From: John Schmuck [John_Schmuck@Cameco.com]
Sent: Friday, October 12, 2012 5:55 PM
To: Burrows, Ronald; elise.stritz@nrc.gov
Cc: Michelle Shellhart
Subject: Three Crow Erosion Study and Completion of Baseline Ore Zone Monitoring
Attachments: Three Crow Hydrologic and Erosion Study.pdf

Ron- Attached please find Cameco's Three Crow Erosion Study.

Thanks. .john

Cameco

CAMECO RESOURCES
Corporate Office
2020 Carey Avenue
Suite 600
Cheyenne, WY
82001 USA

Tel: (307) 316-7600
Fax: (307) 635-9949
www.cameco.com

October 12, 2012

Ronald Burrows, Program Manager
Decommissioning & Uranium Recovery License Directorate
Division of Waste Management and Environmental Protection
Federal/State Materials and Environmental Management Program
US NRC
Mailstop T8-F5
Washington DC 20555-0001

Three Crow Erosion Study

Dear Mr. Burrows:

Attached please find Cameco's Three Crow Erosion Study and associated replacement pages. At the present time, I have not attempted to make final page changes to the document. Instead I will perform technical editing late in the process to completely and correctly incorporate the added pages and to correctly assign a sequential designation to the new appendix.

Also, as a matter of information, we have just completed one year of baseline monitoring in the ore zone. The data will be provided when time permits.

A hard copy of this letter will also be mailed to your attention.

Sincerely,

J.P. Schmuck

John P. Schmuck
Senior Permitting Manager

Ec: Elise Stritz

Appendices (Volume II)

Assessment Erosion Potential

The potential for erosion that could impact the proposed Three Crow facilities and mine units has been assessed. The complete report of the hydrologic and erosion study, including tables and figures, is provided in Appendix XX (ARCADIS 2012). The study addressed guidance in NUREG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium *in-situ* facility. The ultimate objective of the TCEA study was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented.

The study focused on catchment and watershed delineation, hydrologic characteristics, and determination of areas most prone to flooding and erosion due to rainfall runoff. The analysis identifies proposed wells and facilities in areas of moderate to high risk of erosion that may require mitigation measures. Four primary tasks comprise the comprehensive hydrologic and erosion analysis:

- Data collection and analysis: rainfall, digital elevation data, soil and land use data
- Watershed delineation: divide the project area basin into watersheds for detailed hydrologic analysis
- Hydrologic and erosion analysis: determine the flood routing characteristics of watersheds and generating the erosion risk map using hydrologic, land use, and soil data
- Erosion risk assessment: identify TCEA wells and other site facilities in locations of high erosion potential that may require erosion mitigation

3.1.3.2 Data Collection

The data necessary to complete the study included terrain data or a digital elevation model (DEM), existing floodplain maps, land use and land cover data (LULC), National Hydrography Dataset (USGS NHD) published stream network data, soil data, and rainfall data.

The terrain data were downloaded from the USGS National Elevation Dataset (NED) at a resolution of 30 m. DEM data were used throughout the model domain to describe watershed topography and streams within the hydrologic model. The project area is in the watershed HUC12 101500020607 (Belmont Cemetery-Niobrara River Basin).

As noted in Appendix XX land use data for the study area were the National Land Cover Data (NLCD), which were downloaded from the USGS seamless online Data Warehouse. Supplementary data used to prepare and recondition the DEM include the USGS National Hydrography Dataset (NHD) published stream network, NHD Flowline and the NRCS published 12-digit hydrologic unit (HUC12) watershed delineation.

Soil data were downloaded from the NRCS geospatial data gateway, Soil Survey Geographic Database (SSURGO). Regional soil characteristics, most importantly the infiltration rate, were represented by the Soil Conservation Service (SCS) Curve Number Method. Soil data were downloaded from the NRCS geospatial data gateway.

Meteorological data, including precipitation, evaporation, and runoff values, were collected from the National Ocean and Atmospheric Administration (NOAA) NWS and NCDC.

3.1.3.3 Analysis Procedures

A detailed description of procedures used for watershed delineation and basin characteristics, hydrologic and soil erosion analysis, and modeling is presented in Appendix XX.

A GIS-based erosion model (Revised Universal Soil Loss Equation [RUSLE]).was used to investigate potential erosion in the project area. The model provides a fine spatial resolution of the model results. The RUSLE model is relatively simple and is one of the most practical methods to estimate soil erosion potential and the effects of different management practices. It was selected due to its wide acceptance, including for construction site management at the federal level in National Pollutant Discharge Elimination System Phase II permitting.

The RUSLE is the modified version of U.S. Department of Agriculture's Universal Soil Loss Equation (USLE), which has been in used to measure soil loss from agriculture lands with relatively uniform slopes. The RUSLE modified certain factors in USLE to more accurately account for more complex terrain. The output of the RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, as opposed to erosion resulting from specific storm events. A detailed description of RUSLE is presented in Appendix XX

3.1.3.4 Erosion Risk Analysis

Mine units and other TCEA facility locations were compared to the RUSLE map to evaluate erosion risk potential for each location. Proposed mine units, the satellite building, and the areas adjacent to the satellite building for potential placement of the access road and DDW were all evaluated. Table 5 of Appendix XX lists the risk of erosion for each mine unit. Maps displaying the average annual erosion potential as estimated by the RUSLE model in relation to the MUs and satellite facility locations are provided in Appendix XX.

Mining Unit (MU)-1 and MU-2 were found to have some high erosion areas but some of them low or very low erosion risk throughout the unit, while MU-3, MU-4, MU-8 and MU-9 have no erosion to low erosion risk throughout the unit. However, MU-5, MU-6, and MU-7 are found to have locations of moderate and high erosion risk. MU-1 and MU-2 have multiple locations of moderate to high erosion risk. Figure 20 shows the distribution of erosion rate for different erosion intensity. Placement of well locations around areas of moderate and high potential erosion is a possibility in these units. For the mining units with large areas of moderate and high erosion, it may be more difficult to place wells without additional mitigation measures due to the widespread erosion risk in the units. If wells cannot be placed outside of areas within the wellfields deemed to have moderate to high risks, mitigation measures (e.g., berms) can be implemented to minimize the potential for flooding and erosion. The mitigation measures can be defined during final engineering and prior to any construction.

Figure 13 displays the erosion potential for the satellite facility and evaporation ponds. The locations in the image represent the proposed area for placement of the satellite facility, and access roads. The erosion risk at the satellite facility was found to be low or very low throughout the area. The location of the evaporation ponds covers some high erosion areas which are not a problem. Constructing the facilities and access roads in the noted area would minimize the potential for erosion issues.

Calibration vendors will provide a certificate of calibration for all instruments. These calibration certificates will be maintained by the Radiation Safety Officer (RSO) on file for that instrument. Records of repair completed by the calibration vendor will also be maintained in the instrument file.

Documentation of calibration of air samplers performed on site will be maintained. This documentation will be maintained by the RSO in the sampler file.

Record of instrument checks including the daily checks and initial checks will be maintained in a format determined by the RSO. These records will be readily available and in a format that will allow the RSO to review the records for the types of potential problems (e.g., background drift in a continuous direction, battery check that does not respond, ratemeter that does not zero and alpha background rates greater than 0.5 cpm).

All records of instrument calibration and checks will be retained until NRC License termination. The RSO will be responsible for record retention.

Details as to calibration, functional tests, procedures and recordkeeping/retention are discussed in the SHEQMS Volume IV *Health Physics Manual.*

3.4 References

Arcadis, Hydologic and Erosion Study Three Crow Expansion Area, July 2012, Arcadis 2012

National Fire Protection Association (NFPA). NFPA-50, *Standard for Bulk Oxygen Systems at Consumer Sites*, (NFPA, 1996).

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Compressed Gas Association. (CGA). CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems*, (CGA, 1993).

APPENDIX XX

Hydrologic and Erosion Study

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Hydrologic and Erosion Study
Three Crow Expansion Area

July 2012

ARCADIS

Hydrologic and Erosion Study

Three Crow Expansion Area

Prepared for:
CAMECO Resources

Prepared by:
ARCADIS U.S., Inc.
630 Plaza Drive
Suite 200
Highlands Ranch
Colorado 80129
Tel 720 344 3500
Fax 720 344 3535

Our Ref.:
CO001636.0001.00012

Date:
July 2012

Table of Contents

Tables

Figures

1. Introduction

This report outlines the construction of a hydrologic and erosion model of the Three Crow Expansion Area (TCEA) and provides an assessment of potential erosion in the project area (**Figure 1**). The TCEA Project will consist of a uranium insitu recovery (ISR) satellite processing facility, individual well fields (mine units), and other associated assets. The basic layout of the proposed license boundary, mine units and satellite facility locations is shown in **Figure 1**.

This study addresses guidance in NUREG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium ISR facility. The ultimate objective is to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented.

The study focuses on catchment and watershed delineation, hydrologic characteristics, and determination of areas most prone to flooding and subsequent erosion due to rainfall runoff. The analysis identifies wells and facilities in areas of moderate to high risk of erosion that may require mitigation measures. Four primary tasks comprise the comprehensive hydrologic and erosion analysis:

1) Data collection and analysis: rainfall, digital elevation data, soil and land use data.
2) Watershed delineation: divided the project area basin into watersheds for detailed hydrologic analysis.
3) Hydrologic and erosion analysis: determining the flood routing characteristics of watersheds and generating the erosion risk map using hydrologic, land use and soil data.
4) Erosion risk assessment: identifying TCEA wells and other site facilities in locations of high erosion potential that may require scour mitigation.

2. Data Collection

The consequential data necessary to complete the study are terrain data or a digital elevation model (DEM), land use and land cover data (LULC), National Hydrography Dataset (USGS NHD) published stream network data, soil data, and rainfall data.

The terrain data are downloaded from the USGS National Elevation Dataset (NED). NED data is available at a resolution of 10 m. The vertical datum is NAVD88, while the coordinate system was converted to UTM Zone 13N. DEM data was utilized throughout the model domain to describe the watershed terrain. Using this data, the watershed and streams within the study area were described within the hydrologic model. The project area is in the three watersheds, including HUC12 101402010108 (Glendale Cemetery-White River Basin), HUC12 101402010203 (Cherry Creek-White River Basin) and HUC12 101402010201 (Bozle Creek Basin). **Figure 2** depicts the DEM in the study area.

Land use data for the study area were the National Land Cover Data (NLCD) 2006, which were downloaded online from the USGS seamless Data Warehouse. **Figure 3** depicts the NLCD land use map.

Supplementary data to prepare and recondition the DEM include the USGS National Hydrography Dataset (NHD) published stream network, NHD Flowline (Simley and Carswell 2009) and the Natural Resources Conservation Service's (NRCS) published 12-digit hydrologic unit (HUC12) watershed delineation (NRCS 2009). **Figure 4** depicts the NHD published stream network. **Table 1** lists the associated Hydrologic Unit Code (HUC) 12-digit identification number for each NHD stream.

Soil data was downloaded from the NRCS geospatial data gateway, Soil Survey Geographic Database (SSURGO). Regional soil characteristics, most importantly the infiltration rate, were represented by the SCS Curve Number Method. Soil data was downloaded from the Natural Resources Conservation Service's (NRCS) geospatial data gateway. **Figure 5** depicts the SSURGO soil map for the project areas. **Table 2** lists the SSURGO K factor values and associated percentages of sand, silt and clay for each SSURGO soil type.

The meteorological data, including precipitation, evaporation and runoff values, were collected from National Ocean and Atmospheric Administration (NOAA) National Weather Service (NWS) or National Climate Data Center (NCDC).

Details of the available geospatial, stream flow and meteorological data can be found in **Table 3**.

3. Watershed Delineation and Basin Characteristics

Prior to catchment processing and watershed delineation, there are several pre-processing steps required for the DEM. First, the HUC12 data is utilized to clip the DEM boundary, such that only the primary watersheds pertinent to the TCEA analysis are maintained. **Figure 2** demonstrates that the area, much larger than the permit boundary, is clipped out of the DEM domain.

Once the clipped DEM is constructed, drainage patterns are defined using an Arc Hydro tool. The Arc Hydro tool identifies ridges and valleys in the DEM. Arc Hydro constructs a drainage network by connecting valleys that have been identified. Because of limited DEM resolution of 30 meters, it is possible that the DEM data is not able to fully replicate the hydrologic reality of a catchment when deriving the drainage pattern in Arc Hydro. Thus the drainage network initially mapped by Arc Hydro requires adjustments to fully replicate the hydrologic reality of the system. The elevations within the raw DEM were reconditioned to revise elevations along published NHD Flowline (Simley and Carswell 2009) shown in **Figure 4.** Reconditioning the DEM ascertains proper drainage in the study area. This process is known as the AGREE method. The GIS parameters used for the AGREE method were chosen carefully, as it is imperative that they have minimal effects on further terrain analysis (Callow et al. 2007).

Subsequent to the AGREE method for DEM reconditioning, local, small scale depressions and pits in the DEM were raised using GIS. The software applies an algorithm that searches for localized pits and depressions that could capture flow and inadvertently delineate watersheds incorrectly. Once these depressions are identified, the GIS model raises the elevation of the pits to a smoothed elevation based on neighboring elevations to create an improved, depression-less terrain.

Using the final reconditioned, depression-less terrain data, the Arc Hydro tool identifies a definitive system of ridges and valleys used to calculate flow direction and accumulation. **Figure 6** depicts the result of the watershed delineation into 107 subbasins. **Figure 7** depicts the associated drainage line network.

4. Hydrologic and Soil Erosion Analysis

The soil erosion model was constructed to investigate potential erosion in the project area. The results of the model highlight areas where erosion would be most substantial. Areas of high erosion may require mitigation measures or project modification to achieve maximum project success and minimize environmental impacts.

The susceptibility of sediment to transport and delivery is largely affected by local terrain. The terrain in the study area is highly varied, as shown in **Figure 2**. Principal vegetative cover in the study area is grassland and farmland in the project area. The hydrologic and soil erosion analysis is broken into two components for this study. The first is a comprehensive watershed analysis utilizing the Revised Universal Soil Loss Equation (RUSLE) for sheet flow analysis. The second component is a comparison of TCEA mining unit to the drainage network lines and potential flood plain displayed in **Figure 19** for the channelized flow.

4.1 RUSLE

A GIS-based erosion model was used for this analysis, which provides a fine spatial resolution of model results. The RUSLE model is a relatively simple model and one of the most practical methods to estimate soil erosion potential and the effects of different management practices. It was selected to use due to its wide acceptance, including construction site management at the federal level in National Pollutant Discharge Elimination System Phase II permitting (Wachal and Banks 2007, USEPA 2000).

The RUSLE is the modification version of USLE which has been in used to measure soil loss from agriculture lands with relative uniform slopes. The RUSLE modified certain factors in USLE and these modifications allow RUSLE model to more accurately account for more complex terrain. The output of RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, instead of specific storm events. The model is able to provide a quantitative measurement of erosion that occurs as a result of project-related soil disturbance.

The RUSLE formula computes average annual erosion as follows:

$$A = R * K * LS * C * P$$

Where:

A = computed average annual soil loss in tons/acre/year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length and slope steepness

C = land cover management factor

P = conservation practice factor

The factors can be divided into two categories: (1) environmental variables (R, L, S, and K), which remain relative constant over time, (2) management variables (C and P) which may change over time.

4.1.1 R-factor

The R-factor represents the rainfall erosivity which is the erosive power of rainfall. It is derived from the product of the total kinetic energy of a storm event and the maximum 30-minute intensity. The R-factor accounts for both amount of rainfall and intensity of rainfall.

