REVISED TERRESTRIAL FOOD WEB MODEL

NRG-Indian River Generating Station, Burton Island OU2

A terrestrial food web model was included in the Screening Level Ecological Risk Assessment (SLERA) for Operable Unit No. 2 (OU2) of the Burton Island Historical Ash Disposal Area (the 'Site') in order to assess the potential impacts of site-related chemical constituents on various feeding guilds that might utilize OU2 for foraging, nesting, and other activities. The OU2 SLERA was presented in the OU2 Remedial Investigation (RI) report (Shaw, 2011). The OU2 SLERA was conducted in accordance with the guidelines set forth in *Hazardous Substance Cleanup Act Guidance Manual* (Delaware Department of Natural Resources and Environmental Control [DNREC], 1994), *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act* (DNREC, 1999) and *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (U.S. Environmental Protection Agency [USEPA], 1997).

The terrestrial food web model assessed the following eight different feeding guilds:

Representative Surrogate Species for Feeding Guilds at OU2

Feeding Guild	Surrogate Species
Herbivorous Bird	Northern Bobwhite (*Colinus virginianus*)
Herbivorous Mammal	Eastern Cottontail (*Sylvilagus floridanus*)
Small Omnivorous Mammal	White-Footed Mouse (*Peromyscus leucopus*)
Omnivorous Bird	American Robin (*Turdus migratorius*)
Invertivorous Mammal	Short-Tailed Shrew (*Blarina brevicauda*)
Invertivorous Bird	American Woodcock (*Scolopax minor*)
Large Omnivorous Mammal	Red Fox (*Vulpes vulpes*)
Carnivorous Bird	Red-Tailed Hawk (*Buteo jamaicensis*)

The results of the terrestrial food web model (assuming lowest-observed-adverse-effect-level [LOAEL]-based toxicity reference values [TRVs]) indicated that arsenic and barium concentrations in surface soil at OU2 have the potential to pose adverse effects to the omnivorous bird feeding guild. The terrestrial food web model indicated that all of the other constituents of potential ecological concern (COPECs) including methyl-mercury, mercury, nickel, selenium, and thallium were present at concentrations that were protective of all of the feeding guilds assessed. These results are presented below. The highlighted values in the table below are the LOAEL-based Ecological Hazard Quotients (EHQs) greater than 1 which indicates potential ecological risk.

Summary of Terrestrial Food Web LOAEL-Based EHQs

Terrestrial Feeding Guild	LOAEL-Based EHQs						
	As	Ba	me-Hg	Hg	Ni	Se	Tl
Herbivorous Bird	1.46E-01	1.09E-01	1.42E-03	7.48E-05	1.48E-03	1.57E-02	1.44E-03
Herbivorous Mammal	9.20E-02	4.95E-03	1.94E-04	7.55E-05	4.89E-04	4.45E-03	1.12E-02
Omnivorous Small Mammal	5.42E-01	2.99E-02	2.63E-02	2.77E-04	1.49E-03	4.87E-02	1.39E-01
Omnivorous Bird	2.21E+00	1.38E+00	2.96E-01	8.97E-04	1.68E-02	3.60E-01	3.68E-02
Invertivorous Small Mammal	7.96E-01	3.63E-02	5.27E-02	3.08E-04	1.45E-03	8.78E-02	2.61E-01
Invertivorous Bird	8.78E-01	5.04E-01	1.85E-01	2.99E-04	5.30E-03	1.72E-01	1.80E-02
Omnivorous Large Mammal	5.93E-03	2.50E-04	2.48E-04	3.33E-06	1.89E-05	5.32E-04	1.56E-03
Carnivorous Bird	2.24E-03	1.34E-03	5.32E-04	7.51E-07	1.23E-05	4.58E-04	4.82E-05

HQ – hazard quotient.
LOAEL – lowest-observed-adverse-effect- level.

No-observed-adverse-effect-level (NOAEL)-based EHQs are also presented in the OU2 SLERA (Shaw, 2011), and are summarized below.

