Elizabeth Mine

Strafford, Vermont

EPA Facility ID: VTD988366621

Basin: Waits

HUC: 01080103

Executive Summary

The Elizabeth Mine is an abandoned copper mine along the West Branch Ompompanoosuc River in South Strafford, Vermont. Mining, copper smelting, and ore processing have left behind tailings piles, which are suspected to be the primary sources of metals contamination at the site. When water percolates through the tailings piles, sulfuric acid, which is toxic to aquatic resources, is formed. The sulfuric acid dissolves and mobilizes the metals in the tailings piles; the metals are then released into surface water and groundwater that flows into the West Branch Ompompanoosuc River. Metals are also released into stream sediments and soils on and near the site. Contaminants from the Elizabeth Mine site are considered a threat to Atlantic salmon, a NOAA trust resource. The NOAA habitat of concern is the surface waters of the Ompompanoosuc River; the river and its tributaries are part of the Connecticut River Atlantic Salmon Restoration Program.

Site Background

The Elizabeth Mine is an abandoned copper mine in Strafford, Vermont (Figure 1). The mine property is surrounded by woodlands, and there are residential and undeveloped properties along the site's western border. The property encompasses three mine tailings piles and two open-cut mines, as well as several adits (horizontal mine entrances), underground shafts and tunnels, ventilation shafts, and former ore processing buildings (Figure 2; USEPA 2000).

Four primary contaminant source areas have been identified at the Elizabeth Mine site: tailings pile one (TP-1), tailings pile two (TP-2), tailings pile three (TP-3), and a continuous discharge of groundwater from an old air shift connected to the underground work areas of the mine (Figure 2). All four of these source areas eventually discharge contaminants to the West Branch Ompompanoosuc River (WBOR).

The materials that make up TP-1 and TP-2 were generated through the milling of sulfide ores between 1942 and 1958 (Arthur D. Little 2001a). TP-1 and TP-2 are approximately 12 ha (30 acres) and 2.0 ha (5 acres) in area, respectively (Arthur D. Little 2001a). TP-3 was generated from mining and copper smelting operations during the 1800s and early 1900s. TP-3 is approximately 2.4 ha (6 acres) in area and ranges from a few meters to more than 12 m (40 ft) in thickness (Arthur D. Little 2001a).

The Elizabeth Mine site is primarily drained by Copperas Brook (Tetra Tech 2000). Surface water flow in this brook varies within the course of a normal year. During the summer, flow within the Copperas Brook watershed is intermittent. Except during rain events, winter flow is often at near-summer conditions (Arthur D. Little 2001a). When there is sufficient surface water in the Copperas Brook watershed, the brook drains northward from its origin at TP-3, through a divide in TP-2,

