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D11 WETLANDS

D11.1 Introduction

The purpose of the wetland study is to evaluate the Permit Area for the presence of wetlands, and to describe cover and species compositions in any identified wetlands.

D11.2 Methods

Evaluation of potential wetland areas was initially conducted by reviewing aerial photographs of the Permit Area for topographic low areas and drainages. Other than the Crooked Well Reservoir, no potential wetland areas were identified from the aerial photographs. Three potential wetlands were identified using the GIS layers from the National Wetlands Inventory (NWI) database (National Wetlands Inventory, 2006) (**Figure D11-1**).

The potential wetland areas were visited in the field during the 2006 growing season and again in the spring of 2009. The sites were evaluated using the criteria listed in the US Army Corps of Engineers wetland delineation manual (Department of the Army, 1987). Two of the three locations were not wetlands as none of the criteria related to hydrology, soils, or vegetation were met. A more detailed evaluation of the vegetation at one potential location, the Crooked Well Reservoir, was done because of the potential for inundation of the area during some seasons.

Wetland vegetation delineation is based on the presence and abundance of obligate wetland plants, facultative wetland plants, facultative plants, facultative upland plants and obligate upland plants. The indicator status for wetland species has been developed by the US Fish and Wildlife Service, and a specific publication for Region 9 (which includes western Wyoming) is available (Reed, 1988). Specific categories include the following.

- Obligate Wetland Species: Under natural conditions, occur almost always (estimated probability greater than 99 percent) in wetlands.
- Facultative Wetland Species: Usually occur in wetlands (estimated probability 67 to 99 percent), but occasionally found in non-wetlands.
- Facultative Species: Equally likely to occur in wetlands or non-wetlands (estimated probability 34 to 66 percent).
- Facultative Upland Species: Usually occur in non-wetlands (estimated probability 67 to 99 percent), but occasionally found in wetlands (estimated probability 1 to 33 percent).

- Obligate Upland Species: Occur almost always (estimated probability greater than 99 percent) in non-wetlands under natural conditions in this region.

Had wetlands been identified during the April 2006 vegetation survey (Appendix D8) using indicator species, a point-intercept approach would have been used to sample species composition and cover. Areas that met the wetland determination criteria based on the field evaluations would have been delineated and mapped.