Summary of Terrestrial Food Web NOAEL-Based EHQs

Terrestrial Feeding Guild	NOAEL-Based EHQs						
	As	Ba	me-Hg	Hg	Ni	Se	Tl
Herbivorous Bird	2.68E-01	2.19E-01	1.42E-02	7.48E-04	2.43E-03	3.13E-02	1.44E-02
Herbivorous Mammal	1.65E-01	3.05E+00	9.68E-04	7.55E-04	9.78E-04	6.20E-02	1.12E-01
Omnivorous Small Mammal	9.72E-01	1.84E+01	1.32E-01	2.77E-03	2.97E-03	6.80E-01	1.39E+00
Omnivorous Bird	2.21E+00	2.76E+00	2.96E+00	8.97E-03	2.76E-02	7.20E-01	3.68E-01
Invertivorous Small Mammal	1.43E+00	2.23E+01	2.64E-01	3.08E-03	2.90E-03	1.22E+00	2.61E+00
Invertivorous Bird	1.61E+00	1.01E+00	1.85E+00	2.99E-03	8.73E-03	3.44E-01	1.80E-01
Omnivorous Large Mammal	1.06E-02	1.54E-01	1.24E-03	3.33E-05	3.79E-05	7.42E-03	1.56E-02
Carnivorous Bird	4.11E-03	2.69E-03	5.32E-03	7.51E-06	2.03E-05	9.17E-04	4.82E-04

EHQ – ecological hazard quotient.
NOAEL – no-observed-adverse-effect- level.

It should be noted that risk management decisions are typically based on LOAEL-based EHQs and LOAEL-based clean-up values. The guiding principal behind this risk management strategy is the fact that COPEC concentrations less than their respective LOAELs are unlikely to pose ecological hazards and that NOAEL-based clean-up values are generally considered overly conservative for risk management decisions.

It is also important to note that the terrestrial food web model presented in the OU2 RI (Shaw, 2011), by its conservative design and the current state of the science of ecological risk assessment, assessed sensitive individuals within each feeding guild, and did not assess ecological populations or communities. USEPA (1997) guidance provides for the assessment of ecological communities and/or populations; however, the current state of the science of ecological risk assessment does not support population-level assessments. In order to account for the difference between adverse impacts to individuals and adverse impacts at the population level, the *de minimus* HQ of one could be raised to some higher level based on professional judgment and experience; for instance 5 or 10. If the *de minimus* HQ were assumed to be 5 to account for population-level impacts and LOAEL-based TRVs are assumed, then all of the calculated HQs would be less than the *de minimus* level and no food web impacts to terrestrial populations would be expected.

The terrestrial food web model that was included in the OU2 SLERA and presented in the OU2 RI (Shaw, 2011) utilized conservative point estimates as input values for many of the variables as is standard practice in USEPA SLERA protocol. Each exposure parameter in the food web model was represented by a single upper-bound point estimate for the given surrogate species. The use of single upper-bound point estimates for each exposure parameter ensures that exposures are not under-estimated and the results are protective of sensitive individuals. The result of this simplification is that exposures are routinely over-estimated for most species in a given feeding guild. Most, if not all, of the input parameters in the terrestrial food web model are more accurately represented by ranges of values in order to account for the variability that is inherent in natural biological systems. Some of the input parameters that could affect the results of the terrestrial food web model for OU2 include:

- COPEC exposure point concentrations;
- habitat preferences;
- toxicity reference values;
- soil-to-invertebrate bioaccumulation factors (BAFs);
- receptor body weight;
- food ingestion rates;
- soil ingestion rates;
- dietary composition;
- dietary assimilation efficiency; and
- foraging range.

If more realistic values were used for some of the input parameters in the terrestrial food web model, a more realistic estimation of potential exposures would result, while still maintaining the overall conservative nature of the assessment. Several of the common wildlife exposure parameters with well-established and published ranges of values are discussed below with respect to their impact on the results of the terrestrial food web model. This discussion is focused on arsenic and barium and the omnivorous bird feeding guild because these constituents and this feeding guild were identified in the terrestrial food web model presented in the OU2 RI report (Shaw, 2011) as having the greatest potential to pose ecological hazards (LOAEL-based EHQs greater than one).

