre that the tube represents. Most drill seeders contain either a slide bar with number settings or gear ratios with numbers to increase or decrease the seed output. These adjustments should be made if more than a 10 % variance of less seed than required occurs. Also, adjustments should be made for too much seed being put down which can be a costly mistake as well as planting too much seed for what the soil and environment will support.

The simplest way to calibrate a seed drill is to place two acres worth of seed in the seed box and drill seed ½ acre. Fill the seed box back up to the height it existed with two acres worth of material. Next determine if you had to fill more than a ½ acre of material or less than, or you were right on with the calibration. Be aware that if you had to place less seed back in the box, than the volume you started with, you are not seeding enough. Calibration of a seed drill can change overnight if seed is left in the drill. Seed may settle in the seed box causing a slight amount of packing and humidity can change the way seed flows from the drill. It is best to finish out the seed in the seed box by the end of the day and start fresh the next day. Remember to check the calibration of the drill at least every 10 acres or each time you refill the drill. Always keep the drill boxes full enough that the seed feeds properly. Remember when seeding on side slopes that seed can slide to the down hill side of the seed box leaving little or no seed to be planted on the high side of the drill. Most drills come equipped with divider boxes to keep seed from sliding all the way to the low end of the drill. If the seed drill does not have divider boxes think of ways to place sheet metal or even card board in the drill to divide it into at least three different compartments.

All drill seeding should be completed parallel to slopes or on the slope contour. Drill seeding up and down a slope can result in accelerating erosion after rainfall since the indentations from the drill rows help to concentrate flow and accelerate soil movement down hill. Most native grass species and forbs germinate best if seeded to a depth of ¼ to ½ inch. Most depth bands on drills are set at ½ inch so the seed can not be planted any deeper.

4.0 Broadcast Seeding

Broadcast seeding is typically done where steep slopes prohibit safe operation of a farm tractor or the soil surface is covered with large rock that cannot be economically removed. Hand seeding may be needed in small, tight access areas where machinery cannot effectively operate. Broadcast seeding can be performed either with a hand seeder (See photo #21: Hand Broadcast Seeder) or tractor mounted spreader (See photo #1: Three Point Spreader). Broadcast spreaders typically spread an even swath of seed onto the soil surface. Depending on the roughness of the ground, the seed can end up at various depths in the soil. Broadcast seeding by hand or machine alone will not typically provide good results unless the seed is covered with soil. Broadcast seeding with a tractor should be followed by using a flex harrow to cover the seed with soil. Hand broadcast seeding should be followed by hand raking with a hard tine rake. In both cases the seed should not be raked deeper than ½ inch into the ground.

5.0 Hydroseeding

Hydroseeding is completed with an actual hydroseeder machine. Most people in the industry use the term hydroseeder/hydromulcher interchangeably since they do both operations (See photo #22: Hydroseeder – 3000 Gallon Tank). A hydroseeder/hydromulcher machine consists of a water tank equipped with a motor that operates a hydraulic agitation system. The top of the machine contains a turret or gun where the seed is discharged (See photo #23: Hydroseeder with Gun Operator). The operator will mix the seed and a small amount of hydromulch in the tanker. The green dyed hydromulch will help the operator see the sprayed area during the seeding operation. The objective of using the hydraulic pressure of the machine is to use enough force from the engine RPM's to shoot or push the seed into the ground. If the seed is not adequately covered with soil, hand raking of the area or slope harrowing should be employed.

6.0 Seed Planting Rates and Species Selection for Individual Seed Mixtures

Establishing seed mixtures and planting rates for different native grass, forbs, and shrub seeds is normally done by a revegetation specialist, soil scientist, plant ecologist, or agronomist. These professionals have several years of experience in knowing how many pounds of each type of seed are needed to increase the chances of revegetation success. Any expert in the revegetation industry knows that there are no absolutes in designing a seed mixture. Designing a seed mixture combines both an "Art and a Science".

The consultant takes into account what vegetation species are currently growing by vegetation zone on the site. A native vegetation zone or community is controlled by several environmental factors including elevation, degree of slope, aspect of slope (East, west, north, or south facing), soil type (for example sandy or clayey), and the amount of precipitation that the area receives each year. Vegetation communities will typically have at least two grass species to as many as eight species. Shrub and forbs species will also typically be present. There should be at least three grass species in a revegetation seed mixture. Having a number of species in the mixture will promote diversity in the final vegetative cover and will reduce the risk of revegetation failure if one or more of the species does not adapt to site conditions.

Typically a consultant will base the poundage of each species on several factors. Some species are hard to establish and may require higher poundage of seed to have a chance to establish. Some species may be easy to establish and are seeded at a higher rate to ensure some initial vegetation cover after seeding. Some vegetation species are very aggressive and should represent a small percentage of the seed mixture or they will dominate the site. Each vegetation species has a different number of seeds per pound. For example, Western Wheat Grass has approximately 110,000 seeds per pound while Blue Grama has 825,000 seeds per pound. There are different opinions with scientist as to how much seed to plant on an acre or square foot basis. Typically, the number of seeds planted per square foot is a consideration.

Chenoweth & Associates believes that 30 to 75 seeds per square foot should be planted on any site. Others believe that 144 seeds per square foot should be planted on any site, especially steeper windblown slopes. The higher number of seeds per square foot could be based on the risk of loosing seed to water erosion on steep hill sides or wind erosion in high wind prone areas. Higher seeding rates could also be based on very good topsoil replacement that will allow a site to support more vegetation.

The general role of thumb for hydroseeding and broadcast seeding is to double the drill seed rate of seed. This rule was established since broadcast and hydroseeding does not typically provide for optimum seed placement and planting depth as compared to drill seeding.

A seed mixture at a minimum will consist of native grasses and forbs. As previously mentioned at least three grass species should be in any revegetation seed mixture. The operator (such as EnCana), landowner (either private landowner or federal agencies such as the Forest Service or BLM), and Revegetation Specialist typically consult with one another to determine what the seed mixture should contain. These individuals or organization will determine if the seed mixture should contain only grasses or whether shrub and forbs seed should be added to the seed mixture as well. Typically cost of seed is a driving factor on deciding if these species are added to a seed mixture.

7.0 Seed Quality

Seed purchased from a reputable seed dealer should contain a seed tag that provides the germination and purity of each species in the bag. The seed tag should also indicate the Lot number of the seed (See photo #24: Seed Tag). The lot number is to document where and when the seed was harvested. The seed supplier should supply seed that has been tested within one year of the purchase date.

8.0 Seed Storage

Seed should be properly stored until it is used. Seed should be kept in a cool dark environment. The temperature in the storage area should never exceed 85ºF for enclosed containers and 90ºF for good ventilated storage. Seed is not typically impacted by freezing temperatures and in fact some seeds benefit from cold and heat scarification in order to germinate. Seed which becomes wet for any period of time exceeding 48 hours should not be used. If seed is stored over winter or for any extended period of time should be retested. Some seed species will decrease in germination percentage faster than others. Additional seed of some species may have to be purchased and reblended into the original seed mixture to bring the mixture back up to the proper PLS rate desired.

9.0 Seeding Dates for Colorado Oil & Gas Fields

Desirable seeding dates are typically tied to periods when precipitation will closely follow the actual seed planting. Moisture in the Colorado oil & gas fields typically comes during the summer monsoon period which occurs in July and winter rain or snow which is highest in January, February and March. Seeding needs to be completed when the soil is not frozen or wet. Therefore, consultants feel that optimum seeding dates are early in the spring until May 1, mid-July until September 1, and after the first heavy frost until permanent ground freeze. These dates do not always coincide with construction schedules and the urgency to seed after earth work is completed to help control erosion. There are times that seeding a cover crop during a poor seeding period may be beneficial. There are several sterile hybrid seeds on the market today that germinate easily as long as there is some degree of soil moisture available. They are considered sterile since they will not reseed themselves. These hybrids are called treticale. They are typically a cross between winter wheat and a wheatgrass.

10.0 Seed Germination

Depending on the vegetation species, germination can occur as soon as 10 days after seeding. Germination is dependent on adequate soil moisture and soil temperature. Normally grass seed needs at least 54ºF surface soil temperature to germinate. These temperatures should exist from late April until late August in the Colorado oil & gas fields depending on elevation and soil shading. Germination of all species can often times take several days or weeks depending on the number of species in the seed mixture. Again, this assumes there is adequate soil moisture in addition to proper soil temperatures for seed germination. At the time of peak germination flush as many as 10 to 20 seedlings per square foot may be present. Approximately 75% of the seedlings die off shortly after germination as the plants reach equilibrium of what the soils moisture and nutrient levels will support. If hot dry periods follow germination, some or all of the grasses and forbs may die. A further discussion of this situation is provided in the following section.

11.0 Seeding Success

After germination occurs, new seedlings are very dependent on continued available soil moisture to survive. Some grass species are more susceptible to desiccation and die back than others. Thus, if adequate and timely precipitation does not occur during the first growing season failure of the revegetation may occur. This is why it is very important to use the proper materials and procedures identified throughout this report.

There are at least two university research units that agree on determining revegetation success after the first growing season. Typically, 3 to 4 live healthy seedlings per square foot after the first growing season will yield long term revegetation success. These seedlings will ultimately yield approximately 40% to 60% canopy cover after the plants mature.

12.0 Seed Mixtures for the Colorado Oil & Gas Fields

Seed mixtures will have to be prepared for use in the Colorado oil & gas fields of EnCana Oil & Gas (USA), Inc. well pads, road cut and fill slopes, pipelines and borrow pits. These seed mixtures will be site specific to the ecosystems present. See Appendix A – Seed Mixture Charts with geographic photos for the seven zones of the Colorado oil & gas fields.

13.0 Mulching and Erosion Control

Conserving soil moisture and controlling surface erosion are very important during seedling establishment. Lack of proper erosion control can result in seed being washed away before it germinates. Mulch materials can help conserve soil moisture and reduce erosion. Mulch materials also provide other beneficial functions. They include increasing moisture infiltration from rain and snow, cooling the soil surface, and providing valuable soil organic matter to increase soil structure.

Several different types of mulch materials can be used for revegetation purposes. The most common ones used are hay/straw mulch, hydromulch, Flexible Growth Medium and Bonded Fiber Matrix. There are also several types of roll out erosion control blankets that are available to be used in place of mulches on steep slope areas, drainage areas, and stream channels.

Erosion control is now required by federal and state laws on most disturbed construction sites and falls under what is called Storm Water Management Permitting. A separate report was prepared for EnCana Oil & Gas (USA), Inc. dealing with education on Storm Water Management Planning and Permitting. An extensive list of mulching and erosion control products is discussed in this report.

14.0 Maintenance of Seeded Areas

Maintenance of seeded areas includes weed control, erosion control, and touch up seeding. Most newly seeded sites require these maintenance operations during the first growing season to help insure successful revegetation. In general weed control should be employed anytime weed cover exceeds 20% canopy cover. Site specifics will vary; sometimes 20% weed canopy cover may be desirable. Mechanical weed control must be used immediately after seeding is completed and most likely until the second growing season. Mechanical weed control consists of mowing or hand pulling weeds. Herbicide applications will kill new seedlings and seed in the ground. Herbicides can only be used after the vegetation becomes established at mature height. Reseeding or touch up seeding should occur after adequate time for germination and when bare spots greater than 10 square feet exist. A more extensive discussion of maintenance of seeded areas and weed control can be found in Oil & Gas Field Specific Revegetation Plans.

APPENDIX A: SEED MIXTURE CHARTS WITH GEOGRAPHIC PHOTOS

APPENDIX A: SEED MIXTURE CHARTS WITH GEOGRAPHIC PHOTOS

Seed Mixture # 1 = to be developed per field area
Seed Mixture # 2 = to be developed per field area
Seed Mixture # 3 = to be developed per field area
Seed Mixture # 4 = to be developed per field area
Seed Mixture # 5 = to be developed per field area
Seed Mixture # 6 = to be developed per field area
Seed Mixture # 7 = to be developed per field area

APPENDIX B: EQUIPMENT PHOTOS

Photo 1: Three Point Spreader

Photo 2: Fertilizer Buggy Wagon

Photo 3: Tandem Disk

Photo 4: Rhome Offset Construction Disk

Photo 5: Chisel Plow – Brillion 8'

Photo 6: Chisel Plow – John Deere

Photo 7: Subsoiler – John Deere

Photo 8: Spike Tooth Harrow

Photo 9: Flex-tine Tooth Harrow

Photo 10: Spring Tooth Harrow

Photo 11: Cultipacker – Brillion

Photo 12: Truax Brand Drill Seeder

Photo 13: Horizon Brand Drill Seeder

Photo 14: Close-up of Double Disk Furrow Openers and Depth Bands

Photo 15: Press Wheels

Photo 16: Drag Chains in Transport Position

Photo 17: Trashy Seed Box Picker Wheels

Photo 18: Small Grain Standard Seed Box/Seed Cups

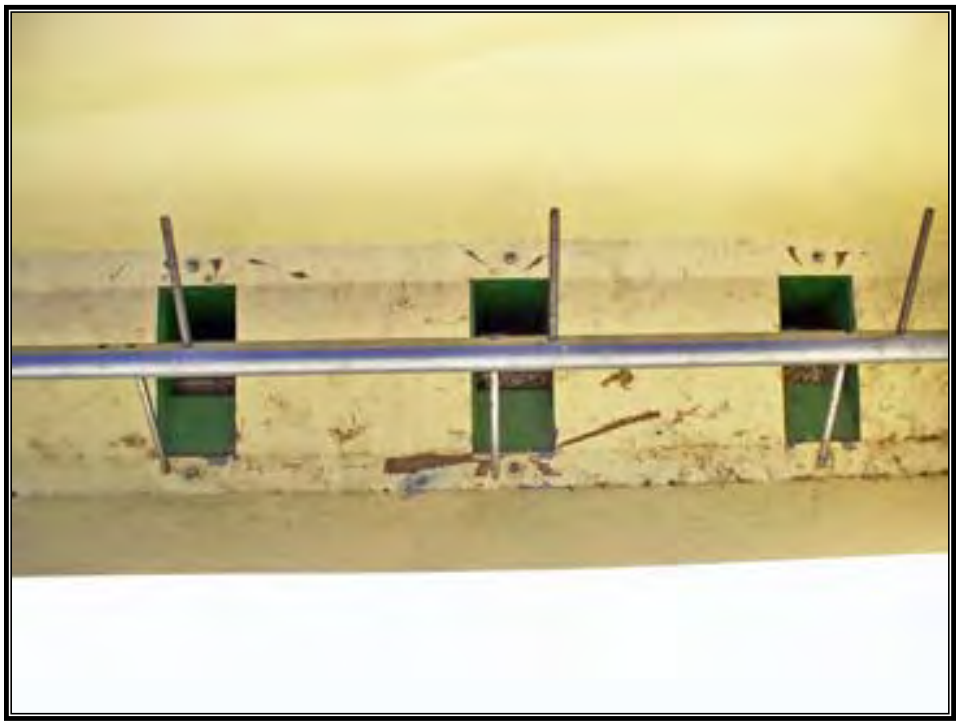


Photo 19: Seed Drill Gear Assembly

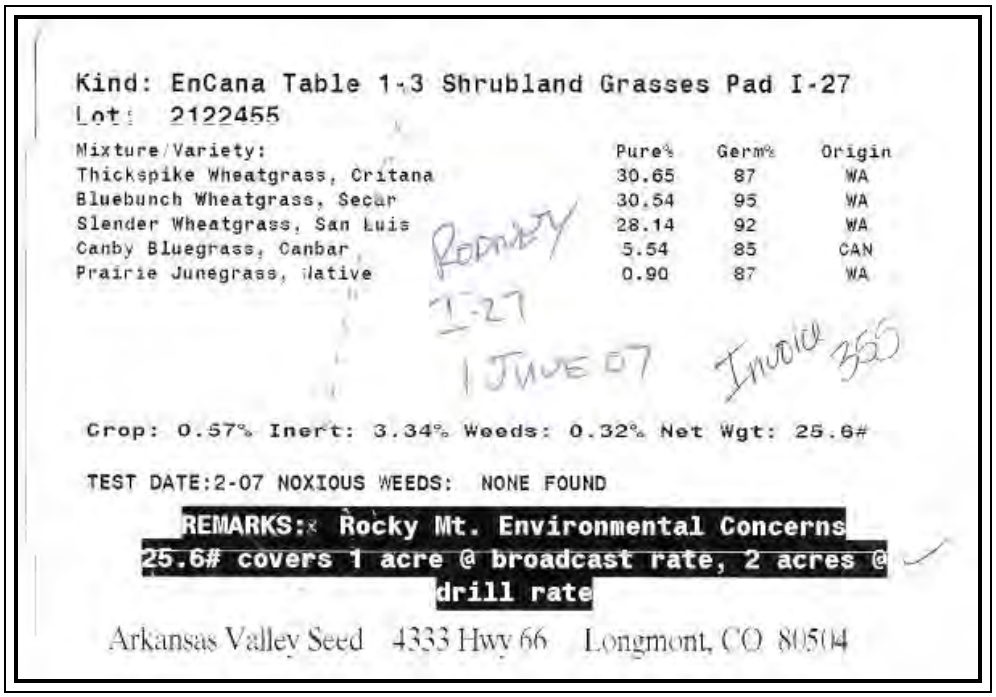
Photo 20: Seed Tubes

Photo 21: Hand Broadcast Seeder

Photo 22: Hydroseeder – 3000 Gallon Tank

Photo 23: Hydroseeder with Gun Operator

Photo 24: Seed Tag



Kind: EnCana Table 1-3 Shrubland Grasses Pad I-27
Lot: 2122455

Mixture/Variety:	Pure%	Germ%	Origin
Thickspike Wheatgrass, Critana	30.65	87	WA
Bluebunch Wheatgrass, Secar	30.54	95	WA
Slender Wheatgrass, San Luis	28.14	92	WA
Canby Bluegrass, Canbar	5.54	85	CAN
Prairie Junegrass, Native	0.90	87	WA

RODNEY
I-27
1 JUNE 07 Invoice 355

Crop: 0.57% Inert: 3.34% Weeds: 0.32% Net Wgt: 25.6#

TEST DATE:2-07 NOXIOUS WEEDS: NONE FOUND

REMARKS: Rocky Mt. Environmental Concerns
25.6# covers 1 acre @ broadcast rate, 2 acres @ drill rate

Arkansas Valley Seed 4333 Hwy 66 Longmont, CO 80504

Appendix C

Existing Soil and Vegetation Data

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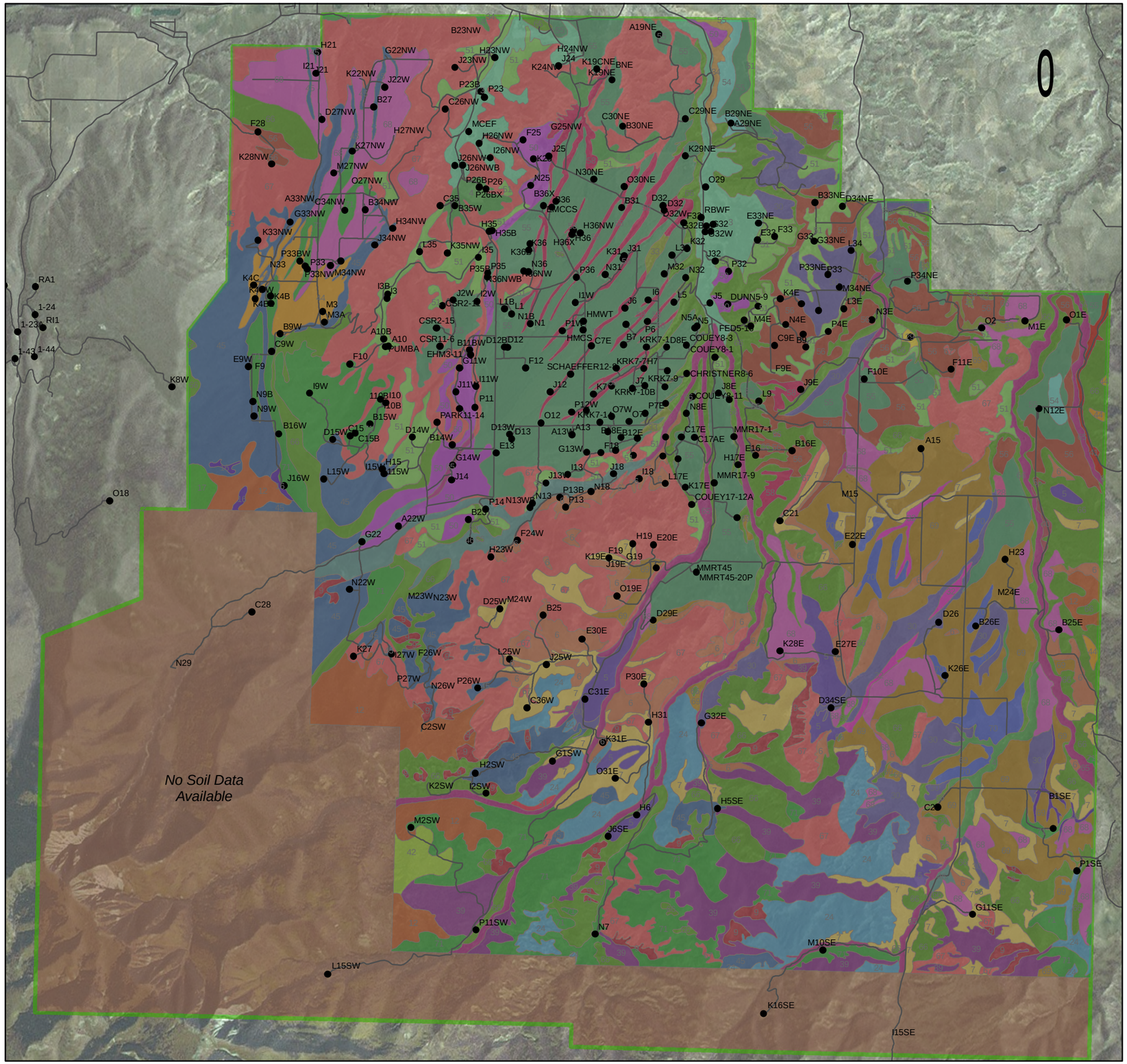
Figure 1. Mamm Creek Soil Types

Mamm Creek Unit Soils

MAP SYMBOL, SOIL NAME

- 12, Bucklon-Inchau loams
- 16, Cimarron loam
- 17, Cochetopa loam
- 24, Dollard-Rock outcrop, shale, complex
- 28, Heldt clay loam
- 29, Heldt clay loam
- 3, Arvada loam
- 30, Heldt clay loam
- 31, Heldt clay loam
- 32, Holderness Variant clay loam
- 33, Ildefonso stony loam
- 34, Ildefonso stony loam
- 39, Jerry loam
- 4, Arvada loam
- 40, Kim loam
- 41, Kim loam
- 42, Lamphier loam
- 44, Morval loam
- 45, Morval-Tridell complex
- 46, Nihill channery loam
- 5, Ascalon fine sandy loam
- 50, Olney loam
- 51, Olney loam
- 54, Potts loam
- 55, Potts loam
- 56, Potts loam
- 58, Potts-Ildefonso complex
- 6, Ascalon fine sandy loam
- 65, Torrifluvents
- 66, Torriorthents-Camborthids-Rock outcrop complex
- 67, Torriorthents--Rock outcrop complex
- 68, Vale silt loam
- 69, Vale silt loam
- 7, Ascalon-Pena complex
- 70, Vale silt loam
- 71, Villa Grove -Zoltay loams
- 9, Badland



Reference: Soil Survey Staff, Natural Resources, Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/accessed [02/01/2008]

APPENDIX C
Soils Table - Mamm Creek Unit SWMP
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Map Unit Number - Soil Name	Surface Runoff (slow/ medium/ rapid)	Erosion Potential (slight/ moderate/ severe)	Soil Description	Soil Depth	USDA Texture(s)	Unified Classification	Permeability (inch/hour)	Available Water Capacity (inch/inch)	Organic Matter (%)
R3-Arvada loam, 1 to 6% slope	medium	moderate	Deep, well drained, sloping soil on fans and high terraces.	0-3	Loam	CL-ML	0.60-2.00	0.16-0.18	0.5-1
				3-17	Clay, Silty clay loam	CL, CH	0.06-0.20	0.07-0.09	
				17-60	Clay loam, Silty clay loam	CL	0.06-0.20	0.09-0.11	
R4-Arvada loam, 6 to 20% slope	moderate/rapid	severe	Deep, well drained, sloping soil on fans and high terraces.	0-3	Loam	CL-ML	0.60-2.00	0.16-0.18	0.5-1
				3-17	Clay, Silty clay loam	CL, CH	0.06-0.20	0.07-0.09	
				17-60	Clay loam, Silty clay loam	CL	0.06-0.20	0.09-0.11	
R5-Ascalon fine sandy loam, 1 to 6% slope	medium	moderate	Deep, well drained, nearly level to gently sloping soil on mesas, alluvial fans, and terraces.	0-5	Fine sandy loam	SM	0.60-6.00	0.11-0.16	1-3
				5-30	Sandy clay loam	SC, CL	0.60-2.00	0.13-0.15	
				30-60	Sandy clay loam	SC, CL	0.60-6.00	0.11-0.15	
R6-Ascalon fine sandy loam 6 to 12% slope	medium	moderate	Deep, well drained, moderately sloping to rolling soil on mesas, terraces, sides of valleys and alluvial fans.	0-5	Fine sandy loam	SM	0.60-6.00	0.11-0.16	1-3
				5-30	Sandy clay loam	SC, CL	0.60-2.00	0.13-0.15	
				30-60	Sandy clay loam	SC, CL	0.60-6.00	0.11-0.15	
R7-Ascalon-Pena complex, 6 to 25% slope	medium	moderate	Moderately sloping to hilly soils are on sides of valleys an alluvial fans.	0-5	Fine sandy loam - Ascalon	SM	0.60-6.00	0.11-0.16	1-3
				5-30	Sandy clay loam - Ascalon	SC, CL	0.60-2.00	0.13-0.15	
				30-60	Sandy clay loam - Ascalon	SC, CL	0.60-6.00	0.11-0.15	
				0-12	Stony Loam - Pena	CL-ML	0.60-2.00	0.12-0.15	1-3
				12-60	Very stony loam - Pena	SC	0.60-2.00	0.03-0.08	
R9-Badland	rapid	severe	Steep and very steep, nearly barren land dissected by many intermittent drainage channels.	NA	Not Available	Not Available	Not Available	Not Available	Not Available
R12-Bucklon-Inchau loams, 25 to 50% slope	medium	severe	Moderately sloping to very steep soils on ridges and mountainsides.	0-4	Loam	CL, CL-ML, ML	0.06-2.00	0.16-0.20	2-5
				4-25	Clay loam, Loam, Gravelly loam, Gravelly clay loam	CL, GM-GC, GM, GC	0.06-2.00	0.11-0.18	
				25-60	Clay loam, Silty clay loam	N/A	0.00-0.00	0.00-0.00	
R16-Cimarron loam, 2 to 12% slope	medium	moderate	Deep, well drained, nearly level to undulating soil in narrow mountain valleys and drainage ways.	0-4	Loam	ML	0.60-2.00	0.16-0.18	2-4
				4-60	Clay, silty clay loam, silty clay	CH, ML	0.06-2.00	0.14-0.16	
R17- Cochetopa loam, 9 to 50% slope	slow	severe	Deep, well drained, rolling to steep soil is on mountainsides and alluvial fans.	0-21	Loam	ML	0.60-2.00	0.16-0.18	3-6
				21-60	Clay, stony clay, Stony clay loam	CL, CH	0.06-2.00	0.11-0.14	
R21-Cushman-Lazear stony loams, 15 to 65% slope	Not available.	Not available.	Hilly to very steep soils are on mountainsides and mesa banks.	0-4	Stony loam	GM-GC	0.60-2.00	0.08-0.11	0.5-1
				4-16	Stony loam	SM-SC	0.60-2.00	0.08-0.11	
				16	Unweathered bedrock	N/A	N/A	N/A	
R24-Dolland-Rock outcrop, shale, complex, 25 to 65% slope	rapid	very severe	Complex consists of moderately steep to steep Dollard soil and shale outcrop on hills and mountainsides.	0-5	Clay	CL, CH	0.06-0.20	0.17-0.19	1-2
				5-25	Silty clay, Silty clay loam, Clay	CH,CL	0.06-0.20	0.13-0.18	
				25	Weathered bedrock	N/A	N/A	N/A	
R27-Halaquepts, nearly level	Not Available	Not Available	Broadly defined unit consists of deep, somewhat poorly drained to poorly drained, nearly level and gently sloping, salt-affected soils in narrow foothill valleys, on fans, and on low terraces.	0-8	Clay Loam	CH- CL	Not available.	Not available.	Not Available
				8-24	Loam	ML			
				24-60	Gravelly cobbly sand	GM, SM			
R28-Heldt clay loam, 1 to 3% slope	Not available	Not available	Deep, well drained, nearly level soil on alluvial fans and sides of valleys.	0-8	Clay loam	CH- CL	0.06-0.20	0.12-0.17	1-2
				8-60	Silty clay, Clay, Clay loam	CH- CL	0.06-0.20	0.12-0.17	
R29-Heldt clay loam, 3 to 6% slope	medium	moderate	Deep, well drained, gently sloping soil on alluvial fans and sides of valleys.	0-8	Clay loam	CH- CL	0.06-0.20	0.12-0.17	1-2
				8-60	Silty clay, Clay, Clay loam	CH- CL	0.06-0.20	0.12-0.17	
R30-Heldt clay loam, 6 to 12% slope	medium	moderate	Deep, well drained, moderately sloping to rolling soil on alluvial fans and sides of valleys.	0-8	Clay loam	CH- CL	0.06-0.20	0.12-0.17	1-2
				8-60	Silty clay, Clay, Clay loam	CH- CL	0.06-0.20	0.12-0.17	
R31-Heldt clay loam, 12 to 25% slope	medium	moderate	Deep, well drained, moderately steep to hilly soil on alluvial fans and sides of valleys.	0-8	Clay loam	CH- CL	0.06-0.20	0.12-0.17	1-2
				8-60	Silty clay, Clay, Clay loam	CH- CL	0.06-0.20	0.12-0.17	
R32-Holderness variant clay loam, 6 to 25% slope	Not available.	Not available.	Deep, well drained, moderately sloping to hilly soil on alluvial fans and sides of valleys.	0-11	Clay loam	CL-ML, CL	0.2-0.6	0.15-0.19	2-4
				11-30	Clay	CL-CH	0.06-0.20	0.15-0.19	
				30-60	Clay loam	CL	0.2-0.6	0.15-0.19	
R33-Ildefonso stony loam, 6 to 25% slope	moderate	moderate	Moderately-sloping to hilly, deep, well-drained stony loam formed from reworked alluvium derived from basalt. Found on mesas, benches, and the sides of valleys.	0-8	Stony loam	SM, GM	2.00-6.00	0.08-0.10	1-2
				8-60	Very stony loam, very gravelly sandy loam.	SM, GM	2.00-6.00	0.06-0.08	0.5-1
R34-Ildefonso stony loam, 25 to 45% slope	moderate	severe	Hilly, deep, well-drained stony loam formed from reworked alluvium derived from basalt. Found on mesa breaks, alluvial fans and the sides of valleys.	0-8	Stony loam	SM, GM	2.00-6.00	0.08-0.10	1-2
				8-60	Very stony loam, very gravelly sandy loam.	SM, GM	2.00-6.00	0.06-0.08	0.5-1
R35-Ildefonso-Lazear complex, 6 to 65% slope	medium/rapid	moderate/severe	Moderately sloping to very steep soils on hillsides and mesa breaks.	0-6	Stony loam, Gravelly loam	SM, GM, ML	0.60-6.00	0.08-0.16	0.5-1
				6-16	Very stony loam, Very gravelly sandy loam, Gravelly loam, Cobbly loam	SM, GM, ML	0.60-6.00	0.06-0.16	
				16-60	Very stony loam, Very gravelly sandy loam, Unweathered bedrock	SM, GM	0.00-0.00	0.00-0.00	

APPENDIX C
Soils Table - Mamm Creek Unit SWMP
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Map Unit Number - Soil Name	Characteristic Plant Communities	Suitability For:									
		Small Commercial Buildings	Local Roads & Streets	Roadfill	Topsoil	Pond Reservoir Areas	Embankments, Dikes, & Levees	Drainage	Irrigation	Terraces and Diversions	Grassed Waterways
R3-Arvada loam, 1 to 6% slope	Western wheatgrass, Alkali sacaton, Inland saltgrass, Winterfat, Bottlebrush Squirreltail, Gardner saltbrush, Greasewood	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: too clayey, excess sodium.	Favorable	Excess sodium	Percs slowly, excess sodium, slope.	Slope, percs slowly, excess sodium.	Percs slowly.	Percs slowly, excess sodium.
R4-Arvada loam, 6 to 20% slope	Big sagebrush, Greasewood, Galleta, Shadscale, Bottlebrush Squirreltail, Western wheatgrass	Severe: slope, shrink-swell.	Severe: shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: too clayey, excess sodium.	Slope	Excess sodium	Percs slowly, excess sodium, slope.	Slope, percs slowly, excess sodium.	Slope, percs slowly.	Slope, percs slowly, excess sodium.
R5-Ascalon fine sandy loam, 1 to 6% slope	Needleandthread, Western wheatgrass, Bluebunch wheatgrass, Big sagebrush, Utah serviceberry	Moderate: low strength	Moderate: frost action, low strength.	Poor: low strength.	Fair: too clayey.	Seepage, slope.	Favorable.	Slope.	Slope.	Slope.	Slope.
R6-Ascalon fine sandy loam 6 to 12% slope	Needleandthread, Western wheatgrass, Bluebunch wheatgrass, Big sagebrush, Utah serviceberry	Severe: slope.	Moderate: slope, frost action, low strength.	Poor: low strength.	Fair: slope, too clayey.	Seepage, slope.	Favorable.	Slope.	Slope.	Slope.	Slope.
R7-Ascalon-Pena complex, 6 to 25% slope	Needleandthread, Western wheatgrass, Bluebunch wheatgrass, Big sagebrush, Utah serviceberry- Ascalon	Severe: slope.	Moderate: slope, frost action, low strength.	Poor: low strength.	Fair: slope, too clayey.	Seepage, slope.	Favorable.	Slope.	Slope.	Slope.	Slope.
	True mountain mahogany, Big sagebrush, Utah serviceberry, Bluebunch wheatgrass, Western wheatgrass, Indian ricegrass, Bottlebrush squirreltail - Pena	Severe: slope, large stones.	Severe: slope, large stones.	Poor: large stones.	Poor: slope, large stones.	Slope, large stones.	Large stones.	Slope, large stones.	Slope, large stones droughty.	Slope, large stones.	Slope, large stones droughty.
R9-Badland	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
R12-Bucklon-Inchau loams, 25 to 50% slope	Gambel oak, Elk sedge, Mountain brome, Utah serviceberry, Western wheatgrass, Slender wheatgrass, Common snowberry	Severe: depth to rock, slope.	Severe: depth to rock, slope, low strength.	Poor: thin layer, slope, area reclaim.	Poor: slope, area reclaim, thin layer, small stones.	Depth to rock, slope, seepage.	Thin layer.	Slope, depth to rock.	Rooting depth, slope.	Slope, depth to rock.	Slope, rooting depth.
R16-Cimarron loam, 2 to 12% slope	Idaho fescue, Bearded wheatgrass, Western wheatgrass, Mountain brome, Big sagebrush, Muttongrass, Slender wheatgrass, Needlegrass, Nodding bromegrass	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: too clayey.	Slope.	Hard to Pack	Slope, percs slowly.	Percs slowly, slope.	Slope, percs slowly.	Slope, percs slowly.
R17- Cochetopa loam, 9 to 50% slope	Gambel oak, Mountain brome, Utah serviceberry, Elk sedge, Bearded wheatgrass, Columbia needlegrass, Mountain snowberry	Severe: shrink-swell, slope, low strength.	Severe: shrink-swell, slope, low strength.	Poor: shrink-swell, slope, low strength.	Poor: slope, small stones.	Slope.	Hard to Pack	Percs slowly, slope.	Slope, percs slowly.	Percs slowly, slope.	Percs slowly, slope.
R21-Cushman-Lazear stony loams, 15 to 65% slope	Not available.	Severe: slope, depth to rock.	Severe: depth to rock, slope.	Poor: thin layer, area reclaim.	Poor: slope, small stones.	Slope, depth of rock.	Thin layer, large stones.	Slope, depth to rock.	Slope, rooting depth, large stones, droughty.	Slope, depth to rock, large stones,	Slope, depth to rock, large stones,
R24-Dolland-Rock outcrop, shale, complex, 25 to 65% slope	Western wheatgrass, Muttongrass, Big sagebrush, Utah serviceberry, Arizona fescue, True mountain mahogany	Severe: slope, shrink-swell, low strength.	Severe: slope, shrink-swell, low strength.	Poor: thin layer, slope, low strength.	Poor: slope, too clayey.	Slope, depth of rock.	Thin layer, hard to pack.	Depth to rock, slope, percs slowly.	Slope, percs slowly, rooting depth.	Depth to rock, percs slowly, slope.	Slope, percs slowly, rooting depth.
R27-Halaquepts, nearly level	Not Available	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.
R28-Heldt clay loam, 1 to 3% slope	Western wheatgrass, Big sagebrush, Green needlegrass, Squirreltail, Winterfat, Prairie junegrass, Low rabbitbrush, Sandberg bluegrass	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: too clayey.	Slope	Hard to Pack	Percs slowly, slope.	Slope, percs slowly.	Percs slowly.	Percs slowly.
R29-Heldt clay loam, 3 to 6% slope	Western wheatgrass, Big sagebrush, Green needlegrass, Squirreltail, Winterfat, Prairie junegrass, Low rabbitbrush, Sandberg bluegrass	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: too clayey.	Slope	Hard to Pack	Percs slowly, slope.	Slope, percs slowly.	Percs slowly.	Percs slowly.
R30-Heldt clay loam, 6 to 12% slope	Western wheatgrass, Big sagebrush, Green needlegrass, Squirreltail, Winterfat, Prairie junegrass, Low rabbitbrush, Sandberg bluegrass	Severe: slope, shrink-swell, low strength.	Severe: shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: too clayey.	Slope	Hard to Pack	Percs slowly, slope.	Slope, percs slowly.	Percs slowly, slope.	Slope, percs slowly.
R31-Heldt clay loam, 12 to 25% slope	Western wheatgrass, Big sagebrush, Green needlegrass, Squirreltail, Winterfat, Prairie junegrass, Low rabbitbrush, Sandberg bluegrass	Severe: slope, shrink-swell, low strength.	Severe: slope, shrink-swell, low strength.	Poor: shrink-swell, low strength.	Poor: slope, too clayey.	Slope	Hard to Pack	Percs slowly, slope.	Slope, percs slowly.	Slope, percs slowly.	Slope, percs slowly.
R32-Holderness variant clay loam, 6 to 25% slope	Western wheatgrass, Letterman needlegrass. Muttongrass, Slender wheatgrass, Prairie junegrass, Big sagebrush, Utah serviceberry	Severe: slope, shrink-swell, low strength.	Severe: slope, shrink-swell, low strength.	Poor: low strength, shrink-swell.	Poor: slope.	Slope	Hard to Pack	Slope, percs slowly.	Slope, percs slowly.	Slope, percs slowly.	Slope, percs slowly.
R33-Ildefonso stony loam, 6 to 25% slope	N/A	Severe: slope, large stones.	Severe: slope, large stones.	Poor: slope, large stones.	Poor: slope, large stones.	Seepage, slope.	Large stones.	Slope, large stones.	Slope, large stones, droughty.	Large stones, slope.	Slope, large stones, droughty.
R34-Ildefonso stony loam, 25 to 45% slope	N/A	Severe: slope, large stones.	Severe: slope, large stones.	Poor: slope, large stones.	Poor: slope, large stones.	Seepage, slope.	Large stones.	Slope, large stones.	Slope, large stones, droughty.	Large stones, slope.	Slope, large stones, droughty.
R35-Ildefonso-Lazear complex, 6 to 65% slope	Junegrass, Serviceberry, bitterbrush, wheatgrass, sagebrush.	Severe: slope, large stones, depth to rock.	Severe: slope, large stones, depth to rock.	Poor: slope, thin layer, area reclaim.	Poor: slope, large stones, small stones, area reclaim.	Seepage, slope, depth to rock.	Large stones, thin layer.	Slope, large stones, depth to rock.	Slope, large stones, droughty, rooting depth.	Large stones, slope, depth to rock.	Slope, large stones, droughty, rooting depth.

APPENDIX C
Soils Table - Mamm Creek Unit SWMP
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Map Unit Number - Soil Name	Surface Runoff (slow/ medium/ rapid)	Erosion Potential (slight/ moderate/ severe)	Soil Description	Soil Depth	USDA Texture(s)	Unified Classification	Permeability (inch/hour)	Available Water Capacity (inch/inch)	Organic Matter (%)
R39-Jerry loam, 12 to 50% slope	slow	moderate	Deep, well drained, strongly sloping to steep soil is on mountainsides.	0-3	Loam	ML	0.60-2.00	0.16-0.18	3-5
				3-40	Gravelly clay loam, cobbly clay loam, cobbly clay	GC, CL, CH	0.06-0.20	0.13-0.15	
				40-60	Gravelly loam, cobbly clay	GC, CL, CL-ML, GM-GC	0.60-2.00	0.13-0.15	
R40-Kim loam, 3 to 6% slope	slow	slight	Deep, well drained, gently sloping soil on alluvial fans and benches.	0-60	Loam	ML	0.60-2.00	0.15-0.18	0.5-1
R41-Kim loam, 6 to 12% slope	slow	slight	Deep, well drained, moderately sloping to rolling soil on alluvial fans and benches.	0-60	Loam	ML	0.60-2.00	0.15-0.18	0.5-1
R42-Lamphier loam, 15 to 50% slope	slow	slight	Deep, well drained, steep soil on fans and mountainsides.	0-60	Loam	ML	0.60-2.00	0.18-0.21	2-4
R44-Morval loam, 3 to 12% slope	slow	slight	Deep, well drained, gently sloping to rolling soil on mesas and sides of valleys.	0-5	Loam	CL	0.60-2.00	0.18-0.21	1-2
				5-17	Silty clay loam, clay loam	CL	0.60-2.00	0.14-0.21	
				17-60	Stony clay loam, stony loam	CL, SC	0.60-2.00	0.08-0.10	
R45-Morval-Tridell complex, 6 to 25% slope	medium	moderate	Moderately sloping to hilly soils are on alluvial fans and sides of mesas.	0-5	Loam	CL	0.60-2.00	0.18-0.21	1-2
				5-17	Silty clay loam, clay loam	CL	0.60-2.00	0.14-0.21	
				17-60	Stony clay loam, stony loam	CL, SC	0.60-2.00	0.08-0.10	
R46-Nihill channery loam, 1 to 6% slope	slow	severe	Deep, well drained, gently sloping soil is on alluvial fans and side of valleys derived from Green River shale and sandstone	0-11	Channery loam	GM, GM-GC, SM, ML	0.60-2.00	0.12-0.16	0-1
				11-60	Very channery loam, very channery sandy loam.	GM, GM-GC	2.00-6.00	0.06-0.09	
R50-Olney loam, 3 to 6% slope	slow	severe	Deep, well drained, gently sloping soil is on alluvial fans and side of valleys	0-12	Loam	CL-ML, ML	0.60-2.00	0.15-0.18	1-2
				12-33	Sandy clay loam	SC, SM-SC	0.60-2.00	0.14-0.16	
				33-43	Gravelly sandy clay loam, gravelly sandy loam	SC, SM-SC, GC, GM-GC	0.60-2.00	0.10-0.15	
				43-60	Very gravelly sandy loam, very gravelly sandy clay loam	GM, GM-GC, GC	0.60-2.00	0.07-0.10	
R51-Olney loam, 6 to 12% slope	slow	severe	Deep, well drained, moderately sloping to rolling soil on alluvial fans and sides of valleys.	0-12	Loam	CL-ML, ML	0.60-2.00	0.15-0.18	1-2
				12-33	Sandy clay loam	SC, SM-SC	0.60-2.00	0.14-0.16	
				33-43	Gravelly sandy clay loam, gravelly sandy loam	SC, SM-SC, GC, GM-GC	0.60-2.00	0.10-0.15	
				43-60	Very gravelly sandy loam, very gravelly sandy clay loam	GM, GM-GC, GC	0.60-2.00	0.07-0.10	
R54-Potts loam, 1 to 3% slope	slow	slight	Deep, well drained soil on mesas, benches, and sides of valleys.	0-4	Loam	ML	0.60-2.00	0.16-0.18	1-2
				4-28	Clay loam	CL	0.60-2.00	0.19-0.21	
				28-60	Loam	ML	0.60-2.00	0.16-0.18	
R55-Potts loam, 3 to 6% slope	slow	moderate	Moderately-sloping, deep, well-drained loam and clay loam formed from in alluvium derived from sandstone, shale, and basalt. Found on mesas, benches, and the sides of valleys.	0-4	Loam	ML	0.60-2.00	0.16-0.18	1-2
				4-28	Clay loam	CL	0.60-2.00	0.19-0.21	
				28-60	Loam	ML	0.60-2.00	0.16-0.18	
R56-Potts loam, 6 to 12% slope	moderate	severe	Gently-sloping to rolling, deep, well-drained loam and clay loam formed from in alluvium derived from sandstone, shale, and basalt. Found on mesas, benches, and the sides of valleys.	0-4	Loam	ML	0.60-2.00	0.16-0.18	1-2
				4-28	Clay loam	CL	0.60-2.00	0.19-0.21	
				28-60	Loam	ML	0.60-2.00	0.16-0.18	
R57-Potts-Ildefonso complex, 3 to 12% slope	slow	moderate	Gently-sloping to rolling, deep, well-drained loam and clay loam formed from in alluvium derived from sandstone, shale, and basalt. Found on mesas and the sides of valleys.	0-4	Loam	ML	0.60-2.00	0.16-0.18	1-2
				4-28	Clay loam	CL	0.60-2.00	0.19-0.21	0.5-1
				28-60	Loam	ML	0.60-2.00	0.16-0.18	0-0.5
R58-Potts-Ildefonso complex, 12 to 25% slope	moderate	moderate	Strongly-sloping to hilly, deep, well-drained loam and clay loam formed from in alluvium derived from sandstone, shale, and basalt. Found on mesas and the sides of valleys.	0-4	Loam	ML	0.60-2.00	0.16-0.18	1-2
				4-28	Clay loam	CL	0.60-2.00	0.19-0.21	0.5-1
				28-60	Loam	ML	0.60-2.00	0.16-0.18	0-0.5
R59-Potts-Ildefonso complex, 25 to 45% slope	moderate	severe	Hilly to very steep, deep, well-drained loam and clay loam formed from in alluvium derived from sandstone, shale, and basalt. Found on alluvial fans and the sides of valleys.	0-4	Loam	ML	0.60-2.00	0.16-0.18	1-2
				4-28	Clay loam	CL	0.60-2.00	0.19-0.21	0.5-1
				28-60	Loam	ML	0.60-2.00	0.16-0.18	0-0.5
R65-Torrifluvents, 0 to 6% slope	Not available.	low	Broadly defined unit consisting of deep, well drained to somewhat poorly drained, nearly level soils on flood plains adjacent to the Colorado River and its major tributaries.	Not available.	The surface layer ranges from loamy sand and fine sandy loam to silty loam and clay loam. The underlying layers are generally sandy loam or loam stratified with sand, gravel, and cobbles.	Not available.	Not available.	Not available.	Not available.
R66-Torriorthents-Camborthids-Rock outcrop complex, 15 to 70% slope	very rapid	very severe	Exposed sandstone and shale bedrock, loose stones, and shallow to deep stony loams and clay found on toe slopes and concave open areas on foothills and mountainsides.	0-4	Variable, Unweathered bedrock	CL-ML, ML, SC-SM, SM	0.00-6.00	0.00-0.18	0.5-1
				4-30	Clay loam, Fine sandy loam, Loam, Unweathered bedrock	CL, CL-ML, SC-SM, SM	0.00-2.00	0.00-0.18	0-0.5
				30-34	Unweathered bedrock	N/A	0.00-0.20	0.00-0.00	0
R67-Torriorthents- Rock outcrop complex, 15 to 70% slope	very rapid	very severe	Exposed sandstone and shale bedrock, loose stones, and shallow to deep stony loams and clay found on toe slopes and concave open areas on foothills and mountainsides.	0-4	Variable, Unweathered bedrock	CL-ML, ML, SC-SM, SM	0.00-6.00	0.00-0.18	0.5-1
				4-30	Clay loam, Fine sandy loam, Loam, Unweathered bedrock	CL, CL-ML, SC-SM, SM	0.00-2.00	0.00-0.18	0-0.5
				30-34	Unweathered bedrock	N/A	0.00-0.20	0.00-0.00	0
R68-Vale silt loam, 3 to 6% slope	medium	moderate	Deep, well drained, gently sloping soil on mesas, terraces, and alluvial fans.	0-11	Silt loam	CL, CL-ML	0.60-2.00	0.19-0.22	2-4
				11-26	Silty clay loam, clay loam, silt loam	CL	0.60-2.00	0.17-0.22	
				26-60	Loam, silty clay loam, silt loam	CL, CL-ML	0.60-2.00	0.13-0.20	
R69-Vale silt loam, 6 to 12% slope	Not available.	Not available.	Deep, well drained, moderately sloping to rolling soil on mesas, benches, and alluvial fans.	0-11	Silt loam	CL, CL-ML	0.60-2.00	0.19-0.22	2-4
				11-26	Silty clay loam, clay loam, silt loam	CL	0.60-2.00	0.17-0.22	
				26-60	Loam, silty clay loam, silt loam	CL, CL-ML	0.60-2.00	0.13-0.20	

APPENDIX C
Soils Table - Mamm Creek Unit SWMP
Page 4 of 6

Map Unit Number - Soil Name	Characteristic Plant Communities	Suitability For:									
		Small Commercial Buildings	Local Roads & Streets	Roadfill	Topsoil	Pond Reservoir Areas	Embankments, Dikes, & Levees	Drainage	Irrigation	Terraces and Diversions	Grassed Waterways
R39-Jerry loam, 12 to 50% slope	Gambel oak, Sedge, Big sagebrush, Utah serviceberry, Nodding bromegrass, Big bluegrass, Western wheatgrass, Slender wheatgrass, Common snowberry	Severe: shrink-swell, slope.	Severe: shrink-swell, slope, low strength.	Poor: shrink-swell, slope, low strength.	Poor: slope, too clayey, large stones.	Slope	Hard to Pack	Slope, percs slowly.	Slope, percs slowly.	Slope, percs slowly.	Slope, percs slowly.
R40-Kim loam, 3 to 6% slope	Indian ricegrass, Bluebunch wheatgrass, Prairie junegrass, Muttongrass, Western wheatgrass, Big sagebrush, Needleandthread, Low rabbitbrush	Moderate: shrink-swell, slope.	Moderate: shrink-swell, low strength.	Fair: low strength.	Good.	Slope, seepage.	Piping.	Slope.	Slope.	Favorable.	Favorable.
R41-Kim loam, 6 to 12% slope	Indian ricegrass, Bluebunch wheatgrass, Prairie junegrass, Muttongrass, Western wheatgrass, Big sagebrush, Needleandthread, Low rabbitbrush	Severe: slope.	Moderate: slope, shrink-swell, low strength.	Fair: low strength.	Fair: slope.	Slope, seepage.	Piping.	Slope.	Slope.	Slope.	Slope.
R42-Lamphier loam, 15 to 50% slope	Not available	Severe: slope.	Severe: slope.	Poor: slope.	Poor: slope.	Slope, seepage.	Piping.	Slope.	Slope.	Slope.	Slope.
R44-Morval loam, 3 to 12% slope	Western wheatgrass, Needleandthread, Big sagebrush, Bluebunch wheatgrass, Utah serviceberry	Moderate: slope, shrink-swell.	Moderate: low strength, shrink swell, slope.	Fair: low strength, shrink-swell, frost action. .	Good.	Seepage, slope.	Favorable.	Slope.	Erodes easily, slope.	Erodes easily.	Erodes easily.
R45-Morval-Tridell complex, 6 to 25% slope	Western wheatgrass, Needleandthread, Big sagebrush, Bluebunch wheatgrass, Utah serviceberry	Severe: slope, large stones.	Moderate: low strength, shrink swell, slope. Severe: slope, large stones.	Fair: low strength, shrink-swell, frost action. Poor: large stones.	Fair: slope. Poor: slope, large stones.	Seepage, slope.	Large stones.	Slope, large stones.	Slope, large stones, droughty.	Large stones, slope.	Slope, large stones, droughty.
R46-Nihill channery loam, 1 to 6% slope	Western wheatgrass, Bluebunch wheatgrass, Big sagebrush, Needleandthread grass, Indian ricegrass, Low rabbitbrush	Slight	Slight	Good	Poor: small stones, area reclaim.	Seepage.	Seepage.	Slope.	Slope, droughty.	Favorable.	Droughty.
R50-Olney loam, 3 to 6% slope	Western wheatgrass, Bluebunch wheatgrass, Big sagebrush, Needleandthread grass, Indian ricegrass, Rabbitbrush	Slight	Slight	Fair: low strength.	Fair: small stones.	Slope, seepage.	Favorable.	Slope.	Slope.	Slope.	Slope.
R51-Olney loam, 6 to 12% slope	Western wheatgrass, Bluebunch wheatgrass, Big sagebrush, Needleandthread grass, Indian ricegrass, Rabbitbrush	Severe: slope.	Severe: slope.	Fair: low strength.	Fair: small stones, slope.	Slope, seepage.	Favorable.	Slope.	Slope.	Slope.	Slope.
R54-Potts loam, 1 to 3% slope	Western wheatgrass, Needleandthread, Bluebunch wheatgrass, Big sagebrush, Indian ricegrass, Low rabbitbrush, Squirreltail	Slight	Slight	Fair: low strength.	Fair: small stones.	Seepage.	Piping.	Slope.	Slope, erodes easily.	Erodes easily.	Erodes easily.
R55-Potts loam, 3 to 6% slope	Western wheatgrass, Needleandthread, Bluebunch wheatgrass, Big sagebrush, Indian ricegrass, Low rabbitbrush, Squirreltail	Moderate: slope.	Slight	Fair: low strength.	Fair: small stones.	Seepage.	Piping.	Slope.	Slope, erodes easily.	Erodes easily.	Erodes easily.
R56-Potts loam, 6 to 12% slope	Western wheatgrass, Needleandthread, Bluebunch wheatgrass, Big sagebrush, Indian ricegrass, Low rabbitbrush, Squirreltail	Severe: slope.	Moderate: slope.	Fair: low strength.	Fair: slope, small stones.	Seepage.	Piping.	Slope.	Slope, erodes easily.	Slope, erodes easily.	Slope, erodes easily.
R57-Potts-Ildefonso complex, 3 to 12% slope	Western wheatgrass, Needleandthread, Bluebunch wheatgrass, Big sagebrush, Indian ricegrass, Low rabbitbrush, Squirreltail	Moderate/Severe: slope, large stones.	Slight/Severe: large stones.	Fair/Poor: low strength, large stones.	Fair/Poor: small stones, large stones.	Seepage, slope.	Piping, large stones.	Slope, large stones.	Slope, erodes easily, large stones, droughty.	Erodes easily, large stones, slope.	Erodes easily, slope, large stones, droughty.
R58-Potts-Ildefonso complex, 12 to 25% slope	Western wheatgrass, Needleandthread, Bluebunch wheatgrass, Big sagebrush, Indian ricegrass, Low rabbitbrush, Squirreltail	Severe: slope, large stones.	Severe: slope, large stones.	Fair/Poor: slope, low strength, large stones.	Poor: slope, large stones.	Seepage, slope.	Piping, large stones.	Slope, large stones.	Slope, erodes easily, large stones, droughty.	Slope, erodes easily, large stones.	Slope, erodes easily, large stones, droughty.
R59-Potts-Ildefonso complex, 25 to 45% slope	Western wheatgrass, Needleandthread, Bluebunch wheatgrass, Big sagebrush, Indian ricegrass, Low rabbitbrush, Squirreltail	Severe: slope, large stones.	Severe: slope, large stones.	Poor: slope, large stones.	Poor: slope, large stones.	Seepage, slope.	Piping, large stones.	Slope, large stones.	Slope, erodes easily, large stones, droughty.	Slope, erodes easily, large stones.	Slope, erodes easily, large stones, droughty.
R65-Torrifluvents, 0 to 6% slope	Cottonwood, Willow, Tamarisk, Water-tolerant grasses, sedges, and rushes.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.
R66-Torriorthents-Camborthids-Rock outcrop complex, 15 to 70% slope	Not available.	Not rated	Not rated	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.
R67-Torriorthents- Rock outcrop complex, 15 to 70% slope	Not available.	Not rated	Not rated	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.	Not available.
R68-Vale silt loam, 3 to 6% slope	Western wheatgrass, Prairie sandreed, Needleandthread, Blue grama, Green needlegrass, Rabbitbrush, Utah Serviceberry	Moderate: slope.	Moderate: low strength.	Poor: low strength.	Good.	Seepage.	Piping.	Favorable.	Favorable.	Erodes easily.	Erodes easily.
R69-Vale silt loam, 6 to 12% slope	Western wheatgrass, Prairie sandreed, Needleandthread, Blue grama, Green needlegrass, Rabbitbrush, Utah Serviceberry	Severe: slope.	Moderate: slope, low strength.	Poor: low strength.	Fair: slope.	Slope, seepage.	Piping.	Slope.	Slope.	Erodes easily, slope.	Slope, erodes easily.

APPENDIX C
Soils Table - Mamm Creek Unit SWMP
Page 5 of 6

Map Unit Number - Soil Name	Surface Runoff (slow/ medium/ rapid)	Erosion Potential (slight/ moderate/ severe)	Soil Description	Soil Depth	USDA Texture(s)	Unified Classification	Permeability (inch/hour)	Available Water Capacity (inch/inch)	Organic Matter (%)
R70-Vale silt loam, 12 to 25% slope	Not available.	Not available.	Deep, well drained, strongly sloping to hilly soil on mesas, mesa sides, and alluvial fans.	0-11	Silt loam	CL, CL-ML	0.60-2.00	0.19-0.22	2-4
				11-26	Silty clay loam, clay loam, silt loam	CL	0.60-2.00	0.17-0.22	
				26-60	Loam, silty clay loam, silt loam	CL, CL-ML	0.60-2.00	0.13-0.20	
R71-Villa Grove-Zoltay loams, 15 to 30% slope	slow/medium	slight/moderate	Moderately steep to hilly soils on mountainsides and alluvial fans.	0-4	Loam	CL	0.20-2.00	0.16-0.19	2-4
				4-17	Clay loam, Sandy clay loam, Gravelly clay, Cobbly clay, Cobbly clay loam	CL, SC, GC	0.60-6.00	0.10-0.19	
				17-60	Sandy loam, Loam, Gravelly clay, Cobbly clay, Cobbly clay loam	SM-SC, CL-ML, CL, GC, SC	0.06-2.00	0.13-0.16	
R72-Wann sandy loam, 1 to 3% slope	slow	moderate	Deep, somewhat poorly drained, nearly level to gently sloping, low-lying soil on terraces and bottom land in valleys.	0-17	Sandy loam	SM, SM-SC	2.00-6.00	0.16-0.18	3-6
				17-60	Sandy loam, Fine sandy loam, Coarse sandy loam	SM, SM-SC	2.00-6.00	0.15-0.17	

*The R preceding the soil number represents the Soil Survey of Rifle Area, Colorado.

APPENDIX C
Soils Table - Mamm Creek Unit SWMP
Page 6 of 6

Map Unit Number - Soil Name	Characteristic Plant Communities	Suitability For:									
		Small Commercial Buildings	Local Roads & Streets	Roadfill	Topsoil	Pond Reservoir Areas	Embankments, Dikes, & Levees	Drainage	Irrigation	Terraces and Diversions	Grassed Waterways
R70-Vale silt loam, 12 to 25% slope	Western wheatgrass, Prairie sandreed, Needleandthread, Blue grama, Green needlegrass, Rabbitbrush, Utah Serviceberry	Severe: slope.	Severe: slope.	Fair: low strength, slope.	Poor: slope.	Slope, seepage.	Piping.	Slope.	Slope.	Slope, erodes easily.	Slope, erodes easily.
R71-Villa Grove-Zoltay loams, 15 to 30% slope	Gambel oak, Utah serviceberry, Western wheatgrass, Elk sedge, Mountain brome, Mountain snowberry	Severe: slope, shrink-swell.	Severe: slope, low strength, shrink-swell.	Poor: low strength, shrink-swell.	Poor: slope, small stones.	Slope, seepage.	Favorable.	Slope, excess salt, percs slowly.	Slope, excess salt, percs slowly.	Favorable, slope, percs slowly.	Excess salt, slope, percs slowly.
R72-Wann sandy loam, 1 to 3% slope	Alkali sacaton, Saltgrass, Baltic rush, Low rabbitbrush, Skunkbush shumac, Sedge	Severe: floods.	Severe: floods, frost action.	Fair: low strength, wetness.	Good.	Seepage.	Seepage.	Floods, frost action.	Floods.	Favorable.	Favorable.

*The R preceding the soil number represents the Soil Survey of Rifle Area, Colorado.

Appendix D

Master SWMP Permit Area Map

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SWMP Boundary

R94W R93W R92W

T6S T7S T8S

EnCana Oil & Gas (USA) Inc.

Mamm Creek Unit SWMP Boundary
COR 034840
T6S-T8S, R92W-R94W, 6th P.M.

Tri-State Land Surveying Inc.
(435) 781-2501
180 North Vernal Ave. Vernal, Utah 84078

SCALE: 1" = 2,000'
DRAWN BY: mw
DATE: 02-13-2008

Legend
- Existing Road
- Proposed Access
- Gas Pipeline
- SWMP Boundary Line

Appendix E

Stormwater Manual of Best Management Practices (BMPs)

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Prepared for:
EnCana Oil & Gas (USA) Inc.
Parachute, CO 81635

Stormwater Manual of Best Management Practices (BMPs)

June 2008

THIS PAGE LEFT BLANK FOR TWO-SIDED DUPLICATION.

Prepared for:
EnCana Oil & Gas (USA) Inc.
Parachute, CO 81635

Stormwater Manual of Best Management Practices (BMPs)

June 2008

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Contents

Contents (continued)

1.0 Introduction

The primary purpose of this Stormwater Manual of Best Management Practices (BMPs) is to provide EnCana personnel, contractors, and subcontractors with information on the proper selection, design, installation, and maintenance of BMPs to manage oil and gas (O&G) related stormwater and to meet federal and state Stormwater Management Plan (SWMP) implementation requirements. The BMPs found in this manual are operating practices that may be used to control erosion, drainage, and sedimentation associated with stormwater runoff from areas disturbed by clearing, grading, and excavating activities related to site preparation and construction of oil and gas production facilities. Although the BMPs in this manual were derived from both common industry practices and from practical field experience, they may not be applicable for certain sites and field conditions.

Personnel responsible for stormwater management, whether it is design, construction, maintenance, or environmental compliance, should have a thorough knowledge of the applicable erosion and sediment control measures and the related specifications.

The main objectives of this manual are to:

1. Serve as an easy-to-use guide for selecting, designing, constructing, and maintaining BMPs.

2. Function as a reference for construction plans and specifications.

3. Ultimately lead to the avoidance of any net increase in off-site erosion and sedimentation of waters of the U.S.

In the preparation of this document, emphasis was placed on the selection and practical application of BMPs, given a variety of basic physical circumstances. The series of figures within this document are provided as a tool to quickly evaluate which BMPs may be useful at a given construction site, whether new or existing. This document anticipates that the user will be prudent and exercise good judgment in evaluating site conditions and deciding which BMP or combination of BMPs is to be used at a specific site. If the BMPs selected are not effective to prevent discharges of potentially undesirable quantities of sediment to a regulated water body, different or additional BMPs should be employed.

2.0 Planning

Planning for the inclusion of appropriate BMPs should occur early in the site development process, and can be divided into five separate steps:

1. Site Assessment – Collect the information from the site regarding topography, soils, drainage, vegetation, and other predominant features. Also make note of any existing erosion that is present. Analyze the information to anticipate erosion and sedimentation problems.

2. Avoidance and Minimization – Avoiding or minimizing disturbances on construction sites are the best protection measures against erosion and sedimentation problems. Inclusion of these measures will also decrease the amount of BMPs required during construction.

3. Construction Scheduling and Phasing – Develop a construction schedule and phasing plan that minimizes the amount of area exposed thus minimizing erosion and impacts to the area from development.

4. SWMP – Develop and implement a SWMP that specifies effective BMPs, taking into consideration the information generated from the site assessment and the construction schedule and phasing.

5. Inspections and Maintenance – Inspection and maintenance of BMPs are required by the SWMP. Evaluate the BMPs that will be implemented and allocate the necessary resources to provide for timely and thorough inspections and maintenance.

3.0 Types of Best Management Practices

Erosion Control – any source control practice that protects the soil surface and/or strengthens the subsurface in order to prevent soil particles from being detached by rain or wind, thus controlling raindrop, sheet, and/or rill erosion.

Drainage Control – any practice that reduces or eliminates gully, channel, and stream erosion by minimizing, diverting, or conveying runoff through engineered systems.

Sediment Control – any practice that traps the soil particles after they have been detached and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them prior to leaving the site boundary.

Non-Stormwater Control – any general site and materials management measure that indirectly aids in minimization of erosion and pollution of water. Types of pollution sources include, but are not limited to, litter, oil and grease, hazardous material spills, and sediment.

4.0 Principles and practices of erosion control

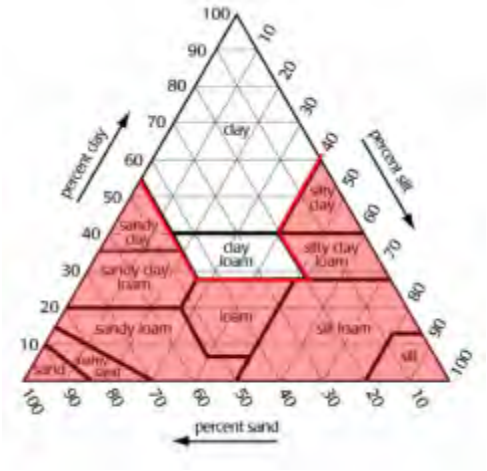
Types of erosion

Splash	Energy from the raindrop dislodges soil particles and initiates the erosion process.
Sheet	Uniform removal of saturated soil particles.
Rill	Long, narrow incisions in the soil caused by increased runoff velocities.
Gully	Deep, wide incisions caused by concentrated flow.
Streambank	Bank sloughing, toe cutting in a natural drainage pattern.

Factors affecting erosion

Soil type

The primary soil property that affects erosiveness is the cohesiveness of the soil. While there are other factors, this is the most dominant factor when considering temporary erosion controls. The generalized soil triangle shows the break between soils that can be considered cohesive or noncohesive soils. This rule of thumb has to be applied with good professional judgment.



Vegetation

Vegetation is the primary permanent erosion control for un-stabilized exposed surfaces. Anytime the existing vegetation is removed, there is immediate potential for wind and water erosion. Therefore, any un-vegetated surface should be treated with an appropriate BMP to prevent surface erosion. The appropriate BMP depends on the other factors affecting erosion.

Climate

The key climatic factors affecting erosion are rainfall intensity, duration, and return frequency, which in turn determine soil particle detachment and transport in runoff. Other climatic properties, such as temperature and growing season, have more to do with reestablishing permanent erosion controls.

Topography

The slope and length of slope have a direct influence on the transport of dislodged sediment and soil particles down slope. Even very erosive soils on flat slopes will not produce large amounts of sediment because there is not sufficient potential gravitational force to accelerate the surface runoff to velocities that will suspend and transport sediments. As slopes become steeper, the velocity of flow of surface runoff increases with a subsequent increase in sediment loads. That is why velocity management is a critical part of any erosion control practice.

5.0 Erosion control concepts

Surface protection

Protecting the soil surface will help minimize the amount of soil that is detached and transported as sediment.

Minimization of concentrated flows

Concentrated flows generate more energy and velocity than sheet flows. Greater depths and velocity generate more erosion and suspension of eroded materials. If concentrated flows develop, BMPs, such as check dams, can be used to reduce the velocity. Where concentrated flows are directed to uniform surfaces, level spreaders can be used to reestablish sheet flows.

Velocity reduction

Velocity reduction is a key component of BMP strategies. Control measures such as rock check dams, wattles, etc., are placed perpendicular to the direction of flow, whether sheet flow or concentrated flow, to slow the velocity of the water. The BMP type must be selected based on the anticipated depth, velocity, and frequency of flows over the surface or in the channel.

Sediment capture

Effective sediment control measures are designed and implemented to slow the runoff velocity and retain the sediment-laden water to allow soil particles to fall from suspension and settle out of the runoff. This will facilitate transport reduction and thereby the quantities of sediment that leave the site.

Runoff management

Runoff management tools are designed to utilize proper grading, diversions, barriers, or interceptor ditches to minimize concentrated flows and divert runoff away from denuded slopes or other critical areas. This can be done by minimizing slope steepness and length through the use of terraces, interceptor berms or ditches or diversion ditches. The concept is to divert clean runoff before it becomes sediment laden.

6.0 Selection and implementation of controls

Implementation of BMPs will be successful if used appropriately, taking into account a number of factors. The following are guidelines recommended in determining the appropriate BMPs for the site:

1. *Determine the limits of clearing and grubbing.* If the entire site will not undergo excavation and grading, the boundaries of cut-and-fill operations should be defined. Buffer strips of natural vegetation may be utilized as a control measure.

2. *Define the layout of buildings and roads.* This will have been decided previously as part of the general development plan. If building layout is not final, the road areas stabilized with pavement and the drainage features related to roads should be defined as they relate to the plan.

3. *Determine permanent drainage features.* The location of permanent channels, storm sewers, roadside swales, and stormwater quality controls such as ponds, wetlands, grassed-lined swales, buffer strips, and areas of porous pavement, if known, should be defined.

4. *Determine extent of temporary channel diversions.* If permanent channel improvements are a part of the plan, the route, sizing, and lining needed for temporary channel diversions should be determined. Location and type of temporary channel crossings can be assessed.

5. *Determine the boundaries of watersheds.* The size of drainage basins will determine the types of sediment controls to be used. Areas located off site that contribute overland flow runoff must be assessed. Measures to limit the size of upland overland flow areas, such as run-on diversions, may be initially considered at this stage.

6. *Select erosion controls.* All areas exposed will require a control measure be defined dependent on the duration of exposure. These can be selected based on the schedule of construction.

7. *Select sediment controls*. Areas greater than 5 acres will require the installation of sediment basins. Consideration can be given to dividing large drainage basins into sub-areas, each served by a sediment basin.

8. *Determine staging areas*. The schedule of construction will determine what areas must be disturbed at various stages throughout the development plan. The opportunity for staging cut-and-fill operations to minimize the period of exposure of soils can be assessed. The sequence for installing sediment controls and erosion controls can also be determined at this time.

9. Identify locations of topsoil and other stockpiles.

10. Identify location of construction roads, access points, and material storage areas.

Once BMPs have been selected, each control should be incorporated into a site-specific plan drawing as a requirement of the SWMP. Each of the following BMPs includes design criteria (to properly locate and size each control) and construction specifications (to properly install the control with the appropriate materials and methods), if applicable.

7.0 Inspection and maintenance

All BMPs must be properly inspected and maintained throughout the life of the entire operation according to the “Maintenance Considerations” section in each of the following BMPs. In general, the maintenance program should provide for inspection of BMPs on a regular basis in accordance with the SWMP. Inspection of BMPs should also occur as soon as possible after major rainfall events, particularly at sensitive areas in proximity to a perennial drainage. The inspection should include repair or replacement of the BMPs, where needed, to ensure effective and efficient operation.

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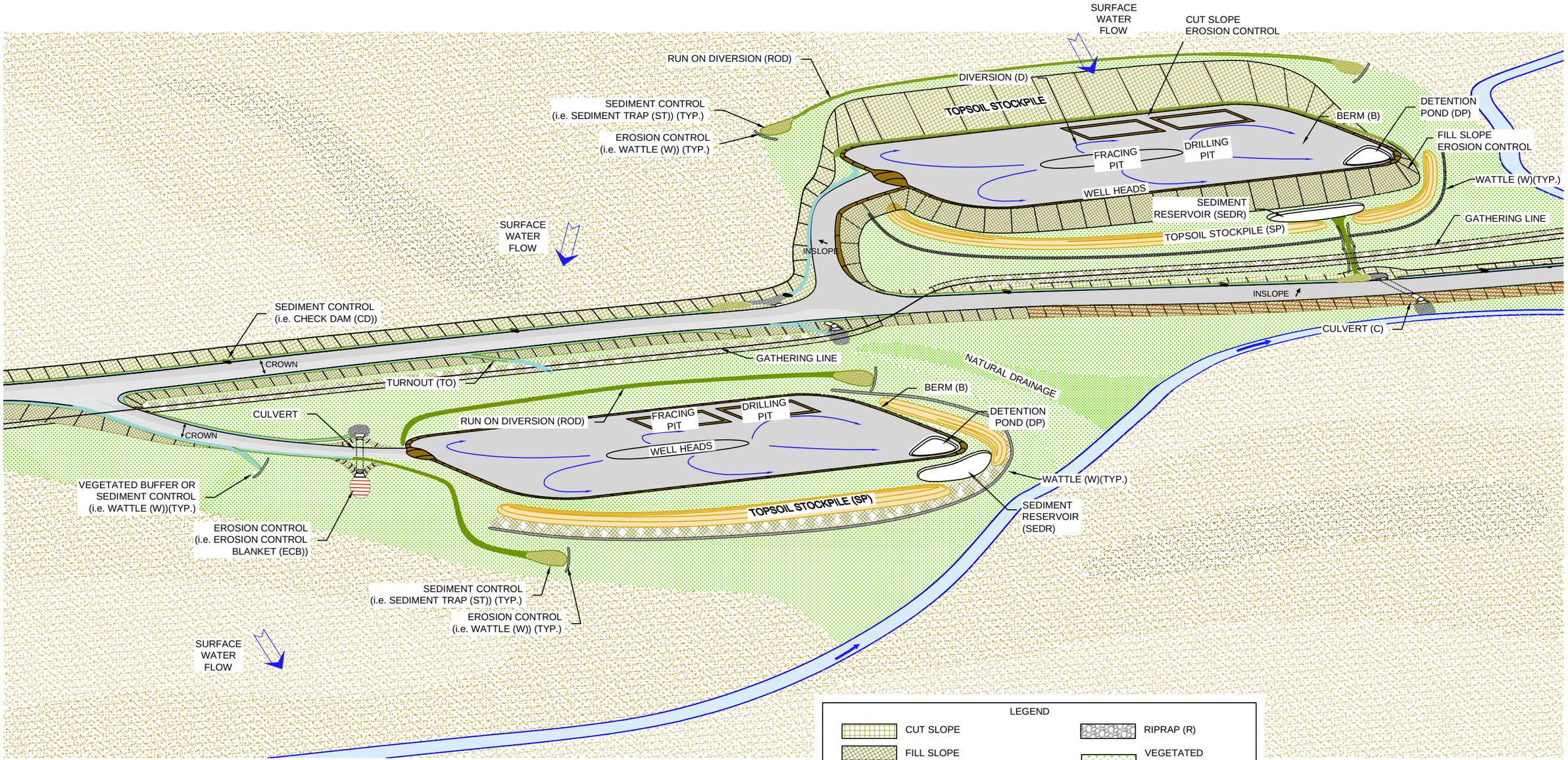

LEGEND

- CUT SLOPE
- FILL SLOPE
- ROADSIDE DITCH (RSD)
- DIVERSION (D) OR (ROD)
- BERM (B)
- TOPSOIL STOCKPILE (TS)
- EROSION CONTROL BLANKET (ECB)
- WATTLE (W)
- RIPRAP (R)
- VEGETATED BUFFER (VB)
- CHECK DAM (CD)
- SEDIMENT TRAP (ST)
- GROUND SURFACE CONTOUR (BEFORE CONSTRUCTION)
- FLOW

SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

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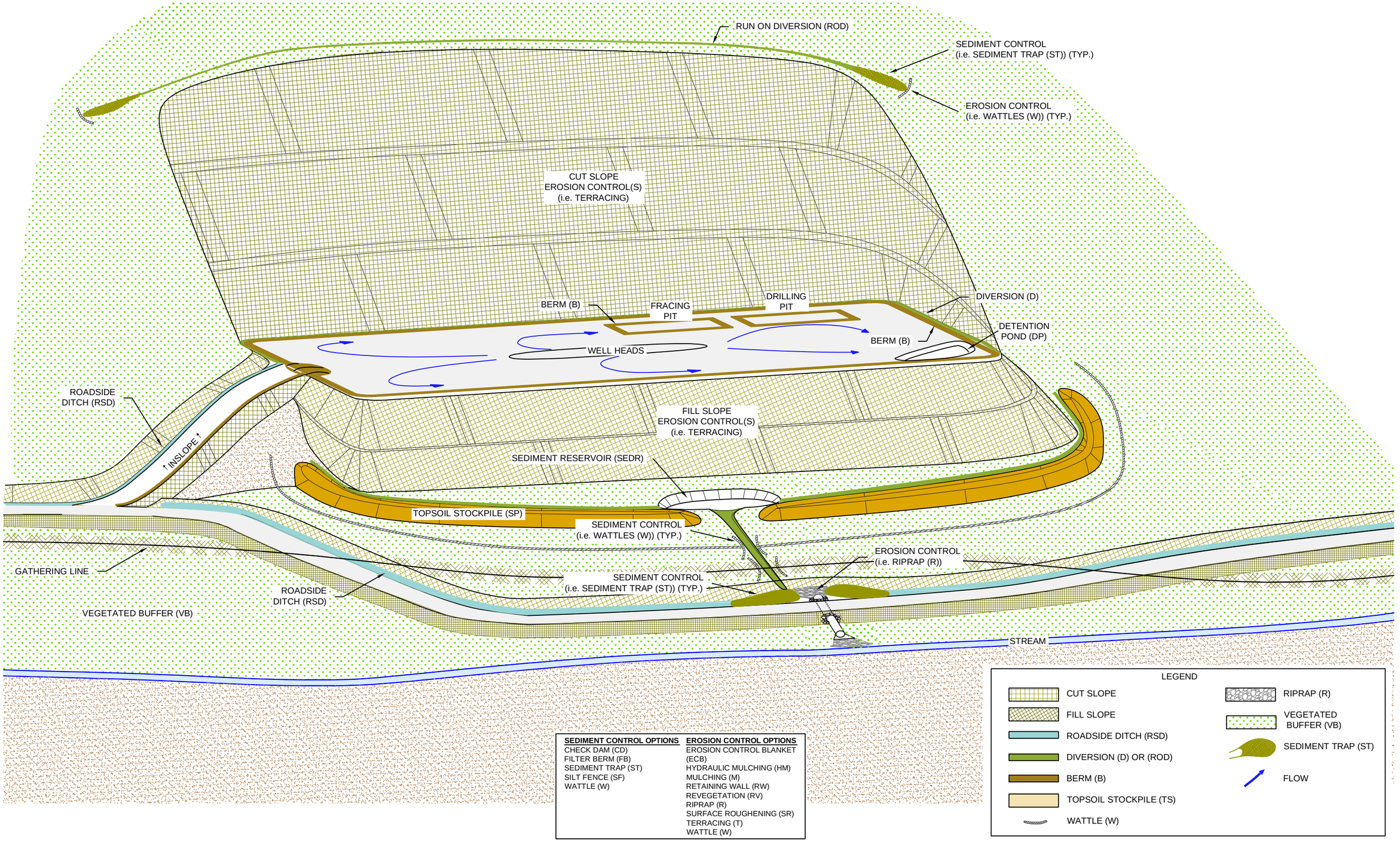
Encana, Parachute, Colorado

SITE ISOMETRIC
FLAT AND GENTLY SLOPING TERRAIN

DATE: 05/30/08 | DRWN: E.S.S./GOL | **FIGURE SI-1**

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SI-1.DWG Layout: FIGURE SI-1 User: eschneider Plotted: Jun 09, 2008 - 1:53pm Xref's:



SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

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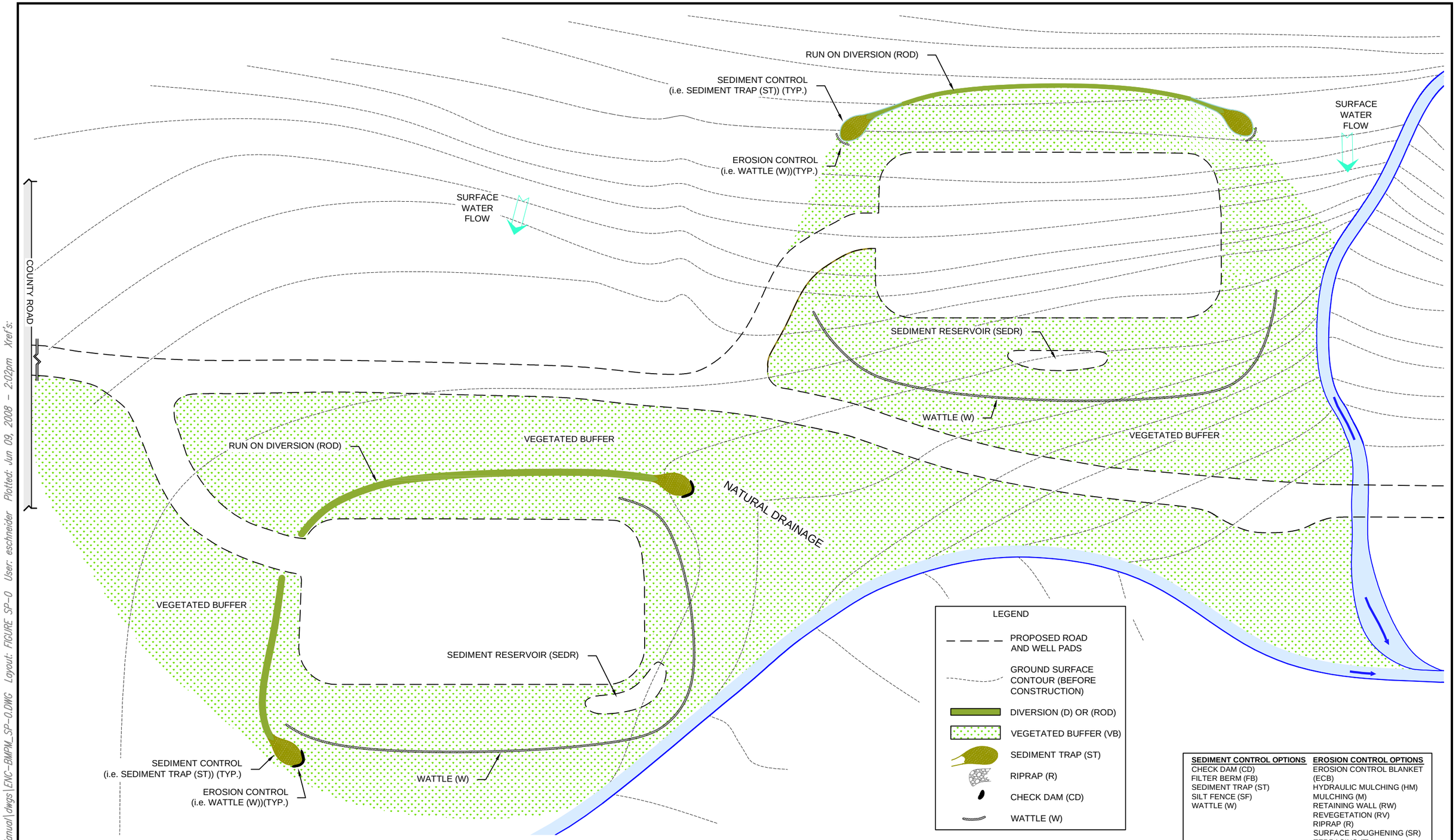
SITE ISOMETRIC
STEEP TERRAIN

DATE: 06/06/08 | DRWN: E.S.S./GOL | **FIGURE SI-2**

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SI-2.DWG Layout: FIGURE SI-2 User: eschneider Plotted: Jun 09, 2008 – 2:02pm Xref's:



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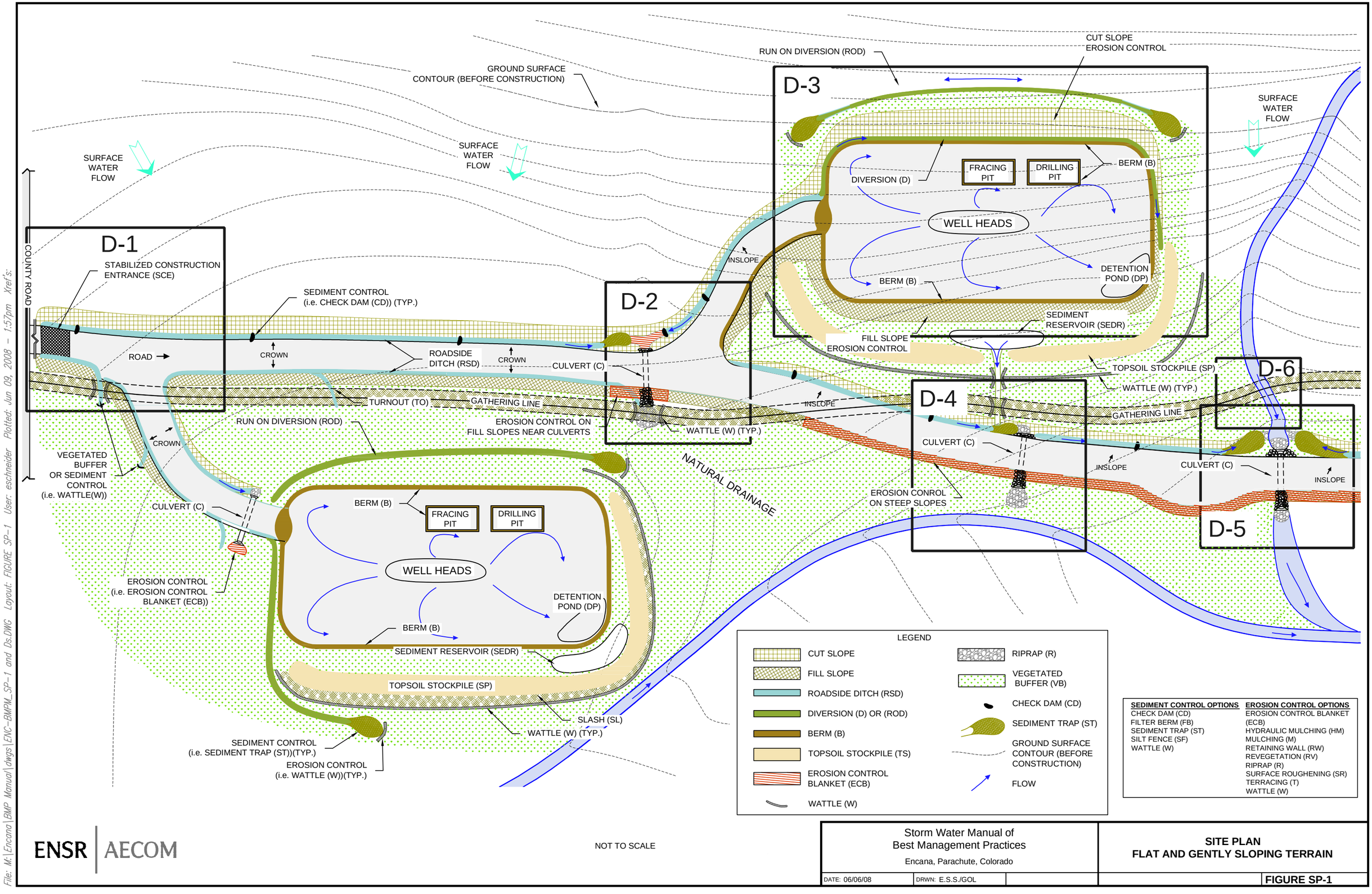
Storm Water Manual of Best Management Practices Encana, Parachute, Colorado			SITE PLAN PRECONSTRUCTION
DATE: 05/30/08	DRWN: E.S.S./GOL		FIGURE SP-0

