Appendix I

Rationale for Waste Rock Pile Cover Thickness

ABSTRACT

Based on the results of Residual Radiation (RESRAD) modeling for this specific proposed action and a comparative study from similar uranium mines, the calculated dose for a 14-day camper who resides on the reclaimed waste rock area would not exceed either the EPA guideline (100 millirems per year (mrem/yr) (10 CFR 20.1301)) or twice the natural exposure (300–440 mrem/yr). RESRAD modeling predicts a 0.1 mrem/yr exposure to the 14-day per year camper. Comparatively, calculations for the Whirlwind Mine show RA-226 = 31 picocuries per gram (pCi/g) and a dose = 0.2 mrem/yr, whereas for Daneros, Ra-226 = 8.7 pCi/g and a dose = 0.1 mrem/yr.

INTRODUCTION

Addressing the question of public health and safety regarding possible radiation exposure from the reclaimed waste rock pile requires an estimate of the appropriate thickness of cover. Other questions regarding public health and safety are addressed in the EA. In order to keep the EA analytic, and so as to not burden the EA with a lengthy discussion of background information relevant to the 14-day camper scenario, this report will present results of site-specific RESRAD modeling and summarize the available comparative information regarding uranium mine waste cover. This will allow the EA to focus on impact analysis.

Several measurements of the potential waste rock properties were conducted by an independent laboratory and are documented in the Daneros Mine Acid Producing Sampling Program report and in Items J and K of the POO (UEC 2008). This information will be used but not repeated in its entirety. Waste rock volumes, percentages, and weights will be brought forward into this document from the POO, other parts of the EA, or more recent emails that have clarified previously submitted information.

It was determined that, for purposes of this analysis, that a camper choosing to camp on the reclaimed waste rock pile for 14 days after all mining had been completed and the site had been reclaimed would represent the standard for consideration. Exposure could not exceed the EPA's 100 mrem/yr guideline for radiation exposure (additional exposure over background dosage). As a second consideration, an exposure rate of twice the natural background exposure (300–440 mrem/yr) was also evaluated.

This report discusses typical background radiation levels, RESRAD modeling that was conducted for this specific location, and presents comparative information regarding waste rock piles at other uranium mines in Utah and Colorado, to glean any applicable lessons for the current project.

TYPICAL BACKGROUND RADIATION LEVELS

NEPA requires that context and intensity be discussed (CFR Sec. 1508.27). Context means that the significance of an action must be analyzed in several contexts, such as society as a whole (human, national), the affected region, the affected interests, and the locality. Intensity refers to the severity of impact.

Nationwide, people are exposed to an average of about 300 mrem/yr of natural background radiation (National Council on Radiation Protection and Measurements 1987). Based on data from near Blanding, Utah, the total natural background radiation dose in the region is about 440 mrem/yr, which is higher than the national average (U.S. Department of Energy (DOE) 2007:4–27).

Other similar projects from the region that have information that could be useful for comparison and perspective are presented here. This allows for a comparative study to see if the possible exposure exceeds established limits or presents a similar risk as other routine sources of radiation exposure. Because radiation is naturally occurring and found in many sources, typical radiation exposure levels for an average person living on the Colorado Plateau are listed as follows (DOE 2007):

- From air (radon): 200 mrem/yr
- Terrestrial radiation (from the ground): 46–90 mrem/yr
- From food and water: 40 mrem/yr
- Medical x-rays: 40 mrem/each
- Travel-related radiation: 1 mrem/yr per 1,000 miles traveled
- Miscellaneous sources: 5–10 mrem/yr

DANEROS WASTE ROCK PILE

Approximately 14,860 cubic yards of waste rock are projected to be produced (UEC 2008:Item C). The waste would be stored on the portal pad, the mine yard, and the waste dump shown on Plan 6 of the POO (UEC 2008). The Daneros waste dump would be located on the historic waste dump of the McCarty-Coleman Decline. The existing McCarty-Coleman waste rock pile is approximately 17 feet thick with an average Ra-226 concentration of 11 pCi/ (UEC 2008:Item N). The McCarty-Coleman Decline waste dump has a larger footprint than what will be covered by the proposed project, which will only cover approximately 0.41 acre towards the southern end of the existing waste rock pile. The final waste rock pile will average 25 feet thick (personal communication, John Hasleby 2009) with an estimated Ra-226 level of 8.7 pCi/g (based on RESRAD modeling).

