Big Lake

Lake Management Plan

August 1998

Prepared By:

Big Lake Citizen's Advisory Committee

USKH

A quarter century of design for Alaska

Dames & Moore

INTRODUCTION

What is the Lake Management Plan?

Lakes, because of their popularity for residential use, recreation activities, and environmental sensitivity, often require special planning attention. Big Lake, located in the Matanuska-Susitna Borough 10 miles west of Wasilla and 90 road miles northwest of Anchorage, is no exception.

Not only is Big Lake an established, growing year-round community of more than 2,000, with a school and library, it also serves as a recreational destination for residents from Anchorage and other areas. The population influx during weekends, holidays, and summer months pose unique challenges, as the permanent residents try to balance their own recreational and land use needs with those of seasonal property owners and users. At the request of property owners and residents, the Matanuska-Susitna Borough is addressing concerns associated with Big Lake's new development and growing popularity, specifically:

Water Quality

Recreational opportunities, fish and wildlife habitat, and property values are all dependent on water quality; possible contamination of a lake would impact all of these issues. What is the current water quality of Big Lake?

Are septic systems causing problems or will they in the future? How can the water quality be maintained and enhanced?

Public Safety

Big Lake is valued for its recreational opportunities. The lake is used for waterskiing, jetskiing, loon watching, fishing, swimming, canoeing, float planes, ice fishing, snowmachining, and many other activities. Residents have expressed concerns regarding boating congestion and conflicts and several boating accidents have recently occurred. How can all the different user groups continue to safely use the lake? Is there enough access to the lake and is it the right kind?

Enforcement/Education

To protect the lake's resources and public health, lake users and land owners need to be informed about existing regulations. More importantly, they need to follow the rules. How can we improve enforcement of existing regulations and educate users about boating safety, litter control, noise, and fish and wildlife protection? How can we encourage people to behave responsibly?

Based on public input and analytical studies, the goal of the Lake Management Plan is to define the issues facing Big Lake today and develop specific management guidelines that will maintain and enhance the quality of life and the "lake" experience for Big Lake, Mud Lake, and Flat Lake. Because lake shore development can directly threaten water quality, fish and wildlife habitat, and the recreational use of the lake, land surrounding the lake and 1/4 mile upland of the shoreline is included in the lake management planning effort. While activity within the overall watershed of Big Lake is important to the lake, analysis of the watershed features and processes is outside the scope of this study.

How was the Plan Created?

Big Lake currently is not an incorporated community within the Matanuska-Susitna Borough; however, Big Lake Community Council is recognized by the Borough. The community of Big Lake recognizes the need to plan for the future of their community, and more specifically, the lake. The Big Lake Comprehensive Plan, adopted in February 1996, outlines a preferred future vision for the community of Big Lake in its mission statement:

> *"Big Lake is and should remain primarily a residential and recreational community that is part of a larger region. As such, accommodation should be made to infrastructure and transportation corridors servicing the region in ways that are compatible with other community values. Although the local economy is currently based primarily upon recreation and tourism, diversification should be encouraged in ways compatible with recreational use and enjoyment of the area. This diversification should be supported by locally sufficient business, infrastructure, and amenities. Development in the community will be compatible with the maintenance and conservation of the natural environment. The community would like the Borough and State to recognize, accept and expand the great potential for the development of a highly diversified year-round recreational economy in the Big Lake area."*

This Lake Management Plan implements many of the specific goals and recommendations identified in the Comprehensive Plan. In fact, the Comprehensive Plan states:

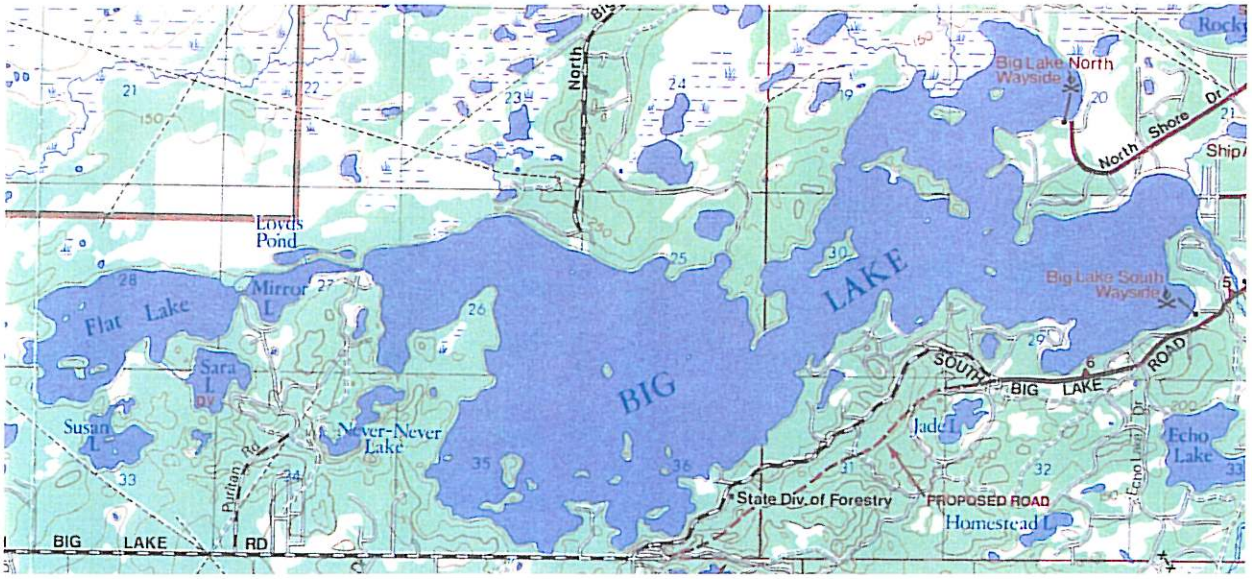
> *"The community encourages recreation and tourism but is interested in protecting the natural environment. One way of accomplishing this is to do lake management plans for various lakes in the planning area. This would identify areas in need of protection and allow the community to take the appropriate actions to preserve such areas."*

This plan involved local residents and interest groups in the decision making process. All together, a Citizen's Advisory Committee, Focus Groups, user surveys, public workshops, and newsletters comprised the foundation of the public involvement process designed to guide the Lake Management Plan. Insight from these groups and individuals assisted in the identification of common values, issues, and solutions. Management guidelines for Big Lake were crafted based on goals and objectives developed during the public involvement process.

How is the Plan Organized?

The plan has the following sections:

- **Background**: Serves as an introduction to the lake's history. Existing regulations are highlighted that seek to protect the public's health and safety and the environment.
- **Existing Conditions**: Describes the physical (topography, geology, soils, hydrology, and climate), biological (vegetation, fish, and wildlife), and human uses of the lake.
- **Issues and Trends**: Identifies the relationship between lake and land uses on water quality and public safety.
- **Management Action Plan**: Evaluates a range of management alternatives. Management guidelines are presented that have been formulated specifically for Big Lake.



BACKGROUND

History of Big Lake

The history of Big Lake is rich and the selected highlights from the past only begin to paint a picture of the interaction of land use development, fisheries, wildlife habitat, water quality, and lake use that have shaped the lake into what it is today. Many of the issues the Lake Management Plan addresses are not new to the lake. As the popularity of Big Lake continues to flourish, proper management and planning is critical to ensure a healthy lake system. The following chronology of events serves as an introduction to the unique history of Big Lake from the 1830s to present day.

1830s. Native populations fished, hunted and gathered in the Big Lake area until a small pox epidemic introduced by Russian traders decimated Athabaskan populations in the area, leading to the abandonment of many village sites.

1897. Gold was discovered in Willow Creek approximately 20 miles from Big Lake. The Big Lake area became a transitory route for merchandise to and from the mines.

1916. The lake, itself, was first homesteaded in 1916 by Herman Gronwald, a mink farmer who harvested fish from Big Lake to support his mink farm. As a hunter and trapper he depended on traffic to the gold fields for sale of one of his products - boot leg whiskey.

1922. Big Lake was bypassed by the new railroad from Seward to Fairbanks, but the area became a favorite beaver and small game hunting ground for occupants of the new railroad towns of Anchorage, Palmer, and Wasilla.

1937. A fish counting weir was established on Fish Creek to record salmon returns.

1940s. The second known homesteader, Oscar Anderson, settled at Fish Creek. The cabin is still standing and used today. Mr. Anderson managed Big Lake's water level by controlling the height of beaver dams. He selectively removed material from the top of the dams whenever he felt the beavers had built them too high. During World War II, the lake was used by the military for recreation and as a training site for army float plane pilots.

1952. According to U.S. Fish and Wildlife studies, 10.9 percent of all sport fishing on the Alaska mainland south of the Alaska Range occurred on Big Lake.

1953. Approximately 100 lakeshore cabins were already established at Big Lake and it was considered the most popular fishing and boating lake in the Anchorage area.

1955. As more summer residents arrived, conflicting opinions on water level management appeared. Someone using a bulldozer knocked out the beaver dams, lowering the lake level by two to three feet. Thereafter, the water level was regulated by dumping rocks and boulders causing the

lake's water level to fluctuate chaotically by as much as two feet in a single season. The cabin owners, lodge and boat livery operators, the homesteaders along Fish Creek and the sport and commercial fisheries interests all had different ideas about the ideal level of Big Lake, but there was general consensus that a permanent fixed level was highly desirable.

1962. Six homesteaders who lived on the Big Lake-end of Fish Creek originally used water from Fish Creek for domestic uses and irrigation, but in 1962, water samples sent to the Department of Health for analysis were deemed to be not fit for human consumption.

1963. The Department of Fish and Game (ADF&G) reported that Big Lake was an important recreational unit. Of the estimated 600-plus cabins, more than 400 were accessible only by boat or floatplane. Big Lake hosted a few year-round residences and five commercial lodges and boat liveries.

1966. ADF&G reported that the waters of Big Lake were definitely polluted and had been declared unfit for human consumption for several years by Arctic Health Research. More than 700 cabins were present, many had drains emptying raw sewage into the lake. One dog musher with more than 40 animals lived adjacent to the lakeshore. It is reported that a practice was also made of emptying cans and bags of garbage into deep water over the sides of boats.

1967. The potential for contamination of Big Lake from septic tank discharges into the nearshore, shallow aquifer was addressed in a water-resource reconnaissance conducted by the U.S. Geological Survey (USGS). The Division of Waters and Harbors, Department of Public Works requested from the Department of Natural Resources a water use permit for the purpose of constructing a lake stabilization weir in the Fish Creek.

1972. As a result of increasing concern over declining levels of salmon production and harvest, a study of the salmon watershed in the Cook Inlet was initiated.

1974. ADF&G reported that the Big Lake watershed was of considerable importance to the Cook Inlet commercial fisheries. Salmon migration had been recorded since 1932 and showed an average annual movement of 80,227 sockeye salmon and 9,787 coho salmon, with peaks of 306,982 sockeye and 19,417 coho. There was also an appreciable sport fishery for trout in both the lake and creek.

1975. A petition was sent to the Commissioner of Public Safety. It read:

> *"There may already be adequate laws regarding safety on the lake but if so the general public is not informed and the regulations are not enforced. It is our desire to have good boating regulations made available to the public and then enforced...We as a group are not against anything but are for whatever is necessary to make the lake enjoyable for us all. The only negative replies we have had are 'No one is going to tell me what to do on the lake'. Unfortunately, these are the very people who make restrictions necessary."*

1975. The Big Lake Hatchery was constructed on Meadow Creek to restore the watershed's historic sockeye salmon production. Sockeye salmon returns to the Big Lake drainage were strongly depressed from the mid-1960s to the late 1970s. The hatchery assumes responsibility for lake level and flow.

1976. The number of seasonal and permanent lakeshore homes had grown to approximately 450. The Alaska Department of Environmental Conservation found that approximately ½ of the residences at Big Lake had inadequate or improperly constructed sewage disposal systems.

1980. Discussions continued on the Big Lake water control structure and the optimal lake level. The 1980 U.S. Census showed the larger community of Big Lake as having a population of 410 with 570 houses (162 occupied).

1983. The importance of the aquatic resources of Big Lake and concerns expressed for potential degradation of the lake's water quality resulted in the USGS conducting a limnological study of Big Lake. Little data on water quality had been collected prior to this study.

1988. Approximately 600 boat docks were observed in the combined lake system. Most docks and shoreline activities appeared to be in compliance with current regulatory guidelines necessary to protect bank stabilization and fish habitat.

1988. Big Lake was stocked with rainbow trout.

1990. It was recommended that detailed studies be conducted on the health of the lake, the biological interaction between sockeye and coho salmon, and the impact of residential and commercial development on water quality.

1994. An intoxicated boater collided with another boat carrying two families. Both fathers were killed and one mother and three children were injured.

1995-1997. The Big Lake hatchery closed. ADF&G currently controls the water level of the lake. U.S. Census population (1990) for the community of Big Lake showed a population of more than 1,477 with 1,933 houses, 548 of which were occupied. The Miller's Reach fire burned 37,000 acres north of Big Lake. A major new marina is being developed and approximately 730 docks line the lakeshore. Five commercial businesses offer boat launching and water-oriented services.

Existing Regulations

Big Lake and its adjacent shorelines are currently subject to a variety local, state, and federal regulations, plans and management guidelines. The lake is owned by the State of Alaska. The United States Coast Guard (USCG) and the U.S. Army Corps of Engineers (Corps) also have regulatory jurisdiction over the lake because it is classified as a navigable water body. An understanding of existing regulations is important because they have helped shape Big Lake into what it is today, and will play a role in future development.

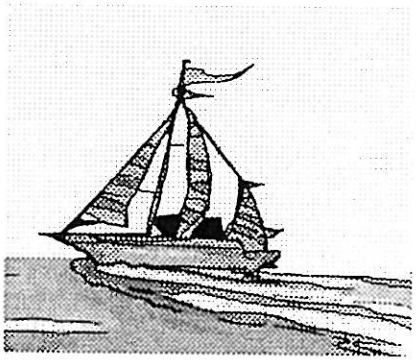
Highlights of ***key*** regulations directly affecting the management of the lake and shoreline are presented below. This list is not meant to be all-inclusive. The most applicable excerpts from the regulations have been summarized and divided into categories representing their ***primary*** purpose.

Navigable Waterway Status

In the 1970s, Big Lake was designated as a navigable water body by both the USCG and the Corps. A navigable water body of the United States is defined as:

> *"those waters of the United States that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the water body, and is not extinguished by later actions or events which impede or destroy navigable capacity."*

Several reasons have surfaced to justify the navigable water body status of Big Lake. One reason is that barges delivered building supplies that originated from outside Alaska to sites around the lake, therefore, triggering the "interstate commerce" condition. A second reason is vessels have been used in a commercial capacity to show visitors the lake.



Public Safety Regulations

Alaska is the only state in the nation without a boating safety program, as encouraged by the 1971 Boating Safety Act. The USCG and the Alaska Department of Public Safety, which includes the Alaska State Troopers and Division of Fish and Wildlife Protection, have jurisdiction over Big Lake. Boat operators are expected to ensure that their boats carry at least a minimum of safety equipment and comply with state (Title 5) and federal (33 CFR 173) regulations. The USCG does not regularly patrol or enforce federal regulations on Big Lake due to lack of resources. The Department of Public Safety also lacks the staff and resources to maintain a full-time patrol on the lake. The lack of agency resources and enforcement is a fundamental problem in terms of ensuring public safety. Below are highlights of regulations in place:

- Registration is required for all vessels with engines. This definition includes personal watercraft. The registration is issued by the USCG and costs $6 for 3 years. A copy of the registration form is included in Appendix A.

- Operating a vessel while intoxicated is prohibited by both federal and state law. Negligent or grossly negligent operation of a vessel that endangers lives and/or property also is prohibited by both federal and state law.

- Accidents must be reported to the Department of Public Safety if death, injury, or property damage occurs in excess of $100. Accidents must be reported to the USCG if an injury requiring more than first aid, a fatality, loss of vessel, or more than $500 in property damage occurs. A copy of the Boating Accident Report is included in Appendix A.

- The USCG also sets minimum safety standards for vessels and associated equipment including personal floatation devices (PFD) and throwable devices. A water skier is considered onboard the vessel and is required to wear an approved PFD. The state requires individuals on the deck of a boat under the age 13 on the deck to wear a PFD.

