

## 5.0 SUMMARY AND CONCLUSIONS

This Report describes the results of the RSE conducted at the Site and adjacent properties between August 14, 2006 and December 5, 2006. The RSE consisted of investigating surface and subsurface soils and sediments at various areas within and near the Site, in accordance with the RSEWP.

The Site was initially divided into eleven individual survey areas, which included NECR-1, NECR-2, Ponds 1 and 2, Pond 3/3a, Sandfill 1, Sandfill 2, Sandfill 3, Sediment Pad, Boneyard, NEMSA, and the Unnamed Arroyo. Two additional areas were added during the field investigation based on preliminary radiological scans; these areas were investigated in a judgmental manner only. These areas are Vent Hole 3/8 and the Trailer Park. Additionally, nine Home Sites located northeast of the Site were also investigated as part of the RSE and a soil removal action was subsequently carried out at five of the Home Sites (consisting of three properties) based on the results of the RSE. These home sites are located between NECR and the Quivera mine and are situated on the Quivera mine lease. Potential impacts to the Home Sites may have occurred due to wind or water transport of materials stemming from historical operations at NECR, historical operations at the Quivera mine, or background conditions.

Field investigation methods included scan and static gamma surveying, surface soil sampling, and subsurface soil sampling. The gamma radiation surveys indicated that surface soils within the initial boundaries of each of the on-site areas contain surface soils with Ra-226 concentrations above the 2.24 pCi/g FSL. The FSL for Ra-226 was derived from the residential PRG and mean background concentration of Ra-226, as described in Section 2.5. Small fractions of the survey points within the initial boundaries areas are below the FSL. The locations of exceedances of Ra-226 (equivalent) are frequent and closely spaced such that delineation of any smaller, clean areas within the interior of the areas is not practical, except possibly in Sandfill 1, where about 11 contiguous survey grid points are below the FSL.

The results of the static gamma radiation survey show that the average surface soil Ra-226 concentrations, as determined by correlation with the gamma survey results (CPM), range from approximately four to twenty times the 2.24 pCi/g FSL within each survey area. The surface soil Ra-226 concentration range is wide, with high standard deviations near or above the average concentrations indicating sporadic occurrence of elevated Ra-226 in surface soil.

Based on the static survey level results (i.e., locations below the Ra-226 FSL), an outer boundary for each area was interpreted and is shown on Figures 3-1 and 3-3 as the "FSL Boundary". This boundary was drawn outside of most Ra-226 exceedances of the FSL. The FSL Boundary was confirmed and slightly revised based on the results of the surface soil sampling. In many cases, the edge of impacted ground was established in the field, based on the following:

- Undisturbed ground, such as in wooded areas with native soils.
- Roads, structures, and fences.
- Topographic limitations such as precipices, and steep hillsides.
- Boundaries of adjoining survey areas.

The RSEWP also specified one-point surface soil sampling at 20% of the 80-foot triangular grid nodes (sample locations), or at least 13 grid nodes within an area, as well as from the five scan locations with the highest CPM readings at each of the nine Home Sites. The results show that although there may be some variation between Ra-226 surface soil concentrations by soil sampling versus static gamma radiation survey at some locations, the averages are comparable.

Surface soil samples ( $\leq 0.5$  feet bgs) were collected from each of the fourteen survey areas, and analyzed for the preliminary COPCs (Ra-226, As, Mo, Se, U, and V). The results show that Ra-226 and uranium exceed the field screening levels at some locations, while all results for molybdenum, selenium and vanadium were below their respective field screening levels. Screening levels for As, Mo, Se, U, and V were based on the mean background concentrations, or in the case of arsenic, the published EPA Region 9 PRG, as described in Section 2.5. Ra-226, uranium and arsenic concentrations in surface soil were as follows:

- Ra-226 values ranged from 0.8 to 875 pCi/g with 70% of the 268 surface soil samples analyzed for Ra-226 [includes stepouts] exceeding the FSL of 2.24 pCi/g.
- Uranium values ranged from 0.7 to 3,970 mg/kg with 9% of the 230 samples analyzed for uranium exceeding the field screening level of 200 mg/kg.
- Arsenic values ranged from non-detect to 14.9 mg/kg with 60% of the 230 samples analyzed for arsenic exceeding the field screening level of 3.7 mg/kg. The data do not show any correlation between arsenic and Ra-226 or uranium concentrations, and there does not appear to be any spatial pattern in concentrations within the survey areas.

