

Characterization of the Burma Road Rubber Pit at the Savannah River Site, Aiken, South Carolina

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CHARACTERIZATION OF THE BURMA ROAD RUBBLE PIT AT THE SAVANNAH RIVER SITE, AIKEN, SOUTH CAROLINA

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ABSTRACT

The Burma Road Rubble Pit (BRRP) is located at the Savannah River Site (SRS) in Aiken County, South Carolina. The BRRP unit consists of two unlined earthen pits dug into surficial soil and filled with various waste materials. It was used from 1973 until 1983 for the disposal of dry inert rubble such as metal, concrete, lumber, poles, light fixtures, and glass. No record of the disposal of hazardous substances at the BRRP has been found. In 1983, the BRRP was closed by covering it with soil. In September 1988, a Ground Penetrating Radar survey detected three disturbed areas of soil near the BRRP, and a detailed and combined RCRA Facility Investigation/Remedial Investigation was conducted from November 1993 to February 1994 to determine whether hazardous substances were present in the subsurface, to evaluate the nature and extent of contamination, and to evaluate the risks posed to the SRS facility due to activities conducted at the BRRP site. Metals, semi-volatile organic compounds, volatile organic compounds, radionuclides and one pesticide (Aldrin) were detected in soil and groundwater samples collected from seventeen BRRP locations. A baseline risk assessment (BRA) was performed quantitatively to evaluate whether chemical and radionuclide concentrations detected in soil and groundwater at the BRRP posed an unacceptable threat to human health and the environment. The exposure scenarios identifiable for the BRRP were for environmental researchers, future residential and occupational land use. The total site noncancer hazard indices were below unity, and cancer risk levels were below $1.0E-06$ for the existing and future case environmental researcher scenario. The future case residential and occupational scenarios showed total hazard and risk levels which exceeded U. S. EPA criterion values relative to groundwater scenarios. For the most part, the total carcinogenic risks were within the $1.0E-04$ to $1.0E-06$ risk range. Only the future adult residential scenario was associated with risks exceeding $1.0E-04$. Interpretation of the findings of human health risk assessment for the BRRP is complicated by the fact that many of the chemicals and radionuclides detected in soil and groundwater at the unit were also detected in background/upgradient sampling locations such as the F- and H-Areas Inactive Process Sewer Line wells. The most significant fact of this presentation is to explain how the upgradient sources are affecting the groundwater at the unit. As part of the BRA, a screening-level ecological risk assessment (ERA) was conducted for the BRRP. The ERA was conducted to assess potential impacts to biota caused by exposure to chemical and radionuclide stressors. The ERA for this effort was prepared in accordance with U.S. EPA guidance. Based on the screening-level ERA, ecological impacts from the BRRP are unlikely. The proposed plan for the BRRP is a No Action.

The overall strategy for addressing the BRRP source unit was to: (1) characterize the waste unit delineating the nature and extent of contamination and identifying the media of concern (perform the RFI/RI); (2) perform a baseline risk assessment to evaluate media of concern, chemicals of concern, exposure pathways, and characterize potential risks; and (3) evaluate and perform a final action to remediate, as needed, the identified media(s) of concern.

INTRODUCTION

On December 21, 1989, SRS was included on the National Priorities List (NPL). This inclusion created a need to integrate the established Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Program with Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements to provide for a focused environmental program. In accordance with Section 120 of CERCLA, DOE has negotiated a Federal Facility Agreement (FFA, 1993) with EPA and SCDHEC to coordinate remedial activities at SRS into one comprehensive strategy which fulfills these dual regulatory requirements.

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The FFA lists the BRRP source unit (231-4F; Figure 1) as a RCRA/CERCLA unit requiring further evaluation using an investigation/assessment process that integrates and combines the RFI process with the CERCLA RI to determine the actual or potential impact to human health and the environment.

“Place Fig. 1 here.”

The Department of Energy (DOE), the lead agency for SRS remedial activities, with concurrence by the EPA and SCDHEC, issued a proposed plan (PP) to the public for comment. This PP is a summary of the Administrative Record File leading to the preferred alternative. DOE, in consultation with EPA and SCDHEC, will select the appropriate final remedial action to be performed at the BRRP source unit following a public comment period. The PP summarizes the remedial investigation activities and the baseline risk assessment that were completed for the BRRP unit.

