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ASSESSMENT OF COASTAL WATER RESOURCES AND WATERSHED CONDITIONS AT PICTURED ROCKS NATIONAL LAKESHORE

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Cover photos:
Upper left, Arch at Chapel Rock
Upper right, AuSable Lighhouse
Lower left, Chapel Creek
Lower right, Legion Lake Bog
Photographs by Kristen Keteles

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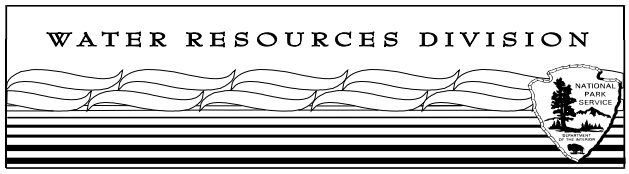

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Executive Summary

Pictured Rocks National Lakeshore (PIRO) was authorized as America's first national lakeshore by Public Law 89-668 on October 15, 1966, and it was formally established on October 6, 1972. PIRO is situated along the southern shore of Lake Superior in Alger County in Michigan's Upper Peninsula. It extends 62 kilometers (km) between Munising on the west end and Grand Marais on the east end, and is 4.8 km at its widest point. PIRO's boundary extends into Lake Superior out to 0.4 km perpendicular to shore.

The region is dominated by northern hardwood and mixed conifer forests. The average annual temperature is 5^{o} C, and the average annual precipitation is 85.9 centimeters (cm), 32% of which is in the form of snow during the winter months.

PIRO is unique among National Park Service (NPS) units because it includes an Inland Buffer Zone (IBZ) of 15,907 hectares (ha) owned by corporate, state, federal, and private entities. The IBZ was established to protect the watersheds of the 13,731 ha of the NPS Shoreline Zone (Fee Zone) while allowing timber harvesting and seasonal and permanent housing development that complies with local zoning regulations.

Lake Superior is the coldest, clearest, and cleanest of the Great Lakes, and 2,452 ha of its surface is included within PIRO's boundaries. The colorful 60-meter (m) sandstone cliffs that give PIRO its name rise along the Lake Superior shoreline for 19 km on PIRO's western end. East of the cliffs are 19 km of unspoiled sand and pebble beaches. At PIRO's eastern end, the Grand Sable Dunes formed as the prevailing winds reshaped ancient Lake Superior beaches. Among PIRO's significant cultural resources are several former Coast Guard facilities (the Munising Range Lights, Munising Coast Guard Station at Sand Point, Au Sable Coast Guard Station and Light, Grand Marais Coast Guard Station, and Grand Marais Harbor of Refuge) that help to preserve the area's maritime history.

PIRO has 14 named inland lakes, with surface areas ranging from 2 ha (Sevenmile Lake) to 310 ha (Beaver Lake). Four of these lakes (Section 36 Lake, Kingston Lake, and Upper and Lower Shoe Lakes) are located in the IBZ. Inland lakes are shallow, 3-6 m in depth, except for Beaver, Chapel, and Grand Sable Lakes. The water chemistry of PIRO lakes varies, but generally most can be classified as brown water, moderately productive alkaline lakes. Secchi transparency readings, a measurement of water quality and an indicator of productivity, generally range from 2-5 m.

PIRO also includes 19 named streams. Miners River is the longest and has the greatest discharge. Many first and second order low discharge streams drain directly to Lake Superior, some only seasonally. In general, PIRO streams are short and have steep gradients. Discharge is generally highest in the late spring and early summer. Beaver and Grand Sable Creeks originate in lakes, and Miners River flows through Miners Lake. A number of waterfalls are found within PIRO, including Munising, Miners, Mosquito, Little Mosquito, Bridalveil, Chapel, Spray, and Sable Falls. PIRO watersheds drain into Lake Superior, with the exception of the closed basin watersheds containing Legion, Section 36, and the Shoe Lakes, which are in the Lake Michigan drainage basin. PIRO's watersheds and their drainage patterns are determined mostly by the topography of underlying Cambrian rock and surficial Pleistocene and Holocene sediments.

PIRO is home to a number of rare plant species, including the federally threatened Pitcher's thistle (*Cirsium pitcheri*) and the state-endangered acute-leaved moonwort (*Botrychium acuminatum*). Grand Sable Dunes alone is home to ten species on Michigan Endangered Species or Species of Concern lists. Three state listed species are aquatic: autumnal water starwort (*Callitriche hermaphtroditica*), alternate-leaved water-milfoil (*Myriophyllum alterniflorum*) amd Farwell's water-milfoil (*Myriophyllum farwellii*). PIRO's mussel communities, although not listed on state or federal lists of species of concern, may become key remnant fauna within the next 10 to 15 years, as the expanding distribution of non-native zebra mussels (*Dreissena polymorpha*) leads to the extirpation of native mussels elsewhere.

Potential sources of pollution to PIRO are numerous and vary greatly in magnitude. Toxic organic contaminants, which are of particular concern in Lake Superior, may originate as air pollutants as far away as Mexico and Central America. Local sources of air pollutants are well-regulated, but the potential impact on PIRO of permitted local emissions is unknown. The pH of precipitation in Michigan's Upper Peninsula has increased somewhat since the 1980s, but acid precipitation is still a concern for those lakes with low to moderate buffering capacity.

Point sources of water pollution to Lake Superior near PIRO include the Munising municipal wastewater treatment plant and a Munising paper mill. Nonpoint sources include Great Lakes shipping activities, commercial tour boats and private boats, marinas, and stormwater discharges. Great Lakes cargo ships travel within 7 km of PIRO, and have the potential to accidentally spill cargoes or fuel, or discharge bilge water or ballast water that could contain exotic species. Munising and Grand Marais, which border PIRO on either end, discharge stormwater to the lake but are too small to be covered by USEPA stormwater regulations. Potential sources of water pollution to PIRO's inland water resources include on-site wastewater treatment systems, logging, and road building. PIRO staff oversight of development and logging activities in the IBZ has been a successful and essential method for protecting the park's inland waters.

