Ecological Risk Assessment

FOR THE

ST. ANTHONY MINE PIT 1 SITE

November, 2023

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United Nuclear Corporation

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ACRONYMS AND ABBREVIATIONS

AVM	AVM Environmental Services Inc.
BAF	Bioaccumulation Factor
BCG	Biota Concentration Guide
BW	Body weight
CCOP	closure-closeout plan
Cedar Creek	Cedar Creek Associates Inc.
COI	Constituents of Interest
COPC	Constituents of Potential Concern
CSM	Conceptual Site Model
DCF	Dose Conversion Factor
DOE	Department of Energy
EMNRD	Energy, Minerals, and Natural Resources Department
ERA	Ecological Risk Assessment
ESL	Ecological Screening Levels
g	Gram
GWQB	Ground Water Quality Bureau
HI	Hazard Index
HQ	Hazard Quotient
INTERA	INTERA, Inc.
kg	Kilogram
L	Liter
LANL	Los Alamos National Laboratory
mL	Milliliter
MMD	Mining and Minerals Division
NAS	National Academy of Science

NMAC	New Mexico Administrative Code
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environmental Department
NRC	National Research Council
NOREL	No Observed Radionuclide Effect Level
pCi	Picocurie
Ra-226	Radium-226
Ra-228	Radium-228
rad/d	Absorbed Radiation Dose per Day
RESL	Radiological Effect Screening-Level
Site	St. Anthony Mine
S2M	Stage 2 Abatement Plan
SPLP	Synthetic Precipitation Leaching Procedure
Stantec	Stantec Consulting Services Inc.
STPP	Sodium tripolyphosphate
TDS	Total Dissolved Solids
TRV	Toxicity Reference Value
U-234	Uranium 234
U-235	Uranium 235
U-238	Uranium 238
UNC	United Nuclear Corporation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife
WQC	Water quality criteria
WQCC	Water Quality Control Commission
WTV	Wildlife Threshold Value

1.0 INTRODUCTION

This document describes an Ecological Risk Assessment (ERA) prepared for the St. Anthony Mine (Site) for the purpose of determining potential risks to wildlife and livestock from radiological and other constituent concentrations associated with Pit 1.

The Site consists of two open pits, overburden, topsoil, and mine material piles, and two underground mines. The Site is subject to closure requirements under the New Mexico Mining Act and abatement requirements under the New Mexico Water Quality Act. United Nuclear Corporation (UNC) developed and submitted a 30% closure-closeout plan (30% CCOP) (Stantec 2022) to the New Mexico Mining and Minerals Division (MMD) and a request for modification of the 2015 Stage 2 Abatement Plan (S2M) (INTERA 2022) to the New Mexico Environmental Department (NMED). These submissions describe a proposed reclamation approach that includes a partial backfill of Pit 1 to maintain the current hydraulic sink. The final configuration of the proposed Pit 1 reclamation will allow sections of bedrock stratigraphy along the highwall that surrounds Pit 1 to remain exposed and assumes a future expression of groundwater at the base of Pit 1 as described in the 30% CCOP and S2M.

As presented in the S2M, the expressed water in Pit 1 is classified as a private water under the New Mexico Statutes Annotated, 1978 Compilation (NMSA 1978), § 74-6-2(h) and is not subject to New Mexico surface water standards. Therefore, an ERA was completed to address the potential for ecological risks associated with the proposed Pit 1 reclamation approach.

This assessment involves the following steps: (1) identify sources and concentrations of Constituents of Interest (COIs), (2) identify plausible wildlife receptors and exposure pathways, (3) quantify and characterize risk. These steps are consistent with risk assessment guidance described by federal and state entities, for example the United States Environmental Protection Agency (USEPA 1998a, 1998b) and the New Mexico Environmental Department (NMED 2017, 2000).

1.1 Site Location

The Site is located in Cibola County, New Mexico, in a remote, sparsely populated area on the Cebolleta Land Grant approximately 40 miles west of Albuquerque and 4.6 miles southeast of Seboyeta. UNC mined uranium at the St. Anthony Mine from 1975 to 1981 pursuant to a mineral lease with the Cebolleta Land Grant, the current surface and mineral rights owner. The original lease covered approximately 2,560 acres. This lease was obtained on February 10, 1964 and was surrendered by a Release of Mineral Lease dated October 24, 1988. UNC has access to the Site through access agreements with the Cebolleta Land Grant and an adjacent landowner.

Areas disturbed during the former mining operations encompass approximately 430 acres and include roads, building and shaft pads, former settling ponds, along with the open pits and noneconomic mine material piles. The two open pits at the Site are located in Sections 19 and 30, Township 11 North, Range 4 West, and the entrance to the newer underground mine is located in Section 24, Township 11 North, Range 5 West. The Old St. Anthony underground mine is located in Section 30.

1.2 Regional Ecological Setting

The Site is located in the southeastern part of the San Juan Basin geologic structural basin, which is characterized by a combination of mesas that dip gently to the north and broad valleys with intermittent streams. Arroyos have incised the mesas by headward erosion, forming steep-sided canyons. No perennial streams occur within the Site, but an arroyo (Meyer Draw) passes through the Site and other ephemeral drainages occur at the Site as delineated by SWCA (2020).

Natural vegetation of the ecoregion is a mix of desert scrub, semi-desert shrub-steppe, and semi-desert grasslands, with junipers occurring on higher mesas. Mesas in and around the Site are dominated by grasslands, with pockets of juniper scrub occurring on steep rocky escarpments and areas where soils are coarse (Cedar Creek 2006). The escarpments occasionally form vertical cliff faces which provide habitat for nesting raptors. Alluvial valleys are dominated by juniper scrub, and/or grass and forb vegetation ("bottomland," as described in Cedar Creek 2006). Ephemeral drainages and the arroyo are generally dominated by weedy forb species, and tamarisk was observed in Meyer Draw. Where pit water expression is more persistent, small stands of emergent vegetation have established in Pit 1 along the littoral margin (SWCA 2020).

The San Juan New Mexico region contains a diversity of game species, migratory birds and raptors, bats, and other New Mexico sensitive, rare, and special status species. Big game species that may occur in the vicinity of the Site, based on game management unit information from the New Mexico Department of Game and Fish (NMDGF), include mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis nelson*), and pronghorn antelope (*Antilocapra americana*). Other common game and non-game species typical of the region include mourning dove (*Zenaida macroura*), cottontail (*Sylvilagus* sp.), jackrabbit (*Lepus sp*.), coyote (*Canis latrans*), fox (*Vulpes sp*), skunk (*Mephitidae*), and rodents. There is a high diversity of migratory birds in this region. Protected, sensitive, and other special status species are discussed in Section 2.4.

Wildlife and their sign inventoried at the Site (from Cedar Creek 2006) included several species of birds including shorebirds, sparrows, and raptors; game species, including mule deer, elk, and black bear; small mammals, such as cottontail and mice; and lizards and snakes. Tadpoles were observed in a seasonal water source near the arroyo. More recently, during Site visits on January 10, 2023 and June 6, 2023, waterfowl were noted to be resting on the Pit 1 surface and a red-tailed hawk nest was observed along the highwall.

A query of potential sensitive, threatened, or endangered species was completed for the Site. Queries for listed threatened, endangered, or candidate species and New Mexico Species of Concern were obtained from the United States Fish and Wildlife (USFWS) IPAC database and the New Mexico Natural Heritage Program's Bison M database for Cibola County. The results of these queries are provided in Appendix A. Federally-listed wildlife species that are listed for the County (but would not necessarily occur at the Site) include the Mexican wolf (*Canis lupus baileyi*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax traillii extimus*), and yellow-billed cuckoo (*Coccyzus americanus*). Critical habitat for the yellow-billed cuckoo and southwestern willow flycatcher occurs in Cibola County. However, it does not occur in or around the Site based on mapping data from the New Mexico Environmental Review Tool (NMDGF 2023) and would not be expected to develop in a future pit environment. State-listed threatened or endangered wildlife species potentially present in Cibola County also include raptors (peregrine falcon, bald eagle), migratory birds (gray vireo), and bats (spotted bat).

2.0 CONCEPTUAL SITE MODEL

Cedar Creek developed a conceptual site model (CSM) to describe the relationship between constituent sources, exposure pathways, and wildlife that potentially use the pit environment. The CSM establishes a framework in which to evaluate hypotheses about potential ecological impacts could occur from the environmental conditions at Pit 1.

The proposed reclamation approach includes partial backfilling of Pit 1. The future configuration of Pit 1 is predicted to result in an expression of groundwater in Pit 1. The surface expression of groundwater may attract wildlife and support growth of aquatic vegetation or invertebrates. Existing highwall structures would remain in place. The highwalls could provide nesting habitat on ledges or roosting habitat in crevices.

The duration of water expression will affect both the frequency of use by receptors and the ability of a trophic food web to develop. The approach utilized in this ERA adopts conservative estimates of exposure where uncertainties exist. Accordingly, this CSM assumes that the duration of surface water expression in Pit 1 will be long enough for rooted aquatic plants and sediment-dwelling invertebrates to inhabit the pit and for a relatively complex trophic food web to develop.

2.1 Constituents Evaluated in Detail

The primary environmental medium addressed in this assessment is the surface water expression at Pit 1 and gamma-emitting radionuclides from the pit highwall. As described in the S2M, isotopes of uranium and radium are identified as constituents of potential concern and reducing exposures to these isotopes are a driver of reclamation alternative selection in the 30% CCOP. Therefore, uranium and radium isotopes are identified as COIs and evaluated in detail in this ERA. Specifically, isotopes quantified in the ERA included Uranium-234 (U-234), Uranium-235 (U-235), Uranium-238 (U-238), Radium-226 (Ra-226), and Radium-228 (Ra-228).

Additionally, non-radiological constituents were evaluated by comparing concentrations in these media to screening level ecological benchmarks. A supplementary screen of future Pit 1 soil and sediments follows this initial screening exercise to ensure all COIs have been identified.

Future maximum surface water concentrations are expected to be similar to concentrations measured in Pit 1 prior to the Sodium tripolyphosphate (STPP) pilot test. These measured Pit 1 concentrations would therefore be representative of undisturbed expressed water conditions over the 30-year period after mine closure. Maximum concentrations of non-radiological constituents measured in Pit 1 were compared to New Mexico Administrative Code (NMAC) surface water standards for livestock, wildlife, and aquatic life (Table 2-1). The following non-radiological constituents were retained for detailed analysis in the ERA: selenium and uranium. Therefore, both isotopes of uranium (pCi/L) and the total concentration of uranium in milligrams per liter (mg/L) were evaluated in the ERA. All of the constituents to be evaluated in detail in this ERA are referred to in the remainder of this report as COIs.

Sulfate and TDS do not have NMAC standards, and maximum concentrations of chloride, a component of TDS, was higher than NMAC criteria for aquatic life. A discussion of these constituents and their potential for risk is included in Section 2.2. Ultimately these constituents were not further evaluated in the ERA, as described in Section 2.2. In addition, a single measured concentration of iron in pit water was greater than the NMAC aquatic life standard. The average detected concentration of iron (average of detections was 0.6 mg/L, and rate of detection was approximately 40%), however, was lower than the NMAC standard of 1 mg/L. Iron is considered essential to animal life and health. Animal based maximum tolerance of iron is reported by NRC (2005) in the range of 500 to 1,000 mg/kg in the food, which translates to about 90 mg/L or higher in water. Based on the low frequency of iron exceedance of NMAC standards and lack of toxicity to wildlife or livestock at levels measured in Pit 1, this constituent was not evaluated in further detail in this ERA.

The future Pit 1 environment will also include sediments beneath and adjacent to expressed pit water, and transitional and upland soils. Future Pit 1 sediments and soils will be created by placing loose material from the Pit 1 highwalls into the pit, overlain by soil borrow materials from the West Borrow Area and North Topsoil Pile. Borrow materials were characterized by MWH (2007), Stantec (2018), and as part of a supplemental surface radiological characterization performed by Stantec in 2023

(Stantec 2023). Radiological testing of proposed borrow materials indicates that concentrations of measured metals and radiological constituents are similar to background soils. Radionuclide isotopes and bulk metals concentrations measured for the North Topsoil Pile and a South Borrow Area (the latter materials are similar to West Borrow Area) were either less than detection limits and/or within background soil ranges reported by MWH (2007). Therefore, no additional COIs were identified in future soil or sediment materials. For completeness, however, risks from additional exposure to soil/sediment COIs was included in the detailed analysis of this ERA.

2.2 Supplemental Screening

TDS is a measure of all constituents dissolved in water. In natural water bodies, the most abundant of these constituents are typically major ions such as chlorides, carbonates, bicarbonates, sulfates (collectively referred to as 'anions'), and calcium, magnesium, potassium, and sodium (collectively referred to as 'cations'). Other constituents are usually present sporadically at minor to moderate concentrations.

Some components of TDS are nutrients required by animals, while other components may have little to no nutritional value. For example, calcium, magnesium, sodium, and chloride are involved in acid-base balance, muscle contraction, nerve signal transmission, nutrient transport, and other functions (Murray et al. 2000). Daily requirements of sulfur for livestock and poultry are recommended between 10% and 45% of dietary intake (NRC 2005). Therefore, toxicity of TDS to animals will depend on the individual constituents that make up this analytic measure.

Most compounds must be solubilized in water to be absorbed from the digestive tract. Solubility will affect the mass absorbed and the rate of absorption (Church 1979). Solubility is also affected by the relative ratios of different constituents. Availability of magnesium, for example, is ~60% when consumed on its own, but it can be reduced by high potassium intake.

Effects of excessive TDS intake, as measured mostly in livestock species, can include excess salivation, vomiting, diarrhea, ataxia, disorientation, blindness, seizures, and paralysis (NRC 2005). These effects reflect acute exposures. Field-based observations of animal response to high TDS environments is to avoid or limit drinking waters containing high TDS levels. Long-term toxicity tests in which laboratory animals were given only high TDS water and/or feed indicated that significant effects on animals resulted from the prolonged refusal to eat or drink, rather than a mechanism of toxicity from TDS. Studies evaluating wildlife toxicity to outdoor impoundments showed that wildlife mortalities and other effects did not occur even when predicted to do so. For example, several studies of hypersaline tailings impoundments showed that, despite high concentrations of cyanide in the impoundment, no wildlife mortalities occurred because wildlife reduced foraging and drinking frequencies in these areas due to the salinity of the impoundment (Donato 2007 and 2010, Griffiths et al. 2014). Bats, birds, and other wildlife would naturally avoid the more saline impoundments in favor of freshwater impoundments, leading to absence of mortalities and other predicted effects of ingesting constituent concentrations.