Subsurface soil samples ( $> 0.5$  feet bgs) were collected from each of the (original) eleven on-site survey areas, which includes the Unnamed Arroyo. Samples were collected in test pits, soil borings, and hand auger holes and analyzed for the preliminary COPCs. The results show that Ra-226, uranium and arsenic exceed the field screening levels at some locations, while all results for molybdenum, selenium and vanadium were below their respective field screening levels. Ra-226, uranium and arsenic concentrations in surface soil were as follows:

- Ra-226 values ranged from 0.6 to 438 pCi/g; 66% of the 145 subsurface soil samples analyzed for Ra-226 exceeded the FSL of 2.24 mg/kg.
- Total uranium values ranged from 0.7 to 760 mg/kg; 12% of the 145 samples analyzed for uranium exceeded the field screening level of 200 mg/kg.

Arsenic values ranged from non-detect ( $< 0.5$ ) to 13.9 mg/kg; 52% of the 145 samples analyzed for arsenic exceeded the field screening level of 3.7 mg/kg. The arsenic concentrations do not correlate with Ra-226 concentrations (e.g., locations of high arsenic concentrations are not necessarily co-located with high uranium concentrations) and there does not appear to be any spatial pattern in concentrations within the survey areas. Exceedances of the field screening levels in subsurface soils was confined to the top 5 to 14 feet at all sample locations, except at NECR-1. At NECR-1, exceedances of the field screening levels were detected in one soil boring (SB-090) in all samples collected from 5 to 25 feet bgs.

An evaluation of the the ratio of U-nat to Ra-226 concentrations in soils at the Home Sites was conducted. The average ratio of soils from around the Home Sites sampled for the RSE was 1.14. This is compared to an average ratio for background soils of 1.11, indicating that the Home Site soils are similar in nature to the background soils.

The HHRA that was conducted for the Site was based on the laboratory analysis results for surface soils ( $< 0.5$  feet bgs), and subsurface soils to a depth of 10 feet bgs. The HHRA is a quantitative and qualitative evaluation of potential impacts of Site-derived contaminants on human health, in the absence of remediation or institutional controls. Results of the HHRA are used to determine whether residual levels of contaminants in Site media are protective of human health and may be left in place, or consideration of remedial alternatives are warranted. The HHRA results also provide the basis for the development of alternatives and risk-based cleanup goals for the Site, as appropriate.

The HHRA described herein was conducted in accordance with methods described in Section 6.0 of the approved *Removal Site Evaluation Work Plan* (MWH, 2006). This HHRA is comprised of a site-specific conceptual site model (CSM), screening-level HHRA, and baseline HHRA. Risk characterization results expressed as cancer ILCR and non-cancer HI estimates for on-site receptors (current/future maintenance personnel, hypothetical future livestock grazers, and hypothetical future on-site residents) and for off-site receptors (current/future residents and hypothetical future livestock grazers) exposed to soils and sediments at the NECR Site are described below.

For each off-site and on-site area, two scenarios were evaluated: Scenario 1 summarizes risks to receptors when only direct soil exposure pathways are considered (i.e., incidental ingestion and inhalation of fugitive dust), while Scenario 2 includes five exposure pathways (i.e., incidental ingestion, inhalation of fugitive dust, consumption of homegrown produce, consumption of homegrown meat/eggs, and external radiation) (USEPA, 2007).

Additionally, the total combined risk for each area was calculated across all exposure pathways. Because the results of the risk calculations indicate that even naturally occurring (background) conditions exceed EPA's target risk range, incremental risk, which is the result of the background risk subtracted from the total combined risk, was also calculated for each survey area, as well as the Home Sites.

Located within the main NECR Site, there are 12 areas of concern which include: NECR-1, NECR-2 Ponds 1 & 2, Pond 3/3a, Sediment Pad, Sandfill 1, Sandfill 2, Sandfill 3, NEMSA, Boneyard, Vents 3 & 8, and the Trailer Park. Each on-site location was evaluated for current/future maintenance personnel, the hypothetical future livestock grazer, and hypothetical future on-site residents. The results of the assessment indicated the following:

- For current/future maintenance personnel under Scenario 1, no surface or subsurface soils in the on-site areas have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1.
- For current/future maintenance personnel under Scenario 2, surface soils in eight of the areas, and subsurface soils in five of the areas have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1. A surface soil Ra-226 concentration of 50 pCi/g would result in an estimated incremental risk or HQ within the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ < 1.
- For the hypothetical future livestock grazer, under Scenario 1, no surface or subsurface soils in the on-site areas have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1.
- For the hypothetical future livestock grazer, under Scenario 2, surface soils in all but one of the areas, and subsurface soils in all but three of the areas have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1. A surface soil Ra-226 concentration of 2.5 pCi/g would result in an estimated incremental risk or HQ within the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ < 1.
- For the hypothetical future on-site resident under Scenario 1, surface soils in all but three of the areas have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1. Risk drivers under Scenario 1 were Ra-226 and uranium. A surface soil Ra-226 concentration of 110 pCi/g would result in an estimated

incremental risk or HQ within the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ < 1. A surface soil uranium concentration of 48 mg/kg would result in an estimated incremental risk or HQ within the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ < 1.

