Red Dog Mine UAA

Abstract

Complexity: Medium

Type of Action: Removal of aquatic life uses & development of site-specific criterion

Region: 10

131.10(g) Factors: 1, 3

A use attainability analysis (UAA) was performed on Red Dog Creek, which runs through the site of Red Dog mine, the largest zinc mine in the world. Red Dog Creek flows only 3–4 months of the year. Several parts of the creek are affected by mining discharges and some acid rock drainage. In addition, the area contains natural ore bodies, resulting in naturally high concentrations of cadmium, lead, zinc, aluminum, and other metals. Pre-mining surveys done in this area indicated that aquatic life uses were not present because of the toxic concentrations of metals, as well as naturally low pH. The UAA for Red Dog Creek demonstrated that aquatic life uses should be removed because of the naturally occurring pollutants. Because of the natural conditions, the criteria for cadmium, lead, zinc, aluminum, and pH cannot be met without human intervention, precluding that aquatic life uses being met. However, treatment of mine wastewater had led to the presence of Arctic grayling that should be protected. A site-specific criterion for total dissolved solids (TDS) was developed to protect the grayling when spawning. EPA approved these changes to Alaska's water quality standards.

Background

Red Dog Mine, in the DeLong Mountains of northwestern Alaska (Figure 1), is the largest zinc mine in the world. The mine discharges treated water into Red Dog Creek, a tributary to

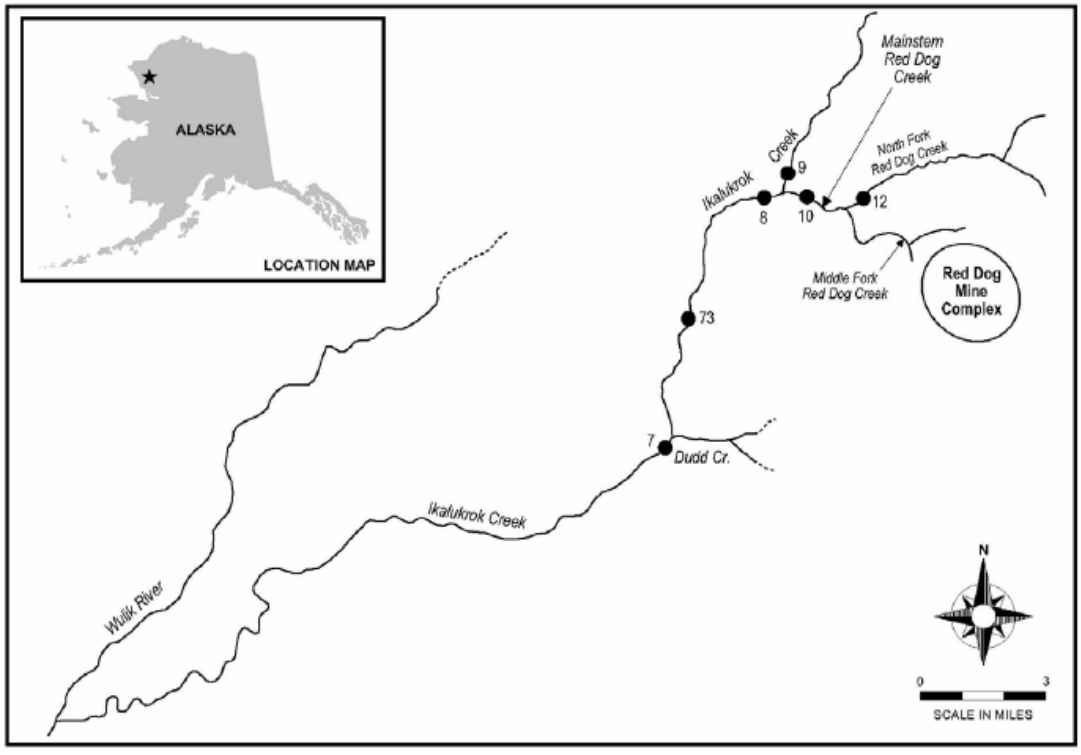

Figure 1. Red Dog Area (Alaska Department of Environmental Conservation, 2005).

Ikalukrok Creek, which feeds the Wulik River. The Wulik River drains into the Chukchi Sea and is the drinking water source for Kivalina, a native village 54 miles southwest of the mine. Several parts of Red Dog Creek are affected by mining discharges and some acid rock drainage.

In addition, the area contains natural ore bodies with naturally high concentrations of cadmium, lead, zinc, aluminum, and other metals. Pre-mining surveys performed in the early 1980s indicated that aquatic life uses were not present because of the toxic concentrations of metals, as well as naturally low pH.

Data Collection and Analysis

By default, Alaska designates all waters for all uses (Table 1). A use attainability analysis (UAA) was performed on Red Dog Creek to assess whether its aquatic life uses were being met. In 1997 Alaska submitted the UAA to EPA for review. On the basis on the information presented in the UAA, EPA approved the removal of the aquatic life uses for Red Dog Creek in February 1998. A site-specific criterion for total dissolved solids (TDS) was applied to the main stem of the creek to protect Arctic grayling when spawning. The entire process of performing the UAA through EPA approval of changes to Alaska's water quality standards took 3 years.