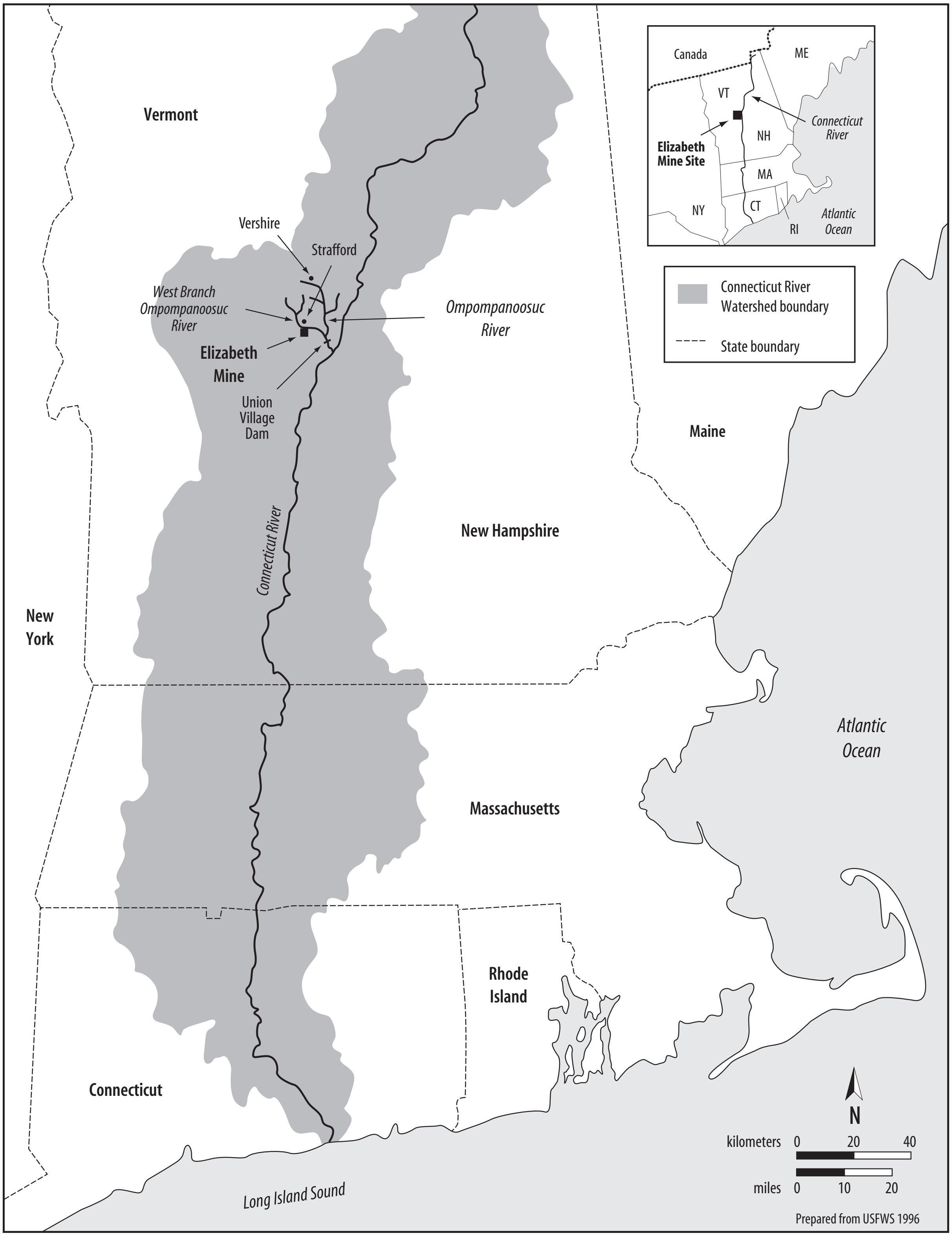

Figure 1. Location of Elizabeth Mine, Strafford, Vermont.