SITE DESCRIPTION AND LOCATION

The BRRP, 231-4F, is located approximately one-half mile southwest of the F-Area Separations Facility and one-tenth mile southwest of C Road. It is between Upper Three Runs Creek (approximately 4000 feet to the northwest) and Four Mile Creek (approximately one mile to the southwest) (see Figure 1). A westward trending tributary to Upper Three Runs Creek is located approximately 2,000 feet to the north. The BRRP ground surface elevation is approximately 290 feet mean sea level. Surface runoff is northwestward toward the tributary.

The BRRP consists of two unlined earthen pits dug into surficial soil and filled with various waste materials. The BRRP was originally reported to be 485 feet long, 125 to 150 feet wide, and at least 10 feet deep. A GPR survey, conducted in September 1988, indicated that the BRRP area consists of two generally rectangular pits (GPR Zone 1 and GPR Zone 2), each about 400 feet long, up to 50 feet wide, and 10 feet deep. A small circular area (GPR Zone 3) of disturbed soil was detected adjacent to these pits, and is considered to have been used as a source of backfill for the pits.

The soils at BRRP were so extensively graded, exposed, transported, mixed, and compacted during earth moving and construction that they can not be assigned to a particular soil series with a high level of confidence. The soils are generally more friable, but may be firmer due to compaction. Organic matter and other plant nutrients are usually low in these soils due to stripping and mixing, and extreme variations may occur laterally within very small distances. The soil pH may be low, and permeability is low to moderate.

HISTORY OF THE UNIT

The BRRP was used from 1973 to 1983 for the disposal of dry inert rubble such as wood, trash, wire, bottles, plastic, rubble, foam, and concrete. No record of hazardous substances disposal at the BRRP has been found. In 1983, disposal at the BRRP ceased and it was backfilled with soil. The area is currently delineated by orange marker balls at the perimeter of the waste unit.

CHARACTERIZATION

The BRRP RFI/RI investigation was conducted from November 1993 to February 1994. Samples were collected to characterize the chemical concentrations in soil, groundwater, sediments, and surface water. Sampling and investigation activities are summarized below. Detailed information regarding sampling/investigation activities can be found in the *Final RFI/RI Report for Burma Road Rubble Pit (231-4F)*, (WSRC, 1995).

Surface and subsurface soil samples were collected from the BRRP site at seventeen locations suspected of contamination (e.g., the soil borings were located in areas where a soil gas anomaly was detected, or adjacent to potential underground objects or areas of high metal concentrations as indicated by the GPR, electromagnetic, or magnetometer surveys). Soil samples were collected at depths of 0 to 2 feet (surficial) and 8 to 32 feet (subsurface), representing soil conditions above and below the fill material. During the sampling, the soil borings encountered no

containers (e.g., drums), liquid, or sludge, nor experienced a rod-drop indicating that a drum or container had been punctured. Only inert materials (e.g., wood, trash, wire, bottles, plastic, rubble, foam, concrete) were encountered during the soil sampling.

During the investigation, it was observed that standing water was present in a low lying area adjacent to the BRRP source unit. A field decision was made to collect two surface water samples in addition to the sampling specified in the *Phase II RFI/RI Work Plan for the Burma Road Rubble Pit* (WSRC, 1993) in order to be conservative and to provide additional characterization data. One surface water sample was collected near the water's edge, while the other was collected from a high turbidity area in the pond. A sediment sample was also collected (at a depth of 3 to 4 inches near the water's edge) from the borrow pit adjacent to the BRRP, to determine if the BRRP has impacted the quality of sediment in the borrow pit.

Two surface runoff soil (sediment) samples were collected from depths of 6 to 12 inches at a ditch located down slope from the BRRP. The results were used to determine if runoff from the unit has carried possible contamination to off site areas.

Background soil samples were taken from areas away from GPR Zones 1, 2, 3 and outside of the soil gas anomalies. Four background subsurface soil samples were taken at a depth of 10 to 12 feet, a depth corresponding to the base of the BRRP source unit. Two background surface soil samples were taken at a depth of 0 to 2 feet from an area located upgradient and at a distance from the BRRP source unit sufficient to preclude any impact from the unit. Background surface water samples were unavailable because there is no upgradient body of surface water within a reasonable distance of the waste unit from which to obtain unit-specific background samples.