Ranges of TDS tolerance limits have been reported between 1,000 mg/L (NAS 1972) and more than 15,000 mg/L (Weeth and Haverland 1961, USEPA 1976). The toxicity of TDS to animals will depend on the individual constituents that make up the given analytic measure. For example, the USEPA (1976) advised that "livestock and poultry can survive on saline waters up to 15,000 mg/L salts of sodium and calcium combined with bicarbonates, chlorides, and sulfates. But only 10,000 mg/L of corresponding salts of potassium and magnesium could be tolerated." Other differences in tolerance limits are attributable to the species under consideration, and environmental conditions, including forage quality and heat stress.

Given the avoidance behavior observed by animals in outdoor environments, the nutritional value of some components of TDS, including sulfate and chloride, and the lack of a definitive toxicity mechanism for TDS, the associated constituents are not identified as a toxicological risk to wildlife and were not further evaluated in the ERA.

2.3 Sources and Exposure Pathways

Sources of COIs to the future Pit 1 environment include groundwater and backfill soils, which will become Pit 1 sediments in the future. Partial backfilling of Pit 1 will result in an expression of groundwater to the surface at the base of Pit 1. Gamma-emitting radioisotopes in the pit highwalls can also contribute to external radiation exposures to wildlife. Vegetation anticipated to grow in and around Pit 1 includes water-obligate rooted vegetation in the littoral zone, transitioning to a groundwater-modified vegetation community and then upland vegetation as surface elevations rise out of the pit bottom and depth to groundwater increases. For purposes of this evaluation, upland soils and vegetation immediately surrounding Pit 1 were included in the conceptual model to incorporate cumulative exposures to receptors from COIs.

Potential exposure pathways to wildlife in this future environment include direct contact, ingestion, external radiation exposures, and indirect absorption via trophic transfer. Wildlife could be exposed by drinking the water that expresses in the base of Pit 1, incidentally ingesting sediment, and consuming plants, invertebrates, or prey that eat and drink in the pit environment. Animals would be expected to be exposed primarily to surface soils, which would include the backfill soil. Waterfowl may rest on the surface of the expressed water in Pit 1. Inhalation of soil particles was assumed to be negligible for this environment as the primary media are aquatic-based.

Direct external radiation exposure to ecological receptors could occur from gamma-emitting radionuclides present in water, sediment or soil, and highwall material.

Exposed bedrock stratigraphy along the pit highwall includes Jackpile and Dakota sandstones and Mancos shale. Photos are provided in Appendix B showing the distribution of these lithologies along the highwall. Raptors could nest on ledges or large crevices that are associated with the Mancos shale or perhaps the Dakota sandstone. Some bat species could also roost in the crevices of Dakota or Mancos formations. It is less likely that birds would build nests on the Jackpile sandstone, given its position low to the ground. The lack of deep crevices would likely preclude its use by bats as well. However, based on concerns expressed by agencies regarding Jackpile exposures, potential risks to nesting birds or bats from exposure to Jackpile was included in the conceptual model and is modeled in this ERA.

2.4 Potential Receptors

Based on the regional ecological setting of the Site described in Section 1.2, and expected wildlife species in the general area, the major groups of ecological receptors that would be attracted to the Pit 1 environment include a variety of birds, mammals, and big game species. Livestock grazing also occurs in the vicinity. Amphibians are unlikely to thrive in the Pit 1 environment given the salinity levels associated with Pit 1 water. Small reptiles, such as lizards, are ubiquitous in high desert environments but would not necessarily be drawn to an aquatic environment.

In order to quantify exposure to wildlife, specific species receptors were identified because species-specific numerical information about each organism is needed to compute dose and risk. Both common species and potential sensitive, rare, or listed species were considered in the identification of potential receptors.

NMED (2017) identified representative wildlife ecological receptors to evaluate in its ecological risk assessment guidance for soil. The wildlife receptors, which included deer mouse, horned lark, kit fox, red-tailed hawk, and pronghorn antelope, represent the varying trophic levels (primary, secondary, and tertiary) in a typical terrestrial food web for a New Mexico environment. Receptors selected for this ERA incorporate the same trophic level considerations, but also considered species with a high affinity for an aquatic-based food web. For example, a different small bird species (the cliff swallow) was utilized in this ERA to address consumption of aquatic-based invertebrates rather than a horned lark, which consumes primarily terrestrial-based invertebrates. A cliff swallow is also more likely to nest along a pit highwall and be exposed to sediments that are used to build its nest. Additional species were also added to capture potential exposures by sensitive and listed species, waterfowl species that may be attracted to an aquatic environment, and livestock (cattle). The livestock and wildlife receptors used to characterize risk for this ERA, and their representativeness of various trophic levels and exposure pathways, are summarized as the following:

- **Cliff Swallow (*Petrochelidon pyrrhonota*)** - Represents small insectivorous birds (a secondary consumer) that would consume aquatic invertebrates, drink pit water, use sediments for nest building, and could nest on the pit highwall. This species would also represent potential listed small birds present in the County.

- **Deer Mouse (*Peromyscus maniculatus*)** - Represents an omnivorous small mammal (a secondary consumer) that would drink pit water and serve as prey to predators. Could also burrow into soils.

- **Kit Fox (*Vulpes macrotis*)** - Represents carnivorous predatory mammals (a tertiary consumer) that would consume wildlife prey in the pit environment, consume pit water and could den in soils near the pit. This species would also den in upland soils. This species would also represent listed large mammal predators that could be present in the County.

- **Little Brown Bat (*Myotis lucifugus*)** - Represents small insectivorous mammals (a secondary consumer) that would consume aquatic invertebrates, drink pit water, and could roost in crevices along the pit highwall. This species would also represent potential listed and protected bats present in the County. Bats could also serve as prey to predators.

- **Mallard Duck (*Anas platyrhynchos*)** - Represents waterfowl and omnivorous birds (a secondary consumer) that would consume aquatic plants and invertebrates, drink pit water, and may rest on the pit water surface.

- **Pronghorn Antelope (*Antilocapra americana*)** - Represents herbivorous mammals (a primary consumer) that may drink the pit water. This species also represents big game.

- **Red-tailed Hawk (*Buteo jamaicensis*)** - Represents carnivorous predatory raptors (a tertiary consumer) that would consume wildlife prey in the pit environment, consume pit water, and could nest on the pit highwall. This species would also represent listed and protected raptors that could be present in the County.

- **Livestock** - Exposures and risk to beef cattle were computed because there is livestock grazing in the area. UNC plans to fence access points around Pit 1 to prevent livestock access. However, if the fencing is not effective in preventing occasional access, or final closure plans do not include fencing, risks to livestock were determined for planning purposes.

3.0 RADIOLOGICAL RISK MODEL

3.1 Available Guidance

The U.S. Department of Energy (DOE) developed a graded approach for evaluating ionizing radiation risks to biota (DOE 2002). The basic approach is to compare an environmental medium concentration to a limiting concentration, called a Biota Concentration Guide (BCG), which represents the upper concentration limit of a radionuclide in soil, sediment, or water that would not exceed an effect threshold for protection of populations of biota. The ratios of each COI to BCG are summed per media to estimate risk. No risk is assumed where summed constituents are less than one. In the simplest step, media is compared to screening level BCGs developed by DOE. More detailed steps involve modifying the BCGs with a limited range of variables offered in the companion RAD-BCG calculator developed by DOE. The variables offered are thought to reflect variations between sites, such as exposure duration. However, the basic DOE model and companion calculator are limited in the types of receptors considered and their exposure pathways.

The Los Alamos National Laboratory (LANL) used a similar approach in its development of Ecological Screening Levels (ESLs). LANL developed an open-source ECORISK Database as a screening tool to evaluate impacts on biota from chemicals and radionuclides in soil, water, sediment, and air. ESLs, like BCGs, are the upper limit concentrations that would not result in risk to an ecological receptor. In LANL's database, more receptors are considered, as are more exposure pathways, at least for soil-based exposures, such as different intake rates and diets for birds and mammals. However, LANL did not consider trophic web complexities when developing water-based ESLs. Water-based ESLs only consider water consumption by wildlife (no trophic transfer). Multimedia exposures are also not considered (e.g., sediment plus water). Thus, the ESLs can be used to screen COIs, primarily for soil, but would not address all of the exposure pathways for the Pit 1 environment.

NMED also developed radiological effect screening-levels (RESLs) to screen for ecological risks posed by radionuclides (NMED 2000). The NMED guidance is based on the approach used by USEPA for soil screening guidance (USEPA 1996). Like LANL, RESLs are derived for sediment, water, and soil using both No Observed Radiological Effect Levels (NORELs) and Low Observed Radiological Effect Levels

(LORELs). Like LANL, RESLs do not address water to wildlife exposure or trophic transfer. Water RESLs address potential risks to fish and aquatic life, specifically.

3.2 General Approach

For this assessment, the DOE approach was used to characterize risks. Limiting concentrations, termed in this ERA as Wildlife Threshold Value (WTVs), were calculated by first setting a target wildlife dose and then back-calculating to the medium concentration necessary to produce the applicable dose from radionuclides in the organism (internal dose), plus the external dose components from radionuclides in the environment (external dose). The WTVs were derived for each media, COI, and receptor.

$$Limiting\ Concentration\ (WTV) = \frac{Target\ Wildlife\ Dose}{(Internal\ Dose\ Rate) + (External\ Dose\ Rate)}$$

Similar to approaches used by LANL and NMED, both NORELs and LORELs are considered in computations of risk. A NOREL-based wildlife target dose for radionuclides is 0.1 absorbed radiation dose per day (rad/d) (IAEA 1992). Dose rates below this limit are thought to cause no measurable adverse effects to populations of plants and animals. Limiting concentrations were also computed using a LOREL-based wildlife target dose of 1 rad/d. Dose rates above this limit would be more likely to cause a measurable adverse effect.

Cumulative wildlife risks from exposures to COIs in soil, sediment, water, incorporating exposures by trophic transfer, were then summed for each COI and environmental medium. In the risk characterization step, these ratios were summed and compared to a threshold of 1. Wildlife would not be at risk if the summed risks were less than 1, i.e.,

$$\left[\frac{C_A}{WTV_A} + \frac{C_B}{WTV_B} + .. \frac{C_N}{WTV_N}\right]_{Soil} + \left[\frac{C_A}{WTV_A} + \frac{C_B}{WTV_B} + .. \frac{C_N}{WTV_N}\right]_{Water} + \left[\frac{C_A}{WTV_A} + \frac{C_B}{WTV_B} + .. \frac{C_N}{WTV_N}\right]_{Highwall} < 1.0$$

Where concentrations (C) of radionuclides A, B, ... N are compared to corresponding WTV values WTV_A, WTV_B, ... WTV_N. If the sum of fractions (the summed ratios between the radionuclide concentrations in environmental media and the radionuclide specific WTVs) is less than 1.0, the dose to a receptor is below the biota dose limit, and therefore no adverse effects would be expected.

3.3 Exposure Model Inputs

3.3.1 Media Concentrations

As described in Section 2.1, Pit 1 currently captures groundwater in the Jackpile sandstone via a cone of depression that has developed in response to the evaporation of water from the pit. Naturally-occurring, uranium-rich mineralized zones in the Jackpile sandstone influence groundwater chemistry by releasing uranium, radium, and other constituents. Although Pit 1 will be partially backfilled, the chemistry of the groundwater that will express at the bottom of Pit 1 in the future is expected to be similar to current conditions measured in Pit 1 prior to the STPP pilot test. These measured Pit 1 concentrations would therefore be representative of undisturbed expressed water conditions over the 30-year period after mine closure.

Future Pit 1 sediments and soils will be created by placing loose material from the Pit 1 highwalls into the pit, overlain by soil borrow materials from the West Borrow Area and North Topsoil Pile. Wildlife receptors would therefore be exposed to the borrow area and topsoil piles. Both maximum and average exposure concentrations for surface water and soil/sediment media were computed from the following data previously collected at the Site:

- Pit water data reported in INTERA (2015) between years 2008 and 2010, and untreated water from a pilot study reported in INTERA (2020), were used for surface water model inputs. Table 3-1 shows the surface water concentrations used for the risk model.

- The planned soil backfill materials, characterized by MWH (2007), Stantec (2018), and Stantec (2023) were used for sediment and soil inputs (Table 3-2). Table 3-2 also includes calculated concentrations of selenium and uranium (mg/kg) reported from MWH (2007) and Stantec (2022) for the non-radiological risk model (see Section 4.0).

Exposed bedrock stratigraphy along the pit highwall include Jackpile and Dakota sandstones and Mancos shale. As described in Section 2.3, nesting raptors and birds, and roosting bats would most likely be exposed to radiation associated with the Mancos shale or Dakota sandstone. Isotope concentrations associated with these formations were estimated from material characterized in the 2018 Geotechnical Investigation (Stantec 2018). Piles 1 and 2 characterize shale piles, which would be similar to the Mancos Shale and assumed to be similar to Dakota sandstone.

It is less likely that birds would build nests on the Jackpile sandstone, because the formation is low to the ground, or that bats would roost in this formation, given the lack of deep crevices. However, there are concerns expressed by agencies regarding Jackpile risks to wildlife. Therefore, risks to nesting birds and bats from Jackpile exposure were also modeled. Isotope concentrations associated with the Jackpile sandstone were estimated from samples collected from ore, mine materials, and precipitates in Pit 1 (INTERA 2015) thought to represent materials derived largely from Jackpile sandstone. The samples used for the estimates included SALP-12-01, SALP-12-02, SALP-12-04, and SALP-12-05. These samples are described as having a range of variability in color and texture observed in the Jackpile sandstone within the pit (SALP-12-04 and 05), a sample corresponding to a high gamma meter reading (SALP 12-01), and an example of uranium mineral surface precipitate (SALP-12-02) (INTERA 2015). These samples are thought to represent the highest potential gamma meter readings and therefore may overestimate COI concentrations for the exposed Jackpile in general. A correlation analysis was completed by AVM (2023) to estimate Ra-226 concentrations, and other isotope levels were estimated from data presented in INTERA (2015).

Exposure concentration data for highwall exposures are summarized in Table 3-3.

3.3.2 Wildlife and Livestock Exposure Parameters

Body weights, ingestion rates, and other species-specific exposure conditions for wildlife and livestock receptors were compiled based on empirical data available in the literature, or else estimated using models presented in USEPA (1993). Tables 3-4 through 3-11 summarize these parameters.

