TC1
WHE.

Tuttle & Associates

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PO Box 485
Broomfield, CO 80038
garyjtuttle@gmail.com

RECEIVED
JUL 27 2015
DIVISION OF RECLAMATION
MINING AND SAFETY

July 22, 2015

Tim Cazier
DRMS
1313 Sherman Street
Rm. 215
Denver, CO 80203

Re: Canon Dolomite Quarry, File # 1977-376
Response to Preliminary Adequacy Review for TR #02

Dear Tim:

With this letter, we will present our responses to your Preliminary Adequacy Review of June 30, 2015. The same numbering system will be used as in your letter.
A replacement title page is provided for TR #02.

1. Exhibit C-1, Pre-mining Plan
   a. I have measure 1"=2100' and 1'=210' on those bar scales. My engineers scale shows the correct measure within 1/64".
   b. We are mining through and beyond the Reclamation Liability Dashed Line. We can better understand this during our upcoming field trip to the site.
   c. Note #6 on Exhibit C-1 should be on Exhibit C-2. It makes sense on Exhibit C-2. The word "fill in Note #4 is changed to "fines".
   d. The old note #8, now note #7, has Section 30.
   e. The fine lines on Detail 2 of Exhibit C-1 are the previous limits of mining from the 1982 amendment. We thought it may be helpful for you to see the existing mining limits, but we should have labeled them.
2. Exhibit C-2, Mining Plan
   a. See explanation in 1.a.
   b. During most of the operation (down through bench 6060'), the majority of the excess fines produced by the processing plant will be moved to the Old Quarry Fines Disposal Area. The remainder will be used to backfill the vertical benches. Toward the end of the operation (benches 6030' and 6000'), an ample amount of the excess fines will be temporarily stockpiled on these benches for the cover on the large open portion of the final bench

✓ **Compliance**
✓ **VIOLATION(s): MV-1987-028 & MV-2000-043**

(6000'). We expect little fines will be hauled to the Old Quarry area in the last stages of mining. These retained fines will be pushed down from bench 6030' or pushed around bench 6000'. The open area of bench 6000' will absorb the excess fines and the cover depth may vary from 6" to 12". Volume calculations will periodically be done to insure adequate fines are temporary stored and fines are not hauled back from the Old Quarry area to get adequate cover on bench 6000'.

3. Third Page, Section (c.), Timetable
    a. The second paragraph in this sections should read "This mining operation may have periods of inactivity exceeding 180 days during a year and will always resume activity the next year. This may occur in the fall and winter when landscaping is usually not installed and if rock stockpiles at the sales yard in Pueblo West are full. This statement serves as the Notice of Intermittent Status".
    b. This TR is <u>not</u> requesting phased bonding, which varies over time. Enclosed with this letter is our Exhibit L, which was inadvertently omitted with the June 4, 2015 documents. Exhibit L was emailed to you in early July. Our proposed financial warranty is calculated for a point in the operation when disturbed land is at the maximum.
4. Second Page, Exhibit E, Section (9), inert backfill – we acknowledge the requirements of Rule 3.1.5(9).
5. Third page, Section (e), Reclamation Schedule, Mine Area –
    a. To clarify, this "small piece of disturbance" is the dashed area on Exhibit C-1. This area will be reclaimed within the next three years if it is not used for a water tank.
    b. The beginning of the placement of the fines will start in the eastern finger at the low elevation of 5840'. Successive filling will be done in lifts and move westward up the slope and into the box canyon. As approximately 100 horizontal feet of filling is completed, the fines will be graded, revegetated, and the channel built. As the fill area in the box canyon becomes larger, the fines will be laid in by contouring with a hump of material (12" height) approximately every 100" horizontal distance. The fines are very porous and minimum runoff is anticipated.
6. Exhibit F, Reclamation Plan
    a. See explanation in 1.a.
    b. The proposed mining plan mines over and through the Reclamation Liability Area. Since this area will be mined and lowered in elevation, it will be reclaimed per the proposed reclamation plan, and not reclaimed on the schedule of the Fines Disposal Area (Detail 1).
    c. In Detail 3, all mining disturbance is pre-law.
7. Drainage Report Items 7 thru 12
    a. Based on your July 13, 2015 meeting with John Jankousky, you both have agreed on the exact requirements of the drainage design in the Old Quarry Fines Disposal Area. To that end, John has revised the Drainage Report and it is enclosed with this letter. Your questions 7 thru 12 should be

answered in the new report. Also we have produced Exhibit F-2 which contains construction details for the rock chute channel.

Also enclosed is a new title page sheet with Technical Revision #2

Thank you for your attention to our application.

Cordially:
Tuttle & Associates
Gary J Tuttle
Gary J. Tuttle

Encl: Drainage Report
Exhibits C-1, C-2, F-1, F-2
Title page

Cc: file, Jerry S.

CANON DOLOMITE QUARRY
M1977-376

TECHNICAL REVISION #2

To clarify the mining and reclamation plan and to update the financial warranty. This technical revision includes Exhibits C, D, E, F, and L.

Operator:	**Continental Materials Corp.** **444 East Costilla** **Colorado Springs, CO 80903**
Consultants:	**Tuttle & Associates** **EME Solutions**
Date:	**June 4, 2015**

6.4.11 EXHIBIT L – RECLAMATION COSTS

The reclamation work at the site will proceed concurrently with the mining. Therefore the costs to finish reclamation at a point in time can vary. The costs for reclamation in this Exhibit are calculated for a point in the operation where disturbed land is identified as maximum. That point is several years from now (4 to 7 years) when:

- The Fines Disposal Area is seeded but not released. Reseeding may be necessary.
- The Mine Area has mining on the second bench (elev. 6135 at the north to elev. 6153 at the south) and a substantial flat area of the bench is open. The post law disturbed area east of the mine must be reclaimed.
- The Old Quarry Fines Disposal Area is undergoing filling and is half disturbed.

Acres in various stages of reclamation are:

- Fines Disposal Area 3
- Mine Area 19
- Old Quarry 3
- Total 25

The table on the following pages details the reclamation work items, provides quantities, and calculates costs.

Exhibit L **Reclamation Costs**

TABLE L-1 Estimated 5/29/2015

#	ITEM	QTY	UNITS	UNIT COST	COST
A	**Fines Disposal Area, Detail 1, Exh. F**				
1	reseed by broadcast	3	ac	$300.00	$900.00
2	apply mulch and fertilizer by hydrospray	3	ac	$550.00	$1,650.00
B	**Mine Area, Detail 2, Exh. F**				
1	fill at 4:1 the vertical face of bench, 1000'	16667	cy	$1.15	$19,167.05
2	Haul & dump fines on half of flat second bench with fines, 6 acres, 8" to 12" depth, 3500' haul	6486	cy	$4.10	$26,592.60
3	grade out fines on second bench	6486	cy	$0.55	$3,567.30
4	Haul & dump fines on half of flat first bench with fines, 4 acres, 8" to 12" depth, 4500' haul	4324	cy	$4.25	$18,377.00
5	Grade out fines on first bench	4324	cy	$0.55	$2,378.20
6	Haul & dump fines at east edge of bench	3243	cy	$4.10	$13,296.30
6	Push fines over onto post law disturbed area on east side of bench, 3 acres, 8" to 12" depth	3243	cy	$0.55	$1,783.65
7	Hydrospray seed, fertilizer, and mulch on #1 face	1.4	ac	$850.00	$1,190.00
8	Drill seed, fertilizer, and straw mulch on bench, #2	6	ac	$850.00	$5,100.00
9	Drill seed, fertilizer, and straw mulch on bench, #4	4	ac	$850.00	$3,400.00
10	Remove water tank	1	ea	$600.00	$600.00
C	**Old Quarry Fines Disposal Area, Detail 3, Exh. F**				
1	Haul large diam. rock from mine for channel, 4000'	800	cy	$2.25	$1,800.00
2	Construct rock lined channel, 450 ', See p. A-18 of Drainage Report, Exh. E	450	lf	$143.29	$64,480.50
3	Hydrospray seed, fertilizer, & mulch on sloped area, 1 acre	1	ac	$850.00	$850.00
4	Drill seed, fertilize, and straw mulch on open area, 2 acres	2	ac	$850.00	$1,700.00
	Weed control for two years	2	ea	$4,000.00	$8,000.00
	Subtotal				$174,832.60
	Adminstration			0.1	$17,483.26
	Contingency			0.05	$8,741.63
	GRAND TOTAL				$201,057.49
	FINANCIAL WARRANTY AMOUNT				**$202,000.00**

Final Drainage Report for the Canyon Dolomite Old Quarry Project Cañon City, Colorado

Prepared For:
Transit Mix Concrete Co.
444 E. Costilla Street
Colorado Springs, Colorado

Prepared By:
EME Solutions, Inc.
15248 W. Ellsworth Drive
Golden, CO 80401
John L. Jankousky, P.E.
Phone: 303-279-1707
john.jankousky@eme-solutions.com

May 29, 2015
Revised July 24, 2015

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This report for the drainage design of the Canyon Dolomite Old Quarry Project was prepared by me or under my direct supervision in accordance with good engineering standards and was designed to comply with the provisions thereof.

COLORADO REGISTERED
JOHN LIBBY JANKOUSKY
30941
PROFESSIONAL ENGINEER

John L. Jankousky, P.E.
Registered Professional Engineer
State of Colorado No. 30941

I. GENERAL LOCATION AND DESCRIPTION

EME Solutions, Inc. (EME) has been retained by Transit Mix Concrete Company (Client) to provide this Final Drainage Report for the Canyon Dolomite Old Quarry Project.

A. Location

The Project Site (or Site) is located at the Canyon Dolomite Quarry Site located approximately 1 mile west of Cañon City, Colorado. The latitude and longitude of the site are 38.453954°, -105.267026°.

B. Description of Property and Proposed Development

The Old Quarry portion of the Canyon Dolomite Quarry site will be used for fines disposal. The purpose of this report is to provide the calculations and design for a channel and rock chute that can safely pass the 100-year storm flows across this fines disposal area.

C. Other Drainage Studies

No other drainage studies were provided or discovered.

II. DRAINAGE BASINS AND SUB-BASINS

A. Basin Description

The drainage basin area that contributes flows to the Site is 33.7 acres. Flows from the Site go to Sand Creek, located about 1 mile east of the Site. The terrain within the basin is relatively steep. There is no baseflow. Although the soil hydrologic type is D, the runoff does not appear to be substantial or rapid. At a site visit during a rainstorm on May 19, 2015 (Cañon City recorded 1.42 inches, approximately equal to the 1-year storm, on that day), the runoff across the site was estimated at less than 50 gallons per minute.

B. Sub-Basin Description

Because the Project is located at the mouth of a small canyon, the hydrology was evaluated as a single basin.

The Proposed Project will not affect existing offsite drainage flow patterns, and vice versa.

III. DRAINAGE DESIGN CRITERIA

A. Regulations and Criteria

The Division of Reclamation, Mining, and Safety (DRMS) does not have defined drainage design criteria. This drainage report has been prepared in accordance with good engineering practices and the references provided.

B. Selection of BMPs

The major Best Management Practice (BMP) under consideration for this Project is a rock chute.

C. Hydrological Criteria

The rainfall data presented in the *NOAA Atlas 14, Volume 8, Version 2* was used. The Rational Method was used to calculate runoff. The Site was evaluated for the 10-year and 100-year rainfall events. Site soils are Hydrologic Group D based on soil survey data and site observations.

D. Hydraulic Criteria

The rock chute was designed using the methods presented in a series of papers by K.M. Robinson and others. See the References section. The channel leading to the rock chute was designed using the Manning Equation. See attached calculations.

IV. DRAINAGE DESIGN

A. Design Elements

The site design consists of the rock chute and its approach channel.

B. Offsite Runoff Considerations

The Project is designed to safely pass the offsite runoff from the upstream basin. The

Project should have no impact on flows at upstream or downstream sites.

C. Tables, Charts, Figures, and Drawings

This drainage report includes the following tables, charts, figures, and drawings:

- Drainage Basin Map
- Soil Survey information
- Basin area, % impervious, and Time of Concentration calculations
- Rainfall from NOAA Atlas
- Runoff by Rational Method
- Approach channel flow calculations by Manning Equation
- Rock chute calculations using methods by K.M. Robinson

All calculations are in conformance with the design criteria presented above.

B. Summary of Results

Hydrology Results
Flows for the 10-year 100-year storms were calculated using the Rational Method. The 10-year flow is estimated at 29.6 cubic feet per second (cfs) and the 100-year flow is estimated at 98.7 cfs.

Hydraulics Results
The approach channel shall be trapezoidal, with bottom width 6 feet, side slopes 3:1, and two feet deep.

The rock chute has a slope from ranging from approximately 15% to 25%. To be conservative, it was assumed that the entire chute is 25% slope. See the calculation sheets for the configuration of the rock chute.

VI. CONCLUSIONS

The calculations and design elements presented here are designed to safely pass the 100-year storm flows through the Canyon Dolomite Old Quarry Site.

VII. REFERENCES

American Society of Agricultural Engineers 2010. Rock Chute Design Program – Rock_Chute.xls. Excel spreadsheet based on "Design of Rock Chutes," Robinson et. al., 1998.

NRCS 2015. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed May 21, 2015.

Robinson et. al., 1997. *Design of Rock Chutes.* K. M. Robinson, P.E., C. E. Rice, P.E. and K. C. Kadavy, P.E. Research Hydraulic Engineers and Agricultural Engineer, USDA, Agricultural Research Service, Stillwater, Oklahoma. Written for presentation at the 1997 ASAE Annual International Meeting. Sponsored by ASAE. Minneapolis Convention Center, Minneapolis, Minnesota. August 10-14, 1997

Robinson et. al., 1998. *Design of Rock Chutes.* K. M. Robinson, C. E. Rice, K. C. Kadavy. Transactions of the ASAE. VOL. 41(3):621-626. 1998 American Society of Agricultural Engineers.

APPENDIX A
Drainage Calculations

APPENDIX A
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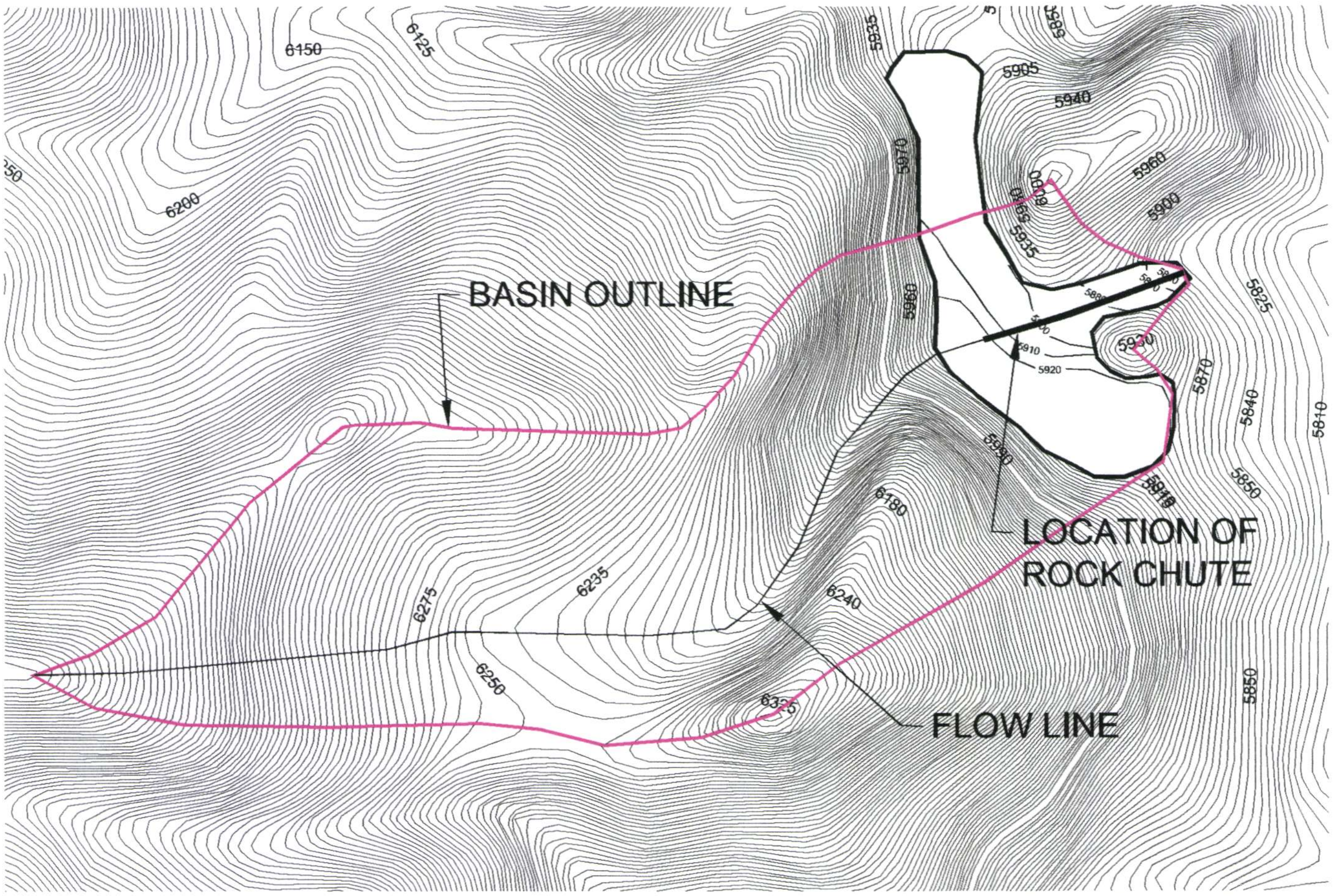

OLD QUARRY – DRAINAGE BASIN

PREPARED BY:	PREPARED FOR:	PROJECT:
EME SOLUTIONS, INC. 15248 W. ELLSWORTH DR. GOLDEN, CO 80401 303-279-1707	Transit Mix Concrete Co. 444 E. Costilla Street Colorado Springs, CO 80903	Canyon Dolomite Quarry Old Quarry – Fines Disposal Canon City, Colorado

JOB NO	DATE	SCALE	DRAWN BY	DESIGNED BY	APPROVAL	REV	SHEET
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SUMMARY OF NRCS WEB SOIL SURVEY INFORMATION

Soils survey information from the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) was accessed at the Web Soil Survey on May 21, 2015 (NRCS 2015. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed May 21, 2015).