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SP-0.DWG Layout: FIGURE SP-0 User: eschneider Plotted: Jun 09, 2008 - 2:02pm Xref's:



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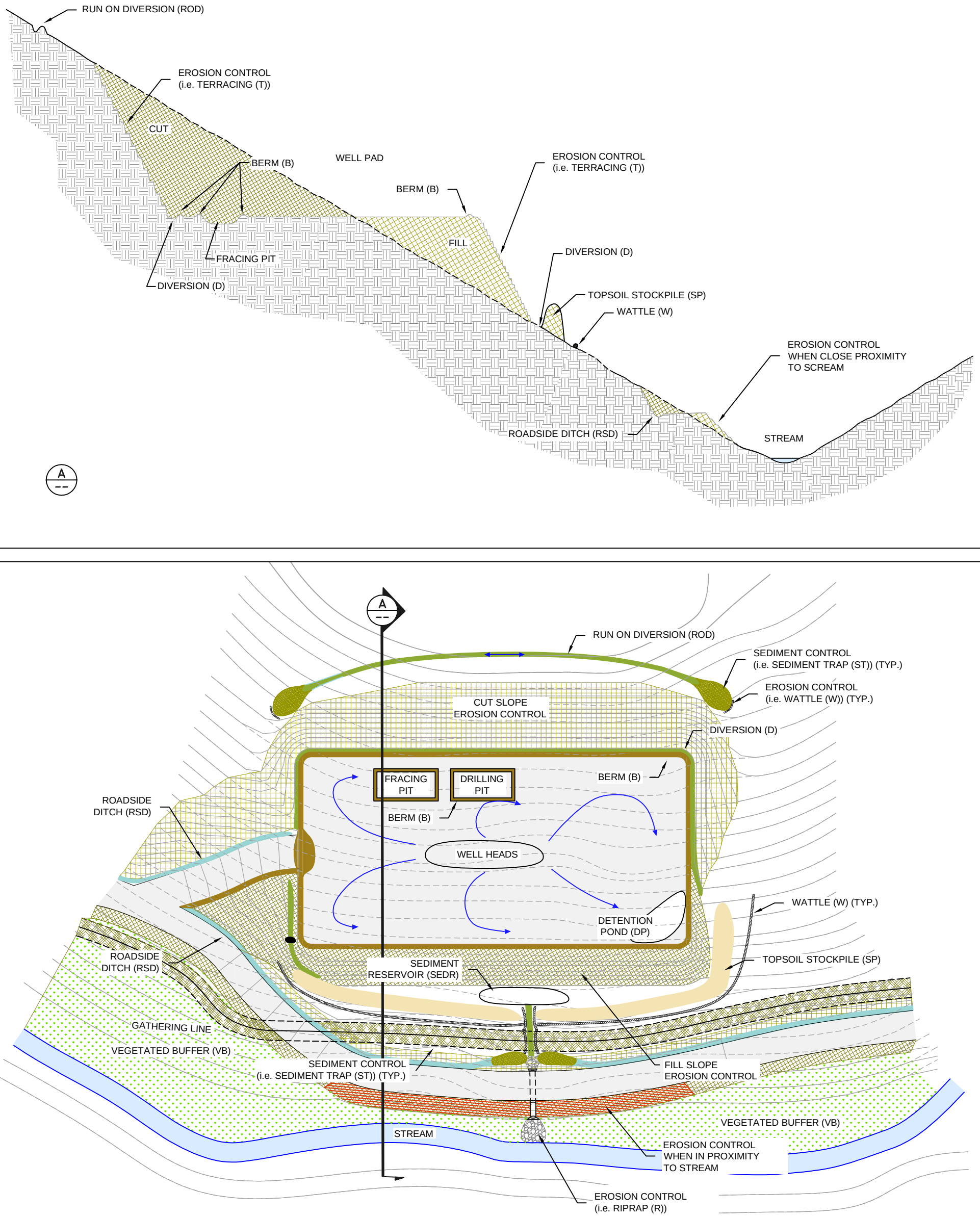
DATE: 06/06/08 | DRWN: E.S.S./GOL

SITE PLAN
FLAT AND GENTLY SLOPING TERRAIN

FIGURE SP-1

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SP-1 and Ds.DWG Layout: FIGURE SP-1 User: eschneider Plotted: Jun 09, 2008 - 1:57pm Xref's:



LEGEND

- CUT SLOPE
- FILL SLOPE
- ROADSIDE DITCH (RSD)
- DIVERSION (D) OR (ROD)
- BERM (B)
- TOPSOIL STOCKPILE (TS)
- EROSION CONTROL BLANKET (ECB)
- WATTLE (W)
- RIPRAP (R)
- VEGETATED BUFFER (VB)
- CHECK DAM (CD)
- SEDIMENT TRAP (ST)
- GROUND SURFACE CONTOUR (BEFORE CONSTRUCTION)
- FLOW

SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

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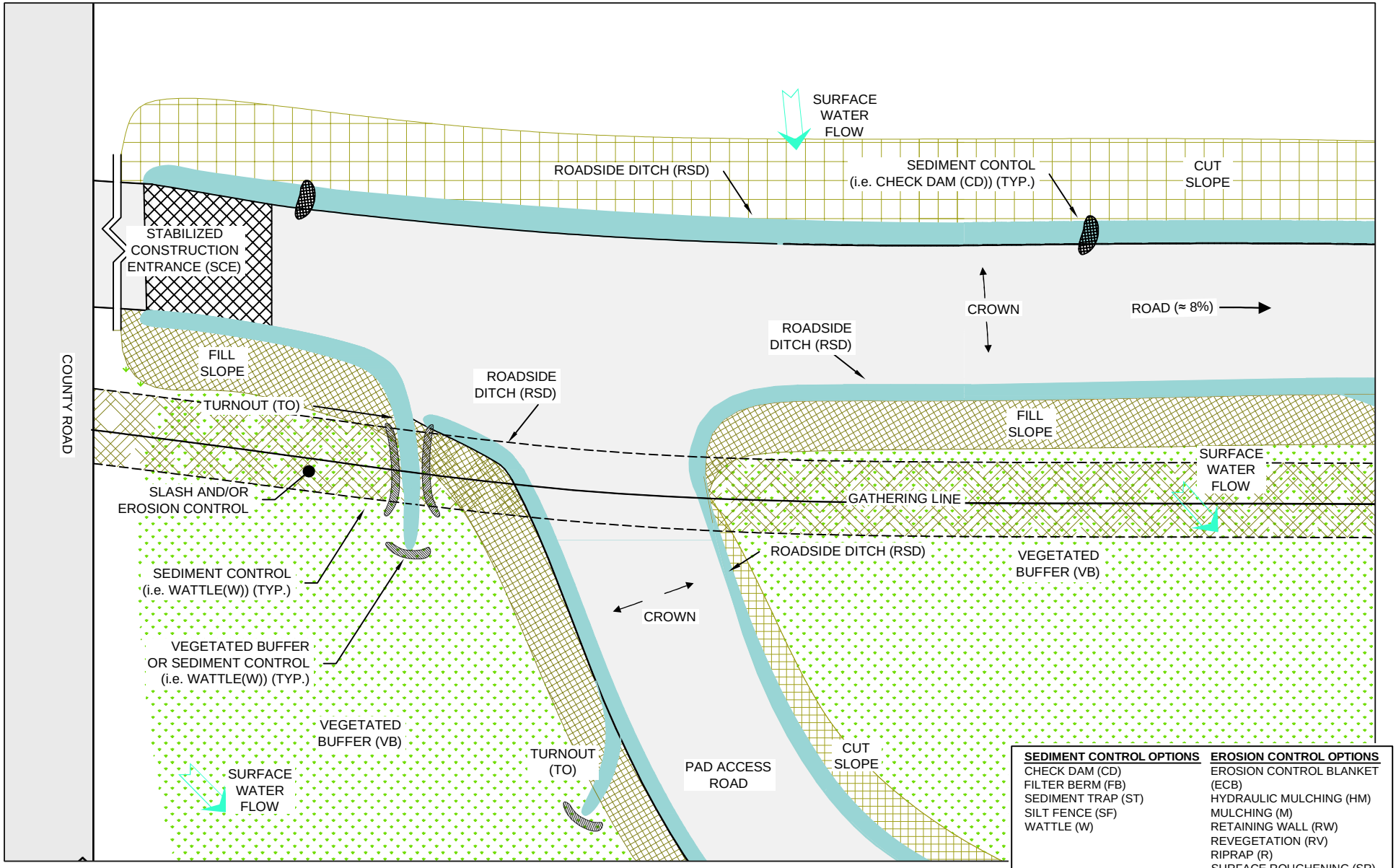
Encana, Parachute, Colorado

DATE: 06/06/08 DRWN: E.S.S./GOL

SITE PLAN
STEEP TERRAIN

FIGURE SP-2



SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

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Encana, Parachute, Colorado

ACCESS ROAD INTERSECTION
WELL PAD BELOW ROAD

DATE: 06/06/08 | DRWN: E.S.S./GOL

FIGURE D-1

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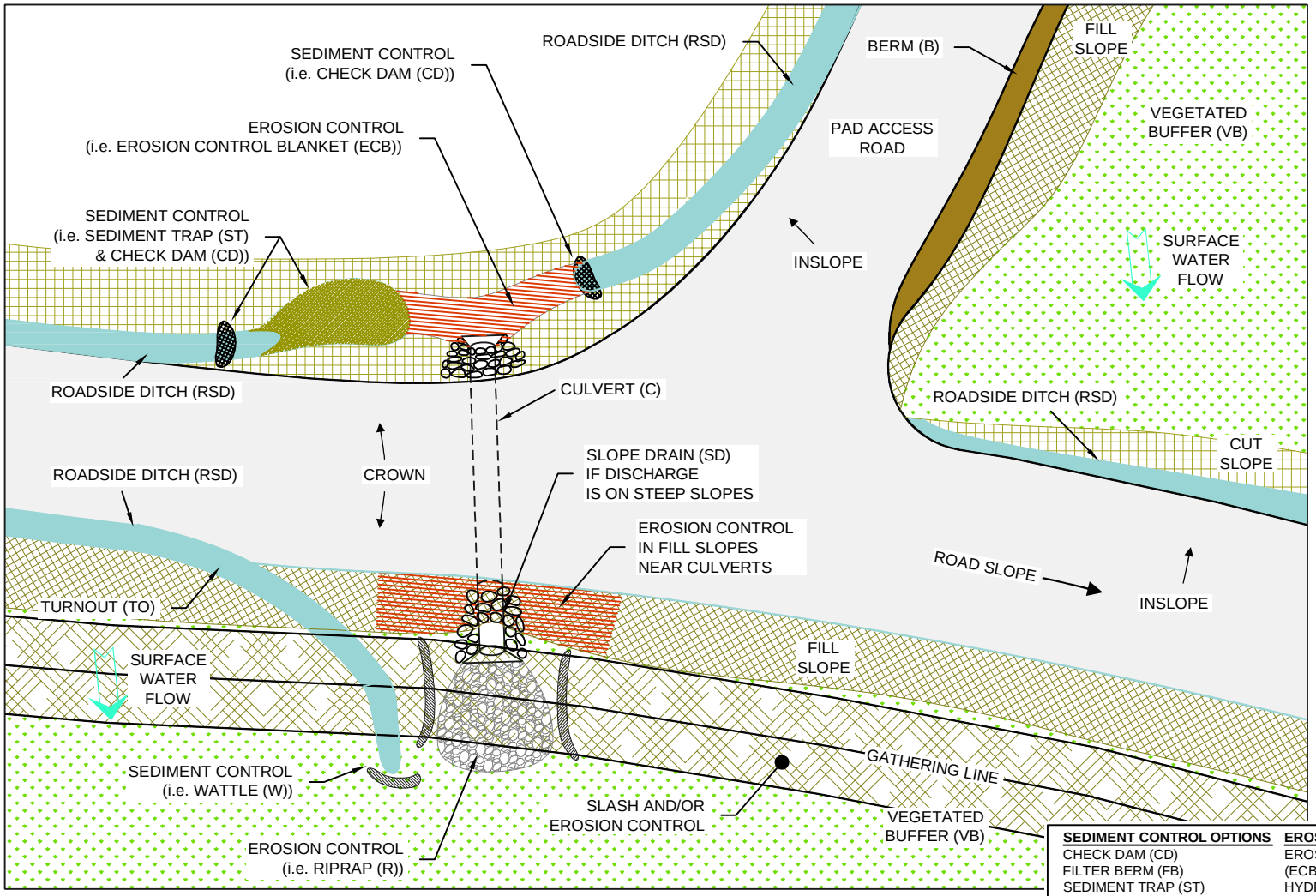

SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

NOT TO SCALE

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Encana, Parachute, Colorado

ACCESS ROAD INTERSECTION
WELL PAD ABOVE ROAD

DATE: 06/06/08 | DRWN: E.S.S./GOL

FIGURE D-2

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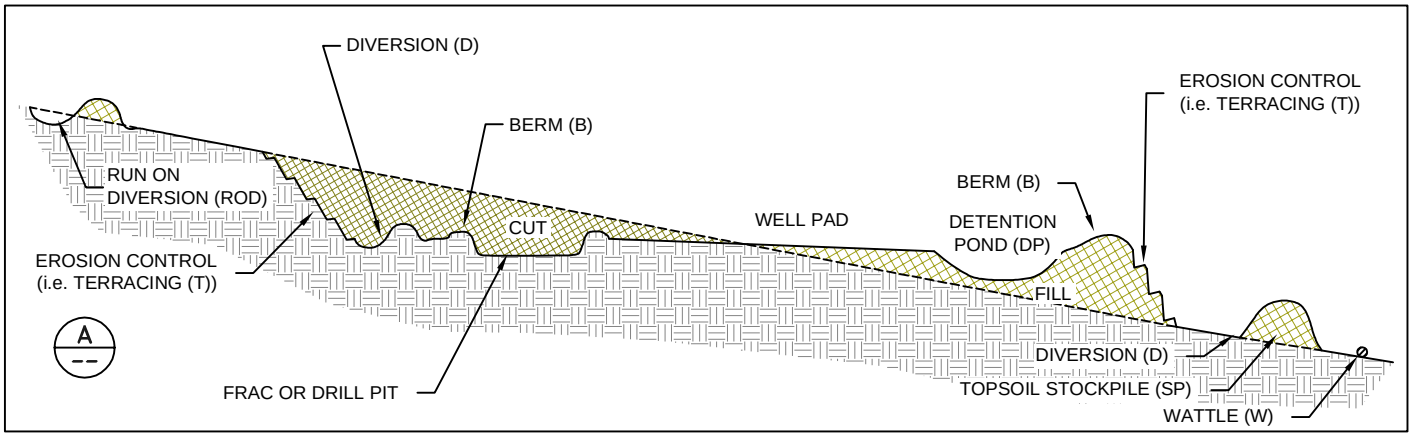

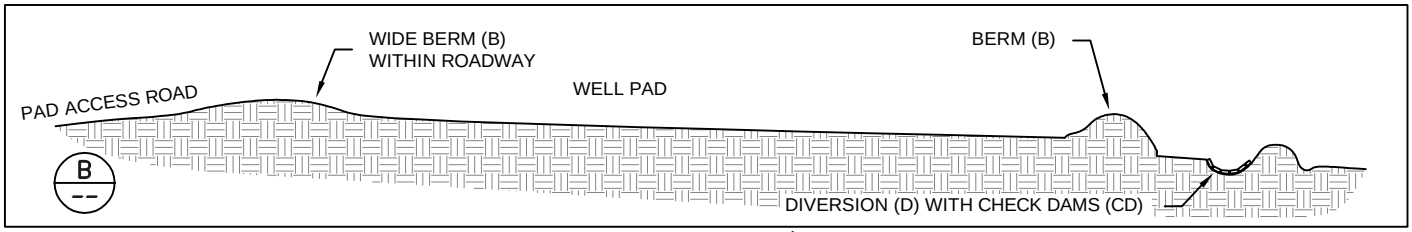

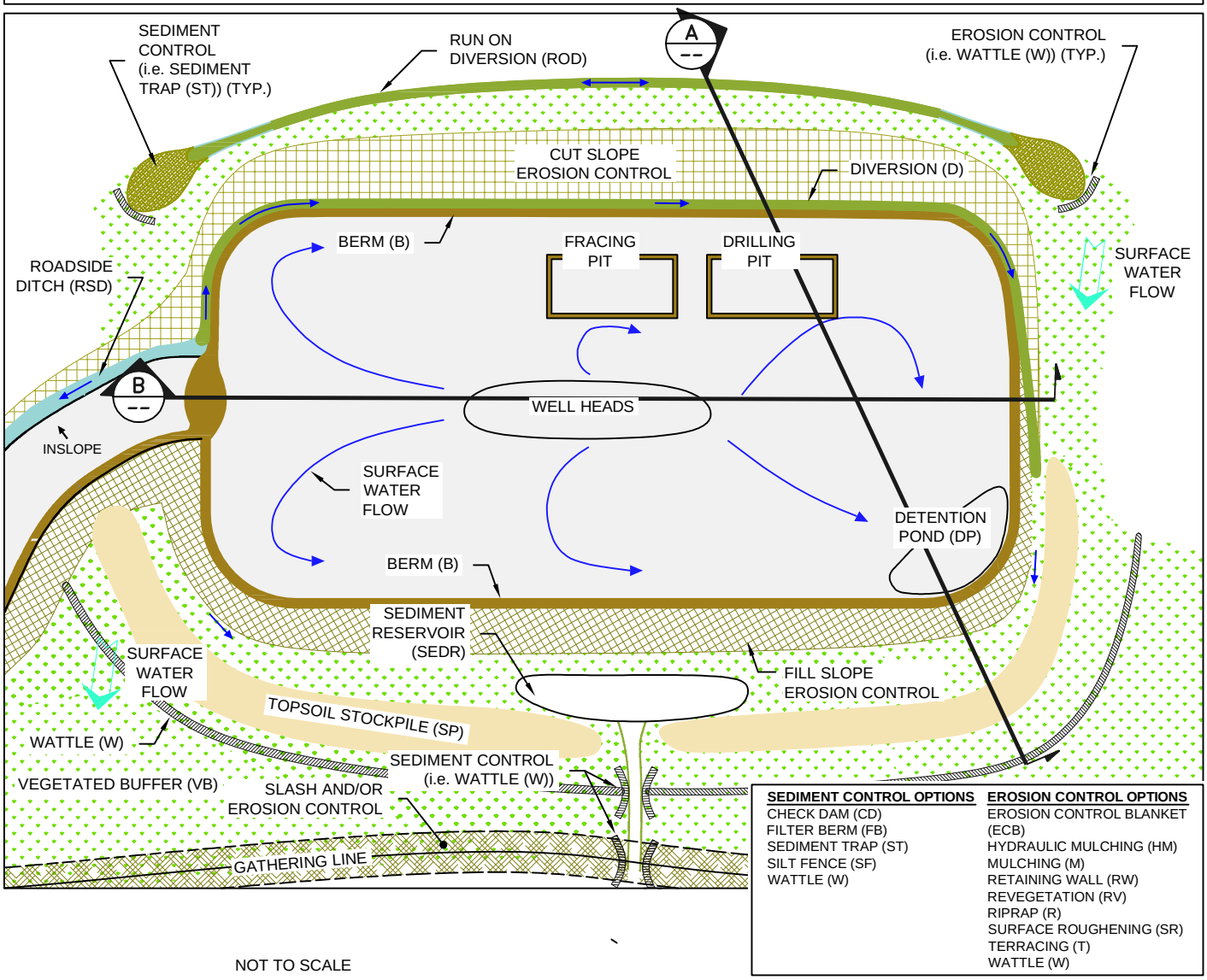

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Encana, Parachute, Colorado

WELL PAD

DATE: 06/06/08 | DRWN: E.S.S./GOL | **FIGURE D-3**

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SP-1 and Ds.DWG Layout: FIGURE D-3 User: eschneider Plotted: Jun 09, 2008 - 1:59pm Xref's:

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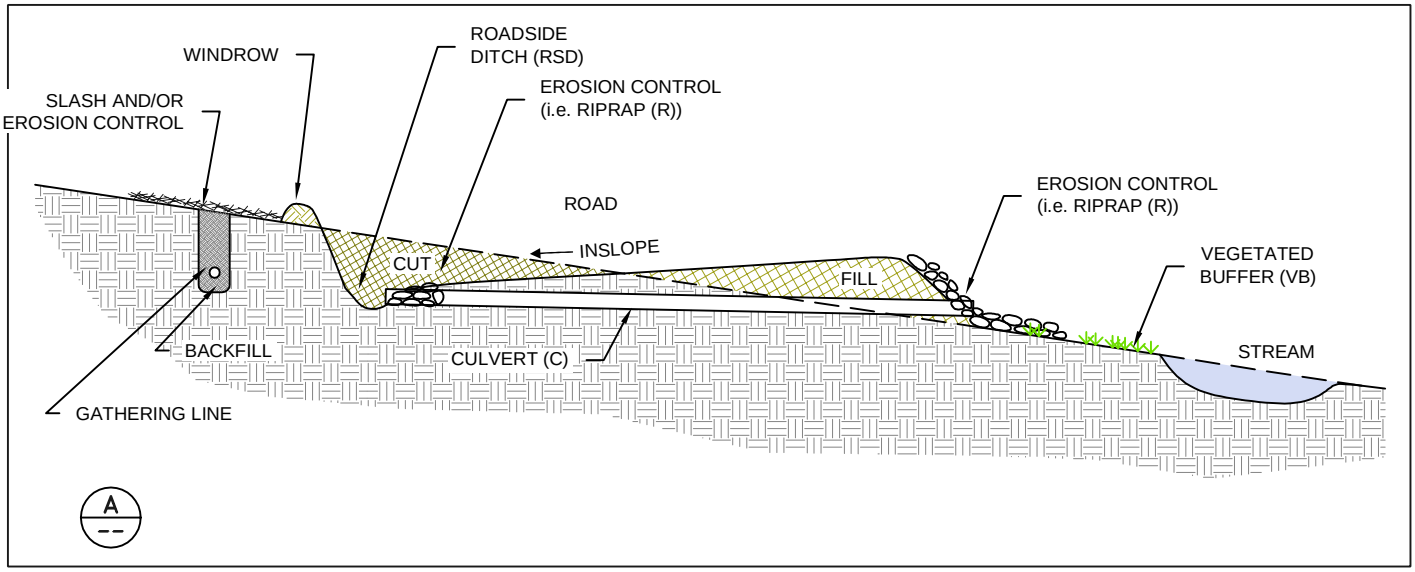

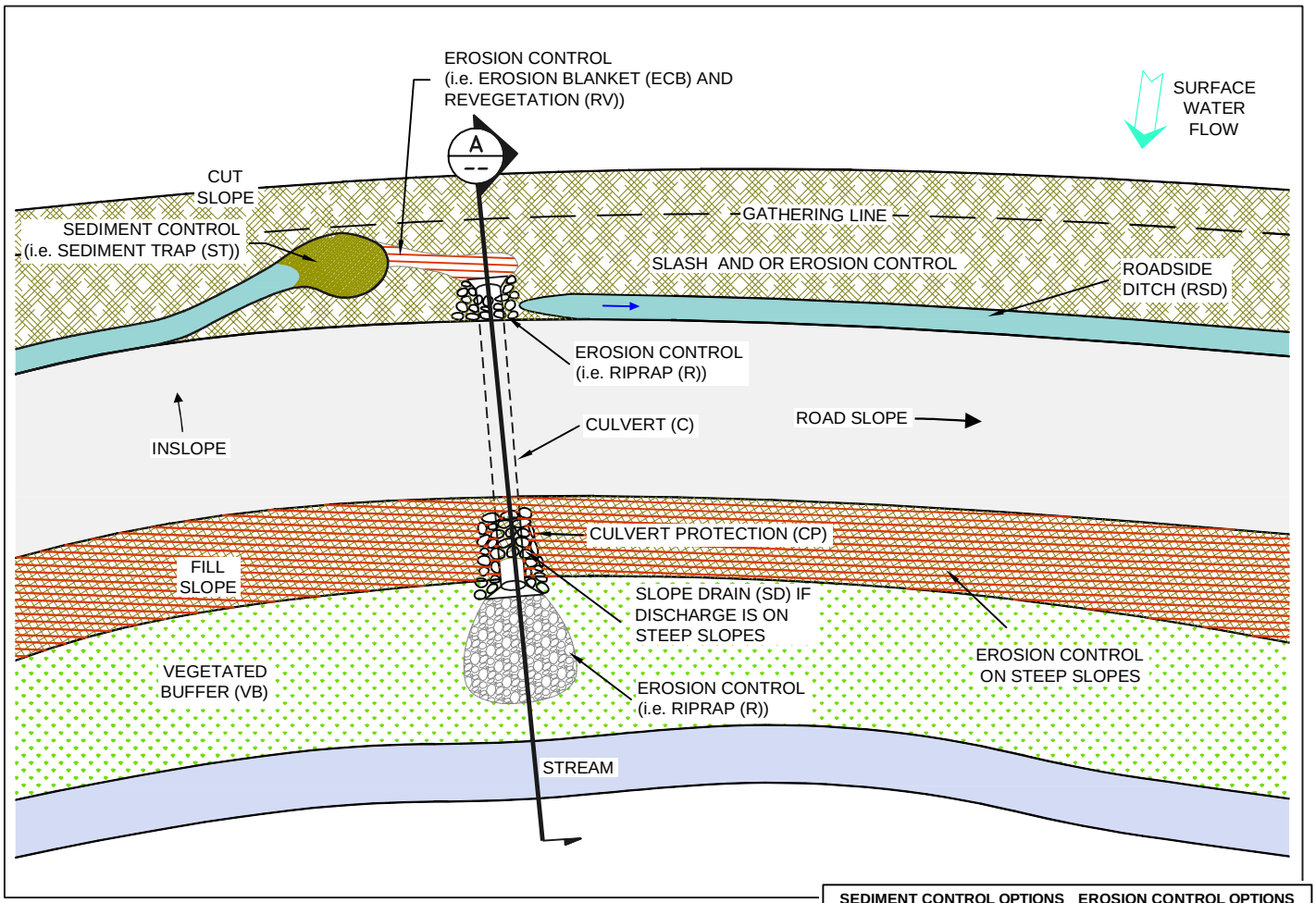

SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

NOT TO SCALE

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ROAD PARALLEL TO GATHERING LINE AND STREAM

DATE: 06/06/08 | DRWN: E.S.S.\GOL | **FIGURE D-4**

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SP-1 and Ds.DWG Layout: FIGURE D-4 User: eschneider Plotted: Jun 16, 2008 - 11:39am Xref's:

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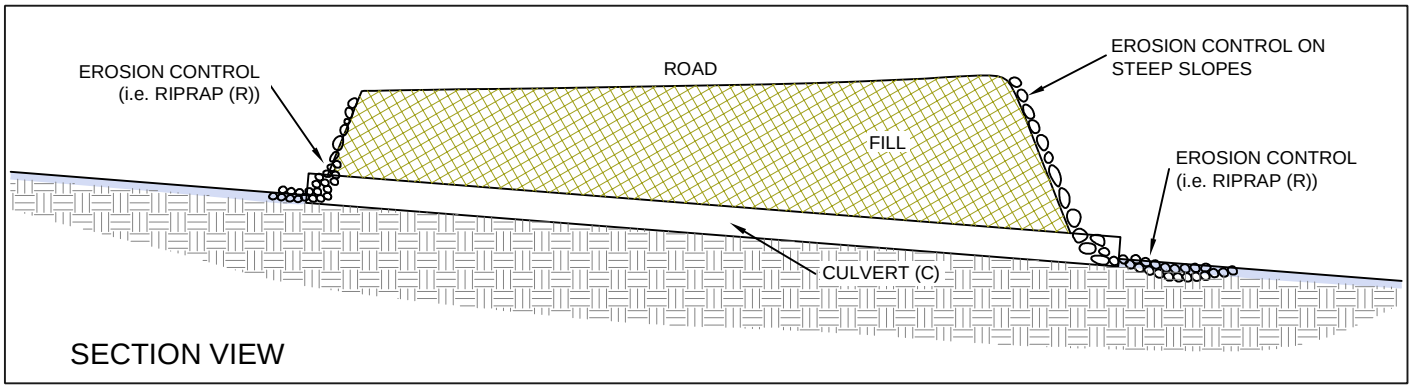
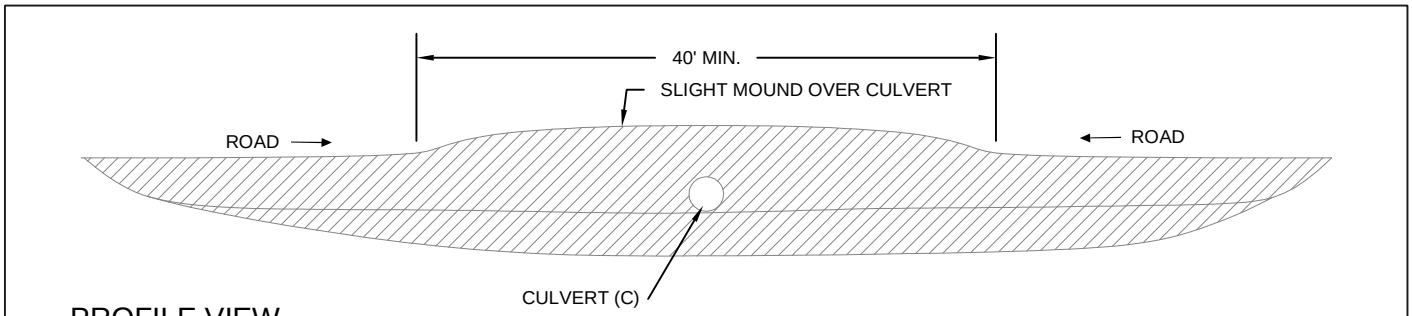
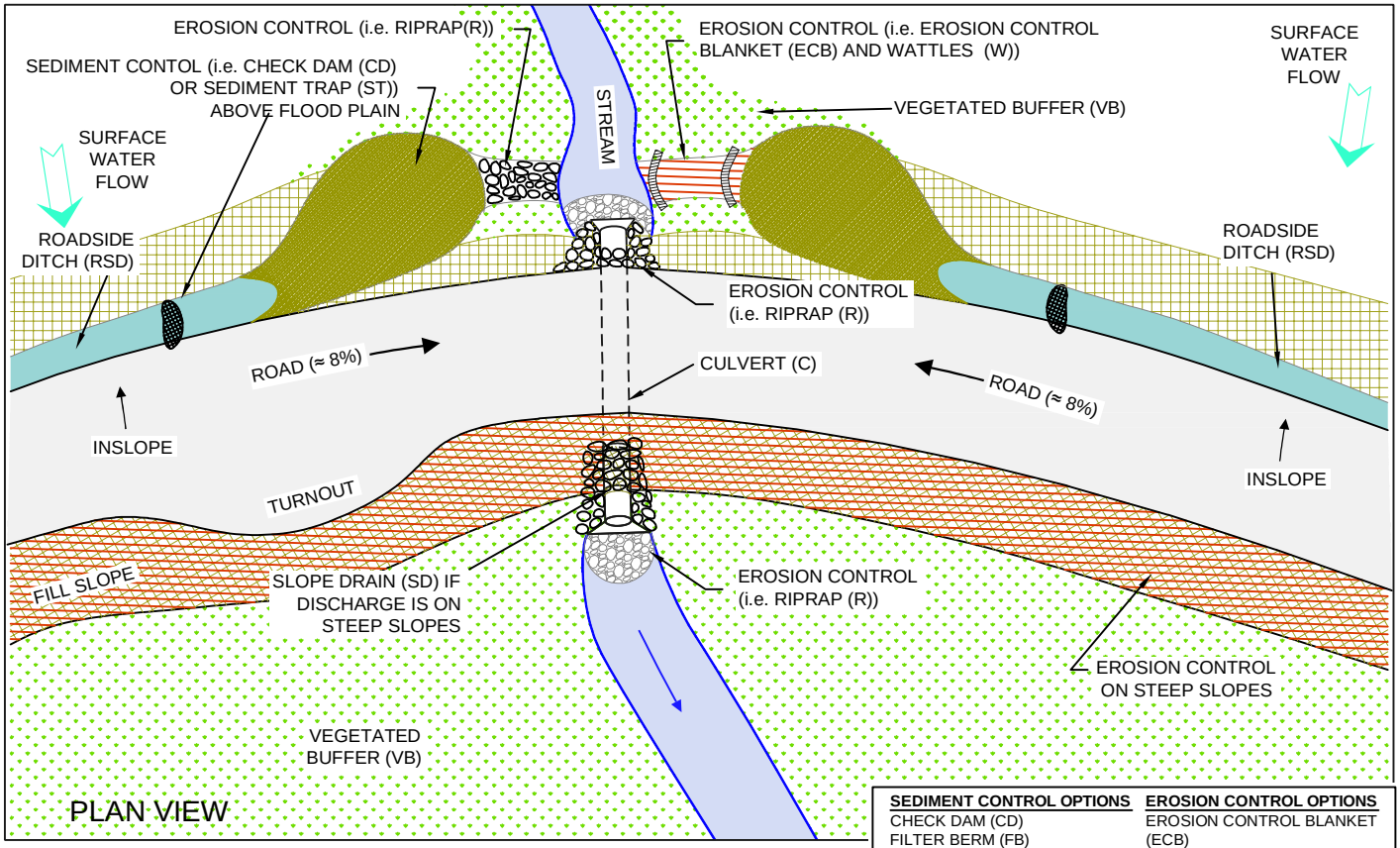


SECTION VIEW



PROFILE VIEW



PLAN VIEW

SEDIMENT CONTROL OPTIONS	EROSION CONTROL OPTIONS
CHECK DAM (CD)	EROSION CONTROL BLANKET (ECB)
FILTER BERM (FB)	HYDRAULIC MULCHING (HM)
SEDIMENT TRAP (ST)	MULCHING (M)
SILT FENCE (SF)	RETAINING WALL (RW)
WATTLE (W)	REVEGETATION (RV)
	RIPRAP (R)
	SURFACE ROUGHENING (SR)
	TERRACING (T)
	WATTLE (W)

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404 STREAM CROSSING

DATE: 06/06/08 | DRWN: E.S.S./GOL | **FIGURE D-5**

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SP-1 and Ds.DWG Layout: FIGURE D-5 User: eschneider Plotted: Jun 09, 2008 - 2:01pm Xref's:

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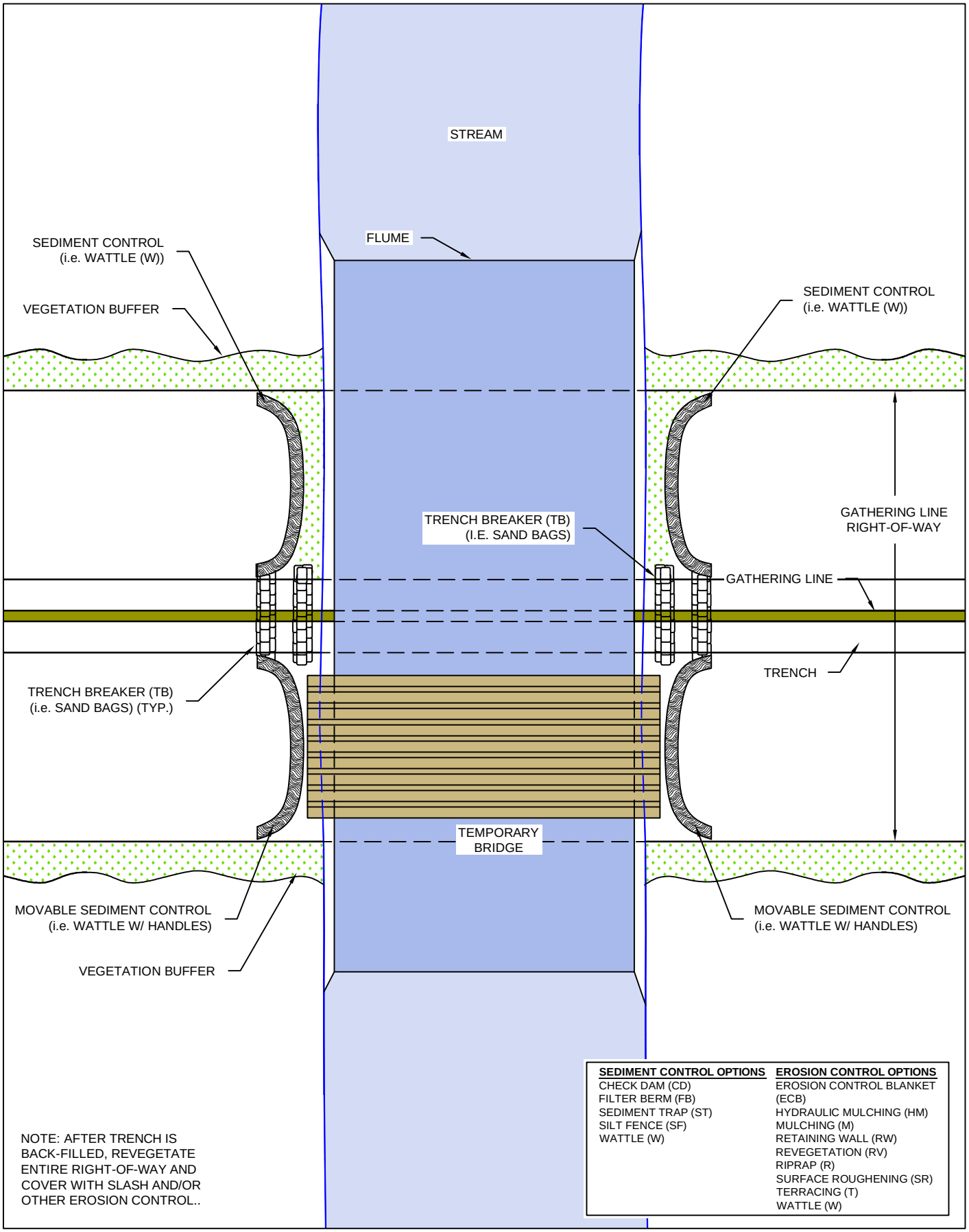

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Best Management Practices

Encana, Parachute, Colorado

DATE: 06/06/08 | DRWN: E.S.S./GOL

GATHERING LINE CROSSING STREAM (DURING CONSTRUCTION CONDITION)

FIGURE D-6

File: M:\Encana\BMP Manual\dwgs\ENC-BMPM_SP-1 and Ds.DWG Layout: FIGURE D-6 User: eschneider Plotted: Jun 09, 2008 - 2:01pm Xref's:

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Erosion Control BMPs

Erosion Control Blanket (ECB)
Hydraulic Mulching (HM)
Land Grading (LG) – Roads
Low Water Crossing (LWC)
Mulching (M)
Retaining Wall (RW)
Revegetation (RV)
Riprap (R)
Soil Stabilizers (SS)
Stockpiling (SP) – Topsoil and Subsoil
Surface Roughening (SR)
Terracing (T)
Turf Reinforcement Mat (TRM)
Vegetated Buffer (VB)
Wattles (W)

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Erosion Control Blanket (ECB)

Description

Erosion control blankets are porous fabrics and are manufactured by weaving or bonding fibers made from organic or synthetic materials. Erosion control blankets are installed on steep slopes, over berms, or in channels to prevent erosion until final vegetation is established. However, blankets can also be used as separators or to aid in plant growth by holding seeds, fertilizers, and topsoil in place.

Applicability

Erosion control blankets may be used in the following applications:

- To control erosion on steep slopes and to promote the establishment of vegetation.
- To stabilize channels against erosion from concentrated flows.
- To protect berms and diversions prior to the establishment of vegetation.
- To protect exposed soils immediately and temporarily, such as when active piles of soil are left overnight.
- As a separator between riprap and soil to prevent soil from being eroded from beneath the riprap and to maintain the riprap's base.
- May be used on slopes as steep as 1:1.

Limitations

- Blankets used on slopes should be biodegradable, or photodegradable, non-toxic to vegetation or germination of seed, and non-toxic or injurious to humans.
- Should not be used on slopes where vegetation is already established.
- Some blankets might promote increased runoff and might blow away if not firmly anchored.
- If the fabric is not properly selected, designed, or installed, the effectiveness may be reduced drastically. Manufacturer's specifications should be followed.

Design criteria

There are many types of erosion control blankets available. Therefore, the selected fabric should match its purpose. Effective netting and matting require firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil, and erosion will occur underneath the material. Fabric should be purchased at an appropriate with to cover the whole width of the channel, if possible. Table ECB-1 indicates some recommended criteria for the selection of erosion control blankets.

Construction specifications

1. Smooth soil prior to installation and apply seed prior to fabric installation for stabilization of construction sites.
2. Select the appropriate fabric type. North American Green products are listed in Table ECB-1. However, other products may also be used. Site specifics shall dictate blanket selection and use.
3. Select the appropriate seed mix according to the specification in Revegetation (RV).
4. Installation of the blankets shall be in accordance with the manufacturer's recommendations and according to Figure ECB-1. For blankets being placed in channels, the fabric should be rolled out parallel to the channel if the width is sufficient to cover the entire width of the channel. The fabric needs to be in continuous contact with exposed soil.
5. Pins or staples shall be made of wire 0.162 inch or larger in diameter. "U" shaped staples shall have legs 8" long, and a 1" crown. "T" shaped pins shall have a minimum length of 8". The bar of the "T" shall be at least 4" long. Triangular survey stakes can also be used.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspections should determine if cracks, tears, or breaches have formed in the fabric. If the effectiveness of the BMP has been reduced, the fabric should be repaired or replaced immediately. Re-anchor loosened matting and replace missing matting and staples as required. It is necessary to maintain contact between the ground and the blanket at all times. Trapped sediment should be removed after each storm event.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

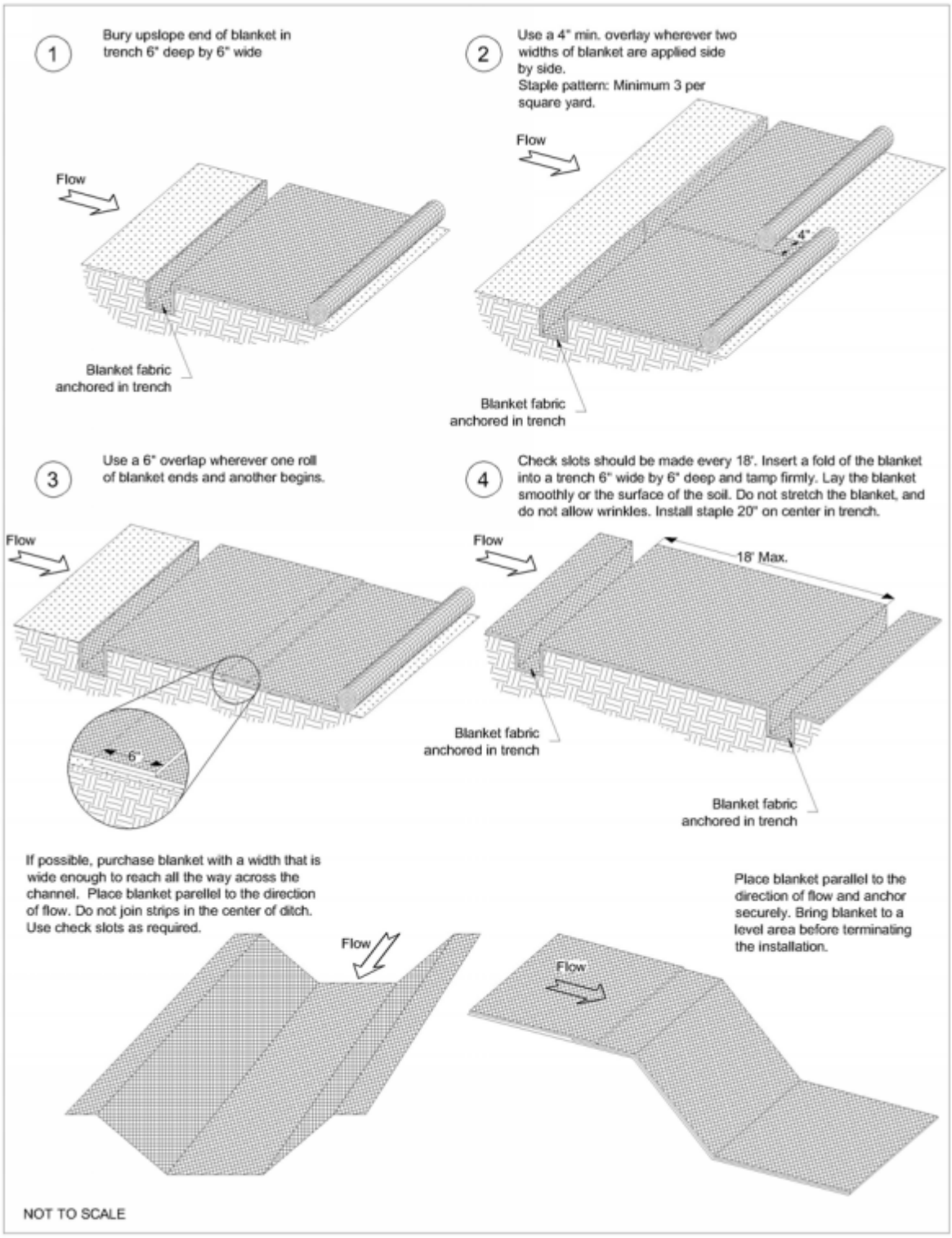
Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

North American Green, 2004. <http://www.nagreen.com>

Table ECB-1
Suggested Blanket Types

Description (North American Green Product #)	Longevity	Applications	Max. Flow Velocity (feet/sec.)
Single Net Straw Blanket (S75)	12 months	4:1 - 3:1 Slopes Low Flow Channels	5
Rapid Degrading Net (DS75)	45 - 60 Days		
Double Net Straw Blanket (S150)	12 months	3:1 - 2:1 Slopes Moderate Flow Channels	6
Rapid Degrading Nets (DS150)	45 - 60 Days		
Double Net Blanket 70% Straw/30% Coconut (SC150)	24 months	2:1 - 1:1 Slopes Medium Flow Channels	8
Double Net Blanket 100% Coconut (C125)	36 months	1:1 & Greater Slopes High Flow Channels	10
Double Net Blanket Polypropylene Fiber (P300)		1:1 Slopes Extended Flow Areas High Flow Channels	9 (unveg.) 16 (veg.)
Organic Net (S75BN)	12 months	4:1 - 3:1 Slopes Low Flow Channels	5
Organic Net (S150BN)	12 months	3:1 - 2:1 Slopes Moderate Flow Channels	6
Organic Net (SC150BN)	18 months	2:1 - 1:1 Slopes Medium Flow Channels	8
Organic Net (C125BN)	24 months	1:1 & Greater Slopes High Flow Channels	10

Figure ECB-1
Erosion Control Blanket Installation



Hydraulic Mulching (HM)

Description

Hydraulic mulching (hydro-mulching) is a temporary erosion control practice in which materials such as grass, hay, wood chips, wood fibers, straw, or gravel are hydraulically applied to exposed or recently planted soil surfaces. Hydraulic mulching stabilizes soils by minimizing rainfall impact and reducing stormwater runoff velocity. When used in combination with seeding or planting, hydraulic mulching can aid plant growth by holding seeds, fertilizers, and topsoil in place, preventing birds from eating seeds, retaining moisture, and insulating plant roots against extreme temperatures.

Hydraulic application of mulch (as well as seed) can be done quickly and efficiently with the correct equipment and ingredients.

Applicability

Hydraulic mulching is often used in steep areas where regular mulching is difficult because of environmental constraints. Hydraulic mulches can be used on seeded and planted areas where slopes are as steep as 1:1.

Limitations

- Hydro-mulching might delay seed germination because the cover changes soil surface temperatures.
- The mulch itself is subject to erosion and may be washed away in a large storm.
- Maintenance is necessary to ensure that hydro-mulch provides effective erosion control.
- Hydraulic application of mulch must be done when no rainfall is expected, preferably within a 24-hour time period.

Design criteria

No formal design is required.

Construction specifications

1. Site preparation:

    a. Prior to mulching, install the necessary temporary or permanent erosion control practices and drainage systems within or adjacent to the area to be mulched.

    b. Slope, grade, and smooth the site to fit needs of selected mulch products.

    c. Remove all undesirable stones and other debris to meet the needs of the anticipated land use and maintenance required.

2. Hydraulic mulching:

    a. For steep slopes an Erosion Control Mulch (ECM) consisting of a hydraulic matrix such as a Bonded Fiber Matrix (BFM) or Flexible Growth Medium (FGM) may be used. A BFM refers to a continuous layer of elongated wood fiber strands that are held together by a water-resistant bonding agent to form a water-absorbing crust.

    b. The ECM shall be a hydraulically-applied, flexible erosion control blanket composed of long strand, thermally refined wood fibers, crimped, interlocking fibers, and performance enhancing additives. The ECM shall require no curing time period and upon application shall form an intimate bond with the soil surface to create a continuous, porous, absorbent and erosion resistant blanket that allows for rapid germination and accelerated plant growth.

    c. The ECM shall conform to the property values in Table HM-1 when uniformly applied at a rate of 3500 pounds per acre (3900 kilograms/hectare) under laboratory conditions. Composition shall be as follows:

        Thermally Processed Wood Fibers: 74.5% ± 2.5%
        Crosslinked Hydro-Colloid Tackifier: 10% ± 1%
        Crimped, Interlocking Fibers: 5% ± 1%
        Moisture Content: 10.5% ± 1.5%

3. Installation:

    a. Strictly comply with manufacturer's installation instructions and recommendations. Use approved hydro-spraying machines with fan-type nozzle (50-degree tip) whenever possible to achieve best soil coverage. Apply ECM from opposing directions to soil surface to assure 95% soil surface coverage. Slope interruption devices or water diversion techniques are recommended when slope lengths exceed 100 ft (30m).

    b. Step One: Apply seed, fertilizer and other soil amendments with tackifier and a small amount of ECM for visual metering (see Revegetation (RV) for application rates).

    c. Step Two: Mix 50 lb of ECM per 125 gallons (23 kg/475 liters) of water; confirm loading rates with equipment manufacturer (different manufacturers rates may vary slightly).

    d. Install materials at the typical application rates in Table HM-2.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Areas should be identified where mulch has loosened or been removed. Such areas should be reseeded (if necessary) and the mulch cover replaced. If washout, breakage, or erosion occurs, surfaces should be repaired, reseeded, and re-mulched. Inspections should be continued until vegetation is firmly established.

References

California Stormwater Quality Association, Stormwater Best Management Practice (BMP) Handbook – Construction. January, 2003. <http://www.cabmphandbooks.com/Construction.asp>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Table HM-1

Property Values for Erosion Control Mulch

Property	Test Method[1]	English	SI
Physical			
Mass Per Unit Area	ASTM D-6566	11.5 oz/yd^2	390 g/m^2
Thickness	ASTM D-6525	0.19 in	4.8 mm
% Ground Cover	ASTM D-6567	99%	99%
Flexural Rigidity (wet)	ASTM D-6575	0.138 oz-in	10,000 mg-cm
Color (fugitive dye)	Observed	Green	Green
Endurance			
Functional Longevity	Observed	Up to 18 months	Up to 18 months
Performance			
Cover Factor[3] (6 in/hr event)	ECTC Test Method #2	0.0066	0.0066
% Effectiveness[3]	ECTC Test Method #2	99.34%	99.34%
Shear Stress	ECTC Test Method #3	1 lb/ft^2	48 Pa
Vegetation Establishment	ECTC Test Method #4	800%	800%

1. ASTM and ECTC (Erosion Control Technology Council) test methods developed for Rolled Erosion Control Products.
2. Cover Factor is calculated as soil loss ratio of treated surface versus an untreated control surface.
3. % Effectiveness = 1 minus Cover Factor multiplied by 100%.

Table HM-2

Typical Mulch Application Rates

Slope Gradient/Condition	English	SI
≤3H to 1V	3000 lb/ac	3400 kg/ha
>3H to 1V and ≤2H to 1V	3500 lb/ac	3900 kg/ha
>2H to 1V and ≤1H to 1V	4000 lb/ac	4500 kg/ha
>1H to 1V	4500 lb/ac	5100 kg/ha
Below ECB or TRM	1500 lb/ac	1700 kg/ha
As infill for TRM	3500 lb/ac	3900 kg/ha

Slope Gradient/Condition	Performance Specification
≤3H	70-80% soil coverage, minimum 0.16 inch depth
≤3H to 1V	90-100% soil coverage, ≤2" rocks uncovered, minimum 0.19 inch depth
>3H to 1V and ≤2H to 1V	95-100% soil coverage, ≤6" rocks uncovered, minimum 0.22 inch depth
>2H to 1V and ≤1H to 1V	100% soil coverage, ≤12" boulders uncovered, minimum 0.22 inch depth
>1H to 1V	All exposed surfaces including rock outcrops shall be covered at a minimum of 0.24 inch depth
Below ECB or TRM	1500-2500 lb/ac slope dependent, minimum 0.08 inch depth
As infill for ECB	1500-3500 lb/ac, minimum 0.19 inch depth
As infill for TRM	Perpendicular application with 100% infill, minimum 0.19 inch depth

Land Grading (LG) – Roads

Description

Land grading of roads involves reshaping the ground surface to planned grades as determined by an engineering survey, evaluation, and layout. This BMP shall include the following:

- Proper road cut and fill techniques to ensure road remains stable over time.
- Road crowning or sloping to properly route runoff off the roadway.
- Surfacing the road with gravel to avoid mud, rutting, and large quantities of sediment that will wash away during storms.

Applicability

- This BMP is applicable to the construction and maintenance of any road, but particularly those located on steep topography or easily erodible soils.
- Road gravel is applicable to all roads with "soft" sections, steep grades, highly erosive soils, or where all-weather access is needed. Road gravel may be used as "fill" material in ruts or as a full structural section over the entire road.

Limitations

- Improper cut and fill slopes that disrupt natural stormwater patterns might lead to poor drainage, high runoff velocities, and increased peak flows during storm events.
- Rutting and washboarding may develop if surface gravel is not designed properly or if road is not sloped.
- Flat-blading to maintain the roadway must be done properly to avoid changes in gravel thickness, road slope, and road grade.

Design criteria

Grading plan

A grading plan should be prepared that establishes the extent to which the road will be graded, how drainage patterns will be directed, and how runoff velocities will affect receiving waters. The grading plan also includes information regarding when earthwork will start and stop, establishes the degree and length of finished slopes, and dictates where and how excess material will be disposed of (or where borrow materials will be obtained if needed). Practices must be developed for erosion control, slope stabilization, and safe disposal of runoff water and drainage, such as ditches and culverts, grade stabilization structures, retaining walls, and surface drains. Berms, roadside ditches, and other stormwater practices that require excavation and filling also should be incorporated into the grading plan.

Slope failures

Landslides and failed road cuts and fills can be a major source of sediment, they can close the road or require major repairs, and they can greatly increase road maintenance costs. Slope failures, or landslides, typically occur where a slope is over-steep, where fill material is not compacted, or where cuts in natural soils encounter groundwater or zones of weak material. Good road location can often avoid landslide areas and reduce slope failures. When failures do occur, the slide area should be stabilized by removing the slide material, flattening the slope, adding drainage, or using structures, as discussed below. Designs are typically site specific and may require input from geotechnical engineers and engineering geologists. Failures that occur typically impact road operations and can be costly to repair. Failures near streams and channel crossings have an added risk of impact to water quality.

Road slope

See Figure LG-1. All roads should be designed with one of the following three slope types:

- Outsloped roads minimize the concentration of water and minimize road width by avoiding the need for an inside ditch, but may require roadway surface and fill slope stabilization. Outsloped roads with clay rich, slippery road surface materials often require surface stabilization with gravel or limited use during rainy periods to assure traffic safety. On road grades over 10 to 12 percent and on steep hill slope areas, outsloped roads are difficult to drain and can feel unsafe.
- Insloped roads are the best method to control surface water. However, insloped roads also concentrate water and require a system of ditches and turnouts or cross-draining culverts.
- Crowned roads are appropriate for higher standard, two lane roads on gentle grades. They may or may not require roadside ditches, turnouts, and/or cross-drains. It is difficult to create and maintain a crown on a narrow road, so generally insloped or outsloped road drainage is more effective.

Construction specifications

Cut and fill slopes

1. All applicable perimeter erosion and sediment control practices and measures (berms, diversions, silt fence, vegetated buffer, or wattles) shall be constructed prior to any road grading activities, and maintained in accordance with this BMP and the Stormwater Management Plan (SWMP). Perimeter controls should remain in place until all graded or disturbed areas, including slopes, are adequately stabilized.
2. All areas to be disturbed (both cut and fill) shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material.

3. Fill material shall be free of brush, logs, stumps, roots, or other objectionable materials that would interfere with, or prevent, construction of satisfactory fills. This material can be set aside and later used at the toe of fill slopes as filter berms. Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.
4. Table LG-1 presents a range of commonly used cut and fill slope ratios appropriate for the soil and rock types described. Figures LG-2 and LG-3 present typical cut slope and fill slope design options for varying slope and site conditions. Vertical cut slopes should not be used unless the cut is in rock or very well cemented soil. Ideally, both cut and fill slopes should be constructed with a 2:1 or flatter slope to promote growth of vegetation, but cut slopes in dense, sterile soils or rocky material are often difficult to vegetate.
5. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence, or other related problems.
6. Topsoil required for the establishment of vegetation shall be stockpiled in the amount necessary to complete finished grading of all exposed areas. Areas that are to be topsoiled shall be scarified to a minimum depth of 4 inches prior to placement of topsoil.
7. Terraces or contour trenches (see Terracing (T)) shall be provided whenever the vertical interval (height) of any 2:1 cut or fill slope exceeds 20 feet; for 3:1 slope it shall be increased to 30 feet and for 4:1 to 40 feet.
8. All graded cut and fill areas shall be stabilized, either structurally or vegetatively, immediately following finished grading. Some common slope stabilization options appropriate for roads include hydroseeding, hydromulching, erosion control blankets, riprap, and retaining walls.

Road slope

1. See Figure LG-1. Compact soil or road base material to direct runoff.
2. If crowning a road, runoff is directed to both sides of the road requiring two roadside ditches, unless runoff will drain directly to well stabilized areas.
3. If using an inslope design, runoff is directed toward the hillside and requires a roadside ditch with periodic turnouts or cross drain culvert installation.
4. If using an outslope design, ensure a moderate road slope with dense vegetative cover.

Surface gravel

1. Gradation of gravel should be according to Figure LG-4. This figure shows the typical gradation ranges of aggregates used in road construction, how the materials, ranging from coarse to fine, best perform for a road, and the approximate limitations to the desirable gradation ranges. Ideally, aggregate surfacing material is (1) hard, durable, and crushed or screened to a minus 2-inch size; (2) well graded to achieve maximum density; (3) contains 5-15% clayey binder to prevent raveling; and (4) has a Plasticity Index of 2 to 10.
2. Gravel should be placed to a thickness of at least twice the diameter of the largest stone with a minimum thickness of 4 inches. Over very weak soils gravel thickness can be reduced with the use of geotextile or geogrid subgrade reinforcement. Also, geotextile layers are useful over soft soils to separate the gravel from the soil, keep it uncontaminated, and extend the useful life of the gravel.
3. Compact the aggregate during construction and maintenance to achieve a dense, smooth road surface and thus reduce the amount of water that can soak into the road.
4. “Spot” stabilize local wet areas and soft areas with 4 to 6 inches of coarse rocky material. Add more rock as needed.

5. Blend coarse aggregate and fine clay-rich soil (when available) to produce a desirable composite roadway material that is coarse yet well-graded with 5-15% fines for binder.

Maintenance considerations

The frequency of inspections should be in accordance with the SWMP. Inspect cut and fill slopes for rills or other indications of erosion. Maintain all crowns, outslopes, inslopes, and surface gravel.

The road surface and shoulders should be periodically smoothed and reshaped with a grader blade (flat-blading). This should be done when the gravel is moist. Maintain the proper road slope and grade while flat-blading. Also be sure to avoid plugging roadside ditches or altering adjacent drainage structures, as this may cause them to not function properly. Flat-blading may also cause road gravel to be pushed off the main roadway and onto the shoulders. To avoid this, blade toward the center of the road.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book." BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

Table LG-1
Stable Slope Ratios for Various Conditions

Soil/Rock Condition	Slope Ratio (Hor:Vert)
Most rock	¼:1 to ½:1
Very well cemented soils	¼:1 to ½:1
Most in-place soils	¾:1 to 1:1
Very fractured rock	1:1 to 1 ½: 1
Loose coarse granular soils	1 ½: 1
Heavy clay soils	2:1 to 3:1
Soft clay rich zones or wet seepage areas	2:1 to 3:1
Fills of most soils	1 ½:1 to 2:1
Fills of hard, angular rock	1 1/3 :1
Low cuts and fills (<10 ft high)	2:1 or flatter (for revegetation)

Figure LG-1
Typical Road Surface Drainage Options

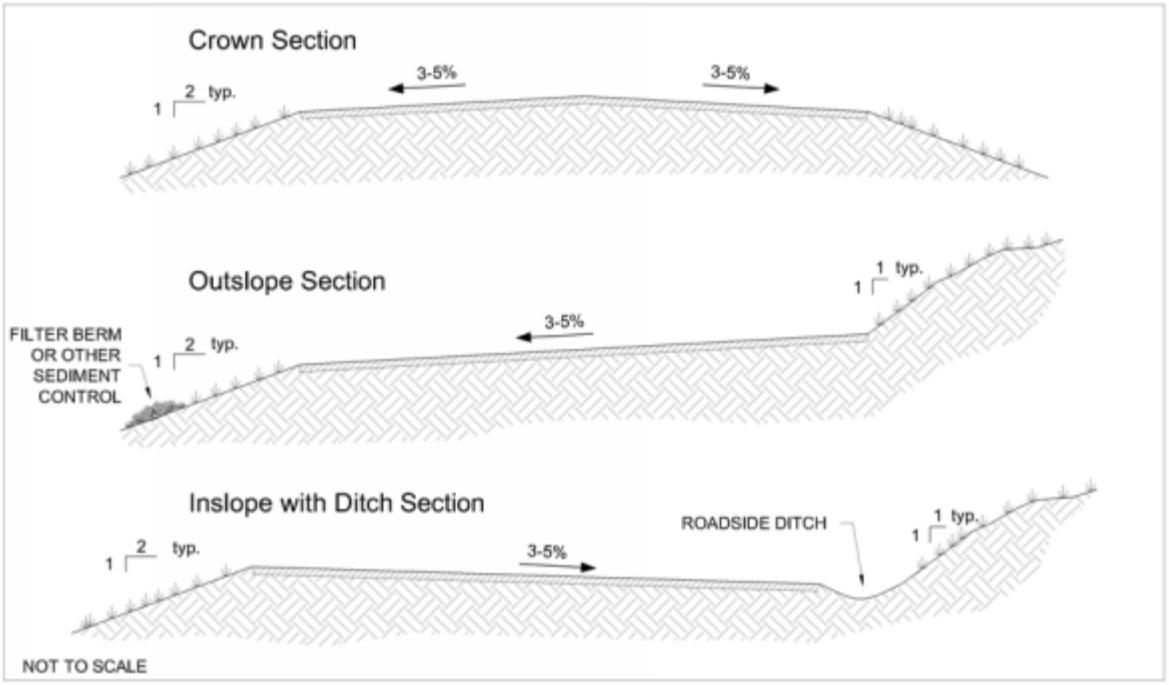


Figure LG-2
Cut Slope Design Options

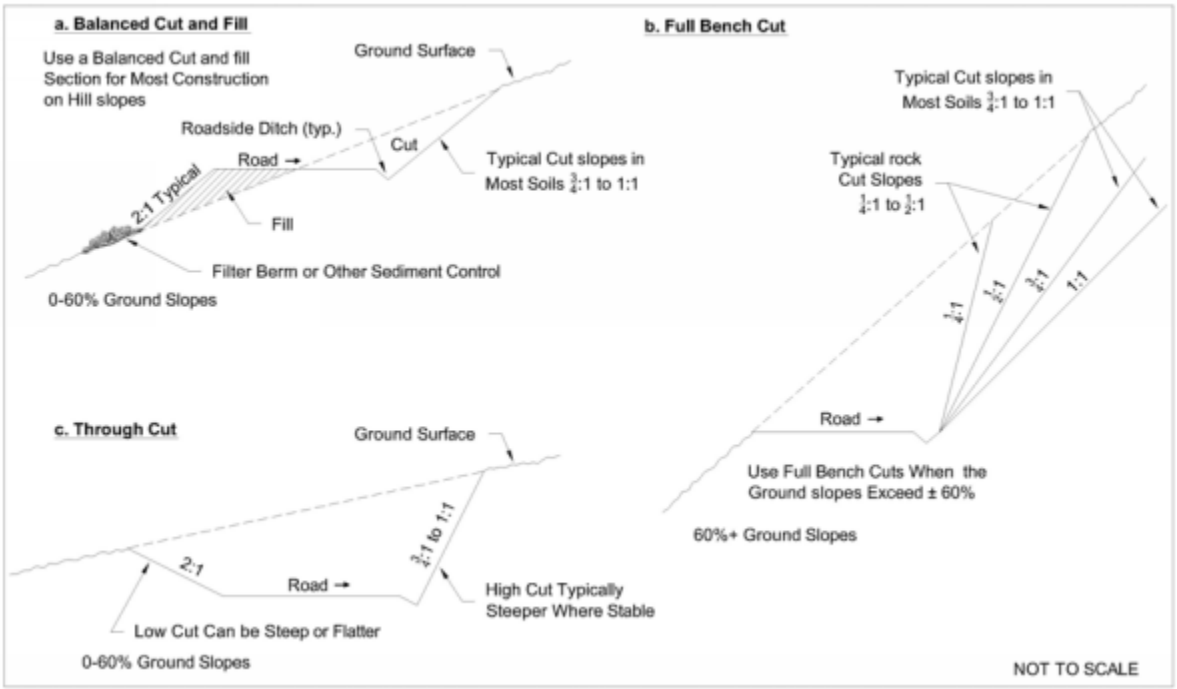


Figure LG-3
Fill Slope Design Options

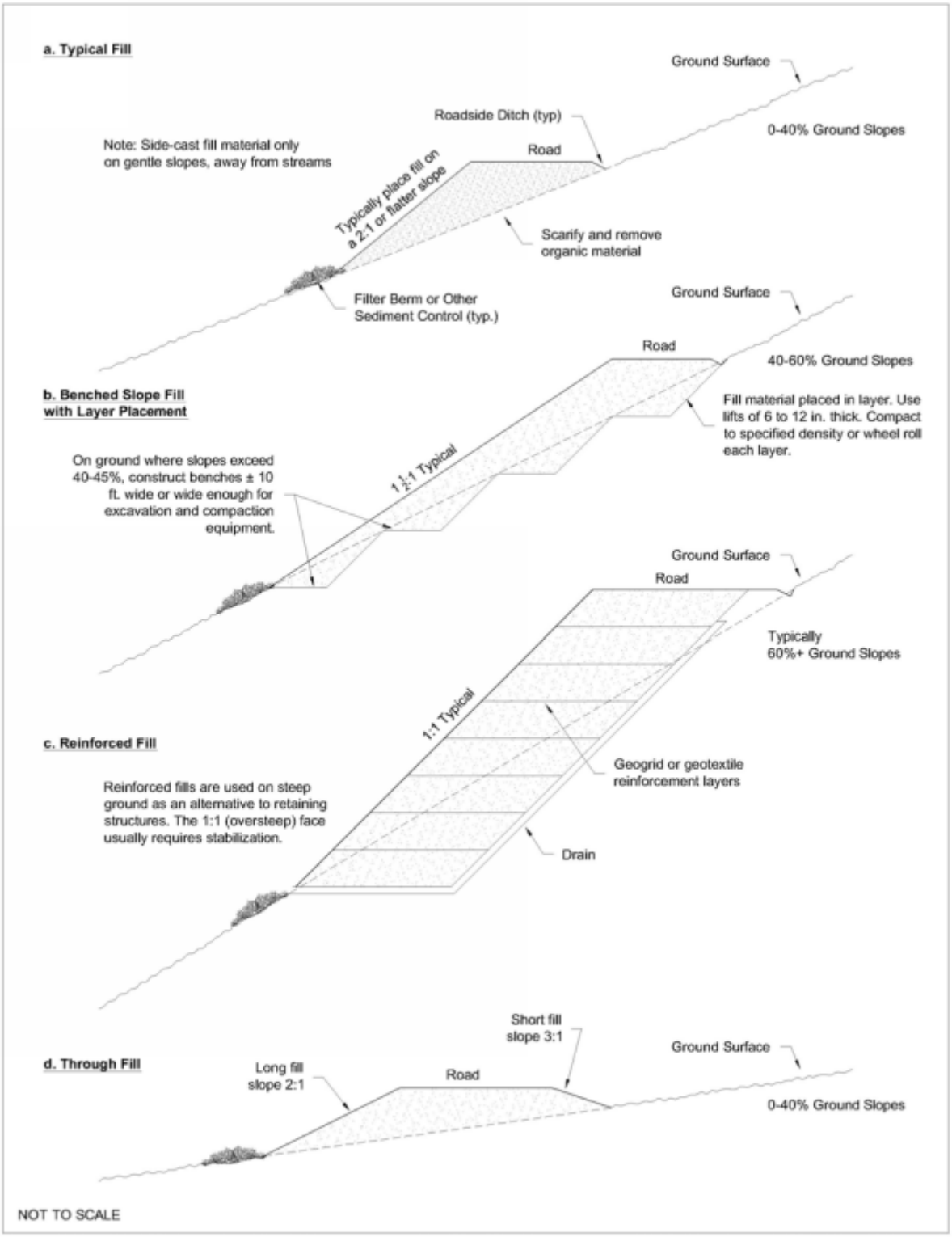
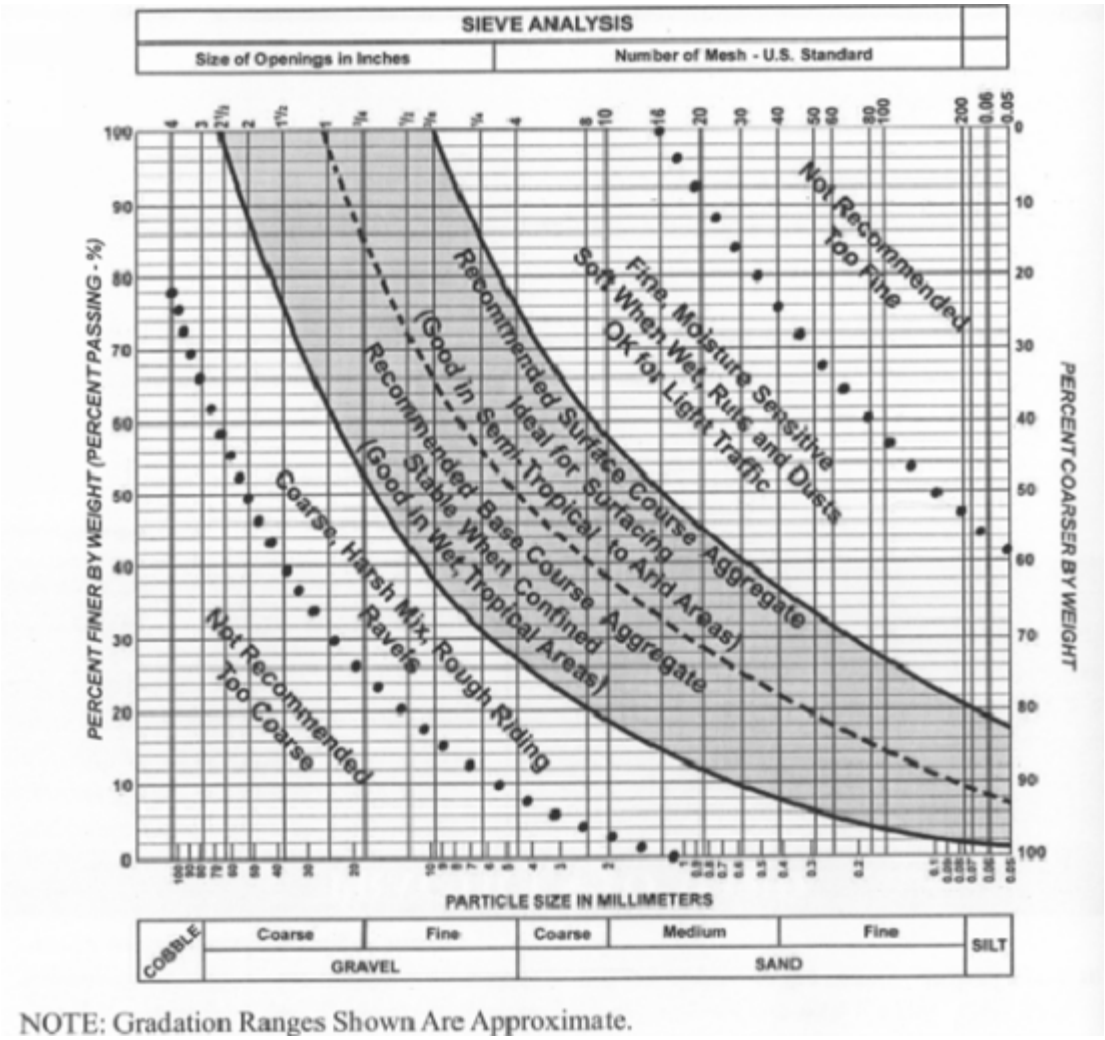


Figure LG-4
Gradation and Performance of
Roadway Surfacing Materials



NOTE: Gradation Ranges Shown Are Approximate.

Low Water Crossing (LWC)

Description

A low water crossing is a temporary structure erected to provide a safe and stable way for construction vehicle traffic to cross waterways. The primary purpose of such a structure is to provide streambank stabilization, reduce the risk of damaging the streambed or channel, and reduce the risk of sediment loading from construction traffic. A low water crossing may be a bridge, a culvert, or a ford surfaced with gravel, rip rap, or concrete.

Applicability

Low water crossings may be used for the following applications:

- Wherever heavy construction equipment must be moved from one side of a stream channel to the other, or where lighter construction vehicles will cross the stream a number of times during the construction period.
- Bridges are ideal to pass the year-round flows associated with perennial drainages.
- Vented fords can be used to pass drainages with low flows and keep vehicles out of the water, avoiding water quality degradation.
- Fords can be designed as a broadcrested weir in order to pass larger flow.
- Fords can be "forgiving" and accommodate uncertainties in the design flow and thus are ideal for ephemeral and intermittent drainages with unknown or variable flow characteristics.

Limitations

- Low-water crossings that are not surfaced should not be used in wet conditions.
- Installation may require dewatering or temporary diversion of the stream.
- Bridges can be a safety hazard if not properly designed and constructed. Bridges might also prove to be more costly in terms of repair costs and lost construction time if they are washed out or collapse.
- The construction and removal of culverts are usually very disturbing to the surrounding area and erosion and downstream movement of soils is often great.
- The approaches to fords often have high erosion potential. In addition, excavation of the streambed and approach to lay riprap or other stabilization material causes major stream disturbance. Mud and other debris are transported directly into the stream unless the crossing is used only during periods of low flow.
- Ford-type structures may imply some periodic or occasional traffic delays during periods of high flow.

Design Criteria

Site location

Locate the crossing where there will be the least disturbance to the soils of the existing waterway banks. When possible, locate the crossing at a point receiving minimal surface runoff.

Elimination of fish migration barriers

Bridges pose the least potential for creating barriers to aquatic migration. The construction of any specific crossing method shall not cause a significant water level difference between the upstream and downstream water surface elevations.

Crossing alignment

Where possible, the low water crossing shall be at right angles to the stream.

Road approaches

The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.

Bridges

Over-stream bridges are generally the preferred low water crossing structure. The expected load and frequency of the stream crossing, however, will govern the selection of a bridge as the correct choice for a temporary stream crossing. Bridges usually cause minimal disturbance to a stream's banks and cause the least obstruction to stream flow and fish migration. They should be constructed only under the supervision and approval of a qualified engineer.

Culverts

Temporary culverts are used where a) streams are perennial or intermittent, b) the channel is too wide for normal bridge construction, or c) anticipated loading may prove unsafe for single span bridges. Culverts are normally preferred over a ford type of crossing, since disturbance to the waterway is only during construction and removal of the culvert.

Fords

Fords are appropriate in steep areas subject to flash flooding, where normal flow is shallow or intermittent across a wide channel. Fords should be used for crossing seasonally dry streambeds (ephemeral or intermittent drainages) or streams with low flows during most periods of road use. Use fords in place of culverts when there is a high possibility of plugging by debris or vegetation. Use improved (vented) fords with pipes or concrete box culverts to pass low water flows and keep vehicles out of the water.

Construction specifications

Bridges

See Figure LWC-1.

1. Clearing and excavation of the stream shores and bed should be kept to a minimum.
2. A temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.
3. Abutments should be parallel to the stream and on stable banks.
4. If the crossing is to extend across a channel wider than 8 feet (as measured from top of bank to top of bank), the bridge should be designed with one in-water support for each 8 feet of stream width. No footing, pier, or bridge support will be permitted within the channel for waterways less than 8 feet wide.
5. Stringers shall either be logs, saw timber, pre-stressed concrete beams, metal beams, or other approved materials.
6. Decking shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.
7. Run planking (optional) shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.
8. Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option, which will provide additional safety.
9. Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.
10. All areas disturbed during installation shall be stabilized in accordance with Revegetation (RV).

Culverts

See Culvert (C).

Fords

See Figure LWC-2.

1. Locate fords where stream banks are low and where the channel is well confined.
2. Clearing and excavation of the stream shores and bed should be kept to a minimum.
3. Excavate streambed as necessary and place an 18-inch thick layer of 4-inch to 8-inch riprap. Cover this layer of riprap with a 6 inch thick layer of 2 inch to 4 inch crushed aggregate. The total thickness of riprap/aggregate should be a minimum of 24 inches thick. This type of simple low water crossing is ideal for ephemeral drainages.
4. For all approach roads the cut banks shall be no steeper than 5:1. The road approach shall be a minimum distance of 50 feet from each bank. Spoil material from the banks shall be stored out of the floodplain and stabilized.

5. Use an adequately long aggregate surface to protect the "wetted perimeter" of the natural flow channel. Add protection above the expected level of the high flow. Allow for some freeboard, typically a minimum of 12 inches in elevation, between the top of the reinforced driving surface and the expected high water level.
6. The downstream edge of a ford is a particularly critical location for scour and may need energy dissipaters or riprap protection.
7. Use well-placed, sturdy depth markers at fords to advise traffic of dangerous water depths.
8. All areas disturbed during ford installation shall be stabilized in accordance with Revegetation (RV).

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan.

Bridges

Inspection shall ensure that the bridge, streambed, and streambanks are maintained and not damaged. If any structural damage is reported, construction traffic should stop use of the structure until appropriate repairs are made. Evidence of streambank erosion should be repaired immediately. Any trapped sediment or debris shall be removed and disposed of outside of the floodplain and stabilized.

Culverts

Inspection shall ensure that the culverts, streambed, and streambanks are not damaged, and that sediment is not entering the stream or blocking fish passage or migration. Evidence of structural or streambank erosion should be repaired immediately. Any trapped sediment or debris shall be removed and disposal of outside of the floodplain and stabilized.

Fords

Inspections shall ensure that stabilization material (aggregate) remains in place. If the material has moved downstream during periods of peak flow, the lost material should be replaced immediately.

Removal

All low water crossings shall be removed when the structure is no longer needed.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

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United States Department of the Interior, Bureau of Land Management (BLM), United States Department of Agriculture (USDA), Forest Service, Surface Operating Standards for Oil and Gas Exploration and Development "Gold Book". Fourth Edition, 2005.

Figure LWC-1
Bridge Installation

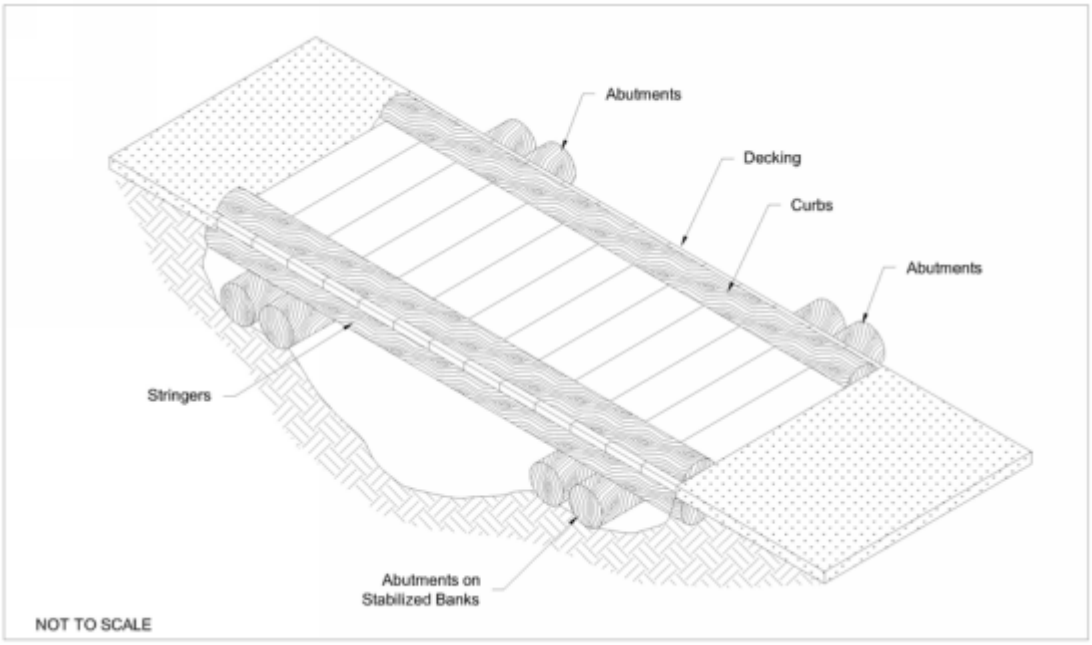
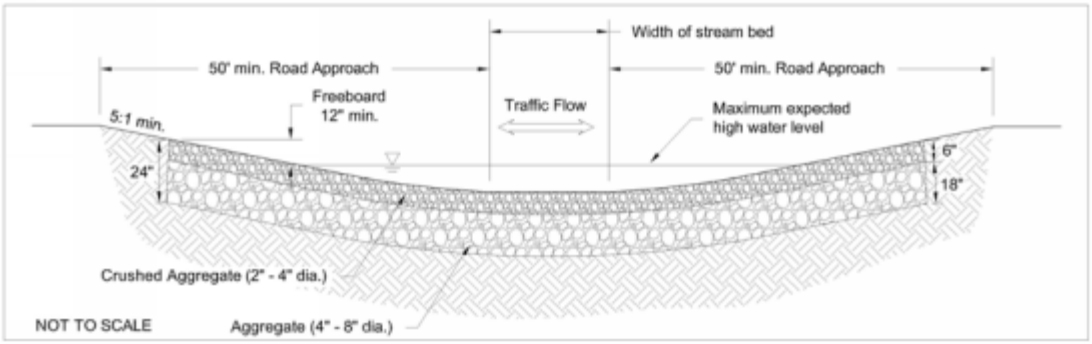


Figure LWC-2
Ford Installation



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Mulching (M)

Description

Mulching is a temporary erosion control practice in which materials such as grass, hay, wood chips, wood fibers, straw, or gravel are placed on exposed or recently planted soil surfaces. Mulching stabilizes soils by minimizing rainfall impact and reducing stormwater runoff velocity. When used in combination with seeding or planting, mulching can aid plant growth by holding seeds, fertilizers, and topsoil in place, preventing birds from eating seeds, retaining moisture, and insulating plant roots against extreme temperatures.

Mulch mattings are materials such as jute or other wood fibers that are formed into sheets and are more stable than loose mulch. Jute and other wood fibers, plastic, paper, or cotton can be used individually or combined into mats to hold mulch to the ground. Netting can be used to stabilize soils while plants are growing, although netting does not retain moisture or insulate against extreme temperatures. Mulch binders consist of asphalt or synthetic materials that are sometimes used instead of netting to bind loose mulches.

Hydraulic mulching is a temporary erosion control practice in which materials such as grass, hay, wood chips, wood fibers, straw, or gravel are hydraulically applied to exposed or recently planted soil surfaces. See Hydraulic Mulching (HM) for details.

Applicability

Mulching is often used in areas where temporary seeding cannot be used because of environmental constraints. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place. Mulches can be used on seeded and planted areas where slopes are steeper than 2:1 or where sensitive seedlings require insulation from extreme temperatures or moisture retention. Mulch is most effective when used on an area less than 2 acres in size and can last for 1 to 2 years.

Limitations

- Mulching, matting, and netting might delay seed germination because the cover changes soil surface temperatures.
- The mulches themselves are subject to erosion and may be washed away in a large storm.
- Maintenance is necessary to ensure that mulches provide effective erosion control.

Design criteria

No formal design is required.

Construction specifications

1. Site preparation:
    a. Prior to mulching, install the necessary temporary or permanent erosion control practices and drainage systems within or adjacent to the area to be mulched.
    b. Slope, grade, and smooth the site to fit needs of selected mulch products.
    c. Remove all undesirable stones and other debris to meet the needs of the anticipated land use and maintenance required.

2. Mulching & anchoring for relatively flat slopes:
    a. Select the appropriate mulch and application rate that will best meet the need and availability of material. When possible, organic mulches should be used for erosion control and plant material establishment. See Table M-1 for suggested materials and application rates. Other materials include hydraulic mulch products with 100-percent post-consumer paper content and yard trimming composts. All materials should be free of weed and seed.
    b. Apply mulch immediately after soil amendments and planting is accomplished or simultaneously if hydroseeding is used. See Table M-1 for installation guidelines.
    c. Mulch before seeding if construction of restoration activity is interrupted for extended periods, such as when seeding cannot be completed due to seeding period restrictions. If mulching before seeding, increase mulch rate. Of application on all slopes within 100 feet of waterbodies and wetlands.
    d. Use a mulch crimper to apply and anchor mulch. Crimper should have approximately 6 inch cleats with perpendicular, dull, disc blades. If a crimper is unavailable the Contractor shall apply mulch and anchor it to the soil using one of the methods described in Table M-2. The mulch should be anchored the same day as mulch application. Materials that are heavy enough to stay in place (for example, bark or wood chips on flat slopes) do not need anchoring. Mulches may or may not require a binder, netting, or tacking. Mulch binders should be applied at rates recommended by the manufacturer. Effective use of netting and matting material requires firm, continuous contact between the materials and the soil.

3. Hydraulic mulching for steeper slopes:

    See Hydraulic Mulching (HM).

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Areas should be identified where mulch has loosened or been removed. Such areas should be reseeded (if necessary) and the mulch cover replaced. If washout, breakage, or erosion occurs, surfaces should be repaired, reseeded, and re-mulched, and new netting should be installed. Inspections should be continued until vegetation is firmly established.

Removal

Anchor netting and any other artificial mulch material should be removed when protection is no longer needed and disposed of in a landfill.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

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United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Field Office Technical Guide. 2002. <www.nrcs.usda.gov/technical/efotg>

Table M-1

Typical Mulching Materials and Application Rates

Material	Rate per Acre	Requirements	Notes
Organic Mulches			
Straw	1 - 2 tons	Dry, unchopped, unweathered; certified weed free.	Spread by hand or machine; must be tacked or tied down.
Wood fiber or wood cellulose	½ - 1 ton		Use with hydroseeder; may be used to tack straw. Do not use in hot, dry weather.
Wood chips	5 - 6 tons	Air dry. Add fertilizer N, 12 lb/ton.	Apply with blower, chip handler, or by hand. Not for fine turf areas.
Bark	35 yd^3	Air dry, shredded, or hammermilled, or chips	Apply with mulch blower, chip handler, or by hand. Do not use asphalt tack.
Nets and Mats			
Jute net	Cover area	Heavy, uniform; woven of single jute yarn. Used with organic mulch.	Withstands water flow.
Excelsior (wood fiber) mat	Cover area		

Table M-2

Mulch Anchoring Guide

Anchoring Method or Material	Kind of Mulch to be Anchored	How to Apply
1. Mulch netting	Hay or straw	Staple the light-weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations. Should be biodegradable. Most products are not suitable for foot traffic.
2. Wood cellulose fiber	Hay or straw	Apply hydroseeder immediately after mulching. Use 500 lbs. Wood fiber per acre. Some products contain an adhesive material, possibly advantageous.
3. Mulch anchoring tool/Crimper	Hay or straw	Apply mulch and pull a mulch anchoring tool (blunt, straight discs) over mulch as near to the contour as possible. Mulch material should be "tucked" into soil surface about 3".
4. Chemical	Hay or straw	Apply Terra Tack AR 120 lbs./ac. In 480 gal. of water (#156/ac.) or Aerospray 70 (60 gal/ac.) according to manufacturer's instructions. Avoid application during rain. A 24-hour curing period and a soil temperature higher than 45 deg. Fahrenheit are required.