For most constituents there are a number of TRVs cited in the scientific literature based on different test species, different routes of exposure, different endpoints, and a number of other factors. A routine practice in conducting SLERAs is to use the most conservative (i.e. lowest) TRV so that the ensuing assessment results are protective of sensitive individuals. Current USEPA guidance suggests the use of the TRVs utilized to derive Ecological Soil Screening Levels (Eco-SSLs) as the most appropriate TRVs for ecological risk assessment. The LOAEL-based avian TRV for arsenic (7.45 mg/kg/day) is the mean LOAEL value for reproduction, growth, and survival as presented in the Eco-SSL for Arsenic (USEPA, 2005a). Although the USEPA did not derive an avian TRV for barium because there was only one study that reported the toxicity of barium to avian species (USEPA protocol requires a minimum of 3 results for two test species to derive a TRV), this single reference (Johnson, et al., 1960) did provide a LOAEL value for barium of 41.7 mg/kg/day. These two USEPA-recommended values were used as the LOAEL-based avian TRVs for arsenic and barium in the revised terrestrial food web model.

BAFs, and specifically soil-to-invertebrate BAFs ($BAF_{soil\text{-}invert}$), also vary based on different test species, different soil types and soil characteristics, different test protocols, and a number of other factors. Similar to the use of USEPA-recommended TRVs referenced from the Eco-SSL guidance documents, current USEPA guidance also suggests the use of BAFs presented in the Eco-SSL guidance documents. The $BAF_{soil\text{-}invert}$ value from the Eco-SSL for Arsenic (USEPA, 2005a) document is reported as the following regression:

$$\text{Ln}\,(C_{invert}) = 0.706 \times \text{Ln}\,(C_{soil}) - 1.421$$

where:

C_{invert} = arsenic concentration in terrestrial invertebrates (mg/kg);

C_{soil} = arsenic concentration in soil (mg/kg).

The $BAF_{soil\text{-}invert}$ value from the Eco-SSL for Barium (USEPA, 2005b) document is reported as the following:

$$C_{invert} = 0.091 \times C_{soil}$$

where:

C_{invert} = barium concentration in terrestrial invertebrates (mg/kg);

C_{soil} = barium concentration in soil (mg/kg).

These USEPA-recommended $BAF_{soil\text{-}invert}$ values for arsenic and barium were used in the revised terrestrial food web model.

Food ingestion rates for different feeding guilds are highly variable based on a number of individual and species-specific factors (e.g. size, metabolic rate, feeding preferences, etc.) and also a number of environmental factors (e.g. food type, food availability, inter-species competition, season, temperature, location, etc.). The omnivorous bird food ingestion rate used in the terrestrial food web model reported in the OU2 RI was the mean of all of the values reported in the USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993). The food ingestion rate used in the revised terrestrial food web model was the value for both male and female free-living American robins (omnivorous bird) in California (0.89 g/g/day) referenced in the USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993), which is likely more representative of current conditions at the Site where omnivorous birds may not use OU2 as their sole foraging area.

If the terrestrial food web model for OU2 were run using the USEPA-recommended values for the avian TRVs for arsenic and barium, and the USEPA-recommended $BAF_{soil\text{-}invert}$ values for arsenic and barium, and the food ingestion rate referenced from the USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993), then the LOAEL-based ecological hazard quotients for all of the COPECs and all of the feeding guilds potentially present at OU2 would be less than one, indicating negligible ecological hazards, as summarized below.

Summary of the Revised Terrestrial Food Web Model EHQs

Terrestrial Feeding Guild	Revised LOAEL-Based EHQs		Revised NOAEL-Based EHQs	
	Arsenic	**Barium**	**Arsenic**	**Barium**
Herbivorous Bird	8.97E-02	1.12E-01	2.72E-01	2.24E-01
Herbivorous Mammal	9.34E-02	5.09E-03	1.67E-01	3.13E+00
Omnivorous Small Mammal	3.87E-01	2.09E-02	6.94E-01	1.29E+01
Omnivorous Bird	8.36E-01	7.99E-01	2.53E+00	1.60E+00
Invertivorous Small Mammal	4.71E-01	1.71E-02	8.45E-01	1.05E+01
Invertivorous Bird	3.96E-01	3.03E-01	1.20E+00	6.08E-01
Omnivorous Large Mammal	4.44E-03	1.63E-04	7.96E-03	1.00E-01
Carnivorous Bird	9.68E-04	7.66E-04	2.93E-03	1.53E-03