There are three types of soils in the basin above the site:

- Roygorge very gravelly sandy, clay loam, 25 to 50 percent slopes
- Ustic Torriorthents, bouldery-Rock outcrop complex, 35 to 90 percent slopes
- Wesix very channery loam, 5 to 40 percent slopes

These soils are all Soil Hydrologic Group D.

Table 1. Areas, Lengths, and Elevation Changes from Site Map
Canyon Dolomite - Old Quarry
Final Drainage Report

Calculated by: John Jankousky   Revision: 7/24/2015

Number	Basin Designation	Area (ft^2)	Area (acres	Area (mi^2)	Flow Length, L (ft)	Flow Length, L (mi)	Length of Overland Flow, L(OL) (ft	Length of Concentrated Flow, L(P) (ft	Top Elevation (ft	Bottom Elevation (ft	Change in elevation, H (ft	Overall Slope, S = H/L (ft/ft	Overland Flow Top Elevation (ft	Overland Flow Bottom Elevation (ft	Overland Change in elevation, H (ft	Overland Flow Slope, S = H/L (ft/ft	Concentrated Flow Top Elevation (ft	Concentrated Flow Bottom Elevation (ft	Concentrated Change in elevation, H (ft	Concentrated Flow Slope, S = H/L (ft/ft
1	Quarry-outlet	1,467,897	33.70	0.053	2814	0.53	500	2314	6565.0	5847.0	718.0	0.2552			0.0	0.2552			0.0	0.2552

Canyon Dolomite - Old Quarry
Final Drainage Report
Percent Impervious Calculations and Rational Method "C" Calculations

Calculated by: John Jankousky   Revision: 7/24/2015

Soil Hydrologic Group   D

Land Use	% Imp.	C2	C5	C10	C100
Grass, shrub, tree cover (Landscape Area)*	0	0.04	0.15	0.25	0.5
Railroad Yard Area	40	0.28	0.35	0.42	0.58
Gravel Street	80	0.6	0.63	0.66	0.74
Building/Roof Area	90	0.73	0.75	0.77	0.83
Rock Outcrop Area (Pavement Area)	100	0.89	0.90	0.92	0.96

Number	Basin Designation	Total Area (ft^2)	Total Area (acres)	Grass, shrub, tree cover*	Railroad Yard Area (ft^2)	Gravel Street Area (ft^2)	Building/Roof Area (ft^2)	Rock Outcrop Area (ft^2)	Combined % Impervious	Combined C2	Combined C5	Combined C10	Combined C100
1	Quarry-outlet	1,467,897	33.70	1,394,502		0	0	73,395	5.00	0.083	0.188	0.28	0.52

* For "Grass, shrub, tree cover (Landscape Area)", assume zero percent impervious

Combined C values are equal to area weighted average; that is, C combined = summation(C_ix $Area_i$) / total Area

hydrology--Canyon-Dolomite-Rev1-July2015.xlsx %Imp

STANDARD FORM SF-1
TIME OF CONCENTRATION
Canyon Dolomite - Old Quarry
Final Drainage Report

Calculated by: John Jankousky   Revision: 7/24/2015

	Sub-Basin Data			Initial Overland Time (t_i)			Travel Time (t_t)				$t_c = t_i + t_t$	Check t_c	Final t_c	Remarks
Number	Designation	Area, Ac	C5	Overland Flow Length, L, Ft.	Slope, %	t_i, min*	Concen-trated Flow Length, Ft.	Slope, %	Velocity, FPS **	t_t, min	Comp. t_c, min	t_c = (L/180) +10, min	Final t_c, min	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)		(14)	
PROPOSED CONDITIONS														
1	Quarry-outlet	33.70	0.19	500	25.52	13.0	2314	25.52	11.70	3.3	16.3	25.6	16.3	

* Calculated using formula: t_i = (0.395 * (1.1 - C5) * L^0.5) / (S^0.333); where C5 = runoff coeff for 5-year storm; L = overland flow length (ft); and S = slope in FT/FT

** For travel time velocity, use Manning's equation for a grass-lined channel, v = 1.49/n * r^0.667 * s*0.5
Where r = hydraulic radius = area / wetted perimeter; n = Manning's "n" = 0.025; s = slope in ft/ft

2.0 RATIONAL METHOD

For urban catchments that are not complex and are generally 160 acres or less in size, it is acceptable that the design storm runoff be analyzed by the Rational Method. This method was introduced in 1889 and is still being used in most engineering offices in the United States. Even though this method has frequently come under academic criticism for its simplicity, no other practical drainage design method has evolved to such a level of general acceptance by the practicing engineer. The Rational Method properly understood and applied can produce satisfactory results for urban storm sewer and small on-site detention design.

2.1 Rational Formula

The Rational Method is based on the Rational Formula:

$$Q = CIA \tag{RO-1}$$

in which:

Q = the maximum rate of runoff (cfs)

C = a runoff coefficient that is the ratio between the runoff volume from an area and the average rate of rainfall depth over a given duration for that area

I = average intensity of rainfall in inches per hour for a duration equal to the time of concentration, t_c

A = area (acres)

Actually, Q has units of inches per hour per acre (in/hr/ac); however, since this rate of in/hr/ac differs from cubic feet per second (cfs) by less than one percent, the more common units of cfs are used. The time of concentration is typically defined as the time required for water to flow from the most remote point of the area to the point being investigated. The time of concentration should be based upon a flow length and path that results in a time of concentration for only a portion of the area if that portion of the catchment produces a higher rate of runoff.

The general procedure for Rational Method calculations for a single catchment is as follows:

1. Delineate the catchment boundary. Measure its area.
2. Define the flow path from the upper-most portion of the catchment to the design point. This flow path should be divided into reaches of similar flow type (e.g., overland flow, shallow swale flow, gutter flow, etc.). The length and slope of each reach should be measured.
3. Determine the time of concentration, t_c, for the catchment.

4. Find the rainfall intensity, I, for the design storm using the calculated t_c and the rainfall intensity-duration-frequency curve. (See Section 4.0 of the RAINFALL chapter.)

5. Determine the runoff coefficient, C.

6. Calculate the peak flow rate from the watershed using Equation RO-1.

2.2 Assumptions

The basic assumptions that are often made when the Rational Method is applied are:

1. The computed maximum rate of runoff to the design point is a function of the average rainfall rate during the time of concentration to that point.

2. The depth of rainfall used is one that occurs from the start of the storm to the time of concentration, and the design rainfall depth during that time period is converted to the average rainfall intensity for that period.

3. The maximum runoff rate occurs when the entire area is contributing flow. However, this assumption has to be modified when a more intensely developed portion of the catchment with a shorter time of concentration produces a higher rate of maximum runoff than the entire catchment with a longer time of concentration.

2.3 Limitations

The Rational Method is an adequate method for approximating the peak rate and total volume of runoff from a design rainstorm in a given catchment. The greatest drawback to the Rational Method is that it normally provides only one point on the runoff hydrograph. When the areas become complex and where sub-catchments come together, the Rational Method will tend to overestimate the actual flow, which results in oversizing of drainage facilities. The Rational Method provides no direct information needed to route hydrographs through the drainage facilities. One reason the Rational Method is limited to small areas is that good design practice requires the routing of hydrographs for larger catchments to achieve an economic design.

Another disadvantage of the Rational Method is that with typical design procedures one normally assumes that all of the design flow is collected at the design point and that there is no water running overland to the next design point. However, this is not the fault of the Rational Method but of the design procedure. The Rational Method must be modified, or another type of analysis must be used, when analyzing an existing system that is under-designed or when analyzing the effects of a major storm on a system designed for the minor storm.

2.4 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations. The time of concentration relationships recommended in this *Manual* are based in part on the rainfall-runoff data collected in the Denver metropolitan area and are designed to work with the runoff coefficients also recommended in this *Manual*. As a result, these recommendations need to be used with a great deal of caution whenever working in areas that may differ significantly from the climate or topography found in the Denver region.

For urban areas, the time of concentration, t_c, consists of an initial time or overland flow time, t_i, plus the travel time, t_t, in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time, t_i, plus the time of travel in a defined form, such as a swale, channel, or drainageway. The travel portion, t_t, of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation RO-2 for both urban and non-urban areas:

$$t_c = t_i + t_t \tag{RO-2}$$

in which:

t_c = time of concentration (minutes)

t_i = initial or overland flow time (minutes)

t_t = travel time in the ditch, channel, gutter, storm sewer, etc. (minutes)

2.4.1 Initial Flow Time

The initial or overland flow time, t_i, may be calculated using equation RO-3:

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \tag{RO-3}$$

in which:

t_i = initial or overland flow time (minutes)

C_5 = runoff coefficient for 5-year frequency (from Table RO-5)

L = length of overland flow (500 ft maximum for non-urban land uses, 300 ft maximum for urban land uses)

S = average basin slope (ft/ft)

Equation RO-3 is adequate for distances up to 500 feet. Note that, in some urban watersheds, the overland flow time may be very small because flows quickly channelize.

2.4.2 Overland Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the overland travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure RO-1 or the following equation (Guo 1999):

$$V = C_v S_w^{0.5} \qquad \text{(RO-4)}$$

in which:

V = velocity (ft/sec)

C_v = conveyance coefficient (from Table RO-2)

S_w = watercourse slope (ft/ft)

Table RO-2—Conveyance Coefficient, C_v

Type of Land Surface	Conveyance Coefficient, C_v
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

The time of concentration, t_c, is then the sum of the initial flow time, t_i, and the travel time, t_t, as per Equation RO-2.

2.4.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (i.e., initial flow time, t_i) in an urbanized catchment should not exceed the time of concentration calculated using Equation RO-5.

$$t_c = \frac{L}{180} + 10 \qquad \text{(RO-5)}$$

in which:

t_c = maximum time of concentration at the first design point in an urban watershed (minutes)

L = waterway length (ft)

Equation RO-5 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method.

The first design point is the point where runoff first enters the storm sewer system. An example of definition of first design point is provided in Figure RO-2.

Normally, Equation RO-5 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

2.4.4 Minimum Time of Concentration

Should the calculations result in a t_c of less than 10 minutes, it is recommended that a minimum value of 10 minutes be used for non-urban watersheds. The minimum t_c recommended for urbanized areas should not be less than 5 minutes and if calculations indicate a lesser value, use 5 minutes instead.

2.4.5 Common Errors in Calculating Time of Concentration

A common mistake in urbanized areas is to assume travel velocities that are too slow. Another common error is to not check the runoff peak resulting from only part of the catchment. Sometimes a lower portion of the catchment or a highly impervious area produces a larger peak than that computed for the whole catchment. This error is most often encountered when the catchment is long or the upper portion contains grassy parkland and the lower portion is developed urban land.

2.5 Intensity

The rainfall intensity, I, is the average rainfall rate in inches per hour for the period of maximum rainfall of a given recurrence frequency having a duration equal to the time of concentration.

After the design storm's recurrence frequency has been selected, a graph should be made showing rainfall intensity versus time. The procedure for obtaining the local data and drawing such a graph is explained and illustrated in Section 4 of the RAINFALL chapter of this *Manual*. The intensity for a design point is taken from the graph or through the use of Equation RA-3 using the calculated t_c.

2.6 Watershed Imperviousness

All parts of a watershed can be considered either pervious or impervious. The pervious part is that area where water can readily infiltrate into the ground. The impervious part is the area that does not readily allow water to infiltrate into the ground, such as areas that are paved or covered with buildings and sidewalks or compacted unvegetated soils. In urban hydrology, the percentage of pervious and impervious land is important. The percentage of impervious area increases when urbanization occurs

Rainfall Estimates for Design Storms

Canyon Dolomite - Old Quarry

Rainfall Depth

Minutes	10-Year	100-Year
5	0.45	0.81
10	0.65	1.18
15	0.80	1.44
30	1.11	2.01
60	1.35	2.53
120	1.58	3.05
360	1.67	3.30

Rainfall Intensity

Minutes	10-Year	100-Year
5	5.36	9.70
10	3.92	7.08
15	3.19	5.76
30	2.22	4.02
60	1.35	2.53
120	0.79	1.53
360	0.28	0.55

Source: NOAA Atlas 14, Volume 8, Version 2
Accessed at http://hdsc.nws.noaa.gov/hdsc/pfds/ on 5/26/2015

NOAA Atlas 14, Volume 8, Version 2
Location name: Cañon City, Colorado, US*
Latitude: 38.4540°, Longitude: -105.2670°
Elevation: 5916 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)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.220 (0.172-0.286)	0.270 (0.211-0.352)	0.362 (0.281-0.473)	0.447 (0.345-0.587)	0.577 (0.436-0.805)	0.688 (0.505-0.970)	0.808 (0.573-1.17)	0.939 (0.639-1.40)	1.13 (0.736-1.74)	1.28 (0.810-1.99)
10-min	0.322 (0.251-0.419)	0.396 (0.308-0.515)	0.530 (0.411-0.692)	0.654 (0.505-0.859)	0.845 (0.639-1.18)	1.01 (0.740-1.42)	1.18 (0.839-1.72)	1.38 (0.935-2.05)	1.65 (1.08-2.54)	1.88 (1.19-2.91)
15-min	0.393 (0.307-0.511)	0.483 (0.376-0.628)	0.646 (0.502-0.844)	0.798 (0.616-1.05)	1.03 (0.779-1.44)	1.23 (0.903-1.73)	1.44 (1.02-2.09)	1.68 (1.14-2.51)	2.01 (1.32-3.10)	2.29 (1.45-3.55)
30-min	0.548 (0.427-0.713)	0.673 (0.524-0.876)	0.901 (0.699-1.18)	1.11 (0.858-1.46)	1.44 (1.09-2.00)	1.71 (1.26-2.41)	2.01 (1.42-2.91)	2.33 (1.59-3.48)	2.80 (1.83-4.31)	3.18 (2.01-4.93)
60-min	0.697 (0.544-0.907)	0.830 (0.647-1.08)	1.09 (0.846-1.42)	1.35 (1.04-1.77)	1.76 (1.34-2.48)	2.12 (1.57-3.02)	2.53 (1.80-3.69)	2.98 (2.04-4.48)	3.65 (2.39-5.64)	4.20 (2.66-6.51)
2-hr	0.846 (0.668-1.09)	0.987 (0.779-1.27)	1.28 (1.01-1.65)	1.58 (1.24-2.05)	2.08 (1.61-2.92)	2.54 (1.90-3.57)	3.05 (2.20-4.41)	3.63 (2.51-5.40)	4.50 (2.98-6.86)	5.22 (3.34-7.98)
3-hr	0.933 (0.742-1.19)	1.06 (0.844-1.35)	1.35 (1.07-1.73)	1.67 (1.31-2.14)	2.21 (1.74-3.10)	2.72 (2.06-3.82)	3.30 (2.41-4.75)	3.97 (2.77-5.87)	4.98 (3.33-7.56)	5.83 (3.75-8.83)
6-hr	1.09 (0.875-1.36)	1.22 (0.982-1.53)	1.53 (1.23-1.93)	1.88 (1.50-2.38)	2.48 (1.97-3.42)	3.04 (2.33-4.21)	3.69 (2.72-5.24)	4.44 (3.13-6.48)	5.57 (3.77-8.34)	6.53 (4.25-9.74)
12-hr	1.26 (1.02-1.55)	1.44 (1.17-1.79)	1.82 (1.48-2.26)	2.20 (1.78-2.75)	2.83 (2.26-3.80)	3.40 (2.63-4.60)	4.04 (3.01-5.61)	4.77 (3.39-6.80)	5.84 (3.98-8.56)	6.73 (4.42-9.89)
24-hr	1.47 (1.21-1.79)	1.70 (1.40-2.07)	2.13 (1.75-2.61)	2.55 (2.09-3.15)	3.22 (2.59-4.22)	3.81 (2.96-5.04)	4.46 (3.34-6.05)	5.17 (3.71-7.24)	6.22 (4.28-8.95)	7.09 (4.71-10.2)
2-day	1.68 (1.40-2.02)	1.97 (1.65-2.37)	2.50 (2.08-3.02)	2.99 (2.47-3.62)	3.73 (3.01-4.77)	4.36 (3.42-5.65)	5.04 (3.81-6.70)	5.77 (4.18-7.91)	6.83 (4.73-9.63)	7.69 (5.16-10.9)
3-day	1.83 (1.54-2.18)	2.15 (1.81-2.57)	2.73 (2.29-3.27)	3.27 (2.73-3.93)	4.07 (3.31-5.16)	4.75 (3.75-6.10)	5.48 (4.17-7.22)	6.27 (4.56-8.51)	7.40 (5.16-10.3)	8.31 (5.61-11.7)
4-day	1.96 (1.66-2.32)	2.30 (1.95-2.73)	2.92 (2.47-3.48)	3.49 (2.93-4.17)	4.34 (3.55-5.47)	5.06 (4.02-6.45)	5.83 (4.46-7.63)	6.66 (4.87-8.97)	7.84 (5.50-10.9)	8.80 (5.97-12.3)
7-day	2.31 (1.98-2.71)	2.70 (2.31-3.17)	3.39 (2.90-3.99)	4.02 (3.41-4.74)	4.95 (4.08-6.14)	5.73 (4.59-7.19)	6.55 (5.06-8.45)	7.45 (5.49-9.89)	8.71 (6.15-11.9)	9.72 (6.65-13.4)
10-day	2.63 (2.27-3.05)	3.05 (2.63-3.55)	3.80 (3.26-4.43)	4.46 (3.81-5.23)	5.44 (4.51-6.68)	6.25 (5.04-7.77)	7.11 (5.52-9.08)	8.02 (5.95-10.6)	9.31 (6.61-12.6)	10.3 (7.11-14.2)
20-day	3.50 (3.07-4.01)	4.04 (3.53-4.62)	4.93 (4.30-5.67)	5.71 (4.94-6.59)	6.81 (5.69-8.16)	7.69 (6.26-9.35)	8.59 (6.74-10.7)	9.54 (7.14-12.3)	10.8 (7.77-14.4)	11.8 (8.25-16.0)
30-day	4.22 (3.72-4.79)	4.85 (4.28-5.51)	5.89 (5.17-6.71)	6.76 (5.90-7.74)	7.97 (6.70-9.43)	8.91 (7.30-10.7)	9.86 (7.77-12.2)	10.8 (8.15-13.8)	12.1 (8.74-15.9)	13.1 (9.18-17.5)
45-day	5.11 (4.55-5.74)	5.88 (5.23-6.62)	7.12 (6.31-8.04)	8.14 (7.16-9.22)	9.50 (8.02-11.1)	10.5 (8.67-12.5)	11.5 (9.14-14.0)	12.5 (9.48-15.7)	13.8 (10.0-17.9)	14.8 (10.4-19.5)
60-day	5.85 (5.24-6.54)	6.76 (6.04-7.56)	8.19 (7.30-9.18)	9.34 (8.26-10.5)	10.8 (9.19-12.5)	12.0 (9.89-14.0)	13.0 (10.4-15.7)	14.1 (10.7-17.5)	15.4 (11.2-19.7)	16.3 (11.5-21.3)

