

# Update on Selenium Projects at Tilden and Empire Mines

Volume 4

October 2013

## Purpose Statement:

Cliffs Natural Resources' Michigan Operations Tilden and Empire Mines move over 60 million tons of rock annually in order to produce approximately 12 million tons of iron pellets. This large scale operation generates significant environmental interest. This newsletter will focus on selenium.

## Inside This Issue

- 1 Cliffs Completes Improvements for Warner Creek
- 2 Avian Field Study Complete
- 3 Environmental Interaction between Mercury and Selenium Produces a Surprise
- 4 Selenium Reduction Efforts

## **Cliffs Completes Improvements for Warner Creek**

By: Jay Parent, MDEQ

Cliffs Natural Resources completed a stream restoration and enhancement project on Warner Creek in Richmond Township last winter as part of an agreement with the Michigan Department of Environmental Quality (MDEQ) regarding tailings releases from the Tilden and Empire Mines. The project is related to discovery of historical tailings settled at the bottom of the creek bed. Tailings are a combination of water and finely ground rock from the mining process. Tailings are removed from the ore at the plant during the concentrating process and transported through a pipeline to a nearby tailings basin. Over the past few years, Cliffs has made significant improvements to the Tilden's tailings line including an \$8,000,000 line replacement. Historic tailings deposits in Warner Creek and the surrounding wetlands were discovered during a thorough investigation of the tailings pipeline area. Working cooperatively, Cliffs and the State of Michigan developed a restoration plan to remove the tailings and enhance the Warner Creek habitat. The

habitat enhancement was so successful that rainbow trout were already using the spawning gravel this spring!



The Warner Creek improvement project began with removing tailings from 1,200 feet of channel. Using natural channel design principals, an engineered plan was developed to install in-stream habitat features, such as gravel runs and riffles that mimic features found in other areas of Warner Creek. The stream features installed for this project provide additional spawning habitat for trout, aquatic insect habitat, and deep water pools, while providing stream channel stability. These improvements should provide added recreational opportunities to the fishing public. Jay Parent, who oversaw the Warner Creek work for the DEQ observed: “The project was a great success. It was undertaken during subzero temperatures and blizzards to minimize impacts to adjacent wetlands by supporting equipment with timber mats on frozen soil. This created great hardship for

MJ VanDamme, Inc., but they pulled it off beautifully.”

In addition to the creek restoration and enhancement project, Cliffs has agreed to pay \$67,200 in civil fines and approximately \$7,600 in administrative costs to the MDEQ. A conservation easement has also been established to provide permanent preservation for 169 acres of wetland in the Green Creek watershed.



### **Avian Field Study Complete**

By: Cliffs Natural Resources' Michigan Operations

The avian study conducted by the Michigan State University Wildlife Toxicology Laboratory and sponsored and supported by Cliffs Natural Resources, which began in 2010, was completed following the 2012 breeding season. This study, which was centered on the Empire

and Tilden mines, examined the breeding success of resident and migratory birds that nest in Marquette County. Bird nests were monitored for measurements including: nest initiation date; clutch size; hatching success and fledging success. Nestling and adult passerines (songbirds) from these were fitted with U.S. Geological Survey leg bands. Concentrations of selenium were measured in egg samples.

Nearly 400 nest boxes were placed to attract cavity-nesting songbirds and waterfowl. The nest boxes covered an area greater than 80 square miles and were monitored daily throughout the breeding seasons, which occurred during the spring and summer. Waterfowl species that occupied nest boxes included wood ducks, hooded mergansers, and common mergansers. Songbird species that occupied nest boxes included: blue birds, house wrens, chickadees, and tree swallows. In 2011 and 2012, several species that nest in the area but do not use boxes or natural cavities were included, namely: mallards, Canada geese, and savannah sparrows which nest on the ground, and eastern kingbirds, which nest in trees.