Additionally, most feeding guilds have habitat requirements that include a source of fresh drinking water in order to support viable resident populations. The fact that there are no fresh water sources on the Site significantly reduces the potential that many species (including omnivorous birds) would utilize OU2 as their sole foraging area and/or breeding habitat. The terrestrial food web model conservatively assumes that the herbivorous bird, herbivorous mammal, omnivorous bird, omnivorous mammal, invertivorous bird, and invertivorous mammal feeding guilds use OU2 as their sole foraging area. Therefore, although OU2 may provide a certain portion of foraging habitat for a number of feeding guilds, there may not be any resident populations of omnivorous birds or other feeding guilds on OU2 due to this natural habitat restriction. This natural habitat restriction (no fresh water on-site) would further reduce the potential for ecological exposures and lower the estimated EHQs for the feeding guilds assessed in the food web model.

This is an important consideration in the risk management process of OU2 since the results of the revised terrestrial food web model indicate that under current site conditions, ecological hazards at OU2 may already be at acceptable levels and remedial actions may not be necessary in order to ensure the protection of ecological receptors at OU2.

References:

Delaware Department of Natural Resources and Environmental Control (DNREC), 1994. *Hazardous Substance Cleanup Act Guidance Manual*. Division of Air and Waste Management, Site Investigation and Restoration Branch, October.

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Johnson, D., A.L. Mehring, and H.W. Titus, 1960. *Tolerance of Chickens for Barium*. Proceedings of the Society for Experimental Biology and Medicine. 104: 436-438. Ref ID: 25921.

Shaw Environmental, Inc. (Shaw), 2011. *Remedial Investigation Report, Indian River Generating Station, Operable Unit No. 2, Burton Island Historical Ash Disposal Area, Millsboro, Delaware, Site Number DE-1399*. August 2011.

U.S. Environmental Protection Agency (USEPA), 2005a. *Ecological Soil Screening Levels for Arsenic*. Office of Solid Waste and Emergency Response, Washington, DC. OSWER Directive 9285.7-62.

USEPA, 2005b. *Ecological Soil Screening Levels for Barium*. Office of Solid Waste and Emergency Response, Washington, DC. OSWER Directive 9285.7-63.

USEPA, 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Office of Solid Waste and Emergency Response, Washington, DC. USEPA 540-R-97-006.

USEPA, 1993. *Wildlife Exposure Factors Handbook*. Office of Research and Development, Washington, DC. USEPA/600/R-93/187.

TABLE B-1
TERRESTRIAL FOODWEB INDICATOR SPECIES LIFE HISTORY PARAMETERS
Burton Island OU2
NRG-Indian River Generating Station

Common Name	Scientific Name	Feeding Guild	Foraging Area (Ha)	Body Weight (kg)	Water Intake (L/day)	Food Intake (kg/day-dry wt.)	Soil / Sediment Intake (kg/day-dry wt.)	Dietary Fraction	Dietary Component
Northern Bobwhite	*Colinus virginianus*	Herbivorous Bird	11.58 (a)	0.174 (a)	0.019 (a)	0.0065 (a)	0.00053 (a)	1.0	Terrestrial Vegetation
Eastern Cottontail	*Sylvilagus floridanus*	Herbivorous Mammal	3.13 (a)	1.132 (a)	0.1098 (a)	0.0157 (a)	0.00099 (a)	1.0	Terrestrial Vegetation
White-Footed Mouse	*Peromyscus leucopus*	Omnivorous Mammal	0.049 (a)	0.0148 (a)	0.0028 (a)	0.00129 (a)	0.00003 (a)	0.5 0.5	Terrestrial Invertebrates Terrestrial Vegetation
American Robin	*Turdus migratorius*	Omnivorous Bird	0.25 (a)	0.0773 (a)	0.0108 (a)	0.02193 (a)	0.00219 (a)	0.5 0.5	Terrestrial Invertebrates Terrestrial Vegetation
Short-Tailed Shrew	*Blarina brevicauda*	Invertivorous Mammal	0.39 (a)	0.015 (a)	0.0033 (a)	0.00133 (a)	0.00003 (a)	1.0	Terrestrial Invertebrates
American Woodcock	*Scolopax minor*	Invertivorous Bird	24.8 (a)	0.1338 (a)	0.0134 (a)	0.0165 (a)	0.00172 (a)	1.0	Terrestrial Invertebrates
Red Fox	*Vulpes fulva*	Omnivorous Mammal	923 (a)	3.94 (a)	0.3349 (a)	0.1318 (a)	0.00369 (a)	0.1 0.1 0.4 0.4	Terrestrial Vegetation Terrestrial Invertebrates Herbivorous Prey Omnivorous Prey
Red-Tailed Hawk	*Buteo jamaicensis*	Carnivorous Bird	842 (a)	0.957 (a)	0.0545 (a)	0.0302 (a)	0.00060 (a)	0.5 0.5	Herbivorous Prey Omnivorous Prey