Other federal regulations administered by the USCG designed to protect public safety include:

- Regattas and Marine Parades (33 CFR 100) - this regulation provides control over regattas and marine parades conducted on navigable waters of the United States to ensure safety of life. An individual or organization planning to hold a regatta or marine parade that may introduce hazards to life must submit an application to the USCG.

- Passenger Vessels (46 CFR 114.110; 46 CFR 175.110). A permit from the USCG is required for vessels that carry paying passengers.

Land Use Regulations

Big Lake is an unincorporated community. With the exception of the Alaska Department of Natural Resources which adopted the Willow Subbasin Plan, adopted in October 1982, the Borough is the only governing body that has land use policy plans and regulations affecting Big Lake. The Borough is responsible for the enforcement of the following regulation through their Code Compliance Division:

- The Subdivision Ordinance (Title 16) outlines development standards. A subdivision map or plat shows the number and dimensions of lots, public rights-of-way, setbacks, roads, access utilities, and easements. Of special concern to development at Big Lake is a minimum lot size of 40,000 square feet with on-site water and sewer, and a minimum lot width when measured at the lake's water line of 125 feet unless community septage is provided, then the minimum width may be 85 feet. Most subdivision activity took place prior to the adoption of this

subdivision ordinance and many of the lots do not meet the current standards; however any new subdivisions fall subject to Title 16. Currently, substandard lots can be developed as long as the required setback distances can be met from property lines, rights-of-way, and water bodies. If the lot is too small to allow development in compliance with current regulations, the property owner can apply for a variance to reduce setbacks.

- In 1994, voters in the Borough adopted an ordinance that allows restrictions on lakes and water bodies that include limiting or eliminating motorized use of lakes, establishing quiet hours, and establishing a 100-foot, no-wake zone from the ordinary high water mark. Additionally, any development that seeks to establish or operate a mobile home park, junkyard, refuse area or landfill, or to dispense alcohol must first obtain a conditional use permit.

- The Matanuska-Susitna Coastal Management Program is based on the federal Coastal Zone Management Act of 1972 and the Alaska Coastal Management Act of 1978. One of the more controversial provisions of the Matanuska-Susitna Coastal Management Program addresses the development of setbacks from water bodies:

  "Proposed uses and activities within 75 feet of the ordinary high water line of rivers, streams, and lakes that require local, state or federal authorization must be reviewed to protect water quality and fish and wildlife habitat. Water-dependent structures such as docks, piers, marinas, float plane hangars, or boathouses, and access to such structures are allowable within the 75 feet provided they are constructed and used in a way that minimizes adverse impacts to water quality and fish and wildlife habitat. Other uses and activities within 75 feet are also allowable if the proposed development will have no significant adverse impacts to water quality and fish and wildlife habitat, and complies with other applicable federal, state, and local requirements."

For activities requiring state or federal permits, the state conducts a consistency review. Where a Borough permit or approval is required, the Borough conducts a consistency review, either as part of the state review, or a separate review as part of the normal local review process.

Structural setback requirements within the Borough have been revised several times since they were first adopted. Setbacks from water bodies were originally 75 feet. They were subsequently reduced to 45 feet for a very short period and are now 75 feet again. These factors have contributed to development inconsistencies in the planning area. Existing structures in violation of current setback requirements for property lines, right-of-ways, and bodies of water have not yet been identified. Many structures predate regulations specifying setback requirements, while others were actually built in violation of the required setbacks.

- The Willow Subbasin plan outlines future use or development of State and Borough lands and waters. Specific management guidelines applying to areas around lakes include a recommendation for retention of approximately 25 percent of state-owned waterfront to distance of approximately 500 feet inland. It recommends that all islands, inlets and outlets of lakes capable of sustaining year-round natural or stocked game fish species remain in public ownership for habitat protection and public recreation. Adequate public access to these lakes should also remain in public ownership. On Borough land, all lakes larger than 20 acres with the capability of sustaining year-round natural or stocked game fish species should have some amount of waterfront held in public ownership.

Natural Resource Protection

The ADEC, ADF&G Habitat and Restoration Division, and the Corps are responsible for water quality and the protection of fish and game. The Division of Fish and Wildlife Protection has the primary responsibility for enforcing fish, wildlife, and habitat protection laws. ADF&G provides biological and ecological expertise and assistance. Again, due to a lack of staff and resources, enforcement of the regulations is lacking. Below are key regulations for the protection of natural resources.

- Administered by ADEC, it is the state's policy that designated freshwater uses in Alaska's water quality standards [18 AAC 70.020(a)] including water supply, recreation, and growth and propagation of fish and other aquatic life are maintained and protected. Water quality standards are legal standards based on either numeric limits or narrative descriptions of water quality designed to protect the designated water uses (ADEC 1996). Monitoring determines whether existing water quality meets the relevant standard(s). A Section 401 water quality certificate under the ADEC Clean Water Act is required for any federally permitted projects or discharges into navigable waters.

- Installation of sanitary wastewater disposal facilities also is regulated by the ADEC. No holding tank, septic tank, soil absorption system, seepage pit, privy, or other waste water collection, treatment, or disposal system may be within 100 feet, measured horizontal, of the mean annual high water level of a lake, river, stream, spring, slough, or the mean higher water level of coastal waters {Title 18 - Waste Water Disposal, 18 AAC 72.015(f)}. A 100-foot separation distance is also required by ADEC between private wells and sanitary waste disposal systems. ADEC provides the standards and regulations for the installation and certification of the systems, they do not currently enforce the regulations or inspect the systems. Recent budget cuts makes future enforcement by ADEC unclear at this time. ADEC encourages individuals to follow the regulations and maintain adequate documentation so the system can be certified later by a private entity. No forms of enforcement exist to prevent individuals from installing septic systems without professional certification other than lending institutions requiring certification prior to financing approval. Any discharge greater than 500 gallons per day requires a permit from ADEC.

- The Anadromous Fish Permit (AS16.05.870) addresses protection of fish and game, particularly, protection of anadromous fish such as salmon. Any activity associated with construction of a hydraulic project, or use that diverts, obstructs, pollutes, or changes the natural flow or bed of a specified river, lake, or stream requires a permit from ADF&G. Activities or structures that (1) obstruct fish passage; (2) damage critical spawning and rearing areas including banks and vegetation along the shore; (3) wastewater discharges that degrade water quality.

- ADF&G is responsible for enforcing fishing and hunting regulations. Regulations may vary from year to year and require verification and updating each season.

- ADF&G, pursuant to AS16.05.870(b), has issued a general permit authorizing the use of certain categories of motorized wheeled and tracked vehicles on frozen waters including Big Lake. This regulation is designed to protect fish and game. Vehicles covered by the general permit include any wheeled, tracked, or other ground-effect motorized vehicles less than 2,000 pounds, such as snow machines, 4-wheelers; and wheeled vehicles under 10,000 pounds. Vehicles requiring permits for using ice roads on Big Lake include all fuel trucks; wheeled vehicles that weigh more than 10,000 pounds; and track vehicles weighing more than 2,000 pounds.

- Big Lake, as U.S. water body, requires a Section 404 permit from the Corps for the discharge of dredged, graded, and fill material into the lake in accordance with the Clean Water Act. The three-step sequence to mitigate potential adverse impacts to the aquatic environment from a proposed discharge includes: (1) avoiding impacts; (2) minimizing impacts by reducing the footprint of a proposed project; (3) Co-locating facilities, seeking to locate a project in lower value aquatic areas; (4) or compensatory mitigation through restoration or creation of wetlands and/or other aquatic areas.

- Section 9 and 10 of the Rivers and Harbors Act (33 USC 403) applies to waters designated as navigable by the Corps. Since Big Lake is a navigable waterbody, permits are required for construction of a dam or dike, and for any dredging, filling, or obstruction of the lake's water. This definition includes the construction of docks.

The State of Alaska has developed a General Concurrence with the Corps wherein a dock may be 400 square feet and not extend more than 50 feet into Big Lake. The General Concurrence is regulated by ADF&G.

- The USFWS regulates the taking, possession, transportation, sale, and purchasing of wildlife and migratory birds (50 CFR 10).

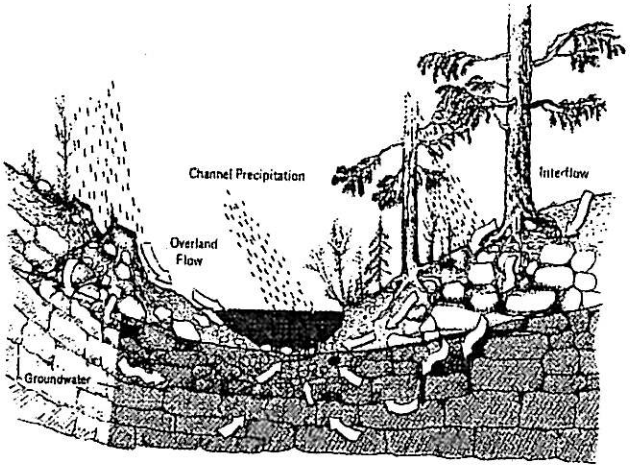
EXISTING CONDITIONS

Inventory of Existing Conditions

How a lake functions and can be used for recreation is determined in part by its watershed, size, volume, shoreline length, water quality, and the amount of water entering and leaving the lake. This section presents an inventory of existing physical and environmental conditions, activities, use patterns, the types and number of support facilities (boat ramps, public use areas, docks, and marinas) and other resource-related items that influence the health of the lake system and recreational opportunities.

The Watershed

The watershed includes the entire land form drained by particular creeks and rivers and is the ultimate water source of the lake. The visible area of a watershed is the surface on which rain and snow fall. The larger, invisible portion of the watershed lies beneath the surface where water seeps into the ground and collects as ground water. A raindrop can get from a mountain top to a lake in three ways: (1) some is absorbed by the soil; (2) some collects on the ground in depressions; and (3) some flows overland. The raindrop absorbed by the soil may eventually become groundwater and flow underneath the surface. The raindrop that collects in the depression is surface water but it may also seep into the ground and become part of the groundwater system. With overland flow, the raindrop forms rivulets, which in turn, join to form streams, and the streams join to form rivers, and so on. Whatever that raindrop picks up from the land along its journey ends up in the lake. Climate, topography or slope, rock and soil types, surface water and groundwater flow, vegetation, and human impacts all change the quality and quantity of water draining through the watershed and ultimately into the lake.



The Big Lake watershed consists of approximately 67.9 square miles (Figure 1-1). Big Lake is the largest lake in the watershed. Other principal lakes include Beaver, Blodget, Flat, Jacobsen, Lucille, Rocky, Wallace, and West Beaver. Meadow Creek is the most extensive watercourse in the watershed; it drains several bodies including Little Meadow Creek, Lucille Creek, and Lucille Lake. Surface water generally moves through the watershed from north to south, meeting in Fish Creek, which serves as the outlet of Big Lake. Fish Creek drains to the Knik Arm of Cook Inlet approximately 7 miles to the south.

Ground water flow into and out of the muskegs, ponds, and lakes in the watershed is expected to be high because of the low profile topography and relatively shallow aquifers. Ground water resources are largely contained in outwash and gravel laid down by glacial meltwater streams (Freethy and Scully 1980). The outwash deposits or layers can be further broken down into unconfined and confined aquifers. The unconfined aquifer is at depths from 3- to 90-feet and consists of sheet-like deposits that lie just beneath the land surface. It typically yields water at a rate of 0.08 to 0.8 gallons/second to wells in the area (Hogan 1995). The confined aquifer is buried beneath till. It may be as thick as 60 feet and provide yields up to 4.8 gallons/second (Hogan, 1995).

Climate

The climate of the Big Lake watershed is characterized by a combination of maritime and continental influences. Temperatures range from an average of about 58° F in July to about 11°F in January. Mean annual precipitation is approximately 22 inches and mean annual snowfall is about 59 inches (Leslie,1989). Ice forms on lakes within the drainage basin in late October and generally melts by late May.

The two major winds that influence the area are the Matanuska and Knik winds. The Matanuska winds come from the northeast and can reach a velocity in excess of 60 miles per hour (mph). They typically occur for approximately 16 days during the winter. Knik winds come from Cook Inlet to the southeast and also have a velocity of more than 60 mph. They generally occur during summer months, for 2 to 3 days annually.

Topography

The topography of shorelines and uplands in the watershed can be a constraint to development. Steep slopes are more susceptible to erosion and can cause sediment to enter lakes and streams. They also present construction and sewage disposal constraints.

Topographic relief in the watershed ranges from level terrain to rolling hills with elevations from approximately 144 to 551 feet above sea level (Woods 1992). Low relief in parts of the watershed results in poor drainage and large areas of swampy ground and numerous lakes and ponds. Areas of low relief are evident to the north and northwest of Big Lake. Mean annual runoff in the watershed is about 0.005 m3/s (Freethey and Scully, 1980).

Soils

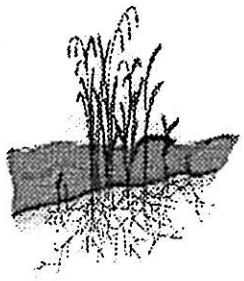
Soils are important because of their potential for erosion, varying suitability for development, and their role in sewage treatment for septic systems. Soil conditions that would restrict the development potential of an area include slow permeability, very rapid permeability, and high or seasonally high water tables.

The watershed shows evidence of glacial activity. Bedrock is buried beneath thick deposits of glacial drift and alluvium (river deposits) composed chiefly of unconsolidated gravel, silt, clay, and sand (Schoephorster, 1968). These deposits are estimated to be at a depth of more than 984 feet thick in the Big Lake area.

Much of the watershed consists of well-drained, silty, upland soil of the Nancy-Homestead and Homested-Salamtof associations (A "well drained" soil means that water readily flows through the soil and that the soil does not have long periods of saturation). These soils appear to be most common in the southern and eastern portions of the watershed. The watershed also has poorly drained course peat in muskegs ("Poor drainage" means that soil is frequently or permanently saturated and may often have standing water on it). Prevalent soil associations in these areas include Naptowne-Salamatof and Salamatof-Moose River. Permafrost is known to occur in lowland areas. (Ferrians 1965).

Wetlands and Vegetation

The Big Lake watershed contains extensive wetlands as mapped in the National Wetlands Inventory by USFWS. Wetlands protect and enhance lake water quality and the shoreline area and provide important habitat for fish and wildlife. Wetlands buffer shorelines from wave impact, slow storm water runoff from uplands, and remove phosphorous from water during spring and summer growth periods. Wetlands are seldom suitable for building due to the occurrence of shallow groundwater; possible pollution by septic tank wastes not adequately absorbed by the soil; poor support capabilities and frost action that may crack foundations and roads; the likelihood of flooding in spring and other times of high water.



Vegetation, especially riparian vegetation (vegetation along a shoreline and extending inland to include wetland and upland plant communities) maintains high water quality by stabilizing banks, preventing erosion, trapping sediment and pollution; and providing fish and wildlife habitat.

A lowland spruce-hardwood forest is the predominant vegetation type in the Big Lake area. It is composed of a variable dense to open lowland forest that supports black spruce, white spruce, white birch, black cottonwood, and aspen in stands that range from mixed evergreen/deciduous to pure stands of black spruce on muskeg bogs. The lowland spruce-hardwood forest type most commonly occurs on areas of shallow peat, glacial deposits, outwash plains, and on north-facing slopes of the rolling hills. Associated understory plants include cotton grass, horsetail, fireweed, parsley fern, marsh fern, fragile fern, lichens, and mosses (Figure 1-2).

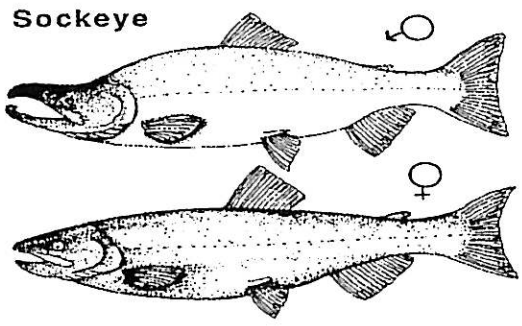
Areas with a higher water table and poor drainage support a vegetation community of low brush bog and muskeg. Dwarf shrubs are generally dominant above a ground cover mat of sedges, mosses, and lichens. This vegetation type is most prevalent in wet, flat basins where conditions are too moist for tree growth, and ponds or standing water are seasonally present in the peaty substrate. Associated understory plants in this shrub-dominated community include cotton grass, sedges, rushes, lichens, and mosses.