[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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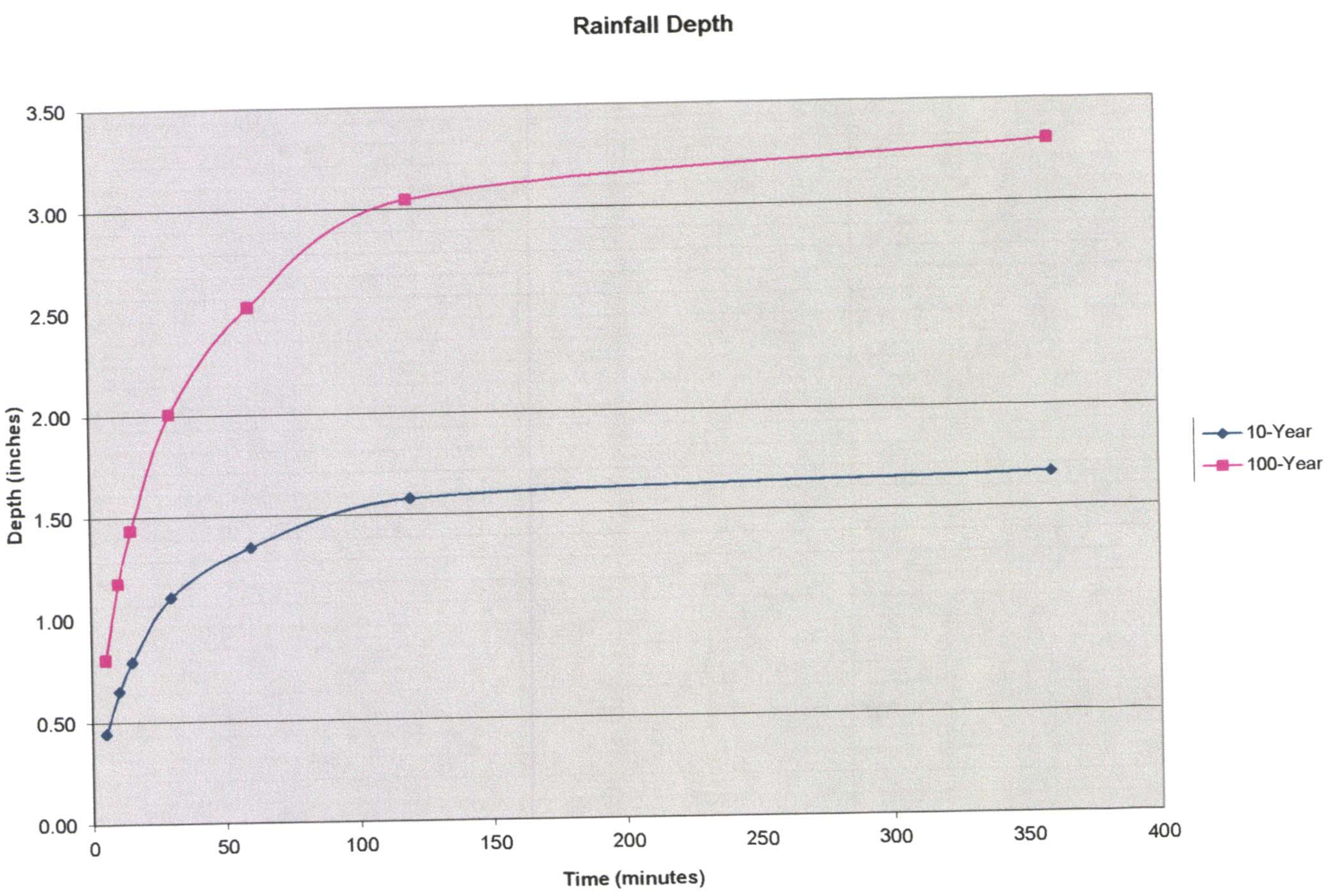
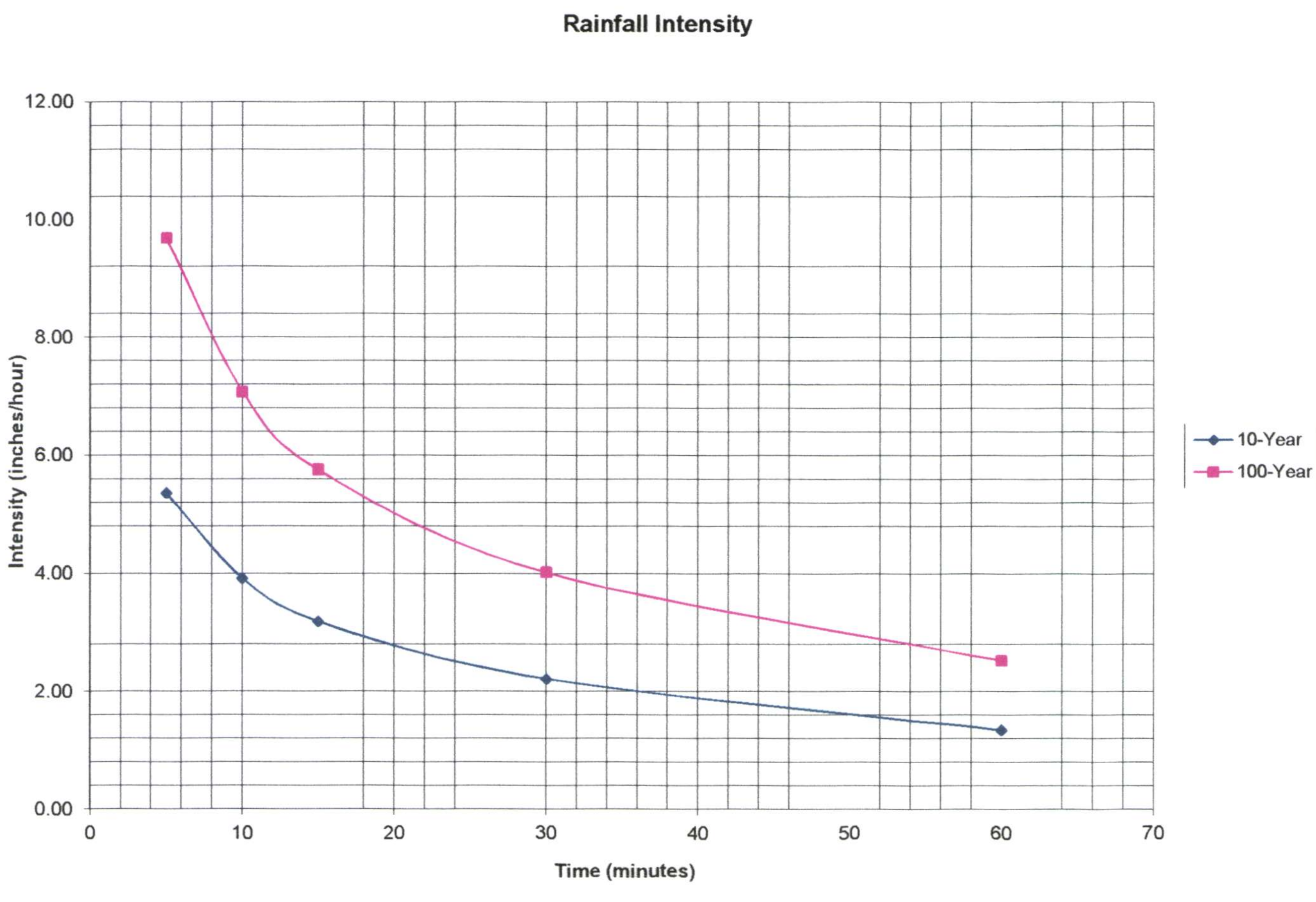
PF graphical


Rainfall Depth
Depth (inches)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
50
100
150
200
250
300
350
400
Time (minutes)
10-Year
100-Year


Rainfall Intensity
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Intensity (inches/hour)
0
10
20
30
40
50
60
70
Time (minutes)
10-Year
100-Year

Standard Form SF-2 -- Rational Method Procedure -- Storm Drainage System Design

Canyon Dolomite - Old Quarry

Calculated by: John Jankousky Revision: 7/24/2015

DESIGN STORM: 10-YR

			DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			
	Street	Design Point	Area Designation	Area (ac)	Runoff Coeff., C	tc (min)	C*A (AC)	Intensity, I (in/hr)	Q (cfs)	t_c (min)	sum(C*A) (AC)	Intensity, I (in/hr)	Q (cfs)	Slope (%)	Street Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (in)	Length (ft)	Velocity (fps)	t_t (min)	REMARKS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1		Quarry-outlet	Quarry-outlet	33.70	0.28	16.3	9.55	3.10	29.62													

FORMULA: Q = C i A (Q is flow in cfs; C is runoff coefficient [dim'less]; i is rainfall intensity in inches/hr (based on t_c); A is area in acres;

Velocity in pipe estimated by V = (1.49/0.013) x ((Diameter(inches)/(12*4))^0.667) x ((Slope(%)/100)^0.5); Travel time, T_t = Length (ft) / Velocity (fps) /(60 sec/min)

Velocity in street flow estimated from Figure RO-1; Travel time, T_t = Length (ft) / Velocity (fps) /(60 sec/min)

Standard Form SF-2 -- Rational Method Procedure -- Storm Drainage System Design

Canyon Dolomite - Old Quarry

Calculated by: John Jankousky Revision: 7/24/2015

DESIGN STORM: 100-YR

			DIRECT RUNOFF							TOTAL RUNOFF				SWALE		PIPE			TRAVEL TIME			
	Street	Design Point	Area Designation	Area (ac)	Runoff Coeff., C	tc (min)	C*A (AC)	Intensity, I (in/hr)	Q (cfs)	t_c (min)	sum(C*A) (AC)	Intensity, I (in/hr)	Q (cfs)	Slope (%)	Swale Flow (cfs)	Design Flow (cfs)	Slope (%)	Pipe Size (in)	Length (ft)	Velocity (fps)	t_t (min)	REMARKS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1		Quarry-outlet	Quarry-outlet	33.70	0.52	16.3	17.6	5.60	98.70													

FORMULA: Q = C i A (Q is flow in cfs; C is runoff coefficient [dim'less]; i is rainfall intensity in inches/hr (based on t_c); A is area in acres;

Velocity in pipe estimated by V = (1.49/0.013) x ((Diameter(inches)/(12*4))^0.667) x ((Slope(%)/100)^0.5); Travel time, T_t = Length (ft) / Velocity (fps) /(60 sec/min)

Velocity in street flow or swale flow estimated from Figure RO-1; Travel time, T_t = Length (ft) / Velocity (fps) /(60 sec/min)

Required Cross-Sectional Areas for Channels

Description	Channel A	Channel A
Flows Collected in Channel	Basin C-D	Basin C-D
Length of Channel (ft)	100	100
Change in Elevation (ft)	0.5	0.5
Slope, S (ft/ft)	0.0050	0.0050
Roughness Factor, n (dimension-less) for sandy, gravelly channel	0.025	0.025
Design for 100-year with freeboard		
Design Storm	10-year	100-year
Source of Peak Flow, Q	Basin C-D	Basin C-D
Required Peak Flow (cfs)	29.6	98.7
Manning Formula Peak Flow (cfs)	**29.6**	**98.8**
Side Slope factor, Z (Z:1)	3.0	3.0
Cross-sectional Area, A (ft^2)	8.8	20.9
Wetted Perimeter, P (ft)	12.2	17.5
Hydraulic Radius, R (ft^2/ft)	0.72	1.19
Slope, S (ft/ft)	0.005	0.005
Flow Depth, Y (ft)	0.98	1.82
Top Width, T (ft), without freeboard	11.9	16.9
Bottom Width, W (ft)	6	6
Flow Velocity, V (fps)	3.4	4.7
Hydraulic Mean Depth, D	0.74	1.23
Froude Number, F	0.69	0.75
Subcritical/Supercritical	Subcritical	Subcritical

Note: assume 1 foot freeboard above 100-year flow level

Total depth (ft) =	**2.82**
Top Width, T (ft), with freeboard	**22.9**

APPROACH CHANNEL SHALL BE TRAPEZOIDAL, BOTTOM WIDTH 6 FEET, SIDE SLOPES 3:1, 2.82 FEET (minimum) DEEP.

Equations:

Slope, S = Change in Elevation / Length of Channel

Area, $A = Z \times Y^2 + Y \times W$

Wetted Perimeter, $P = 2 \times Y \times (1 + Z^2)^{0.5} + W$

Hydraulic Radius, $R = A / P$

Top Width, $T = 2 \times Z \times Y + W$

Flow, $Q = (1.49 \times A \times R^{0.667} \times S^{0.5}) / n$

Flow Velocity, $V = Q / A$

Bottom Width, W = initial assumption

Height, Y = trial and error input

Hydraulic Mean Depth, $D = A / T$

Froude Number, $F = V / (g \times D)^{0.5}$

where: g = gravity acceleration = 32.2 ft/sec^2

Rock chute calculations using methods by K.M. Robinson

Rock Chute Design Data

(Version WI-July-2010, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Canyon Dolomite - Old Quarry **County:** Fremont County, CO
Designer: John Jankousky **Checked by:**
Date: July 24, 2015 **Date:**

Input Geometry:

Upstream Channel	Chute		Downstream Channel
Bw = 6.0 ft.	Bw = 6.0 ft.		Bw = 6.0 ft.
Side slopes = 3.0 (m:1)	Factor of safety = 1.20 (F_s)	1.2 Min	Side slopes = 3.0 (m:1)
Velocity n-value = 0.025	Side slopes = 3.0 (m:1)	→ 2.0:1 max.	Velocity n-value = 0.025
Bed slope = 0.0050 ft./ft.	Bed slope (4:1) = 0.250 ft./ft	→ 3.0:1 max.	Bed slope = 0.0050 ft./ft.
Note: n value = a) velocity n from waterway program	Freeboard = 0.5 ft. →		
or b) computed mannings n for channel	Outlet apron depth, d = 1.0 ft.		Base flow = 0.0 cfs

Design Storm Data (Table 2, FOTG, WI-NRCS Grade Stabilization Structure No. 410):

Apron elev. --- Inlet = 5920.0 ft. ------- Outlet 5850.0 ft. --- (H_{drop} = 69 ft.)

Q_{high} = *Runoff from design storm capacity from Table 2, FOTG Standard 410*
Q_5 = *Runofff from a 5-year, 24-hour storm.*

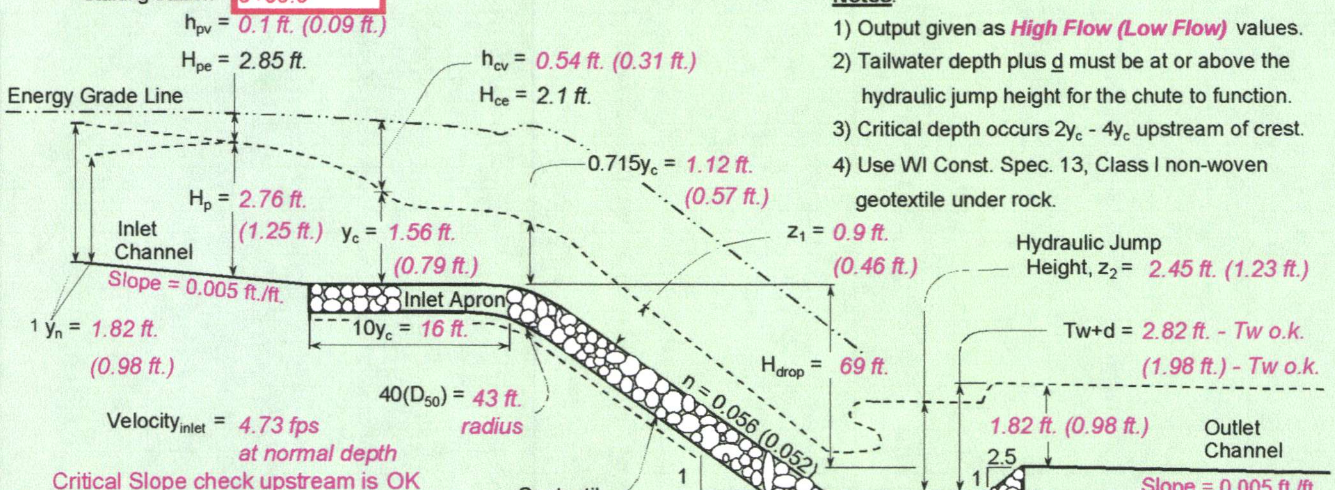
Q_{high} = 98.7 cfs High flow storm through chute → Tw (ft.) = Program
Q_5 = 29.6 cfs Low flow storm through chute → Tw (ft.) = Program

***Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.*
***Input tailwater (Tw)**:* 0.25 1.20

Profile and Cross Section (Output):

Starting Station = 0+00.0

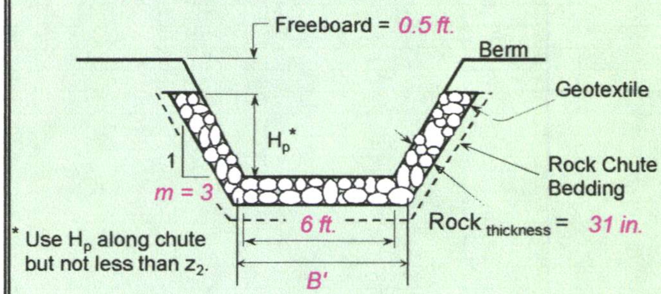
Notes:
1) Output given as ***High Flow (Low Flow)*** values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c$ - $4y_c$ upstream of crest.
4) Use WI Const. Spec. 13, Class I non-woven geotextile under rock.