Retaining Wall (RW)


Rock Retaining Wall


Timber Retaining Wall


Gabion Retaining Wall

Description

Retaining walls are structures that are used to stabilize and hold soil in place, gain space on roadways or well pads, or to keep soil contained within a site boundary. This BMP will cover retaining walls constructed with rock, boulders, or gabions. Gabions are rectangular, rock-filled wire baskets that are pervious, semi-flexible building blocks which can be used to armor the bed and/or banks of channels or to divert flow away from eroding channel sections.

Several different retaining wall types are:

1. **Rigid gravity and semi-gravity walls.** These walls may be constructed of concrete or stone masonry. The rigid gravity and semi-gravity walls develop their capacity from their dead weights and structural resistance, and are generally used for permanent applications.

2. **Non-gravity cantilevered walls.** These walls develop lateral resistance through the embedment of vertical wall elements and support retained soil with wall facing elements. Vertical wall elements are normally extended deep in the ground to provide lateral and vertical support. The vertical wall elements can be piles, drilled shafts, steel sheet piles, etc. Wall faces can be reinforced concrete, metal, or timber. Cantilevered walls are generally limited to a maximum height of about 15 feet.

3. **Anchored walls.** These walls typically consist of the same elements as the non-gravity cantilevered walls but derive additional lateral resistance from one or more tiers of anchors. The anchored walls are typically used in the cut situation, in which the construction proceeds from the top to the base of the wall.

Applicability

Retaining walls should be used when sites have very steep slopes or loose, highly erodible soils that cause other methods, such as vegetative stabilization or regrading, to be ineffective. The preconstruction drainage pattern should be maintained to the extent possible. Retaining walls may be used for the following applications:

- Near the toe of a cut or fill slope to mechanically stabilize steep slopes and so that a flatter slope can be constructed to prevent or minimize slope erosion or failure. Particularly useful along access road cut slopes.
- Along a stream bank or drainage channel, to keep a toe of a slope from encroaching into a stream and thus prevent potential undercutting of the toe by flowing water.
- As headwalls at culvert inlets and outlets to prevent scour and undercutting.

Limitations

- Some retaining walls are a structural element that must be professionally designed.
- To be effective, retaining walls must be designed to handle expected loads. Non-engineered walls should not be used where traffic is expected near the top of the wall.
- Retaining walls must be properly installed and maintained to avoid failure.
- Some types of retaining walls must be placed on a good foundation, such as bedrock or firm, in-place soil.
- Some walls have height restrictions and backfill may be required to meet specific material property requirements.
- Materials costs and professional design requirements may make use of gabions impractical.
- When used in channels with high sediment loads, the galvanizing wire on gabion cages quickly wears off, causing rusting and the premature failure of the cages.

Design criteria

Most retaining walls require a site-specific design. Wall heights, requirements for drainage, and suitable materials must be determined through on-site investigation. An engineered retaining structure is a designed structure that is supported by plans and specifications signed and sealed by a Professional Engineer. Non-engineered retaining structures may be designed by an engineer; however, if the design is not supported by the seal and signature, the retaining structure is not considered engineered.

Gabions

Gabions should be designed and installed in accordance with manufacturer's standards and specifications and must be able to handle expected storm and flood conditions. At a minimum, they should be constructed of a hexagonal triple twist mesh of heavily galvanized steel wire (galvanized wire may also receive a polyvinyl chloride coating). The maximum linear dimension of the mesh opening shall not exceed 4 ½ inches and the area of the mesh opening shall not exceed 10 square inches.

Design velocity

The design water velocity for channels utilizing gabions should not exceed those listed as follows:

Gabion Thickness (feet)	Maximum Velocity (feet per second)
0.5	6
0.75	11
1.0	14

Construction specifications

Rock retaining wall guidelines

See Figure RW-1.

1. Excavate a footing trench at the location of the proposed wall.
2. Place the largest rocks in the footing trench with their longitudinal axis normal to the wall face. Arrange subsequent rock layers so that each rock above the foundation course has a firm seating on the underlying rocks.
3. The batter of the wall face shall be between ½H:1V and vertical, depending upon the height of the wall, the height of the slope, the width of the right-of-way, or other limitations on space.
4. Place fill material behind the rock wall. Slope above the wall should be maintained at 2H:1V or flatter. Backfill the footing trench with excavated material. If a roadway is located at the toe of the wall, pave the roadway up to the base of the rock wall and provide roadway curb for water transport. If a roadway is not located at the toe of the retaining wall, slope the backfilled material away from the wall.
5. Revegetate the stabilized slope with a method applicable to the particular site.

Gabion retaining wall guidelines

See Figure RW-2. Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the construction site into a rectangular basket of the specified sizes. Gabions shall be of single unit construction and shall be installed according manufacturer's recommendations. General specifications are listed below.

1. Clear and grade the area of trees, brush, vegetation, and unsuitable soils. Compact subgrade firmly to prevent slumping or undercutting.
2. Install a filter fabric or granular filter according to the Riprap (R) BMP to maintain separation of rock material with the underlying soil, if required.
3. Place empty gabion baskets. Each row, tier, or layer of baskets should be reasonably straight and should conform to the specified line and grade (see Figure RW-2 for details). The empty gabion baskets should be fastened to the adjacent baskets along the top and vertical edges. Each layer should be fastened to the underlying layer along the front, back and ends. Fastening should be performed in the same manner as provided for assembling the gabion units.
4. Unless otherwise indicated on the plans, the vertical joints between basket units of adjacent tiers or layers, along the length of the structure, should be staggered by at least one cell.
5. Before filling each gabion with rock, all kinks and folds in the wire mesh should be removed and all baskets should be properly aligned. A standard fence stretcher, chain fall or steel rod may be used to stretch the wire baskets and hold alignment.

6. The gabion cells should be carefully filled with 4 to 8-inch rock placed by hand/machine in such a manner that the alignment of the structure will be maintained and so as to avoid bulges and to minimize voids. Rock should be sound, durable, and well graded. All exposed rock surface should have a reasonably smooth and neat appearance. No sharp rock edges should project through the wire mesh.
7. The gabion cells in any row or layer should be filled in stages so that local deformations may be avoided.
8. At no time should any cell be filled to a depth exceeding 12 inches more than any adjacent cell.
9. The layer of rock should completely fill the gabion basket so that the lid will bear on the rock when it is secured. The lid should be joined to the sides, ends, and diaphragms in the same manner as specified for joining the vertical edges. The gabion basket lid should be secured so that no more than 1-inch gap remains at any connection.
10. Gabion rows or layers not completed at the end of each shift should have the last gabion filled with rock tied internally as an end gabion.
11. The area behind the gabion structure should be backfilled with granular material. Geotextile, if required, should be spread uniformly over the back of the gabion structure. Joining edges of the geotextile should be overlapped a minimum of 12 inches and should be anchored in position with approved anchoring devices. The Contractor should place the backfill material in a manner that will not tear, puncture, or shift the geotextile.

All other retaining walls should be constructed as designed by a Professional Engineer.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Check for structural failure, erosion, damage, instability, or other signs of deterioration. In stream bank installations and culvert inlets and outlets also inspect for signs of undercutting. Check wire of gabion cages for rusting and wear. Repair or replace any damaged areas immediately to restore designed effectiveness and to prevent damage or erosion of the slope or stream bank.

References

City of Knoxville, Stormwater Engineering, Knoxville BMP Manual - Best Management Practices. July 2003. <http://www.ci.knoxville.tn.us/engineering>

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<http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Figure RW-1
Construction of Rock Retaining Structures

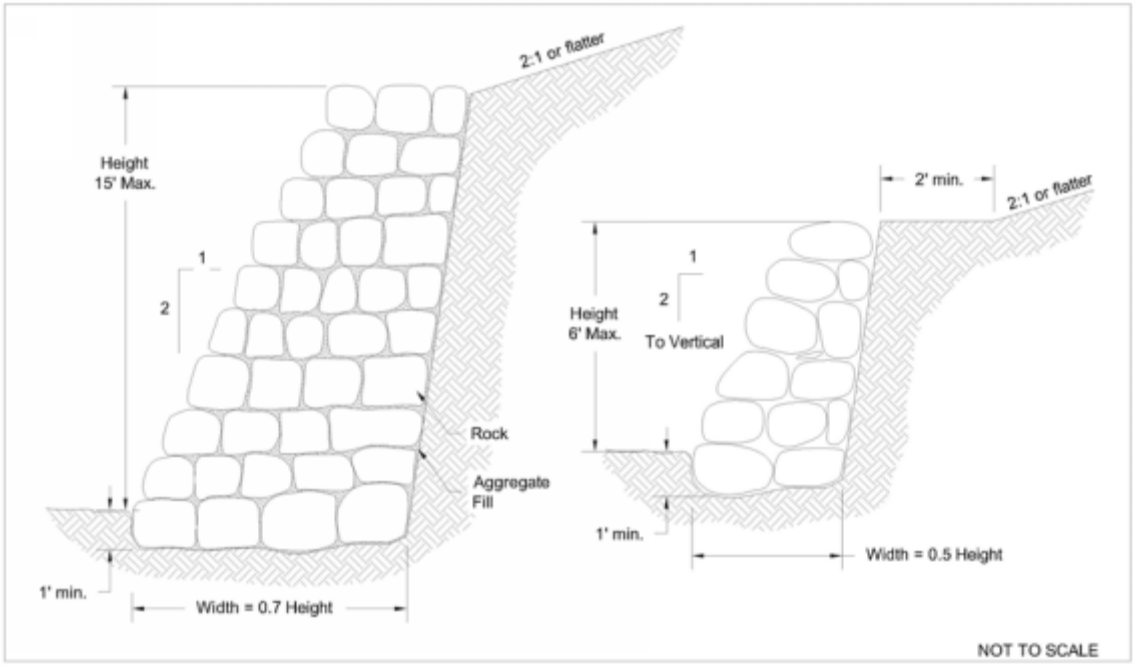
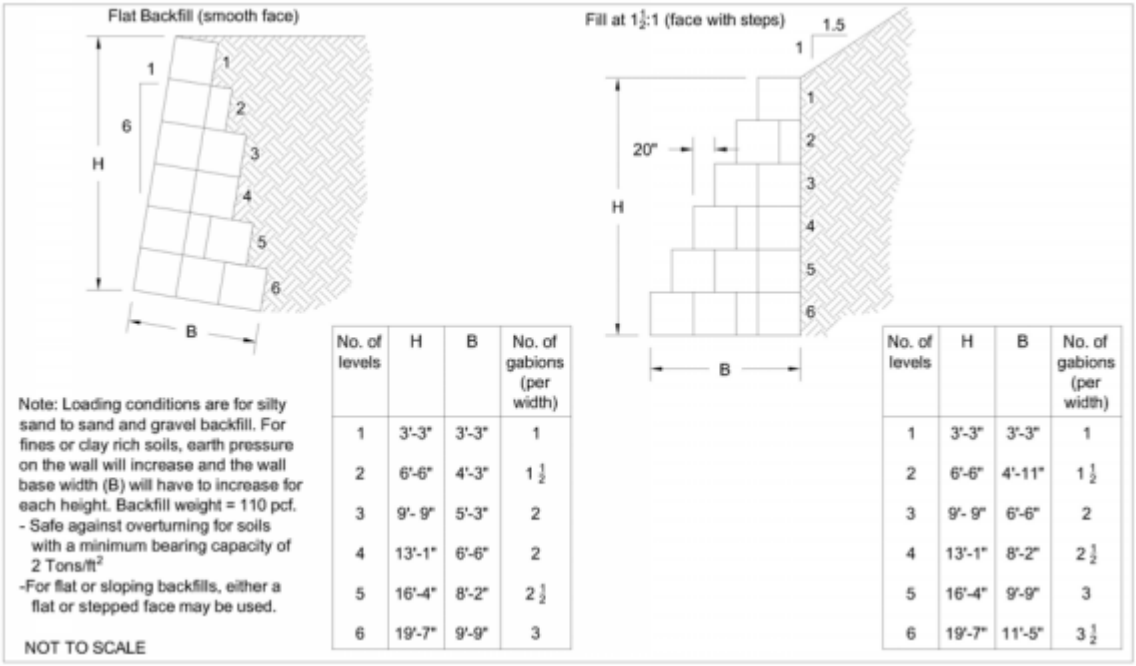


Figure RW-2
Gabion Design



No. of levels	H	B	No. of gabions (per width)
1	3'-3"	3'-3"	1
2	6'-6"	4'-3"	1 ½
3	9'- 9"	5'-3"	2
4	13'-1"	6'-6"	2
5	16'-4"	8'-2"	2 ½
6	19'-7"	9'-9"	3

No. of levels	H	B	No. of gabions (per width)
1	3'-3"	3'-3"	1
2	6'-6"	4'-11"	1 ½
3	9'- 9"	6'-6"	2
4	13'-1"	8'-2"	2 ½
5	16'-4"	9'-9"	3
6	19'-7"	11'-5"	3 ½

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Revegetation (RV)

Description

Revegetation involves planting seed to establish a vegetative cover on disturbed areas. Revegetation reduces erosion and sedimentation by stabilizing disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials. Revegetation also:

- Absorbs the impact of raindrops
- Reduces the velocity of runoff
- Reduces runoff volumes by increasing water percolation into the soil
- Binds soil with roots
- Protects soil from wind
- Improves wildlife habitat
- Enhances natural beauty

Applicability

Revegetation is most effective on slopes no steeper than 2:1 and may be used in areas where exposed soil surfaces are not to be regraded for periods longer than 30 days. Such areas include denuded areas, soil stockpiles, berms, temporary road banks, etc.

Limitations

The effectiveness of revegetation can be limited due to the following:

- High erosion potential during establishment.
- The need for stable soil temperature and soil moisture content during germination and early growth.
- The need to reseed areas that fail to establish.

Proper seedbed preparation and the use of quality seed are important in this practice. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Seeding does not immediately stabilize soils. Prior to seeding, install necessary erosion and sediment control practices such as diversions, straw bales, and basins until vegetation is established.

Design criteria

Successful plant establishment can be maximized with proper planning; consideration of soil characteristics; selection of plant materials that are suitable for the site; adequate seedbed preparation, liming, and fertilization; timely planting; and regular maintenance. A Revegetation Manual, which indicates the methods and materials needed to accomplish revegetation on differing site conditions, is provided as Appendix B to the Stormwater Management Plan (SWMP).

Coordination and scheduling

1. Coordinate installation of seeding materials during normal planting seasons for each type of seed material required.
2. Seeding in areas that are non-irrigated or not provided with sprinkling or watering systems shall be restricted according to the following schedule:

    a. Below 6000' elevation: Spring seeding shall occur between spring thaw and July 1st. Fall seeding shall occur from September 1st until consistent ground freeze.

    b. 6000' to 7000' elevation: Spring seeding shall occur between spring thaw and July 1st. Fall seeding shall occur from August 15th until consistent ground freeze.

    c. 7000' to 8000' elevation: Spring seeding shall occur between spring thaw and July 15th. Fall seeding shall occur from August 1st until consistent ground freeze.

    d. Above 8000' elevation: Seeding shall occur from spring thaw until consistent ground freeze.

    e. Spring thaw shall be defined as the earliest date in a calendar year in which seed can be buried ½ inch into the topsoil thru normal drill seeding methods.

    f. Consistent ground freeze shall be defined as that time during fall months in which the topsoil, due to freeze conditions, prevents burying seed ½ inch thru normal drill seeding operations.

Seed, soil amendments, and fertilizer

1. Seed mixes will vary depending on landowner requirements and the site elevation.
2. Soil amendments:

    a. AV Superphosphate 18-46-0: Commercial, phosphate mixture, soluble; minimum of 20 percent available phosphoric acid.

        Arkansas Valley Seed, 400 Moffat CR 220, Craig, CO 81625
        Willard McLaughlin - District Sales Manager
        Mobile: 970-629-0263. Fax: 970-234-8023
        Email: wmmclaughlin@seedsolutions.com

    b. Other soil amendments may also be used.

3. Fertilizers:

    a. Sustane 8-2-4: Slow release granular fertilizer.

        Sustane – Natural Fertilizer of America, Inc.
        310 Holiday Avenue P.O. Box 19 Cannon Falls, MN 55009
        Phone: 1-800-352-9245 Fax: 507-263-3029 www.sustane.com

    b. Other fertilizers may also be used.

Mulches

See Mulching (M) and Hydraulic Mulching (HM) for mulch materials to be used for flat and steep slopes, respectively.

Erosion control materials

1. Flexible Growth Medium: Flexterra FGM. Strictly comply with manufacturer's installation instructions and recommendations. Use approved hydro-spraying machines with fan-type nozzle (50-degree tip). Apply FGM from opposing directions to soil surface.

   Nilex, 15171 E. Fremont Drive, Centennial, CO 80112
   Phone: 1-800-537-4241 Fax: 303-766-1110 www.nilex.com

2. Non-asphaltic Tackifier: Organic derivative vegetative gum tackifier recommended by fiber-mulch manufacturer for slurry application, nontoxic and free of plant growth- or germination-inhibitors.

3. Other erosion control materials may also be used.

Construction specifications

See Table RV-1 for typical seeding guidelines. See Table RV-2 for typical seeding guidelines when using an Erosion Control Blanket (ECB) or a Turf Reinforcement Mat (TRM).

Seeding

1. Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.
2. Seed shall be uniformly sown by drill, by hydro-seeding (without mulch admixture), or by broadcasting. Drill and Hydro-seeding rates shall be the amount specified. Broadcast seeding rates shall be one and a half times the amount specified. Broadcast seeding shall be raked or chain dragged into the soil to a depth of approximately one-quarter inch (1/4") to one-half inch (1/2").
3. The seeding shall be done in one application crossing the area at right angles to one another to guarantee even coverage.
4. Protect seeded areas against erosion by uniformly spreading mulch after completion of seeding operations in accordance with Mulching (M) and Hydraulic Mulching (HM).

Cleanup and protection

1. During stormwater management & reclamation activities, keep pavements clean and work areas in an orderly condition.
2. Protect well pad, access road, private property, and federal lands from damage due to stormwater management & reclamation operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged well pad, access road, private property, and federal lands work as directed.

Maintenance considerations

The frequency of inspections should be in accordance with the SWMP. Vegetation is considered established when a density of at least 70 percent of pre-disturbance levels has been reached. Seeded areas should be inspected for failure and any necessary repairs and re-seedings should be made within the same season, if possible.

References

EnCana Oil & Gas (USA), Inc, Revegetation Manual. Chenoweth & Associates Environmental Consultants. 2007.

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United States Army Corps of Engineers (USACE), Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities. February 1997. http://www.usace.army.mil/inet/usace-docs/eng-pamphlets/ep1110-1-16/

Table RV-1

Typical Seeding Guidelines

All slopes accessible to drill seeder and straw crimper

Material	Description	Quantity
Seed Mix	Drill Seeding (twice in perpendicular directions)	20 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1000 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre
Certified Weed Free Straw	Weed Free Crimped Straw	2000 lbs./acre

All slopes accessible to drill seeder

Material	Description	Quantity
Seed Mix	Drill Seeding (installed in perpendicular directions)	20 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1000 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre

Four wheeler broadcast seeding & tine harrowing

Material	Description	Quantity
Seed Mix	Broadcast Seeded & Tine Harrowed	40 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1000 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre

Chest broadcast seeding & hand raking

Material	Description	Quantity
Seed Mix	Broadcast Seeded & Hand Raked	40 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1000 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre

Table RV-2

Typical Seeding Guidelines if using

Erosion Control Blankets (ECB) or Turf Reinforcement Mats (TRM)

SLOPES 1:1 and/or Greater and Medium to High Concentrated Flows

Material	Description	Quantity
Seed Mix	Seed Hydraulically Applied	50 lbs./acre
Guar Tackifier	Guar Tackifier (Nylex dlamanna@nilex.com)	75 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1100 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre
ECB or TRM	Per Table ECB-1 or TRM-1	per spec.

SLOPES 2:1 to 1:1 and Medium Concentrated Flows

Material	Description	Quantity
Seed Mix	Seed Hydraulically Applied	45 lbs./acre
Guar Tackifier	Guar Tackifier (Nylex dlamanna@nilex.com)	75 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1100 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100lbs./acre
ECB or TRM	Per Table ECB-1 or TRM-1	per spec.

SLOPES 2:1 to 3:1 and Medium Concentrated Flows

Material	Description	Quantity
Seed Mix	Broadcast Seeding	45 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1100 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre
ECB or TRM	Per Table ECB-1 or TRM-1	per spec.

SLOPES 3:1 or less and Low Concentrated Flows

Material	Description	Quantity
Seed Mix	Seed Hydraulically Applied	40 lbs./acre
Guar Tackifier	Guar Tackifier (Nylex dlamanna@nilex.com)	40 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1100 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre
ECB or TRM	Per Table ECB-1 or TRM-1	per spec.

SLOPES 3:1 or less and Low Concentrated Flows

Material	Description	Quantity
Seed Mix	Broadcast Seeding	40 lbs./acre
SUSTANE 8-2-4	Sustane 8-2-4 (Nylex dlamanna@nilex.com)	1100 lbs./acre
Soluble Humates	Soluble Humates (Nylex dlamanna@nilex.com)	1100 lbs./acre
ECB or TRM	Per Table ECB-1 or TRM-1	per spec.

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Riprap (R)

Description

Riprap is a permanent, erosion-resistant layer made of stones or boulders. It is intended to stabilize areas subject to erosion and protect against scour of the soil caused by concentrated, high velocity flows.

Applicability

Riprap can be used for areas subject to erosion or weathering, particularly where conditions prohibit the establishment of revegetation or where flow velocities exceed 5 ft/sec. Riprap may be used in the following applications:

- Cut-and-fill slopes
- Channel side slopes and/or bottoms
- Inlets and outlets to sediment traps
- Roadside ditches

Limitations

Riprap is limited by steepness of slope, because slopes greater than 1.5:1 have potential riprap loss due to erosion and sliding. When working within flowing streams, measures should be taken to prevent excessive turbidity and erosion during construction. Bypassing base flows or temporarily blocking base flows are two possible methods.

Design criteria

Gradation

A well-graded mixture of rock sizes should be used instead of one uniform size (with the exception of dry stacking boulders). 50% by weight should be larger than the specified design size. The diameter of the largest stone size in such a mixture should be 1.5 times the d50 size with smaller sizes graded down to 1 inch. When dry stacking up a slope, boulders may be uniform in size or may get gradually smaller as the boulders are placed up the slope.

Quality

Riprap must be durable so that freeze/thaw cycles do not decompose it in a short time. They should be angular and not subject to breaking down when exposed to water or weathering. The specific gravity should be at least 2.5.

Size

The sizes of stones used for riprap protection are determined by purpose and specific site conditions:

1. Slope Stabilization. Riprap stone for slope stabilization not subject to flowing water should be sized for the proposed grade. The gradient of the slope to be stabilized should be less than the natural angle of repose of the stone selected. Angles of repose of riprap stones may be estimated from Figure R-1. Riprap used for surface stabilization of slopes does not add significant resistance to sliding or slope failure and should not be considered a retaining wall. Slopes approaching 1.5:1 may require special stability analysis. The inherent stability of the soil must be satisfactory before riprap is used for surface stabilization.

2. Stream bank Protection. If the shear stress is estimated, riprap stone for stream bank protection can be selected from the gradations in Table R-1, below. The shear stress can be estimated from the depth of flow and the channel slope (see note for Table R-1). The riprap should extend 2 feet below the channel bottom and be keyed into the bank both at the upstream end and downstream end of the proposed work or reach.

Filter material

Filter material is sometimes used between riprap and the underlying soil surface to prevent soil from moving through the riprap. Filter cloth material or a layer of sand and/or gravel is usually used for the filter.

The design of a sand/gravel filter blanket is based on the ratio of particle size in the overlying filer material to that of the base material in accordance with the criteria below. Multiple layers (each a minimum of 6 inches thick) may be designed to affect a proper filter if necessary. A sand/gravel filter blanket should have the following relationship for a stable design:

$$\frac{\text{d15 filter}}{\text{d85 base}} \leq 5$$

$$5 < \frac{\text{d15 filter}}{\text{d50 base}} \leq 40$$

$$\frac{\text{d50 filter}}{\text{d50 base}} \leq 40$$

The design of a synthetic filter fabric, which may be used with or in place of gravel filters, is based upon the following particle size relationships:

1. Filter fabric covering a base containing 50% or less by weight of fine particles (#200 sieve size):
   a. d85 base (mm)

      EOS*filter fabric (mm) > 1

   b. total open area of filter fabric should not exceed 36 %

2. Filter fabric covering other soils:
    a. EOS is no larger than 0.21 mm (#70 sieve size)
    b. total open area of filter fabric should not exceed 10%

        *EOS - Equivalent opening size compared to a U.S. standard sieve size

No filter fabric should have less than 4% open area or an EOS less than U.S. Standard Sieve #100 (0.15 mm). The permeability of the fabric must be greater than that of the soil. The fabric may be made of woven or non-woven monofilament yarns and should meet the following minimum requirements:

Thickness 20-60 mils
Grab strength 90-120 lbs
Conform to ASTM D-1682 or ASTM D-177

Construction specifications

See Figure R-2 for riprap slope stabilization and stream bank protection. See Figure R-3 for dry stacking boulders. See Sediment Trap (ST) for a detail of a riprap lined channel leading into a sediment trap.

1. Subgrade Preparation. Prepare the subgrade for riprap to the required lines and grades shown on the plans. Compact any fill required in the subgrade to a density approximating that of the undisturbed material or overfill depressions with riprap. Remove brush, trees, stumps, and other objectionable material. Cut the subgrade sufficiently deep so that the finished grade of the riprap will be at the elevation of the surrounding area. Channels should be excavated sufficiently to allow placement of the riprap in a manner such that the finished inside dimensions and grade of the riprap meet design specifications.
2. Sand/gravel filter blanket. If using a granular filter, spread filter stone in a uniform layer to the specified depth. Where more than one layer of filter material is used, spread the layers with minimal mixing.
3. Synthetic filter fabric. If using a filter fabric, place the cloth directly on the prepared foundation. Where large stones are to be placed, a 4¬-inch layer of fine sand or gravel is recommended to protect the filter cloth. Filter fabric is not recommended as a filter on slopes steeper than 2 horizontal to 1 vertical.
4. Stone placement. Place riprap so that it forms dense, well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement. Place riprap to its full thickness in one operation. Do not place riprap by dumping through chutes or other methods that cause segregation of stone sizes. If a filter is used, be careful not to dislodge the underlying base filter or damage the filter cloth when placing the stones. If damage occurs, remove the riprap and repair filter.
5. The toe of the riprap should be keyed into a stable foundation at its base as shown in Figure R-2 if required for slope stabilization and stream bank protection. The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface. The finished grade of the riprap should blend with the surrounding area.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan (SWMP). If riprap has been damaged or dislodged, repairs should be made to prevent a progressive failure. If repairs are needed repeatedly at one location, the site should be evaluated to determine if the original design conditions

have changed. Channel obstructions such as trees and sediment bars can change flow patterns and cause erosive forces that may damage riprap. Control of weed and brush growth may be needed in some locations.

Removal

Riprap is generally not removed.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Table R-1

Riprap Gradations

Unit shear stress (lb/ft^2)	D_{50}	d_{max}	Minimum blanket thickness (inches)
0.67	2	4	6
2	6	9	14
3	9	14	20
4	12	18	27
5	15	22	32
6	18	27	32
7.8	21	32	38
8	24	36	43

Unit shear stress calculated as T=y*d*s where:

T = shear stress in lb/ft^2

y = unit weight of water, 62.4 lb/ft^2

d = flow depth in ft

s = channel gradient in ft/ft

Figure R-1

Angles of Repose of Riprap Stones

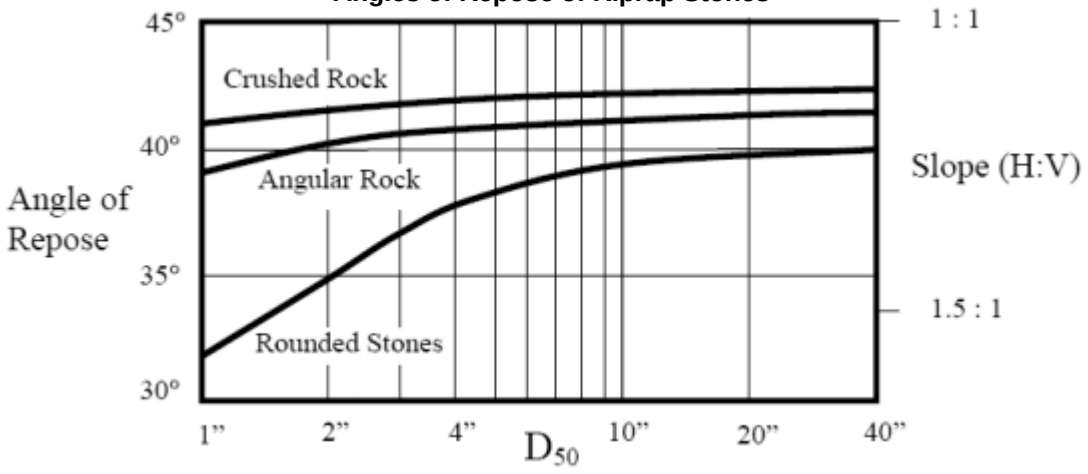


Figure R-2
Typical Riprap Slope Protection Detail

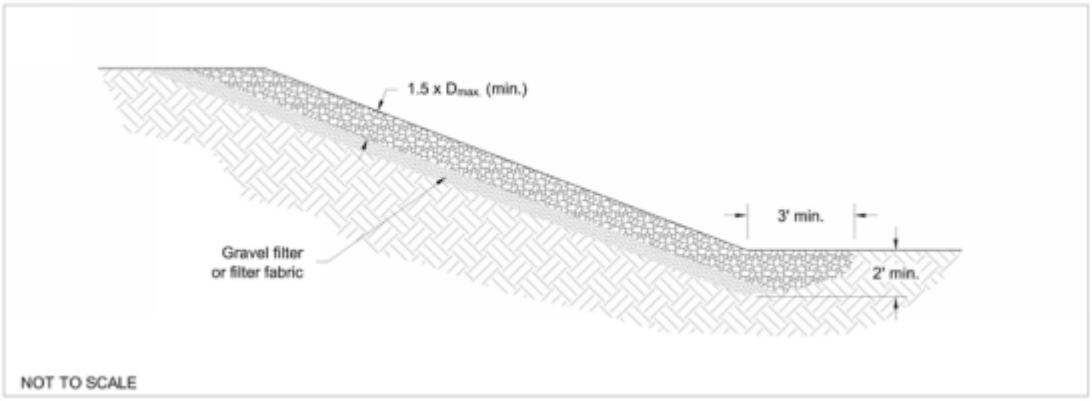
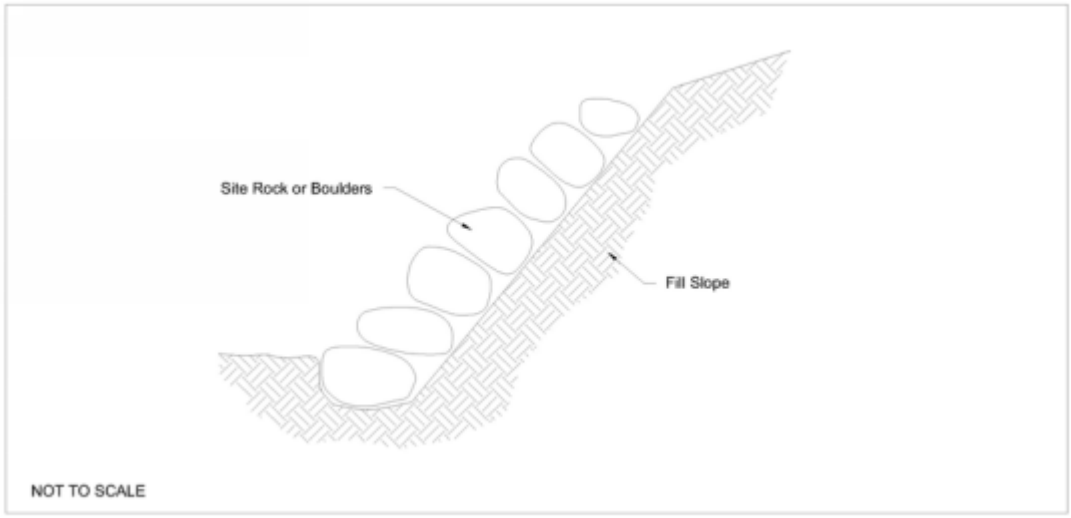


Figure R-3
Typical Boulder Drystack Detail



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Soil Stabilizers (SS)

Description

Soil stabilizers (also known as soil binders) consist of stabilizing emulsions that are applied directly to the surface of disturbed soil to temporarily reduce soil erosion. Soil binders are categorized as:

- Short-lived plant-based materials
- Long-lived plant-based materials
- Polymeric emulsion blends (acrylic polymers)
- Cementitious-based binders

Applicability

Soil binders are used on bare soil areas where vegetation may not be desired (such as near compressor stations) in order to reduce soil loss. Soil binders are also suitable for use on stockpiles.

Limitations

- Soil binders are a temporary measure.
- Product must be reapplied 6-12 months after initial application.
- Soil binders may not be compatible with certain soils.
- Runoff can penetrate a treated area at the top of a slope, undercut the treated soil, and cause spot failures by discharging at a point further down the slope.
- Performance depends on temperature, humidity, and traffic across treated areas.

Design criteria

No formal design is required.

Construction specifications

1. Soil binder must be non-toxic to plant and animal life. Some examples include Guar, Starch, Pitch & Rosin Emulsion, Liquid Polymers of Methacrylates & Acrylates, and Gypsum. However, many others are available and may be used. Select a soil binder that is appropriate for the region, use and soil type.

2. Soil binder is typically mixed in a water truck or hydroseeder and applied in a liquid state. Use emulsion formulas for applications with water trucks.
3. Apply soil binder over a roughened soil surface on slopes not greater than 1H:1V. Do not apply immediately before or during a rain event or where standing water is present.
4. Soil binder can be applied in combination with organic fertilizers and humates, if desired.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan (SWMP). Inspect for rill erosion and reapply soil binder if necessary, usually every 6 to 12 months or when the surface has been disturbed.

References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

California Stormwater Quality Association, Stormwater Best Management Practice (BMP) Handbook – Construction. January, 2003. <http://www.cabmphandbooks.com/Construction.asp>

Stockpiling (SP) – Topsoil and Subsoil

Description

Stockpiling during construction of well pads involves the removal and stockpiling of all surface soil materials (topsoil) from the entire cut and fill area for later reuse during interim and final reclamation. Topsoil provides a planting and growth medium that is more desirable than deeper subsoils for use during reclamation and revegetation activities. If there is an excess of cut material, however, subsoil may als7o be stockpiled.

Stockpiling during construction of roads involves the removal and temporary stockpiling of all surface soil materials (topsoil) from the entire cut and fill area for reuse along cut and fill slopes and roadside ditches. This helps to reduce the loss of forage, habitat, and sediment, decreases maintenance costs, and helps maintain the scenic quality. If there is an excess of cut material, subsoil may also be stockpiled.

Applicability

Stockpiling applies for the construction of all well pads, roads, pipelines, and any other construction activity where soil is disturbed and later revegetated.

Limitations

- Stockpiling increases the overall area of disturbance at a site.
- Stockpiles often require revegetation and also require other erosion and sediment controls during the establishment of vegetation such as silt fences or diversions.

Design criteria

No formal design is required.

Construction specifications

Location

1. Locate the stockpile so that it meets specifications and does not interfere with work on the site.
2. Stockpiles should be located and protected so that wind and water erosion are minimized and reclamation potential is maximized.
3. Stockpiles located down slope of a well pad will serve as tertiary spill containment and a reservoir during storm events. See Figure SP-1.

4. Stockpiles located upslope of a well pad will serve as a berm to divert surface runoff around the site and to a stabilized outlet. See Figure SP-2.
5. During the installation of pipelines, soil will be stockpiled according to Figure SP-3.

Stripping and excavation

1. All perimeter stormwater controls shall be in place prior to stripping topsoil or excavating subsoil.
2. Stripping shall be confined to the immediate construction areas.
3. The depth of topsoil to be stripped and stockpiled should be determined during an on-site inspection prior to the start of any excavation activity, but is commonly 4 to 6-inches.

Stockpiling

1. Soil shall be stockpiled in such a manner that natural drainage is not obstructed and no off-site sediment damage shall result.
2. Keep topsoil segregated and stored separately from subsoil materials to avoid mixing during construction, storage, and interim reclamation. Never place subsoil materials on top of topsoil material.
3. Side slopes of the stockpile shall not exceed 2:1.
4. Stockpiles should be tracked according to Surface Roughening (SR) and stabilized to prevent erosion and off-site sedimentation. Perimeter controls shall be placed around the stockpile immediately. This may involve a diversion to route sediment laden runoff to a stabilized outlet, a silt fence to capture sediments, or any other applicable stormwater perimeter control. Revegetation of the stockpile, according to Revegetation (RV), can help reduce erosion as well as maintain its biological viability.

Topsoiling during reclamation

Part of the reclamation process involves salvaging and reusing all available topsoil to spread over disturbed areas prior to revegetation. Reclamation measures should begin as soon as possible after the disturbance and continue until successful reclamation is achieved.

1. **Well pads – interim reclamation –** Minimize the footprint of disturbance by reclaiming all portions of the well site not needed for production operations. Respread topsoil over areas not needed for operations prior to revegetation.
2. **Well pads – final reclamation –** Where the topography is flat and it is, therefore, unnecessary to recontour the well location at the time of final reclamation, the operator should set aside sufficient topsoil for final reclamation of the small, unreclaimed area around the wellhead. On sloped ground, during final reclamation, the topsoil and interim vegetation must be restripped from portions of the site that are not at the original contour, the well pad recontoured, and the topsoil respread over the entire disturbed site to ensure successful revegetation.
3. **Roads – interim reclamation –** Reclaim portions of the road not needed for vehicle travel wherever possible by covering cut slopes, fill slopes, and borrow ditches with topsoil salvaged during road construction prior to revegetation.
4. **Pipelines – final reclamation –** Reclaim disturbed area on completion of pipeline installation. The stripped topsoil shall be respread over the entire ROW to ensure successful revegetation.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan (SWMP). Inspect for rills and other evidence of stockpile erosion. Also inspect perimeter stormwater controls in accordance with the appropriate BMP.

Removal

Stockpiles may be removed when the site is ready for interim or final reclamation.

References

United States Army Corps of Engineers (USACE), Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities. February 1997. <http://www.usace.army.mil/inet/usace-docs/eng-pamphlets/ep1110-1-16/>

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book." BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

Figure SP-1
Topsoil Stockpile – Located Below Well Pad

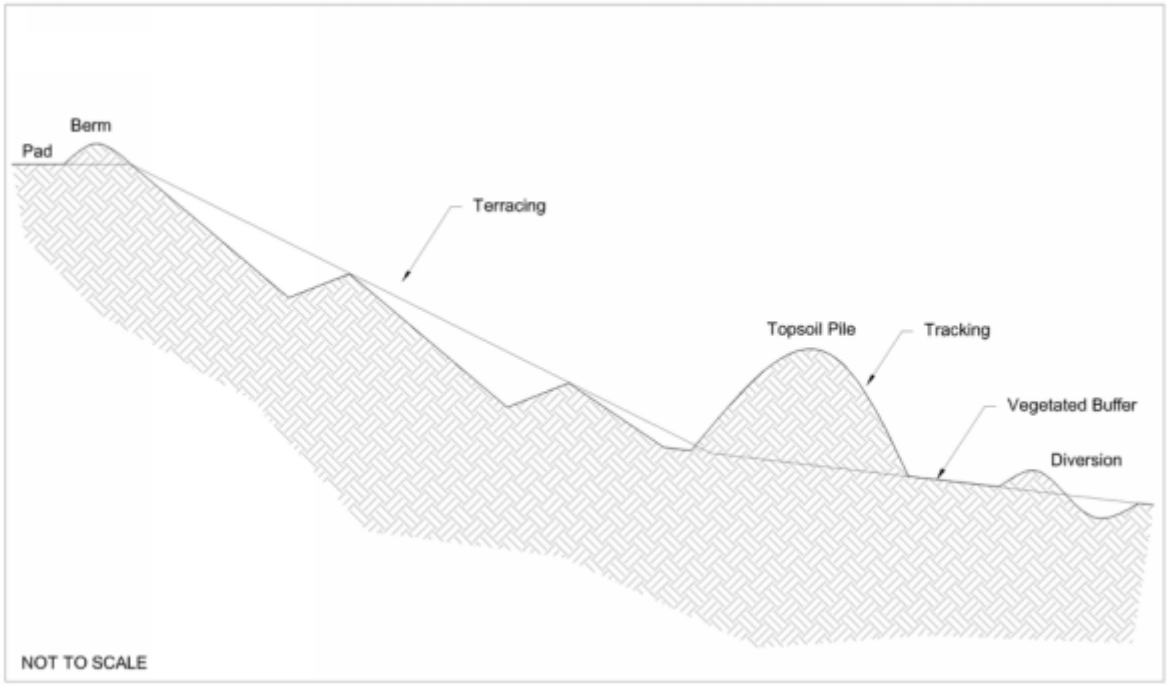


Figure SP-2
Topsoil Stockpile – Located above Well Pad

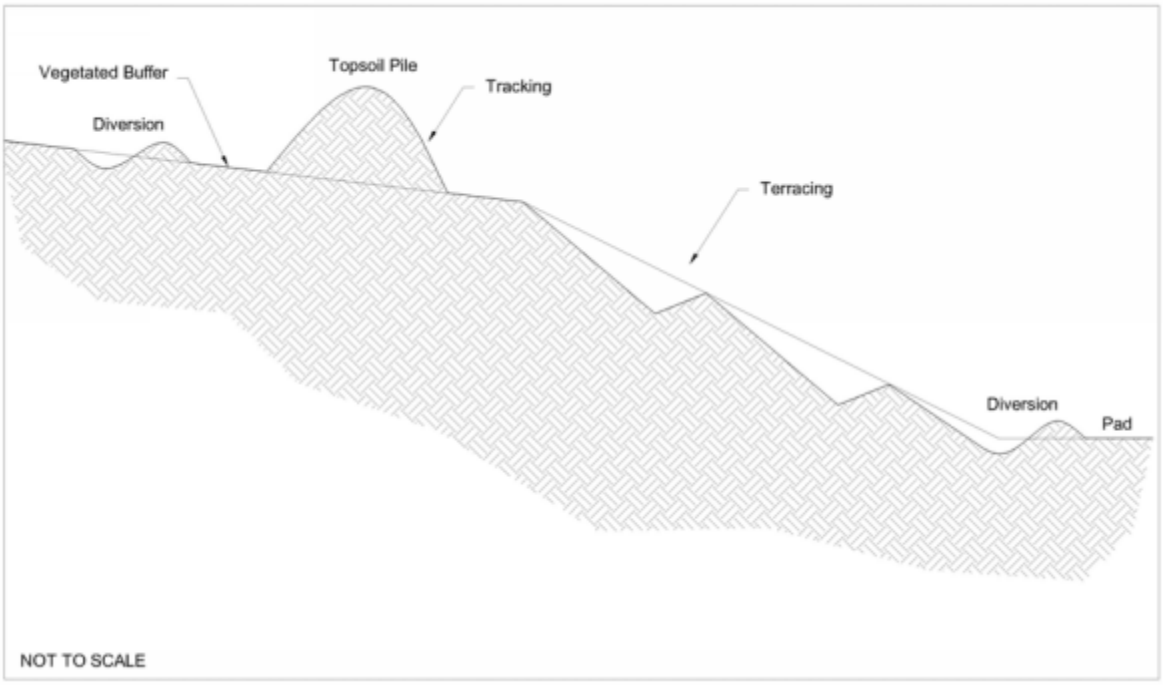
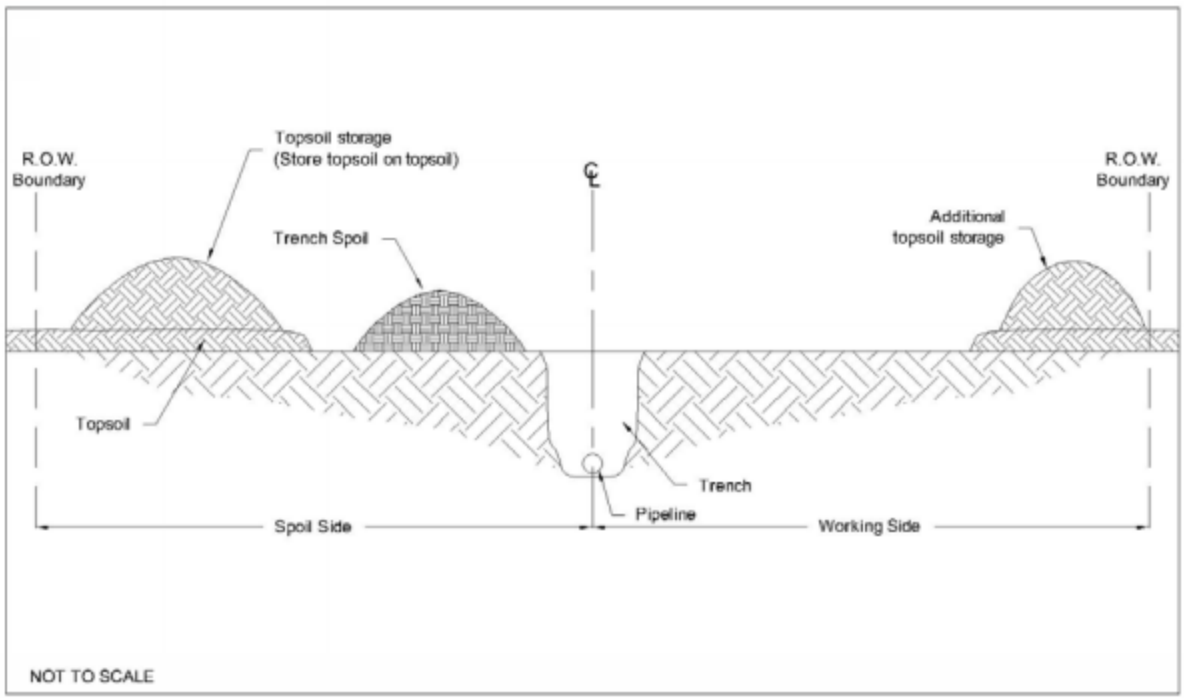


Figure SP-3
Topsoil Stockpile for Pipeline Installation



Surface Roughening (SR)

Corrugating

Tracking

Minibenching

Description

Surface (soil) roughening is a temporary erosion control practice often used in conjunction with grading. Soil roughening involves increasing the relief of a bare soil surface using construction equipment. Slopes that are not fine graded and that are left in a roughened condition can reduce erosion. Soil roughening reduces runoff velocity, increases infiltration, reduces erosion, traps sediment, and prepares the soil for seeding and planting by giving seed an opportunity to take hold and grow. The following types of soil roughening are discussed in this BMP:

- Corrugating
- Tracking
- Minibenching

Applicability

Soil roughening is most effective for areas of 1 acre or less, and works well for the following applications:

- Any slope, but particularly fill slopes greater than 3:1
- Areas with highly erodible soils
- Soils that are frequently disturbed
- Prior to application of permanent or temporary seeding

Limitations

- Soil roughening is not appropriate for rocky slopes.
- Soil compaction might occur when roughening with tracked machinery.
- Soil roughening is of limited effectiveness in anything more than a gentle or shallow depth rain.
- If roughening is washed away in a heavy storm, the surface will have to be re-roughened and new seed laid.

Design criteria

No formal design required. However, the selection of the appropriate method (corrugating or tracking) depends on the type of slope. Steepness, mowing requirements, and/or a cut or fill slope operation are all factors considered in choosing a roughening method.

Construction specifications

To slow erosion, roughening should be done as soon as possible after grading activities have ceased (temporarily or permanently) in an area. All cut and fill slopes should be roughened wherever possible. Do not blade or scrape the final fill slope face. Excessive compacting of the soil surface should be avoided during roughening, and areas should be seeded as quickly as possible after roughening is complete.

Corrugating

Corrugating (Figure SR-1) uses machinery to create a series of ridges and depressions that run across the slope on the contour. Groove using any appropriate implement that can be safely operated on the slope, such as disks, tillers, spring harrows, or the teeth of a front-end loader bucket. Do not make the grooves less than 3 inches deep or more than 15 inches apart.

Tracking

Tracking is the most common method of soil roughening and is sometimes used as a method to hold down mulch. However, tracking is generally not as effective as corrugating. Tracking should be used primarily in sandy soils to avoid undue compaction of the soil surface. Operate tracked machinery up and down the slope to leave horizontal depressions in the soil (Figure SR-2). Do not back-blade during the final grading operation.

Minibenching

Benches shall be constructed on an even contour line. Benches shall be constructed approximately 2 feet deep and according to Figure SR-3.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Roughening might need to be repeated after storm events. Inspections of roughened slopes will indicate where additional erosion and sediment control measures are needed. If rills appear, they should be filled, graded again, and reseeded as soon as possible. Proper dust control methods should be used.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Figure SR-1
Corrugating

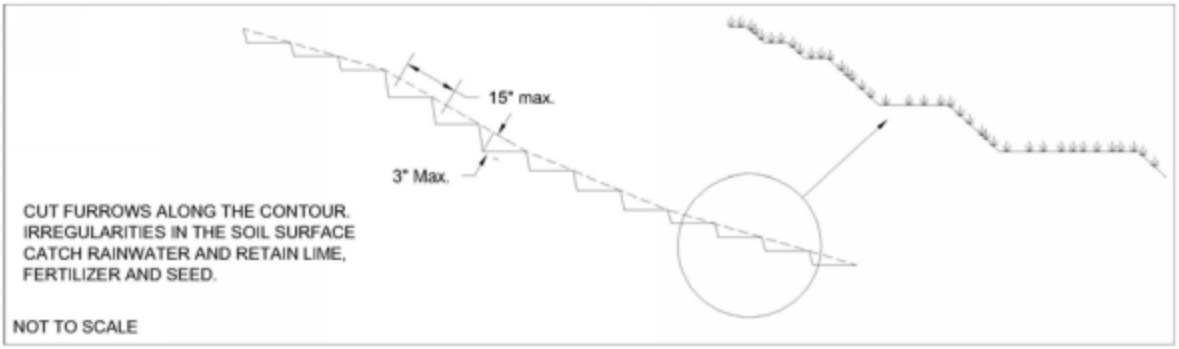


Figure SR-2
Tracking

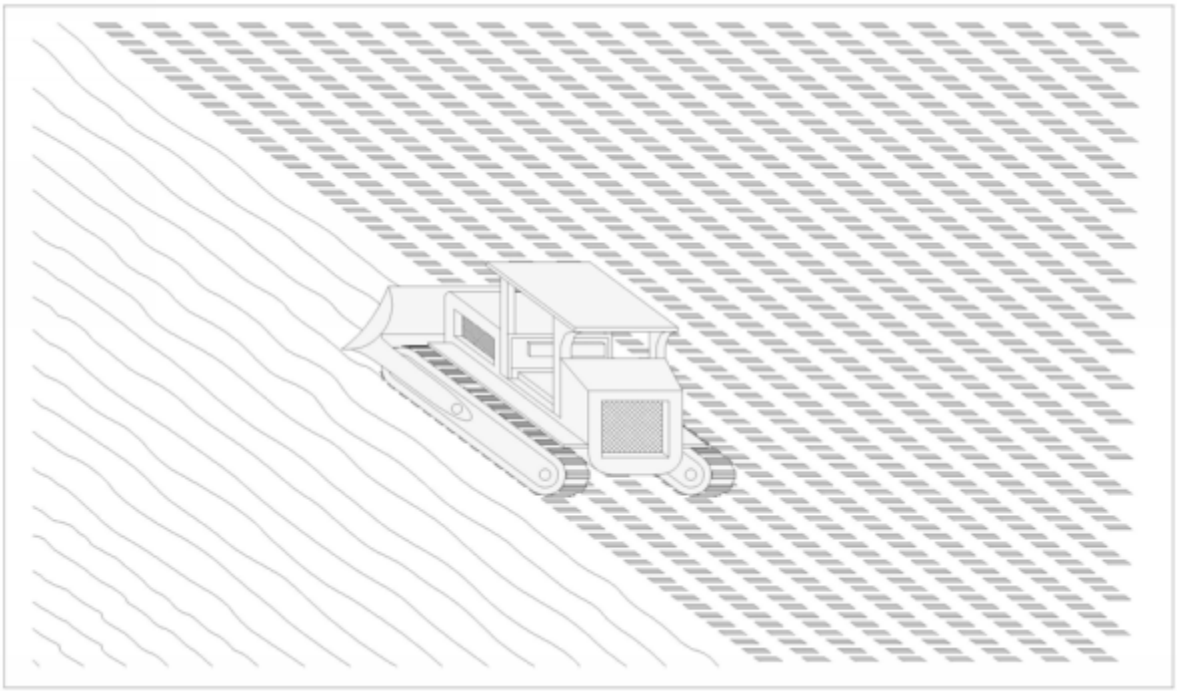
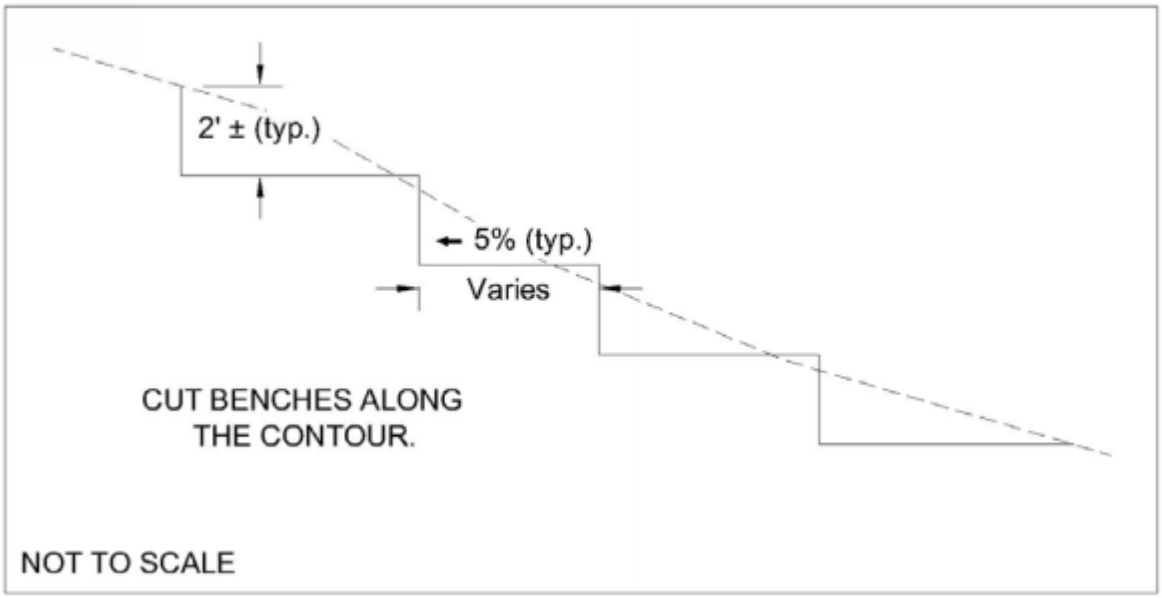


Figure SR-3
Minibenching



Terracing (T)

Description

Terraces (also called benches or contour trenches) are properly spaced along a cut or fill slope and made of either earthen embankments, ridge and channel systems, or are cut directly into a rock face of a cut slope. Terraces are often constructed with an adequate grade to promote drainage to a stabilized outlet. Terraces reduce damage from erosion by collecting and redistributing surface runoff to stable outlets at slower speeds and by decreasing the distance of overland runoff flow. They also surpass smooth slopes in holding moisture and help to minimize sediment loading of surface runoff. When terraces are constructed into steep bedrock faces they help to stabilize the slope by catching loose rocks and other material which may fall from above.

Applicability

Terraces are most effective for areas less than 10 acres in size and, are suitable for the following applications:

- Areas with an existing or expected water erosion problem and no vegetation.
- Cut or fill slopes greater than 5 feet in height, which are not part of a trench or excavation.
- Graded areas with smooth hard surfaces or any cleared area prior to seeding.
- Where the length of slopes need to be shortened by terracing.
- On steep rock walls, particularly those greater than 60 feet in height.

Limitations

- Terraces are not appropriate for use on sandy or shallow soils.
- If too much water permeates the soil in a terrace system, sloughing could occur, and cut and fill costs could increase substantially.

Design criteria

The design of terraces should be determined by a civil engineer based upon actual site conditions.

Construction specifications

In the absence of a specific design, terraces may be constructed according to Figure T-1 for cut slopes and Figure T-2 for fill slopes.

1. Construct diversion ditches at the top of the slope (if necessary for large upslope drainage areas) to prevent or reduce surface water from running down the slope face.
2. The upper terrace should begin immediately below the top of the fill slope. Continue constructing terraces down to the toe of the slope. Terraces shall be a minimum of 6 feet wide. However, a minimum width of 8 feet is ideal so that a crimper has access for mulching.
3. Terraces must drain to a stabilized outlet, such as a stabilized waterway, vegetated area, or other suitable outlet. Slope drains (Slope Drain (SD)) may be needed to convey surface runoff from the terraces or benches to the toe of the slope without causing erosion. Analysis of the local site conditions should determine the needed outlets.
4. Remove the loose material that collects at the end of terraces or benches and blend the ends of each terrace or bench into the natural ground surface.
5. Stabilize or revegetate the slope with methods applicable to the particular site.

For terraces constructed into high rock walls of cut slopes, the vertical spacing may be anywhere from 10 to 100 feet and the width anywhere from 6 to 100 feet, as determined by a civil engineer.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Maintain terrace ridge height and outlet elevations. Remove sediment that has accumulated in the terrace to maintain capacity and a positive channel grade. If excessive seepage or surface runoff is a problem, control the seepage/runoff with appropriate drainage facilities. Take prompt action as needed to ensure proper drainage and slope stability. Repair rills and reseed damaged areas as they develop. Substantial maintenance of the newly planted or seeded vegetation may be required.

References

City of Knoxville, Stormwater Engineering, Knoxville BMP Manual - Best Management Practices. July 2003. http://www.ci.knoxville.tn.us/engineering

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Field Office Technical Guide. 2002. <www.nrcs.usda.gov/technical/efotg>

Figure T-1
Terracing – Cut Slopes

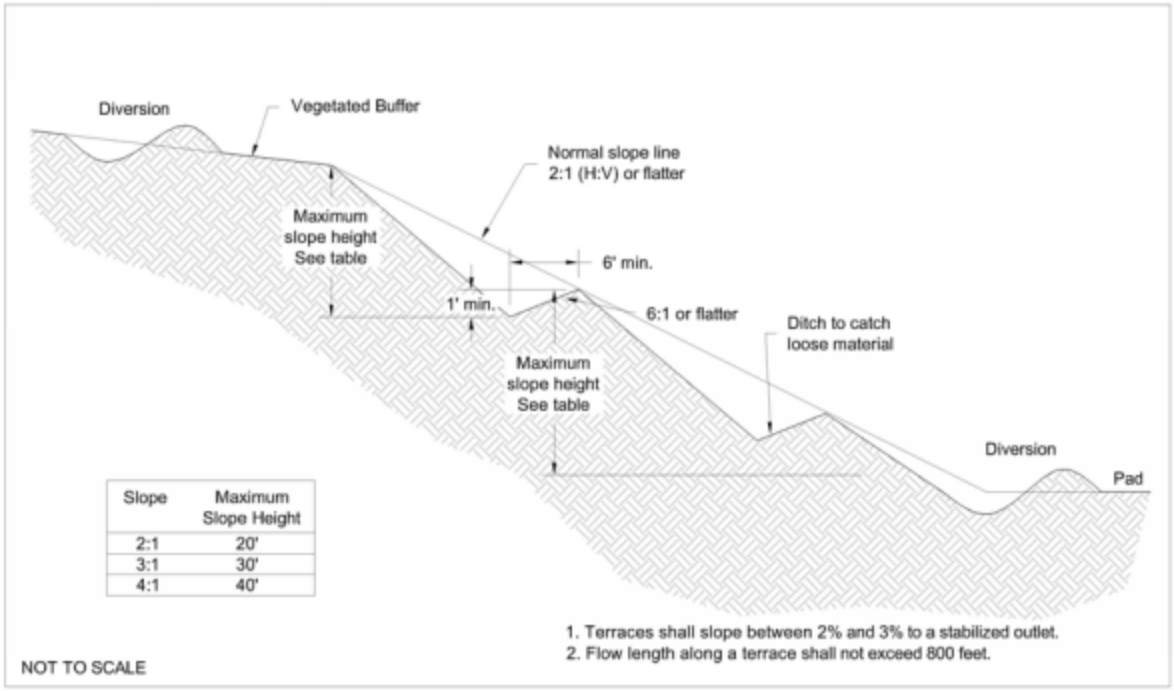
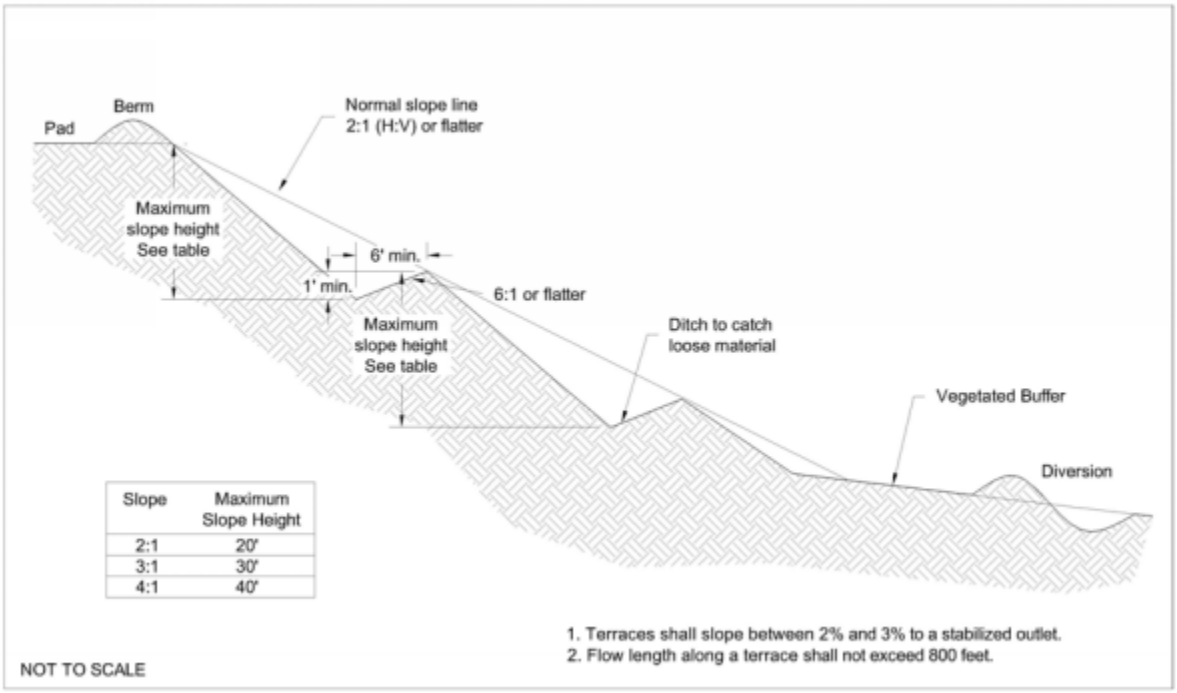


Figure T-2
Terracing – Fill Slopes



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Turf Reinforcement Mat (TRM)

Description

A turf reinforcement mat (TRM) is a rolled permanent erosion control product composed of UV-stabilized, non-degradable, synthetic materials (which may include an organic, biodegradable fiber component) processed into a three-dimensional matrix. TRMs are typically installed in ditches, swales, channels, and slopes where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation to prevent erosion.

Applicability

TRMs may be used in the following applications:

- To control erosion on steep slopes and to promote the establishment of vegetation.
- To stabilize channels against erosion from concentrated flows.
- Used in transition areas before and after hard armor (i.e., riprap, concrete, asphalt etc.) to provide for stable and non-erosive transition.
- May be used on slopes steeper than 1:1.

Limitations

- In an unvegetated state, velocities should not exceed 14 ft/sec maximum or the limitations provided by the manufacturer.
- In a vegetated state, velocities should not exceed 25 ft/sec maximum or the limitations provided by the manufacturer.
- Maximum slope is dictated by the soil stability and above referenced limited velocity and shear stress limitations.
- Soils must be conducive to the establishment of vegetation.

Design criteria

No formal design is required.

Construction specifications

1. All vegetation, roots, rocks, and other objectionable material shall be removed and disposed of so as not to create loss of soil contact by the TRM when installed.
2. Select the appropriate TRM. North American Green Products are listed in Table TRM-1. However, other products, such as Green Armor (www.greenarmorsystem.com) may also be used. Site specifics shall dictate TRM use.
3. Select the appropriate seed mix according to Revegetation (RV). Apply seed prior to fabric installation for stabilization of construction sites.
4. Installation of the blankets shall be in accordance with the manufacturer's recommendations and according to Figure TRM-1. For blankets being placed in channels, the fabric should be rolled out parallel to the channel if the width is sufficient to cover the entire width of the channel. The fabric needs to be in continuous contact with exposed soil.
5. Pins or staples shall be made of wire 0.162-inch or larger in diameter. "U" shaped staples shall have legs 8" long, and a 1" crown. "T" shaped pins shall have a minimum length of 8". The bar of the "T" shall be at least 4" long. Triangular survey stakes can also be used.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspections should determine if cracks, tears, or breaches have formed in the fabric. If the effectiveness of the BMP has been reduced, the fabric should be repaired or replaced immediately. Re-anchor loosened matting and replace missing matting and staples as required. It is necessary to maintain contact between the ground and the blanket at all times. Trapped sediment should be removed after each storm event.

References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

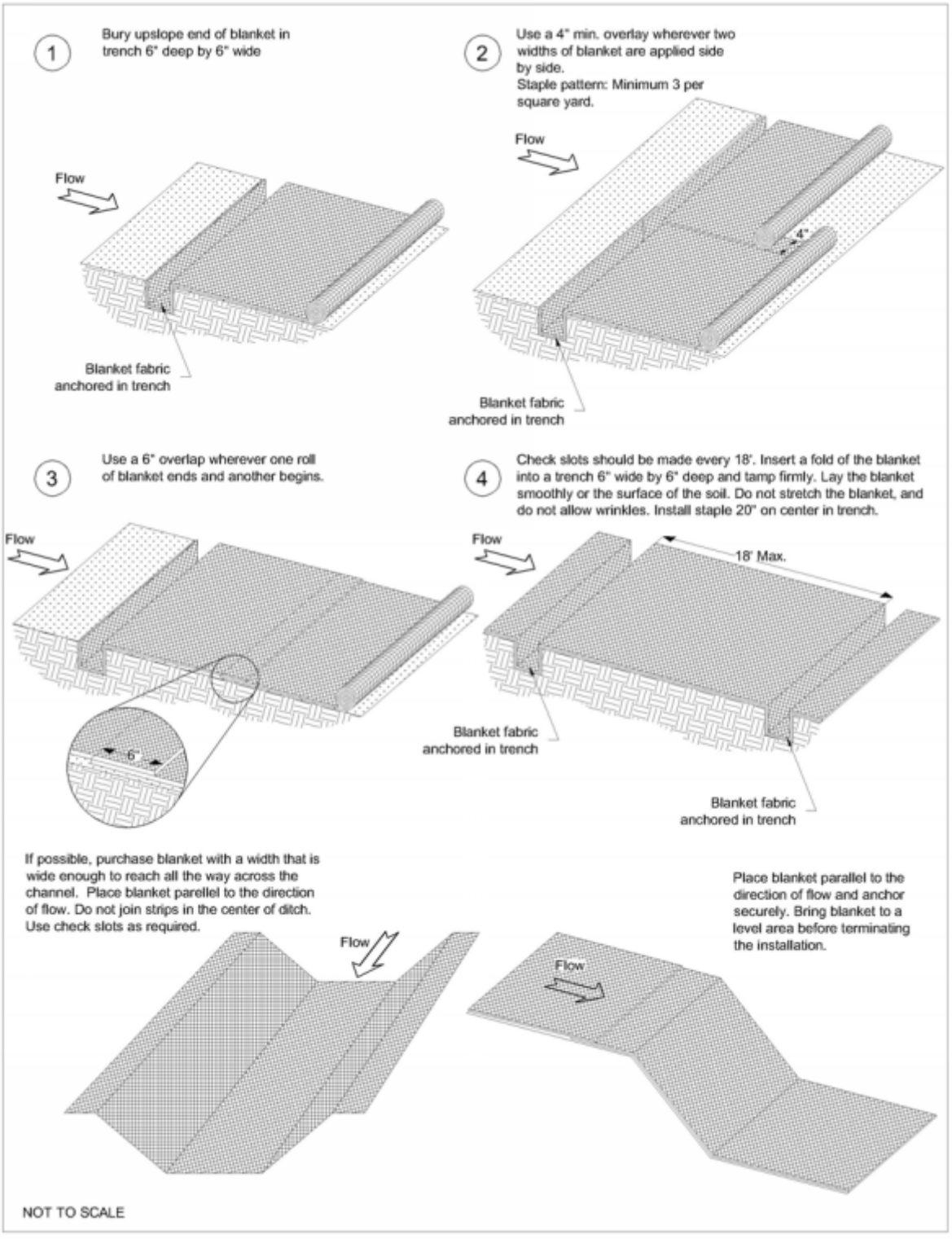
North American Green, 2004. http://www.nagreen.com

Table TRM-1

Suggested Blanket Types

Description (North American Green Product #)	Longevity	Applications	Max. Flow Velocity (feet/sec.)
Three UV Stable Nets Top Net 5 lb. Black Corrugated Center Net 24 lb. Black Bottom Net 5 lb. Black 70% Straw / 30% Coconut Matrix Material (SC250)	24 month grow-in period	1:1 & Greater Slopes Medium to High Flow Channels	9.5 (unveg.) 15 (veg.)
Three UV Stable Nets Top Net 8 lb. Black Corrugated Center Net 24 lb. Black Bottom Net 8 lb. Black 100% Coconut Fiber Matrix Material (C350)	36 month grow-in period	1:1 & Greater Slopes High Flow Channels	10.5 (unveg.) 20 (veg.)
Three UV Stable Nets Top Net 24 lb. Black Corrugated Center Net 24 lb. Black Bottom Net 24 lb. Black 100% Polypropylene Fiber Matrix Material (P550)	36 month grow-in period or when sparse vegetation stand is expected	1:1 & Greater Slopes Extreme High Flow Channels	12.5 (unveg.) 25 (veg.)

Figure TRM-1
Turf Reinforcement Mat Installation



Vegetated Buffer (VB)

Description

Vegetated buffers (also known as vegetated filter strips) are areas of either natural or established vegetation that are maintained to protect the water quality of neighboring areas. Buffers reduce the velocity of stormwater runoff, provide an area for the runoff to permeate the soil, contribute to groundwater recharge, and act as filters to catch sediment. The reduction in velocity also helps to prevent soil erosion.

The use of existing natural vegetation is preferred over newly established vegetation for the following reasons:

- Can process higher quantities of stormwater runoff than newly seeded areas.
- Does not require time to establish.
- Has a higher filtering capacity than newly planted vegetation because aboveground and root structures are typically denser.
- Reduces stormwater runoff by intercepting rainfall, promoting infiltration, and lowering the water table through transpiration.
- Provides a fully developed habitat for wildlife.

Applicability

Vegetated buffers can be used in any area that is able to support vegetation but they are most effective and beneficial on floodplains, near wetlands, along streambanks, and as stabilized outlets to runoff controls such as diversions, water bars, or culverts. Buffers are also effective in separating land use areas that are not compatible and in protecting wetlands or water bodies by displacing activities that might be potential sources of non-point source pollution.

Limitations

- Vegetated buffers require plant growth before they can be effective, and land on which to plant the vegetation must be available.
- Although vegetated buffers help to protect water quality, they usually do not effectively counteract concentrated stormwater flows to neighboring or downstream wetlands.

Design criteria

No formal design is required.

Construction specifications

1. Buffer widths should be determined after careful consideration of slope, vegetation, soils, depth to impermeable layers, runoff sediment characteristics, type and quantity of stormwater pollutants, and annual rainfall. Buffer widths should increase as slope increases.
2. Zones of vegetation (native vegetation in particular), including grasses, deciduous and evergreen shrubs, and understory and overstory trees, should be intermixed.
3. Fertilizing seeded or planted ground may enhance growth (and improve its effectiveness as a buffer).
4. When using naturally vegetated areas, vegetation should be marked for preservation before clearing activities begin. Barriers may be used to prevent the approach of equipment within protected areas.
5. Direct sediment-laden water onto the naturally vegetated or stabilized planted ground.
6. Do not place any equipment, construction debris, or extra soil in the buffer area.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Keeping vegetation healthy in a recently established buffer requires routine maintenance, which (depending on species, soil types, and climatic conditions) may include weed control, fertilizing, liming, and irrigating. Once established or if using a naturally vegetated area, buffers do not require much maintenance beyond repairing or replacing damaged vegetation. Inspections should focus on encroachment, gully erosion, density of vegetation, evidence of concentrated flows through the areas, and any damage from foot or vehicular traffic. If there is more than 6 inches of sediment in one place, it should be removed.

Removal

During final site cleanup, any barriers placed around preserved natural areas should be removed.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Wattles (W)

Description

A wattle (also called a fiber roll) consists of straw, flax, or other similar materials bound into a tight tubular roll. Excelsior log (aspen fiber) is the preferred wattle. When wattles are placed at the toe and on the face of slopes, they intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff. By interrupting the length of a slope, fiber rolls can also reduce erosion.

Applicability

Wattles may be suitable:

- As slope breakers along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length, reduce runoff velocity, and spread runoff as sheet flow
- At the end of a downward slope where it transitions to a steeper slope
- Along the perimeter of a project
- At the overflow locations of sediment traps
- As check dams in unlined ditches
- Around temporary stockpiles

Limitations

- Wattles are not effective unless trenched.
- Wattles placed directly at the toe of slopes greater than 5:1 (H:V) should be a minimum of 20-in. diameter or installations achieving the same protection (i.e. stacked smaller diameter wattles, etc.).
- Difficult to move once saturated.
- If not properly staked and trenched in, wattles could be transported by high flows.
- Wattles have a very limited sediment capture zone.
- Wattles should not be used on slopes subject to creep, slumping, or landslide.
- Wattles should not be used where periodic road or surface maintenance activities are expected.

Design criteria

No formal design is required.

Construction specifications

Wattles should be either prefabricated rolls or rolled tubes of erosion control blanket. (If using an erosion control blanket, roll the length of erosion control blanket into a tube of minimum 8 in. diameter and bind roll at each end and every 4 ft along length of roll with jute-type twine.)

See Figure W-1 for wattles used to control erosion along slopes.

1. Locate wattles on level contours spaced as follows:
    a. Slope inclination of 4:1 (H:V) or flatter: Fiber rolls should be placed at a maximum interval of 20 ft.
    b. Slope inclination between 4:1 and 2:1 (H:V): Fiber Rolls should be placed at a maximum interval of 15 ft. (a closer spacing is more effective).
    c. Slope inclination 2:1 (H:V) or greater: Fiber Rolls should be placed at a maximum interval of 10 ft. (a closer spacing is more effective).
2. Turn the ends of the wattles up slope to prevent runoff from going around the roll.
3. Stake wattles into a 2 to 4 in. deep trench with a width equal to the diameter of the wattle. Drive stakes at the end of each wattle and spaced 4 ft maximum on center. If wattles are part of a layered BMP system (3 or more) and a vegetated buffer (VB) is used, the wattles may be staked without trenching. Staking must insure continuous contact with the ground.
4. If more than one wattle is placed in a row, the rolls should be overlapped, not abutted.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Repair or replace split, torn, unraveling, or slumping rolls. If the wattle is used as a sediment capture device, or as an erosion control device to maintain sheet flows, sediment that accumulates must be periodically removed in order to maintain wattle effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage depth, usually one-half the distance between the top of the wattle and the adjacent ground surface.

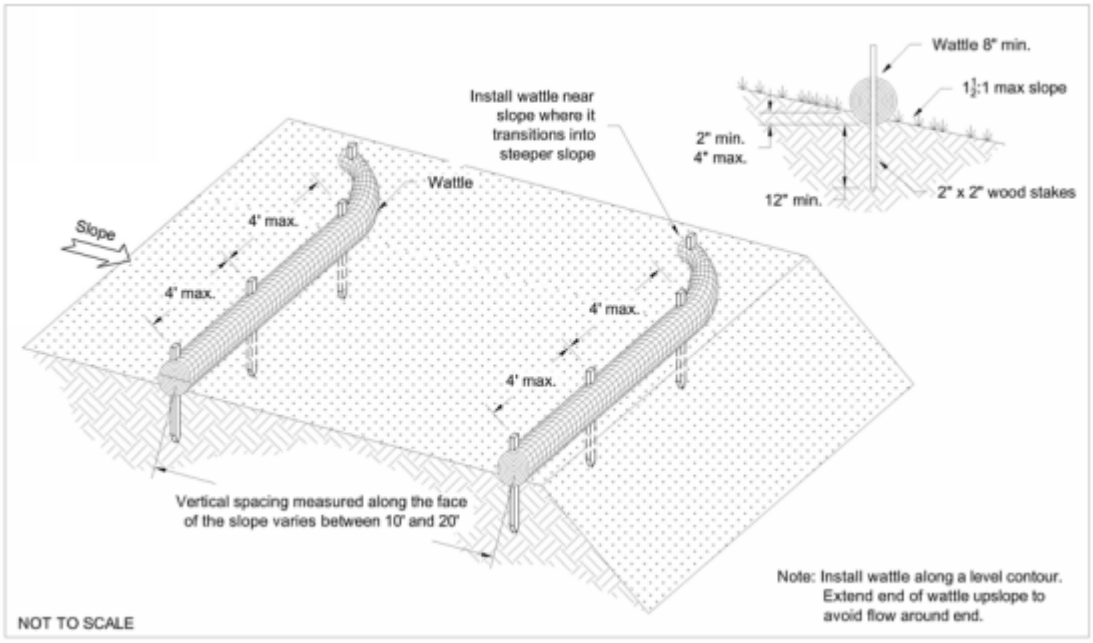
Removal

Wattles are typically left in place. If wattles are removed, collect and dispose of sediment accumulation, and fill and compact holes, trenches, depressions or any other ground disturbance to blend with adjacent ground.

References

California Stormwater Quality Association, Stormwater Best Management Practice (BMP) Handbook – Construction. January, 2003. <http://www.cabmphandbooks.com/Construction.asp>

Figure W-1
Wattle Installation



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Drainage Control BMPs

Berm (B)
Culvert (C)
Culvert Inlet Protection (CIP)
Culvert Outlet Protection (COP)
Diversion (D)
Drainage Dip (DD)
Level Spreader (LS)
Roadside Ditches (RSD) and Turnouts (TO)
Run-On Diversion (ROD)
Slope Drain (SD)
Trench Breaker (TB)
Water Bar (WB)

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Berm (B)

Description

A berm is a ridge of compacted soil located at the top or base of a sloping disturbed area to contain or divert surface runoff. Berms may be constructed from either excavated topsoil or subsoil.

The purpose of a berm is to control runoff velocity, divert on-site surface runoff to a sediment trapping device, and/or divert clean water away from disturbed areas.

Applicability

Berms are usually appropriate for drainage basins smaller than 5 acres, but with modifications they can be capable of servicing areas as large as 10 acres. With regular maintenance, earthen berms have a useful life span of approximately 18 months. Berms are applicable for the following applications:

- At the perimeter of a well pad (particularly the outer edge) to ensure that runoff remains on the pad and is diverted to a well pad detention pond, if available. See Detention Pond (DP).
- Along the outside shoulder of an insloped road to ensure that runoff from the roadway drains inward and to protect the fill slope from continual disturbances during road blading and maintaining. See Land Grading (LG) – Roads.
- Upslope of cut or fill slopes to divert flows away from disturbed areas.
- Downslope of cut or fill slopes to divert on-site runoff to a stabilized outlet or sediment trapping device, although diversions are more commonly used for this application. See Diversion (D).
- As temporary slope breakers to reduce runoff velocity and divert water off the construction right-of-way.

Limitations

- Berms may erode if not properly compacted and stabilized with vegetation or an erosion control blanket. Berms which are adjacent to concentrated flows will require erosion blanketing according to Erosion Control Blanket (ECB).
- If a berm crosses a vehicle roadway or entrance, its effectiveness can be reduced. Wherever possible, berms should be designed to avoid crossing vehicle pathways.

Design criteria

No formal design is required.

Construction specifications

1. Prior to berm construction, remove all trees, brush, stumps, and other objects in the path of the berm and till the base of the berm before laying the fill. Fill may consist of topsoil or subsoil excavated during the construction of nearby roads or well pads. If fill material is excavated adjacent to berm, follow the specification for Diversion (D).
2. Construct the berm according to Figure B-1 for the appropriate drainage area. For points where vehicles will cross the berm, the side slope should be no steeper than 3:1 and the mound may be constructed of gravel rather than soil. This will prolong the life of the berm and increase effectiveness at the point of vehicle crossing. For well pad perimeter installation the pad side of the berm should be sloped at 1.5:1 to help prevent vehicles from backing over the edge of the pad.
3. To remain effective, berms should be compacted with tracked equipment, if possible.
4. All berms shall have positive drainage to a stabilized outlet so that runoff does not collect in ponds on the upslope side of the berm, but instead flows along the berm until it reaches a stabilized outlet. Field location should be adjusted as needed. Stabilized outlet may be a well-vegetated area, a well pad detention pond, or a sediment control such as a silt fence or a sediment trap where sediment can settle out of the runoff before being discharged to surface waters.
5. If the expected life span of the berm is greater than 15 days, it is strongly recommended that the berm be stabilized with vegetation or an erosion control blanket immediately after construction. Stabilization is required where concentrated flows are expected. See Table B-1 for recommended stabilization methods for berms on various slopes.
6. Berms should be constructed and fully stabilized prior to commencement of major upslope land disturbance. This will maximize the effectiveness of the structure as a stormwater control device.
7. If using berms as temporary slope breakers to reduce runoff velocity, space the berms according to the following table:

Slope (%)	Spacing (feet)
5 – 15	300
>15 – 30	200
>30	100

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Berms should be inspected for evidence of erosion or deterioration to ensure continued effectiveness. Berms should also be maintained at the original height. Any decrease in height due to settling or erosion, which impacts the effectiveness of the BMP, should be repaired immediately.

Removal

Berms should remain in place and in good condition until all upslope disturbed areas are permanently stabilized. There is no need to formally remove the berm on completion of stabilization until interim or final reclamation.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. http://www.dec.state.ny.us/website/dow/toolbox/escstandards

Table B-1

Temporary Berm Stabilization

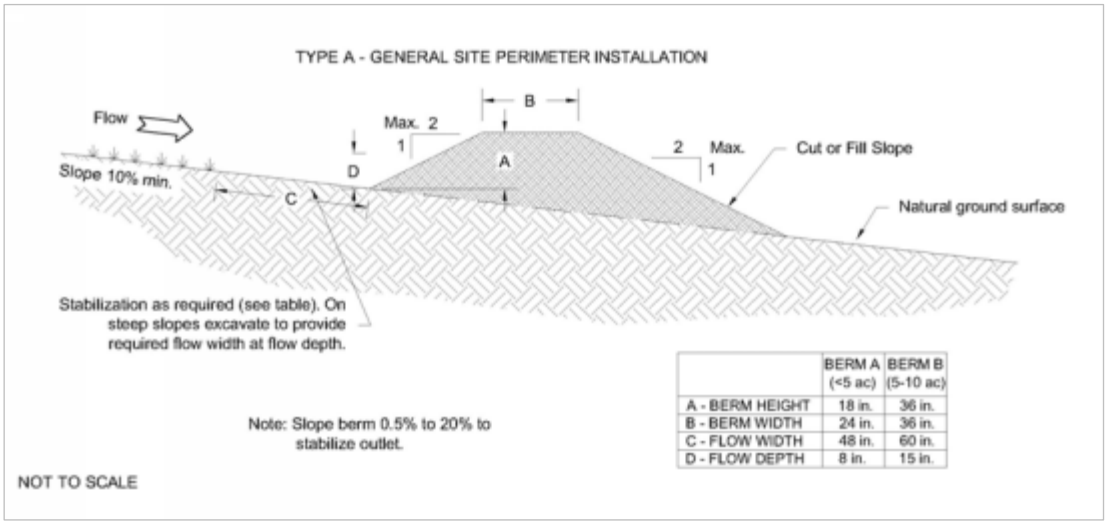
Type of Treatment	Channel Grade[1]	A (<5 Ac.)	B (5-10 Ac)
1	0.5-3.0%	Seed & Straw Mulch	Seed & Straw Mulch
2	3.0-5.0%	Seed & Straw Mulch	Seed and cover with erosion control blanket, or lined with 2-inch stone
3	5.0-8.0%	Seed and cover with erosion control blanket, or line with 2-inch stone	Line with 4 to 8-inch stone or rock[2]
4	8.0-20.0%	Line with 4 to 8-inch or stone or rock[2]	Engineering Design

Notes:

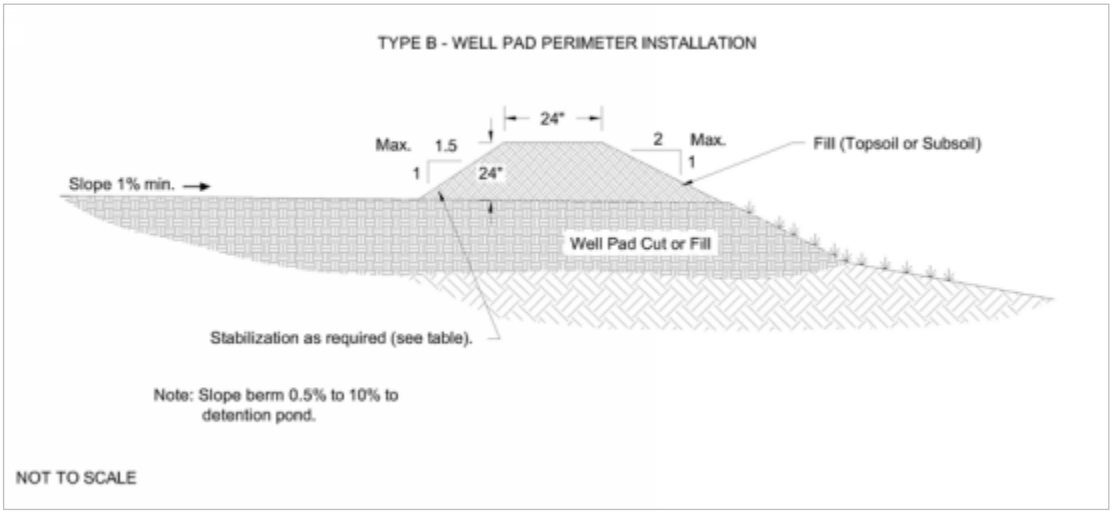
[1] In highly erodible soils, as defined by the local approving agency, refer to the next higher slope grade for type of stabilization.