The R-factor value is typically obtained from an isoerodent map provided in the USDA Handbook 703. The erosion index values for locations between the lines can be obtained by linear interpolation. The R-factor value for the entire study area used in this analysis is 48 based on the published isoerodent map.

4.1.2 K-factor

The K-factor represents soil erodibility, measures the ability of a particular soil type to resist erosion. The ability of soil to resist the erosion depends on the specific contents in the soil (such as percentage of silt, sand, clay and organic matter), the soil structure and the permeability of the soil. The most widely used and frequently cited relationship is the soil-erodibility nomograph (USDA Handbook 703).

The K-factor values range from 0 for water and, although in practice the maximum K-factor does not generally exceed 0.67. Large K-factor values reflect greater potential soil erodibility. The most common used soil database SSURGO has compiled the K-factors into the database. These values are based on the dominant classified soil components in the surficial layers for each map unit. The K-factor value used in this analysis is the SSURGO K-factor. **Table 2** lists the SSURGO K-factor values and associated percentages of sand, silt and clay. **Figure 8** exhibits TCEA K-factor values.

4.1.3 LS-factor

The LS-factor is the critical factor in accurately estimating soil erosion potential. It is a combination of two data sets: slope length (L) and slope steepness (S). Longer slope length equate to a higher amount of accumulative runoff. Similarly, the steeper slopes generate higher runoff velocity. Both factors are notable contributors to erosion.

The slope length affects erosion potential more than slope steepness. Slope length is the distance from the origin of the overland flow to the nearest stream or the concentrated flow.

The original equation to calculate the LS-factor was an empirical equation published in the USDA Hankbook 537. The new published equation used in this analysis is as follows (Moore and Burch1986, Breiby 2006):

$$LS = (\textit{flow accumulation} * \text{cell size} / 22.13)^{0.4} *(\sin(\textit{slope})*0.01745)/0.0896)^{1.4} * 1.4$$

The flow accumulation and slope values are determined using ArcHydro tools in a similar fashion as the DEM reconditioning procedures. **Figure 9** and **Figure 10** respectively demonstrate flow accumulation and topographic slope values.

4.1.4 C-factor

The C-factor represents land cover and management aspects, accounting for the effects of plants and soil cover on soil loss. The C-factor is useful for analysis of various project alternatives with soil disturbing activity. This factor is the main mechanism in which project alternative differences are modeled.

The C-factor values in this analysis are derived from the current conditions described in the National Land Cover Dataset (NLCD 2006). The C-factor for various land use types is shown in the **Table 4**. **Figure 11** illustrates the C-factor for TCEA.

4.1.5 P-factor

The P-factor is the support or land management factor, accounting for such practices as farming, terracing and cropping. The P-factor value ranges from 0 to 1, which P=1 equating to zero disturbing activity. The P=1 is used in this analysis assuming no disturbance of this type.

4.2 Concentrated Flow Analysis

Erosion via sheet flow is the focus of the RUSLE component of the study. However, drainage networks on the TCEA site, particularly the sections in the drainage line network of the watershed, are at the added risk of concentrated flows. Detailed analysis of the drainage networks during flood events was not completed as part of this study. Rather, the location of TCEA mining units and other facilities were compared drainage network locations as well as published Federal Emergency Management

Agency (FEMA) Digital Flood Insurance Rate Map (DFIRM) 100 year floodplain extents (FEMA 2011). Well fields and facilities adjacent to drainage paths, particularly those in the DFIRM floodplain, should be located carefully on the TCEA site to ensure a safe distance from the drainage route and floodplain and protect from concentrated flows.

5. Erosion Risk Assessment

The RUSLE map displaying the average annual erosion potential is shown in **Figure 12**. **Figure 13** through **Figure 18** respectively display the erosion potential for the mining units and the satellite facility on the site. The final map should be interpreted as the erosion risk potential.

Well fields and other TCEA facility locations are compared to the RUSLE map to evaluate erosion risk potential for each location. Proposed well fields, the satellite building, and the areas adjacent to the satellite building for potential placement of the access road were all evaluated. **Table 5** lists the risk of erosion for each well field and percentage of moderate to high erosion area. Mining Unit (MU)-1, and MU-2 were found to have some high erosion areas but some of them low or very low erosion risk throughout the unit, while MU-3, MU-4, MU-8 and MU-9 have no erosion to low erosion risk throughout the unit. However, MU-5, MU-6, and MU-7 are found to have locations of moderate and high erosion risk. MU-1 and MU-2 have multiple locations of moderate to high erosion risk. **Figure 20** shows the distribution of erosion rate for different erosion intensity. Placement of well locations around areas of moderate and high potential erosion is a possibility in these units. For the mining units with large areas of moderate and high erosion, it may be more difficult to place wells without additional mitigation measures due to the widespread erosion risk in the units. If wells cannot be placed outside of areas within the wellfields deemed to have moderate to high risks, mitigation measures (e.g., berms) can be implemented to minimize the potential for flooding and erosion. The mitigation measures can be defined during final engineering and prior to any construction.

Figure 13 displays the erosion potential for the satellite facility and evaporation ponds. The locations in the image represent the proposed area for placement of the satellite facility, and access roads. The erosion risk at the satellite facility was found to be low or very low throughout the area. The location of the evaporation ponds covers some high erosion areas which are not a problem. Constructing the facilities and access roads in the noted area would minimize the potential for erosion issues.

As part of the concentrated flow analysis, drainage lines and DFIRM floodplain extents are compared to mining unit locations. **Figure 7** demonstrates the high flow accumulation along drainage lines. Drainage lines are the primary contributor to increased erosion risk as part of the RUSLE analysis. However, the RUSLE analysis is unable to accurately define erosion risk in these areas of concentrated flow in flood events. Therefore, published FEMA DFIRM 100 year floodplain extents were compared to mining units in the area. Mining unit locations within the 100 year floodplain should be considered at risk to flooding as well as erosion caused by flood events. Further analysis, mitigation measures or modification of well locations should be considered for those wells near concentrated flow routes or in the 100 year floodplain during the final engineering phase and prior to well installation and construction activities.

Figure 19 displays the drainage lines and floodplain extents relative to the mining unit locations. Mining units MU-6 is positioned such that drainage line and the associated DFIRM floodplain cross the unit. The drainage line runs generally southwest to northeast. The well locations in these drainage units should be positioned outside of the floodplain or included flood protection measures in the final engineering plans. Additionally, the proposed access roads, as shown in **Figure 12**, are not in the 100 year floodplain.

6. References

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ARCADIS

Tables

Table 1 National Resources Conservation Services (NRCS) Hydrological Unit (HU) Codes

Figure 4 Stream ID Numbers	NRCS Hydrologic Unit Code Identification
3	126552430
4	126552429
5	126552887
9	126554593
15	126552425
19	160601769
22	126552428
24	126552421
27	126552424
28	126552894
37	126552442
54	160603442
56	126552900
58	126552439
63	126552889
76	126552880
83	126565832
94	126552422
102	126565771
103	160603557
109	126552888
113	126552417
119	160603609
120	126552890
127	160603608
130	160603556
138	126565779
150	126552896
151	126552871
155	126552883
160	126552426
161	126552885
192	160602348
206	126552892
208	126552891
212	126552416
213	160601521

Note: NRC HUC Codes are for each National Hydrography Dataset (NHD).

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
1001 Bankard, channeled, frequently flooded	100	A	0.10	5	95.4	0.6	4.0
1004 Bankard	100	A	0.15	4	87.3	6.7	6.0
1006 Bankard, channeled, frequently flooded	100	A	0.10	5	87.3	4.7	8.0
1008 Bankard variant	99	A	0.15	4	87.3	6.7	6.0
1012 Bankard	100	A	0.37	5	61.2	20.8	18.0
1013 Bankard, frequently flooded	100	A	0.10	4	83.2	10.8	6.0
1014 Bankard	100	A	0.15	4	87.3	6.7	6.0
1030 Glenberg	100	B	0.20	5	66.1	21.9	12.0
1031 Glenberg, channeled	100	B	0.20	5	66.1	21.9	12.0
1036 Glenberg	100	B	0.37	5	80	10	10.0
1037 Glenberg	100	B	0.37	5	80	10	10.0
1114 Bankard	100	A	0.10	5	87.3	4.7	8.0
1187 Las Animas	99	C	0.28	4	42.1	37.9	20.0
1350 Bridget	100	B	0.43	5	42.2	42.8	15.0
1355 Bridget	100	B	0.43	5	14	71	15.0
1356 Bridget	99	B	0.43	5	14	71	15.0
1357 Bridget	99	B	0.43	5	14	71	15.0
1358 Bridget	100	B	0.43	5	14	71	15.0
1361 Bridget	99	B	0.37	5	60.7	27.8	11.5
1362 Bridget	99	B	0.37	5	60.7	27.8	11.5
1363 Bridget	100	B	0.37	5	60.7	27.3	12.0
1364 Bridget	100	B	0.37	5	60.7	27.3	12.0
1535 Sulco	55	B	0.49	5	44.3	44.7	11.0
Halvorson	45	B	0.24	5	37.9	35.6	26.5

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
1616 Keith	50	B	0.43	5	13.7	69.3	18.0
Ulysses	49	B	0.4	5	13.6	68.9	17.5
1618 Keith	100	C	0.43	5	41.2	41.8	18.0
1620 Keith	99	B	0.43	5	13.7	69.3	18.0
1621 Keith	99	C	0.43	5	41.2	38.8	18.0
1631 Keith	99	B	0.43	5	13.7	69.3	18.0
1690 Manvel	100	B	0.37	3	6.8	61.7	31.5
1697 Minnequa	100	C	0.37	3	6.8	61.7	31.5
1698 Minnequa	100	C	0.37	3	6.8	61.7	31.5
1726 Rosebud	99	C	0.28	3	44.8	41.2	14.0
1730 Rosebud	99	C	0.37	3	30.1	54.9	15.0
1736 Rosebud	60	C	0.24	3	43.2	38.8	18.0
Canyon	39	D	0.43	2	64.4	25.6	10.0
1742 Rosebud	74	C	0.28	3	44.8	41.2	14.0
Canyon	25	D	0.32	2	44.3	40.7	15.0
1762 Richfield	99	B	0.37	5	29.3	53.7	17.0
1812 Satanta	99	B	0.28	5	63.5	26.5	10.0
1813 Satanta	100	B	0.28	5	63.5	26.5	10.0
1822 Satanta	65	B	0.28	5	63.5	26.5	10.0
Canyon	35	D	0.32	2	44.3	40.7	15.0
1823 Satanta	60	B	0.28	5	63.5	26.5	10.0
Canyon	40	D	0.32	2	44.3	40.7	15.0
1862 Ulysses	100	B	0.43	5	13.6	68.9	17.5
1881 Dwyer	50	A	0.20	5	78.2	16.3	5.5
Valent	50	A	0.15	5	86.8	6.7	6.5

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
1882 Valent	50	A	0.15	5	86.8	6.7	6.5
1882 Dwyer	49	A	0.20	5	78.2	16.3	5.5
1884 Valent	65	A	0.10	5	95.4	0.6	4.0
Valent	35	A	0.10	5	95.4	0.6	4.0
1885 Valent	100	A	0.10	5	95.4	0.6	4.0
1886 Valent	99	A	0.10	5	95.4	0.6	4.0
1891 Valent	99	A	0.10	5	86.8	4.2	9.0
1892 Valent	99	A	0.10	5	84.5	6.5	9.0
1894 Valent	100	A	0.15	5	86.8	6.7	6.5
2360 Munjor	100	B	0.20	4	66.5	20.0	13.5
2361 Munjor, channeled, frequently flooded	100	B	0.20	4	66.5	20.0	13.5
4223 Bolent	98	A	0.15	5	86.8	6.7	6.5
4524 Els	98	A	0.10	5	94.9	0.6	4.5
4636 Hoffland	100	D	0.10	3	63.1	19.4	17.5
4649 Ipage	100	A	0.20	5	78.6	16.4	5.0
4713 Orpha	100	A	0.10	5	86.4	6.6	7.0
4716 Orpha	65	A	0.10	5	86.4	6.6	7.0
4716 Niobrara	35	D	0.20	2	79.9	16.6	3.5
5003 Lohmiller, frequently flooded	100	C	0.32	5	17.3	47.7	35.0
5056 Bufton	99	C	0.24	5	33.3	36.7	30.0
5058 Bufton	100	C	0.32	5	17.3	47.7	35.0
5060 Bufton	100	C	0.32	5	17.3	47.7	35.0
5061 Bufton	69	C	0.32	5	17.3	47.7	35.0
Hisle	30	D	0.43	2	24.8	52.7	22.5

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value % Sand	% Silt	% Clay
5070 Vetal	50	B	0.17	5	66.1	19.9	14.0
Bayard	49	B	0.24	5	62.5	26.0	11.5
5101 Alliance	100	B	0.37	4	41.0	41.0	18.0
5102 Alliance	99	B	0.37	4	41.0	41.0	18.0
5105 Alliance	99	B	0.37	4	13.6	68.9	17.5
5106 Alliance	99	B	0.37	4	13.6	68.9	17.5
5107 Alliance	99	B	0.37	4	13.6	68.9	17.5
5112 Bufton	99	C	0.24	5	33.3	36.7	30.0
5114 Bufton	100	C	0.32	5	17.3	47.7	35.0
5115 Bufton	100	C	0.32	5	17.3	47.7	35.0
5118 Busher	60	A	0.32	4	80.0	10.0	10.0
Tassel	40	D	0.43	2	81.8	12.2	6.0
5123 Busher	99	A	0.32	4	80.0	10.0	10.0
5124 Busher	99	A	0.32	4	80.0	10.0	10.0
5125 Busher	100	A	0.37	4	80.0	10.0	9.0
5126 Busher	100	A	0.32	4	80.0	10.0	10.0
5128 Busher	99	A	0.32	4	80.0	10.0	10.0
5129 Busher	100	A	0.32	4	80.0	10.0	10.0
5133 Busher	59	A	0.32	4	80.0	10.0	10.0
Jayem	40	B	0.32	5	80.0	10.0	10.0
5134 Busher	59	A	0.32	4	80.0	10.0	10.0
Jayem	40	B	0.32	5	80.0	10.0	10.0
5135 Busher	60	A	0.32	4	80.0	10.0	10.0
Jayem	40	B	0.32	5	80.0	10.0	10.0

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
5139 Busher	59	A	0.37	4	80.0	11.0	9.0
Tassel	40	D	0.37	2	81.8	10.2	8.0
5143 Busher	59	A	0.32	4	80.0	10.0	10.0
Tassel	40	D	0.43	2	81.8	12.2	6.0
5152 Canyon	100	D	0.32	2	44.3	40.7	15.0
5153 Canyon	100	D	0.32	2	44.3	40.7	15.0
5162 Canyon	50	D	0.32	2	44.3	40.7	15.0
Rock outcrop	50	D	—	—	—	—	0.0
5184 Keota	70	B	0.49	3	14.3	73.2	12.5
Epping	29	D	0.49	2	30.1	54.9	15.0
5188 Keya	99	B	0.24	5	39.5	37.5	23.0
5191 Norrest	100	C	0.20	3	33.2	34.8	32.0
5192 Norrest	100	C	0.20	3	33.2	34.8	32.0
5195 Norrest	100	C	0.32	3	17.3	52.2	30.5
5196 Norrest	100	C	0.32	3	17.3	52.2	30.5
5197 Norrest	100	C	0.32	3	17.3	52.2	30.5
5200 Oglala	100	B	0.43	4	42.7	43.3	14.0
5206 Oglala	65	B	0.37	4	60.3	27.7	12.0
Canyon	35	D	0.43	2	64.4	25.6	10.0
5207 Oglala	59	B	0.43	4	42.7	43.3	14.0
Canyon	40	D	0.32	2	44.3	40.7	15.0
5210 Oglala	64	B	0.37	4	60.3	27.7	12.0
Canyon	35	D	0.43	2	64.4	25.6	10.0
5211 Oglala	70	B	0.43	4	42.7	43.3	14.0
Canyon	30	D	0.32	2	44.3	40.7	15.0