All samples were analyzed in accordance with EPA-approved protocols. The detailed analytical results are contained in the *Quality Control Summary Report for the Burma Road Rubble Pit RFI/RI Unit Assessment* (WSRC, 1994). Validation and verification of the analytical data were performed as part of the RFI/RI data review process; therefore, the data were considered acceptable for this evaluation. Soil data from 0 to 2 feet were used in the risk assessment as the primary direct contact exposure interval for soils. Soils collected from 8 to 32 feet were evaluated for potential soil to groundwater migration.

Nine new groundwater monitoring wells were installed at varying depths in 3 three-well clusters. Of the 14 wells that now exist at BRRP, six wells are considered to be upgradient wells. However, the entire BRRP is downgradient of the SRS F-Area Separations Facility, and the entire BRRP well network may be impacted by groundwater migration from F-Area.

The groundwater beneath the BRRP is divided into three aquifers, designated B, C, and D. Aquifer B, the water table aquifer, is the shallowest, located approximately 61 to 83 feet below land surface. Aquifer C is beneath Aquifer D and is approximately 100–140 feet below land surface. Aquifer D, the deepest aquifer, is located approximately 150 to 170 feet below land surface. The depths of the aquifers are approximate since they are based on well elevations.

Human Health Risk Assessment

As part of the investigation/assessment process for the BRRP waste unit, a risk assessment was performed using the data generated during the characterization phase. Detailed information regarding the development of contaminants of potential concern, the fate and transport of contaminants, and the risk assessment can be found in the *Final RFI/RI Report for Burma Road Rubble Pit (231-4F)*, (WSRC, 1995).

The process of designating the chemicals of potential concern (COPCs) was based on consideration of background concentrations, frequency of detection, relative toxic potential of the chemicals, and chemical nutrient status. COPCs included volatile organic compounds, semi-volatile organic compounds, metals and other inorganic analytes, and radionuclides identified through approved site characterization activities.

An exposure assessment was performed to indicate the potential exposures which could occur based on the chemical concentrations detected during sampling. Three exposure scenarios in two categories were evaluated. For current land uses, the scenario was the environmental researcher who may work or traverse the BRRP on an intermittent or limited basis. Future exposure scenarios identified for the BRRP included future environmental researchers as well as conservative future adult and child residents, and an occupational worker. The exposure routes identified for these scenarios were incidental ingestion of soil, dermal contact with soil, inhalation of chemicals in ambient air, external radiation/air immersion exposure to radionuclides, ingestion of groundwater, dermal contact with groundwater, and inhalation of chemicals that volatilize from groundwater.

Per EPA guidance, the carcinogenic (cancer) risks and non-carcinogenic hazards were calculated to determine the appropriate remedial action. Cancer risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of pathway-specific exposure to carcinogenic contaminants. The risk to an individual resulting from exposure to non-radioactive chemical carcinogens is expressed as the increased probability of cancer occurring over the course of a 70 year lifetime. Cancer risks are related to the EPA target range of one in ten thousand (1.0×10^{-4}) to one in one million (1.0×10^{-6}) for incremental cancer risk at NPL sites. Risk levels at or above 1.0×10^{-4} are considered significant. In order to account for simultaneous exposure to multiple carcinogens through a given pathway, the risk calculated for each carcinogen in that medium were summed to obtain an estimate of the total cancer risk for the pathway.

Non-carcinogenic effects are evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. To evaluate the non-carcinogenic effects of exposure to soil contaminants, the hazard quotient (HQ), which is the ratio of the exposure dose to the RfD, is calculated for each contaminant. The non-carcinogenic HQ assumes that below a given level of exposure (e.g., the RfD), even sensitive populations are unlikely to experience adverse health effects. If the exposure level exceeds the threshold, there may be concern for potential non-carcinogenic health effects. HQs are summed for each exposure pathway to create a pathway specific hazard index (HI) for each exposure scenario. The more the HI exceeds unity (1.0), the greater the concern that adverse health effects will occur. The reasonable maximum exposure concentration value was used as the exposure point concentration.

Current Land Use - Noncarcinogenic Hazards—The total noncarcinogenic (noncancer) hazard index did not exceed unity for the environmental researcher receptor evaluated in the current land use scenario.