Fish

The Big Lake watershed is important to the Cook Inlet commercial fisheries, which has been under management since at least 1937 when a counting weir was established on Fish Creek. The lakes, streams, and wetlands in the Big Lake area provide important aquatic habitats for spawning, rearing, migration, and overwintering of both anadromous and resident fish. Five species of salmon (chinook, coho, sockeye, chum, and pink) and resident fish including rainbow trout, Arctic grayling, Dolly Varden, stickleback, whitefish, burbot, sculpin, and eels are present in the area.

Big Lake, Fish Creek and Meadow Creek are important migration corridors in the watershed for anadromous fish and provide critical rearing habitat for sockeye and coho salmon during their fresh water stage. Pike have reportedly been observed in Meadow Creek and at the headwaters of Meadow Creek and Big Lake (Gilleland, 1997). According to the ADF&G, pike could adversely impact the Big Lake system and have impacted nearby systems (i.e. Nancy Lake) reducing trout and other fish populations.

In 1976, the Big Lake Fish Hatchery located on Meadow Creek, was constructed to produce and release sockeye salmon fry in response to depressed sockeye salmon returns from the mid-1960s to the late 1970s. In 1995, the hatchery was closed. The Matanuska-Susitna Borough supports development of a long-term plan for re-instituting hatchery operations.



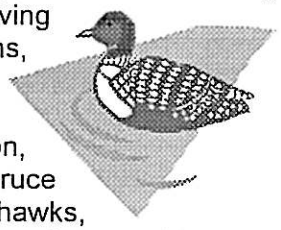
Wildlife

The mixed spruce hardwood forest, low shrub wetlands, and network of lakes, ponds, and streams provide an interspersion of habitats for large and small mammals, waterfowl and other birds, and fish. Mammals in the Big Lake area include moose, black bear, grizzly bear, wolf, wolverine, beaver, coyote, red fox, mink, muskrat, weasel, land otter, lynx, snowshoe hare, and red squirrel.

Moose use forested areas, shrub thickets, wetlands, and riparian zones adjacent to streams, lakes, and wetlands near Big Lake and in extensive areas east of the Little Susitna River for calving, summer feeding, winter browse habitat, and as migration corridors. Winter feeding concentration areas for moose occur west and north of Flat Lake in the extensive shrub and mixed spruce/birch communities of the Susitna River Basin. A moose calving concentration area is present north of Crooked Lake along the Little Susitna River drainage (ADF&G 1985). Winter browse habitat is critical to moose survival and productivity. Suitable calving areas are dependent on availability of habitats that are relatively free from disturbance and excessive predator pressure during the critical calving period.

Black bear are widely dispersed in forested habitats throughout the Big Lake area. During spring, summer, and fall black bear distribution is largely determined by availability of food. Black bear are opportunistic feeders that consume plants, animals, and carrion seasonally; berries when available; and salmon, an important part of their diet during spawning season. Black bear are more commonly associated with forested habitats, but they can become nuisance animals in developed areas if they become accustom to improperly disposed food wastes.

Birds present in the Big Lake area including dabbling ducks, diving ducks, geese, swans, grebes, loons, sandhill crane, bald eagle, marsh hawk, gyrfalcon, shorebirds, owls, spruce grouse, raven, hawks, woodland owls, and passerine songbirds.



Ducks and geese are seasonally present in the Big Lake area during the spring/fall migration, summer nesting, and brood rearing. Key concentration areas for these waterfowl are located west and north of the planning area. Wetlands along the Little Susitna River are recognized as important concentration areas for duck and geese for preparation of their southward migration in the fall (ADF&G, 1985).

Dispersed Trumpeter swan nesting and brood rearing occur from Flat Lake west throughout the Susitna River Basin. Trumpeter swans are present seasonally in the Big Lake area but significant nesting and brood-rearing areas have not been identified. Trumpeter swans are sensitive to activity and noise disturbances during nesting and brood rearing.

The Lake

Lake Morphology

Big Lake occupies an area of approximately 3,085 acres with a total shoreline length of approximately 31 miles. The lake consists of an east and west basin of near equal size and has a total of 22 islands. At its northeast end, Big Lake is connected by a narrow channel to Mud Lake (a.k.a. Mirror Lake) which in turn connects directly to Flat Lake. Mud Lake has a surface area of approximately 53 acres and a shoreline length of 1.5 miles; Flat Lake's surface area is approximately 317 acres and with a shoreline length of 5.4 miles.

Surface elevation of Big Lake is approximately 144 feet above sea level. The lake level is controlled by the ADF&G at a concrete weir at the Fish Creek outlet. Mean lake depth is 29 feet and the maximum depth is 88.6 feet (Woods, 1992). The total lake volume of Big Lake at full pool elevation is about 90,628 acre-feet. Lake depth (bathymetry) and topography surrounding Big, Mud, and Flat lakes are shown in Figure 1-3.

Big Lake Water Budget

The water budget is the volume of water entering and leaving a lake over a period of time, usually a year. The water budget is highly susceptible to changes caused by urban development. Development can decrease the rate of ground water recharge and divert both surface and ground water for consumptive use. Changes in the water budget can affect water quality, temperature, and turbidity, which in turn impact fish, wildlife, aesthetic appeal of the lake, and recreational

opportunities. A change in storage volume occurs when the input/output terms differ. The primary components of a water budget are as follows (typically measured as acre-feet per year):

change in storage =

(INFLOW (SURFACE & GROUND WATER) + PRECIPITATION) –

(OUTFLOW (SURFACE & GROUND WATER) + EVAPORATION)

Inflow: Surface Water and Ground Water + Precipitation

The primary source of surface water inflow to Big Lake is Meadow Creek. Meadow Creek drains a large portion of the watershed and flows into the east basin of the lake. A number of smaller, unnamed streams also enter the lake. The channel connecting Big Lake to Mud Lake, which in turn is directly connected to Flat Lake is another source of inflow to Big Lake. Although inflow data are not available, a substantial flow of water into Big Lake (0.5 to 1 feet/second) from the channel was observed (approximately 40 feet at its narrowest point) during a field investigation conducted August 1996.

Based on soil and topographical features, net inflow of groundwater into Big Lake could be substantial, although it is not expected to equal the magnitude of surface water input. The majority of groundwater inflow is expected to occur from low lying ponds and muskegs to the north. The overall boundaries of subsurface water supplies are assumed to correspond to those of surface waters (i.e., the watershed). Subsurface hydrologic connections to land areas northwest of the Big Lake watershed boundary may exist (Hogan, 1995).

Direct precipitation into Big Lake is likely small relative to other inflow sources. At approximately 3,000 acres, the lake represents approximately 6.9 percent of the overall watershed. Based on mean annual rainfall (22 inches) and snowfall (59 inches), annual direct precipitation into the lake would total 5,500 acre-feet of rain and 14,750 acre-feet of snow.

The present development pattern in the watershed has probably not had a significant impact on the net flow of surface water into the lake. No major water diversion has been constructed, and the majority of water consumption is from groundwater supplies. Development impacts to surface water changes are probably limited to localized, small increases in discharge volume and velocity related to increases in impermeable surfaces (i.e., roofs, roadways, and parking areas). Most water wells in the area provide water for household use and, to a large extent, the withdrawn water is ultimately returned to local aquifers via land application (irrigation and septic systems).

Outflow: Surface Water and Ground Water + Evaporation

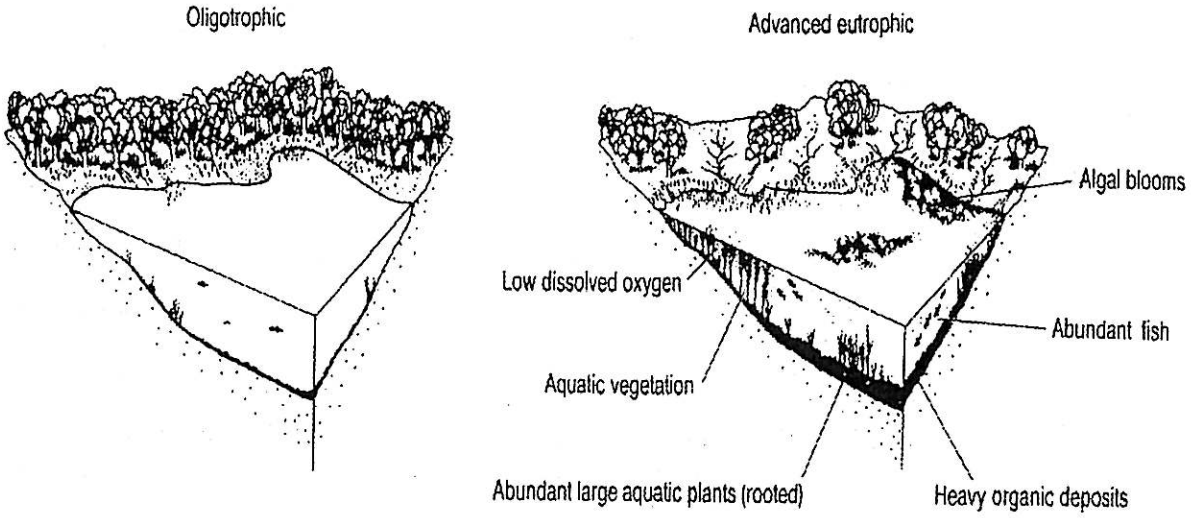
Surface water exits Big Lake primarily through Fish Creek, located in the east basin. Typical discharge rates during low flow periods range from 25 to 27 cubic feet/second (USGS, 1972-1986). Spring snow-melt and wet weather outflows are likely to be much higher, although data are not presently available.

Estimates of ground water outflow are not available at this time; however, outflow could be significant because of the landscape and relatively high permeability of underlying materials.

Estimates for direct evaporation from the water surface and sublimation from snow cover are not available but are expected to represent a small fraction of the total water budget.

Change in Storage

The water level, and therefore the storage volume, of Big Lake does not change significantly over time due to placement of a flow control structure at the Fish Creek outlet. Intermittent lake level records for 1972 though 1986 generally show seasonal changes less than 6 inches (USGS 1972-1986).



Water Quality

Lakes undergo a natural aging process known as eutrophication. Eutrophication is the natural physical, chemical, and biological changes that take place as nutrients, organic matter, and sediment are added to a lake. A lake is eutrophic when it is productive in the same way a grassy field is more productive than a desert. Massive growths of aquatic plants in a lake will lead to a change in the balance of dissolved oxygen, carbon dioxide, and micro-organisms and an increase in the production of total organic matter. These changes lead to alterations in the lake, most of which are undesirable. Eutrophication can be accelerated by human-caused influences within the watershed such as fertilizers, detergents, failing septic systems, eroding soil, and animal waste. Depending on how biologically productive (trophic) they are, lakes can be:

- Clear; nutrient-poor and with little life (oligotrophic).
- Murky, nutrient rich and full of life (eutrophic).
- Somewhere in between (mesotrophic).

Between 1983 and 1984, an assessment of Big Lake's water quality was conducted by the USGS. Apparently, this was the first time an overall study of the lake chemistry (limnological evaluation) has been done.

Water quality was reported as relatively good and generally classified as oligotrophic. The oligotrophic classification was based on annual mean values for total phosphorus, total nitrogen, chlorophyll-a, secchi-disc transparency, and algal primary production. During summer temperature layering (stratification) and winter ice cover, the lake's bottom waters (hypolimnion) were found to be rapidly depleted of oxygen, an unhealthy condition (Woods 1992). These seasonal problems suggest that the eutrophication process is accelerating. The cause may be the introduction of organic, oxygen-depleting substances coming from development within the watershed (Woods, 1992).

Land Use

The Watershed

The Big Lake watershed includes the community of Big Lake, which surrounds Big Lake, and Wasilla to the east. The community of Big Lake encompasses approximately 138 square miles. It is located 13 road miles southwest of Wasilla along the Parks Highway and 90 road miles north of Anchorage.

Land ownership in the larger community of Big Lake is evenly divided between private, Borough, and state. Approximately 5 percent of the total land and 15 percent of privately-owned land is developed. Subdivided private land tends to be concentrated along lake shorelines and is developed primarily as permanent and seasonal single family residences. In 1990, housing units 1,933. Of these, 1,131 (58%) were noted as seasonal reflecting the recreational nature of the area. Large blocks of vacant private land tend to be located away from shorelines and can accommodate a great deal of growth. Considerable vacant state land is also designated for settlement and small farms.

No public water systems, sewer systems, or storm drain systems are within the community of Big Lake. Water is provided with on-site wells and sanitary waste is disposed by on-site facilities such as septic systems, cribs, holding tanks, and pit privies.

A community core area is developing at the east end of the lake. Existing development in this area includes retail and service oriented businesses, and public services such as schools, a post office, library, fire station, the Big Lake Airport, and residential housing. Current development within this area indicates a trend toward higher density land uses than in other portions of the planning area. Existing land use in the larger community of Big Lake, including the Lake Management Plan boundary is shown in Table 1-1.

Land use to the north and east of the Lake is in transition due to the 1996 Miller's Reach Fire, which burned 37,000 acres. Lands that were previously developed in 1995 may now be vacant or under construction.

Table 1-1: Big Lake Community Land Use

	Acreage
Private Land Use	**21,790**
Residential	2,549
Commercial	65
Industrial	25
Vacant	19,151
Public Land Ownership	**55,038**
Federal	Negligible
State-Land	14,278
State-Waterbodies	10,000
Matanuska Susitna Borough	24,298
Native	4,388
University of Alaska	2,074

Source: Matanuska-Susitna Borough 1995

Most year-round Big Lake residents are employed in the Palmer/Wasilla area or in one of the estimated 657 jobs serving the Big Lake community (DCRA 1997). Big Lake's economy is under-represented in entertainment and recreation services. This is surprising given the recreational nature of the area.

Also located within the Big Lake watershed, is the community of Wasilla. The commercial center of Wasilla lies between Wasilla and Lucille lakes, 43 miles north of Anchorage and encompasses approximately 11.2 square miles. Wasilla has a population of 4,714 (DCRA 1997). The developed portion of the watershed is dominated by residential use.

During the 1990 Census, housing units totaled 1,723 total with vacant 313 units. The majority of homes use individual water wells and septic systems, although the city operates a piped water and sewer system. Commercial development is concentrated along the Parks Highway. Estimated jobs in the community total 1,726 with approximately 30 percent of the work force commuting to Anchorage.

Lake Management Planning Area

The lake management planning area is located within the community of Big Lake but only includes the land within 1/4 mile of lake. The total land surface within the lake management planning area encompasses approximately 3,665 acres (5.7 square miles; this includes partial lots if greater than 50 percent of the lot falls within the study boundary). Land use and ownership information is based on an analysis of mapping and data compiled as part of the 1995 Big Lake Comprehensive Plan. Although it has been updated by the Borough in 1996, it may not reflect all of the changes resulting from the Miller's Reach fire. Based on historical Big Lake development, surrounding land uses, and recent construction, the majority of lands impacted by the Miller's Reach fire are likely to be redeveloped as seasonal cabins or permanent residences.

More than 2,761 acres (85 percent) of the land within the study area is privately owned. The state of Alaska is the second largest land owner with 382 acres (12 percent) and the Borough is third with 68 acres (See Figure 1-4: Land Ownership for the distribution of land ownership within the planning area). More than half of the land (1,869 acres) in the study boundary is classified as vacant. Residential is the second largest land use consisting of approximately 840 acres. Commercial development is minimal and concentrated on the east end of the lake (See Figure 1-5: Land Use). Table 1-2 tabulates land use within the study boundary.

Table 1-2: Lake Management Boundary Land Use

Land Use*	# of Lots	Acreage**
Residential	**750**	**840**
Commercial	**11**	**52**
Vacant	**783**	**1869**
Public Land	**25**	**452**
Borough	4	68
State of Alaska	22	382
University of AK	1	30
Church	1	10
Total	**1569**	**3213**

Source Matanuska Susitna Borough 1995
*95 lots/289 acres were partial lots with no records
**Acreage has been rounded.