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
5215 Oglala	55	B	0.32	4	59.0	23.0	18.0
Canyon	45	D	0.37	2	61.2	20.8	18.0
5225 Pierre	99	D	0.20	3	17.1	27.9	55.0
5226 Pierre	100	D	0.20	3	17.1	27.9	55.0
5227 Pierre	70	D	0.24	3	2.5	42.5	55.0
Hisle	30	D	0.43	2	24.8	52.7	22.5
5230 Ponderosa	100	B	0.37	5	79.5	12.0	8.5
5231 Ponderosa	100	B	0.37	5	79.5	11.5	9.0
5234 Ponderosa	60	B	0.37	5	79.5	11.5	9.0
Tassel	20	D	0.37	2	81.8	10.2	8.0
Vetal	20	B	0.32	5	62.0	24.0	14.0
5240 Samsil	65	D	0.24	2	2.6	44.9	52.5
Pierre	35	D	0.20	3	17.1	27.9	55.0
5241 Samsil	65	D	0.24	2	18.2	31.8	50.0
Pierre	35	D	0.20	3	17.1	27.9	55.0
5243 Samsil	70	D	0.24	2	2.6	44.9	52.5
Rock outcrop	30	D	—	—	—	—	0.0
5254 Schamber	100	A	0.24	2	58.6	19.9	21.5
5255 Skilak	99	C	0.37	5	6.9	62.1	31.0
5257 Thirtynine	99	B	0.37	5	13.7	69.3	17.0
5258 Thirtynine	99	B	0.37	5	13.7	69.3	17.0
5259 Thirtynine	99	B	0.37	5	13.7	69.3	17.0
5260 Thirtynine	100	B	0.37	5	41.2	41.8	17.0
5261 Thirtynine	100	B	0.37	5	41.2	41.8	17.0
5262 Thirtynine	100	B	0.37	5	41.2	41.8	17.0

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value % Sand	% Silt	% Clay
5281 Vetal	100	B	0.20	5	66.1	21.9	12.0
5282 Vetal	100	B	0.17	5	66.1	19.9	14.0
5288 Vetal	100	B	0.10	5	85.9	6.6	7.5
5291 Vetal	99	B	0.37	5	62.0	26.0	12.0
5292 Vetal	99	B	0.37	5	62.0	26.0	12.0
5350 Enning	50	D	0.37	2	19.3	52.2	28.5
Minnequa	50	C	0.37	3	6.8	61.7	31.5
5351 Enning	60	D	0.37	2	19.3	52.2	28.5
Minnequa	40	C	0.37	3	6.8	61.7	31.5
5352 Enning	70	D	0.37	2	19.3	52.2	28.5
Rock outcrop	30	D	—	—	—	—	0.0
5353 Enning	65	D	0.37	2	19.3	52.2	28.5
Shale outcrop	35	D	—	—	—	—	0.0
5355 Hisle	70	D	0.32	2	39.8	38.2	22.0
Slickspots	30	D	0.20	3	17.1	27.9	55.0
5358 Kyle	100	D	0.20	5	2.3	40.2	57.5
5359 Kyle	99	D	0.20	5	2.3	40.2	57.5
5360 Kyle	70	D	0.20	5	2.3	40.2	57.5
Hisle	30	D	0.43	2	24.8	52.7	22.5
5600 Bigwinder	100	D	0.17	5	66.1	19.9	14.0
5612 Craft, channeled, frequently flooded	100	B	0.43	5	42.7	41.3	16.0
5637 Haverson	100	B	0.32	5	23.5	50.0	26.5
5638 Haverson	100	B	0.32	5	23.5	50.0	26.5
5639 Haverson	100	B	0.37	5	20.0	53.5	26.5
5640 Haverson	98	B	0.24	5	37.9	35.6	26.5

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
5657 Lisco, occasionally flooded	100	C	0.43	5	63.6	25.4	11.0
5810 Buffington	100	B	0.28	5	7.7	49.8	42.5
5834 Mitchell	100	B	0.43	5	11.3	67.7	21.0
5836 Mitchell	100	B	0.43	5	11.3	67.7	21.0
5838 Mitchell	100	B	0.43	5	11.3	67.7	21.0
5839 Mitchell	100	B	0.43	5	11.3	67.7	21.0
5849 Epping	50	D	0.49	2	30.1	54.9	15.0
Mitchell	50	B	0.43	5	11.3	67.7	21.0
5870 Tripp	99	B	0.37	5	14.2	71.8	14.0
5871 Tripp	99	B	0.37	5	14.2	71.8	14.0
5872 Tripp	100	B	0.43	5	14.2	71.8	14.0
5943 Duroc	99	B	0.43	5	41.0	41.5	17.5
5947 Duroc	99	B	0.32	5	59.3	23.2	17.5
5964 Jayem	50	B	0.32	5	80.0	10.0	10.0
Vetal	50	B	0.37	5	79.5	12	8.5
5965 Jayem	99	B	0.24	5	63.5	26.5	10.0
5966 Jayem	99	B	0.24	5	63.5	26.5	10.0
5978 Jayem	99	B	0.32	5	80.0	10.0	10.0
5979 Jayem	100	B	0.32	5	80.0	10.0	10.0
5980 Jayem	100	B	0.32	5	80.0	10.0	10.0
5983 Rock outcrop	65	D	—	—	—	—	0.0
Tassel	35	D	0.15	2	78.6	13.4	8.0
5987 Orella	100	D	0.24	2	26.1	28.9	45.0
5988 Orella	100	D	0.43	2	18.7	47.8	33.5

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
6026 Tassel	100	D	0.43	2	81.8	12.2	6.0
6028 Tassel	100	D	0.43	2	81.8	12.2	6.0
6031 Tassel	55	D	0.37	2	81.8	10.2	8.0
Ashollow	25	B	0.37	5	81.8	9.2	9.0
Rock outcrop	20	D	—	—	—	—	0.0
6036 Tassel	55	D	0.37	2	81.8	10.2	8.0
Busher	30	A	0.32	4	80	10	10.0
Rock outcrop	15	D	—	—	—	—	0.0
6043 Tassel	45	D	0.43	2	81.8	12.2	6.0
Ponderosa	35	B	0.37	5	79.5	12.0	8.5
6043 Rock outcrop	20	D	—	—	—	—	0.0
6045 Tassel	75	D	0.37	2	65.5	26.0	8.5
Rock outcrop	25	D	—	—	—	—	0.0
6048 Orella	55	D	0.43	2	18.7	47.8	33.5
Badland	45	D	—	—	—	—	0.0
6090 Sarben	70	A	0.37	5	81.5	7.0	11.5
Vetal	30	B	0.37	5	79.5	12.0	8.5
6091 Sarben	100	A	0.20	5	66.1	19.9	14.0
6092 Sarben	99	A	0.20	5	66.1	19.9	14.0
6093 Sarben	100	A	0.20	5	66.1	19.9	14.0
6109 Sarben	100	A	0.37	5	81.5	9.5	9.0
6201 Epping	100	D	0.49	2	30.1	54.9	15.0
6203 Epping	60	D	0.49	2	30.1	54.9	15.0
Badland	40	D	—	—	—	—	0.0
6240 Keota	99	B	0.49	3	14.3	73.2	12.5

Table 2 Revised Universal Soil Loss Equation, Version 2 Related Attributes, Dawes County, Nebraska

Map Symbol and Soil Name	Pct of Map	Hydrologic Group	Kf	T factor	Representative Value		
					% Sand	% Silt	% Clay
9971 Arents, earthen dam	100	—	—	—	—	—	—
9973 Badland	100	D	—	1	—	—	—
9983 Pits	100	A	—	2	—	—	—
9986 Water, sewage lagoons	100	—	—	—	—	—	—
9999 Water	100	—	—	—	—	—	—

[This report shows only the major soils in each map unit]

Table 3 Details of Available Geospatial, Stream Flow and Meteorological Data

Datat Type	Resource Agency	Resource Information	Notes
Terrain DEM	USGS NED	http://seamless.usgs.gov/ned13.php	30 meter resolution
Land Use	USGS NLCD	http://seamless.usgs.gov/nlcd.php	2006 version
Flowline Data	USGS NHD	http://nhd.usgs.gov/	
Soil data	NRCS	http://datagateway.nrcs.usda.gov/	SSURGO
Meteorological	NOAA NWS and NCDC	NWS and NCDC websites	Precipitation, evaporation and runoff values

Table 4 *C-factor Values for Various Land Use Types*

Land Use Category	C Value
open water	0.000
developed,open space	0.003
developed, low intensity	0.002
developed, medium intensity	0.002
developed, high intensity	0.000
barren land	0.500
deciduous forest	0.002
evergreen forest	0.001
mixed forest	0.001
shrub/scrub	0.003
grassland/herbaceous	0.010
pasture/hay	0.470
cultivated crops	0.470
woody wetland	0.001
emergent herbaceous wetlands	0.001

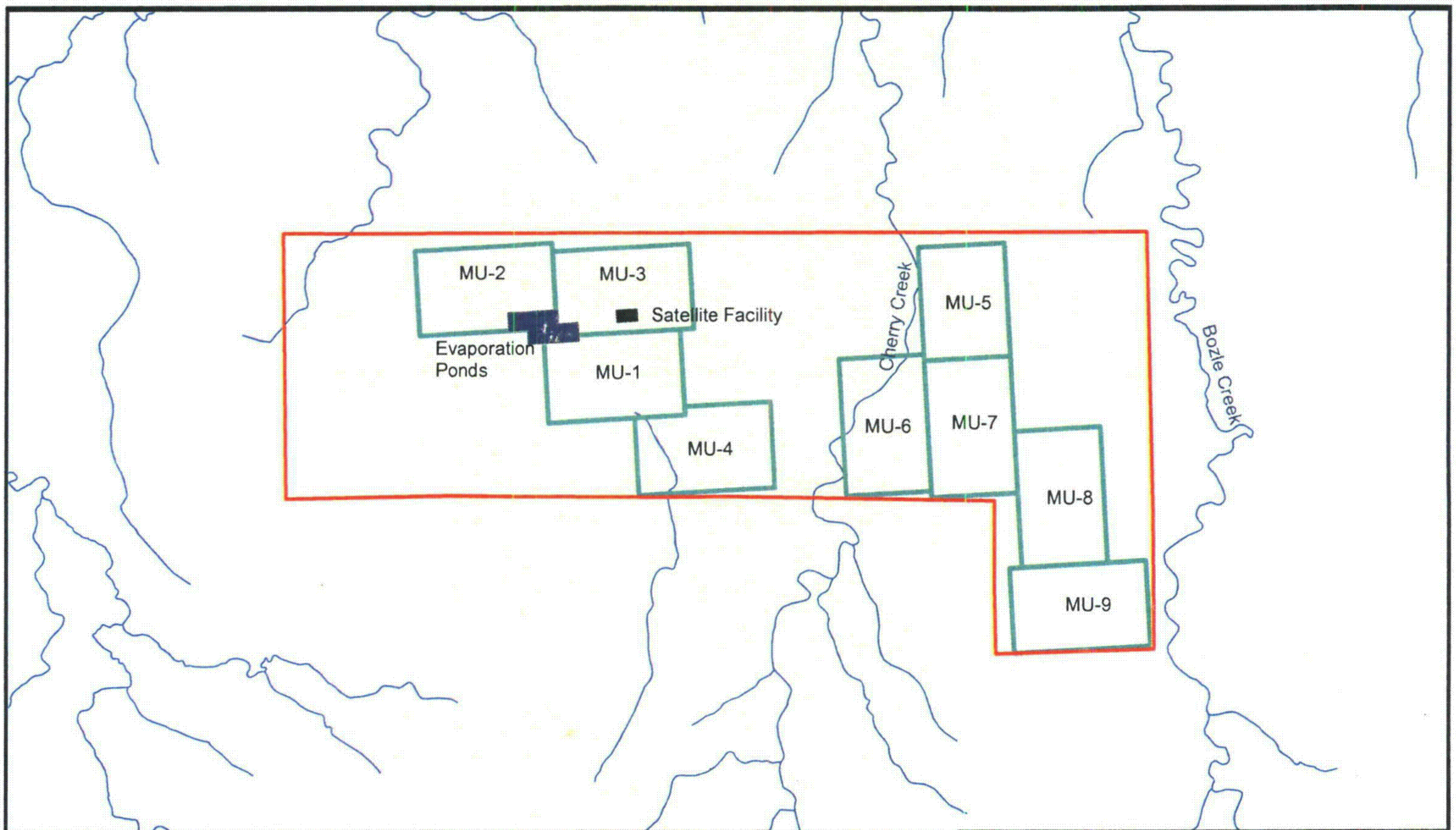
Note:
C-factor values derived from current conditions described in the National Cover Dataset (NLCD 2006).

Table 5 TCEA Mine Units Determined to be at a High or Moderate Risk of Erosion

Mining Unit	MU Mean Soil Loss (tons/acre/year)	MU Erosion Risk	Percent MU Area of Moderate to High Erosion Risk	Streams Crossing MU
MU-1	2.9	High	10	N/A
MU-2	4.8	High	15	N/A
MU-3	0.7	Very Low	0	N/A
MU-4	0.4	Very Low	0	No Name Creek
MU-5	1.7	Moderate	8	Cherry Creek
MU-6	4.7	High	21	Cherry Creek
MU-7	1.7	Moderate	7	N/A
MU-8	0.5	Very Low	0	N/A
MU-9	0.4	Very Low	1	N/A

ARCADIS

Figures



LEGEND

- Mine Unit Boundary
- Proposed Three Crow Expansion Area
- Evaporation Ponds
- Satellite Facility

CROW BUTTE RESOURCES, INC.