Cavity-nesting duck participation increased steadily through all three years of the study. Waterfowl nest box occupancies through the egg-laying period were approximately 3% during the first year, 28% in 2011, and 38% in 2012. This increase in participation was expected, because nest boxes typically

become more attractive to birds as the wood weathers and more closely resembles natural tree cavities.

Cavity-nesting songbird participation varied from year to year but showed no clear trend. Songbird nest box occupancies through the egg-laying period were approximately 7% in 2010, 8% in 2011, and 6% in 2012. In 2010, 193 songbird nest boxes were installed. An additional 60 boxes were installed for the 2011 season and 10 additional boxes were installed for the 2012 season. In spite of the added effort to increase participation, songbird nest box occupancies remained consistent. The relatively low participation by songbirds suggests that the availability of natural cavities may be adequate to support the existing songbird population. Approximately 86 adult and 200 nestling songbirds were banded during the study; no waterfowl were banded in this study.

After year three of an ambitious study and more than 5,000 observations, the MSU scientist concluded that cavity-nesting duck and songbird species residing in aquatic habitats near the Empire and Tilden Mines are not experiencing negative individual health or population level effects. Hatching success and fledging success for all species were within the normal range reported for each of the species examined from 2010 to 2012. In addition, average percent hatching and fledging values, for nests that weren't affected by predators or abandoned by the female, were similar

between locations near Cliffs Michigan Operations and local reference areas.



Juvenile hooded mergansers (Photo by Michigan State University Wildlife Toxicology Laboratory)

---

## **Environmental Interaction between Mercury and Selenium Produces a Surprise**

By: Jay Parent, MDEQ

Mercury is a naturally occurring element found in air, water and soil. It exists in several forms: elemental or metallic mercury, inorganic mercury compounds and organic mercury compounds such as methyl mercury. Atmospheric deposition of inorganic mercury is considered to be primarily responsible for mercury accumulated in fish from lakes throughout the Upper Midwest. Once present in the aquatic food web, inorganic mercury can

be converted to methyl mercury, which bioaccumulates in the food chain. The Michigan Department of Community Health has issued a statewide fish consumption advisory because of elevated mercury for all of Michigan's 11,000 lakes.

Selenium is another naturally occurring element with bioaccumulation concerns. It can be found in coal, shale/sedimentary rocks, petroleum source rocks, and phosphate rich rock. Though an essential micronutrient, elevated levels of selenium can cause adverse impacts on aquatic life. Drainage from rock stockpiles has resulted in elevated selenium levels in watersheds nears Cliffs Natural Resources.

An interesting relationship has been documented between mercury and selenium. Researchers in the 70's and 80's began to recognize that more mercury bioaccumulates in fish in areas where selenium is poorly available, but where selenium is abundant, the amount of mercury in fish was notably lower. Evidence began to indicate an inverse relationship between the levels of mercury to selenium in aquatic organisms.

In 1987, researchers tested this hypothesis on 11 lakes with low natural selenium located in Sweden. Inorganic selenium was added to the lakes over a period of three years while mercury and selenium concentrations were tracked in European Perch. After two years, perch were found to have a 75% reduction in mercury concentration. A later study using a

lower dose of selenium in three Swedish lakes resulted in decreased levels of mercury at various trophic levels, including zooplankton, crayfish, perch, and pike.

Could this type of relationship be present in waters with elevated selenium in Marquette County? Goose Lake seems to supply some supporting evidence. Goose Lake is a 450 acre lake that receives drainage from the Empire Mine rock stockpiles, historic mine caving grounds, and the city of Negaunee. From the early 20<sup>th</sup> century until 1953, untreated sewage from Negaunee was routed to Goose Lake. When compared to other area lakes, sediments of Goose Lake have been shown to have elevated levels of mercury.

A 2011 report (Distribution of Total and Methyl Mercury in Michigan's Upper Peninsula Lakes) gathered mercury information on selected lakes that have fish with elevated levels of mercury, including Goose Lake. Along with other media, sediments were measured for mercury concentration. With higher sediment mercury levels it would be reasonable to expect to see elevated levels in the fish. Surprisingly, despite having the highest sediment levels of mercury in the surveyed lakes, Goose Lake had the lowest mercury concentrations in fish.

