

Tables

Table 9-1
Selected Ecological Species for Risk Evaluation

Receptor Group	Feeding Guild	Receptor Species
Benthic invertebrate community	N/A	Multiple infaunal species, including <i>Hyaella azteca</i> , <i>Chironomus dilutus</i> , and <i>Ampelisca abdita</i> , polychaetes (i.e., <i>Nereis virens</i>), and oligochaetes (i.e., <i>Lumbriculus variegatus</i>)
Macroinvertebrate populations	N/A	Blue crab ¹
Mollusk populations	N/A	Ribbed mussel (<i>Geukensia demissa</i>) and freshwater mussel (<i>Elliptio complanata</i>)
Fish populations	Benthic omnivore (small forage fish)	Mummichog, other small forage fish (e.g., banded killifish/darter), and common carp
	Invertivore	White perch, channel catfish, brown bullhead, white catfish and white sucker
	Piscivore	American eel, largemouth bass, smallmouth bass and northern pike
Bird populations	Aquatic herbivore	Mallard duck ²
	Sediment-probing invertivore	Spotted sandpiper
	Migratory piscivore	Heron/egret species ³
	Resident piscivore	Belted kingfisher
Mammal populations	Piscivore	River otter ⁴
Zooplankton community	N/A	Multiple species
Amphibian/ Reptile populations	N/A	Multiple species ⁵
Aquatic plant community	N/A	Multiple species, including submerged macrophytes ⁶

Notes:

1. Crayfish were identified in the PFD as representing freshwater macroinvertebrate populations. However, per agreement between CPG and USEPA (Windward 2010e), blue crab will be the only species used to represent the macroinvertebrate population, for the estuarine and freshwater portions of the LPRSA because of the limited number of crayfish collected in the freshwater portion.
2. In the PFD (Windward and AECOM 2009), the mallard duck was not proposed to be a quantitatively evaluated receptor because the potential exposure to chemicals is expected to be higher for other higher-trophic-level avian receptors (i.e., invertivores and piscivores).
3. Herons/egrets were evaluated as migratory and resident species using two difference area use factors.
4. The selected semi-piscivorous mammal (i.e., river otter) is expected to be protective of herbivorous and omnivorous mammals (e.g., muskrat) because piscivorous and omnivorous mammals feed on organisms that are higher on the food chain. The mink was also assessed since possible mink tracks were observed near Dundee Dam during the CPG LPRSA Feasibility Study Phase 2 biological surveys.
5. Amphibians and reptiles have a limited presence in the estuarine portion of the LPRSA.
6. The aquatic plant community in the LPRSA is limited by the physical development of the shoreline and poor light penetration of the water.

CPG: Cooperating Parties Group

FSP: field sampling plan

LPRSA: Lower Passaic River Study Area

N/A: not applicable

PFD: problem formulation document

USEPA: United States Environmental Protection Agency

Table 9-2
Summary of Chemicals of Potential Ecological Concern

COPEC	Sediment		Surface Water		Tissue				Diet		
	Benthic Invertebrates	Aquatic Plants	Invertebrates, Fish, Aquatic Plants, and Zooplankton	Amphibians/ Reptiles	Benthic Invertebrates	Fish	Fish Egg	Bird Egg	Fish	Birds	Mammals
Metals											
Antimony	X	X									
Arsenic	X	X			X	X					X
Cadmium	X	X	X		X	X			X	X	X
Chromium	X	X	X	X	X	X			X	X	
Cobalt	X	X			X				X		
Copper	X	X	X	X	X	X			X	X	X
Lead	X	X	X	X	X	X				X	X
Mercury	X	X	X	X	X	X	X	X	X	X	X
Methylmercury ¹	X				X	X	X	X	X	X	X
Nickel	X	X		X	X				X	X	X
Selenium	X	X	X		X	X			X	X	X
Silver	X		X	X	X	X					
Vanadium	X	X			X				X	X	X
Zinc	X	X	X	X	X	X			X	X	X
Butyltins											
TBT	X		X						X		
PAHs											
1-Methylnaphthalene	X										
1-Methylphenanthrene	X										
2,6-Dimethylnaphthalene	X										
2-Methylnaphthalene	X										
Acenaphthene	X	X									

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Acenaphthylene	X										
Anthracene	X		X								
Benzo(a)anthracene	X		X								
Benzo(a)pyrene	X		X						X		
Benzo(b/j)fluoranthene	X										
Benzo(e)pyrene	X										
Benzo(g,h,i)perylene	X										
Benzo(k)fluoranthene	X										
Chrysene	X										
Dibenzo(a,h)anthracene	X										
Fluoranthene	X		X								
Fluorene	X										
Indeno(1,2,3-cd)pyrene	X										
Naphthalene	X										
Perylene	X										
Phenanthrene	X										
Pyrene	X		X								
Total benzofluoranthenes	X										
Total HPAHs	X				X	X				X	X
Total LPAHs	X				X	X				X	
Total PAHs	X								X		

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	Benthic Invertebrates	Aquatic Plants	Invertebrates, Fish, Aquatic Plants, and Zooplankton	Amphibians/ Reptiles	Benthic Invertebrates	Fish	Fish Egg	Bird Egg	Fish	Birds	Mammals
SVOCs											
2,4-Dinitrotoluene	X										
2,6-Dinitrotoluene	X										
4-Methylphenol	X										
BEHP	X		X								
Butylbenzylphthalate	X		X								
Dibenzofuran	X										
Diethylphthalate	X										
Dimethylphthalate	X										
Di-n-butylphthalate	X										
Di-n-octylphthalate	X										
Isophorone	X										
n-Nitrosodiphenylamine	X										
Pentachlorophenol	X										
Phenol	X										
VOCs											
1,2,3-Trichlorobenzene	X										
1,2,4-Trichlorobenzene	X										
1,4-Dichlorobenzene	X										
1,4-Dioxane	X										
Acetone	X										
m, p-Xylene	X										
Toluene	X										

