AOC 4 Ecological Risk Assessment: Technical Briefing Paper

This briefing paper summarizes the findings of the Ecological Risk Assessment (ERA) Report for Area of Concern 4 (AOC 4) of the former E.I. du Pont de Nemours and Company (DuPont) Plant (the site), in Waynesboro, Virginia. Mercury was released to the South River system from the site between 1929 and 1950, during the period of mercury use in acetate flake and yarn production. In February 2014, under the authority of the Resource Conservation and Recovery Act (RCRA), Commonwealth of Virginia, Department of Environmental Quality (VDEQ) modified the Hazardous Waste Management Permit for Corrective Action (VAD003114832) for the site to include AOC 4. This ERA Report has been prepared pursuant to the February 2014 permit modification and provides a summary of its key components; additional details are documented in the AOC 4 ERA Report (URS, 2014).

Introduction

The AOC 4 ERA followed EPA guidelines for ecological risk assessment (EPA, 1997 and 1998). The goals of the ERA were (1) to evaluate potential risks to ecological receptors within AOC 4 due to exposure to site-related constituents, including mercury and (2) to support remedial decision-making within AOC 4. AOC 4 includes off-site aquatic and riparian terrestrial systems (including the floodplain) along approximately 25 miles of the South River downstream of the site, and a segment of the South Fork Shenandoah River (SFSR) in Virginia. AOC 4 was divided into 16 Assessment Reaches for the ERA including:

References

- ✓ EPA. 1998. Guidelines for Ecological Risk Assessment. US EPA. Washington, DC 20460, EPA/630/R-95/002F. April, 1998.
- ✓ EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. US EPA. Washington, DC 20460, EPA/540/R-97/006. June 1997.
- ✓ URS Corporation. 2014. Ecological Risk Assessment Report for the Former DuPont Waynesboro site, Area of Concern (AOC) 4, South River and a Segment of the South Fork Shenandoah River, Virginia. September 12, 2014. Submitted to VDEQ.

- ❑ A reference reach upstream of the plant site located between relative river mile (RRM) -2.7 to RRM -0.7;
- ❑ A buffer reach (located between RRM -0.7 and RRM 0);
- ❑ Thirteen reaches between RRM 0 and RRM 24; and
- ❑ A segment of the SFSR downstream of RRM 24.

The ERA uses information from numerous reports and publications regarding conditions in AOC 4. A Retrospective Data Quality Assessment (RDQA) was performed at the request of VDEQ to evaluate existing data sets in terms of their usability for the ERA. Data comparability, sample integrity, accompanying QA/QC elements, and overall representativeness and relevance of the datasets for the ERA were evaluated as part of the RDQA.

Key components of the ecological risk process include problem formulation, ecological effects analysis, exposure analysis, and risk characterization. Summaries of these components are provided in the subsequent sections, along with conclusions of the assessment.

Problem Formulation

The problem formulation identifies factors to be addressed in the ERA including:

- Contaminant of potential ecological concern (COPEC);
- Ecological conceptual site model(s);
- Fate and transport of COPECs;
- Potentially complete exposure pathways; and
- Receptors and assessment and measurement endpoints.

A screening-level ecological risk evaluation was performed to focus the evaluation of ecological risks in AOC 4 and define the boundaries of the baseline ecological risk assessment. The evaluation identified mercury [total mercury (THg) and methylmercury (MeHg)] as COPECs.

An ecological conceptual site model (ECSM, see Figure 1) was developed to represent the current understanding of the mercury source, fate, and transport, and potential exposure of various ecological receptors to mercury within AOC 4. Based on mercury concentrations detected in various media and existing potential ecological habitats within AOC 4, the following exposure routes and exposure pathways were identified:

- Direct contact with soil, sediment, pore water, and surface water (e.g., aquatic and benthic invertebrates, fish, and soil invertebrates);
- Incidental ingestion of soil and sediment (e.g., sediment ingestion by mallard ducks and soil ingestion by short-tailed shrew); and
- Dietary ingestion of mercury containing food items by aquatic organisms, birds, and mammals.

Included in the exposure assessment was the aquatic-to-terrestrial trophic transfer pathway involving terrestrial birds (e.g., Tree swallow) feeding on invertebrates (e.g., emergent insects) and invertebrates that prey on aquatic invertebrates (e.g., wolf spiders).