Since development adjacent to the lakeshore can impact water quality by increasing the potential for pollutants and sediments to directly enter the lake from septic systems, surface water runoff, and erosion, only land uses with lake frontage are provided in Table 1-3. In addition, the density of waterfront lots can adversely impact fish and wildlife habitat and visual aesthetics, and result in a loss of public access and increased noise.

Table 1-3: Lake Frontage Land Use

Land Use*	# of Lots	Acreage**
Residential	**575**	**564**
Commercial	**8**	**35**
Vacant	**315**	**652**
Public Land	**13**	**217**
Borough	2	18
State of Alaska	10	189
Church	1	10
Total	**911**	**1468**

Source, Matanuska Susitna Borough 1995
*39 lots/38 acres were partial lots with no records
**Acreage has been rounded.

Properties along the east and south sides of Big Lake are accessible by road. The west end of Big Lake has limited road access near the channel to Mud Lake and the east side of Flat Lake. The north shore and a portion of the west shore of Big Lake, and the majority of Mud and Flat lakes, including all islands, are only accessible by water in the summer or ice roads during the winter. During periods of freezing and thawing, some properties can not be accessed; however, some homeowners use air boats during this time period.

Expansion of the road system in the Big Lake area was identified as a long-range goal in the Comprehensive Plan. Providing access around Big Lake was identified as a priority. Water and ice road transportation are also recognized by the community as an important part of the surface transportation system which provide access to non-road accessible properties. Residents support the private sector development of commercial water taxi services within the Big Lake area to provide access to non-road accessible properties.

Public Access

Public access to Big Lake is limited to the east end (Figure 1-6). Five private businesses provide boat launches and water-oriented services. Three of the businesses include marinas and together provide slips for approximately 241 boats and 10 personal watercraft. The largest of the marinas has 160 boat slips. A new marina, south of the Big Lake South State Park, will have approximately 126 boat slips and 72 personal watercraft slips. Fish Creek Day Park, a public use area on the east shore of Fish Creek, is owned by the Matanuska-Susitna Borough and operated by the Big Lake Chamber of Commerce. A private sailing club on the south shore of the west basin, provides boat launching and services for members.

A significant number of public easements that run between subdivided lots are dedicated by plat to provide access to Big Lake. The majority of these easements have not been developed or analyzed for feasibility of physical access. The Borough reports that a history of conflicts has been associated with the easements. Conflicts usually occur when a party without lake access wants to improve an easement to obtain access and adjacent landowners object.

Two state-owned parks, Big Lake North Wayside and Big Lake South Wayside, are located on Big Lake. Big Lake North Wayside is a 19-acre park on the northeast shore of Big Lake. Amenities include camp and picnic sites, toilets, a boat ramp, and a swimming beach. Big Lake South Wayside on the southeast corner of the lake is 48 acres and has camp sites, toilets, and a boat ramp. Alcohol is not permitted in the parks. Table 1-4 presents a summary of revenue generated in 1994 and 1995 from Memorial Day to Labor Day. According to State Parks, payment compliance is only 10- to 20-percent the park is unattended. Payment compliance is generally much lower at the South State Park as only random checks are conducted by State Parks.

Table 1-4: State Park Revenue 1994/1995

North Park	1994*	1995*
Boat Launch $5/launch	$4,460 892 launches	$5,400 1,080 launches
Day Use $3/day	$2,000 666 vehicles	$3,000 1,000 vehicles
Camping $10/night	$5,600	$7,700
Total	**$12,060**	**$16,100**
South Park	**1994***	**1995***
Boat Launch $5/launch	$2,500 500 launches	$2,700 540 launches
Day Use $3/day	$450 150 vehicles	$800 267 vehicles
Camping $10/night	$3,000	$2,500
Total	**$5,950**	**$6,000**
Grand Totals	**1,392 launches 816 vehicles $18,010**	**3,780 launches 1,267 vehicles $22,100**

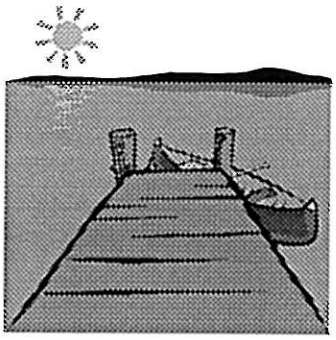
Source: State Parks 1997.
*Users with annual decal passes are not included.

Revenue generated from the two parks does not cover the cost of operation. Values from 1996 were not considered because of impacts to the recreational use of Big Lake from the Miller's Reach Fire.

Surface Water Use

Big Lake supports a variety of recreational activities enjoyed be residents, seasonal homeowners, and visitors. In the summer, the lake is used for transportation to and from cabins and homes, waterskiing, boating, personal watercraft, float planes, swimming, sailing, fishing, paragliding, boat tours, picnicking, wildlife viewing, hunting, and camping. In the winter, ice roads provide access and the lake is used for snowmachining, dog mushing, ice fishing, and cross country skiing. In addition, organizations and businesses within the area sponsor recreational events throughout the year such as the Big Lake Regatta, the Big Lake Fishing Derby, and various forms of ice and water racing including a snowmachine race on the lake in the summer and a motorcycle race on the ice in the winter. Most intensive use tends to be limited to weekends and holidays.

Docks



The Corps conducted an inventory of docks on Big Lake from a July 1996 aerial photograph. Based on this inventory, approximately 730 docks are on Big, Flat, and Mud lakes (Figure 1-6). Of these, only 40 (approximately 5 percent) have been permitted as required by Section 10 of the River and Harbors Act. The first permit at Big Lake was issued in 1984; nine permits were issued in 1996. Excessive numbers of docks and slips reduce the area of surface water available for surface water activities. According to the Corps, none of the unpermitted docks appear to pose navigational or resource problems at this time (Joy, 1996 - Personal communication).

ISSUES AND TRENDS

People are attracted to Big Lake, yet the closer they live to it, and the more they recreate, the greater the impact they may have on it. The saying "We are loving our lakes to death" is no exception to Big Lake. Throughout Big Lake's history, environmental conditions have indicated problems at Big Lake may be developing, including increased shoreline erosion, increased plant/algae growth, and declining fish populations. The single most important indicator of a decline in the overall lake experience is the fact that the community of Big Lake came forward and requested a lake management plan largely as a result of increased user conflicts, noise, congestion, accidents, injuries, and property damage. This section provides a general introduction to the environmental and social carrying capacities at Big Lake.

Environmental carrying capacity can be defined as the maximum level of land or water use that can occur before there is an unacceptable or irreversible decline in environmental values. In the case of Big Lake, the focus is on water quality and fish and wildlife habitat. Specific issues identified by residents, property owners, and resource agencies associated with environmental carrying capacity concerns include:

- Shoreline damage and bank erosion caused from wakes, especially on the east end of the lake near public use areas, and as a result of personal watercraft using Meadow and Fish creeks.
- Potential fuel pollution from boats, refueling operations, and vehicle parking on the lake in the winter.
- Half-burnt debris and litter from ice houses found floating in the lake in the spring.
- Impacts from septic systems which reportedly range from those that are properly installed and maintained to those that are not only improperly installed, but constructed from wooden cribs, buried cars with vent pipes, and 55-gallon drums.
- A change in the quality of drinking water. Several residents noted a change in the taste of their drinking water and have had their wells tested yearly. Laboratory tests have reportedly indicated the well water is safe to drink.
- Need to protect fish resources. Increased sedimentation may be adversely impacting fish populations.

Social carrying capacity is defined as the perceptions of lake users regarding how much crowding and conflict is acceptable before a decline occurs in the recreational or residential experience. Below is a summary of key issues identified during the public process:

- Reckless boating and operation of PWC, and operating watercraft while intoxicated are commonly observed on the lake. Two fatalities occurred in 1994 as a result of boating while intoxicated. In 1997, a PWC collided with a boat while jumping wakes, injuring 3 people.
- Conflicts between users (motorized, non-motorized, float planes, water skiing, swimming, and PWC) is increasing.
- The amount of noise is increasing.
- Lack of enforcement of existing regulations is contributing to the boating safety issues.
- Lack of education on how to operate watercraft and use the lake safely is contributing to public safety issues.

Defining an environmental and social carrying capacity is complex. A single or combined carrying capacity cannot be defined for Big Lake without extensive data collection and monitoring. The scope of this lake management plan is to begin to define a preliminary environmental and social carrying capacity; identify potential threats to the water quality of Big Lake, and in turn, its fisheries, wildlife habitat and recreational opportunities; and develop a set of management actions to ensure the health of the entire system.

Environmental Carrying Capacity

Land use within the watershed and especially along the shoreline adjacent to Big Lake can have a major impact on the health of the lake system. The number of sewage disposal systems, the intensity and type of land use development and lot sizes, the distance to roads, and the amount of land devoted to public use are indicators of a lake's vulnerability to pollution (Sargent, 1991). Secondary activities associated with development such as oiling and compacting of roads and driveways, fuel spills, the improper use of toxic substances such as paints and solvents and preservatives like creosote for dock and pier construction, lawn maintenance, paved surfaces, and dog lots can also adversely impact water quality.

One indicator of a lake's vulnerability to pollution from land use is the relationship of the watershed area to the lake volume. The smaller the lake is in relation to the land that drains into it, the less ability the lake has to accommodate nutrients and sediments entering the lake. The Big Lake watershed-to-lake ratio is approximately 14.5 to 1, which is in the moderate range. A ratio of 10 to 1 or less is considered a small watershed (EPA, 1990). The watershed-to-lake ratio suggests the lake may be vulnerable to activities in the watershed. However, the numerous muskegs, lakes, and ponds in the watershed provide filtration of most contaminants before they reach Big Lake. Therefore, from a land use standpoint, the lake is most vulnerable to activities at the lake shoreline and immediately adjacent to the tributaries (Meadow Creek) that flow directly into the lake.

Based on the 1983 water quality study of Big Lake, the lake can generally be classified as oligotrophic, meaning that there are no regular occurrences of algal blooms; the water is clear and has abundant dissolved oxygen. Periodically, the lake has an increase in suspended sediments (turbidity) and the deeper waters are depleted of oxygen. Additional water quality studies on Big Lake have not been conducted since the 1983 study. It is important to note that the two main communities in the watershed have experienced a substantial growth in population since the last water quality study. In 1980, the Big Lake community had a population of 410; in 1990 it increased to 1,477. Wasilla had a population of 1,559 in 1980 that grew to 4,028 in 1990. The 1996 Big Lake Comprehensive Plan indicates that the population of Big Lake will continue to increase and reach a population of approximately 2,139 by the year 2005. The growth to date may have caused changes in water quality that have not yet been documented.

Land Use Impacts

The type and intensity of development can have a direct impact on water quality and the acceleration of erosion, siltation, and turbidity. Development usually brings with it an increase in paved or compacted surfaces, a reduction in native plants and grasses, and in the case of Big Lake, an increase in on-site septic systems. In addition, pedestrian and vehicular traffic may also contribute to shoreline damage by destroying vegetation and weakening banks. Docks and other structures interrupt the natural shoreline movement of water and redirect erosive forces in unexpected directions.

The highest density of development around Big Lake occurs on the east side of the lake and along areas of the shoreline where road access is available. Developed land is largely single-family residential in nature. Single family use encumbers approximately 840 acres, or 26 percent of the total acreage in the lake management planning area.

Approximately 564 acres of lakefront property is developed as residential. Public use areas including boat launching sites, public and private beaches, parks, marinas, and campgrounds are concentrated on the east end of Big Lake and comprise 44 acres of the lakefront.

A significant amount of undeveloped, subdivided land exists within the study boundary. Approximately, 1,869 acres (58 percent) are undeveloped in the study boundary and of those, 652 acres (44 percent) front the lake. The amount of vacant land in the study area indicates a low intensity of development; however, the potential for future development is significant.

Much of the subdivision activity in the area occurred prior to the adoption of the subdivision regulations that currently require a minimum lot size of 40,000 square feet if using on-site septic systems. Additionally, for properties fronting the lake, 125 feet of lake frontage is required as well as a structural setback of 75 feet from the waterbody. Substandard lots are a concern to management of Big Lake because of the potential for the following negative impacts:

- Inadequate room to separate well and septic systems on the lot itself and from adjacent lots and water bodies.
- Lack of sufficient area for absorption/leach fields that could negatively impact water quality.
- Density of uses and impacts to lifestyles.
- Lack of buildable area and the need for lot setback variances.
- Increase in runoff and erosion.

Substandard lots can be developed as long as the required setback distances from property lines, rights-of-way, and waterbodies can be met. If a lot is too small to permit development in compliance with current regulations, the property owner must apply for a variance from the Borough.

A variance grants a special exception to a law. Existing lot sizes within the study boundary are tabulated in Table 2-1 and illustrated in Figure 2-1. The lot sizes are classified according to the current subdivision ordinance.

Table 2-1: Lot Sizes

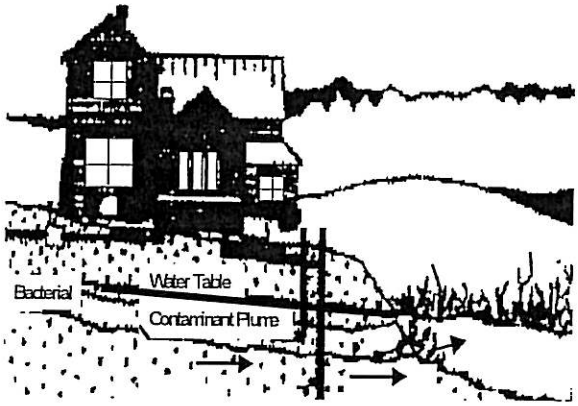
Number Lake Front Lots	
Less than 40,000 sqft, less than 125 feet	498
Less than 40,000 sqft, more than 125 feet	169
More than 40,000 sqft, less than 125 feet	75
More than 40,000 sqft, more than 125 feet	236
Number of Lots Without Lake Frontage	
Less than 40,000 sf.	439
More than 40,000 sf.	279
Source: Matanuska Susitna Borough 1995	

Of the developed residential lakefront lots, approximately 310 lots (133 acres) are less than 40,000 square feet and have less than 125 feet of lake frontage. Approximately 160 vacant lakefront lots (69 acres) have less than 40,000 square feet and 125 feet of frontage. Information on the number of structures closer than 75 feet to the shoreline is not available.

The higher the percentage of "substandard" lots, the greater the risk of surface water runoff and sediments entering the lake, both of which carry nutrients such as nitrogen and phosphorus. The result can be a localized reduction of water clarity, an increase in plant growth, and a reduction in dissolved oxygen levels and fish spawning areas. Also associated with development is an increase in litter and the use of pesticides.

Septic System Impacts

When septic systems are installed within 200 feet of a lakeshore, there is a risk that some of the nutrients, bacteria (fecal coliform), and other pollutants can enter the lake. Adequately sized, properly maintained, and regularly inspected septic systems should provide adequate on-site treatment; however, malfunctioning septic systems can result in unwanted nutrients or bacteria entering the lake through surface water or groundwater.



The 1983 water quality study indicated that Big Lake had a high ratio of phosphorus-to-nitrogen during the summer months (Woods 1983). This is important because if both nitrogen and phosphorous are abundant, plant productivity is high, if either is scarce like the nitrogen in Big Lake, plant productivity may be low. As a result, additional inputs of nitrogen into Big Lake could significantly increase algae growth. Discharges high in nitrogen include runoff from fertilized lawns and seepage from septic systems. An increase in algae growth will lead to decreased levels of dissolved oxygen and increased organic matter. In turn, these changes will adversely impact fish spawning areas, and cause a decline in aesthetic quality and recreational values resulting from unpleasant odors and decreased water clarity.

Currently, approximately 575 residences, 8 commercial businesses, and 2 state parks front the lake and use on-site septic systems. ADEC regulations require all systems be designed properly and located a minimum of 100 feet from all surface water or wetlands; however, systems are not inspected nor monitored for compliance. Most sewage disposal systems are thought to be standard septic-tank and drain field systems, although comprehensive data as to design, condition, and groundwater flow characteristics are not available (Pinard, 1997). These systems may contain high concentrations of nitrogen species such as ammonia and may discharge wastewater that is not completely treated into Big Lake or it's tributaries.

