

Assessment of OU2 Human Health Risks and Hazards Post-Remediation NRG-Indian River Generating Station, Burton Island OU2

A human health risk assessment was completed for the Burton Island Historical Ash Disposal Area (the 'Site') that assessed the carcinogenic risks and non-carcinogenic hazards from exposure to ash material as presented in the Facility Evaluation (FE; Shaw, 2008) and Remedial Investigation (RI; Shaw, 2011). The only potential human exposure to ash material that was considered somewhat routine was for recreational boaters/fishermen who frequent Indian River/Island Creek and trespass on the Site. This population was considered to be potentially exposed to ash material via three exposure routes:

- ingestion of recreationally caught fish/shellfish;
- incidental ingestion of surface soil; and
- dermal absorption of surface soil.

The ingestion of fish/shellfish is a potential exposure pathway that is associated with shoreline (Operable Unit 1 [OU1]) and off-shore (OU3) surface water and sediment, and not OU2 (area inside OU1). The inclusion of the fish/shellfish ingestion pathway in the OU2 human health risk assessment was solely for the purpose of providing an estimate of total cumulative risk/hazard to the potentially exposed recreational fishermen population. The potential risks from OU1 and OU3 were assessed in the *Facility Evaluation Report, Indian River Generating Station, Burton Island Old Ash Landfill* (Shaw, 2008) and the final remedy for OU1 and OU3 was stipulated in the *Approval of Final Plan of Remedial Action for Burton Island Ash Disposal Area (Operable Units 1 & 3)* (DNREC, 2008), as shoreline stabilization. Therefore, potential exposures associated with shoreline (OU1) and off-shore (OU3) surface water and sediment have been addressed via the implementation of the shoreline stabilization that has been completed at the Site and are not addressed in the Feasibility Study (FS) for OU2.

The human health risk assessment for OU2 at the Site, as presented in the RI (Shaw, 2011) assessed the only population determined to have the potential for exposures to ash material at the Site: recreational fishermen and their families. The estimated risks/hazards for OU2 were based on the two exposure pathways associated with OU2: incidental ingestion of surface soil and dermal absorption of surface soil. The quantification of exposures through these two pathways was accomplished using standard U.S. Environmental Protection Agency (USEPA) risk assessment exposure algorithms and USEPA and Delaware Department of Natural Resources and Environmental Control (DNREC) input parameters. The algorithms and input parameters for the two potentially complete exposure pathways at OU2 are described below.

Soil Ingestion Algorithm. The chronic daily intake (CDI) of constituents due to incidental ingestion of surface soil is calculated by the following formula:

$$CDI_{soil-ing} = \frac{C_{soil} \times IR_{soil} \times ABS \times EF \times ED \times CF}{BW \times AT}$$

where:

$CDI_{soil-ing}$	=	Chronic daily intake of surface soil from incidental ingestion (mg/kg-day);
C_{soil}	=	Constituent exposure point concentration in surface soil (mg/kg);
IR_{soil}	=	Ingestion rate of soil (kg/day);
ABS	=	Absorption factor (1.0, unitless);
EF	=	Exposure frequency (days/yr);
ED	=	Exposure duration (years);
CF	=	Conversion factor (10^{-6} kg/mg);
BW	=	Body weight (kg); and
AT	=	Averaging time (days).

Soil Dermal Absorption Algorithm. The CDI of constituents due to dermal absorption of surface soil is calculated by the following formula:

$$CDI_{soil-abs} = \frac{C_{soil} \times ABS \times SA \times AF \times EF \times ED \times CF}{BW \times AT}$$

where:

$CDI_{soil-abs}$	=	Chronic daily intake of surface soil from dermal absorption (mg/kg-day);
C_{soil}	=	Constituent exposure point concentration in surface soil (mg/kg);
SA	=	Surface area of exposed skin (cm^2 /event);
AF	=	Soil adherence factor (mg/cm^2);
ABS	=	Dermal absorption factor (0.01, unitless);
EF	=	Exposure frequency (events/yr);
ED	=	Exposure duration (years);
CF	=	Conversion factor (10^{-6} kg/mg);
BW	=	Body weight (kg); and
AT	=	Averaging time (days).