Based on the potentially complete exposure routes and pathways identified in AOC 4, the following ecological receptor groups and focal receptors were selected for the BERA:

- ***Aquatic Receptors:*** Benthic macroinvertebrates and larval and emergent aquatic invertebrates, fish species [largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*)], and submerged aquatic vegetation;
- ***Semi-Aquatic Receptors:*** Amphibians, piscivorous birds [belted kingfisher (*Megaceryle alcyon*)], omnivorous birds [mallard duck (*Anas platyrhynchos*)], piscivorous mammals [river otter (*Lontra canadensis*)]; and
- ***Terrestrial Receptors:*** Terrestrial vegetation, soil invertebrates (earthworms), invertivorous birds [Tree swallow (*Tachycineta bicolor*) – an aerial insectivore and American robin (*Turdus migratorius*) – a ground insectivore], carnivorous birds [Eastern screech owl (*Megascops asio*)], invertivorous mammals [Big brown bat (*Eptesicus fuscus*) – an aerial insectivore, short-tailed shrew *(Blarina brevicauda*) – a ground insectivore, and white-tailed deer (*Odocoileus virginianus*) – an herbivore].

Population-level potential risks were evaluated for the above receptor groups and focal species based on measurement endpoints related to population survival, growth, and reproduction. Individual level impacts were considered for the evaluation of potential risks to endangered and/or special status species.

Ecological Effects Analysis

A comprehensive literature review was performed to develop no effects and low effects thresholds or benchmarks to serve as a basis for comparison with estimated exposures as follows:

- No Observed Effects Concentrations (NOECs) and Lowest Observed Effects Concentrations (LOECs) for THg and MeHg in surface water and pore water, sediment, and soils;
- No Observed Effects and Low Observed Effects Critical Body Residues (CBR_{NOECs} and CBR_{LOECs}, respectively) for THg or MeHg in tissues of various receptors (whole body, blood, feather, fur, etc.); and
- Toxicity Reference Values (TRVs) based on No Observed Adverse Effects Level (NOAEL) and Lowest Observed Adverse Effects Level (LOAEL) doses for MeHg and inorganic mercury (IHg) for specific focal species representing the avian and mammalian receptors.

Exposure Analysis

Relationships were established between the chemical stressor (mercury, either as THg, MeHg, or IHg) and the focal receptors through: (1) spatial distribution of mercury concentrations across AOC 4 and reference areas, (2) calculation of exposure point concentrations (EPCs) for exposure medium/focal receptor pairs based on the most likely exposure scenario for each focal receptor, and (3) calculation of reasonable maximum daily mercury intake rates (DMIRs) via the food chain from abiotic and biotic sources by focal avian and mammalian receptors.

Following the standard practice, EPCs for THg, MeHg, and IHg were calculated to be the higher of the maximum detected concentrations or the 95% Upper Confidence Level of the Mean. EPCs were calculated for abiotic media (surface water, pore water, sediment, and soil) and biological tissues (e.g., whole body, blood, fur, etc.).

Reasonable maximum DMIRs were estimated for each Assessment Reach within AOC 4 using food web models (or dose rate models), for each of the following receptors: belted kingfisher, mallard duck, eastern screech owl, tree swallow, American Robin, river otter, short-tailed shrew, big brown bat, and white tailed deer.

Risk Characterization

Deterministic or point estimates of risks were quantified based on the Hazard Quotient (HQ) approach and the evaluation of available site-specific studies provided further information for a weight-of-evidence (WOE) evaluation of the potential risks. A summary of the findings is provided below; measurement endpoints are provided, followed by a risk statement:

- ***Benthic Invertebrates:*** abiotic bulk chemistry, sediment toxicity, benthic community analysis, and tissue residue; adverse effects to benthic invertebrates are unlikely.
- ***Fish:*** surface water chemistry, age/growth survey, condition survey, community structure survey, and tissue residue; fish population level effects are not likely.
- ***Aquatic Vegetation:*** surface water, pore water; adverse effects are not likely.
- ***Amphibians:*** surface water, whole body tissues; adverse effects are unlikely.
- ***Terrestrial Plants and Soil Invertebrates:*** soils; population-level adverse effects are unlikely.
- ***Avian Receptors:*** blood mercury concentrations; potential for adverse effects may exist for several avian receptors, including piscivores (such as belted kingfisher), carnivores (such as Eastern screech owl), and insectivores (such as tree swallow).
- ***Mammalian Receptors:*** blood and fur THg EPCs; potential for adverse population level effects to aerial insectivorous mammals (e.g., the big brown bat) exists.