Current Land Use - Carcinogenic Risks—The total carcinogenic (cancer) risk (for chemicals and radionuclides) did not exceed a level of 1.0×10^{-6} for the environmental researcher investigated for the current land use scenario.

Future Land Use - Noncarcinogenic Hazards—The total noncarcinogenic hazard indices were calculated by adding the HQs for both the soil and groundwater for each receptor. The total noncancer hazard indices for the hypothetical future environmental researcher were below unity.

The total noncancer hazard index for the future receptor exceeded unity for the hypothetical future resident (adult and child) scenarios. The total hazard for the future residential adult for soil and groundwater in Aquifer B was calculated to be 1.2, with the ingestion of nitrate from groundwater in Aquifer B as the primary contributor. Nitrate was also the primary contributor for the future residential child total noncancer hazard index of 2.9, again due to the ingestion of groundwater in Aquifer B.

The future residential child scenario also yielded other cases where the total noncancer hazard index exceeded unity. These cases were the calculations for soil and groundwater in Aquifers C and D, where the total HI was 1.6 and 1.4 respectively. The primary contributor for the ingestion of groundwater in Aquifer C was arsenic. In Aquifer D, the primary contributor for the ingestion of groundwater was carbon tetrachloride (see results in Table I for pathways that exceeded unity).

“Place Table I here.”

The maximum nitrate concentration detected at the BRRP was 4.1 mg/L, which is below the maximum contaminant level for nitrate. The nitrate concentrations detected in the BRR wells are a result of migration from the F-Area Seepage Basins groundwater (Rabin, 1995): FSB wells which were screened in this aquifer were often higher than the concentrations found in the BRR wells.

The BRR wells were sampled for arsenic twice in 1994, and the maximum concentration detected was 2.32×10^{-3} mg/L, which is above the detection limit for arsenic, but is below the remediation goal for the F-Area Seepage Basins Remediation Project. None of the FSB wells had measured arsenic values above the maximum contaminant level. Therefore, it can not be determined if arsenic is a result of upgradient migration.

Carbon tetrachloride was detected in the BRR wells at a maximum concentration of 4.45×10^{-3} mg/L, which is below the maximum contaminant level for that substance. Carbon tetrachloride was detected in FSL wells at elevated concentrations. Since the BRRP soil analyses for carbon tetrachloride were below the detection limit, it appears that the source of carbon tetrachloride measured in the BRR wells is a result of contamination migrating from the groundwater below the F-Area Inactive Process Sewer Lines.

Future Land Use - Carcinogenic Risks—For the future residential adult, the only estimated risk from the unit soils was the ingestion of arsenic, with a risk value of 1.9×10^{-6} . And, for the future residential child, the only estimated risk from the unit soils was the ingestion of arsenic with a risk value of 2.8×10^{-6} . The arsenic level associated with both risks was 1.74 mg/kg. It should be noted that arsenic was used as a component of agricultural chemicals in the period before SRS existed. Thus, the detected value may be a result of farming activities in the 1930's through 1950. There were also radionuclide and chemical risk drivers for the ingestion and inhalation of groundwater for the future residential adult, the future residential child, and the future occupational worker pathways.

For the hypothetical future residential adult, the chemicals associated with carcinogenic risks above 1.0×10^{-6} included arsenic, beryllium, carbon tetrachloride, and bis(2-ethylhexyl) phthalate for the ingestion of groundwater. For the ingestion of groundwater, cesium-137, radium, and tritium were risk drivers. Carbon tetrachloride, radium, and tritium were the risk drivers for the future residential adult for the inhalation of groundwater. The risk drivers for Aquifer B were tritium and cesium-137. The risk values for Aquifer B were 5.7×10^{-5} (ingestion pathway) and 3.2×10^{-5} (inhalation pathway). Aquifer C risk drivers were arsenic, tritium, and bis(2-ethylhexyl) phthalate. For Aquifer C, the risk values were 5.2×10^{-5} (ingestion of chemicals), 9.3×10^{-5} (ingestion of radionuclides), and 5.3×10^{-5} (inhalation of radionuclides). Beryllium, carbon tetrachloride, cesium-137, and radium were the risk drivers for Aquifer D. Aquifer D chemicals were associated with risk values of 5.7×10^{-5} and 1.3×10^{-6} for the ingestion and inhalation pathways, respectively. The risk values associated with the radionuclides in Aquifer D were 1.1×10^{-5} (ingestion pathway) and 1.5×10^{-5} (inhalation pathway). See results shown in Tables II and III.