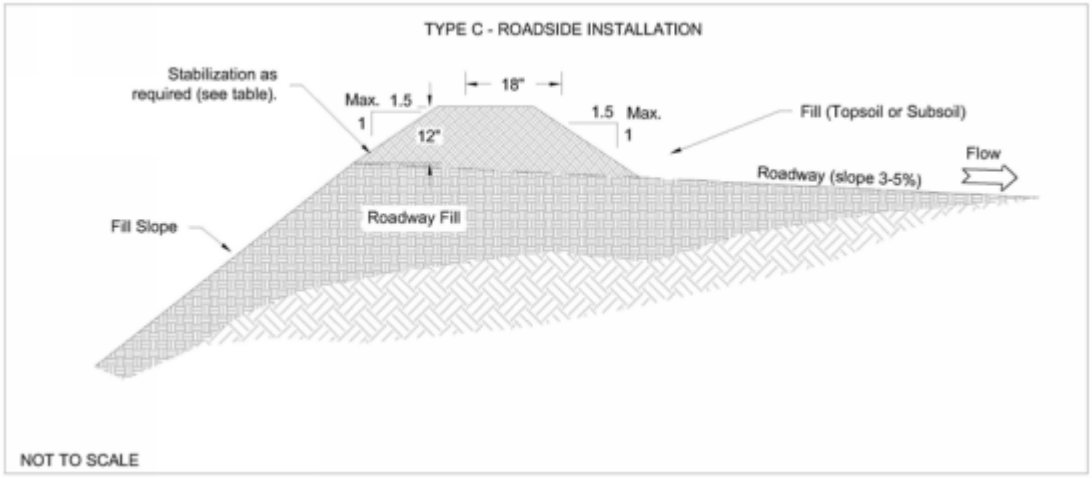
[2] Site rock if available, shall be broken into the required size.

Figure B-1
Berm Installation



	BERM A (<5 ac)	BERM B (5-10 ac)
A - BERM HEIGHT	18 in.	36 in.
B - BERM WIDTH	24 in.	36 in.
C - FLOW WIDTH	48 in.	60 in.
D - FLOW DEPTH	8 in.	15 in.





Culvert (C)

Description

Culverts are typically concrete, steel, aluminum, or plastic pipe used to move ditch water under the road or to direct stream flow under the road or construction area.

Applicability

Culverts are ideal on road grades less than 15%. For grades over 15%, it is difficult to slow down the water or remove it from the road surface rapidly. On such steep grades, it is best to use frequently spaced relief culverts and drainage crossing culverts with armored ditches. Culverts may be used in the following applications:

- As drainage crossing culverts in streams and gullies to allow normal drainage to flow under the traveled way.
- As ditch relief culverts to periodically relieve the inside ditch line flow by piping water to the opposite side of the road where the flow can be dispersed away from the roadway. Culverts placed in natural drainages may be utilized for ditch relief.

Limitations

- If undersized, culverts are susceptible to plugging and require cleaning.
- Culverts will not filter sediment.
- Culverts are easily crushed if not properly designed.

Design criteria

Capacity

All culverts should be designed for a minimum 25-year-frequency storm with an allowable head that does not overlap the roadway. However, the minimum acceptable size culvert diameter to prevent failure from debris blockage is 18 inches for intermittent stream crossings and 36 inches for perennial stream crossings. Pipe

size can be determined using general design criteria, such as in Table C-1, but is ideally based upon site-specific hydrologic analysis.

Depth

The depth of culvert burial must be sufficient to ensure protection of the culvert barrel for the design life of the culvert. This requires anticipating the amount of material that may be lost due to road use and erosion.

Headwalls

Use headwalls on culvert pipes as often as possible (see Retaining Wall (RW)). The advantages of headwalls include: preventing large pipes from floating out of the ground when they plug; reducing the length of the pipe; increasing pipe capacity; helping to funnel debris through the pipe; retaining the backfill material; and reducing the chances of culvert failure if it is overtopped.

Construction specifications

Drainage crossing culverts

1. Make road crossings of natural drainages perpendicular to the drainage to minimize pipe length and area of disturbance (Figure C-1).
2. Use single large pipes versus multiple smaller diameter pipes to minimize plugging potential in most channels (unless roadway elevation is critical). In very broad channels, multiple pipes are desirable to maintain the natural flow spread across the channel. All culverts should be concrete, corrugated metal pipe (CMP) made of steel or aluminum, or properly bedded and backfilled corrugated plastic pipe.
3. Align culverts in the bottom and middle of the natural channel flowline so that installation causes no change in the stream channel alignment or stream bottom elevation. Culverts should not cause damming or pooling or increase stream velocities significantly.
4. Extend the outlet of the culvert at least 1 foot beyond the toe of the slope to prevent erosion of the fill material. Alternatively, use retaining walls (headwalls) to hold back the fill slope.
5. It may be necessary to install riprap, erosion control blanketing, a combination of the riprap and blanketing, or other energy dissipater device at the outlet end of the culvert to reduce soil erosion or to trap sediment (see Culvert Outlet Protection (COP)).
6. It may be desirable to construct pulloffs/turnouts for vehicles on one or both sides of narrow culvert crossings. This will help avoid culvert crushing as well as disturbance to roadside ditches and berms.

Ditch relief culverts

1. See Figure C-2 for installation details.
2. Ditch relief culverts can provide better flow when skewed 0 to 30 degrees perpendicular to the road.
3. The culvert gradient should be at least 2% greater than the approach ditch gradient. This improves the flow hydraulics and reduces siltation and debris from plugging the culvert inlet.
4. Discharge culvert at natural ground level where possible (see Figure C 3 Type A), on firm, non-erosive soil or in rocky or brushy areas. If discharged on the fill slopes, armor outlets with riprap or slash (see Figure C-3 – Type B), or use down-drain structures (see Figure C-3 – Type C and Slope Drain (SD)).
5. Extend the inlet of the culvert at least 1 foot beyond the flowline of the roadside ditch. Extend the outlet of the culvert at least 1 foot beyond the toe of slopes to prevent erosion of the fill material.

6. It may be necessary to install riprap or other energy dissipater devices at the outlet end of the culvert to prevent soil erosion or to trap sediment (see Culvert Outlet Protection (COP)).
7. Spacing of culverts is dependent on the road gradient, soil types, and runoff characteristics according to the following table:

Soil type	Road grade		
	2–4%	**5–8%**	**9–12%**
Highly corrosive granitic or sandy	240’	180’	140’
Intermediate erosive clay or load	310’	260’	200’
Low erosive shale or gravel	400’	325’	250’

8. It may be desirable to construct pulloffs/turnouts for vehicles on one or both sides of narrow culvert crossings. This will help avoid culvert crushing as well as disturbance to roadside ditches and berms.

Backfill and compaction

1. See Figure C-4.
2. Firmly compact well-graded fill material (soil or road base) around culverts, particularly around the bottom half, using placement in layers to achieve a uniform density. Use slightly plastic sandy gravel with fines. Avoid the use of fine sand and silt rich soils for bedding material because of their susceptibility to piping. Pay particular attention to culvert bedding and compaction around the haunches of the pipe. Do not allow the compaction to move or raise the pipe. In large fills, allow for settlement.
3. Cover the top of metal and plastic culvert pipes with fill to a depth of at least 1 foot to prevent pipe crushing by heavy trucks. Use a minimum cover of 2 feet of fill over concrete pipe. For maximum allowable fill height, follow the manufacturer’s recommendations.
4. Mound fill over the top of culvert pipes so that the road is slightly raised at culvert locations to help prevent erosion and water from ponding over culvert crossings. This practice, as well as placing large boulders around the culvert outlets, will also help to prevent culverts from crushing.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. If any damage to culvert or inlet/outlet protection is noted or if there is any evidence of scour, repairs should be made immediately. Any debris that may be blocking the culvert inlet or outlet should be removed.

References

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book". BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

Table C-1
Culvert Sizing

Drainage Area (acres)	Size of Drainage Structure (diameter and area)			
	Steep Slopes (Light Vegetation) C=0.7		Gentle Slopes (Heavy Vegetation) C=0.2	
	Round Pipe (in)	Area (sq. ft)	Round Pipe (in)	Area (sq. ft)
0 – 10	30"	4.9	18"	1.8
10 - 20	42"	9.6	24"	3.1
20 - 35	48"	12.6	30"	4.9
35 - 75	72"	28.3	42"	9.6
75 - 125	84"	38.5	48"	12.6
125 - 200	96"	50.3	60"	19.6

Notes: If pipe size is not available, use the next larger pipe size for the given drainage area. For intermediate terrain, interpolate between pipe sizes. Pipe size is based upon the Rational Formula and Culvert Capacity curves. Assumes a rainfall intensity of 3 to 4 in/hr. Values of "C" are the Runoff Coefficients for the terrain.

Figure C-1
Drainage Crossing Culvert Alignment & Overflow Dip

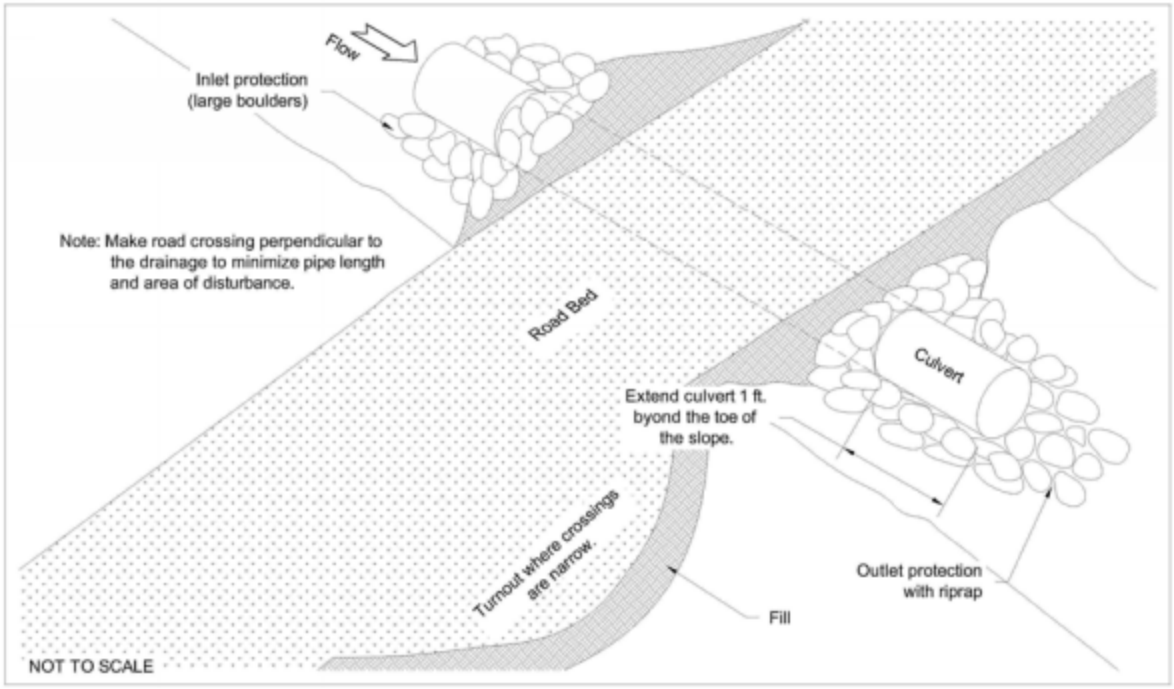


Figure C-2
Ditch Relief Culvert Installation

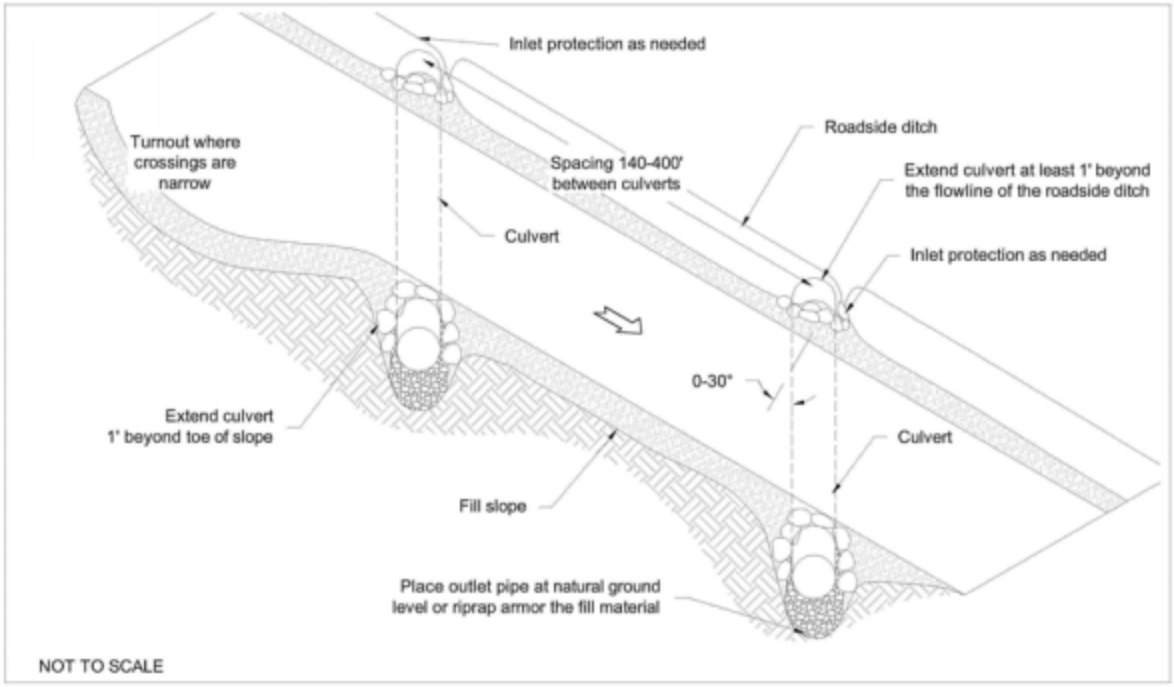


Figure C-3
Culvert Installation Options

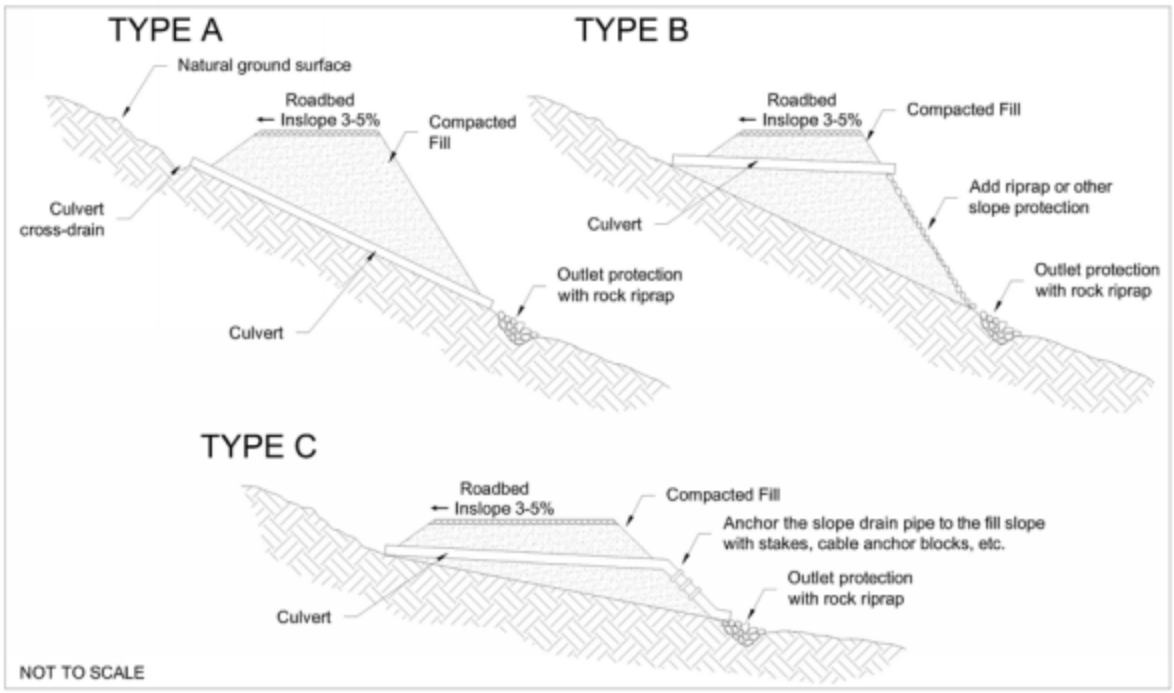
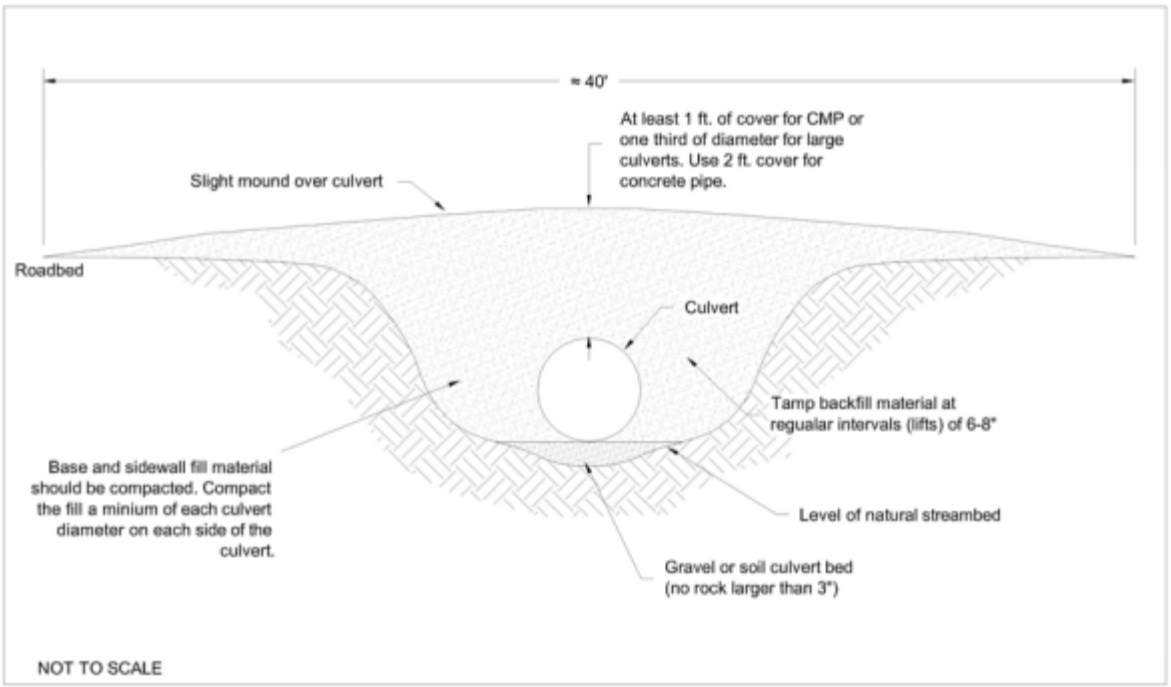


Figure C-4
Culvert Backfill and Compaction



Culvert Inlet Protection (CIP)

Description

Culvert protection is required at both the inlet to the culvert (upstream side) and the outlet to the culvert (downstream side).

Culvert inlet protection may involve placing boulders, riprap, gabions, rock retaining walls, slash, and/or any other protection at the inlets of pipes. Riprap, or other energy-dissipating devices, will reduce the velocity of stormwater flows and thereby prevent erosion and help protect the inlet structure.

Applicability

Riprap inlet protection should be used where velocities and energies at the inlets of culverts are sufficient to erode around the inlet structure. Riprap may also be used to help channel the stormwater to the inlet of the culvert.

Design criteria

Riprap, gabions, or rock retaining walls at culvert inlets shall be designed according to their appropriate BMPs.

Construction specifications

Figure CIP-1 shows typical culvert inlet protection. However, site specifics shall dictate actual design.

1. Riprap, gabions, or rock retaining walls at culvert inlets shall be constructed according to their appropriate BMPs.
2. After installation of a culvert, examine the stream channel for the amount of debris, logs, and brushy vegetation present. In channels with large amounts of debris, consider using oversized pipes.
3. Boulders should be drystacked around the culvert inlet and up the slope to the edge of the road.

Maintenance considerations

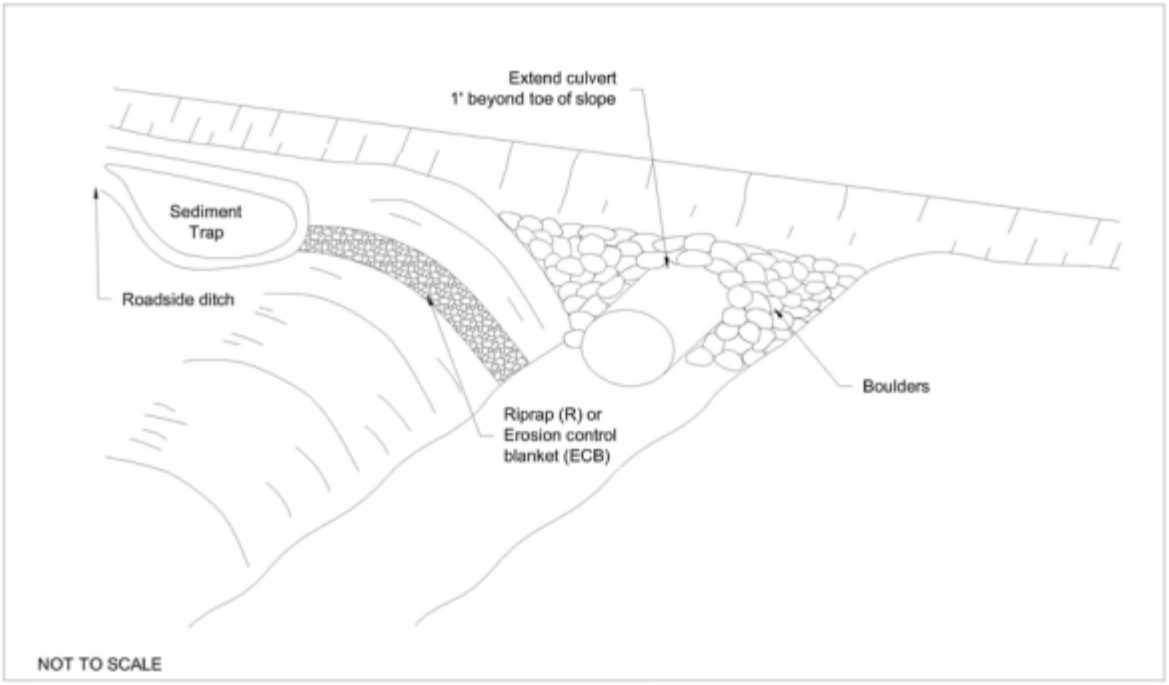
The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect for debris at the entrance to culverts and within culverts. Inspect riprap at culvert inlets for damaged or dislodged stones. Any needed repairs that reduce the effectiveness of the BMP should be made immediately.

References

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Figure CIP-1
Typical Inlet Protection



Culvert Outlet Protection (COP)

Description

Culvert protection is required at both the inlet to the culvert (upstream side) and the outlet to the culvert (downstream side).

Culvert outlet protection involves placing structurally lined aprons or other appropriate energy-dissipating devices, such as large boulders or plunge pools, at the outlets of pipes to reduce the velocity of stormwater flows and thereby prevent scouring at stormwater outlets, protect the outlet structure, and minimize potential for erosion downstream.

Applicability

Culvert outlet protection should be used where discharge velocities and energies at the outlets of culverts or channels are sufficient to erode the next downstream reach.

Limitations

Rock aprons at culvert outlets should not be placed on slopes steeper than 10 percent. Runoff from pipe outlets at the top of cuts/fills or on slopes steeper than 10 percent should be routed via slope drains or riprap chutes to a rock apron at the toe of the slope. Otherwise flows will re-concentrate and gain velocities as the flow leaves the apron.

Design criteria

Gabions or rock retaining walls at culvert outlets shall be designed according to their appropriate BMPs. No formal design is required for plunge pools at outlets. Riprap aprons at culvert outlets shall be designed as follows:

Tailwater depth. The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. If the tailwater depth is less than half the diameter of the outlet pipe, and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

Riprap apron size & D50. The apron length (LA) and the D50 of the riprap shall be determined from Table COP-1 according to the design flow and whether there is a minimum or maximum tailwater condition. The apron width (W) shall then be determined as:

$$W = d + 0.4\ L_A$$

where d is the diameter of the culvert.

If the pipe discharges directly into a well defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation 1 foot above the maximum tailwater depth or to the top of the bank, whichever is less. The upstream end of the apron, adjacent to the pipe, shall have a width two (2) times the diameter of the outlet pipe, or conform to pipe end section if used.

Riprap materials. The outlet protection may be done using rock riprap or grouted riprap. Riprap shall be composed of a well-graded mixture of stone size so that 50 percent of the pieces, by weight, shall be larger than the D50 size determined from Table COP-1. A well-graded mixture, as used herein, is defined as a mixture composed primarily of larger stone sizes, but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the D50 size. All grout for grouted riprap must be one part Portland cement for every 3 parts sand, mixed thoroughly with water.

Filter. If a filter cloth or gravel is used, it should be designed according to Riprap (R).

Apron thickness. The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter for D50 of 15 inches or less; and 1.2 times the maximum stone size for D50 greater than 15 inches.

Riprap stone quality. Stone for riprap shall consist of field stone or rough unhewn quarry stone. The stone shall be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5. Site rock or site boulders may be used provided it has a density of at least 150 pounds per cubic foot, and does not have any exposed steel or reinforcing bars.

Construction specifications

Gabions or rock retaining walls at culvert outlets shall be constructed according to their appropriate BMPs. Riprap aprons at culvert outlets shall be constructed according to Figure COP-1 and as follows:

1. Prepare the subgrade for the riprap to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.
2. If a pipe discharges into a well-defined channel, the channel's side slopes may not be steeper than 2:1.
3. Construct apron to the design length and width with no slope (Figure COP-1). The invert elevations must be equal at the receiving channel and the apron's downstream end. No overfall at the end of the apron is allowed. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground. The outlet protection apron shall be located so that there are no bends in the horizontal alignment.
4. Line the apron with riprap, grouted riprap, or concrete. Riprap should be the appropriate size and thickness as designed. See Riprap (R) for the placement of riprap.

5. If a culvert outlets at the top of cuts/fills or on slopes steeper than 10 percent one of the following two options is suggested:

    a. Transition culvert to a slope drain according to Slope Drain (SD). The slope drain shall convey stormwater to the bottom of the slope where a riprap apron, as designed above, shall prevent erosion at the slope drain outlet.

    b. Line slope below culvert outlet with a riprap channel to convey stormwater to the bottom of the slope where a riprap apron, as designed above, shall prevent erosion at the bottom of the slope. The riprap channel shall be designed according to the table in the Riprap (R) BMP that is based on depth of flow and slope. The riprap channel shall dip into the slope so that all water is contained within the channel, flows to the riprap outlet apron at the base of the slope, and does not spill over the sides onto unprotected soil.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. The maintenance needs are usually very low for properly installed riprap aprons at culvert outlets. However, inspect for evidence of scour beneath riprap at outlet aprons or for dislodged stones. And needed repairs that reduce the effectiveness of the BMP should be made immediately.

References

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Table COP-1
Outlet Protection Design

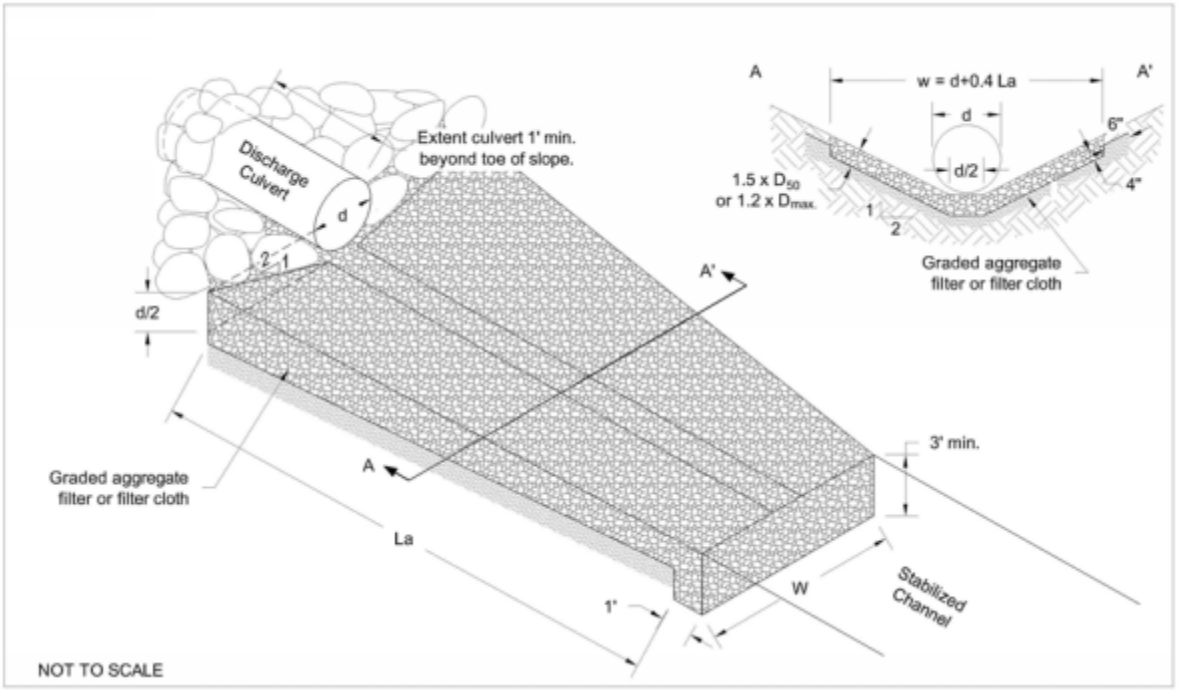
Riprap Aprons for Low Tailwater
(downstream flow depth < 0.5 x pipe diameter)

Culvert Diameter	Lowest value			Intermediate values to interpolate from									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	7	2.5	6	10	3.5	9	131	6	12	16	7	14	17	8.5
15"	6.5	8	3	10	12	5	15	16	7	20	18	10	25	20	12
18"	10	9	3.5	15	14	5.5	20	17	7	30	22	11	40	25	14
21"	15	11	4	25	18	7	35	22	10	45	26	13	60	29	18
24"	21	13	5	35	20	8.5	50	26	12	65	30	16	80	33	19
27"	27	14	5.5	50	24	9.5	70	29	14	90	34	18	110	37	22
30"	36	16	6	60	25	9.5	90	33	15.5	120	38	20	140	41	24
36"	56	20	7	100	32	13	140	40	18	180	45	23	220	50	28
42"	82	22	8.5	120	32	12	160	39	17	200	45	20	260	52	26
48"	120	26	10	170	37	14	220	46	19	270	54	23	320	64	37

Riprap Aprons for High Tailwater
(downstream flow depth > 0.5 x pipe diameter)

Culvert Diameter	Lowest value			Intermediate values to interpolate from									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	8	2	6	18	2.5	9	28	4.5	12	36	7	14	40	8
15"	7	8	2	10	20	2.5	15	34	5	20	42	7.5	25	50	10
18"	10	8	2	15	22	3	20	34	5	30	50	9	40	60	11
21"	15	8	2	25	32	4.5	35	48	7	45	58	11	60	72	14
24"	20	8	2	35	36	5	50	55	8.5	65	68	12	80	80	15
27"	27	10	2	50	41	6	70	58	10	90	70	14	110	82	17
30"	36	11	2	60	42	6	90	64	11	120	80	15	140	90	18
36"	56	13	2.5	100	60	7	140	85	13	180	104	18	220	120	23
42"	82	15	2.5	120	50	6	160	75	10	200	96	14	260	120	19
48"	120	20	2.5	170	58	7	220	85	12	270	105	16	320	120	20

Figure COP-1
Typical Outlet Protection



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Diversion (D)

Definition

A diversion is a drainage way of parabolic or trapezoidal cross section with a supporting ridge on the lower side that is constructed across the slope. The purpose of a diversion is to prevent off-site storm runoff from entering a disturbed area, to prevent sediment laden storm runoff from leaving the construction site or disturbed area, to prevent flows from eroding slopes, and to direct sediment laden flows to a trapping device.

Applicability

Diversions may be designed for temporary or permanent use. The maximum drainage area for temporary, un-compacted diversions is 2 acres. For drainage areas larger than 2 acres but less than 10 acres, the diversion should be compacted. For undisturbed drainage areas larger than 10 acres, a permanent diversion may be designed to handle larger flows. Diversions may be used for the following applications:

- Upslope of cut or fill slopes to convey or divert flows away from disturbed areas. See Run-On Diversion (ROD).
- Down-slope of cut or fill slopes to divert on-site runoff to a stabilized outlet or sediment trapping device.
- At the outer edge of a well pad to ensure that runoff remains on the pad and is diverted to a well pad detention pond, if available. See Detention Pond (DP).
- Where runoff from higher areas has potential for causing erosion, or interfering with, or preventing the establishment of, vegetation on lower areas.
- Where the length of slopes needs to be reduced so that soil loss will be kept to a minimum.
- At the perimeter of a site or disturbed area.

Limitations

- The area around the diversion channel that is disturbed by its construction must be stabilized (with vegetation or other erosion control) so that it is not subject to similar erosion as the steep slope the channel is built to protect.
- To alleviate erosion capability, diversions must be directed into a stabilized outlet or well-vegetated area or to sediment trapping devices, where erosion sediment can settle out of the runoff before being discharged to surface waters.

- Temporary diversions should be designed to avoid crossing vehicle pathways.
- Diversions should be used with caution on soils subject to slippage.

Design criteria

For a temporary diversion (drainage area less than 10 acres), no formal design is necessary. For a run-on diversion see the Run-On Diversion (ROD) BMP. For other permanent diversions (drainage area larger than 10 acres) the following guidelines apply:

Location

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, and the development layout.

Capacity

Peak rates of runoff values used in determining the capacity requirements shall be as outlined by TR-55, Urban Hydrology for Small Watersheds. The constructed diversion shall have capacity to carry, as a minimum, the peak discharge from a 10-year frequency rainfall event with freeboard of not less than 0.3 feet.

Cross section

See Figure D-2 for details. The diversion channel shall be parabolic or trapezoidal in shape, if possible. The diversion shall be designed to have stable side slopes. The side slopes shall not be steeper than 2:1 and shall be flat enough to ensure ease of maintenance of the diversion and its protective vegetative cover. The ridge shall have a minimum width of 4 feet at the design water elevation; a minimum of 0.3 feet freeboard and a reasonable settlement factor (10%) shall be provided.

Velocity and grade

The permissible velocity for the specific soil type will determine the maximum grade. The maximum permissible velocity for sand and silt vegetated channels is 3 ft/sec, and 5 ft/sec for clay vegetated channels. Diversions are not usually applicable below high sediment producing areas unless structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with, or before, the diversions.

Construction specifications

General

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.
2. All diversions shall have uninterrupted positive grade to an outlet.
3. Each diversion must have an adequate outlet where outflow will not cause damage. Diverted runoff from a disturbed area shall be conveyed to a sediment trapping device. Diverted runoff from an undisturbed area shall outlet to a sediment trapping device or into an undisturbed stabilized area at non-erosive velocities. Vegetated outlets shall be installed before diversion construction, if needed, to ensure establishment of vegetative cover in the outlet channel.

Temporary diversion (drainage area <10 acres)

See Figure D-1.

1. The diversion shall be excavated or shaped to line, grade, and cross section as required to meet the specified criteria. The diversion does not need to be compacted if the contributing drainage area is less than 2 acres.
2. Stabilization with vegetation is not required as long as sediment traps or other sediment control devices are provided.

Permanent diversion (drainage area >10 acres)

See Figure D-2.

1. The diversion shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein, and be free of bank projections or other irregularities which will impede normal flow.
2. Parabolic and triangular-shaped, grass-lined channels should not have a top width of more than 30 feet. Trapezoidal, grass-lined channels may not have a bottom width of more than 15 feet unless there are multiple or divided waterways, they have a riprap center, or other methods of controlling the meandering of low flows are provided.
3. If grass-lined channels have a base flow, a stone center or subsurface drain or another method for managing the base flow must be provided.
4. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete diversion.
5. All earth removed and not needed in construction shall be spread or disposed of on the construction side of the diversion so that it will not interfere with the functioning of the diversion.
6. Immediately after the ridge and channel are constructed, they must be seeded or hydro-seeded and mulched according to Revegetation (RV) and Mulching (M) or Erosion Control Blanket (ECB) along with any disturbed areas that drain into the diversion.
    a. For design velocities less than 3.5 ft/sec, seeding and mulching may be used for establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means should be used to prevent water from entering the diversion during the establishment of the vegetation.
    b. For design velocities of more than 3.5 ft/sec, the diversion shall be stabilized with seeding protected by Jute or Excelsior matting, or with seeding and mulching until the vegetation is established.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Channels should be cleared of sediment, repairs made when necessary, and seeded areas reseeded if a vegetative cover is not established. Maintain diversion capacity, ridge height, and outlet elevations especially if high sediment yielding areas are in the drainage area above the diversion. Establish necessary cleanout requirements. Redistribute sediment as necessary to maintain the capacity of the diversion.

Removal

Temporary and un-compacted diversions shall remain in place only until the disturbed areas are permanently stabilized. Permanent diversions shall remain in place until final reclamation.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Field Office Technical Guide. 2002. <www.nrcs.usda.gov/technical/efotg>

Figure D-1
Temporary Diversion Installation

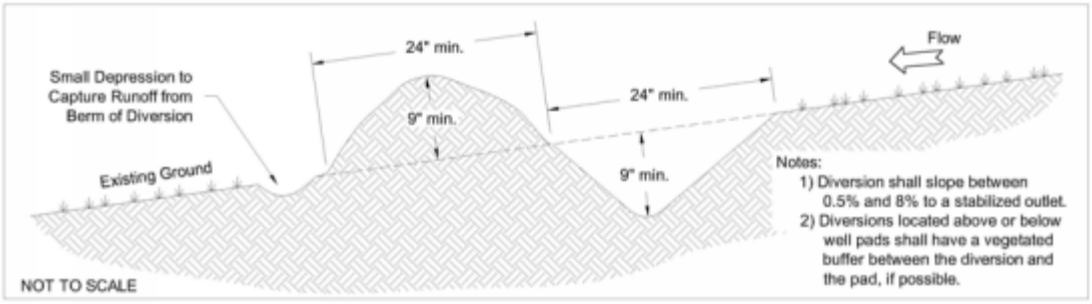
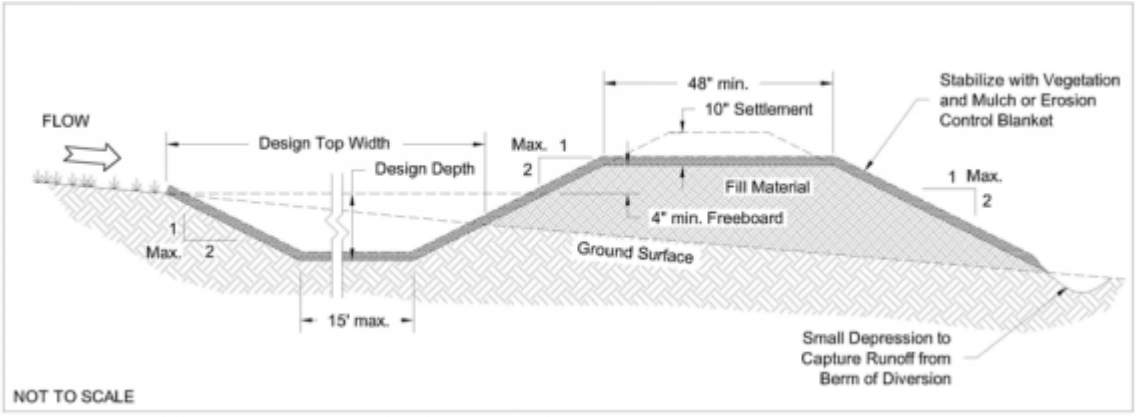


Figure D-2
Permanent Diversion Installation



Drainage Dip (DD)

Description

Drainage dips intercept and remove surface water from the road and shoulders before the combination of water volume and velocity begins to erode the surface materials. Drainage dips are constructed diagonally across and as part of the road surface, and will pass slow traffic while dispersing surface water.

Applicability

Drainage dips may be used in the following applications:

- To move water off the road surface efficiently and economically
- In place of a culvert, which is costly and susceptible to plugging or failure
- On low volume, low to moderate speed roads (10-35 mph) with grades less than 12%

Limitations

- Size limited by the safe passage of trucks and equipment
- May cause concentrated flows from sheet flows
- Requires vegetative cover or other sediment filter/trap at discharge point

Design criteria

No formal design required.

Construction specifications

See Figure DD-1.

1. Construct rolling dips deep enough to provide adequate drainage, angled 0-25 degrees from perpendicular to the road, with a 3-5% outslope, and long enough (50 to 200 feet) to pass vehicles and equipment.

2. In soft soils, armor the mound and dip with gravel or rock, as well as the outlet of the dip.

3. Spacing of drainage dips depends upon local conditions such as soil material, grade, and topography. See Table DD-1 for recommended maximum distances between drainage dips.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspections should pay close attention to discharge points.

References

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

Maine Department of Conservation, Best Management Practices for Forestry: Protecting Maine's Water Quality. Maine Forest Service, Forest Policy and Management Division. Augusta, Maine. 2004. <http://www.state.me.us/doc/mfs/pubs/pdf/bmp_manual/bmp_manual.pdf>

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development "Gold Book". BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

Table DD-1

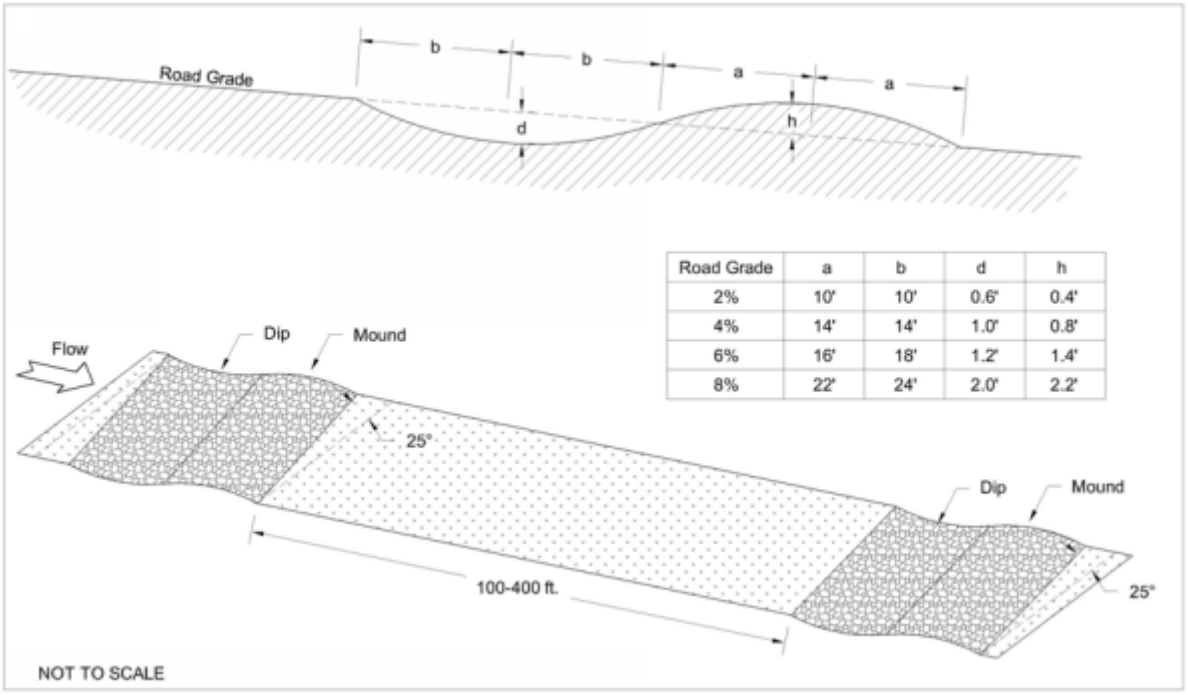
Maximum Distance between Drainage Dips

Road Grade, %	Low to Non-Erosive Soils (1)	Erosive Soils (2)
0 - 3	400'	200'
4 - 6	300'	160'
7 - 9	250'	130'
10 - 12	200'	110'
12+	160'	100'

(1) Low Erosion Soils = Coarse Rocky Soils, Gravel, and Some Clay

(2) High Erosion Soils = Fine, Friable Soils, Silt, Fine Sands

Figure DD-1
Typical Drainage Dip



Road Grade	a	b	d	h
2%	10'	10'	0.6'	0.4'
4%	14'	14'	1.0'	0.8'
6%	16'	18'	1.2'	1.4'
8%	22'	24'	2.0'	2.2'

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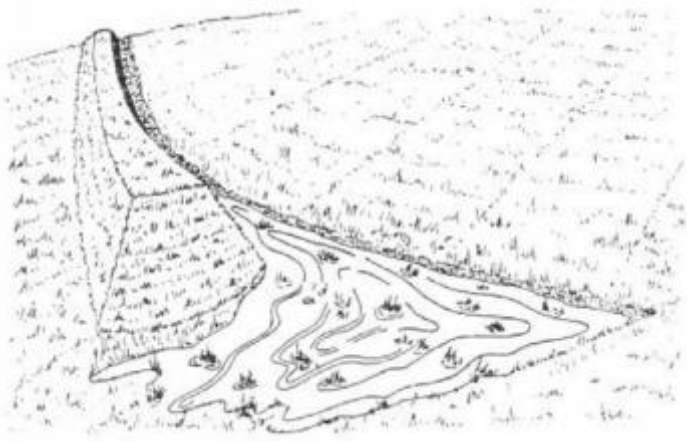
Level Spreader (LS)



Description

A level spreader is a device used to prevent erosion and to improve infiltration by spreading concentrated stormwater runoff evenly over the ground as shallow flow instead of through channels. It usually involves a depression in the soil surface that disperses flow onto a flatter area across a slight slope and then releases the flow onto level vegetated areas. This reduces flow speed and increases infiltration.

Applicability

A level spreader is most effective for a contributing area less than 5 acres in size and slopes no steeper than 2:1. Level spreaders may be used where:

- Sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion.
- A level lip can be constructed without filling.
- The area below the level lip is uniform with a slope of 10% or less and the runoff will not re-concentrate after release.
- No traffic will be allowed over the spreader.

Limitations

This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is uniform with a slope of 10% or less and is stabilized by natural vegetation. The runoff water should not be allowed to reconcentrate after release unless it occurs during interception by another measure (such as a detention basin) located below the level spreader.

Design criteria

Capacity

The design capacity shall be determined by estimating the peak flow from the 10-year storm. The drainage area shall be restricted to limit the maximum flows into the spreader to 30 cubic feet per second (cfs).

Construction specifications

See Figure LS-1 for details.

1. A transition section will be constructed from the diversion channel to the spreader to smoothly blend the different dimension and grades.

2. The level lip will be constructed in undisturbed soil to a uniform height and zero grade over the length of the spreader. For design flows less than 5 cfs, a vegetated level lip may be constructed with an erosion-resistant material, such as jute or excelsior blankets, to inhibit erosion and allow vegetation to become established. The matting should be a minimum of 4 ft. wide extending 6 inches over the lip and buried 6 inches deep in a vertical trench on the lower edge.

3. For design flows higher than 5 cfs and permanent installations, a rigid level lip of non-erodible material, such as site rock and gravel, should be used.

4. The runoff will be discharged onto a stabilized and generally smooth vegetated slope not exceeding 10%.

5. Seed and mulch the disturbed area immediately after construction.

6. Heavy equipment and traffic should not be allowed on the level spreader, as they can cause compaction of soil and disturbance of the slope grade.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. The spreader should be regraded if ponding or erosion channels develop. Dense vegetation should be sustained and damaged areas reseeded when necessary.

Removal

Level spreaders may be left in place or removed upon final site reclamation.

References

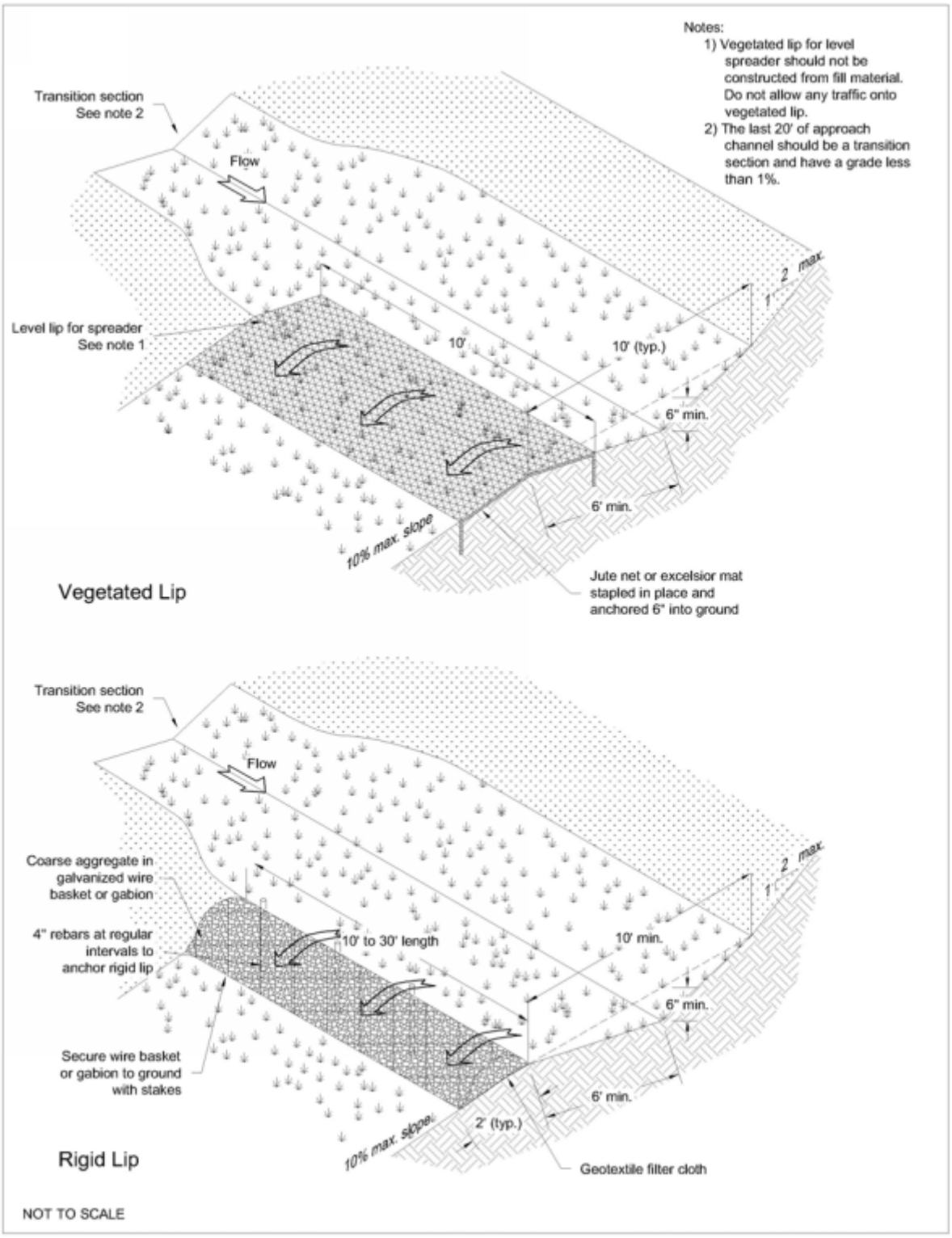
City of Knoxville, Stormwater Engineering, Knoxville BMP Manual - Best Management Practices. July 2003. http://www.ci.knoxville.tn.us/engineering

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

United States Army Corps of Engineers (USACE), Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities. February 1997. http://www.usace.army.mil/inet/usace-docs/eng-pamphlets/ep1110-1-16/

Figure LS-1
Level Spreader Installation



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Roadside Ditches (RSD) and Turnouts (TO)

Description

Roadside ditches are channels constructed parallel to roads. The ditches convey concentrated runoff of surface water from roads and surrounding areas to a stabilized outlet. Turnouts (wing ditches) are extensions of roadside ditches. Turnouts effectively remove runoff water from the roadside ditch into well-stabilized areas before it reaches a waterway.

Applicability

- Roadside ditches should be used for all roads built on sloping topography and with either an insloped or a crowned design.
- Ditch turnouts should be used as much as possible but their best use may be on slopes longer than 150 ft or greater than 5%, as conditions allow.
- Turnouts are applicable where fairly flat naturally vegetated areas exist at intervals by the roadside.

Limitations

- If these structures are not installed correctly they may become a source of erosion.
- Roadside ditches do not necessarily filter sediment from runoff.
- Turnouts should be on gradual slopes only.
- Turnouts require vegetative cover or other filter at the discharge point.
- Turnouts only work well if small volumes of runoff drain into the turnout. Turnouts should only receive runoff from the road and ditch surface, not from large, uphill watersheds.

Design criteria

No formal design is required.

Construction specifications

Roadside ditches

1. Roadside ditches should be constructed with no projections of roots, stumps, rocks, or similar debris.
2. Excavate ditches along roadside to a width and depth that can handle expected flows according to Figure RSD-1.
3. All ditches shall have uninterrupted positive grade to an outlet. Slope ditch so that water velocities do not cause excessive erosion, but no less than 0.5%. If steep slopes and high velocities exist, use check dams to slow runoff and catch sediment.
4. To control erosion and collect sediment, construct aggregate check dams according to Figure CD-1 of Check Dam (CD).
5. All ditches shall convey runoff to a sediment trapping device such as a Sediment Trap (ST) or an undisturbed, well vegetated, and stabilized area at non-erosive velocity.
6. If necessary, stabilize ditches with Riprap (R) or erosion control blanketing.

Turnouts

1. Use turnouts wherever possible and on undisturbed soil.
2. Slope turnout gradually down from bottom of roadside ditch.
3. Angle turnout at approximately 30 degrees to the roadside ditch.
4. Discharge turnout into well-vegetated area or install a secondary control such as a wattle, sediment trap, or silt fence. As a good Rule of Thumb, the vegetated outlet area should be a minimum of one-half the size of the total drainage area draining into it. If well-vegetated outlet areas are not available, use culverts or other controls to direct runoff to a stabilized area.
5. Space turnouts according to slope as indicated on Figure TO-1.
6. Turnouts only work well if small volumes of runoff drain into the turnout. Turnouts should only receive runoff from the road and ditch surface, not from large, uphill watersheds.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Road ditches and turnouts should be inspected for any signs of channelization, and repaired as necessary. Structures will fail if water exits in channelized flow. Also inspect for sediment buildup at the outlet and at aggregate check dams and remove if necessary.

References

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

United States Department of the Interior and United States Department of Agriculture. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development “Gold Book”. BLM/WO/ST-06/021+3071. Bureau of Land Management (BLM). Denver, Colorado. Fourth Edition, 2006.

Figure RSD-1
Roadside Ditch Installation

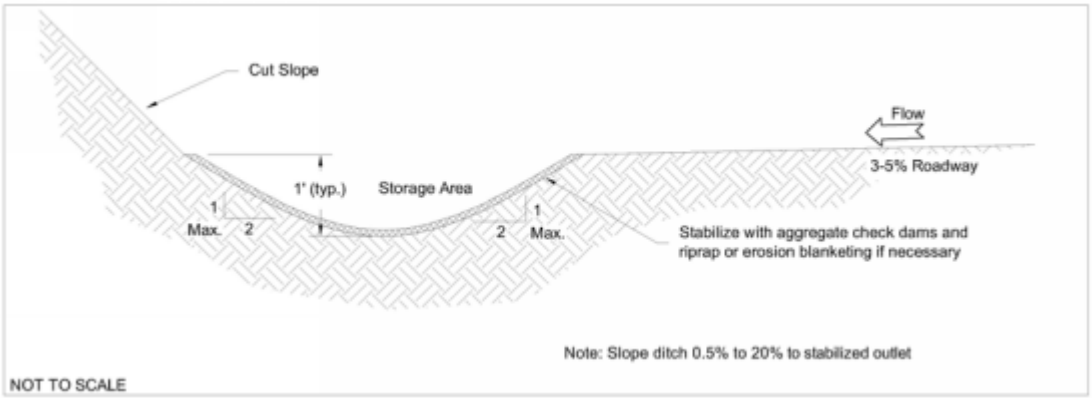
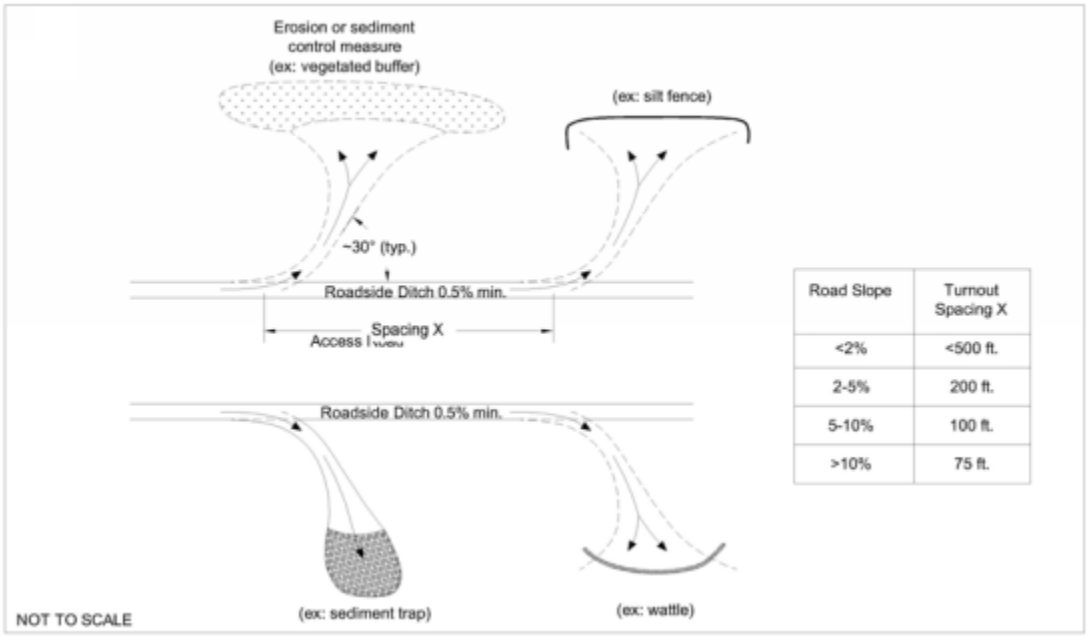


Figure TO-1
Turnout Layout



Road Slope	Turnout Spacing X
<2%	<500 ft.
2-5%	200 ft.
5-10%	100 ft.
>10%	75 ft.

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Run-On Diversion (ROD)

Definition

A run-on diversion is a drainage way of parabolic or trapezoidal cross section with a supporting ridge on the lower side that is constructed across the slope. The purpose of a run-on diversion is to prevent off-site storm runoff from entering a disturbed area and to direct the runoff to a sediment or erosion control device.

Applicability

A run-on diversion is typically a permanent control designed for a drainage area larger than 10 acres where high flow is expected. Run-on diversions are used upslope of cut or fill slopes to convey or divert flows away from disturbed areas.

Limitations

- The area around the diversion channel that is disturbed by its construction must be stabilized (with vegetation or other erosion control) so that it is not subject to erosion similar to that of the steep slope the diversion is built to protect.
- To alleviate erosion capability, diversions must be directed into a stabilized outlet or well-vegetated area or to sediment trapping devices, where erosion sediment can settle out of the runoff before being discharged to surface waters.
- Run-on diversions should be used with caution on soils subject to slippage.

Design criteria

Location

Run-on diversions should be located above cut or fill slopes. Where possible (shallow slopes), a vegetated buffer strip should be left between the edge of the cut or fill slope and the diversion. Location shall also depend on outlet conditions, topography, land use, soil type, length of slope, and the development layout.

Capacity

Peak rates of runoff values used in determining the capacity requirements shall be as outlined by TR-55, Urban Hydrology for Small Watersheds. The constructed diversion shall have capacity to carry, as a minimum, the peak discharge from a 10-year frequency rainfall event with freeboard of not less than 0.3 feet.

Cross section

See Figure ROD-1 for details. The diversion channel shall be parabolic or trapezoidal in shape. The diversion shall be designed to have stable side slopes. The side slopes shall not be steeper than 2:1 and shall be flat enough to ensure ease of maintenance of the diversion and its protective vegetative cover. The ridge shall have a minimum width of 4 feet at the design water elevation; a minimum of 0.3 feet freeboard and a reasonable settlement factor (10%) shall be provided.

Velocity and grade

The permissible velocity for the specific soil type will determine the maximum grade. The maximum permissible velocity for sand and silt vegetated channels is 3 ft/sec, and 5 ft/sec for clay vegetated channels. Run-on diversions are not usually applicable below high sediment producing areas unless structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with, or before, the diversions.

Construction specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion

2. All diversions shall have uninterrupted positive grade to an outlet.

3. Each diversion must have an adequate outlet where outflow will not cause damage. Diverted runoff shall outlet to a sediment trapping device or into an undisturbed stabilized area at non-erosive velocities. Vegetated outlets shall be installed before diversion construction, if needed, to ensure establishment of vegetative cover in the outlet channel.

4. The diversion shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein, and be free of bank projections or other irregularities which will impede normal flow.

5. Parabolic and triangular-shaped, grass-lined channels should not have a top width of more than 30 feet. Trapezoidal, grass-lined channels may not have a bottom width of more than 15 feet unless there are multiple or divided waterways, they have a riprap center, or other methods of controlling the meandering of low flows are provided.

6. If grass-lined channels have a base flow, a stone center or subsurface drain or another method for managing the base flow must be provided.

7. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete diversion.

8. All earth removed and not needed in construction shall be spread or disposed of on the well pad side of the diversion so that it will not interfere with the functioning of the diversion.

9. Immediately after the ridge and channel are constructed, they must be seeded or hydroseeded, and mulched or covered with erosion blanketing according to Revegetation (RV), Mulching (M), and/or Erosion Control Blanket (ECB) along with any disturbed areas that drain into the diversion.

    a. For design velocities less than 3.5 ft/sec, seeding and mulching may be used for establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means should be used to prevent water from entering the diversion during the establishment of the vegetation.

    b. For design velocities or more than 3.5 ft/sec, the diversion shall be stabilized with seeding protected by Jute or Excelsior matting, or with seeding and mulching including temporary diversion of the water until the vegetation is established.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Channels should be cleared of sediment, repairs made when necessary, and seeded areas reseeded if a vegetative cover is not established. Maintain diversion capacity, ridge height, and outlet elevations especially if high sediment yielding areas are in the drainage area above the diversion. Establish necessary cleanout requirements. Redistribute sediment as necessary to maintain the capacity of the diversion.

Removal

Run-on diversions shall remain in place until final reclamation.

References

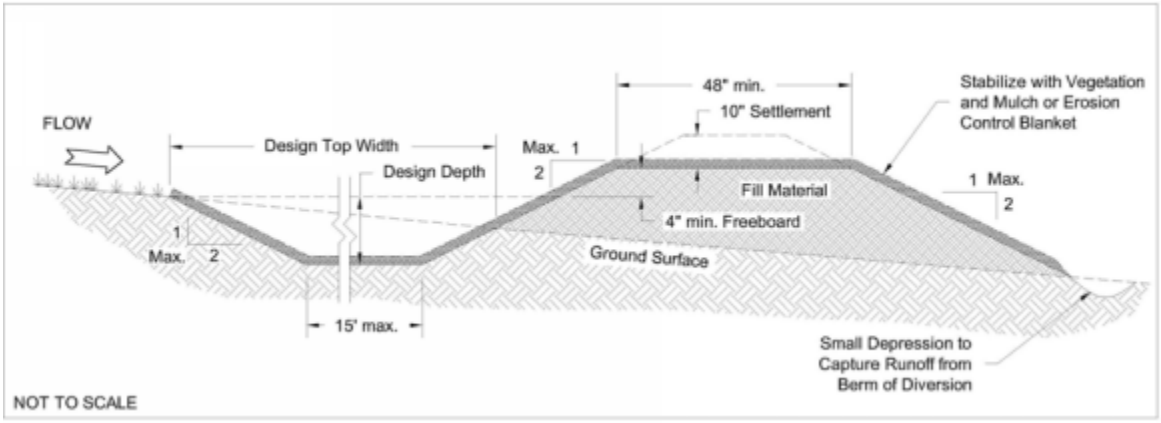
Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Field Office Technical Guide. 2002. <www.nrcs.usda.gov/technical/efotg>

Figure ROD-1

Run-On Diversion Installation



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Slope Drain (SD)

Description

A slope drain is a conduit extending the length of a disturbed slope and serving as a temporary outlet for a diversion. Slope drains convey runoff without causing erosion on or at the bottom of the slope. This practice is a temporary measure used during grading operations until permanent drainage structures are installed and until slopes are permanently stabilized. They are typically used for less than 2 years.

Applicability

Slope drains can be used on most disturbed slopes to eliminate gully erosion problems resulting from concentrated flows discharged at a diversion outlet. Recently graded slopes that do not have permanent drainage measures installed should have a slope drain and a temporary diversion installed. A slope drain used in conjunction with a diversion conveys stormwater flows and reduces erosion until permanent drainage structures are installed.

Limitations

The area drained by a temporary slope drain should not exceed 5 acres. Physical obstructions substantially reduce the effectiveness of the drain. Other concerns are failures from overtopping because of inadequate pipe inlet capacity, and reduced diversion channel capacity and ridge height.

Design criteria

No formal design is required.

Construction specifications

See Figure SD-1 for installation details.

1. The slope drain shall have a slope of 3 percent or steeper.
2. The top of the diversion berm over the inlet pipe, and those diversions carrying water to the pipe, shall be at least 6 inches higher at all points than the top of the inlet pipe.
3. A flared end section of corrugated metal shall be attached to the inlet end of the pipe with a watertight connection. The corrugated metal pipe should have watertight joints at the ends.

4. The drain should consist of heavy-duty material manufactured for the purpose and have grommets for anchoring at a spacing of 10 feet or less. The pipe is typically corrugated plastic or flexible tubing, although for flatter, shorter slopes, a polyethylene-lined channel is sometimes used. Where flexible tubing is used, it shall be the same diameter as the inlet pipe and shall be constructed of a durable material.
5. The soil around and under the pipe and end section shall be hand tamped in 4 in. lifts to the top of the diversion berm.
6. The slope drain shall outlet into a sediment trapping device when the drainage area is disturbed. A riprap apron shall be installed below the pipe outlet where water is being discharged into a stabilized area.
7. A riprap apron shall be used below the pipe outlet where clean water is being discharged into a stabilized area.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspections should determine if capacity or slope drain was exceeded or if blockages occurred. Repairs should be made promptly. Construction equipment and vehicular traffic must be rerouted around slope drains.

Removal

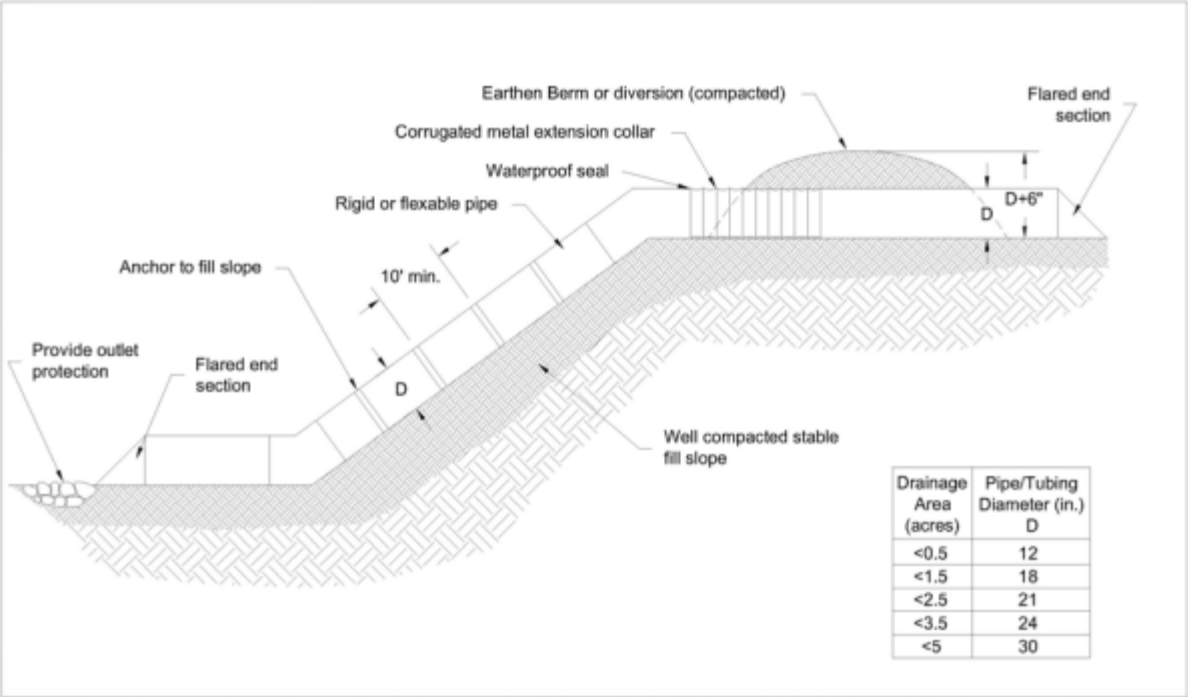
Remove slope drain on completion of construction and stabilization activities.

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Figure SD-1
Slope Drain Installation



Drainage Area (acres)	Pipe/Tubing Diameter (in.) D
<0.5	12
<1.5	18
<2.5	21
<3.5	24
<5	30

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Trench Breakers (TB)

Description

Trench breakers, also known as trench plugs, are used to slow the flow of subsurface water along a pipeline trench. Trench breakers may be constructed of materials such as sand bags or polyurethane foam.

Applicability

Trench breakers may be used in the following applications:

- On steep slopes.
- Above wetlands.
- At waterbody crossings.
- At road crossings.

Design criteria

No formal design is required.

Construction specifications

1. Trench breakers should be installed both before and after the lowering-in of pipeline.

2. An engineer or similarly qualified professional shall determine the need for and spacing of trench breakers. Otherwise, spacing shall be according to the following table:

Slope (%)	Spacing (feet)
5 – 15	300
15 – 30	200
>30	100

3. At a minimum, install a trench breaker at the base of slopes greater than 5 percent where the base of the slope is less than 50 feet from a waterbody or wetland and where needed to avoid draining a waterbody or wetland.

4. Trench breakers should be installed to the top of the excavated trench line.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Repair any damaged areas.

References

Federal Energy Regulatory Commission (FERC), Upland Erosion Control, Revegetation, and Maintenance Plan. January 2003.

Water Bar (WB)

Description

A water bar is an earthen ridge, or ridge and channel, constructed diagonally across a sloping road, trail, or disturbed area that is subject to erosion. Water bars are normally used for drainage and erosion protection of buried pipelines or closed, blocked, or infrequently used roads to limit the accumulation of erosive volumes of water by diverting surface runoff at pre-designed intervals.

Applicability

Water bars are applicable where runoff protection is needed to prevent erosion on sloping access right-of-ways or long, narrow sloping areas generally less than 100 feet in width. This is a practice that is often used on buried pipelines, limited-use roads, trails, and firebreaks. It is an excellent method of retiring roads and trails as well as abandoned roads where surface water runoff may cause erosion of exposed mineral soil.

Limitations

- Not for use on concentrated flows
- May cause concentrated flows from sheet flow
- Requires vegetative cover or other filter at discharge point

Design criteria

No formal design is required.

Construction specifications

See Figure WB-1.

1. Clear the base for the ridge before placing fill.
2. Install the water bar across the right-of-way according to Figure WB-1 as soon as the base is cleared and graded. The off-slope drainage should be 2 to 5 percent.
3. Use a trackhoe or bulldozer to compact the ridge to the design cross section.
4. Vehicle crossings shall be stabilized with gravel. Exposed areas shall be immediately seeded and mulched.
5. Extend the water bar inlet and outlet 1 foot or more beyond the edge of the right-of-way or disturbed area to keep the diverted water from re-entering the area.
6. Space the water bars according to Table WB-1.
7. Locate the outlet on an undisturbed area. Field spacing shall be adjusted to use the most stable outlet areas. Outlet protection will be provided when natural areas are not adequate.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect water bars for erosion damage and sediment. Check outlet areas and make repairs as needed to restore operation.

Removal

If water bars are used on a closed or blocked road, they should be removed prior to re-opening of the road. Water bars on infrequently used roads or other disturbed areas may remain in place as long as necessary.

References

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

Maine Department of Conservation, Best Management Practices for Forestry: Protecting Maine's Water Quality. Maine Forest Service, Forest Policy and Management Division. Augusta, Maine. 2004. <http://www.state.me.us/doc/mfs/pubs/pdf/bmp_manual/bmp_manual.pdf>

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Table WB-1

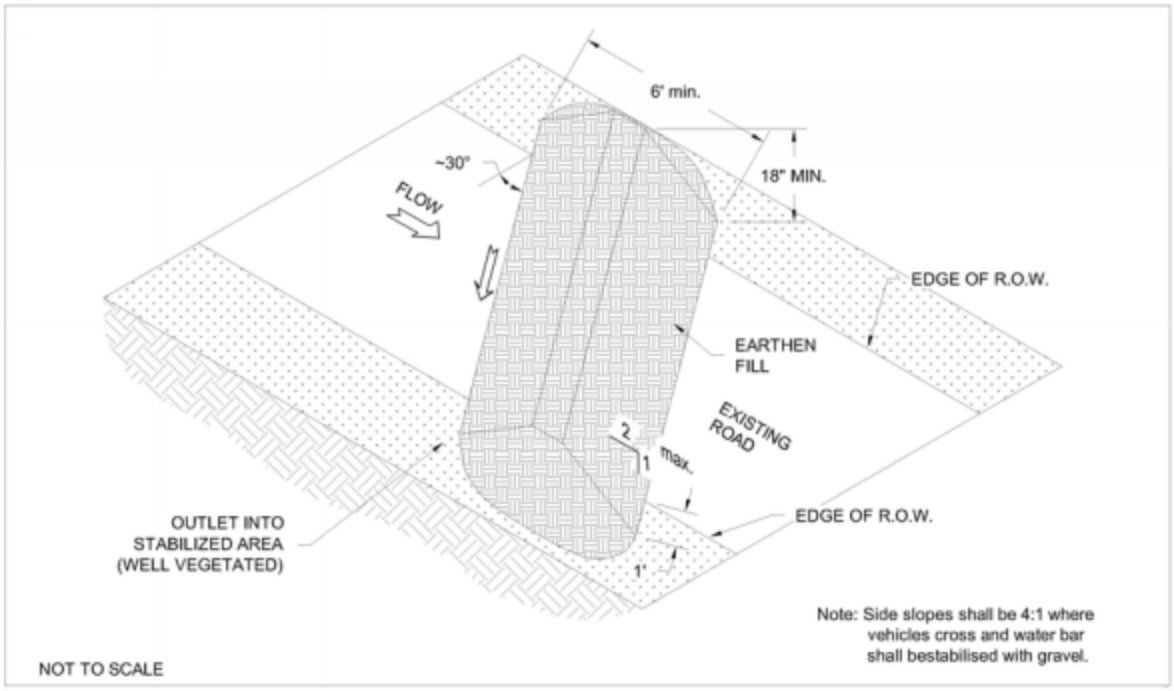
Water Bar Spacing

Road/Trail Grade (%)	Low to Non-Erosive Soils (1)	Erosive Soils (2)
0 - 5	245'	130'
6 – 10	200'	100'
11 - 15	150'	65'
16 - 20	115'	50'
21 - 30	100'	40'
31+	50'	30'

[1]Low Erosion Soils = Coarse Rocky Soils, Gravel, and Some Clay

[2]High Erosion Soils = Fine, Friable Soils, Silt, Fine Sands

Figure WB-1
Water Bar Installation



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Sediment Control BMPs

Check Dam (CD)
Detention Pond (DP)
Filter Berm (FB)
Sediment Reservoir (SedR)
Sediment Trap (ST)
Silt Fence (SF)
Slash (SL)
Stabilized Construction Entrance (SCE)
Straw Bale Barrier (SBB)
Wattles (W) (BMP is provided with erosion controls)

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Check Dam (CD)

Description

Check dams are small, temporary dams constructed across a diversion or roadside ditch. Check dams can be constructed using aggregate, rock, sandbags, gravel bags, earth with erosion control blanketing, straw bales, or wattles and are used to slow the velocity of concentrated flow in a channel and thus reduce erosion. As a secondary function, check dams can also be used to catch sediment from the channel itself or from the contributing drainage area as stormwater runoff flows through or over the structure.

Applicability

- Check dams are most often used in small, open channels with a contributing drainage area of less than 10 acres, and side slopes of 2:1 or less. Check dams may be used in the following applications:
- In diversions or roadside ditches where it is not practical to line the channel or implement other flow control and sediment control practices.
- In diversions or roadside ditches where temporary seeding has been recently implemented but has not had time to take root and fully develop.
- As a series of check dams, spaced at appropriate intervals, used in one of the above two applications.

Limitations

- Check dams should not be used in live, continuously flowing streams unless approved by an appropriate regulatory agency.
- Check dams may require frequent removal of accumulated sediments. Dams should therefore be located in areas accessible to maintenance vehicles.
- Leaves have been shown to be a significant problem by clogging check dams in the fall. Therefore, they might necessitate increased inspection and maintenance.
- Straw bale check dams decompose over time, and may be consumed by livestock.

Design criteria

No formal design is required.

Construction specifications

1. Install aggregate check dams according to Figure CD-1. Other types of check dams shall have similar designs.
2. Check dams should be located in areas accessible to maintenance vehicles for the periodic removal of accumulated sediments.
3. Dams should be installed with careful placement of the construction material. Mere dumping of the dam material into a channel is not appropriate and will reduce overall effectiveness.
4. Check dams can be constructed from a number of different materials. When using rock, the material diameter should be 1 to 15 inches depending on the expected velocity and quantity of runoff within the channel. Aggregate check dams, ideal for application within roadside ditches, should use a material diameter between 3/4 to 1-1/2". Earth collected during excavation of diversions or roadside ditches may also be placed as check dams if covered with erosion control blanketing. Straw bales, wattles, or sand/gravel bags may also be used, but only if rock or aggregate is unavailable or not feasible for the location.
5. All check dams should have a maximum height of 3 feet with sufficient space up slope from the barrier to allow ponding, and to provide room for sediment storage. The center of the dam should be at least 6 inches lower than the edges. This design creates a weir effect that helps to channel flows away from the banks and prevent further erosion.
6. Additional stability can be achieved by implanting the dam material approximately 6 inches into the sides and bottom of the channel.
7. In order to be most effective, dams used in a series should be spaced such that the base of the upstream dam is at the same elevation as the top of the next downstream dam.
8. When installing more than one check dam in a channel, outlet erosion stabilization measures should be installed below the final dam in the series. Because this area is likely to be vulnerable to further erosion, riprap, erosion control blanket lining, or some other stabilization measure is highly recommended.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. During inspection, large debris, trash, and leaves should be removed. The center of a check dam should always be lower than its edges. If erosion or heavy flows cause the edges of a dam to fall to a height equal to or below the height of the center, and the effectiveness of the BMP is compromised, repairs should be made immediately. Accumulated sediment should be removed from the upstream side of a check dam when the sediment has reached a height of approximately one-half the original height of the dam (measured at the center). Close attention should be paid to the repair of damaged or rotting straw bales, end runs, and undercutting beneath bales. Replacement of bales should be accomplished promptly.

Removal

Removal of check dams is optional. Check dams within roadside ditches are usually used as temporary controls, where other check dams may be left in place to silt out. If removing a check dam, all accumulated sediment should be removed. Removal of a check dam should be completed only after the contributing drainage area has been completely stabilized. Permanent vegetation should replace areas from which gravel, stone, logs, or other material has been removed.

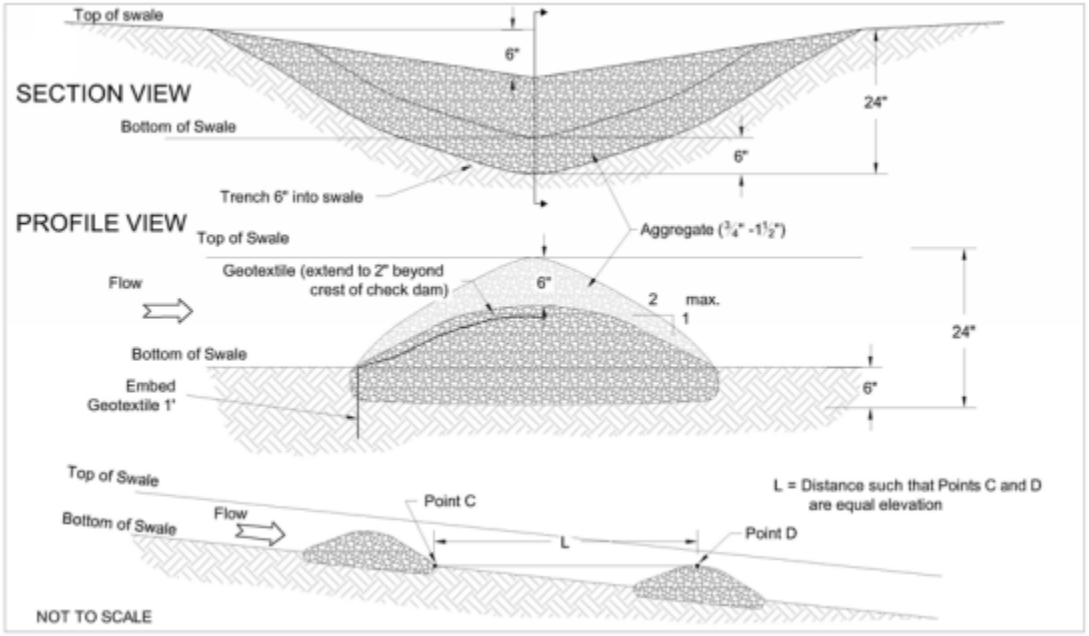
References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. <http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Figure CD-1
Aggregate Check Dam Installation



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Detention Pond (DP)

Description

A detention pond shall be constructed on each well pad to collect and store all runoff from the surface of the pad. A culvert with a locking gate may be installed to allow dewatering to occur if the water tests clean and is acceptable for release from the pad.

Applicability

Detention ponds are applicable to all well pads.

Limitations

Well pads that have not been properly designed may collect runoff from areas other than the surface of the pad, which may be more volume than the detention pond is designed to handle.

Design criteria

Detention ponds shall be sized for a 25-year frequency storm. In general, 4,000 cubic feet (150 cubic yards) of dry storage volume should be provided for each acre of pad surface area.

Construction specifications

Construct detention pond according to Figure DP-1.

Location

Detention ponds shall be located at an outside edge of the pad and as far as possible from the pad access road, utilities, and all infrastructures.

Dewatering

Dewatering may be achieved through a 6- to 12-inch corrugated metal culvert. The culvert invert shall be located approximately 1 foot above the bottom of the pond to allow space for sedimentation. The culvert shall be sloped and routed through the berm at the perimeter of the well pad to discharge down the fill slope and directly into a pad perimeter diversion. A steel slide gate as manufactured by Waterman Industries, or similar, may be installed at the culvert inlet. The gate may use a positive one-quarter turn cam lock which will hold the gate in any position to enables easy regulation of flow.

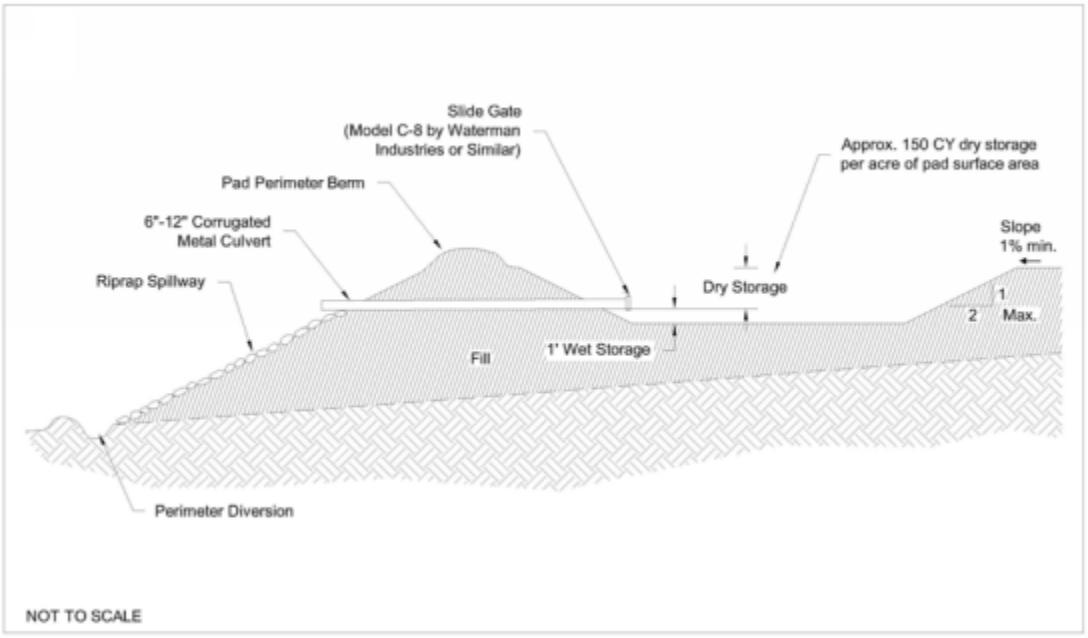
Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspections shall verify that the pond has not been disturbed and that the original storage capacity has been maintained. If sedimentation has accumulated to within 2 inches of the culvert inlet, the sediment shall be removed while avoiding any unnecessary disturbance to the pond.

Removal

The detention pond and culvert shall be removed upon completion of well pad activities and final stabilization.

Figure DP-1
Detention Pond Installation



Filter Berm (FB)

Description

A filter berm is a temporary ridge made up of natural materials that already occur on the project site such. Brush filter berms use small tree branches, root mats, grass, leaves, stone, or other debris or material naturally available or left over from site clearing and grubbing (slash). Rock filter berms use site gravel, stone, or rock. Both types of filter berms are placed along a level contour to slow, filter, and divert flow and act as an efficient form of sediment control. In some configurations, filter berms are covered with a filter cloth to stabilize the structure and improve barrier efficiency.

Applicability

The drainage area for filter berms must be no greater than 2 acres. In addition, the drainage slope leading down to a filter berm must be no greater than 2:1 and no longer than 100 feet. The following are suitable applications:

- 5 to 7 feet beyond the toe of slopes.
- Along the site perimeter.
- Along streams and channels, or adjacent to roadways.
- Around temporary spoil areas or other small cleared areas.

Limitations

- Intended to be used only in gently sloping areas, and are not appropriate for high-velocity flow areas.
- Brush filter berms have limited usefulness because they are constructed of materials that decompose.
- A large amount of material is needed to construct a useful filter berm. Therefore, filter berms are only applicable to sites where there is enough brush material from clearing and grubbing or rock material to form a sufficiently sized berm.
- May be difficult to remove after construction.

Design criteria

No formal design is required.

Construction specifications

Brush (slash) filter berms

See Figure FB-1 for installation details.

1. Place material cleared from the site across the slope or swale. Material with a diameter larger than 6 inches should not be used.
2. Cut up brush if necessary and compact to avoid large voids within the barrier.
3. The barrier mound should be at least 3 feet high and 5 feet wide at its base.
4. It is recommended, but not required, that the mound be covered with a filter fabric barrier to hold the material in place and increase sediment barrier efficiency. If using a filter fabric cover, bury the edge in a trench 4 inches deep and 6 inches wide on the drainage side of the barrier. This is done to secure the fabric and create a barrier to sediment while allowing stormwater to pass through the water-permeable filter fabric. The fabric should be extended just over the peak of the brush mound and secured on the down-slope edge of the fabric by fastening it to twine or small-diameter rope that is staked securely.

Rock filter berms

See Figure FB-2 for installation details.