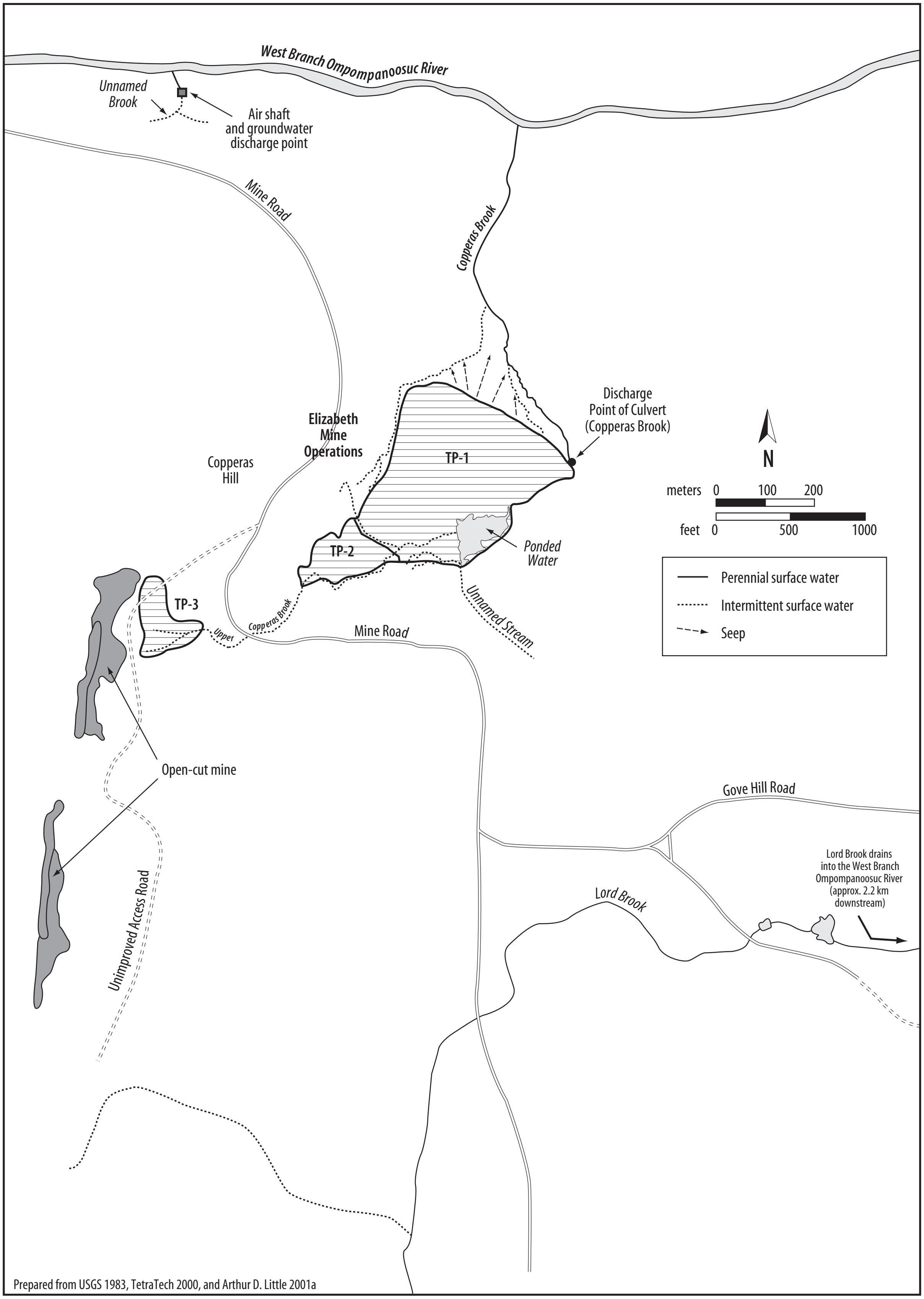

Figure 2. Detail of Elizabeth Mine site.

and toward TP-1, where it forms a small pond (Figure 2). Some water leaves this pond through concrete pipes and discharges at the northeast corner of TP-1, and some percolates through TP-1 (Arthur D. Little 2001a). The water that percolates through TP-1 produces sulfuric acid, which then dissolves and mobilizes the metals within the tailings piles into the surface water, ultimately draining into the WBOR (USEPA 2000).

Since the Elizabeth Mine site was abandoned in 1958, underground work areas have been flooded with groundwater, which mixes with acid mine drainage and discharges from an old air shaft that originally provided ventilation for the mine (Figure 2). Drainage from the old air shaft flows overland and empties into an unnamed brook, which discharges into the WBOR (Tetra Tech 2000).

Although they are not considered a primary source of contamination at the site, two open-cut mines discharge acid mine drainage to surface waters near the site. The northernmost open-cut mine drains into Copperas Brook, while drainage from the southernmost open-cut mine enters Lord Brook. Lord Brook empties into the WBOR downstream of the WBOR's confluence with Copperas Brook (Figure 2; Tetra Tech 2000).