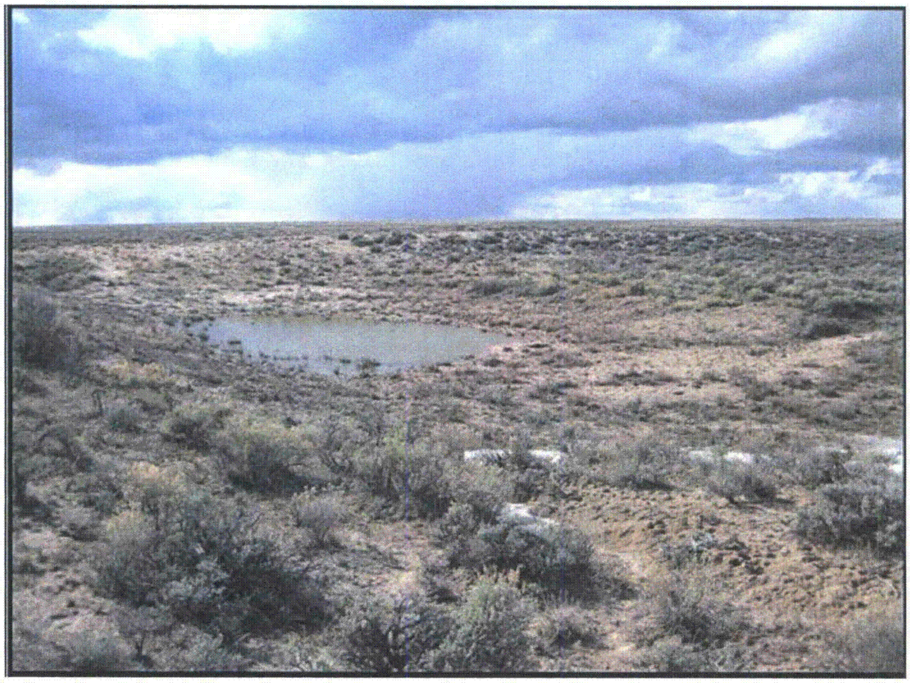
D11.3 Results and Discussion

All potential wetlands identified by aerial photo analysis and the National Wetlands Inventory were field-checked in April 2006 and again in April 2009. No wetlands were identified. The Permit Area consists almost entirely of upland environments dominated by big sagebrush *(Artemisia tridentata)*. The Permit Area is dissected by several small ephemeral drainages, but none of these areas support wetlands. The channels are dominated by big sagebrush, which tends to have higher cover percentages and grow larger in the lowland areas. However, flow in the drainages is occasional, and none of the areas has the hydrology to support wetland vegetation. For nearly the entire growing season, the Permit Area has no standing surface water.

Of the three potential wetlands in the NWI, only one appeared to be a potential wetland based on initial field observations, specifically the Crooked Well Reservoir, located near the center of T25N, R92W, Section 16. This stock pond is an off-channel reservoir next to the Battle Spring Draw in the northeastern part of the Permit Area (**Figure D11-1**). However, based on more detailed field observations during the April 2006 vegetation survey (Appendix D8), surface water sampling (Appendix D6), and other site activities, this site is not a wetland under the 1987 ACOE criteria (hydrology, soils, and vegetation). Figures 11-2a, 2b, and 2c show the reservoir conditions in April of 2006, 2007, and 2009, respectively. Hydrology is the criteria most likely to be met in a given year; however, the variability and timing of precipitation do not result in innudation for at least five days during the growing season each year. There may be sufficient snowmelt for water to accumulate for five days in some years, but because of the variability in temperatures, snowmelt often occurs (and the reservoir dries) before the growing season starts in June (National Climatic Data Center, 2008). There may also be water present after an intense summer thunderstorm, but only at rare intervals from year to year. The bottom of the reservoir is composed of sand, silt, and clay, with no surficial evidence of extensive organic material or anaerobic conditions. The bottom of the reservoir is essentially bare, probably due in part to wind scour. Although there is no specific vegetation density requirement for wetlands, the density is a factor that should be taken into account (Department of the Army, 1987). Scattered small sagebrush and grasses are present along the edges of the bare area, and these grade quickly to the more dense sagebrush community.

Of the other two potential wetlands identified in the NWI, one is off-channel and may have been an old turn-around off the east-west road in the northern portion of T25N, R93W, Section 24 (Figure D11-3). The other location is near a channel and just south of the Permit Area. It was apparently associated with the BLM Battle Spring Draw Well No. 4551 in the northern portion of T25N, R92W, Section 21. When the site was first visited in April 2006, and again in November 2007, the well was apparently not in use (Figure D11-4). However, when the site was visited in April 2009, the well had apparently been put back into service and a dirt 'tank' established (Figure D11-4).