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	Benthic Invertebrates	Aquatic Plants	Invertebrates, Fish, Aquatic Plants, and Zooplankton	Amphibians/ Reptiles	Benthic Invertebrates	Fish	Fish Egg	Bird Egg	Fish	Birds	Mammals
Trichloroethene				X							
PCBs											
Aroclor 1254	X										
Aroclor 1260	X										
Total PCBs	X		X		X	X	X	X	X	X	X
PCB TEQ ²	X		X		X	X		X	X	X	X
PCDDs/PCDFs											
2,3,7,8-TCDD	X		X		X	X					
PCDD/PCDF TEQ ²	X		X		X	X	X	X	X	X	X
Total TEQ ²	X		X		X	X	X	X	X	X	X
Organochlorine Pesticides											
4,4'-DDD	X										
4,4'-DDE	X		X								
4,4'-DDT	X		X								
Aldrin	X										
alpha-BHC	X										
alpha-chlordane	X										
beta-BHC	X										
gamma-BHC (Lindane)	X										
Dieldrin	X		X		X	X		X			X
Endrin	X										
Endosulfan I	X					X					
Endosulfan II	X										

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COPEC	Sediment		Surface Water		Tissue				Diet		
	Benthic Invertebrates	Aquatic Plants	Invertebrates, Fish, Aquatic Plants, and Zooplankton	Amphibians/ Reptiles	Benthic Invertebrates	Fish	Fish Egg	Bird Egg	Fish	Birds	Mammals
gamma-chlordane	X										
Heptachlor	X										
Heptachlor epoxide	X				X						
Hexachlorobenzene	X		X								
Methoxychlor	X										
Total chlordane	X		X								
Total DDx	X		X		X	X		X	X	X	
Herbicides											
2,4,5-TP (Silvex)	X										
Other											
Cyanide	X		X								

Notes:

1. Total mercury is included as well as methylmercury for tissue and diet COPECs because some of the tissue and dietary TRVs were based on total mercury in tissue. Typically, more than 50% of total mercury in lower-trophic-level fish and invertebrate tissue is in the form of methylmercury. Methylmercury made up 87% of the mercury in LPRSA fish collected in 2009, 84% in blue crab collected in 2009, and 76% in mummichog collected in 2010, but only 14% in bioaccumulation worms.
2. TEQs are based on fish TEFs for sediment exposure for benthic invertebrates, and for surface water exposure for invertebrates, fish, aquatic plants, and zooplankton. TEQs for fish, birds, and mammals are based on TEFs for their respective receptors.

BEHP: bis(2-ethylhexyl) phthalate

BHC: benzene hexachloride

COPEC: chemical of potential ecological concern

DDD: dichlorodiphenyldichloroethane

DDE: dichlorodiphenyldichloroethylene

DDT: dichlorodiphenyltrichloroethane

HPAH: high-molecular-weight polycyclic aromatic hydrocarbon

LPAH: low-molecular-weight polycyclic aromatic hydrocarbon

LPRSA: Lower Passaic River Study Area

PAH: polycyclic aromatic hydrocarbon

PCB: polychlorinated biphenyl

PCDD: polychlorinated dibenzo-p-dioxin

PCDF: polychlorinated dibenzofuran

SVOC: semivolatile organic compound

TBT: tributyltin

TCDD: tetrachlorodibenzo-p-dioxin

TEF: toxic equivalency factor

TEQ: toxic equivalent

total DDx: sum of all six DDT isomers (2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDE, 2,4'-DDT and 4,4'-DDT)

TRV: toxicity reference value

VOC: volatile organic compound

Table 9-3
Summary of Ecological Preliminary COCs

Selected Receptor Group and Species Evaluated	LOE	COPECs ¹	Preliminary COCs Using a Range of TRVs ^{2, 3}
Protection and maintenance (i.e., survival, growth, and reproduction) of the benthic invertebrate community, both as an environmental resource in itself and as one that serves as a forage base for fish and wildlife populations			
Benthic invertebrate community	SQT (benthic community metrics; toxicity test data; surface sediment chemistry)	Not identified using the SQT analysis	No preliminary COCs identified using the SQT analysis; however, locations with impacts were identified as follows: • No, low, or likely low impacts (indicative of insignificant benthic invertebrate risk) relative to urban reference conditions were observed at ~37% of the 97 SQT locations. Medium, likely, or high impacts were observed at 63% of the 97 SQT locations. • Likely or high impacts (indicative of clear impacts) were observed at ~31% of the 97 SQT locations. • At ~32% of the SQT locations, medium impacts were observed, suggesting moderate risk.
Benthic invertebrates (including benthic invertebrate community, macroinvertebrates, and mollusks)	Surface water	Cadmium, chromium, copper, lead, mercury, selenium silver, zinc, TBT (estuarine), anthracene, benzo(a)anthracene, benzo(a)pyrene, fluoranthene, pyrene, BEHP, BBP, total PCBs, 2,3,7,8-TCDD, 4,4'-DDE, 4,4'-DDT, dieldrin (estuarine), hexachlorobenzene, total chlordane, total DDx, cyanide	2,3,7,8-TCDD, copper, cyanide
Protection and maintenance (i.e., survival, growth, and reproduction) of healthy populations of benthic invertebrates (worms, blue crab and crayfish, and bivalve mussels) that serve as a forage base for fish and wildlife populations and as a base for sports fisheries³			
Benthic invertebrates (worms, blue crab, and caged mussels)	Tissue	Arsenic, cadmium, chromium, cobalt, copper, lead, mercury, methylmercury, nickel, selenium, silver, vanadium, zinc, total LPAHs, total HPAHs, total PCBs, PCB TEQ-fish, 2,3,7,8-TCDD, PCDD/PCDF TEQ-fish, total TEQ-fish, dieldrin, heptachlor epoxide, total DDx	Arsenic, chromium, copper, lead, mercury/methylmercury, nickel, selenium, silver, HPAHs, total PCBs, 2,3,7,8-TCDD, PCDD/PCDF TEQ -fish, total TEQ-fish, total DDx

