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THE GREAT SALT LAKE PLANNING PROJECT

STATEMENT OF CURRENT CONDITIONS AND TRENDS

Prepared by the Great Salt Lake Planning Team
Utah Department of Natural Resources

OCTOBER 15, 1998

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FORESTRY, FIRE AND STATE LANDS

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MEMORANDUM

RE: Great Salt Lake Statement of Current Conditions and Trends

DATE: October 22, 1998

The Department of Natural Resources Great Salt Lake Planning Team is pleased to announce the availability of the Draft Great Salt Lake Planning Project Statement of Current Conditions and trends for review. This Draft Statement has been developed as a baseline resource inventory for the development of a Comprehensive Management Plan for the Great Salt Lake.

A copy of the Statement of Current Conditions and trends may be requested by calling Brenda Landureth at 801-538-5273. Comments, changes, deletions or additions may be proposed in writing to the Department of Natural Resources, 1594 West North Temple, Suite 3710, P.O. Box 145610, Salt Lake City, Utah 84114-5610 or by email to nradm.blandure@state.ut.us. You may also view the document on our web page at www.nr.state.ut.us/dwr/gslplan.htm by October 26, 1998. All comments must be received by November 23, 1998.

The volume of available information on the Great Salt Lake and its resources is very large, and the Statement does not represent an exhaustive compendium of all information about the lake. The Planning Team's objective is for the Statement to provide background relevant to the development of sound management policies and objectives for the lake and its resources. The Planning Team requests that the GSL Technical Team and other interested parties review this document for scientific accuracy and omissions which are relevant to management decisions regarding the lake.

Upcoming opportunities to participate in this planning process will include examining various alternatives regarding management of the lake. The Planning Team will generate a range of alternatives based on internal and external scoping information received through correspondence, public and individual stakeholder meetings. This phase of the Great Salt Lake Planning Project may involve public meetings, workshops and individual stakeholder meetings.

THE GREAT SALT LAKE PLANNING PROJECT STATEMENT OF CURRENT CONDITIONS AND TRENDS

INTRODUCTION

The Utah Department of Natural Resources and the Utah Division of Forestry, Fire and State Lands are jointly sponsoring the Great Salt Lake Planning Project to develop a coordinated natural resources management plan for the lands and resources of the Great Salt Lake. Primary management responsibility for the lake's resources lies with the Division of Forestry, Fire and State Lands pursuant to Title 65A of the Utah Code, which governs management of all State lands. Specifically, Section 65A-10-8, Great Salt Lake - Management Responsibilities of the Division, requires the Division to:

> "(1) Prepare and maintain a comprehensive plan for the lake which recognizes the following policies:
> (a) develop strategies to deal with a fluctuating lake level; (b) encourage development of the lake in a manner which will preserve the lake, encourage availability of brines to lake extraction industries, protect wildlife, and protect recreation facilities; © maintain the lake's flood plain as a hazard zone; (d) promote water quality management for the lake and its tributary streams; (e) promote the development of lake brines, minerals, chemicals, and petro-chemicals to aid the state's economy; (f) encourage the use of appropriate areas for the extraction of brines, minerals, chemicals, and petro-chemicals; (g) maintain the lake and the marshes as important to the waterfowl flyway system; (h) encourage the development of an integrated industrial complex; (I) promote and maintain recreation areas on and surrounding the lake; (j) encourage safe boating use of the lake; (k) maintain and protect state, federal, and private marshlands, rookeries, and wildlife refuges; (l) provide public access to the lake for recreation, hunting and fishing."

Section 65A-2-1 of the Utah Code provides; "The division [of Forestry, Fire and State Lands] shall administer state lands under comprehensive land management programs using multiple use, sustained yield principles." Briefly stated, the overarching management objectives of the Division of Forestry, Fire and State Lands and the Department of Natural Resources are to protect and sustain the trust resources of the Great Salt Lake, and to provide for reasonable beneficial uses of those resources, consistent with their long-term protection and conservation. What these statements mean, of course, is open to discussion, but any beneficial use of public trust resources is subsidiary to long-term conservation of the resource.

Although primary lake planning and management responsibilities lie with the Division of Forestry, Fire and State Lands, the other divisions of the Department of Natural Resources also

have management responsibilities for resources on and around Great Salt Lake. The Division of Wildlife Resources, for example, has plenary authority for managing wildlife in, on and around the lake. The Division of Parks and Recreation manages Antelope Island State Park and coordinates search and rescue and boating enforcement on the lake. The Division of Water Rights regulates the diversion and use of lake and tributary waters. The Division of Water Resources conducts research and operates the West Desert Pumping Project. Other Department divisions regulate mineral extraction activities, conduct hydrologic research and identify and map geologic hazards around the lake.

In order to more specifically articulate the Department's management objectives for the resources of Great Salt Lake, and to reconcile the diverse mandates of the divisions of the Department, the Great Salt Lake Planning Project was initiated. The purposes of the Great Salt Lake Planning Project are:

(1) To establish unifying Department of Natural Resources management objectives and policies for Great Salt Lake trust resources,

(2) To coordinate the management, planning and research activities of Department divisions on the Great Salt Lake,

(3) To coordinate management with the actions of land and resource owners and managers on and adjacent to Great Salt Lake,

(4) To develop a sovereign lands and resources management plan, and

(5) To establish processes for plan implementation, monitoring, evaluation and amendment.

STATE OWNERSHIP AND TRUST RESPONSIBILITIES

Under English common law, the Crown held title to all lands underlying navigable waterways, subject to the Public Trust Doctrine. Following the American Revolution, title to such lands in the United States vested in the 13 original colonies. Under the Equal Footing Doctrine, fee title to those lands also vested in each state subsequently admitted to the Union, upon admission. Utah's public trust lands, known as "sovereign" lands, lie below the ordinary high water mark of navigable bodies of water.

The boundaries of sovereign lands are established by the location of the ordinary high water mark of a water body. For the ocean and most rivers and lakes, the ordinary high water mark is relatively constant, and can be identified reliably from year to year. Because rivers and streams, which establish many important boundaries, can move over time, the common law doctrine of reliction and accretion holds that slow, gradual movement of a river or stream course over time will result in relocation of the property boundary to follow the movement. Sudden

changes in course, as by flooding or other upset, will not result in the relocation of the property line.

In 1959, The Bureau of Land Management challenged the State's claim to much of the shoreline of the lake, arguing that the declining lake level was resulting in the "reliction" of shore lands, and the relocation of the boundary between state and adjacent federal land, to the BLM's advantage. This view, of course, was without the benefit of knowing that the lake would reach record high levels in the 1980's calling for another relocation, this time in the State's favor. In 1975, the United States Supreme Court determined that the State owns of all the lands, brines, and other minerals within the bed and waters of the lake, and all shore lands located within the officially surveyed meander line.

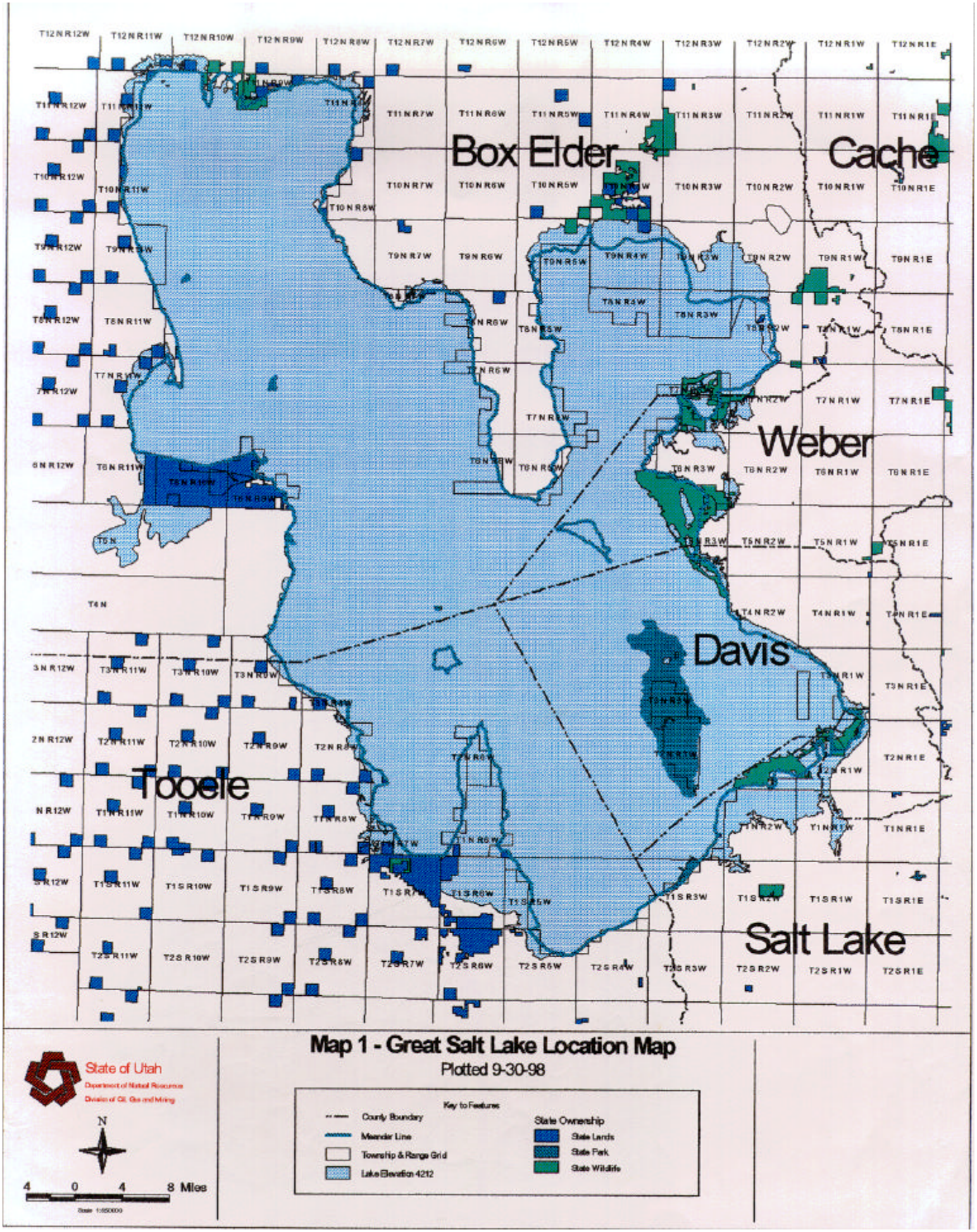
The Surveyed Meander Line

The surveyed meander line is not, however, a constant elevation around the lake. The meander line was surveyed in segments between 1855 and 1966, during which time the water level of the lake fluctuated. Different segments of the line therefore lie at different elevations. The elevation of the meander line generally ranges between about 4202 and 4212 feet above mean sea level. In some locations the meander line runs across topographical features of higher elevation substantially inland of the shoreline. Regardless of its location relative to the water's edge and lake level, the officially surveyed meander is the adjudicated, fixed and limiting boundary between sovereign land and the upland owners. (See Map 1)

The surveyed meander line usually is not identifiable on the ground without the aid of surveying or global positioning system equipment. In order to avoid trespass situations, the Division of Forestry, Fire and State Lands requires applicants to provide surveyed legal descriptions for leases and easements on Great Salt Lake. Upland owners likewise should have the meander line located by survey whenever they need to know the location of the boundary between sovereign land and adjoining land.