“Place Tables II and III.”

For the future residential child, the chemicals associated with carcinogenic risks above 1.0×10^{-6} included arsenic, beryllium, and carbon tetrachloride for the ingestion of groundwater. There were no chemicals associated with any risks above 1.0×10^{-6} for the future residential child for the inhalation of groundwater.

Radium and tritium were radionuclide risk drivers for the inhalation and ingestion of groundwater. For the future residential child, tritium was the risk driver for Aquifer B; arsenic and tritium were the risk drivers for Aquifer C; and beryllium, carbon tetrachloride, and radium were the risk drivers for Aquifer D. For the radionuclides in Aquifer B, the risk values were 8.5×10^{-6} and 9.7×10^{-6} for the ingestion and inhalation pathways, respectively. The ingestion pathways for Aquifer C had risk values of 1.9×10^{-5} (chemicals) and 1.4×10^{-5} (radionuclides). For the inhalation of radionuclides in Aquifer C, the risk value was 1.6×10^{-5} . Aquifer D risk values were 2.1×10^{-5} , 2.1×10^{-6} , and 6.7×10^{-6} for the ingestion of chemicals, ingestion of radionuclides, and the inhalation of radionuclides pathways, respectively. See results shown in Tables II and III.

The future occupational worker scenario had three chemicals and three radionuclides associated with cancer risks above 1.0×10^{-6} for groundwater ingestion. Arsenic, beryllium, and carbon tetrachloride were the chemicals; and, cesium-137, radium, and tritium were the radionuclides. There were no risk drivers for the inhalation of groundwater for the future occupational worker. Tritium was the risk driver for Aquifer B; arsenic and tritium were the risk drivers for Aquifer C; and beryllium, carbon tetrachloride, cesium-137, and radium were the risk drivers in Aquifer D. The risk value for the radionuclides in Aquifer B is 1.9×10^{-5} . Aquifer C had a risk value of 1.6×10^{-5} for chemicals and 3.1×10^{-5} for radionuclides. The chemicals and radionuclides in Aquifer D had associated risk values of 1.7×10^{-5} and 3.6×10^{-6} , respectively.

For Aquifer B, tritium was the risk driver at a maximum level of 9.94×10^4 pCi/L. However, the FSB wells that are screened in the same aquifer zone had higher concentrations of tritium. The maximum level of cesium-137 found in the BRR wells in Aquifer B was 3.98 pCi/L. This maximum level is less than the concentrations found in the FSB wells. This means that the tritium and cesium-137 concentrations detected in the BRR wells are result of migration from upgradient sources.

For Aquifer C, the maximum arsenic concentration was 2.32×10^{-3} mg/L. As stated before, it could not be determined if the arsenic concentrations found in the BRRP groundwater were the result of upgradient sources. The maximum bis(2-ethylhexyl) phthalate concentration detected in the BRR wells was 1.30×10^{-2} mg/L, which is significantly lower than the FSB well concentrations. Bis(2-ethylhexyl)phthalate is also known to be a common lab artifact. Therefore, it is concluded that this contaminant is either a lab artifact or the result of groundwater migration from upgradient sources (Rabin, 1995). Tritium was detected in this aquifer at a maximum concentration of 1.68×10^5 pCi/L. However, the F-Area Inactive Process Sewer Line (FSL) wells that are upgradient of the BRRP and the FSB wells that are screened in the same aquifer zone had much higher concentrations of tritium. Based on this information, the tritium concentrations detected beneath the BRRP are the result of migration from upgradient sources.

The concentrations of the contaminants found in the BRR Aquifer D wells were also compared to the FSL and FSB wells. The BRR wells were analyzed for beryllium from 1991 to 1994. In 1994, the detection limit for beryllium was lowered, and the groundwater samples showed concentrations that were above the detection limit. That year, the maximum concentration detected was 9.90×10^{-4} mg/L, which is below the maximum contaminant level. All samples in the FSL well series were below the detection limit; and, no samples were taken for beryllium in 1994. Therefore it is difficult, based on this information, to determine if the beryllium detected in the groundwater is from upgradient sources.

