Case Study: Risk Assessment and Remediation of PCBs in Sediments of Johnson Lake in Portland, Oregon, USA

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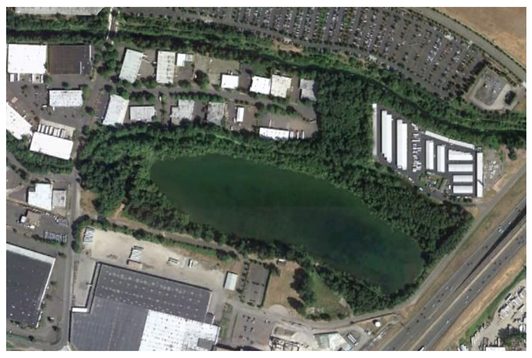
INTRODUCTION

Johnson Lake is a seven-hectare lake in an industrial area of Portland, Oregon, USA. Polychlorinated biphenyls (PCBs), metals, insecticides, petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) have been detected in lake sediments. ENVIRON performed human health and ecological risk assessments for the site and developed a cost-effective remedy to address potential risks.



Aerial view of Johnson Lake

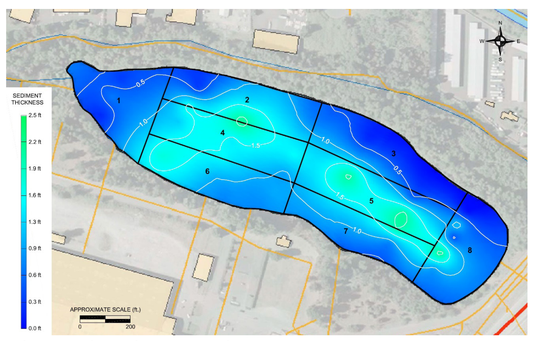
DATA COLLECTION

Various media were sampled and parameters analysed during multiple studies between 1994–2004 including:

- Media sampled:
  - Surface and subsurface sediment
  - Surface water
  - Biota tissue (plant, invertebrate and fish)
  - Sediment pore water
- Contaminants analysed:
  - PCBs
  - Semi-volatile organic compounds (SVOCs)
  - Volatile organic compounds (VOCs)
  - Pesticides
  - Herbicides
  - Metals
- Other parameters analysed:
  - Total organic carbon (TOC)

SEDIMENT IMPACTS

- PCBs were detected in all eight zones with the highest concentrations detected in zones six and seven.
- Petroleum hydrocarbons were detected in all eight zones with the highest concentration detected in zone six.
- Metals and the PAH benzo(g,h,i)perylene exceeded baseline or ambient concentrations (developed for the Columbia Slough) in zone six.
- DDT and/or its metabolites were detected in zones two, five, six and seven.

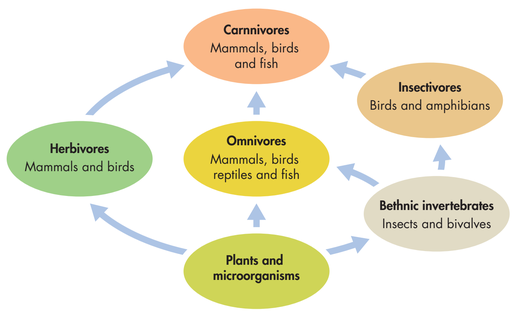


Johnson Lake sediment sampling zones

SELECTION OF CHEMICALS OF INTEREST

Based on evaluation of site sampling data, the chemicals of interest (COIs) in Johnson Lake sediment included:

- PCBs
- PAHs
- Two groups of pesticides (DDT and its metabolites, DDE and DDD, collectively referred to as total DDT, and endosulfans including endosulfan I and II and endosulfan sulfate)
- Eight metals (arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc)
- Total petroleum hydrocarbons (TPH), at the request of Oregon Department of Environmental Quality (DEQ)



Johnson Lake simplified food web

HUMAN HEALTH RISKS

- Potential exposure to chemicals in Johnson Lake via direct contact and incidental ingestion of water and sediment (waders and anglers) and consumption of fish (anglers).
- Potential cancer risks and non-cancer hazards evaluated.
- For waders, ENVIRON predicted none of the chemical-specific or cumulative cancer risks or non-cancer hazards would exceed the DEQ's benchmarks of acceptable risk or hazard.
- For adult anglers, ENVIRON predicted non-cancer hazards would not exceed the DEQ's benchmarks of acceptable risk or hazard and cumulative cancer risks would equal the acceptable benchmark.
- The DEQ calculated alternative risk estimates for adult anglers based on other assumptions including higher fish ingestion rates and a methodology that assesses certain PCB congeners according to their dioxin-like potency.
- Using their assumptions, the DEQ estimated that cancer risks (1×10^{-4} excess lifetime cancer risk through fish consumption) would exceed its benchmarks of acceptable risk.