1. Place filter berm along a level contour. Use well-graded, angular site gravel or crushed rock of medium to large diameter with larger rocks on the bottom.
2. If desired, cover with geotextile fabric or wire screen (especially if concentrated flows are expected) to help keep berm in tack. Anchor fabric or wire by placing under the berm or use stakes.
3. Trenching is not required.
4. Berms should be spaced according to the steepness of the slope, with berms spaced closer together as the slope increases.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. If channels form through void spaces in the barrier, the barrier should be reconstructed to eliminate the channels. Ensure that sediment has not built up and that no damage has been done by vehicles. Regular inspection should indicate the frequency of sediment removal needed. Accumulated sediment should be removed from the uphill side of the barrier when sediment height reaches between 1/3 and 1/2 the height of the barrier. Sediment should be disposed of and the filter material and/or fabric should be replaced if necessary. It is important that repairs be performed at the first sign of deterioration to ensure that the berm is functioning properly.

Removal

Remove filter berms after uphill drainage areas are stabilized. Rock and brush may be left in place only if it does not cause any landscaping problems. Remove all manmade materials (wire, fabric, and/or stakes).

References

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Figure FB-1
Brush Filter Berm Installation

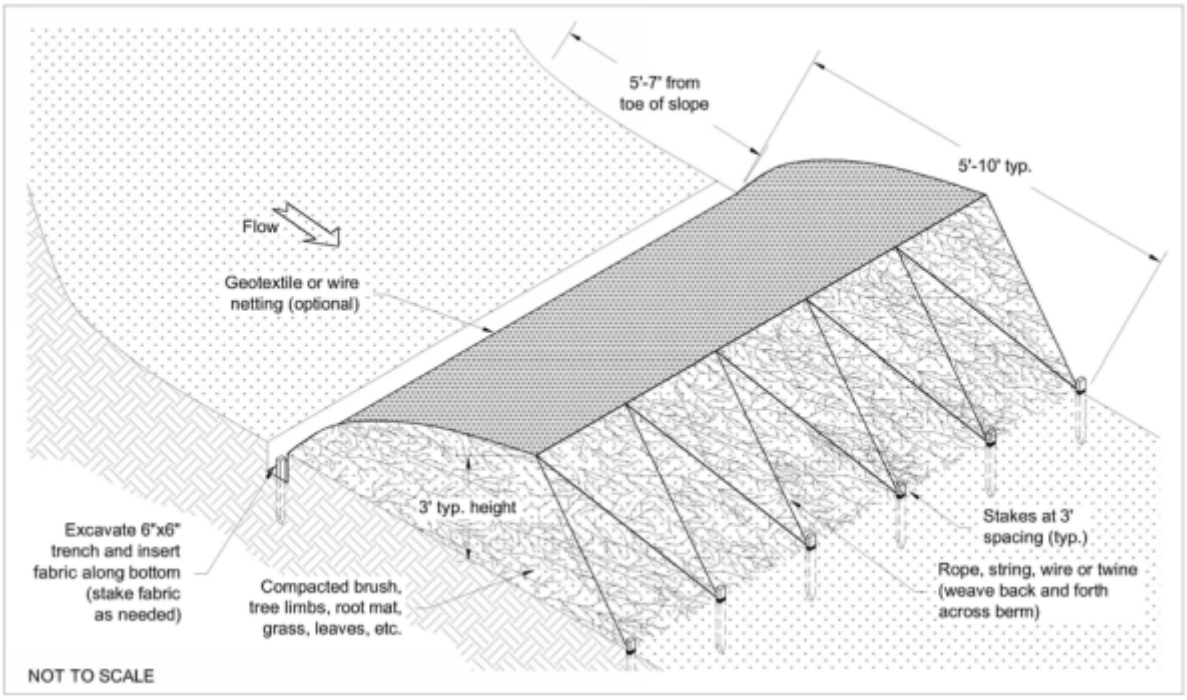
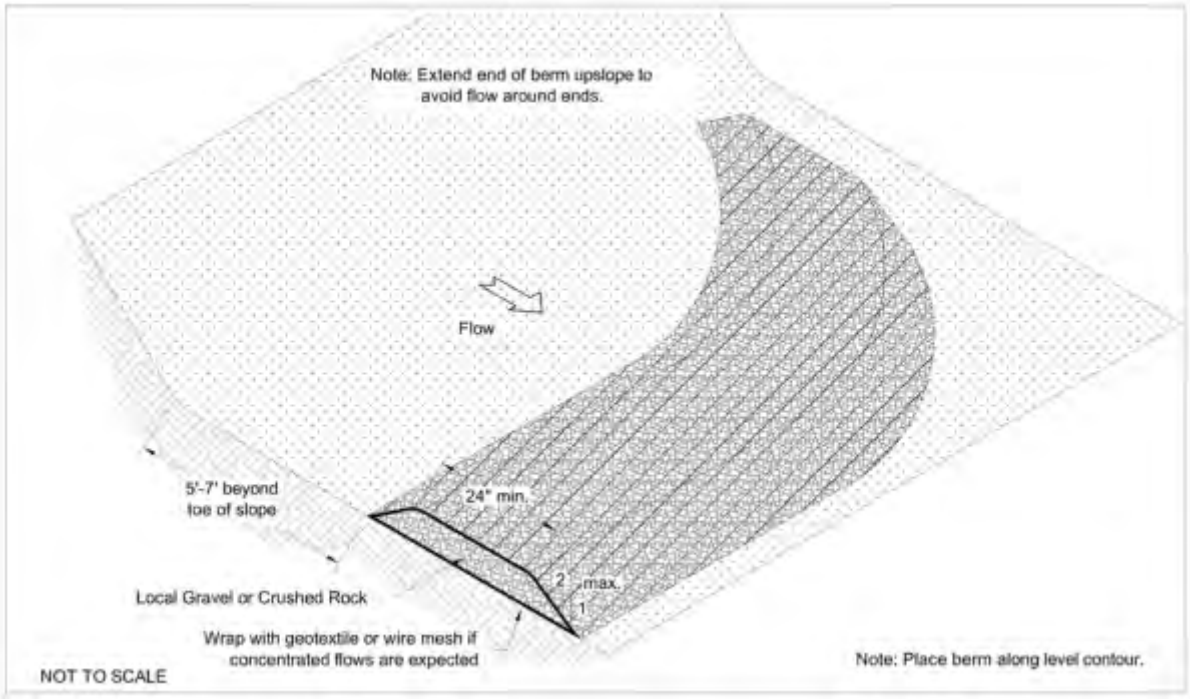


Figure FB-2
Rock Filter Berm Installation



Sediment Reservoir (SedR)

Description

Sediment reservoirs are large ponding areas that allow sediment to settle out of runoff water. They are often installed at the base of well pads or down-slope of other large disturbed areas. Sediment reservoirs are formed by excavating below grade and/or by constructing an earthen embankment with a level spreader type of spillway to slow the release of runoff.

Applicability

Sediment reservoirs are applicable to any location where it is desired to capture runoff from a large drainage area (up to 10 acres). Sediment reservoirs are also used as tertiary spill containment to prevent any accidental discharges from leaving the site.

Limitations

- Regular maintenance is needed to remove sediment. Reservoirs should be located near roads or where accessible to remove sediment.
- Water may remain in the reservoir for extended periods causing an ideal spot for mosquitoes and other insects to gather. Locate the reservoir in a sunny spot if possible.
- Never construct a sediment reservoir on a live flowing stream or in wetlands.

Design criteria

Location

Reservoirs should be located at points of discharge from disturbed areas. The location will be determined by the natural terrain, drainage pattern of the runoff, and the accessibility for maintenance. Sediment reservoirs should not be located in areas where their failure due to stormwater runoff excess can lead to further erosive damage of the landscape. Alternative diversion pathways should be designed to accommodate these potential overflows. Sediment reservoir locations should also allow for easy maintenance access for the periodic removal of accumulated sediment.

Storage capacity

A sediment reservoir should be designed to maximize surface area for infiltration and sediment settling. This will increase the effectiveness of the reservoir and decrease the likelihood of backup during and after periods of high runoff intensity. The approximate storage capacity of each trap should be 3,600 ft^3 per acre of contributing drainage area. The volume of a natural sedimentation reservoir can be approximated by the following equation:

$$\text{Volume } (ft^3) = 0.4 \times \text{surface area } (ft^2) \times \text{maximum pool depth (ft)}$$

If the volume is more than 100 acre-feet the sediment reservoir should be constructed as designed by a Professional Engineer.

Embankment

If the embankment is more than 10 feet high (measured vertically from the ground surface to the crest of the spillway) the sediment reservoir should be constructed as designed by a Professional Engineer.

Construction specifications

1. If possible, sediment reservoirs, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.
2. Reservoirs should be located above the floodplain, where possible.
3. Area under embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared.
4. The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Seeding of the embankment should be performed as soon as possible after construction of the sediment reservoir. Erosion control blanketing may also be used to cover the embankment in combination with seeding or during time periods when seeding is ineffective.
5. The spillway shall typically consist of a level spreader which may extend around as much as half of the reservoir berm. The level spreader may consist of compacted earth, which will be vegetated on completion of construction. However, if erosion is noted during inspections it may be necessary to install aggregate, erosion control blanketing, straw bales, or wattles along the length of the level spreader (see applicable BMP).

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. The primary maintenance consideration for sediment reservoirs is the removal of accumulated sediment from the basin to ensure the continued effectiveness of the reservoir. Sediments should be removed when the basin reaches approximately 50 percent sediment capacity. Inspectors should also ensure that the reservoir is draining properly and check the structure, specifically the level spreader, for damage from erosion.

Removal

After the contributing area has been properly stabilized, the reservoir may remain in place if the reservoir itself is also fully stabilized, or the reservoir may be removed and the newly disturbed area shall be stabilized.

References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. <http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003 <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

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Sediment Trap (ST)

Description

Sediment traps are small to medium sized ponding areas that allow sediment to settle out of runoff water. They are usually installed in a drainage way or other point of discharge from a disturbed area. Sediment traps are formed by excavating below grade and/or by constructing an earthen embankment with a lined spillway to slow the release of runoff.

Applicability

Sediment traps are generally temporary control measures used at the outlets of stormwater diversion structures, channels, slope drains, construction site entrance wash racks, or any other runoff conveyance that discharges waters containing erosion sediment and debris. Sediment traps should be used for drainage areas less than 5 acres. The effective life span of these temporary structures is usually limited to 24 months. Traps may be located in series to allow for backup control in case one trap fails.

Limitations

- Regular maintenance is needed to remove sediment. Traps should be located near roads or where accessible to remove sediment.
- Although sediment traps allow for settling of eroded soils, because of their short detention periods for stormwater they typically do not remove fine particles such as silts and clays.
- Water may remain in trap for extended periods causing an ideal spot for mosquitoes and other insects to gather. Locate the trap in a sunny spot if possible.
- Never construct a sediment trap on a live flowing stream or in wetlands.

Design criteria

Location

Traps should be located at points of discharge from disturbed areas. The location will be determined by the natural terrain, drainage pattern of the runoff, and the accessibility for maintenance. Sediment traps should not be located in areas where their failure due to stormwater runoff excess can lead to further erosive damage of the landscape. Alternative diversion pathways should be designed to accommodate these potential overflows. Sediment trap locations should also allow for easy maintenance access for the periodic removal of accumulated sediment.

Storage capacity

A sediment trap should be designed to maximize surface area for infiltration and sediment settling. This will increase the effectiveness of the trap and decrease the likelihood of backup during and after periods of high runoff intensity. The approximate storage capacity of each trap should be 3,600 ft3 per acre of contributing drainage area. Half of this volume may be in the form of wet storage (a permanent pool) and the other half may be in the form of dry storage. When possible, the wet storage volume should be contained within the excavated portion of the trap. The volume of a natural sedimentation trap can be approximated by the following equation:

Volume (ft3) = 0.4 x surface area (ft2) x maximum pool depth (ft)

Construction specifications

See Figure ST-1 for installation details.

1. If possible, sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.
2. Traps should be located above the floodplain, where possible. If there are space constraints, several small sediment traps may be constructed in series.
3. Area under embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. The pool area shall be cleared.
4. The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed. Seeding of the embankment should be performed as soon as possible after construction of the sediment trap. Erosion control blanketing may also be used to cover the embankment in combination with seeding or during time periods when seeding is ineffective.
5. The spillway may consist of a stone section in the embankment formed by a combination coarse aggregate/riprap to provide for filtering/detention capability. Riprap shall be 4- to 8-inch rock, while the coarse aggregate shall be 1/2 to 3/4 inches. A geotextile may be placed at the stone-soil interface to act as a separator.
6. Another option for the spillway is to use straw bales or wattles at the overflow point in the trap and line the rest of the spillway with an erosion control blanket (see applicable BMP).

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. The primary maintenance consideration for temporary sediment traps is the removal of accumulated sediment from the basin to ensure the continued effectiveness of the sediment trap. Sediments should be removed when the basin reaches approximately 50 percent sediment capacity. Inspectors should also ensure that the trap is draining properly and check the structure for damage from erosion. The depth of the spillway should be checked and maintained at a minimum of 1.5 feet below the low point of the trap embankment.

Removal

The structure shall be removed and the area stabilized when the drainage area has been properly stabilized.

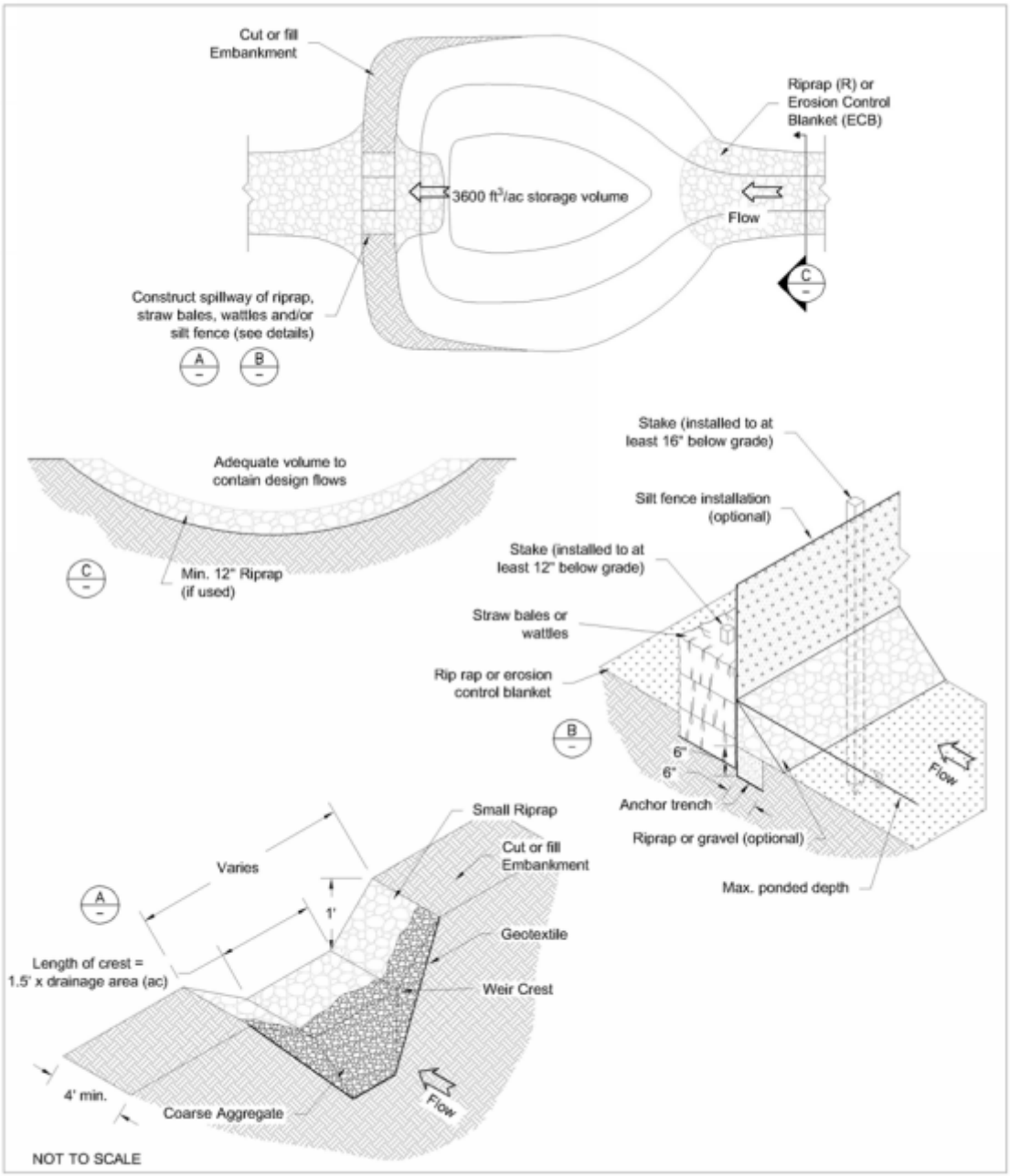
References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. <http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Figure ST-1
Sediment Trap Installation



Silt Fence (SF)

Description

Silt fences are used as temporary perimeter controls around sites where there will be soil disturbance due to construction activities. They consist of a length of filter fabric stretched between anchoring posts spaced at regular intervals along the site perimeter.

Applicability

Silt fences are generally applicable to construction sites with relatively small drainage areas. They are appropriate in areas where runoff will be occurring as low-level shallow flow, not exceeding 0.5 cubic feet per second. The drainage area for silt fences generally should not exceed 0.25 acre per 100-foot fence length. Slope length above the fence should not exceed 100 feet. Silt fence may be used as temporary slope breakers to reduce runoff velocity.

Limitations

- Silt fences should not be installed along areas where rocks or other hard surfaces will prevent uniform anchoring of fence posts and entrenching of the filter fabric. This will greatly reduce the effectiveness of silt fencing and can create runoff channels leading off site.
- Silt fences are not suitable for areas where large amounts of concentrated runoff are likely.
- Open areas where wind velocity is high may present a maintenance challenge, as high winds may accelerate deterioration of the filter fabric.
- Silt fences should not be installed across streams, ditches, or waterways.
- When the pores of the fence fabric become clogged with sediment, pools of water are likely to form on the uphill side of fence. Siting and design of the silt fence should account for this and care should be taken to avoid unnecessary diversion of stormwater from these pools that might cause further erosion damage.

Design criteria

The fence should be designed to withstand the runoff from a 10-year peak storm event.

Construction specifications

1. Erect silt fence according to Figure SF-1.
2. If standard strength fabric is used in combination with wire mesh, the support posts should be spaced no more than 10 feet apart. If extra-strength fabric is used without wire mesh reinforcement, the support posts should be spaced no more than 6 feet apart.
3. Stakes used to anchor the filter fabric should be either wooden or metal. Wooden stakes should be at least 3 feet long and have a minimum diameter of 2 inches if a hardwood such as oak is used. Softer woods such as pine should be at least 4 inches in diameter. When using metal post in place of wooden stakes, they should have a minimum weight of 1.00 to 1.33 lb/linear foot. If metal posts are used, attachment points are needed for fastening the filter fabric using wire ties. The height of the fence posts should be between 16 and 34 inches above the original ground surface.
4. Material for silt fences should be a pervious sheet of synthetic fabric such as polypropylene, nylon, polyester, or polyethylene yarn, chosen based on minimum synthetic fabric requirements, as shown in the following table:

Physical Property	Requirements
Filtering Efficiency	75 – 85% (minimum): highly dependent on local conditions
Tensile Strength at 20% (maximum) Elongation	Standard Strength: 30 lbs/linear inch (minimum) Extra Strength: 50 lbs/linear inch (minimum)
Ultraviolet Radiation	90% (minimum)
Slurry Flow Rate	0.3 gal/ft^2/min (minimum)

5. Use a continuous roll of fabric to eliminate unwanted gaps in the fence. If a continuous roll of fabric is not available, the fabric should overlap from both directions only at stakes or posts with a minimum overlap of 6 inches.
6. Extend silt fence across grade and upslope for a short distance.
7. Compact backfill at base of fabric.
8. A trench should be excavated to bury the bottom of the fabric fence at least 6 inches below the ground surface. This will help prevent gaps from forming near the ground surface that would render the fencing useless as a sediment barrier.
9. If using silt fence as temporary slope breakers to reduce runoff velocity, space according to the following table:

Slope (%)	Spacing (feet)
5 – 15	300
>15 – 30	200
>30	100

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect silt fences to ensure that they are intact and that there are no gaps at the fence-ground interface or tears along the length of the fence. If gaps or tears which impact the effectiveness of the BMP are found, they should be repaired or the fabric should be replaced immediately. Accumulated sediments should be removed from the fence base when the sediment reaches one-third to one-half the height of the fence. Sediment removal should occur more frequently if accumulated sediment is creating noticeable strain on the fabric and there is the possibility of the fence failing from a sudden storm event.

Removal

Remove silt fences and all accumulated sediment after uphill drainage areas are stabilized by vegetation or other means.

References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. <http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

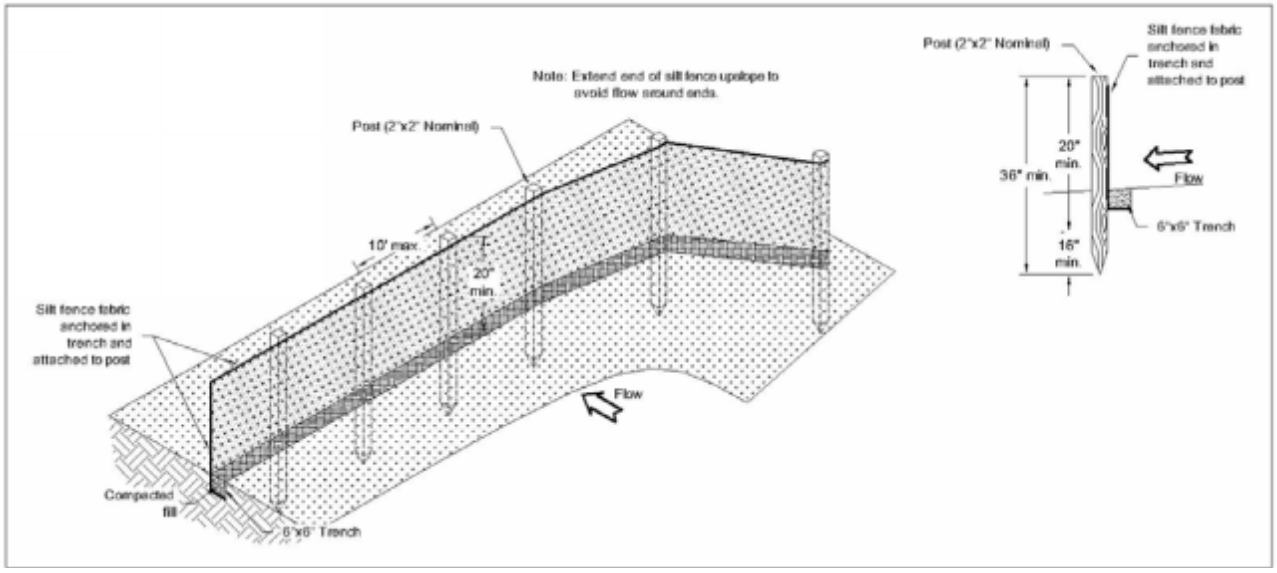
Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Keller, Gordon, and James Sherar, Low-Volume Roads Engineering, Best Management Practices Field Guide. United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. <http://www.blm.gov/bmp/field%20guide.htm>

Figure SF-1

Silt Fence Installation



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Slash (SL)

Description

Slash is any natural debris or material left over from site clearing and grubbing. Slash may include small tree branches, root mats, grass, leaves, stone, etc... Placement of slash over disturbed areas can help control off-site transport of sediment by slowing the flow of runoff, which minimizes erosion, and trapping sediment until vegetation is established at the sediment source.

Applicability

Slash may be used for the following:

- To create a filter berm or windrow.
- As a blanket over any disturbed area, particularly pipeline corridors and areas of fill.
- As outlet protection for culverts.

Limitations

- Material may need to be cut up or broken into smaller pieces.
- Slash does not eliminate the need to revegetate.
- Slash is not applicable for steep slopes.

Design criteria

No formal design is required.

Construction specifications

1. For slash filter berms, see the Filter Berm (FB) BMP.
2. Prior to spreading slash over a disturbed area, the area should be seeded in accordance with the Revegetation BMP.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect for any excessive erosion and replace slash with an alternate BMP if necessary (such as erosion control blanket).

Removal

Removal of slash is not necessary.

Stabilized Construction Entrance (SCE)

Description

A stabilized construction entrance (tracking pad) is a pad of gravel over filter cloth where construction traffic leaves a site. The purpose of a stabilized entrance to a site is to minimize the amount of tracked mud and dust that leaves a site. As a vehicle drives over the gravel pad, mud and sediment are removed from the vehicle's wheels and off-site transport of soil is reduced. The gravel pad also reduces erosion and rutting on the soil beneath the stabilization structure. The filter fabric separates the gravel from the soil below, preventing the gravel from being ground into the soil. The fabric also reduces the amount of rutting caused by vehicle tires by spreading the vehicle's weight over a larger soil area than just the tire width.

Applicability

Typically, stabilized construction entrances are installed at locations where construction traffic leaves or enters an existing paved road. However, the applicability of site entrance stabilization should be extended to any roadway or entrance where vehicles will access or leave the site.

Limitations

- Although stabilizing a construction entrance is a good way to help reduce the amount of sediment leaving a site, some soil may still be deposited from vehicle tires onto paved surfaces. To further reduce the chance of these sediments polluting stormwater runoff, sweeping of the paved area adjacent to the stabilized site entrance is recommended.
- Sediment traps or other secondary sediment controls are needed to capture that sediment that accumulates at the pad and may run off during storm events.

Design criteria

No formal design is required.

Construction specifications

See Figure SCE-1 for installation details.

1. Locate the pad approximately 60 feet back from the entrance at any county road.
2. If the pad is constructed on a crowned road, a roadside ditch with check dams or sediment traps shall be located on both sides of the road to collect runoff from the pad. If the road slopes to only one side of the road then only one roadside ditch with sediment controls will be needed.
3. Place woven or non-woven fabric filter cloth over the entire area prior to placing the stone. Piping of surface water under entrance shall be provided as required.
4. Place a matrix of 1" and 2" stone gravel, or reclaimed or recycled concrete equivalent, to a minimum thickness of six (6) inches, a minimum width of 12 feet and a minimum length of 50 feet.
5. All surface water flowing or diverted toward construction entrance shall be piped across the entrance. If piping is impractical, a mountable berm with 5:1 slopes will be permitted.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Stabilization of site entrances should be maintained until the remainder of the construction site has been fully stabilized. Stone and gravel might need to be periodically added to each stabilized construction site entrance to keep the entrance effective. Soil that is tracked off site should be swept up immediately for proper disposal.

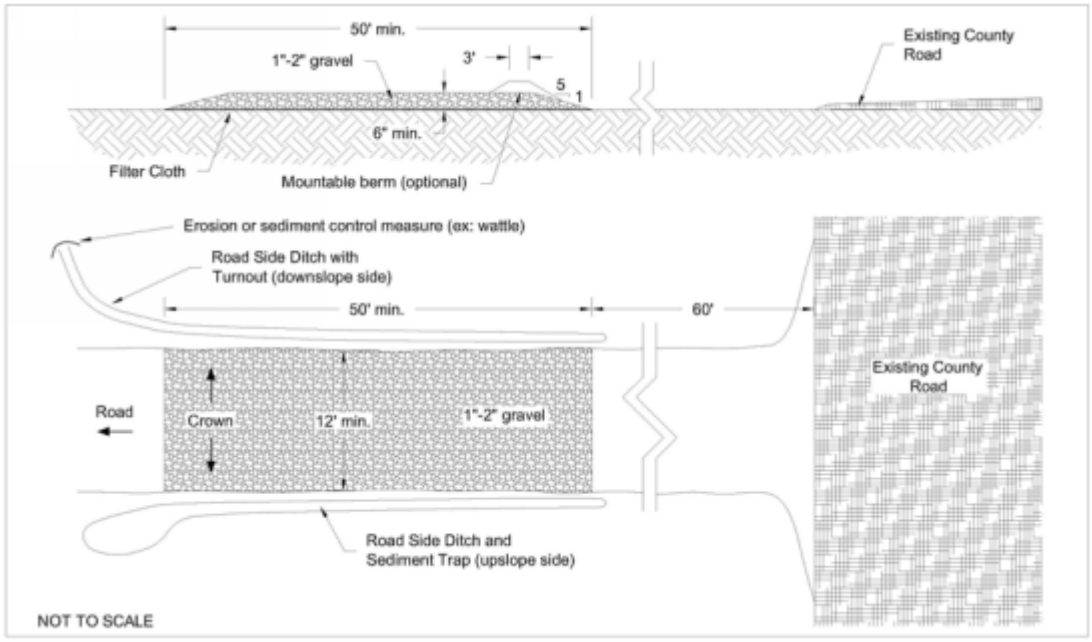
References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. <http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Environmental Protection Agency (EPA), National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control. Washington, D.C., February, 2003. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

Figure SCE-1
Stabilized Construction Entrance Installation



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Straw Bale Barrier (SBB)

Description

A straw bale barrier is a series of entrenched and staked straw bales placed on a level contour to intercept sheet flows. The barrier reduces runoff velocity and filters sediment laden runoff from small drainage areas of disturbed soil. The barrier may also be used to protect against erosion. Straw bale barriers have an estimated design life of three (3) months.

Applicability

Straw bale barriers may be used below disturbed areas subject to sheet and rill erosion where the length of slope above the straw bale barrier does not exceed the following limits:

Constructed Slope	Percent Slope	Slope Length (ft)
2:1	50%	25’
3:1	33%	50’
4:1	25%	75’

Straw bales may be used in the following applications:

- Below the toe of erodible slopes or other small cleared areas
- At the top of slopes to divert runoff away from disturbed slopes
- As sediment traps at outlets to culverts, ditches, turnouts, etc.
- Along the perimeter of a site
- Around temporary stockpiles and spoil areas
- Along streams and channels for both erosion and sediment control
- As check dams across mildly sloped swales or construction roads

Limitations

- For short-term use only
- For use below small drainage areas less than 2 acres
- Decomposes over time
- May be consumed by livestock
- Straw bales must be certified weed free to avoid invasive weeds that may develop and should not be used in areas where weeds are a concern.
- Removal of anchor stakes will be necessary after stabilization is complete
- Not recommended for concentrated flow, live streams, or swales where there is the possibility of a washout

Design criteria

No formal design is required.

Construction specifications

See Figure SBB-1 for installation details.

1. Bales shall be placed in a single row on a level contour with ends of adjacent bales tightly abutting one another. Bales shall be certified weed free.
2. Allow sufficient space up slope from the barrier to allow ponding, and to provide room for sediment storage.
3. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings.
4. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. Stake the bales with minimum 2" x 2" x 36" wood stakes or standard "T" or "U" steel posts (minimum weight of 1.33 pounds per linear foot).
5. After the bales are staked and chinked (gaps filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.
6. Each bale shall be securely anchored by at least two stakes driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 12 inches deep into the ground to securely anchor the bales.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Close attention should be paid to the repair of damaged or rotting bales, end runs and undercutting beneath bales. Necessary repairs to barriers or replacement of bales should be accomplished promptly. Sediment deposits should be removed when the level of deposition reaches approximately one-half the height of the barrier.

Removal

Straw bale barriers may be removed when they have served their usefulness or may remain in place to decompose over time. Straw bales should not be removed, however, until the upslope areas have been

permanently stabilized. Any sediment deposits remaining in place after the straw bale barrier is no longer required should be dressed to conform to the existing grade, prepared and seeded.

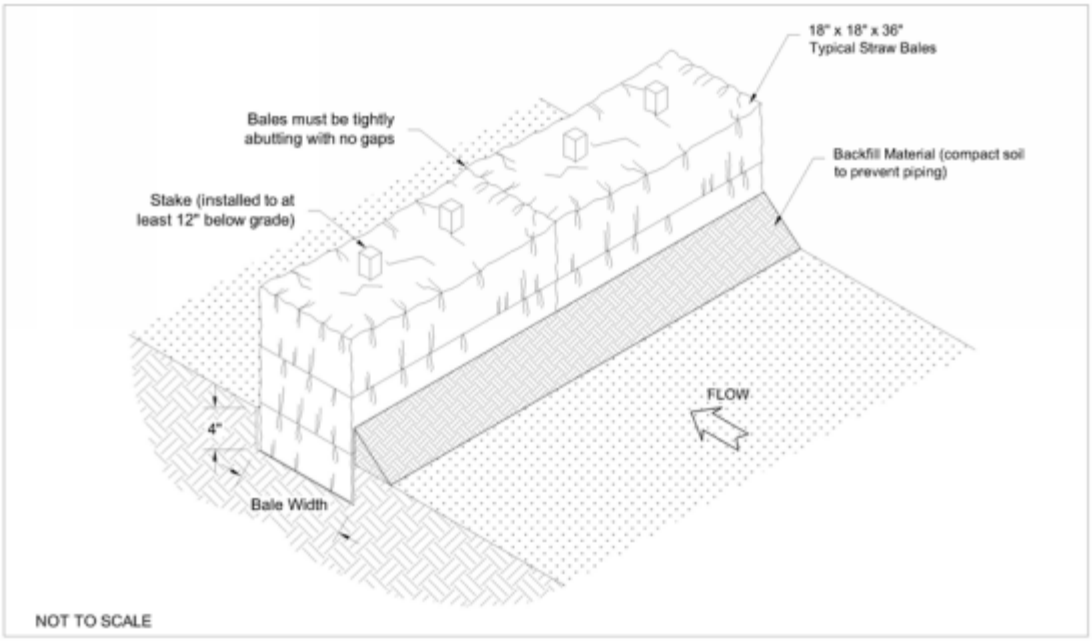
References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. <http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp>

Horizon Environmental Services, Inc, Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites. April 2004.

New York State Department of Environmental Conservation, New York Guidelines for Urban Erosion and Sediment Control. New York. Fourth Edition, 1997. <http://www.dec.state.ny.us/website/dow/toolbox/escstandards>

Figure SBB-1
Straw Bale Installation



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Wattles (W)

Wattles BMP is provided in Erosion Control section above.

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Non-Stormwater BMPs

Dewatering (DW)
Dust Control (DC)
Material Delivery and Storage (MDS)
Scheduling (S)
Spill Prevention and Control (SPC)
Vehicle and Equipment Maintenance (VEM)
Waste Management (WM)

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Dewatering (DW)

Description

Dewatering involves the removal and discharge of excess water from construction sites. Excess water may be due to groundwater, accumulated precipitation after a storm event (stormwater), or water used during construction activities (i.e. for the testing of pipelines). Proper removal of excess water helps to prevent potential pollutants (such as sediment or toxic and petroleum products) from entering watercourses. Sediment control from dewatering operations is required on all projects where excess water containing sediment or other pollutants is planned to be discharged. A temporary settling or filtering device should be used to avoid pollutant discharges from dewatering operations.

Applicability

These practices are implemented where groundwater, accumulated precipitation (stormwater), or other water used during construction will be discharged from a site.

Limitations

- Site conditions will dictate design and use.
- A settling device often allows only minimal settling time for sediment particles.
- Multiple sediment control methods shall be used, if necessary, for better sediment removal when site conditions allow.
- The controls discussed in this BMP address sediment only. If the presence of polluted water is identified, dewatering pollution controls should be implemented in accordance with regulatory requirements.

Standards

Groundwater dewatering

1. All dewatering operations must comply with the Stormwater Management Plan. Discharges to the ground of water from construction dewatering activities may be authorized, provided that:

a. The source is groundwater and/or groundwater combined with stormwater that does not contain pollutants in concentrations exceeding the State groundwater standards in Regulations 5 CCR 1002-41 and 42

b. The source is identified

c. BMPs are utilized

d. These discharges do not leave the site as surface runoff or to surface waters

2. Dewatered groundwater shall be pumped or diverted to a sediment control BMP prior to discharge to the ground.

Stormwater Dewatering

1. The discharge of pumped stormwater (not including groundwater or other non-stormwater sources) from excavations, ponds, depressions, etc., to surface water, or to a municipal separate storm-sewer system is allowed as long as the dewatering activity and associated BMPs are implemented in accordance with this manual.
2. Stormwater that collects in open depressions or trenches during construction activities will be dewatered into an existing sediment control, such as a detention pond, a sediment trap, or simply into a well-vegetated area to percolate into the ground and catch suspended sediment.

Pipeline Dewatering

Once the hydrostatic testing of pipelines has been completed, dewatering of the pipeline will occur.

1. Insert a displacer, commonly referred to as a pig, in the pipeline.
2. Regulate the discharge rate and utilize energy dissipation devices and/or sediment controls as necessary to prevent erosion, streambed scour, suspension of sediments, or excessive stream flow.

Specifications

One of several types of dewatering structures may be constructed depending on site conditions and type of operation:

1. Water may be pumped or directed into existing stormwater sediment controls (such as sediment traps) capable of handling the volume and flow rate of dewatered water.
2. Water may be pumped or directed into a temporary settling device as described below.
3. Water may be land applied to approved non-wetland vegetation areas and allowed to soak into the soil.
4. Water may be hauled away from the project for disposal in accordance with applicable laws and regulations.

If existing stormwater sediment controls are used to control water, the applicable sections of this BMP Manual shall be followed.

If a settling device is utilized, the following design criteria shall be followed:

Straw Bale/Silt Fence Pit

- It is recommended that the structure consist of an excavated basin surrounded by a perimeter control such as wattles, hay bales, or silt fence (see Figure DW-1). Install wattles, hay bales, or a silt fence as described in applicable sections of this BMP Manual.
- The following formula should be used to determine the storage volume of the sediment tank:

  Pump discharge (gpm) x 16 = cubic feet of storage required

- The excavated area should be a minimum of 3 feet below the base of the perimeter control. The excavated portion will serve for wet storage, and the remainder will provide dry storage.
- When water reaches the outlet crest, pumping must stop until the water drains down to the elevation of the excavated area.
- The remaining water may be removed only after a minimum of 6 hours of sediment settling time. This effluent should be pumped across an area with established vegetation or through a silt fence prior to entering a watercourse.
- When the excavated area becomes filled to one-half of the excavated depth, accumulated sediment should be removed and properly disposed of.

Sediment Filter Bag

- A filter bag, constructed of non-woven geotextile material (to provide adequate filtering ability to capture the larger soil particles from the pumped water), will be clamped around the dewatering pump discharge hose so that all of the pumped water passes through the bag.
- The filter bag should be used in combination with a straw bale/silt fence pit when located within 50 feet of a stream. When the distance to a stream is greater than 50 feet, the bag may be placed on well-vegetated area, or on an aggregate pad. The bag should never be placed on bare soil.
- The capacity of the bag should be adequate to handle the dewatering pump discharge, and should be based on the bag manufacturer's recommendation.
- When used in conjunction with a straw bale/silt fence pit, a filter bag may be operated until the water in the pit reaches the crest of the emergency overflow.
- When placed on either a stone pad or well-vegetated area, the bag may be operated until such time the discharge from the bag reaches a stream.
- When the bag has been completely filled with sediment it should be cut open, sediment regraded in place, and immediately stabilized with an erosion control.

A settling device and/or sediment control may not be needed if the water is discharged to a well stabilized, on-site, vegetated area. The stabilized area should be capable of filtering sediment while at the same time withstanding the velocity of the discharged water without eroding. A minimum filtering length of 75 feet is recommended for the stabilized area.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. If using a settling device, sediments should be removed once they have accumulated to one-half of the excavated depth and properly disposed of. Sediment removal from dewatering devices shall be stabilized at the project site at pre-designated locations or shall be disposed of properly.

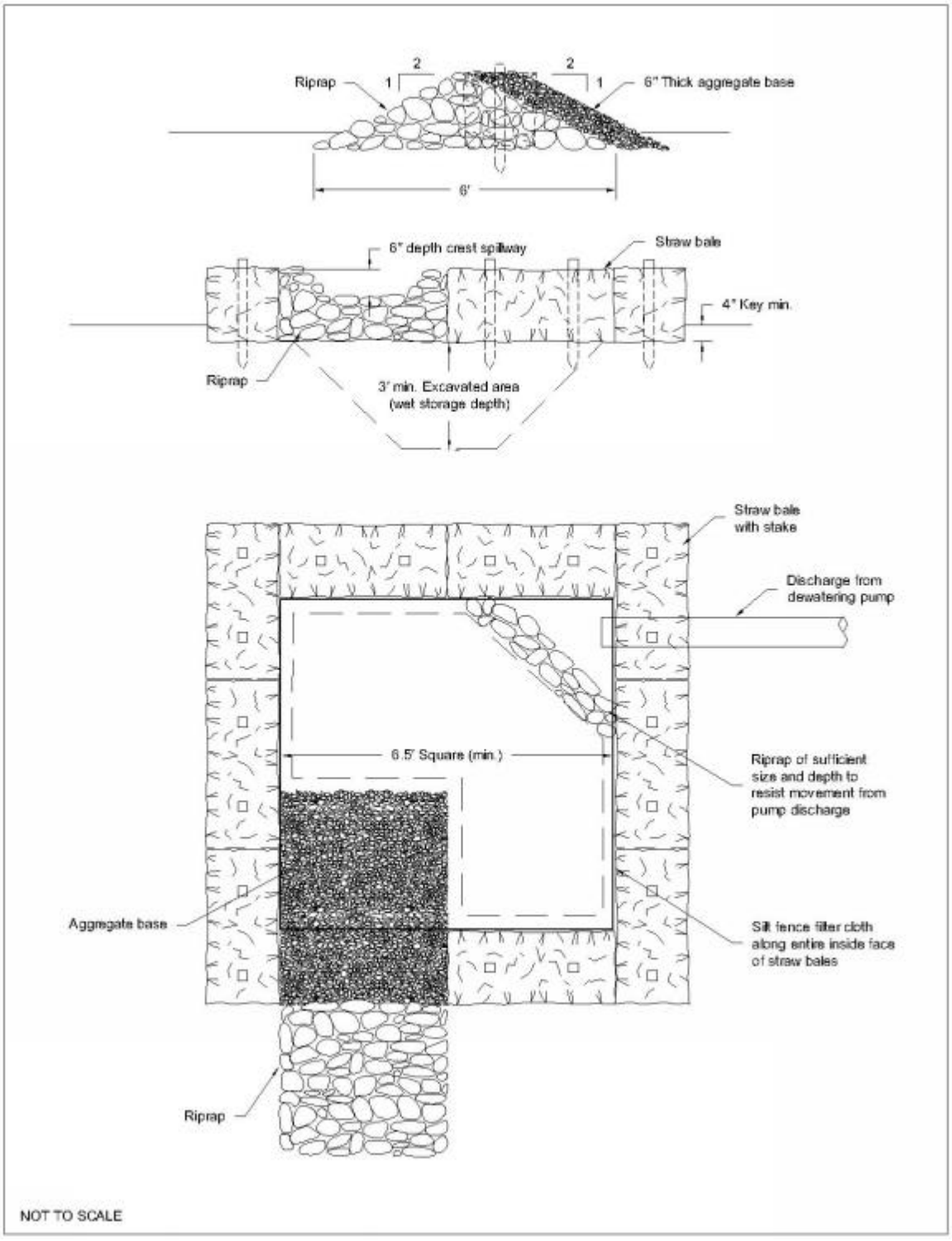
References

Arizona Department of Transportation (ADOT), Erosion and Pollution Control Manual. 2005. http://www.azdot.gov/ADOT_and/Storm_Water/Erosion_Pollution_Control_Manual.asp

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

Federal Energy Regulatory Commission (FERC), Upland Erosion Control, Revegetation, and Maintenance Plan. January 2003.

Figure DW-1
Settling Device Installation



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Dust Control (DC)

Description

Dust control involves practices (such as applying water or dust palliatives) to be implemented during construction operations to prevent dust and wind erosion from exposed soil surfaces.

Applicability

These practices are limited to exposed soil where wind erosion is expected.

Limitations

The effectiveness of this application can be limited by soil, temperature, and wind velocity.

Standards and specifications

Irrigation practices can be applied to a project site until the soil is moist and can be repeated as necessary. However, the soil shall not be oversaturated causing runoff to flow from the project site. The distribution system shall be equipped with a proper spray system to ensure even water distribution. When a distribution system is unavailable, at least one mobile unit shall be available at all times to apply water or a dust palliative to the project site. All non-potable tanks, pipes, and other conveyances shall be marked “non-potable water - do not drink.”

Seeding, mulching, soil binder, and grading techniques are also temporary methods to prevent dust and wind erosion. Refer to the applicable BMPs.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect protected areas for adequate protection and signs of degradation. Perform spot-checks to ensure dust and wind erosion control techniques are properly implemented.

References

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

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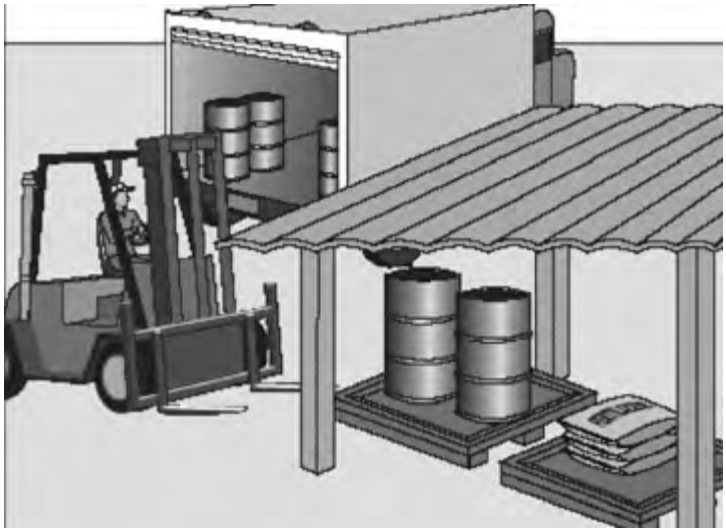
Material Delivery and Storage (MDS)



Description

These practices are to be implemented for proper handling, delivery, and storage of materials in order to prevent spills or leaks into the storm drains or watercourses.

Applicability

These practices are implemented at all construction sites where delivery and storage of materials may be detrimental to the environment. Materials of concern are not limited to soil, pesticides, herbicides, fertilizers, petroleum products, asphalt and concrete components, and hazardous chemicals such as acids, paints, solvents, adhesives, and curing compounds.

Limitations

Space limitation may preclude indoor storage. Storage sheds must meet building and fire code requirements.

Standards and specifications

Deliver and loading/unloading areas

- Keep an accurate, up-to-date inventory of material delivered and stored on site.
- Minimize hazardous material storage on site.
- Employees trained in emergency spill clean-up procedures should be present when dangerous materials or liquid chemicals are unloaded.
- Cover loading and unloading areas to reduce exposure of materials to rainfall.
- Routinely check vehicles and equipment such as valves, pumps, flanges, and connections for leaks.
- Direct off-site stormwater flows away by grading, berming, or curbing the area around the loading/unloading area.

Storage and material handling areas

- Designate storage areas at the project site.
- Locate the storage area away from the storm drain system and watercourses.
- Provide curbs or dikes around the perimeter of material storage areas to prevent run-on from adjacent areas as well as runoff of stormwater from the material storage areas.
- Prevent spills or leakage of liquid materials from contaminating soil (i.e., soaking into the ground) by placing storage areas on impervious surfaces.
- Stockpile soil in accordance with the Stockpiling BMP for topsoil and subsoil.
- Store materials indoors within existing structures or sheds when available.
- Material safety data sheets (MSDS) shall be made available for all materials.
- Training for proper material handing and storage techniques shall be required.
- Provide sufficient separation between storage containers to allow cleanup and emergency response.
- Chemically incompatible materials should not be stored together or in the same storage facility.
- Label all materials properly and maintain current legible labels; also maintain a current inventory of all material delivered and stored.
- Do not store hazardous chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and when possible, under cover in secondary containment.
- Keep hazardous chemicals in their original containers and keep them well labeled.

Spill Clean-up

- Immediately contain and cleanup any spills according to the Spill Prevention and Control BMP as well as the Spill Prevention and Control Countermeasures (SPCC) Plan.
- If significant residual materials remain on the ground after construction is complete, properly remove and dispose of any hazardous materials or contaminated soil.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect equipment and vehicles for leaks. Maintain an ample supply of cleanup materials at all designated storage and handling areas where leaks and spills are likely to occur. Spot-check material storage and handling areas for compliance. Material storage areas shall be checked for accumulation of non-labeled materials and spills. Containment structures or other perimeter controls shall be inspected and repaired when signs of degradation are visible.

References

Arizona Department of Transportation (ADOT), Erosion and Pollution Control Manual. 2005.
http://www.azdot.gov/ADOT_and/Storm_Water/Erosion_Pollution_Control_Manual.asp

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002.
http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

Scheduling (S)

Description

Develop a schedule for every project that includes sequencing of construction activities in conjunction with the implementation of construction site BMPs in order to reduce the amount and duration of soil exposed by construction activities. The purpose is to minimize erosion of disturbed soils by wind, rain, runoff, and vehicle tracking by reducing the amount and duration of soil exposed to erosion and ensuring that BMPs are implemented in a timely manner as construction proceeds.

Applicability

- Construction activities shall be planned to minimize the amount of disturbed land exposed to erosive conditions.
- Stabilization measures shall be installed and maintained as work progresses, not just at the completion of construction.

Standards and specifications

- Schedule the installation of temporary and permanent controls as specified in the Construction General Permit (CGP).
- The schedule of construction activities and concurrent application of temporary and permanent BMPs is developed as part of the Stormwater Management Plan (SWMP).
- Schedule clearing and grubbing activity to allow existing vegetation to remain in place as long as possible.
- For larger projects, the contractor shall not expose more than 750,000 square feet in any location until temporary or permanent BMPs have been installed.
- Schedule shall include dates for significant long-term operations or activities that may have planned non-stormwater discharges such as dewatering, sawcutting, grinding, drilling, boring, crushing, blasting, painting, hydro-demolition, mortar mixing, bridge cleaning, etc.
- Schedule shall include dates for installation of permanent drainage systems and runoff diversion devices. These devices should be installed as early as possible in the construction process.
- The schedule shall include non-stormwater BMPs, waste management, and materials pollution control BMPs.

- Stabilize non-active areas as specified in the CGP.
- Monitor weather forecast and adjust construction schedule to allow for the implementation of soil stabilization and sediment controls on all disturbed areas prior to the onset of rain.

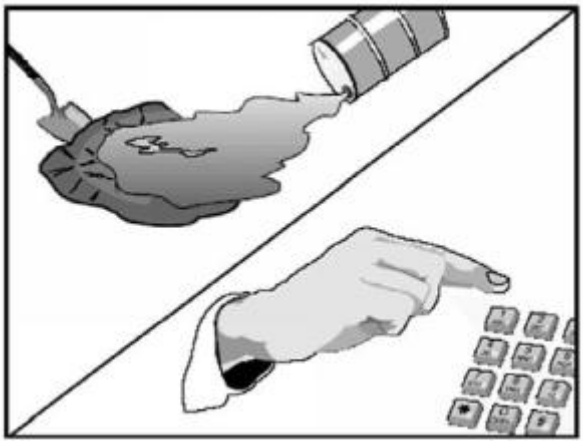
Maintenance considerations

The frequency of inspections should be in accordance with the SWMP. Verify that work is progressing in accordance with the schedule. The schedule must be updated when changes are warranted or when directed by the Engineer.

References

Arizona Department of Transportation (ADOT), Erosion and Pollution Control Manual. 2005. http://www.azdot.gov/ADOT_and/Storm_Water/Erosion_Pollution_Control_Manual.asp

Spill Prevention and Control (SPC)



Description

These practices are implemented to prevent and control spills to ensure that spills and leaks do not result in water quality impacts.

Applicability

This BMP applies to all construction activities. Spill prevention and control measures shall be implemented any time chemicals or hazardous substances are used, stored, or handled.

Limitations

The measures described in this BMP are general. Appropriate practices for specific materials used, stored, or handled on a project site should be identified by site personnel.

Standards and specifications

The following general design guidelines can be implemented for spill prevention and control measures for various activities and areas:

- Identify materials delivered, handled, stored, and used at a project site.
- Identify project areas and activities potentially susceptible to spills. Areas and activities that are most vulnerable to spills include: transportation facilities, loading and unloading areas, fuel and chemical storage areas, process activities, dust or particulate generating processes, and waste disposal activities.
- Develop spill response procedures.

Spill Prevention Control and Countermeasures (SPCC) Plan

A Spill Prevention Control and Countermeasures (SPCC) Plan has been developed and will be implemented for certain products that are stored at the site. The SPCC Plan identifies areas where spills can occur on site, specifies material handling procedures and storage requirements, and identifies spill cleanup procedures. The purpose of this plan is to establish standard operating procedures and the necessary employee training to minimize the likelihood of accidental releases of pollutants that can contaminate stormwater runoff. Spill

prevention is prudent both environmentally and economically, since spills increase operating costs and lower productivity.

Emergency spill cleanup plans should include the following information:

- A description of the facility including the nature of the facility activity and general types and quantities of chemicals stored at the facility.
- A site plan showing the location of storage areas for chemicals, location of storm drains, site drainage patterns, fire-fighting equipment and water source locations, and the location and description of any devices used to contain spills such as positive control valves.
- Notification procedures to be implemented in the event of a spill, such as, posting phone numbers of key personnel and appropriate regulatory agencies.
- Instructions regarding cleanup procedures.
- Designating personnel with overall spill response cleanup responsibility.
- A summary of the plan should be written and posted at appropriate points in the building (i.e., project trailer and areas with a high spill potential), and shall identify the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill.
- Cleanup of spills should begin immediately. No emulsifier or dispersant should be used. In fueling areas, absorbent materials should be packaged in small bags for easy use, and small drums should be available for storage of absorbent and/or used absorbent. Absorbent materials shall not be washed into the floor drain or storm sewer.

Cleanup response procedures

Response guidelines have been identified below for contractors responding to spills that may potentially result in an illicit discharge. It is the contractor's responsibility to have all emergency phone numbers available at the construction site as well to notify the proper response agencies in a timely manner. It is also the contractor's responsibility to ensure timely and proper cleanup of any spill.

Minor spills

For **non–hazardous materials** such as gasoline, paint, or oil that may be spilled in **small quantities** which do not enter state waters or pose a potential to do so, the following measures shall be implemented:

1. Use absorbent materials to contain spills. Do not hose down spill area with water or bury the spill.
2. Recover spilled materials.
3. Clean the contaminated area of residuals and/or properly dispose of the absorbent material.

Semi-significant spills

For **non-hazardous materials** that qualify as a **semi-significant spill** or spills of any size which do not enter state waters or pose a potential to do so and can be controlled by the first responder along with the aid of other personnel, the following measures shall be implemented:

1. Notify the project foreman immediately. The foreman should notify the resident engineer.
2. Contain the spills to prevent spreading.
3. If the spills occur on paved or impermeable surfaces, clean-up using "dry" methods (adsorbent materials, cat litter, and/or rags). Contain the spill by encircling with absorbent materials and do not let the spill spread widely.

4. If the spill occurs in a dirt area, immediately contain it by constructing an earthen dike. Dig up and properly dispose of contaminated material.
5. If the spills occur during rain, cover affected area if possible.

Significant spills

For **non-hazardous materials** that qualify as a **significant spill** or spills of any size that enter state waters or have the potential to do so, the following measures shall be implemented:

1. Contact the Colorado Department of Public Health and Environment (CDPHE) Environmental Emergency Spill Reporting Line (1-877-518-5608) within 24 hours of the spill event. A written notification to the CDPHE-Emergency Management Program (EMP) is necessary within 5 days.
2. Contact the Colorado State Patrol 24-hour hotline (1-303-239-4501) if the spill is on a state highway.
3. Notify the project foreman and maintenance personnel on patrol immediately and follow up with a written report.
4. If possible, cleanup the spill immediately. Use absorbent materials if the material is on an impermeable surface. Construct an earthen dike to contain a spill on dirt areas. If rainfall is present at the time of the spill, cover the spill with a tarp to prevent contaminating runoff.

Hazardous spills

For all spills involving **hazardous materials**, the following measures shall be implemented:

1. Contact the local emergency response team by dialing 911.
2. Contact the CDPHE-EMP 24 Environmental Emergency Spill Reporting Line (1-877-518-5608) within 24 hours of the spill event. A written notification to the CDPHE-EMP is necessary within 30 days.
3. Contact the Colorado State Patrol 24-hour hotline (1-303-239-4501) if the spill is on a state highway.
4. Report spills to project foreman and maintenance personnel on patrol and follow up with a written report.
5. Construction personnel shall not try to clean up the spill.
6. Cleanup spill immediately; a licensed contractor or HazMat team shall be used to properly clean up spills.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan. Inspect equipment and vehicles for leaks. Maintain an ample supply of cleanup materials at all designated maintenance areas where leaks and spill are likely to occur. Spot-check material storage and handling areas for compliance. Material storage and use areas shall be checked for accumulation of non-labeled materials and spills. Identify spills or leaks into to the storm drain at or near work areas. Containment structures or other perimeter controls shall be inspected and repaired when signs of degradation are visible.

References

Arizona Department of Transportation (ADOT), Erosion and Pollution Control Manual. 2005. http://www.azdot.gov/ADOT_and/Storm_Water/Erosion_Pollution_Control_Manual.asp

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide.

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Waste Management (WM)

Description

Stormwater runoff from areas where construction wastes are stored or disposed can be polluted. Wastes leached or spilled from management areas may build up in soils or on other surfaces and be carried by stormwater runoff. The optimal approach to reduce the potential for stormwater contamination from wastes is to reduce the amount generated and, consequently, the amount stored on site. The following types of waste management are covered under this BMP:

Concrete waste management: Practices to be used in order to minimize and prevent concrete waste associated with construction activities from entering storm drains and watercourses. Concrete waste may be generated where concrete trucks or concrete-coated equipment are washed on site, where slurries containing concrete are generated, or where mortar-mixing areas exist.

Solid waste management: Practices to be used in order to minimize and prevent solid waste associated with construction activities from entering storm drains and watercourses. Solid waste can be classified as non-hazardous solid material including: concrete, rock, debris, soil, wood, vegetative material, plastic, fabrics, mortar, metal scraps, Styrofoam, and general litter such as but not limited to beverage containers and plastic wrappers.

Sanitary and septic waste management: Practices to be used in order to minimize and prevent sanitary and septic waste associated with construction activities from entering storm drains and watercourses.

Liquid waste management: Practices to be used in order to minimize and prevent liquid waste associated with construction activities from entering storm drains and watercourses.

Hazardous waste management: Practices to be used in order to prevent hazardous waste associated with construction activities from entering storm drains and watercourses. Hazardous wastes may be discovered or generated (by lead paint removal operations) and are designated as hazardous by the Code of Federal Regulations or Colorado state laws.

Contaminated waste management: Practices to be used in order to minimize and prevent pollutants from contaminated soils from leaching into watercourses or drainage systems.

Applicability

Facilities or designated construction work areas where each type of waste is discovered or generated.

Limitations

During the non-rainy season or in arid portions of the state, temporary stockpiling of non-hazardous solid waste may not require stringent drainage control measures. The engineer for the project shall determine if drainage control measures are warranted for a specific construction site where non-hazardous solid waste is being stockpiled.

Liquid waste management does not apply to solid wastes, hazardous wastes, concrete slurries/wastes, dewatering operations, sanitary/septic wastes, or permitted allowable non-stormwater discharges. Disposal of some liquid wastes may be subject to regulations or requirements of other permits secured for the construction site.

This BMP provides general hazardous waste management guidelines, but does not relieve the contractor from full responsibility of complying with federal, state, and local laws regarding storage, handling, transportation, and disposal of hazardous wastes. It is the contractor's full responsibility to identify all hazardous waste generated at the project site.

The contractor is responsible for identifying pollutant-specific handling and disposal procedures for contaminated soils at the project site.

Standards

Concrete waste
Waste generated from concrete activities shall not be allowed to flow into drainage ways, inlets, or receiving waters.

Concrete waste shall be placed in a temporary concrete washout facility.

- Concrete washout facilities will be comprised of an excavation with erosion bales and construction fences along the perimeter. The facility may be similar to the settling device used for dewatering (see Figure DW-1). The bottom of the excavation must be proven to be at least 5 vertical feet above groundwater or, alternatively, the excavation must be lined with either a clay or synthetic liner that is designed to control seepage. The facilities shall be maintained in good condition to contain all liquid and concrete waste generated by operations at a project site.
- Proper signage such as "Concrete Washout" shall be placed near concrete washout facilities to inform construction personnel of the location of designated concrete washout facilities.
- Temporary concrete washout facilities shall be located 50 horizontal feet from drainageways, inlets, and receiving waters unless otherwise approved by the engineer.
- Adding solvents, flocculents, or acid to washwater is prohibited.
- Whenever a concrete washout area is within 300 feet of the access to a road or highway, a stabilized construction entrance must be built as part of the washout, or at the entrance to the road or highway.
- Hardened concrete waste shall be properly disposed of following solid waste management procedures.
- Removal of temporary facilities, including the solid concrete waste and the material used to construct the facilities, shall be the responsibility of the contractor, who shall remove the waste from the project site and dispose of it properly following guidelines outlined in solid, liquid waste management and any applicable regulations.

Solid waste

- Litter shall be minimized at all construction sites and collected on a weekly basis into water-tight dumpsters. Trash receptacles shall be provided in various locations within the construction site boundaries.
- Collected trash shall not be placed near drainage inlets or watercourses.
- A trash hauling contractor shall be used to properly dispose of the collected waste in a timely manner. Dumpster washout at the construction site is not permissible.
- Priority shall be given to remove waste and debris from drainage inlets, trash racks, and ditches in order to prevent clogging of the stormwater system.
- Waste storage areas shall be pre-approved by the engineer.
- Storage areas for solid waste shall be located at least 50 feet from drainageways and watercourses, and shall not be located in areas susceptible to frequent flooding. Sediment barriers such as berms, dikes, or other temporary diversion structures shall be used to prevent stormwater runoff from contacting stored solid waste at the project site.
- Solid waste shall be segregated properly into various categories for recycling or disposal. Proper disposal is required for each waste category. The contractor shall make every attempt to recycle useful vegetation, packaging material, and surplus construction materials when practical.
- Most construction materials can be recycled at recycling facilities.

Septic and sanitary waste

- Temporary sanitary facilities shall be located away from drainage ways, inlets, receiving waters, areas of high traffic, and areas susceptible to flooding or damage by construction equipment.
- Temporary sanitary facilities shall be properly connected into a sanitary sewer system where permissible to prevent illicit discharges. Authorized sanitary sewer system connections shall comply with local health agency, county, and sanitary sewer district requirements.
- Wastewater generated from sanitary facilities shall not be allowed to flow into drainageways, inlets, or receiving waters.
- Only licensed sanitary/septic waste haulers shall be used to properly dispose of waste from temporary sanitary facilities.
- In project areas susceptible to strong winds, temporary sanitary facilities shall be secured to prevent overturning.

Liquid waste

- The contractor shall oversee and enforce all liquid waste measures and will instruct all employees and subcontractors on the identification of hazardous and non-hazardous liquid waste, and non-hazardous handling, storage, and proper disposal.
- The contractor shall hold regular safety meetings to ensure proper liquid waste measures are being adhered to and efforts are being made to minimize the amount of liquid waste produced.
- The contractor shall ensure compliance with all liquid waste management procedures and practices.
- Liquid wastes generated from operational procedures such as drilling residue and fluids shall not be allowed to flow into drainageways, inlets, or receiving waters.
- All liquid wastes shall be contained in designated areas such as sediment basins, holding pits, or portable tanks. Designated containment areas shall be located away from drainageways, inlets, receiving waters, areas of high traffic, and areas susceptible to flooding.

- Precautions shall be taken to ensure that proper spill prevention and control measures are being implemented to avoid accidental spills.
- If a liquid waste is released or spilled, capture the liquid with proper cleanup methods. Do not allow the liquid waste to flow uncontrolled or into drainageways, inlets, and receiving waters. Use diverting methods such as temporary dikes to control the spill and direct it to containment areas for capture.
- The contractor shall be responsible for adhering to all permit requirements, federal, state, and local regulations for properly disposing liquid waste.

Hazardous waste

The following are general guidelines provided for planning the management of hazardous wastes.

- Hazardous waste storage, transportation, and disposal shall comply with 49 CFR 172, 173, 178, 179, and 261-263, and state regulations.
- Special materials and equipment may be required to manage wastes that are corrosive, combustible, flammable, oxidizer, poison, toxic, or reactive. Clearly label all waste containers with the appropriate description of the wastes being contained.
- Hazardous wastes shall be segregated, and incompatible or reactive wastes shall be disposed of properly in a manner to prevent fires and explosion. Always consult the health and safety officer, engineer, and/or project manager prior to mixing hazardous wastes for disposal. Hazardous waste shall be segregated properly into various categories such as liquids, semi-liquids, and solids.
- Select the most appropriate disposal container to store the hazardous waste. Additionally, select a container that is compatible with the hazardous material being stored. For instance, use plastic or plastic-lined steel drums for storing corrosive materials. Corrosive materials will react with steel and cause the waste to be released from the drum. Always consult the engineer or project manager to ensure that the container and waste are compatible.
- Waste containers shall be stored and managed in temporary containment facilities that shall meet the following requirements:
  - A spill containment volume 1.5 times the volume of all containers
  - Impervious to the materials contained for a minimum contact time of 72 hours
  - Free of accumulated rainwater or spills, with sufficient separation provided between stored containers to allow for spill cleanup
  - Incompatible, ignitable, and reactive materials shall not be stored in the same temporary containment facility
  - “Caution: Flammable Material” signs must be posted near containment areas to prevent fires or explosions
- The following management guidelines are recommended for containment facilities:
  - Keep containers closed at all times except when adding or removing waste from the container. Use a funnel or hose to transfer wastes to drums.
  - You must open, handle, and store containers to prevent ruptures or leaks. Make sure to open drums with a spark-proof wrench.
  - If the container begins to leak or you notice dents or bulges, transfer the waste to another container.

- Locate containment areas away from high-traffic areas, waterways, drainage inlets, sensitive habitats, and areas prone to flooding or ponding.
- Waste residuals from equipment or brushes shall be cleaned in designated containment areas and shall not be allowed to seep into soils causing soil contamination or to discharge into watercourses or drainageways.
- Secondary containment needs to be provided for all hazardous waste containers. In addition, containment berms shall be used in fueling and maintenance areas where the potential for spills is high.
- Hazardous waste containment areas shall be pre-approved by the engineer and/or project manager.
- It is the contractor's responsibility to ensure that all hazardous waste discovered or generated at a project site is disposed of properly by a licensed hazardous material disposal contractor/facility utilizing properly completed Uniform Waste Manifest forms. The contractor is responsible for not exceeding hazardous waste storage requirements mandated by the state or other localities.
- Additional disposal guidelines for non-hazardous solid and liquid waste are included in Sections WM 2 and WM 4, respectively.

Contaminated waste

The following are general guidelines provided for planning the management of contaminated soils.

- The contractor is responsible for reviewing relevant environmental reports, appropriate plans, and project special provisions for contaminated soils information. The contractor shall also take initiative to further inform the engineer of any potential or identified contaminated soils on the project site.
- Contractor and employees are responsible for meeting safety training requirements mandated by 29 CFR 1910.120 prior to performing any construction work or excavation at projects sites where contaminated soils have been classified as hazardous materials.
- The contractor is responsible for following all rules and regulations applicable to the excavation, handling, transport, and disposal of contaminated and hazardous materials. The applicable rules and regulations are not limited to the standards of Occupational Safety and Health Administration, U.S. Environmental Protection Agency, U.S. Department of Transportation (USDOT), Colorado Department of Public Health and Environment (CDPHE), and local agencies.
- Contaminated soils should be placed in a lined and bermed area.
- Surround the perimeter of the exclusion zone with a security fence for safety.
- Collect impacted soil samples and complete a characterization analysis.
- Collect non-reusable protective equipment used at the project site and dispose of it properly. Additionally, treat and/or dispose of wastewater from decontamination procedures.
- Contaminated soil shall be transported to a licensed disposal facility on vehicles registered for that purpose.
- When an underground storage tank is discovered at a construction site, coordinate with the regional environmental project manager for guidance on handling and disposal procedures.
- Preventive measures, such as berms, freeze walls, cofferdams, and grout curtains, should be installed to prevent stormwater runoff or groundwater from mixing with hazardous materials or underground tank excavations. Water exposed to contaminated areas should be placed in water-tight holding tanks, tested, and properly disposed.

Maintenance considerations

The frequency of inspections should be in accordance with the Stormwater Management Plan.

The contractor shall monitor concrete activities to ensure proper waste management techniques are being utilized. Maintenance of temporary concrete washout facilities shall include removing hardened concrete and proper disposal. It is recommended that facilities be cleaned out once they are 75 percent full, or new facilities shall be constructed to provide additional concrete waste storage.

Check for and remove litter and debris from drainage grates and other drainage structures. Provide cover for dumpsters and waste containers to prevent entry of rainwater and loss of contents by high winds.

Inspect perimeter controls, containment structures, berms, covers, and liners. Repair or replace as needed to function properly.

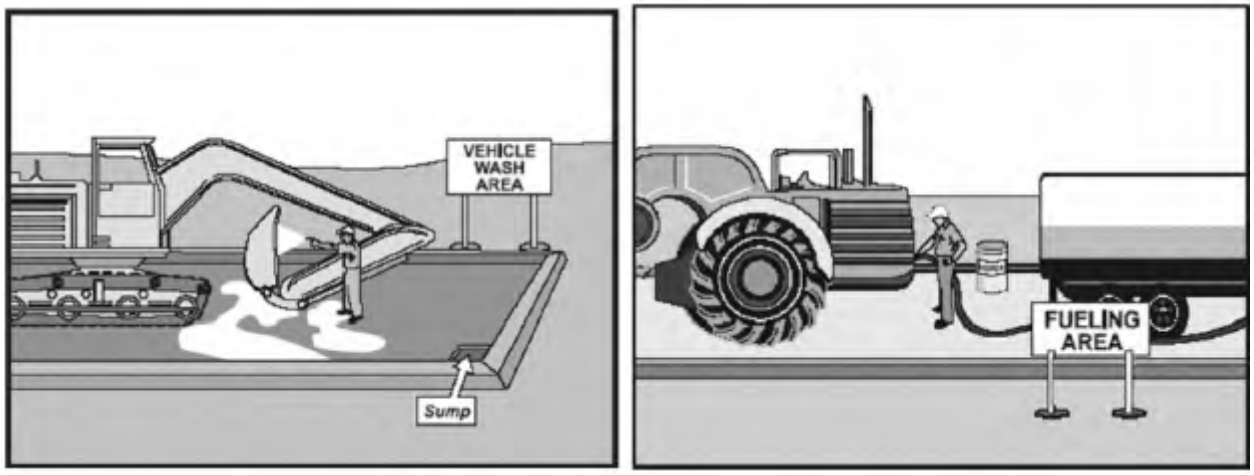
The contractor shall be responsible for monitoring on-site contaminated storage and disposal procedures.

References

Arizona Department of Transportation (ADOT), Erosion and Pollution Control Manual. 2005.
http://www.azdot.gov/ADOT_and/Storm_Water/Erosion_Pollution_Control_Manual.asp

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002.
http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

Vehicle and Equipment Management (VEM)



Description

Procedures and practices used to minimize or eliminate the discharge of pollutants during the following operations:

- Cleaning of vehicles and equipment prior to or during use on project site.
- Fueling of vehicles.
- Maintenance of vehicles and equipment.

Applicability

These procedures are applied on all construction sites where vehicle and equipment cleaning, fueling, and/or maintenance takes place.

Limitations

Only use on-site vehicle and equipment fueling when it is impractical to send vehicles and equipment off site to be refueled. Comply with local codes and ordinances regarding the disposal of fluids and consumables, and the on-site maintenance of equipment.

Standards and specifications

Vehicle and equipment cleaning

- On-site vehicle and equipment washing is discouraged, but may be necessary to eliminate spread of invasive species to areas outside of project site.
- Cleaning of vehicles and equipment with soap, solvents, or steam shall not occur on the project unless the Engineer has been notified in advance and the resulting wastes are fully contained and disposed of outside of the highway right-of-way in conformance with the Standard Specifications. Resulting wastes shall not be discharged or buried.
- When equipment/vehicle washing/cleaning must occur on site and the operation cannot be located within a structure or building equipped with appropriate disposal facilities, the outside cleaning shall have the following characteristics and shall be arranged with the Erosion Control Coordinator:
  - A washout area shall be an excavated pit, which will later be backfilled or where the concrete wash can harden and be properly disposed of.

- Locate wash out areas close to the active construction site on the project.
- Locate wash out pits away from storm drains, open ditches, or receiving waters.
- Use only when necessary.
- When cleaning vehicles/equipment with water use as little water as possible. Consider using high pressure sprayers, which require less water.

Vehicle and equipment fueling

- When fueling must occur on site, the contractor shall select and designate an area to be used, subject to approval by the Engineer.
- Federal, state, and local requirements shall be observed for any stationary aboveground storage tanks.
- Mobile fueling of construction equipment throughout the site shall be minimized. Whenever practical, equipment shall be transported to the designated fueling area.
- Spill prevention, containment, and countermeasures shall be included in the Stormwater Management Plan (SWMP) if the volume of project site fuel in a single container exceeds 660 gallons, or if the total fuel storage volume at any one site exceeds 1,320 gallons.
- Designated fueling areas shall be protected from stormwater runoff and shall be located at least 50 feet from downstream drainage facilities or watercourses. Fueling must be performed on level-grade areas.
- Protect fueling areas with berms and/or dikes to prevent run-on, runoff and to contain spills.
- Absorbent spill clean-up materials and spell kits shall be available in fueling areas and on fueling trucks and shall be disposed of properly after use.
- Drip pans or absorbent pads shall be used during vehicle and equipment fueling, unless the fueling is performed over an impermeable surface in a dedicated fueling area.
- Nozzles used in vehicle and equipment fueling shall be equipped with an automatic shut-off to control drips. Fueling operations shall not be left unattended. Fuel tanks shall not be "topped off."

Vehicle and equipment maintenance

- Plan for the proper recycling or disposal of used oils, hydraulic fluids, gear lubricants, batteries, and tires.
- Use appropriate, leak-proof containers for fuels, oils, and lubricants to provide for proper disposal.
- Use steam or high-pressure water instead of thinners and solvents to wash down equipment. Wash water and detergents can be disposed of in the sanitary sewer system after grit is removed, after checking with local authorities.
- Use drip pans or absorbent pads under equipment during maintenance that involves fluids.
- Equipment maintenance and wash-out areas should be located at least 50 feet away from drainages.
- Provide spill containment areas around stored oil and chemical drums.
- Provide a contained wash-out area to wash down heavy equipment.

Maintenance considerations

The frequency of inspections should be in accordance with the SWMP. Vehicles and equipment shall be inspected for leaky gaskets and damages hoses. Leaks shall be repaired immediately or problem vehicles or equipment shall be removed from the project site. Any damaged hoses shall be repaired or replaced as needed. Fueling areas and storage tanks shall be inspected. Immediately clean up spills and properly dispose of contaminated soil and cleanup materials. Inspect equipment maintenance areas and wash-out areas. Inspect fluid containers for leaks. Repair leaky fluid containers immediately.

References

Arizona Department of Transportation (ADOT), Erosion and Pollution Control Manual. 2005. http://www.azdot.gov/ADOT_and/Storm_Water/Erosion_Pollution_Control_Manual.asp

Colorado Department of Transportation (CDOT), Erosion Control and Stormwater Quality Guide. 2002. http://www.dot.state.co.us/environmental/envWaterQual/wqms4.asp

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Appendix F

Oil and Gas Construction Field Permit Certification NOTICE OF AMENDMENT OF PERMIT COVERAGE and/or Final Stabilization Certification

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STATE OF COLORADO

Oil and Gas Construction Field Permit Certification

NOTICE OF AMENDMENT OF PERMIT COVERAGE

Terminating coverage for a portion of a permitted area

GENERAL PERMIT FOR

STORMWATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITY

This form is for construction activities associated with oil and gas construction only. The form is applicable to field permit certifications **only**, and is **not** applicable to construction activities for other sectors, such as residential, commercial, or transportation. Additional options for administration and amendments for construction permits, including for activities not associated with oil and gas, is available on the Division's permitting web page, coloradowaterpermits.com (follow the link to "Stormwater Permitting," and then "Construction Stormwater").

This form is to be used to amend an oil and gas field permit certification under Colorado's Stormwater Construction Permit, to terminate permit coverage when **all of the following conditions have been met**:

1. The permit certification to be amended is a field permit certification for construction associated with oil and gas construction. The field permit covers all construction activities disturbing over one acre, or that are part of a common plan of development exceeding one acre, within the applied-for field.
2. The area is a distinct and separate area where construction has been completed and is not part of a specific facility, such as a single well pad or road segment, where construction is ongoing.
3. The area must be **Finally Stabilized**. An area is Finally Stabilized when all ground surface disturbing activities at the site have been completed, and all disturbed areas have been either built on, paved or equivalently hard-armored, or a uniform vegetative cover has been established with an individual plant density of at least 70 percent of pre-disturbance levels.

Upon acceptance of this notice by the Water Quality Control Division (the Division), the permit certification will be automatically amended to exclude the specific portion described in the notice. **The current permittee will not receive a revised certification**. The corrected information will be placed in the permit file. In order to receive notification of the Division's receipt of this information, it is up to the permittee to request verification of delivery from the carrier (i.e., by sending certified mail).

If the Area Has Not Been Finally Stabilized: This form is only for terminating an area that has been finally stabilized. If the area has not been finally stabilized the permittee must either maintain permit coverage, or can reassign permit coverage to another entity that owns or has operational control over that area. The Division's Notice of Reassignment of Permit Coverage form should be used. The form is available at coloradowaterpermits.com

Stormwater Management Plan (SWMP): The permittee must maintain a SWMP that accurately reflects the activities and BMPs for the areas for which they will have permit coverage. Therefore, the SWMP must be updated to reflect the changes described in this form. Appendix A of the General Permit Application and SWMP Guidance for Stormwater Discharges Associated with Construction Activity (available from the Division's web site at coloradowaterpermits.com) contains the requirements for the SWMP.

Failure by the permittee to maintain a SWMP in accordance with this guidance is a violation of the permit. Additional guidance for multi owner/operator development is also available in the Stormwater Fact Sheet for Construction, available from the Division's web site.

Notice Due Dates: At least **ten days** prior to the requested effective date for permit coverage to end, the permittee shall submit this form to the Division. This form may be reproduced, and is also available from the Division's web site at coloradowaterpermits.com.

Permit Fee: There are no new permit fees associated with amending the construction permit certification.

Application Completeness: All items on the form must be completed accurately and in their entirety or the notice will be deemed incomplete, and processing of the form will not begin until all information is received. A map of the revised area **must** be included that clearly indicates the area with continued coverage under the permit certification, and the area excluded. (Do **not** include a copy of the SWMP.) One original copy of the completed form (**no faxes or e-mails**), signed by the current permittee, shall be submitted, only to:

Colorado Department of Public Health and Environment
Water Quality Control Division - Permits
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

If you have questions on completing this application, you may contact the Division at cdphe.wqstorm@state.co.us or (303) 692-3517.

SITE MAP INSTRUCTIONS

Site Map: A Site Map **must** be provided. The map must clearly define the boundaries of the area to be excluded from permit coverage relative to that with continued coverage. The level of detail that must be provided will depend on the nature of the project, and must be adequate to determine during a field audit what construction activities are still covered under the issued certification. Two maps (a vicinity map and excluded site boundary map) may be necessary to provide sufficient detail to meet this requirement for large field areas. Maps must not exceed 8 ½ x 17 inches. Do not submit grading plans or other blueprints as the site map.

Colorado Department of Public Health & Environment
Water Quality Control Division
WQCD-P-B2
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

FOR AGENCY USE ONLY

REC_____ _____ _____
EFF _____ _____ _____
YEAR MONTH DAY

Amendment notice for
Oil and Gas Construction Field Permit Certification
CONSTRUCTION STORMWATER DISCHARGE GENERAL PERMIT CERTIFICATION

Please print or type. Form must be filled out completely.

Certification Number: **COR-03** 1234 ___ ___ ___

Permittee (Company) Name: _____

Permittee Address: _____

Phone No. _____

Field Permit Certification Information (refer to your permit certification):

Field Permit Site/Facility Name: _____ County(s): _____

Contact Person: _____

Contact Person Phone No.: _____ Contact Person Email: _____

Information on Area to be Excluded from Permit Coverage:

Site Map: **Must include Site Map indicating the boundaries of the area to be excluded from permit coverage.**

Refer to the Site Map Instructions on page ii of this form. Maps must be folded to 8½ x 11 inches.

Map enclosed? Yes ☐ No ☐

Summary of work performed and **description of final stabilization for the area shown in the attached map**:

_____

_____

I certify under penalty of law that by the date of my signature below, at the **identified construction site area,** all disturbed soils have been finally stabilized; all temporary erosion and sediment control measures have been removed; all construction and equipment maintenance wastes have been disposed of properly; and all elements of the Stormwater Management Plan have been completed.

I understand that by submitting this notice of amendment, I am no longer authorized to discharge stormwater associated with construction activity by the general permit, **for this specific area**. I understand that discharging pollutants in stormwater associated with construction activities to the waters of the State of Colorado, where such discharges are not authorized by a CDPS permit, is unlawful under the Colorado Water Quality Control Act and the Clean Water Act.

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (See 18 U.S.C 1001 and 33 U.S.C. 1319.)

Signature of Permit Applicant (Legally Responsible Party) Date Signed

Name (printed) Title

Encana SWMP – Final Stabilization Certification

Date: _____

Site ID: _____

Type of Area:

- ☐ Well Pad
- ☐ Access Road to Well Pad
- ☐ Other Road
- ☐ Pipeline
- ☐ Other Facility _____

"The above referenced site has reached final stabilization. All ground surface disturbing activities have been completed, including the removal of all temporary BMPs, and all disturbed areas have been either built on, or a uniform vegetative cover has been established with an individual plant density of at least 70 percent of pre-disturbance levels, or equivalent permanent, physical erosion reduction methods have been employed."

_____

Printed name Title

_____

Signature Date

Appendix G

Inspection and Maintenance Report Form

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EnCana SWMP Inspection and Maintenance Report Form

Area Inspected (Site ID): _____

Title of Inspector: Name of Inspector: Date:

Type of Area: Well Pad ☐ Access Road to Well Pad ☐ Other Road ☐ Pipeline ☐ Other Facility:_____

Phase of Construction: ☐ Preconstruction ☐ onstruction ☐ rilling ☐ ompletions
☐ Reoccupy ☐ erm Reclamation ☐ inal Reclamation

Type of Inspection: ☐ Active (14 days since last inspection) ☐ ompleted (1 month since last inspection)
☐ Active (Within 24 hours of a rain/snowmelt event that causes surface erosion or 72 hours for temporarily idle sites)
☐ Winter Conditions Exist

Site Specific Information

Approximate area of site to be disturbed (acres): Receiving Water(s):

Soil Type(s):

Ecosystem/Vegetation Type(s):

Other Site Specific Information:

Vegetation Observations

Site Revegetated: Yes ☐ No ☐ Current Vegetation: _____%

Pre-disturbance Vegetation: _____% (estimate from undisturbed surrounding areas)

Vegetation Growth uniform and at least 70% of pre-disturbance levels: Yes ☐ lo ☐

Best Management Practice (BMP) Check List

Erosion Control:	In Use?	Comments	Drainage Control:	In Use?
Erosion Control Blanket	☐		Berm	☐
Hydraulic Mulching	☐		Culvert	☐
Land Grading - Roads (slopes/gravel/etc)	☐		Culvert Inlet Protection	☐
Mulching	☐		Culvert Outlet Protection	☐
Retaining Wall	☐		Diversion	☐
Revegetation	☐		Drainage Dip	☐
Riprap	☐		Level Spreader	☐
Soil Stabilizers	☐		Roadside Ditches and Turnouts	☐
Stockpiling - Topsoil and Subsoil	☐		Run On Diversion	☐
Surface Roughening	☐		Slope Drain	☐
Terracing	☐		Trench Breaker	☐
Turf Reinforcement Mat	☐		Water Bar	☐
Vegetated Buffer	☐			☐
Wattles	☐			☐
Sediment Control:	**In Use?**	**Comments**	**Sediment Control:**	**In Use?**
Check Dam	☐		Slash	☐
Detention Pond	☐		Stabilized Construction	☐
Filter Berm	☐		Straw Bale Barrier	☐
Sediment Reservoir	☐		Riprap	☐
Sediment Trap	☐		Wattles	☐
Silt Fence	☐			☐
Non-Stormwater Control:	**In Use?**	**Comments**	**Non-Stormwater Control:**	**In Use?**
Dewatering	☐		Dust Control	☐

Location/Observation:				Additional Comments: New BMPs installed , changes, dates performed, etc...)
Site perimeter/discharge points inspected?	Yes ☐	No ☐	N/A ☐	
All disturbed areas inspected?	Yes ☐	No ☐	N/A ☐	
Vehicles entrance(s)/exit(s) inspected?	Yes ☐	No ☐	N/A ☐	
Material storage areas inspected?	Yes ☐	No ☐	N/A ☐	
Acceptable waste management procedures?	Yes ☐	No ☐	N/A ☐	
Acceptable vehicle/equipment maintenance?	Yes ☐	No ☐	N/A ☐	
Any sediment/pollutant discharged off-site?	Yes ☐	No ☐	N/A ☐	
If no change since above inspection (no changes to BMPs or SWMP)				

Date	Signature	Type of Inspection	
		14 day ☐ Monthly ☐ Pptn. Event ☐	
		14 day ☐ Monthly ☐ Pptn. Event ☐	
		14 day ☐ Monthly ☐ Pptn. Event ☐	
		14 day ☐ Monthly ☐ Pptn. Event ☐	
		14 day ☐ Monthly ☐ Pptn. Event ☐	

Signature certifying that the site is in compliance (after all necessary repairs, maintenance, and changes have been made):

_____ _____
Date Signature

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Appendix H

Inactivation Form

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Colorado Department of Public Health & Environment
Water Quality Control Division
WQCD-P-B2
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

FOR AGENCY USE ONLY

REC_____ _____ _____
EFF _____ _____ _____
YEAR MONTH DAY

INACTIVATION NOTICE FOR

CONSTRUCTION STORMWATER DISCHARGE GENERAL PERMIT CERTIFICATION

Please print or type. Form must be filled out completely.

Certification Number: **COR-03** ___ ___ ___ ___ Taxpayer ID or EIN ___ ___ ___ ___ ___ ___ ___ ___ ___

Permittee (Company) Name: _____

Permittee Address: _____

_____

Phone No. ( )

_____

Site/Facility Name: _____

Construction Site Address/Location: _____

_____

County: Contact Person: _____

Summary of work performed and **description of final site stabilization**: _____

_____

_____

_____

I certify under penalty of law that by the date of my signature below, all disturbed soils at the identified construction site have been finally stabilized; all temporary erosion and sediment control measures have been removed; all construction and equipment maintenance wastes have been disposed of properly; and all elements of the Stormwater Management Plan have been completed.

I understand that by submitting this notice of inactivation, I am no longer authorized to discharge stormwater associated with construction activity by the general permit. I understand that discharging pollutants in stormwater associated with construction activities to the waters of the State of Colorado, where such discharges are not authorized by a CDPS permit, is unlawful under the Colorado Water Quality Control Act and the Clean Water Act.

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (See 18 U.S.C 1001 and 33 U.S.C. 1319.)

_____

Signature of Permit Applicant (Legally Responsible Party) Date Signed

_____

Name (printed) Title

9/97/cn/in

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Article 4-203.E.18 Reclamation Plan

Encana Oil & Gas (USA) Inc K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2797

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Encana Oil and Gas (USA) Inc.
Operator # 100185

K19NE Laydown Yard
Surface Reclamation Plan

Location ID: 335338
NESE Section 19 T6S R92W
Garfield County

Site Description:

The existing well pad is a 5.3 acre disturbance. The land surface is fee (Encana), with fee minerals (Encana). The dominant vegetation community in the lease area can be characterized as sagebrush shrublands. The average annual temperature for Rifle, CO is 47.75° F, with an average precipitation accumulation of 11.61 inches, with somewhat similar averages expected for this site. The existing surrounding land use is rangeland, and the site elevation is 5,500 feet.