The soil ingestion rates, exposure frequency, exposure duration, body weights and averaging times are default exposure parameters presented in the *Hazardous Substance Cleanup Act Guidance Manual* (DNREC, 1994). The soil adherence factor (0.11 mg/cm²) used in this assessment is the average for the hands, arms, legs, face, and feet for gardeners presented in the USEPA's *Exposure Factors Handbook* (1997). The surface area of exposed skin for adults (5,800 cm²) is the upper percentile for outdoor soil contact presented in USEPA (1997a). The surface area of exposed skin for children (5,028 cm²) is the 90th percentile of surface area of the head, arms, hands, legs, and feet for children aged two to six years (USEPA, 1997a). The exposure parameters used in the formulae above, as presented in the RI (Shaw, 2011) are summarized in the following table.

Exposure Parameters for Surface Soil Ingestion and Dermal Absorption

Exposure Parameter	RME value
Soil ingestion rate (adult)	100 mg/day
Soil ingestion rate (child)	200 mg/day
GI absorption factor	1.0 (unitless)
Exposure frequency	78 days/year
Exposure duration (adult and child)	6 years
Soil Adherence Factor	0.11 mg/cm ²
Body weight (adult)	70 kg
Body weight (child)	17 kg
Surface Area of Exposed Skin (adult)	5,800 cm ²
Surface Area of Exposed Skin (child)	5,028 cm ²
Dermal Absorption Factor	0.001 (unitless)
Carcinogenic averaging time (adult and child)	25,550 days
Non-carcinogenic averaging time (adult and child)	2,190 days

mg/day – milligrams per day.

mg/cm² - milligram per square centimeter.

kg - kilogram

cm² - square centimeter.

The human health risk assessment presented in the RI (Shaw, 2011) determined that the estimated carcinogenic risks and non-carcinogenic hazards for adults potentially exposed to ash material at OU2 were within regulatory limits (i.e. cumulative carcinogenic risks less than 1 x 10⁻⁵ and non-carcinogenic hazards less than 1). However, the estimated carcinogenic risks and non-carcinogenic hazards for children potentially exposed to ash material at OU2 slightly exceeded regulatory limits. Carcinogenic risks for recreationally exposed children were estimated to be 4.6 x 10⁻⁵ and non-carcinogenic hazards were estimated to be 1.6.

Because the human health risk assessment presented in the RI (Shaw, 2011) determined that the estimated carcinogenic risks and non-carcinogenic hazards for children potentially exposed to ash material at OU2 may slightly exceed regulatory limits, a feasibility study (FS) was warranted. The FS has identified the following four remedial alternatives for soil at OU2:

- S-1: No Action;
- S-2: Targeted Soil Cover with Land Use Controls;
- S-3: Full Soil Cover with Institutional Controls; and
- S-4: Excavation and Off-site Disposal.

In order to determine the level of effectiveness for each remedial alternative in providing for the protection of human health and reaching the remedial action objectives (RAOs) of ensuring human cancer risk less than 1×10^{-5} and ensuring human non-cancer hazard index less than 1, human health risks/hazards were calculated for each remedial alternative assuming the remedial actions were completed. This entailed revising the exposure scenarios for the potentially exposed population based on the proposed remedial actions.

Remedial alternative S-1 is the No Action alternative. The No Action alternative does not include any active remediation, treatment, containment, removal, land use controls, or monitoring. The existing conditions would not be altered except perhaps by ongoing natural processes. As such, the human exposure scenarios would remain the same as those assessed in the FE and RI and the human health risks/hazards would also remain the same.