Residents of Big Lake report that macrophyte cover has been expanding in recent years near the outlet of Meadow Creek and adjacent to densely populated areas. This could be evidence that the nutrient level has been significantly modified (i.e., that resource carrying capacity of the oligotrophic system is being exceeded). Seepage from septic systems appears to be the greatest source of nutrients and fecal coliform bacteria to Big Lake. This can only be confirmed by water quality monitoring and/or development of a nutrient loading/lake response model.

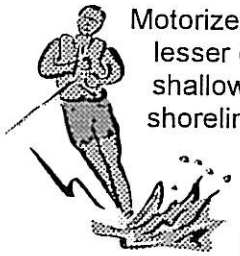
Public Access Impacts

Road construction and maintenance (i.e., clearing, grading, paving, ditching, and culvert construction), parking lots, and high use public access areas where soil compaction and loss of vegetation occur can result in increased erosion and transport of sediments and nutrients to surface waters. These materials can also be present in runoff from winter road maintenance. In addition, roadway and parking lot runoff is a potential source of heavy metals such as lead, chromium, zinc, and cadmium which can be toxic to humans, fish, and wildlife.

Roadway construction, parking lots, and high use public access areas in the immediate vicinity of Big Lake have not been extensive. Currently, the south and southeast portions of the planning area are relatively well-serviced by roads, although many are unpaved. The remainder of the lake has limited road development. Vacant land tends to be concentrated in areas not accessed by roads.

Most roads are not adjacent to the shoreline. As a result, the road system is not expected to have much influence on water quality. Increased erosion, sediments, and nutrients resulting from public access is likely to be localized and concentrated at the east of the lake near the state parks, commercial marinas, and parking areas.

Surface Water Use Impacts



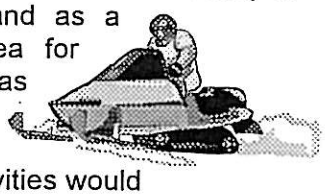
Motorized boating, PWC and, to a lesser extent, floatplanes can disturb shallow sediments and cause shoreline erosion, reducing water clarity, destroy and/or disperse macrophytes, disturb fish and wildlife, and introduce contaminants during operation, repair, and refueling.

Highly turbid water conditions have been reported on Big Lake during and for a few days after a busy summer weekend. These impacts are the direct result of motorized activity in or near shallow areas of the lake. Depths of less than 10 feet are the most likely areas to be impacted by propeller and water jet-induced turbulence (Yousef et al., 1978). However, larger boats (at medium speeds) and PWC are thought to disturb fine-grained sediments to depths as great as 20 feet (Wagner, 1996). Snowmachine racing on the water in the summer months also causes localized turbidity. Additionally, property owners have reported increased shoreline erosion near the public use areas on the east end of the lake. Erosion is largely attributed to the wakes from boats and personal watercraft entering and leaving the use areas. Decreased water clarity and increased sedimentation are the primary effects of increased turbidity and erosion. In turn, the disturbed sediments release nutrients that have settled to the lake bottom resulting in a possible increase of algae blooms.

Big Lake is also likely to experience small fuel spills at launch ramps, docks, marinas, and during spring breakup resulting from oil drips from parking on the ice. Fuel spills may also result from the occasional vehicle or snowmachine falling into the lake, and from snowmachine racing on the lake in the summer months. Engines are another source of potential contamination to the lake. Engine sources include crankcase condensate discharges, fuel vapor discharges, and gas emissions. Old (pre-1972) outboard motor engines can waste as much as 50 percent of their fuel through these discharges (Jackivicz and Kuzminski, 1973). Fuel waste in modern engines is typically less than 1 percent (Wagner 1990).

Non-motorized boating, swimming, and other passive uses are unlikely to have a significant impact on the environment with the exception of potential shoreline and fish and habitat damage resulting from accessing the lake.

During much of the year, the frozen lake surface of Big Lake is used as a roadway to access residences and as a winter recreation area for activities such as snowmachining and special event racing.

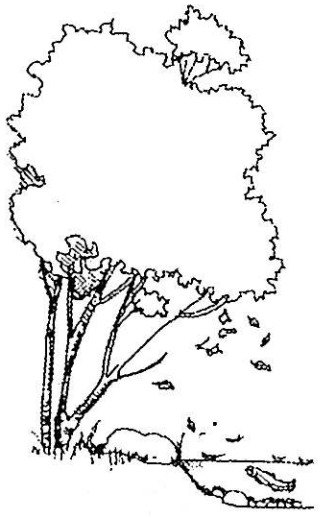


Generally, these activities would have little or no effect on the lake environment. Debris and spilled fuel may accumulate on the ice but typically the debris will be dispersed within the lake following ice breakup. Ice fishing seems to pose little to no threat to the lake system; however, impacts may result from associated litter, debris, and ice houses regularly falling into the water. Miscellaneous debris found floating in the water could impact fish and wildlife habitat, damage float planes and boats, as well as being aesthetically unpleasing.

Impacts to Fish and Wildlife

Although no critical nesting habitats have been identified by ADF&G, Big Lake does provide habitat for numerous waterfowl, primarily ducks and loons. The ducks and loons tend to be concentrated near the mouth of Meadow Creek, Flat Lake, the north side of Mud Lake, and in the west basin of Big Lake along the southern shoreline.

Fish habitats are highly sensitive to disturbances that negatively impact water quality, alter important shoreline or riparian vegetation, or introduce sediments or contaminants to the lake system, including neighboring wetland habitats. Removal of overstory vegetation can cause a decrease in dissolved oxygen and intergravel flow through loss of shading (warming of water reduces the amount of oxygen it can hold), and the introduction of sediments and organic materials that take oxygen from the water as they decompose. Areas of greatest concern to Big Lake are shown in Figure 1-2 as "areas of cultural influence" where development has largely replaced native vegetation.



Changes in fish habitat were first noted in the mid-1960s to late 1970s, when sockeye salmon populations in the Big Lake watershed were strongly depressed. No comprehensive assessment of the quality or productivity of spawning areas in the Big Lake watershed was conducted to determine the exact cause of the declining fish population, nor has one been done since. The Big Lake Hatchery was constructed in 1976 in response to declining populations to produce and release sockeye salmon fry. In 1983, the ADF&G reported anaerobic (low oxygen) conditions in Big Lake as potentially impacting fish populations. This condition was linked to sewage input from surrounding development, although no data was collected to verify this. During a 1988 ADF&G field investigation, lack of fish in areas of unauthorized bank stabilization and lake fill, and where shorelines had disturbed vegetation were noted. Fish were found near docks and along vegetated shorelines that provided protection. ADF&G has also recently expressed concern regarding localized habitat damage resulting from unauthorized filling along the shoreline and increased sediment in the lake (Gilleland, 1997 - Personal communication). Sediment and siltation of fish spawning gravels along the shoreline may be occurring during periods of high boat use and from eroding banks.

Commonly used nitrogen fertilizers for lawn care are relatively non-toxic to aquatic organisms. However, accelerated blooming of aquatic plants can result from excess nitrogen and phosphorus entering into streams, lakes, or wetland environments through surface runoff, storm water drainage systems, or from septic waste disposal systems. A significant increase in nutrients can lead to serious problems with depletion of dissolved oxygen in the water, particularly during the winter as the organic material decomposes under the ice cover.

Fish harvests in Big Lake are reportedly stable at this time, including naturally occurring Arctic char. Pike, an aggressive predatory fish not common to the lake system, has been rumored to be in Meadow Creek and could severely impact the Big Lake system (Gilleland. 1997 - Personal communication).

Environmental Carrying Capacity Summary

Based on available information, it appears that Big Lake is experiencing a decline in environmental conditions. Increased development along its shorelines and in the watershed may be upsetting the lake's natural balance. Seepage from septic systems, surface water runoff carrying sediments and nutrients, increased turbidity from recreational watercraft, and boat wakes causing shoreline erosion have been attributed to an increase in plant production, a decrease in oxygen levels, and declines in fish populations throughout the history of Big Lake. With more than 50 percent of the land around Big Lake available for development and documented growth of the community and surrounding region, Big Lake will continue to grow in popularity. This means more structures, more septic systems, more surface water use, and more risks to the lake system.

Since no regular water quality monitoring of Big Lake has taken place, the need to establish a baseline water quality level and periodic monitoring thereafter, is vital to clearly define potential problems and solutions to ensure the continued health of the lake.

Without proper management of the lake system, Big Lake's environmental carrying capacity will continue to be threatened until one day it is irreversible or unacceptable. Table 2-2 identifies potential risks to the environmental carrying capacity of Big Lake and the possible causes and effects of allowing the problems to continue.

Table 2-2: Characteristics of Water Quality Problems

Potential Problem	Possible Causes	Possible Results
Erosion, Siltation, Turbidity	❑ Buildings, roads, parking lots, and land cleared for development increase the amount and speed of runoff ❑ Damage to lake banks from vehicular and pedestrian traffic and intensive use. ❑ Shoreline erosion and sediment churned from boat and PWC	❑ Decreased water transparency and photosynthesis ❑ Clogged aquatic animal gills, smothered eggs ❑ Less variety of fish ❑ Impaired use of shallow water by boats ❑ Increased maintenance of recreational equipment
Increased Nutrients	❑ Overuse/misuse of lawn fertilizers ❑ Improperly treated sewage ❑ Runoff, erosion ❑ Boating and PWC activity releasing nutrients from lake sediments	❑ Increased algae and aquatic macrophytes ❑ Decreased transparency ❑ Decreased dissolved oxygen resulting in stress on aquatic animals ❑ Decline in fish
Coliform Bacteria	❑ Improperly treated sewage ❑ Erosion ❑ Waste from waterfowl and pets	❑ Diminished swimming from skin rashes ❑ Intestinal problems from viral infections
Insecticides Herbicides	❑ Chemicals from dust control, snow, and ice melt ❑ Pest and weed control	❑ Health effects on wildlife and fish resulting in population declines ❑ Increase or decrease in algae and macrophyte growth
Fluctuation in Water Level	❑ Changes in management of the water level at Fish Creek	❑ Possible water temperature change resulting in impacts to vegetation, fish, and wildlife ❑ Decrease in rooted aquatic plants resulting in less fish spawning ❑ Can make docks unusable ❑ Diminished use of waterway
Grease, Oil, Gasoline	❑ Fuel discharge from marinas ❑ Roads and parking lot runoff ❑ Operation and maintenance of watercraft ❑ Vehicle/snowmachine submersion	❑ Decrease in plant and animal populations ❑ Diminished aesthetic appeal ❑ Decline in fisheries ❑ Increased maintenance of recreational equipment
Trash	❑ Littering ❑ Ice fishing activity debris	❑ Decreased aesthetic appeal ❑ Habitat destroyed ❑ Damage to boats

Social Carrying Capacity

Big Lake's growing popularity can be attributed to its size and, perhaps more importantly, to its location. The region has shown incredible growth in the last 30 years. From 1960 to 1990, Anchorage grew by 173.2 percent and the Borough grew by 664.9 percent (Department of Labor, 1991). From 1980 to 1990, the community of Big Lake increased by 1,067 people and 1,363 new houses. Located only our 1½ hours by driving time from Anchorage and within the Matanuska Susitna Borough, Big Lake is easily accessible for seasonal cabin owners and recreational users. Permanent residents enjoy the lake experience and still have ample employment opportunities and support services in the community itself, Palmer, Wasilla, and Anchorage. The common and uniting theme throughout the lake management planning effort has been an overriding concern for public safety and the increase in recreational users on Big Lake.

Overcrowding

Overcrowding can impact the ability to safely maneuver boats, floatplanes, and PWCs, resulting in more conflicts as competition for space increases, increased noise disturbing both residents and wildlife, increased accidents and injuries, and additional environmental degradation.

Big Lake, which is over 3,000 acres, is physically able to accommodate a large number of lake uses ranging from high speed water craft to more passive recreation; but only if these activities are conducted in a responsible manner. In addition, the numerous islands and bays within the lake provide areas of sheltered waters. Mud and Flat lakes are also open to most lake uses as the channels are passable to all but the largest boats.

It is a common practice in lake management planning to estimate "spatial carrying capacity" limits or the maximum number of boats that can safely and efficiently use the lake. Ideally, spatial carrying capacity should consider the size, depth, and shoreline configuration; however, the typical approach is to express a general standard as acres per boat. User satisfaction and conflicts between different users are rarely taken into account (Sowman, 1987; Zwick Associates, et. al., 1991).

A depth of 10 feet or more is typically used as the basis for calculating recreational "boatable" acreage (Wagner 1996). Based on this depth, Big, Mud, and Flat lakes would have a total boatable area of approximately 2,761 acres. Other than adjacent to the shoreline, Big Lake does not have extensive shallow areas where boating is restricted. However, Meadow Creek and Fish Creek are very shallow where they intercept Big Lake, restricting navigation into and out of the lake to small boats.

To illustrate how capacity standards might be applied to Big Lake, a mid-range capacity value has been identified. This value is based on results from a comprehensive review of capacity standards used throughout North America for several types of boat uses (Zwick Associates, et al., 1991). Total theoretical spatial capacity for Big Lake was then calculated using the total boatable acreage (Table 2-3).

Table 2-3: Spatial Carrying Capacity

	Non-Power	Power (<10 hp)	Power (unlimited)	Sailing	Water Skiing	Fishing
Range of Spatial Capacity Limits * (acres per boat)	0.33 - 1.5	0.5 - 20	3 - 18	0.25 - 8	3 - 40	0.2 - 10
Mid-range of Spatial Capacity* (acres per boat)	0.92	10.25	10.5	4.13	21.5	5.1
Calculated Big Lake Capacity** (total boats in lake)	3001	269	262	669	128	541

* Source: Zwick Associates 1991
** Based on total boatable area of 2,761 acres

Actual boat use within Big Lake has not been quantified as part of this study, so a direct comparison to capacity limits presented in literature presently is not possible. However, it is possible to develop a scenario based on the number of docks (730) on Big Lake and the number of slips at the marinas. If it is assumed that 50 percent of those who own docks also own a power boat or PWC, and that half of those watercraft owners are out on the lake on any given weekend day, that would equal 183 boats/PWC. Next we could assume that 25 percent of those who use the boat/PWC slips at the marinas (449 total slips including the new marina) are on the lake, putting an additional 224 boats/PWC in Big Lake for a grand total of 407 boats/PWC on the lake. This number does not include the number of boats/PWC being launched at Big Lake Park South and Big Lake Park North or any of the other commercial boat launches. Based on the above estimate, Big Lake is being used at the medium to high range of its spatial capacity for watercraft with engines larger than 10 horsepower. This number does not consider all of the other uses occurring on the lake during the weekend such as waterskiing, swimming, non-motorized boating, and float planes. Taking into account these additional uses, Big Lake may be at risk of exceeding its spatial carrying capacity on weekends.

Conflicting Uses

The eastern-most basin of Big Lake has been identified as having the most user conflicts associated with congestion and conflicts that tend to peak during weekends and holidays. This can be attributed to its road access, proximity to services, and the concentration of commercial and public use areas. The number and type of surface water uses, alcohol use, irresponsible behavior, and the lack of enforcement are threatening public safety and causing near misses, accidents, and property damage.

User conflicts and congestion may be partially attributed to public access and services being limited to the east end of the lake which tends to cause users to concentrate in this area. The State of Alaska, excluding the North and South state parks, owns 8 lots (161 acres) around Big Lake; however with the exception of two parcels, one between Big Lake and Mud Lake, and one between Mud Lake and Flat Lake, there is no road access. With severe budget constraints and the two existing state parks operating at a deficit, it is unlikely these two parcels would be improved and maintained by the state for public access.

The Borough owns 2 lots (18 acres), neither have road access. The Borough also owns a third lot with road access adjacent to the Sailing Club, which is currently leased. This could potentially be developed and maintained by the Borough.

Other potential public access points that could be improved and serve to disperse congestion at the east end of the lake are easements dedicated on paper during past subdivision developments. According to the Borough, there are more dedicated easements than necessary and improving some of them have caused conflicts among neighbors. Often the easements run between two developed lots, and property owners are concerned about trespassing, noise, and loss of privacy as non-lake front owners and other recreational users gain access to the lake. According to the Susitna Area Plan when lakefront property is conveyed to private ownership, a minimum 50 foot pedestrian easement will be reserved along waterbodies.

