The Watts Bar N-Waste Reservoir

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Geography: Watts Bar Reservoir, built in 1942, extends 72 miles from the dam upstream on the Tennessee River to Fort Loudoun Dam near Lenoir City and an additional 23 miles up the Clinch River to Melton Hill Dam near Oak Ridge. The Lower Watts Bar Reservoir area extends 38 miles from the mouth of the Clinch River to the Watts Bar Dam.

The Department of Energy's 34,600-acre Oak Ridge Nuclear Weapons Complex is located on the Clinch River arm of Watts Bar Reservoir in Anderson and Roane counties.

Water Quality Standards for the Lower Watts Bar Reservoir: The TN Department of Environment and Conservation designates the Tennessee River in the Lower Watts Bar Reservoir for use as domestic water supply and industrial water supply, for fish and aquatic life, recreation, irrigation, livestock watering, wildlife, and navigation.

Source of Drinking Water: An estimated 43,200 people obtain water from surface water intakes on the Tennessee River along a 118-mile stretch downstream from the Oak Ridge nuclear weapons complex. Five separate communities draw their drinking water from Watts Bar Reservoir, but only the Spring City and Rockwood municipal intakes are in Lower Watts Bar Reservoir. These communities draw their water from tributary embayments (Piney River and King Creek, respectively) rather than from the main channel. The City of Kingston's water intake is located just above the Lower Watts Bar Reservoir area and could potentially be affected by Oak Ridge nuclear weapons complex effluents, depending on flow conditions. Water from the Kingston Water Treatment Plant is monitored for radionuclides by DOE as part of DOE's Environmental Monitoring Program.

Don't Eat the Fish: The State has advised against consuming fish and coming into contact with water from Poplar Creek, which flows to the Clinch River and ultimately to the Tennessee River. Fish advisories are also posted for the Lower Watts Bar Reservoir. The Tennessee Wildlife Resources Commission voted in September 2008 to maintain the ban for commerical fishing in the Watts Bar Reservoir.

Recreational Use: Within the Watts Bar area are 20 recreational parks and 27 commercial recreational facilities, including marinas, resorts, and golf courses. Twenty-two commercial recreational facilities are located in the lower one-fourth of the reservoir, within the Lower Watts Bar Reservoir area. More than six million recreational visits per year are made to the area, most occurring in that portion of the reservoir from the dam to Kingston. Popular recreational activities include swimming, skiing, boating, and fishing.

Surface Water: At full pool, Watts Bar Reservoir has a surface area of 39,000 acres, a length of 96 miles, and a shoreline of 783 miles. It has an average depth of 26 ft. and a depth of 105 ft. at the dam. The average water retention time in the reservoir is 18 to 19 days.

Clinch River Drainage of the Oak Ridge Reservation: White Oak Creek drains the Oak Ridge National Labs site. Poplar Creek and its tributary the East Fork Poplar Creek flow through and drain the K-25 and Y-12 plants.

Sediment

Reservoirs as Sediment Traps: Reservoirs trap sediment because they have an increased cross-sectional area and decreased water velocity compared to a free-flowing river. Organic matter and fine particles, such as silts and clays, settle out of the water column and accumulate on the reservoir bottom. Accumulated sediments in Lower Watts Bar Reservoir are almost entirely silt and clay. Sediments are primarily from the Tennessee River (60%) and the Clinch River (35%), the balance coming in from smaller tributaries. The Watts Bar Reservoir traps 60% of the sediment passing through upstream dams and up to 85% of the local sediment.

Collection of Sediment: Deep-water areas along the main channel accumulate sediment at a greater rate than do shallow-water areas. Sediment collects in the Lower Watts Bar Reservoir at a rate of 1.15cm/year. Significant deposition occurs immediately upstream of Thief Neck Island and the dam.

Watts Bar as the Oak Ridge Sediment Trap: The vast majority of sediment-associated contaminants released from the Oak Ridge Weapons Complex have collected in the Lower Watts Bar Reservoir above the dam.

Oak Ridge Weapons Complex Releases into Watts Bar

The Oak Ridge Reservation site, a U.S. Department of Energy (DOE) facility, covers 37,000 acres and includes 294 on-site contaminated areas and off-site contaminated surface waters including Poplar Creek, the Clinch River and lower Watts Bar Reservoir of the Tennessee River. The site consists of three large industrial facilities: Y-12, K-25, and X-10.

Y-12, completed in 1943, was the production facility that formerly enriched uranium-235 by an electromagnetic process for use in the production of nuclear weapons at the Los Alamos National Labs. The manufacture of nuclear weapons components was discontinued at Y-12 in 1992. It currently disassembles nuclear weapon components, processes nuclear materials, and performs other functions that relate to energy and national defense programs.