Approximately 13,420 cubic yards (90%) of the waste rock generated during extraction, primarily from construction of the ventilation shafts and declines, would be mudstone and sandstone of the basal Chinle Formation and underlying Moenkopi Formation. Core samples were analyzed for a broad spectrum of 70 elements by American Assay Laboratories. Based on this analysis "there is no potential for the presence of appreciable radiological or heavy metal elements in decline development waste rock or the development of acid mine drainage from such waste rock" (UEC 2008:5). This benign non-mineralized rock will average about 1.05 pCi/g (UEC 2008:Item N).

It is anticipated that approximately 1,440 cubic yards (10%) of the waste dump material could be mineralized waste (rock with sub-economic mineralization), extracted and disposed of on the waste rock dump during ore production as a normal function of the mine waste removal process. This material will be less than 0.05% U3O8 (the current proposed ore cut of grade). Based on mixing and dilution, anticipated values are more likely to be less than 100 parts per million (ppm) U3O8 (0.01%) (personal communication, John Hasleby 2009). The Proposed Action (UEC 2008:5) states, "low grade material from the ore zones will be stock piled on part of the ore stockpile and either mixed with ore and shipped to the mill, or returned to mined-out areas of the mine." Subsequent clarification from UEC (personal communication, John Hasleby 2009) explained that "it will be more cost effective for the Company to ship to the mill any waste or sub-ore that exceeds 0.015% that has been necessary to mine and transport to the surface (i.e. it pays the transport cost to the mill) than to rehandle it and transport it back to the workings."

Detailed characterization of the mineralization is documented in the POO (UEC 2008:Item J, pages 1–2). Because the low-grade mineralized rock for the Daneros Mine would be produced from the same sandstone-type uranium deposits in the Shinarump Member that were the source of a portion of the waste rock material at the McCarty-Coleman Decline, and since the material is essentially from the same geologic setting with similar ore controls, and considering the close proximity of the two uranium deposits, the low-grade mineralized rocks are expected to be very similar.

Based on the information above it is reasonable to estimate that the total volume of waste rock — approximately 14,860 cubic yards consisting of a blend of 13,420 cubic yards of benign rock with the 1,440 cubic yards of low-grade mineralized rock — would produce a blend similar to the existing McCarty-Coleman waste rock pile on which it will be placed. Based on a weighted average and random mixing of the two sources of rock, the material in the final waste rock stock pile is expected to be less than 100 ppm U3O8 (0.01%). The reason the waste rock pile material would be 0.01% when the cut-off grade is 0.05% is because UEC proposes to sort and place the "sub-ore" material onto an intermediate stockpile located on part of the ore stockpile areas for mixing with ore or hauling the material back into the mine workings before final abandonment. Sub-ore is mineralized material that is less than the cut-off grade of 0.05% but can be mixed with higher grade ore to meet milling specifications.

CONSIDERATION OF INFORMATION FROM RESRAD MODELING FOR DANEROS

A radiological dose rate assessment of the proposed waste rock pile was conducted for a casual visitor (e.g., recreational camper). The input data for the composition of the waste rock and the proposed cover were provided by UEC. This section describes the method used to determine the concentrations of radioactivity in the waste rock, and reports the results of the assessment. The calculations for the assessment were performed using the Residual Radioactivity (RESRAD) computer model, version 6.4 (RESRAD 6.4).

Waste Rock Pile Assumptions:

- The existing waste rock pile is approximately 17 feet thick. The average Radium-226 concentration of the existing waste rock pile is 11 pCi/g (UEC 2008:Item N).
- The final waste rock pile will be 35 feet thick at its highest point but average 25 feet. (personal communication, John Hasleby 2009). On average, 8 feet of additional waste rock will be added to the existing waste rock pile.

Ninety percent of the waste rock to be added to the waste pile will be unmineralized development waste, and will have only trace uranium content (personal communication, John Hasleby 2009). The remainder will have low uranium values and be less than 100 ppm U3O8 (0.01%) (personal communication, John Hasleby 2009) because low grade material from the ore zones will be stockpiled on part of the ore stockpile and either mixed with ore and shipped to the mill, or returned to mined-out areas of the mine.

Therefore, 68 percent of the final waste rock pile will consist of the existing waste rock material (Ra-226 = 11 pCi/g), and 32 percent of the waste rock material will be added during the Proposed Action.

To calculate the Ra-226 level for the final waste rock pile the following assumptions were made:

- 10% of the added waste rock will consist of 0.01% U3O8 (28.3 pCi/g).
- 90% will consist of unmineralized rock at background concentrations of 1.05 pCi/g (UEC 2008:Item N).
- The waste rock pile will be covered with 12 inches of alluvial sandy loam.

The resulting Ra-226 level for the final waste rock pile used in the RESRAD modeling effort is equal to 8.7 pCi/g.