Alcohol, irresponsible behavior, and lack of boating knowledge and enforcement of existing regulations are also directly attributed to user conflicts, accidents, and congestion.

Noise

Residents at Big Lake report that noise levels from boats, PWCs, and other lake activities are increasing and often continue long into the night. Residents tend to find late night and early morning noise the most disturbing and define it as "repetitive" noise associated with power watercraft circling in coves or in front of docks.

Noise is a subjective term that refers to unwanted sound. While the noise from powerful engines may not be offensive to waterskiers and boaters, it may disturb individuals on the shore, especially late at night. The three primary components of sound are intensity, frequency, and harmonics. We interpret sound intensity as loudness and perceive frequency and harmonics as pitch and quality of sound. Not everyone will perceive a sound in an identical manner but loudness readings provide the best appraisal of how loudly most people will hear a sound. Loudness is measured in decibels {dB(A)}. When sound levels exceed 75 dB(A), they typically start becoming a nuisance (Wagner, 1994). Approximate decibel readings for typical lake activities are as follows:

- A still quiet evening on a lake is 40 dB(A).
- Conversational speech is 60 dB(A).
- Background levels on a busy beach range from 50 to 60 dB(A) with peaks of 70 to 80 dB(A).
- A person riding in an outboard power boat would experience 80 to 100 dB(A).
- A PWC operator would be exposed to 85 to 105 dB(A)
- Jet boats may have sound levels exceeding 110 dB(A).
- Propeller aircraft are usually in the range of 120 dB(A).

Boat sounds are generated by both the engine and the boat hull. Sound levels increase with the speed of operation, however, it is not necessarily true that the bigger the engine, the louder the boat. The sound created by a boat depends on the interaction of the boat with the water surface. Hull-induced noise can be significant. Also impacts to the receptor (the individual hearing the noise) depends on whether the noise is constant and the time of day. Most people find a constant drone and day time noise less annoying than intermittent sounds above average ranges and late night noise. In one noise study, a constant sound of 90 dB(A) was perceived as less annoying than an intermittent sound of 75 dB(A). This may help to explain why more people tend to be annoyed by PWC than boats since the changes in loudness and pitch for PWC are much greater than for most boats.

The National Marine Manufacturers Association (NMMA) and National Association of Safe Boating Law Administrators (NASBLA)

have prepared model watercraft noise regulations. NMMA recommends a maximum of 75 to 90 decibels at the power source, depending on whether the boat is moving or stationary. NASBLA recommends an 88 decibel maximum.

Social Carrying Capacity Summary

Big Lake appears to be at risk of exceeding its social carrying capacity on sunny weekends and holidays both in terms of its estimated spatial carrying capacity and public perception. Communication with lake users, property owners, residents, and regulating agencies indicates that overcrowding, user conflicts, and increased noise levels are excessive on sunny weekends and holidays. Big Lake may sporadically exceed its social carrying capacity during these times. The east basin of the lake is perceived to experience a decline in the recreational experience more often than the rest of the lake due to the concentration of users taking advantage of public access and services. Threats to public safety and the probable cause of most accidents, conflicts, and increases in noise appears to be attributable to a combination of operator carelessness or error, irresponsibility, lack of enforcement, and lack of appropriate access to the lake, rather than the social carrying capacity continuously being exceeded.

If Big Lake continues on its present course, conflicts and congestion will continue to remain unchecked resulting in an overall decline in the recreational experience. With proper management of the lake, threats to the social carrying capacity can be addressed and ameliorated, before they escalate. Table 2-4 identifies potential indicators of social carrying capacity problems associated with its increased use and potential causes.

Table 2-4: Characteristics of Social Carrying Capacity Problems

Problem	Possible Causes	Possible Results
Accidents and Near Accidents	❑ Lack of boating safety education ❑ Reckless operation ❑ Boating while intoxicated ❑ Hazards on the waterway ❑ Conflicting uses	❑ Injuries or Deaths ❑ Property Damage ❑ Fines and Imprisonment ❑ Decline in recreational experience ❑ Loss of business
Overcrowding	❑ Location and popularity of lake ❑ Lack of dispersed access ❑ Uncontrolled shoreline management ❑ Conflicting uses	❑ Users moving to other lakes, loss of business ❑ Decline in recreational experience ❑ Increased noise ❑ Increased accidents
Conflicts Among Lake Users	❑ Non-compatible uses (fishing, power boating, waterskiing, PWC, floatplanes) ❑ Lack of information and education ❑ Reckless operation ❑ Boating while intoxicated ❑ Hazards on the waterway	❑ Increased accidents ❑ Property damage ❑ Decline in recreational opportunities and enjoyment
Conflicts between Lake Users and Adjacent Land Owners (e.g., trespassing, noise)	❑ Users may not know land is private ❑ Lack of designated public use areas ❑ Lack of information and education ❑ Easements between developed lakefront lots ❑ Reckless operation ❑ Lack of courtesy	❑ Property damage ❑ Lawsuits ❑ Loss of "community" spirit ❑ Decline in recreational opportunities and enjoyment

MANAGEMENT ACTION PLAN

The community of Big Lake is in the unique position to take a proactive approach to address existing problems and find community-based solutions through lake management. Weed growth problems are not so extensive that chemical treatment is required, or lake use conflicts so extreme that certain uses must be banned from the lake. Preventive management guidelines and regular water quality monitoring can be used to: (1) reduce the amount of nutrients and other pollutants entering the lake; (2) control soil erosion and runoff; (3) improve enforcement of regulations; and (4) promote public safety and encourage appropriate behavior before irreversible harm is done in terms of both environmental and social values. A large number of issues and apparent trends have been identified as well as the limits of our understanding of the processes at work. The resolution of these issues are the focus this Management Action Plan and are summarized in detail below:

- Based on available water quality data and anecdotal information regarding increased plant growth, the lake appears to be experiencing an acceleration of the natural process of nutrient eutrophication. The primary cause is likely leaking septic systems along the lake shoreline and adjacent to the stream channel in Meadow Creek. Although the severity of the problem is unknown, the potential for serious problems is particularly high given:

  - ✓ The lake is sensitive to nitrogen inputs (found at high levels in septic waste and lawn fertilizers).

  - ✓ Septic system installation and maintenance is largely uncontrolled.

  - ✓ Lakeshore and streamside development is expected to increase based on area population growth and the number of vacant lots.

- There is a real need for a water quality data collection program. The main areas that should be addressed include the water budget and internal circulation patterns, and sources of contamination especially nutrients, sediments, and bacteria.

- Based on direct observations from residents, recreational users, and environmental regulators, it appears that sediment disturbance and shoreline erosion caused by power boats and PWC are causing temporary and localized cases of water turbidity. It tends to be worse during busy summer weekends This is a high priority problem because:

  - ✓ It likely contributes to eutrophication (i.e., the release of nutrients from the sediments provides food for algae growth).

  - ✓ It may be a factor in the observed decline of fish populations (smothering of eggs, disturbance of feeding and spawning activities).

  - ✓ It is expected to get worse as recreational uses continue to increase.

- Several homeowners have noted a change in the taste of drinking water from local wells. Likely sources of contamination are nearby septic systems. Although no health hazards have been identified, this is perceived as a potential problem that should be addressed now because:

- Many more wells and septic systems will likely be constructed around the lake in the future; and

  - ✓ There is little information available on the extent of and interaction between Big Lake and local groundwater supplies.

- Localized littering (from parks, icehouses, etc) and fuel spills (docks, marinas, cars on the ice, and snowmachine races on the water) are a growing problem. Although the impact to overall lake water quality is not high today, it could be in the future and the problem is significant from an aesthetic standpoint. The cause is thought to be a lack of responsible behavior by some of the lake users.

- There is a relatively high probability that fecal coliform levels are high and moderate to high at certain shoreline locations, representing a potential health hazard to summer contact recreation. The primary suspected source is partially-treated sewage from non-conforming septic systems. Secondary sources would include feces from resident waterfowl.

- Declines in salmon and trout fisheries have been observed in the past, however, it is unknown whether this trend is continuing. ADF&G reports the harvests are currently steady; however, given the importance of the fishery any potential threats to the population should be identified.

- Generally, Big Lake does not provide a particularly high quality of unique habitat for wildlife species, although Flat Lake, Mud Lake, the mouth of Meadow Creek, and sheltered coves do attract birds such as loons. The development of remaining shoreline lots and associated structures could significantly reduce existing habitat.

- Several accidents and near-accidents have occurred because of reckless boating and PWC operation, as well as boating while intoxicated. This problem is life threatening and deserves immediate attention. The primary cause appears to be irresponsible behavior, lack of information about safe boating, and misuse of alcohol.

- General overcrowding has also begun to impact user satisfaction, particularly on sunny weekends. This has led to conflicts between incompatible uses. Typical concerns expressed by lake users include reduction in maneuvering room, wake generated chop, and increased noise disturbance. Particular attention has been directed towards PWC, racing boats, water skiers, and float planes.

- Little concern has been expressed about the visual impacts of shoreline development; however, as more and more development occurs, this may become a future issue.

The remainder of this chapter focuses on management actions. A summary of management alternatives is presented, followed by a detailed discussion of each alternative as it relates to the key issues stated above. Based on research, experience from other lakes in the nation, agency and public comment, and focus group and planning team discussions, an array of possible implementation strategies for each management technique is presented.

Management Alternatives

Public waters are held in trust for all people by the state. Effective management actions need to be sensitive to the rights of land owners, lake users, and financial requirements of developers and commercial businesses. Management guidelines cannot operate to restrict non-residents nor can they unreasonably interfere with the basic rights of private property owners or the public gaining access to the water. Management actions should be equal to the local ability to enforce them. Most users favor stricter enforcement of existing rules rather than developing new ones. New rules and regulations are sometimes necessary to enhance boating safety and protect resources.

To address the existing and potential risks to the environmental and social carrying capacity of Big Lake, an initial list of management alternatives was developed. A preliminary screening of the management alternatives was then conducted by the Citizen's Advisory Committee and focus groups based on the characteristics of Big Lake, cost, acceptance, ease implementation, effectiveness, and enforcement. Five management alternatives were dropped from the initial list:

- New boating safety laws - This management alternative is recommended for future implementation depending on changing technologies, levels of resource use, and types of uses. Until new boating safety laws are needed, existing laws should be enforced because they are adequate for the boating technologies, types of uses, and levels of use at Big Lake.

- Require public notification of all major new developments- This was not viewed as a priority and again, the perception maintains that if existing laws were enforced, and existing methods of informing the public are used (e.g., community council, letters to adjacent land owners), residents would be notified.

- Volunteer Lake Watch - A similar effort was attempted by property owners around Big Lake in response to burglaries. It places an unfair burden on year-round residents and the same people tend to always volunteer. In addition, even if violations were reported, the agencies may not respond due to a lack of resources.

- Special District Land Use Zoning - This management alternative is being addressed through the Comprehensive Planning Process.

- Borough Management of State Parks - This alternative was not carried forward due to funding and revenue considerations.

Table 3-1 highlights the list of management actions that were recommended for further consideration and the opportunities and challenges associated with each one.

Table 3-1: Management Alternatives

Technique	Opportunities	Challenges
Information and Education	When people are informed, they tend to do the right thing. Wide-range application including boating safety, habitat protection, septic system compliance, identification of winter snowmachine trails, and proper use of local ice roads. Relatively inexpensive. Year-round use.	Requires personal responsibility. Some people won't conform. No enforcement. Who develops and distributes information? It could be expensive.
Lake Advisory Board	Property owners and lake users would form an advisory board and regularly inform Borough planners about lake status.	Requires volunteer time of property owners and lake users.
Safety Classes	Promotes boating safety. Educates. Could use a variety of media, like posters in a store. Could be associated with violations; multiple violations requires attendance at a safety class.	Who does the training and bears the cost? How do you get people to take classes? Classes need to be offered on a regular basis. Equipment already comes with safety videos.
Licenses for Minors	Increases safety. Prevents shoreline erosion and protects habitat through education. Starts operators off right and there is a history of licenses for minors. May facilitate insurance for kids.	Compliance. Enforcement. Expense. Who is responsible for licenses?
Water body Setbacks	Protects water quality, habitat, and aesthetics. Best Management Practices promotes flexibility and may be cheaper than a set distance. Increases property values. Educational.	May be too complicated. Who inspects setbacks? Need to define criteria. What about existing structures and variances? Cost?
Develop New Roads	Provides access to west end, easing congestion on east end. Expansion of existing road system is recommended in the Comprehensive Plan. Opens land for development, increasing tax base.	Cost of building and maintaining road may be prohibitive. It would take money from other road projects. May increase overall lake use and privacy may be lost.
One-Stop Land Use Permit	It would facilitate permitting process. Less confusion about what is required. Simplicity.	Cost. Requires more staff and interagency agreements. May be viewed as another permit.
No Wake Zones	Reduces shoreline erosion, protects habitats, makes congested areas safer, reduces conflicts, property damage, and noise.	May be difficult to agree where the zones should go. Enforcement. Need to educate users.
Classification of Public Access	Vacation of unneeded access. Prevents over access to lake and allows areas to be designated for conservation. Relieves congestion by redistributing people. Protects property values. Reduces neighbor conflicts.	Could be arbitrary. May hurt some property values. If access is limited, existing points may become even more congested.
Ice House Registration	Controls litter/debris and location. Allows identification of owner if there is a problem.	Will be viewed as another permit. Can Borough issue permit on a state lake?
Registration of Watercraft	Fees could be used for lake improvements, education, and navigation aids. Allows for identification of violating operators. Helps prevent theft.	Compliance and enforcement. Viewed as another tax. Can funds be directed to Big Lake?
Quiet Hours	Easy to implement. Reduces neighbor conflicts and late night/early morning noise. Could be limited to holidays and weekends.	Enforcement. May be viewed as too restrictive for a recreational lake.

Information/Education Campaign

Objective: Provide more and better information to encourage public safety, proper waterway use, and natural resource protection in both the winter and summer seasons.

An information/education campaign will remind lake users and land owners that their actions can help to reduce accidents and activity conflicts, protect fish and wildlife, and safeguard the quality of the lake experience for themselves and others. A multitude of existing educational kits are available for public use and many of the agencies offer classes; however, agencies report that they are understaffed. The under staffing makes it extremely difficult to enforcing violations of regulations, let alone conduct public service educational courses on boating safety or natural resource protection. Two informational/educational programs related to public safety that occur at Big Lake are:

- The USCG Auxiliary conducts free boating safety classes and Courtesy Marine Examinations (CMEs). CMEs evaluate the safety of a boat and its equipment. The CMEs are informational for the boat operator as the USCG Auxiliary does not have enforcement authority.

- Some Big Lake businesses report that they show instructional videos prior to renting PWCs to lake users. Some of the new boats and PWCs come with instructional videos when purchased.

Implementation Strategies

A range of opportunities exist to disperse information to the public concerning natural resource protection and public safety.

- Signs and message boards
- Brochures and newsletters
- Public service announcements
- Videos
- Boater's guides
- Floating informational kiosks
- Boating Safety Checklists
- Site Evaluation Checklists

Numerous informational/educational programs on boating safety and PWC safety have already been developed by groups and agencies such as the USCG and the BOAT/US Foundation. Many are available by contacting the sponsor directly or on the Internet. The variety, diversity, and amount of informational material available provides a foundation for the Big Lake program. As an example, BOAT/US Foundation, in coordination with the National Safe Boating Council and the NASBLA has a free boating safety course that provides a general overview of the basics of boating safety, regulations, navigation, and operation (Appendix B). They also provide at least $35,000 each year for grassroots programs that solve specific problems that can be adopted by other groups to improve boating safety. Most non-governmental volunteer and non-profit groups are eligible for grant funding. An example of information available on PWC safety is included in Appendix C.

Waterway and winter recreation safety information should be located at boat launches, trailheads, local businesses selling and renting recreation equipment, public use areas, popular commercial establishments, schools, in local newsletters and newspapers, on community bulletin boards, and the Internet. A local waterway council could be developed that would be responsible for distributing information and promoting public safety.