The Public Trust over Sovereign Lands

Under 6th Century Roman law, and perhaps earlier, the air, the sea and running waters were things common to all citizens and the separate property of none. All rivers and ports were public and the right of fishing was common to all. Any person was at liberty to use the seashore to the highest tide, to build a retreat on it, or to dry his nets on it, so long as he did not interfere with the use of the sea or beach by others. Although the banks of a river could be privately owned, all persons had the right to bring vessels to the banks, to fasten to them by ropes and to place any of their cargo there. The influence of Roman civil law carries forward through English common law to today's Public Trust Doctrine, which recognizes the special public interest in rivers, lakes, tidelands and waters. The Public Trust Doctrine "is founded upon the necessity of preserving to the public the use of navigable waters free from private interruption and



Map 1 - Great Salt Lake Location Map

Plotted 9-30-98

encroachment."[1]

Sovereign lands are held in trust by the state for the benefit of the public. The "trust" is a real trust in the legal sense of the word. There is a clear and definite trust corpus (the lands, waters and living resources therein), clear beneficiaries (the public), elected and appointed state officials with fiduciary responsibilities in managing the trust corpus, and a clear purpose for the trust. The Public Trust Doctrine establishes the right of the public to use and enjoy these trust waters, lands and resources for a wide variety of recognized public uses. The original purpose of the doctrine was to assure public access to navigable waters for commerce, navigation and fishing. That has evolved to include modern uses that the legislature has determined appropriate to multiple use management of Great Salt Lake: preservation of the lake; availability of brines to lake extraction industries; wildlife protection; recreation protection; safe boating; availability of appropriate areas for extraction of brine, minerals, chemicals and petrochemicals to aid the state's economy; maintenance and protection of marshlands, rookeries and wildlife refuges, and public access to the lake for recreation, hunting and fishing.[2]

The Public Trust Doctrine has been, and will continue to be, flexible to accommodate changing demands for public trust resources. There is no particular hierarchy of uses, but when there are competing public benefits, the public trust requires that those benefits that best preserve the purpose of the public trust under the circumstances should be given a higher priority. The Utah legislature has assigned responsibility for management of sovereign lands, including the Great Salt Lake, to the Division of Forestry, Fire and State Lands of the Utah Department of Natural Resources. As trustee, the Division of Forestry, Fire and State Lands must strive for an appropriate balance among compatible and competing uses specified in statute. It is desirable to maintain the latitude to adjust the allocation of public trust resources in response to changes in demand and changes in administrative and legislative policy.

Fee disposal (sale) of sovereign lands is generally precluded by the constitutionally-imposed duty of the state to manage sovereign lands for the public. The general exception to this prohibition is if the disposition itself is in the furtherance of the public interest. The Utah Legislature has chosen to protect the public interest when sovereign land is sold or leased by requiring that "...the lease, contract of sale, or deed shall contain a provision that:

> (a) these lands shall be open to the public for the purpose of hunting, trapping, and fishing upon them during the lawful season, except:
>
> (I) where the lands are situated in incorporated or unincorporated towns or cities: and
>
> (ii) when it is mutually agreed by the director of the Division of Forestry, Fire, and State Lands and the Wildlife Board that the lands may be leased or sold for

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[1] *Illinois Central R.R. Co. v. Illinois*, 146 U.S. 387, 436 (1892)

[2] Section 65A-10-8

exploration or development of minerals including oil and gas; and
(b) no charge may be made by the lessee, contractee, or grantee to any person who desires to go upon the land for the purpose of hunting, trapping, or fishing."[3]

Even so, there are circumstances under which a lessee or grantee must be able to restrict public access in order to fully enjoy the rights granted under a lease, permit or sale. Examples include restrictions during mining operations, construction of improvements, harbor operations, military operations and access to personal property. The test of any disposition of an interest in sovereign land is that it must be done without any substantial impairment of the public interest in the lands and waters remaining. Once again, this involves a judgement call on the degree of impairment of the trust resource or the public's trust rights therein.

Navigation

The navigability of Great Salt Lake, which is a key component of establishing state ownership under the Equal Footing Doctrine, was challenged by the Justice Department early in the contest over ownership. This challenge was based on the theory that the shore lands were remote, and in most places along the shore the water was so shallow that it would be impracticable to construct facilities for meaningful navigation on the lake. Utah was successful in proving that, both before and after statehood, the lake had been used for a variety of navigational purposes.[4] Historical navigation includes watercraft use during construction of the Lucin Cutoff (the original northern railroad trestle and earth-fill), and tour boating during the heyday of resort development on Great Salt Lake. Present navigation includes recreational sailboating, most of which occurs within six miles of the two marinas operated by the Division of Parks and Recreation, a tour boat which operates out of the Antelope Island marina, commercial brine shrimp harvesting, salvage of the old railroad trestle, air boating, some power boating, and law enforcement and search and rescue activity.

Two box culverts in the northern railroad causeway between Little Mountain, Promontory Point and Lakeside, initially allowed small watercraft to pass between the north and south arms of the lake through the causeway under certain lake levels. The culverts are no longer useful for this purpose. The breach near the west end of the causeway is not deep enough for navigation by anything but small craft when the lake level is high enough.

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[3] Subsection 23-21-4(2)

[4] Great Salt Lake a Scientific, Historical and Economic Overview, Utah Geological and Mineral Survey, 1980.

HISTORY OF PLANNING AND MANAGEMENT OF THE GREAT SALT LAKE

Great Salt Lake Authority (1963)

In 1963, the Utah legislature enacted House Bill No. 33 creating the Great Salt Lake Authority, and an advisory council to the Authority (Laws of Utah 1963, chapter 161). The Authority was empowered to, among other things: "coordinate multiple use of [Great Salt Lake] property for such purposes as grazing, fish and game, mining and mineral removal, development and utilization of water and other natural resources, industrial, and other uses in addition to recreational development, and adopt such reasonable rules and regulations as the Authority may deem advisable to insure the accomplishment of the objectives and purposes of the act." The bill specified that both the State Department of Fish and Game and the State Land Board would retain the powers and jurisdiction conferred upon them, subject to such reasonable rules and regulations as the Authority may make to ensure the accomplishment of the objectives and purposes of the act (Laws of 1963). The Authority made little progress in discharging its duties and, in 1966, the Utah Supreme Court declared that the Act creating the Authority was unconstitutional as it failed to define the Authority's geographical jurisdiction.

Re-establishment of Authority (1967)

The Legislature cured the jurisdictional defect in 1967 when it re-created the Great Salt Lake Authority (Laws of Utah 1967, chapter 187). Within this legislation, the Authority's geographical jurisdiction was defined, and included the mainland, peninsulas, islands, and waters within the Great Salt Lake meander line established by the United States Surveyor General.

The purpose of the re-created Authority was to establish and coordinate programs for the development of recreational areas and water conservation within the Great Salt Lake and its environs, and in conjunction therewith to provide for: (1) the development of such area of Antelope Island as the Authority may determine to be suitable and desirable for recreational usage, (2) testing the feasibility of the use of [Kennecott Copper] tailings in the development of Great Salt Lake and its environs, (3) the use of tailings in the development of the Great Salt Lake and its environs, and (4) the restoration and preservation of points of historical interest on Antelope Island.

A preliminary feasibility study for the recreational development of the north end of Antelope Island was prepared by Snedaker & Budd and Allred & Associates for the Great Salt Lake Authority, and was submitted on June 26, 1964. In 1965, a document entitled, A Preliminary Master Plan for the Development of Great Salt Lake Over a Period of the Next 75 Years was prepared for the Great Salt Lake Authority. This latter plan envisioned the use of surplus waters from the Bear River, Weber River, and Jordan River drainage areas, and using Kennecott tailing material for the construction of dikes, highways, and land reclamation within Farmington Bay.

Department of Natural Resources (1967)

After the creation of the Utah Department of Natural Resources in 1967, the Great Salt Lake Authority was abolished, and the functions of the Authority were merged into the Department's Division of Parks & Recreation.

Division of the Great Salt Lake (1975)

The 1975 general session of the Utah Legislature enacted House Bill Number 23 which established a Board and Division of Great Salt Lake within the Utah Department of Natural Resources for the purpose of establishing and coordinating programs for the development of recreation areas, flood control, wildlife resources, industrial uses, and conservation of the Great Salt Lake. The Great Salt Lake Division was given the responsibility to determine the direction and implementation of all lake-related activities, working through existing Department divisions. In addition, the division was given the following powers and duties:

> (1) direct the preparation and adopt a comprehensive plan for the lake in a manner which will assure the maximum interchange of information, ideas, and programs with affected state, federal, and local agencies, private concerns, and the general public. Implement the provisions of the plan by utilizing the existing authority of the various state and local entities or agencies concerned. Weigh the policies and programs of agencies that affect the lake to ensure their compatibility with the adopted comprehensive plan. Revise and update the plan at periodic intervals. 2) employ assistants and advisors deemed necessary for the purposes of the act, (3) initiate studies of the lake and its related resources, (4) publish or authorize the publication of scientific information, (5) define the lake's flood plain, (6) qualify for, accept and administer loan payments, grants, gifts, loans or other funds for carrying out any functions under the act, (7) determine the need for and desirability of public works and utilities for the lake area, (8) Cooperate with the state engineer and all upstream entities in considering the water relationship between the lake and its tributaries, and (9) Perform all other acts reasonably necessary to carry out the purposes and provisions of the act. (House Bill 23, 1975)

Comprehensive Management Plan (1976)

Under the directive of House Bill Number 23, the Great Salt lake Division began preparation of a Comprehensive Management Plan in July of 1975. The Plan was developed through the efforts of the Inter-agency Technical Team which was established under the terms of the 1975 legislation. The Inter-agency Technical Team was made up of representatives from various interests, public and private, and included representatives from several division of the Department of Natural Resources, Department of Transportation, County Commissioners of the five counties surrounding the lake, and other representatives who served on the basic committees.

The Comprehensive Management Plan for the Great Salt Lake was intended to serve as a general statement for use and management of the lake. Goals and policies based on the concepts set forth in the legislation, and as adopted by the Great Salt Lake Board, served as a guide for preparation of the plan. The plan consists of six major elements: minerals, recreation, tourism, wildlife, transportation, and hydrology. The plan for each of the elements was developed after consideration of the interrelationship of each plan element to the others, and was intended as a general guide for development, but not as a detailed development plan for private agencies or for divisions of local, state, or federal government

Great Salt Lake Environs Report (1976)

The Great Salt Lake Environs Report was prepared in 1976 as a companion report to the Comprehensive Management Plan. The purpose of the report was to summarize and graphically portray the most current, accurate and reliable data available concerning land use, land ownership, soils, vegetation, man-made structures, access ways, fresh water and utilities lying between the water's edge of the Great Salt Lake on January 1, 1976, and the upper limits study line established at approximately the 4,212-foot level.

Division of Forestry, Fire, and State Lands (1979)

In 1979, the Division of Great Salt Lake was eliminated, and the staff functions for the management of Great Salt Lake were transferred to the Department of Natural Resources. Later, the management was administratively delegated to the Division of State Lands and Forestry, now known as the Division of Forestry, Fire and State Lands.