Table 9-3
Summary of Ecological Preliminary COCs

Selected Receptor Group and Species Evaluated	LOE	COPECs ¹	Preliminary COCs Using a Range of TRVs ^{2, 3}
Protection and maintenance (i.e., survival, growth, and reproduction) of omnivorous, invertivorous, and piscivorous fish populations that serve as a forage base for fish and wildlife populations and as a base for sports fisheries			
Fish populations (mummichog/other forage fish, common carp, white perch, channel catfish, white catfish, brown bullhead, American eel, largemouth bass, smallmouth bass, and northern pike)	Tissue	Arsenic, cadmium, chromium, copper, lead, methylmercury, selenium, silver, zinc, total HPAHs, total LPAHs, total PCBs, PCB TEQ-fish, 2,3,7,8-TCDD, PCDD/PCDF TEQ-fish, total TEQ-fish, dieldrin, endosulfan I, total DDx	Copper, ⁴ mercury/methylmercury, total PCBs, 2,3,7,8-TCDD, PCB TEQ-fish, PCDD/PCDF TEQ-fish, total TEQ-fish, total PCBs, dieldrin, total DDx
	Diet	Cadmium, chromium, cobalt, copper, mercury methyl mercury, nickel, selenium, vanadium, zinc, tributyltin, total PAHs, benzo(a)pyrene, total PCBs, PCT TEQ-fish, PCDD/PCDF TEQ-fish, total TEQ-fish, total DDx	Cadmium, mercury, PCB TEQ-fish, PCDD/PCDF TEQ-fish, total TEQ-fish
	Surface water	Cadmium, chromium, copper, lead, mercury, selenium, silver, zinc, TBT (estuarine), anthracene, benzo(a)anthracene, benzo(a)pyrene, fluoranthene, pyrene, BEHP, BBP, total PCBs, PCB TEQ- fish, 2,3,7,8-TCDD, PCDD/PCDF TEQ-fish, total TEQ- fish, 4,4'-DDE, 4,4'-DDT, dieldrin (estuarine), hexachlorobenzene, total chlordane, total DDx, cyanide	Copper and cyanide
	Egg tissue (mummichog)	Mercury, methylmercury, total PCBs, PCDD/PCDF TEQ-fish, and total TEQ-fish	Mercury, total PCBs
	Mummichog egg count	None identified based on qualitative LOE	None identified based on qualitative LOE
	Health assessment	None identified based on qualitative LOE	None identified based on qualitative LOE

Table 9-3
Summary of Ecological Preliminary COCs

Selected Receptor Group and Species Evaluated	LOE	COPECs ¹	Preliminary COCs Using a Range of TRVs ^{2, 3}
Protection and maintenance (i.e., survival, growth, and reproduction) of herbivorous, omnivorous, sediment-probing, and piscivorous bird populations			
Bird populations (spotted sandpiper, belted kingfisher, and great blue heron)	Diet	Cadmium, chromium, copper, lead, methylmercury, nickel, selenium, vanadium, zinc, total LPAHs, total HPAHs, total PCBs, PCB TEQ-bird, PCDD/PCDF TEQ-bird, total TEQ-bird, total DDx	Copper, lead, methylmercury, total HPAHs, total PCBs, PCB TEQ-bird, PCDD/PCDF TEQ-bird, total TEQ-bird, total DDx
	Egg tissue	Mercury/methylmercury, total PCBs, PCB TEQ-bird, PCDD/PCDF TEQ-bird, total TEQ-bird, total DDx, dieldrin	Total PCBs, PCDD/PCDF TEQ-bird, total TEQ TEQ-bird, PCB TEQ TEQ-bird, total DDx
Protection and maintenance (i.e., survival, growth, and reproduction) of aquatic mammal populations			
Mammal populations (river otter and mink)	Diet	Arsenic, cadmium, copper, lead, mercury/methylmercury, nickel, selenium, vanadium, and zinc, total HPAHs, total PCBs, PCB TEQ-mammal, PCDD/PCDF TEQ-mammal, total TEQ-mammal, dieldrin	Total PCBs, PCB TEQ-mammal, PCDD/PCDF TEQ-mammal, total TEQ-mammal
Maintenance of the zooplankton community that serves as a food base for juvenile fish			
Zooplankton community	Surface water	Cadmium, chromium, copper, lead, mercury, selenium, silver, zinc, TBT (estuarine), anthracene, benzo(a)anthracene, benzo(a)pyrene, fluoranthene, pyrene, BEHP, BBP, total PCBs, 2,3,7,8-TCDD, 4,4'-DDE, 4,4'-DDT, dieldrin (estuarine), hexachlorobenzene, total chlordane, total DDx, cyanide	Copper and cyanide
Protection and maintenance (i.e., survival, growth, and reproduction) of healthy amphibian and reptile populations			
Amphibians and reptile populations (multiple species represented)	Surface water	Chromium, copper, lead, mercury, nickel, silver, zinc	None identified

Table 9-3
Summary of Ecological Preliminary COCs

Selected Receptor Group and Species Evaluated	LOE	COPECs ¹	Preliminary COCs Using a Range of TRVs ^{2, 3}
Maintenance of healthy aquatic plant populations as a food resource and habitat for fish and wildlife populations			
Aquatic plant populations (multiple species represented)	Sediment	Antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, vanadium, zinc, and acenaphthene	Chromium, copper, lead, mercury, selenium, vanadium, and zinc
	Surface water	Cadmium, chromium, copper, lead, mercury (estuarine), zinc, TBT, total PCBs (estuarine), 2,3,7,8-TCDD, 4,4'-DDE, cyanide (estuarine)	Copper, zinc, TBT, cyanide

Notes:

1. COPECs are those COIs for which the maximum concentration exceeded its TSV in the SLERA. If a TSV was exceeded based on any species in a receptor group, it was retained as a COPEC for all species in that receptor group. COPECs for surface water are for both estuarine (RM 0 to RM 13) and freshwater (RM 4 to RM 17.4) unless noted otherwise.
2. Preliminary COCs are identified as those COPECs with HQs ≥ 1.0 based on any LOE and effect-level concentration (i.e., HQ ≥ 1.0 based on a ranges of LOAELs for tissue and diet LOEs, HQ ≥ 1.0 based on acute or chronic surface water TRVs; HQ ≥ 1.0 based on plant-specific sediment TRVs).
3. The NJDEP acknowledges that the BERA for the LPRSA identifies unacceptable risk. However, the NJDEP's *Ecological Evaluation Technical Guidance*, August 2018 (NJDEP 2018), does not advocate the use of more than one set of TRVs for individual contaminant-receptor pairs. It is the NJDEP's position that a single TRV set (NOAEL and LOAEL) that evaluates the more sensitive species and endpoints to characterize risk to invertebrates, fish, birds, and wildlife should be selected in a BERA, not two sets of TRVs as presented in this document. It is the NJDEP's position that, for the LPRSA, use of one conservative TRV set derived for sensitive receptors and sensitive endpoints most clearly demonstrates the degree of risk for individual contaminant-receptor pairs and ensures protection of threatened, endangered, and species of special concern.
4. Preliminary COCs for regulated metals based on the tissue residue LOE were based on EFs rather than HQs.