Table 1. Designated Uses for Alaska

Fresh water uses		Marine water uses	
Water supply	Drinking, culinary, and food processing	**Water supply**	Aquaculture
	Agriculture, including irrigation and stock watering		Seafood processing
	Aquaculture		Industrial
	Industrial		
Water recreation	Contact recreation	**Water recreation**	Contact recreation
	Secondary recreation		Secondary recreation
Growth and propagation of fish, shellfish, other aquatic life, and wildlife		**Growth and propagation of fish, shellfish, other aquatic life, and wildlife**	
		Harvesting for consumption of raw mollusks or other raw aquatic life	

The aquatic life use removal was based on naturally occurring pollutant concentrations, 40 CFR 131.10(g) factor 1. Water quality and biological data collected during baseline studies were used to describe pre-mining conditions. Many of the same monitoring stations that had been used in the original studies were used to conduct monitoring after the development of Red Dog Mine. These studies showed toxic concentrations of cadmium, zinc, lead, aluminum, and other metals. Poor water quality resulted from the natural chemical breakdown of sulfide minerals, a process that contributes to acid rock drainage. The observed reddish-orange color of the creek water indicated a metal sulfide deposit.

In the Red Dog Creek UAA, aquatic life was defined to include all aspects of the aquatic community, including fish, macroinvertebrates, microinvertebrates, periphyton, and macrophytes. Pre- and post-mining surveys done at this location indicated limited aquatic life in Red Dog Creek due to the toxic concentrations of metals and the naturally low pH. Fish use of Red Dog Creek was limited to migration to the North Fork Red Dog Creek, upstream of Red Dog Creek, during spring high flows. Fish experienced high mortalities in Red Dog Creek during downstream migration because of the high levels of metals and low pH. There are also few subadult-age grayling in the North Fork Red Dog Creek, which is hypothesized to be the result of the poor conditions in Red Dog Creek, in which migrating adults must swim.

Site-specific Criterion for TDS

Red Dog Mine discharges into the Lower Middle Fork of Red Dog Creek. Mine drainage water is collected in the tailings pond, treated with lime to remove harmful heavy metals, and discharged in the summer. Although this treatment is appropriate to keep heavy metals out of surface waters, it results in higher concentrations of dissolved solids that are discharged into the creek. High levels of TDS can affect some aquatic species, particularly salmonids, during critical life stages such as spawning. As a result of the treatment to reduce metals in the effluent from the mine, the TDS levels exceed the current water quality criterion of 500 mg/L. Lowering the TDS in the effluent would reduce the effectiveness of the wastewater treatment and cause higher metal concentrations and higher toxicity in the mine wastewater discharge and downstream waters.

Discharge from the mine has led to more consistent (non-ephemeral) flows in the main stem of Red Dog Creek and has allowed aquatic life to develop in the segment. In the absence of the effluent from the mine, the main stem would flow only 3–4 months of the year. If the discharge were to be discontinued, the aquatic productivity in the stream would decrease. Ten years of aquatic surveys have demonstrated that aquatic productivity in the main stem has increased from pre-mining conditions due to effective water management practices and treatment. Arctic grayling spawn in the main stem of the creek from late May to mid-June. Because TDS has been shown to adversely effect fish fertilization, a fish barrier was constructed across the main stem of Red Dog Creek to block the passage of fish up the Middle Fork of Red Dog Creek, which leads to the point of discharge of the mine.

In January 2001 a site-specific criterion was proposed for the main stem of Red Dog Creek to allow higher levels of TDS during most of the year while limiting TDS and protecting the grayling while they spawn. A site-specific criterion is a water quality limit that pertains to only a specific area in a stream, lake, or bay. In this case it applies to only the main stem of Red Dog Creek. Studies showed that Arctic grayling were the only salmonids spawning in Red Dog Creek. Because fertilization was observed to be the most critical and vulnerable life stage for salmonids, a site-specific TDS criterion of 500 mg/L during spawning was proposed. A criterion of calcium-dominated TDS of 1500 mg/L was proposed for all other times. Calcium-dominated TDS contain calcium greater than 50 percent by weight of all cations. Although studies showed that 1500 mg/L was protective of salmonids and aquatic invertebrates, there were no data on protective levels for fertilization.

Conclusion

The site-specific criterion for TDS was adopted into the Alaska Water Quality Standards in June 2003 and submitted to EPA for approval. EPA approved the 1500 mg/L TDS during non-spawning but requested additional testing on the effects of TDS on the spawning success of Artic grayling. Additional studies were developed in consultation with EPA, the Alaska Department of Natural Resources' Office of Habitat Management and Permitting, the Alaska Department of Fish and Game, and the Alaska Department of Environmental Conservation. In 2004 and 2005 studies were conducted on site at the Red Dog Mine. The results indicated that calcium-dominated TDS levels up to 1500 mg/L would be protective during Arctic grayling spawning. A change to Alaska's water quality standards is in progress to incorporate the 1500 mg/L TDS level for Red Dog Creek at all times. Water quality monitoring data indicated that setting the

1500 mg/L TDS level in the main stem of Red Dog Creek would be protective of all downstream uses in Ikalukrok Creek and the Wulik River as well.

References

ADEC. 2005. *Basis for Total Dissolved Solids Site Specific Criterion Update in Main Stem Red Dog Creek*. Alaska Department of Environmental Conservation, Division of Water.

Sonafrank, N. 2005. *Red Dog and Ikalukrok Creeks Use Attainability Analysis*. Alaska Department of Environmental Conservation.