Figure D11-2a Photos of Crooked Well Reservoir
T25N, R92W, Section 16
April 2006



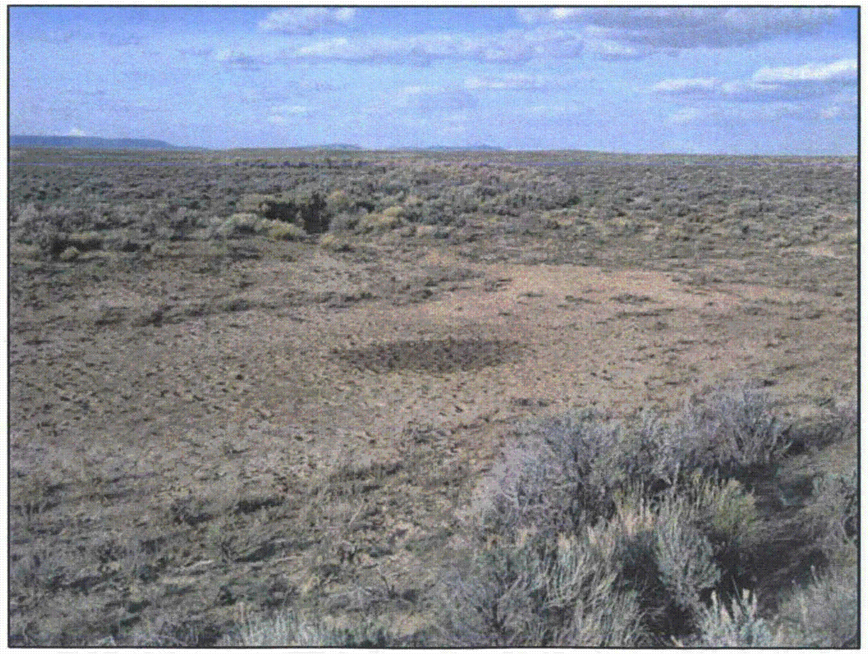
Looking southwest.

Figure D11-2b **Photos of Crooked Well Reservoir**
T25N, R92W, Section 16
April 2007

Looking north.

Looking north.

Looking southwest.



Looking north.

Looking north.

Figure D11-2c **Photos of Crooked Well Reservoir**
T25N, R92W, Section 16
April 2009

Looking north.

Looking east.

Looking west.

Looking south.

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D5.1.2 Structure

The present physiographic feature of the Basin was generated by the Laramide Orogeny. During the Late Cretaceous and Early Tertiary, the structures surrounding the Basin were either rejuvenated or were formed, transforming the area into a bowl-shaped geological structure, the Basin. During this upheaval, the Wind River Mountains and Granite Mountains were uplifted on the north side of the Basin. The Rawlins Uplift formed to the east; the Wamsutter Arch formed to the south; and the Rock Spring Uplift formed to the west. All of these highs formed a ring around the Basin, turning the Basin into a bowl-like structure with drainage being inward. The Continental Divide, extending from the south, splits into two and forms half circles on the east and west sides of the Basin, joining again as one topographic high on the north side of the Basin.

The Basin is asymmetrical with its major axis trending west-northwest. Several anticlines and synclines have been mapped within the Basin, and some of these features are oil-bearing (at much deeper levels than the uranium-bearing formations). Noteworthy among these structures is the Lost Soldier anticline in the northeastern part of the Basin, approximately 15 miles northeast of the Permit Area. The Battle Spring and Fort Union formations, as well as older rocks crop out in the anticline; and the formations on the southwestern flank of the anticline dip 20 to 25 degrees to the southwest. The dip gradually becomes gentler, and, at the Permit Area, it is merely three degrees to the west.

Contemporaneous with the uplift of the mountains surrounding the Basin, there were episodes of normal and thrust faulting within and around the Basin. Most of the major faults are located in the northern part of the Basin, with displacement ranging from a few feet to over 3,000 feet. But, toward the center of the Basin near the Permit Area, faulting seems to be only on a minor scale. For example, the displacement at the Lost Creek Fault which traverses the mineralized area from west-southwest to east-northeast is zero to about 80 feet. More details about the Lost Creek Fault are given in **Section D5.2.2**.

D5.2 Site Geology

The Permit Area is located near the north-central part of the Basin, where the Basin fills are predominantly the Eocene Battle Spring Formation and the Paleocene Fort Union Formation. Geological cross sections throughout the Permit Area are presented in **Plates D5-1a**, **b**, **c**, **d**, **e**, **f**, and **g**, and thickness (isopach) maps of the major sands and shales are presented in **Plates 5-2a**, **b**, **c**, and **d**. The locations of the cross sections are illustrated in **Plate D5-3** (General Location Map-Geology) and also on insets within each cross section. These cross sections display stratigraphic and structural relationships interpreted from drill hole log data and projected onto true north-south or east-west planes. The true distance between drill holes are annotated near the top of each section. Endpoints of each cross-section are projected to the permit boundaries. Extrapolation of the stratigraphy to the permit boundary is based on data from historic exploration drill holes located just outside of the permit boundary. These hole locations have not been identified on drill hole maps or cross-sections as they are outside of the permit boundary. The following information presents the historic drill holes used for the extrapolations:

Cross-Section F-F' (**Plate D5-1e**) - The northern extrapolation of the stratigraphy is based on exploration Drill Hole #85-1, which is about 180 feet north of the property boundary. This drill hole is located at the following coordinates: Easting 2,204,464; Northing 598,174 (NAD 83, State Plane).
Cross-Section G-G' (**Plate D5-1f**) - The northern extrapolation is based on exploration Drill Hole #TT-10, about 120 feet north of the property boundary. This drill hole is located at: Easting 2,209,068; Northing 599,245 (NAD 83, State Plane).
Cross-Section H-H' (**Plate D5-1g**) - The northern extrapolation is based on exploration Drill Hole #A-530, about 940 feet north of the property boundary. This drill hole is located at: Easting 2,213,017; Northing 601,164 (NAD 83, State Plane). The southern extrapolation is based on exploration Drill Hole #RD-187, about 174 feet south of the property boundary. This drill hole is located: Easting 2,213,202; Northing 594,142 (NAD 83, State Plane).

The cross sections also illustrate the piezometric surfaces for the DE, LFG, HJ and UKM horizons. Depiction of these surfaces on the cross sections were generated by tracking the intersection of the plane of the cross section profile with potentiometric contours plotted for the given horizons (**Plates D6-11a to D6-11d**). **Attachment D5-1** contains copies of typical geophysical logs from the Permit Area, and **Attachment D6-3** contains copies of the geophysical logs from the baseline monitoring wells.

Section 16 of T25N, R92W was not included on the cross-sections because of the limited subsurface data in this section and because no mining of this section is planned. Twenty holes have been drilled in Section 16, five of which are regional baseline monitor wells installed by LC ISR, LLC. Two of the exploration holes, OH1 and RD393, were shallow and did not penetrate to a depth sufficient to fully measure any of the stratigraphic units. Similarly, two of the existing monitor wells, MB-07 and MB-08, were only drilled to monitor shallow units. The stratigraphy and structure in Section 16 are discussed in the following sections. If LC ISR, LLC's plans change for Section 16, additional subsurface information will be collected and the permit revised to include that information.

D5.2.1 Stratigraphy

The entire Permit Area is covered by the upper part of the Battle Spring Formation, which is the host to uranium mineralization. Generally, in the Basin, Battle Spring and Wasatch formations, which are time equivalent, interfinger with one another. In the Permit Area, the upper half of the lithologic units consists of Battle Spring Formation and the lower half is made up of Wasatch Formation. The total thickness of the Battle Spring and Wasatch formations under the Permit Area is about 6,200 feet. The Fort Union Formation is 4,650 feet thick beneath the Permit Area and unconformably underlies the Battle Spring/Wasatch formations. Deeper in the Basin and lying unconformably are various Cretaceous, Jurassic, Triassic, Paleozoic, and Precambrian basement lithologic units (**Table D5-1**). A schematic geologic cross section across the Permit Area is shown in **Figure D5-2a**, depicting all lithologic units present under the Permit Area.

The Battle Spring Formation in the Permit Area is part of a major alluvial system, consisting of thick beds of very fine- to coarse-grained arkosic sandstones separated by various layers of mudstones and siltstones. Conglomerate beds may exist locally. Economic uranium mineralization is generally associated with medium to coarse-grained sandstone, which may contain minor organic matter locally. At least five horizons with various amounts of mineralization have been identified in and near the Permit Area.

Aquifers in the Battle Spring Formation typically consist of thick sequences of multiple, medium to coarse-grained, fluvial channel-fill sands. *Mapable sand units* (for example: the UHJ Sand) may range from five to 50 feet in composite thickness, and typically consist of multiple stacked channel-fill sands. *Aquifers*, in turn, typically consist of multiple stacked sand units. Sand units are commonly separated vertically by locally thick beds of mudstone, claystone, siltstone or fine-grained sands. These interbeds represent local aquitards and aquicludes which can be considered internal to the regional aquifer. Total composite thickness of an aquifer (for example: the HJ Horizon) is commonly in excess of 100 feet.