Notes:

a USEPA, 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a

b Omnivorous Prey are modeled as white-footed mouse for this assessment

IR_F = 0.00666 kg/day

IR_W = 0.0028 l/day

IR_{SO} = 0.000113 kg/day

c Herbivorous Prey are modeled as eastern cottontail for this assessment

IR_F = 0.0958 kg/day

IR_W = 0.1098 l/day

IR_{SO} = 0.00958 kg/day

TABLE B-2
BIOLOGICAL FATE AND TRANSPORT PROPERTIES FOR THE
CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN THE TERRESTRIAL FOODWEB
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituents of Potential Ecological Concern	CAS Number	Molecular Weight	Henry's Law Constant (atm/m^3-$mole^{-1}$)	Octanol-Water Partition Coefficient (log K_{ow}) (M_{oct}/M_{water})	Organic Carbon Partition Coefficient (log K_{oc}) (L/kg)	Soil to Plant BAF (unitless)	Soil to Invertebrate BAF (unitless)	Mammal Biotransfer Factor (BTF_{prey}) (day/kg)	Plant to Herbivorous Prey BCF (unitless)	Soil to Herbivorous Prey BCF (unitless)	Water to Herbivorous Prey BCF (unitless)	Plant to Omnivorous Prey BCF (unitless)	Soil to Omnivorous Prey BCF (unitless)	Water to Omnivorous Prey BCF (unitless)
Inorganic Constituents														
Arsenic	7440-38-2	74.92	0.00E+00	NA	NA	0.0375 [2]	$e^{0.706*ln(soil)-1.421}$ [2]	2.00E-03 [1]	1.92E-04	1.92E-05	2.20E-04	6.66E-06	2.26E-07	5.60E-06
Barium	7440-39-3	137.33	0.00E+00	NA	NA	0.156 [3]	0.091 [3]	1.50E-04 [1]	1.44E-05	1.44E-06	1.65E-05	5.00E-07	1.70E-08	4.20E-07

1. Baes, C.F., R.D. Sharp, A.L. Sjoreen and R.W. Shor, 1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, Prepared for the U.S. Department of Energy under contract No. DE-AC05-84OR21400.
2. USEPA, 2005a. Ecological Soil Screening Levels for Arsenic.
2. USEPA, 2005b. Ecological Soil Screening Levels for barium.

TABLE B-3
Burton Island OU2
NRG-Indian River Generating Station

Constituents of Potential Ecological Concern	Octanol-Water Partition Coefficient (log Kow) (M_{oct}/M_{water})	Food Chain Multipliers		
		Trophic Level 2	Trophic Level 3	Trophic Level 4
Inorganic Constituents				
Arsenic	NA	1	1	1
Barium	NA	1	1	1
Methyl Mercury	NA	1	1	1
Mercuric Chloride	NA	1	1	1
Nickel		1	1	1
Selenium	NA	1	1	1
Thallium	NA	1	1	1