Natural resource public educational programs are also available from agencies such as the ADF&G, ADEC, the Alaska Natural Resource and Outdoor Education Association, USFWS, and the EPA. Examples are included in Appendix D.

Programs such as "Adopt a Shoreline" could be implemented by community groups to maintain and enhance specific shoreline areas.

A site evaluation checklist for land use development could also be prepared and distributed to property owners. The checklist would include a list of potential permits for lake and land development, a list of Best Management Practices and other miscellaneous information on methods to maintain and improve water quality. The checklist should be readily available in the community, at real estate offices, and sent out with tax notices or with other Borough information. Agencies such as ADF&G and the Corps may also be able to assist in the developing and distributing the checklists as well as other natural resource protection programs. Non-regulatory site inspections by Borough or other agency staff and voluntary demonstration sites for certain Best Management Practices would also serve as useful information tools.

Recommendation

The advantage of an aggressive informational/educational campaign is that it can be developed to address all or some of the issues facing Big Lake. As a management technique, an education/information program has widespread, year-round application and offers a tremendous amount of flexibility. It can focus on the most pressing issues at Big Lake, and if those change, the program can easily adapt. The management technique is dependent on the willingness of people to behave responsibly and do the right thing, rather than on enforcement activities.

Initiating an education/information program will require researching available material, developing a program designed specifically for Big Lake, and reproducing and distributing materials. After the initial start up phase, regular maintenance of the program will be required. The bulk of the cost will be during the initiating phase and to produce the materials, including printing brochures, placing newspaper ads, and posting signs.

Alaska is the only state in the nation without a boating safety program as encouraged by the 1971 Boating Safety Act. A statewide boating safety program would allow boater registration fees to go to the state rather than the federal government and make available approximately $300,000 in statewide grant money. The USCG is currently developing a proposed boating safety program to be adopted by the state legislature. If adopted approximately $750,000 in revenue would be available from grants and registration fees. A portion of this funding could be used for Big Lake's boating education and information campaign.

Lake Advisory Board

Objective: Establish an Advisory Board to monitor the status of the lake and the effectiveness of the lake management guidelines.

With cuts in government funding at every level, regulating agencies are given more and more tasks, and fewer resources to implement those responsibilities. A Lake Advisory Board made up of property owners and lake users would regularly inform the Borough on the status of the lake and management issues. Because members of the Advisory Board live and recreate on the lake, they are experts on identifying changes to the lake. The Advisory Board would also serve to motivate other lake users and property owners to be lake advocates through newsletters and public meetings.

Implementation Strategy

Membership on the Advisory Board would be on a volunteer basis but should consist of a representative cross section of lake users including year-round and seasonal residents, property owners, and winter and summer recreational users. The Advisory Board should assist the Borough and other agencies in implementing the Lake Management Plan; monitoring environmental and social conditions; and prioritizing the distribution of any funds available for Big Lake. In turn, the Borough could offer the Advisory Board technical assistance on lake quality issues by

providing speakers on lakes and watersheds, training sessions on volunteer monitoring, and educational materials on lake management.

A possible outgrowth of the Lake Advisory Board would be to create a Lake Improvement District. Formation of a District would require a majority vote by the property owners within the District and approval by the Matanuska-Susitna Borough Assembly. The Lake Improvement District could tax property owners in the District. It should be noted that an assessment on state lands within the District would require appropriation from the legislature before the state could pay. The tax rate would be decided by the District members. Revenue generated by the District would be put back into Big Lake for such things as increased enforcement of rules and regulations; an information/education campaign; natural resource protection such as specific bank stabilization or fish habitat projects; water quality monitoring; and the development of appropriate public access points.

Recommendation

A Lake Advisory Board should be established in the short-term. It will serve to establish regular communication between Big Lake users and the Borough. This will provide the Borough an opportunity to respond to issues in a timely manner and allow the Advisory Board to monitor, understand, and protect the lake.

The Lake Improvement District has merit but should be considered in the future. It may be difficult to get the majority of the property owners around the lake to agree to tax themselves for lake improvement. If successful, however, it would be a powerful tool for the future management of Big Lake ensuring that money would always be available to protect the lake and those using the lake.

Safety Classes And Licenses for Minors

Objective: Increase public safety and reduce impacts to natural resources.

Safety classes can reduce personal injuries, injuries to others, property damage, environmental damage, and conflicts. Rental businesses at Big Lake report that they show a training video prior to renting PWCs.

Implementation Strategies

A basic boating and PWC safety class should cover the following topics:

- Navigation rules: rules to help prevent collisions.
- Rules of Operation: negligent operation, alcohol and boating, handling accidents.
- Legal Requirements: registration, required equipment, required reporting.
- Reading charts: use of compass, reading nautical charts.
- Maneuvering and handling: casting off, docking safety.
- Emergency procedures: managing rescues, first aid.
- Water Activities: fishing, waterskiing, PWC rules.
- Trailering A Boat: towing precautions.

Environmental concerns could also be added to the class to educate users about actions that can adversely impact the health of the lake system and recreational opportunities. The safety class could be tied to a license/or certificate or it could be non-enforceable and only a courtesy offering.

Many other states have placed age limits on certain activities. Age limits are often tied to adult supervision or some form of mandatory safe boating education course. In Wisconsin, PWC operators must be older than 12 years, and at least 16 years old to rent. A 12-year-old in Wisconsin can operate speed boats as long as a certified boating safety course has been passed. New York requires renters to be 16 years old and they must have proof of identification. Those under 18 years are required to show a boating safety certificate. Operators are also required to carry a sound producing device and flares or distress flags.

The NASBLA Model Act (Appendix E) for PWC proposed model regulations states that:

> *"No person shall rent a PWC to another person without first providing safety instruction to that person. Such instruction shall include but not be limited to (1)operational characteristics of PWC; (2) laws and regulations, boating rules, personal responsibility; and (3) local characteristics of the waterway to be used. No person under the age of 16 shall operate a PWC, except a person 12 to 16 years old may operate a PWC if a person at least 18 years of age is aboard the vessel."*

The Personal Watercraft Industry Association (Appendix E) also has proposed Model Watercraft Regulations that states:

> *"No person under the age of 16 shall operate a PWC. It is unlawful for the owner of any PWC or any person having charge over or control of a PWC to authorize or knowingly permit the same to be operated by a person under 16 years of age."*

Recommendation

Mandatory safety classes/licenses should be a state-wide regulation to be effective. It may be perceived as too restrictive if Big Lake is the only waterbody with the requirement with so many recreational users coming from outside the area. Age limits may be more effective to implement at Big Lake. The precedence for this management action comes from the fact that a training course and licenses are required to operate a motor vehicle. Age limits are easily enforced by rental companies and may be easier to enforce by regulatory agencies as it is easier to identify an underage user than ascertain visually whether the operator has a permit.

The Personal Watercraft Industry Association standard restricting anyone under the age of 16 from operating a PWC should be used. It is interesting to note that the nationwide average age of a PWC operator is 34 indicating this may not be overly restrictive.

Develop New Roads

Objective: Provide additional access to areas of the lake currently not serviced by roads to disperse lake use, relieving congestion and activity conflicts in the east basin.

Implementation Strategy

The Big Lake Comprehensive Plan lists expansion of the road system to provide access around Big Lake as a long-term goal and priority including the extension of the South Big Lake Road to the Little Susitna River. It also states that public investment in expanding the road system should be concentrated on arterial roads and those collector roads that provide better traffic circulation within the entire Big Lake community.

Water and ice road transportation is another important component of the surface transportation system. The Comprehensive Plan states that the private sector should be encouraged to develop commercial water taxi service and the continuation of the development and maintenance of ice road by businesses and residents.

Recommendation

This management alternative is largely driven by the availability of funding and the ability to maintain the road once it is constructed. In terms of addressing the issues at Big Lake, this management alternative would be the least effective, while being the most

expensive. It also benefits relatively few lake users and Big Lake residents; however, as development continues, additional access will become imperative. In the short-term, expansion of water taxi service may be a more viable alternative.

One Stop Land Use Permit

Objective: Increase compliance with existing and future regulations by establishing a simplified and more consistent permitting process.

Land owners are sometimes unsure of what the regulations are and where they can go to find help. The regulatory agencies can also be intimidating to some people. A one-stop land use permit administered by the Borough would allow property owners to clearly understand their responsibilities. A one-stop permit system was temporarily used after the Miller's Reach fire to facilitate rebuilding efforts.

Implementation Strategy

One approach to this management action would be to have the Borough identify and coordinate all of the permits for each particular development. This would require interagency agreements between the Borough and all regulatory agencies. To be successful, the land use permit would have to be compulsory for all development within the designated planning area and Borough staff would have to be familiar with the latest policies of the other permitting agencies.

As an alternative, the Borough could simply provide permit assistance. A checklist could be developed to identify the appropriate permits for a development, and the Borough could provide assistance in filling them out. Both alternatives would likely require additional staff to handle the permitting.

Recommendation

While a one-stop land use permit is appealing to land owners and would greatly simplify the process, there may be legal constraints facing agencies that will not allow them to delegate permitting authority to another agency. However, during the Miller Reach Fire, the Borough obtained interagency agreements with all of the involved parties to distribute information on permitting requirements and applications and could likely do so again. With a more long-term far-reaching program, the Borough would likely require new staff to implement and enforce the permits. Providing permitting assistance would still appeal to property owners and offer many of the same benefits. This option is more realistic in the short-term while a one-stop permit should continue to be explored and implemented in the future.

Waterbody Setbacks

Objective: Protect water quality, fish and wildlife habitat, and the aesthetic value of Big Lake.

Setbacks from water bodies and wetlands have been described as buffers, stream-side management zones, and riparian zone protection areas. Their intended purpose is to provide an area of undisturbed, natural habitat to maintain or protect one or more that provides a source of woody debris, shading, and root systems to stabilize lake shorelines against excessive erosion, and to maintain seasonal ambient water temperatures:

- Water quality in wetlands, streams, or lakes as it is affected by surface runoff and groundwater from nearby areas of development.
- Spawning, rearing, feeding, overwintering, or migration corridors for resident and anadromous fish.
- Wildlife habitat provided by riparian vegetation and water body-contiguous wetlands such as winter browse areas for moose and summer use areas for waterfowl.

The use of natural buffer zones to protect freshwater from pollution is attracting considerable interest within the United States and globally. There are many concepts of what constitutes an effective buffer, both in terms of hydrology, vegetation, and position within the catchment.

The Big Lake setback policy has ranged from 45 to 75 feet over the years. This has resulted in inconsistent development around the lake depending on when the structure was built and what setback was in place. Some structures were built in violation of the setback. Some subdivided lots are shaped such that an undue hardship would be placed on the landowner to comply with the setback; variances could be granted in these cases. It is recognized that variances may be appropriate in some instances on a case-by-case basis; however, if variances are required for the development of most lots within an area, the regulations may need to be reviewed. The 1996 Comprehensive Plan states that the community would like the water body setback changed again from 75 feet to 45 feet.

Implementation Strategy

The use of setback buffers is most effective when setback criteria reflect site-specific characteristics of the development area, focus on resources with the greatest sensitivity and vulnerability to disturbance, and incorporate flexibility in implementation to achieve management plan objectives. Setbacks must also recognize existing land uses around streams and lakes in the management area. Properly incorporated into planning, design, permitting, and construction criteria, setback buffers can be an invaluable tool to minimize future requirements for mitigation or restoration of disturbed areas.

The width of setbacks and buffer zones varies depending on the resource values to be protected and site characteristics that include:

- Slope and topography of lands adjoining the watercourse.
- Overstory and ground cover vegetation present.
- Vulnerability of the soil to erosion.
- Type of disturbance or land use proposed.
- Surface and groundwater hydrology.
- Function of the habitat in the buffer strip (sediment filtering, shading, shoreline stabilization by vegetation root systems, and food and cover for fish).

Given the variety of development near lakes, wetlands, rivers, streams, and ponds, waterbody setbacks have been studied in the Pacific Northwest, Canada, and Alaska to identify a range of setbacks designed to achieve some level of resource protection.
In Alaska, the Department of Natural Resources has frequently incorporated a setback buffer approach in state land management plans. Under the Alaska Coastal Management Program, local district coastal management plans commonly include water body setback criteria to protect fish and wildlife habitat and water quality. Cities and boroughs often use setback criteria to protect development structures from the potential effects of flooding, stream bank migration, and winter icing. "Recommended Buffer Strip Characteristics for Alaska" (discussion primarily involved timber harvest activities but is still relevant to Big Lake; Sinnott, 1989) indicates the following:

- Buffer strips are best when adapted to local conditions; interdisciplinary teams are one of the most effective means for adapting criteria to local conditions.
- Phosphorus is a limiting nutrient in Alaska, and increased concentrations in aquatic systems may cause algal blooms in lakes.
- Clear water habitats are recognized as valuable habitats for fish rearing, spawning, and feeding; Big Lake and its associated inlet/outlet streams are clear water aquatic habitats.

- If overstory trees are removed, natural groundcover and the organic mat must remain intact and undisturbed, particularly if permafrost is present. Exposed mineral soil is the primary source of sediments impacting water bodies.

- Riparian forest canopy adjacent to streams is probably important in maintaining ambient water temperature in both summer and winter.

- Limited availability of information suggests a conservative approach to protecting riparian resource values; setbacks should be used along all perennial streams and lake shorelines and streams inhabited by resident and anadromous fish.

- Buffer strip setbacks are important to maintain stream water temperature, protect against increased sediments and dissolved nutrients, and provide necessary large woody debris for stream systems.

- ADF&G recommends at least a 100-foot setback buffer for all timber harvest activities from streams or lake shorelines, the upland edge of all stream/lake contiguous wetlands, all fish streams, and all lakes connected by surface drainage to fish streams.

The results of a literature search on setbacks from water bodies is summarized in the following table. It presents the range of possible setback distances to be considered at Big Lake.

Table 3-2: Setbacks

Location	Setback (from ordinary high water mark)	Purpose
Municipality of Anchorage Title 21- Stream Protection	A minimum width of 25 feet on either side of the stream. No vegetation may be cleared or disturbed, no grading or excavation, and no structures, fill or paving may occur within 15 feet of the stream. Landscaping is allowed within 15 and 25 feet of the setback.	Protect fish and wildlife habitat and water quality.
Anchorage Wetlands Management Plan 1995	100 feet from anadromous fish streams; 85 feet from certain headwaters and tributaries; 65 feet from all other water bodies. Minimum setback is 25 feet.	Protect fish and wildlife habitat and water quality.
ADF&G	Recommended 100 feet.	Protect fish and wildlife habitat and water quality.
Timber on Land South of the Alaska Range	Minimum 100 feet from anadromous fish streams or other acceptable measures.	Protect fish and wildlife habitat and water quality.
Hatcher Pass Management Plan	- 200-foot buffers for timber harvest on specific streams. - 100 foot buffers (for timber harvest) on all other perennial streams to include all riparian vegetation (but not less than 50 feet)	Protect fish and wildlife habitat and water quality.
Susitna Area Plan	-On State and Brough land, a 100-foot building setback andpublicly owned buffer along most waterbodies in the Susitna Area Plan	Protect water quality, habitat, and enhance lakeshore public recreational opportunities.
Pacific Northwest	Recommended 50 to 100 feet.	Protect fish habitat, maintain stream temperature, and prevent erosion and sedimentation.
Southeast Alaska	Recommended 15 to 130 feet.	Protect fish habitat and maintain large woody debris.

