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In the Matter of:	CROW BUTTE RESOURCES, INC. (Marsland Expansion Area)		
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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	Docket No. 40-8943-MLA-2
CROW BUTTE RESOURCES, INC.	ASLBP No. 13-926-01-MLA-BD01
(Marsland Expansion Area)	

<u>Hearing Exhibit</u>

Exhibit Number: CBR019

Exhibit Title: Appendix K-1 - Final Marlsand Hydrologic and Erosion Study 04.12.2012

Imagine the result

Hydrologic and Erosion Study
Marsland Expansion Area

April 12, 2012

Hydrologic and Erosion Study

Marsland Expansion Area

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Table of Contents

Tables

Figures

1. Introduction

This report outlines the construction of a hydrologic and erosion model of the Marsland Expansion Area (MEA) and provides an assessment of potential erosion in the project area (**Figure 1**). The MEA Project will consist of a uranium insitu satellite processing facility, individual wellfields (mine units), deep disposal well, 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 in situ 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 MEA 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 30m. The vertical datum is NAVD88, while the coordinate system was converted to UTM Zone 13N. DEM data were 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 watershed HUC12 101500020607 (Belmont Cemetery-Niobrara River 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. The extents of the data shown in **Figures 1-5** are defined by the NRCS watershed delineation.

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. **Figure 6** through **Figure 8** respectively show the SSURGO soil map information for the northern, central and southern portions of the project area. **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 MEA analysis are maintained. **Figure 2** demonstrates that two regions along on the western edge of the MEA are clipped out of the DEM domain. These regions are removed from the analysis due to the fact that they lie at high elevations in the neighboring HUC12 watershed. Due to their location in the watershed, these regions have limited flow accumulation and thus a low risk of erosion. Flow accumulation is discussed in more detail a part of the hydrologic and soil erosion analysis.

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 9** depicts the result of the watershed delineation into 107 subbasins. **Figure 10** 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 forest in the upper reaches of the watershed. Grassland, farmland and wetland are the primary vegetative cover in the lower reaches of the watershed. 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). The second component is a comparison of MEA facility locations to the drainage network lines displayed in **Figure 10**.

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 occur 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 11** exhibits MEA 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):

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

The flow accumulation and slope values are determined using ArcHydro tools in a similar fashion as the DEM reconditioning procedures. **Figure 12** and **Figure 13** 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 14** illustrates the C-factor for MEA.

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 MEA site, particularly the sections in the lower part of 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 MEA well fields 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 MEA 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 15**. **Figure 16** through **Figure 21** 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 MEA 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 and deep disposal well were all evaluated. **Table 5** lists the risk of erosion for each well field. Mining Unit (MU)-A and MU-1 were found to have low or very low erosion risk throughout the unit, while MU-C, MU-D, MU-E and MU-F have very low erosion risk throughout the unit. However, MU-2, MU-3, MU-4, and MU-B are found to have locations of moderate and high erosion risk. MU-5 has multiple locations of moderate erosion risk. Though MU-2, MU-3, MU-4 and MU-B are found to have high erosion risk in areas, 2-7% of the area within the units is at a moderate to high risk. Placement of well locations around areas of moderate and high potential erosion is a possibility in these units, particularly MU-3 were only 2% of the land is at an increased risk of erosion. MU-5 on the other hand is exposed to a moderate risk of erosion in 11% of the total area. Though the overall risk of MU-5 is lower than other units, it may be more difficult to place wells without additional mitigation measures due to the widespread erosion risk in the unit. 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 18 displays the erosion potential for the satellite facility, access road and deep disposal well. The gray line in the image represents the proposed area for placement of the satellite facility, and access roads to both locations. The star denotes the proposed deep disposal location. The erosion risk was found to be low or very low throughout the area. 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 12** 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. Thus 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 22 through **Figure 27** display the drainage lines and floodplain extents relative to the mining unit locations. Mining units MU-2, MU-3, MU-4 and MU-5 all are positioned such that drainage line 21 and the associated DFIRM floodplain crosses the units. Drainage line 21 is NRCS HUC number 149152245 and shown in **Figure 10**. Drainage line 21 runs generally north to south. 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 road to the satellite facility crosses drainage line 24, as seen in **Figure 18**. Drainage line 24 is NRCS HUC number 149157281. Note however, as seen in **Figure 24**, the proposed access road and satellite facility are not in the 100 year floodplain. The access road should however be positioned carefully, understanding that a potential drainage route crosses the area.

6. References

Breiby, Todd. 2006. Assessment of Soil Erosion Risk within a Subwatershed using GIS and RUSLE with a Comparative Analysis of the use of STATSGO and SSURGO Soil Databases. Volume 8, Papers in Resource Analysis. 22pp. Saint Mary's University of Minnesota Central Services Press. Winona, MN. [webpage]. Located at: http://www.gis.smumn.edu. Accessed on: September 13, 2011.

Federal Emergency Management Agency. (FEMA). 2011. Map Service Center. [Webpage]. Located at: http://www.msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1. Accessed on: October 7, 2011.

Moore, I., and G. Burch. 1986. Physical Basis of the Length-Slope Factor in the Universal Soil Loss Equation. Soil Science Society of America Journal. 50:1294-1298

NLCD 2006 citation: Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, Vol. 77(9):858-864.

NRCS 2009, U.S. Department of Agriculture, http://datagateway.nrcs.usda.gov/ Version Date: Feb. 2009

Schmidt, J. A.J. Anderson, and J.H. Paul. 2007. Spatially-variable, physically-derived flash flood guidance, 21st conference on hydrology, American Meteorological Society Annual Meeting.

Simley, J.D. and W.J. Carswell Jr. 2009. The National Map—Hydrography: U.S. Geological Survey Fact Sheet 2009-3054, 4pp.

USDA. 1996. Agriculture Handbook No. 703: Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation.

USEPA. 2000. Stormwater Phase II Final Rule: Small Construction Site Program Overview. EPA 833-F_00-013. Washington, D.C.

Wachal, D. and K.E. Banks. 2007. Integrating GIS and Erosion Modeling: A Tool for Watershed Management, ESRI 2007 International User Conference, Paper No. UC1038.

Xu, A.L. 2006. A new curve number calculation approach using GIS technology, ESRI 26th International User Conference.

Tables

Figures