- The earlier production processes generated significant quantities of liquid wastes that were discharged directly to the plant's storm sewer system and into the East Fork of Poplar Creek. By the time the electromagnetic process ended in 1947, an estimated 88,000 lbs. of uranium were discharged into the creek.

- In the mid-1940s, Y-12 developed into a facility for the production of enriched uranium weapons components. Again, the processes resulted in releases of uranium-containing liquid wastes to the storm sewer and into East Fork Poplar Creek. The peak releases occurred between 1959-70. Other likely released contaminants include thorium, lithium, beryllium, and lead.
- **Bear Creek Burial Ground**: For many years until 1976, cutting oils at Y-12 contained PCBs. Waste PCB oils were collected in storage tanks and also disposed of in the Bear Creek Burial Ground. Runoff and seepage from the burial grounds have contaminated Bear Creek, a tributary to the East Fork of Poplar Creek
- **Mercury Releases**: In the early 1950s, Y-12 switched to the large-scale separation of lithium isotopes for the production of hydrogen bombs. The Colex process used millions of pounds of mercury to separate the lithium ions. Large quantities of mercury were released within buildings, soils, and surface water as a result of leaky plumbing and accidental spills. By the time the Colex process was closed in 1963, an estimated 239,000 lbs. of mercury were lost to the East Fork of Poplar Creek, and another 428,000 lbs. to the ground in the plant area. Several hundred thousand pounds of mercury remain in Y-12 buildings and process equipment. Contaminated storm sewer system, buildings, and soils at Y-12 continue to release up to 25g/day of mercury to the creek.
- **S-3 Seepage Ponds:** In the early 1950s, Y-12 began processing enriched uranium from the Savannah River Plant and the Idaho Chemical Processing Plant for purification and processing into metal components. These transuranic wastes, containing plutonium, neptunium, and technetium, were transferred to seepage ponds.

  The four S-3 ponds were constructed in 1953 to provide a 10-million gallon storage capacity for liquid wastes containing low levels of radionuclides such as uranium and plutonium. In addition, wastes such as nitric acid, other strong acids, and coolants were disposed of in the ponds. Seepage from the ponds flowed to Bear Creek, a tributary to the East Fork of Poplar Creek. Groundwater beneath the former ponds is contaminated with nitrates, volatile organic compounds, and radionuclides. Discharge to the ponds ended in 1984, and the S-3 ponds underwent EPA closure in 1988.

K-25 (formerly the Oak Ridge Gaseous Diffusion Plant and now known as the East Tennessee Technology Park): Construction of the K-25 site began in 1943. Before 1964, the plant produced highly enriched uranium for use in nuclear weapons production. Between 1964 and 1985 when the plant was shutdown, it produced commercial-grade enriched uranium for nuclear power generating facilities.

- **Building K-1420** recovered uranium from various waste streams. Plutonium and other transuranic component of the building's waste stream were introduced as a result of the recovery of uranium from spent nuclear reactor fuels from the Savannah River and Hanford Plants.
- **Building K-1420** also housed a metal cleaning and plating operations. The surface corrosion of steel parts by fluorine gases in the gaseous diffusion cascade was prevented by coating these parts with nickel.
- **K-1407A Neutralization Pit,** operated since the 1940s, received wastewater from the uranium recovery operations, the metal plating operations, and the maintenance facility operations. Contaminants in these

wastes included uranium, plutonium and other transuranic radionuclides, metals, chlorinated solvents, and corrosives. These wastewaters were neutralized with lime and then sent to the holding pond. The use of the neutralization pit ended in 1987 with the opening of another facility.