TABLE B-4
EXPOSURE POINT CONCENTRATIONS FOR THE CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN IN THE TERRESTRIAL FOODWEB
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituents Of Potential Ecological Concern	Constituent Concentration					
	Surface Water (mg/L)	Soil (mg/kg)	Terrestrial Vegetation (mg/kg)	Terrestrial Invertebrates (mg/kg)	Omnivorous Prey (mg/kg)	Herbivorous Prey (mg/kg)
Inorganic Constituents						
Arsenic	9.90E-03	1.50E+02	5.63E+00	8.30E+00	4.15E+00	3.42E-03
Barium	6.17E-02	5.26E+02	8.21E+01	4.79E+01	2.39E+01	1.35E-03

TABLE B-5
CONSTITUENT EXPOSURES
FOR HERBIVOROUS BIRD (Northern Bobwhite)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	EXPOSURE POINT CONCENTRATIONS			CONSTITUENT DOSES			
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Vegetation (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents							
Arsenic	1.50E+02	9.90E-03	5.63E+00	4.57E-01	1.08E-03	2.10E-01	6.68E-01
Barium	5.26E+02	6.17E-02	8.21E+01	1.60E+00	6.74E-03	3.07E+00	4.67E+00

TABLE B-6
CONSTITUENT EXPOSURES
FOR HERBIVOROUS SMALL MAMMAL (Eastern Cottontail)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	CONSTITUENT CONCENTRATION			CONSTITUENT EXPOSURE			
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg- day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents							
Arsenic	1.50E+02	9.90E-03	5.63E+00	1.31E-01	NA	7.80E-02	2.09E-01
Barium	5.26E+02	6.17E-02	8.21E+01	4.60E-01	NA	1.14E+00	1.60E+00

TABLE B-7
CONSTITUENT EXPOSURES
FOR OMNIVOROUS SMALL MAMMAL (White-Footed Mouse)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	CONSTITUENT CONCENTRATION				CONSTITUENT EXPOSURE				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents									
Arsenic	1.50E+02	9.90E-03	8.30E+00	5.63E+00	2.61E-01	NA	3.61E-01	2.45E-01	8.68E-01
Barium	5.26E+02	6.17E-02	4.79E+01	8.21E+01	9.17E-01	NA	2.08E+00	3.57E+00	6.57E+00

TABLE B-8
CONSTITUENT EXPOSURES
FOR OMNIVOROUS BIRD (American Robin)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	EXPOSURE POINT CONCENTRATIONS				CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg-day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents									
Arsenic	1.50E+02	9.90E-03	8.30E+00	5.63E+00	4.25E+00	NA	1.18E+00	7.98E-01	6.23E+00
Barium	5.26E+02	6.17E-02	4.79E+01	8.21E+01	1.49E+01	NA	6.79E+00	1.16E+01	3.33E+01

TABLE B-9
CONSTITUENT EXPOSURES
FOR INVERTIVOROUS SMALL MAMMAL (Short-Tail Shrew)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	EXPOSURE POINT CONCENTRATIONS			CONSTITUENT DOSES			
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents							
Arsenic	1.50E+02	9.90E-03	8.30E+00	3.20E-01	NA	7.36E-01	1.06E+00
Barium	5.26E+02	6.17E-02	4.79E+01	1.12E+00	NA	4.24E+00	5.37E+00

TABLE B-10
CONSTITUENT EXPOSURES
FOR INVERTIVOROUS BIRD (American Woodcock)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	CONSTITUENT CONCENTRATION			CONSTITUENT EXPOSURE			
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents							
Arsenic	1.50E+02	9.90E-03	8.30E+00	1.92E+00	NA	1.02E+00	2.95E+00
Barium	5.26E+02	6.17E-02	4.79E+01	6.75E+00	NA	5.90E+00	1.27E+01