FIGURE 1
PROPOSED CAMECO THREE CROW EXPANSION AREA

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

ARCADIS
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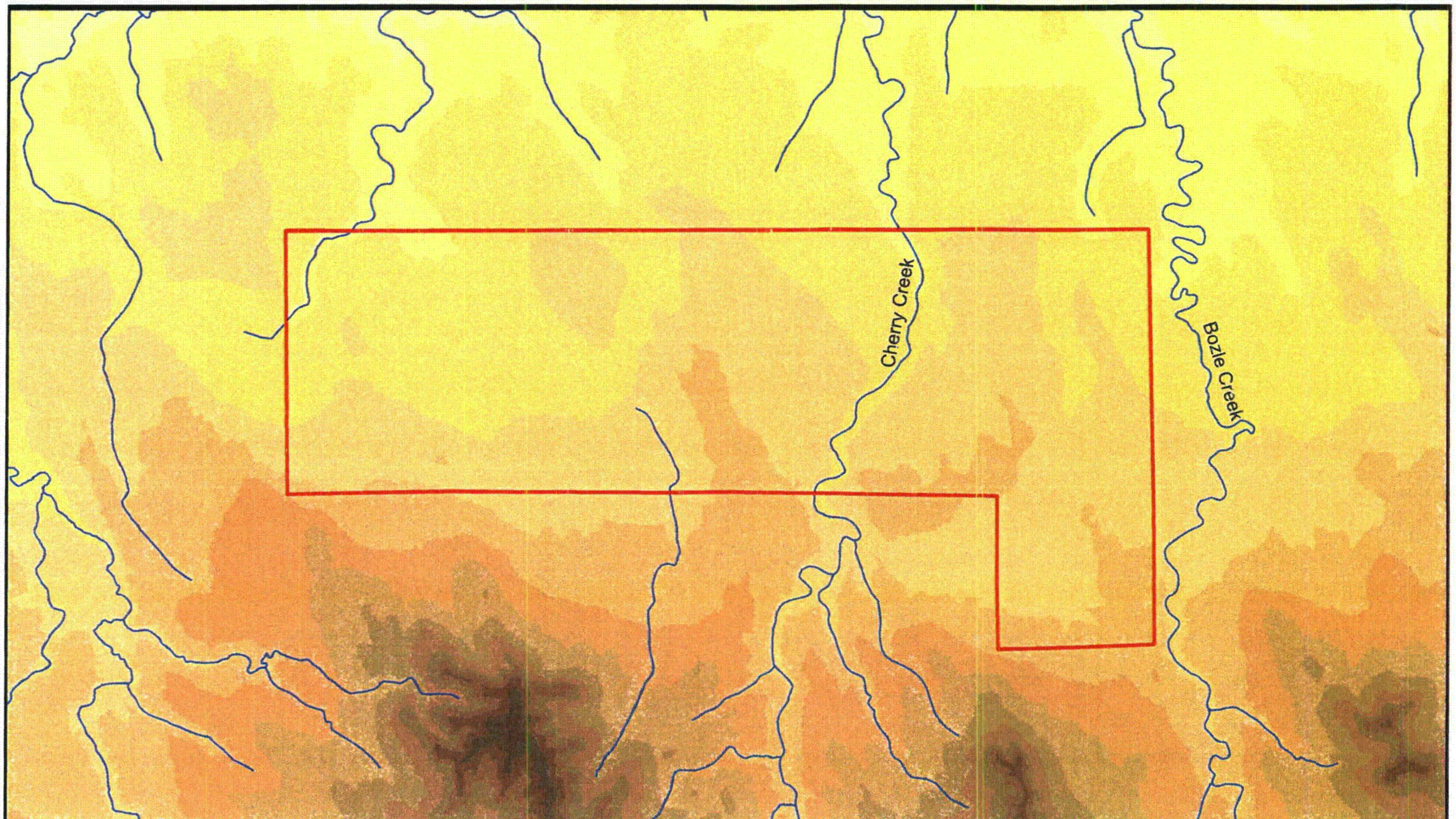

LEGEND

Proposed Three Crow Expansion Area

Meters, NAVD88

- 1,133 - 1,155
- 1,155 - 1,171
- 1,171 - 1,185
- 1,185 - 1,199
- 1,199 - 1,214
- 1,214 - 1,230
- 1,230 - 1,246
- 1,246 - 1,262
- 1,262 - 1,276
- 1,276 - 1,291
- 1,291 - 1,306
- 1,306 - 1,322
- 1,322 - 1,339
- 1,339 - 1,357
- 1,357 - 1,385

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 2
DIGITAL ELEVATION MODEL
(DEM)

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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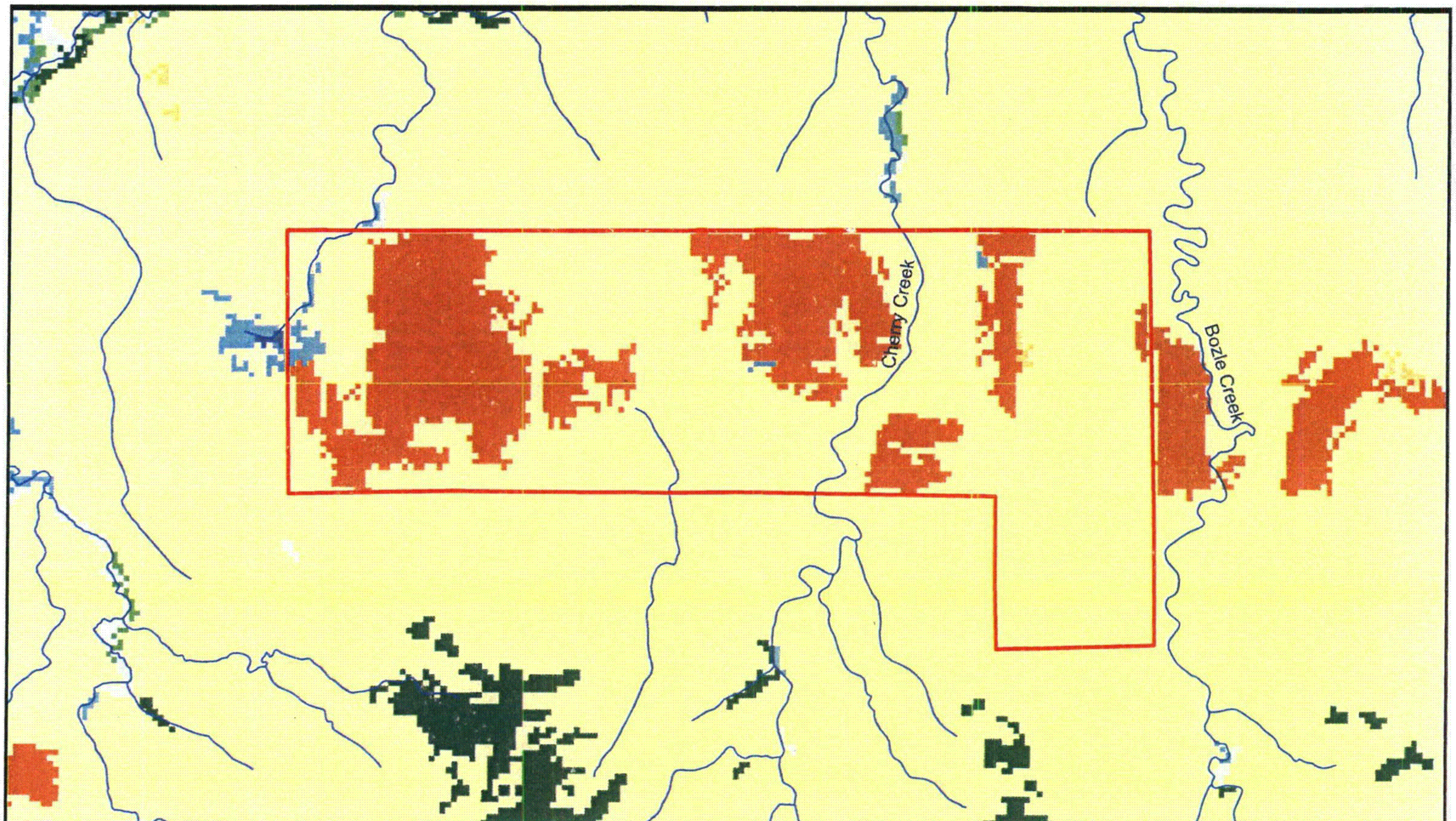

LEGEND

- Proposed Three Crow Expansion Area
- open water
- developed,open space
- developed, low intensity
- deciduous forest
- evergreen forest
- mixed forest
- shrub/scrub
- grassland/herbaceous
- cultivated crops
- woody wetland
- emergent herbaceous wetlands

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 3
LAND CLASSIFICATIONS
NLCD 2006

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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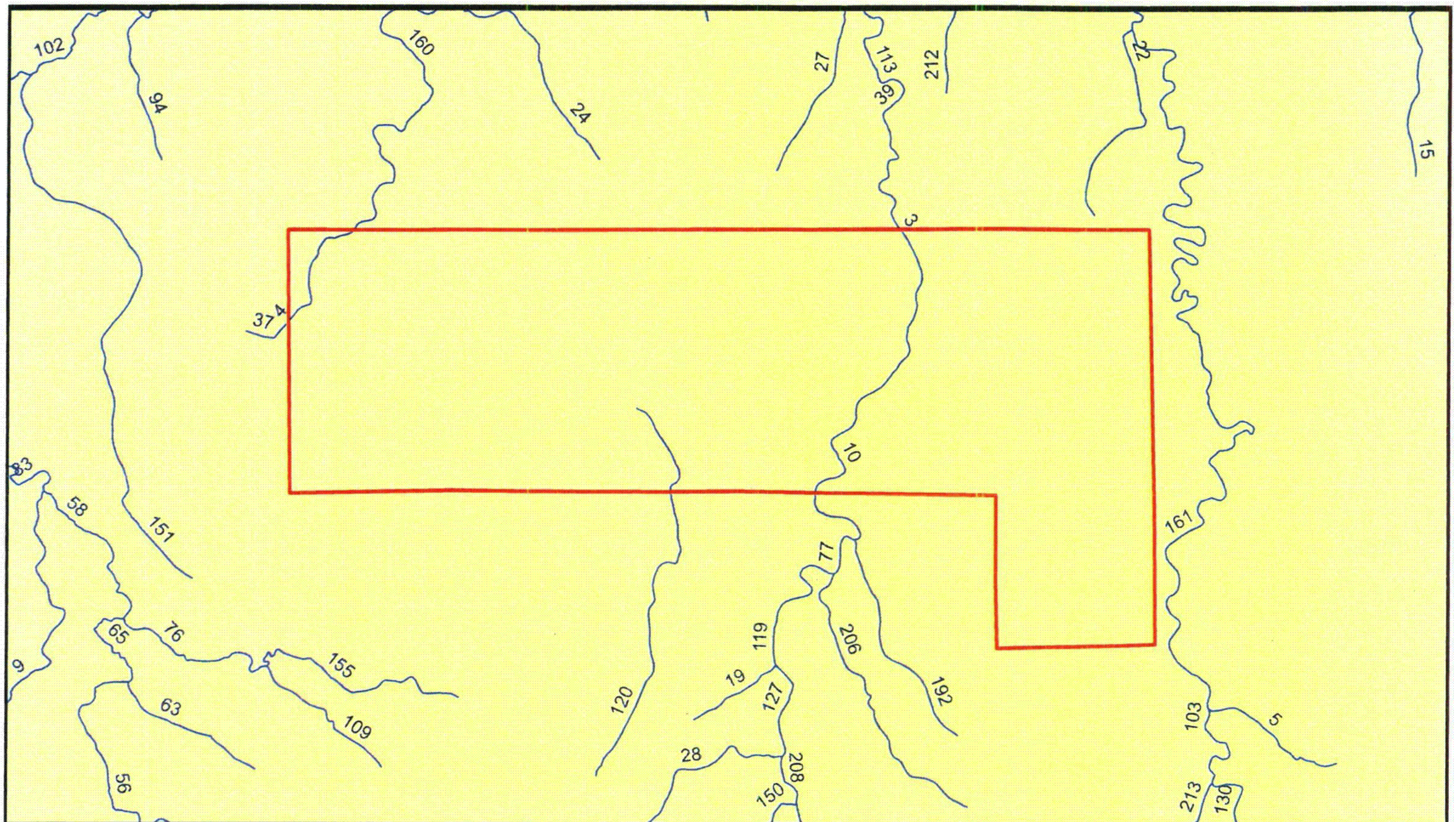

LEGEND

Proposed Three Crow Expansion Area

NHD Stream Network

0 1,000 2,000

Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 4
NHD PUBLISHED STREAM NETWORK

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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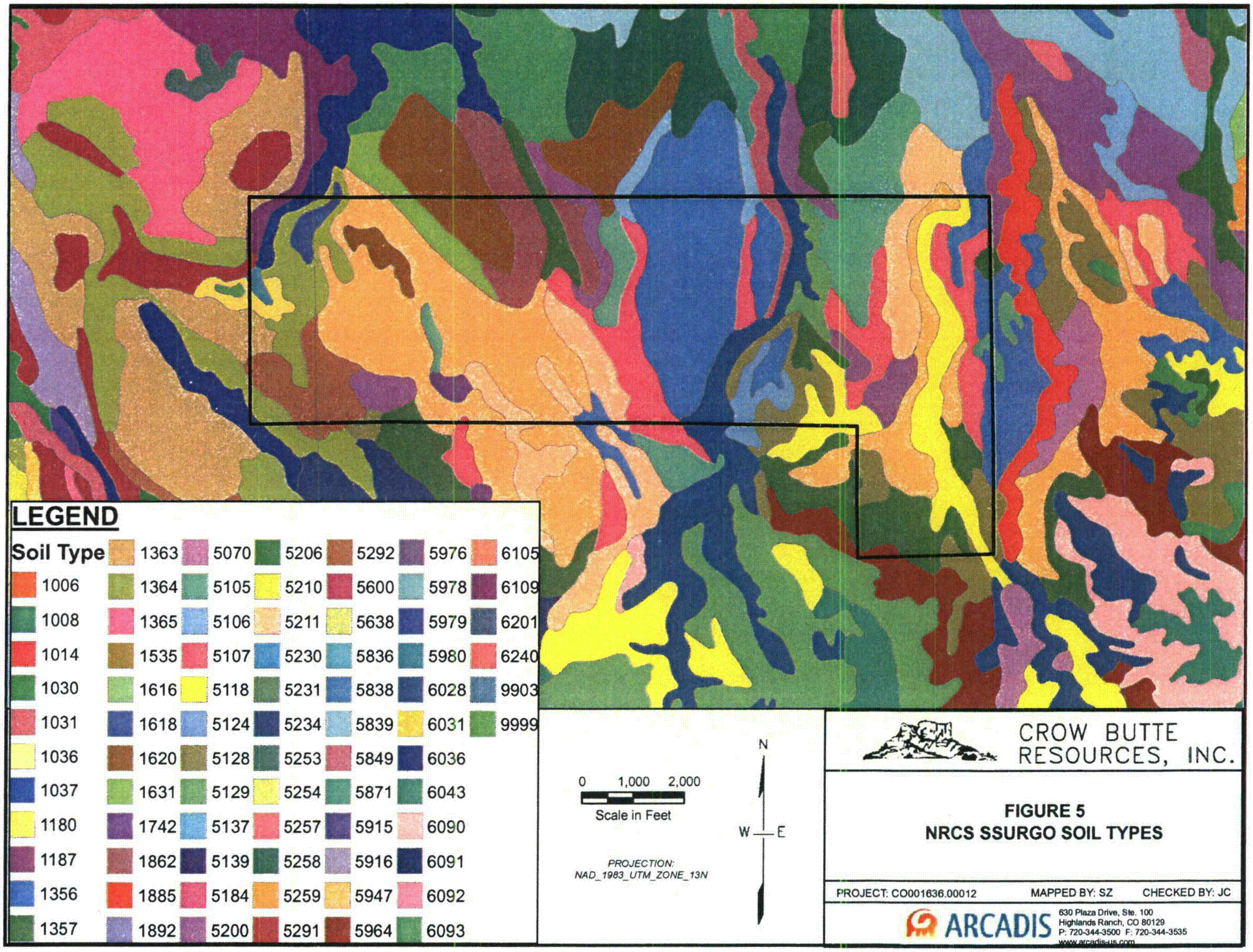
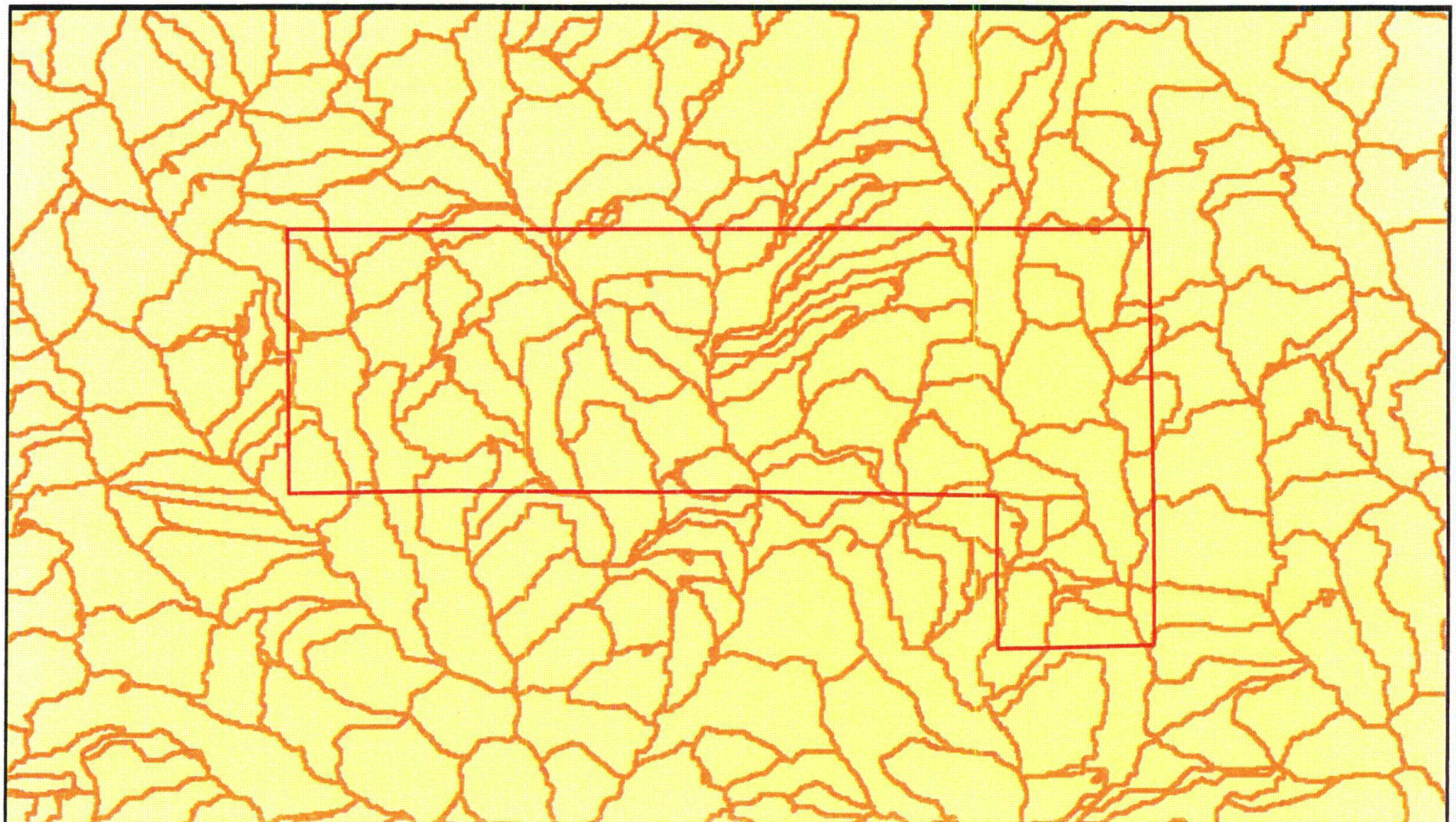