Results of the RESRAD modeling efforts indicated that the calculated dose for a camper who resides on the reclaimed waste rock area over a 14-day period (24 hours/day) would be about 0.2 mrem/year. Compared to the EPA guideline of 100 mrem/yr (10 CFR 20.1301), exposure to the casual recreational camper is approximately 0.2 percent of these guidelines.

CONSIDERATION OF INFORMATION FROM THE WHIRLWIND URANIUM MINE

Laboratory analyses of three waste rock samples collected from the Whirlwind Mine on the Utah/Colorado border provide an indication that the Ra-226 levels would vary from 2.8 to 4.2 pCi/g. Because of some intermixing of ore and waste occurring during mining, Energy Fuels used the RESRAD model to estimate the waste rock at approximately 31 pCi/g, which is slightly above the 23.7 pCi/g or 0.015%, reported by EPA in the Uranium Leasing EA. The proposed project estimates the final Daneros waste rock pile to be about 8.7 pCi/g, which is much less than either the 23.7 pCi/g or 31 pCi/g of the referenced studies.

Based on all of the information considered for the Whirlwind Mine it was determined that the exposure for a "camper who resides on the reclaimed waste rock storage area over a 7-day period (24 hours/day) would be about 0.2 mrem/yr. This dose represents only 2 percent of the EPA's guideline for radiation exposure" (BLM 2008:4–46). Further, consideration of a worst-case scenario where a camper could legally reside on a reclaimed waste rock storage area for a maximum of one year, would "be 244 days, resulting in a dose of 6.8 mrem, which is below the EPA's guideline. Therefore, potential health risks from the reclaimed waste rock storage areas would be low" (BLM 2008:4–46). This study does not use the 14-day camper scenario; it uses a 7 day and 1 year time frame. An estimate of the 14-day camper scenario is approximately 0.4 mrem/yr; still below any recommended exposure limit.

Based on all of the information in the BLM Whirlwind EA, approximately 12 inches of topsoil would be adequate to reduce impacts to the public to acceptable levels. "Salvaged topsoil would equate to an average topsoil depth of 12 inches uniformly redistributed over the approximate..area associated with the Whirlwind Portal area" (BLM 2008:3–35). As stated above, the final Daneros waste rock would have much less U308 (8.7 pCi/g compared to 23.7 pCi/g).

CONSIDERATION OF INFORMATION FROM THE DEPARTMENT OF ENERGY URANIUM LEASING

The DOE conducted a study of potential radiation exposure from proposed uranium mine leasing that has application to the current proposed action (DOE 2007). In the study, a health risk evaluation was completed to evaluate potential risk from a hypothetical worst-case scenario which included a person camping directly on top of a uranium waste rock pile for a two-week period. The study concluded that a person who camped directly on top of a waste-rock pile 24 hours per day for a two-week period would have an increased radiation exposure of approximately 50 mrem/yr. This is similar to the exposure from cosmic radiation (from outer space) that a person residing on the Colorado Plateau receives yearly.

To determine the potential safety risks of the waste rock storage area to a casual visitor following completion of mining activities and reclamation, a radiological dose calculation was projected using RESRAD v6.3. Modeling projections included a 12-inch topsoil cover using a clay loam texture characteristic of the native soils. The model is capable of calculating the dose to an individual from a known source with a wide variety of radionuclides and from all direct exposure, biological, and airborne pathways. The radiological content of the waste rock storage area was conservatively modeled by

including 25 percent low grade mineralized rock (0.0558 percent U308) with 75 percent benign waste rock.

The current Proposed Action anticipates mixing 10 percent low grade mineralized rock (100 ppm U308 (0.01%)) with 90 percent benign waste rock (33 ppm U308 (0.003%)). The proposed project mixture would be much less than that analyzed by DOE, which required only 12 inches of topsoil to reduce the exposure to less than 100 mrem/yr.

The resulting Ra-226 level used in the modeling effort was equal to 31.0 pCi/g, which is above the benign waste-rock pile average of only 23.7 pCi/. Results of the modeling effort indicated that the calculated dose for a camper who resides on the reclaimed waste rock storage area over a 7-day period (24 hours/day) would be about 0.2 mrem/yr. This dose is minor compared to EPA's 100 mrem/yr guideline for radiation exposure and is more than what is expected at the Daneros property, because the Daneros material is only 8.7 pCi/g.

The DOE report states, "The degree to which exposures would be reduced would depend on the reclamation method used…for both methods the potential for radiation exposures after reclamation is expected to be negligible" (DOE 2007).

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