Ingestion rates are based on the conservative assumption that wildlife and livestock will use the pit for all of their water and food needs for the entire year. This assumption is rarely the case for wildlife species, even in arid environments near perennial sources (Morgart et al. 2005, Bleich et al. 2010), as seasonal patterns of wildlife and other behaviors limit species' use of a single water body. It is also highly unlikely that cattle would use the Pit 1 environment as a sole source of drinking or food. As also discussed in Section 2.2, the saline nature of the water in Pit 1 may also limit wildlife and livestock uses of the pit for long-term drinking needs.

3.3.3 Transfer Factors and other Model Inputs

Transfer factors are used to calculate the transfer of radionuclide activity levels from one media to the next, for example, how many pico-curies of Ra-226 per gram of soil are transferred to the edible parts of a plant. Transfer factors used in the ERA are based on published literature studies. Literature references are provided by media in Section 3.4.

Plant uptake of COIs occurs through the root-soil pore water (or root-sediment pore water) interface. In addition, emerging scientific evidence indicates that pore water is a more relevant exposure medium for uptake of chemicals by sediment-dwelling invertebrates (e.g., Peijnenburg et al. 2012, Gerzabek et al. 1998). Future pore water concentrations in saturated soils or sediments will be affected by pit water inundation, which will affect the exposure environment of aquatic plants and sediment-dwelling invertebrates. Because the exact concentration to which aquatic plant roots or sediment-dwelling invertebrates may be exposed in the future Pit 1 environment is unknown, exposure concentrations used to compute aquatic plant and invertebrate uptake were assumed to be equal to the maximum concentration of Pit 1 water.

Other model inputs include radionuclide retention times, and internal and external Dose Conversion Factor (DCFs). Retention times are COI-specific based on the longevity of each receptor. Receptor longevity estimates and retention times are shown in Table 3-12. DCFs were obtained from DOE (2002) as referenced in the next section.

3.4 Wildlife Threshold Value Computations

The equations to estimate WTVs by media are as follows:

The equation to derive the WTV for Soil/Sediment is the following **(Equation 1)**:

$$WTV_{Soil} = \frac{Wildlife\,Target\,Dose}{\left[\left[\left[IR_{Soil} + \left[(TF_{Ter\_Invert} \times IR_{Ter\_Invert}) + (TF_{Ter\_Plant} \times IR_{Ter\_Plant}) + (TF_{Ter\_Prey} \times IR_{Ter\_Prey})\right]\right] \times TF_{Blood\_Ter} \times RT \times DCF_{Int}\right] + (DCF_{Ext} \times Deg_{Soil})\right]}$$

Where:

Variable	Units	Description	Source of Data
WTVSoil	pCi-COI/g-dry soil	The concentration-based Wildlife Threshold Value for soil (or sediment), pCi/g.	Calculated, Equation 1.
Wildlife Target Dose	rad/d	The target dose to wildlife below which adverse effects would not be expected (NOREL) is 0.1 rad/d, and above which low effects would be measurable (LOREL) is 1 rad/d.	IAEA (1992).
DCFInt	rad/d per pCi-COI/g-fresh tissue	Internal dose conversion factor.	Table 2.4 from DOE Module 3, Part 1, with progeny (DOE 2002).
DCFExt	rad/d per pCi-COI/g-dry soil	External dose conversion factor.	Table 2.3 from DOE Module 3, Part 1, with progeny (DOE 2002).
DegSoil	Fraction (unitless)	Degrees of exposure to soil – either 180 (fraction = 0.5) or 360 (fraction = 1) degree exposure.	Receptor-specific; see Wildlife Exposure Tables.

Variable	Units	Description	Source of Data
$\mathbf{IR}_{Soil}$	g dry soil/g BW-day	Daily ingestion rate of soil (or sediment) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Ter\_Plant}$	g fresh plant matter/g BW-day	Daily ingestion rate of terrestrial plants (in wet weight or fresh plant matter) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Ter\_Invert}$	g fresh invertebrates/g BW-day	Daily ingestion rate of terrestrial invertebrates (in wet weight or "fresh" weight) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Ter\_Prey}$	g fresh tissue/g BW-day	Daily ingestion rate of terrestrial-based animal prey (in wet weight or "fresh" weight) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
Rt	days	Retention time, COI-specific based on the longevity of a receptor.	Based on calculation in LANL (2022), see Table 3-12.
$\mathbf{TF}_{Blood\_Ter}$	unitless	Terrestrial-based food to blood transfer factor.	Calculated, Equation 2.
$\mathbf{TF}_{Ter\_Plant}$	unitless	Soil to terrestrial plant transfer factor.	IAEA (2014)
$\mathbf{TF}_{Ter\_Invert}$	unitless	Soil to terrestrial invertebrate transfer factor.	IAEA (2014)
$\mathbf{TF}_{Ter\_Prey}$	unitless	Soil to terrestrial-based prey transfer factor.	Calculated, Equation 3.

The equation to calculate the terrestrial-based food ingestion rate to blood transfer factor is **(Equation 2):**

$$TF_{Blood\_Ter} = \left[\left(IR_{Ter\_Food} \times BW\right) + \left(IR_{Soil} \times BW\right)\right] \times TF_{Beef}$$

Where:

Variable	Units	Description	Source of Data
TFBlood_Ter	unitless	Terrestrial-based food to blood transfer factor.	Calculated, Equation 2.
IRTer_Food	g fresh matter/g BW-day	Ingestion rate of all terrestrial-based food items.	Receptor-specific; see Wildlife Exposure Tables.
IRSoil	g dry soil/g BW-day	Daily ingestion rate of soil (or sediment) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
BW	kg	Body weight.	Receptor-specific; see Wildlife Exposure Tables.
TFBeef	pCi-COI/kg-fresh beef per pCi-COI/d or d/kg-fresh beef	Transfer factor from soil to beef.	Wang et al. (1993)

The transfer factor from prey to consumer is calculated by **(Equation 3)**:

$$TF_{Ter\_Prey} = TF_{Beef} \times \left[\left(IR_{Ter\_Plant} \times TF_{Ter\_Plant}\right) + \left(IR_{Ter\_Invert} \times TF_{Ter\_Invert}\right)\right]$$

Where:

Variable	Units	Description	Source of Data
$\mathbf{TF}_{Ter\_Prey}$	unitless	Soil to terrestrial-based prey transfer factor.	Calculated, Equation 3.
$\mathbf{TF}_{Beef}$	pCi-COI/kg-fresh beef per pCi-COI/d or d/kg-fresh beef	Transfer factor from soil to beef.	Wang et al. (1993)
$\mathbf{IR}_{Ter\_Plant}$	g fresh plant matter/g BW-day	Daily ingestion rate of terrestrial plants (in wet weight or fresh plant matter) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Ter\_Invert}$	g fresh invertebrates/g BW-day	Daily ingestion rate of terrestrial invertebrates (in wet weight or "fresh" weight) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{TF}_{Ter\_Plant}$	unitless	Soil to terrestrial plant transfer factor.	IAEA (2014)
$\mathbf{TF}_{Ter\_Invert}$	unitless	Soil to terrestrial invertebrate transfer factor.	IAEA (2014)

All consumers of bird and mammal prey are assumed to ingest 50% prey that consume a terrestrial-based diet of plants and invertebrates, and 50% prey that consume an aquatic-based diet. The deer mouse is selected as the representative receptor with an terrestrial-based diet..

The equation to derive the WTV for the surface water that will express in Pit 1 is the following **(Equation 4)**:

$$WTV_{Water} = \frac{Wildlife\ Target\ Dose}{\left[\left[\left[IR_{Water} + \left[(TF_{Aq\_Invert} \times IR_{Aq\_Invert}) + (TF_{Aq\_Plant} \times IR_{Aq\_Plant}) + (TF_{Aq\_Prey} \times IR_{Aq\_Prey})\right]\right] \times TF_{Blood\_Aq} \times RT \times DCF_{Int}\right] + (DCF_{Ext} \times Deg_{Water})\right]}$$

Where:

Variable	Units	Description	Source of Data
WTVWater	pCi-COI/L water	The concentration-based Wildlife Threshold Value for pit water, pCi/L.	Calculated, Equation 4.
Wildlife Target Dose	rad/d	The target dose to wildlife below which adverse effects would not be expected (NOREL) is 0.1 rad/d, and above which low effects would be measurable (LOREL) is 1 rad/d.	IAEA (1992)
DCFInt	rad/d per pCi-COI/g-fresh tissue	Internal dose conversion factor.	Table 2.4 from DOE Module 3, Part 1, with progeny (DOE 2002).
DCFExt	rad/d per pCi-COI/mL-water	External dose conversion factor.	Table 2.3 from DOE Module 3, Part 1, with progeny (DOE 2002). Assume external radiation from water is same as soil.

Variable	Units	Description	Source of Data
$\mathbf{Deg}_{Water}$	Fraction (unitless)	Degrees of exposure to pit water – either 180 (fraction = 0.5) or 360 (fraction = 1) degree exposure.	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Water}$	mL water/g BW-day	Daily ingestion rate of water per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Aq\_Plant}$	g fresh plant matter/g BW-day	Daily ingestion rate of aquatic plants (in wet weight or fresh plant matter) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Aq\_Invert}$	g fresh invertebrates/g BW-day	Daily ingestion rate of aquatic invertebrates (in wet weight or "fresh" weight) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
$\mathbf{IR}_{Aq\_Prey}$	g fresh tissue/g BW-day	Daily ingestion rate of aquatic-based animal prey (in wet weight or "fresh" weight) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
Rt	days	Retention time, COI-specific based on the longevity of a receptor.	Based on calculation in LANL (2022), see Table 3-12.
$\mathbf{TF}_{Blood\_Aq}$	unitless	Aquatic-based food to blood transfer factor.	Calculated, Equation 5.
$\mathbf{TF}_{Aq\_Plant}$	unitless	Aquatic plant transfer factor.	IAEA (2014). Therefore, soil-to plant uptake factors are used to estimate TFAq_Plant; see Section 3.3.3.

Variable	Units	Description	Source of Data
TFAq_Invert	unitless	Water to terrestrial invertebrate transfer factor.	Baker and Soldat (1992)
TFAq_Prey	unitless	Water to aquatic-based prey transfer factor.	Calculated, Equation 6.

The equation to calculate the aquatic-based food ingestion rate to blood transfer factor is **(Equation 5):**

$$TF_{Blood\_Aq} = \left[\left(IR_{Aq\_Food} \times BW\right) + \left(IR_{Water} \times BW\right)\right] \times TF_{Beef}$$

Where:

Variable	Units	Description	Source of Data
TFBlood_Aq	unitless	Aquatic-based food to blood transfer factor.	Calculated, Equation 2.
IRAq_Food	g fresh matter/g BW-day	Ingestion rate of all aquatic-based food items.	Receptor-specific; see Wildlife Exposure Tables.
IRWater	mL water/g BW-day	Daily ingestion rate of water per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
BW	kg	Body weight.	Receptor-specific; see Wildlife Exposure Tables.
TFBeef	pCi-COI/kg-fresh beef per pCi-COI/d or d/kg-fresh beef	Transfer factor from soil to beef.	Wang et al. (1993).

The transfer factor from aquatic-based prey to consumer is calculated by **(Equation 6)**:

$$TF_{Aq\_Prey} = TF_{Beef} \times [(IR_{Aq\_Plant} \times TF_{Aq\_Plant}) + (IR_{Aq\_Invert} \times TF_{Ter\_Invert})]$$

Variable	Units	Description	Source of Data
TFAq_Prey	unitless	Water to aquatic-based prey transfer factor.	Calculated, Equation 6.
IRAq_Plant	g fresh plant matter/g BW-day	Daily ingestion rate of aquatic plants (in wet weight or fresh plant matter) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
IRAq_Invert	g fresh invertebrates/g BW-day	Daily ingestion rate of aquatic invertebrates (in wet weight or "fresh" weight) per gram of body weight (BW).	Receptor-specific; see Wildlife Exposure Tables.
TFAq_Plant	unitless	Aquatic plant transfer factor.	IAEA (2014).
TFAq_Invert	unitless	Water to terrestrial invertebrate transfer factor.	Baker and Soldat (1992).

All consumers of bird and mammal prey are assumed to ingest 50% prey that consume a terrestrial-based diet of plants and invertebrates, and 50% prey that consume an aquatic-based diet. The little brown bat is selected as the representative receptor with an aquatic-based diet.

The equation to derive a WTV for exposures to the highwall is calculated as **(Equation 7)**:

$$WTV_{HW} = \frac{Wildlife\ Target\ Dose}{[(DCF_{Ext} \times Deg_{HW})]}$$

Where:

Variable	Units	Description	Source of Data
WTV$_{HW}$	pCi-COI/g	The concentration-based Wildlife Threshold Value for pit highwall, pCi/g.	Calculated, Equation 7.
Wildlife Target Dose	rad/d	The target dose to wildlife below which adverse effects would not be expected (NOREL) is 0.1 rad/d, and above which low effects would be measurable (LOREL) is 1 rad/d.	IAEA (1992).
DCF$_{Ext}$	rad/d per pCi-COI/g-dry material	External dose conversion factor.	Table 2.3 from DOE Module 3, Part 1, with progeny (DOE 2002).
Deg$_{HW}$	Fraction (unitless)	Degrees of exposure to the pit highwall – either 180 (fraction = 0.5) or 360 (fraction = 1) degree exposure.	Receptor-specific; see Wildlife Exposure Tables.

4.0 NON-RADIOLOGICAL RISK MODEL

For non-radiological COIs, the approach used to characterize risk followed guidance in USEPA (1993). Risks were characterized by computing the ratios of estimated daily wildlife dose over Toxicity Reference Values (TRVs). This ratio is referred to as a Hazard Quotient (HQ). HQ values were computed for each COI and receptor, and then summed per receptor to estimate cumulative non-radiological risks. The summed value is referred to as a Hazard Index (HI). The exposure model, model inputs, and TRVs, are described below.

4.1 Non-Radiological Wildlife Exposure Model

Exposures by wildlife to non-radiological COIs was modeled using the dose equation from USEPA (1993). The equation is **(Equation 8)**:

$$Dose = \frac{\left[\left(IR_{food} x C_{food}\right) + \left(IR_{water} x C_{water}\right) + \left(IR_{soil} x C_{soil}\right)\right]}{BW}$$

Where:

Variable	Units	Description	Source of Data
Dose	mg/kg BW/day	Estimated daily dose of COI from ingestion	Calculated, Equation 8.
IRwater	L-day	Daily ingestion rate of water.	Receptor-specific; see Wildlife Exposure Tables.
IRfood	kg wet-day	Daily ingestion rate of food items, including invertebrates, plants, or prey.	Receptor-specific; see Wildlife Exposure Tables.
IR$_{soil}$	kg dry-day	Amount of soil or sediment incidentally ingested per day (wet weight assumed to be the same as dry weight).	Receptor-specific; see Wildlife Exposure Tables.
Cwater	mg/L	Concentration of a COI in water.	Mean of detected concentrations for metal COIs, see Table 2-1.