FIGURE 5
NRCS SSURGO SOIL TYPES



LEGEND

Proposed Three Crow Expansion Area

Watershed Delineation

0 1,000 2,000

Scale in Feet

N

W E

PROJECTION:
NAD_1983_UTM_ZONE_13N

CROW BUTTE RESOURCES, INC.

FIGURE 6
WATERSHED DELINEATION FOR THE CAMECO THREE CROW EXPANSION WITH RECONDITIONED DEM

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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Highlands Ranch, CO 80129
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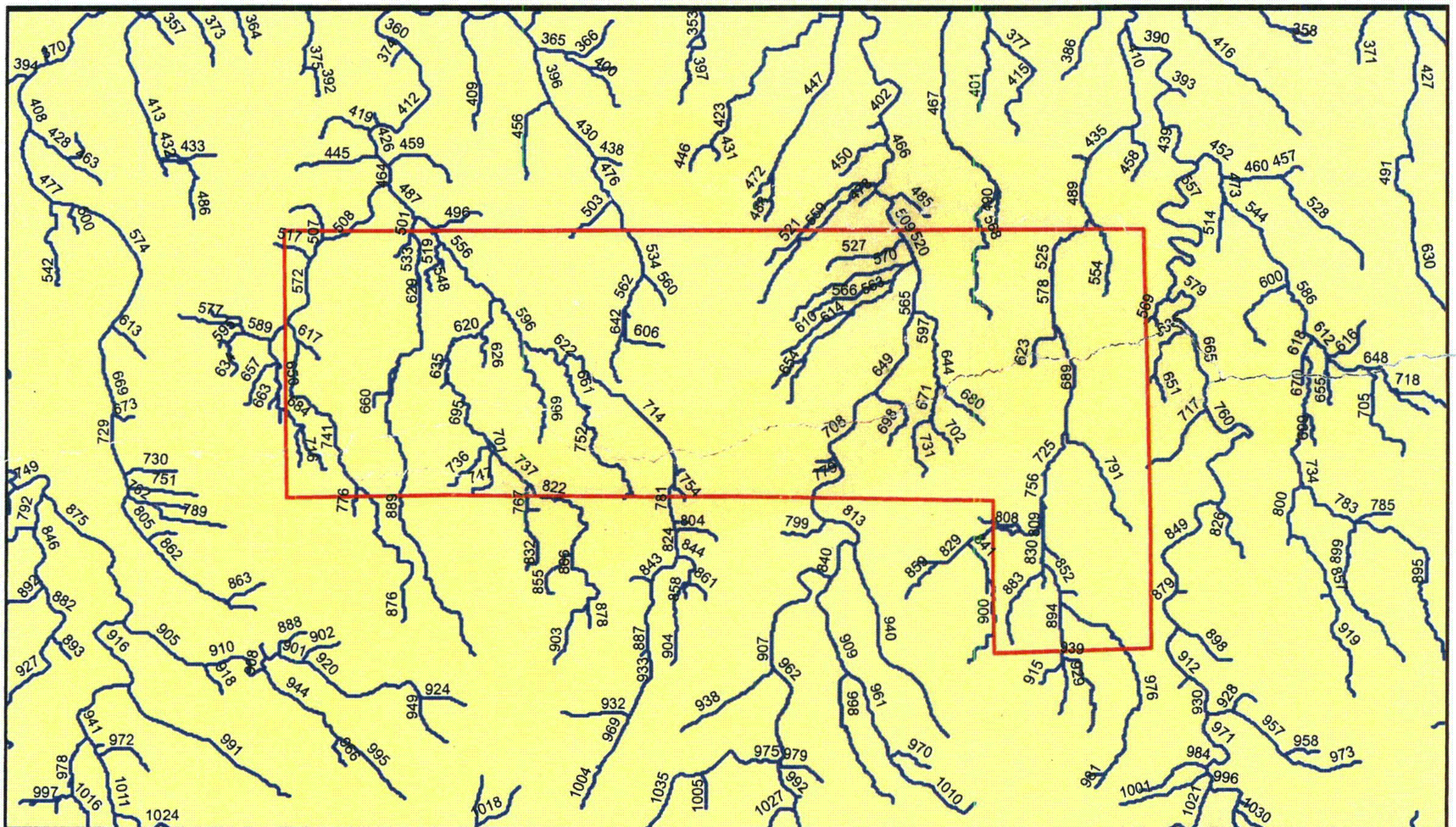

LEGEND

Proposed Three Crow Expansion Area

Drainage Lines

0 1,000 2,000

Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

N W E

CROW BUTTE
RESOURCES, INC.

FIGURE 7
DRAINAGE LINES

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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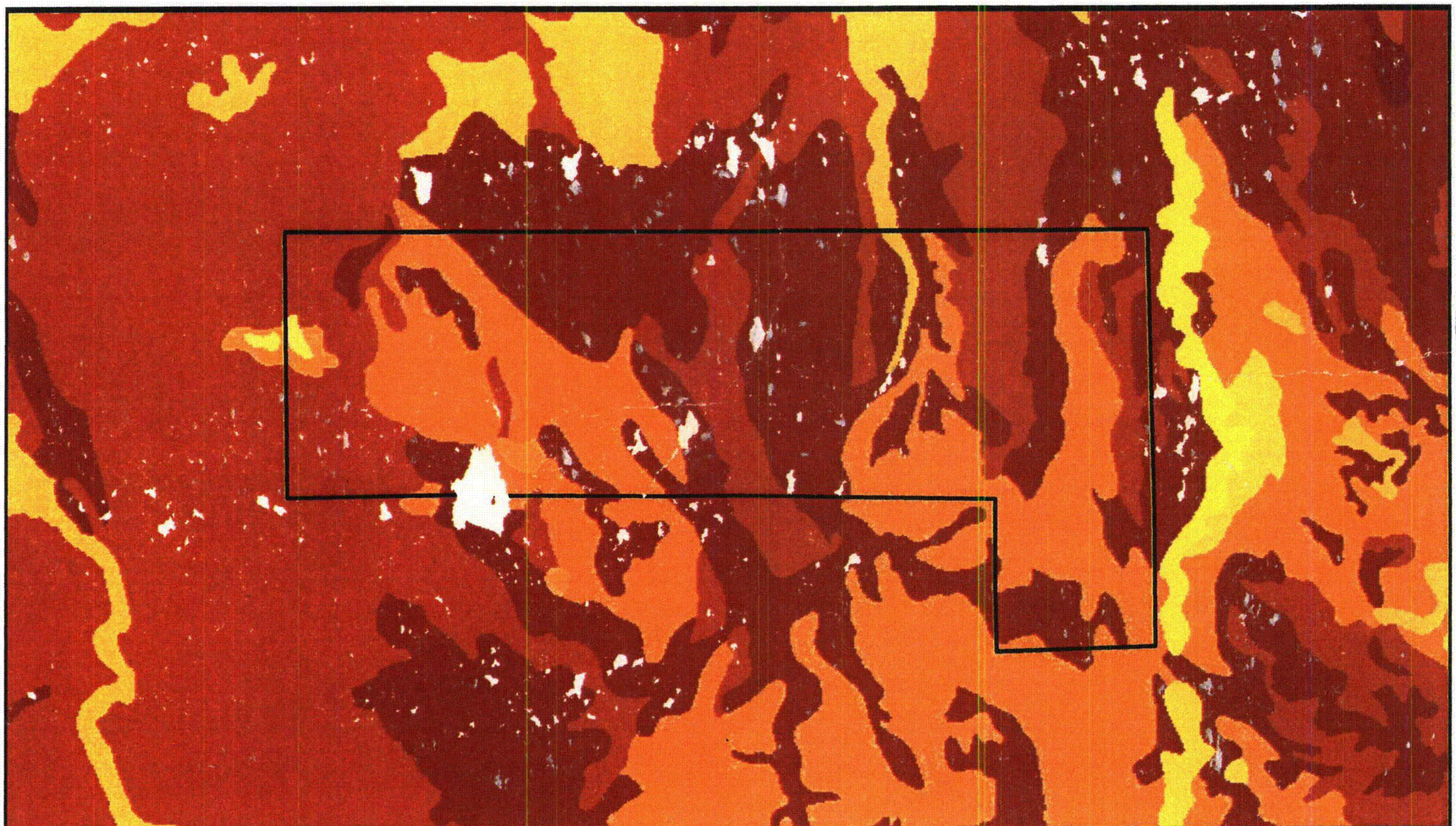

LEGEND

- Proposed Three Crow Expansion Area
- 0 - 0.1
- 0.1 - 0.17
- 0.17 - 0.2
- 0.2 - 0.24
- 0.24 - 0.29
- 0.29 - 0.32
- 0.32 - 0.34
- 0.34 - 0.39
- 0.39 - 0.44
- 0.44 - 0.49

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 8
RUSLE SOIL ERODIBILITY
K FACTOR

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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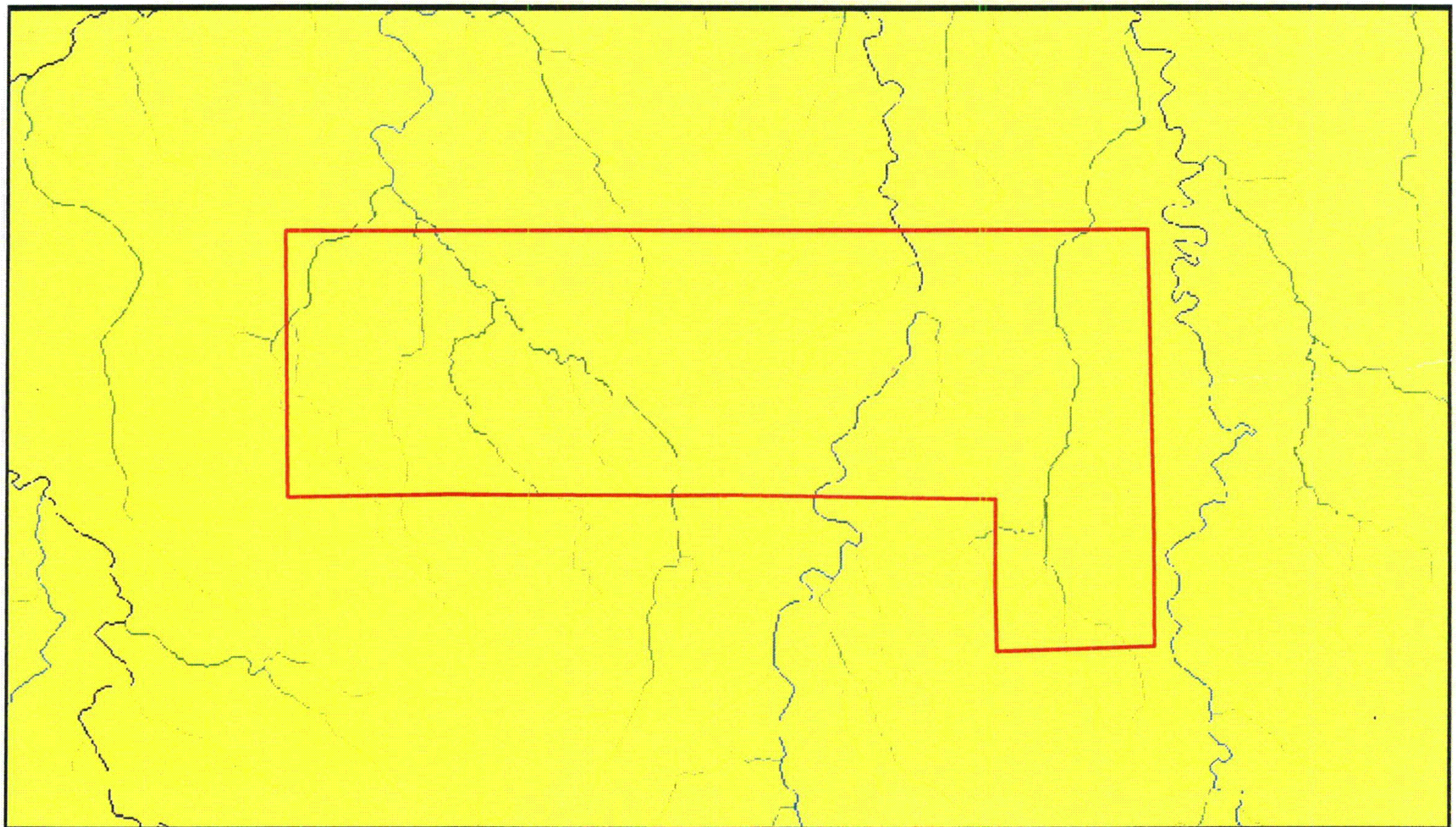

LEGEND

Proposed Three Crow Expansion Area

<VALUE>

- 0 - 630
- 630- 1,800
- 1,800 - 4,500
- 4,500 - 8,100
- 8,100 - 12,600
- 12,600 - 20,700
- 20,700 - 32,400
- 32,400 - 49,500
- 49,500 - 70,200
- 70,200 - 88,200
- 88,200 - 157,500
- 157,500 - 213,300
- 213,300 - 280,800
- 280,800 - 357,300
- 357,300 - 1,755,157

0 1,000 2,000

Scale in Feet

PROJECTION: NAD_1983_UTM_ZONE_13N

N

W E

CROW BUTTE RESOURCES, INC.