BBP: butyl benzyl phthalate
 BEHP: bis(2-ethylhexyl) phthalate
 BERA: baseline ecological risk assessment
 COC: chemical of concern
 COI: chemical of interest
 COPEC: chemical of potential concern
 DDD: dichlorodiphenyldichloroethane
 DDE: dichlorodiphenyldichloroethylene
 DDT: dichlorodiphenyltrichloroethane
 EF: exceedance factor
 FS: feasibility study
 HPAH: high-molecular-weight polycyclic aromatic hydrocarbon

HQ: hazard quotient
 LOAEL: lowest-observed-adverse-effect level
 LOE: line of evidence
 LPAH: low-molecular-weight polycyclic aromatic hydrocarbon
 LPRSA: Lower Passaic River Study Area
 NJDEP – New Jersey Department of Environmental Protection
 NOAEL: no-observed-adverse-effect level
 PCB: polychlorinated biphenyl
 PCDD: polychlorinated dibenzo-*p*-dioxin
 PCDF – polychlorinated dibenzofuran
 RM: river mile
 SSD: species sensitivity distribution

SLERA: screening-level ecological risk assessment
 SQT: sediment quality triad
 TBT: tributyltin
 TCDD: tetrachlorodibenzo-*p*-dioxin
 TEQ: toxic equivalent
 total DDx: sum of all six DDT isomers (2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDE, 2,4'-DDT and 4,4'-DDT)
 TSV: toxicity screening value
 WOE: weight of evidence

Table 9-4
Summary of HQs and EFs for Ecological Preliminary COCs

Preliminary COC ¹	Risk Results (Range of LOAEL HQs/EFs) ^{2, 3}					
	Benthic Invertebrates	Fish	Birds	Mammals	Aquatic Plants	Zooplankton
Metals						
Arsenic	Tissue: worm (2.2); blue crab (2.2)	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk
Cadmium	No unacceptable risk	Diet: mummichog (1.3); common carp (1.2); white perch (1.1); white sucker (1.2); American eel (0.70-1.2)	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk
Chromium	Tissue: worm (6.0); mussel (3.7)	No unacceptable risk	No unacceptable risk	No unacceptable risk	Sediment (160)	No unacceptable risk
Copper	Surface water (estuarine: 0.14-2.7; freshwater: 0.034-1.0)	Surface water (estuarine: 0.14-2.7; freshwater: 0.023-1.0)	Diet: spotted sandpiper (0.30-3.6); great blue heron (0.029-1.3)	No unacceptable risk	Sediment (2.4)	Surface water (estuarine: 0.14-2.7; freshwater: 0.023-1.0)
	Tissue: blue crab (2.1)	Tissue: mummichog (2.1), other forage fish (2.7), white perch (9.3), American eel (1.7)			Surface water (estuarine: 1.8)	
Lead	Tissue: worm (0.16-2.5)	No unacceptable risk	Diet: spotted sandpiper (0.20-10); belted kingfisher (0.015-1.1)	No unacceptable risk	Sediment (2.3)	No unacceptable risk

Table 9-4
Summary of HQs and EFs for Ecological Preliminary COCs

Preliminary COC ¹	Risk Results (Range of LOAEL HQs/EFs) ^{2, 3}					
	Benthic Invertebrates	Fish	Birds	Mammals	Aquatic Plants	Zooplankton
Mercury/ Methyl- mercury	Tissue: blue crab: (1.3-1.5)	Tissue: white catfish (0.71-1.1); American eel (0.74–1.1); largemouth bass (1.5–2.6); smallmouth bass (0.63-1.1)	Diet: great blue heron (0.031–1.6); belted kingfisher (0.13–1.6)	No unacceptable risk	Sediment (9.7)	No unacceptable risk
		Diet: mummichog (1.3); common carp (1.1); white perch (1.3); white catfish (1.1); American eel (1.1-1.3)				
		Egg tissue: mummichog (0.11-1.1)				
Nickel	Tissue: worm (12); mussel (6.0)	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk
Selenium	Tissue worm (1.1); blue crab (1.5)	No unacceptable risk	No unacceptable risk	No unacceptable risk	Sediment (1.8)	No unacceptable risk
Silver	Tissue: blue crab (1.0)	No unacceptable risk	Not evaluated (no toxicity data available)	Not evaluated (no toxicity data available)	No unacceptable risk	No unacceptable risk
Vanadium	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk	Sediment (14)	No unacceptable risk
Zinc	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk	Sediment (3.1)	No unacceptable risk
					Surface water (estuarine: 21)	
Organometals						
TBT	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk	Surface water (estuarine: 1.1; freshwater: 50)	No unacceptable risk