Soils Description:

The USDA National Soils Cooperative website was used to identify boundaries of soils mapping units. The site resides within the Arvada loam mapping unit, which averages 6-20% slopes; the Potta loam unit, which averages 3-6% slopes; the Potts-Ildefonso complex, which averages 12-25% slopes; and the Torriothents-Rock outcrop complex, which is classified as steep.

Pre-Disturbance Vegetation Composition:

Ocular assessment for canopy cover on near-by undisturbed land is 35%.

Known weed infestations:

There are no known or identified Colorado List A or B weed infestations at this location

Management of Waste Material:

Before reclamation earthwork is initiated, qualified Environmental personnel will complete a site-assessment for the purpose of identifying soil impacts resulting from current and historic activities on the pad. The site-assessment includes collection of field notes and a photographic record of site conditions. Soil samples are collected from the footprint of removed production equipment, from any visibly stained soil, and wherever stormwater accumulations may concentrate contaminants. Collected soil samples are analyzed for compliance with Colorado Oil and Gas Conservation Commission (COGCC) Table 910-1 constituents of concern.

If laboratory analysis identifies hydrocarbon contaminated soil, impacted material will be excavated using heavy equipment and transported to an offsite facility for disposal. All remediation and disposal activities will be directed by qualified Environmental personnel using field screening techniques, verified by laboratory analysis, and in compliance with COGCC 900 Series Rules. Removal of contaminated material will be reported to the landowner and the COGCC.

Access Road:

There are no existing well pads or public permitted access beyond this well. The access road associated with this pad is the entrance on the West side. It will be decommissioned and is included in the reclamation area. Pre-existing roads to the West and North will remain in place.

Recontouring:

Re-contouring will start with pulling the fill material back to the cut and blending with the natural slope of the area. Micro drainages will be re-established to allow natural flow. The surface cover and size distribution of exposed rock will not exceed pre-disturbance site conditions. Any gravel will be removed from the working surface prior to re-contouring.

If the topsoil pile is present, it will be spread evenly across the reclaimed pad. If a topsoil stockpile is not present, we will use the soil at the bottom of the fill side of the location. On older pads, prior to topsoil storage practices, all topsoil was pushed to the bottom of the pad and covered with fill. We will make every effort to save and distribute any available topsoil found.

Re-establish and stabilize drainage features:

The goal for stormwater management on this location will be to stabilize soils on the reclaim and to prevent excessive erosion, such as slope or soil instability, subsidence and or slumping. All structural BMPs, such as culverts and ditches, will be removed during final reclamation. The site will be maintained to keep the location free of any trash or construction debris.

Seedbed Preparation and Seeding:

All seed beds will be prepared by contour ripping to 6-10" in depth. Contours will be shaped to natural repose of the reclaim surface. Seeding will take place within 24 hours of completion of the dirt work. Seed depth will be drilled to a minimum depth of 0.25" and a maximum of 0.50". Soil amendments that are recommended by the BAR will be applied.

Encana will drill where possible or broadcast and drag on steeper slopes where drilling is not safe. Encana also would like to keep all available options open such as Hydro-seeding, seeded wattles and erosion blankets along with new technology to improve on the success of re-vegetation of the site.

Establish desired self-perpetuating plant community:

The anticipated seed mix for this location is listed below. The recommended application rate is 24 lbs/acre at drill rate. Double rate will be used for broadcast seeding. However, based upon the soil conditions determined by the BAR soil analysis, another seed mix may be better suited for the location if needed.

Common Name	Scientific Name	Variety	Pounds Pure Live Seed (PLS) per acre
Grasses			
Slender Wheatgrass	*Elymus trachycaulus*	Revenue	3.49
Pubescent Wheatgrass	*Thinopyrum intermedium*	Luna	2.96
Western Wheatgrass	*Pascopyrum smithii*	Rosana	2.97
Sideoats Grama	*Bouteloua curtipendula*	El Reno	2.44
Thickspike wheatgrass	*Elymus lanceolatus*	Critana	1.91
Intermediate Wheatgrass	*Thinopyrum intermedium*	OAHE	1.90
Galleta	*Pleuraphis jamesii*	Viva	1.91
Russina Wildrye Bozoisky	*Psathyrostachys juncea*	VNS	1.10
Idaho Fescue	*Festuca idahoensis*	VNS	0.80
Perennial Ryegrass	*Lolium multiflorum*	VNS	0.86
Indian Ricegrass	*Achnatherum hymenoides*	Rimrock	0.56
Alkali Sacaton	*Sporobolus airoides*	VNS	0.33
		Total PLS	**21.23**

Fencing:

If needed, Encana will install BLM standard wildlife friendly fence installed at perimeter of reclaim disturbance, to reduce the potential for herbivory impacts to the germinating and establishing desired species.

Manage Invasive Plants:

Through the annual site visits, noxious and invasive weeds will be identified, inventoried and treated by licensed contracted herbicide applicators. Encana will monitor, control and reduce the spread of noxious and invasive weed species within Encana's disturbances as determine in the Colorado Noxious Weed Act and rules pertaining to the administration and enforcement of the Colorado Noxious Weed Act.

Reclamation Monitoring and Reporting:

State regulations and Encana's Best Management Practices require routine site visits and active management over construction activities, along with annual reclamation reporting requirements. At a minimum, the location will be visited every 14 days during active construction and monthly thereafter until the vegetation has reached 70% cover of pre-disturbance levels. Once final reclamation has been reached, vegetation establishment is 80% cover of pre-disturbance levels, and Encana has received the approved Final Abandonment Notice (FAN) from COGCC, any wildlife friendly fence present will then be removed.

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COGIS - Surety Detail

COMPANY DETAIL REPORT for Surety ID: 2009-0011
ENCANA OIL & GAS (USA) INC - #100185
370 17TH ST STE 1700
DENVER , CO 80202-5632
USA

SURETY DETAIL INFORMATION

Surety ID:	2009-0011
Status:	ACTIVE
Operator Number:	100185
Bond Amount:	$25,000.00
Instrument:	INSURANCE
Instrument Number:	105189968
Coverage:	BLANKET
Bond Type:	SURFACE
Limitation:	0
Deposit Number:	
PDPA Number:	
Received Date:	2/12/2009
Approved Date:	3/12/2009
Maturity Expire Date:	
FA Provider Number:	200097
FA Provider Name:	TRAVELERS CASUALTY AND SURETY COMPANY OF AMERICA
Deposit Date:	
Release Request Date:	N/A
Release Date:	N/A

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Article 4-203.G
Impact Analysis

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Article 4 – Impact Analysis
Encana Oil & Gas (USA) Inc.
K19 Storage Facility (Laydown Yard)

SECTION 4-203.G. IMPACT ANALYSIS

1. Adjacent Land Use

The proposed site is located within the boundaries of an 88.5 acre property. The storage use would be limited to a 5.17 acre area. Natural gas development, agriculture, light industrial, and wasteland are the uses on the subject parcel and surrounding properties. Natural gas development is the predominate use in the immediate area. The closest residential use to the proposed laydown yard is approximately a half mile to the north.

2. Site Features

The subject property is located in the Rural (R) zone district of Garfield County on Lot 3 of Section 19, Township 6 South, Range 92 West of the 6th PM. Access to the laydown yard is via Garfield County Road (CR) 315 (Mamm Creek Road) for approximately 4 miles from I-70 exit 94 to CR 333 (Hunter Mesa Road) for approximately 2.8 miles to a private access road (see Access Road Map). The K19NE Laydown Yard location is approximately 0.5 miles east of CR 333 on this private access road.

The elevation of the site is approximately 5,689 feet.

All native vegetation has been removed from the project site and the area is currently being used as a COGCC permitted well pad. The proposed laydown yard exists in a disturbed vegetation community dominated by grasses. The site appears to have been dominated previously by sagebrush/greasewood shrublands. Scattered patches of grease wood and big sagebrush, rabbitbrush, fourwing saltbush, and shadscale still persist in some areas. The understory is not diverse and was dominated by downy brome with scattered patches of galleta grass and weedy annuals. Additional species occurred in lesser coverage and amounts.

3. Soil Characteristics

Soils, consisting of the following units, are within the study area around the proposed laydown yard:

- Potts Loam, Map Symbol 55, is a moderately sloping soil found on mesas, benches, and the sides of valleys at elevations ranging from 5,000 feet to 7,000 feet amsl. The soil formed in alluvium derived from sandstone, shale, or basalt. Typically the surface layer is brown loam about four inches thick, the subsoil is reddish brown clay loam

about 24 inches thick, and the substratum is pinkish white loam to a depth of 60 inches thick.

Permeability is moderate, and the available water capacity is high. Surface runoff is slow and the erosion hazard is moderate. Community development and recreation are limited by low strength and the shrink-swell potential. Dwellings and roads can be designed to overcome these limitations.

4. Geology and Hazard

This is a summary of the Natural and Geologic Hazard Assessment Report that is provided with this application.

- The K19NE Storage Yard is not expected to have any buried or aboveground utilities.
- Avalanche conditions are not expected to be a hazard in the area of the Site.
- Rockfall areas are not a geological hazard in the area of the Site, but may exist in areas along Mamm Creek and its tributary drainages.
- The Site is not in an area mapped as an alluvial fan hazard area.
- Slope is not a geologic hazard in the vicinity of the site, but is in areas to the north and west along West Mamm Creek and Mamm Creek drainages.
- The Potts Loam soils are listed as a high risk of corrosion to uncoated steel and a low risk of corrosion to concrete. These soil characteristics are not expected to pose a geologic hazard for the proposed development at the K19NE Storage Yard.
- The shrink-swell potential for the Potts Loam is low to moderate. Therefore, expansive soils are not a geologic hazard at the K19NE Storage Yard.
- Collapsible soils are not present in the vicinity of the proposed K19NE Storage Yard.
- No significant faults have been mapped or are known in the K19NE Storage Yard. The Site is located to the northwest of the Divide Creek anticline which was formed as a result of movement along a blind thrust fault associated with the uplift of the Colorado Rocky Mountains.
- The Site is not mapped as being within the 100-year flood plain. Flash flooding is a hazard for lower elevations along the West Fork of Mamm Creek, Mamm Creek and its tributaries, and areas along the Colorado River located approximately two miles to the north and at elevations that are 100 feet to 200 feet lower than the Site elevation. Therefore, flooding is not expected to be a natural hazard affecting the Site.
- Uranium and Vanadium were mined to the northeast of the town of Rifle; and approximately ten miles north of the Site.
- There are no significant radioactive mineral deposits known in the immediate area of the Site. The presence of NORM may be an issue with exploration and production and could be an issue with used pipe scale or used equipment stored at the site. Radioactive materials are not expected to pose a significant hazard at the Site.

5. Groundwater and Aquifer Recharge Areas

No flood prone areas are mapped in the vicinity of the site. Areas along the West Fork of Mamm Creek are potentially prone to flash floods. An individual sewage disposal system (ISDS) is not being used at this site, so soils will not have to support waste disposal. The site was previously graded. Minor soil disturbance and construction activity may be required to accommodate the grading and drainage plan. All soil disturbances have been fully stabilized according to CDPHE and COGCC criteria.

6. Environmental Impacts

a. Determination of long-term and short-term effects on flora and fauna

Flora

The continued use and redevelopment of the existing location would not adversely affect federally listed plant species. No additional vegetation removal is associated with the laydown yard. Vegetation communities and conditions will not be affected on a long- or short-term basis and would remain in their present condition.

Fauna

Federally Listed Threatened, Endangered, and Candidate Wildlife Species

The continued use of the existing site as a laydown yard would not adversely affect federally listed wildlife species due to the lack of suitable habitat within or surrounding the project area. No federally designated critical habitat occurs within or near the site.

Colorado State listed Threatened, Endangered or Sensitive wildlife species would not be impacted by the proposed laydown yard due to the lack of suitable habitat available for those species within or surrounding the proposed project area.

Raptors, Birds of Conservation Concern, Migratory and Non-Migratory birds

No additional vegetation removal would be associated with the proposed laydown yard; therefore no suitable raptor, BCC, or other migratory or non-migratory bird species nesting habitat would be impacted. Long- or short-term effects related to the project area would be minimal due to the area being previously disturbed from activities associated with the operation and maintenance of the existing oil and gas well pad, and a lack of suitable nesting habitat in proximity to the site. Loud noises and human activities at the site during the breeding and nesting season may have limited indirect impacts on habitat effectiveness around the pad site, possibly reducing the suitability or effectiveness for nesting activities in the native shrubland habitats; but as mentioned, a lack of suitable nesting habitat in proximity to the pad limits the amount of potential impacts. Foraging and other habitat use would likely continue within adjacent habitats, as available.

American Elk and Deer

The existing site is absent of any vegetation, and no additional direct impacts to elk or deer habitats would occur. Elk and deer may be indirectly impacted during the winter months by increased noise and human presence and increased traffic along the

access road, which may cause elk and deer to avoid this area during certain times of day or during times of more intense human activities. The winter months are a critical time of year for big game species, when deer and elk are more likely to be utilizing lower elevations, and disturbance can have a larger relative impact due to poor foraging opportunities and already stressed animals. Intensive use of the laydown yard during the winter months may force deer and elk away from the area, which could increase energy expenditures for the individuals impacted.

During the summer and fall months, most deer and elk are at higher elevation habitats, and therefore use of the pad site outside of the winter would likely have no impact on deer or elk. The use of the laydown yard would not block or impede migration corridors for elk or mule deer. Long-term, reclamation of the site is recommended in order to improve winter range habitat effectiveness in the area.

b. Determination of the effect on designated environmental resources, including critical Wildlife Habitat

The K19NE Laydown Yard is not expected to affect any critical habitat for any wildlife species, as no federally designated critical habitat or species were identified within or near the site.

According to the CPW GIS data, the project area occurs within Overall, Severe Winter Range, Winter Concentration Areas and Winter Range for elk and mule deer. No additional vegetation removal or new construction is associated with the site that would further decrease habitat. The site would not impede any natural migration or movement through the area, but use of the site during the winter months may temporarily cause animals to avoid habitats around the site. Given the limited size and temporary nature of activities associated with laydown yard use, these impacts would likely be short-term in nature, and no measureable impact to mule deer or elk herds would be expected from this project. Activities in the winter months would have a relatively larger potential effect given the condition of animals in the winter months, and reduced availability of forage and security habitats. As mentioned, some individual animals may be indirectly impacted by moving away from the site, but no significant impacts to herds, or long-term impacts to critical wildlife habitat would be expected.

c. Impacts on wildlife and domestic animals through creation of hazardous attractions, alteration of existing native vegetation, blockade of migration routes, use patterns, or other disruptions

The laydown yard would not create hazardous attractions to avian or mammalian wildlife species or domestic animals, alter additional native vegetation, block migration routes, or cause a change in habitat use.

Wildlife species may be indirectly impacted by increased noise and human presence while equipment is being transferred and stored. Use of habitats by wildlife would still likely occur on or adjacent to the pad and storage yard site during the nighttime hours, and during times when there are no human activities at the laydown yard. The majority of the species occurring within the area have widespread habitats; therefore, most

wildlife species that may be indirectly affected would have other habitats in the greater area that are still available for foraging, reproduction, dispersal and shelter. The proposed project may impact individuals indirectly but would not likely impact populations. No impacts to domestic animals would be expected.

d. Evaluation of any potential radiation hazard that may have been identified by the State or County Health Departments

Radon is not expected to be a significant problem at the proposed Site, since the development will not include any occupied structures, personnel will not be onsite for extended periods, and the Site will not be developed with structures containing basements or substructures in which radon can accumulate. Colorado oil and gas operations are not known to have a significant problem with naturally occurring radioactive materials (NORM) or technologically enhanced naturally occurring radioactive materials (TENORM); however, there have been some instances where pipe scale has contained radium and associated radon gas. A NORM survey including site specific testing could be performed to further assess the radon potential at the Site to serve as a baseline assessment if used pipe or pipe scale is stored and is to be disposed offsite in the future.

7. Nuisance

Adjacent land uses will not be adversely impacted by the generation of vapor, dust, smoke, glare or vibration generated by the storage use beyond the limits set forth by Garfield County, the COGCC, the CDPHE and other regulatory agencies.

There will be no equipment stored on site that requires a CDPHE Air Quality Permit. Dust will be mitigated by use of water or other dust suppressants. A copy of Encana's Fugitive Dust Control Plan is included with this submittal.

There will be no equipment associated with the laydown yard permanently installed on the site that could potentially create a noise nuisance.

8. Hours of Operation

The K19 Laydown Yard will be accessible to Encana personnel 24 hours a day, year round. Materials will be picked-up and dropped-off on an as-needed basis. No personnel will be stationed at the facility on a regular basis.

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Article 4-203.G.3
NRCS Soils Report

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Rifle Area, Colorado, Parts of Garfield and Mesa Counties

Encana K29NE Storage Yard

November 6, 2014

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- 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
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Rifle Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 8, Sep 22, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 7, 2011—Sep 3, 2011

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Map Unit Legend

Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	5.5	100.0%
Totals for Area of Interest		**5.5**	**100.0%**

Map Unit Descriptions

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, 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. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. 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 includes general facts about the unit and gives important soil properties and qualities.

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.

Rifle Area, Colorado, Parts of Garfield and Mesa Counties

55—Potts loam, 3 to 6 percent slopes

Map Unit Setting

National map unit symbol: jnyr
Elevation: 5,000 to 7,000 feet
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Potts and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Potts

Setting

Landform: Mesas, benches, valley sides
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Alluvium derived from basalt and/or alluvium derived from sandstone and shale

Typical profile

H1 - 0 to 4 inches: loam
H2 - 4 to 28 inches: clay loam
H3 - 28 to 60 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 10.3 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3c
Hydrologic Soil Group: C
Ecological site: Rolling loam (R048AY298CO)

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

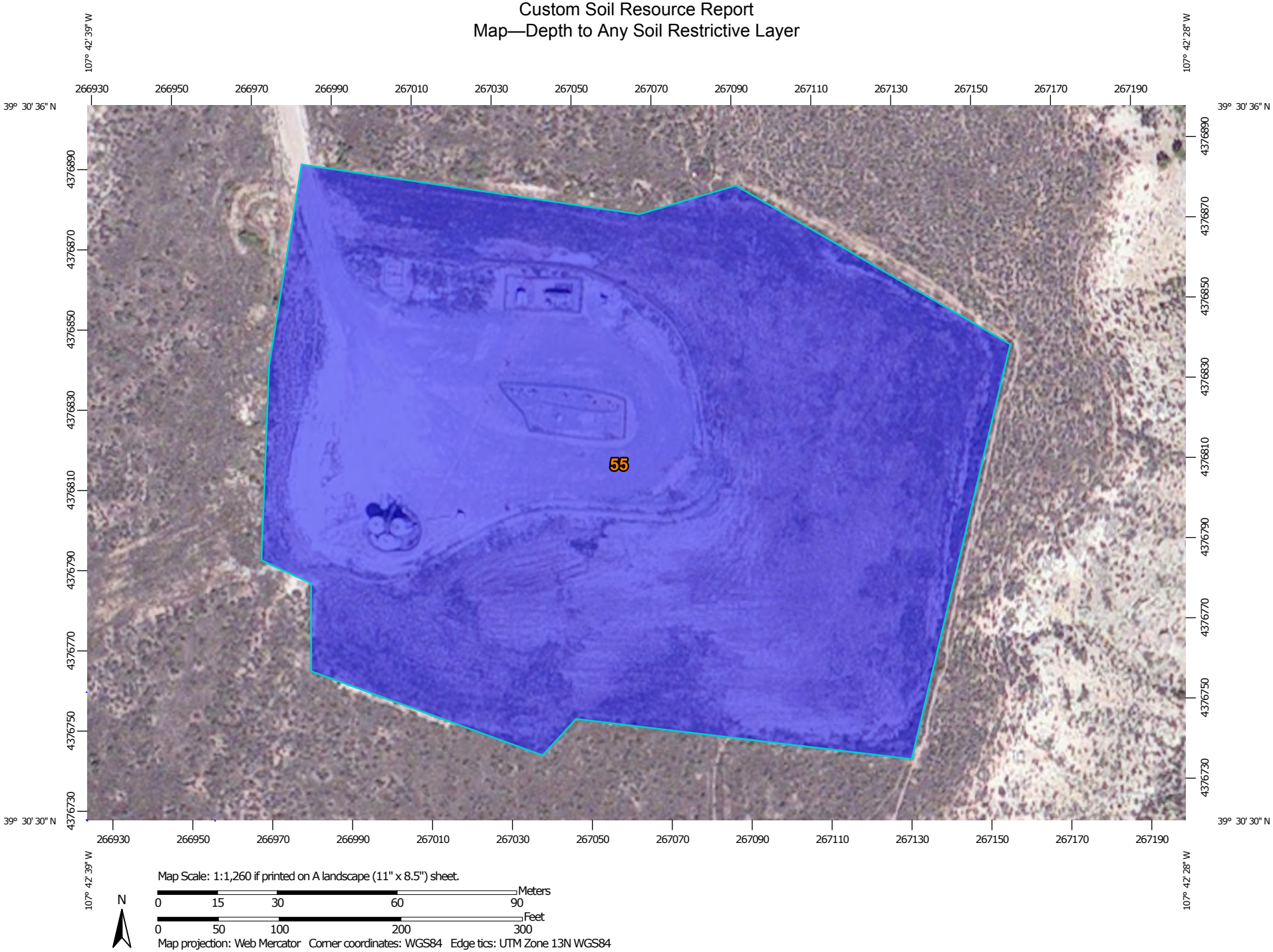
Depth to Any Soil Restrictive Layer

A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers.

This theme presents the depth to any type of restrictive layer that is described for each map unit. If more than one type of restrictive layer is described for an individual soil type, the depth to the shallowest one is presented. If no restrictive layer is described in a map unit, it is represented by the "> 200" depth class.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Depth to Any Soil Restrictive Layer



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Soil Rating Lines

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Soil Rating Points

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Table—Depth to Any Soil Restrictive Layer

Depth to Any Soil Restrictive Layer— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating (centimeters)**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	>200	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Depth to Any Soil Restrictive Layer

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

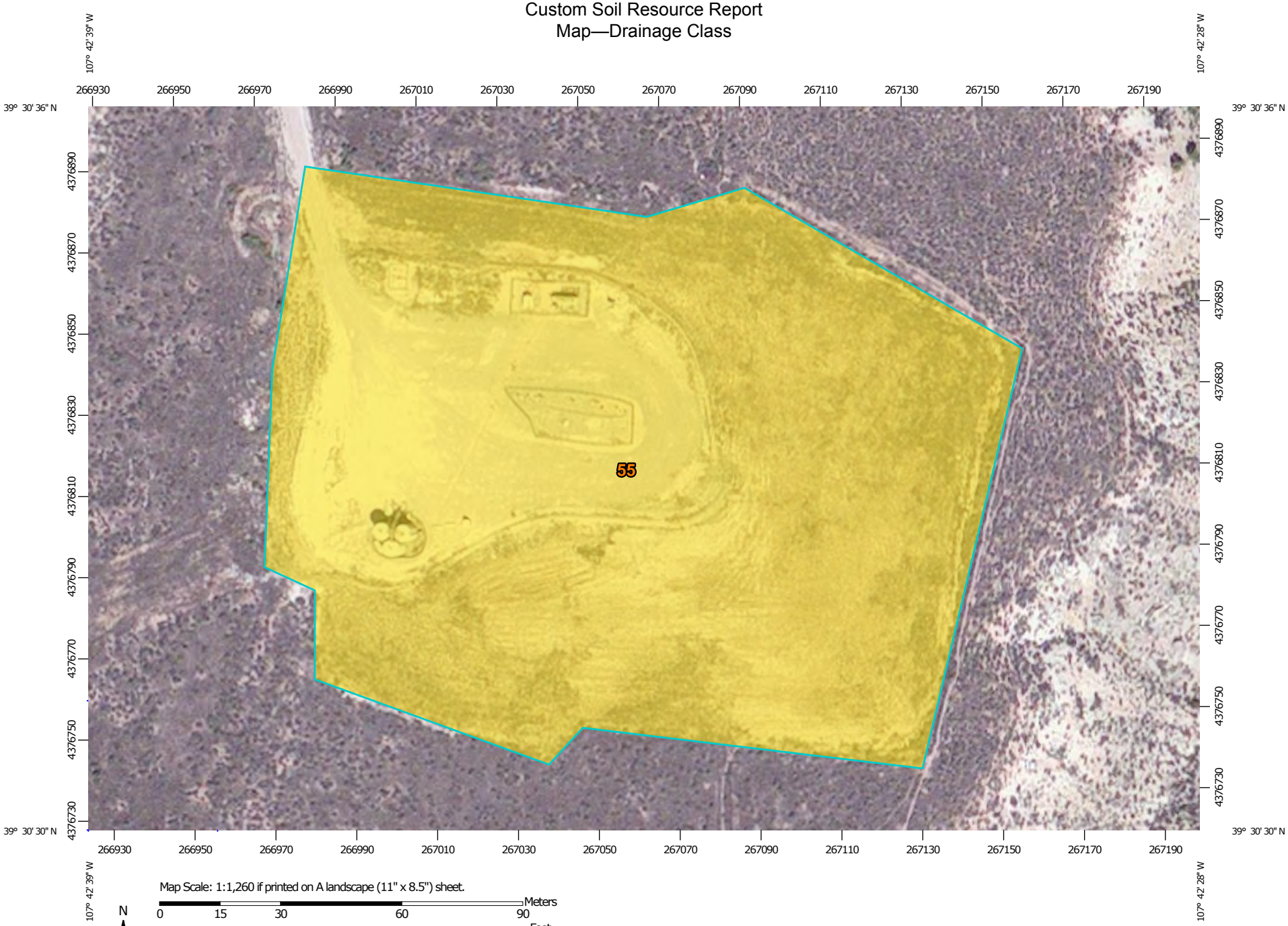
Tie-break Rule: Lower

Interpret Nulls as Zero: No

Drainage Class

"Drainage class (natural)" refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Custom Soil Resource Report
Map—Drainage Class



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Subaqueous
- Not rated or not available

Soil Rating Lines

- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Subaqueous
- Not rated or not available

Soil Rating Points

- Excessively drained
- Somewhat excessively drained
- Well drained
- Moderately well drained
- Somewhat poorly drained
- Poorly drained
- Very poorly drained
- Subaqueous
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

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Please rely on the bar scale on each map sheet for map measurements.

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Table—Drainage Class

Drainage Class— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	Well drained	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Drainage Class

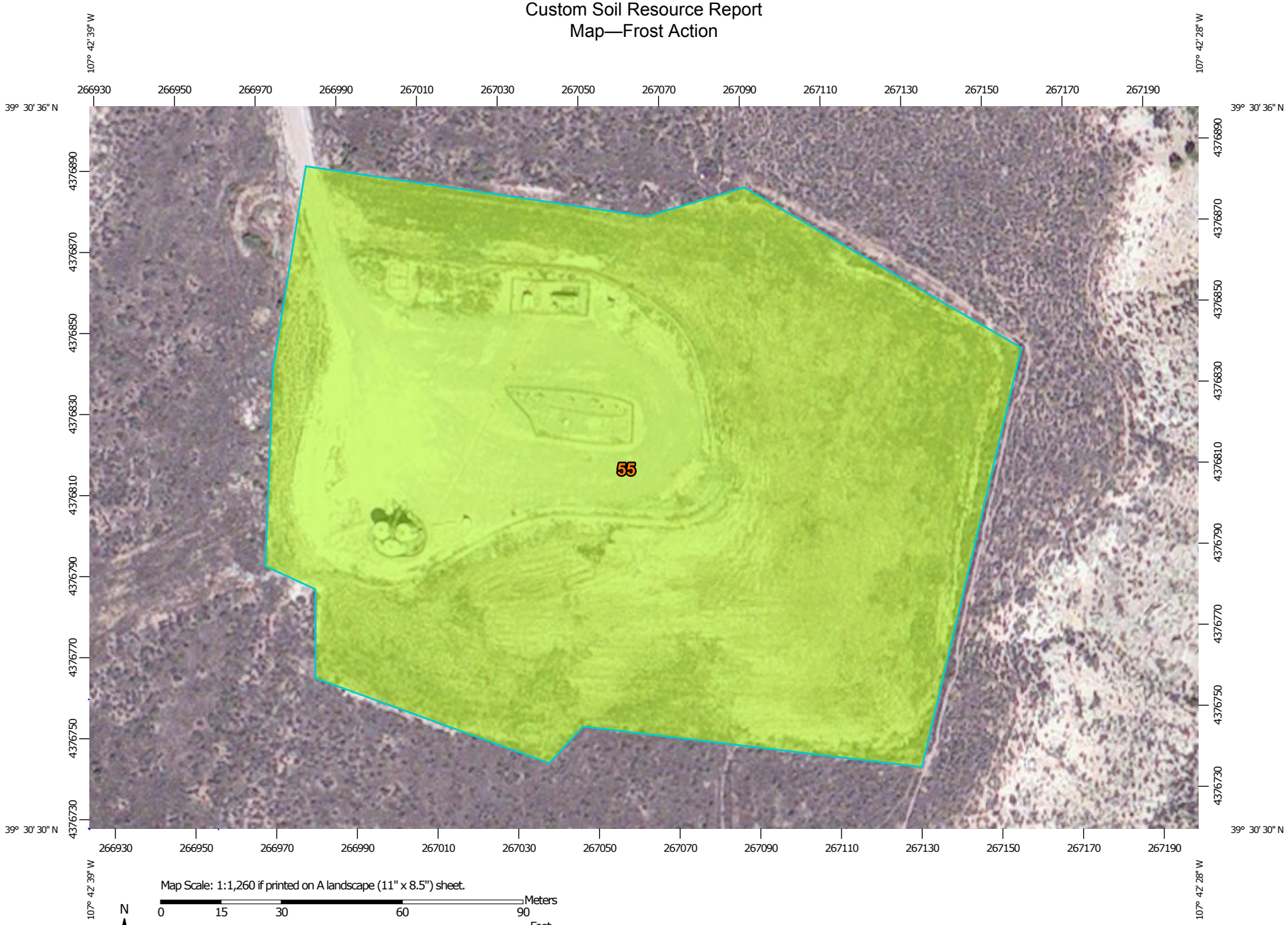
Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Frost Action

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.


107° 42' 39" W
107° 42' 28" W
39° 30' 36" N
39° 30' 30" N
266930
266950
266970
266990
267010
267030
267050
267070
267090
267110
267130
267150
267170
267190
4376890
4376870
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4376790
4376770
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4376730
55
N
Map Scale: 1:1,260 if printed on A landscape (11" x 8.5") sheet.
Meters
0 15 30 60 90
Feet
0 50 100 200 300
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- High
- Moderate
- Low
- None
- Not rated or not available

Soil Rating Lines
- High
- Moderate
- Low
- None
- Not rated or not available

Soil Rating Points
- High
- Moderate
- Low
- None
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

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Table—Frost Action

Frost Action— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	Low	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Frost Action

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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:

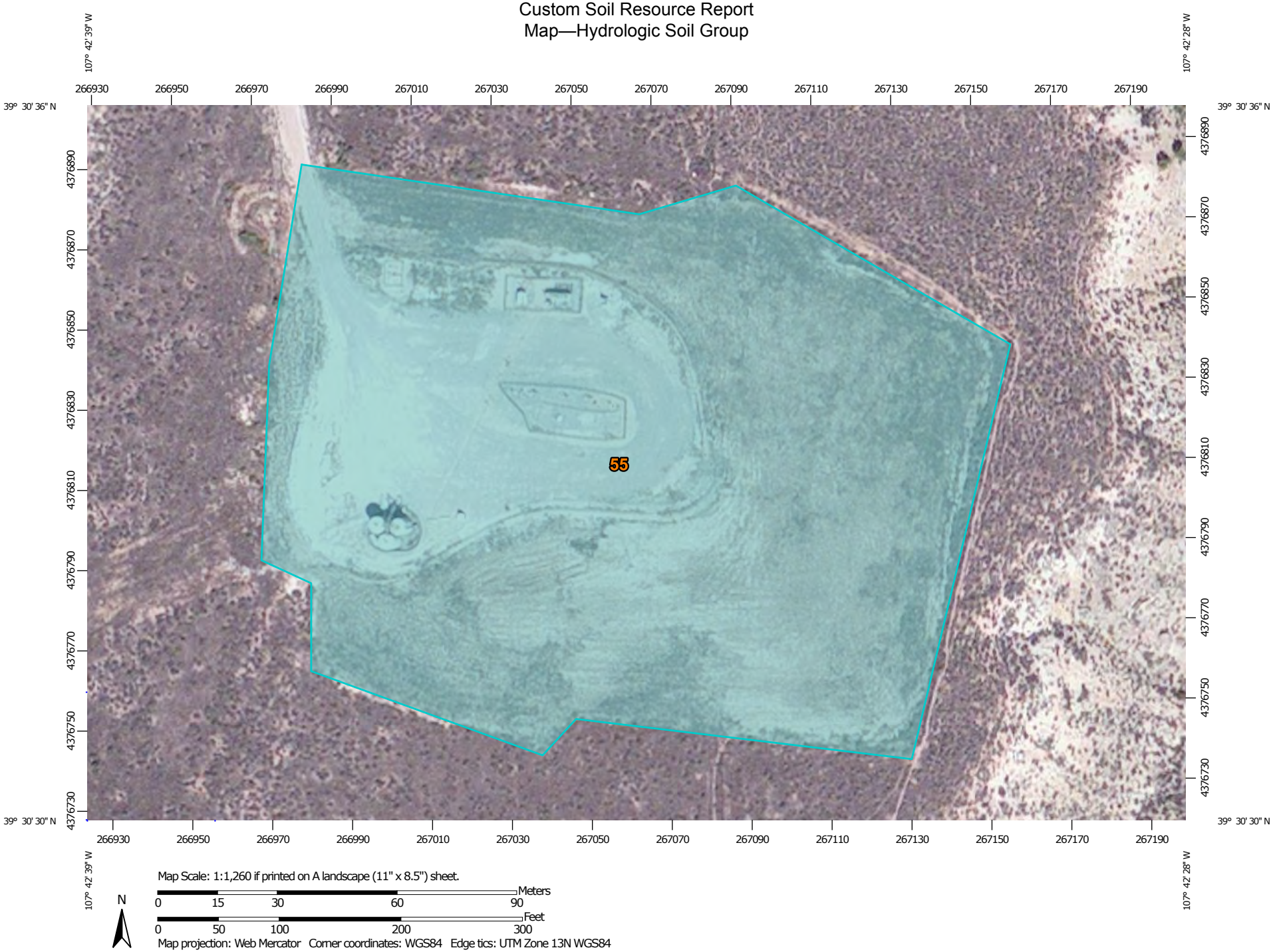
Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

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.


107° 42' 39" W
107° 42' 28" W
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39° 30' 30" N
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267090
267110
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55
Map Scale: 1:1,260 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 15 30 60 90
Feet
0 50 100 200 300
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

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Table—Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	C	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

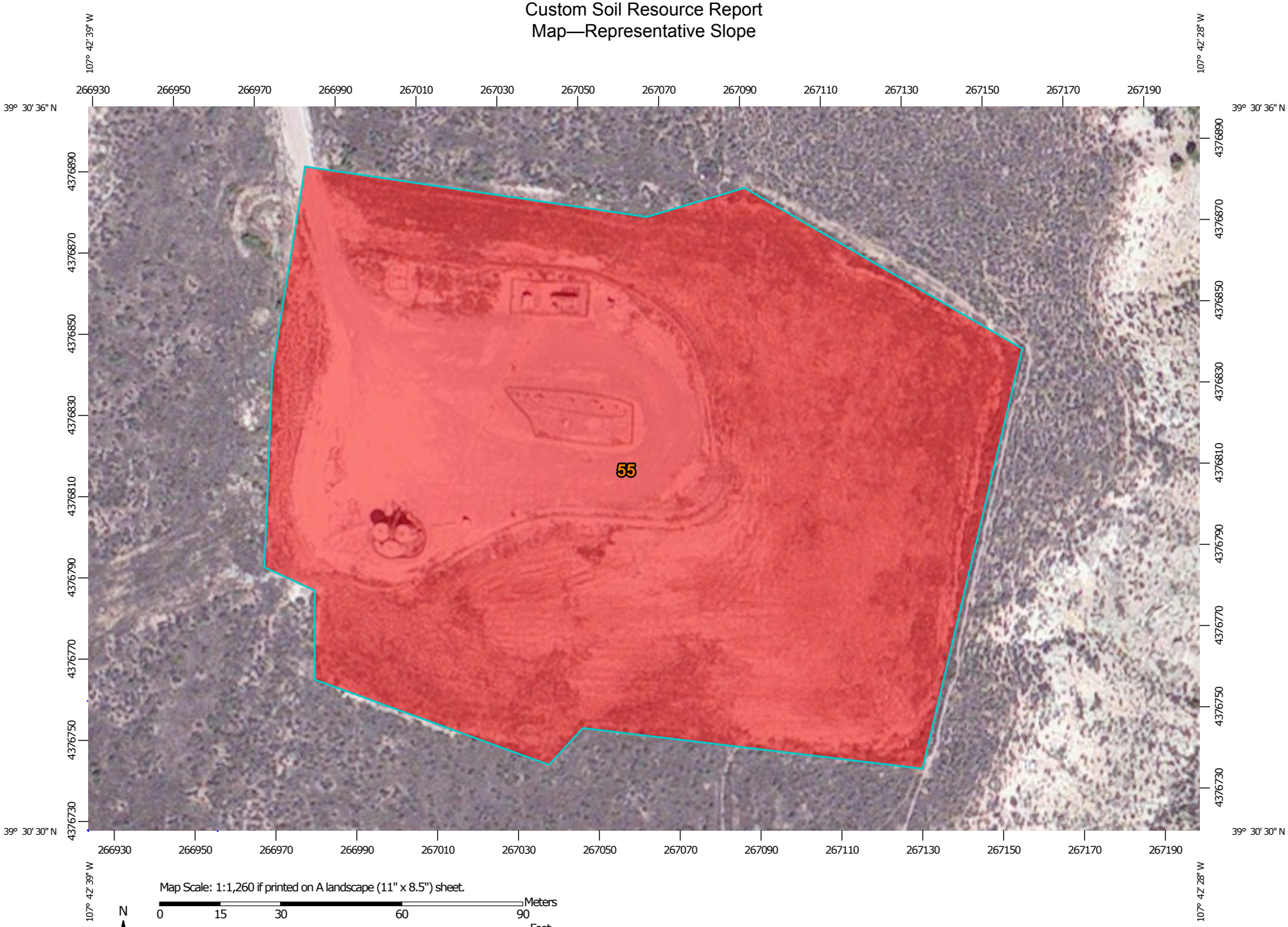
Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Representative Slope

Slope gradient is the difference in elevation between two points, expressed as a percentage of the distance between those points.

The slope gradient is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.


107° 42' 39" W
107° 42' 28" W
39° 30' 36" N
39° 30' 30" N
266930
266950
266970
266990
267010
267030
267050
267070
267090
267110
267130
267150
267170
267190
4376890
4376870
4376850
4376830
4376810
4376790
4376770
4376750
4376730
55
Map Scale: 1:1,260 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 15 30 60 90
Feet
0 50 100 200 300
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

0 - 5

5 - 15

15 - 30

30 - 45

45 - 60

60 - 100

Not rated or not available

Soil Rating Lines

0 - 5

5 - 15

15 - 30

30 - 45

45 - 60

60 - 100

Not rated or not available

Soil Rating Points

0 - 5

5 - 15

15 - 30

30 - 45

45 - 60

60 - 100

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Rifle Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 8, Sep 22, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 7, 2011—Sep 3, 2011

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.

Table—Representative Slope

Representative Slope— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating (percent)**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	5.0	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Representative Slope

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

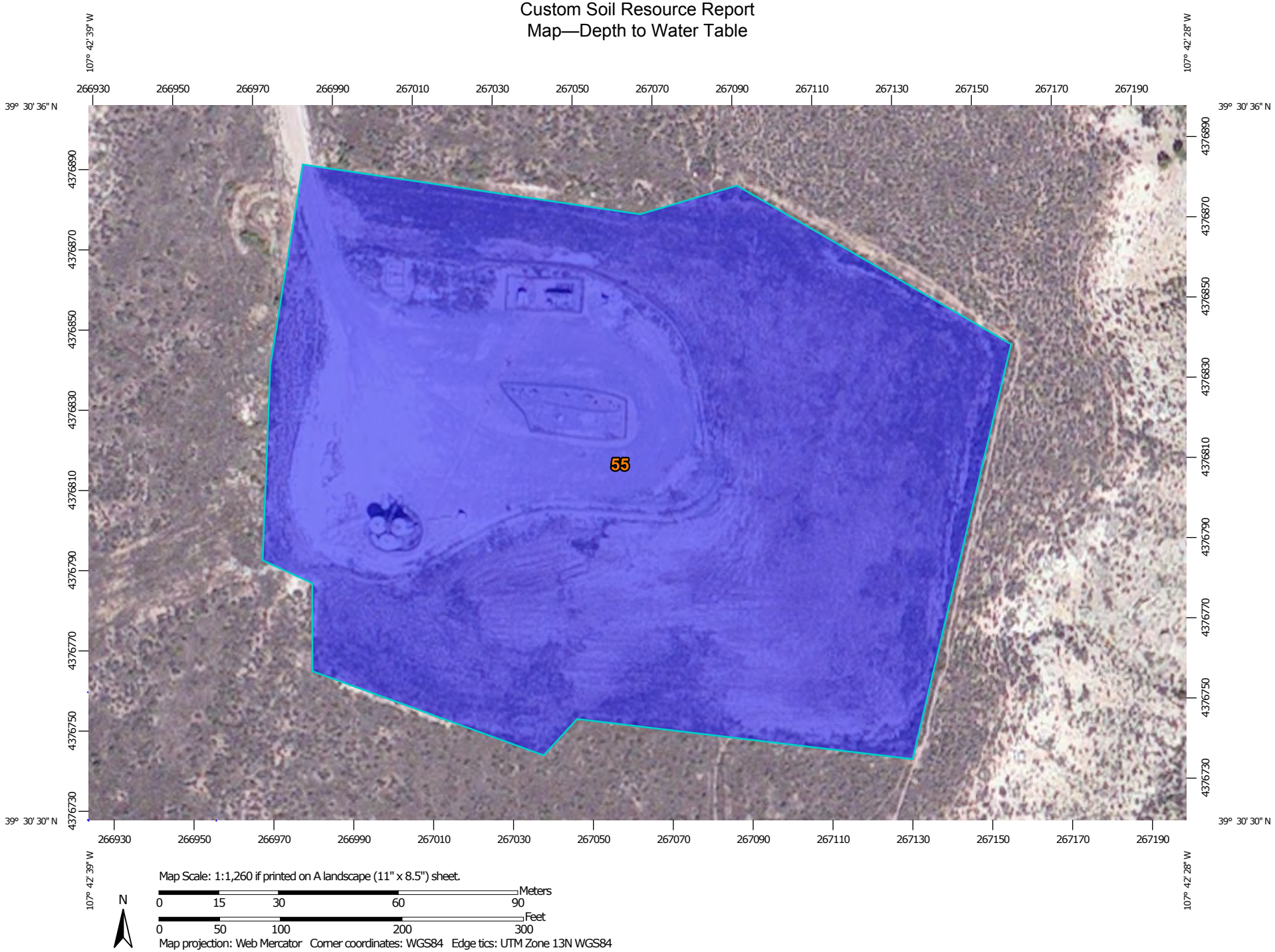
Water Features

Water Features include ponding frequency, flooding frequency, and depth to water table.

Depth to Water Table

"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.


107° 42' 39" W
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55
Map Scale: 1:1,260 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 15 30 60 90
Feet
0 50 100 200 300
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- 0 - 25
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- > 200
- Not rated or not available

Soil Rating Lines
- 0 - 25
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- > 200
- Not rated or not available

Soil Rating Points
- 0 - 25
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- > 200
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Rifle Area, Colorado, Parts of Garfield and Mesa Counties
Survey Area Data: Version 8, Sep 22, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 7, 2011—Sep 3, 2011

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.

Table—Depth to Water Table

Depth to Water Table— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating (centimeters)**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	>200	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Depth to Water Table

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Interpret Nulls as Zero: No

Beginning Month: January

Ending Month: December

Ponding Frequency Class

Ponding is standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes. Ponding frequency classes are based on the number of times that ponding occurs over a given period. Frequency is expressed as none, rare, occasional, and frequent.

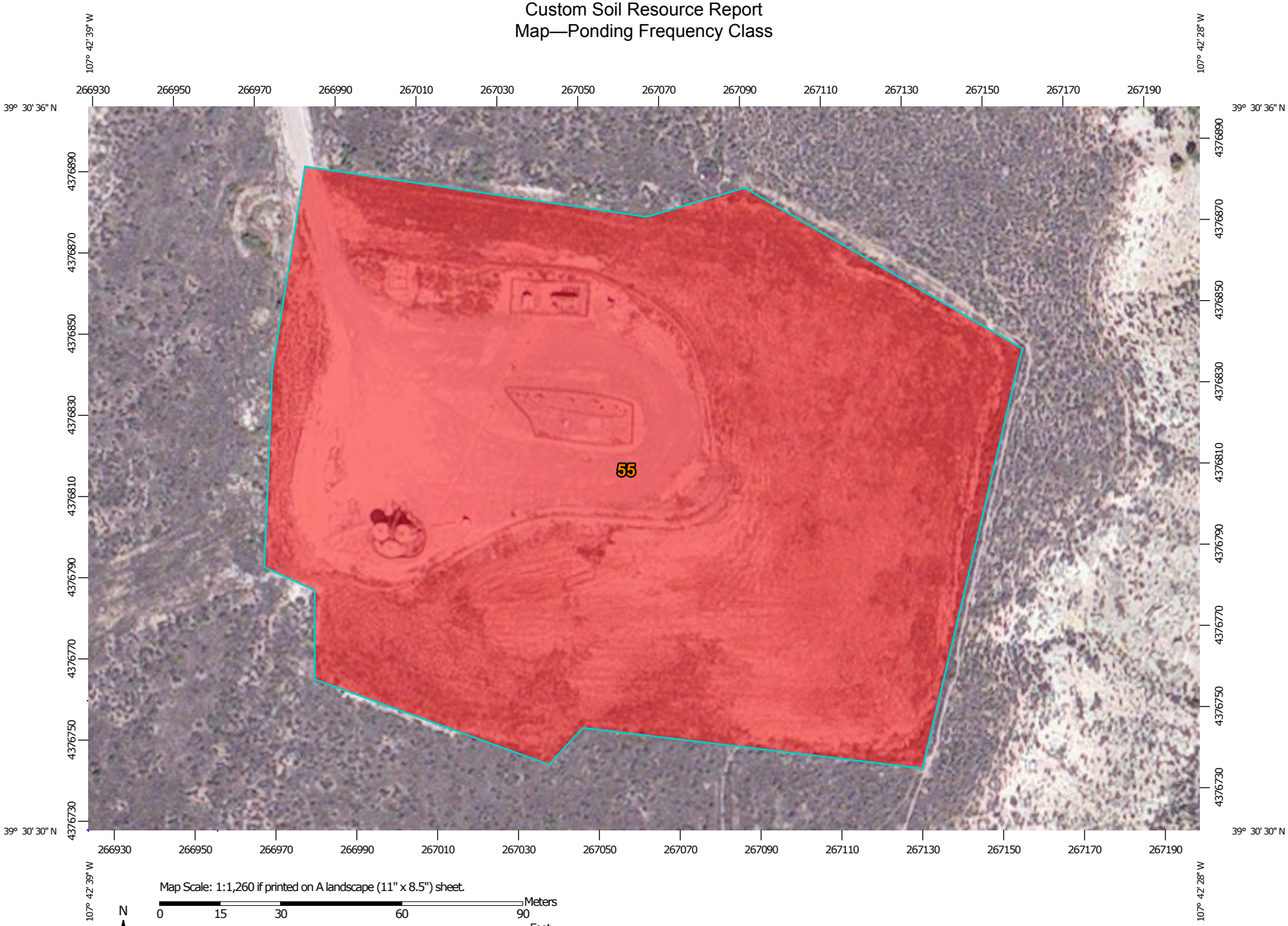
"None" means that ponding is not probable. The chance of ponding is nearly 0 percent in any year.

"Rare" means that ponding is unlikely but possible under unusual weather conditions. The chance of ponding is nearly 0 percent to 5 percent in any year.

"Occasional" means that ponding occurs, on the average, once or less in 2 years. The chance of ponding is 5 to 50 percent in any year.

"Frequent" means that ponding occurs, on the average, more than once in 2 years. The chance of ponding is more than 50 percent in any year.

Custom Soil Resource Report
Map—Ponding Frequency Class



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- None
- Rare
- Occasional
- Frequent
- Not rated or not available

Soil Rating Lines
- None
- Rare
- Occasional
- Frequent
- Not rated or not available

Soil Rating Points
- None
- Rare
- Occasional
- Frequent
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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Coordinate System: Web Mercator (EPSG:3857)

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

Soil Survey Area: Rifle Area, Colorado, Parts of Garfield and Mesa Counties
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Date(s) aerial images were photographed: Aug 7, 2011—Sep 3, 2011

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.

Table—Ponding Frequency Class

Ponding Frequency Class— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
55	Potts loam, 3 to 6 percent slopes	None	5.5	100.0%
Totals for Area of Interest			**5.5**	**100.0%**

Rating Options—Ponding Frequency Class

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: More Frequent

Beginning Month: January

Ending Month: December

References

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Article 4-203.G.4 Geologic and Soils Hazard Report

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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NATURAL AND GEOLOGIC HAZARDS ASSESSMENT REPORT

ENCANA OIL & GAS (USA) INC.
K19NE STORAGE YARD
NE ¼ SW ¼ (LOT 3) SECTION 19, T6S, R92W, 6TH P.M.
GARFIELD COUNTY, COLORADO

PREPARED FOR

ENCANA OIL & GAS (USA) INC.
143 DIAMOND AVENUE
PARACHUTE, COLORADO 81635

PREPARED BY

OLSSON ASSOCIATES
4690 TABLE MOUNTAIN DRIVE, SUITE 200
GOLDEN, COLORADO 80403

FEBRUARY 2015

PROJECT NO. 014-2797

OLSSON ASSOCIATES®

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Natural and Geologic Hazard Report Preface

Garfield County, Colorado, finalized the Land Use and Development Code (LUDC) with an effective date of July 15, 2013, last amended December 16, 2013. According to Section 7-108 Use of Land Subject to Natural Hazards of the Garfield County LUDC *"Land subject to identified Natural and Geologic Hazards, such as falling rock, landslides, snow slides, mud flows, radiation, flooding, or high water tables, shall not be developed unless it has been designed to eliminate or mitigate the potential effects of hazardous site conditions as designed by a qualified professional engineer and as approved by the County."*

The LUDC requires a Natural and Geologic Hazard Study be prepared by a qualified professional geologist and submitted with a development plan or plat. The LUDC defines a geologic hazard as "*A geologic phenomenon that is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property."*

The LUDC defines a Hazard Area as *"An area that contains or is directly affected by a geologic hazard, including but not limited to the following types of areas."*

A. Avalanche Area. "*A mass of snow or ice and other material that may become incorporated therein as such mass moves rapidly down a slope*."
B. Landslide Area. "*An area with demonstrably active mass movement of rock and soil where there is a distinct surface rupture or zone of weakness that separates the landslide material from more stable underlying material.*"
C. Mudflow Debris Area. "*An area subject to rapid mud and debris movement or deposit occurring after mobilization by heavy rainfall or snowmelt runoff. Such areas are formed by successive episodes of deposition of mud and debris.*"
D. Radioactive Area. "*An area subject to various types of radiation emission from radioactive minerals that occur in natural or manmade deposits of rock, soil, or water*."
E. Potentially Unstable Soils. "*An area of land identified as having soils that may cause damage to structures, such as buildings and roadways, as a result of over saturation or some other outside influence.*"

According to the Garfield County LUDC Section 4-203 Description of Submittal Requirements, the professional qualifications for preparation and certification of certain documents required by this Code are as follows:

> "*Geologist: Geology reports shall be prepared by either a member of the American Institute of Professional Geologists, a member of the Association of Engineering Geologists, or a qualified geotechnical engineer licensed in the State of Colorado."*

Currently, the State of Colorado does not require licensure or registration of geologists; however, Colorado Revised Statutes do require that geologic reports be prepared or authorized by a professional geologist, and the term “Professional Geologist” is defined in Colorado Statutes.

The references for these Statutes are shown here:

34-1-201. Definitions. As used in this part 2, unless the context otherwise requires:

(1) “Geologist” means a person engaged in the practice of geology.
(2) “Geology” means the science which treats of the earth in general; the earth’s processes and its history; investigation of the earth’s crust and the rocks and other materials which compose it; and the applied science of utilizing knowledge of the earth’s history, processes, constituent rocks, minerals, liquids, gases, and other materials for the use of mankind.
(3) “Professional geologist” is a person who is a graduate of an institution of higher education which is accredited by a regional or national accrediting agency, with a minimum of thirty semester hours (forty-five quarter) hours of undergraduate or graduate work in a field of geology and whose post baccalaureate training has been in the field of geology with a specific record of an additional five years of geological experience to include no more than two years of graduate work.
(4) 34-1-202. Reports containing geologic information. Any report required by law or by rule and regulation, and prepared as a result of or based on a geologic study or on geologic data, or which contains information relating to geology, as defined in Section 34-1-201 (2), and which is to be presented for any state agency, political subdivision of the state, or recognized state or local board or commission, shall be prepared or approved by a professional geologist as defined in Section 34-1-201(3).

Professional Geologist Certification

By means of this certification, I attest that:

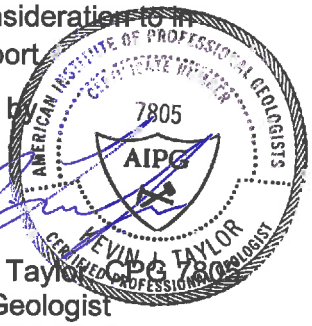
- I am qualified to prepare a Natural and Geologic Hazard Study in accordance with the provisions of Section 7-207 of the Garfield County LUDC, and that I am a member of the American Institute of Professional Geologists per LUDC 4-203.
- Although I have not visited the proposed Site, I am familiar with the geology and have performed field work in the area of the proposed Encana Oil & Gas (USA) Inc. Storage Yard located in the NE ¼ SW¼, (Lot 3) Section 19 Township 6 South, Range 92 West, 6th Principal Meridian in Garfield County, Colorado.
- Although Colorado does not currently have a licensing board or registration program for professional geologists practicing in the state of Colorado, there are requirements within local and State statutes that require that geologic reports be prepared by a professional geologist. I attest that I meet the requirements of the Colorado Geological Survey's definition of a professional geologist having completed and met the educational requirements of the Colorado Geological Survey definition.
- I am a licensed Professional Geologist and Professional Geoscientist in other States, including Texas, Utah, and Wyoming which do have licensing programs for professional geologists.
- I have reviewed published geologic maps and reports applicable to this area and have considered the implications of these conditions in the context of the proposed development.
- This report has been prepared in accordance with good scientific principles and engineering practices including consideration of applicable industry standards, and with consideration of the requirements of the National Association of State Boards of Geology. The conclusions and recommendations contained in this report are based on information available and known to me at the time of this report. Good scientific principles and standard engineering practices were taken into consideration in arriving at the conclusions and recommendations made in this report.

Prepared by

James W. Hix

James W. Hix, PG
Senior Geologist
Date: 02/02/2015

Reviewed by



Kevin J. Taylor, CPG 7805
Senior Geologist
Date: 02/02/2015

Note: The PG's certification does not relieve the owner/operator of the facility of the duty to review this report or fully implementing the recommendations in accordance with all applicable Federal, State, and local requirements in order to achieve the desired goals or objectives.

TABLE OF CONTENTS

FIGURES

List of Figures

1.0 EXECUTIVE SUMMARY

Olsson Associates (Olsson) was contracted by Encana Oil & Gas (USA) Inc. (Encana) to assess natural and geologic hazards potentially present in the area of the proposed Storage Yard (Site) located in the Lot 3 of Section 19, Township 6 South, Range 92 West, of the 6th Principal Meridian, in Garfield County, Colorado. The Site location is shown on the **V-1 Vicinity Map**. The Site is at an elevation of about 5,689 feet above mean sea level (amsl) as shown on the attached **T-1 Topographic Map**.

The purpose of this report is to identify geologic conditions that may pose hazards to a land development project in order that appropriate mitigation or avoidance techniques may be implemented as described in the Garfield County LUDC. According to the Garfield County LUDC, Section 7-207, the types of natural and geologic hazards identified pertain to the following:

A. Utilities;
B. Development in Avalanche Hazard Areas;
C. Development in Landslide Hazard Areas;
D. Development in Rock-fall Hazard Areas;
E. Development in Alluvial Fan Hazard Areas;
F. Slope Development;
G. Development on Corrosive or Expansive Soils and Rock;
H. Development in Mudflow Areas; and
I. Development Over Faults.

This report presents Olsson findings following an evaluation of these and other geologic hazards potentially affecting the Site and proposed development. The Encana site was found to be suitable for the proposed development with consideration of the following identified geologic hazards.

- No utilities are planned for the proposed Site development.
- The Site is not in an Avalanche Hazard Area.
- The Site is located on a gently sloping parcel of land south of the Mamm Creek drainage and bound to the west by the West Mamm Creek drainage and to the east by unnamed tributary drainages to Mamm Creek. Slopes do not appear to be a hazard affecting the Site since it is in an area of gentle slopes.
- The soil beneath the Site is mapped as the Potts Loam (Map Unit # 55). These soils are found on three percent to six percent slopes; however, soil in adjacent areas along Mamm Creek and the tributary drainages are mapped as Rock outcrop –Torriothents complex and are found on steep slopes ranging from 12 percent to 25 percent to the west, and steep slopes to the north.
- The Site is not located in an area of rock-fall or landslide hazards.
- According to the Colorado Oil and Gas Conservation Commission (COGCC) GIS online map, the bedrock geology has been mapped (scale of 1:500,000) in the vicinity of the Site as the Tertiary age Wasatch Formation including the Fort Union equivalent at its

base and the Ohio Creek Formation. Quaternary gravels and alluviums of Pinedale and Bull Lake Age are shown to the south in Section 30, Township 6 South, Range 92 West. According to the Geologic Map of the Silt Quadrangle, Garfield County (1:24,000), the Site surficial geology consists of Quaternary age loess deposits overlying older terrace alluvium and bedrock consisting of the Eocene Shire Member of the Tertiary Wasatch Formation.

- According to the Geologic Map of the Leadville Quadrangle, alluvial fan gravels are mapped on Grass Mesa to the west, but the site is not in an area mapped as having alluvial fan deposits; therefore, the site is not in an alluvial fan hazard area.
- According to the Geologic Map of the Leadville 1° x 2° Quadrangle, Colorado (scale 1:250,000), and the Geologic Map of the Silt Quadrangle, there are no mapped faults in the area of the Site. The axis of the Rifle Syncline lies to the north of the Site subparallel to the Colorado River drainage.
- The Eocene Shire Member bedrock dip angles in the vicinity of the Site have been measured and range from seven degrees to ten degrees to the west and northwest as plotted on the Geologic Map of the Silt Quadrangle. This compares to dip angles of nearly 90 degrees along the Grand Hogback north of the town of Rifle and areas where the bedrock strata is overturned. This is evidence of thrust faulting in the region.
- The Silt topographic quadrangle map and the Geologic Map of the Silt Quadrangle do not show any mining operations in the immediate vicinity of the site. There are sand and gravel quarries located along the Colorado River drainage to the north. Natural gas wells and production facilities are present in the vicinity of the Site and surrounding areas.
- The Site is not mapped within the FEMA 100-year flood plain. The Site is located at an elevation of approximately 5,689 feet approximately two miles south of the Colorado River which is at an elevation of approximately 5,368 feet above mean sea level (amsl). The bottom of the drainage to the west of the Site is at an elevation of approximately 5,581 feet amsl. These drainages and the Colorado River may experience flash floods, but the K19NE Site is located above the expected flood stage.

There do not appear to be any significant natural or geologic hazards associated with the Site proposed for the Encana Site. This report should be read in its entirety, including but not limited to the conclusions and recommendations in Section 4.0.

2.0 GENERAL SITE LOCATION AND BACKGROUND

Encana contracted Olsson Associates (Olsson) to conduct a natural and geologic hazards assessment as part of the proposed development of the K19NE storage yard (Site). The proposed facility will be used to store surplus equipment and materials used in the drilling and production of natural gas wells in the area. The following sections provide information about the proposed development and the Site geologic setting.

2.1 Project and Site Description

The proposed Site is located southeast of the town of Rifle, Colorado off of Garfield County Road 333 south of the Garfield County Municipal Airport. The Site is located in the Lot 3 of Section 19, T6S, R92W, 6th P.M. (39.50956° N -107.70974°W) and is located on parcel #2179-193-00-128. The surface land parcel encompasses approximately 88.42 acres and is owned by Encana; however the storage yard occupies approximately 2.7 acres in the south central part of the parcel.

2.2 Structural Geology

The Site is located in the southeastern part of the Piceance Basin. The Piceance Basin is an irregularly-shaped elongated basin formed by tectonic forces associated with the Laramide orogeny. These forces down warped the earth's crust and formed the Piceance Basin as a result of the uplift of the surrounding Colorado Rocky Mountains and the Colorado Plateau. The area geology is shown on the **G-1 Geologic Map**.

The Piceance Basin is the major structural geologic feature in the region. It is bound to the east by the Grand Hogback monocline, the White River Uplift to the northeast, the Gunnison Uplift to the south, the Uncompahgre Uplift to the south and southwest, the Douglas Creek Arch to the west-northwest, and the axial basin uplift to the north. Sedimentary rocks in the southwestern Piceance Basin gently dip to the north-northeast except where this regional dip is interrupted by low-amplitude folds. Numerous small sub-parallel northwest trending folds have been identified within the basin. The Divide Creek and Wolf Creek anticlines are two gentle, north-northwest trending, natural gas producing intrabasin folds located near the eastern margin of the Piceance basin. (Grout and Verbeek, 1992). These anticlines are located south-southeast of the Site. The bedrock in the vicinity of the Site dips at angles between seven degrees and ten degrees to the west-northwest.

A fault is a fracture in rock along which movement has occurred. Mountains are bound by faults and are a visible indication of a structural weakness in the earth's crust. The Colorado Rocky Mountains are bound by faults; however, these faults are not always visible at the ground surface either because the fault trace is 'blind', meaning that the fault does not have surface expression since it does not cut across overlying sedimentary bedrock units, or that it has been buried and concealed by unconsolidated sediments deposited over the area where the faults are present.

There are no mapped faults shown in the immediate area of the Site on the Geologic Map of the Leadville 1° x 2° Quadrangle, Garfield County, Colorado (Tweto, Moench, and Reed, 1978) or on the Geologic Map of the Silt Quadrangle, Garfield County, Colorado (Shroba and Scott,

2001) (Scale 1:24,000). However, folds such as the intrabasinal Divide Creek anticline and Wolf Creek anticline, and the Grand Hogback monocline, which defines the eastern margin of the Piceance Basin, have been interpreted as the surface expression of thrust faulting in which a wedge of basement rock was moved west-southwest during the uplift of the Rocky Mountains during the Laramide orogeny. Movement along the thrust fault compressed the overlying sedimentary rock which formed these low amplitude folds and the Grand Hogback (Grout and Verbeek, 1992).

2.3 Site Geology

The area geology is shown on the **G-1 Geologic Map**. According to the Geologic Map of the Silt Quadrangle ((Shroba and Scott, 2001), bedrock mapped in the area of the Site consists of the Eocene Shire Member of the Wasatch Formation which consists of variegated purple, lavender, red, gray, and brown claystone; some locally lenticular, fine- to coarse-grained sandstone and conglomerate, and thin limestone beds. The maximum exposed thickness of the Shire Member is approximately 1,600 feet, and reaches up to 3,900 feet thick in the Silt Quadrangle (Shroba and Scott, 2001).

The Shire Member is the upper member of the Wasatch Formation and overlies the Molina Member and Atwell Gulch Member, which in turn lie above the Ohio Creek Formation. The Ohio Creek Formation marks the boundary between the Cretaceous and Tertiary sedimentary rocks in the Piceance Basin (Donnell, 1969).

The bedrock at the site is mantled by Quaternary age terrace alluvium and loess deposits. Terrace deposits associated with Pinedale and Bull Lake age are mapped to the south in Section 30 and the SE ¼ SE ¼ Section 19, T6S, R92W.

2.4 Soil

The Natural Resources Conservation Service (NRCS) **S-1 Soils Map** shows the area soil types. Soils, consisting of the following units, are within the study area around Site:

Potts Loam, Map Symbol 55, is a moderately sloping soil found on mesas, benches, and the sides of valleys at elevations ranging from 5,000 feet to 7,000 feet amsl. The soil formed in alluvium derived from sandstone, shale, or basalt. Typically the surface layer is brown loam about four inches thick, the subsoil is reddish brown clay loam about 24 inches thick, and the substratum is pinkish white loam to a depth of 60 inches thick.

Permeability is moderate, and the available water capacity is high. Surface runoff is slow and the erosion hazard is moderate. Community development and recreation are limited by low strength and the shrink-swell potential. Dwellings and roads can be designed to overcome these limitations.

2.5 Hydrologic Setting

The Site is located at an elevation of approximately 5,689 feet, bound to the west by the West Fork of Mamm Creek and the main branch of Mamm Creek lies to the north. The surface water hydrology and shallow groundwater contained in the alluvium are controlled by Mamm Creek and its tributary drainages. Surface water flow is to the west – southwest toward the confluence

with the main branch of Mamm Creek. Shallow groundwater is expected to follow topography and flow toward and parallel the flow of the West Fork of Mamm Creek to the north toward the confluence with Mamm Creek and its confluence with the Colorado River approximately two miles north of the Site. These surface water features are shown on the **H-1 Hydrography Map**.

2.6 Aquifers

The Wasatch Formation consists predominantly of very fine-grained claystone and mudstone with lenses of very fine-grained to coarse-grained sandstone and conglomerate. The matrix of these rock types generally exhibits low porosity, relatively low hydraulic conductivity, or the ability to transmit groundwater. Therefore the Wasatch Formation is generally considered a confining unit. Some lenticular sandstones yield water wells in some areas south of the town of Rifle; however, the quantity and quality of this water is variable. The most productive wells are those completed in areas with secondary porosity or interconnected bedrock fractures.

Alluvial aquifers consist of unconsolidated sediments deposited along the Colorado River, Mamm Creek, and major tributaries to these streams. The thickness of the unconsolidated sediments must provide for sufficient volume and stream valley size to be capable of yielding groundwater to domestic wells to be of significance for domestic or use for livestock.

2.7 Permitted Water Wells

Three groundwater monitoring holes were permitted by Encana in 2007 in anticipation of constructing a centralized E&P waste management facility per COGCC Rule 908 on the property. The E&P waste management facility was never constructed, and it does not appear that the monitoring wells were ever drilled as the last correspondence with the Colorado Division of Water Resources was to request an extension.

There are permitted water wells located in the NW ¼ NW ¼ Section 19, Township 6 South, Range 92 West. Well permit #190496 MH 26571 was drilled in November 1995, and recorded in May 1996 by the Division of Water Resources. The total depth of the well is listed at 203 feet. The driller's log indicates that from the surface to 56 feet below ground surface (bgs) consisted of large river gravels, from 56 feet to 130 feet bgs consisted of hard red sandstone, from 130 feet to 135 feet consisted of fractured gray shale, from 135 feet to 180 feet bgs consisted of hard red sandstone, and from 180 feet to 203 feet bgs consisted of gray shale. Groundwater was reportedly encountered at 130 feet to 135 feet bgs with a yield of approximately one gallon per minute (gpm).

Water well permit 26571 MH is a monitoring hole permitted in 1995. The notification for this well was for a second monitoring/observation well drilled since the first hole was drilled to 333 feet in depth, was dry, and was plugged and abandoned per state rules (see 25935 MH) to the Division of Water Resources.

A water well was drilled in the NW ¼ NW ¼ of Section 19 in April 1998, and was advanced to 400 feet bgs. Lithologies consisted of sandstone, shale, mudstone to the total depth. Groundwater was reportedly encountered at 285 feet to 292 feet bgs with a yield of ½ gpm, and at 360 feet to 367 feet with a yield of 1 to 1½ gpm.

3.0 NATURAL AND GEOLOGIC HAZARD ASSESSMENT

The following sections present the assessment of geologic hazards in the vicinity of the Site. The **T-1 Topographic Map** shows the location of the Site in relation to the affected parcel and local roads.

3.1 Utilities

Trenches for water pipelines, natural gas pipelines, and electrical lines are not expected to be associated with the proposed development of the Site. The slopes and rocky soil may pose technical challenges to the installation of utilities; however, it is expected that these limitations can be overcome with proper design and installation if utilities are installed.

Aboveground utility facilities located in Hazard Areas are to be protected by barriers or diversion techniques approved by a qualified professional engineer. The determination to locate utility facilities aboveground will be based upon the recommendation and requirements of the utility service provider and approved by the County. Aboveground utilities, such as transformers and electrical lines, are not expected to be affected by geologic or other natural hazards.

3.2 Avalanche Hazard Area

Winters are cold in the mountainous areas of Garfield County, and valleys are colder than the lower parts of adjacent mountains due to cold air drainage. Average seasonal snowfall in Garfield County is 50 inches. The greatest snow depth at any one time during the period of record from 1951 to 1974 was 29 inches recorded at Rifle, Colorado approximately 5 miles to the northwest of the proposed Site.

Avalanches are not expected to affect the proposed Site, since it is located at an elevation of approximately 5,689 feet amsl. Areas in eastern Garfield County are at higher elevations, receive more snow pack, and are, therefore, more prone to avalanches in certain years.

Avalanches are the most dangerous geologic hazard in Colorado resulting in injuries, loss of life, and about $100,000 in direct property damage, and indirect economic losses in the millions of dollars annually. However, the avalanche prone areas include the Park Range and Flat Tops in northeastern Garfield County, Colorado, to the north of Glenwood Springs. Glenwood Springs, near the east edge of the area, averages about one degree cooler than Rifle and receives about five inches more precipitation per year (Harman and Murray, 1985).

3.3 Landslide Areas or Potential Landslide Hazard Areas

The Shire Member has been identified in areas of steeper slopes on the Rifle Quadrangle to the west as being a potential landslide hazard, but these conditions are not present in the vicinity of the Site. According to Map 24 – Surface Geology map, Geologic Hazards Identification Study (Lincoln Devore, 1975-1976), there are landslide areas shown to the southwest of the town of Rifle, but not in areas to the southeast of Rifle or County Road 333 (Garfield County, Surface Geology, 2007).

3.4 Rockfall Areas

The Site is located in an area with moderate to gentle slopes ranging from three percent to six percent slopes. The underlying bedrock in the vicinity of the Site dips seven to ten degrees to the west-northwest. Rock fall is not a potential geologic hazard in the vicinity of the Site. Rockfall is a potential geologic hazard in areas along the West Mamm Creek and Mamm Creek drainages to the west and north of the Site.

3.5 Alluvial Fan Hazard Areas

The Site is not located in an area that is mapped as being in an alluvial fan hazard area according to the Garfield County Surficial Geology, 2007. The Site is located on loess deposits and older alluvium mantling bedrock of the Wasatch Formation. There are alluvial fans to the west on Grass Mesa.

3.6 Unstable or Potentially Unstable Slopes

According to the Garfield County Slope Hazard Study Areas 1, 2, & 3 Map 22, areas of moderate slope are depicted south of the Colorado River and Interstate 70 near the town of Rifle, Colorado, but have not been mapped as being areas of major slope hazard. The areas along County Road 333 are not mapped as a slope hazard area in the vicinity of the Site. Moderate slope hazard areas were identified along the West Mamm Creek and Mamm Creek drainages.

3.7 Corrosive or Expansive Soils and Rock

According to the Soil Survey of the Rifle Area, the Potts Loam soils pose a high risk of corrosion to uncoated steel, but a low risk of corrosion to concrete. The Potts Loam soils have a low to moderate shrink-swell potential. These soil characteristics are not expected to pose a hazard to the proposed Site development as a storage yard.

Some Tertiary and Cretaceous age sedimentary rocks with high clay content are capable of accepting water into their chemical structure and expanding many times their volume when dry. These sedimentary rocks and soils formed from these rock types, may expand or contract as they become wet and then dry out resulting in damage to structures built upon them.

3.8 Mudflow and Debris Fan Areas

The Site is not located in an area of mapped mud flow and debris fan areas. Mudflows and debris flows have been mapped on the Rifle Quadrangle and Rulison Quadrangle further to the west of the Site.

3.9 Development Over Faults and Risk of Seismic Activity

There are no major faults shown in the immediate area of the Site; however, the Site is located to the northwest of the Divide Creek anticline which trends to the northwest. The Divide Creek anticline and Wolf Creek anticline are the surface expression of compressional forces associated with movement along a blind thrust fault that occurred during the uplift of the Colorado Rocky Mountains.

Today, Colorado is considered a region of minor earthquake activity; however, there is uncertainty due to the relatively short historic record. According to the USGS Colorado Earthquake History online, newspaper accounts were the primary source of earthquake data in Colorado prior to 1962. Few earthquakes have been reported in this part of Colorado. A very minor earthquake occurred in the northwestern part of Colorado on November 22, 1982 at 3:09 a.m. MST. The magnitude 2.9 (Richter scale) earthquake was located about 18 miles northeast of the town of Rifle and was felt at a fish hatchery in the area.

The largest quake in the area occurred on April 22, 1984 and had a magnitude of 3.1 on the Richter scale. The quake was felt in Carbondale and in Glenwood Springs. Of the hundreds of quakes that occurred in the Carbondale area during that time period, 12 were reported as felt.

3.10 Flood Prone Areas

The facility is not shown within the FEMA 100 year flood hazard zone based on the Flood Plain Map in the Vicinity of the Town of Rifle, Garfield County, Colorado, or a Firmette Map generated from the FEMA data along the Colorado River. The Site is located approximately two miles south of the Colorado River. The Colorado River lies at an elevation of approximately 5,368 feet amsl, and the Site is located at an elevation of approximately 5,689 feet amsl.

Areas along the West Fork of Mamm Creek are potentially prone to flash floods; however, the creek is located at an elevation of 5,589 feet, or 100 feet below the Site. The flood plain along the Colorado River is shown in relation to the Site on the attached **F-1 Flood Plain Location Map**.

3.11 Collapsible Soils

According to the Soil Hazard Profile, Study Areas 1, 2, & 3, Garfield County, prepared by Lincoln-Devore Testing Laboratory in 1975-1976, the area southeast of Rifle was not identified as a soil hazard area.

Collapsible soils are another type of subsidence that occurs in parts of western Colorado where unconsolidated sediments are present. This ground settlement can damage man-made structures such as foundations, pavements, concrete slabs, utilities, and irrigation works. Collapsible soils have not been mapped in the area and are not expected to be encountered in the vicinity of the Site.

3.12 Mining Activity

There is no mining activity in the immediate area of the Site. There are sand and gravel operations located along the Colorado River, and there are natural gas exploration and production facilities in the area of the Site.

3.13 Radioactivity

Naturally occurring radioactive materials are not expected to be an issue at the Site. Colorado oil and gas operations are not known to have a significant problem with naturally occurring radioactive materials (NORM) or technologically enhanced naturally occurring radioactive materials (TENORM); however, there have been some instances where pipe scale has contained radium and associated radon gas. A NORM survey including site specific testing

could be performed to further assess the radon potential at the Site to serve as a baseline assessment if used pipe or pipe scale is stored and is to be disposed offsite in the future.

Olsson reviewed the Colorado Bulletin 40, Radioactive Mineral Occurrences of Colorado which states that nearly all of Garfield County's uranium production came before 1954, and most of that came from the Rifle and Garfield mines. Both of these mines were located along the same ore body northeast of the town of Rifle in Section 34 and Section 35, Township 4 South, Range 92 West, or approximately 10 miles to the north of the Site (Fischer, 1960).

These occurrences were all hosted in the Jurassic Morrison and Entrada Formations, and the Triassic-Jurassic Navajo Sandstone, or the Triassic Chinle Formation which are known to contain uranium and vanadium deposits in the county and in the Colorado Plateau in general (Nelson-Moore, Collins, and Hornbaker, 1978). These formations lie at great depth in the vicinity of the Site and are stratigraphically below the depth of the Wasatch Formation.

The Colorado Department of Public Health and Environment (CDPHE) has posted a statewide radon potential map on their website based on data collected by the EPA and the U.S. Geological Survey. Garfield County and most of Colorado has been mapped as being within Zone 1 – High Radon Potential, or having a high probability that indoor radon concentrations will exceed the EPA action level of 4 picocuries per liter (pCi/L).

Radon is not expected to be a significant problem at the proposed Site, since the development will not include any occupied structures, personnel will not be onsite for extended periods, and the Site will not be developed with structures containing basements or substructures in which radon can accumulate.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were made following a review of the available site data for natural and geologic hazards in the vicinity of Site located in Garfield County, Colorado.

- The Site is not expected to have any buried or aboveground utilities.
- Avalanche conditions are not expected to be a hazard in the area of the Site.
- Rockfall areas are not a geological hazard in the area of the Site, but may exist in areas along Mamm Creek and its tributary drainages.
- The Site is not in an area of landslides or potential landslides.
- The Site is not in an area mapped as an alluvial fan hazard area.
- Slope is not a geologic hazard in the vicinity of the site, but is in areas to the north and west along West Mamm Creek and Mamm Creek drainages.
- The surface runoff is slow and the soil erosion hazard for the Potts Loam is moderate.
- The Site is not located in an area of mapped mud flow or debris fan areas.
- The Potts Loam soils are listed as a high risk of corrosion to uncoated steel and a low risk of corrosion to concrete. These soil characteristics are not expected to pose a geologic hazard for the proposed development at the Site.
- The shrink-swell potential for the Potts Loam is low to moderate. Therefore, expansive soils are not a geologic hazard at the Site.
- Collapsible soils are not present in the vicinity of the proposed Site.
- No significant faults have been mapped or are known in the Site. The Site is located to the northwest of the Divide Creek anticline which was formed as a result of movement along a blind thrust fault associated with the uplift of the Colorado Rocky Mountains.
- The Site is not mapped as being within the 100-year flood plain. Flash flooding is a hazard for lower elevations along the West Fork of Mamm Creek, Mamm Creek and its tributaries, and areas along the Colorado River located approximately two miles to the north and at elevations that are 100 feet to 200 feet lower than the Site elevation. Therefore, flooding is not expected to be a natural hazard affecting the Site.
- Uranium and Vanadium were mined to the northeast of the town of Rifle; and approximately ten miles north of the Site. However, these mines were developed in Jurassic age geologic formations that lie at great depth stratigraphically below the Wasatch Formation. There are no significant radioactive mineral deposits known in the immediate area of the Site. The presence of NORM may be an issue with exploration and production and could be an issue with used pipe scale or used equipment stored at the site. Radioactive materials are not expected to pose a significant hazard at the Site.

5.0 REFERENCES

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- Slope Hazards: http://garfield-county.com/geographic-information-systems/documents/6439291200422slopehaz.pdf
- Tax Assessor parcel information http://garfieldco.mygisonline.com
- Soil Hazards: http://garfield-county.com/geographic-information-systems/documents/64335291200423soilhaz.pdf
- Surficial Geology of Garfield County: http://garfield-county.com/geographic-information-systems/documents/geologic-hazards/24surfgeo.pdf
- Colorado Geological Survey: http://geosurvey.state.co.us/hazards
- Colorado Geological Survey: http://geosurvey.state.us/land/Pages/Professional Geologist
- Colorado Department of Public Health and Environment: http://co-radon.info/CO_radon_map.html

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FIGURES

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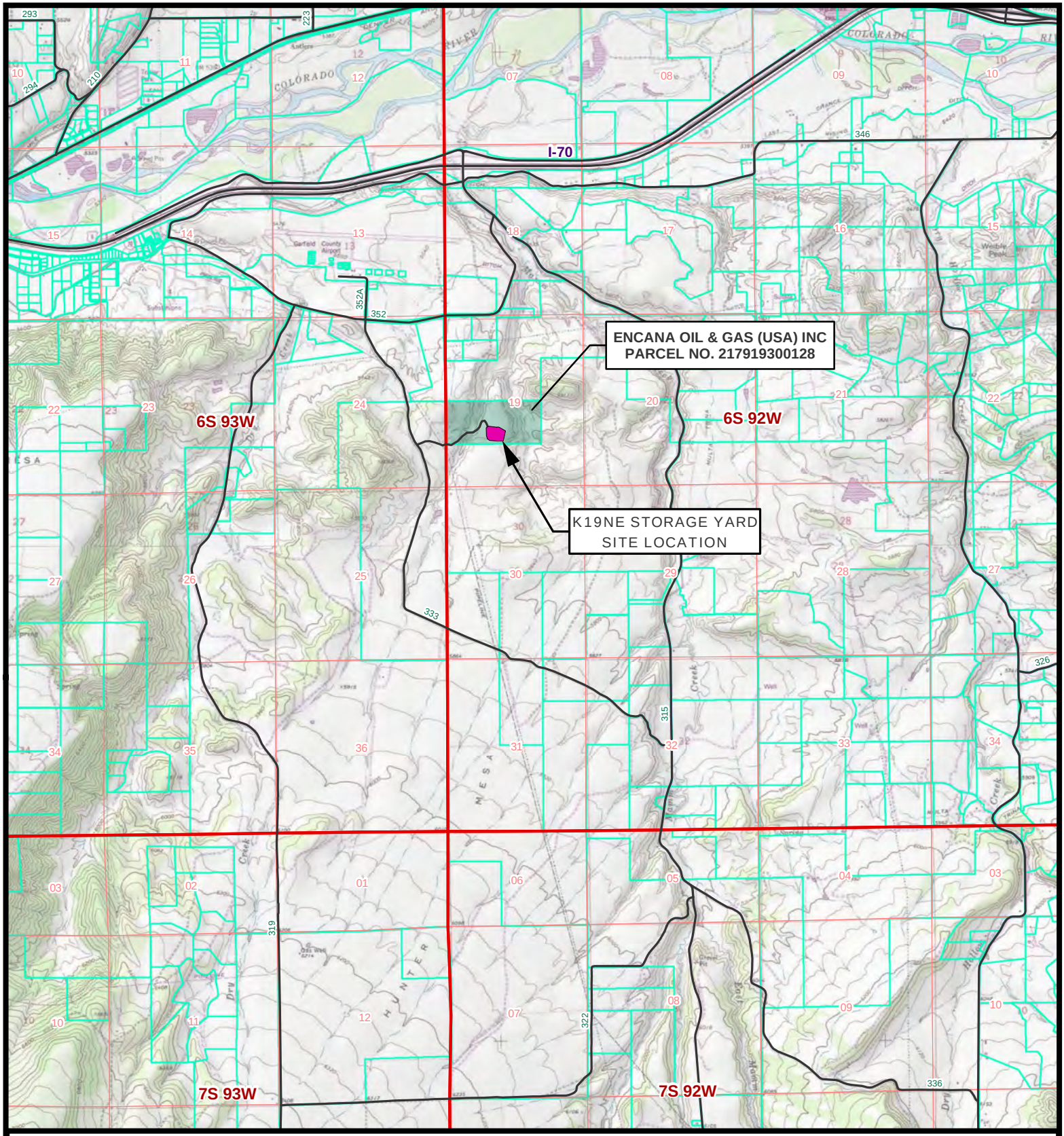

Encana Oil & Gas (USA) Inc.