TABLE B-11
CONSTITUENT EXPOSURES
FOR OMNIVOROUS LARGE MAMMAL (Red Fox)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	CONSTITUENT CONCENTRATION						CONSTITUENT EXPOSURE						
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Herbivorous Prey (mg/kg)	Omnivorous Prey (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg - day)	Herbivorous Prey (mg/kg - day)	Omnivorous Prey (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents													
Arsenic	1.50E+02	9.90E-03	8.30E+00	5.63E+00	3.42E-03	4.15E+00	1.40E-01	NA	2.78E-02	1.88E-02	4.57E-05	5.55E-02	9.95E-03
Barium	5.26E+02	6.17E-02	4.79E+01	8.21E+01	1.35E-03	2.39E+01	4.92E-01	NA	1.60E-01	2.74E-01	1.80E-05	3.20E-01	5.11E-02

TABLE B-12
CONSTITUENT EXPOSURES
FOR CARNIVOROUS BIRD (Red-Tailed Hawk)
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	EXPOSURE POINT CONCENTRATIONS				CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Herbivorous Prey (mg/kg)	Omnivorous Prey (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg-day)	Herbivorous Prey (mg/kg-day)	Omnivorous Prey (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents									
Arsenic	1.50E+02	9.90E-03	3.42E-03	4.15E+00	9.47E-02	NA	5.39E-05	6.55E-02	7.21E-03
Barium	5.26E+02	6.17E-02	1.35E-03	2.39E+01	3.32E-01	NA	2.12E-05	3.78E-01	3.19E-02

TABLE B-13
AVIAN TOXICITY REFERENCE VALUES
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	Dose (mg/kg/day)	Uncertainty Factor	Toxicity Reference Value (mg/kg/day)	Reference	LOAEL (mg/kg/day)	Reference
Inorganic Constituents								
Arsenic	Brown-headed cowbird	NOAEL	2.46	1	2.46	USFWS, (1969) in USEPA, 1999	7.45	USEPA, 2005a
Barium	Chick	Sub-chronic NOAEL	208.26	0.1	20.826	Johnson, et al. (1960) in USEPA, 1999	41.7	Johnson, et al. (1960)

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TABLE B-14
MAMMALIAN TOXICITY REFERENCE VALUES
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	Dose (mg/kg/day)	Uncertainty Factor	Toxicity Reference Value (mg/kg/day)	Reference	LOAEL (mg/kg/day)	Reference
Inorganic Constituents								
Arsenic	Dog	Chronic NOAEL	1.25	1	1.25	Byron, et. al. (1967) in USEPA, 1999	2.24	USEPA, 2005a
Barium	Rat	Chronic NOAEL	0.51	1	0.51	Perry, et al. (1983) in USEPA, 1999	314	USEPA, 2005b

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TABLE B-15
COMPARISON OF TOTAL CONSTITUENT EXPOSURES WITH TOXICITY REFERENCE VALUES FOR HERBIVOROUS BIRD
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Birds (mg/kg-day)	LOAEL For Birds (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	6.68E-01	2.46E+00	7.45E+00	2.72E-01	8.97E-02	No
Barium	4.67E+00	2.08E+01	4.17E+01	2.24E-01	1.12E-01	No

TABLE B-16
COMPARISON OF TOTAL CONSTITUENT EXPOSURES
WITH TOXICITY REFERENCE VALUES FOR HERBIVOROUS SMALL MAMMAL
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Mammals (mg/kg-day)	LOAEL For Mammals (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	2.09E-01	1.25E+00	2.24E+00	1.67E-01	9.34E-02	No
Barium	1.60E+00	5.10E-01	3.14E+02	3.13E+00	5.09E-03	No

TABLE B-17
COMPARISON OF TOTAL CONSTITUENT EXPOSURES
WITH TOXICITY REFERENCE VALUES FOR OMNIVOROUS SMALL MAMMAL
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Mammals (mg/kg-day)	LOAEL For Mammals (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	8.68E-01	1.25E+00	2.24E+00	6.94E-01	3.87E-01	No
Barium	6.57E+00	5.10E-01	3.14E+02	1.29E+01	2.09E-02	No

TABLE B-18
COMPARISON OF TOTAL CONSTITUENT EXPOSURES WITH TOXICITY REFERENCE VALUES FOR OMNIVOROUS BIRD
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Birds (mg/kg-day)	LOAEL For Birds (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	6.23E+00	2.46E+00	7.45E+00	2.53E+00	8.36E-01	No
Barium	3.33E+01	2.08E+01	4.17E+01	1.60E+00	7.99E-01	No

