Introduction
Residues from historical mining activities can be found near waterways throughout the Keweenaw Peninsula and have resulted in copper concentrations that are elevated above background levels in many local surface waters [4]. Earlier studies conducted in the region have shown that trace metals in the sediments affect benthic macroinvertebrate populations and more recent work has shown that copper is being continually released from the stamp sands into surface waters [4].

As defined by the Michigan Department of Environmental Quality (MDEQ), the coastal zone includes all land within 100 ft. of shoreline. The goal of this project is to identify which streams have been most impacted by mine tailings within the coastal zone of the Keweenaw Peninsula.

Stream selection
Between the Montreal River—near the Wisconsin border—and Keweenaw Bay, there are narrow over 100 streams that empty into Lake Superior. In order to narrow the number of sites down to approximately 50, several criteria were applied. First, all streams with known mining residues in the watershed were included as potentially mining-impacted. From the remaining unimpacted streams only those that were perennial and greater than 3 m in width were included in the inventory. In total, 92 streams fulfilled these initial criteria.

As a result, additional considerations were needed to further reduce the number of streams in the inventory. These included the likelihood of finding mining-impacted streams, stream length and ease of access. All streams located west of the Porcupine Mountains Wilderness State Park were eliminated as it was unlikely that there would be any mining-impacted streams in this area. According to the satellite data available on Google Earth, White Pine and the associated stamp sand deposits are the western most mining residues in the Peninsula.

Currently, 51 streams have been selected (Fig. 1, table 1). The majority have some evidence of mining residues in their respective waterways (39) and the remainder (13) are considered to be reference streams.

Macroinvertebrate sampling
Benthic macroinvertebrate sampling is often used as an indicator of stream health. In order to assess impairment the EPA has developed a pollution tolerance index (PTI) that local organizations have adapted to reflect various regions (table 2). While a PTI can be used to determine if a stream is impaired, it does not indicate the exact cause of the impairment.

In laboratory testing, Warrick and Bell found the 96-hr. mean tolerance limit (TLm) for mayflies (Ephemeroptera subordinata) to be 8.32 mg/l of Cu[6]. While toxicity data based on laboratory data may not be the most appropriate analog for streams, it provides a starting point for determining which macroinvertebrates are most sensitive to copper. Much of the fieldwork focused on heavy metals in streams targets on macroinvertebrates from the orders Ephemerida (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), or EPT. Of these three taxa, work done by Clements in Colorado streams suggests that mayflies are the most sensitive to copper, followed by stoneflies, and then non-net spinning caddisflies [2].

Data gathered during the rapidly approaching spring sampling season will be used to modify the fall sampling procedure.

Sampling habitat
Based on a review of sampling protocols, two habitats often targeted for benthic macroinvertebrate surveys include riffles and pools. The benefit to sampling pools is that they are found in almost all streams.

The MiCorps volunteer stream monitoring protocol calls for the sampling of all available habitats within a selected reach. However, the MiCorps protocol is concerned with assessing overall stream health. Much of the performed to determine the impacts of heavy metals has been done in riffles. This is most likely a result of the organisms targeted by these surveys, as EPT taxa are primarily found in riffle habitats.

Metric selection
There is still some debate as to which metrics are most appropriate for streams contaminated with heavy metals. In an analysis of the sensitivity of several metrics within these categories, 44% EPT, EPT taxonomic richness, and intolerant richness were found to be sufficiently responsive to environmental stressors [6]. Work done in other streams impacted by heavy metals found that metrics involving taxa richness and total abundance were poor indicators of impairment, as less tolerant taxa were simply replaced by more tolerant taxa [5].

Conclusions
The selection of mining-impacted and unimpacted streams for the spring survey has been completed. It is still unclear which macroinvertebrates are most sensitive. Riffles have been selected the habitat to be sampled. Appropriate metrics for the analysis of macroinvertebrates have yet to be determined and will require more research.

References

Acknowledgements
Financial assistance for this project was provided, in part, by the Michigan Capital Management Program, Department of Environmental Quality. The authors wish to thank the Water and Society (MiCorps) program for support in field activities for assessing impacts of heavy metals at the Arnold River, Montana.

Table 1. Sample pollution tolerance index adapted from the EPA [5] and used for the analysis of macroinvertebrates [1].

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
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<tbody>
<tr>
<td>Pollution tolerant</td>
<td>Pollution intermittent</td>
<td>Pollution intolerant</td>
</tr>
<tr>
<td>Mayfly nymph</td>
<td>Ephemerylmorganisi</td>
<td>Ceratopogon镙a</td>
</tr>
<tr>
<td>Stonefly nymph</td>
<td>Baetis镙a</td>
<td>Crustacea &amp; aquatic insects</td>
</tr>
<tr>
<td>Caddisfly larva, non-net spinning</td>
<td>Aquatic insects</td>
<td>Amphipod</td>
</tr>
<tr>
<td>Fly larvae, adult</td>
<td>Aquatic insects</td>
<td>Ants</td>
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<tr>
<td>Water pennybeaver larva</td>
<td>Ants</td>
<td>Ants</td>
</tr>
<tr>
<td>Sedge</td>
<td>Calamagrostis镙a, net spinning</td>
<td>Calamagrostis镙a, non-net spinning</td>
</tr>
</tbody>
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Figure 1. Flow chart for metric selection, adapted from Stoddard [5].