Human health risks evaluated for anglers and waders

ECOLOGICAL RISK: RECEPTORS OF INTEREST

- Benthic invertebrates
- Fish
- Amphibians
- Reptiles
- Herbivorous, piscivorous and omnivorous mammals (muskrat, raccoon and mink)
- Insectivorous, herbivorous and piscivorous birds (spotted sandpiper, Canada goose, belted kingfisher and great blue heron)

Great blue heron

ECOLOGICAL RISKS

- The ecological risk assessment indicated that there are no unacceptable risks to populations of ecological receptors in Johnson Lake.
- Based partially on bioassay test results, the DEQ determined that levels of TPH, metals and PAHs presented an unacceptable risk to benthic organisms.

REMEDIAL ACTION OBJECTIVES

- Eliminate potential hot spots in Johnson Lake sediments by managing sediments to the extent practicable to reduce the average PCB concentration by approximately 72%.
- Prevent human consumption of fish with tissue concentrations greater than 0.003 µg/kg for the PCB congener 126.
- Reduce risk to benthic organisms by managing sediment with elevated concentrations of metals, TPH and PAHs.
- Prevent erosion of PCB-contaminated soil into Johnson Lake via storm water runoff.

REMEDY ALTERNATIVES

1. No action
2. Institutional controls
3. Monitored natural recovery
4. Thin-layer capping
5. Dredging and dewatering
6. Upland source control
7. Containment and disposal

Typically, remedies include components of several general response actions.

REMEDY SELECTION

- ENVIRON's feasibility study (FS) summarised human health and ecological risks for Johnson Lake and remedial alternatives.
- Based on the FS, the DEQ selected an initial remedy for the site in a Record of Decision (ROD) that included excavation of the most contaminated sediment from the lake and upland source control.
- Investigations carried out in preparation for remedial design identified increased sediment volume to remove and decreased PCB concentrations resulting in reduced cost effectiveness of the initial remedy.
- A ROD Amendment revised the selected remedy to include a cost-effective thin layer cap and upland source control.

DESCRIPTION OF SELECTED LAKE REMEDY

- Thin layer cap (at least six inches of clean sand/top soil mix).
- Specifications for grain size and TOC content.
- Capping material added in two four-inch lifts.
- Shoreline erosion protection and outfall aprons.
- Small portion of the lake uncapped to support the re-establishment of the local mussel population.

Sand cannon used to disperse sand for thin layer cap

Spreader table used to create thin layer cap

SHORT TERM PERFORMANCE MEASURES

Cap thickness confirmation by rain gauge method

Confirmation sampling of the upper 10 inches of sediment

SAMPLING RESULTS FOR SHORT TERM MEASURES

- Sampling indicated average first and second lift thicknesses of 4.0 and 3.8 inches, respectively. Average lakewide total thickness of 7.8 inches achieved.
- Lakewide average PCB concentration of zone-composited sediment samples was 5.94 µg/kg.

LONG TERM PERFORMANCE MEASURES

Fish tissue monitoring will be conducted five years after remedial action to re-evaluate the need to continue fish consumption advisories.

- Fillet samples (human health) including game, pan and rough.
- Whole-body samples (ecological) including small and large.

Collection of fish from Johnson Lake

Fish sample preparation

CONFOUNDING FACTORS OF UNCONTROLLED SOURCES OF PCBS

- Investigation of other potential sources of PCBs was not supported by the DEQ during cleanup process.
- During the remedial action, highly turbid water was observed discharging to project area.
- Surface water samples were collected and analysed for total suspended solids and PCBs (0.18-0.67 µg/L PCBs).
- Agency initiated upgradient investigation and culvert clean-out.

Turbid water discharging to Johnson Lake

Outfall discharging turbid water into Johnson Lake

CONCLUSION

The risk assessments performed by ENVIRON indicated no unacceptable risks to human or ecological receptors at the Johnson Lake site. However, using conservative assumptions of high fish consumption rates and a methodology that assesses certain PCB congeners according to their dioxin-like potency, the DEQ estimated the cumulative cancer risks would exceed the DEQ's benchmarks of acceptable risk. Based partially on bioassay test results, the DEQ determined that levels of TPH, metals and PAHs presented an unacceptable risk to benthic organisms. Several remedy alternatives to address potential human and ecological risks were evaluated. A cost-effective remedy including upland soil removal and thin layer capping of sediment was developed to address human and ecological risks due to sediment impacts at Johnson Lake. Active remediation was completed in March 2012 and the DEQ has issued a conditional no further action determination. Long-term monitoring of remedy effectiveness is ongoing.

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