[1] **Note**: When the normal depth (y_n) in the inlet channel is less than the weir head (H_p), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

Profile Along Centerline of Chute

Typical Cross Section



* Use H_p along chute but not less than z_2.

	11.08 cfs/ft.	Equivalent unit discharge
F_S =	1.20	Factor of safety (multiplier)
z_1 =	0.9 ft.	Normal depth in chute
n-value =	0.056	Manning's roughness coefficient
$D_{50}(F_s)$ =	15.5 in.	Minimum Design D50*
$2(D_{50})(F_s)$ =	31 in.	Rock chute thickness
Tw + d =	2.82 ft.	Tailwater above outlet apron
z_2 =	2.45 ft.	Hydraulic jump height
****** The outlet***	***will***	***function adequately***

High Flow Storm Information

Rock Chute Design Calculations

(Version WI-July-2010, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Canyon Dolomite - Old Quarry **County:** Fremont County, CO
Designer: John Jankousky **Checked by:** ______
Date: 7/24/2015 **Date:** ______

I. Calculate the normal depth in the inlet channel

High Flow			***Low Flow***			
y_n =	**1.82**	**ft.**	**y_n =**	**0.98**	**ft.**	(Normal depth)
Area =	20.8	ft^2	Area =	8.8	ft^2	(Flow area in channel)
Q_{high} =	98.7	cfs	Q_{low} =	29.6	cfs	(Capacity in channel)
Scupstreamchannel =	0.009	ft/ft				

II. Calculate the critical depth in the chute

High Flow			***Low Flow***			
y_c =	**1.56**	**ft.**	**y_c =**	**0.79**	**ft.**	(Critical depth in chute)
Area =	16.7	ft^2	Area =	6.6	ft^2	(Flow area in channel)
Q_{high} =	98.7	cfs	Q_{low} =	29.6	cfs	(Capacity in channel)
H_{ce} =	2.10	ft.	H_{ce} =	1.10	ft.	(Total minimum specific energy head)
h_{cv} =	0.54	ft.	h_{cv} =	0.31	ft.	(Velocity head corresponding to y_c)
$10y_c$ =	**15.62**	**ft.**	---	---		(Required inlet apron length)
$0.715y_c$ =	**1.12**	**ft.**	**$0.715y_c$ =**	**0.57**	**ft.**	(Depth of flow over the weir crest or brink)

III. Calculate the tailwater depth in the outlet channel

High Flow			***Low Flow***			
Tw =	**1.82**	**ft.**	**Tw =**	**0.98**	**ft.**	(Tailwater depth)
Area =	20.8	ft^2	Area =	8.8	ft^2	(Flow area in channel)
Q_{high} =	98.7	cfs	Q_{low} =	29.6	cfs	(Capacity in channel)
H_2 =	0.00	ft.	H_2 =	0.00	ft.	(Downstream head above weir crest, $H_2 = 0$, if $H_2 < 0.715*y_c$)

IV. Calculate the head for a trapezoidal shaped broadcrested weir

Cd = 1.00 (Coefficient of discharge for broadcrested weirs)

High Flow					
H_p =	2.82	ft.	**2.76**	**ft.**	(Weir head)
Area =	40.8	ft^2	39.4	ft^2	(Flow area in channel)
V_o =	0.00	fps	**2.51**	**fps**	(Approach velocity)
h_{pv} =	0.00	ft.	0.10	ft.	(Velocity head corresponding to H_p)
Q_{high} =	98.7	cfs	98.7	cfs	(Capacity in channel)

Trial and error procedure solving simultaneously for velocity and head

Low Flow					
H_p =	1.32	ft.	**1.25**	**ft.**	(Weir head)
Area =	13.1	ft^2	12.2	ft^2	(Flow area in channel)
V_o =	0.00	fps	**2.43**	**fps**	(Approach velocity)
h_{pv} =	0.00	ft.	0.09	ft.	(Velocity head corresponding to H_p)
Q_{low} =	29.6	cfs	29.6	cfs	(Capacity in channel)

Trial and error procedure solving simultaneously for velocity and head

Rock Chute Design Calculations

(Version WI-July-2010, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Canyon Dolomite - Old Quarry **County:** Fremont County, CO
Designer: John Jankousky **Checked by:** ______
Date: 7/24/2015 **Date:** ______

V. Calculate the rock chute parameters (w/o a factor of safety applied)

	High Flow			*Low Flow*		
q_t =	1.03	cms/m	q_t =	0.37	cms/m	(Equivalent unit discharge)
D_{50} (mm) =	328.57 ⟶ ***(12.94 in.)***		D_{50} =	191.76	mm	(Median ***angular*** rock size)
n =	0.056		n =	0.052		(Manning's roughness coefficient)
z_1 =	0.90	ft.	z_1 =	0.46	ft.	(Normal depth in the chute)
A_1 =	7.8	ft^2	A_1 =	3.4	ft^2	(Area associated with normal depth)
Velocity =	12.68	fps	Velocity =	8.63	fps	(Velocity in chute slope)
z_{mean} =	0.68	ft.	z_{mean} =	0.39	ft.	(Mean depth)
F_1 =	2.70		F_1 =	2.44		(Froude number)
$L_{rock\ apron}$ =	16.17	ft.	----	----		(Length of rock outlet apron = 15*D_{50})

VI. Calculate the height of hydraulic jump height (conjugate depth)

	High Flow			*Low Flow*		
z_2 =	**2.45**	**ft.**	**z_2 =**	**1.23**	**ft.**	(Hydraulic jump height)
Q_{high} =	98.7	cfs	Q_{high} =	29.6	cfs	(Capacity in channel)
A_2 =	32.7	ft^2	A_2 =	11.9	ft^2	(Flow area in channel)

VII. Calculate the energy lost through the jump (absorbed by the rock)

	High Flow			*Low Flow*		
E_1 =	3.39	ft.	E_1 =	1.62	ft.	(Total energy before the jump)
E_2 =	2.59	ft.	E_2 =	1.33	ft.	(Total energy after the jump)
R_E =	23.61	%	R_E =	18.23	%	(Relative loss of energy)

Calculate Quantities for Rock Chute

-------Rock Riprap Volume-------

Area Calculations	Length @ Rock CL
h = 2.76	Inlet = 15.84
x_1 = 8.17	Outlet = 19.41
L = 8.73	Slope = 288.62
A_s = 22.55	2.5:1 Lip = 2.42
x_2 = 7.75	**Total = 326.29 ft.**
A_b = 37.69	**Rock Volume**
A_b+2*A_s = 82.78 ft^2	**1000.39 yd^3**

-------Bedding Volume-------

Area Calculations	
h = 5.34	**Bedding Thickness**
x_1 = 0.00	t_1, t_2 = ***0.00*** in.
L = 16.89	
A_s = 0.00	**Length @ Bed CL**
x_2 = 0.00	**Total = 326.27 ft.**
A_b = 0.00	**Bedding Volume**
A_b+2*A_s = 0.00 ft^2	**0.00 yd^3**

-------Geotextile Quantity-------

Width	Length @ Bot. Rock
2*Slope = 33.77	**Total = 326.27 ft.**
Bottom = 6.84	**Geotextile Area**
Total = 40.61 ft.	**1472.27 yd^2**

Note: 1) The radius is not considered when calculating quantities of riprap, bedding, or geotextile.
2) The geotextile quantity does not include over-overlapping (18-in. min.) or anchoring material (18-in. min. along sides, 24-in. min. on ends).

Rock Chute Design - Plan Sheet

(Version WI-July-2010, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: Canyon Dolomite - Old Quarry **County:** Fremont County, CO
Designer: John Jankousky **Checked by:**
Date: 7/24/2015 **Date:**

Minimum Design Values		Enter Plan Values
15.5 in.	D_{50} dia. =	15.50 in.
31.0 in.	$Rock_{chute}$ thickness =	31.00 in.
16 ft.	Inlet apron length =	16.00 ft.
19 ft.	Outlet apron length =	19.00 ft.
43 ft.	Radius =	43 ft.

Will bedding be used? No

Rock Gradation Envelope

% Passing		Diameter, in. (weight, lbs.)
D_{100}	--------	23 - 31 (890 - 2108)
D_{85}	--------	20 - 28 (579 - 1537)
D_{50}	--------	16 - 23 (264 - 890)
D_{10}	--------	12 - 20 (135 - 579)

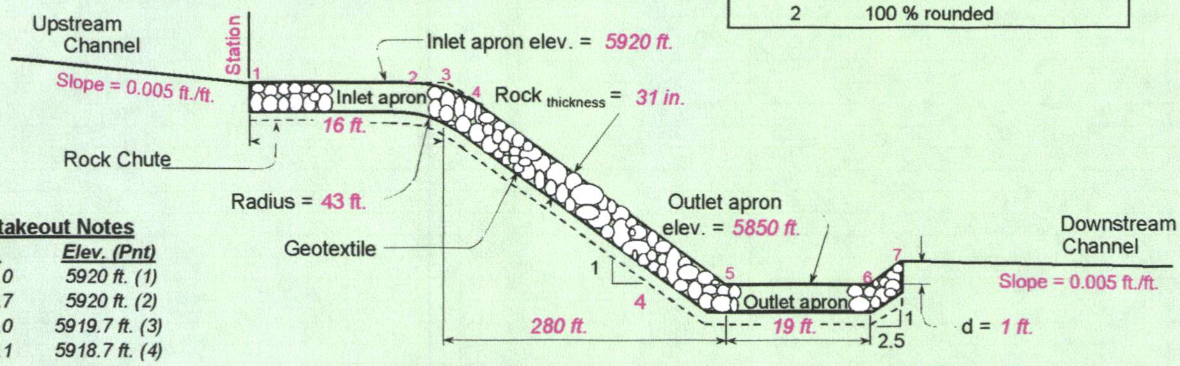
Quantities [a]

Rock = 1001 yd^3
Geotextile (WCS-13)[b] = 1473 yd^2
Bedding = 0 yd^3
Excavation = 0 yd^3
Earthfill = 0 yd^3
Seeding = 0.0 acres

Notes: [a] *Rock, bedding, and geotextile quantities are determined from the x-section below (neglect radius).*
[b] *Geotextile Class I (non-woven) shall be overlapped and anchored (18-in. min. along sides and 24-in. min. on the ends).*

Degree of angularity = 1

1	50% angular, 50% rounded
2	100 % rounded



Profile Along Centerline of Rock Chute

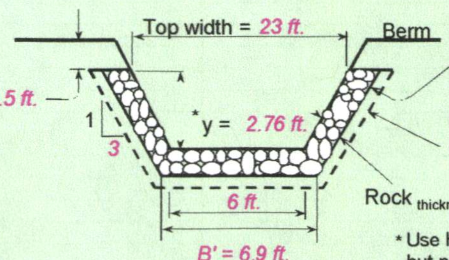
*****Note***: *The outlet will function adequately*

Stakeout Notes

Sta.	*Elev. (Pnt)*
0+00.0	5920 ft. (1)
0+10.7	5920 ft. (2)
0+16.0	5919.7 ft. (3)
0+21.1	5918.7 ft. (4)
2+96.0	5850 ft. (5)
3+15.0	5850 ft. (6)
3+17.5	5851 ft. (7)

Class I non-woven

Rock gradation envelope can be met with Gradation printed



* Use H_p throughout chute but not less than z_2.

Rock Chute Cross Section

Profile, Cross Sections, and Quantities

Rock Chute Cost Estimate

Unit	Unit Cost		Cost
Rock	See	/yd^3	#VALUE!
Geotextile	Eng	/yd^2	#VALUE!
Bedding	Est.	/yd^3	#VALUE!
Excavation	$0.00	/yd^3	$0.00
Earthfill	$0.00	/yd^3	$0.00
Seeding	$0.00	/ac.	$0.00
	Total		#VALUE!

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

Canyon Dolomite - Old Quarry
Fremont County, CO County

	Date	
Designed	John Jankousky	
Drawn		
Checked		
Approved		

File Name
Drawing Name
Sheet ___ of ___

Engineer's Cost Estimate for Rock Chute

Calculated by: John Jankousky Revision: 42209

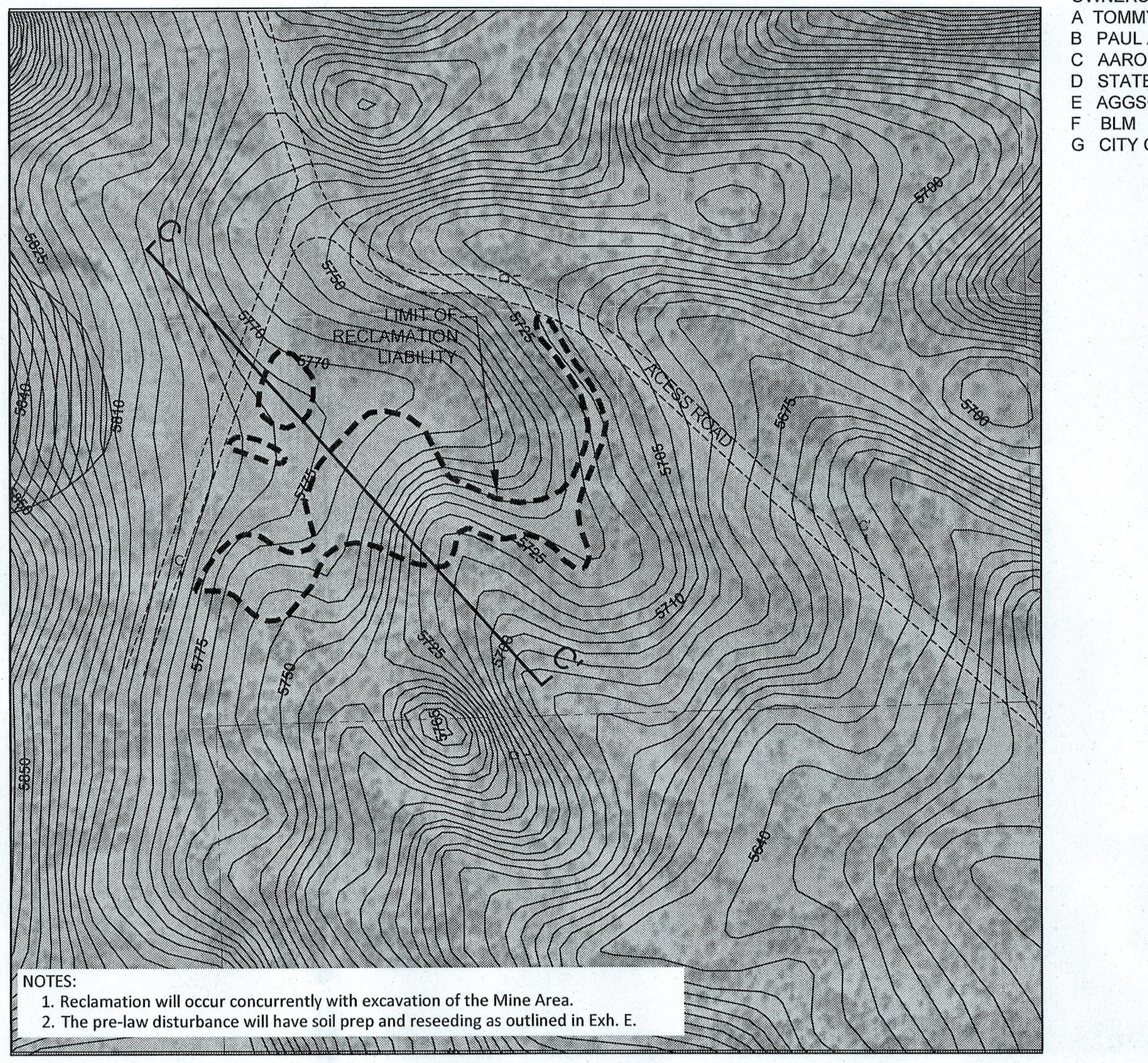
Description	Number	Units	Cost $/unit	Cost
Length of Chute	**454**	ft		
Excavation Bottom Width, Wb	6.00	ft		
Excavation Top Width, Wt	25.50	ft		
Depth of Excavation	5.83	ft		
Cross Sectional Area of excavation	**91.88**	ft^2		
Volume of Excavation	41,711	ft^3		
Volume of Excavation	**1,545**	yd^3	$ 12.00	$ 18,538.33
Cross Sectional Area of Rock	**70.00**	ft^2		
Volume of Rock	31,780	ft^3		
Volume of Rock	**1,177**	yd^3	$ 25.00	$ 29,425.93
Geotextile	**1413**	yd^2	$ 12.00	$ 16,956.00
Approximately 28 ft^2 per LF				
TOTAL COST				**$ 64,920.26**

NOTES:
1. The current disturbance and the post-law disturbance will have soil prep and reseeding as outlined in Exh. E.
2. Access road from US 50 will remain in final reclamation.
3. Bench backfill varies from 4:1 slope to 6:1 slope to avoid the visual appearance of a horizontal fill line on the rock.
4. Backfilling of each bench will occur as mining progresses on that bench.
5. Native topsoil on the undisturbed areas and in stockpiles from previous mining does not exist. Crusher fines with fertilizer and mulch will be used to establish vegetation.
6. The mine floor will be covered with 6" to 12" of crusher fines.
7. Lip on the eastern edge of the mine floor will be removed. Grading of the mine floor will direct drainage to existing swales.