Table 9-4
Summary of HQs and EFs for Ecological Preliminary COCs

Preliminary COC ¹	Risk Results (Range of LOAEL HQs/EFs) ^{2, 3}					
	Benthic Invertebrates	Fish	Birds	Mammals	Aquatic Plants	Zooplankton
PAHs						
HPAHs	Tissue: worms (0.090–3.0)	No unacceptable risk	Diet: spotted sandpiper (1.9–10)	No unacceptable risk	No unacceptable risk	No unacceptable risk
PCBs						
Total PCBs	Tissue: worm (0.46–14.1), blue crab (0.67–21), mussel (0.046–1.4)	Tissue: mummichog (0.16–1.1), other forage fish (0.14–1.0), common carp (1.4–9.8), white perch (0.66–4.7), channel catfish (0.45–3.2), brown bullhead (0.37–2.6), white catfish (0.89–6.4), white sucker (0.76–5.5), American eel (0.53–3.8), largemouth bass (2.1–15), northern pike (0.53–3.8), smallmouth bass (0.37–2.6)	Diet: spotted sandpiper (0.047–1.2), great blue heron (0.031–1.1)	Diet: mink (0.94–3.1); river otter (2.6–3.7)	No unacceptable risk	No unacceptable risk
		Diet: northern pike (1.3)				
		Egg tissue: mummichog (2.2–18)	Egg tissue: great blue heron (0.078–284); belted kingfisher (0.22–76)			
PCB TEQ	No unacceptable risk	Tissue: common carp (0.037–2.4), white perch (0.018–1.2), channel catfish (0.015–1.0); white catfish (0.029–1.9), white sucker (0.027–1.8), largemouth bass (0.14–9.4), northern pike (0.019–1.3)	Diet: spotted sandpiper (0.073–3.9); great blue heron (0.030–1.6), belted kingfisher (0.10–1.5)	Diet: mink (0.12–1.1); river otter (0.31–1.4)	Not evaluated	Not evaluated
		Diet: white perch (1.0); American eel (0.95–1.8); largemouth bass (1.6); smallmouth bass (1.5); northern pike (2.1)	Egg tissue: great blue heron (0.56–36); belted kingfisher (0.46–12)			

Table 9-4
Summary of HQs and EFs for Ecological Preliminary COCs

Preliminary COC ¹	Risk Results (Range of LOAEL HQs/EFs) ^{2, 3}					
	Benthic Invertebrates	Fish	Birds	Mammals	Aquatic Plants	Zooplankton
PCDD/PCDFs						
2,3,7,8-TCDD	Surface water (estuarine: 0.0028-4.3)	Tissue: mummichog (0.41–27), other forage fish (0.38–26), common carp (5.1–340), white perch (1.6–110), channel catfish: (0.80–53), brown bullhead (1.3–83), white catfish (1.8–120), white sucker (1.1–72), American eel (0.19–13), largemouth bass (1.5–100), northern pike (0.79–53), smallmouth bass (0.63–42)	Not evaluated	Not evaluated	No unacceptable risk	No unacceptable risk
	Tissue: worm (0.013–29); blue crab (0.019–44); mussel (0.00073–1.7)					
PCDD/PCDF TEQ	Tissue: worm (0.013–29), blue crab (0.021–48), mussel (0.00077–1.8)	Tissue: mummichog (0.43–28), other forage fish (0.41–27), common carp (5.2–340), white perch (1.7–110) channel catfish (0.83–56), brown bullhead (1.3–89), white catfish (1.8–120), white sucker (1.1–72), American eel (0.20–13), largemouth bass (1.5–100), northern pike (0.83–56) smallmouth bass (0.63–42)	Diet: spotted sandpiper (0.014–21), great blue heron (0.020–1.9), belted kingfisher (0.090–1.9)	Diet: mink: (0.79–8.7), river otter (1.8–10)	Not evaluated	Not evaluated
		Diet: mummichog (200), common carp (200), white perch (170), channel catfish (190), white catfish (160), white sucker (190), American eel (180–190), largemouth bass (150), smallmouth bass (140), northern pike (200)	Egg tissue: great blue heron (0.42–37), belted kingfisher (0.38–14)			

Table 9-4
Summary of HQs and EFs for Ecological Preliminary COCs

Preliminary COC ¹	Risk Results (Range of LOAEL HQs/EFs) ^{2, 3}					
	Benthic Invertebrates	Fish	Birds	Mammals	Aquatic Plants	Zooplankton
Total TEQ	Tissue: worm (0.013–30); blue crab (0.021–48); mussel (0.00077–1.8)	Tissue: mummichog: (0.43–28), other forage fish: (0.41–27), common carp: (5.2–340), white perch: (1.7–110), channel catfish: (0.83–56), brown bullhead: (1.3–89), white catfish: (1.9–130), white sucker: (1.1–72), American eel: (0.21–14), largemouth bass: (1.5–100), northern pike: (0.92–61), smallmouth bass: (0.68–46)	Diet: spotted sandpiper (0.089–25), great blue heron (0.044–3.5), belted kingfisher (0.18–3.1)	Diet: mink (1.0–9.9), river otter (2.4–12)	Not evaluated	Not evaluated
		Diet: mummichog (210); common carp (200); white perch (170); channel catfish (190); white catfish (160); white sucker (190); American eel (190–200); largemouth bass (150); smallmouth bass (140); northern pike (200)	Egg tissue: great blue heron (1.0–74), belted kingfisher (0.85–23)			
Pesticides						
Total DDx	Tissue: worm: (0.12–1.6), blue crab (0.52–6.8)	Tissue: common carp (1.3–1.7)	Diet: spotted sandpiper (0.018–1.4); great blue heron (0.020–2.4); belted kingfisher (0.066–1.8)	No unacceptable risk	No unacceptable risk	No unacceptable risk
			Egg tissue: great blue heron (0.14–18); belted kingfisher (0.37–4.6)			
Dieldrin	No unacceptable risk	Tissue: common carp (0.28–1.4), channel catfish (0.24 – 1.2), American eel (0.27–1.4), largemouth bass (0.20–1.0), northern pike (0.22–1.1)	No unacceptable risk	No unacceptable risk	No unacceptable risk	No unacceptable risk

Table 9-4
Summary of HQs and EFs for Ecological Preliminary COCs

Preliminary COC ¹	Risk Results (Range of LOAEL HQs/EFs) ^{2, 3}					
	Benthic Invertebrates	Fish	Birds	Mammals	Aquatic Plants	Zooplankton
Other						
Cyanide	Surface water (estuarine: 1.3-4.1; freshwater: 0.23-1.0)	Surface water (estuarine: 1.6 to 5.3)	Not evaluated	Not evaluated	Surface water (estuarine: 2.0)	Surface water (estuarine: 1.6 to 5.3)

Notes:

1. Preliminary COCs are identified as those COPECs with HQs ≥ 1.0 based on any LOE and effect-level concentration (i.e., HQ ≥ 1.0 based on a range of LOAELs for tissue and diet LOEs, HQ ≥ 1.0 based on acute or chronic surface water TRVs; HQ ≥ 1.0 based on plant-specific sediment TRVs). See Sections 6.2.4, 6.3.4, 7.1.4, 7.2.4, 7.3.4, 7.4.4, 8.1.4, 8.2.4, and 9.1.4 of the BERA.
2. COPECs with HQs ≥ 1.0 based on a range of NOAEL TRVs are summarized in the BERA (Sections 6.3.4, 7.1.4, 7.2.4, 7.4.4, 8.1.4, 8.2.4, and 9.1.4).
3. The NJDEP acknowledges that the BERA for the LPRSA identifies unacceptable risk. However, the NJDEP's *Ecological Evaluation Technical Guidance*, August 2018 (NJDEP 2018), does not advocate the use of more than one set of TRVs for individual contaminant-receptor pairs. It is the NJDEP's position that a single TRV set (NOAEL and LOAEL) that evaluates the more sensitive species and endpoints to characterize risk to invertebrates, fish, birds, and wildlife should be selected in a BERA, not two sets of TRVs as presented in this document. It is the NJDEP's position that, for the LPRSA, use of one conservative TRV set derived for sensitive receptors and sensitive endpoints most clearly demonstrates the degree of risk for individual contaminant-receptor pairs and ensures protection of threatened, endangered, and species of special concern.

BERA: baseline ecological risk assessment

COC: chemical of concern

COPEC: chemical of potential concern

DDD: dichlorodiphenyldichloroethane

DDE: dichlorodiphenyldichloroethylene

DDT: dichlorodiphenyltrichloroethane

EF: exceedance factor

HPAH: high-molecular-weight polycyclic aromatic hydrocarbon

HQ: hazard quotient

LOAEL: lowest-observed-adverse-effect level

LOE: line of evidence

NJDEP – New Jersey Department of Environmental Protection

NOAEL: no-observed-adverse-effect level

PCB: polychlorinated biphenyl

PCDD: polychlorinated dibenzo-*p*-dioxin

PCDF: polychlorinated dibenzofuran

RM: river mile

SQT: sediment quality triad

TBT: tributyltin

TCDD: tetrachlorodibenzo-*p*-dioxin

TEQ: toxic equivalent

total DDx: sum of all six DDT isomers (2,4'-DDD, 4,4'-

DDD, 2,4'-DDE, 4,4'-DDE, 2,4'-DDT and 4,4'-DDT)

WOE: weight of evidence

Table 9-5
Considerations for Risk Management on Ecological Risk Drivers

Risk Driver and LOE	LOAEL HQ range ^{1, 2, 3}		
	Based on TRV – A ⁴	Based on TRV – B ⁵	Risk Management Considerations
Benthic invertebrate community	No risk drivers identified using the SQT analysis; however, locations with impacts were identified as follows: - No, low, or likely low impacts (indicative of insignificant benthic invertebrate risk) relative to urban reference conditions were observed at ~37% of the 97 SQT locations. Medium, likely, or high impacts were observed at 63% of the 97 SQT locations. - Likely or high impacts (indicative of clear impacts) were observed at ~31% of the 97 SQT locations. - At ~32% of the SQT locations, risk was unclear (medium impacts). Medium impacts suggest moderate chemical risk.		- The reference area chemistry and toxicity screens are conservative and results in dataset that may not represent realistic reference conditions. The quantitative analysis of uncertainty (Appendix P to the BERA) provides an alternative screening process. - The sediment chemistry LOE is conservative and potentially unreliable for predicting effects in the LPRSA. The quantitative analysis of uncertainty (Appendix P) provides an alternative chemistry LOE. The multivariate analysis of SQT data (Appendix P), which is separate from the WOE evaluation, indicates that sediment chemical factors are potentially related to benthic community impacts and exacerbated by habitat variables. - The comparison of non-urban reference data to LPRSA SQT data is conservative. Effects in the LPRSA associated with the urban setting are not addressed by that type of comparison. - Impacts at freshwater LPRSA SQT locations LPRT17A and LPRT17D were potentially influenced (at least in part) by differences between habitat conditions immediately below Dundee Dam and those in the area above Dundee Dam. The area above the dam has finer sediments than the area just below, which is predominately composed of coarse sand and cobble. In general, such sediments are not expected to have elevated sediment contamination.
Total PCBs			
Benthic invertebrate tissue	0.046-0.67 (mussels, worm, and blue crab)	1.4-21 (mussels, worm, and blue crab)	- TRV-A based on SSD that is lower than lowest measured LOAEL evaluated - TRV-B based on WB tissue concentrations interpolated from measured egg tissue concentrations
Fish tissue	0.14-2.1 (all LPRSA fish receptors)	1.0-15 (all LPRSA fish receptors)	- TRV-A based on SSD that is lower than lowest measured LOAEL - TRV-B based on changes in smolt seawater preference in Atlantic salmon - EPC for largemouth bass based on max tissue concentration
Fish diet	1.3 (northern pike)	ne	LOAEL based on fecundity (number of eggs per female), but no significant reduction on egg weight or hatching rate was reported.