Aquiclides and aquitards (for example: the Lost Creek Shale or Sage Brush Shale) represent quiescent floodplain and overbank sedimentary environments between channel fill sequences. Generally referred to as 'shales' they are, in essence, sedimentary sequences dominated by mudstone and claystone lithology; but also may include substantial amounts of siltsone and fine-grained sands. These lithologies can exhibit considerable lateral facies changes and interfingering, and are often transitional to the aquifers above or below. As a result, dramatic thickening and thinning of the aquicludes can occur locally. Thicknesses of the Lost Creek and Sagebrush Shales are commonly in excess of 25 feet. The thinnest observed occurrences of these units are approximately five feet thick. These thicknesses are based on the interpretation of down-hole geophysical logs. The thicknesses are accurate to within six inches (plus or minus six inches of the true thickness) .

Aquicludes may locally include occurrences of mineralization in the vicinity of lithologic interfingering and facies changes with mineralized sands. Mineralization in this setting will not be targeted for mining and thus will experience minimal, if any, contact with production lixiviant. Given the very low concentrations of uranium within the shales (0.05% or less), the structural integrity and confinement characteristics of the shales will remain unchanged, even if uranium in the shales were incidentally contacted and removed through mining.

Figure D5-2c provides a detailed illustration of the lithologic changes over a 400-foot section in the central portion of the ore-body in the Permit Area. The five mineralized horizons in the Permit Area are designated, from the surface down: the BC, DE, FG, HJ, and KM Horizons. The two horizons with the most mineralization are HJ and KM, which have been further divided into upper, middle and lower sub-units of sandstones (UHJ Sand, MHJ Sand, and LHJ Sand; and UKM Sand, MKM Sand, and LKM Sand). Geological cross sections through the mineralized zones in the Permit Area are presented in **Plates D5-1a**, **b**, **c**, **d**, **e**, **f**, and **g**. Thickness (isopach) maps of the HJ Horizon and UKM Sand, as well as the shales above the HJ Horizon (Lost Creek Shale) and below the HJ Horizon (Sage Brush Shale), are presented in **Plates D5-2a**, **b**, **c**, and **d**.

The HJ Horizon is 110 to 130 feet thick, averaging about 120 feet. The thinner part of HJ is generally south of the Lost Creek Fault. A thicker part of the HJ Horizon runs parallel to the Lost Creek Fault, trending in a west-southwest to east-northeasterly direction. The mineralization is mostly concentrated in the middle part of the HJ Horizon and occurs as both roll front and tabular deposits. The subdivided sand units within the HJ Horizon are separated by discontinuous shale, siltstone and mudstones. The shales overlying and underlying the HJ Horizon are the Lost Creek and Sage Brush Shales, which range from five to over 25 feet thick. The UKM Sand lies under the Sage Brush Shale and is 20 to more than 60 feet thick, averaging about 40 feet. In the eastern part of the Permit Area, the unit is 20 to 50 feet thick; whereas the sand unit in the western portion of the permit area is 40 to more than 60 feet thick, indicating the development of a major paleo-channel. The mineralization occurs as both roll front and tabular deposits.

The stratigraphic layering extends east into Section 16. The layers of interest (DE, EF, FG, LCS, HJ, SBS, KM and KSH) have very similar thicknesses to MU1, although the uppermost BC layer is absent and the underlying layers are slightly shallower in Section 16 because of dip. (The strike at Lost Creek is approximately NE/SW with a dip of roughly 2° NW.) Gamma log signatures for holes drilled in the southeastern portion of Section 16 indicate the existence of mineralized roll front trends. Based on the trends in the HJ and KM Horizons in the rest of the Permit Area, LC ISR, LLC expects these fronts to extend into this portion of Section 16. The top of the HJ Horizon is on the order of 320 feet below surface. The thicknesses of the HJ and KM Horizons range from about 100 to 140 feet and 90 to 135 feet, respectively, somewhat thicker than in the rest of the Permit Area. (The HJ Horizon was not subdivided in Section 16 because of the limited data.) The Lost Creek and Sage Brush Shales are about the same thickness as in the rest of the Permit Area. The LCS ranges from about 5 to 25 feet thick, and the SBS ranges from about 5 to 40 feet thick.