SIGNED: Gary J Tuttle

DATE: 7-15-2015

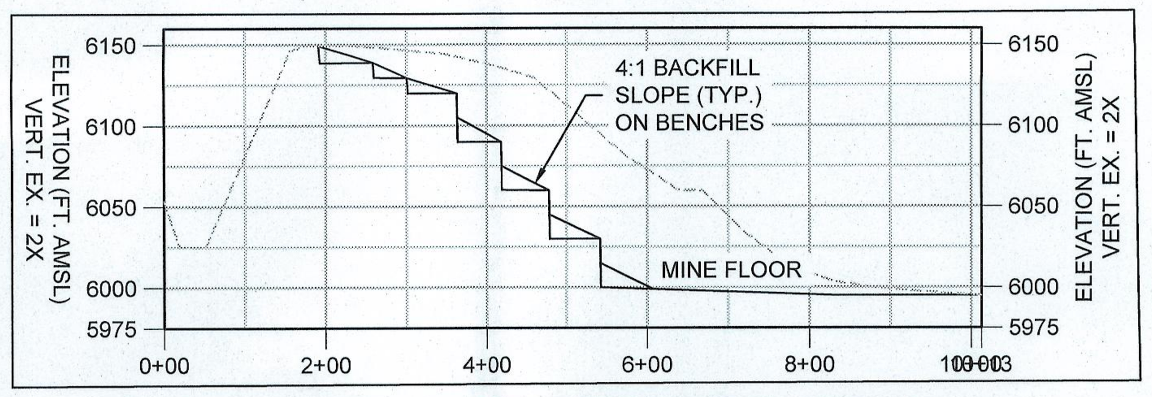
(2) MINE AREA
SCALE: 1"=200'



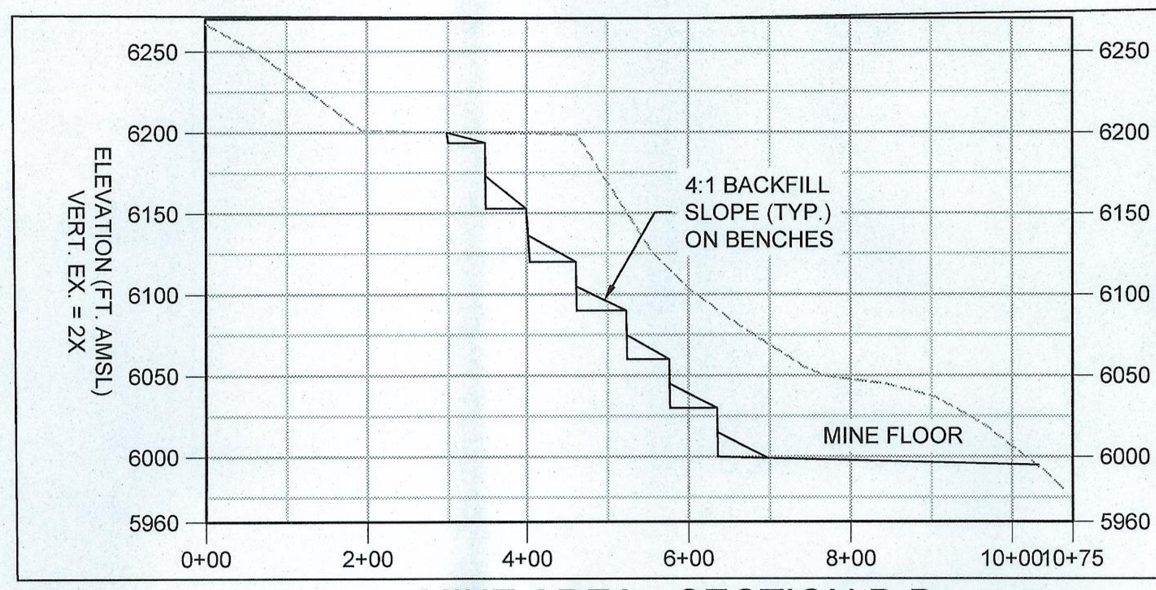
NOTES:
1. Reclamation will occur concurrently with excavation of the Mine Area.
2. The pre-law disturbance will have soil prep and reseeding as outlined in Exh. E.

(1) FINES DISPOSAL AREA
SCALE: 1"=200'

LEGEND:
- LIMITS OF PRESENT MINING
- LIMIT OF RECLAMATION LIABILITY
- ROADS
- × 0.0 EXISTING ELEVATION
- • 0.0 PROPOSED ELEVATION

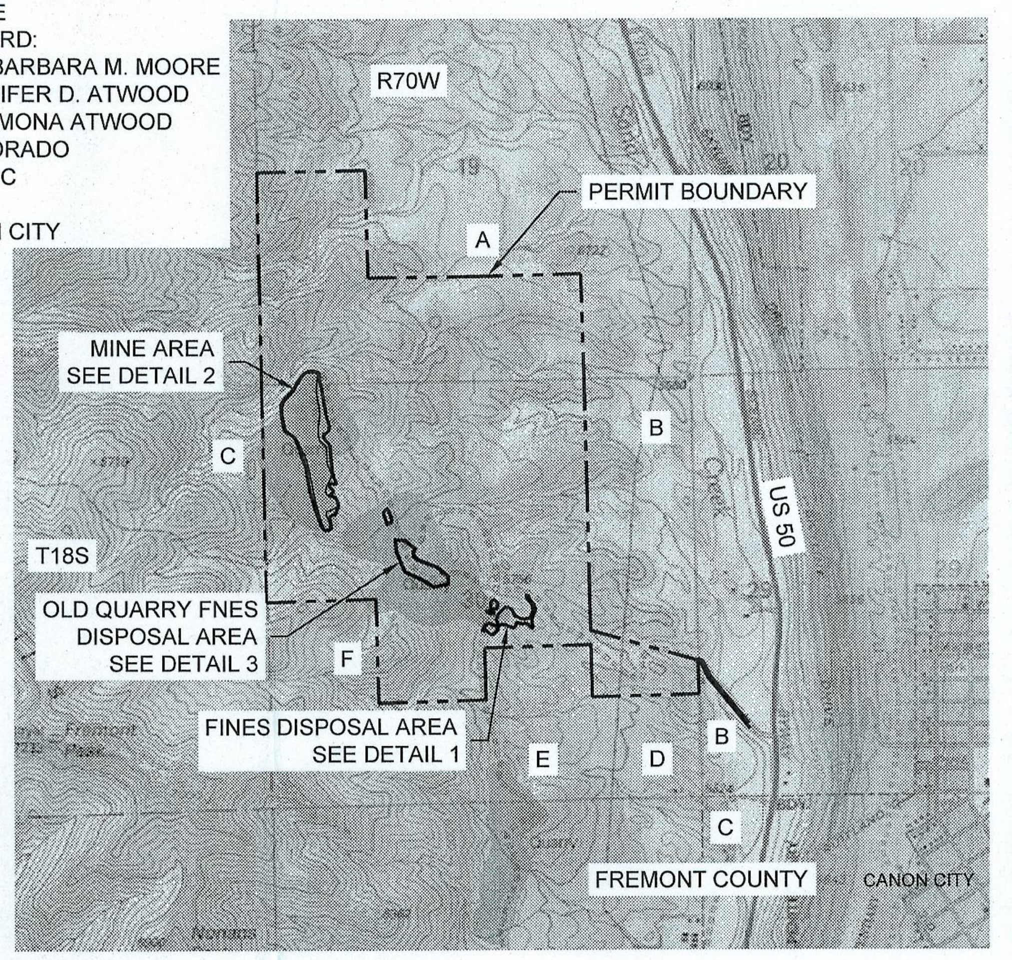


(A) MINE AREA - SECTION A-A
SCALE: H=1"=200' V=1"=100'

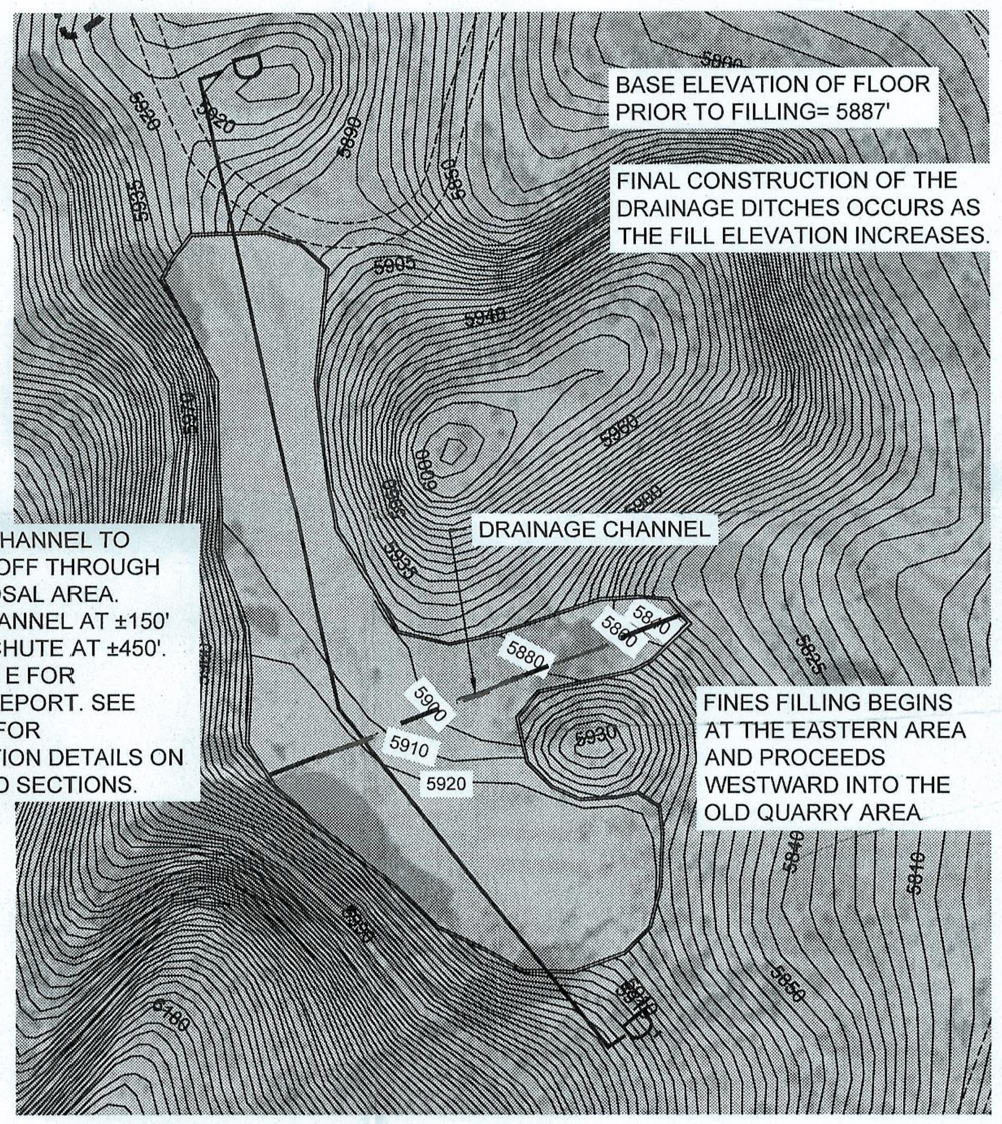


(B) MINE AREA - SECTION B-B
SCALE: H=1"=200' V=1"=100'

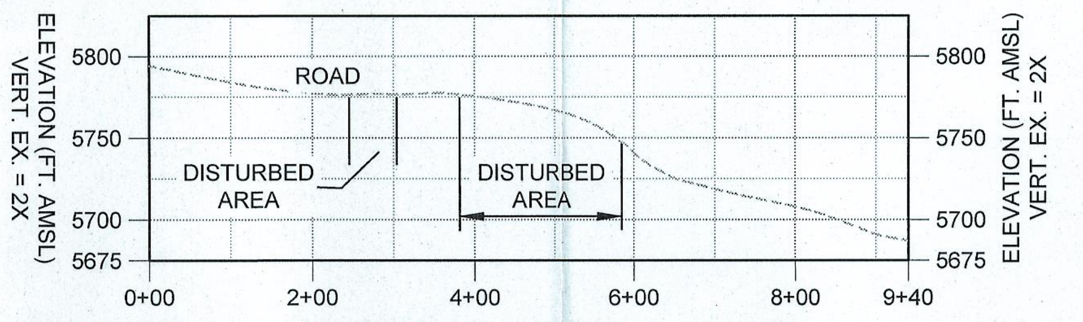
AJACENT SURFACE OWNERS OF RECORD:
A TOMMY E. AND BARBARA M. MOORE
B PAUL AND JENNIFER D. ATWOOD
C AARON AND RAMONA ATWOOD
D STATE OF COLORADO
E AGGSOURCE LLC
F BLM
G CITY OF CANON CITY



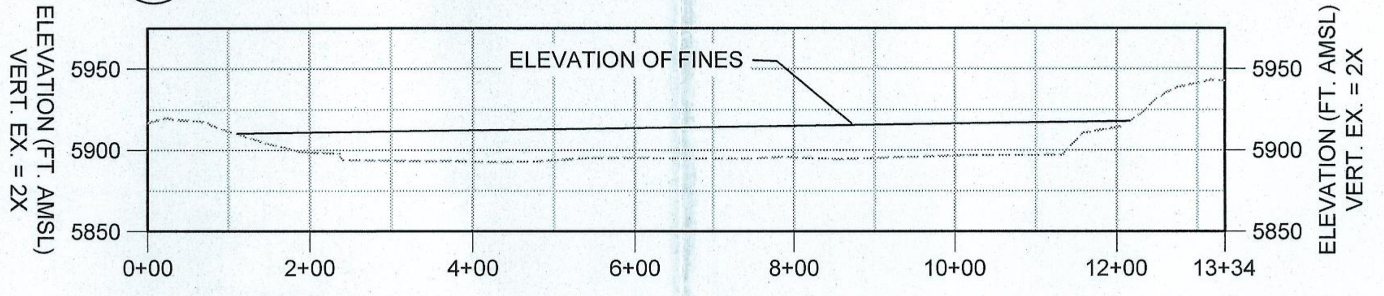
KEY MAP - PERMIT AREA
SCALE: 1"=2000'



(3) OLD QUARRY FINES DISPOSAL AREA
SCALE: 1"=200'



(C) FINES DISPOSAL AREA - SECTION C-C
SCALE: H=1"=200' V=1"=100'



(D) OLD QUARRY FINES DISPOSAL AREA - SECTION D-D
SCALE: H=1"=200' V=1"=100'

DATE:	REVISION:
4-10-15	RE-FORMAT
4-26-15	MINE PLAN AND SECTIONS
5-17-15	ADD OWNERS SIG., SECTIONS, NOTES
7-21-15	NOTES ON DETAIL 3

PREPARED FOR:
TRANSIT MIX CONCRETE
COLORADO SPRINGS, COLORADO

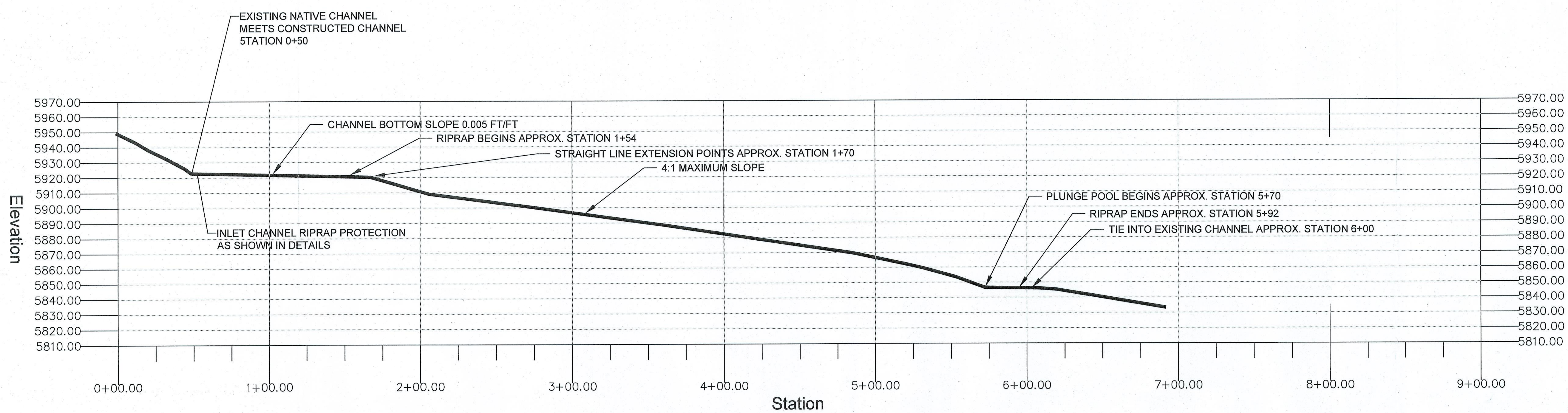
CANYON DOLOMITE QUARRY
M-1977-376
RECLAMATION PLAN
EXHIBIT F-1

PREPARED BY:
Tuttle & Associates
Planning and Permitting Services
PO BOX 485,
Broomfield, Co 80038-0485
Phone: 303.653.5584
garytuttle@gmail.com