Table 9-5
Considerations for Risk Management on Ecological Risk Drivers

Risk Driver and LOE	LOAEL HQ range ^{1, 2, 3}		
	Based on TRV – A ⁴	Based on TRV – B ⁵	Risk Management Considerations
Fish egg	2.2–3.6 (mummichog)	11–18 (mummichog)	• TRV-A and TRV-B based on same literature source; TRV-A is based on observed adverse effect on reproduction (reduced hatchability) and TRV-B is based on reduced fecundity, but no effect on egg weight or hatchability • Mummichog egg concentration modeled using literature-based CFs and LPRSA mummichog-specific lipid content
Bird diet	0.031-0.70 (spotted sandpiper, great blue heron)	0.11-1.2 (spotted sandpiper, great blue heron)	• TRV-A based on non-chicken reproduction • TRV-B based on interpolated value from chicken hatchability data • Low HQs and HQs <1.0 conflicts with bird egg LOE, which relies on literature-based BMFs to estimate egg tissue concentrations
Bird egg	0.078-1.0 (great blue heron and belted kingfisher)	1.0-284 (great blue heron and belted kingfisher)	• TRV-A based on non-chicken reproduction and limited dataset (two studies) • TRV-B based on interpolated value from chicken hatchability data • Uncertainty associated with use of literature-based BMFs used to predict bird egg concentrations; receptor-specific BMF for heron and kingfisher based heron and kingfisher data, respectively for comparison to TRV – A and range of BMFs evaluated for comparison to TRV – B
Mammal diet	0.94–3.2 (mink and river otter)	1.1-3.7 (mink and river otter)	• TRV-A and TRV-B based on same literature source with slightly different ingestion rates and body weight assumptions used to derive TRV • HQ based on range of dietary scenarios and two exposure areas; HQs slightly lower based on site-wide exposure area (vs. >RM 10); mink HQs lower based on consumption of aquatic prey and assuming zero exposure from terrestrial prey
PCB TEQ			
Fish tissue	0.014-0.037 (0.010-0.74) (common carp, white perch, channel catfish, white catfish, white sucker, largemouth bass, northern pike)	1.0-9.4 (common carp, white perch, channel catfish, white catfish, white sucker, largemouth bass, northern pike)	• TRV-A based on SSD within range of measured LOAELs evaluated • Alternative TRV-A based on SSD which has a relatively poor visual and statistical fit to the empirical data and likely overpredicts risk; alternative SSD is lower than lowest measured LOAEL • TRV-B is based on interpolated larvae concentration from egg tissue

Table 9-5
Considerations for Risk Management on Ecological Risk Drivers

Risk Driver and LOE	LOAEL HQ range ^{1, 2, 3}		
	Based on TRV – A ⁴	Based on TRV – B ⁵	Risk Management Considerations
Fish diet	1.5-2.1 (American eel-large; largemouth bass; smallmouth bass; northern pike)	ne	LOAEL TRV is 2 orders of magnitude lower than LOAELs reported for two other species
Bird diet	0.030-0.78 (all bird receptors)	0.13-3.9 (all bird receptors)	- TRV-A and TRV-B based on same literature source based on weekly injection of pheasants - TRV-B extrapolated from study using an interspecies extrapolation factor of 5 - High variability of bird TEFs and differences in species sensitivities to dioxin-like compounds - Low HQs and HQs <1.0 conflicts with bird egg LOE, which relies on literature-based BMFs to estimate egg tissue concentrations
Bird egg	0.46-7.2 (great blue heron and belted kingfisher)	0.57-36 (great blue heron and belted kingfisher)	- TRV-A based on SSD with no chicken reproduction data (SSD not expected to have changed significantly with inclusion of chicken data) - TRV-B based on SSD inclusive of chicken reproduction data - TEQ sensitivities vary with AH-receptor; chickens are in "high sensitivity" group and great blue heron is in "low sensitivity" group - Uncertainty associated with use of literature-based BMFs used to predict bird egg concentrations; receptor-specific BMF for heron and kingfisher based heron and kingfisher data, respectively for comparison to TRV – A and range of BMFs evaluated for comparison to TRV – B
Mammal diet	0.12-0.34 (mink and river otter)	0.49-1.4 (mink and river otter)	- TRV-A based on mink fed laboratory-prepared diet and TRV-B based on mink fed field-collected carp - HQ based on range of dietary scenarios and two exposure areas; HQs slightly lower based on site-wide exposure area (vs. >RM 10); mink HQs lower based on consumption of aquatic prey and assuming zero exposure from terrestrial prey

Table 9-5
Considerations for Risk Management on Ecological Risk Drivers

Risk Driver and LOE	LOAEL HQ range ^{1, 2, 3}		
	Based on TRV – A ⁴	Based on TRV – B ⁵	Risk Management Considerations
PCDD/PCDF and Total TEQ			
Benthic invertebrate tissue	0.00077–0.021 (PCDD/PCDF TEQ; worm, blue crab and mussels) 0.00077–0.021 (total TEQ; worm, blue crab and mussels)	1.8-48 (PCDD/PCDF TEQ; worm, blue crab and mussels) 1.8-48 (total TEQ; worm, blue crab and mussels)	• TRV-A based on injected (not measured) concentration in crayfish • TRV-B based on uncontrolled field data and limited sample size (n=1 tissue composite); LOAEL is based on relative reduction at Arthur Kill site compared to Sandy Hook site. • Evaluation as TEQ (based on fish TEFs) is questionable for invertebrates because there is limited evidence for ligand activation of the Ah (dioxin) cellular receptor in these organisms and, as such, they are not susceptible to the dioxin-like effects reported for vertebrates (Van den Berg et al. 1998).
Fish tissue	0.20–5.2 (1.0-27) (PCDD/PCDF TEQ-fish; all fish receptors) 0.21–5.2 (1.1-27) (total TEQ-fish; all fish receptors)	13-340 (PCDD/PCDF TEQ-fish; all fish receptors) 14-340 (total TEQ-fish; all fish receptors)	• TRV-A based on SSD within range of measured LOAELs evaluated • Alternative TRV-A based on SSD which has a relatively poor visual and statistical fit to the empirical data and likely overpredicts risk; alternative SSD is lower than lowest measured LOAEL • TRV-B is based on interpolated larvae concentration from egg tissue
Fish diet	140-200 (PCDD/PCDF TEQ-fish; all fish receptors) 140-210 (Total TEQ-fish; all fish receptors)	ne	• LOAEL TRV is 2 orders of magnitude lower than LOAELs reported for two other species
Bird diet	0.014-4.2 (PCDD/PCDF TEQ-bird; all bird receptors) 0.044-5.0 (Total TEQ-bird; all bird receptors)	0.071-21 (PCDD/PCDF TEQ-bird; all bird receptors) 0.22-25 (Total TEQ-bird; all bird receptors)	• TRV-A and TRV-B based on same literature source based on weekly injection of pheasants • TRV-B extrapolated from study using an interspecies extrapolation factor of 5 • High variability of bird TEFs and differences in species sensitivities to dioxin-like compounds