The maximum carbon tetrachloride concentration detected in Aquifer D was 4.4×10^{-3} mg/L. Carbon tetrachloride concentrations detected in FSL wells were elevated. Based on this information and the fact that the BRRP carbon tetrachloride soil analyses were below detection, the source of the carbon tetrachloride beneath the BRRP is a result of contamination migrating from groundwater beneath the F-Area Inactive Process Sewer Line.

Cesium-137 was detected in the BRR wells at a maximum concentration of 10.2 pCi/L. Concentrations of cesium-137 in the FSL well series were measured at elevated levels. Therefore, the cesium-137 observed in the BRR wells is the result of contaminant migration from the groundwater beneath the F-Area Inactive Process Sewer Line.

Total alpha emitting radium was observed at concentrations above detection limit in Aquifer D BRR wells, with a maximum concentration of 9.4 pCi/L. FSL wells located upgradient of the BRR wells had elevated concentrations

of radium, but they were below the maximum concentration detected in the BRR wells. However, it should be noted that the FSL well analyses for total alpha emitting radium occurred after January 1993. The elevated levels of radium indicates that radium has already passed the FSL wells and has migrated to the BRR wells.

Only one future residential pathway exceeded the 1×10^{-4} risk level; this was for the combined ingestion and inhalation of groundwater pathways. The risk to exposure to radionuclides for the future resident adult was 1.5×10^{-4} , which barely exceeds the 1×10^{-4} range. The risk was due to the ingestion and inhalation of the groundwater from Aquifer C. Again, tritium at a maximum level of 1.68×10^5 pCi/L, was the risk driver. As stated previously, tritium concentrations detected beneath the BRRP are the result of migration from upgradient sources.

For the future residential adult, the only estimated risk from the unit soils was the ingestion of arsenic with a risk value of 1.9×10^{-6} . And, for the future residential child, the only estimated risk from the unit soils was the ingestion of arsenic with a risk value of 2.8×10^{-6} . The arsenic level associated with both risks was 1.74 mg/kg. It has been noted that this detected value may be a result of farming activities in the 1930's through 1950.

Table IV provides a summary of the carcinogenic risks and applicable COCs associated with the future land use scenario for the BRRP unit soils.

“Place Table IV here.”

Ecological Risk Assessment

A screening-level ecological risk assessment was conducted to assess the potential impacts to biota caused by exposure to chemicals and radionuclides at the BRRP. A site ecological reconnaissance was conducted in August 1994. No wetlands or threatened and endangered (T&E) species were observed in the vicinity of the BRRP, and use of the site by T&E species was not expected. The potential media of contaminant exposure were surface soil, sediment, and surface water at or near the BRRP. Based on the screening-level ecological risk assessment, ecological impacts from the BRRP are unlikely.

Summary of the Considered Alternative

EPA clarified the role of the BRA in OSWER Directive 9355.0-30, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (EPA, 1991). The EPA states “where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 1.0×10^{-4} , and the non-carcinogenic hazard quotient is less than 1, action is generally not warranted unless there are adverse environmental impacts.” (EPA, 1991). Based on the risk assessment, the BRRP unit soil poses no risk to human health or the environment. Therefore, no action is required at the BRRP unit soil and no other alternatives were considered for the unit soil.

Although there is groundwater contamination (e.g., carbon tetrachloride, bis(2-ethylhexyl)phthalate, nitrate, cesium-137, radium, and tritium,) beneath the BRRP, the groundwater contamination is due to migration from upgradient sources such as the F-Area Inactive Process Sewer Lines. It is proposed that any groundwater contamination detected beneath the BRRP be cleaned up under the RCRA Corrective Action Plan to remediate groundwater contamination at the F- and H-Areas Seepage Basins.

REFERENCES

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Table I. Future Land Use—Noncarcinogenic Hazards (Exposure to Chemicals)