Variable	Units	Description	Source of Data
C_{food}	mg/kg	Concentration of a COI in food.	Estimated with bioaccumulation factors, see Section 4.1.
C_{soil}	mg/kg	Concentration of a COI in soil or sediment.	See Table 3-2.

4.2 Food Exposure Estimates

Concentrations of COIs in plants, invertebrates, and prey were estimated using bioaccumulation factors. BAFs describe the relationship between COIs environment and uptake into biota. BAFs for these items were obtained from studies that measured organism bioaccumulation from similar media where possible. BAFs used for selenium and uranium are summarized in Table 3-13.

As described in Section 3.3.3, COI uptake by rooted aquatic plants and sediment-dwelling invertebrates is more directly correlated to sediment pore water concentrations. Future pore water concentrations in saturated soils or sediments will be affected by pit water inundation, which will affect the exposure environment of plant roots and sediment-dwelling invertebrates. Because the exact concentration to which aquatic plant roots or sediment-dwelling invertebrates may be exposed in the future Pit 1 environment is unknown, exposure concentrations used to compute aquatic plant and invertebrate uptake were assumed to be equal to the maximum concentration of Pit 1 water.

Concentrations in food items are calculated using the following equation **(Equation 9)**:

$$C_{food-k} = C_{media} \; x \; BAF_k$$

Where:

Variable	Units	Description	Source of Data
C_{food-k}	mg/kg	Concentration of a COI in food item k (k is receptor specific; see Wildlife Exposure Tables).	Calculated using Equation 9.

Variable	Units	Description	Source of Data
C_{media}	mg/kg or mg/L	Concentration in the exposure media (soil, sediment, mg/kg, or water, mg/L)	See references for Equation 8.
BAF_k	unitless	bioaccumulation factor for the kth food item	Table 3-13.

4.3 Wildlife Threshold Values for Metals

Wildlife TRVs were obtained from dose-based TRVs for birds and mammals in LANL (2022). TRVs are estimates of exposure levels below which unacceptable adverse effects are not expected to occur. Table 3-14 summarizes the TRVs used in the ERA for selenium and uranium.

5.0 RISK CHARACTERIZATION

5.1 Results and Discussion

Computations of NOREL and LOREL-based WTVs for soil/sediment, water and highwall are presented in Table 4-1, Table 4-2, and Table 4-3, respectively. HQ and HI computations of non-radiological COIs are shown in Table 4-4.

Non-radiological HQs and the HI are all less than 1, indicating no risk to wildlife or livestock receptors from exposures to selenium or uranium mass in the Pit 1 environment.

A base case was chosen to characterize the risks of radiological COIs. The base case included comparing maximum estimated concentrations of highwall, soil/sediment, and pit water to NOREL-based WTVs. Values for the Mancos shale and Dakota sandstone were used to estimate pit highwall exposures. The ratios of exposure concentrations to NOREL WTVs were then computed, summed by COI and media, and compared to the risk threshold of 1.0. The results of these base case computations are shown in Table 4-5. Risk computations comparing base case exposures to LOREL-based risk ratios are shown in Table 4-6.

Ratios less than 1 indicate that risk is unlikely to occur for that receptor. Ratios greater than 1 indicate a possibility of risk. NOREL-based WTVs are determined based on a threshold below which risk is unlikely; therefore, exposure concentrations above these thresholds suggest a potential risk, but do not indicate risk is certain. LOREL-based WTVs are determined based on a threshold above which risk is likely; therefore, exposure concentrations above these thresholds indicate likely risk.

As shown in Table 4-5 and Table 4-6, both NOREL and LOREL-based risk ratios are all less than 1, indicating no expected risk for wildlife or livestock from exposures to the Pit 1 environment.

It is less likely that birds would nest on Jackpile sandstone areas of the highwall or that bats would roost in this formation. However, bird nesting behavior and bat use on exposed Jackpile is an uncertainty. Therefore, potential risks to birds and bats to estimated concentrations associated with Jackpile sandstone were also compared to

NOREL and LOREL-based WTVs, as shown in Table 4-7 and Table 4-8, respectively. Maximum estimated concentrations in the Jackpile sandstone were used for the computations. As discussed above in Section 3.3.1, the maximum concentrations were estimated based on samples collected from mine materials and precipitates thought to represent higher than average Jackpile COI concentrations and therefore are considered very conservative. Comparisons of exposure to NOREL-based WTVs indicate risk ratios greater than 1 for birds and bats who might nest or roost directly on the Jackpile formation. Using the LOREL-based WTV, risk ratios are less than 1. The interpretation of these computations is that risks to nesting birds or roosting bats, if they nest directly on the Jackpile sandstone, is possible but is not certain. It is also noted that the estimated radioactivity levels along this bench are approximate, as direct measurements could not be made due to the angle of the formation and safety issues in accessing this area (ERG 2021).

5.2 Uncertainties

Quantitative estimates of risk inherently contain artifacts of uncertainty due to chemical, environmental, and biological variability. Typical uncertainties associated with dose-based risk assessments are described in DOE, NMED and USEPA guidance documents in detail and not reiterated in detail here. These documents generally identify the following sources of uncertainties: limited data from the literature or laboratory on wildlife ecology and effects levels, and uncertainties with exposure assumptions including variability of exposures to environmental media and limited studies on species-specific transfer factors.

There are two types of error rates in any quantitative estimate of risk: Type I and II. A Type I error is also known as a false positive and occurs when a researcher incorrectly rejects a true null hypothesis. In application, this would mean that the risk assessment reports findings as significant when in fact they have not occurred. A Type II error is also known as a false negative and occurs when a researcher fails to reject a null hypothesis which is really false. In application this would mean that the risk assessment reports that there is not a significant effect when, in actuality, there is. In modeled predictions of risk, a Type I error is preferable over a Type II error. Hence this risk assessment incorporated conservative exposure estimates including 100% Site use by all receptors on a year-round, life-long basis. The high salinity and fluctuating nature of groundwater expression at the surface in the base of Pit 1 may limit its use as a source of drinking water to potential receptors and the trophic food web that could develop. However, it was assumed nevertheless that a robust trophic web could develop and wildlife would use Pit 1 as the sole source of food and water. These assumptions are consistent with a Type I error approach but likely overestimate wildlife and livestock exposures.

Pit 1 highwall concentrations were estimated based on limited data and are therefore a source of uncertainty. Different exposure conditions were evaluated, including exposures to maximum concentrations in Mancos Shale and Dakota Sandstone, or exposures to maximum concentrations in the Jackpile Sandstone. As noted in Section 5.1, based on the samples that were used for estimating concentrations which targeted certain conditions, estimated radioactivity levels along this bench are approximate and likely higher than average concentrations..

This risk assessment estimated future concentrations for sediments and future expressed water in Pit 1 based on current mass measurements made in borrow fill and Pit 1 water, respectively. The interaction between groundwater and backfill soil may affect future sediment concentrations (or concentrations in future expressed water), which in turn affect estimated uptake by aquatic plants or sediment-dwelling invertebrates, or direct exposures to receptors. In base case computations, it was assumed that sediment-dwelling invertebrates and plants rooted in sediments or saturated soils would be exposed to concentrations in the soil pore water that are equal to maximum pit water COI concentrations (for both radiological and non-radiological COIs). Transfer factors and BAFs are also a source of uncertainty in ERA models. Literature-based equations were used to estimate concentrations in plants, invertebrates, and prey that may then be ingested, which may over or under-estimate concentrations in ingested food items.

The effects on wildlife of physical environmental conditions were not examined in depth in this risk assessment and can affect the kind of species present and the duration of exposure. Exposures to Jackpile sandstone, for example, are thought to be limited due to the physical elevation and lack of deep crevices.

Effects limits were based on IAEA (1992), which proposed conservative limits based on limited empirical studies. Toxicological data are, in many cases, absent for most representative species, and extrapolation from the available toxicity data to specific receptors is a source of uncertainty. Uncertainty factors were applied to threshold estimates in IAEA. There is little consensus on the appropriate use and magnitude of uncertainty factors in the derivation of effects levels. The use of uncertainty factors in general is inherently conservative and therefore is more likely to overestimate rather than underestimate risk. There are no benchmarks or thresholds available for radon gas risks to ecological receptors. This exposure pathway remains an uncertainty for risk to ecological receptors.

5.3 Conclusion

The results of this ERA indicate that wildlife and livestock are not at risk from exposure to the Pit 1 environment. No risk was predicted from exposure to radiological and non-radiological constituents to livestock or wildlife that may eat or drink in the Pit 1 environment, or nest or roost along Mancos shale or Dakota sandstone areas of the Pit 1 highwall, or otherwise use the Pit 1 environment.

A supplemental evaluation for the Pit 1 highwall indicates a very slight potential for risk to nesting birds or roosting bats if they nest or roost directly on exposed Jackpile formation in Pit 1. Because conservatively estimated Jackpile sandstone concentrations of radiological COIs were slightly greater than NOREL-based WTVs, the potential for risk could not be completely ruled out. However, LOREL-based risk estimates to birds and bats from Jackpile sandstone exposures indicate risk is not certain and given the physical position relative to the ground and lack of deep crevices in the formation, it is unlikely that birds or bats would use the Jackpile sandstone.

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Tables

Table 2-1. Initial Screening of Non-Radiological Constituents in Pit Water

Constituent	Pit Water Sample Statistic (mg/L) (a)					New Mexico SWQC, mg/L (b)			Determination
	Maximum Reported	Maximum Detected	Mean of Detections	Number of Samples	Number of Non-detects	Aquatic Life (total rec.)	Aquatic Life (diss.)	Livestock & Wildlife (d)	
Aluminum	<3	0.1	NC	28	25	4.035	NS (c)	NS	Screened out. Maximum detected is less than NMAC criteria.
Arsenic	0.03	0.03	NC	28	18	NS	0.15	0.2	Screened out. Maximum detected is less than NMAC criteria.
Barium	<0.4	0.1	NC	22	10	NS	NS	NS	Screened out. No NMAC criteria available, maximum detected is below NRC (2005) criteria for animals.
Beryllium	<0.05	ND	NC	17	17	NS	NS	NS	Screened out. Constituent not detected.
Boron	4.4	4.4	2.2	27	0	NS	NS	5.0	Screened out. Maximum detected is less than NMAC criteria.
Cadmium	<0.1	ND	NC	19	19	NS	0.00122	0.05	Screened out. Constituent not detected.
Chloride	720	720	372.2	10	0	230	NS	NS	Supplemental analysis. See discussion in report.
Chromium	<1	ND	NC	17	17	NS	0.23	1.0	Screened out. Constituent not detected.
Cobalt	<0.5	ND	NC	14	14	NS	NS	1.0	Screened out. Constituent not detected.
Copper	0.1	0.1	NC	18	17	0.0293	0.029	0.5	Screened out. Maximum detected is less than NMAC criteria.
Fluoride	<10	1.5	1.1	19	11	NS	NS	NS	Screened out. No NMAC criteria available, maximum detected is below EPA livestock criteria of 2 mg/L.
Iron	4.6	4.6	0.6	27	17	1.0	NS	NS	Supplemental analysis. See discussion in report.
Lead	<0.05	ND	NC	19	19	NS	0.011	0.1	Screened out. Constituent not detected.
Manganese	0.5	0.5	NC	27	22	NS	2.62	NS	Screened out. Maximum detected is less than NMAC criteria.
Mercury	<0.001	ND	NC	15	15	0.00077	NS	0.00077	Screened out. Constituent not detected.
Molybdenum	<0.1	ND	NC	21	21	NS	1.8	NS	Screened out. Constituent not detected.
Nickel	<0.1	ND	NC	18	18	NS	0.17	NS	Screened out. Constituent not detected.
Nitrate/Nitrite	<4	ND	NC	10	10	NS	NS	132	Screened out. Constituent not detected.
Selenium	0.1	0.1	0.02	18	7	0.005	NS	0.05	**Carried through for detailed analysis.**
Silver	<0.1	ND	NC	18	17	NS	0.035	NS	Screened out. Constituent not detected.
Strontium	12.0	12.0	NC	5	0	NS	NS	NS	Screened out. No available benchmarks.
Sulfate	68,300	68,300	28,913	24	0	NS	NS	NS	Supplemental analysis. See discussion in report.
TDS	90,900	90,900	49,875	24	0	NS	NS	NS	Supplemental analysis. See discussion in report.

Table 2-1. Initial Screening of Non-Radiological Constituents in Pit Water

Constituent	Pit Water Sample Statistic (mg/L) (a)					New Mexico SWQC, mg/L (b)			Determination
	Maximum Reported	Maximum Detected	Mean of Detections	Number of Samples	Number of Non-detects	Aquatic Life (total rec.)	Aquatic Life (diss.)	Livestock & Wildlife (d)	
Thallium	0.028	0.028	NC	11	9	NS	NS	NS	Screened out. No NMAC criteria available. Maximum detected is below aquatic life and wildlife ESLs in LANL.
Titanium	<0.03	ND	NC	5	5	NS	NS	NS	Screened out. Constituent not detected.
Uranium	17.0	17.0	8.4	30	0	NS	NS	NS	**Carried through for detailed analysis.**
Vanadium	<10	ND	NC	23	23	NS	NS	0.1	Screened out. Constituent not detected.
Zinc	<0.25	ND	NC	19	18	NS	0.428	25	Screened out. Constituent not detected.

Notes:

(a) Data reflects all samples from the Large Pit, Tables 2 and 5, Appendix F from Intera (2015), Large Pit A samples collected before the pilot test and Large Pit B samples from Intera (2020).

(b) Surface Water Quality Critera (SWQC) in NMAC 20.6.4.900, September 22, 2022 publication

(c) Aluminum chronic aquatic life criteria only applies to water <6.5.

All results and criteria shown in mg/L = milligrams per liter

NC = Not calculated

ND = not detected

NS = no standard

Ag, Al, Cd, Cr, Cu, Pb, Mn, Ni, Zn are hardness dependent. Al was calculated with a hardness of 220 mg/L, and other constituents calculated at 400 mg/L. Noted in NMAC: With the exception of aluminum, the equations are valid only for dissolved hardness concentrations of 0-400 mg/L. For dissolved hardness concentrations above 400 mg/L, the criteria for 400 mg/L apply. For aluminum the equations are valid only for dissolved hardness concentrations of 0-220 mg/L. For dissolved hardness concentrations above 220 mg/L, the aluminum criteria for 220 mg/L apply. Ag reflects acute criteria as no chronic criteria are availabe for this constituent.