- **K-1407B Holding Pond** was a 1.5 million gal., unlined settling basin that received wastes for more than 40 years. Contaminants known to be discharged to the pond include uranium, plutonium, other transuranic, solvents, oils, PCBs, and heavy metals. In 1973, sludge from the pond was removed and disposed of in the K-14047C Retention Basin. An EPA closure of the pond began in 1988. The sludges from the pond were placed in drums to which cement was added to fix the wastes. Effluents from the pond flowed into Mitchell Branch, a tributary to Poplar Creek.
- **K-1407C Retention Basin** was a 2.5 million-gal surface impoundment constructed in 1973 to store the sludge from the K-1407B pond. It also stored potassium hydroxide scrubber sludge generated at the plant. A closure began in 1988, but the underlying soil remains contaminated with metals and radionuclides.
- **K-1417 Drum Storage Area:** The sludge from the holding pond and retention pond were collected and fixed in drums as described above. The resulting 46,000 drums of sludge from these pond closures were stored outside at the Drum Storage Area. Leaking drums were first detected in 1989. Runoff from this area went directly into Mitchell Branch. A portion of these drums has since been moved to indoor waste storage vaults at the K-25 site. The leaking drums were repackaged and moved into the storage area.
- **K-901A Holding Pond** received wastes from the late 1950s until 1985. The pond was initially a wetlands area until a dam was constructed in 1965 to create the holding pond. In addition to cooling water system wastes, the pond was used to dispose of compressed gas cylinders containing unknown quantities of uranium hexafluoride and various fluoridated and chlorinated hydrocarbons. The pond discharges directly to the Clinch River.
- **K-1007B Holding Pond** received wastewater from laboratory drains in several plant buildings. The wastes included uranium, other radionuclides, acids, solvents, mercury, PCBs, and cadmium. The pond discharges directly into Poplar Creek.
- **Onsite Burial Grounds**: The K-1070 burial ground operated from the late 1940s through 1975 for the disposal of low-level radioactive contaminants and mixed wastes. K-1070B area was used from the late 1950s to 1976 to disposed of radioactively contaminated classified equipment. This area was created by filling a low marshy area adjacent to a small creek that flowed into Poplar Creek. The K-1070C & D classified burial ground received wastes from 1972 to 1989, receiving approximately 9100 gallons of waste solvents and 1600 lbs. of chemicals. From 1979 to 1985, the K-1070A landfarm was used to dispose of a chemical used to remove impurities in the diffusion cascacde oil. Several other on-site areas were used for the open burning of waste solvents or the incineration of plant waste. Still other areas were used for waste storage, including the storage of radioactively contaminated scrap metals or various liquid wastes in drums.

Oak Ridge National Laboratory (X-10) was the pilot-scale facility for the production of plutonium used in nuclear weapons research at Los Alamos National Labs. Construction of X-10 began in 1943. The source of the plutonium was a nuclear reactor built specifically for this purpose. By late fall 1943, the graphite reactor was on-line. The plutonium was separated from the resulting fission products in a neighboring chemical separation processing pilot plant. The first shipment of plutonium to Los Alamos occurred in February 1944. At the end of 1944, the use of the graphite reactor shifted to production and research of other radionuclides. ORNL became a center for the development and testing of nuclear reactors, for the chemical and physical separation of nuclear materials, and for the production of radionuclides for research, medicine, and industry.

- **Gunnite Tanks**: A series of concrete tanks were constructed to contain the wastes from the operation of the pilot facility. When the operations of X-10 expanded, these tanks were deemed inadequate to manage the waste volume. The materials in the tanks were treated to precipitate sludges. The remaining liquids were released directly into White Oak Creek.
- **White Oak Dam** was constructed across the creek in 1943 for additional settling of any remaining solids. In 1955, the reservoir was drained as it was no longer effectively diluting and retaining radioactive materials. Approximately 150,000 cubic ft. of contaminated sediment was allowed to erode from the lake bed before the impoundment was reestablished in 1960. In 1957, a process waste water treatment plant was built to recover fission products from liquid wastes. In 1983 congressional hearings, White Oak Lake was labeled the most radioactively polluted body of water in the U.S.

- **Holding Pond 3513** was built in 1944 to receive the sludges from the gunnite tanks. The pond discharged into White Oak Creek.
- **Waste Disposal Open Pits 1-4 (1951-59)**: As the liquid waste volume continued to grow, X-10 dumped its waste into four open disposal pits. The first liquid waste disposal pit was opened and closed in 1951 when it was discovered that radionuclides were leaking from it. Large quantities of radioactive rubidium leaked from Pit 4 in 1959, and a trench was constructed to collect the leachate and pump it back into the pit.
- **Waste Disposal Covered Trenches 5-7 (1960-67):** Pits 5-7 were constructed as covered pits to minimize accidental exposure to the contaminants in the trench and to minimize the collection of rainwater. In 1961, significant leakage of cesium and strontium was detected from Trench 6, and its use was discontinued.
- **Hydrofracture Disposal (1964-84):** The process used hydraulic pressure to initiate cracks on the layers of shale bedrock underlying the disposal site. Alkaline solutions of low-level wastes were then mixed with cement and injected under pressure into the fracture zone at an approximate depth of 700-1000 ft. This disposal practice was discontinued because of the growing concern for groundwater contamination.
- **Solid Waste Areas (1943-2008):** The first three landfills were located in Bethel Valley, selected for convenience and with little regard for the potential mobility of the wastes in the soil. Three other landfills were located in Melton Valley. One 68-acre site is still in use.
- **Greatest Quantities Released:** Tritium, rubidium, strontium, and rare earth elements are the radionuclides that have been released in the greatest quantities from ORNL directly to surface water during the period 1949-1987. The radionuclides disposed of in greatest quantities are cesium and strontium. 60% of the cesium and 78% of the strontium were disposed of in the hydrofracture facility. The remaining was disposed of in the pits, trenches, and landfills.