Using a reference size of 25.6 inches, five Upper Peninsula lakes had mercury concentrations in Northern Pike between 1.04 and 1.33 mg/kg. Samples of Northern Pike from Goose Lake, collected in 1988 and 2008,

showed mercury at 0.23 and 0.11 mg/kg. Walleye showed a similar trend. Four Upper Peninsula lakes showed mercury levels in walleye to be between 0.43 and 1.34 mg/kg (17.7 inch fish), while fish from Goose Lake contained 0.18 mg/kg of mercury. The Goose Lake fish had some of the lowest mercury concentrations for fish sampled throughout the State of Michigan.

The biogeochemistry of selenium and mercury in aquatic ecosystems is complex and controlled by multiple factors. This quick look at selenium and mercury does not even begin to consider the cycling and speciation that takes place in the environment. The United States Geological Survey has expressed an interest in studying the interaction of selenium and mercury in Goose Lake, with an eye towards developing a means to reduce mercury levels in fish in other water bodies. The selenium/mercury interaction is an interesting and unexpected sidelight to Cliffs Natural Resources and MDEQ efforts to reduce selenium.



## **Selenium Reduction Efforts**

By: Cliffs Natural Resources' Michigan Operations

Cliffs Michigan Operations continues to characterize selenium concentration and flows in the waters surrounding the Empire and Tilden mines along with the mass loading

model. Since late Fall/early Winter of 2011, Cliffs has targeted several locations to refine understanding of flow characteristics through the use of “cut-throat” flumes and continuous water level data logging equipment. Data generated by this enhanced flow monitoring effort will refine the mass balance-loading model and ultimately assist with evaluation of various selenium reduction management alternatives.

Cut-throat flume with continuous water level data logger



Pilot Scale Biochemical Reactor



In 2011 Cliffs Michigan Operation executed its plan to change the handling of pit dewatering at Empire by rerouting water to an inactive pit on the property and thereby preventing it from being discharged. On a similar note in 2013 a storm water source was redirected to be used in the pellet production process. These noteworthy milestones have reduced the amount of selenium going into both Goose Lake Inlet and Warner Creek.

In the latter half of 2011 and in 2012, several selenium reduction water treatment processes were evaluated at the bench-scale and pilot-scale levels; including biochemical reactors (BCRs), aerobic wetland cells (AWCs) and zero valent iron (ZVI), to determine if they could be utilized in select applications to remove selenium from storm water at Empire and Tilden mine properties. Both the BCRs and AWCs are designed to convert the more dissolvable forms of selenium found in waters at the site (selenate and to a lesser extent selenite) to less dissolvable forms of selenium (elemental selenium), and after converting them, trap the less dissolvable forms of selenium in the treatment media. Preliminary results from both BCR and AWC bench-scale studies indicated that treatment systems are effective in removing 75% to 90% of selenium from storm water. The construction of pilot scale BCR's and AWC's were completed in 2012 and two demonstration scale BCR systems are scheduled to be constructed and operational in 2013. These best management

practices efforts will further reduce selenium discharges to Goose Lake Inlet, Warner Creek, and Ely Creek.

Cliffs is encouraged by the promising results from the mass loading model described above, the results from the Bench scale studies, and the implementation of pilots scale studies. Cliffs remains committed to continue addressing the presence of selenium in the storm water at both mine sites and will continue to evaluate means of reducing selenium in discharges from the mine sites to the receiving waters.



This newsletter was developed and distributed by the Michigan Department of Environmental Quality with cooperation from Cliffs Natural Resources. It is intended to assist the public with information on the activities in and around the Empire and Tilden mines. If you have any questions, suggestions or would like to be added to the electronic mailing list, please contact Steve Casey by e-mail at [caseys@michigan.gov](mailto:caseys@michigan.gov).