K19NE Storage Yard Vicinity Map
SECTION 19, T6S, R92W, 6th, P.M.
GARFIELD COUNTY, COLORADO

N

0 2,000 4,000

Scale in Feet

WASATCH SURVEYING
EVANSTON, WYOMING

Wasatch Surveying Associates
906 Main Street Evanston, Wyoming 82930
Phone No. (307) 789-4545 Fax (307) 789-5722

VICINITY MAP

PROJECT No. 14-04-12
DATE: 8/22/2014
SCALE: 1:48,000

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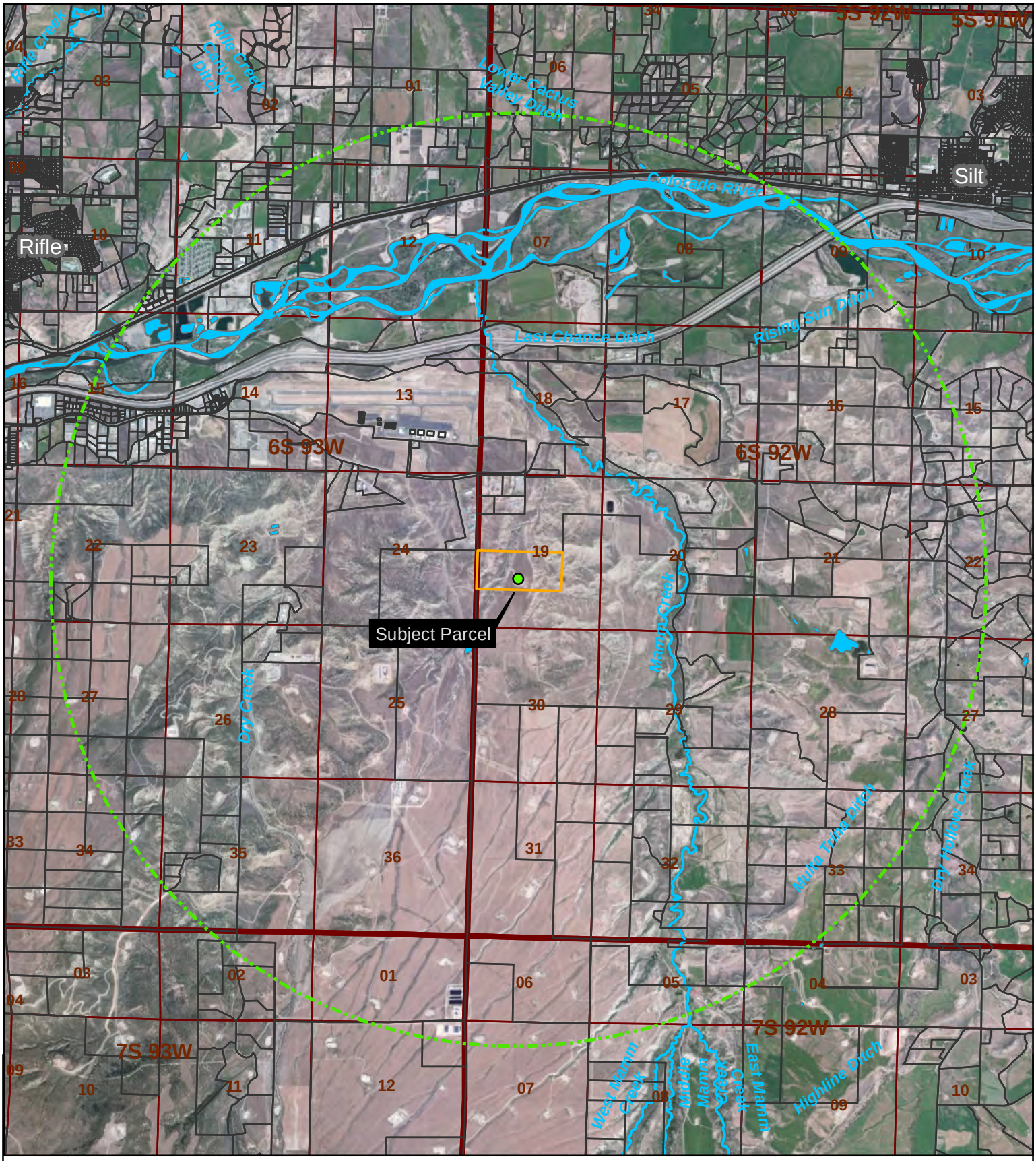

PROJECT NO: 014-2797	VICINITY MAP	OLSSON ASSOCIATES	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO			V-1
DATE: 11/25/2014				

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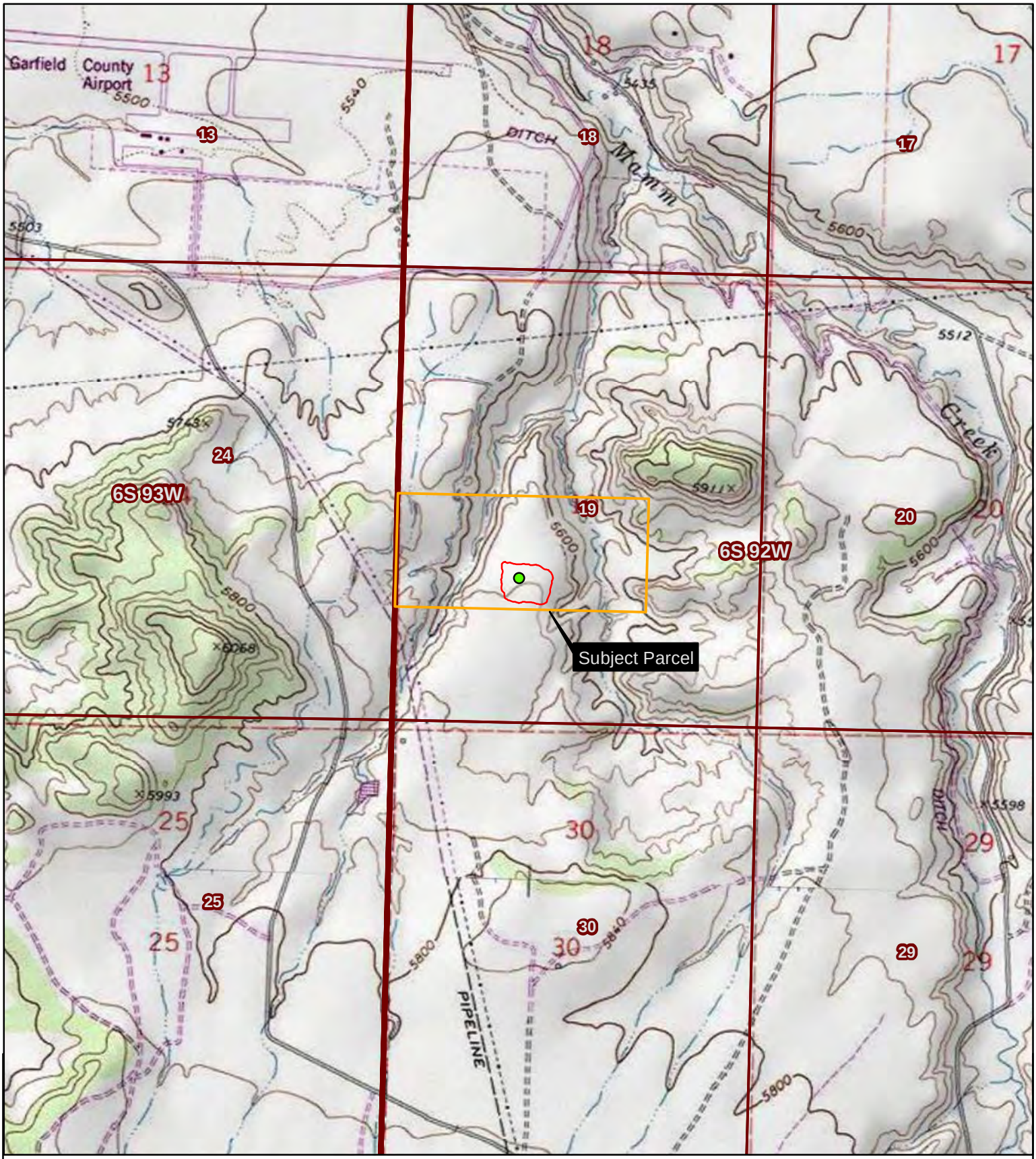

K19NE Storage Yard

K19NE Storage Yard Boundary

Subject Parcel

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PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

TOPOGRAPHIC MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES

760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

T-1

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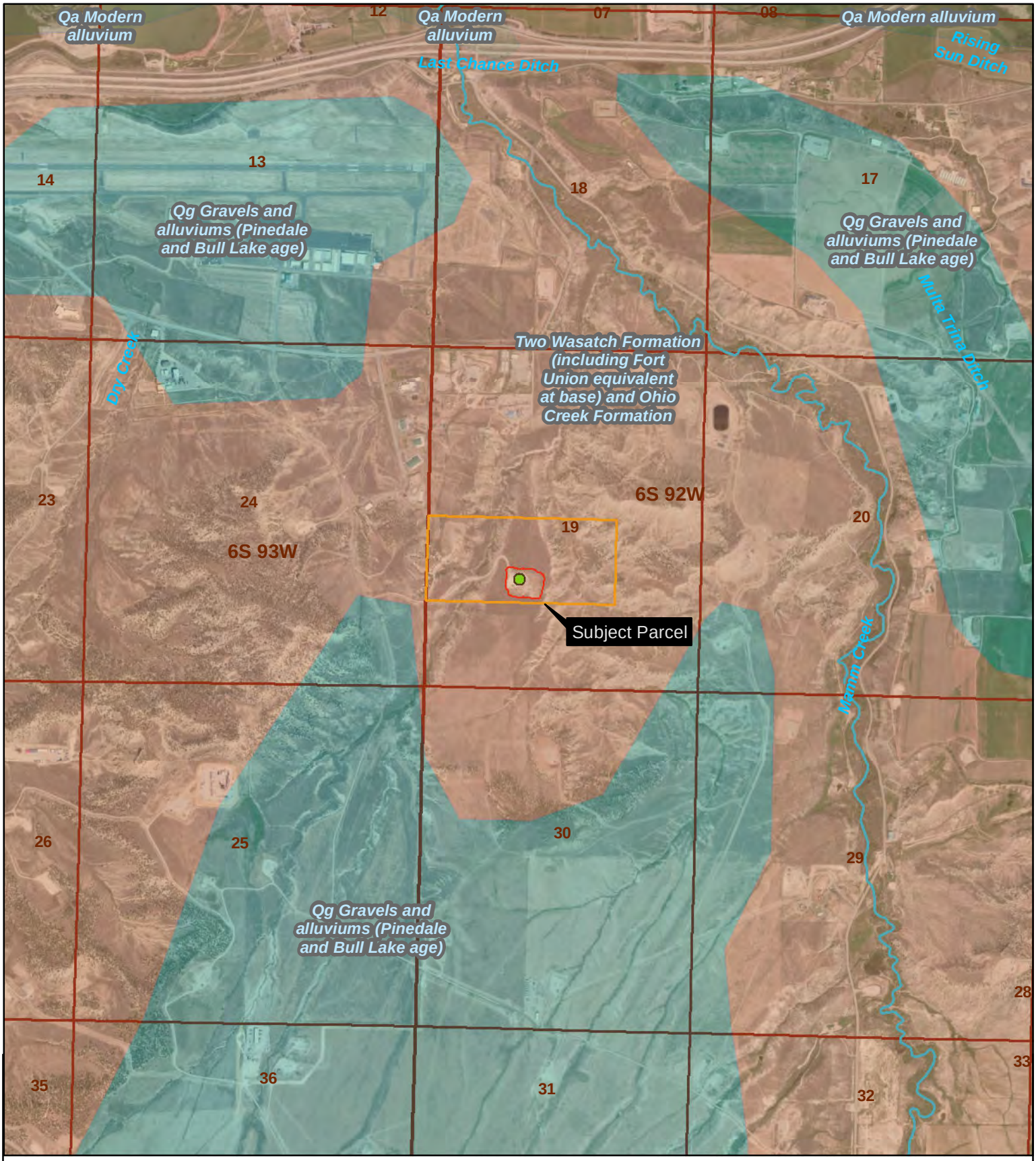

PROJECT NO: 014-2797	GEOLOGY MAP	OLSSON ASSOCIATES	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO			G-1
DATE: 11/25/2014				

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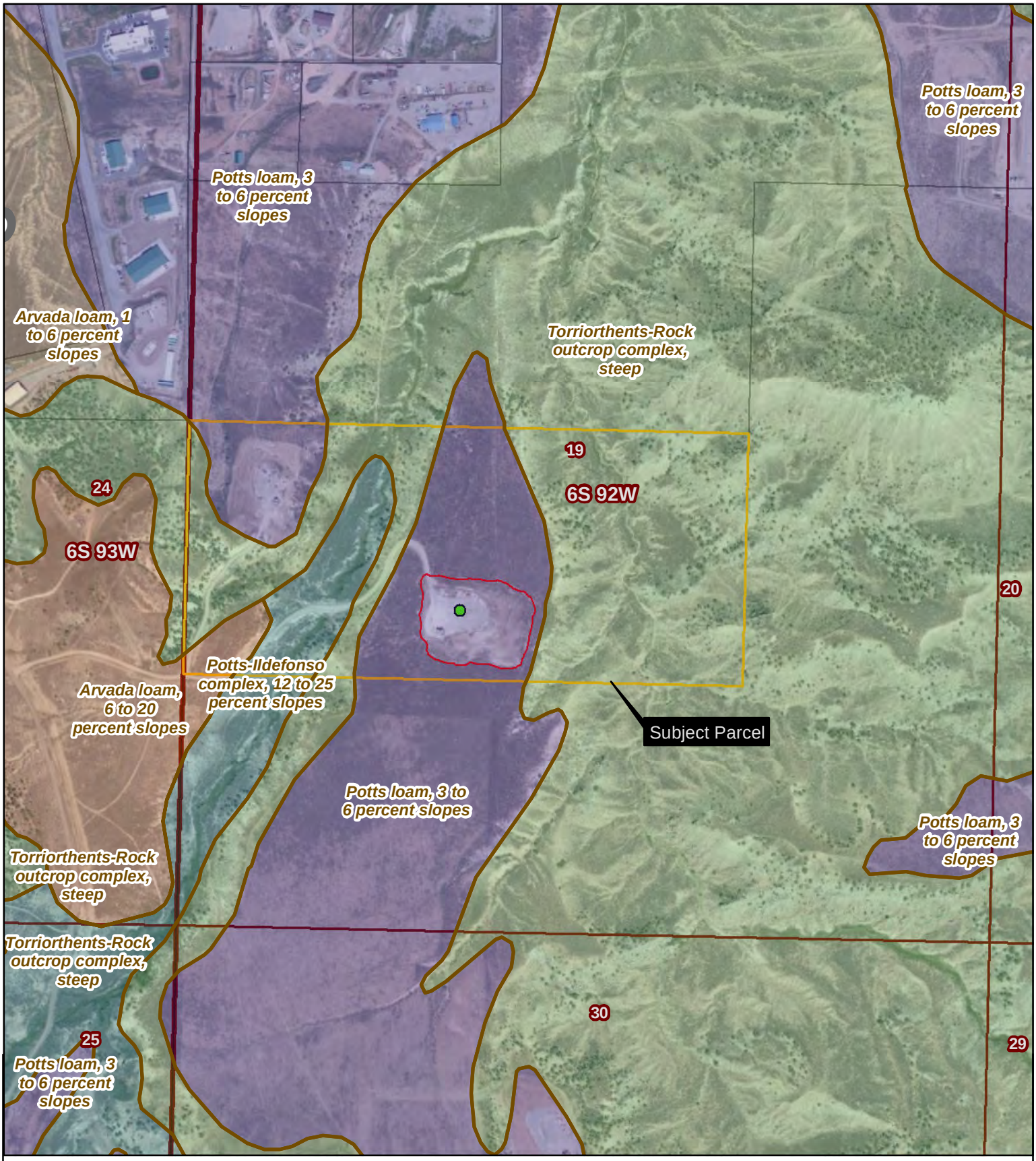

K19NE Storage Yard
K19NE Storage Yard Boundary
Subject Parcel
Perennial Stream

N
W
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S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

SOILS MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

S-1

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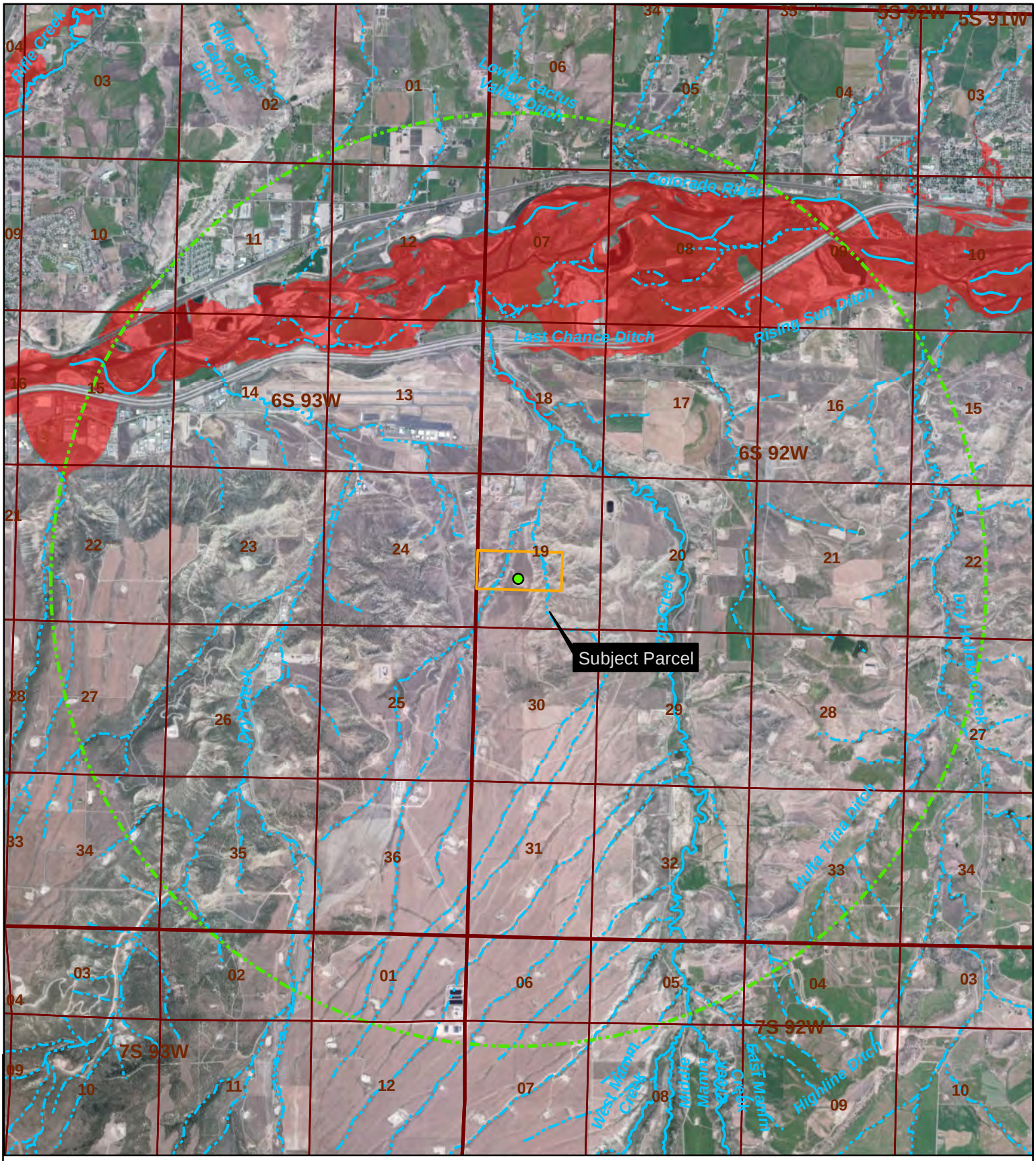

K19NE Storage Yard
Subject Parcel
3 Mile Buffer
Perennial Stream
Intermittent Stream
Floodplain

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PROJECT NO: 014-2797	FLOODPLAIN MAP	OLSSON ASSOCIATES	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	F-1
DATE: 11/25/2014			

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Article 4-203.G.6 Wildlife and Vegetation Impact Analysis

Encana Oil & Gas (USA) Inc K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2797

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WILDLIFE AND VEGETATION ASSESSMENT FOR THE K19 LAYDOWN YARD

PREPARED FOR

ENCANA OIL AND GAS (USA) INC.
Parachute, Colorado

PREPARED BY

Olsson Associates
760 Horizon Drive, Suite 102
Grand Junction, Colorado 81506
970.263.7800

Cinnamon Levi-Flinn – Assistant Scientist

Lilly Griffin – Assistant Scientist

December 2014

Olsson Associates Project No. 014-2797

OLSSON ASSOCIATES®

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List of Figures

1.0 PROJECT DESCRIPTION

Olsson Associates (Olsson) was contracted by Encana Oil and Gas (USA) Inc. to develop an impact analysis to fulfill the legal requirements set forth in Section 4-203.G of the Garfield County Land Use and Development Code (amended October 2014). Section 4-203.G requires proposed developments to describe existing conditions and potential changes created by the proposed land use change. This document provides an assessment of impacts on wildlife habitat, the creation of hazardous attractions, the alteration of existing native vegetation, blocking of migration routes, and changes in habitat use or disruption of habitat use by wildlife.

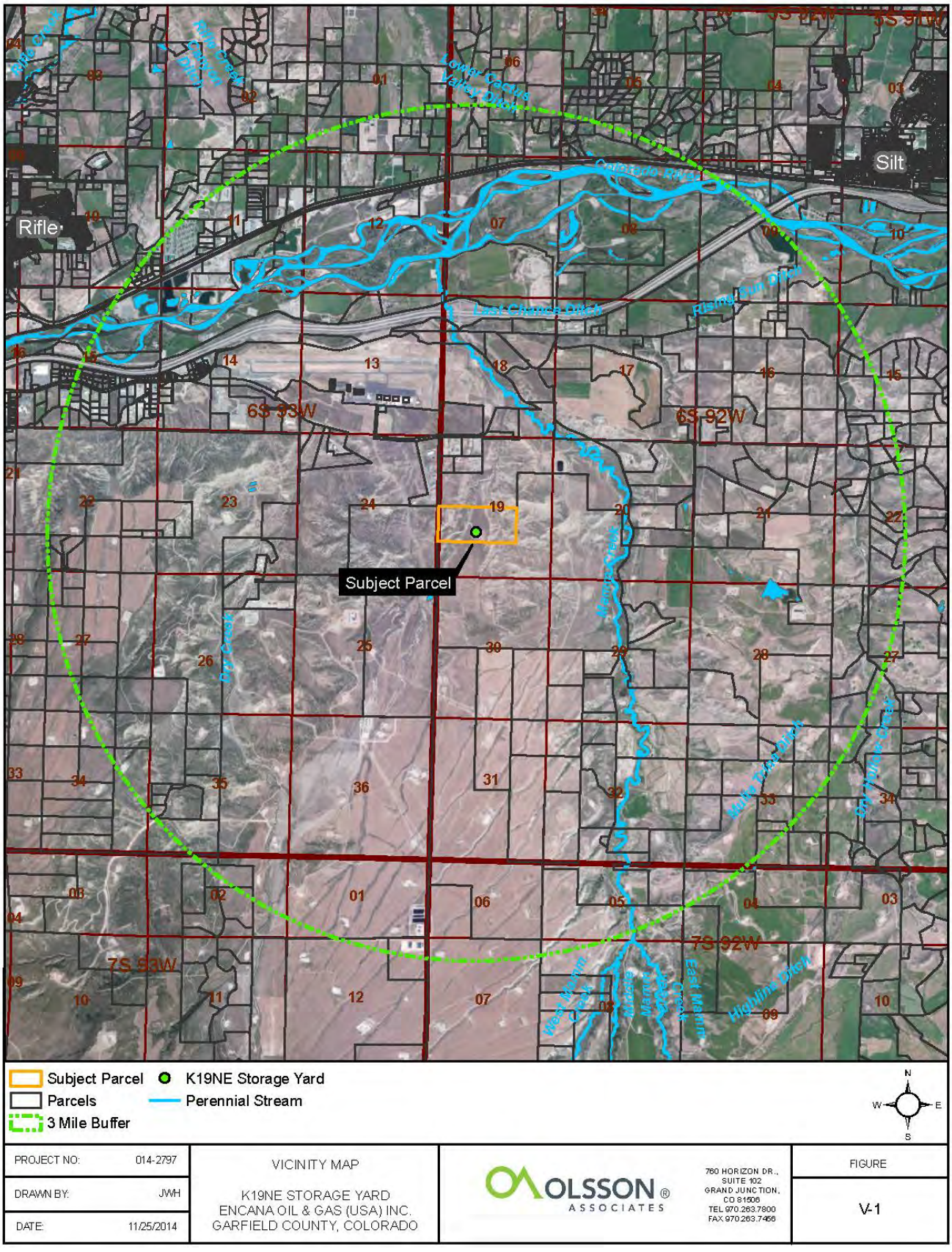
The K19NE Laydown Yard is located approximately 1.0 mile south of the Garfield County Airport, in unincorporated Garfield County in the NE¼ of the SW¼ of Section 19, Township 6 South, Range 92 West of the 6th P.M. Elevation at this site is approximately 5,686 feet (**Figure 1**).

The K19 pad is an existing permitted oil and gas well pad. The proposed laydown storage yard would have no new surface disturbance since the site is a previously disturbed area, and would be operated within the existing footprint of the K19 pad.

Photo of pad site, and habitat conditions

Photo of reclaimed areas adjacent to site

Figure 1: Project Vicinity



PROJECT NO: 014-2797	VICINITY MAP	OLSSON ASSOCIATES	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO			V-1
DATE: 11/25/2014				

OLSSON ASSOCIATES

2.0 SURVEY METHODS

A preliminary review of the K19NE laydown yard was conducted to determine the presence/absence of threatened, endangered, or sensitive wildlife and plant species and their habitats. The review utilized aerial photographs and a review of GIS data from the U.S. Fish and Wildlife Service's (USFWS) Information, Planning, and Conservation System (IPAC) for listed species in Garfield County (USFWS 2014). Additionally, sensitive or rare wildlife or plant species were reviewed from Colorado Parks and Wildlife's (CPW) Natural Diversity Information source (NDIS) ArcGIS website. Colorado Oil and Gas Conservation Commission (COGCC) GIS data for wildlife habitat was also utilized (COGCC 2013). Species located in the range of the project site were further reviewed for suitable habitats in the vicinity of the project area.

On November 4, 2014, Olsson biologists conducted surveys of the project area as well as the surrounding area to assess potential impacts to wildlife and wildlife habitat. Field data collected during the survey were documented and/or recorded using a GPS (NAD83 map datum, UTM coordinate system in Zone 12).

Vegetation types were determined during an on-site visit. Photographs of the site location, as well as the surrounding area, were taken to record general biological communities, site conditions, and terrain. As this survey was conducted late in the growing season, some plant species and noxious weeds may not have been identifiable.

3.0 EXISTING ENVIRONMENTAL CONDITIONS

3.1 Wetlands and Other Waters of the U.S.

A desktop assessment of waterbodies and wetlands was evaluated by reviewing areas that could potentially be identified as jurisdictional wetlands and other (non-wetland) waters of the U.S. (WoUS). Impacts to potentially jurisdictional WoUS require permitting through Section 404 of the Clean Water Act (CWA). Section 404 of the CWA authorizes the U.S. Army Corps of Engineers (USACE) to issue permits for the discharge of dredge or fill materials into WoUS.

Based on the desktop review and on-site surveys, there currently are no wetlands or drainages conveying WoUS that would be affected by the proposed project.

3.2 Vegetation Assessment

The K19NE laydown yard is located in an area where the primary land uses include agricultural activities and natural gas development. The project area is located on an existing natural gas well pad, and the surrounding cut and fill slopes are dominated by interim reclamation grasses and forb species. The area of the proposed laydown yard is not surrounded by a fence; however, a fence does border the south side of the location but is maintained by the adjacent landowner. Encana maintains the access road, and

Photo of sparse native vegetation near site

currently has no plans for future fencing or gates

The proposed facility exists in a disturbed vegetation community dominated by grasses. The site appears to have been dominated previously by sagebrush/greasewood shrublands. Scattered patches of greasewood (*Sarcobatus vermiculatus*) and big sagebrush (*Artemesia tridentata*), rabbitbrush (*Ericameria nauseosa*), fourwing saltbush (*Atriplex canescens*), and shadscale (*Atriplex confertifolia*) still persist in some areas. The understory is not diverse, and was dominated by downy brome (*Anisantha tectorum*) with scattered patches of galleta grass (*Hilaria jamesii*), and weedy annuals. Additional species occurred in lesser coverage and amounts.

The pad location has been kept mostly clear of vegetation. The berms, cut slopes, and fill slopes support weedy species and seeded grasses. The dominating vegetation includes downy brome, crested wheatgrass (*Agropyron cristatum*), slender wheatgrass (*Elymus trachycaulus*), and scattered shrubs ncluding big sagebrush, rabbitbrush, greasewood, and saltbush species (*A. confertifolia* and *A. canescens*).

Table 1. Dominant Plant Species within the Project Area

Common Name	Scientific Name
Cheatgrass (Downy Brome)	*Anisantha tectorum*
Crested wheatgrass	*Agropyron cristatum*
Big Sagebrush	*Artemesia tridentata*
Rabbitbrush	*Ericameria nauseosa*
Slender wheatgrass	*Elymus trachycaulus*
Greasewood	*Sarcobatus vermiculatus*
Fourwing saltbush	*Atriplex canescens*
Shadscale	*Atriplex confertifolia*
Russian Thistle	*Salsola iberica*
Tall tumblemustard	*Sisymbrium altissimum*
Clasping pepperweed	*Lepidium perfoliatum*
Redstem Filaree	*Erodium cicutarium*

3.3 Threatened, Endangered, and Sensitive Plant Species

The vegetation survey included an assessment to identify potential habitat for the following plant species, which may occur in the area (USFWS 2014):

- Colorado hookless cactus (*Sclerocactus glaucus*)
- DeBeque phacelia (*Phacelia submutica*)
- Parachute beardtongue (*Penstemon debilis*)
- Ute ladies'-tresses (*Spiranthes diluvialis*)

None of the above mentioned species or potential habitats was located within the project area.

3.4 Noxious Weeds

Two Colorado State C-list weed species were found on the cut and fill slopes of the project area: downy brome (*Anisantha tectorum*) and redstem filaree (*Erodium cicutarium*). The presence of downy brome is prolific in the surrounding area, and will likely be difficult to control. It is possible that other weed species occur on the project site and in the nearby area but were not detected due to the time of inspection.

Table 2. Noxious Weeds Observed

Common Name ***Scientific Name***	**Growth Cycle/Weed List**	**Comment**
Redstem Filaree *Erodium cicutarium*	Biennial/Colorado C list	Worldwide; crowds out more desirable crop species.
Cheatgrass (Downy brome) *Anisantha tectorum*	Annual/Colorado C list	Highly adaptable to many environments; promoted by fire; highly competitive and early emergent..

As outlined in *Encana Oil & Gas (USA) Weed Management Effort Summary*, the weed conditions will be assessed on an individual basis, such that the best, site-specific weed management techniques may be executed. Please reference *Encana Oil & Gas (USA) Weed Management Effort Summary.*

3.5 Wildlife Species Considered

3.5.1 Federal and Colorado State Threatened, Endangered, Candidate, and Species of Concern

The K19NE Laydown Yard was evaluated for threatened, endangered, or sensitive wildlife species and their habitats potentially occurring on or adjacent to the project area. According to the USFWS IPAC, there are ten federally listed threatened, endangered, and candidate wildlife species that have the potential to occur in Garfield County (**Table 3**). Additionally, CPW's list of Threatened, Endangered and Species of Concern was reviewed to determine if any of those species had potential habitat on or adjacent to the proposed laydown yard (**Table 4**).

Table 3. USFWS Federal Threatened, Endangered and Candidate Wildlife Species for Garfield County

Common Name	Scientific Name	Habitat	Status	Habitat Present
Birds				
Greater Sage Grouse	*Centrocercus urophasianus*	Large sagebrush shrublands, north of I-70 in Colorado	Candidate	No
Mexican Spotted owl	*Strix occidentalis lucida*	Canyons with mixed conifer old growth mostly in Southwestern Colorado and east of Colorado Springs	Threatened	No
Yellow-Billed Cuckoo	*Coccyzus americanus*	Large cottonwood stands along large Rivers; found along North Fork of Gunnison, Colorado, Dolores, Yampa and Rio Grande Rivers	Threatened	No
Fish				
Bonytail chub	*Gila elegans*	Large, swift-flowing waters of the Colorado River system	Endangered	No
Colorado pikeminnow	*Ptychocheilus lucius*	Large, swift-flowing muddy rivers with quiet warm backwaters in the Green, Yampa, White, Colorado, Gunnison, San Juan, and Dolores Rivers	Endangered	No
Greenback Cutthroat Trout	*Oncorhynchus clarki stomias*	Clear, cold mountain streams on the Front Range of Colorado, recently found to occur on the west slope	Threatened	No
Humpback chub	*Gila cypha*	Prefers deep, fast-moving, turbid waters often associated with large boulders and steep cliffs in the Green, Yampa, and Colorado Rivers	Endangered	No
Razorback sucker	*Xyrauchen texanus*	Deep, clear to turbid waters of large rivers and reservoirs, with silt and gravel substrates in the lower Yampa and lower Colorado Rivers	Endangered	No
Mammals				
Canada lynx	*Lynx canadensis*	Spruce/fir and lodgepole pine forests, sometimes aspen, and shrublands	Threatened	No
Black-Footed ferret	*Mustela nigripes*	Associated with prairie dog colonies. Found to occur in Rio Blanco and Moffat Counties	Endangered	No

Nine of the listed species in the above table do not have mapped habitat occurring within or near the site (CPW-NDIS 2013). Potential habitat is not present for the Mexican spotted owl, Yellow-billed cuckoo, Greenback cutthroat trout, Canada lynx, the Black-Footed ferret, or for the four federally listed endangered fish species.

The greater sage-grouse (GrSG) has CPW mapped Historic Habitat overlaying the site. GrSG mapped Production Area (includes majority of nesting habitat), Overall Range, Brood Areas, and Winter Range habitats all occur greater than 20 miles northwest of the site, north of the town of Parachute. The proposed laydown yard is not within the GrSG habitat areas as depicted in the Garfield County Greater Sage-Grouse Conservation Plan.

Table 4. Colorado State Threatened, Endangered, and Sensitive Species List

Common Name	Scientific Name	Habitat	Status	Potential Habitat present within Project Area?
Mammals				
Black-Footed Ferret	*Mustela nigripes*	Associated with prairie dog colonies. Found to occur in Rio Blanco and Moffat Counties	FE,SE	No
Black-Tailed Prairie Dog	*Cynomys ludovicianus*	Shortgrass steppe on the eastern plains of Colorado	SC	No
Botta's Pocket Gopher	*Thomomy bottae rubidus*	Occurs mostly in riparian areas with sandy soils along lower elevations of the Utah border and the Arkansas Valley	SC	No
Gray Wolf	*Canis lupus*	Mountains, woodlands and plains of the Northern Rockies	FE,SE	No
Grizzly Bear	*Ursus arctos*	Woodlands, forests, alpine meadows and riparian areas near streams and rivers	FT,SE	No
Kit Fox	*Vulpes macrotis*	Semi-desert shrublands; found to occur in Colorado and Lower Gunnison River Valleys	SE	No
Canada Lynx	*Lynx canadensis*	Spruce/fir and lodgepole pine forests, sometimes aspen, and shrublands	FT,SE	No
Northern Pocket Gopher	*Thomomys talpoides macrotis*	Occurs in meadows and along streams in mountain areas along the Front Range of Colorado	SC	No
Preble's Meadow jumping mouse	*Zapus hudsonius preblei*	Foothills riparian areas and along front range streams of Colorado into northern Wyoming	FT,ST	No
River Otter	*Lontra Canadensis*	Widespread in large montane river systems	ST	No
Swift Fox	*Vulpes velox*	Shortgrass prairie and riparian woodlands on eastern plains of Colorado	SC	No
Townsend's Big-eared Bat	*Corynorhinus townsendii pallescens*	Semi-desert shrublands, Pinyon/juniper, open montane forests, caves and abandoned mines	SC	No
Wolverine	*Gulo gulo*	Boreal forests and tundra	SE	No
Birds				
American Peregrine Falcon	*Falco peregrinus anatum*	Nest on cliffs, forages over forests and shrublands throughout Colorado	SC	No
Bald Eagle	*Haliaeetus leucocephalus*	Forages by roosting along larger rivers, stream and waterbodies, also around big game winter ranges throughout Colorado	SC	No
Burrowing Owl	*Athene cunicularia*	Arid grasslands and shrublands on the eastern slope of Colorado; some occurrences in western Colorado	ST	No
Columbian Sharp-Tailed Grouse	*Tympanuchus phasianellus columbianus*	High mountain shrub-grassland communities and associated edges in Northwestern Colorado	SC	No

Common Name	Scientific Name	Habitat	Status	Potential Habitat present within Project Area?
Ferruginous Hawk	*Buteo regalis*	Grasslands and semi-desert shrublands, winter resident in Colorado	SC	No
Greater Sage Grouse	*Centrocercus urophasianus*	Large sagebrush shrublands, north of I-70 in Colorado	SC	No
Gunnison Sage-Grouse	*Centrocercus minimus*	Large sagebrush shrublands with diversity of grasses and riparian areas; occurs in Gunnison basin and a small population south of Grand Junction	SC	No
Greater Sandhill Crane	*Grus canadensis tabida*	Wetlands, marshes and large waterbodies; Colorado migrant but the Rocky Mountain Population breeds in northwestern Colorado	SC	No
Least Tern	*Sterna antillarum*	Migratory in Colorado, found in large reservoirs and rivers in southeastern Colorado	FE,SE	No
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	Great plains grasslands and shrublands in southeastern Colorado	FT,ST	No
Long-billed Curlew	*Numenius americanus*	Larger reservoirs and river systems in Colorado, mostly on eastern plains	SC	No
Mexican Spotted Owl	*Strix occidentalis lucida*	Canyons with mixed conifer old growth mostly in Southwestern Colorado and east of Colorado Springs	FT,ST	No
Mountain Plover	*Charadrius montanus*	Summers on eastern plains in Colorado in native short-grass steppe; winters in Southern California & Mexico	SC	No
Plains Sharp-Tailed Grouse	*Tympanuchus phasianellus jamesii*	Grasslands and river canyons in northeastern Colorado	SE	No
Piping Plover	*Charadrius melodus circumcinctus*	Sandbars and beaches along larger rivers in eastern Colorado	FT,ST	No
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Dense lower elevation riparian habitats	FE,SE	No
Western Snowy Plover	*Charadrius alexandrines*	Sandy beaches and barrens in eastern Colorado plains	SC	No
Western Yellow-Billed Cuckoo	*Coccyzus americanus*	Large cottonwood stands along large Rivers; found along North Fork of Gunnison, Colorado, Dolores, Yampa and Rio Grande Rivers	SC	No
Whooping Crane	*Grus Americana*	Migratory through Colorado; found to occur in wetlands, marshes and salt flats	FE,SE	No
Fish				
Arkansas Darter	*Etheostoma cragini*	Shallow, clear, sandy streams with spring-fed pools in the Arkansas drainage in eastern Colorado	ST	No

Common Name	Scientific Name	Habitat	Status	Potential Habitat present within Project Area?
Bonytail	*Gila elegans*	Large, swift-flowing waters of the Colorado River system	FE,SE	No
Brassy Minnow	*Hybognathus hankinsoni*	Moderately clear tributary streams with sand or gravel bottoms; native to Republican and South Platte river basins	ST	No
Colorado Pikeminnow	*Ptychocheilus lucius*	Large, swift-flowing muddy rivers with quiet warm backwaters in the Green, Yampa, White, Colorado, Gunnison, San Juan, and Dolores Rivers	FE,ST	No
Colorado River Cutthroat trout	*Oncorhynchus clarki pleuriticus*	Headwater streams and lakes in widespread localized reaches	SC	No
Colorado Roundtail Chub	*Gila robusta*	Large rivers in the Colorado River system through Glenwood Canyon, downstream on White River, Milk and Divide Creeks	SC	No
Common Shiner	*Luxilus cornutus*	Lakes, rivers and streams, common in pools of streams and small rivers in the South Platte River Basin	ST	No
Flathead Chub	*Platygobio gracilus*	Main branches of turbid streams and rivers, fast currents with sand/gravel substrates in the Arkansas River basin	SC	No
Greenback Cutthroat trout	*Oncorhynchus clarki stomias*	Clear, cold mountain streams on the Front Range of Colorado, recently found to occur on the west slope	FT,ST	No
Humpback Chub	*Gila cypha*	Prefers deep, fast-moving, turbid waters often associated with large boulders and steep cliffs in the Green, Yampa, and Colorado Rivers	FE,ST	No
Iowa Darter	*Etheostoma exile*	Clear, slow flowing streams and lakes with undercut banks and some vegetation or algal mat in Northeastern plains streams, Eleven Mile Reservoir and Shadow Mountain Reservoir	SC	No
Lake Chub	*Couesius plumbeus*	Lakes and large pools in Boulder Creek and the Cache la Poudre River	SE	No
Mountain Sucker	*Catostomus playtrhynchus*	Throughout west on both sides of Continental Divide-prefer clear cold creeks and small to medium rivers with rubble, gravel, or sand substrate	SC	No
Northern Redbelly Dace	*Phoxinus eos*	Small slow-flowing streams and connected lakes with vegetation in the South Platte basin	SE	No
Plains Minnow	*Hybognathus placitus*	Main channels of rivers in the Arkansas and Platte River basins	SE	No

Common Name	Scientific Name	Habitat	Status	Potential Habitat present within Project Area?
Plains Orangethroat Darter	*Etheostoma spectabile*	Found in small streams with shallow riffles and gravel substrate in the Republican basin	SC	No
Rio Grande Chub	*Gila Pandora*	Pools and streams with gravel substrate and overhanging banks and brush in the Rio Grande basin	SC	No
Rio Grande Cutthroat trout	*Oncorhynchus clarki virginalis*	Clear, cold isolated headwater streams and lakes in the Rio Grande basin	SC	No
Rio Grande Sucker	*Catostomus plebeius*	Slow moving reaches of streams in the Rio Grande basin	FE,SE	No
Razorback Sucker	*Xyrauchen texanus*	Deep, clear to turbid waters of large rivers and reservoirs, with silt and gravel substrates in the lower Yampa and lower Colorado Rivers	FE,SE	No
Southern Red Belly dace	*Phoxinus erythrogaster*	Clear, streams and rivers with sand and gravel substrates in the South Platte and Arkansas River drainages	SE	No
Stonecat	*Noturus flavus*	Large creeks and small rivers with fast moving riffles and rocky substrates; occurs in the South Platte and Republican basins	SC	No
Suckermouth Minnow	*Phenacobius mirabilis*	Clear, shallow riffles with sand and gravel substrates in the South Platte and Republican basins	SE	No
Amphibians				
Boreal Toad	*Anaxyrus boreas boreas*	Subalpine forest meadows, wetlands, beaver ponds and margins of lakes in distinct populations within 8,500- 12,000 feet elevation	SE	No
Couch's Spadefoot	*Scaphiopus couchii*	Occurs in pools and stock ponds in the prairie grasslands of Southeastern Colorado	SC	No
Great Plains Narrowmouth Toad	*Gastrophryne olivacea*	Grassy areas on rocky slopes and in rock-rimmed canyons in southeastern Colorado	SC	No
Northern Cricket Frog	*Acris crepitans*	Margins and edges of permanent and semi-permanent ponds and wetlands of the eastern plains of Colorado	SC	No
Northern Leopard Frog	*Lithobates pipiens*	Wetlands, beaver ponds, marshes, and wet meadows throughout mid-to lower-elevations of Colorado	SC	No
Plains Leopard Frog	*Rana blairi*	Wetlands, marshes, and ponds on eastern plains	SC	No
Wood Frog	*Rana sylvatica*	Subalpine wetlands, beaver ponds, lakes, and wet meadows in eastern Grand, northern Larimer, and Jackson Counties	SC	No

Common Name	Scientific Name	Habitat	Status	Potential Habitat present within Project Area?
Reptiles				
Triploid Checkered Whiptail	*Cnemidophorus neotesselatus*	Hillsides, arroyos, and canyons associated with the Arkansas River valley	SC	No
Midget Faded Rattlesnake	*Crotalus viridis concolor*	Semi-arid shrublands and rocky arroyos in lower elevations in western Colorado	SC	No
Longnose Leopard lizard	*Gambelia wislizenii*	Flat or gently sloping shrublands and desert plains in western Colorado along the Utah border	SC	No
Yellow Mud Turtle	*Kinosternon flavescens*	Permanent and intermittent streams, ponds and marshes bordering grasslands and sand hills in eastern Colorado	SC	No
Common King Snake	*Lampropeltis getula*	Low elevation, semi desert shrublands near waterways in extreme southwest and southeast Colorado	SC	No
Texas Blind Snake	*Leptotyphlops dulcis*	Canyon slopes and bottoms in pinyon/juniper and shrub habitats in extreme southeastern Colorado	SC	No
Texas horned lizard	*Phrynosoma cornutum*	Plains grassland with large patches of bare ground in southeastern Colorado	SC	No
Roundtail Horned lizard	*Phrynosoma modestum*	Dry grasslands and shrubland in southeastern Colorado	SC	No
Massasauga	*Sistrurus catenatus*	Dry plains grassland and sand hill areas with sandy soils in southeastern Colorado	SC	No
Common Garter Snake	*Thamnophis sirtalis*	Wetlands and aquatic and riparian habitats in northeastern Colorado	SC	No
Mollusks				
Rocky Mountain Capshell	*Acroloxus coloradensis*	Cold water lakes in mid-to-low elevations with high amounts of calcium and other ions; occurs in north central Colorado	SC	No
Cylindrical Papershell	*Anodontoides ferussacianus*	Headwater creeks and streams with silty/muddy substrates in Boulder County	SC	No

FE= Federally Endangered, FT=Federally Threatened, SE=State Endangered, ST=State Threatened, SC= State Special Concern (not a statutory category)

3.5.2 Raptors, Birds of Conservation Concern, Migratory, and Non-Migratory Birds

Olsson evaluated the site for raptor species that could potentially occur in the area (Andrews & Righter 1992, Kingery 1998, and Righter et al. 2004, CPW NDIS 2013). Olsson conducted a habitat survey on November 4, 2014 to determine if any potential raptor nesting habitat was present. The typical raptor nesting season occurs from February 15-August 15, depending on the species (**Table 4**).

In addition to raptors, Olsson evaluated the site for bird species which could potentially be affected by the proposed laydown yard. Birds of Conservation Concern (BCC) have been identified by the USFWS for priority conservation management in an attempt to prevent or

remove the need to list additional species under the Endangered Species Act (USFWS 2008). A literature review was conducted to identify the potential presence of BCC species that could occur in mixed grasslands and sagebrush habitats near the site. **Table 5** shows the BCC species for the Southern Rockies/Colorado Plateau that may have potential to occur within the habitats adjacent to the site.

The site has been cleared of all vegetation from the previous disturbance of the K19NE gas well pad; therefore, the site does not provide suitable nesting habitat for some species. Habitat surrounding the proposed laydown yard may provide potential foraging habitat for raptors and nesting and foraging habitat for various, migratory and non-migratory bird species.

Table 5. Raptors, Birds of Conservation Concern, Migratory and Non-migratory Bird Species in Project Area

Common Name	Scientific Name	Preferred Habitat	BCC
Cassin's Finch	*Carpodacus cassinii*	Associated with pinyon/ juniper woodlands, Douglas-fir trees, and lodgepole and ponderosa pine forests. May breed in open sagebrush and shrubland with scattered juniper (*Juniperus scopulorum*)	Yes
Northern Harrier	*Circus cyaneus*	Prefers wetlands in both summer and winter; however, these habitats are uncommon in western CO so they will generally nest in sagebrush, montane shrub, grasslands, and hayfields with abundant cover.	No
Brewer's Sparrow	*Spizella breweri*	Primarily nests in sagebrush shrublands but may occasionally nest in greasewood and rabbitbrush or other shrublands in desert valleys. During migration may uses a variety of riparian and desert shrubs.	Yes
Sage thrasher	*Oreoscoptes montanus*	Primarily nests in sagebrush and at low elevations may nest in greasewood, shadscale saltbush, fourwing saltbush and rubber rabbitbrush intermixed with sagebrush. May nest in mountain mahogany or serviceberry at higher elevations.	No

3.5.3 Species Considered

In addition to the review of USFWS and CPW Sensitive species and local species of interest, the following species were evaluated for impacts from the proposed laydown yard. No other listed species have suitable habitats or occupied range within the project area.

- Elk
- Mule Deer

3.5.3.1 American Elk and Mule Deer

Mule deer *(Odocoileus hemionus)* utilize montane forests and pinyon-juniper woodlands with good shrub understory during winter. They rely on sagebrush and shrubs as their primary food

source. Mule deer may utilize the habitat surrounding the site for wintering grounds and will migrate up to higher elevations in the spring (Fitzgerald et al. 1994).

Elk *(Cervus elaphus)* are found in semi-open forests or forest edges adjacent to parks, meadows, and alpine tundra and rely primarily on available grasses and browse for food (Fitzgerald et al. 1994). Elk prefer areas that are less disturbed and generally prefer areas away from roads (Fitzgerald et al. 1994).

The proposed laydown yard is located within CPW Game Management Unit (GMU) 42 and Data Analysis Units (DAU) D-12 and E-14. The site location does not occur within CPW mapped migration corridors or wildlife habitat linkages for either species.

Photo of more effective native habitats south of site

The site occurs within CPW mapped mule deer Overall Range, Severe Winter Range, Winter Range and Winter Concentration Area. The site occurs within CPW mapped elk Overall Range, Winter Range, Severe Winter Range, and Winter Concentration Area (**Figures 2** and **3**). During 2014, no elk or mule deer sign was noted during the survey.

4.0 SECTION 4-203.G (6)(A) DETERMINATION OF THE LONG-TERM AND SHORT-TERM EFFECT ON FLORA AND FAUNA

4.1 Flora

The continued use and redevelopment of the existing laydown yard would not adversely affect federally listed plant species. No additional vegetation removal is associated with the laydown yard. Vegetation communities and conditions will not be affected on a long- or short-term basis and would remain in their present condition.

At this time, it is recommended that noxious weed management be focused on preventing the spread of Redstem filaree, and to prevent any new weed infestations. Please reference Colorado Noxious Weed and Garfield County Weed Lists.

As outlined in *Encana Oil & Gas (USA) Weed Management Effort Summary*, the above mentioned weed conditions will be assessed on an individual basis, such that the best, site-specific weed management techniques may be executed. Please reference *Encana Oil & Gas (USA) Weed Management Effort Summary.*

4.2 Fauna

4.2.1 Federal and Colorado State Listed Threatened, Endangered, Candidate, and Sensitive Wildlife Species

The continued use of the existing site as a laydown yard would not adversely affect federally listed wildlife species due to the lack of suitable habitat within or surrounding the project area. No federally designated critical habitat occurs within or near the site.

Colorado State listed Threatened, Endangered or Sensitive wildlife species would not be impacted by the proposed laydown yard due to the lack of suitable habitat available for those species within or surrounding the proposed project area.

4.2.2 Raptors, Birds of Conservation Concern, Migratory and Non-Migratory Birds

No additional vegetation removal would be associated with the proposed laydown yard; therefore no suitable raptor, BCC, or other migratory or non-migratory bird species nesting habitat would be impacted. Long- or short-term effects related to the project area would be minimal due to the area being previously disturbed from activities associated with the operation and maintenance of the existing oil and gas well pad, and a lack of suitable nesting habitat in proximity to the site. Loud noises and human activities at the site during the breeding and nesting season may have limited indirect impacts on habitat effectiveness around the pad site, possibly reducing the suitability or effectiveness for nesting activities in the native shrubland habitats; but as mentioned, a lack of suitable nesting habitat in proximity to the pad limits the amount of potential impacts. Foraging and other habitat use would likely continue within adjacent habitats, as available.

4.2.3 American Elk and Deer

The existing site is absent of any vegetation, and no additional direct impacts to elk or deer habitats would occur. Elk and deer may be indirectly impacted during the winter months by increased noise and human presence and increased traffic along the access road, which may cause elk and deer to avoid this area during certain times of day or during times of more intense human activities. The winter months are a critical time of year for big game species, when deer and elk are more likely to be utilizing lower elevations and disturbance can have a larger relative impact due to poor foraging opportunities and already stressed animals. Intensive use of the laydown yard during the winter months may force deer and elk away from the area, which could increase energy expenditures for the individuals impacted.

During the summer and fall months, most deer and elk are at higher elevation habitats, and therefore use of the pad site outside of the winter would likely have no impact on deer or elk. The use of the laydown yard would not block or impede migration corridors for elk or mule deer. Long-term, reclamation of the site is recommended in order to improve winter range habitat effectiveness in the area.

5.0 SECTION 4-203.G (6)(B) DETERMINATION OF THE EFFECT ON DESIGNATED ENVIRONMENTAL RESOURCES CRITICAL WILDLIFE HABITAT

The K19NE Laydown Yard is not expected to affect any critical habitat for any wildlife species, as no federally designated critical habitat or species were identified within or near the site.

According to the CPW GIS data, the project area occurs within Overall, Severe Winter Range, Winter Concentration Areas and Winter Range for elk and mule deer. No additional vegetation

removal or new construction is associated with the site that would further decrease habitat. The site would not impede any natural migration or movement through the area, but use of the site during the winter months may temporarily cause animals to avoid habitats around the site. Given the limited size and temporary nature of activities associated with laydown yard use, these impacts would likely be short-term in nature, and no measureable impact to mule deer or elk herds would be expected from this project. Activities in the winter months would have a relatively larger potential effect given the condition of animals in the winter months, and reduced availability of forage and security habitats. As mentioned, some individual animals may be indirectly impacted by moving away from the site, but no significant impacts to herds, or long-term impacts to critical wildlife habitat would be expected.

6.0 SECTION 4-203.G (6)(C) IMPACTS ON WILDLIFE AND DOMESTIC ANIMALS

The laydown yard would not create hazardous attractions to avian or mammalian wildlife species or domestic animals, alter additional native vegetation, block migration routes, or cause a change in habitat use.

Wildlife species may be indirectly impacted by increased noise and human presence while equipment is being transferred and stored. Use of habitats by wildlife would still likely occur on or adjacent to the pad and storage yard site during the nighttime hours, and during times when there are no human activities at the laydown yard. The majority of the species occurring within the area have widespread habitats; therefore, most wildlife species that may be indirectly affected would have other habitats in the greater area that are still available for foraging, reproduction, dispersal and shelter. The proposed project may impact individuals indirectly but would not likely impact populations. No impacts to domestic animals would be expected.

7.0 SECTION 7-202 MITIGATION OF WILDLIFE HABITATS

There would be no direct loss of wildlife habitat from a change in use of the site. At this time, there are no recommendations for seasonal restrictions, mitigations or special requirements due to the previous disturbance of the existing oil and gas pad. Ongoing noxious weed management will be required to maintain existing vegetation and wildlife habitat quality, and to control any spread of existing noxious weeds. If larger elk or deer herds begin to congregate around the site during the winter months, Encana should consider consulting with CPW to minimize potential impacts to wintering big game species.

Figure 2: Mule Deer Winter Ranges

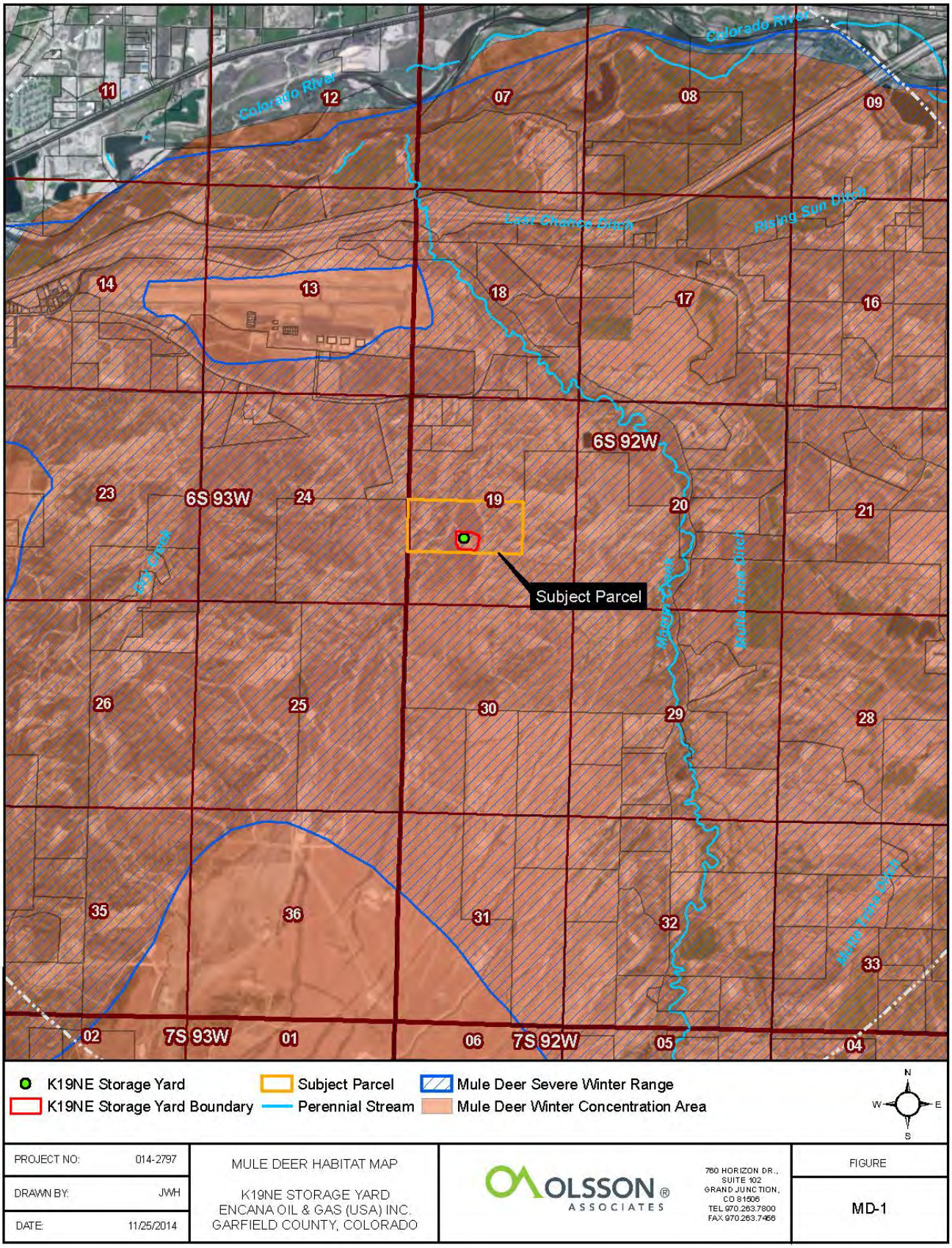
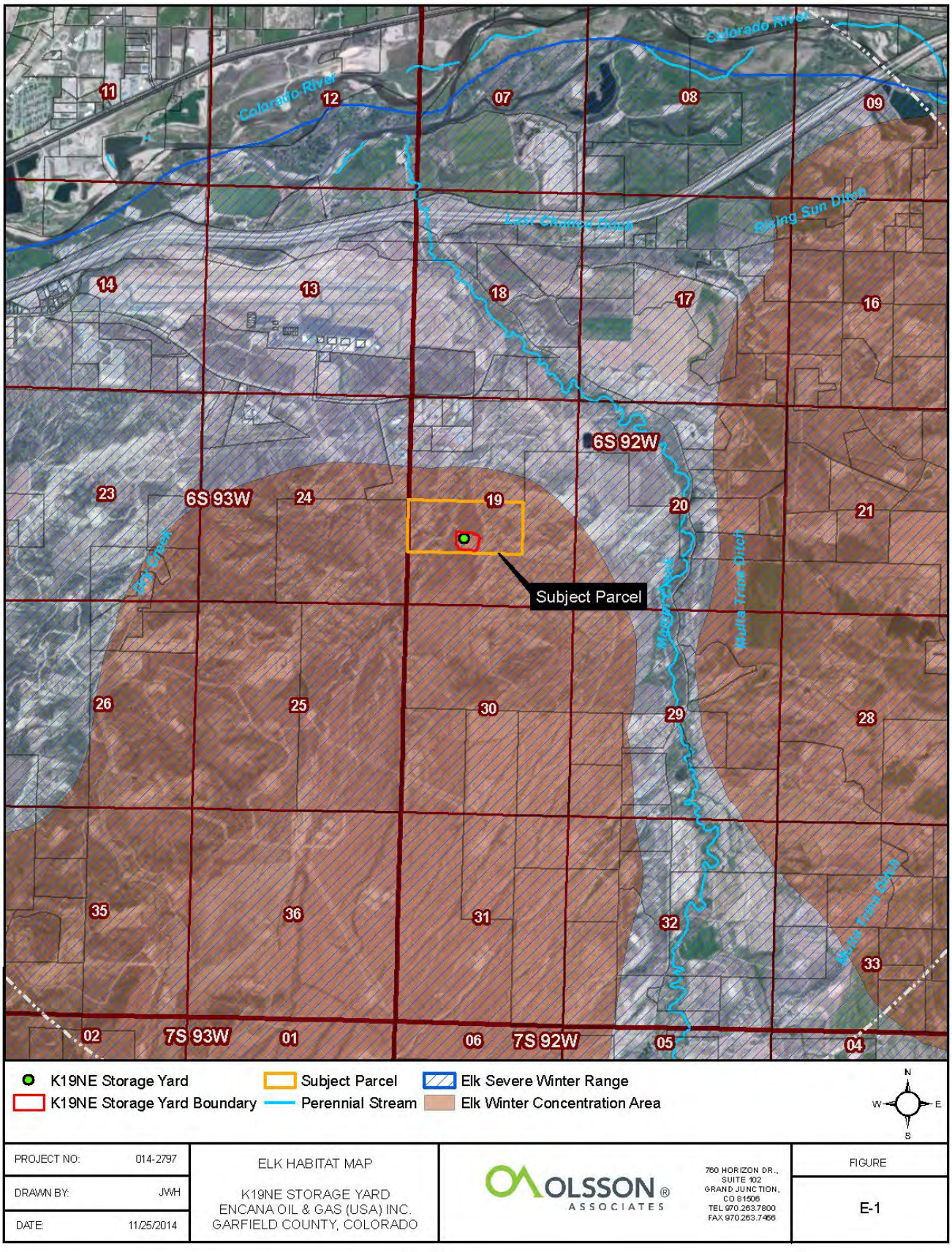


Figure 3: Elk Winter Ranges



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Article 4-203.G.7
Fugitive Dust Control Plan

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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ENCANA U.S.A. Inc.	**Fugitive Dust Control Plan** Piceance Basin Natural Gas Development Projects
Piceance Unit	

Scope	The scope of these guidelines is to outline some basic principles to minimize and control fugitive dust emissions during land development.
Requirements	Encana places the highest priority on the health and safety of our workforce and protection of our assets and the environment.
Applicable Documents	Department of Public Health and Environment Air Quality Control Commission Regulation 1 5CCR 1001-3
Quality	These guidelines will be reviewed periodically and will be shared with employees and contractors to ensure that they have adequate knowledge to minimize fugitive dust emissions.

1.0 Introduction

Land development activities, including clearing, excavating, and grading, release fugitive dust, a pollutant regulated by the Air Pollution Control Division (Division) at the Colorado Department of Public Health and Environment. However, small land development activities that are less than 25 contiguous acres and less than 6 months in duration do not need to report air emissions to the Division, but must use appropriate control measures to minimize the release of fugitive dust from the site.

This Fugitive Dust Control Plan addresses how dust will be kept to a minimum at the Encana's Project sites.

This plan focuses action on:

1. Identifying specific individual sources of fugitive dust.
2. Control options for unpaved roadways.
3. Control options for disturbed areas.
4. Control options for transport, storage and handling of bulk materials.
5. Contingency Plan for alternative action in the event that control strategies are not adequate, effective, or practicable.

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2.0 Specific Sources

Specific types of fugitive dust sources may appear to have negligible dust emissions, but when combined with other specific sources underway at the same time can create dust plumes that are visible beyond that which is appropriate for designated speeds and designs and may exceed nuisance emission limitation guidelines. It is important to consider all activities on the site together in determining compliance with federal, state, and local air quality regulations.

Task:

Provide field personnel and contractors with the information required to limit fugitive particulate matter (fugitive dust) from all specific sources to include:

- Unpaved Roadways and traffic areas.
- Construction activities including Earth Moving and excavation.
- Bulk Material (i.e. gravel and soils).
- Storage and handling of materials

3.0 Control Options for Unpaved Roadways

Any owner or operator responsible for construction or maintenance of any (existing or new) unpaved roadway is required to use all available, practical methods to minimize dust emissions:

Task:

Provide guidelines for minimizing fugitive dust emissions from all specific sources on unpaved roadways and traffic areas:

- Require that all passenger vehicles, construction equipment, and truck traffic obey the posted speed limits on all unpaved County roads to and from the project site.
- Ensure that vehicle speeds on new and existing access roads on the project site do not exceed 15 miles per hour by posting speed limits along these roads.
- Restrict vehicle traffic to existing roads by posting signs and/or providing the locations of allowable access routes to all field personnel and visitors.
- Encourage carpooling to and from the project site to limit traffic on existing County roads.
- Roads and well locations will be surfaced with compacted gravel to protect against wind erosion, to reduce the amount of fugitive dust generated by traffic and other activities, and to reduce carryout/trackout.
- Use dust inhibitors (surfacing materials, water, or non-saline dust suppressants) on all unpaved collector, local, and resource roads to prevent fugitive dust problems (ensure that any dust suppressants used are appropriate for road conditions and will not compromise the safety of workers on the project site).
- Restrict vehicular access during periods of inactivity using gates, fencing, and/or onsite security personnel.

4.0 Control Options for Disturbed Areas

Disturbed areas include new roads, well pads, parking and staging areas, and materials storage areas that have been cleared of vegetation, leveled, or excavated. These areas are susceptible to wind erosion and are a major source of fugitive dust emissions that require the appropriate controls and dust mitigation methods. Note that specific sources are subject to change as project conditions change, and will require an evaluation of current control options to ensure effectiveness and practicality.

Task:

Limit the adverse impacts of fugitive dust emissions through control measures and operational procedures designed so that no off-property transport emissions occur at the project site:

- Ensure that land clearing, grading, earthmoving, and excavation activities are suspended when wind speeds exceed a sustained velocity of 20 miles per hour.
- Surface all bare ground with gravel as soon as practicable after clearing, leveling, and grading.
- Use dust inhibitors (surfacing materials, water, or non-saline dust suppressants) on all disturbed areas as necessary to prevent fugitive dust problems.
- Identify the water source to be used for dust suppression, and ensure that contract water haulers are available when needed.
- Reduce the amount of time between initially disturbing the soil and revegetating or other surface stabilization.
- Apply vegetative or synthetic cover to topsoil and spoil piles as soon as practicable following stockpiling to prevent wind erosion and fugitive dust emissions.
- Compact the soil on disturbed areas that will not be surfaced with gravel or revegetated immediately following construction.
- Minimize surface disturbance to only that necessary for safe and efficient construction and operations.
- Use vegetative mulch, reseeding, or other methods of surface stabilization on all areas adjoining development to include shoulders, borrow ditches, and berms if practical.
- Restrict vehicular access during periods of inactivity using gates, fencing, and/or onsite security personnel.
- Identify any new sources of fugitive dust emissions and evaluate and implement the appropriate control methods for that source.
- Incorporate fugitive dust controls in all lands projects.

5.0 Control Options for Transport, Storage and Handling of Bulk Materials

Transporting bulk materials, such as gravel and fill material, can result in off-property dust emissions and other impacts (i.e. broken windshields) over some distance if the appropriate control measures are not implemented. Storage and handling of bulk materials once they arrive at the project site also requires that controls are in place to ensure that these materials do not exceed regulated nuisance dust emissions.

Task:

Use control measures and operational procedures designed so that no off-property transport emissions occur along public roadways to and from the project site:

- Enclose, cover, water, or otherwise treat loaded haul trucks to minimize the loss of material to wind and spillage.
- Require that all contract haul vehicles obey the posted speed limits on all public roadways to and from the project site.
- Ensure that haul truck speeds on new and existing access roads on the project site do not exceed 15 miles per hour by posting speed limits along these roads.
- Restrict haul trucks to existing roads and pad locations.
- Do not attempt to load/unload haul trucks when wind speeds exceed a sustained velocity of 20 miles per hour.
- Promptly remove dust-forming material from haul trucks to minimize entrainment of fugitive particulate matter.
- Avoid storage and handling of bulk material any more than necessary to complete construction.
- Use covers, enclosures, wind breaks, or watering to prevent fugitive dust emissions from material storage piles
- Restrict access to construction areas and storage piles during periods of inactivity using gates, fencing, and/or onsite security personnel.

6.0 Contingency Planning

Alternative control measures may become necessary in the event that the current dust control strategy is not adequate or effective for conditions. An alternative plan may require addition planning, permitting, or other regulatory compliance requirements to implement. In this case, the current activities at the project site would necessarily be suspended until such time as the alternate dust control methods could be put into place.

Task:

Implement alternative action to fugitive dust control plan and to each specific source if deemed necessary to comply with federal, state, and local air quality regulations:

- Provide field personnel and contractors with contact information for responsible individuals in cases where control measures need to be escalated in response to weather conditions (i.e. increased windiness).
- Use an appropriate alternative dust inhibitor if water does not prove to be effective under normal circumstances, and obtain all regulatory permissions for the use of chemical suppressants on the project site.
- Use vegetative blankets or other methods for cover of topsoil, spoil, and bulk material storage piles if immediate cover becomes necessary.
- Attempt to locate alternative sources of bulk material closer to the project site if fugitive dust emissions or other impacts from contract haul trucks on state or federal highways become an issue with public safety or regulatory compliance.

Appendix A

Contacts

ENCANA PERSONNEL

Name	Title	Office	Cell

CONTRACT CONSTRUCTION

Article 4-203.L
Traffic Study

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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BASIC TRAFFIC ANALYSIS

ENCANA OIL & GAS

K19NE LAYDOWN YARD

GARFIELD COUNTY, COLORADO

OA Project No. 014-2797

January 2015

760 Horizon Dr., Suite 102 | Grand Junction, CO 81506 | 970.263.7800 | Fax 970.263.7456

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INTRODUCTION & OBJECTIVE

This document summarizes findings of a Basic Traffic Analysis performed for the Encana Oil & Gas K19NE Laydown Yard. The current permitted use of the site is as a well pad. Although the site is also being used for some equipment storage today, the laydown yard is proposed to be permitted as an additional use on the property. The laydown yard will be used to store equipment and material associated with natural gas operations. It is expected that the lifespan of the site will be approximately 30 years.

The site is approximately one mile south of the Garfield County Regional Airport. The facility is located on Lot 3 of Section 19, Township 6 South, Range 92 West of the 6th Principal Meridian in unincorporated Garfield County. The subject site encompasses approximately 5.17 acres. The property is owned and operated by Encana Oil & Gas.

The objective of this analysis is to provide traffic data for the additional land use, review the existing road network, and provide traffic projections for public roads impacted by site traffic.

EXISTING ROAD NETWORK

Regional trips to this facility will use the I-70 exit near the Garfield County Regional Airport (Exit 94). Vehicles traveling to the site will drive south for approximately 4 miles along CR 315 to the intersection of CR 315 & CR 333 and make a right turn. They would then travel approximately 2.8 miles to the private access road where they would turn right to access the site. It should be noted that the private access drive is shared with a well pad. **Table 1** tabulates roadway geometry and characteristics for the county roads used by vehicles visiting this site.

An alternate route is to travel west along CR 346 (Rifle-Silt Rd) for approximately 2 miles to CR 352. Vehicles will then turn east onto CR 352 (Airport Road) and travel approximately 1.3 miles to CR 333 (Hunter Mesa Rd). Vehicles will then turn south onto CR 333 and travel approximately 0.8 miles to a private access road, turn left, and drive 0.5 miles to access the site. Both routes follow Garfield County preferred haul routes.

Table 1: Roadway Geometry and Characteristics

Roadway	Lanes	Road Width	Roadway Type	Speed Limit	Condition	Year of Impmt.	Functional Classification
CR 352	2	40’	Asphalt	35 mph	Good (’02)	2004	Minor Collector
CR 333	2	16’	Gravel	35 mph	Fair (’02)	-	Local
CR 346	2	24’	Asphalt	35 mph	Good (’02)	2005	Minor Collector
CR 315	2	24’	Asphalt	35 mph	Good (’05)	2005	Minor Collector

BACKGROUND TRAFFIC

Background traffic volumes were obtained from the Garfield County Road & Bridge department. The count data included 2014 counts at all roadways planned to be used by traffic traveling to the K19NE Laydown Yard. The background traffic volumes are shown in **Table 2** below.

Table 2: Background Traffic

Roadway	2014
CR 352	975
CR 333	125
CR 346	755
CR 315	805

TRIP GENERATION AND DISTRIBUTION

Trip generation is generally determined using rates found in the ITE *Trip Generation* manual. Rates from this publication are applied to values related to the size of the proposed site to estimate the trips expected to enter and exit the site. In this case, no rates are provided for facilities similar to these. To estimate trips expected for this site, information was gathered regarding the expected traffic based on the existing operations.

Existing vehicle activities during daily operations consist of one (1) pickup truck (two trips per day) for daily well inspections. Based on the new use of the site, it is expected that an additional two trips will visit the site daily. The site may also experience one additional heavy truck every two months. The pickup and heavy truck trips related to the storage use will store or remove materials that will be used in daily operations or during drilling and completing wells in the area.

The majority of vehicles accessing this facility will originate from other activities in the immediate area. Many of the existing trips to this site occurring over the public road system are associated with the daily monitoring of the site and are within background traffic projections. The same personnel, in fact, monitor multiple sites on a daily basis.

The trips associated with the storage use will also originate from the surrounding natural gas operations in the general area. They would include existing trips that haul materials and equipment in and out of the greater field. These are trips that would now be contained within the general area. Aside from public roads in the immediate vicinity of the site, the storage use is not expected to generate additional traffic and has the potential to reduce traffic on some roadways by providing a place for extra materials and equipment that would otherwise be hauled in or out of the larger field.

ROADWAY ANALYSIS

Existing Parcel

Current land use on the subject parcel is natural gas development. The majority of existing traffic on area county roads south of the airport is related to natural gas development activities and very limited agricultural activities. Roadways near the Garfield County Regional Airport including CR 346, CR 352, and portions of CR 315 also serve the airport as well as other municipal uses like the Colorado Mountain College, Garfield County Sheriff and Road & Bridge offices, and the Tri-State Generation and Transmission generating station.

State Highway Crossings and Access

There are no state highway crossings along the haul routes. Similarly, there will be no access to the site from a state highway.

Intersection of CR 352 & CR 346

The intersection of CR 352 & CR 346 is a "T" intersection with CR 346 as the stop-controlled minor approach. Sight distance as measured from the stop sign on CR 346 is adequate looking east and west. There is a right-turn deceleration lane leading into a free right (yield-controlled) for the westbound traffic along CR 352. There is also a left-turn deceleration lane for eastbound traffic on CR 352. Southbound CR 346 has a two-lane approach at this intersection. It is not expected site traffic will negatively impact intersection operations.

Intersection of CR 352 & CR 333

The intersection of CR 352 & CR 333 is a "T" intersection with CR 333 as the stop-controlled minor approach. Sight distance as measured from the stop sign on CR 333 is adequate looking east and west. There are left-turn deceleration lanes for traffic on CR 352. It should be noted that trucks are not permitted along CR 352 to the east of this intersection. It is not expected site traffic will negatively impact intersection operations.

Intersection of CR 315 & CR 346

The intersection of CR 315 & CR 346 is a four leg intersection with CR 346 as the stop-controlled minor approach. Sight distance as measured from the stop sign on CR 346 is adequate looking north and south. The Exit 94 I-70 ramp terminal is located approximately 200 feet north of this intersection. Sight distance photos were taken at the stop-controlled legs of this intersection and can be seen at the end of this document. It is not expected site traffic will negatively impact intersection operations.

Intersection of CR 315 & CR 333

The intersection of CR 315 & CR 333 is a “T” intersection with CR 333 as the stop-controlled minor approach. Sight distance as measured from the stop sign on CR 333 is adequate looking north and south along CR 315. It is not expected site traffic will negatively impact intersection operations.

RECOMMENDATIONS

Based on the expected trip generation rates discussed above, the increase in average daily traffic is not expected to be significant on roads generally used by the public. The county roads discussed will see only a minor increase in traffic. The total traffic volumes will remain very low and can be accommodated by the existing roadways. The addition of traffic generated by the proposed updated site use does not increase existing volumes to levels required for State or County permits.

Attachments

Vicinity Map and Haul Routes Map
Sight Distance Photos

LEGEND

- Site Location
- Preferred Haul Route
- Alternative Haul Route
- X,XXX - Background ADT

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OLSSON ASSOCIATES

Vicinity Map and Haul Routes

FIGURE
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OA #14-2797

Encana K19 Laydown Yard – Site Roadway Photos

PHOTO 1: West leg looking north onto County Road 315 from County Road 346.

PHOTO 2: West leg looking south onto County Road 315 from County Road 346.

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Article 4-203.M Water Supply and Distribution Plan

Encana Oil & Gas (USA) Inc K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2797

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Water Supply and Distribution Plan
Encana Oil & Gas (USA) Inc.
K19NE Storage Facility (Laydown Yard)

SECTION 4-203.M. WATER SUPPLY AND DISTRIBUTION PLAN.

The Encana Energy K19NE Storage Facility does not require potable water source for personnel or freshwater for sanitary facilities, landscaping or day to day operations of the facility.

The operations of the facility will be similar to other natural gas operations in relatively remote areas of Garfield County. No potable water will be provided at this facility. The proposed use is an unmanned facility with personnel onsite only for short intervals. Personnel provide their own potable water carried in their vehicles. Encana makes potable water available at their field office to staff and contractors.

Sanitary facilities will not require a source of water and will be provided by portable toilets located at numerous sites in the field per OSHA standards. Landscaping is not being proposed and a water system is not required to maintain any plantings. The storage facility does not use water in its daily operation.

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Article 4-203.N Wastewater Management and System Plan

Encana Oil & Gas (USA) Inc K19NE Storage Facility (Laydown Yard)

OA Project No. 014-2797

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Waste Management and System Plan
Encana Oil & Gas (USA) Inc.
K19 Storage Facility

SECTION 4-203.N. WASTEWATER MANAGEMENT AND SYSTEM PLAN.

The operations of the facility will be similar to other natural gas operations in relatively remote areas of Garfield County. Staff will not be assigned to the facility on a regular basis. Personnel will be at the facility only for short periods of time. Workers will be loading and unloading materials and providing facility maintenance and inspections.

Sanitary facilities are provided by portable toilets placed at numerous sites in the field per OSHA standards. These portable toilets are maintained by Redi Services of Rifle, Colorado. All waste is hauled to a licensed treatment facility. A "Will Serve" letter is provided documenting the maintenance of these sanitary facilities.

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REDI SERVICES, LLC
2143 AIRPORT RD.
RIFLE, CO. 81650
970-625-0233

2/09/2015

SUBJECT: WILL SERVE LETTER

COMPANY: Encana Oil and Gas

LOCATIONS: All Locations Serviced

Redi Services will provide Encana Oil and Gas with Porta John Units on designated locations Redi Services will service and maintain these units and dispose of the waste at an approved disposal site. At this time we are disposing of the waste at The West Garfield County Landfill.

Thanks,

Mario Ramirez
Redi Services, LLC
Trucking / Waste Management Manager

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Article 7
Standards Analysis

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Article 7 – Standards Analysis
Encana Oil & Gas (USA) Inc.
K19 Storage Facility (Laydown Yard)

DIVISION 1. GENERAL APPROVAL STANDARDS FOR LAND USE CHANGE PERMITS

SECTION 7-101. ZONE DISTRICT USE RESTRICTIONS

The subject property is located in the Rural (R) zone district of Garfield County on Lot 3 of Section 19, Township 6 South, Range 92 West of the 6th Prime Meridian. The proposed use is considered a Storage use according to Table 3-403: Use Table of the Garfield County Unified Land Use and Development Code. This use requires a Limited Impact Review (LIR) to obtain a Land Use Change Permit (LUCP).

SECTION 7-102. COMPREHENSIVE PLAN AND INTERGOVERNMENTAL AGREEMENTS

The K19 Laydown Yard generally conforms to the Garfield County Comprehensive Plan. The site is designated in the Garfield County Comprehensive Plan 2030 as a Residential Medium High (RMH) area with a residential density of 2 to 6 acres per dwelling unit. According to the Comprehensive Plan, facilities that are appurtenances to oil/ gas development activities (compressors, etc.) are considered appropriate in all land uses so long as they meet the respective mitigation requirements of the Land Use and Development Code to maintain compatibility with surrounding land uses. The existing use is not within an area governed by an intergovernmental agreement.

SECTION 7-103. COMPATIBILITY

The proposed site is located within the boundaries of an 88.5 acre property. The storage use would be limited to a 5.17 acre area. Rural residential, natural gas development, light industrial, and agriculture are the predominate uses on the subject parcel and surrounding properties. The closest residential use to the proposed laydown yard is approximately 0.75 miles to the north

The proposed use is intended to provide a centralized and convenient storage location for the natural gas operations in the immediate area. This proposed use is compatible with and supportive of the adjacent uses.

SECTION 7-104. SOURCE OF WATER

A source of potable water will not be required for workers utilizing the site. This facility is not manned on a regular basis and does not require a water distribution and wastewater system to properly function. Workers will provide their own potable water in their trucks. Encana will provide personnel bottled or potable water at their field office. A source of water is not required for the

operation of the facility. The site will be used as a storage facility. Water will not be required for the operation of sanitary facilities. Portable toilets will be used, and all wastes will be hauled to a licensed treatment facility. Water will not be required for landscaping. No landscaping is proposed at this site.

SECTION 7-105. CENTRAL WATER DISTRIBUTION AND WASTEWATER SYSTEMS

A. Water Distribution System

As stated above, the proposed facility will not require a source of water or a central water distribution system.

B. Wastewater Systems

As stated above, the proposed facility will not require a centralized wastewater system. Portable toilets will be used and wastes will be hauled to a licensed disposal facility.

SECTION 7-106. PUBLIC UTILITIES

The facility will not require public utilities in order to operate.

SECTION 7-107. ACCESS AND ROADWAYS

A. Access to Public Right of Way

No new roads are proposed to accommodate the additional storage use. Access to the subject property is from County Road (CR) 333 via a private access road. The existing roadway and access are adequate for the anticipated low traffic volumes. Dust from the private driveway will be mitigated as appropriate.

B. Safe Access

The road functions adequately for its intended use and is typical of existing roads providing access to natural gas production facilities in Garfield County.

C. Adequate Capacity

The proposed facility will generate little traffic and the current road system has adequate capacity to support the proposal. See Traffic Analysis and Road Assessment reports included with this application for additional details.

D. Road Dedications

The road has a 45 foot wide Access Easement (Garfield County Reception Number 650315). This private road does not provide access to residential uses nor is it used by the general public on a regular basis. No new public roads are being built or dedicated as part of this project.

E. Impacts Mitigated

County roads will experience minor impacts from this project. The proposed storage use may actually reduce traffic impacts by limiting the need to haul equipment in and out of the area when it is needed. See the Traffic Analysis for further information.

F. Design Standards

The access driveway meets most of the Primitive Roadway/Driveway standards of Table 7-107 of the Land Use and Development Code. The private access road does not meet the design standards for road grade, cross slope, or ditches. See Road Assessment report for more information. A Waiver of Standards request is being submitted as part of this submittal.

SECTION 7-108. USE OF LAND SUBJECT TO NATURAL HAZARDS

According to the Natural and Geological Hazard Assessment Report the project area is not subject to avalanche, rockfall, landslide, alluvial fan, slope, mud flow or debris fan, expansive soils, collapsible soils, faults, or radiation hazards. The Potts Loam soils are listed as having a high risk of corrosion to uncoated steel and a low risk of corrosion to concrete. This should not present a significant hazard.

SECTION 7-109. FIRE PROTECTION

Encana makes their Emergency Response Plan available to the appropriate fire protection district. If requested, Encana will orientate the appropriate fire protection district regarding this facility.

DIVISION 2. GENERAL RESOURCE PROTECTION STANDARDS

SECTION 7-201. AGRICULTURAL LANDS

A. No Adverse Affect to Agricultural Operations

The proposed use will not directly affect any agricultural operation.

B. Domestic Animal Controls

Dogs and other domestic animals will not be permitted on the property or allowed to interfere with livestock.

C. Fences

The site will not be fenced.

D. Roads

No new roads will be constructed to access this facility, and the existing road will be maintained.

E. Irrigation Ditches

The proposed use will not impact irrigation ditches.

SECTION 7-202. WILDLIFE HABITAT AREAS

A. Buffers

Visual or sound buffers are not necessary to screen activity areas from habitat areas. According to the Wildlife Assessment accompanying this submittal, it is not likely that the proposed laydown yard would adversely affect federally listed wildlife species. No additional vegetation removal is associated with the laydown yard, since it was previously disturbed.

As noted in the Wildlife Assessment, the project site was surveyed for the potential habitat for the greater sage grouse. No potential habitat exists in the area for the greater sage grouse. The greater sage grouse inhabits vast, continuous sagebrush communities.

B. Locational Controls of Land Disturbance

The project area is currently disturbed. No additional wildlife habitat disturbance will occur. According to the Biological Assessment the site is within CPW Game Management Unit 42 and Data Analysis Units D-12 and E-14. The site does not occur within CPW mapped migration corridors or habitat linkages for elk or deer.

The site occurs within CPW mapped mule deer Overall Range, Severe Winter Range, Winter Range and Winter Concentration Area. The site occurs within CPW mapped elk Overall Range, Winter Range, Severe Winter Range, and Winter Concentration Area.

C. Preservation of Native Vegetation

The site will be reclaimed after the facility is no longer utilized and will be revegetated with native plant species. Noxious weeds will be controlled during the life of the facility and during the re-establishment of native plants.

D. Habitat Compensation

No critical wildlife habitat will be disturbed at this site.

E. Domestic Animal Controls

Domestic animals will not be kept on the site.

SECTION 7-203. PROTECTION OF WATERBODIES

A. Minimum Setback

The proposed laydown yard is located approximately 500 feet from an unnamed drainage to the west, and 757 feet from an unnamed drainage to the east. The project area will be more than 35 feet from the Typical and Ordinary High Water elevation of this stream.

B. Structures Permitted in Setback

There will not be any structures located in this setback area.

C. Structures and Activity Prohibited in Setback

There will not be any structures or activities located in the buffer zone.

D. Compliance with State and Federal Laws

The facility will comply with all applicable state and federal laws.

SECTION 7-204. DRAINAGE AND EROSION

The site is an existing disturbed surface area. Minor additional surface disturbance may be required to accommodate the Grading and Drainage Plan. BMPs will be used to protect water bodies from stormwater runoff during the operation of this facility. This facility is more than 100 feet from a water body, and it does not create more than 10,000 square feet of impervious area.

SECTION 7-205. ENVIRONMENTAL QUALITY

A. Air Quality

This facility will not cause air quality to be reduced below acceptable levels established by the Colorado Air Pollution Control Division and will comply with appropriate Colorado air emissions regulations as applicable. The equipment and materials proposed to be stored on site will not require an APEN.

B. Water Quality

This facility will be operated in compliance with all applicable State and Federal hazardous material regulations. There will be no hazardous materials stored at this proposed site. Implementation and adherence to Encana's Stormwater Management Plan (SWMP) BMPs and Spill Prevention Control and Countermeasures Plan (SPCC) will assure that water quality is protected.

SECTION 7-206. WILDFIRE HAZARDS

A. Location Restrictions

The site is in a low wildfire hazard area according to the Garfield County on-line GIS map resources.

F. Development Does Not Increase Potential Hazard

The facility will not increase the potential intensity or duration of a wildfire, or adversely affect wildfire behavior or fuel composition.

G. Roof Materials and Design

No structures are being proposed. This standard is not applicable.

SECTION 7-207. NATURAL AND GEOLOGIC HAZARDS

A Natural and Geological Hazard Assessment Report is included with this application under a separate tab.

A. Utilities

B. Trenches for water pipelines, natural gas pipelines, and electrical lines are not expected to be associated with the proposed development of the K19 Storage Yard. The laydown

yard will be used to store sections of pipe and equipment above grade for use elsewhere in the area and region.

C. Development in Avalanche Hazard Areas

The site is not located in a known avalanche hazard area. Winters are cold in the mountainous areas of Garfield County, and valleys are colder than the lower parts of adjacent mountains due to cold air drainage. Average seasonal snowfall in Garfield County is 50 inches. The greatest snow depth at any one time during the period of record from 1951 to 1974 was 29 inches recorded at Rifle, Colorado approximately 30 miles to the east of the proposed site.

Much of the Rifle area is at a higher elevation than the town of Rifle and is somewhat cooler and receives more precipitation. Avalanches are not expected to affect the proposed laydown yard, since it is located at elevations between 6000 feet and 8000 feet.

D. Development in Landslide Hazard Areas

The Site is not in an area of landslides or potential landslides.

E. Development in Rockfall Hazard Areas

Rockfall areas are not a geological hazard in the area of the Site, but may exist in areas along Mamm Creek and its tributary drainages.

F. Development in Alluvial Fan Hazard Area

The Site is not in an area mapped as an alluvial fan hazard area.

G. Slope Development

Slope is not a geologic hazard in the vicinity of the site, but is in areas to the north and west along West Mamm Creek and Mamm Creek drainages.

H. Development on Corrosive or Expansive Soils and Rock

The Potts Loam soils are listed as a high risk of corrosion to uncoated steel and a low risk of corrosion to concrete. These soil characteristics are not expected to pose a geologic hazard for the proposed development at the K19NE Storage Yard.

The shrink-swell potential for the Potts Loam is low to moderate. Therefore, expansive soils are not a geologic hazard at the K19NE Storage Yard.

I. Development in Mudflow Areas

The Site is not located in an area of mapped mud flow or debris fan areas.

J. Development Over Faults

No significant faults have been mapped or are known in the K19NE Storage Yard. The Site is located to the northwest of the Divide Creek anticline which was formed as a result of movement along a blind thrust fault associated with the uplift of the Colorado Rocky Mountains.

SECTION 7-208. RECLAMATION

After the completion of Encana's natural gas production in the area, the facility will be decommissioned and reclaimed in accordance with the reclamation plan provided in this submittal and COGCC Series 1000 Rules. All of Encana's surface disturbances (final reclamation requirements) are covered under a statewide bond.

DIVISION 3. SITE PLANNING AND DEVELOPMENT STANDARDS

SECTION 7-301. COMPATIBLE DESIGN

A. Site Organization

The site was designed to accommodate the functional and efficient operations, monitoring and maintenance of the facility.

B. Operational Characteristics

Operation of the proposed storage facility will be consistent with nearby uses. Adjacent lands will not be impacted by the generation of vapor, dust, smoke, glare, noise or vibration. Noise will not exceed standards established by the COGCC. The facility will be unmanned but accessible to Encana personnel 24 hours a day. There will be minimal impacts, if any, to the existing roadway system during the operational phase.

C. Buffering

The site and the surrounding properties areas located in a Rural (R) zone district. Additional buffering is not required.

D. Materials

Buildings are not being proposed. This standard is not applicable.

SECTION 7-302. OFF-STREET PARKING AND LOADING STANDARDS

Adequate parking will be made available to accommodate Encana's personnel during regular operation, inspection and maintenance of the facility. All activities on this site will be conducted out of any public right-of-way.

SECTION 7-303. LANDSCAPING STANDARDS

This type of industrial use is exempt from the landscape standards of the Development Code.

SECTION 7-304. LIGHTING STANDARDS

A. Downcast Lighting

Any lighting will be directed inward, towards the interior of the site.

B. Shielded Lighting

Any exterior lighting will be shielded so as not to shine directly onto other properties.

C. Hazardous Lighting

Light from the site will not create a traffic hazard or be confused as traffic control devices.

D. Flashing Lights

The facility will not contain flashing lights.

E. Height Limitations

There will be no light sources exceeding 40 feet in height on the site.

SECTION 7-305. SNOW STORAGE STANDARDS

Snow will be stored in a vacant section of the existing disturbed area.

SECTION 7-306. TRAIL AND WALKWAY STANDARDS

The proposed site is located in a rural area of Garfield County. Multimodal connections are not appropriate or feasible.