A hazard ranking system package was completed for the Elizabeth Mine site on December 1, 2000. The site was proposed to the National Priorities List (NPL) on the same date, and was placed on the NPL on June 14, 2001 (USEPA 2000).

NOAA Trust Resources

The NOAA trust habitats of concern are the the Ompompanoosuc River and it's tributaries near the mine. The NOAA trust resource potentially at risk is the Atlantic salmon. The Ompompanoosuc River and its tributaries are part of the Connecticut River Atlantic Salmon Restoration Program.

From its confluence with Copperas Brook, the WBOR flows approximately 10 km (6.2 mi) downstream where it joins the Ompompanoosuc River, which eventually empties into the Connecticut River (Figure 1). From the confluence of the WBOR and the Ompompanoosuc River, it is approximately 1.2 km (¾ mi) to the Union Village Dam (Figure 1) (Arthur D. Little 2001a). There are no fish passage facilities at the Union Village Dam, so upstream migration of fish from the Connecticut River is limited to the first 5.6 km (3.5 mi) of the Ompompanoosuc River, below the dam (Kirn 2002).

Although no Atlantic salmon were found among fish samples recently collected from below Union Village Dam, Atlantic salmon fry are stocked above and below the dam (Kirn 2002; Langdon 2002). Salmon fry are stocked above the dam as far north as Vershire, for the purpose of smolt production. In the Ompompanoosuc River, the majority of the habitat suitable for Atlantic salmon smolts is located upstream of the Union Village Dam (Kirn 2002, 2003). The Union Village Dam is used only for flood-control, allowing the dam to be left open year-round. The design of the dam allows juvenile salmon to pass through the dam, moving with the flow of the water, but the dam is an impassable barrier to the upstream migration of returning adult salmon (McMenemy 2002). Restoration plans that would allow upstream fish passage around the Union Village Dam have been deferred until the numbers of adult salmon returning to the river basin increase (Covington 2002; Kirn 2003).

Atlantic salmon fry are not stocked in the WBOR now, but salmon fry could be stocked there in the future if suitable habitat allowed for their survival (Kirn 2002). The riverine wetlands in the WBOR are classified as upper perennial, open-water wetlands which could provide habitat for Atlantic salmon (Arthur D. Little 2001a).

There is no commercial or recreational fishing of Atlantic salmon in the WBOR. A fish consumption advisory, which recommends reduced fish consumption, is currently in effect for all Vermont waters. The advisory is for resident fish species, including chain pickerel, lake trout, largemouth bass, northern pike, smallmouth bass, and walleye (VDH 2000).

Site-Related Contamination

Metals are the primary contaminants of concern to NOAA at the Elizabeth Mine site. Samples of surface water, groundwater, and sediment collected from the site were analyzed for metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and pesticides, and other water quality parameters were measured. Soil samples were analyzed for metals. The maximum concentrations of metals detected in these media are summarized in Table 1.

Table 1. Maximum concentrations of contaminants of concern at the Elizabeth Mine site (Arthur D. Little 2001a; Arthur D. Little 2001b).

	Soil (mg/kg)		**Water (µg/L)**			**Sediment (mg/kg)**	
Contaminant	Soil	Mean U.S.[a]	Ground-water	Surface water	AWQC[b]	Sediment	TEL[c]
INORGANIC COMPOUNDS							
Arsenic	8.5	5.2	<0.0096	N/A	150	3	5.9
Cadmium	2.5	0.06	0.016	140	2.2[d]	8	0.596
Chromium[g]	57	37	0.032	120	11	62	37.3
Copper	1400	17	13	100,000	9[d]	4600	35.7
Lead	43	16	0.022	30	2.5[d]	25	35
Mercury	0.1	0.058	0.00045	0.63	0.77[e]	0.33	0.174
Nickel	45	13	0.13	1000	52[d]	32	18
Selenium	40	0.26	<0.0044	9	5.0[e]	13	NA
Silver	6.4	0.05	<0.0036	43	0.12[d,f]	4	NA
Zinc	160	48	2.1	17000	120[d]	350	123.1

a: Shacklette and Boerngen (1984), except for cadmium and silver, which represent average concentrations in the Earth's crust from Lindsay (1979).