D5.2.2 Structure

Geologic structural features in the Permit Area are illustrated on: the cross sections (**Plates D5-1a** to **D5-1g**); the isopach maps (**Plates D5-2a** to **D5-2d**; and on **Plate D5-3** (General Location Map). In the Permit Area, the Battle Spring Formation is nearly flat-lying, dipping gently to the northwest at roughly three degrees. This pattern is slightly modified locally due to displacement by normal faulting which is post-mineralization in relative time. The genesis of these faults is not certain, however, they may be the product of regional basin unloading. They are not considered to be currently active.

Three faults have been identified. The primary fault is referred to as the Lost Creek Fault. It is centrally located sub-parallel with the mineral trend. It was initially interpreted to be a scissor fault, with reversal of displacement direction in the western third of the Permit Area. Recent interpretation has revealed that it is, instead, a sequence of sub-parallel faults with opposite displacement occurring in an en-echelon configuration.

The 'main' Lost Creek Fault trends east to west and dissects the eastern two-thirds of the Permit Area. Downward displacement occurs on the south block. Throw is approximately 70 to 80 feet in the eastern portion of the Permit Area, decreasing to the west, and eventually losing identity in the western one-third of the Permit Area. In addition, a minor 'splinter' fault has been identified close to the 'main' fault in the west-central portion of the mineral trend. Maximum displacement on this fault is roughly 20 feet. A subsidiary, sub-parallel fault becomes apparent south of the 'main' Lost Creek Fault in the general vicinity where the 'main' fault loses identity. This portion of the Lost Creek Fault sequence continues west to the western edge of the Permit Area. Direction of throw on this fault is opposite to the 'main' fault; i.e., downthrown to the north. Displacement ranges from approximately 40 to 50 feet in the east, decreasing to 20 to 30 feet to the west.

Recent activity has identified the presence of additional faulting. A second fault (the North Fault) occurs in the northwestern portions of the Permit Area. Limited data indicates that the maximum displacement is approximately 70 feet, with the downthrown block to the north. Likewise, a third fault (the South Fault) is found in the south-central portion of the Permit Area. Maximum displacement is roughly 40 feet, with the downthrown block to the north. Both of these faults are oriented sub-parallel to the Lost Creek Fault sequence. Also, both are located outside of anticipated production areas.

No faulting has not been identified in Section 16. The Lost Creek Fault, however, is known to extend east-northeast out of the central portion of the Permit Area and is suspected to extend into the southeastern portion of Section 16. The current drill hole spacing is insufficient to confidently identify faulting because topographic relief could mask the occurrence of any fault with offset on the order of 20 to 40 feet. However, it is possible that further drilling will identify normal faulting in the southern part of Section 16.

D5.2.3 Ore Mineralogy and Geochemistry

The age of mineralization in the Battle Spring Formation is considered to be between 35 and 26 million years before present. Uranium mineralization in the Basin generally occurs either as tabular or C-shaped roll-front deposits. Oxygen-rich surface water, carrying dissolved uranium, entered various sandstones in the Basin. The water percolated down dip, oxidizing the sandstones on its way down dip. Upon reaching sites rich in organic matter, the water lost its oxidizing potential and deposited the uranium, forming the two types of mineralization mentioned above.

Tabular deposits may form at the interface between oxidizing and reducing conditions (the redox front), where oxidation, for all practical purposes, stops. Localized tabular deposits may also form up-dip from the redox front in an entirely oxidized zone, where carbonaceous materials have gathered and formed locally reducing conditions.