Table 3-1. Pit Water Radiological Concentration Model Inputs

Statistic	Ra-226	Ra-228	U-234	U-235	U-238
	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L
Maximum Reported	49.0	24.0	*5,603.9*	*250.6*	*5,535.5*
Mean of Samples	20.1	3.6	*2,810.8*	*125.8*	*2,741.7*
Minimum Reported	9.5	0.4	725.2	32.4	716.4
Number of Samples	26	25	30	30	30

Notes:

pCi/L = picucuries per liter.

Isotopes of uranium (pCi/L) were estimated based on mass concentration of uranium (mg/L) reported and composition of natural uranium's radioactivity, approximately 2.2 percent U-235, 48.6 percent U-238, and 49.2 percent U-234 https://www.nrc.gov/reading-rm/basic-ref/glossary/natural-uranium.html. Estimated concentrations are shown in italics.

Data reflects all samples from the Large Pit, Tables 2 and 5, Appendix F from Intera (2015), Large Pit A samples collected before the pilot test and Large Pit B samples from Intera (2020).

The reported detection limit value was used to compute means for samples reported below detection limits.

Table 3-2. Sediment and Soil Concentration Model Inputs

Statistic	Ra-226	Ra-228	U-234	U-235	U-238	Selenium	Uranium
	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	mg/kg	mg/kg
Maximum Reported	1.15	*0.14*	*0.24*	*0.011*	*0.24*	0.0007	0.65
Mean of Samples	1.01	*0.12*	*0.19*	*0.009*	*0.19*	0.00055	0.56
Minimum Reported	<1	*<0.12*	*<0.2*	*<0.01*	*<0.2*	<0.005	0.46
Number of Samples	18	18	18	18	18	4	18

Notes:

pCi/g = picucuries per gram.

mg/kg = milligrams per kilogram.

Ra-228 concentrations were estimated assuming equilibrium with Ra-226.

Isotopes of uranium (pCi/g) were estimated based on mass concentration of uranium (mg/kg) reported and composition of natural uranium's radioactivity, approximately 2.2 percent U-235, 48.6 percentU-238, and 49.2 percent U-234 (https://www.nrc.gov/reading-rm/basic-ref/glossary/natural-uranium.html). Estimated concentrations are shown in italics.

Data reflects all samples from West Borrow Area and North Topsoil Pile (Stantec and Intera 2022), plus 2 samples in Borrow Area South and 5 samples from North Topsoil Pile (MWH 2007).

The reported detection limit value was used to compute means for samples reported below detection limits.

Table 3-3. Highwall Radiological Concentration Model Inputs

Statistic	Jackpile Sandstone				
	Table	Ra-228	U-234	U-235	U-238
	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Maximum Reported	*2,664.6*	*319.8*	*2,653.6*	*118.7*	*2,621.2*
Mean of Samples	*1,444.4*	*173.3*	*1,438.4*	*64.3*	*1,420.8*
Minimum Reported	*80.8*	*9.70*	*80.4*	*3.6*	*79.5*
Number of Samples	4	4	4	4	4

Statistic	Mancos Shale / Dakota Sandstone				
	Ra-226	Ra-228	U-234	U-235	U-238
	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Maximum Reported	16.1	*1.9*	*12.0*	*0.54*	*11.8*
Mean of Samples	5.2	*0.6*	*3.3*	*0.15*	*3.3*
Minimum Reported	0.9	*0.11*	*0.2*	*0.01*	*0.2*
Number of Samples	7	7	7	7	7

Notes:

pCi/g = picucuries per gram.

Isotopes of uranium (pCi/g) were estimated based on mass concentration of uranium (mg/kg) reported and composition of natural uranium's radioactivity, approximately 2.2 percent U-235, 48.6 percent U-238, and 49.2 percent U-234 (https://www.nrc.gov/reading-rm/basic-ref/glossary/natural-uranium.html). Estimated concentrations are shown in italics.

Jackpile Sandstone data reflects SALP 1, 2, 4, and 5 samples from Intera (2015). Ra-226 and Ra-228 estimated (AVM 2023).
Mancos Shale data reflects Pile 1 and 2 shale piles in Stantec (2018).

The reported detection limit value was used to compute means for samples reported below detection limits.

Table 3-4. Exposure Profile of the Cliff Swallow (*Petrochelidon pyrrhonota*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Nesting Habitat	--	--	Cliff faces, canyons, walls of bluffs, houses, barns, bridges, culverts	Terres 1980	Nests seasonally on pit wall face
Dietary Composition	df	fraction (wet volume)	Terrestrial and emergent aquatic insects (primarily *Hemiptera, Hymenoptera, Coleoptera, Diptera*) at all times of the year	Brown and Brown 1995	Assume 100% aquatic emergent insects: $df_{aqinv} = 1.0$
Body Weight	BW	kg wet weight	0.0216 - Both sexes; Range: 0.0175 - 0.0267	Dunning 1993	0.021
Food Ingestion Rate	IR_{food}	kg wet weight/day	Estimated using field metabolic rates and dietary composition approach: $IR_{food} = NFMR/ME_{avg}$	Estimated from USEPA 1993	0.018
Water Ingestion Rate	IR_{water}	L/day	$IR_{water} = 0.059\ BW^{0.67}$	Estimated from USEPA 1993	0.0045
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	Sediment ingestion assumed to be 2% during nest building period; nest building period covers up to 3 weeks, or 11% of their 6 month stay. Therefore, the	Brown and Brown 1995, Beyer et al. 1994	0.00001
Longevity	T_c	years	Longevity is 6 y 10 months6 y 10 m ~ 6.83 y = 2492.95 d ~ 2493 d.	Klimkiewicz 2000	6.8
External Exposures	Deg	fraction	Forages over surface of water = 180° exposure. Could nest on highwall = 180° exposure. Negligible exposures to surface of soil.	Based on animal ecology	$Deg_{soil} = 0$ $Deg_{water} = 0.5$ $Deg_{HW} = 0.5$
Exposure Duration	ED	percent of year	Seasonal resident in the southwest, spending breeding and nesting season throughout western North America	Terres 1980	Assume chronic exposure duration

References:

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Table 3-5. Exposure Profile of the Deer Mouse (*Peromyscus maniculatus*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Burrowing Habitat	--	--	Inhabits a variety of habitats including grasslands, grass-sage and sagebrush communities, and upland mixed forests.	USEPA 1993	Burrows in upland habitats
Dietary Composition	df	fraction (wet volume)	Deer mice are ominivorous; diet typically consists of nuts/seeds (43%), terrestrial insects/larvae (30%), forbs (5%), grasses (4%), fruits and fungus (18%).	USEPA 1993	$df_{terrinv}$ = .44, $df_{terrveg}$= .56
Body Weight	BW	kg wet weight	0.022 - Mean - Male; 0.02 - Mean - Female	USEPA 1993	Mean of means: 0.021
Food Ingestion Rate	IR_{food}	kg wet weight/day	0.278 g/g-day - Mean - Females; 0.215 g/g-day - Mean - Males	USEPA 1993	Mean of means (0.247 g/g-day), converted to kg/day based on a BW of 0.021: 0.0052
Water Ingestion Rate	IR_{water}	L/day	Estimated using the equation: $IR_{water} = 0.099\ BW^{0.90}$	USEPA 1993	0.0031
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	Beyer reported <2% for the white-footed mouse. It is assumed that the deer mouse is similar due to a similar diet. Ingestion rate estimated by: $IR_{soil} = IR_{food} * CF * SI$, where CF = 25%	Beyer 1994	0.000013
Longevity	T_c	years	Mean longevity is less than 1 year	USEPA 1993	1
External Exposures	Deg	fraction	Could burrow into soil = 360° exposure. Negligible exposures to surface of water or pit highwall.	Based on animal ecology	Deg_{soil} = 1 Deg_{water} = 0 Deg_{HW} = 0
Exposure Duration	ED	percent of year	Year-round resident, although torpor occurs in winter in northern parts of range	USEPA 1993	Assume chronic exposure duration

References:

Beyer, W.N., E.E. Connor and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J. Wildlife Management 58:375-382.

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Table 3-6. Exposure Profile of the Kit Fox (*Vulpes macrotis*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Habitat	--	--	Inhabits mixed-grass shrublands, shrublands, and margins of pinyon-juniper woodlands over much of the Southwest.	Meaney et al. 2006	Dens in upland environments
Dietary Composition	df	fraction (wet volume)	Mostly rodents and rabbits, especially kangaroo rats	Kelly et al. 2019	df_{mamm} = 1
Body Weight	BW	kg wet weight	Adult weight ranges from 1.5 to 2.5 kg.	Meaney et al. 2006	2
Food Ingestion Rate	IR_{food}	kg wet weight/day	Estimated using field metabolic rates and dietary composition approach: IR_{food} = NFMR/Meavg	USEPA 1993	0.095
Water Ingestion Rate	IR_{water}	L/day	Estimated using the equation: IRwater = 0.099 BW $^{0.90}$	USEPA 1993	1.85
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	No measured values available; estimated fraction of soil in the diet is 0.028 (2.8%).	Beyer et al., 1994	df_{soil} = 0.0009
Longevity	T_c	years	Life span 5 to 7 years	NDOW 2023	6
External Exposures	Deg	fraction	Could burrow into soil = 360° exposure. Negligible exposures to surface of water or pit highwall.	Based on animal ecology	Deg_{soil} = 1 Deg_{water} = 0 Deg_{HW} = 0
Exposure Duration	ED	percent of year	Assume year-round resident	NMED 2017	Assume chronic exposure duration

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Table 3-7. Exposure Profile of the Little Brown Bat (*Myotis lucifugus*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Roosting Habitat	--	--	River canyons, high elevation coniferous forests, mid elevation deciduous forests, underground caves and mines.	Ports and Bradley 1996	Roosts on pit walls
Dietary Composition	df	fraction (wet volume)	100% insects (aquatic)	Anthony and Kuntz 1977	Assume 100% aquatic invertebrates: dfaqinv = 1.0
Body Weight	BW	kg wet weight	Mean - 0.0073	Anthony and Kuntz 1977	0.0073
Food Ingestion Rate	IR_{food}	kg wet weight/day	0.0027 - Mean - females	Anthony and Kuntz 1977	0.0027
Water Ingestion Rate	IR_{water}	L/day	$IR_{water} = 0.099(BW)^{0.90}$	Estimated from USEPA 1993	0.0012
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	No sediment ingestion expected, food consists of aerial insects only.	Anthony and Kuntz 1977	0
Longevity	T_c	years	Life-span of 20 to 30 years and a longevity record of 34 years	Hofmann 2002	30
External Exposures	Deg	fraction	Forages over surface of water = 180° exposure. Could roost in highwall crevices = 360° exposure. Negligible exposures to surface of soil.	Based on animal ecology	$Deg_{soil} = 0$ $Deg_{water} = 0.5$ $Deg_{HW} = 1$
Exposure Duration	ED	percent of year	Year-round resident, although hibernation occurs during winter	Anthony and Kuntz 1977	Assume chronic exposure duration

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Table 3-8. Exposure Profile of the Mallard Duck (*Anas platyrhynchos*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Nesting Habitat	--	--	Bottomland wetlands, rivers, reservoirs and ponds in winter. Dense grassy vegetation at least one-half meter, usually within a few kilometers of water, for nesting.	USEPA 1993	May nest in riparian areas of pit environment.
Dietary Composition	df	fraction (wet volume)	Spring/Summer: 75% insects (aquatic), 25% plants (aquatic); Fall/Winter: 100% plants (aquatic and terrestrial, often croplands).	USEPA 1993	df_{aqinv} = .19, df_{aqveg} = .31; $df_{terrveg}$= 0.31; dfterrinv = .19
Body Weight	BW	kg wet weight	1.225 - Mean - Adult Male 1.043 - Mean - Adult Female 1.043 to 1.814 - Range	USEPA 1993	1.13
Food Ingestion Rate	IR_{food}	kg wet weight/day	Estimated using field metabolic rates and dietary composition approach: $IR_{food} = NFMR/ME_{avg}$	Estimated from USEPA 1993	Mallard, summer: 0.276; Mallard, winter: 1.83
Water Ingestion Rate	IR_{water}	L/day	$IR_{water} = 0.059\ BW^{0.67}$	Estimated from USEPA 1993	0.064
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	Ingestion of sed as percentage of food intake (kg sed dry weight/kg food dry weight) reported at 3.3%; $IR_{sediment} = IR_{food} * CF * SI$, where CF = 13% (year round avg)	Beyer et al. 1994	0.0007
Longevity	T_c	years	5 to 10 years	NDOW 2023	9
External Exposures	Deg	fraction	Could rest on water surface = 180° exposure. Negligible exposures to surface soil or pit highwall.	Based on animal ecology	Deg_{soil} = 0 Deg_{water} = 0.5 Deg_{HW} = 0
Exposure Duration	ED	percent of year	Seasonal, temporary, and year-round use is possible in arid regions of the west and southwest.	Alcorn 1988, Terres 1980	Assume chronic exposure duration

References:
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Table 3-9. Exposure Profile of the Pronghorn Antelope (*Antilocapra americana*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Habitat	--	--	Pronghorn occupy shortgrass to midgrass, mixed grass-shrub, and desert habitats.	Clemente et al. 1995	Grazes upland vegetation
Dietary Composition	df	fraction (wet volume)	Diet consists mainly of sagebrush and other shrubs, grasses, and forbs.	NMED 2017	df_{terrpl} = 1.0
Body Weight	BW	kg wet weight	Mature bucks weigh from 45 to 56 kg; does are about 10 percent smaller (NMFG 1992). Minimum reported adult body weight = 47 kg (O'Gara).	NMDFG 1992 O'Gara 1978	47
Food Ingestion Rate	IR_{food}	kg wet weight/day	The amount of air-dried forage needed to maintain an adult pronghorn averages 1.1 to 1.36 kg.	Ghan et al. 2017	1.2
Water Ingestion Rate	IR_{water}	L/day	May - 0.34 L/day; August - 4.5 L/day (Autenrieth 1978); Yearling male pronghorn needed 85.91 g/kg water per day (equiv of 4 L/day for a 47 kg pronghorn)	Autenrieth 1978	4
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	5.4% of the diet	Beyer et al. 1994	df_{soil} = 0.042
Longevity	T_c	years	Pronghorns can live to be as old as 12-14 years in the wild, but the average lifespan is probably less.	Texas Parks & Wildlife 2023	9
External Exposures	Deg	fraction	Grazes on surface of soil = 180° exposure. Negligible exposures to surface of water or pit highwall.	Based on animal ecology	Deg_{soil} = 0.5 Deg_{water} = 0 Deg_{HW} = 0
Exposure Duration	ED	percent of year	Migrates from winter to summer habitat	Reynolds 1985	Assume chronic exposure duration