Project No. CC001-2012

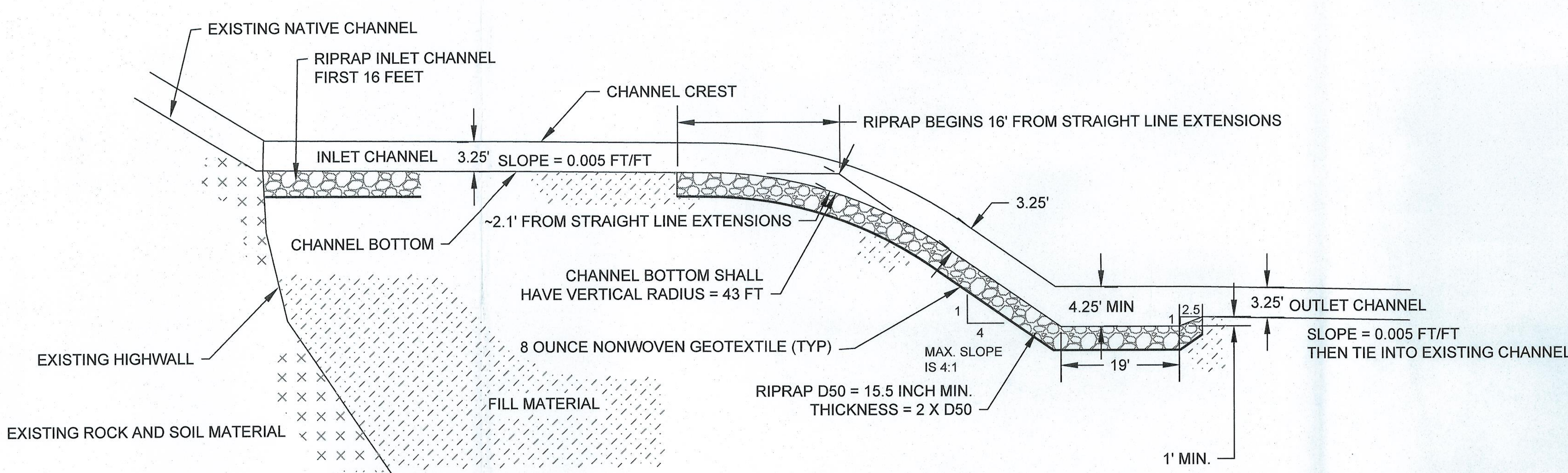
Date	Sheet
03-01-2015	3 OF 4

Date: 4/16/2015 5:16:04 PM D:\mmorison\tuttle-2-16-2105\Exhibit-F-1-Reclamation-Plan.dwg Plotted By: Mike Morrison

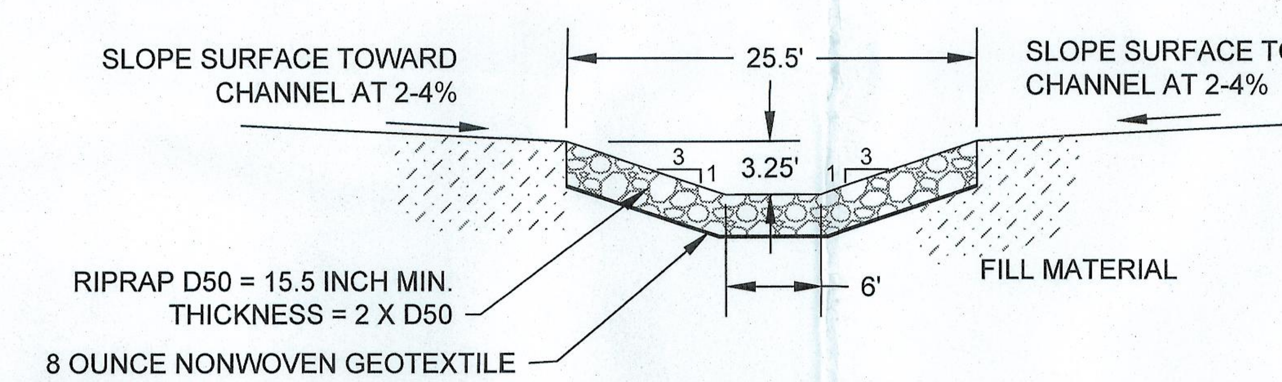


PROFILE ALONG CENTERLINE OF ROCK CHUTE
1" = 40'

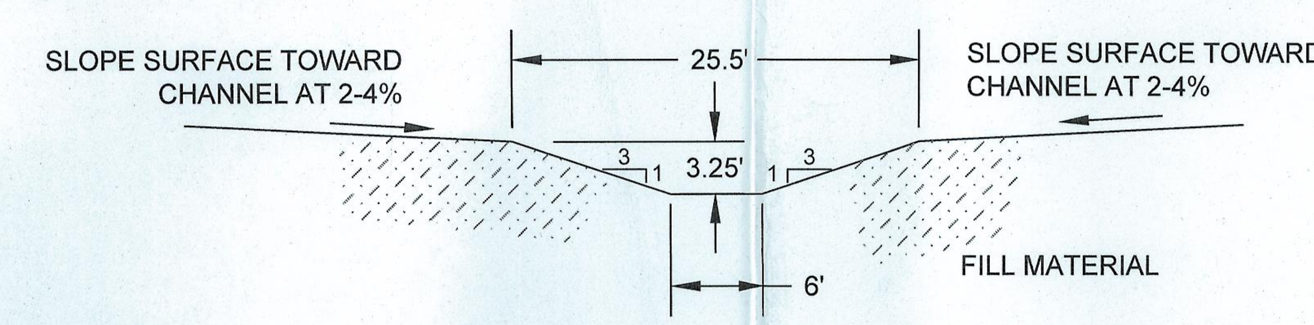
SEE EXHIBIT F-1-DETAIL 3-OLD QUARRY FINES DISPOSAL AREA FOR DRAINAGE CHANNEL LOCATION



PROFILE ALONG CENTERLINE OF ROCK CHUTE - DETAILS
NOT TO SCALE



TYPICAL ROCK CHANNEL CROSS SECTION
NOT TO SCALE



TYPICAL UNLINED CHANNEL CROSS SECTION-
INLET AND OUTLET CHANNELS
NOT TO SCALE

DATE:	REVISION:
4-10-15	RE-FORMAT
4-26-15	MINE PLAN AND SECTIONS
5-17-15	ADD OWNERS SIG., SECTIONS, NOTES
7-20-15	ADDED SHEET EXHIBIT F-2

PREPARED FOR:
TRANSIT MIX CONCRETE
COLORADO SPRINGS, COLORADO

CANYON DOLOMITE QUARRY
M-1977-376
RECLAMATION CONSTRUCTION DETAILS
EXHIBIT F-2

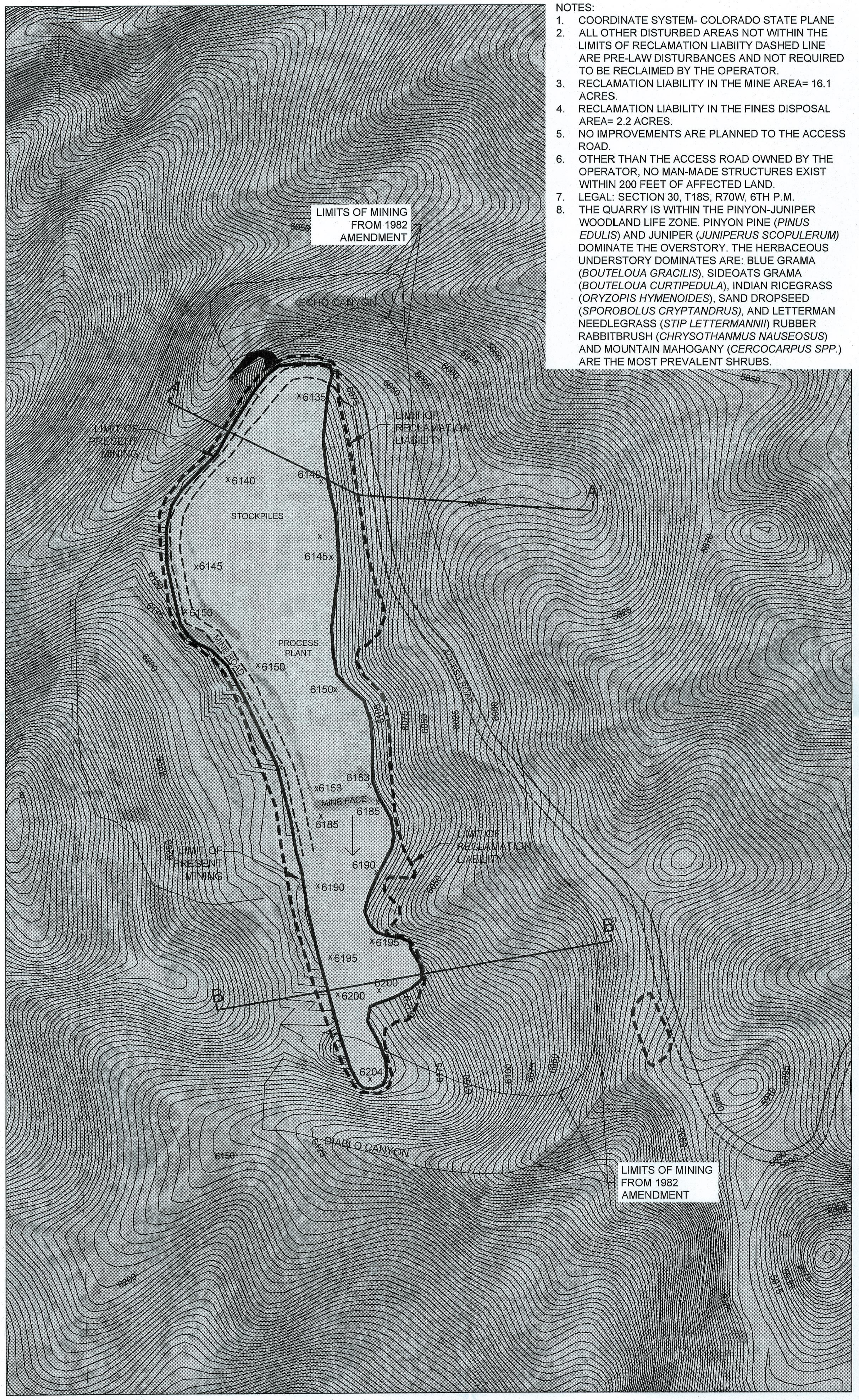
PREPARED BY:
Tuttle & Associates
Planning and Permitting Services
PO BOX 485,
Broomfield, Co 80038-0485
Phone: 303.653.5584
garytuttle@gmail.com

Project No.
CC001-2012

Date	Sheet
03-01-2015	4 OF 4

Gary J. Tuttle
July 22, 2015

NOTES:
1. COORDINATE SYSTEM- COLORADO STATE PLANE
2. ALL OTHER DISTURBED AREAS NOT WITHIN THE LIMITS OF RECLAMATION LIABIITY DASHED LINE ARE PRE-LAW DISTURBANCES AND NOT REQUIRED TO BE RECLAIMED BY THE OPERATOR.
3. RECLAMATION LIABILITY IN THE MINE AREA= 16.1 ACRES.
4. RECLAMATION LIABILITY IN THE FINES DISPOSAL AREA= 2.2 ACRES.
5. NO IMPROVEMENTS ARE PLANNED TO THE ACCESS ROAD.
6. OTHER THAN THE ACCESS ROAD OWNED BY THE OPERATOR, NO MAN-MADE STRUCTURES EXIST WITHIN 200 FEET OF AFFECTED LAND.
7. LEGAL: SECTION 30, T18S, R70W, 6TH P.M.
8. THE QUARRY IS WITHIN THE PINYON-JUNIPER WOODLAND LIFE ZONE. PINYON PINE (*PINUS EDULIS*) AND JUNIPER (*JUNIPERUS SCOPULERUM)* DOMINATE THE OVERSTORY. THE HERBACEOUS UNDERSTORY DOMINATES ARE: BLUE GRAMA (*BOUTELOUA GRACILIS*), SIDEOATS GRAMA (*BOUTELOUA CURTIPEDULA*), INDIAN RICEGRASS (*ORYZOPIS HYMENOIDES*), SAND DROPSEED (*SPOROBOLUS CRYPTANDRUS)*, AND LETTERMAN NEEDLEGRASS (*STIP LETTERMANNII*) RUBBER RABBITBRUSH (*CHRYSOTHANMUS NAUSEOSUS*) AND MOUNTAIN MAHOGANY (*CERCOCARPUS SPP.*) ARE THE MOST PREVALENT SHRUBS.

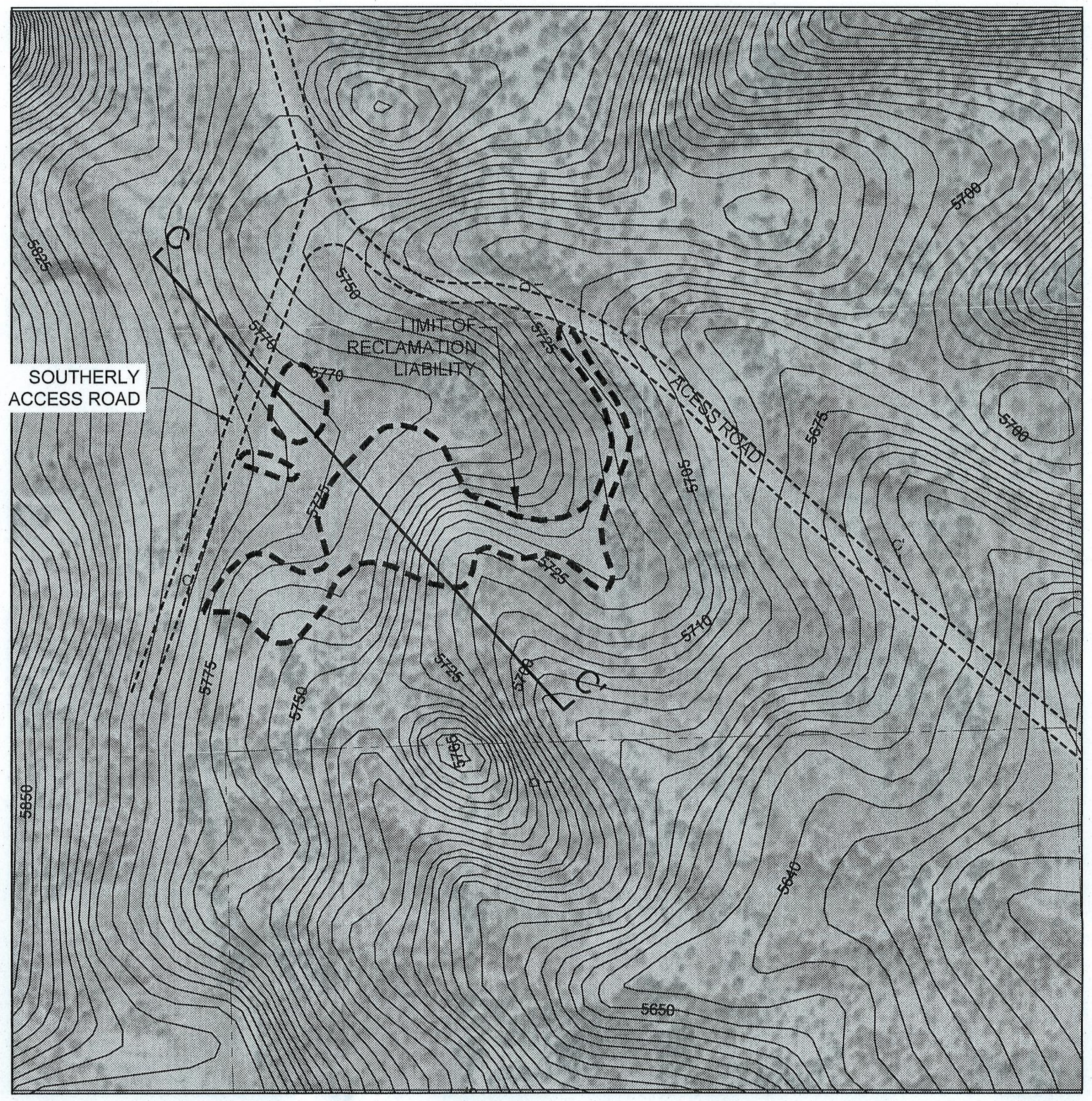


2 MINE AREA

SCALE: 1"=200'

SIGNED: Gary J Tuttle

DATE: July 22, 2015

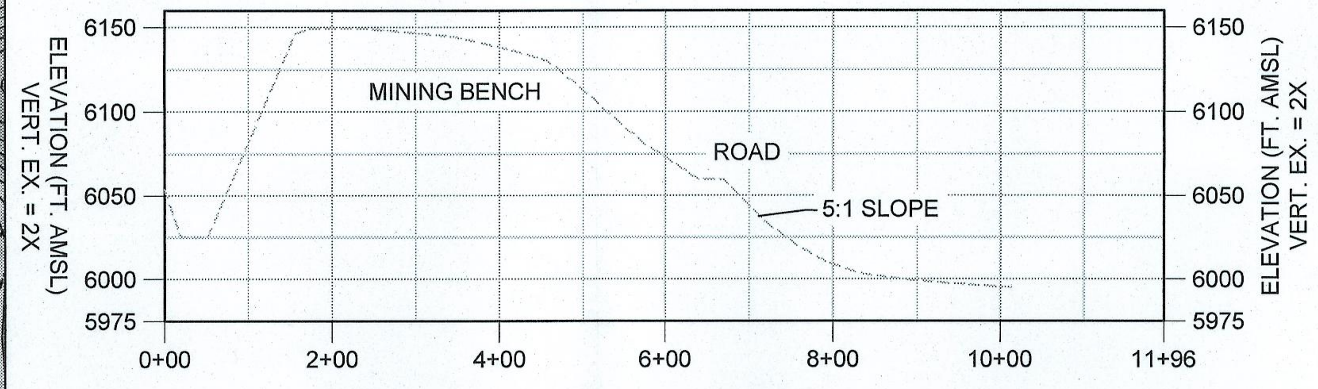


1 FINES DISPOSAL AREA

SCALE: 1"=200'