Great Salt Lake Contingency Plan (1983)

In 1983, the water level of the Great Salt Lake began a rapid rise which prompted the Division of State Lands and Forestry to draft the Great Salt Lake Contingency Plan. This plan was designed to meet legislative mandate for maintaining the water level of Great Salt Lake below an elevation of 4,202 feet, and deals with background, analysis and recommendations for influencing both the high and low levels of Great Salt Lake. The conclusions of the Contingency Plan state: "It is anticipated that lake levels will peak at approximately 4,203 feet in 1983 with potential resultant damages of $20 to $30 million." Ironically, the lake peaked at approximately 4,205 feet that year, and continued upward to an elevation of nearly 4,212 feet in 1987, with estimated capital damages exceeding $250 million. (Robson,1983)

Great Salt Lake Advisory Council (1988)

In 1988, the Great Salt Lake Advisory Council (GSLAC) was created by legislative action to advise the Board of State Lands and Forestry through the Division of State Lands and Forestry, which was designated as manager of the lake. The Great Salt Lake Technical Team (GSLTT) was given statutory authorization at the same time.

General Management Plan, Great Salt Lake (1988)

As Great Salt Lake reached its historic high water level of 4,211.85 feet in 1987, a five-year General Management Plan, Great Salt Lake was prepared for the Great Salt Lake Advisory Council. The General Management Plan, and the Beneficial Development Area (BDA) concept developed by the Utah Division of Comprehensive Emergency Management, were a cooperative attempt to outline the best strategies available to avoid flood-related impacts to those utilizing the lake under its high-water and expected near-future conditions for a variety of purposes. Both the plan and the BDA concept were delivered to the five counties bordering the lake for adoption, and were adopted Federal Emergency Management Agency (FEMA).

Division of Sovereign Lands and Forestry (1994)

In 1994, management responsibilities for school and institutional trust lands were placed with the newly created School and Institutional Trust Lands Administration. The Board of State Lands and Forestry and the GSLAC were eliminated, and the Sovereign Lands Advisory Council (SLAC) was created to advise the newly-named Division of Sovereign Lands and Forestry (DSLF) of the Department of Natural Resources. DSLF retained management responsibility for public trust lands and resources, and became able to devote more time to planning and management of these lands, as public-trust lands, with a broader view of how the lake's many trust resources are interrelated. In 1996, the name of the Division of Sovereign Lands and Forestry was changed to the Division of Forestry, Fire and State Lands.

Great Salt Lake Comprehensive Management Plan (1995)

Completed in 1995, the Great Salt Lake Comprehensive Management Plan - Planning Process and Matrix was prepared by the Great Salt Lake Technical Team for the Division and Board of State Lands and Forestry and the Department of Natural Resources. The goal of the plan was to, "... provide needed information and guidance in the form of recommendations to federal, state and local governments, and recommended legislation to the state legislature to facilitate and enhance management of Great Salt Lake and its environs to assure protection of the unique ecosystem of the lake while promoting balanced multiple-resource uses."

As described in its goal statement, the 1995 Plan comprises analyses of a number of lake management issues, and makes recommendations on those issues to units of local, state and federal government. Several of the recommendations have been acted upon by divisions of the Department of Natural Resources, including development of the Mineral Leasing Plan by the Division of Forestry, Fire and State Lands. The fate of other recommendations is not known.

Mineral Leasing Plan (1996)

As an outgrowth of the 1995 Plan, in 1995 the Division of Sovereign Lands and Forestry

announced the withdrawal of sovereign lands from minerals leasing as part of a comprehensive planning process for management of minerals on those lands. Included were Great Salt Lake, Utah Lake and the Jordan River, and portions of Bear Lake, Bear River, Colorado River and Green River. To accomplish its planning and management mandates, the Division of Forestry, Fire and State Lands is creating mineral leasing plans for each area. The Mineral Leasing Plan for Great Salt Lake is the first of these plans to be completed. This document reviews the history of mineral ownership and leasing, inventories mineral resources, and examines the existing conflicts among resources on the lake. The Mineral Leasing Plan zones the lake bed for mineral commodity production, and specifies new mineral leasing procedures.

CURRENT DEPARTMENT MANAGEMENT RESPONSIBILITIES

Division of Forestry, Fire and State Lands

The Division of Forestry, Fire and State Lands is "...the executive authority for the management of sovereign lands..." in Utah, including the sovereign lands of Great Salt Lake. Title 65A of the Utah Code, entitled State Lands, establishes the Division and the Forestry, Fire and State Lands Advisory Council, and sets forth the powers and responsibilities of the Division and Board. Section 65A-10-8 establishes the Division's responsibility to prepare and maintain a management plan for Great Salt Lake under paragraph (1), and establishes other responsibilities for the lake as follows:

> "(2) Employ personnel and purchase equipment and supplies which the Legislature authorizes through appropriations for the purposes of this chapter.
> (3) Initiate studies of the lake and its related resources.
> (4) Publish scientific and technical information concerning the lake.
> (5) Define the lake's floodplain.
> (6) Qualify for, accept and administer grants, gifts, or other funds from the federal government and other sources, for carrying out any functions under this chapter.
> (7) Determine the need for public works and utilities for the lake area.
> (8) Implement the comprehensive plan through state and local entities or agencies.
> (9) Coordinate the activities of the various divisions within the Department of Natural Resources with respect to the lake.
> (10) Perform all other acts reasonably necessary to carry out the purposes and provisions of this chapter.
> (11) Retain and encourage the continued activity of the Great Salt Lake Technical Team."

Division of Wildlife Resources

Title 23 of the Utah Code establishes the Division of Wildlife Resources and the Wildlife Board and establishes their duties and powers. Section 23-14-1 provides, "The Division of Wildlife resources is the wildlife authority for Utah, and is vested with the functions, powers, duties, rights and responsibilities provided in this title and other law." The Section goes on to

provide, “Subject to the broad policy making authority of the Wildlife Board, the Division of Wildlife resources shall protect, propagate, manage, conserve, and distribute protected wildlife throughout the state.”

The Division manages refuges and wildlife management areas on the Great Salt Lake, regulates hunting, manages terrestrial wildlife on Antelope Island and elsewhere, and regulates the commercial harvest of brine shrimp from the lake. The legislature has authorized the Division to utilize all or parts of 39 townships of sovereign lands on the lake for the “creation, operation, maintenance and management of wildlife management areas, fishing waters, and other recreational activities.” (Section 23-21-5, Utah Code) Not all of the lands so authorized are now under management by the Division for the authorized purposes.

Division of Parks and Recreation

Chapter 63-11 of the Utah Code establishes the Division and the Board of Parks and Recreation, and sets forth their responsibilities. The Division manages Antelope Island State Park in Great Salt Lake, Willard Bay State Park, and the Great Salt Lake Marina on the south shore of the lake.

The Division is also directly responsible for boating enforcement on Great Salt Lake. Parks personnel also work closely with five county Sheriff Offices to respond to search and rescue activities on the lake. Search and rescue along the eastern shore is handled in a cooperative effort with Davis and Weber County Sheriff’s Offices.

Division of Water Rights

The Division of Water Rights regulates the appropriation and distribution of water in the State of Utah, pursuant to Title 73 of the Utah Code. The State Engineer, who is the director of the Division of Water Rights, must give approval for the diversion and use of any water, regulates the alteration of natural streams, and has the authority to regulate dams for the purpose of protecting public safety. All diversions from the lake for all purposes, including mineral extraction by evaporation, requires the prior approval of the State Engineer. Any dam or dike placed in or around Great Salt Lake requires prior approval from the Division.

Division of Oil, Gas and Mining

The Division of Oil, Gas and Mining is the regulatory agency for mineral exploration, development and reclamation on Great Salt Lake, pursuant to Title 40 of the Utah Code. This regulatory role is conducted in close coordination with the Division of Forestry, Fire and State Lands.

Utah Geological Survey

The Utah Geological Survey, a non-regulatory agency, is responsible for collecting, preserving, publishing and distributing reliable information on geology, brine and mineral resources, and geologic hazards related to the entire state, to include Great Salt Lake. UGS is also responsible for assisting, advising and cooperating with state and local agencies and state educational institutions on all subjects related to geology.

Division of Water Resources

The Mission of the Utah Board and the Division of Water Resources is to direct the orderly and timely planning, conservation, development, protection, and preservation of Utah's water resources to the end they will be used to meet the beneficial needs of the citizens of the State of Utah. Although the Division does not have direct regulatory responsibilities on Great Salt Lake, it conducts hydrologic research and planning, and is responsible for maintenance and operation of the West Desert Pumping Project.

THE PLANNING PROCESS

In August, 1997, the Department of Natural Resources assembled the Great Salt Lake Planning Project Team of representatives from each of the divisions of the Department, with the charge to develop a resource management plan for the Department and all its divisions. The planning process utilized by the team is based on the land management planning process set forth in Section 65A-2-4 of the Utah Code, and in implementing rules found at R652-90 adopted by the Division of Forestry, Fire and State Lands, specifically the processes for Comprehensive Management Plans. Because of the scale of the Great Salt Lake as a planning unit, and because of the complexity and significance of the lake and its resources, the Planning Team has implemented steps and public processes in addition to those set forth in the R652 rules.

Public involvement in the planning process was officially initiated on February 3, 1998 with a notification of State Action to the Resource Development Coordinating Committee (RDCC) and locally published public notices inviting participation in several scoping meetings conducted in each of the five counties in which Great Salt Lake is located. However, starting in November, the Planning Team also conducted informal internal and external scoping and issues identification, and attended a number of association, club and individual agency meetings to discuss the plan and the planning process.

Scoping

The Planning Team initiated "internal" scoping with a series of meetings with divisions of the Department of Natural Resources to identify management programs and issues related to the Great Salt Lake. Scoping was then expanded to an effort to identify other State agency management needs and expectations of the Great Salt Lake Planning Process. The Planning

Team's objective was to develop a clear understanding of what each agency identified as significant in management of the lake and its resources. The following State agencies were interviewed for a total of over 38 hours of informal discussion in this first phase of scoping:

Division of Forestry, Fire & State Lands
Division of Oil, Gas & Mining
Division of Water Rights
Office of Energy, & Resource Planning
Attorney General's Office
Division of Air Quality
Division of Environmental Response & Remediation
Department of Community & Economic Development
Division of State History
Division of Wildlife Resources
Division of Parks & Recreation
Division of Water Resources
Utah Geologic Survey
Division of Water Quality
Division of Solid & Hazardous Waste

Other State agencies which have been contacted but which have not become active participants in the planning effort include: Division of Indian Affairs, Division of Business & Economic Development, Department of Agriculture, and the Division of Comprehensive Emergency Management.

"External" scoping included five public meetings in each of the surrounding counties which were conducted between February 12, 1997 and March 5th, 1998. The purposes of these meetings was to introduce the planning effort to the public, invite public comment on both the planning process and substantive issues, and to identify Great Salt Lake management issues which should be addressed in the Plan. Approximately 80 people attended the public meetings.

The most successful part of the external scoping phase was a series of meetings with federal agencies, local governments, citizens' and industry groups, and individuals interested in Great Salt Lake management. At least 85 percent of the comments received came from these meetings, which involved more than 550 individuals between November, 1997 and April, 1998. External scoping also included incoming correspondence, e-mail messages and telephone conversations.

Statement of Current Conditions and Trends

Based upon the input received from both internal and external scoping, the Planning Team assembled the information available which is relevant to good management of the Great Salt Lake. That information is presented here as the Statement of Current Conditions and Trends, and is more thoroughly discussed below. The Great Salt Lake Technical Team will be asked to refine, amend and add to the Statement to ensure that it is as complete and accurate as possible.