Receptor	Soil Ingestion	Soil Dermal	Soil Inhalation	Produce Ingestion	Aquifer B Ingestion	Aquifer B Dermal	Aquifer B Inhalation	Total	Driver(s)
Residential Adult	2.6 x 10 ⁻²	2.9 x 10 ⁻²	2.7 x 10 ⁻⁶	1.3 x 10 ⁻⁴	1.2	4.9 x 10 ⁻³	1.1 x 10 ⁻⁵	1.2	Nitrate (GW)
Residential Child	2.3 x 10 ⁻¹	1.1 x 10 ⁻¹	1.3 x 10 ⁻⁵	3.0 x 10 ⁻⁴	2.5	8.1 x 10 ⁻³	4.9 x 10 ⁻⁵	2.9	Nitrate (GW)
					Aquifer C Ingestion	Aquifer C Dermal	Aquifer C Inhalation		
Residential Child	2.3x 10 ⁻¹	1.1 x 10 ⁻¹	1.3x 10 ⁻⁵	3.0 x 10 ⁻⁴	1.3	1.4 x 10 ⁻²	4.4 x 10 ⁻⁵	1.6	Arsenic (GW)
					Aquifer D Ingestion	Aquifer D Dermal	Aquifer D Inhalation		
Residential Child	2.3 x 10 ⁻¹	1.1 x 10 ⁻¹	1.3 x 10 ⁻⁵	3.0 x 10 ⁻⁴	1.0	1.6x 10 ⁻²	3.3x 10 ⁻²	1.4	CCl4 (GW)

Shaded items represent exceedances

NA - Not applicable

GW - Groundwater

CCl4 - Carbon Tetrachloride

Table II. Future Land Use—Carcinogenic Risks (Exposure to Chemicals)

Receptor	Soil Ingestion	Soil Dermal	Soil Inhalation	Produce Ingestion	Aquifer B Ingestion	Aquifer B Dermal	Aquifer B Inhalation	Total	Driver(s)
Residential Adult	1.9 x 10 ⁻⁶	9.8 x 10 ⁻⁸	4.5x 10 ⁻⁸	1.2 x 10 ⁻⁷	8.8 x 10 ⁻⁷	2.0 x 10 ⁻⁸	2.2 x 10 ⁻⁷	3.3x 10 ⁻⁶	Arsenic (soil)
Residential Child	2.8 x 10 ⁻⁶	6.4 x 10 ⁻⁸	3.6 x 10 ⁻⁸	4.4 x 10 ⁻⁸	3.2 x 10 ⁻⁷	5.4x 10 ⁻⁹	1.6x 10 ⁻⁷	3.4x 10 ⁻⁶	Arsenic (soil)
					Aquifer C Ingestion	Aquifer C Dermal	Aquifer C Inhalation		
Residential Adult	1.9 x 10 ⁻⁶	9.8 x 10 ⁻⁸	4.5x 10 ⁻⁸	1.2 x 10 ⁻⁷	5.2 x 10 ⁻⁵	2.8x 10 ⁻⁷	2.4x 10 ⁻⁷	5.5 x 10 ⁻⁵	Arsenic (soil and GW); BEHP (GW)
Residential Child	2.8 x 10 ⁻⁶	6.4x 10 ⁻⁸	3.6 x 10 ⁻⁸	4.4 x 10 ⁻⁸	1.9 x 10 ⁻⁵	7.5 x 10 ⁻⁸	1.8x 10 ⁻⁷	2.2x 10 ⁻⁵	Arsenic (soil and GW)
Occupational Worker	5.6x 10 ⁻⁷	5.8 x 10 ⁻⁸	9.0x 10 ⁻⁹	NA	1.6 x 10 ⁻⁵	NA	NA	1.6 x 10 ⁻⁵	Arsenic (GW)
					Aquifer D Ingestion	Aquifer D Dermal	Aquifer D Inhalation		
Residential Adult	1.9 x 10 ⁻⁶	9.8 x 10 ⁻⁸	4.5 x 10 ⁻⁸	1.2 x 10 ⁻⁷	5.7 x 10 ⁻⁵	5.8x 10 ⁻⁷	1.3 x 10 ⁻⁶	6.1 x 10 ⁻⁵	Arsenic (soil); Beryllium and CCl4 (GW)
Residential Child	2.8 x 10 ⁻⁶	6.4 x 10 ⁻⁸	3.6 x 10 ⁻⁸	4.4x 10 ⁻⁸	2.1x 10 ⁻⁵	1.6 x 10 ⁻⁷	9.6 x 10 ⁻⁷	2.5x 10 ⁻⁵	Arsenic (soil); Beryllium and CCl4 (GW)
Occupational Worker	5.6 x 10 ⁻⁷	5.8 x 10 ⁻⁸	9.0 x 10 ⁻⁹	NA	1.7 x 10 ⁻⁵	NA	NA	1.8x 10 ⁻⁵	Beryllium, CCl4 (GW)