References:

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Table 3-10. Exposure Profile of the Red-tailed hawk (*Buteo jamaicensis*)

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Nesting Habitat	--	--	Red tailed hawks can be found in a variety of landscapes, including old fields, wetlands and deserts. They typically perch and build nests atop trees.	USEPA 1993	Nests seasonally on pit wall face
Dietary Composition	df	fraction (wet volume)	Small mammals or birds; preference for mice, rabbits and ground squirrels in Nevada. USEPA reports between 78% and 99% mammals.	USEPA 1993; Heron 1985	$df_{terrmam}$ = .90, $df_{terrbird}$ = .10
Body Weight	BW	kg wet weight	1.028 - 1.063 - Male; 1.204 - 1.224 - Female	USEPA 1993, Dunning 1984	1.13
Food Ingestion Rate	IR_{food}	kg wet weight/day	0.109 kg wet per day - average	Sample et al. 1997	0.109
Water Ingestion Rate	IR_{water}	L/day	0.055 g/g/day - Male; 0.059 g/g/day - Female	USEPA 1993	0.059
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	Some soil attached to prey may be ingested, but amount assumed to be negligible.	Sample et al. 1997	0
Longevity	T_c	years	The average longevity for a red-tailed hawk that survives to maturity is 6 to 7 years.	Tesky 1994	6
External Exposures	Deg	fraction	Forages over soil upland = 180° exposure. Could nest on highwall = 180° exposure. Negligible exposures to surface of water.	Based on animal ecology	Deg_{soil} = 0.5 Deg_{water} = 0 Deg_{HW} = 0.5
Exposure Duration	ED	percent of year	Seasonal resident of the southwest region	Heron 1985	Assume chronic exposure duration

References:

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Table 3-11. Exposure Profile for Livestock

Parameter	Symbol	Units	Reported Values	References	Values Identified for ERA
Dietary Composition	df	fraction (wet volume)	100% terrestrial vegetation (primarily grasses)	NRC 2001	df_{terrpl} = 1.0
Body Weight	BW	kg wet weight	Average weight of juvenile beef cow (<1 year old) is 226 kg. Adult beef cow is ~400-1,200 kg	NRC 2001, Winchester and Morris 1956	226.0
Food Ingestion Rate	IR_{food}	kg wet weight/day	136 kg BW = 2.1% BW/day (dry weight) 204 kg BW = 2.3% BW/day 295 kg BW = 2.4% BW/day 454 kg BW = 2.5% BW/day	Osweiler et al. 1976	2.3% BW/day used and 53% moisture: 9.8
Water Ingestion Rate	IR_{water}	L/day	Average daily water ingestion rate for beef cow <1 year, indoor environment	NRC 2001, Winchester and Morris 1956	34.0
Sediment Ingestion Rate	$IR_{sediment}$	kg dry weight/day	1 to 18% of dry matter intake as soil - grazing cattle (median = 9.5%)	Thorton & Abrahams 1983	0.49
Longevity	T_c	years	Maximum longevity for optimum economic returns is within the range of 8 to 11 years for commercial cow-calf operations	Parish 2010	9
External Exposures	Deg	fraction	Grazes on surface of soil = 180° exposure. Negligible exposures to surface of water or pit highwall.	Based on animal ecology	Deg_{soil} = 0.5 Deg_{water} = 0 Deg_{HW} = 0
Exposure Duration	ED	percent of year	Grazing on lands near the site is intermittent	Assumption	Assume chronic exposure duration

References:

NRC. 2001. Nutrient Requirements of Dairy Cattle (7th Ed.). National Academy Press, Washington, DC.

Osweiler, G.D., et al. 1976. Clinical and Diagnostic Veterinary Toxicology. Third Edition. ed. Dubuque, IA: Kendall/Hunt Publishing. 13

Parish, J. 2010. Beef Cow Longevity. From the Cattle Business in Mississippi - November/December 2010 "Beef Production Strategies" article. Reprinted by Missouri State Extension: https://extension.msstate.edu/sites/default/files/topic-files/cattle-business-mississippi-articles/cattle-business-mississippi-articles-landing-page/mca_novdec2010.pdf.

Table 3-12. Retention Times

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Longevity (years)-->	6	9	6.8	1	6	30	9	6
Ra-226	1990	2860	2240	359	1990	7070	2860	1990
Ra-228	1440	1790	1550	339	1440	2380	1790	1440
U-234	144	144	144	133	144	144	144	144
U-235	144	144	144	133	144	144	144	144
U-238	144	144	144	133	144	144	144	144

Notes:

Retention time calculated in LANL (2022) based on longevity of receptor. See Wildlife Exposure Tables for longevity information.

Table 3-13. Bioacummulation Factors for Non-Radiological COIs

Analyte	Aquatic Plants		Terrestrial Plants		Aquatic Invertebrates		Terrestrial Invertebrates		Mammals and Birds	
	Equation and reference		Equation and reference		Equation and reference		Equation and reference		Equation and reference	
Selenium	$\ln(C_{aqp}) = 1.104 * \ln(C_w) - 0.677$	f	$\ln(C_{terrpl}) = 1.104 * \ln(C_s) - 0.677$	f	$C_{aqi} = 3.8 * C_w$	c	$\ln(C_{terrin}) = 0.733 * \ln(C_s) - 0.075$	a	$\ln(C_m) = 0.3764 * \ln(C_s) - 0.4158$	d
Uranium	$C_{aqp} = 0.0085 * C_w$	b	$C_{terrpl} = 0.0085 * C_s$	b	$C_{aqi} = 0.033 * C_w$	c	$C_{terr} = 0.033 * C_s$	c	$C_m = (1 * Cw * 0.5) + (1 * Cs * 0.5)$	e

Notes
a. Sample et al. 1998a - Development and Validation of Bioaccumulation Models for Earthworms.
b. Baes et al. 1984 - A review and analysis of parameters for assessing transport of environmentally released radionuclides through agriculture.
c. BAF referenced in LANL (2022), which is the median reported value in Appendix C of Sample et al. 1998a.
d.Sample et al. 1998b - Development and Validation of Bioaccumulation Models for Small Mammals.
f. Bechtel-Jacobs 1998a - Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants.
e. Baes et al. 1984; BAF is based on livestock which assumes 100% transfer from feed to tissue; assumed 100% transfer from water and soil to tissue, 50% consumption from each source.
BAF for rooted aquatic plants assumes uptake ratio similar to soil, but Cw used for exposured media.
Caqi = Concentration in aquatic invertebrate (mg/kg dry weight)
Caqp = Concentration in aquatic plant tissue (mg/kg dry weight)
Cm = Concentration in small mammal tissue (mg/kg dry weight)
Cs = Concentration in soil (mg/kg dry weight)
Cterrin = Concentration in terrestrial invertebrate (mg/kg dry weight)
Cterrpl = Concentration in terrestrial plant tissue (mg/kg dry weight)
Cw = Concentration in water (mg/L)

Table 3-14. TRVs for Non-Radiological COIs

COI	Selenium	Uranium
Birds	2.07	780.0
Mammals	1.0	15.0

Notes:
units are mg/kg-BW per day
From LANL (2022)

Table 4-1. Wildlife Threshold Values for Soil and Sediment

NOREL-Based WTVs

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	7.07E+05	5.80E+05	3.02E+09	6.52E+05	6.73E+01	nc	3.05E+01	1.43E+03
Ra-228	1.41E+06	8.97E+05	3.66E+09	1.18E+06	7.96E+01	nc	4.11E+01	2.86E+03
U-234	1.50E+08	1.61E+08	8.58E+11	1.51E+08	1.65E+04	nc	2.09E+05	3.03E+05
U-235	5.26E+06	1.02E+07	9.32E+11	5.26E+06	6.77E+03	nc	1.04E+04	1.05E+04
U-238	2.13E+06	4.21E+06	9.53E+11	2.13E+06	3.49E+03	nc	4.23E+03	4.26E+03

LOREL-Based WTVs

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	7.07E+03	5.80E+03	3.02E+10	6.52E+03	6.73E+02	nc	3.05E+02	1.43E+04
Ra-228	1.41E+04	8.97E+03	3.66E+10	1.18E+04	7.96E+02	nc	4.11E+02	2.86E+04
U-234	1.50E+06	1.61E+06	8.58E+12	1.51E+06	1.65E+05	nc	2.09E+06	3.03E+06
U-235	5.26E+04	1.02E+05	9.32E+12	5.26E+04	6.77E+04	nc	1.04E+05	1.05E+05
U-238	2.13E+04	4.21E+04	9.53E+12	2.13E+04	3.49E+04	nc	4.23E+04	4.26E+04

Notes:

All values in pCi/g.

nc = not calculated. Exposure pathway for this receptor is not complete.

Table 4-2. Wildlife Threshold Values for Pit Water

NOREL-Based WTVs

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	9.24E+02	3.31E+03	1.42E+03	1.96E+07	3.17E+02	6.02E+02	9.94E+01	2.36E+05
Ra-228	1.07E+03	4.44E+03	1.72E+03	1.74E+07	3.67E+02	1.50E+03	1.33E+02	2.73E+05
U-234	2.33E+05	1.20E+06	2.79E+06	9.66E+08	7.99E+04	3.71E+06	2.50E+05	5.94E+07
U-235	2.53E+05	1.30E+06	2.37E+06	1.05E+09	8.68E+04	2.94E+06	2.65E+05	6.46E+07
U-238	2.59E+05	1.33E+06	1.80E+06	1.07E+09	8.87E+04	2.11E+06	2.61E+05	6.60E+07

LOREL-Based WTVs

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	9.24E+03	3.31E+04	1.42E+04	1.96E+08	3.17E+03	6.02E+03	9.94E+02	2.36E+06
Ra-228	1.07E+04	4.44E+04	1.72E+04	1.74E+08	3.67E+03	1.50E+04	1.33E+03	2.73E+06
U-234	2.33E+06	1.20E+07	2.79E+07	9.66E+09	7.99E+05	3.71E+07	2.50E+06	5.94E+08
U-235	2.53E+06	1.30E+07	2.37E+07	1.05E+10	8.68E+05	2.94E+07	2.65E+06	6.46E+08
U-238	2.59E+06	1.33E+07	1.80E+07	1.07E+10	8.87E+05	2.11E+07	2.61E+06	6.60E+08

Notes:

All values in pCi/L.

nc = not calculated. Exposure pathway for this receptor is not complete.

Table 4-3. Wildlife Threshold Values for the Pit Highwall

NOREL-Based WTVs

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	nc	nc	1.43E+03	nc	nc	7.14E+02	nc	1.43E+03
Ra-228	nc	nc	2.86E+03	nc	nc	1.43E+03	nc	2.86E+03
U-234	nc	nc	3.03E+05	nc	nc	1.52E+05	nc	3.03E+05
U-235	nc	nc	1.05E+04	nc	nc	5.26E+03	nc	1.05E+04
U-238	nc	nc	4.26E+03	nc	nc	2.13E+03	nc	4.26E+03

LOREL-Based WTVs

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	nc	nc	1.43E+04	nc	nc	7.14E+03	nc	1.43E+04
Ra-228	nc	nc	2.86E+04	nc	nc	1.43E+04	nc	2.86E+04
U-234	nc	nc	3.03E+06	nc	nc	1.52E+06	nc	3.03E+06
U-235	nc	nc	1.05E+05	nc	nc	5.26E+04	nc	1.05E+05
U-238	nc	nc	4.26E+04	nc	nc	2.13E+04	nc	4.26E+04

Notes:

All values in pCi/g.

nc = not calculated. Exposure pathway for this receptor is not complete.

Table 4-4. Hazard Quotients and Hazard Index for Non-Radiological COIs

HQ	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Selenium	4.5E-02	1.7E-03	2.1E-04	1.6E-02	3.0E-03	1.8E-02	1.1E-02	2.0E-03
Uranium	5.4E-01	4.8E-02	2.3E-04	8.7E-02	8.4E-02	1.9E-03	3.9E-02	4.4E-02

HI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Hazard Index	5.8E-01	4.9E-02	4.4E-04	1.0E-01	8.7E-02	2.0E-02	5.0E-02	4.6E-02

Table 4-5. Base Case Cumulative Radiological Risk Estimates with NOREL-Based WTVs

Soil and Sediment Risk Ratios

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	1.63E-03	1.98E-03	3.80E-10	1.76E-03	1.71E-02	nc	3.77E-02	8.05E-04
Ra-228	9.82E-05	1.54E-04	3.77E-11	1.17E-04	1.73E-03	nc	3.35E-03	4.83E-05
U-234	1.62E-06	1.52E-06	2.84E-13	1.62E-06	1.48E-05	nc	1.16E-06	8.05E-07
U-235	2.07E-06	1.07E-06	1.17E-14	2.07E-06	1.61E-06	nc	1.05E-06	1.04E-06
U-238	1.13E-04	5.73E-05	2.53E-13	1.13E-04	6.91E-05	nc	5.69E-05	5.66E-05
Total Risk Soil & Sed:	1.84E-03	2.20E-03	4.19E-10	2.00E-03	1.89E-02	-	4.11E-02	9.12E-04

Pit Water Risk Ratios

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	5.31E-02	1.48E-02	3.45E-02	2.50E-06	1.55E-01	8.14E-02	4.93E-01	2.08E-04
Ra-228	1.12E-02	2.71E-03	6.97E-03	6.89E-07	3.27E-02	8.01E-03	9.02E-02	4.40E-05
U-234	2.41E-02	4.67E-03	1.99E-03	5.80E-06	7.02E-02	1.49E-03	2.24E-02	9.43E-05
U-235	9.91E-04	1.92E-04	8.19E-05	2.39E-07	2.89E-03	6.14E-05	9.46E-04	3.88E-06
U-238	2.14E-02	4.15E-03	1.77E-03	5.15E-06	6.24E-02	1.33E-03	2.12E-02	8.38E-05
Total Risk Pit Water:	1.11E-01	2.65E-02	4.53E-02	1.44E-05	3.23E-01	9.23E-02	6.28E-01	4.34E-04

Table 4-5. Base Case Cumulative Radiological Risk Estimates with NOREL-Based WTVs

Pit Highwall Risk Ratios - Mancos Shale / Dakota Sandstone Exposures								
COI	**Kit Fox**	**Pronghorn Antelope**	**Cliff Swallow**	**Deer Mouse**	**Livestock**	**Little Brown Bat**	**Mallard Duck**	**Red-tailed Hawk**
Ra-226	nc	nc	1.13E-02	nc	nc	2.25E-02	nc	1.13E-02
Ra-228	nc	nc	6.76E-04	nc	nc	1.35E-03	nc	6.76E-04
U-234	nc	nc	3.95E-05	nc	nc	7.90E-05	nc	3.95E-05
U-235	nc	nc	5.08E-05	nc	nc	1.02E-04	nc	5.08E-05
U-238	nc	nc	2.78E-03	nc	nc	5.56E-03	nc	2.78E-03
Total Risk Highwall:	-	-	**1.48E-02**	-	-	**2.96E-02**	-	**1.48E-02**
Cumulative Risks of the Pit Environment:	1.13E-01	2.87E-02	**6.01E-02**	2.01E-03	3.42E-01	**1.22E-01**	6.69E-01	**1.62E-02**

Notes:

Maximum concentrations of pit soil/sediment, water, and highwall (Mancos/Dakota) were used for exposure. Exposures are compared to NOREL-based WTVs to compute risk.
nc = not calculated. Exposure pathway for this receptor is not complete.
- = risk not calculated because exposure pathways are incomplete. A risk input of 0 for this media was used to calculate cumulative risk for all media.