Alternative Management Scenarios

After completion of work on the Statement of Current Conditions and Trends, the Planning Team will develop Alternative Management Scenarios for Great Salt Lake, based upon the Statement and information received during internal and external scoping. The Alternatives will be published for public review and comment, after which the Planning Team will develop a Recommended Management Plan for review and approval by the Division of Forestry, Fire and State Lands and the Department of Natural Resources.

CURRENT CONDITIONS AND TRENDS ON GREAT SALT LAKE

The Department of Natural Resources has in place a number of management programs for the resources of the Great Salt Lake. Those programs are designed to both conserve the lake's resources, and to make those resources available for beneficial uses. The Department's management of Antelope Island State Park and Farmington Bay Wildlife Refuge, the regulation of commercial brine shrimping and sport hunting, and the Mineral Leasing Plan recently adopted by the Division of Forestry, Fire and State Lands are examples of resource management programs currently in operation.

At the same time, there exist factors which are affecting and have the potential to affect the lake, its resources and beneficial uses. Among the objectives of this planning process are to ensure that existing programs contribute optimally to the Department's management objectives for the lake, and that emerging issues and demands are addressed in a coherent and comprehensive manner, consistent with overall management objectives.

The starting point for development of a comprehensive and consistent management plan is the assembly of relevant information and analyses into a resource inventory. Through a six-month internal and external scoping project, the Great Salt Lake Planning Team identified the resource inventory information it feels is relevant to the good management of Great Salt Lake. The inventory information was assembled by resource and use category, and was evaluated to develop descriptions of the current conditions of the lake's resources, and to discern trends which should be taken into account in future management of the lake. Because the information available on Great Salt Lake and its resources is encyclopedic in scope and volume, the Team has digested and presented it in the context of the key issues and needs identified through internal and external scoping. This statement represents a baseline picture of the current condition of the Great Salt Lake and its resources.

This statement of Current Conditions and Trends is organized by resource category, beginning with the water, land, mineral and biological trust resources for which the Department is responsible. These are followed by the recreational, industrial and tourism "use" resources which the Department must manage in concert with its responsibility to sustain the trust resources of the lake.

This Statement is presented to the Great Salt Lake Technical team as a work in progress. The Technical Team is asked to critically review the Statement to ensure that all available information which is relevant to good management is taken into consideration. It is hoped that the characterizations of the information presented will be supported by the Technical Team, but omissions, discrepancies and disagreements should be pointed out to the Planning Team, along with a description of the relevance of the information or issue to the good management of the lake. The Planning Team's objective is to identify those factual matters on which there is general agreement.

The Statement of Current Conditions and Trends should reflect the extent to which the factual bases for development of management plans are generally accepted. There will, of course, be factual disagreements. The Planning Team will need to understand the bases and underlying logic of factual disagreements in order to accurately characterize the state of understanding of the lake's systems for development of management plans and advice to decision-makers. Our request to the Technical Team is to assist the Planning Team in making the Statement of Current Conditions as factually accurate as possible, both on matters on which there is general agreement, and on those which require additional study.

WATER - HYDROLOGY

The Hydrology element addresses matters relating to the physical hydrology of Great Salt Lake, including lake water level, inflows, flooding and diversions. The information collected during the scoping process highlighted three general areas of interest and concern with regard to the hydrology of the lake: lake level, including both low water levels and flooding potential; inflows to the lake, including flow quantities and locations; and diking and causeways in the lake, which affect currents and in-lake water conditions. Although dikes and causeways have significant impacts on lake hydrology, they are addressed in the Water Chemistry section, for the reason that the most significant resource impacts of dikes and causeways are more directly related to water chemistry than to other factors.

Based upon the information gathered during scoping and the resource inventory, the Planning Team has identified two major conditions and trends for the hydrology of the lake which are relevant to future management:

- **Anticipated continued decline in flows to the lake from historic sources. Models of the lake indicate that 100,000 acre-feet of additional depletions per year would lower the average lake level approximately one foot.**

- **The West Desert Pumping Project (WDPP) is presently capable of utilization for mitigation of flood impacts when south arm lake level reaches 4208' by pumping north arm brines, but administrative barriers to its operation, external to the department of Natural Resources, now exist.**

♦ CHANGES IN WATER FLOWS TO THE GREAT SALT LAKE

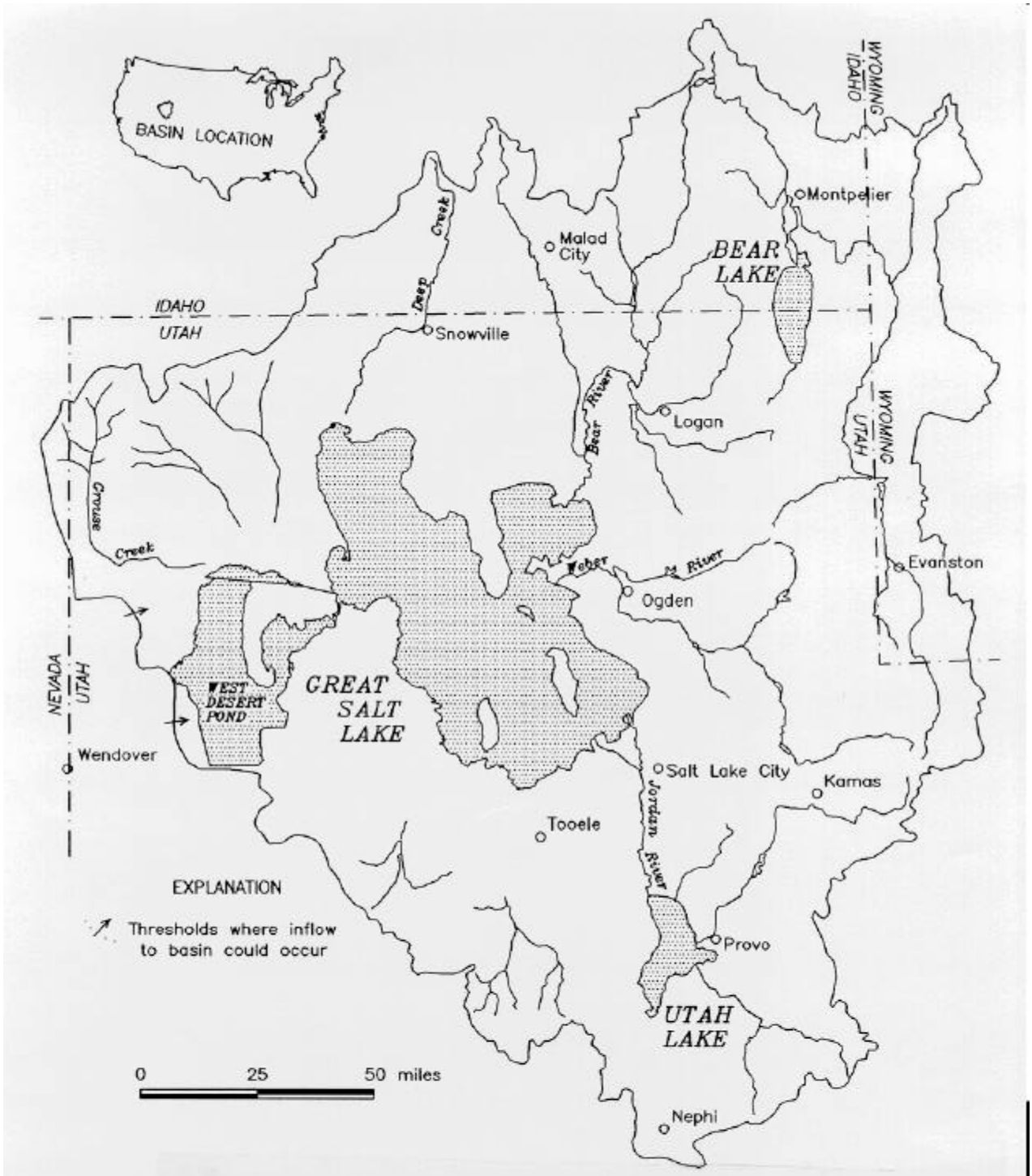
The Great Salt Lake is a remnant of Pleistocene Lake Bonneville, and occupies the lowest point in a 22,000 square mile drainage basin. The lake is a terminal lake, with no outlet at lake water elevations below about 4,217 feet above sea level. This closed basin is formed by the drainages of the Bear, Weber and Jordan Rivers, plus intermittent surface drainage from areas northwest and southwest of the lake. (Map 2) The average annual inflow to the lake, for the years from 1851 to 1992, has been approximately 3,130,000 acre-feet, coming in the form of; 1) gaged or correlated stream flows (1,990,000 acre-feet), 2) estimated un-gaged surface water (170,000 acre-feet), 3) estimated un-gaged groundwater (90,000 acre-feet), and precipitation directly onto the lake surface (880,000 acre-feet). (Figure 1) No water flows out of the lake. The average annual evaporation rate thus equals average annual inflow, although inflow exceeds evaporation during cooler, wetter weather cycles, and evaporation exceeds inflow during hotter, dryer cycles. All of the water which is diverted from the lake is utilized for mineral extraction by evaporation, and is included in the gross evaporation figure.

At the average water elevation of 4,200 feet above sea level, Great Salt Lake has a surface area of 1,500 square miles, making it the fourth largest terminal lake in the world. Great Salt Lake is hyper saline, with average total dissolved salt concentrations in its various arms of from about 8% to over 26%. The average depth of the lake is only twelve feet, so that small changes in lake level either expose or inundate large areas of lake shoreline. For example, at a lake elevation of 4,200 feet above sea level, the lake's waters cover 1,079,259 acres. At 4,204 feet, lake waters inundate approximately 1,223,000 acres. Seasonal and longer term fluctuations in lake level produce dramatic changes in the lake's shoreline on an on-going basis.

The physical configuration of the lake and its high salinity create a "buffering" effect on the movement of the level of the lake. In general terms, as the lake rises, it increases significantly in surface area and declines in salinity. These factors contribute to an increase in annual lake water evaporation, and tend to slow the rise of lake level. Conversely, when the lake level drops, the surface area diminishes and the salinity increases, reducing the total annual evaporation. The lake, therefore, has a natural tendency to protect itself from completely drying up, and has a tendency to slow its own rate of rise. It has been suggested that a one-time removal of water from the lake, while noticeable at the time of removal, will eventually "heal" itself through this buffering effect, returning to pre-removal elevations. Long-term, ongoing increase in diversions will, however, produce long-term changes in lake level.