Remedial alternative S-2 is the Targeted Soil Cover with Land Use Controls alternative. The Targeted Soil Cover with Land Use Controls alternative includes clearing discrete areas of vegetation, grading and placing soil cover over discrete areas of currently exposed ash material and unstable slopes in OU2, performing perimeter patrols, maintaining 'no trespassing private property' signs, establishing a Uniform Environmental Covenant to limit future land use, and long-term monitoring. This remedial alternative would alter the currently existing conditions at OU2 by covering exposed ash material. This will limit potential exposure of humans to ash material at OU2, thereby minimizing risk. In addition, performing perimeter patrols will limit potential human access to the ash material at OU2. By limiting access specifically to the ash material and OU2 as a whole, the assumptions used in the human health risk assessment would be altered; namely the exposure frequency would be reduced. If the exposure frequency was reduced to 16 days per year (down from the default of 78 days per year used in the RI) as a result

of the perimeter patrols, the estimated carcinogenic risks and non-carcinogenic hazards would be reduced to 1.1×10^{-6} and 0.03, respectively for adults and 9.4×10^{-6} and 0.24, respectively for children (Table C-1). The estimated carcinogenic risks and non-carcinogenic hazards resulting from the implementation of this remedial alternative meet the RAOs established for the protection of human health.

Remedial alternative S-3 is the Full Soil Cover with Institutional Controls alternative. The Full Soil Cover with Institutional Controls alternative includes clearing vegetation from the entire surface area of OU2, grading and placing soil over the entire surface area of OU2, maintaining 'no trespassing private property' signs, establishing a Uniform Environmental Covenant to limit future land use, and long-term monitoring. This remedial alternative would effectively eliminate any exposures to surface material at OU2 and, therefore, render the potential human exposure pathways (incidental soil ingestion and dermal absorption) incomplete. If the potential exposure pathways are incomplete, then the estimated carcinogenic risks and non-carcinogenic hazards would be zero, and this remedial alternative would meet the RAOs established for the protection of human health.

Remedial alternative S-4 is the Excavation and Off-site Disposal alternative. The Excavation and Off-site Disposal alternative includes clearing vegetation from the entire surface of OU2, excavating ash material at OU2, temporarily storing stockpiles on-site for waste characterization, transport and disposal of excavated material at a permitted facility, and restoring the excavated areas. This remedial alternative would effectively eliminate any exposures to surface material at OU2 by removing it and, therefore, render the potential human exposure pathways (incidental soil ingestion and dermal absorption) incomplete. If the potential exposure pathways are incomplete, then the estimated carcinogenic risks and non-carcinogenic hazards would be zero, and this remedial alternative would meet the RAOs established for the protection of human health.

As described above and shown in the summary table (Table C-1), remedial alternatives S-2, S-3, and S-4 all meet the RAOs of ensuring human cancer risk less than 1×10^{-5} and ensuring human non-cancer hazard index less than 1. The only remedial alternative that does not meet the RAOs of ensuring human cancer risk less than 1×10^{-5} and ensuring human non-cancer hazard index less than 1 is S-1, the No Action alternative.

Table C-1
Summary of OU2 Human Health Risks and Hazards
Before and After Remediation
 Burton Island OU2, NRG - Indian River Power

Remedial Alternative	Adult Carcinogenic Risk		Child Carcinogenic Risk		Adult Non-Carcinogenic Hazard		Child Non-Carcinogenic Hazard	
	Before Remediation	After Remediation	Before Remediation	After Remediation	Before Remediation	After Remediation	Before Remediation	After Remediation
S-1: No Action	5.6E-06	5.6E-06	4.6E-05	4.6E-05	0.42	0.42	1.6	1.6
S-2: Targeted Soil Cover w/ Land Use Controls	5.6E-06	1.1E-06	4.6E-05	9.4E-06	0.42	0.03	1.6	0.24
S-3: Full Soil Cover w/ Institutional Controls	5.6E-06	0 ^a	4.6E-05	0 ^a	0.42	0 ^a	1.6	0 ^a
S-4: Excavation and Off-Site Disposal	5.6E-06	0 ^a	4.6E-05	0 ^a	0.42	0 ^a	1.6	0 ^a

Notes:

Shaded cells represent risk or hazard greater than or equal to the regulatory limits and quantitative Remedial Action Objectives of 1E-05 for cancer risk and 1 for non-cancer hazard.

^a All exposure pathways are rendered incomplete after implementation of this remedial alternative; therefore, estimated risks/hazards are zero.