Radioioactive Contaminants' Fate

		Half-Life		
Tritium	Isotope of hydrogen	13 years	Readily incorporated into water and moves with it	All but the most recent releases flushed through Watts Bar
Ruthenium -106	Peak release 1960-1962 - greatest seepage from waste pit 4	368 days	Water soluble	Not expected to be currently found in Watts Bar
Cesium-137	Peak release - 1956 - drainage of White Oak Lake	30 years	Readily absorbed by fine particles, especially clays	Found in sediments of Watts Bar
Strontium - 90	Peak release prior to 1961 No disposal data maintained	28 years	Absorbed by clay particles to a lesser degree than cesium	Found in sediment of Watts Bar

Watts Bar Reservoir Contamination Studies

- **ORNL 1951-1966 Studies** : The highest gamma counts were found in the Clinch River below White Oak Lake. The level of activity dropped off markedly upon entering the Tennessee River and continued to decline downstream due to the dilution effect of the larger body of water and deposition of sediment over a much larger area. The most activity was found in the Tennessee River's main channel. Cesium concentrations in sediment in Chickamauga Reservoir (below Watts Bar) were found to be half that found in Watts Bar.

- **Clinch River Study (1960-1964)** found radioactive isotopes of ruthenium, strontium, and cobalt occurred principally in solution in White Oaks Creek. When DOE released that body of water, almost the entire quantity was transported downstream in the dissolved state at least as far as Chattanooga. The cesium from

White Oak Creek had been absorbed by sediments, and when released, these sediments were transported downstream. Most settled out in Watts Bar, but some settled out in Chickamauga Reservoir. The highest concentrations are in the river's main channel. Radionuclide levels in areas exposed during winter drawdown were less than in areas that were continuously inundated.
Strontium was found to be easily removed from fine sediment in salt solutions. The presence of strontium in fish represented one of the significant pathways of potential human exposure. Strontium was found in clam shells as much as 500 miles downstream.

- **Environmental Fate of Mercury and Cesium Discharged from Oak Ridge Facilities 1984**: Subsurface sediment concentrations of mercury and cesium are two times higher in the Watts Bar Reservoir than in the Chickamauga Reservoir, but the surface concentrations are the similar in both. The peaks were found 76 cm or more below the surface in the main channel where the sediment accumulation rate is highest, correlating with the peak releases from the Oak Ridge facilities in the 1950s. ***The authors postulated that dredging and extreme-water drawdown were the only likely activities that could resuspend the buried contaminants and bring them into contact with the biosphere.*** The EPA has imposed institutional controls that restrict dredging of creek sediments and consumption of fish and turtles contaminated with mercury and PCBs.

- **Instream Contaminant Study (1984-1985):** The study investigated the mercury releases from Y-12 to the East Fork Poplar Creek. The sediment study concluded that concentrations of mercury in sediment of both the Clinch and Tennessee Rivers downstream of the DOE complex were elevated. It reported that an estimated 500 pounds of mercury were being transported downstream annually out of the East Fork of Poplar Creek.

- **Transport and Accumulation of Cesium-137 and Mercury in the Clinch River and Watts Bar Reservoir System (1992)**: The authors concluded that the highest concentrations of cesium-137 are associated with soft-mud areas; lowest concentrations are found in areas where surface sediments are sand, gravel, or submerged soil. Sediments in marginal coves contain less cesium-137. An estimated 84 tons of mercury have accumulated in the sediments of the Lower Watts Bar Reservoir.

- **TVA Recreation Area and Water Intake Sampling (1991)**: Low levels of tritium were detected at 6 of 11 water intakes. The most cesium found among the sites was at the Kingston's Southwest Point Park. Organic contaminants were found at three beaches (including Piney River) and at the Kingston water intake.

- **TVA Fish Tissue Studies:** Results from these ongoing PCB studies determine the need for TN Department of Environment and Conservation to issue fish consumption advisories.

Resources: *Remedial Investigation for Lower Watts Bar Reservoir Operable Unit* (ORNL, 1995.)

The Obed Watershed Community Association produced this publication. OWCA is a membership organization of concerned citizens who want to protect and restore our watershed. OWCA sponsors monthly watershed educational programs. The OWCA Stream Team monitors the water quality of streams and helps landowners improve streams and improve their property. For more information about OWCA and its activities, contact Dennis Gregg, Executive Director, 484-9033.