Water Development Impacts on Lake Level

Over the last 20 to 30 years, a number of studies have attempted to define the effects of water development and other man-caused water use on the lake level. The studies indicate that, for each additional 100,000 acre-feet of consumptive use, the average level of the lake would be approximately one foot lower. It must be noted that the diversion of 100,000 acre feet does not



Map 2 Great Salt Lake Drainage Basin

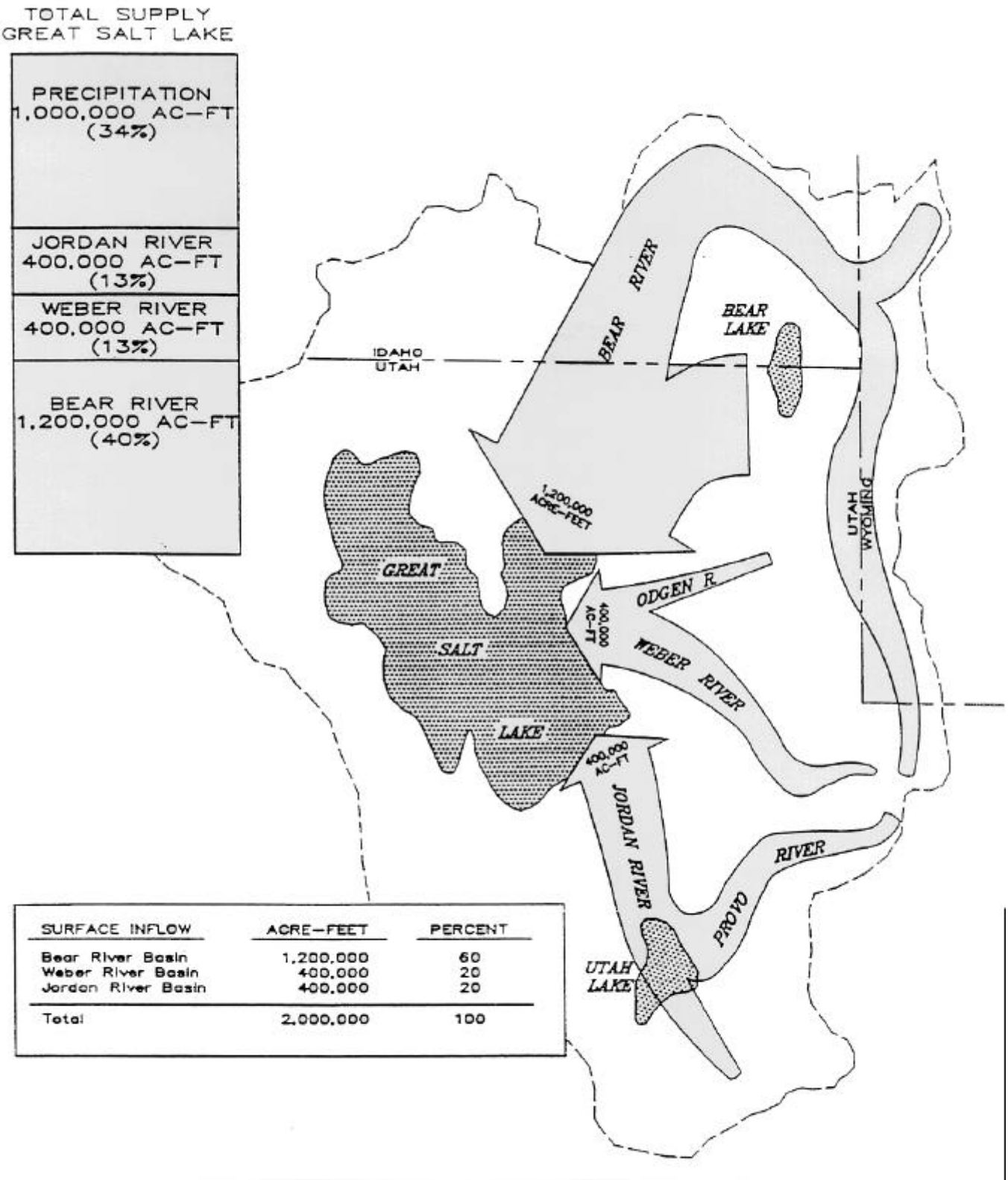


Figure 1 Great Salt Lake Water Supply

result in the consumption of 100,000 acre feet. Water diverted for agricultural uses, and for municipal and industrial uses (M&I) is not entirely consumed ("depleted"), and significant quantities are returned to the system as return flows. At the same time, it should be noted that an average increase of 100,000 acre-feet per year would raise the average lake level by one foot.

It is expected that depletions to the inflow of Great Salt Lake from historical sources will continue through water development on tributaries to the lake and other man-caused water uses. In the Jordan and Weber Basins, which have been highly developed by Weber Basin Water Conservancy District and Central Utah Water Conservancy District projects, it is expected that already diverted and developed water will be converted from agricultural uses to meet municipal and industrial (M&I) demands, rather than large, new water projects developed. M&I uses tend to consume smaller quantities of water per acre than do agricultural uses, and such conversions could mitigate the anticipated reduction in flows, unless the re-use of M&I discharge water is allowed, reducing the quantities which are returned as return flows. Another mitigating factor may be the importation of Uinta Basin water to the Great Salt Lake basin by the Central Utah Project.

In the Bear River Basin, it is expected that major new water diversions and developments will occur. Alternatives for development of water resources in the Great Salt Lake drainage area have been documented in the Utah State Water Plans. These plans guide management and development of water resources in the Great Salt Lake drainage basin, but are not for the purposes of managing inflow, levels or areal extent of Great Salt Lake. Large, new water development projects on the Bear River could increase the depletion of flows to Great Salt Lake.

♦ CHANGES IN WATER DIVERSIONS FROM GREAT SALT LAKE

Administration of Water Rights and Diversions

The diversion of water from Great Salt Lake is governed by the same Utah water appropriation laws and regulations as is the diversion of water from streams, springs or wells. Under Utah law, all waters of the state are the property of the state. A water right secures to an individual or entity the right to divert the water and place it to a recognized beneficial use. All water rights in the state are administered by the State Engineer with the assistance of his staff, the Division of Water Rights.

A water right is acquired by filing an application with the State Engineer and receiving his approval. If the application is approved, the applicant generally has three years to develop his project, place the water to beneficial use, and submit proof of the beneficial use to the State Engineer. Extensions of time for filing proof can be requested. An unapproved water right is considered to be the personal property of the applicant. Once proof of beneficial use is submitted, defining the quantity of water developed and the water uses, the State Engineer issues a Certificate of Appropriation which the applicant files with the local county recorder. At this point, the water right is said to be perfected, and is considered to be real property.

In order for an application to be approved for development, the following conditions must exist: 1) there must be unappropriated water in the proposed source; 2) the proposed use must not interfere with existing rights or interfere with a more beneficial use of the water; 3) the proposed development must be physically and economically feasible and not detrimental to the public welfare; 4) the applicant must have the financial ability to complete the proposed works; and 5) the application must be filed in good faith and not for the purposes of speculation or monopoly[5]. If there is reason to believe that an application will interfere with a more beneficial use, unreasonably effect public recreation or the natural stream environment, or will prove detrimental to the public welfare, the State Engineer will withhold approval.

There is an additional requirement of the law which is important. In order to maintain a water right, the water must be diverted, or physically removed, from its natural source. The only exception to this rule is approved in-stream flow rights, which must be held by either the Utah Division of Wildlife Resources or the Utah Division of Parks & Recreation.

There are several ways a water right may be terminated. An unperfected water right may be terminated by the State Engineer, 1) at the applicant's request, 2) if the applicant fails to meet the criteria for appropriation or the conditions of approval, or 3) the applicant fails to develop his project in the time allotted. Once a water right is perfected there are two ways it may be terminated. The water right holder can file a statement of abandonment and forfeiture with the State Engineer and his local county recorder, or the courts may terminate the water right as part of a civil proceeding.

Tributary Water Rights

Except for the Bear River drainage and the West Desert, all surface waters of the Great Salt Lake basin are considered to be fully appropriated, except during high water years. On the Bear River, appropriations are still allowed, but there are factors which may restrict the amounts available. At present, the Board of Water Resources, by statute, is considering various alternatives for the development of Bear River water for use in various locations along the Wasatch Front. It should be noted that development of the Bear River is subject to the limitations of the Bear River Compact.

While the Jordan River system, the upper Weber River drainage, and Tooele Valley are closed to new appropriations of ground water, ground water is still available in the Bear River drainage, the West Desert, and on portions of the eastern shore of the lake.

Great Salt Lake Water Rights

The State Engineer, for administrative purposes, has divided the Great Salt Lake drainage

[5] Utah Code Annotated, 1953, Title 73, Chapter 3, Paragraph 8.

basin into a number sub-basins. Each sub-basin has its own set of policies governing the appropriation and management of its water. The Great Salt Lake is open to appropriation. However, the siting of diversion facilities is dependent upon the applicant securing the proper easements and/or permits from the responsible regulatory agencies and landowner.

There are currently 11 perfected water rights to divert water from the lake, all owned by companies or individuals in the mineral extraction industry (See map 3 for locations of mineral extraction operations). The earliest priority date of these rights is 1940, the latest is 1986. Under these rights, if used to their fullest, it is possible for the right holders to divert 362,306 acre-feet per year (af/yr). Due to economic limitations, climatic conditions, and the available evaporative surface, only between 95,000 and 180,000 acre-feet per year is currently diverted. The vast majority of this water is evaporated, while very small amounts return to the lake through pond leakage and flushing. There are 6 water rights applications which have been approved for development, one of which is non-consumptive. These rights, all owned by mineral extractors, represent a possible diversion of 444,562 af/yr for mineral extraction. The earliest priority date of these rights is 1962, the latest is 1993. Like the perfected rights, the majority of the water diverted under these applications would be consumed by evaporation.

There are 11 applications which have not been approved for development. Ten of these applications are owned by mineral extractors and one is owned by a quasi-governmental agency to provide cooling water for a proposed nuclear power plant. These applications represent a potential additional diversion of 657,565 af/yr, the great majority of which is for mineral extraction. The earliest priority date is 1964, the latest is 1995. The State Engineer has on file two unapproved applications which do not divert water from the lake, but which would have a large impact on it. Both call for the diking of Farmington Bay and its use as a fresh water reservoir.

Under existing approved rights, an additional 627,000 to 712,000 acre-feet of brine per year could be diverted from Great Salt Lake and consumed by evaporation. However, unless the water so diverted is evaporated in ponds constructed outside the lake area, thereby increasing the effective surface area of the lake, such additional diversions should have no measurable effect on average lake level. Although this quantity is approximately 25% of the total annual inflow to the lake from all sources, the primary limiting factor on greatly increased water diversions from the lake under existing rights and applications is the amount of new land available and suitable for evaporation ponds. The possibility that all the water approved under existing applications will be diverted and consumed at some time in the future is very remote. It is, however, likely that existing mineral extraction operations will seek to expand their evaporation ponds and brine diversions.

♦ FLOODING AND THE OPERATION OF THE WEST DESERT PUMPING PROJECT

Lake Level Fluctuations and Flooding

Great Salt Lake has historically (defined as the period from 1851 to the present), experienced wide cyclic fluctuation of its surface elevation. Since 1851, the total annual inflow (surface, groundwater and precipitation directly on the lake surface) to the lake has ranged from approximately 1.1 to 9.0 million acre-feet. This wide range of inflow to the lake has caused the surface elevation to fluctuate within a 20 foot range. Historically, the surface elevation of the lake reached a high of 4211.5 feet in 1873 and a low of 4191.35 feet in 1963. (Figure 2) A new record high elevation of 4211.85 feet in the south arm was met in 1986 and matched again in 1987.