Table 4-6. Base Case Cumulative Radiological Risk Estimates with LOREL-Based WTVs

Soil and Sediment Risk Ratios

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	1.63E-04	1.98E-04	3.80E-11	1.76E-04	1.71E-03	nc	3.77E-03	8.05E-05
Ra-228	9.82E-06	1.54E-05	3.77E-12	1.17E-05	1.73E-04	nc	3.35E-04	4.83E-06
U-234	1.62E-07	1.52E-07	2.84E-14	1.62E-07	1.48E-06	nc	1.16E-07	8.05E-08
U-235	2.07E-07	1.07E-07	1.17E-15	2.07E-07	1.61E-07	nc	1.05E-07	1.04E-07
U-238	1.13E-05	5.73E-06	2.53E-14	1.13E-05	6.91E-06	nc	5.69E-06	5.66E-06
Total Risk Soil & Sed:	1.84E-04	2.20E-04	4.19E-11	2.00E-04	1.89E-03	-	4.11E-03	9.12E-05

Pit Water Risk Ratios

COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	5.31E-03	1.48E-03	3.45E-03	2.50E-07	1.55E-02	8.14E-03	4.93E-02	1.79E-05
Ra-228	1.12E-03	2.71E-04	6.98E-04	6.89E-08	3.27E-03	8.01E-04	9.02E-03	3.79E-06
U-234	2.41E-03	4.67E-04	2.01E-04	5.80E-07	7.02E-03	1.51E-04	2.24E-03	8.13E-06
U-235	9.91E-05	1.92E-05	1.06E-05	2.39E-08	2.89E-04	8.52E-06	9.46E-05	3.34E-07
U-238	2.14E-03	4.15E-04	3.07E-04	5.15E-07	6.24E-03	2.63E-04	2.12E-03	7.23E-06
Total Risk Pit Water:	1.11E-02	2.65E-03	4.67E-03	1.44E-06	3.23E-02	9.37E-03	6.28E-02	3.74E-05

Table 4-6. Base Case Cumulative Radiological Risk Estimates with LOREL-Based WTVs

Pit Highwall Risk Ratios - Mancos Shale / Dakota Sandstone Exposures								
COI	**Kit Fox**	**Pronghorn Antelope**	**Cliff Swallow**	**Deer Mouse**	**Livestock**	**Little Brown Bat**	**Mallard Duck**	**Red-tailed Hawk**
Ra-226	nc	nc	1.13E-03	nc	nc	2.25E-03	nc	1.13E-03
Ra-228	nc	nc	6.76E-05	nc	nc	1.35E-04	nc	6.76E-05
U-234	nc	nc	3.95E-06	nc	nc	7.90E-06	nc	3.95E-06
U-235	nc	nc	5.08E-06	nc	nc	1.02E-05	nc	5.08E-06
U-238	nc	nc	2.78E-04	nc	nc	5.56E-04	nc	2.78E-04
Total Risk Highwall:	-	-	**1.48E-03**	-	-	**2.96E-03**	-	**1.48E-03**
Cumulative Risks of the Pit Environment:	1.13E-02	2.87E-03	**6.15E-03**	2.01E-04	3.42E-02	**1.23E-02**	6.69E-02	**1.61E-03**

Notes:

Maximum concentrations of pit soil/sediment, water, and highwall (Mancos/Dakota) were used for exposure. Exposures are compared to LOREL-based WTVs to compute risk.
nc = not calculated. Exposure pathway for this receptor is not complete.
- = risk not calculated because exposure pathways are incomplete. A risk input of 0 for this media was used to calculate cumulative risk for all media.

Table 4-7. NOREL-Based Cumulative Risk Computations with Jackpile Sandstone Estimated Highwall Concentrations

Soil and Sediment Risk Ratios								
COI	**Kit Fox**	**Pronghorn Antelope**	**Cliff Swallow**	**Deer Mouse**	**Livestock**	**Little Brown Bat**	**Mallard Duck**	**Red-tailed Hawk**
Ra-226	1.63E-03	1.98E-03	3.80E-10	1.76E-03	1.71E-02	nc	3.77E-02	8.05E-04
Ra-228	9.82E-05	1.54E-04	3.77E-11	1.17E-04	1.73E-03	nc	3.35E-03	4.83E-05
U-234	1.62E-06	1.52E-06	2.84E-13	1.62E-06	1.48E-05	nc	1.16E-06	8.05E-07
U-235	2.07E-06	1.07E-06	1.17E-14	2.07E-06	1.61E-06	nc	1.05E-06	1.04E-06
U-238	1.13E-04	5.73E-05	2.53E-13	1.13E-04	6.91E-05	nc	5.69E-05	5.66E-05
Total Risk Soil & Sed:	1.84E-03	2.20E-03	4.19E-10	2.00E-03	1.89E-02	-	4.11E-02	9.12E-04

Pit Water Risk Ratios								
COI	**Kit Fox**	**Pronghorn Antelope**	**Cliff Swallow**	**Deer Mouse**	**Livestock**	**Little Brown Bat**	**Mallard Duck**	**Red-tailed Hawk**
Ra-226	5.31E-02	1.48E-02	3.45E-02	2.50E-06	1.55E-01	8.14E-02	4.93E-01	2.08E-04
Ra-228	1.12E-02	2.71E-03	6.97E-03	6.89E-07	3.27E-02	8.01E-03	9.02E-02	4.40E-05
U-234	2.41E-02	4.67E-03	1.99E-03	5.80E-06	7.02E-02	1.49E-03	2.24E-02	9.43E-05
U-235	9.91E-04	1.92E-04	8.19E-05	2.39E-07	2.89E-03	6.14E-05	9.46E-04	3.88E-06
U-238	2.14E-02	4.15E-03	1.77E-03	5.15E-06	6.24E-02	1.33E-03	2.12E-02	8.38E-05
Total Risk Pit Water:	1.11E-01	2.65E-02	4.53E-02	1.44E-05	3.23E-01	9.23E-02	6.28E-01	4.34E-04

Table 4-7. NOREL-Based Cumulative Risk Computations with Jackpile Sandstone Estimated Highwall Concentrations

Pit Highwall Risk Ratios - Jackpile Sandstone								
COI	**Kit Fox**	**Pronghorn Antelope**	**Cliff Swallow**	**Deer Mouse**	**Livestock**	**Little Brown Bat**	**Mallard Duck**	**Red-tailed Hawk**
Ra-226	nc	nc	1.87E+00	nc	nc	3.73E+00	nc	1.87E+00
Ra-228	nc	nc	1.12E-01	nc	nc	2.24E-01	nc	1.12E-01
U-234	nc	nc	8.76E-03	nc	nc	1.75E-02	nc	8.76E-03
U-235	nc	nc	1.13E-02	nc	nc	2.25E-02	nc	1.13E-02
U-238	nc	nc	6.16E-01	nc	nc	1.23E+00	nc	6.16E-01
Total Risk Highwall:	-	-	**2.61E+00**	-	-	**5.23E+00**	-	**2.61E+00**
Cumulative Risks of the Pit Environment:	1.13E-01	2.87E-02	**2.66E+00**	2.01E-03	3.42E-01	**5.32E+00**	6.69E-01	**2.61E+00**

Notes:
Maximum concentrations of pit soil/sediment, water, and highwall (Jackpile) were used for exposure. Exposures are compared to NOREL-based WTVs to compute risk.
nc = not calculated. Exposure pathway for this receptor is not complete.
- = risk not calculated because exposure pathways are incomplete. A risk input of 0 for this media was used to calculate cumulative risk for all media.

Table 4-8. LOREL-Based Cumulative Risk Computations with Jackpile Sandstone Estimated Highwall Concentrations

Soil and Sediment Risk Ratios								
COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	1.63E-04	1.98E-04	3.80E-11	1.76E-04	1.71E-03	nc	3.77E-03	8.05E-05
Ra-228	9.82E-06	1.54E-05	3.77E-12	1.17E-05	1.73E-04	nc	3.35E-04	4.83E-06
U-234	1.62E-07	1.52E-07	2.84E-14	1.62E-07	1.48E-06	nc	1.16E-07	8.05E-08
U-235	2.07E-07	1.07E-07	1.17E-15	2.07E-07	1.61E-07	nc	1.05E-07	1.04E-07
U-238	1.13E-05	5.73E-06	2.53E-14	1.13E-05	6.91E-06	nc	5.69E-06	5.66E-06
Total Risk Soil & Sed:	1.84E-04	2.20E-04	4.19E-11	2.00E-04	1.89E-03	-	4.11E-03	9.12E-05

Pit Water Risk Ratios								
COI	Kit Fox	Pronghorn Antelope	Cliff Swallow	Deer Mouse	Livestock	Little Brown Bat	Mallard Duck	Red-tailed Hawk
Ra-226	5.31E-03	1.48E-03	3.45E-03	2.50E-07	1.55E-02	8.14E-03	4.93E-02	1.79E-05
Ra-228	1.12E-03	2.71E-04	6.98E-04	6.89E-08	3.27E-03	8.01E-04	9.02E-03	3.79E-06
U-234	2.41E-03	4.67E-04	2.01E-04	5.80E-07	7.02E-03	1.51E-04	2.24E-03	8.13E-06
U-235	9.91E-05	1.92E-05	1.06E-05	2.39E-08	2.89E-04	8.52E-06	9.46E-05	3.34E-07
U-238	2.14E-03	4.15E-04	3.07E-04	5.15E-07	6.24E-03	2.63E-04	2.12E-03	7.23E-06
Total Risk Pit Water:	1.11E-02	2.65E-03	4.67E-03	1.44E-06	3.23E-02	9.37E-03	6.28E-02	3.74E-05

Table 4-8. LOREL-Based Cumulative Risk Computations with Jackpile Sandstone Estimated Highwall Concentrations

Pit Highwall Risk Ratios - Jackpile Sandstone								
COI	**Kit Fox**	**Pronghorn Antelope**	**Cliff Swallow**	**Deer Mouse**	**Livestock**	**Little Brown Bat**	**Mallard Duck**	**Red-tailed Hawk**
Ra-226	nc	nc	1.87E-01	nc	nc	3.73E-01	nc	1.87E-01
Ra-228	nc	nc	9.33E-02	nc	nc	1.87E-01	nc	9.33E-02
U-234	nc	nc	8.76E-04	nc	nc	1.75E-03	nc	8.76E-04
U-235	nc	nc	1.13E-03	nc	nc	2.25E-03	nc	1.13E-03
U-238	nc	nc	6.16E-02	nc	nc	1.23E-01	nc	6.16E-02
Total Risk Highwall:	-	-	3.43E-01	-	-	3.43E-01	-	3.43E-01
Cumulative Risks of the Pit Environment:	1.13E-02	2.87E-03	3.48E-01	2.01E-04	3.42E-02	3.53E-01	6.69E-02	3.44E-01

Notes:

Maximum concentrations of pit soil/sediment, water, and highwall (Jackpile) were used for exposure. Exposures are compared to LOREL-based WTVs to compute risk.

nc = not calculated. Exposure pathway for this receptor is not complete.

- = risk not calculated because exposure pathways are incomplete. A risk input of 0 for this media was used to calculate cumulative risk for all media.

Appendix A

IPaC **U.S. Fish & Wildlife Service**

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Cibola County, New Mexico

Local office

New Mexico Ecological Services Field Office

(505) 346-2525
(505) 346-2542

2105 Osuna Road Ne
Albuquerque, NM 87113-1001

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species[1] and their critical habitats are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service (USFWS) and the fisheries division of the National Oceanic and Atmospheric Administration (NOAA Fisheries[2]).

Species and critical habitats under the sole responsibility of NOAA Fisheries are **not** shown on this list. Please contact NOAA Fisheries for species under their jurisdiction.

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1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information. IPaC only shows species that are regulated by USFWS (see FAQ).
2. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office

of the National Oceanic and Atmospheric Administration within the Department of Commerce.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
Mexican Wolf *Canis lupus baileyi* No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/3916	Endangered

Birds

NAME	STATUS
Mexican Spotted Owl *Strix occidentalis lucida* Wherever found There is **final** critical habitat for this species. Your location does not overlap the critical habitat. https://ecos.fws.gov/ecp/species/8196	Threatened
Southwestern Willow Flycatcher *Empidonax traillii extimus* Wherever found There is **final** critical habitat for this species. Your location does not overlap the critical habitat. https://ecos.fws.gov/ecp/species/6749	Endangered
Yellow-billed Cuckoo *Coccyzus americanus* There is **final** critical habitat for this species. Your location does not overlap the critical habitat. https://ecos.fws.gov/ecp/species/3911	Threatened

Insects

NAME	STATUS
Monarch Butterfly *Danaus plexippus* Wherever found No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/9743	Candidate

Flowering Plants

NAME	STATUS

Pecos (=puzzle, =paradox) Sunflower Helianthus paradoxus | Threatened

Wherever found

There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
https://ecos.fws.gov/ecp/species/7211

Zuni Fleabane Erigeron rhizomatus | Threatened

Wherever found

No critical habitat has been designated for this species.
https://ecos.fws.gov/ecp/species/5700

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

There are no critical habitats at this location.

You are still required to determine if your project(s) may have effects on all above listed species.