Pacific Northwest	Recommended 20-130 feet.	Protect fish habitat and-water quality.
Bellevue, Washington Shoreline Overlay District	- No clearing, grading, excavating, or fill within 25 feet. - No commercial parking facilities within 25 feet. - 25 feet for structures except docks, piers, and boathouses.	Protect natural resources and public health and safety.
York, Virginia Watershed Overlay District	200-foot buffer strip from tributary streams and public water supply reservoirs.	Prevent causes that harm public water supplies.
Lake Tahoe Shorezone Tolerance Districts	Development standards are based on physical characteristics for 8 shorezone districts.	Protect shoreline, fish spawning, backshore stability, wildlife habitat, and aesthetics.
Ozaukee County, Wisconsin Shoreland Protection	- 75 feet for all buildings except piers, marinas, boathouses. - Tree cutting 35 feet inland shall be limited. - 75 feet for signs intended to be read from the water. - Boathouses must be set back 2 feet.	Prevent and control water pollution, protect habitat, preserve shore cover.
Douglas County, Wisconsin	- Minimum protection zone-75 feet. - More protected zones-100 to 125 feet.	Protect shoreline and water quality resources.
Waukesha County, Wisconsin Ordinance	- Septic systems for single family - 50 feet. - Septic systems for multifamily - 100 feet.	Protect water quality. Prevent pollution.
Maine	- All septic systems 100 feet. - 75 feet along coast. - 250 feet along sensitive wetland areas.	Protect water quality. Prevent pollution.
Statewide Standards for Management of Shoreland Areas - Minnesota	- Setbacks based on density and lot size. - Setbacks range from 75 to 265 feet. 40,000 sqft lot w/single family home requires 150-foot setback. - At least 10 feet for accessory structures.	Preservation of natural areas, aesthetics, habitat protection, water quality.

As noted previously, a large setback will accomplish little in terms of water quality protection if all vegetation is cleared between the structure and the lake, whereas a smaller setback may be adequate with the implementation of Best Management Practices (BMPs). BMPs are a set of criteria developed to minimize land use impacts to the lake shorelines and water quality and should be used in determining the setback. Experimental studies have shown that vegetative buffers can be up to 90 percent efficient in removing sediments if they meet the following design criteria (Marsh, 1991):

- Continuous vegetation cover.
- Buffer widths generally greater than 50 to 100 feet.
- Gentle gradients less than 10 percent.

BMPs that would be appropriate for Big Lake to use as part of the setback policy are presented below:

- Protect bare soil surfaces. Vegetation is the best protection because it both absorbs and uses water.
- Do not concentrate/direct water flow unless absolutely necessary. On undisturbed slopes, water percolates through soil slowly and somewhat steadily. When all runoff is focused on one spot, such as a culvert or roof gutter, the natural protection of the ground surface is often not sufficient to prevent this extra flow from breaking through to bare soil. If runoff must be directed, protect the outflow area with an energy dissipator, such as rock or securely anchored brush, that will withstand storm flows.

- Limit human use or animal use of vulnerable areas. Trails can channel the flow.

- Establish buffer strips of undisturbed vegetation between developed land and banks. Disturb existing vegetation as little as possible. The foliage and roots or plants hold topsoil and even subsoil in place and regulate the speed of water flowing through and over the soil. The native plant community is especially well adapted to suit specific soil and rainfall conditions.

- Use infiltration beds for runoff from paved, compacted or roofed surfaces.

- Limit stream bank-disturbing activities (i.e: utility installation and bridge construction) to the minimum amount necessary and revegetate disturbed areas promptly.

- Develop or enhance shoreline wetlands to diminish bank erosion along waterways, ponds, and lakes.

- Minimize movement of soil near stream banks.

- Build close to existing functioning roadways to minimize impacts from roadway expansion/extension and driveway construction.

- Keep concentrated development away from sensitive areas such as riparian areas and wetlands.

- Establish temporary berms during construction to contain waste water overflows.

- Increase the use of permeable surfaces to encourage infiltration of rainfall into the soil and decrease peak soil runoff.

- Evaluate runoff and sediment loading characteristics of land and design and building according to the existing drainage features.

- Use straw or other fiber mulch to protect soil from erosion until a permanent vegetative cover is established.

- Require buffer strips between roadway ditches and waterways.

- Do no over water lawns. Do not cut grass too short; taller grass holds water better. Leave grass clippings as mulch.

Recommendation

The Big Lake Comprehensive Plan recommends reducing the existing setback of 75 feet to 45 feet. The Borough is currently conducting a Shoreline Management Study to evaluate effective setback distances on a Borough-wide basis. Taking into consideration the controversial history of setbacks in the Borough, the fact that a process exists to apply for a variance to reduce the setback if it presents the property owner with an undue hardship, and the range of setbacks and policies for water quality protection on a nationwide basis, the following is recommended:

- Continue with the current variance application process.

- Wait for the results of the Shoreline Management Study before introducing a change to the setback at Big Lake.

- Implement the applicable Shoreline Management Practices recommended in the study.

- Implement Best Management Practices focused on protecting water quality at Big Lake in accordance with Shoreline Management Practice recommendations.

- Establish criteria for BMPs that is equitable and consistent for all property owners.

Enforcement of this policy will require Borough resources.

Classification System for Public Access

Objective: Reduce conflicts between land owners, disperse access to the lake relieving congestion, and protect sensitive shorelines and habitats.

There are several goals to be achieved by a classification system for public access to the lake including:

- Ensure that the public is provided adequate access to Big Lake.
- Minimize environmental degradation.
- Minimize the proliferation of constructed access.
- Establish a hierarchy of access.
- Maintain property values.
- Enhance public safety.

With the numerous platted public easements, it is important to develop a classification system to reduce future conflicts and ensure that some areas do not have too much or too little access to the lake.

Implementation Strategies

Providing additional public access to Big Lake should be reviewed to minimize negative impacts. To minimize negative impacts it may be necessary to limit the amount of new public access. Therefore, prior to constructing a point of access to Big Lake, the following development criteria shall be considered:

- Authorized agreement to provide maintenance and security.
- Availability of funding for maintenance and security.
- Proximity to nearby commercial, residential, and public development.
- Proximity to nearest lake access.
- Review and comment by Big Lake Advisory Association.
- Impact on Big Lake's recreational carrying capacity.
- Impact on Big Lake's water quality.
- Impact on Big Lake's fish and wildlife and fish and wildlife habitat.

The easements need to be mapped and classified into the most appropriate use. Some may be more suitable for intensive use such as motorized boat launches, others may be better for walk-in or non-motorized boat launches. Some of the existing easements could be converted into conservation easements for water quality and habitat protection and for aesthetic reasons. Others may be appropriate to vacate (abandon). The classification system may identify appropriate lands for future acquisition and development as public access.

Recommendation

The public access points should be classified and the appropriate ones vacated. Development of the access points can be done in the future. Distributing public access points can increase operation and maintenance costs for the Borough.

No Wake Zones

Objective: Protect water quality, shoreline erosion, and increase public safety.

The "no wake" zone is probably the most widely used management technique to control turbidity by reducing sediment disturbance and shoreline erosion. In addition, the zone helps prevent damage to shoreline structures, to craft tied to docks, and to sensitive wildlife and fish habitat. It also reduces user conflicts and accidents by slowing boat traffic near the shorelines where more passive activities tend to occur such as swimming, fishing, and canoeing. This in turn helps to reduce noise.

Implementation Strategies

"No wake" means the slowest possible speed a boat or PWC will go and still provide maneuverability. Some states imply "no wake" by setting 5- to 6-mph speed limits within 100 to 300 feet of the shore. Because PWC-jumping in the water stirs bottom sediments up to 20 feet, some states have restricted their use in certain areas as part of the "no wake" zone. This allows key habitat areas to be set aside, by forcing motorized watercraft to the areas of the least potential impact.

Recommendation

The "no wake" zone is a simple, cost effective management action to reduce the problem. At a minimum a 150-foot (from all shorelines) "no wake" zone is recommended for Big Lake. A 300-foot zone would on the average, place activities in approximately 12 to 15 feet of water which would be more protective and greatly reduce sediment disturbance. However, this may not be popular with lake users.

Restrict PWC and other motorized watercraft from Meadow Creek.

Larger "no wake" zones should be considered for the north arm of the east basin from the mouth of Meadow Creek to Purdy Point, all of Mud Lake, and offshore of the marinas and the south side of Long Island.

Registration of Watercraft

Objective: Generate revenue and facilitate the identification of violators.

Federal regulations administered by the USCG requiring the registration of watercraft are already in place, although few comply with this law. Registration currently costs $6 for 3 years.

Implementation Strategies

The benefit of requiring all watercraft operated at Big Lake or within the Borough to be registered not only at the federal level but also at a local level is that it provides a revenue source and demonstrates the Borough's commitment to the wise use of its resources. Information on resource use and water safety could also be distributed at the time of registration to help increase compliance with other regulations. This program may also facilitate the identification of violators. State Troopers, private businesses or the Borough could issue the registration.

Recommendation

It would not be equitable or economical to implement watercraft registration requirements that apply only to Big Lake. In lieu of a program focused on Big Lake, the Borough could require registration for all motorized watercraft used within the Borough; however, this is beyond the scope of this plan. Additionally, the cost of administering a local program and the expected number of people actually complying should be evaluated to see if enough revenue could be generated to make the program feasible.

It is recommended that this management alternative focus on increased compliance with the existing federal registration program. The Borough could assist in advertising and distributing federal registration forms with safety and resource information on Big Lake. Ideal locations for the registration forms and information on Big Lake would be at marinas, public launches, and other water-oriented businesses.

Ice House Registration

Objective: Reduce litter, distribute information, and have better control over ice houses.

Permit systems help offset management costs and inform and educate lake users about lake use. Additionally, permits would help to identify users who may contribute to the litter problem.

Implementation Strategies

The permit should be issued by private businesses at the lake or associated with

fishing. Permits should be posted on the ice house so that problems can be attributed to the users. A map showing the lake, facilities, and outlining rules and regulations, and common courtesy should be provided with the permit. Fees collected would be dedicated to Big Lake.

Recommendation

The implementation of this management action is recommended as it makes people directly accountable for their actions and should be relatively easy and inexpensive to implement.

Quiet Hours

Objective: Give shoreline residents, property owners, and recreational users a reprieve from noise during late night and early morning hours.

Complaints have been heard that noise from boats, PWCs, and float planes is increasing and continuing into the late night and early morning hours impacting sleep, conversations and other shoreline activities.

Implementation Strategies

Restrictions on engine sizes or speed limits can control noise to some extent and does provide safety benefits as well. The ultimate method to reduce noise is to ban engines from the lake. Both of these however, represent threats to the rights of many lake users and would not be consistent with the recreational nature of Big Lake.

Other methods to reduce noise are to implement space zoning or time zoning. Space zoning requires boats/PWCs to maintain certain distances from swimming areas, fishing areas, residences, or other sensitive receptors. This alternative is largely addressed in the "no wake" zone.

Time zoning limits the hours an activity can take place. Most frequently, limiting activities from sunrise to sunset. Recognizing the challenge of using sunrise and sunset as a benchmark in Alaska, quiet hours would have to designated. Typically, quiet hours begin between 9:00 p.m. and midnight and end between 7:00 a.m. and 9:00 a.m. Quiet hours can be limited to weekdays, or enforced 7 days a week except holidays. Quiet hours could also be directed toward restricting certain activities such as jet skis, watersking, float planes and certain classes of boats during quiet hours. This method may not be effective as many residents are dependent on float planes and watercraft for transportation to and from their homes. Rather than watercraft type, a more effective technique for Big Lake may be to focus on the late night/early morning recreational use on the lake such as watercraft continuously circling in a cove or in front of docks.

Vegetation can also be used to help control noise. Placed in the path of sound, vegetation absorbs and diverts energy. This should be kept in mind before residents remove all vegetation in front of their lakeside homes.

Recommendation

The challenge with quiet hours is enforcement and how to uphold the rights of noise makers and unwilling noise receptors on a multi-use lake. This may be one of the most controversial management actions based on public acceptance and it will depend on continuous enforcement for its success. The need for quiet hours will continue to increase as the lake grows in popularity. This action especially needs to be combined with a strong informational campaign urging users to be considerate of others.

Quiet hours from 11:00 p.m. to 8:00 a.m. are recommended and should focus on activities that cause frequent repetitive noise.

Implement a Water Quality Monitoring Program

Objective: Protect water quality by developing a better understanding of water quality conditions at Big Lake and the processes that influence them.

A water quality monitoring program is important because no regular testing of Big Lake's water quality has ever been accomplished. Monitoring is the only way to tell if Big Lake's water quality is changing over time. This program will:

- Establish a full set of **baseline conditions** for comparison to observed or anticipated future conditions.
- Attempt through **diagnostic monitoring** to further identify factors that influence water quality.
- Provide ongoing **compliance and trend monitoring** to determine if standards are being violated and alert agencies when a problem may be developing.

Implementation Strategies

The annual and seasonal hydrologic budget and internal circulation of the lake should be studied. Parameters that should be tested include dissolved oxygen, turbidity (water clarity; suspended sediments); biochemical oxygen demand (BOD) pH, nitrogen as a nutrient; and ammonia/nitrogen. Less common tests include trace minerals, phosphorous, and toxic chemicals such as heavy metals, pesticides, and herbicides.

With proper monitoring, information will be available that will make the other management actions more effective. For example, water quality monitoring may identify locations where septic system seepage is causing problems, which in turn will better facilitate nutrient control actions. An outline of a proposed water quality monitoring program for Big Lake is included in Appendix F.

Recommendation

The initial multi-season data collection program would likely be costly and with ongoing monitoring less expensive. Costs can be reduced significantly by using volunteer workers for selected data collections and/or applying for federal and state funding assistance (several programs are available). This management action is imperative to the future health of the lake system.

MANAGEMENT ACTION PLAN RECOMMENDATIONS

Short-term (Implement in One to three Years)

Management Recommendations	Initial Implementation Strategies	Responsible Entities
Information and Education	• Prepare Site Evaluation Checklist • Prepare Big Lake User's Guide • Develop Summer and Winter Recreation Safety Guides • Distribute Materials	USCG, USCG Auxiliary, ADF&G, USFWS, State Troopers
Age Limits for Operators of PWC and Certain Classes of Boats Safety Classes	• Establish age limit • Offer safety classes • Enforcement	USCG, USCG Auxiliary, State Troopers, Schools, Community Organizations, Private Businesses
Waterbody Setbacks	• Continue with existing variance application process • Implement Shoreline Management Study. • Identify BMPs appropriate for protecting water quality at Big Lake	Borough, Big Lake Community, ADF&G, USFWS
Lake Advisory Board	• Establish an advisory board to assist agencies and Borough with lake management	Borough, Big Lake Property Owners, Recreational users
Land Use Permit Assistance	• Meet with permitting agencies to assess possibility of distributing permitting information and applications • Identify Borough staffing needs • Develop permit questionnaire • Enforcement	Borough, Corps, USCG, EPA, ADEC
No Wake Zones	• Identify "no wake zones" • Enforcement/education • Restrict jetskis and other motorized watercraft from Meadow Creek	Borough, State Troopers, ADF&G, USFWS
Registration of Watercraft	• Develop and print registration/informational booklets in conjunction with the USCG • Identify appropriate distribution points at Big Lake and in outlying areas • Enforcement	Borough, USCG State Troopers, Water-oriented Businesses, Boat Launches, Marinas, Visitor Centers
Ice House Registration	• Develop registration form • Decide on cost • Dedicate funds to Big Lake	Borough, Private Business, ADF&G, USFWS

MANAGEMENT ACTION PLAN RECOMMENDATIONS

Short-term (Implement in One to three Years)

Management Recommendations	Initial Implementation Strategies	Responsible Entities
Quiet Hours	• Establish quiet hours that limit activities that cause frequent repetitive noise. • Assembly approval • Educate/enforce	Borough, Big Lake Community
Lake Monitoring	• Set up a monitoring program/schedule • Develop a field data sheet • Set up an agreement with a laboratory • Train sample collectors • Develop data base to track results	Schools, Borough, ADF&G, USFWS, Volunteer Groups, Community Group (Boy/Girl Scouts)

Mid-term (Implement in Three to Five Years)

Management Recommendations	Initial Implementation Strategies	Responsible Entities
One-Stop Land Use Permit	• Memorandum of Agreement with Agencies • Develop permit questionnaire • Enforcement	Borough, Corps, USCG, EPA, ADEC
Classification of Public Access	• Map platted access • Develop classification system • Begin vacating or improving accesses	Borough, Big Lake Community

Long-term (Implement in 5 to 10 Years)

Management Recommendations	Initial Implementation Strategies	Responsible Entities
Lake Improvement District	• Advisory Committee to determine the need for a District • Hold an election adopt by-laws • Assess the need to form a tax district to fund Big Lake enhancement	Lake Advisory Board, Borough, Big Lake Property Owners
New Roads	• Prioritize road needs of Big Lake • Identify alternative transportation methods to improve access and disperse congestion	Borough, Alaska Department of Transportation and Public Facilities

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