DIVISION 10. ADDITIONAL STANDARDS FOR INDUSTRIAL USES

SECTION 7-1001. INDUSTRIAL USE

A. Residential Subdivisions

This site is not located in a platted residential subdivision.

B. Setbacks

The laydown yard will maintain at least a 100 foot setback from adjacent property lines.

C. Concealing and Screening

The site is concealed from neighboring properties by a combination of topography and distance. The majority of equipment and materials stored on site will be low-profile in nature.

D. Storing

The site is not in a flood zone or other natural hazard zone that would transfer the materials off site. All products will be stored according to all national, state and local codes. The laydown yard will maintain at least a 100 foot setback from adjacent property lines.

E. Industrial Wastes

All industrial wastes will be disposed of in a manner consistent with Federal and State statures and requirements of the CDPHE.

F. Noise

Noise levels will not exceed state noise standards pursuant to C.R.S., Article 12, Title 25. The site will be used as a storage facility/laydown yard and any operational stationary equipment is associated with the Oil and Gas Drilling and Production uses located in the area. No

additional equipment will be permanently installed on the site that could potentially create a noise nuisance.

G. Ground Vibration

This facility will not generate ground vibrations perceptible beyond the boundary line of the property.

H. Hours of Operation

The facility will not generate noise, odors, or glare beyond the property boundaries greater than what is allowed under the Land Use Development Code. Activities that do generate these impacts within the established standards will occur between the hours of 7:00 a.m. and 7:00 p.m. Monday through Saturday.

I. Interference, Nuisance, or Hazard

This facility will not emit heat, glare, radiation or fumes which will interfere with uses on adjacent properties or constitute a public nuisance. The proposed use will not exceed the standards established by Garfield County or the COGCC.

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Article 7-1003.C
Emergency Response Plan

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Quick Reference Guide

(Condensed copy for permit submittals)
Encana's complete Emergency Response Plan is on file with all applicable Fire Districts and updates are provided as necessary

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encana natural gas	**EMERGENCY RESPONSE PLAN** **U.S.A. DIVISION** **SRBU EMERGENCY RESPONSE REPORTING TEMPLATE**	**Document No:** ERP-0042 SRBU **Revised By/Date:** **Reviewed By/Date:** ERPComm/05.26.2010 **Approved By/Date:** ERPComm/05.26.2010

SBU:	_____
Name of Event:	_____
Date:	_____, ***2010***
Location:	_____ ***Secured :*** ☐ ***Yes*** ☐ ***No***
Town, State:	_____, _____
1. Time of the call.	_____ : _____ (Military Time)
2. What is the location of the emergency? What has happened?	Location?: _____ What Happened?: _____
3. Has anyone been hurt?	☐ No ☐ Yes If so, Who? _____ How? _____
4. Who is the most senior Encana or Company representative on location?	_____
5. Who is the most senior Encana or company representative on location who will be the **INCIDENT COMMANDER**? Do they have the proper Incident Commander Training?	_____ _____ _____ Incident Commander Trained? No ☐ Yes ☐
6. Based on your assessment, what Level of Emergency are you declaring?	Level 1 ☐ Level 2 ☐ Level 3 ☐
7. Who are you appointing as **OPERATION CHIEF**?	_____
8. Do not respond to a man down, or to the emergency, until you have completed a **Risk Assessment**, gained control and understanding of the emergency, and can assure life safety of the responders.	Have you completed a Risk Assessment? N ☐ Y ☐ _____

9. Are there **FIRST RESPONDERS** on location?	☐No ☐Yes Time of Arrival: _____:_____ Who arrived? _____
10. Have you set up an **INCIDENT COMMAND POST**, if so, where?	☐No ☐Yes Location of the Incident Command Center?_____
11. Based on your initial assessment, what is your proposed preliminary response strategy?	_____ _____ _____
12. I will act as **EMERGENCY MANAGER**, and activate the EOC. Plan on calling in to the EOC, using the **Emergency Notification Conference Call Number**, within 15 minutes.	Emergency Manager Activated at: _____ Emergency Operations Center Activated at: _____ We will be using EOC Conference Line: **EOC 1 and EOC 2:** 1-877-445-2224 **EOC 1:** ☐ **Profile #** 2421013 **Password** 10131 **EOC 2:** ☐ **Profile #** 2421014 **Password** 10141 **EOC 3:** ☐ **{20 or more incoming calls}** **North American Dial-In:** 1-866-400-1788 **International Dial-In:** (647) 427-2433 **Conference code:** 835 298 4806 **Leader PIN:** 2846
13. I will notify **EXECUTIVE LEAD, EHS OFFICER**, and put together the **EMERGENCY MANAGEMENT TEAM.**	**Executive Lead Notified:** No ☐ Yes ☐ Time: _____ **EHS Officer Notified:** No ☐ Yes ☐ Time:_____ **EMT Notified:** No ☐ Yes ☐ Time: _____
14. Start to put together a local **INCIDENT COMMAND TEAM.**	**Incident Commander:** _____ **Deputy Incident Commander:** _____ **Safety Officer:** _____ **Liaison Officer:** _____ **Public Information Officer:** _____ **Operations Section Chief:** _____ **Planning Section Chief:** _____ **Logistics Section Chief:** _____

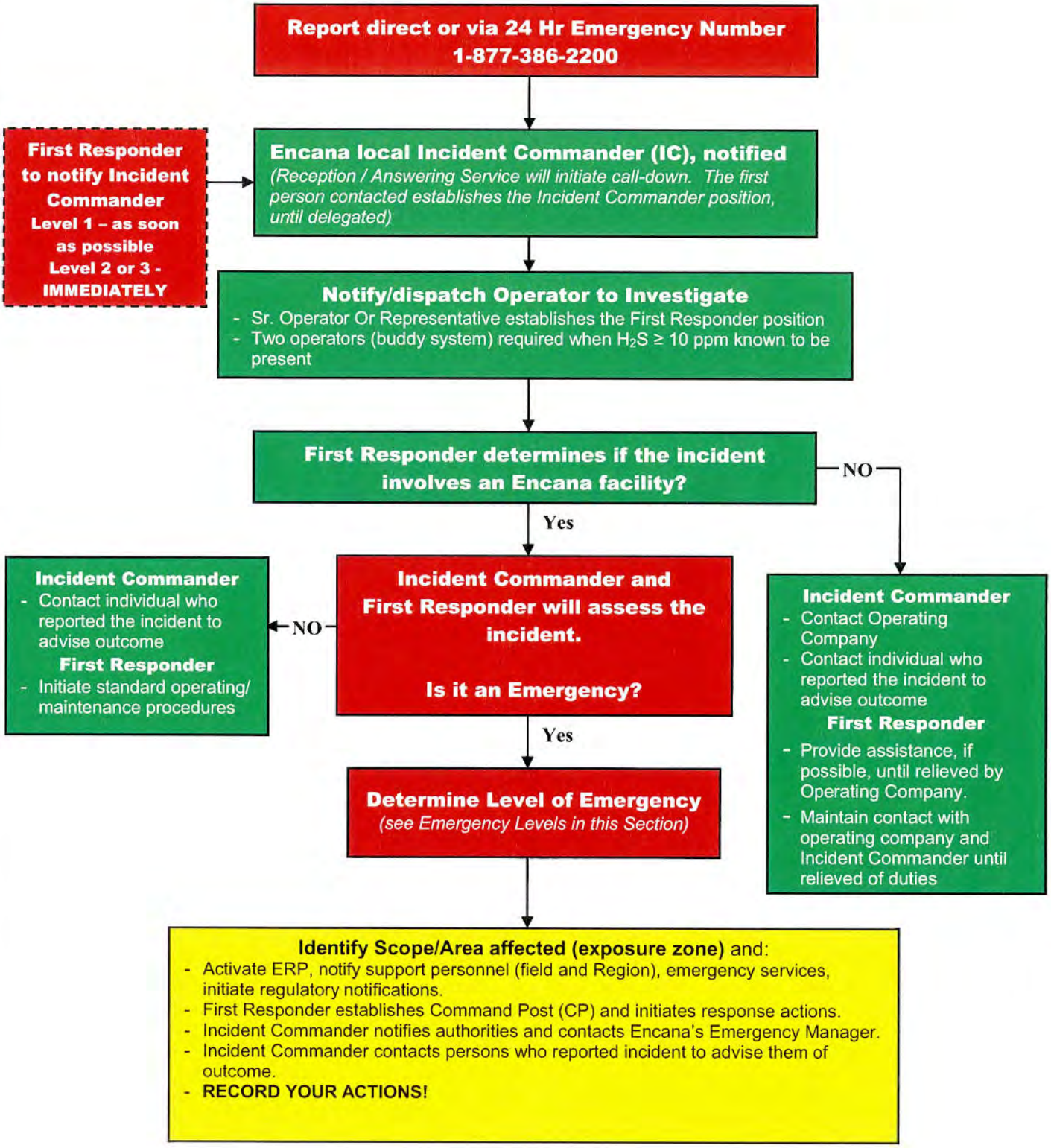
Emergency Classification / Levels

EMERGENCY LEVELS	
Definition / Criteria	**Examples** *(may not reflect area-specific risks or threats)*
LEVEL 1 - Onsite incidents where control of the hazard has been obtained but the potential exists for the imminent loss of control due to deteriorating conditions.	
○ Immediate control of the hazard has been established using available resources, however, conditions are not improving and/or resources are being depleted. ○ Injuries to onsite personnel that are of a moderate impact. ○ Public safety is not threatened, however there is, or may be, a public perception of moderate risk to human health or the environment. ○ Environmental impacts are confined to the site and have limited potential to impact offsite. ○ All control and relief systems are functioning normally.	○ Any controlled situation, outside of normal operation conditions, where the ability to maintain control using onsite resources is in question or offsite resources are required to maintain control such as a fire or explosion where imminent control of the fire is probable. ○ Injuries to personnel requiring offsite medical attention.- ○ Spills and releases that are contained onsite but have the potential to extend offsite. ○ Any incident requiring the advisory notification of the public of a non-routine, onsite occurrence. ○ Weather conditions (i.e., tornado) which may threaten personnel and operations. ○ Potential social / political unrest, labor disputes

LEVEL 2 - An incident where control of the hazard has been lost but where imminent and/or intermittent control of the hazard is possible.	
○ Control of the hazard has been lost, however, through the application of available resources intermittent control is being obtained or hazard control is imminent. ○ Injuries to onsite personnel that are of a major impact. ○ Public safety is not threatened, however, there is or may be a public perception of significant risk to human health or the environment ○ Environmental effects extend offsite and are resulting in minor or short-term detrimental impacts. ○ Some control and relief systems are not operational.	○ Any uncontrolled hazard where the ability to regain control using available resources is imminent or intermittent control is being achieved using available resources such as pipeline integrity failure. ○ Injuries to personnel which have or are likely to result in a lost time (beyond the day of the occurrence) injury or short term health impact. ○ Spills or releases that extend offsite and are, or will, result in minor or short-term detrimental impacts. ○ Any incident requiring the notification of the public of a potential or imminent threat to human health or the environment, such as or pipeline rupture. ○ Some control and/or relief systems are not operational. ○ Imminent security threats, social / political unrest, and labor disputes. ○ Severe weather threats which threatens personnel and/or operations. ○ Overdue vehicle or aircraft.
○ **LEVEL 3 - An incident where control of the hazard has been lost, imminent control is not possible and public safety is, or has the potential, to be threatened.**	
○ Control of the hazard has been lost and regaining control is not imminently possible. ○ Onsite personnel have sustained injuries with a serious impact. ○ Public safety is being, or has the imminent potential to be, jeopardized. ○ Environmental impacts are significant, extend offsite and have the potential to result in long-term environmental degradation. ○ Key control and relief functions have failed and are not operating correctly.	○ Any situation where control of a hazard has been lost and regaining control is not imminently possible such as loss of well control or failure of essential well control equipment. ○ Injuries to personnel which have or are likely to result in permanent disability, long term health impacts or death ○ Any incident that has necessitated the evacuation or sheltering of public such as or a catastrophic facility fire or loss of process control. ○ Spills or releases that have extended off site and are, or likely to, result in significant and substantial detrimental impact to the environment. ○ Key control and relief systems are not operational. ○ Act of terrorism, violence, social/political unrest. ○ Severe weather impacting personnel and/or operations. ○ Overdue vehicle or aircraft, missing person.

ACTIVATION AND NOTIFICATION REQUIREMENTS

Receiving an Emergency Call - Typical Notification



First Responder Actions

Protect Yourself

- ❒ Approach the incident from upwind and uphill, if possible.
- ❒ Position vehicle far enough away from the release, allowing for a safe retreat, if necessary.
- ❒ Resist the urge to rush in, others cannot be helped if you are injured.
- ❒ Avoid any contact with liquids, mists, sludge's, gases, vapors and smoke.

Sound the Alarm

- ❒ Announce level of emergency.
- ❒ Direct others to safe areas and alert other personnel.

Call for Help

- ❒ Notify control room, local office and or the on-call supervisor.
- ❒ Confirm emergency services has been dispatched.
- ❒ Activate Emergency Response Plan.

Assume Command

- ❒ Size up incident and make report.
- ❒ Confirm location (if necessary).
- ❒ Situation found.
- ❒ Make assignments (as necessary). Summon additional help and technical assistance as required. Do not hesitate to summon assistance; it can always be canceled if not needed.
- ❒ Tactical considerations:
  - o Life safety,
  - o Incident stabilization,
  - o Environmental protection, and
  - o Property conservation.
- ❒ Zoning:
  - o Utilize, with caution, the U.S. DOT Emergency Response Guidebook for recommended actions if MSDSs are unavailable for released material,
  - o Establish hazard / hot zone (use fire line tape for **hot line**),
  - o Establish and mark warm zone (**decontamination corridor), and**
  - o Establish cold zone (set **security line**).
- ❒ Immediately provide for proper decontamination of responders and/or injured.
- ❒ Transfer command (as necessary).

Assess Hazard

- ❒ If immediate rescue is required, it should only be attempted when the rescuers are fully aware of the risks posed to them, they are wearing protective clothing, as required, utilizing a bare minimum number of personnel. If the hazards are unknown or exceptionally life-threatening, the rescuer should consider waiting until the situation has been assessed by the IC, SO, and the EHS/HazMat Unit.

Secure the Area

- ❒ Restrict access to location or area.
- ❒ Utilize law enforcement agencies (Emergency Alert System) and any other available resources to evacuate or shelter in-place exposed victims.

Transfer of Command

The process of moving the responsibility for incident command from one Incident Commander (IC) to another is called "transfer of command." It should be recognized that transition of command on an expanding incident is to be expected. It does not reflect on the competency of the current IC. The most important steps in effectively assuming command of an incident in progress are:

Assessment & Briefing

- ❒ Perform assessment of incident situation with existing IC.
- ❒ Receive adequate briefing by the current IC in face-to-face meeting. The briefing must cover the following items:
  - o Incident history (what has happened),
  - o Priorities and objectives,
  - o Current plan,
  - o Resource assignments,
  - o Incident organization,
  - o Resources ordered/needed,
  - o Facilities established,
  - o Status of communications,
  - o Any constraints or limitations,
  - o Incident potential, and
  - o Delegation of Authority.

Written Summary Report

- ❒ Incoming IC to receive written summary to assist in incident briefings. This form contains:
  - o Incident objectives,
  - o A place for a sketch map,
  - o Summary of current actions,
  - o Organizational framework, and
  - o Resources summary.

Notice of Command Change

- ❒ Determine an appropriate time for transfer of command.
- ❒ Provide notice of a change in incident command to:
  - o Emergency Management Team (through dispatch),
  - o General Staff members (if designated),
  - o Command Staff members (if designated), and
  - o All incident personnel and agencies.

  The incoming IC may give the out-going IC another assignment on the incident.
- ❒ There are several advantages of this:
  - o The out-going IC retains first-hand knowledge at the incident site, and
  - o This strategy allows the out-going IC to observe the progress of the incident and to gain experience.

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Western Operations Emergency Notification Chart
Piceance

FIRST RESPONDER
1. Evacuate: Account for all personnel
2. Call for help: Quick Reference Guide / Notification Charts
3. Secure the scene: Establish IC Command

Level 1
Level 2
Level 3

INCIDENT COMMANDER

Brad Ankrum W 970-285-2630 C 435-260-1673	**Clyde Marks** W 970-285-2681 C 970-309-3061	**Mitch Steinke** W 970-285-2654 C 303-918-3844
Operations Control Center (Parachute) W 970-285-2615 C 970-301-1319 *Parachute OCC Alternate* **Operations Control Center** (Denver) W 866-244-0062	**Doug Rosa** W 970-285-2686 C 970-210-2073	**Ryan Tompkins** W 970-285-2685 C 970-640-3294

EHS On Call Number 1-855-759-1855
Axiom Injury Case Management 877-502-9466
USA Security Watch Center 1-855-822-0169

SAFETY & HEALTH	ENVIRONMENTAL
Laura Lancaster W 970-285-2617 C 970-216-1251	**Lindsey Kruckenberg** W 970-285-2711 C 970-456-3229

EMERGENCY MANAGER

Jeff Johnson
W 720-876-5091
C 303-881-7666

Ken Retzlaff
W 720-876-5231
C 303-301-4176

EHS OFFICER

John Keil
W 720-876-3705
C 214-755-2081

EXECUTIVE LEAD	EXECUTIVE MANAGEMENT
Jeff Balmer C 720-206-6382	**Byron Gale**

EMERGENCY MANAGEMENT TEAM

LEGAL	FINANCE	LOSS CONTROL & INSURANCE	CORPORATE COMUNICATIONS	HUMAN RESOURCES	SECURITY	MEDIA RELATIONS	COMMUNITY RELATIONS, LAND, REGULATORY
Matt Baskind W 720-876-3403 C 303-653-4308	**Kelly Vandamme** W 720-876-3829 C 303-829-0573	**David Platt** W 403-645-7514 C 403-606-2877	**Alicia Olson** W 720-876-5486 C 720-412-6802	**Chris Casebolt** W 720-876-3622 C 303-898-6501	**Ken Jackson** W 970-285-2830 C 970-309-2655	**Doug Hock** W 720-876-5096 C 303-328-7048	**Jason Oates** W 720-876-3228 C 720-785-4806

Corporate HQ – Calgary – Security Desk **On Call 24 Hours – (402) -645 - 7777**	**CORPORATE PRESIDENT & CHIEF EXECUTIVE OFFICER** **Doug Suttles**	**CHIEF OPERATING OFFICER** **Mike McAllister**

TACTICAL SUPPORT TEAM

AGENCY CONTACTS

BLM (Grand Junction)	970-244-3050	National Response Cntr	800-424-8802
BLM (Silt)	970-876-9000	Federal OSHA	800-321-6742
BLM (Meeker)	970-878-3800	CO One-Call	800-922-1987
COGCC (Rifle)	970-625-2497	Pipeline ref.	811
CDPHE	877-518-5608		

EMERGENCY CONTACTS

Grand River Hospital (rifle)	970-625-1510	EMS, Fire, Police	911
Garfield County	970-625-8095		
Mesa County	970-242-6707		
Rio Blanco County	970-878-9600		
Colorado State Patrol	970-824-6501		

Cisco Meeting Place Express
Toll Free: 1-877-445-2224
Long Distance: 1-403-645-2224
Meeting ID to start the meeting 2421013#
Password 10131#
To join the meeting 2421013# Password 10131#

Date Reviewed: 10/31/2014 Date Revised: 10/31/2014

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Article 7-107
Roadway Assessment

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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OLSSON ASSOCIATES

ROAD ASSESSMENT

ENCANA OIL & GAS (USA) INC.
K19NE STORAGE FACILITY (LAYDOWN YARD)

The following road assessment is to address Garfield County's Policy 04-01 waivers for roads and demonstration of compliance. The purpose of the road assessment is to assess the subject road for the Garfield County roadway standards listed within Table 7-107 of the Land Use Development Code.

The Encana Oil & Gas (USA) Inc. (Encana) K19NE Storage Facility (Laydown Yard) Road Assessment begins where the road turns off of County Road (CR) 333 in the SESE quarter of Section 24, Township 6 South, Range 93 West of the 6th P.M. and terminates in Lot 3 of Section 19, Township 6 South, Range 92 West of the 6th P.M. at the Encana K19NE Laydown Yard. This road is approximately 0.5 miles in length from CR 333 to the Laydown Yard. Included in the road assessment is a road through private land shared for access to Encana Pad K19CNE, which is approximately 0.2 miles in length. The remaining 0.3 miles is on Encana property and is used solely to access the K19NE Laydown Yard. Encana performs the maintenance on the entire road. Field observations and data gathering were conducted on November 18, 2014. The observations are summarized as an attachment to this assessment.

Statement of Adequacy

This road is typical of roads providing access to natural gas production facilities in Garfield County. The roadway is adequate for the intended use.

Geometry of Road

The following table compares this road to the Garfield County roadway standards found in Table 7-107 of the Land Use and Development Code for Primitive Road/Driveway.

Table 7-107: Roadway Standards		
Design Standards	Primitive/Driveway	Road Assessment
Design Capacity (ADT)	0-20	4-6
Minimum ROW Width (Feet)	15 to 30[1]	45
Lane Width (Feet)	Single Lane 12	13.2 to 23
Shoulder Width (Feet)	0	0.6 to 5.5
Ditch Width (Feet)	3[2]	0 to 7.5
Cross Slope	2%	0.6% to 7.3%
Shoulder Slope	n/a	0.6% to 7.3%
Design Speed	n/a	n/a
Minimum Radius (Feet)	40	50
Maximum % Grade	12%	14.4%
Surface	Native Material	Gravel

760 Horizon Drive, Suite 102
Grand Junction, CO 81506
TEL 970.263.7800
FAX 970.263.7456
www.olssonassociates.com

[1] As determined adequate in an engineering review. Primitive road shall be dedicated ROW, driveway can be dedicated as either an easement or ROW.
[2] If determined necessary for adequate drainage.

The road is across private land, and there is a 45 ft. wide Access Easement (Garfield County Reception Number 650315).

The road width varies between 13.2 and 23 feet. This meets the minimum requirement.

Where ditches are present, they range in width from 2.0 to 7.5 feet. The ditches are fairly shallow.

The cross slope varies between 0.6% and 7.3%. In some places, the road slopes toward the side of the road without a ditch, including some areas where the road is crowned.

There is no posted speed limit on the road.

The horizontal radii range from 50 feet to 310 feet. All the turns meet the minimum 40 foot standard radius.

The grade for the road varies between 0.4% and 14.4%. The areas where the grade is greater than 12% occur in short sections. The road is surfaced with gravel.

The road geometry changes occasionally with maintenance activities. Cross slopes change during maintenance operations. The road was built to follow the general topography of the area with minimal change to the natural grade.

Safety/Structural Issues

A significant drop off adjacent to the road was observed on the right side of the road approximately from stations 13+50 to 19+00 and on the left side of the road approximately from stations 16+70 to 24+00. Mitigation methods should be evaluated during maintenance operations.

Overall the roadway did not exhibit obvious safety or structural issues during the date of the field observation, November 18, 2014.

Maintenance

Encana does all of the maintenance on the road. The road is inspected on a regular basis for maintenance issues. Maintenance includes grading as needed to remove washboard and repair potholes. The road surface is graveled as needed to maintain the road base with attention to dust control. Speeds are low to promote safety and reduce road damage.

Travel Demand

Average Daily Traffic (ADT) for the proposed project is expected to be less than 20 vehicles per day (VPD) as shown in the Basic Traffic Study prepared by Olsson Associates, dated January 2015 (study). As a result, this roadway is being assessed according to the standards for a Primitive Road/Driveway.

As mentioned within the study, traffic associated with the use as a storage facility at the site is primarily pickup trucks, 4 trips per day. Additionally, a heavy truck will access the site one time every two months. Typical daily volumes will be approximately 4 trips per day with the potential for 6 trips.

Other Evidence of Compliance

Section 7-107.A Access to Public Right-of-Way

The private road to the site has direct access to CR 333. A copy of the driveway permit is included at the end of this section.

Section 7-107.B Safe Access

Access to the site is consistent with other similar uses.

Section 7-107.C Adequate Capacity

Traffic congestion is not anticipated as a result of the proposed use. The roadway capacity is expected to be sufficient for the intended use.

Section 7-107.D Road Dedications

The road has a 45 foot wide Access Easement (Garfield County Reception Number 650315).

Section 7-107.E Impacts Mitigated

Based on the expected trip generation rates discussed in the Basic Traffic Study, the increase in average daily traffic is not expected to increase on County Roads such that a modification of the existing access permit would be required. The total traffic volumes are expected to remain very low and are anticipated to be accommodated by the existing roadway.

Conclusions

The road assessment identified areas that deviate from the Design Standards in Table 7-107 for ditch width, cross slope, and maximum grade.

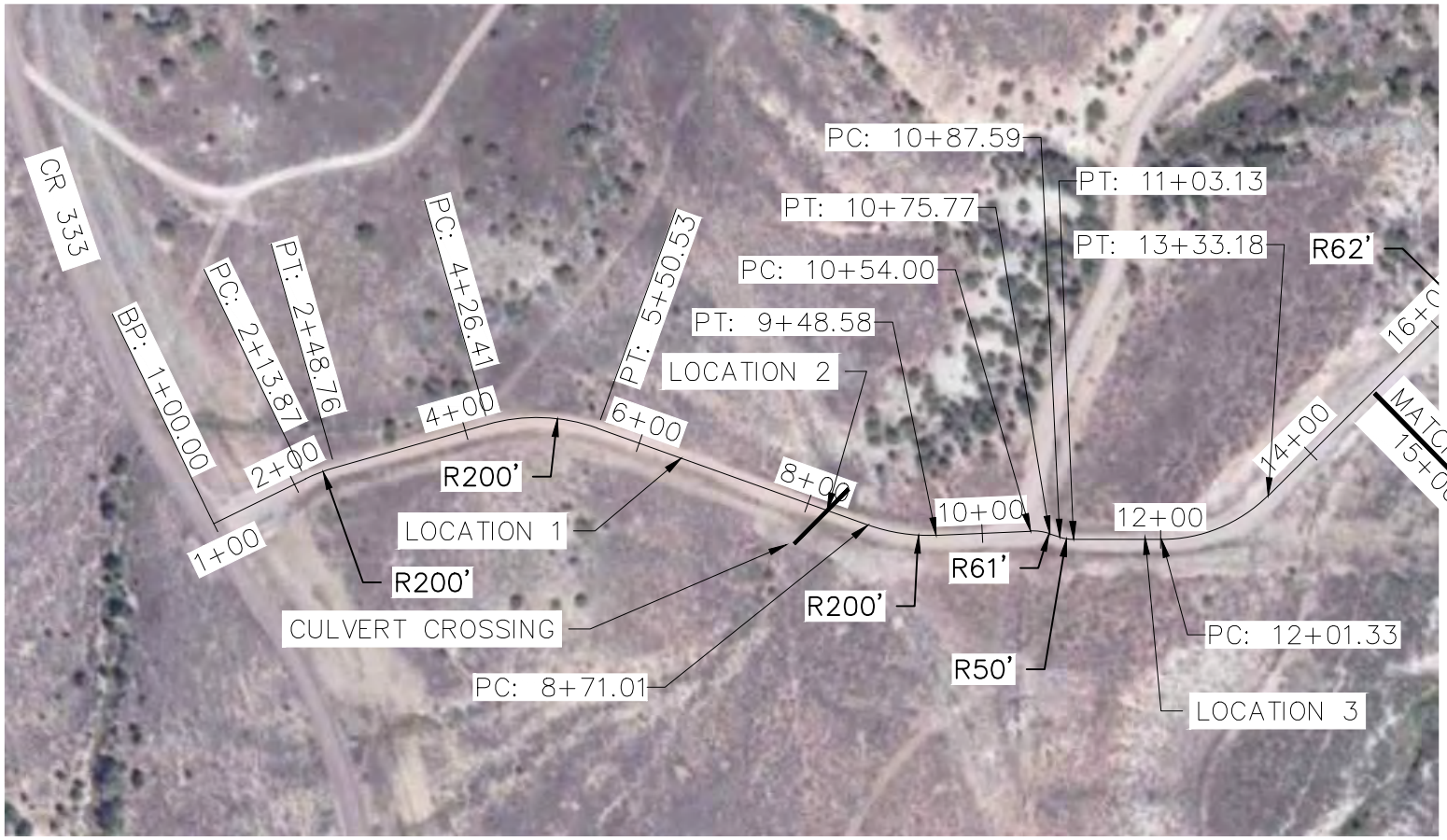
Where there are discernible ditches along the road, the ditch width varies. Locations 1, 2, 4-7 have ditch widths less than 3 feet. Some of the road has ditches on one side only or no ditches at all. In some areas, the cross slope inclines toward the side of the road where there is no ditch. As a result, areas will have ponding water that could lead to the need for additional maintenance over time. There are no defined shoulders though most areas of the roadway are wide enough to consider shoulders as an extension of the lane width. There is a dedicated turn-out at station13+25 with a width of 24.5 feet.

The cross slope varies from 0.6% to 7.3% along the road. The road geometry changes occasionally with maintenance activities. While ponding may occur in areas of shallow cross slope, the road is inspected on a regular basis for maintenance issues, which are addressed in a timely manner.

The grade for the road varies between 0.4% and 14.4%. The areas where the grade is greater than 12% occur in short sections.

The road functions adequately for its intended use and is typical of existing roads providing access to natural gas production facilities in Garfield County.

Wyatt E. Popp, PE



NOTE: INFORMATION SHOWN ON THIS EXHIBIT IS APPROXIMATE. DATA REFLECTED WITHIN THE TABLE IS NOT BASED ON A TOPOGRAPHIC SURVEY. INFORMATION SHOWN IS BASED ON MEASUREMENTS TAKEN DURING A SITE VISIT ON NOVEMBER 18, 2014.

LOCATION	STATION	CROSS SLOPE	GRADE	ROAD WIDTH	LEFT DITCH	RIGHT DITCH
1	6+50	6.8%	−9.4%	23.0'	NONE	2.0'
2	8.20	7.2%	–	19.0'	NONE	NONE
3	11+80	5.8%	−11.5%	13.2'	3.5'	5.0'

N

0' 150' 300' 600'

SCALE IN FEET

DWG: F:\Projects\014-2797_LDVP\Exhibits\K19 Road Assessment.dwg USER: dlheritier
DATE: Jan 28, 2015 11:03am XREFS:

PROJECT NO: 014-2797	ENCANA K19NE STORAGE FACILITY (LAYDOWN YARD) ROADWAY ASSESSMENT GARFIELD COUNTY, COLORADO	OLSSON ASSOCIATES 760 Horizon Dr. Suite 102 Grand Junction, CO 81506 TEL 970.263.7800	SHEET 1
DRAWN BY: ABL			
DATE: 12/01/2014			

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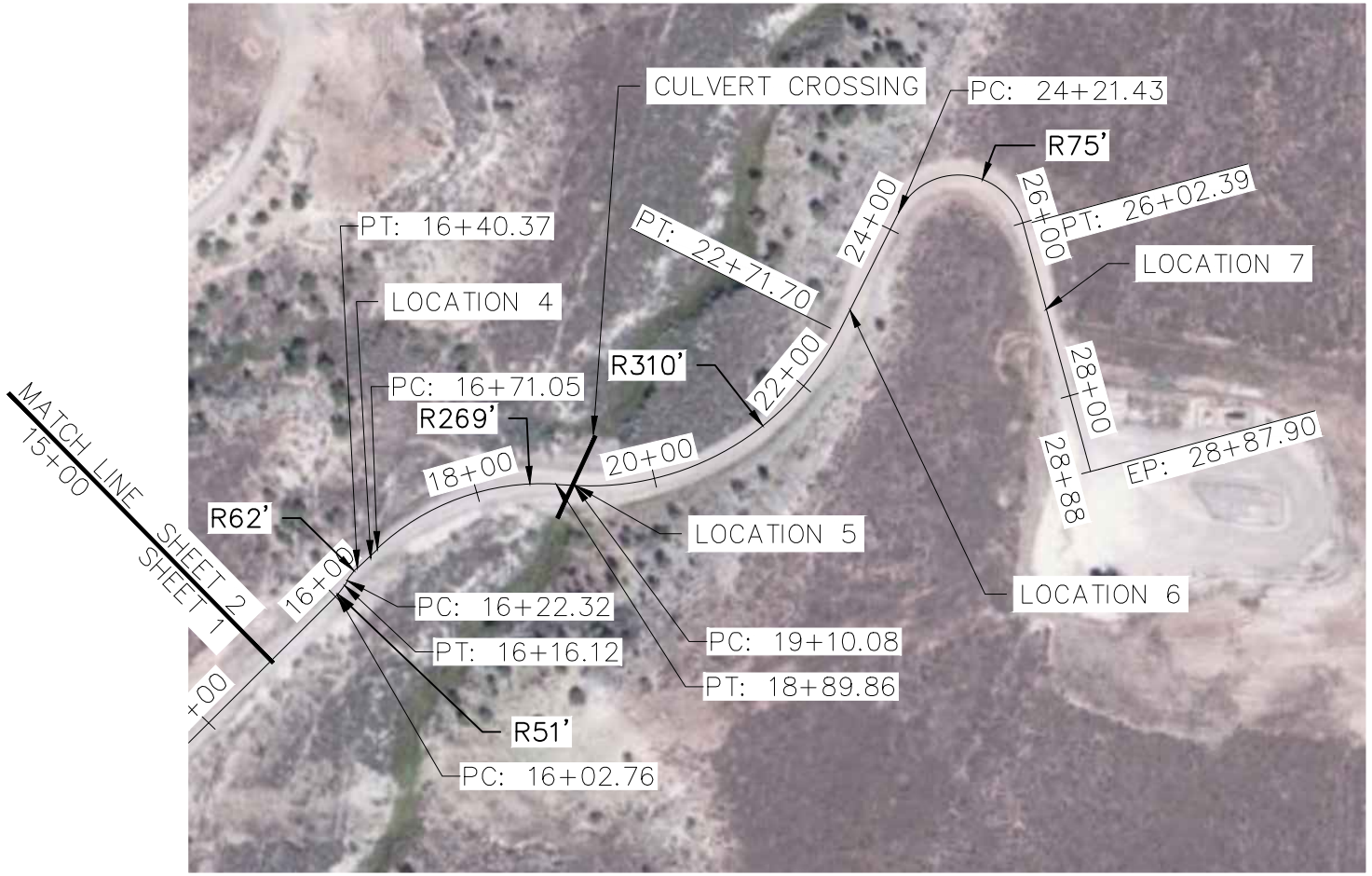

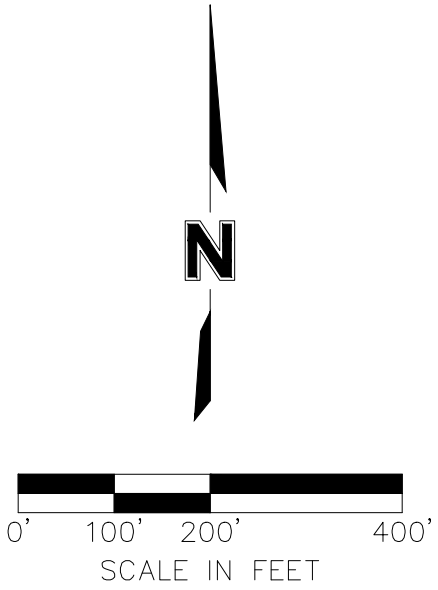

NOTE: INFORMATION SHOWN ON THIS EXHIBIT IS APPROXIMATE. DATA REFLECTED WITHIN THE TABLE IS NOT BASED ON A TOPOGRAPHIC SURVEY. INFORMATION SHOWN IS BASED ON MEASUREMENTS TAKEN DURING A SITE VISIT ON NOVEMBER 18, 2014.

LOCATION	STATION	CROSS SLOPE	GRADE	ROAD WIDTH	LEFT DITCH	RIGHT DITCH
4	16+70	2.2%	−14.4%	16.5'	2.5'	NONE
5	19+10	0.6%	1.7%	16.0'	NONE	NONE
6	23+00	7.3%	10.3%	18.0'	NONE	7.5'
7	27+00	4.8%	4.7%	23.0'	NONE	NONE

DWG: F:\Projects\014-2797_LDVP\Exhibits\K19 Road Assessment.dwg USER: dlheritier
DATE: Jan 28, 2015 11:03am XREFS:

PROJECT NO: 014-2797 DRAWN BY: ABL DATE: 12/01/2014	ENCANA K19NE STORAGE FACILITY (LAYDOWN YARD) ROADWAY ASSESSMENT GARFIELD COUNTY, COLORADO	OLSSON ASSOCIATES 760 Horizon Dr. Suite 102 Grand Junction, CO 81506 TEL 970.263.7800

SHEET 2

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Garfield County

Application for Driveway Permit

Person Obtaining Permit: Encana Oil and Gas(USA), Inc. ***Permit Number: GRB05-D-38***
Application Date: 5/18/2005 ***Termination Date: 6/18/2005***
County Road Number: 333 ***District: Silt*** ***Inspector: Jake Mall***

---

hereby requests permission and authority from the Board of County Commissioners to construct a driveway approach (es) on the right-of-way off of County Road, **333, 1 mile South of Intersection of CR 333 and CR 352 on CR 333**, located on the **East** side of road for the purpose of obtaining access to property.

Applicant submits herewith for the consideration and approval of the Board of County Commissioners, a sketch of the proposed installation showing all the necessary specification detail including:

1. Frontage of lot along road.
2. Distance from centerline of road to property line.
3. Number of driveways requested
4. Width of proposed driveways and angle of approach.
5. Distance from driveway to road intersection, if any.
6. Size and shape of area separating driveways if more than one approach.
7. Setback distance of building(s) and other structure improvements.
8. No unloading of equipment on county road, any damage caused to county road will be repaired at subdivision expense.
9. Responsible for two years from the date of completion.

General Provisions

1) The applicant represents all parties in interest, and affirms that the driveway approach (es) is to be constructed by him for the bona fide purpose of securing access to his property and not for the purpose of doing business or servicing vehicles on the road right of way.

2) The applicant shall furnish all labor and materials, perform all work, and pay all costs in connection with the construction of the driveway(s). All work shall be completed within thirty (30) days of the permit date.

3) The type of construction shall be as designated and/or approved by the Board of County Commissioners or their representative and all materials used shall be of satisfactory quality and subject to inspection and approval of the Board of County Commissioners or their representative.

4) The traveling public shall be protected during the installation with proper warning signs and signals and the Board of County Commissioners and their duly appointed agents and employee shall be held harmless against any action for personal injury or property damage sustained by any reason of the exercise of the Permit.

5) The Applicant shall assume responsibility for the removal or clearance of snow, ice, or sleet upon any portion of the driveway approach (es) even though deposited on the driveway(s) in the course of the County snow removal operations.

Encana Available Credit

Credit from 2004	$	(1,181.50)
Utility Permit GRB05-U-12	$	165.00
Utility Permit GRB05-U-2	$	165.00
Utility Permit GRB05-U-5	$	202.50
Driveway Permit GRB05-D-33	$	75.00
Driveway Permit GRB05-D-32	$	75.00
Driveway Permit GRB05-D-38	$	75.00
Available Credit as of 5/3/05	$	(424.00)

Specifications

1. A driveway approach is understood to be that portion of the county road right-of way between the pavement edge and the property line that is designed and used for the interchange of traffic between the roadway and abutting property.

2. At any intersection, a driveway shall be restricted for a sufficient distance from the intersection to preserve the normal and safe movement of traffic. (It is recommended for rural residence entrances that a minimum intersection clearance of 50 feet be provided and for rural commercial entrances a minimum of 100 feet be provided.)

3. All entrances and exits shall be so located and constructed that vehicles approaching or using them will be able to obtain adequate sight distance in both directions along the county road in order to maneuver safely and without interfering with county road traffic.

4. The Applicant shall not be permitted to erect any sign or display material, either fixed or movable, on or extending over any portion of the county road right-of-way.

5. Generally, no more than one approach shall be allowed any parcel or property the frontage of which is less than one hundred (100) feet. Additional entrances or exits for parcels having a frontage in excess of one hundred 100) feet shall be permitted only after showing of actual convenience and necessity.

6. All driveways shall be so located that the flared portion adjacent to the traveled way will not encroach upon adjoining property.

7. No commercial driveway shall have a width greater than thirty (30) feet measured at right angles to the centerline of the driveway except as increased by permissible radii. No noncommercial driveway shall have a width greater than twenty (20) feet measured at right angles to the centerline of the driveway, except as increased by permissible radii.

8. The axis of an approach to the road may be at a right angle to the centerline of the county road and of any angle between ninety (90) degrees and sixty (60) degrees but shall not be less than sixty (60) degrees. Adjustment will be made according to the type of traffic to be served and other physical conditions.

9. The construction of parking or servicing areas on the county road right-of-way is specifically prohibited. Commercial establishments for customer vehicles should provide off-the-road parking facilities.

10. The grade of entrance and exit shall slope downward and away from the road surface at the same rate as the normal shoulder slope and for a distance equal to the width of the shoulder but in no case less than twenty (20) feet from the pavement edge. Approach grades are restricted to not more than ten percent (10%).

11. All driveways and approaches shall be so constructed that they shall not interfere with the drainage system of the street or county road. The Applicant will be required to provide, at his own expense, drainage structures at entrances and exits, which will become an integral part of the existing drainage system. The Board of County Commissioners or their representative, prior to installation, must approve the dimensions and types of all drainage structures.

Note: This permit shall be made available at the site where and when work is being done. A work sketch or drawing of the proposed driveway(s) must accompany application. No permit will be issued without drawing, blueprint, or sketch.

6) In the event it becomes necessary to remove any right-of-way fence, the posts on either side of the entrance shall be surely braced before the fence is cut to prevent any slacking of the remaining fence and all posts and wire removed shall be turned over to the District Road Supervisor of the Board of County Commissioners.

7) No revisions or additions shall be made to the driveway(s) or its appurtenances on the right-of-way without written permission of the Board of County Commissioners.

8) Provisions and specifications outlined herein shall apply on all roads under the jurisdiction of the Board of County Commissioners of Garfield County, Colorado, and the Specifications, set forth on the attached hereof and incorporated herein as conditions hereof.

9) **Final inspection of driveway will be required upon completion and must be approved by person issuing permit or representative of person issuing permit.**
The inspection and sign off must be done prior to any CO from the Building and Planning Department being issued.

Special Conditions:

1. **Driveway Width- 80ft**
2. **Culvert required? True Size: 15 inch by 80ft**
3. **Asphalt or concrete pad required? False Size of pad:**
4. **Gravel portion required? True Length: 100ft**
5. **Trees, brush and/or fence need to be removed for visibility? False**
6. **Distance and Direction:**
7. **Certified Traffic Control Required? False**
8. **Work zone signs required? True**

In signing this application and upon receiving authorization and permission to install the driveway approach (es) described herein the Applicant signifies that he has read, understands and accepts the foregoing provisions and conditions and agrees to construct the driveway(s) in accordance with the accompanying specification plan reviewed and approved by the Board of County Commissioners.

Signed: _____
Encana Oil and Gas(USA), Inc.

Address: _____

Telephone Number: 970-309-1125

Permit granted **5/18/2005**, subject to the **provisions, specifications and conditions stipulated herein**.

For Board of County Commissioners' of Garfield County, Colorado:

_____

Representative of Garfield County Road and Bridge Signature

Article 7-202.C.3
Noxious Weed Plan

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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Encana Oil & Gas (USA)
Weed Management Effort Summary
July, 2010

Introduction

Encana Oil & Gas (USA) (Encana) is currently implementing several integrated weed management techniques in the Piceance Basin. Whenever possible, weed infestations are assessed on an individual basis, such that the best, site-specific weed management techniques may be executed. Encana employs the benefits of chemical, mechanical, biological, cultural or an integration of these methods in everyday weed management throughout the Piceance field.

Chemical Management

Chemical means of weed control are the most commonly utilized weed management technique at this point in time. The frequency of this treatment method is mostly attributed to the financial feasibility, speed and relative consistency in results associated with herbicide applications. In general, most Encana sites are inventoried, monitored and sprayed a minimum of 3-4 times per year, based upon the accessibility and known infestation status of the site. With every visit, commercial pesticide applicators monitor previous treatments for effectiveness, inventory for new or surviving plants and treat the site. Documentation of this event is recorded into Encana's Noxious Weed Management Database as reported on contractor invoices and daily pesticide application records.

The first site visit and herbicide application is done in the early spring of the approaching growing season or in the late fall of the previous year. At this time, non-selective, residual herbicide applications are made as a safety precaution on active sites. This treatment type also prevents annual weed infestations that are commonly observed on fresh and frequently disturbed sites. During this treatment, pesticide applicators inspect the location and surrounding areas for very young newly emerging weeds, or rosette "flushes" in the circumstance that the site is treated in the fall.

The second site visit and treatment is done in spring to early summer. This treatment is intended to target early perennials (hoary cress, primarily), biennial rosettes and annual "obnoxious weeds" such as Russian thistle and kochia. Again, pesticide applicators will inventory the area for later maturing plant species such as Russian knapweed.

During the third site visit a mid to late summer inventory is conducted with intentions to spray late-bolting biennials and budding perennials; furthermore, mechanical removal of flowers and seed heads on biennial species (most commonly musk thistle) may also be done around this time.

Lastly, on many sites, a late-summer to fall herbicide treatment may be applied on creeping perennials such as Canada thistle and Russian knapweed in order to best capture the opportunity for the use of translocated herbicides. Following this step, the non-selective treatments described above will be used where applicable, and the cycle will start again. This treatment plan is highly site-dependent, thus variations inevitably occur based upon individual site characteristics (i.e. elevation, soils, topography, moisture, etc.) and also upon the various label requirements and recommended target growth stages of the herbicides being used.

Mechanical Weed Management

Second to chemical means of control, Encana utilized mechanical weed management on a frequent basis. Large-scale mowing or "brush-hogging" projects are primarily executed on reclaimed sites that support a desirable plant component, but which also support a significant, spatially-competitive weed community. Generally, these treatments target annual, non-listed weed types. Encana makes a special effort to utilize mechanical weed management techniques in the early stages of reclamation, so as not to disturb newly establishing native and desirable plants. Additionally, Encana will employ mechanical removal as a second resort when chemical weed control means are not an effective option. These treatments are typically goaled towards the removal of weeds when the growth stage of the target specie is not compatible with chemical control (i.e. removal of thistle seed heads following bolt and flower). Additionally, in the case of fuels reduction for safety purposes, mechanical control is preferred with the objective at hand. Generally, mechanical weed removal is conducted throughout the summer and early fall.

Biological Weed Management

Encana has introduced the presence of biological weed control agents in recent years and is in the early stages of monitoring and considering the continued use of similar resources. At this time, Encana has released a limited number of biological control agents. These have been released at sites that were not candidates for chemical or mechanical control, either based upon topography, infestation size, spatial relativity to potentially impacted wildlife habitat or a combination of these factors. All releases to date have been established near the property boundaries of weed-harboring neighbors and have been incorporated with some chemical and mechanical means. Casual ocular monitoring has been conducted and landscape photographs have been taken and recorded. Due to the youth of these projects and the expected long-term results of biological controls, little change has been observed at this point.

Cultural Weed Management

As cultural weed management tools, Encana emphasizes on prevention, early detection/ rapid response (EDRR), and grazing monitoring and rotation grazing, where applicable. As prevention, Encana requires Third Party companies and contractors to clean dirt-moving equipment prior to mobilization into new areas. Encana provides annual, in-house weed identification trainings to their Environmental Field Coordinators to assist in early detection. To support rapid response, Environmental Field Coordinators also carry tools and instructions for mechanical weed removal, in the circumstance that a few, isolated weeds are approached during regular field activities. Lastly, where Encana has authority, livestock grazing plans, pasture rotations and monitoring and inventory plans are implemented to assess and minimize the impacts of grazing on weed infestations and wildlife habitat.

Conclusion

Due to the primarily fragmented, linear structure of the surfaces managed by Encana, successful weed control proves to be challenging and dynamic. Additionally, because Encana's surfaces are relatively small in scale, a great deal of communication and cooperation between landowners, county representatives and federal government agencies is necessary to effectively and sustainably control, isolate and eradicate weed infestations on a local, landscape basis. To meet these challenges, Encana utilizes standardized reporting, invoicing and inspection processes that are all logged and documented in an Access Database.

Figures

Encana Oil & Gas (USA) Inc
K19NE Storage Facility
(Laydown Yard)

OA Project No. 014-2797

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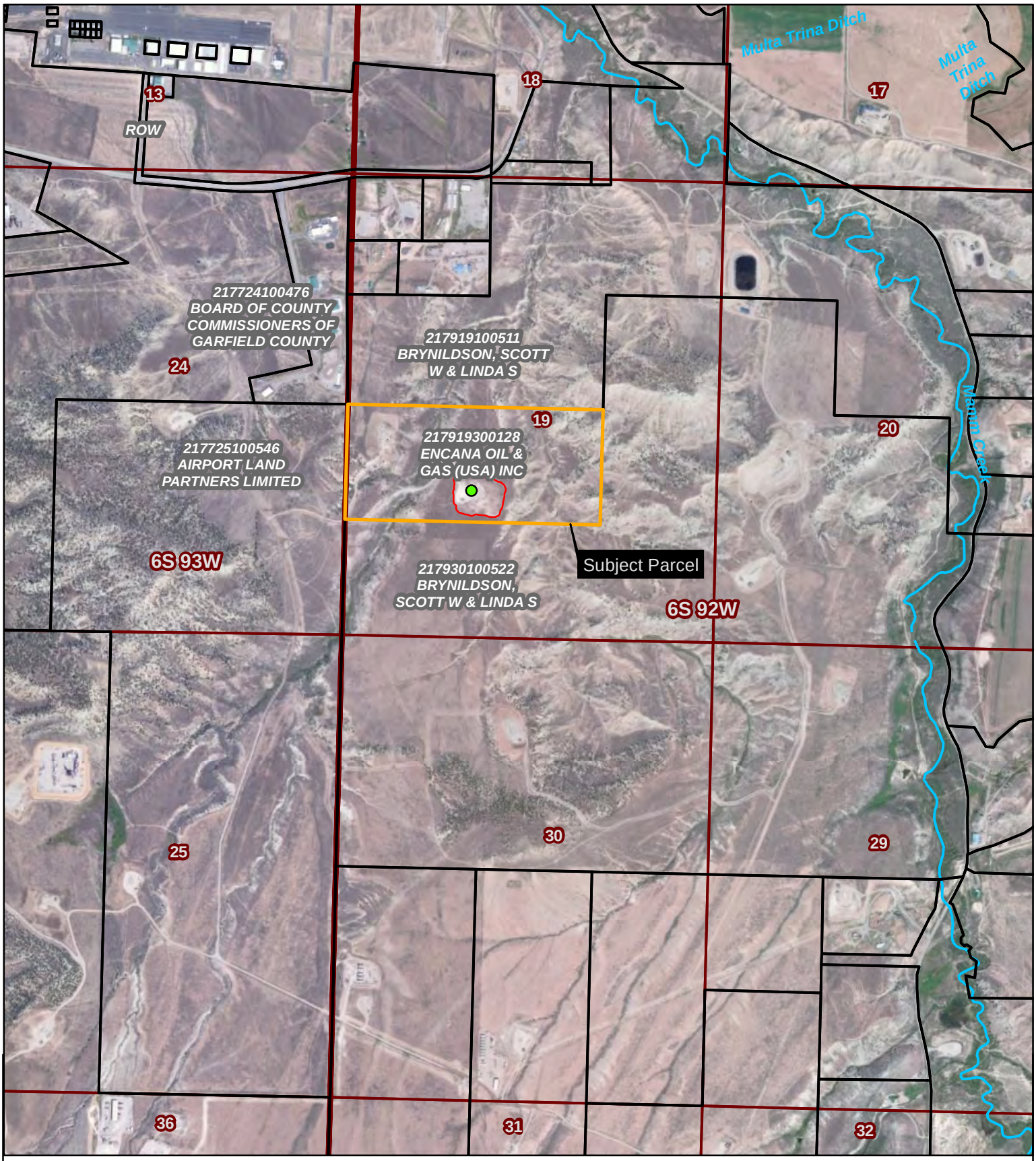

K19NE Storage Yard
K19NE Storage Yard Boundary
Parcels
Subject Parcel
Perennial Stream

N
W
E
S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

ADJACENT LAND OWNERS MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

ALO-1

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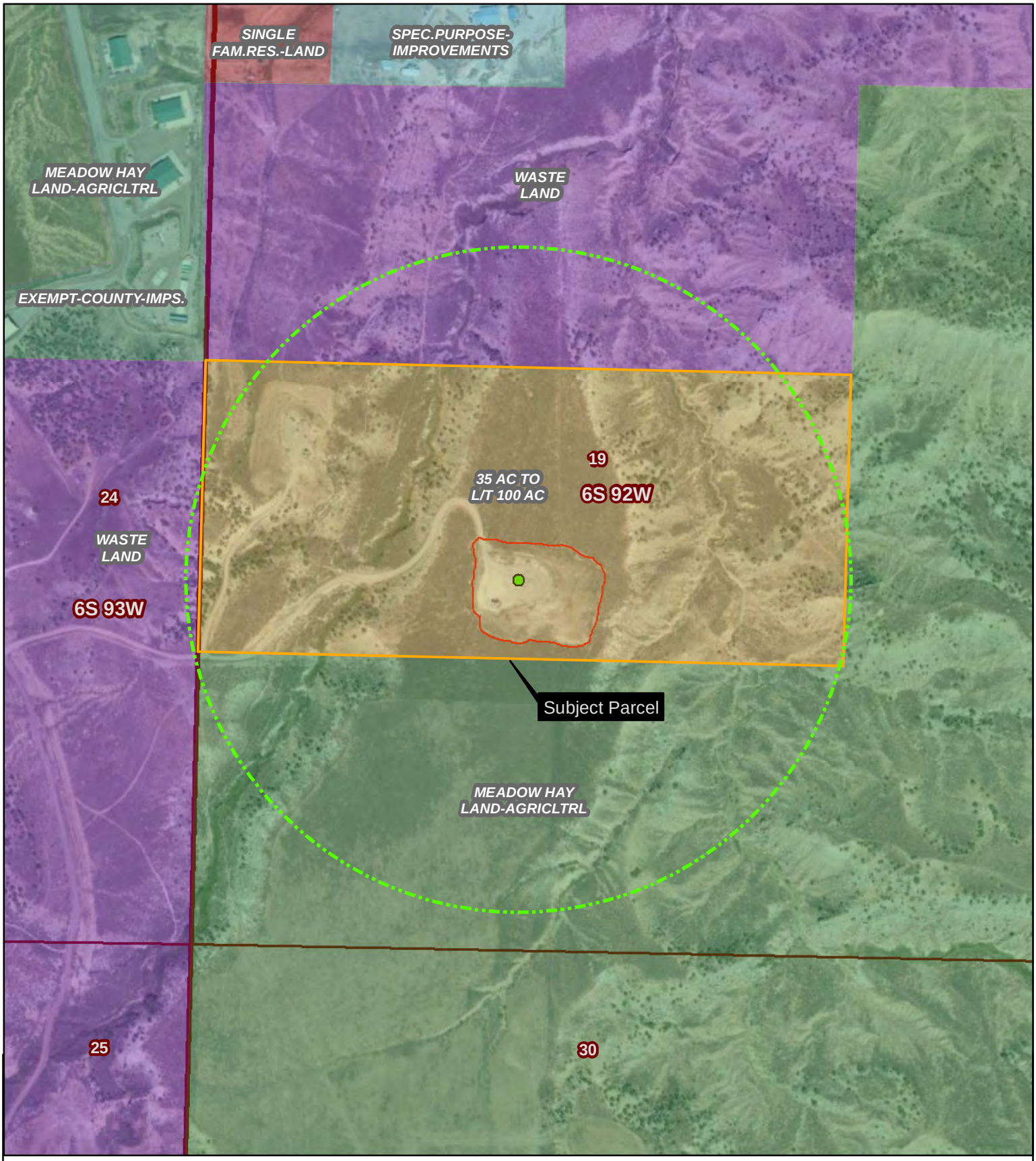

K19NE Storage Yard
K19NE Storage Yard Boundary
Subject Parcel
1500 Foot Buffer

N
W
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PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

ADJACENT LAND USE MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

ALU-1

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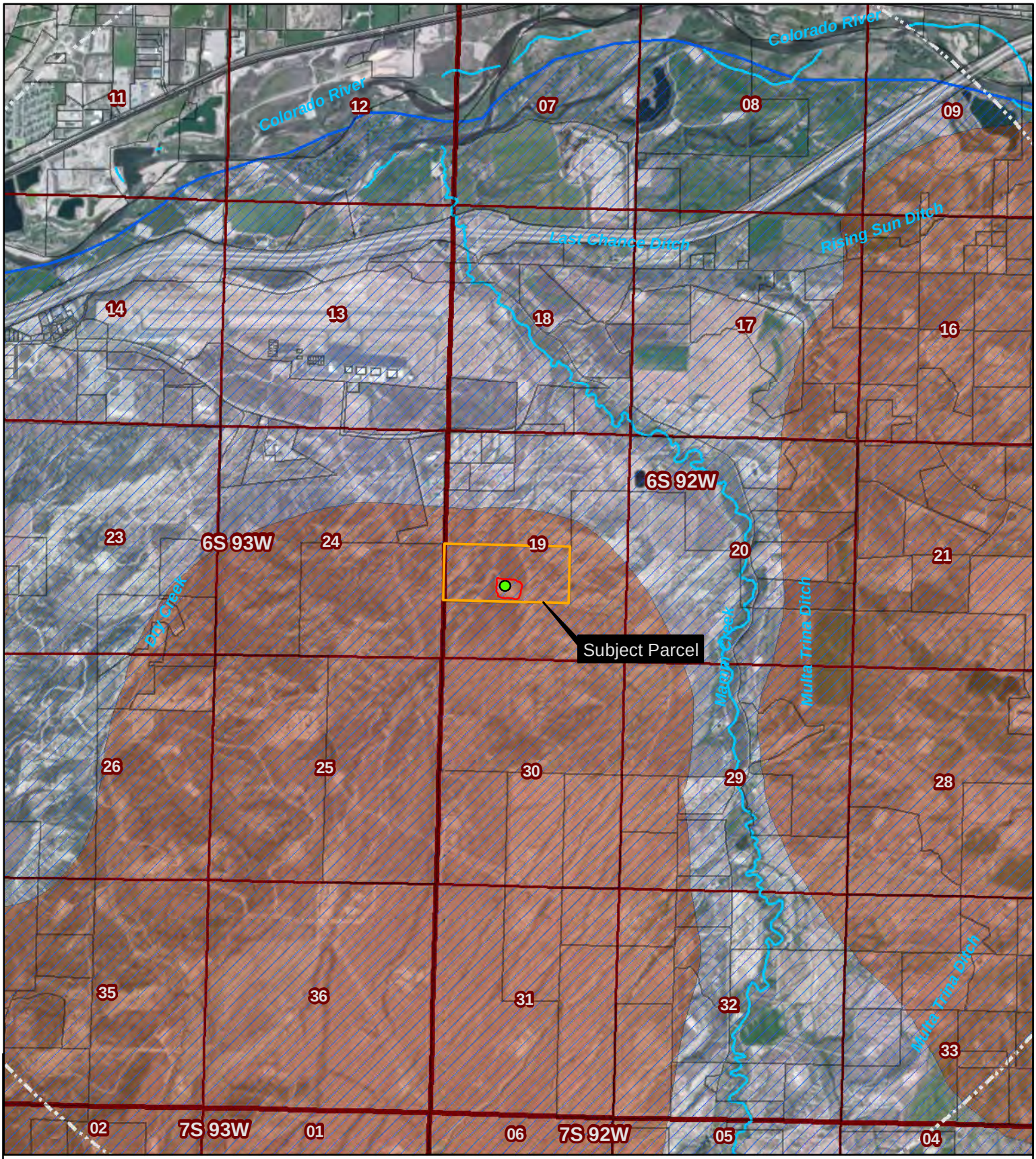

K19NE Storage Yard
K19NE Storage Yard Boundary
Subject Parcel
Perennial Stream
Elk Severe Winter Range
Elk Winter Concentration Area

N
W E
S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

ELK HABITAT MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

E-1

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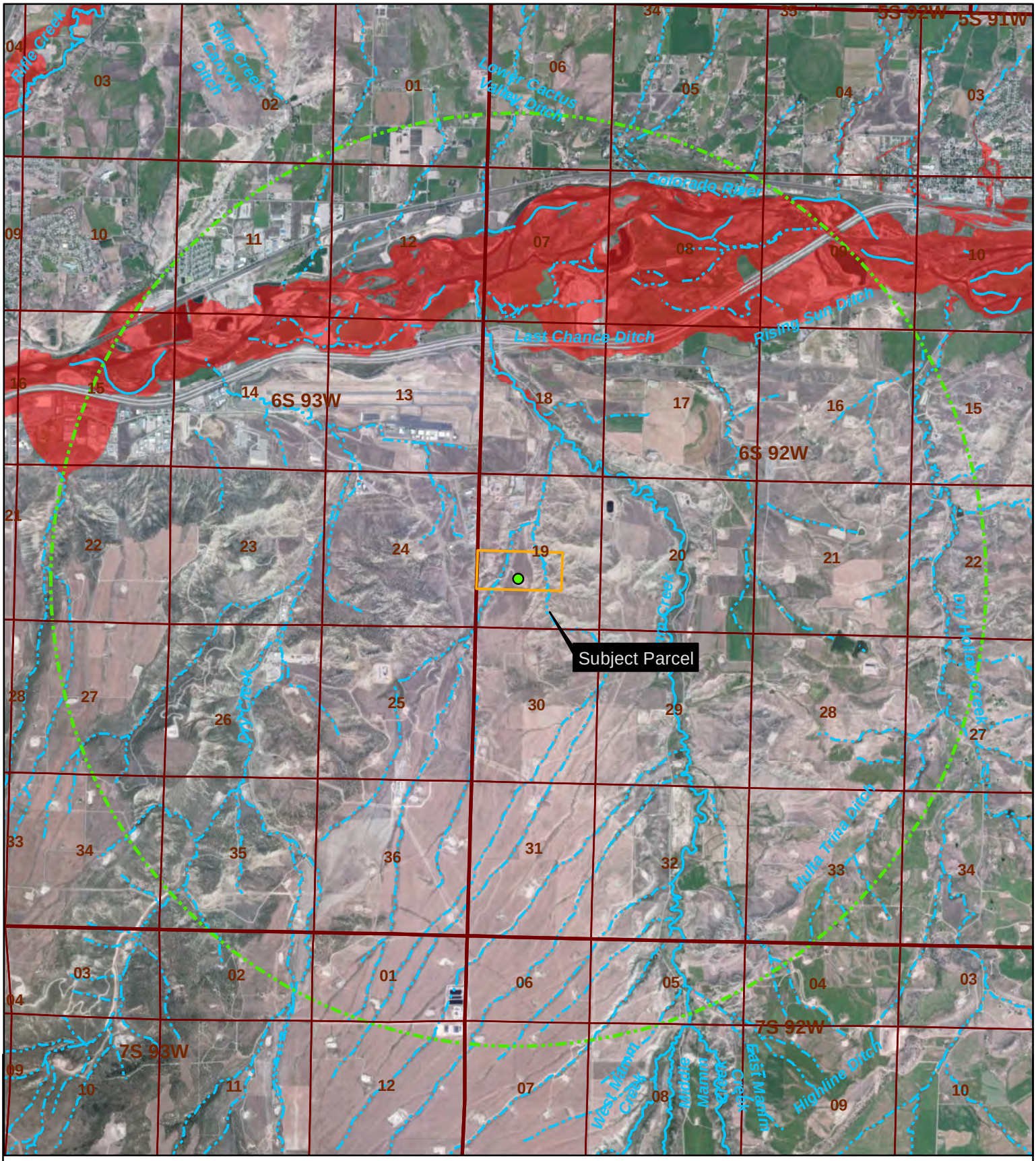

K19NE Storage Yard
Subject Parcel
3 Mile Buffer
Perennial Stream
Intermittent Stream
Floodplain

N
W E
S

PROJECT NO: 014-2797	FLOODPLAIN MAP	OLSSON ASSOCIATES	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	F-1
DATE: 11/25/2014			

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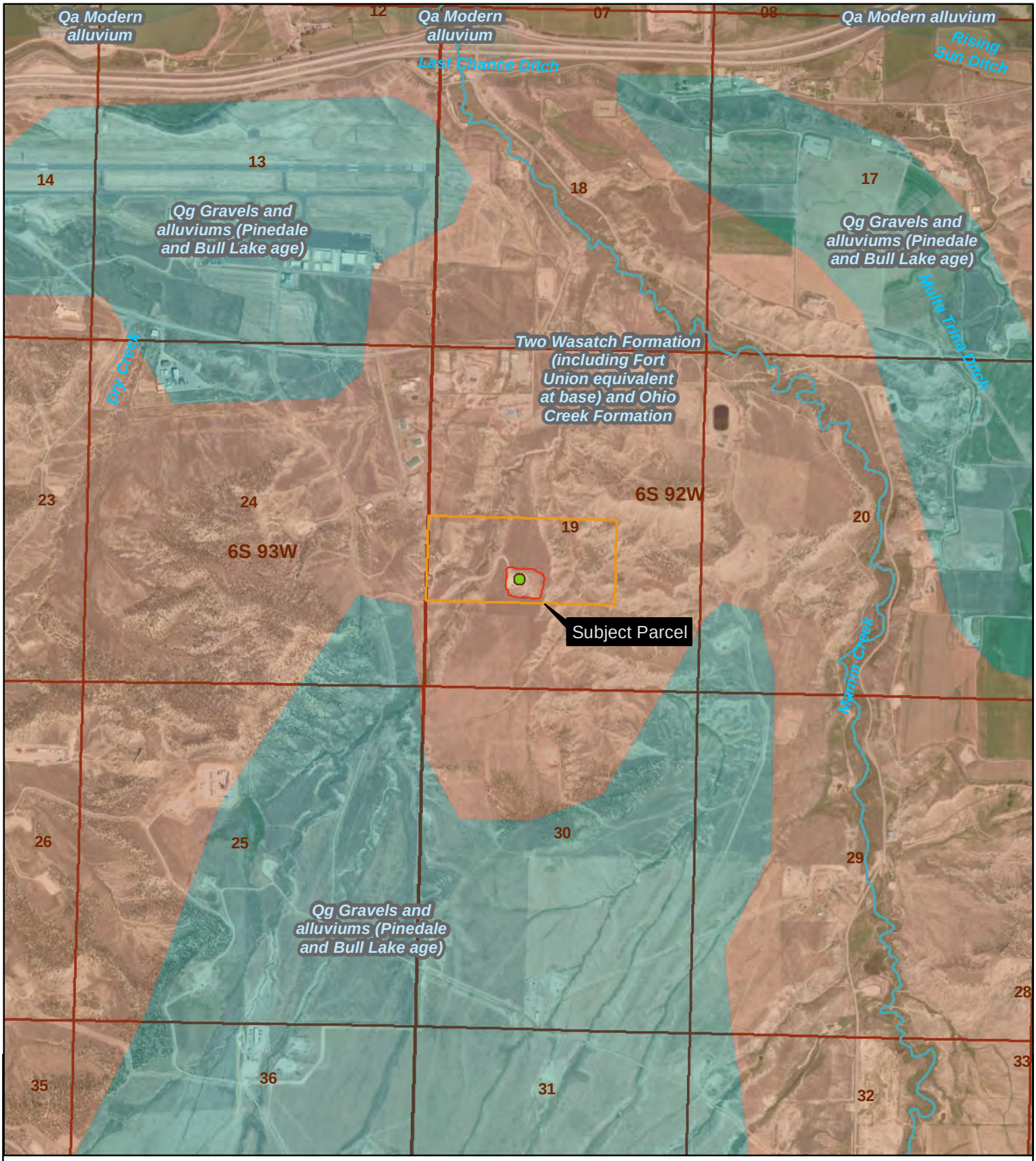

PROJECT NO: 014-2797	GEOLOGY MAP	OLSSON ASSOCIATES	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO			G-1
DATE: 11/25/2014				

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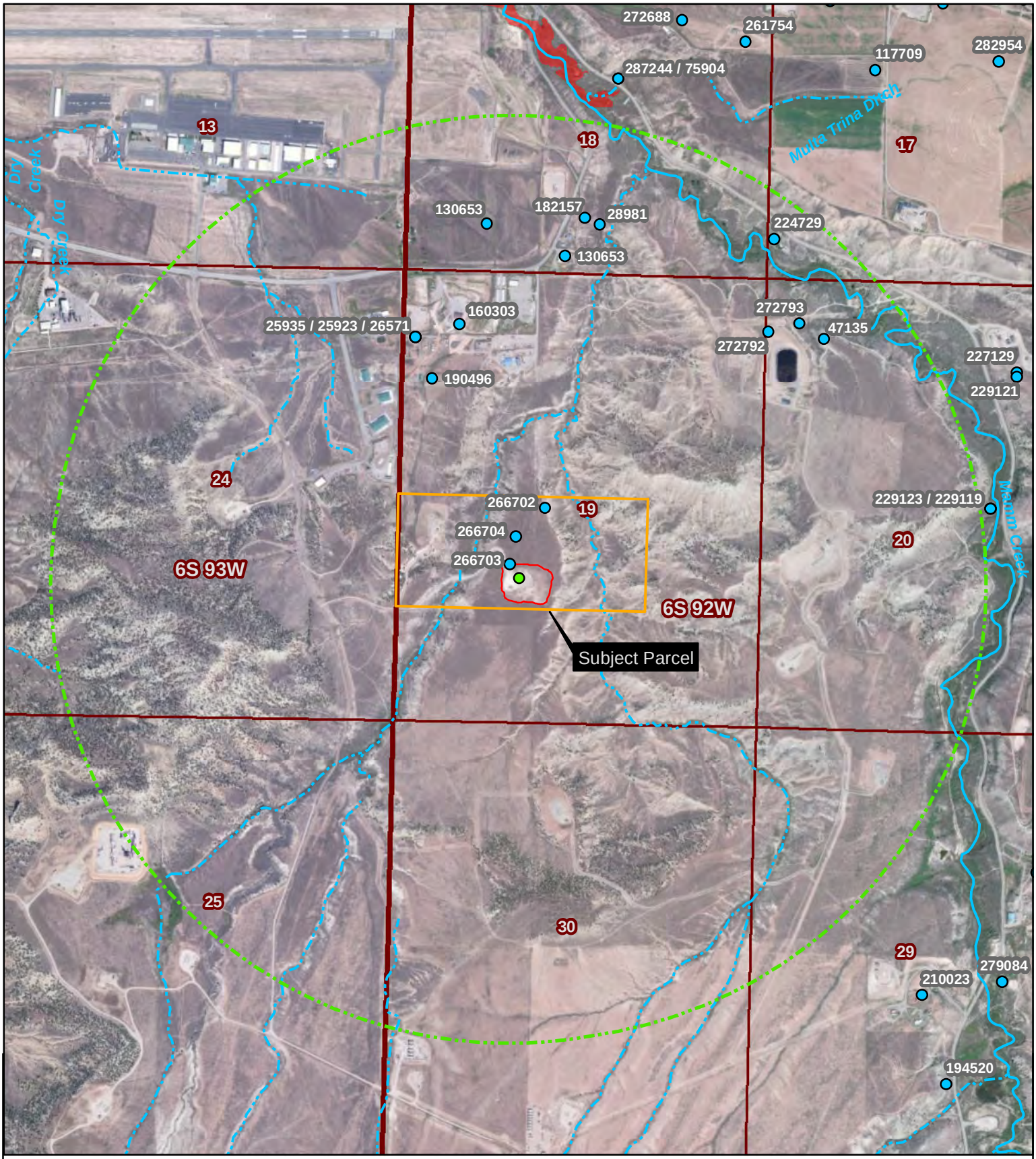

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

HYDROGRAPHY MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

H-1

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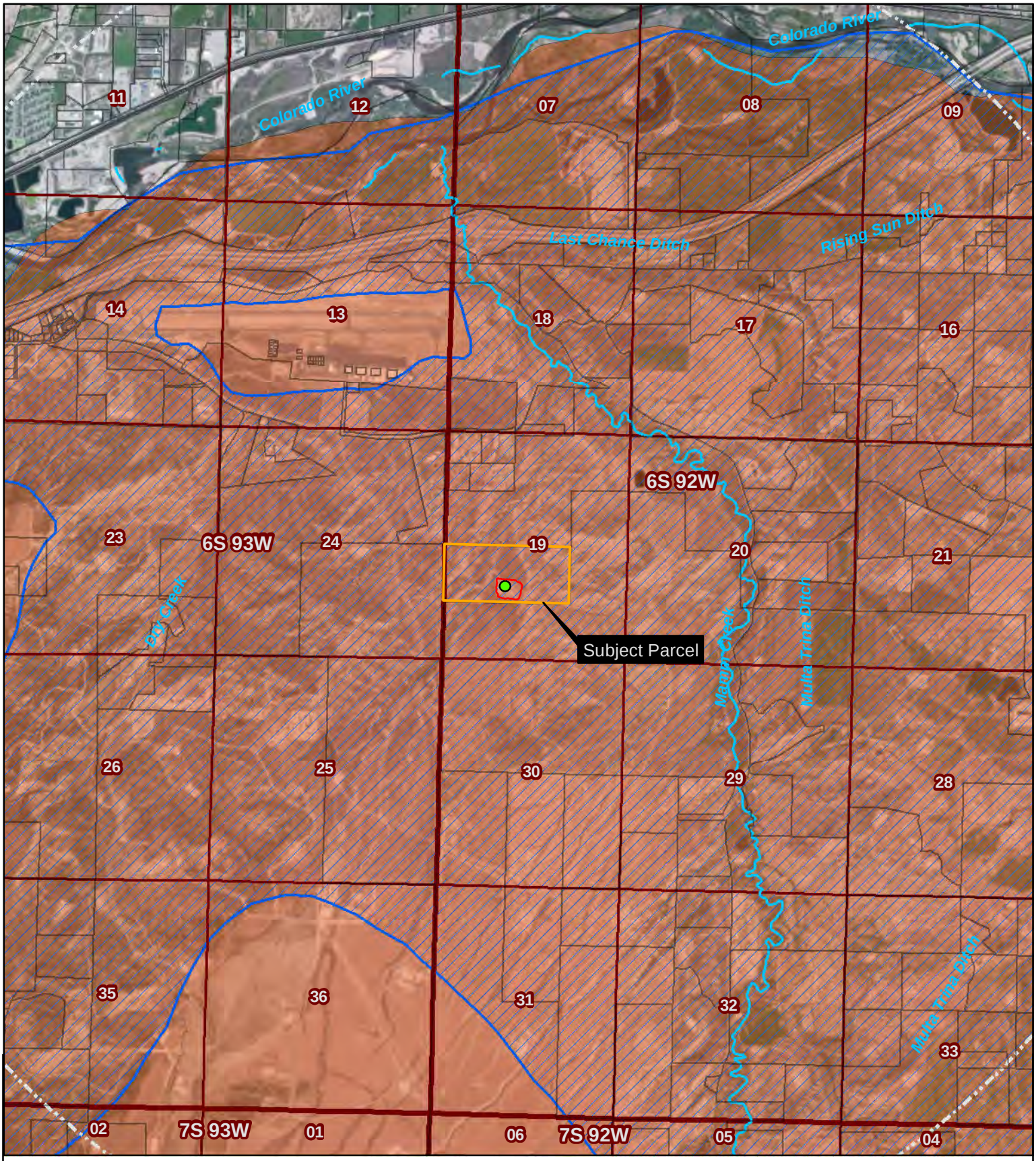

K19NE Storage Yard
K19NE Storage Yard Boundary
Subject Parcel
Perennial Stream
Mule Deer Severe Winter Range
Mule Deer Winter Concentration Area

N
W
E
S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

MULE DEER HABITAT MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

MD-1

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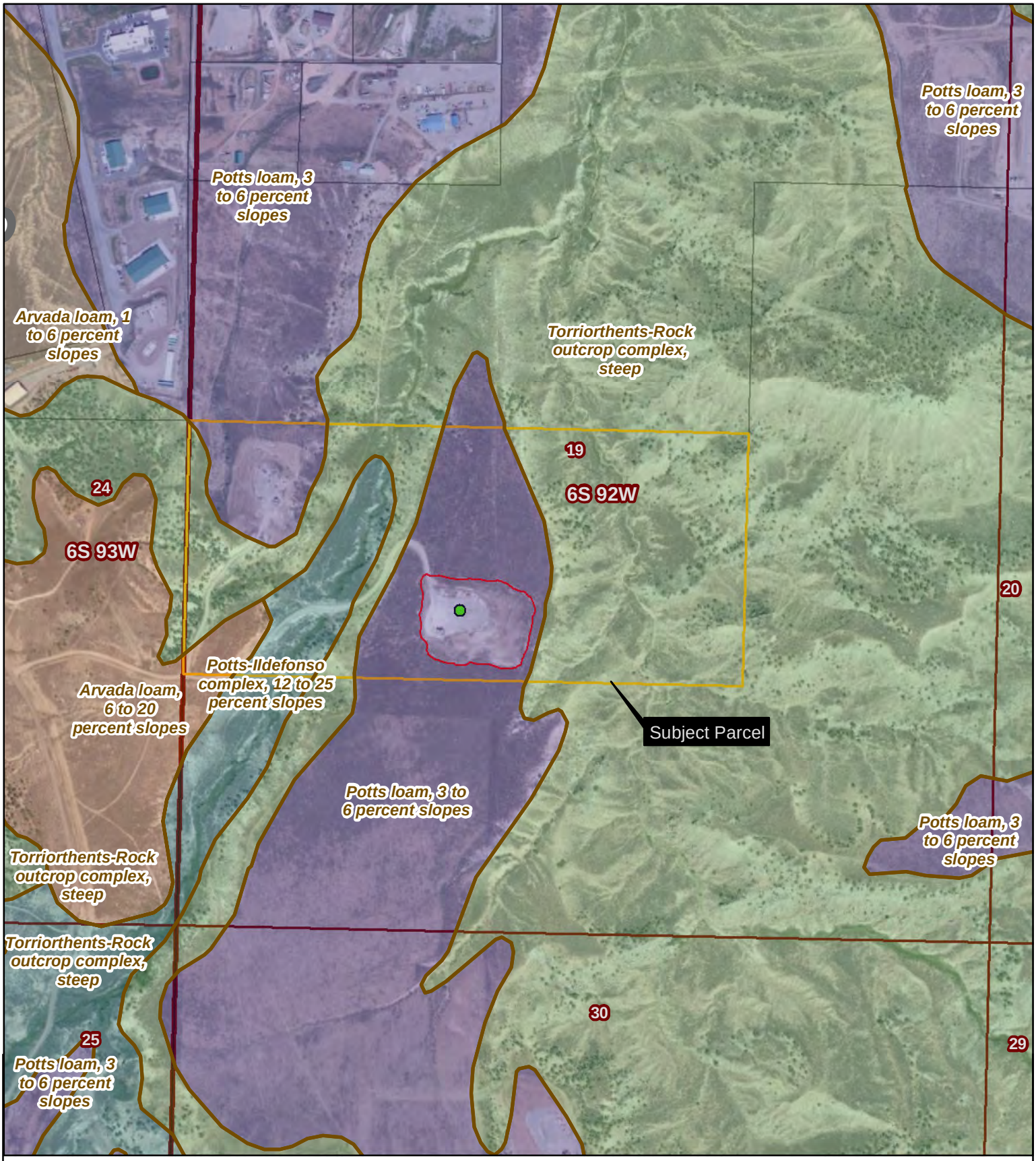

K19NE Storage Yard
K19NE Storage Yard Boundary
Subject Parcel
Perennial Stream

N
W
E
S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

SOILS MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES
760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

S-1

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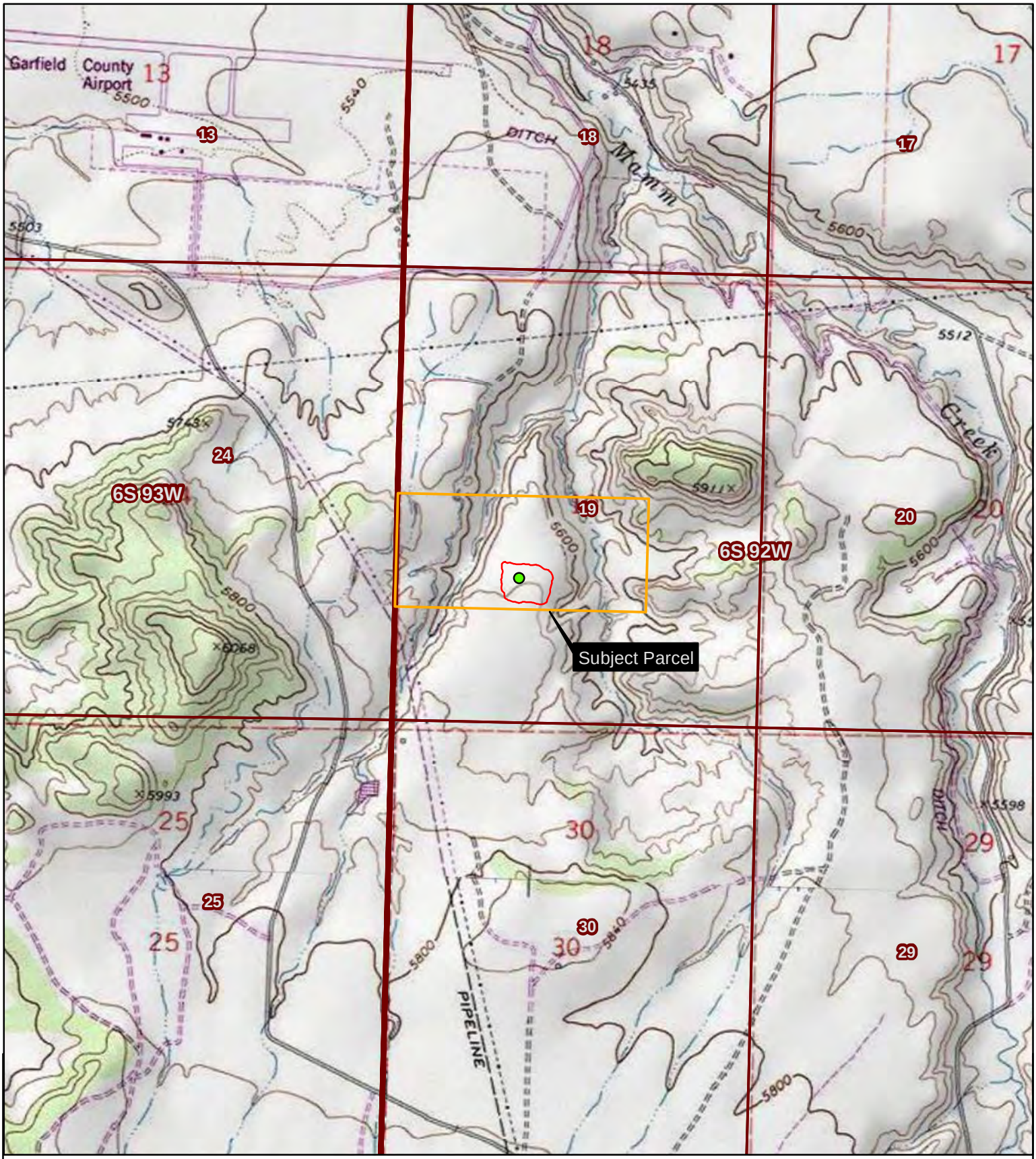

K19NE Storage Yard

K19NE Storage Yard Boundary

Subject Parcel

N

W E

S

PROJECT NO:	014-2797
DRAWN BY:	JWH
DATE:	11/25/2014

TOPOGRAPHIC MAP

K19NE STORAGE YARD
ENCANA OIL & GAS (USA) INC.
GARFIELD COUNTY, COLORADO

OLSSON ASSOCIATES

760 HORIZON DR., SUITE 102
GRAND JUNCTION, CO 81506
TEL 970.263.7800
FAX 970.263.7456

FIGURE

T-1

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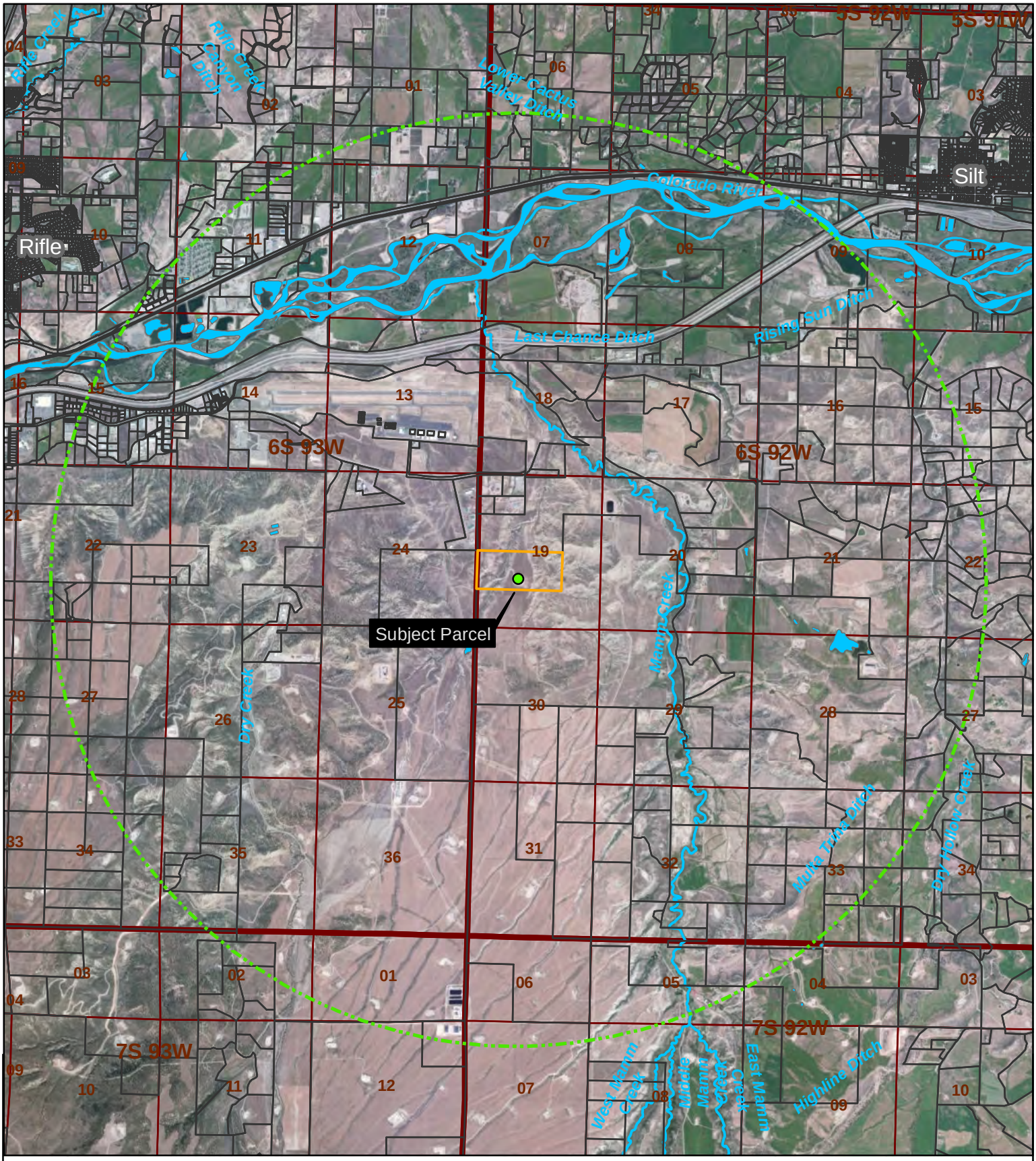

PROJECT NO: 014-2797	VICINITY MAP	OLSSON ASSOCIATES	760 HORIZON DR., SUITE 102 GRAND JUNCTION, CO 81506 TEL 970.263.7800 FAX 970.263.7456	FIGURE
DRAWN BY: JWH	K19NE STORAGE YARD ENCANA OIL & GAS (USA) INC. GARFIELD COUNTY, COLORADO			V-1
DATE: 11/25/2014				

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