FIGURE 9
FLOW ACCUMULATION VALUES USED TO CALCULATE RULSE LS-FACTOR

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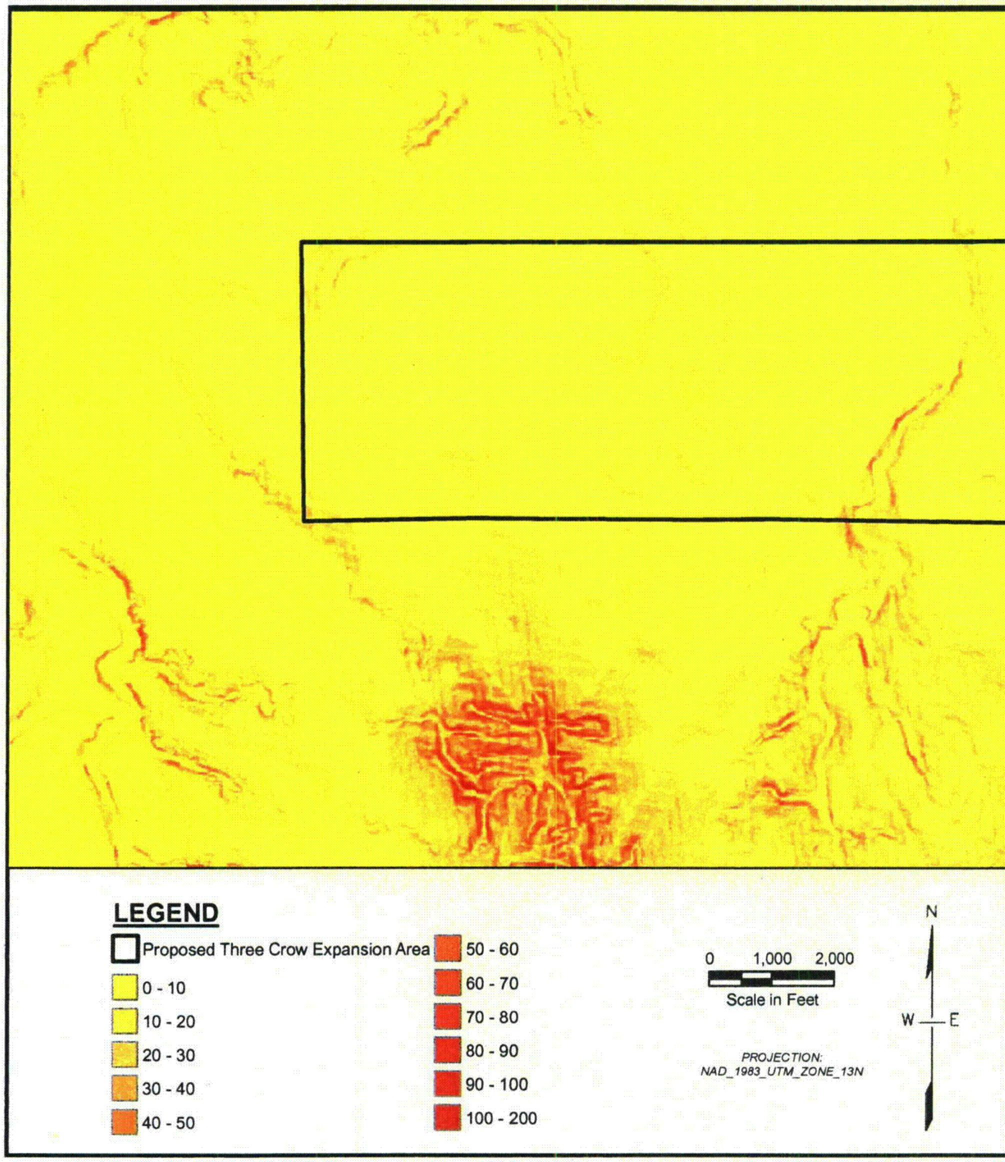

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FIGURE 10
PERCENT TOPOGRAPHIC SLOPE

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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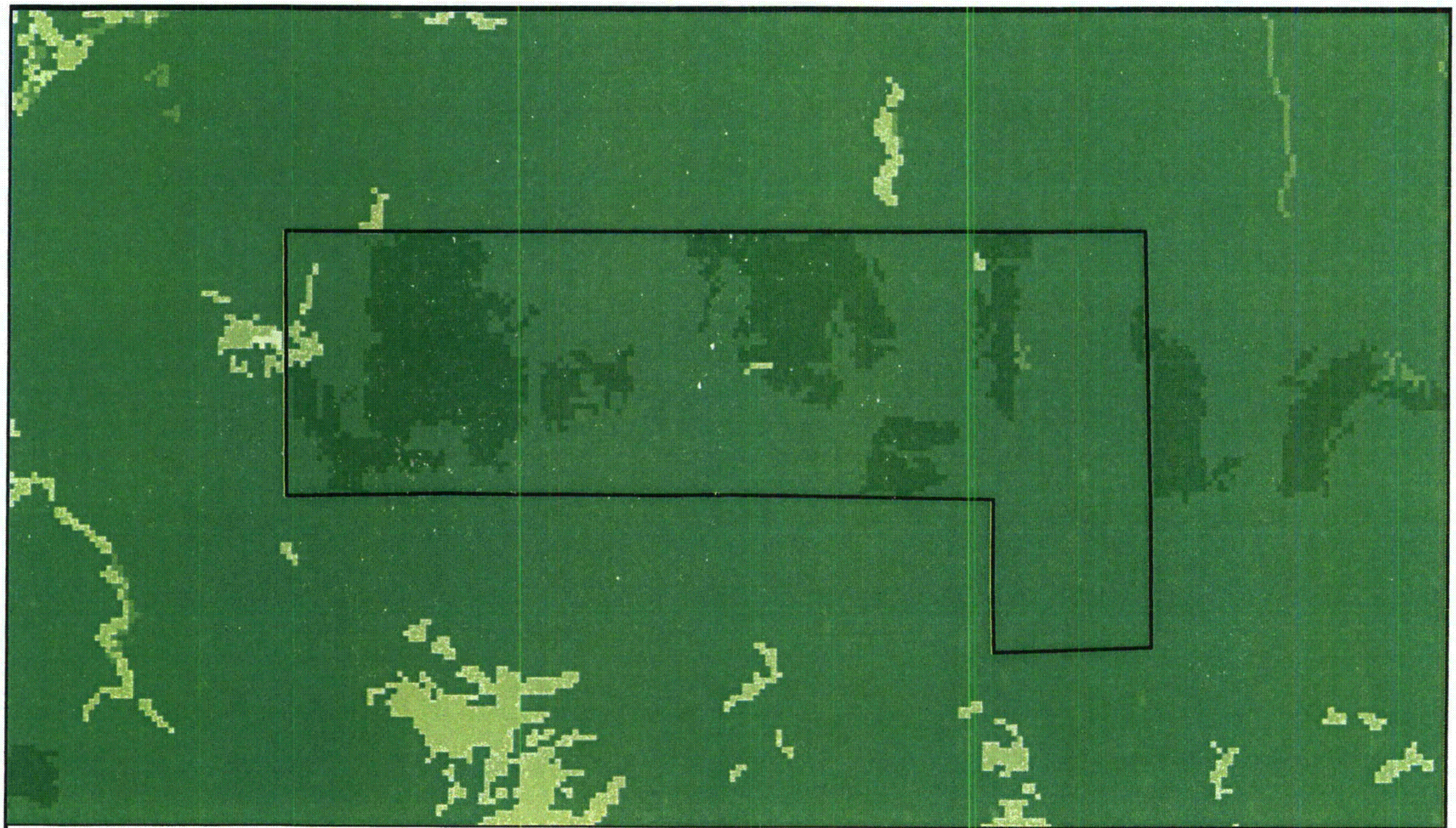

LEGEND

- Proposed Three Crow Expansion Area
- 0
- 0 - 0.001
- 0.001 - 0.003
- 0.003 - 0.01
- 0.01 - 0.47

0 1,000 2,000

Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

N

W E

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FIGURE 11
RUSLE LAND COVER MANAGEMENT
C FACTOR

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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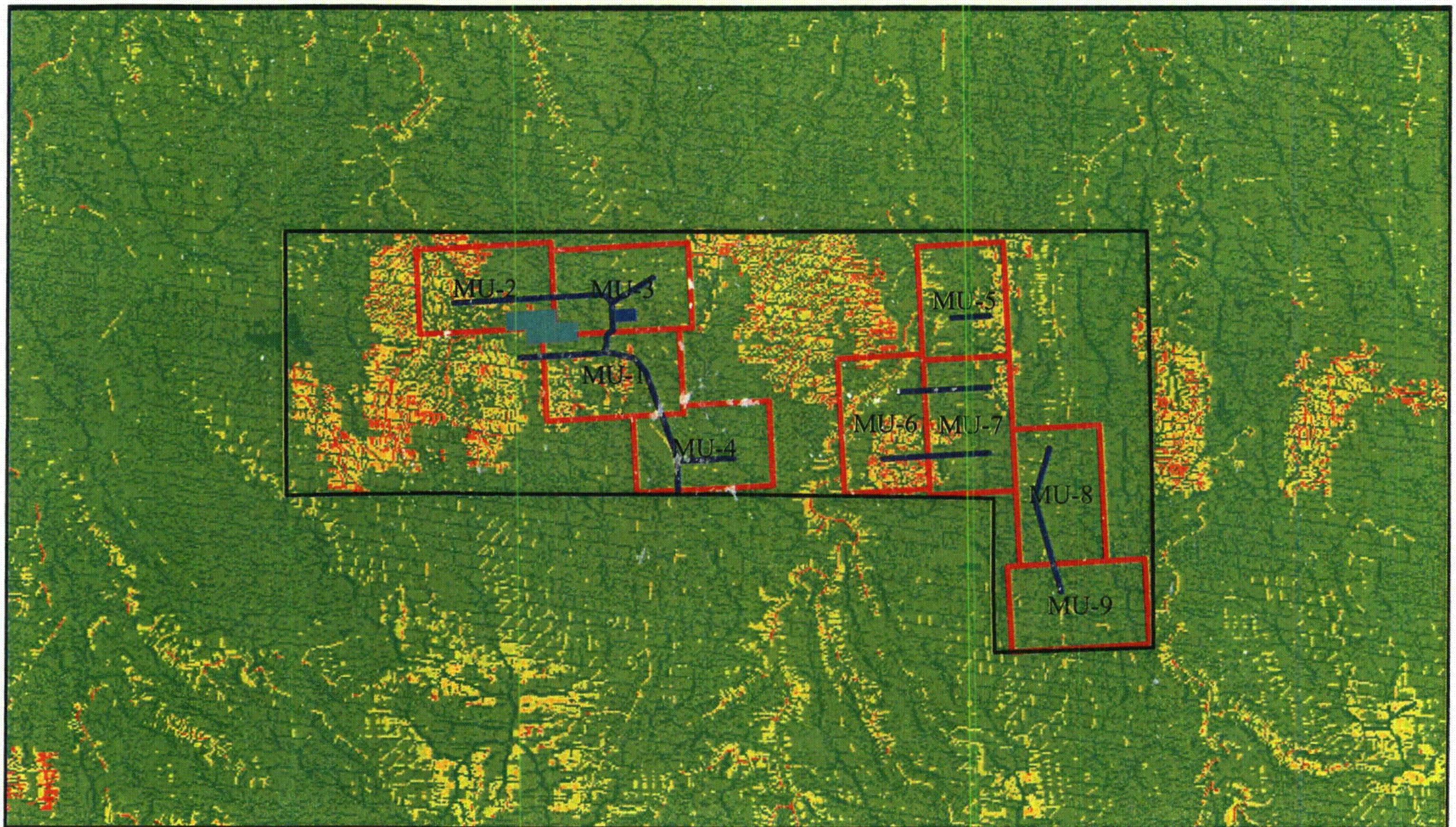

LEGEND

- Proposed Three Crow Expansion Area
- Access Roads
- Evaporation Ponds
- Satellite Facility
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

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W E

CROW BUTTE RESOURCES, INC.