The C-shaped roll-front deposits normally form just at the redox front, where the water loses its oxidizing potential. The uranium precipitates and accumulates in a "C"-shaped deposit, with the concave side facing up-dip toward the oxidized sand. Uranium usually accumulates in finer-grained sandstones that carry various amounts of organic matter, which provides a reducing condition.

The alteration process not only changes the color, but also alters the mineralogy of the host sandstones. The color of unaltered, reduced sandstone is light to dark grey, with carbon trash, dark accessories, and traces of pyrite. Altered, oxidized, sandstone contains iron oxide staining (where former carbonaceous matter and pyrite were present), kaolinized feldspar, and has a pink to tan-buff, greenish-grey to bleached appearance. The presence of pyrite and carbonaceous material appear to be the major controlling factors for the precipitation of uranium mineralization. Thinning of sandstones and diminishing grain size probably slowed the advance of the uranium-bearing solutions and further enhanced the chances of precipitation.

The main uranium minerals are uraninite, a uranium oxide, and coffinite, a uranium silicate. Russell Honea (1979) and John V. Heyse (1979) studied several core samples by scanning electron microprobe (SEM), polished section and thin section. Their conclusions were that the host sands are fine- to coarse-grained, poorly sorted arkose. The uranium mineralization is of sub-microscopic size and can be seen only in SEM magnification. They are associated and at times intergrown with round pyrite particles. The uranium minerals identified are mostly uraninite and, possibly, coffinite. The uranium, besides occurring with pyrite, also occurs as a coating around sand grains and as filling of voids between grains. It also occurs as minute particles within larger clay particles.

The most recent study of the lithology and mineralogy was conducted by Hazen Research under the guidance of Dr. Nick Ferris, Ur-E geologist (Ferris, 2007, company report). He concluded that the rocks, represented by a core sample from a depth of 506 to 507 feet of Hole Number LC-64C, are composed of medium- to coarse-grained sand with interstitial clay and silt. Uranium occurrences are very fine-grained and micron-sized, and are mainly dispersed throughout some of the interstitial clays, and occur similarly in some of the interstitial pyrite as well. Because of the size of uranium mineral particles, it was not certain whether the uranium mineral was coffinite or uraninite. The sample tested, comes from the Upper KM Sand unit and may or may not be representative of the majority of the mineralization in the overlying HJ Horizon within the Permit Area.

Known mineralized intervals are found at depths ranging from near surface down to 1,150 feet below the surface in the Permit Area. It is possible that deeper mineralization may exist as well. The main mineralization horizons trend in an east-northeast direction for at least three miles, and are up to 2,000 feet wide. The thickness of individual mineralized beds at the Permit Area ranges from five to 28 feet and averages about 16 feet. The mineralization grade ranges from 0.03 percent to more than 0.20 percent equivalent uranium oxide (eU_3O_8). Four main mineralized horizons, from depths of 300 to 700 feet, have been identified. The richest mineralized zone occurs in the middle part of the HJ Horizon (MHJ Sand) and it is about 30 feet thick, 400 to 450 feet deep, and is believed to contain more than 50 percent of the total resource under the Permit Area.

D5.2.4 Exploration and Production Activities

D5.2.4.1 Uranium

Historic and current uranium explorations exist in several areas of the Basin; however, uranium mining has been limited. The closest production was at the Kennecott Uranium Project, located about five miles south-southwest of the center of the Project, with about two miles separating the permit boundaries. (NRC License No. SUA-1350; WDEQ-LQD Permit No. 481). The project includes the Sweetwater Mill, a conventional mill which is currently on stand-by, a mill tailings disposal area, and reclaimed surface mining areas.

There has been no uranium production within the Permit Area. Historic exploration activities in the Permit Area can be summarized as follows:

- Pre-1976: Numerous companies held the property; uranium mineralization was discovered by Climax Uranium and Conoco.
- 1976: Texasgulf optioned property from Valley Development Inc.

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"PLATE AD5-2b
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