TABLE B-19
COMPARISON OF TOTAL CONSTITUENT EXPOSURES
WITH TOXICITY REFERENCE VALUES FOR INVERTIVOROUS SMALL MAMMAL
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Mammals (mg/kg-day)	LOAEL For Mammals (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	1.06E+00	1.25E+00	2.24E+00	8.45E-01	4.71E-01	No
Barium	5.37E+00	5.10E-01	3.14E+02	1.05E+01	1.71E-02	No

TABLE B-20
COMPARISON OF TOTAL CONSTITUENT EXPOSURES WITH TOXICITY REFERENCE VALUES FOR INVERTIVOROUS BIRD
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Birds (mg/kg-day)	LOAEL For Birds (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	2.95E+00	2.46E+00	7.45E+00	1.20E+00	3.96E-01	No
Barium	1.27E+01	2.08E+01	4.17E+01	6.08E-01	3.03E-01	No

TABLE B-21
COMPARISON OF TOTAL CONSTITUENT EXPOSURES
WITH TOXICITY REFERENCE VALUES FOR OMNIVOROUS LARGE MAMMAL
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Mammals (mg/kg-day)	LOAEL For Mammals (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	9.95E-03	1.25E+00	2.24E+00	7.96E-03	4.44E-03	No
Barium	5.11E-02	5.10E-01	3.14E+02	1.00E-01	1.63E-04	No

TABLE B-22
COMPARISON OF TOTAL CONSTITUENT EXPOSURES WITH TOXICITY REFERENCE VALUES FOR CARNIVOROUS BIRD
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Total Constituent Exposure (mg/kg-day)	NOAEL For Birds (mg/kg-day)	LOAEL For Birds (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents						
Arsenic	7.21E-03	2.46E+00	7.45E+00	2.93E-03	9.68E-04	No
Barium	3.19E-02	2.08E+01	4.17E+01	1.53E-03	7.66E-04	No

TABLE B-23
SUMMARY OF TERRESTRIAL FOOD WEB
NOAEL-BASED ECOLOGICAL HAZARD QUOTIENTS
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Herbivorous Bird NOAEL Hazard Quotients	Herbivorous Mammal NOAEL Hazard Quotients	Omnivorous Small Mammal NOAEL Hazard Quotients	Omnivorous Bird NOAEL Hazard Quotients	Invertivorous Small Mammal NOAEL Hazard Quotients	Invertivorous Bird NOAEL Hazard Quotients	Omnivorous Large Mammal NOAEL Hazard Quotients	Carnivorous Bird NOAEL Hazard Quotients
Inorganic Constituents								
Arsenic	2.72E-01	1.67E-01	6.94E-01	2.53E+00	8.45E-01	1.20E+00	7.96E-03	2.93E-03
Barium	2.24E-01	3.13E+00	1.29E+01	1.60E+00	1.05E+01	6.08E-01	1.00E-01	1.53E-03

TABLE B-24
SUMMARY OF TERRESTRIAL FOOD WEB
LOAEL-BASED ECOLOGICAL HAZARD QUOTIENTS
Burton Island OU2
NRG-Indian River Generating Station

Bioaccumulative Constituent Of Potential Ecological Concern	Herbivorous Bird LOAEL Hazard Quotients	Herbivorous Mammal LOAEL Hazard Quotients	Omnivorous Small Mammal LOAEL Hazard Quotients	Omnivorous Bird LOAEL Hazard Quotients	Invertivorous Small Mammal LOAEL Hazard Quotients	Invertivorous Bird LOAEL Hazard Quotients	Omnivorous Large Mammal LOAEL Hazard Quotients	Carnivorous Bird LOAEL Hazard Quotients
Inorganic Constituents								
Arsenic	8.97E-02	9.34E-02	3.87E-01	8.36E-01	4.71E-01	3.96E-01	4.44E-03	9.68E-04
Barium	1.12E-01	5.09E-03	2.09E-02	7.99E-01	1.71E-02	3.03E-01	1.63E-04	7.66E-04