FIGURE 12
AVERAGE ANNUAL SOIL LOSS
RUSLE A FACTOR (TONS/ACRE/YAER)

PROJECT: CO001636.00012 | MAPPED BY: SZ | CHECKED BY: JC

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www.arcadis-us.com

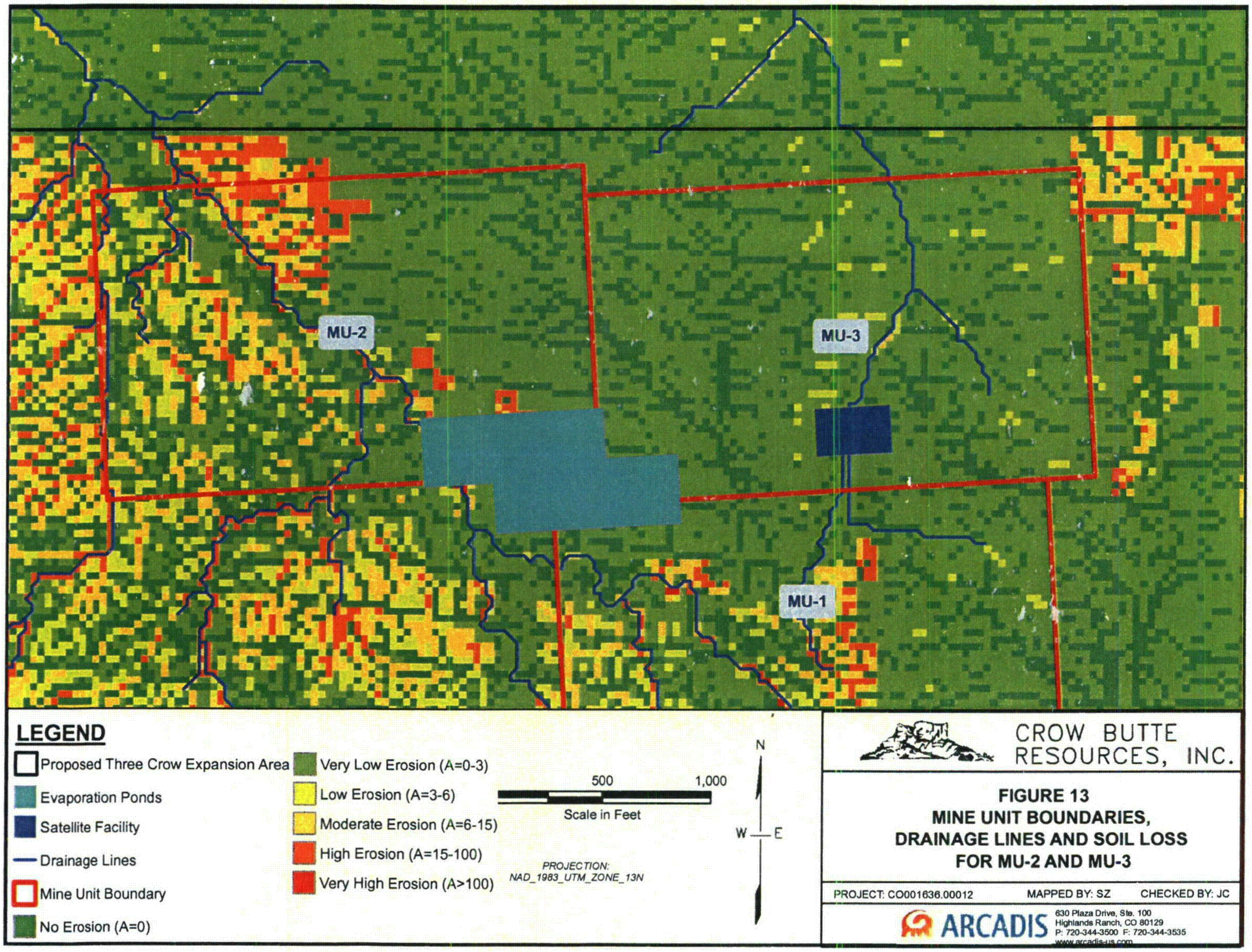

FIGURE 13
MINE UNIT BOUNDARIES, DRAINAGE LINES AND SOIL LOSS FOR MU-2 AND MU-3

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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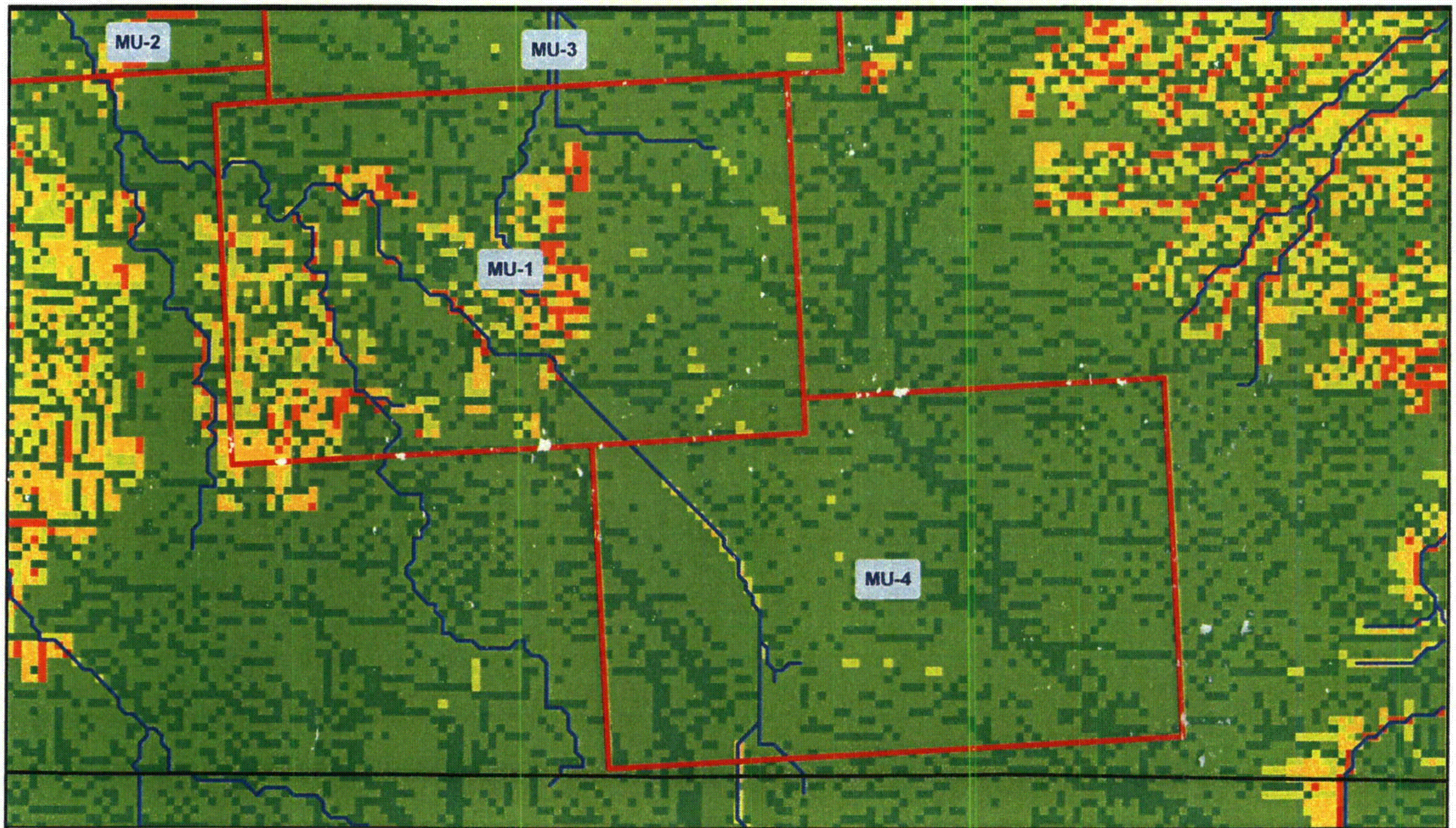

LEGEND

- Proposed Three Crow Expansion Area
- Drainage Lines
- Mine Unit Boundary
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 500 1,000

Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

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W E

CROW BUTTE RESOURCES, INC.

FIGURE 14
MINE UNIT BOUNDARIES, DRAINAGE LINES AND SOIL LOSS FOR MU-1 AND MU-4

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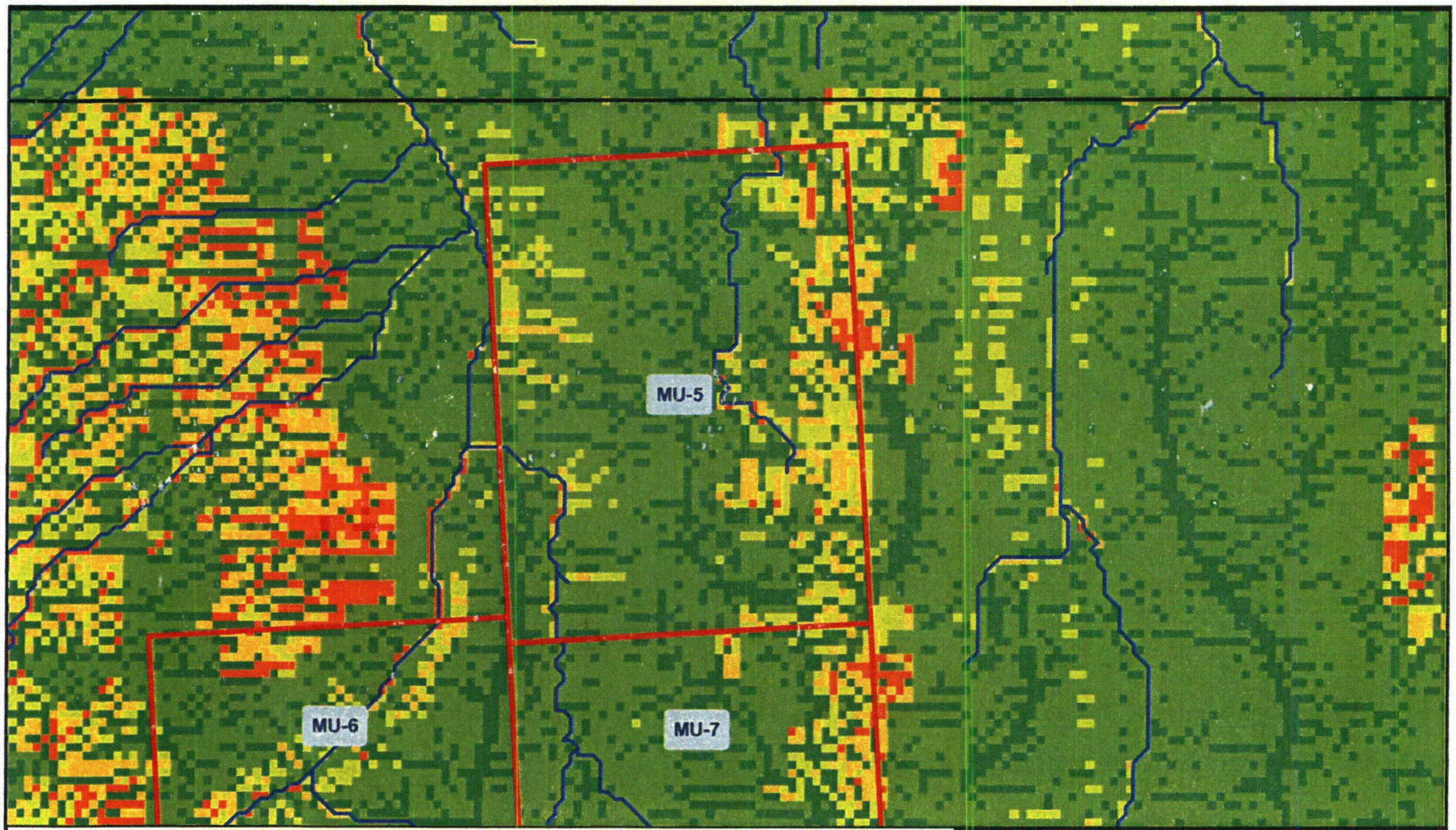

LEGEND

- Proposed Three Crow Expansion Area
- Drainage Lines
- Mine Unit Boundary
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 500 1,000
Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

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W E

CROW BUTTE RESOURCES, INC.

FIGURE 15
MINE UNIT BOUNDARIES, DRAINAGE LINES AND SOIL LOSS FOR MU-5

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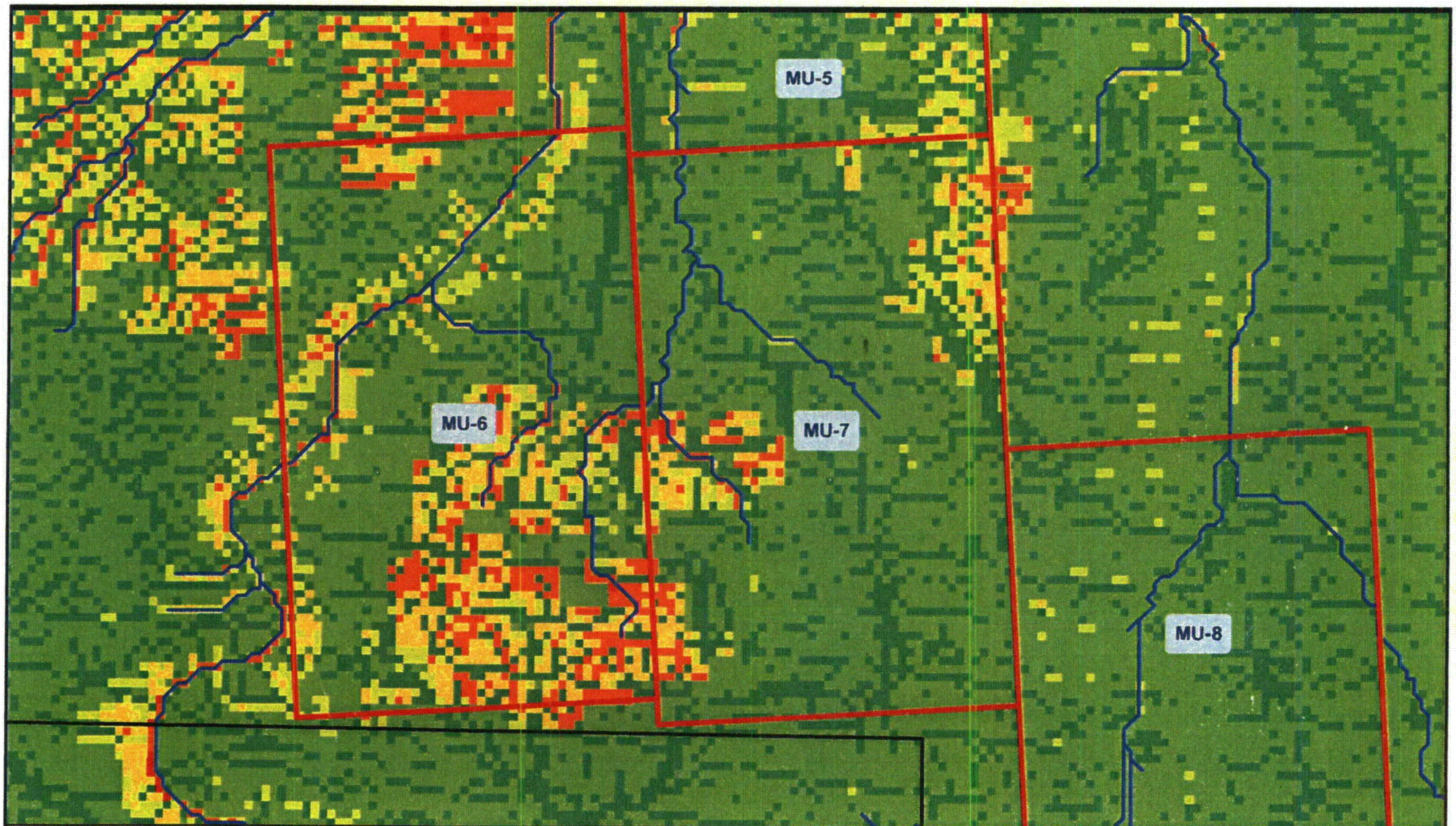

LEGEND

- Proposed Three Crow Expansion Area
- Drainage Lines
- Mine Unit Boundary
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 500 1,000
Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

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W E

CROW BUTTE RESOURCES, INC.