Table 9-5
Considerations for Risk Management on Ecological Risk Drivers

Risk Driver and LOE	LOAEL HQ range ^{1, 2, 3}		
	Based on TRV – A ⁴	Based on TRV – B ⁵	Risk Management Considerations
Bird egg	0.38-7.5 (PCDD/PCDF TEQ-bird; great blue heron and belted kingfisher) 1.0-15 (Total TEQ-bird; great blue heron and belted kingfisher)	0.43-37 (PCDD/PCDF TEQ-bird; great blue heron and belted kingfisher) 1.0-74 (Total TEQ-bird; great blue heron and belted kingfisher)	• TRV-A based on SSD with no chicken reproduction data (SSD not expected to have changed significantly with inclusion of chicken data) • TRV-B based on SSD inclusive of chicken reproduction data • TEQ sensitivities vary with AH-receptor; chickens are in “high sensitivity” group and great blue heron is in “low sensitivity” group • Receptor-specific BMF for heron and kingfisher based heron and kingfisher data, respectively
Mammal diet	0.79–2.6 (PCDD/PCDF TEQ-mammal; mink and river otter) 1.0-2.9 (total TEQ-mammal; mink and river otter)	3.2–10 (PCDD/PCDF TEQ-mammal; mink and river otter) 4.1-12 (total TEQ-mammal; mink and river otter)	• TRV-A based on mink fed laboratory-prepared diet and TRV-B based on mink fed field-collected carp • HQ based on range of dietary scenarios and two exposure areas; HQs slightly lower based on site-wide exposure area (vs. >RM 10); mink HQs lower based on consumption of aquatic prey and assuming zero exposure from terrestrial prey
Total DDx			
Benthic invertebrate tissue	0.15-0.62 (1.6-6.8) (worm and blue crab)	0.12-0.52 (worm and blue crab)	• TRV-A and alternative TRV-A based on SSD that are both lower than lowest measured LOAEL • Alternative TRV-A is based on a relatively poor visual and statistical fit to the empirical data and likely overestimates toxicity
Fish tissue	1.3 (common carp)	1.7 (common carp)	• TRV-A based on SSD that is lower than lowest measured LOAEL evaluated • TRV-B based on SSD within range of measured LOAELs evaluated (which includes TRVs based on field collected organisms) • HQs < 1.0 for the other 11 of 12 fish species evaluated
Bird diet	0.018-0.26 (all bird receptors)	0.16-2.4 (all bird receptors)	• TRV-A based on SSD within range of measured LOAELs evaluated • TRV-B based on field study of eggshell thinning in pelicans • Low HQs and HQs <1.0 conflicts with bird egg LOE, which relies on literature-based BMFs to estimate egg tissue concentrations

Table 9-5
Considerations for Risk Management on Ecological Risk Drivers

Risk Driver and LOE	LOAEL HQ range ^{1, 2, 3}		
	Based on TRV – A ⁴	Based on TRV – B ⁵	Risk Management Considerations
Bird egg	0.14-1.8 (great blue heron and belted kingfisher)	0.19-18 (great blue heron and belted kingfisher)	• TRV-A based on SSD not inclusive of chicken reproductive data • TRV-B based on SSD inclusive of chicken reproduction data • Uncertainty associated with use of literature-based BMFs used to predict bird egg concentrations; receptor-specific BMF for heron based heron data and receptor-specific BMF for kingfisher based on geomean of 5 species for comparison to TRV – A and range of BMFs evaluated for comparison to TRV – B

Notes:

1. HQs based on a range of LOAEL TRVs for tissue and diet LOEs, acute or chronic surface water TRVs, and plant-specific sediment TRVs. See Sections 6.2.4, 6.3.4, 7.1.4, 7.2.4, 7.3.4, 7.4.4, 8.1.4, 8.2.4, and 9.1.4 of the BERA.
2. COPECs with HQs ≥ 1.0 based on a range of NOAEL TRVs are summarized in the BERA (Sections 6.3.4, 7.1.4, 7.2.4, 7.4.4, 8.1.4, 8.2.4, and 9.1.4).
3. The NJDEP acknowledges that the BERA for the LPRSA identifies unacceptable risk. However, the NJDEP's *Ecological Evaluation Technical Guidance*, August 2018 (NJDEP 2018), does not advocate the use of more than one set of TRVs for individual contaminant-receptor pairs. It is the NJDEP's position that a single TRV set (NOAEL and LOAEL) that evaluates the more sensitive species and endpoints to characterize risk to invertebrates, fish, birds, and wildlife should be selected in a BERA, not two sets of TRVs as presented in this document. It is the NJDEP's position that, for the LPRSA, use of one conservative TRV set derived for sensitive receptors and sensitive endpoints most clearly demonstrates the degree of risk for individual contaminant-receptor pairs and ensures protection of threatened, endangered, and species of special concern.
4. TRVs derived from the primary literature review.
5. TRVs based on USEPA's LPR restoration project FFS (Louis Berger et al. 2014) or USEPA's first draft of the LPR restoration project FFS (Malcolm Pirnie 2007).

BERA: baseline ecological risk assessment

BMF: biomagnification factor

CF: conversion factor

COPEC: chemical of potential concern

DDD: dichlorodiphenyldichloroethane

DDE: dichlorodiphenyldichloroethylene

DDT: dichlorodiphenyltrichloroethane

HQ: hazard quotient

LOAEL: lowest-observed-adverse-effect level

LOE: line of evidence

LPRSA: Lower Passaic River Study Area

NJDEP – New Jersey Department of Environmental Protection

NOAEL: no-observed-adverse-effect level PCB: polychlorinated

biphenyl

PCDD: polychlorinated dibenzo-p-dioxin

PCDF – polychlorinated dibenzofuran

RM: river mile

SSD: species sensitivity distribution

SQT: sediment quality triad

TCDD: tetrachlorodibenzo-p-dioxin

TEQ: toxic equivalent

total DDx: sum of all six DDT isomers (2,4'-DDD, 4,4'-

DDD, 2,4'-DDE, 4,4'-DDE, 2,4'-DDT and 4,4'-DDT)

WOE: weight of evidence