Shaded items represent exceedances
 NA - Not applicable
 GW - Groundwater
 BEHP - Bis(2-ethylhexyl) phthalate
 CCl₄ - Carbon Tetrachloride

Table III. Future Land Use - Carcinogenic Risks (Exposure to Radionuclides)

Receptor	Soil Ingestion	Soil External	Soil Inhalation	Produce Ingestion	Aquifer B Ingestion	Aquifer B Dermal	Total	Driver(s)
Residential Adult	1.6x 10 ⁻⁹	3.6 x 10 ⁻⁷	3.7 x 10 ⁻¹³	1.1 x 10 ⁻¹³	5.7 x 10 ⁻⁵	3.2 x 10 ⁻⁵	8.9 x 10 ⁻⁵	Tritium, Cesium 137 (GW)
Residential Child	8.3 x 10 ⁻¹⁰	2.6 x 10 ⁻⁷	2.4 x 10 ⁻¹³	1.4 x 10 ⁻¹⁴	8.5 x 10 ⁻⁶	9.7 x 10 ⁻⁶	1.8 x 10 ⁻⁵	Tritium (GW)
Occupational Worker	9.0 x 10 ⁻¹⁰	1.1 x 10 ⁻⁷	8.5 x 10 ⁻¹⁴	NA	1.9 x 10 ⁻⁵	NA	1.9 x 10 ⁻⁵	Tritium (GW)
					Aquifer C Ingestion	Aquifer C Dermal		
Residential Adult	1.8 x 10 ⁻¹⁰	6.6 x 10 ⁻⁷	1.2 x 10 ⁻¹²	1.1 x 10 ⁻¹³	9.3 x 10 ⁻⁵	5.2 x 10 ⁻⁵	1.5 x 10 ⁻⁴	Tritium (GW)
Residential Child	8.3 x 10 ⁻¹⁰	2.6 x 10 ⁻⁷	2.4 x 10 ⁻¹³	1.4 x 10 ⁻¹⁴	1.4 x 10 ⁻⁵	1.6 x 10 ⁻⁵	3.0 x 10 ⁻⁵	Tritium (GW)
Occupational Worker	9.0 x 10 ⁻¹⁰	1.1 x 10 ⁻⁷	8.5 x 10 ⁻¹⁴	NA	3.1 x 10 ⁻⁵	NA	3.1 x 10 ⁻⁵	Tritium (GW)
					Aquifer D Ingestion	Aquifer D Dermal		
Residential Adult	1.8 x 10 ⁻¹⁰	6.6 x 10 ⁻⁷	1.2 x 10 ⁻¹²	1.1 x 10 ⁻¹³	1.1 x 10 ⁻⁵	1.4 x 10 ⁻⁵	2.6 x 10 ⁻⁵	Cesium 137 Radium Tritium (GW)
Residential Child	8.3 x 10 ⁻¹⁰	2.6 x 10 ⁻⁷	2.4 x 10 ⁻¹³	1.4 x 10 ⁻¹⁴	2.1 x 10 ⁻⁶	6.7 x 10 ⁻⁶	9.1 x 10 ⁻⁶	Radium (GW)
Occupational Worker	9.0 x 10 ⁻¹⁰	1.1 x 10 ⁻⁷	8.5 x 10 ⁻¹⁴	NA	3.6 x 10 ⁻⁶	NA	3.7 x 10 ⁻⁶	Cesium 137 Radium (GW)

Shaded items represent exceedances
 NA - Not applicable
 GW - Groundwater

Table IV. Future Land Use - Carcinogenic Risks (Exposure to Chemicals)

Receptor	Soil - Ingestion	Soil - Dermal	Soil - Inhalation	Produce - Ingestion	Total (Soils Only)	Risk Driver
Residential Adult	1.9 x 10 ⁻⁶	9.8 x 10 ⁻⁸	4.5 x 10 ⁻⁸	1.2 x 10 ⁻⁷	2.2 x 10 ⁻⁶	Arsenic
Residential Child	2.8 x 10 ⁻⁶	6.4 x 10 ⁻⁸	3.6 x 10 ⁻⁸	4.4 x 10 ⁻⁸	2.9 x 10 ⁻⁶	Arsenic

Shaded items represent exceedances