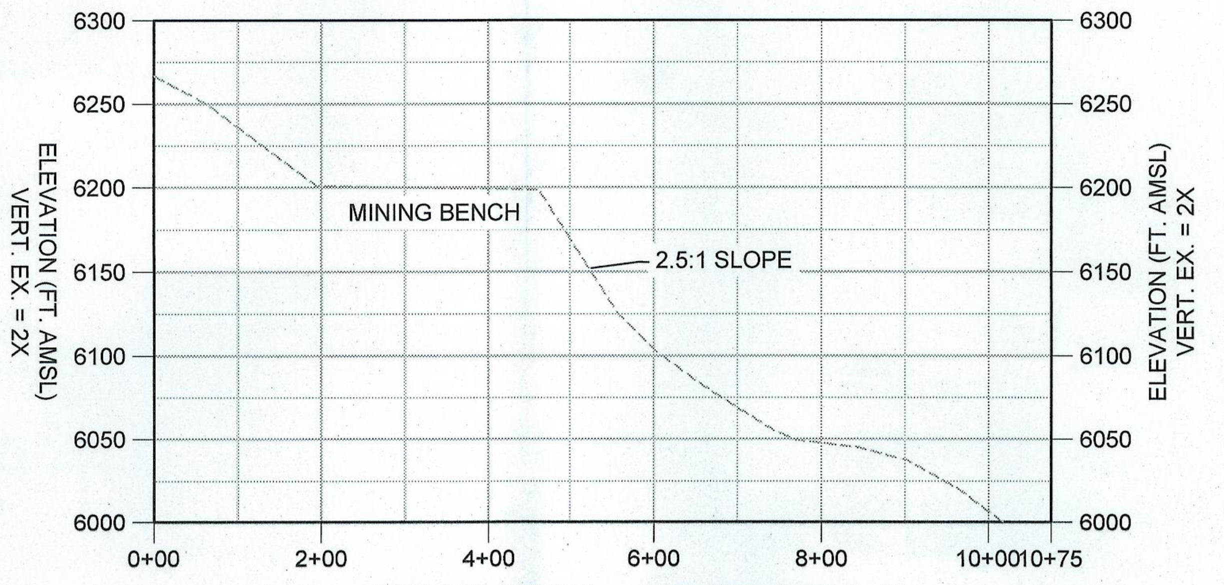
LEGEND:

- LIMITS OF PRESENT MINING
- LIMIT OF RECLAMATION LIABILITY
- ROADS
- × 0.0 EXISTING ELEVATION
- • 0.0 PROPOSED ELEVATION



A MINE AREA - SECTION A-A

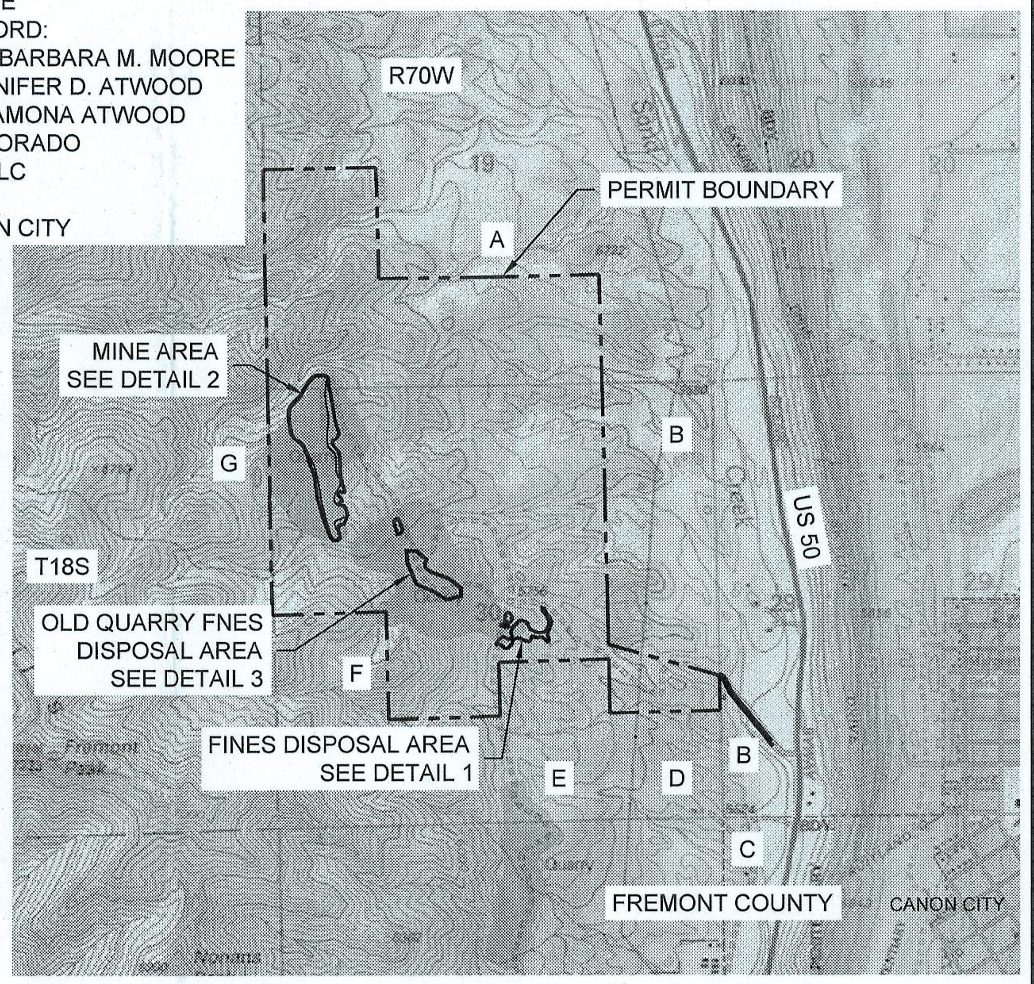
SCALE: H=1"=200' V=1"=100'



B MINE AREA - SECTION B-B

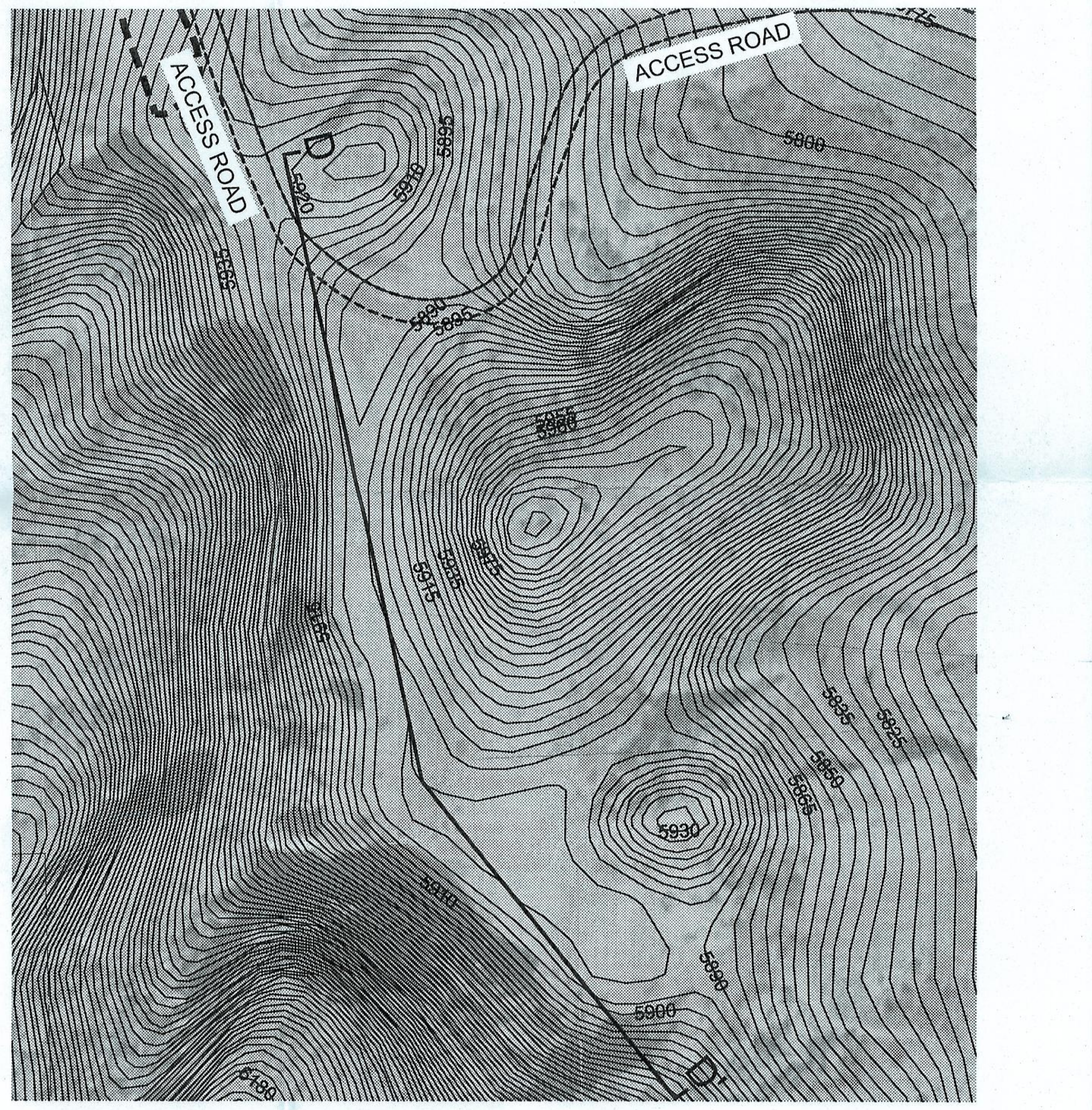
SCALE: H=1"=200' V=1"=100'

AJACENT SURFACE OWNERS OF RECORD:
A TOMMY E. AND BARBARA M. MOORE
B PAUL AND JENNIFER D. ATWOOD
C AARON AND RAMONA ATWOOD
D STATE OF COLORADO
E AGGSOURCE LLC
F BLM
G CITY OF CANON CITY



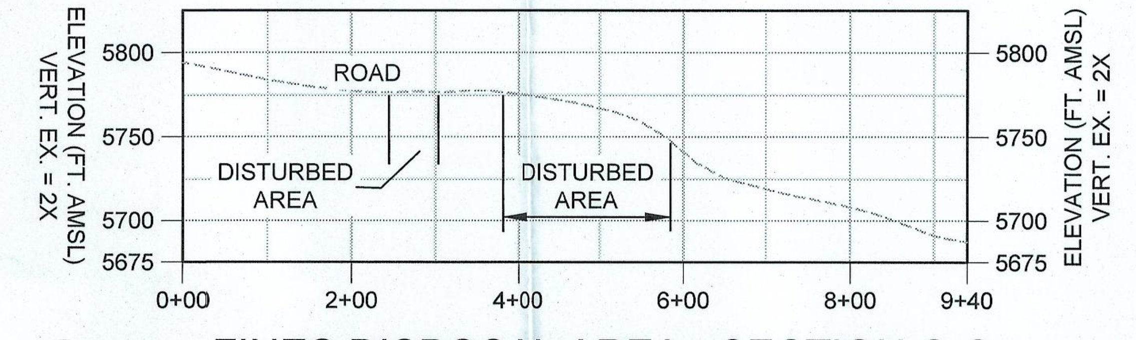
KEY MAP - PERMIT AREA

SCALE: 1"=2000'



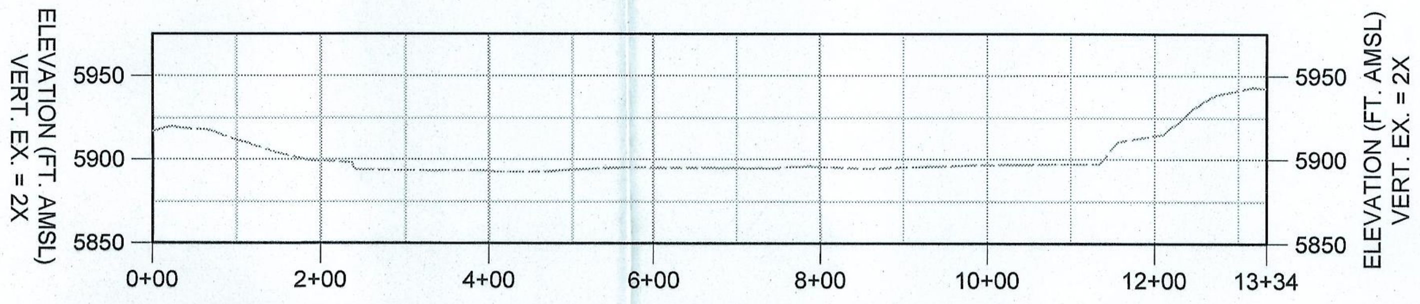
3 OLD QUARRY FINES DISPOSAL AREA

SCALE: 1"=200'



C FINES DISPOSAL AREA - SECTION C-C

SCALE: H=1"=200' V=1"=100'



D OLD QUARRY FINES DISPOSAL AREA - SECTION D-D

SCALE: H=1"=200' V=1"=100'

DATE:	REVISION:
4-10-15	RE-FORMAT
4-26-15	RE-FORMAT
5-17-15	ADD OWNERS SIG., SECTIONS, NOTES
7-20-15	REVISIONS TO NOTES

PREPARED FOR:

TRANSIT MIX CONCRETE

COLORADO SPRINGS, COLORADO

CANYON DOLOMITE QUARRY

M-1977-376

PRE-MINING PLAN

EXHIBIT C-1

PREPARED BY:

Tuttle & Associates

Planning and Permitting Services

PO BOX 485,

Broomfield, Co 80038-0485

Phone: 303.653.5584

garytuttle@gmail.com

Project No. CC001-2012

Date	Sheet
03-01-2015	1 OF 4

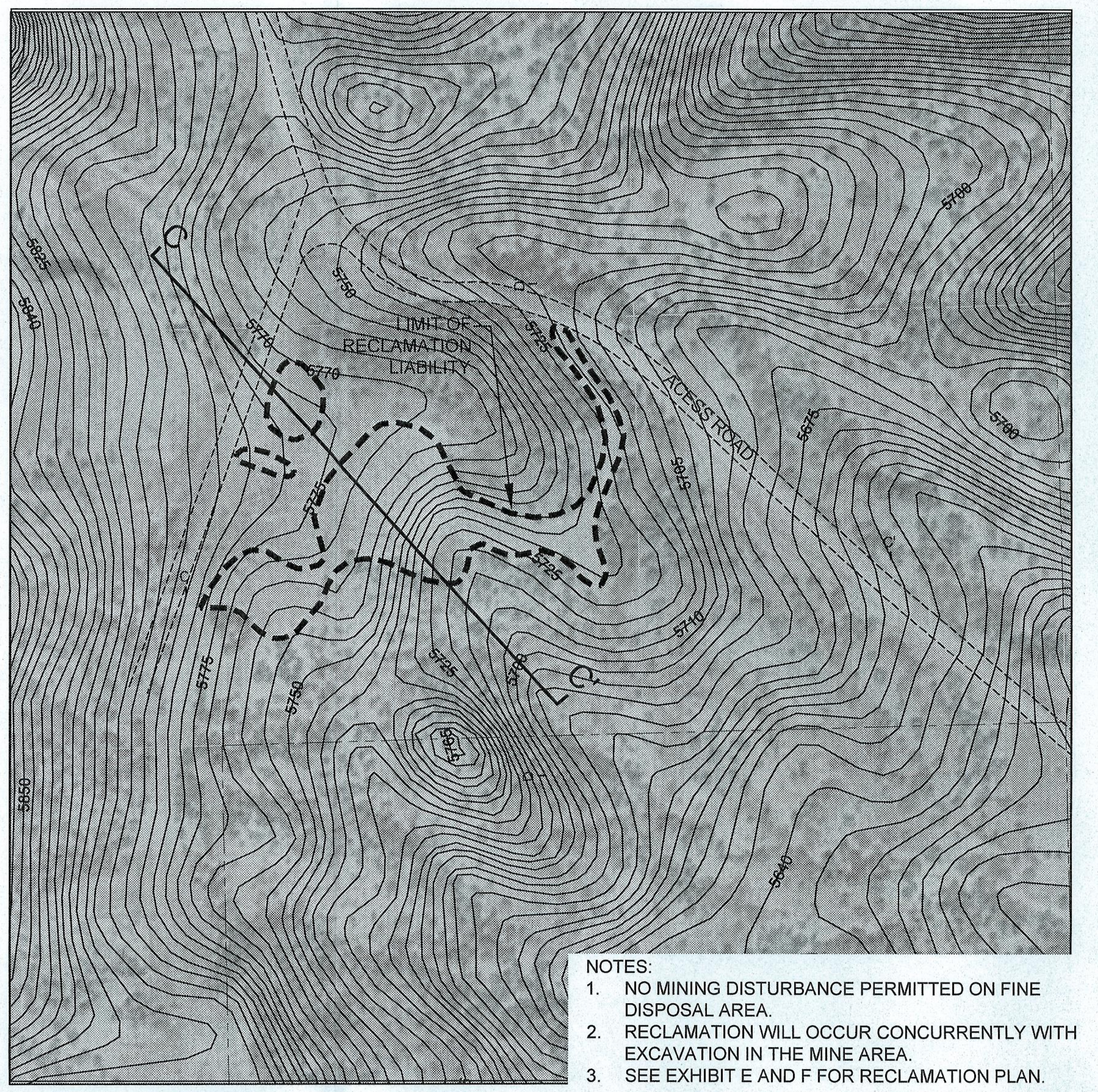
NOTES:
1. Top bench is partially built and labeled as "MINE ROAD" on Exh. C-1.
2. The active mining face will continue to the south.
3. The present mining area slopes upward from north to south at a rate of 3%. Thus the second bench will slope similar to the top bench.
4. Mining of the third bench will level out the bench so drainage moves eastward off the bench.
5. Drainage off each bench will be controlled to specific points into existing swales by a lip of 3' to 5' on the east edge of the bench.
6. Each bench will be mined by blasting a 30' high face in a southerly direction. The mining face will move south in a diagonal orientation from southwest to northeast.
7. Acres in the operation: mined: 36 acres Affected: 55
8. During most of the operation (down through bench 6060'), the majority of the excess fines produced by the processing plant will be moved to the Old Quarry Fines Disposal Area. The remainder will be used to backfill the vertical benches. Towards the end of the operation (benches 6030' and 6000'), an ample amount of the excess fines will be temporarily stockpiled on these benches for the cover on the large open portion of the final bench (6000'). We expect little fines will be hauled to the Old Quarry area in the last stages of mining. These retained fines will be pushed down from bench 6030' or pushed around bench 6000'. The open area of bench 6000' will absorb the excess fines and the cover depth may vary from 6" to 12". Volume calculations will periodically be done to insure adequate fines are temporarily stored and fines are not hauled back from the Old Quarry area to get adequate cover on bench 6000'.