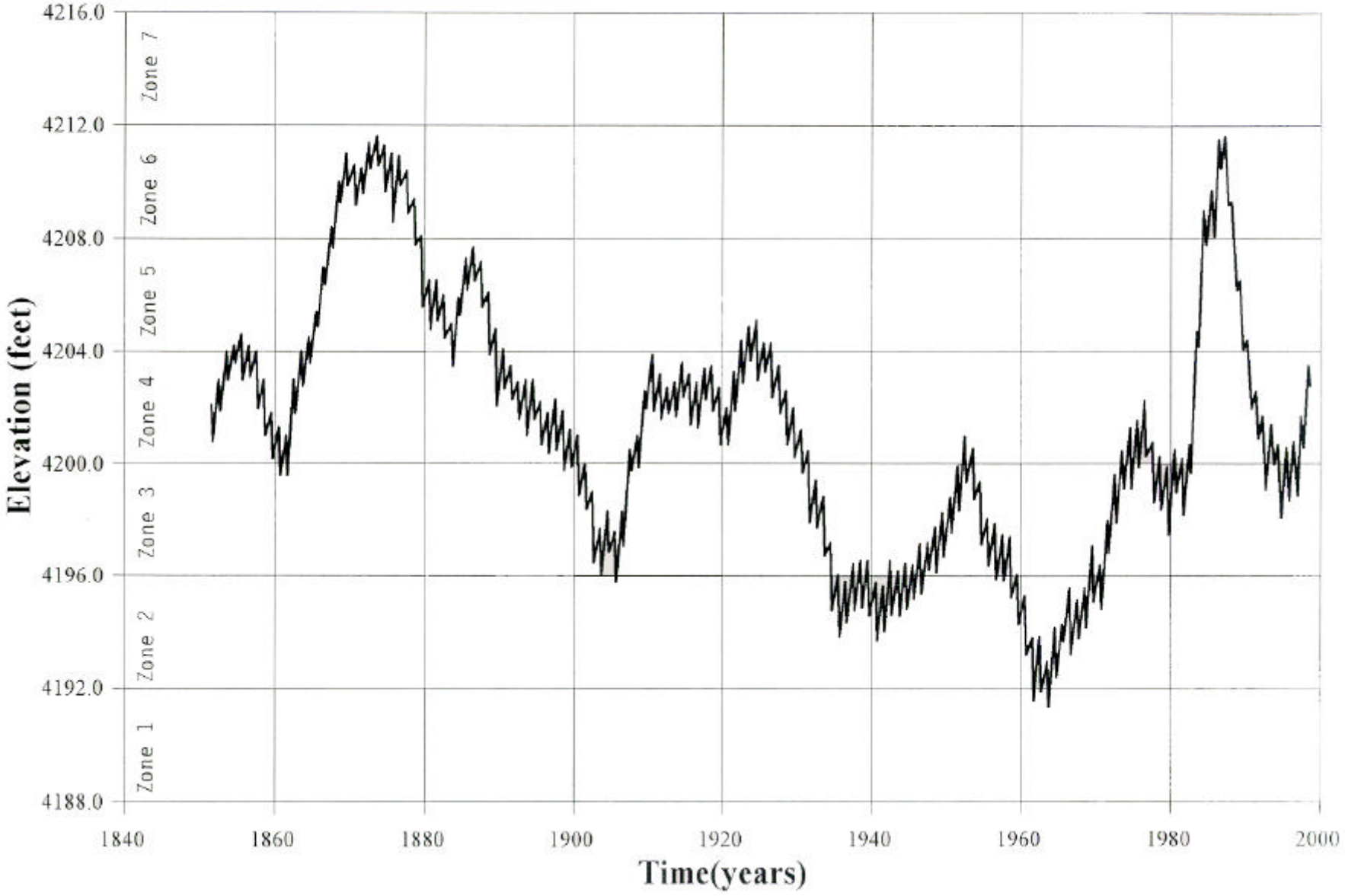
From 1933 to 1983, the average elevation of the lake was 4196.77 feet above mean sea level, with a maximum of 4202.25 feet and a standard deviation of 2.58 feet. Even during the 100 year period prior to 1983, the lake's average elevation was 4198.29 feet with a high of 4207 feet and a standard deviation of 3.60 feet. During the period 1983 to 1987, however, the lake rose rapidly 12.2 feet from 4199.65 to 4211.85 feet, causing extensive flooding. The result was millions of dollars in damages and many millions more spent for mitigation and protection from future damage.

Because Great Salt Lake is a terminal lake in a closed basin, the surface level of the lake changes continuously. Short-term changes occur in an annual cycle of dry, hot summers and wet, cool winters. Long-term climatic changes occur with overlapping periods of about 20 to 120 years, and perhaps longer. They have caused the lake level to vary up to 20 feet during the recorded period. The annual high-lake level, which normally occurs between May and July, is caused by spring-summer runoff. The annual low-lake level occurs in October or November at the end of the hot summer evaporation season. The average annual (pre-1983) fluctuation of the south arm of the lake, between high and low, was about 1.48 feet; the north arm fluctuation averaged 0.99 feet. The difference between the magnitude of the south and north arm fluctuations is due mainly to the flow-restrictive influence of the northern railroad causeway and the lack of tributary inflow to the north arm. The highest recorded annual rise of the south arm, 5.05 feet, occurred the same year (1983). These exceptional fluctuations in lake level were due to a high snow pack and an above-normal spring precipitation during these years.

Because of the broad, shallow nature of Great Salt Lake, its surface area expands rapidly as its elevation increases. Elevations 4200 and 4212 feet, represent a common average lake-level and the historical high-lake elevation, respectively. Between these two elevations, the area of the lake increases over 46 percent from about 1,079,259 to 1,572,000 acres. Within this range, the potential of minor, or increased flooding exists with even normal annual fluctuations. Above-normal fluctuations, such as those experienced during 1983 and 1984, result in extensive flooding.

Figure 2

HISTORICAL GREAT SALT LAKE HYDROGRAPH



The low lying plain surrounding Great Salt Lake is particularly susceptible to flooding and associated hazards. Regarding the flood plain, Lowe (1990a and 1990b) states the following: "Using the best available historical and scientific data on Great Salt Lake, government policy-makers and lake experts have recommended that a beneficial development strategy should exist for lake-shore areas up to 4217 feet in elevation". (Utah Division of Comprehensive Emergency Management, 1985). This strategy establishes a "Beneficial Development Area" (BDA) along the shore of Great Salt Lake between 4191.4 feet (the lake's historic low level in 1963) and 4217 feet. At an elevation of about 4217 feet, the lake naturally flows out onto the broad expanses of the Great Salt Lake Desert. The strategy recommends that, within the elevation interval between 4191.4 and 4217 feet, development take place in a manner that will encourage the maximum use of the land for the people of Utah while avoiding unnecessary disaster losses. Pursuant to the strategy, the Utah Geological Survey would provide technical information and maps showing geologic hazards, and city-county surveyors would provide a BDA line which is at the 4217 foot elevation contour to the planning, zoning and permitting agencies of applicable city, county, and state agencies.

The naturally occurring water level fluctuations of Great Salt Lake are termed "flooding" when the level of the lake begins to adversely affect structures and developments which are located within its flood plain. The impact of flooding is greatest around the shores of the southern arm of the lake where the majority of the recreational, industrial, wildlife management, and transportation facilities have been built. To minimize the chances of flooding, the present and the past elevation of the lake, and its anticipated short and long-term fluctuation (rises and falls), should serve as guides to determine "safe" construction areas, and to identify areas which may be subjected to inundation, wind tides, ice damage or shallow ground water problems.

Long-term lake fluctuations result from a net gain or loss in lake elevation over a specified period of time. For example, between 1873 and 1963, the elevation of the lake fluctuated downward more than 20 feet, from 4211.5 to the historic low of 4191.3 feet. It then moved upward, while fluctuating within a 20 foot range, to the historic high of 4211.85 in 1987.

For planning purposes, it is important to know the maximum movement of the lake level that might be expected during a five-year period of time, for example. Based on lake-level data, it is estimated that during 5-year blocks of time from 1847 through 1982, when the lake's trend is upward, the maximum one-year upward fluctuation is about 6 feet. Notable exceptions to this were seen during 1983-84 when the level of the lake increased by nearly 12 feet during a five-year block. When the trend is downward, the maximum one-year downward fluctuation is about 4.5 feet. The abnormal rise of the lake from 1983 through 1984 was not included in determining these estimates.

Flooding Impacts

Flooding in the recent past has caused enormous financial damage and has required large sums of money to mitigate. The lake flooding episode of 1983-1987 is estimated to have caused

over $240 million (1985 dollars) in damages. Had the lake level continued to rise and interrupted the operation of the northern and southern railroad causeways and Interstate 80, it is estimated that the State could have suffered from $500 million to $1 billion (1985 dollars) in direct and consequential damages. Development and placement of structures in hazardous or flood-prone areas are the major causes of these high damage figures.

Flooding of Interstate 80 and Other Access Roads

Interstate 80 near Great Salt Lake had problems during the flooding period of 1983-87. Several sections had to be raised as much as eight feet, to an elevation of 4214, in order to make the freeway useable. The cost to do this work was some $20 million. The annual average daily traffic (AADT) of I-80 is through Tooele is 5,700-plus vehicles, with an AADT of 3,000 vehicles through Grantsville.

The Utah Department of Transportation (UDOT) subsequently undertook a project of installing concrete pavement (final surface) from Burmester to the Tooele Interchange, replacement of the bridge and modification of the Black Rock Interchange, all of which were completed in 1992. This section of I-80 is not expected to need attention until around 2002, other than routine maintenance. Because of this construction I-80 could operate without adverse impact as long as the lake level did not rise above 4211 feet elevation.

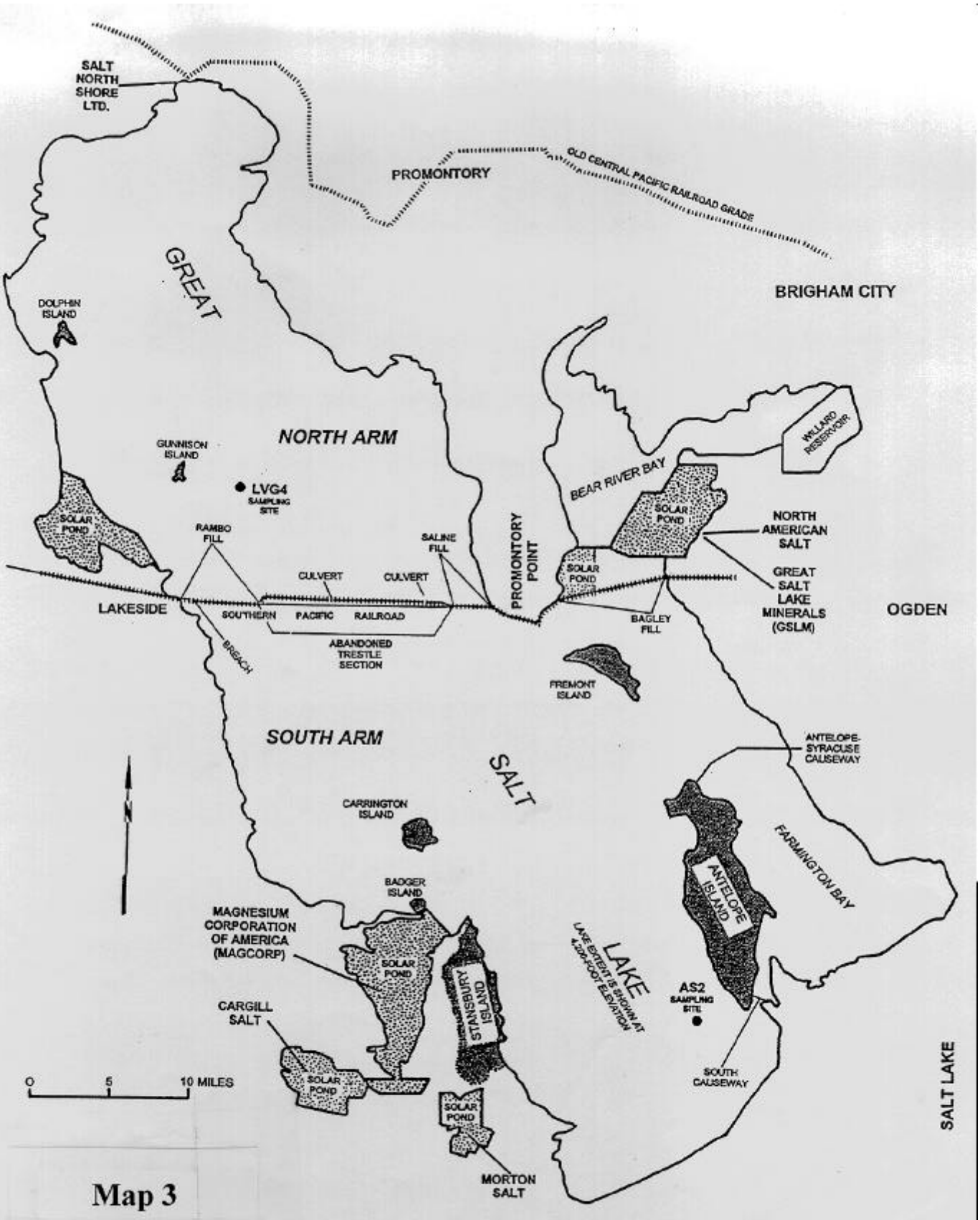
The Davis County causeway to Antelope Island was a State Highway at the time of the severe flooding of the 1980's and was inundated. This highway was transferred to Davis County on May 17, 1991, and was subsequently raised two feet, to 4208.75', and was paved during 1992. The use of the Davis County causeway is adversely affected by lake levels of 4205 feet and higher.