b: Ambient water quality criteria for the protection of aquatic organisms (USEPA 1993, 1999). Freshwater chronic criteria presented.

c: Threshold effects level is the geometric mean of the 15^{th} percentile of the effects data and the 50^{th} percentile of the no-effects data. The TEL is intended to represent the concentration below which adverse biological effects rarely occurred (Smith et al. 1996).

d: Criterion expressed as a function of total hardness; concentrations shown correspond to hardness of 100 mg/L.

e: Criterion expressed as total recoverable metal.

f: Chronic criterion not available; acute criterion presented.

g: Screening guidelines represent concentrations for $Cr.^{+6}$

NA: Screening guidelines not available.

N/A: Not analyzed

The U.S. Environmental Protection Agency collected surface water samples at 46 locations throughout the Elizabeth Mine area (composite sampling resulted in a total of 72 discrete samples). Sediment samples were also collected at the same 46 locations. Groundwater samples were collected from a series of ten residential wells located along Mine Road, west of TP-1 and TP-2. As of 2001, no permanent monitoring wells had been installed at the Elizabeth Mine site. Soil samples were collected in July 2000 from three residences located along Mine Road near the Elizabeth Mine site. Three samples were taken from each of the residential properties (Arthur D. Little 2001a).

In soil samples, all the maximum concentrations of detected metals exceeded the soil screening guidelines. The maximum concentrations of arsenic, cadmium, mercury, selenium, silver, and zinc were all detected at the residence closest to TP-3. The maximum concentration of copper, which was more than an order of magnitude greater than the soil screening guideline, and the maximum concentrations of chromium and nickel were all detected at the residence closest to TP-1 and TP-2.

In surface water samples, the maximum concentrations of detected metals all exceeded ambient water quality criteria (AWQC) by at least one order of magnitude (copper by four orders of magnitude), with the exceptions of mercury, which had a maximum concentration somewhat below its AWQC, and selenium, which had a maximum concentration almost twice its AWQC (Table 1). With the exception of mercury, all the maximum concentrations of metals were detected in samples collected from either Copperas Brook or areas near the tailings piles (frequently just above TP-2 or just downstream of TP-1). The maximum concentration of mercury was located 100 m (335 ft) downstream of the confluence of Copperas Brook and the WBOR.

In groundwater samples, copper was the only metal present at a maximum concentration that exceeded the AWQC. Arsenic, selenium, and silver were not detected in groundwater samples; the remaining metals for which the samples were analyzed were detected at concentrations below the AWQC.

Neither surface water nor groundwater samples collected from the Elizabeth Mine site exceeded applicable water quality criteria for VOCs, SVOCs, PCBs, or pesticides, but detection limits for these contaminants were not provided (Arthur D. Little 2001a).

In sediment samples, the maximum concentrations of several metals exceeded the threshold effects level (TEL) screening guidelines. Maximum concentrations of cadmium and copper both exceeded TELs by at least one order of magnitude. Chromium, mercury, nickel, and zinc were also detected at maximum concentrations in excess of TELs. Arsenic was detected at a maximum concentration below its TEL value. Although selenium and silver were both detected, there are no TELs for those two metals. The maximum concentrations of cadmium, lead, mercury, and selenium were all detected in Copperas Brook sediments within a short distance of TP-1 and TP-2. Maximum concentrations of chromium and copper were detected near the southernmost open-cut mine. The greatest concentration of zinc was detected in a sample collected near the air shaft, just upstream of the confluence of Copperas Brook and the WBOR. The maximum concentration of silver was detected in a sample collected from the confluence of Copperas Brook and the WBOR.

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