SIGNED: Gary J Tuttle

DATE: July 22, 2015

2 MINE AREA

SCALE: 1"=200'



NOTES:
1. NO MINING DISTURBANCE PERMITTED ON FINE DISPOSAL AREA.
2. RECLAMATION WILL OCCUR CONCURRENTLY WITH EXCAVATION IN THE MINE AREA.
3. SEE EXHIBIT E AND F FOR RECLAMATION PLAN.

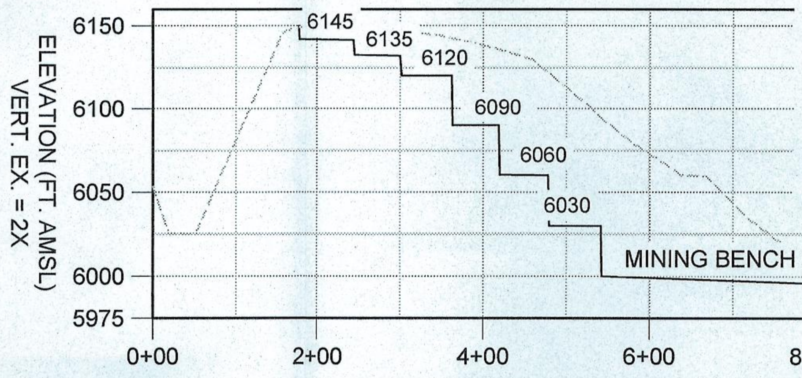
1 FINES DISPOSAL AREA

SCALE: 1"=200'

LEGEND:

- LIMITS OF PRESENT MINING
- LIMIT OF RECLAMATION LIABILITY
- ROADS
- × 0.0 EXISTING ELEVATION
- • 0.0 PROPOSED ELEVATION

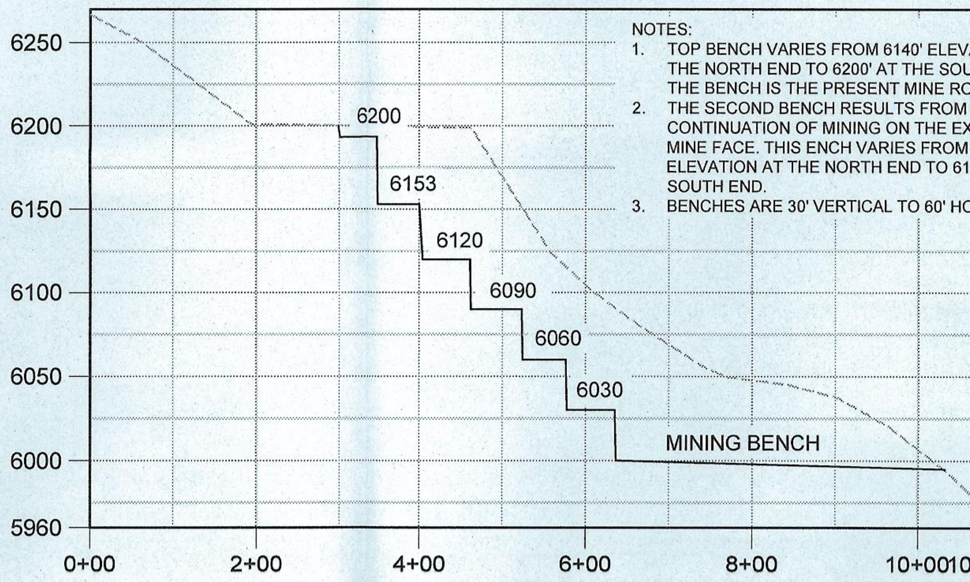
NOTES:
1. NO MINING DISTURBANCE PERMITTED ON FINE DISPOSAL AREA.
2. FINES FILLING AND RECLAMATION WILL OCCUR CONCURRENTLY WITH EXCAVATION IN THE MINE AREA.
3. DURING THE MINING OPERATION, APPROXIMATELY HALF OF THE UNMARKETABLE FINES WILL BE TRUCKED TO THE OLD QUARRY AREA FOR DISPOSAL.
4. OFF-SITE DRAINAGE FROM THE WEST WILL BE DIRECTED THROUGH THE NEW FILL AREA IN A CONTROLLED FASHION.
5. SEE EXHIBIT E AND F FOR RECLAMATION PLAN AND FINAL LAND CONFIGURATION.



NOTES:
1. TOP BENCH VARIES FROM 6140' ELEVATION AT THE NORTH END TO 6200' AT THE SOUTH END. THE BENCH IS THE PRESENT MINE ROAD.
2. THE SECOND BENCH RESULTS FROM THE CONTINUATION OF MINING ON THE EXISTING MINE FACE. THIS ENCH VARIES FROM 6140' ELEVATION AT THE NORTH END TO 6153' AT THE SOUTH END.
3. BENCHES ARE 30' VERTICAL TO 60' HORIZONTAL.

A MINE AREA - SECTION A-A

SCALE: H=1"=200' V=1"=100'



NOTES:
1. TOP BENCH VARIES FROM 6140' ELEVATION AT THE NORTH END TO 6200' AT THE SOUTH END. THE BENCH IS THE PRESENT MINE ROAD.
2. THE SECOND BENCH RESULTS FROM THE CONTINUATION OF MINING ON THE EXISTING MINE FACE. THIS ENCH VARIES FROM 6140' ELEVATION AT THE NORTH END TO 6153' AT THE SOUTH END.
3. BENCHES ARE 30' VERTICAL TO 60' HORIZONTAL.

B MINE AREA - SECTION B-B

SCALE: H=1"=200' V=1"=100'

AJACENT SURFACE OWNERS OF RECORD:
A TOMMY E. AND BARBARA M. MOORE
B PAUL AND JENNIFER D. ATWOOD
C AARON AND RAMONA ATWOOD
D STATE OF COLORADO
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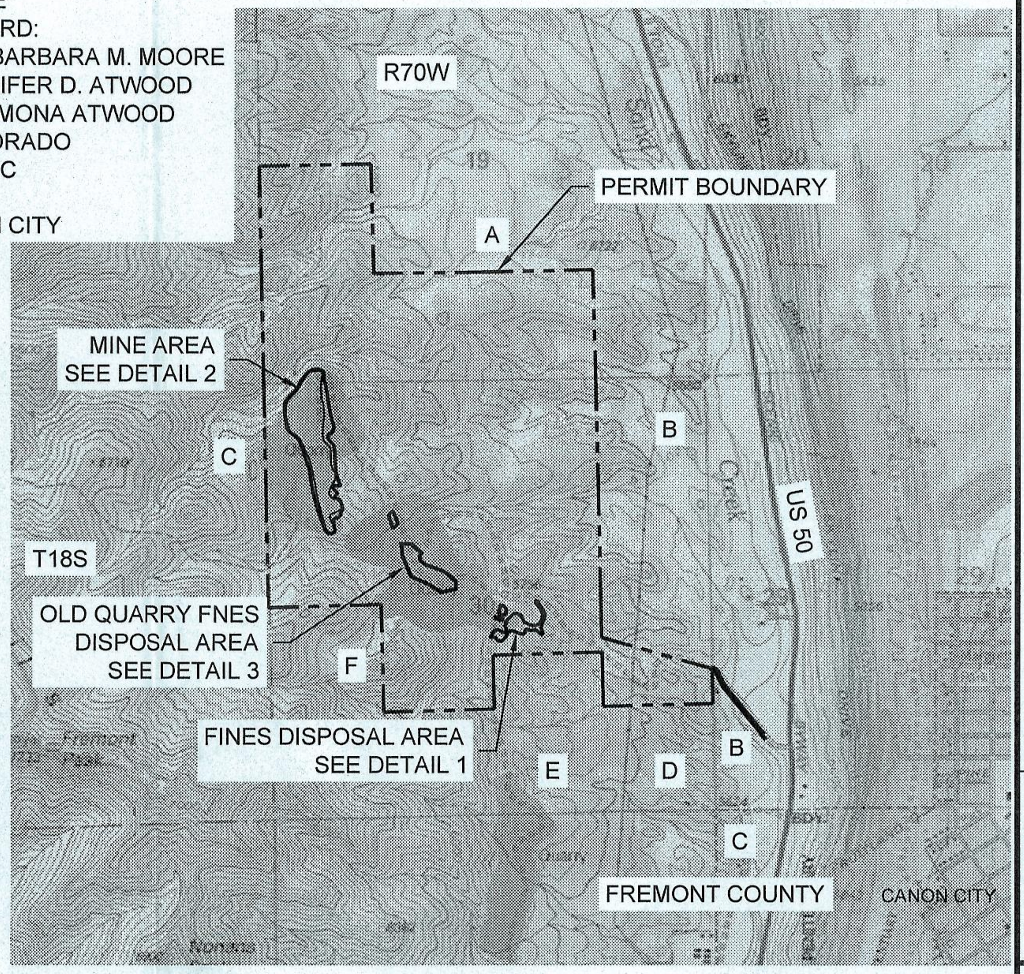
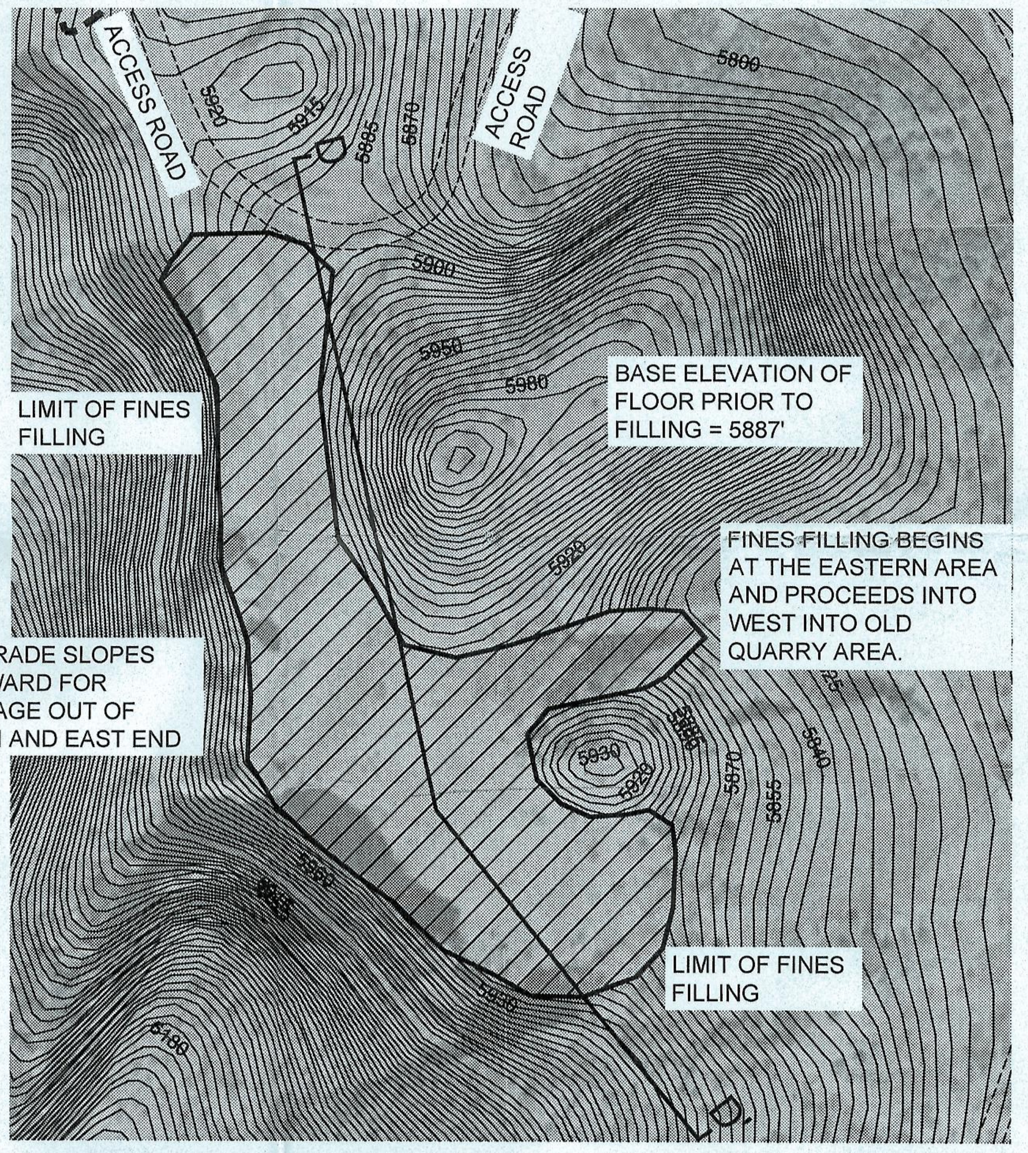
F BLM
G CITY OF CANON CITY



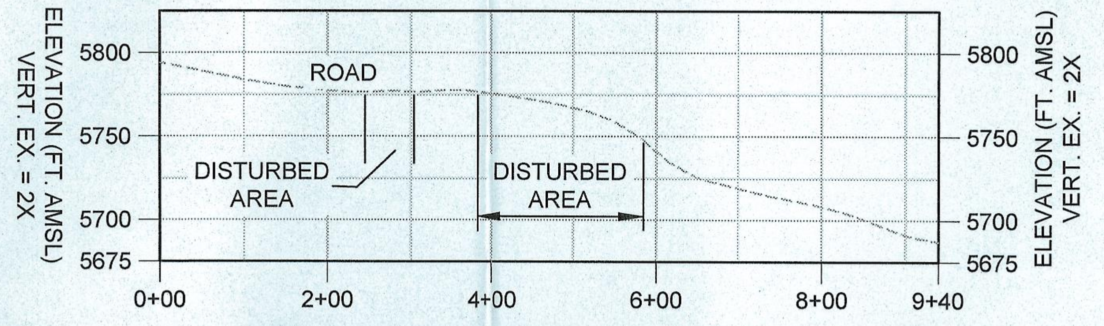
KEY MAP - PERMIT AREA

SCALE: 1"=2000'



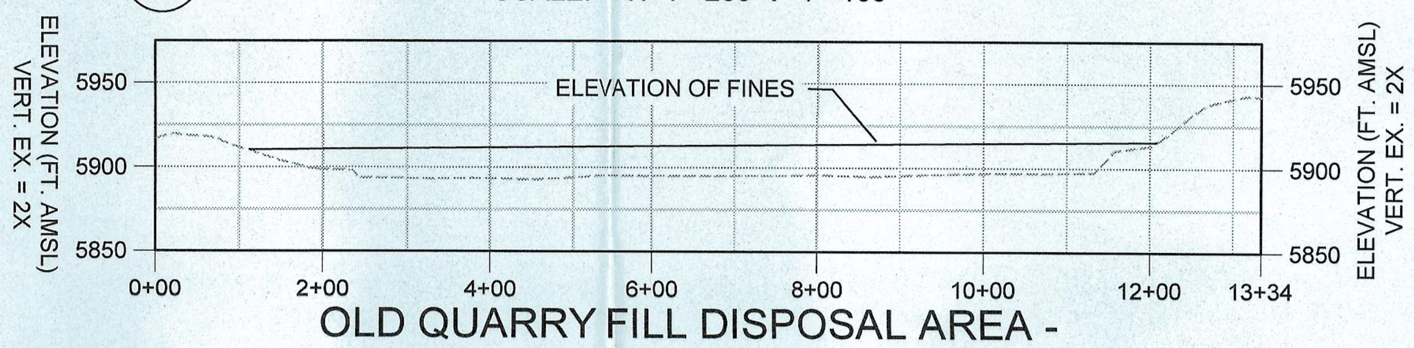
3 OLD QUARRY FINES DISPOSAL AREA

SCALE: 1"=200'



C FINES DISPOSAL AREA - SECTION C-C

SCALE: H=1"=200' V=1"=100'



D OLD QUARRY FILL DISPOSAL AREA - SECTION D-D

SCALE: H=1"=200' V=1"=100'

REVISION:	DATE:
MINE PLAN AND SECTIONS	4-13-15
RE-FORMAT	4-26-15
ADD OWNERS SIG., SECTIONS, NOTES	5-17-15
REVISIONS TO NOTES	7-20-15

PREPARED FOR:

TRANSIT MIX CONCRETE

COLORADO SPRINGS, COLORADO

CANYON DOLOMITE QUARRY

M-1977-376

MINING PLAN

EXHIBIT C-2

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Project No. CC001-2012

Date	Sheet
03-01-2015	1 OF 4