Flooding Impacts on the Southern Railroad Causeway

The Union Pacific Railroad causeway, located at the southern end of Great Salt Lake, is a major rail line to the west coast. It presently serves many chemical industries in this region and provides daily passenger service via Amtrak as part of an east/west rail corridor. In 1983, the rising lake began to effect the railroad track structure. The Union Pacific raised the track in this area to protect it from the rising water. The elevation at the top of the rail for the railroad through most of this area is 4221.0 feet, with the sub-grade (top of the embankment) at an elevation of 4218.5 feet.

Flooding Impacts on the Northern Railroad Causeway

Southern Pacific Transportation Company (SPTC) constructed a wooden trestle spanning the lake through Promontory Point to Lakeside to shorten the time required to go north around the lake. In 1959, the SPTC completed the replacement of the original wooden trestle across the lake with a rock-fill and earthen causeway (See Map 3). The causeway was designed and



Map 3

Map of Great Salt Lake showing locations of industry solar-evaporation ponds, the Southern pacific Railroad causeway, the old Central Pacific Railroad grade, and other physical and cultural features around the lake.

constructed to have a minimum freeboard (vertical distance from maximum water level in the lake to the top of the causeway slope protection) of ten feet. The slope protection design was based on the U.S. Army Corps of Engineers Shore Protection Manual, and was provided by utilizing very large one to three ton stones and placed on a 1.5 to 1 slope. The thickness of the large stone layer was five feet. The causeway settles an average of two to four inches per year, which began ten years after construction. Several areas on the causeway have experienced more settlement than the average, up to a half foot per year, and settlement of up to 17 feet in total.

Great Salt Lake is subject to sudden and violent storms, with winds up to 70 mph. The winds generate waves that can reach 8 feet in height and have 20% more energy than the ocean due to the higher density of the lake waters. The height, length, and period of wind-generated waves are determined by wind speed. The calculated "design wave", which is the average of the highest one-third of all waves, is 7.2 feet for the northern railroad causeway. High winds and waves can occur year round. However, most of the damaging wind and waves occur from the north, from April to July, and from the south, from July to August.

Prior to completion of the northern railroad causeway in 1959, the surface elevation throughout the lake was uniform. After completion of the causeway, however, an elevation difference began to develop between the two arms of the lake, with the south arm being the higher. This elevation difference is due to two factors; the majority of the tributary inflow enters the south arm of the lake, and the causeway restricts the movement of water from the south to the north arm of the lake.

From 1959 to 1982 the freeboard varied from 8 to 17 feet. During periods of the higher water elevations and the low freeboard, the slope protection had some isolated areas that eroded and required repair. In January of 1983, the average elevation of the crest of the causeway fill areas crossing the lake was 4209 to 4210 with some isolated areas as low as 4207. There were approximately 30 miles of fills crossing the lake and 60 miles of exposed slopes. By 1987, the fills crossing the expanding lake increased to 60 miles with over 105 miles of slopes to protect. The decision was made to utilize surplus scrap box cars to create a "boxcar sea wall" on the north side of the causeway, which allowed the tracks and fill to be raised from about 4206 to 4217 feet.

During the flood years, the causeway began to slough-off, settle, and subside into the lake. It experienced five to six feet of subsidence along much of its length due to the weight of additional fill material. By the spring of 1984, the very large inflows of fresh water into the south arm of the lake and the restriction of the flows to the north through the causeway fill and plugged causeway culverts had created a head differential of water levels of nearly 3.5 feet between the north and south arms. The higher elevation in the south arm added greatly to flooding problems on the south and east shores of the lake. The State constructed a 300 foot opening (breach) in the causeway, just off the west shore near Lakeside, to allow the rising waters to flow more freely into the north arm, thus reducing the large head differential and flood damage. The breach lowered the head differential between the lake arms to less than one foot.

Flooding Impacts on Recreation

The rising lake level of the early 1980's damaged many millions of dollars of recreation facilities, and user opportunities were lost due to record-high waters. Antelope Island was isolated, marinas were forced to close, and the southern sandy beaches were inundated by the waters of the lake. Recreation facilities on the lake generally begin to experience damage and interference with operations at lake levels of 4205' and higher.

Flooding Impacts on Wildlife and Wetlands

Most waterfowl management areas around the lake were constructed in the 1930's to 1940's when the lake level was relatively stable at 4198 feet above sea level. At these levels, annual production of waterfowl approached three-quarters of a million birds, with non-game production numbering in the multi-millions. Total bird use of the marshes on the lake exceeded 100 million use-days annually and recreationists would expend on-half million days each year afield. Marshes were managed for mean water depths of about 18 inches.

During the flood years of the 1980's, nearly 300,000 of the 400,000 acres of marsh around the lake were inundated or devegetated due to salt intrusion. Damages to State-owned dikes, water control structures, parking facilities, fences, signs and gates were estimated at over $30 million. Similar damage occurred on the federal Bear River Migratory Bird Refuge. During the floods, production of ducks and geese dropped by 80 percent and fall swan use decreased over 90 percent. Total bird use decreased nearly 90 percent and public use all but disappeared.

Although potentially damaging to structures in wildlife management areas, fluctuations in lake water levels are beneficial to wildlife. Periodic flooding and drying events keep wetlands in young successional stages and increase their productivity. At lake elevations above 4208 feet, most lake-shore fresh-water wetlands have been inundated.

Flooding Impacts on Investor-Owned Public Utilities

Unless flooding is so severe as to enter established commercial and residential developments, damages to the telephone and gas utilities (US West and Mountain Fuel/Questar, respectively) are minimal, even at lake elevations above 4208 feet. Much more vulnerable to flooding are Pacificorp’s power lines. The anticipated loss at 4210 feet is $1.3 million (1993 dollars), adversely affecting several high-voltage transmission lines between the Salt Lake International Airport (SLIA) and Kaysville, two near Saltair, three more near Timpie Springs, a substation in Centerville, and numerous service distribution lines. Damage costs would escalate to an expected level of $19.5 million (1993 dollars) if the lake level reached 4212 feet. The construction of the third commercial runway at SLIA required relocation of several of the major power transmission lines closer to the lake, which could make the damage estimates even greater.

West Desert Pumping Project

Although the name West Desert Pumping Project (WDPP) implies a pumping project, it is actually a project which operates by expanding the surface area of the lake by approximately 26 percent through the creation of the "West Pond"on the west side of the Great Salt Lake. The expanded surface area enhances the evaporation of water from the lake, thereby increasing the rate of evaporation. The increased evaporation slows lake level increases and accelerates lake level declines during periods of high lake levels.

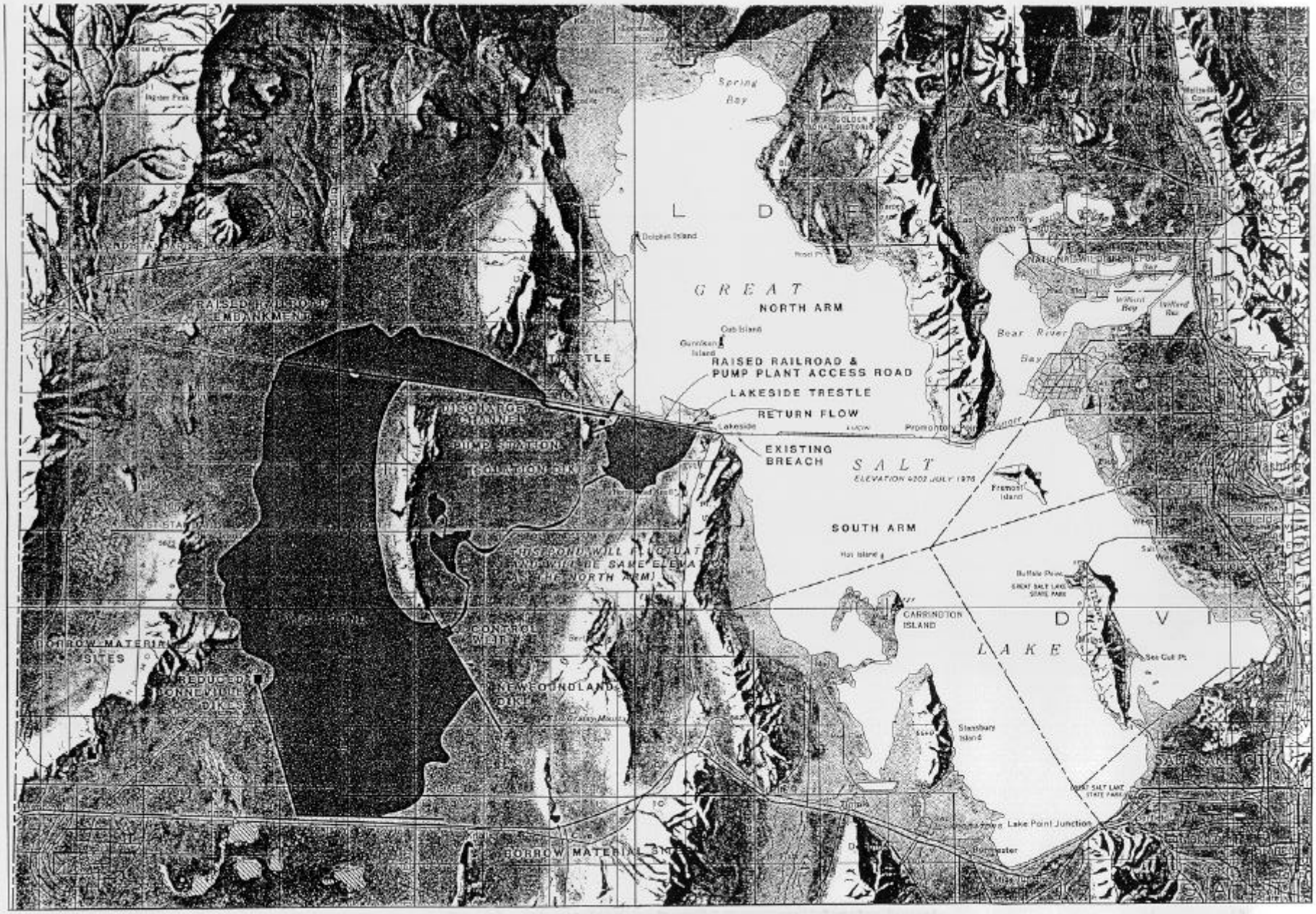
The WDPP consists of a ten mile long access road along the former Southern Pacific Transportation Company railroad causeway, a pumping station, two canals, trestles, dikes, a 37 mile long natural gas pipeline and the west pond in the desert west of the Newfoundland Mountains (See Map 4). The west pond has a surface area of 320,000 acres, approximately 508 square miles, and a volume of 800,000 acre-feet at an elevation of 4216.5 feet. Three large pumps lift up to 3,000 cubic feet per second of water from the north arm of the lake to a 4.1 mile long outlet canal. The canal begins at elevation 4224 feet above sea level and discharges water into the west pond. The project is designed to pump approximately two million acre-feet of water a year into the West Pond to evaporate up to 825,000 net acre-feet of water each year.