FIGURE 16
MINE UNIT BOUNDARIES, DRAINAGE LINES AND SOIL LOSS FOR MU-6 AND MU-7

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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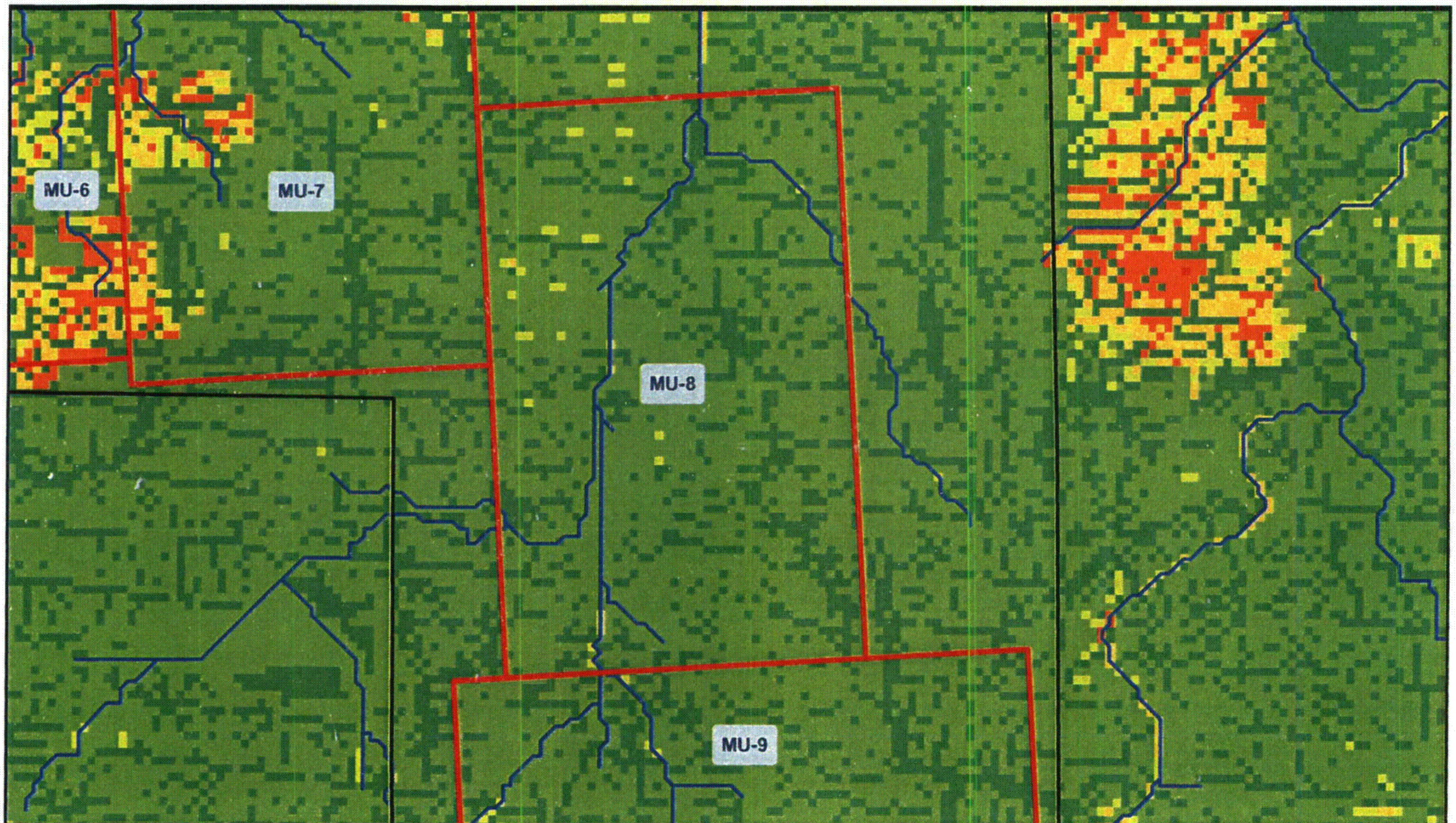

LEGEND

- Proposed Three Crow Expansion Area
- Drainage Lines
- Mine Unit Boundary
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 500 1,000

Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

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FIGURE 17
MINE UNIT BOUNDARIES, DRAINAGE LINES AND SOIL LOSS FOR MU-8

PROJECT: CO001636.00012 MAPPED BY: SZ CHECKED BY: JC

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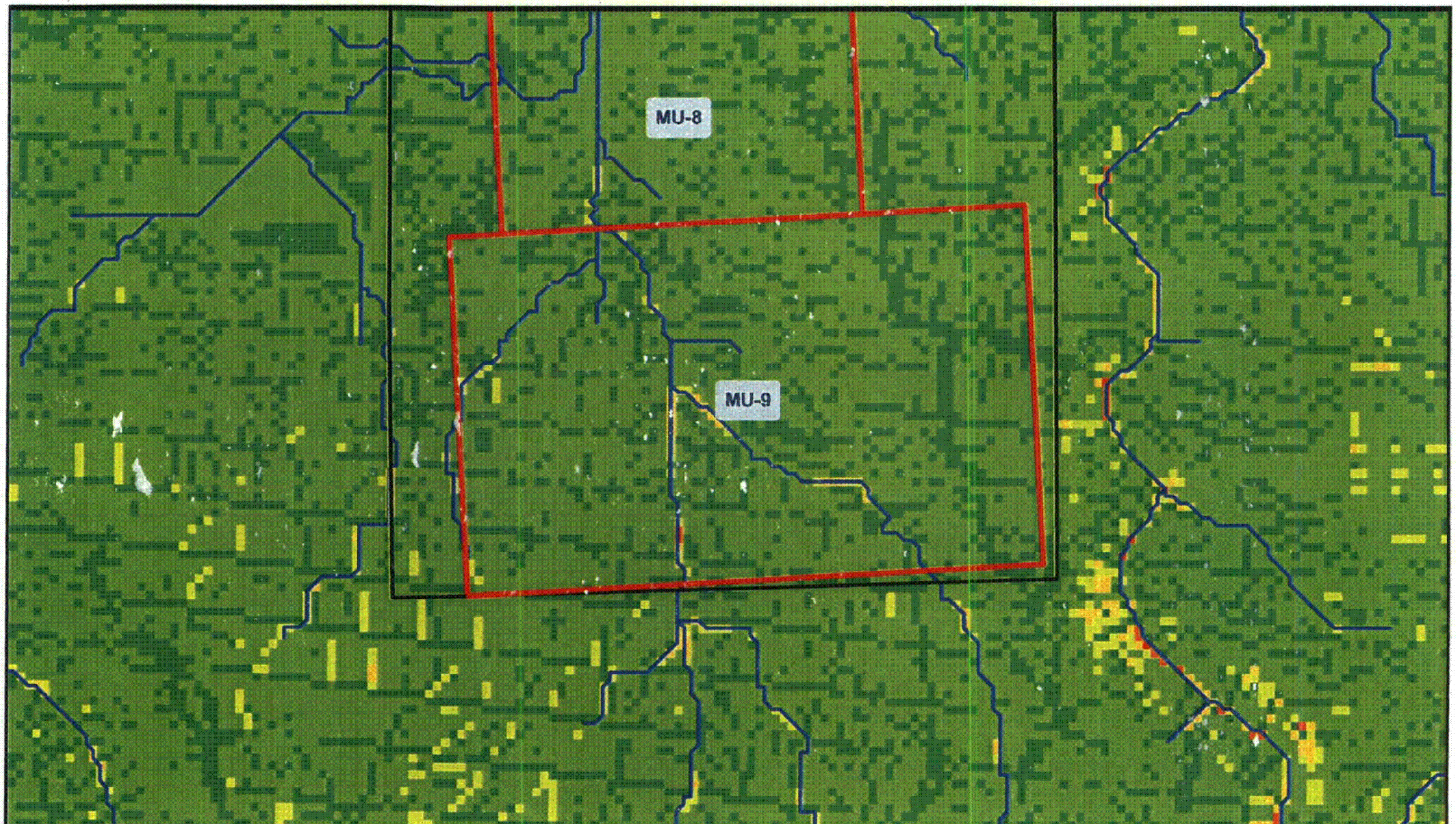

LEGEND

- Proposed Three Crow Expansion Area
- Drainage Lines
- Mine Unit Boundary
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 500 1,000
Scale in Feet

PROJECTION: NAD_1983_UTM_ZONE_13N

N W E

CROW BUTTE RESOURCES, INC.

FIGURE 18
MINE UNIT BOUNDARIES, DRAINAGE LINES AND SOIL LOSS FOR MU-9

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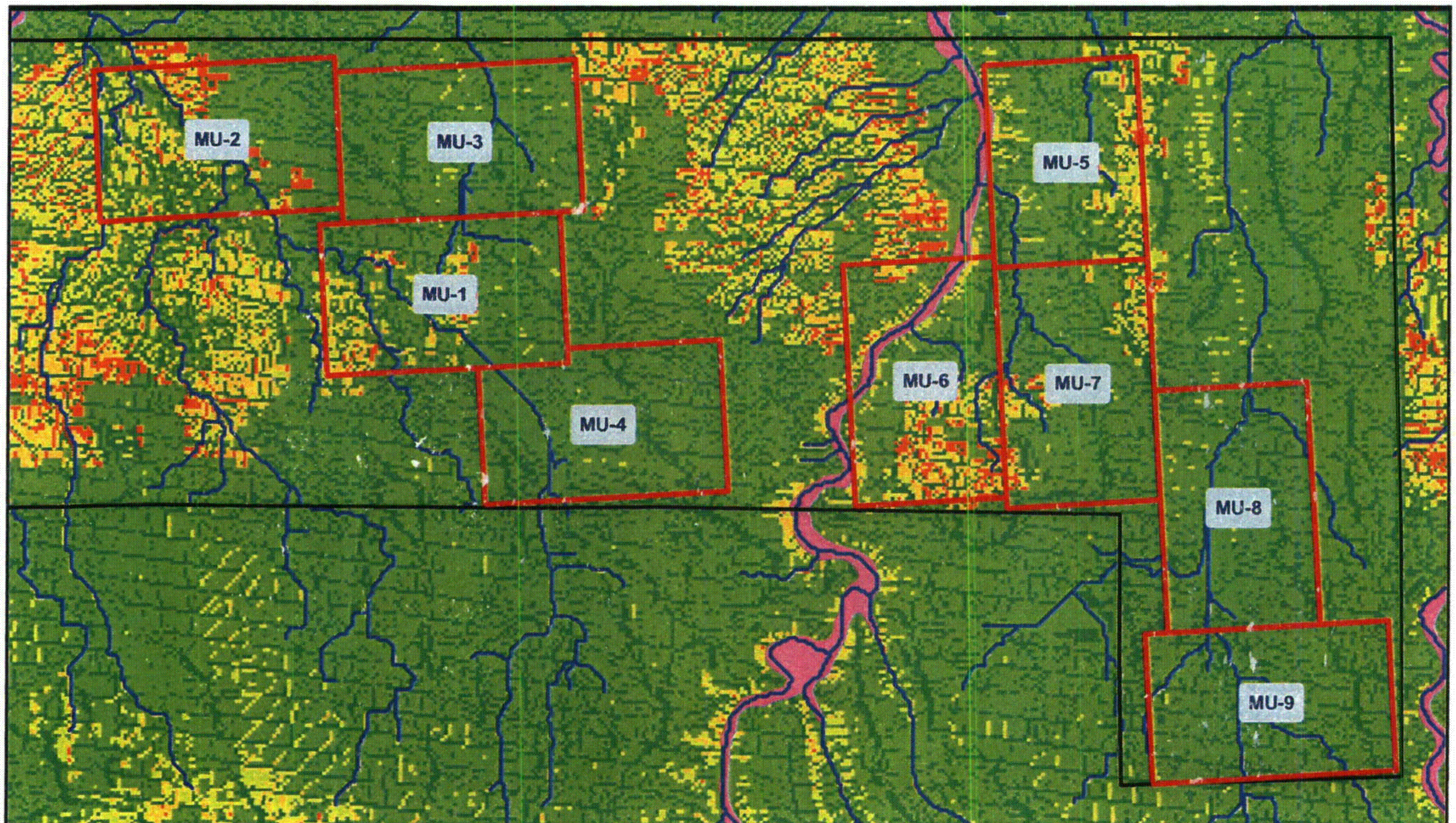

LEGEND

- Proposed Three Crow Expansion Area
- Drainage Lines
- Mine Unit Boundary
- FEMA/DFIRM 100 Year Flood Plain
- No Erosion (A=0)
- Very Low Erosion (A=0-3)
- Low Erosion (A=3-6)
- Moderate Erosion (A=6-15)
- High Erosion (A=15-100)
- Very High Erosion (A>100)

0 500 1,000

Scale in Feet

PROJECTION:
NAD_1983_UTM_ZONE_13N

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W E

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FIGURE 19
MINE UNIT BOUNDARIES, DRAINAGE LINES AND POTENTIAL FLOOD PLAIN

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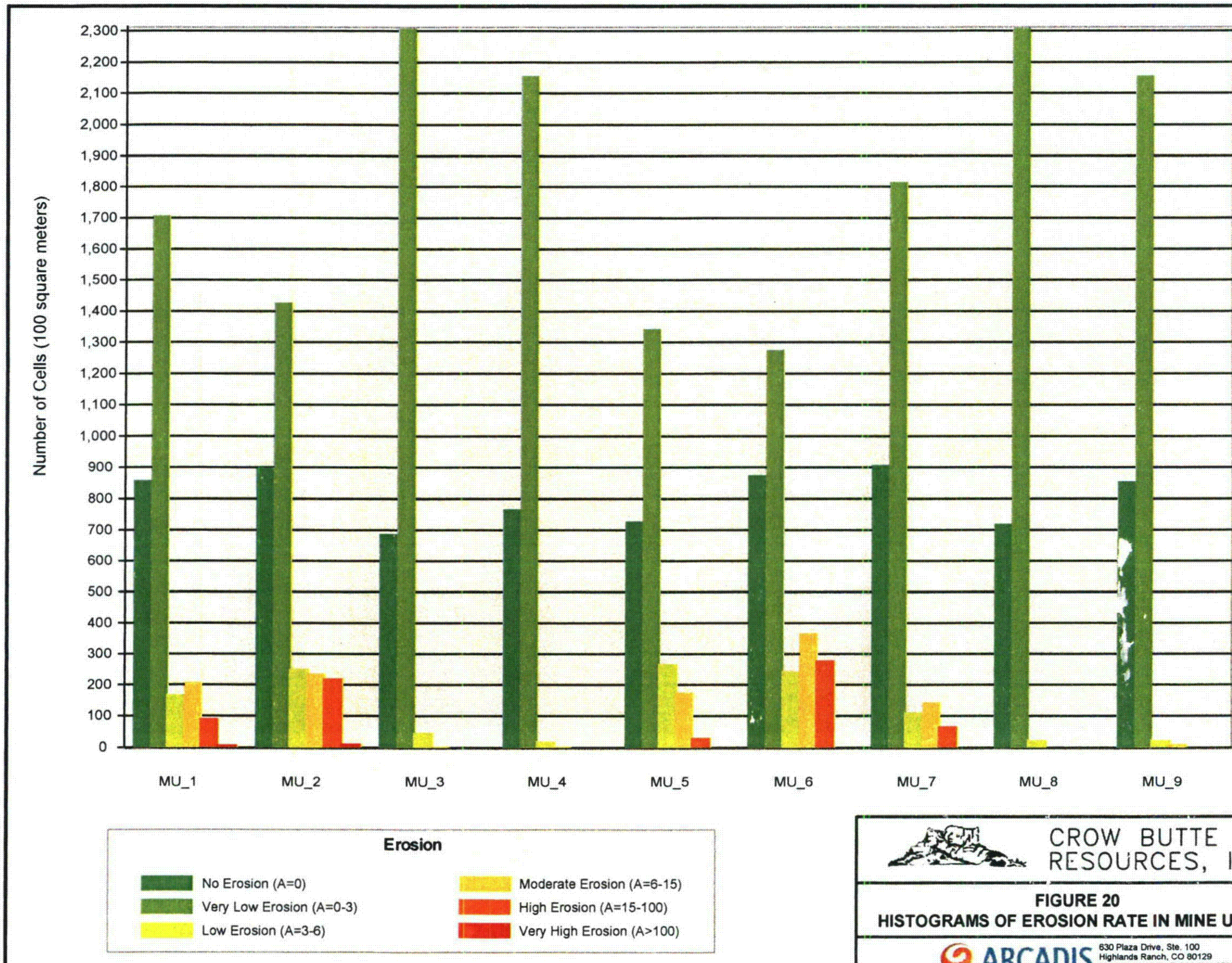

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FIGURE 20
HISTOGRAMS OF EROSION RATE IN MINE UNITS

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