- For the hypothetical future on-site resident under Scenario 2, surface soils in all of the areas have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1. A surface soil Ra-226 concentration of 1.9 pCi/g would result in an estimated incremental risk or HQ within the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ < 1. A surface soil uranium concentration of 48 mg/kg would result in an estimated incremental risk or HQ within the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ < 1.

For a resident under scenario 2, in order to achieve the EPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ <1, concentrations of Ra-226 in surface soil concentrations cannot exceed 1.9 pCi/g, which is below the naturally occurring average levels of Ra-226 levels on the Colorado Plateau.

Off-site areas include the nine Home Sites evaluated for residential receptors, the Unnamed Arroyo evaluated for the hypothetical future livestock grazer, and background data collected for the purpose of comparison to combined risk and hazard estimates for each area.

The results of the risk assessment for residents of the Home Sites indicate the following:

- Scenario 1 - none of the Home Sites have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1. Home Site #5 was associated with the highest ILCR (2E-05) estimated for any of the home sites. However, the ILCR due to background soils under scenario 1 was estimated as 1E-05.
- Scenario 2 – none of the Home Sites on the western side of the Unnamed Arroyo (Home Sites #1 through #5) have an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1.
- Scenario 2 - none of the Home Sites on the eastern side of the Unnamed Arroyo (Home Sites #6, #7, #8 and #9) have incremental ILCR or HQ estimates above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1, based on EPA's post-removal confirmation sampling results. The total ILCR for all Home Sites on the eastern side of the Unnamed Arroyo were equal to 1E-04. For comparison, the total ILCR estimate for background soil was equal to 2E-04. Both the site-related and background risk estimates presented in this baseline ILCR are likely over-estimated as described in the Uncertainty Analysis (Section 4.4).

Incremental risk estimates greater than 1E-04 are attributable to the consumption of homegrown produce, the consumption of homegrown meat, and the external exposure pathways considered in Scenario 2. Actual exposures will be lower than those assumed if vegetable gardens are not used, if livestock do not graze in the area, and/or if a concrete slab is part of the foundation at these Home Sites. In addition, it may not be appropriate to consider the latter indirect exposure pathways given that the risk-based Soil Screening Levels (SSLs) for Ra-226 for external exposure, consumption of homegrown produce, and consumption of homegrown meat based on a risk level of 10<sup>-6</sup> are 0.01 pCi/g, 0.069 pCi/g and 0.024 pCi/g, respectively, and are below the site-specific background level of 1.0 pCi/g. It should also be noted that the exposure and risk estimates described in this HHRA are biased high due to the soil sampling design. Field screening was used to identify biased locations for

the collection of soil samples. In turn, the 95% UCL on the mean concentration of these biased soil samples was used to estimate exposure doses and risk estimates. In most cases, the concentrations observed at biased sample locations are representative of only a very minor portion of the entire home site.

For the hypothetical future livestock grazer within the Unnamed Arroyo evaluated under Scenario 1 and 2, neither surface soil or subsurface soil concentrations of any COPC has an incremental risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1.

For the background data, only surface soil samples were collected. For Scenario 1, no soil concentrations of any COPC have a cumulative risk or HQ above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 or HQ > 1. For Scenario 2, arsenic and Ra-226 contribute to incremental risks above the USEPA risk management range of cancer risk equal to 1E-06 to 1E-04 and/or HQ > 1 due to soil ingestion, the consumption of homegrown produce and meat and exposure to external radiation.

Different sources of uncertainty described in the report are incorporated into the risk estimate. Because the majority of these uncertainties err on the conservative side, the estimated risks presented in the HHRA for NECR most likely represent upper bound estimates; the actual risks are anticipated to be less. The protective nature of these assumptions is demonstrated by risk estimates associated with background concentrations of Ra-226 and non-radiological constituents in soil. The total ILCR for measured concentrations of all constituents in background soil (assuming scenario 2) was estimated as 2E-04. Therefore, it is appropriate to consider both Scenario 1 and 2 in making risk management decisions.

## 6.0 REFERENCES

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