PIRO's surface waters are generally of high quality. However, many inland waters exceed the criteria for total phosphorus for the ecoregion. Phosphorus sources are not evident on the land surface today, but may include sediment eroded from adjacent land during logging in the 1800s. Atmospheric deposition may also be increasing nitrogen levels. Only a few incidences of exceedences of human health or aquatic life criteria have been reported, and the most recent of those was in 1980. Limited groundwater sampling indicates generally good groundwater quality, although some arsenic has been detected in Alger County groundwater at levels below current drinking water quality standards.

Development and population pressures do not appear to be a major concern for PIRO at this time. Population in Michigan's Upper Peninsula is growing only slowly, and the IBZ allows for review of developments that might affect the park. The Shoe Lakes are the only lakes in the IBZ with potential for development. Visitor use is also projected to remain fairly stable over the next 10 years, although the completion of the paving of County Highway H-58 within Alger County may slightly increase park visitation and the proportion of visitors using recreational vehicles.

A number of exotic aquatic invasive species have been found in PIRO, including the sea lamprey (*Petromyzon marinus*), spiny waterflea (*Bythotrephes longimanus*), alewife (*Alosa pseudoharengus*), curly-leaf pondweed (*Potamogeton crispus*), and purple loosestrife (*Lythrum salicaria*). Others, such as the brown trout (*Salmo trutta*), splake (*Salvelinus fontinalis* x *namaycush*), steelhead (rainbow) trout (*Oncorhynchus mykiss*), pink salmon (*Oncorhynchus gorbuscha*), coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tshawytscha)*, and rainbow smelt (*Osmerus mordax*), have been intentionally introduced. The effects of these introductions on park resources are largely unknown, but studies are beginning to address this serious issue. Purple loosestrife and curly-leaf pondweed are no longer believed to be present in PIRO.

Exotic species considered to be encroaching on PIRO include the zebra mussel, quagga mussel (*Dreissena bugensis*), Asian clam (*Corbicula fluminea*), fishhook waterflea (*Cercopagis pengoi*), Eurasian ruffe (*Gymnocephalus cernuus*), round goby (*Neogobius melanstomus*), the zooplankter *Daphnia lumholtzi*, the parasitic copepod *Neoergasilus japonicus*, Eurasian water-milfoil (*Myriophyllum spicatum*), rusty crayfish (*Orconectes rusticus*), white perch (*Morone americana*), threespine stickleback (*Gasterosteus aculeatus*), European frog-bit (*Hydrocharis morsus-ranae*), and flowering rush (*Butomus umbellatus*). Primary vectors for introducing exotic species to Lake Superior are the bilge and ballast water of commercial ships; for PIRO's inland waters, the main vector is recreational activity, including boating and bait bucket transfer. Climate change could also have major impacts on PIRO resources, both by altering the habitats that enable certain rare species to survive as well as by allowing exotic species to compete more successfully.

Other main anthropogenic threats and concerns to PIRO's surface waters include atmospheric deposition of contaminants (including acid deposition, organochlorides, and heavy metals, especially mercury), and sediment loading of streams. Lesser threats include water quality degradation from camping activities, septic systems, point source fuel emissions from boats and personal watercraft, and unsound logging and home building practices.

Table i. Water quality indicators and current and potential stressors of aquatic resources in Pictured Rocks National Lakeshore.

Stressor or Environmental Indicator/Location	**Lake Superior**	**Inland Lakes**	**Streams**	**Wetlands**	**Pictured Rocks escarpment**	**Grand Sable Dunes shoreline**
Water quality indicators						
Water clarity	OK	OK	OK	NA	NA	NA
Nutrients	PP	EP	EP	NA	NA	NA
Dissolved oxygen	OK	OK	OK	NA	NA	NA
Toxic contaminants	EP	PP	PP	PP	NA	NA
Biological indicators						
Zooplankton populations	PP	OK	NA	NA	NA	NA
Fish consumption advisories	EP	EP (Hg)	PP (Hg)	NA	NA	NA
Air quality						
Regional atmospheric deposition and air pollution	EP	EP (Hg)	PP	PP	OK	OK
Local air pollution sources	OK	PP	PP	PP	OK	OK
Water quality						
Wastewater discharges covered by NPDES permits	OK	NA	NA	NA	NA	NA
Stormwater	PP	PP (PAHs)	PP (PAHs)	PP (PAHs)	NA	NA
Agriculture	OK	OK	OK	OK	NA	NA
Landfills	OK	OK	OK	OK	NA	NA
Septic systems	OK	OK	PP	PP	NA	NA
Road building	OK	PP	PP	PP	NA	NA
Logging	OK	PP	PP	PP	NA	NA
Commercial boating	PP	NA	NA	NA	PP	PP
Recreational boating	PP	PP	PP	NA	OK	OK
Invasive species						
Ballast water discharges	PP	NA	NA	NA	NA	NA
Recreational boating	OK	PP	NA	NA	OK	OK
Bait bucket transfer	PP	PP	PP	NA	NA	NA
Development and use						
Visitor use intensity	OK	PP	PP	PP	PP	PP
Residential development	OK	PP	PP	PP	NA	NA
Commercial fishery	OK	NA	NA	NA	NA	NA
Global climate change	PP	PP	PP	PP	PP	PP

Definitions: EP= existing problem; PP = potential problem; OK= no detectable problem

shaded =limited data; NA= not applicable.