Bald & Golden Eagles

Bald and golden eagles are protected under the Bald and Golden Eagle Protection Act[1] and the Migratory Bird Treaty Act[2].

Any person or organization who plans or conducts activities that may result in impacts to bald or golden eagles, or their habitats[3], should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

Additional information can be found using the following links:

- Eagle Managment https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf

- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

There are bald and/or golden eagles in your project area.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.	Breeds Dec 1 to Aug 31

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence ( )

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of

presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.

3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

Breeding Season (■)

Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)

Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)

A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

What does IPaC use to generate the potential presence of bald and golden eagles in my specified location?

The potential for eagle presence is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply). To see a list of all birds potentially present in your project area, please visit the Rapid Avian Information Locator (RAIL) Tool.

What does IPaC use to generate the probability of presence graphs of bald and golden eagles in my

specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the Rapid Avian Information Locator (RAIL) Tool.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur. Please contact your local Fish and Wildlife Service Field Office if you have questions.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats[3] should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle Haliaeetus leucocephalus This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.	Breeds Dec 1 to Aug 31

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in

the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.

2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

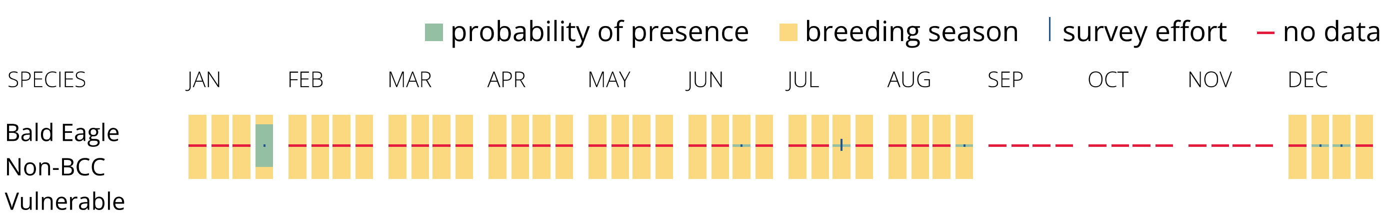
Breeding Season ( )
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.



Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

[Nationwide Conservation Measures](#) describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the list of migratory birds that potentially occur in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the Rapid Avian Information Locator (RAIL) Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets.

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering or migrating in my area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may query your location using the RAIL Tool and look at the range maps provided for birds in your area at the bottom of the profiles provided for each bird in your results. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin

Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

There are no refuge lands at this location.

Fish hatcheries

There are no fish hatcheries at this location.

Wetlands in the National Wetlands Inventory (NWI)

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

This location overlaps the following wetlands:

FRESHWATER EMERGENT WETLAND

PEM1Ah

- PEM1Cx
- PEM1Ch
- PEM1Jh

FRESHWATER POND

- PUBFx
- PUSJh

RIVERINE

- R4SBC
- R4SB3J
- R4SBJ
- R4SB3A

A full description for each wetland code can be found at the National Wetlands Inventory website

NOTE: This initial screening does **not** replace an on-site delineation to determine whether wetlands occur. Additional information on the NWI data is provided below.

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Species of Greatest Conservation Need

Cibola

Taxonomic Group	# Species	Taxonomic Group	# Species
Amphibians	3	Birds	34
Crustaceans	8	Fish	3
Mammals	3	Reptiles	1

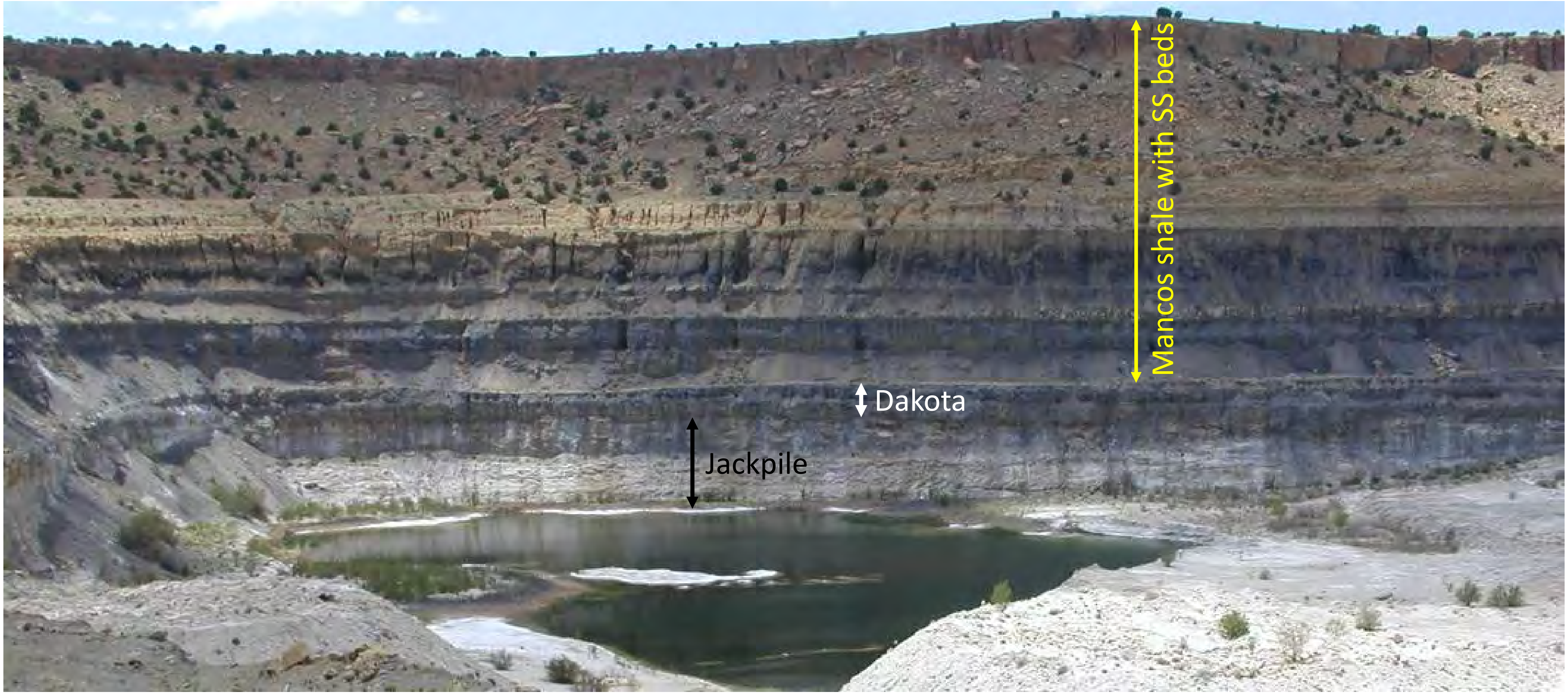
TOTAL SPECIES: 52

Common Name	Scientific Name	NMGF	US FWS	Critical Habitat	SGCN	Photo
Pale Townsend's Big-eared Bat	Corynorhinus townsendii				Y	View
Spotted Bat	Euderma maculatum	T			Y	View
Gunnison's prairie dog	Cynomys gunnisoni				Y	View
Eared Grebe	Podiceps nigricollis				Y	View
Yellow-billed Cuckoo (western pop)	Coccyzus americanus occidentalis		T	Y	Y	View
Common Nighthawk	Chordeiles minor				Y	View
Mountain Plover	Charadrius montanus				Y	View
Long-billed Curlew	Numenius americanus				Y	View
American Bittern	Botaurus lentiginosus				Y	View
Bald Eagle	Haliaeetus leucocephalus	T			Y	View
Flammulated Owl	Psiloscops flammeolus				Y	View
Burrowing Owl	Athene cunicularia				Y	View
Mexican Spotted Owl	Strix occidentalis lucida		T	Y	Y	View
Lewis's Woodpecker	Melanerpes lewis				Y	View
Williamson's Sapsucker	Sphyrapicus thyroideus				Y	View
Peregrine Falcon	Falco peregrinus	T			Y	View
Olive-sided Flycatcher	Contopus cooperi				Y	View
Southwestern Willow Flycatcher	Empidonax traillii extimus	E	E	Y	Y	View
Loggerhead Shrike	Lanius ludovicianus				Y	View
Gray Vireo	Vireo vicinior	T			Y	View
Pinyon Jay	Gymnorhinus cyanocephalus				Y	View
Clark's Nutcracker	Nucifraga columbiana				Y	View
Bank Swallow	Riparia riparia				Y	View
Juniper Titmouse	Baeolophus ridgwayi				Y	View

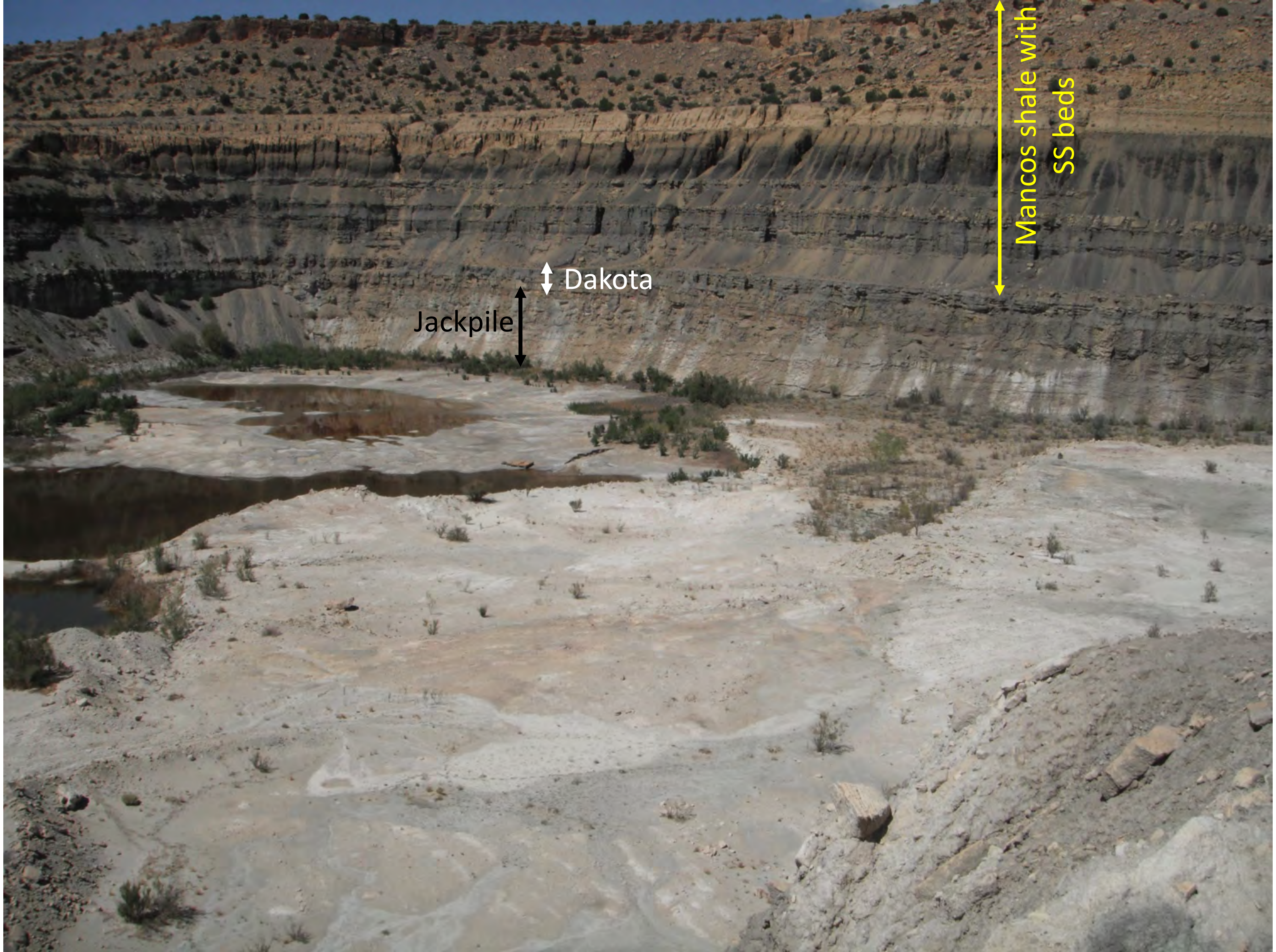
Species of Greatest Conservation Need
Cibola

Common Name	Scientific Name	NMGF	US FWS	Critical Habitat	SGCN	Photo
Pygmy Nuthatch	Sitta pygmaea				Y	View
Western Bluebird	Sialia mexicana				Y	View
Mountain Bluebird	Sialia currucoides				Y	View
Bendire's Thrasher	Toxostoma bendirei				Y	View
Evening Grosbeak	Coccothraustes vespertinus				Y	View
Cassin's Finch	Haemorhous cassinii				Y	View
Cassin's Sparrow	Peucaea cassinii				Y	View
Vesper Sparrow	Pooecetes gramineus				Y	View
Virginia's Warbler	Leiothlypis virginiae				Y	View
Grace's Warbler	Setophaga graciae				Y	View
Black-throated Gray Warbler	Setophaga nigrescens				Y	View
Red-faced Warbler	Cardellina rubrifrons				Y	View
Painted Redstart	Myioborus pictus				Y	View
Sonoran Mud Turtle	Kinosternon sonoriense sonoriense				Y	View
Arizona Treefrog	Hyla wrightorum				Y	View
Boreal Chorus Frog	Pseudacris maculata				Y	View
Northern Leopard Frog	Lithobates pipiens				Y	View
Rio Grande Chub	Gila pandora				Y	View
Zuni Bluehead Sucker	Catostomus discobolus yarrowi	E	E	Y	Y	View
Rio Grande Sucker	Catostomus plebeius				Y	View
Brine Shrimp	Artemia franciscana				Y	View
Packard's Fairy Shrimp	Branchinecta packardi				Y	View
Great Plains Fairy Shrimp	Streptocephalus texanus				Y	View
Beavertail Fairy Shrimp	Thamnocephalus platyurus				Y	View
Mexican Clam Shrimp	Cyzicus mexicanus				Y	No Photo
Clam Shrimp	Eulimnadia follisimilis				Y	No Photo
Short Finger Clam Shrimp	Lynceus brevifrons				Y	No Photo
BLNWR cryptic species Amphipod	Gammarus sp.				Y	No Photo

Appendix B



Mancos SS beds and Dakota form benches in Pit 1 highwall. Dakota tends to overhang Jackpile. Benches are not present in Jackpile except along ramps into pit bottom.


Mancos shale with SS beds
Dakota
Jackpile

Jackpile outcrop in Pit 1 high wall