Conclusions

Conclusions for each of the key receptor groups are summarized as follows:

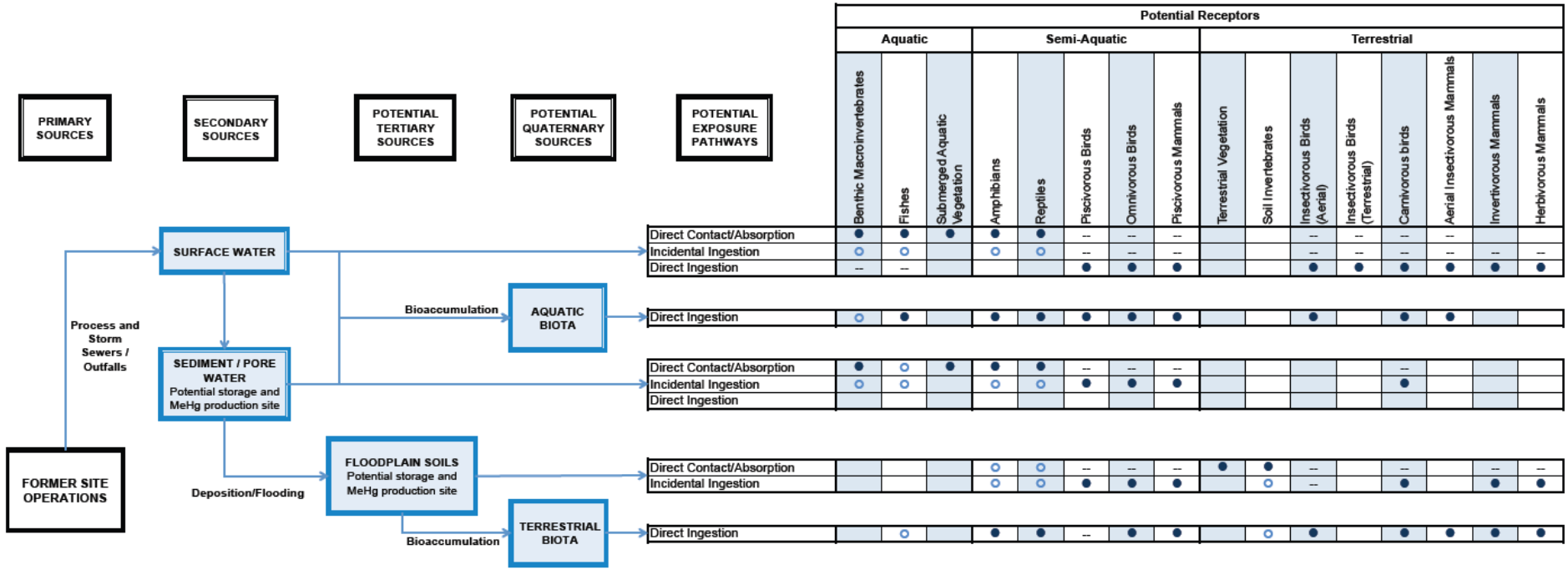
- ***Aquatic Receptors:*** Unlike the direct contact pathway which poses no risk, mercury bioaccumulation by the invertebrates and fish species within AOC 4 poses potential risks of adverse effects.
- ***Semi-Aquatic Receptors:*** While significant uncertainties bias conclusions toward overestimation of risks, potential risks of adverse effects cannot be ruled out for amphibians and piscivorous birds due to bioaccumulation and/or dietary exposures to mercury within AOC 4 Assessment Reaches beyond RRM 2.7.
- ***Terrestrial Receptors:*** Potential risks of adverse effects cannot be ruled out for carnivorous birds, invertivorous songbirds, and bats due to dietary exposures to mercury within AOC 4. However, calculated potential risks for these groups of receptors incorporate significant uncertainties biased toward overestimation of risks.

Recommendations

The results of the ERA indicate that potential adverse effects to the ecological receptors are due to trophic transfer of MeHg originating in the South River system—a finding that is consistent with the current understanding of the system on which the proposed remedial strategy is based. Owing to the size, linear nature, complexity, and spatial variability of the South River system, reduced exposure of ecological receptors (and humans), and subsequent overall risk reduction, will be best achieved in AOC 4 by conducting remedial measures in an adaptive management approach involving integration of various interim measures, monitoring, and community outreach and education. Such an approach is already being planned for the AOC 4 and the results of the ERA provide

further justifications for such an approach in ecological risk management and remedial decision-making.

Figure 1
Ecological Conceptual Site Model (ECSM)
AOC 4 Ecological Risk Assessment Report
Technical Briefing Paper



Notes:
→ CONTAMINANT MIGRATION PATHWAY
● POTENTIALLY COMPLETE EXPOSURE PATHWAY
○ SECONDARY EXPOSURE PATHWAY; NOT DIRECTLY QUANTIFIED
-- EXPOSURE PATHWAY IS POTENTIALLY COMPLETE BUT INSIGNIFICANT
BLANK = INCOMPLETE EXPOSURE PATHWAY