A 24.4 mile dike with a maximum height of six feet retains the southwest portion of the evaporation pond and prevents water from the project from flooding I-80 and the famous Bonneville Speedway. A second dike 8.1 miles long with a maximum height of seven feet extends southeast from the southern tip of the Newfoundland Mountains and is used to contain the water and restrict the surface flooding of the U.S. Air Force military range. A weir in the dike is used to regulate the pond's surface level between 4215 and 4217 feet and to regulate the return of concentrated brine to the lake. Return flow through the military range was not confined, and flowed over the natural topography in an expansive path on its return to the lake.

Pumping started on April 10, 1987 and continued until June 30, 1989. During this period an estimated 2.73 million acre-feet of brine were pumped from the lake. The pumping project was successful in lowering the level of the lake some 15 inches. After pumping had ceased, the lake level continued to drop an additional two feet through the end of 1989 when precipitation dropped to normal levels. The lake level continued to drop an additional four feet through the end of 1993.

<u>Operating Consequences and Constraints</u>

The design of the WDPP was modified prior to construction. The original design called for brine to be pumped from the fresher south arm of Great Salt Lake. The "Bare Bones" modification reduced the cost of the project and sped construction somewhat by pumping brine from the north arm of the lake rather than the south arm. The use of more concentrated north arm brine reduced the evaporation potential of the project and resulted in more salt being left in the West Pond. It is estimated that 400-600 million tons of salts precipitated in the West Pond



Map 4 West Desert Pumping Project and Evaporation Pond

area during the operation of project from April 1987 to June 1989.

In its present configuration, the WDPP is capable of design operation only at south arm lake levels of 4208 feet or higher. The pumps are installed in a manner which would allow operation at a south arm elevation of 4204 feet. The current configuration of the WDPP will allow the pumping of only north arm brines. Pumping the denser north arm brines reduces the efficiency of evaporation, in that less water can be extracted from the brines before salts begin to precipitate in the west pond. Operation of the WDPP should begin in the early spring, as the lake begins its seasonal rise, and continue through the summer evaporation season. Pumping should continue through the fall and into the winter to redissolve the salts left during the summer to return them to the lake.

The relationship between lake levels, the pumping of brine from the north and south arms, and the build-up of salts in the west pond are presented in Figure 3. The upper, more densely stippled shading shows the upper and lower limits of salt precipitation for north arm brines at varying lake level elevations. The lower, less densely stippled shading shows the same limits for south arm brines. Figure 3 shows that the WDPP could operate without precipitation of salts in the west pond if operation is commenced only at lake elevations of 4210 feet above sea level and higher. With the current configuration of the inlet canal and west pond, the WDPP can only be operated at lake levels above 4208 feet, with the feed brine pumped from the north arm of the lake. Unless the west pond is significantly reduced in size, which would significantly reduce the effectiveness of the system, operation of the WDPP in its current configuration will result in precipitation of additional salts in the west pond.

Administrative and Legal Considerations

As part of the original WDPP, various rights-of-way, permits, and memoranda of understanding were executed among the State of Utah, the Bureau of Land Management, the U.S. Air Force and the U.S. Army Corps of Engineers. Several of these were long term agreements to operate the WDPP, such as the right of way issued by the BLM. Others were short term, temporary permission arising out of the emergency nature of the project. The U.S. Air Force never granted an official approval for the use of the range in operation of the WDPP, but instead issued a letter approval for temporary operation for the duration of the flooding emergency. In recent discussions, the Air Force has notified that State that an environmental baseline study would be required, and perhaps an update of the original project EIS, before they would grant official permission to flood parts of the Utah Test and Training Range. They have also indicated that a proposal to utilize the WDPP for purposes other than flood control, would heighten their scrutiny of the request.

The Corps of Engineers has also raised a concern over the impacts the pumping project may have had on the ecology of the Great Salt Lake, including the removal of salts from the lake. The Corps issued a Section 404 permit for construction of much of the WDPP, which permit also covers operations. They have indicated that a resumption of pumping, or a change in the use

LEGEND / NOTES:

(1) Max. weir elev./salt buildup boundary (4216.57 weir elev.)

(2) Min. weir elev./salt buildup boundary (4215.00 weir elev.)

(3) Operating system above max., line allows for maximum pond size with no salt buildup in pond.

(4) Operating system below max. line requires a reduction in pond size (resulting in loss of evap.) to not build up salts. Determination of the weir height can best be done using a computer model of the ponds.

(5) Lowest limit (lowest level of weir setting) at which the system can be operated with no salt build up. System can be operated below min. line but not without salt build up.

(a) ----- North Arm Brines

(b) —— South Arm Brines

(c) Pond evaporation in 1,000 Acre Feet.

(d) All elevations are referenced to South Arm Datum. A 0.9' amount was added to the North Arm gage reading (0.2' for gage correction and 0.7' for level difference), to adjust North Arm data to the South Arm Datum.

Source: Utah Division of Water Resources.

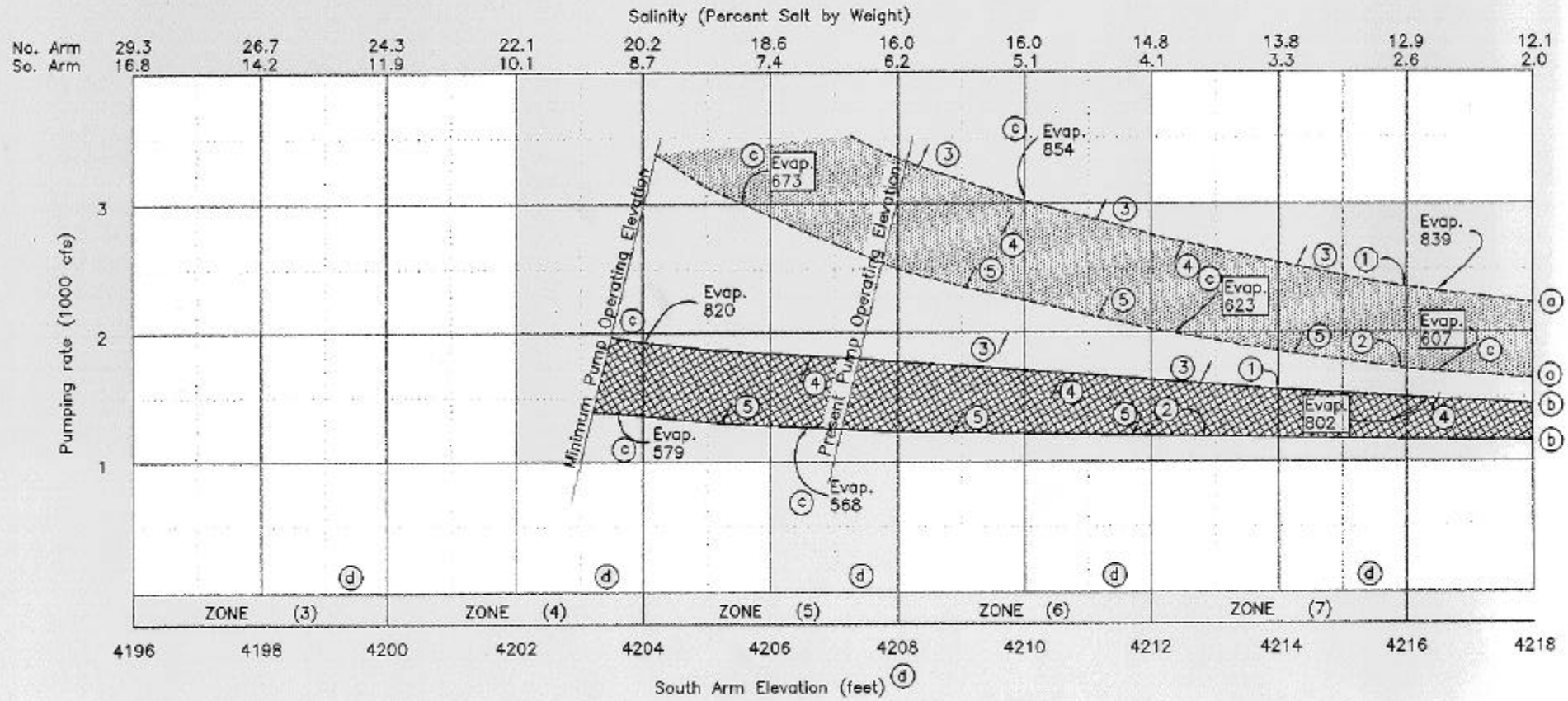


Figure 3

or protocols of the WDPP, would likely trigger an evaluation of the State's performance under the permit in light of their concerns.

WATER - CHEMISTRY

The Water Chemistry element addresses the overall salinity and ion concentrations of the water of the Great Salt Lake. Biological and other chemical water constituents are discussed under the Water Quality element. Based on internal and external scoping, the planning team has identified three major categories of issues related to water chemistry; differentiation in salinities among separate areas of the lake, long-term changes in salinity and ion balance, and the isolation of quantities of soluble salts from the lake system.

The water chemistry and salinity differentials and trends are significant to the aquatic and avian biology of Great Salt Lake, and to the extraction of mineral salts from the brines of the lake. The impacts of varying water chemistries and salinities to the wildlife and mineral industries of the lake are discussed in the Biology and Mineral and Hydrocarbon Extraction elements, respectively. This Water Chemistry Element focuses on the physical and chemical aspects of the brines of Great Salt Lake, and on the hydrologic mechanisms in operation on the lake.

The Planning Team has identified the following lake water salinity and chemistry conditions and trends as relevant to lake management:

- **Continuation of separate and distinct salinity areas in Great Salt Lake.**

- **Continuing net northward movement of dissolved solids from the South Arm to the North Arm of the lake through the northern railroad causeway, with resulting freshening of the South Arm.**

- **Stable lake brine ion concentrations.**

- **Lack of an accurate accounting for the quantities and locations of salts in the lake system.**

♦ SEPARATE WATER SALINITY AREAS IN THE GREAT SALT LAKE

It is believed that, prior to construction of dikes, causeways and mineral extraction facilities in the Great Salt Lake, lake brines were similar in composition and concentration throughout the lake. Beginning in the early 1900's, dikes and causeways have been constructed in the Great Salt Lake for a variety of purposes. Several of these have had the effect of inhibiting the unrestricted movement of lake brines among large areas of the lake. Coupled with the fact that most of the freshwater inflow to the lake occurs on the eastern shore of the lake, distinct

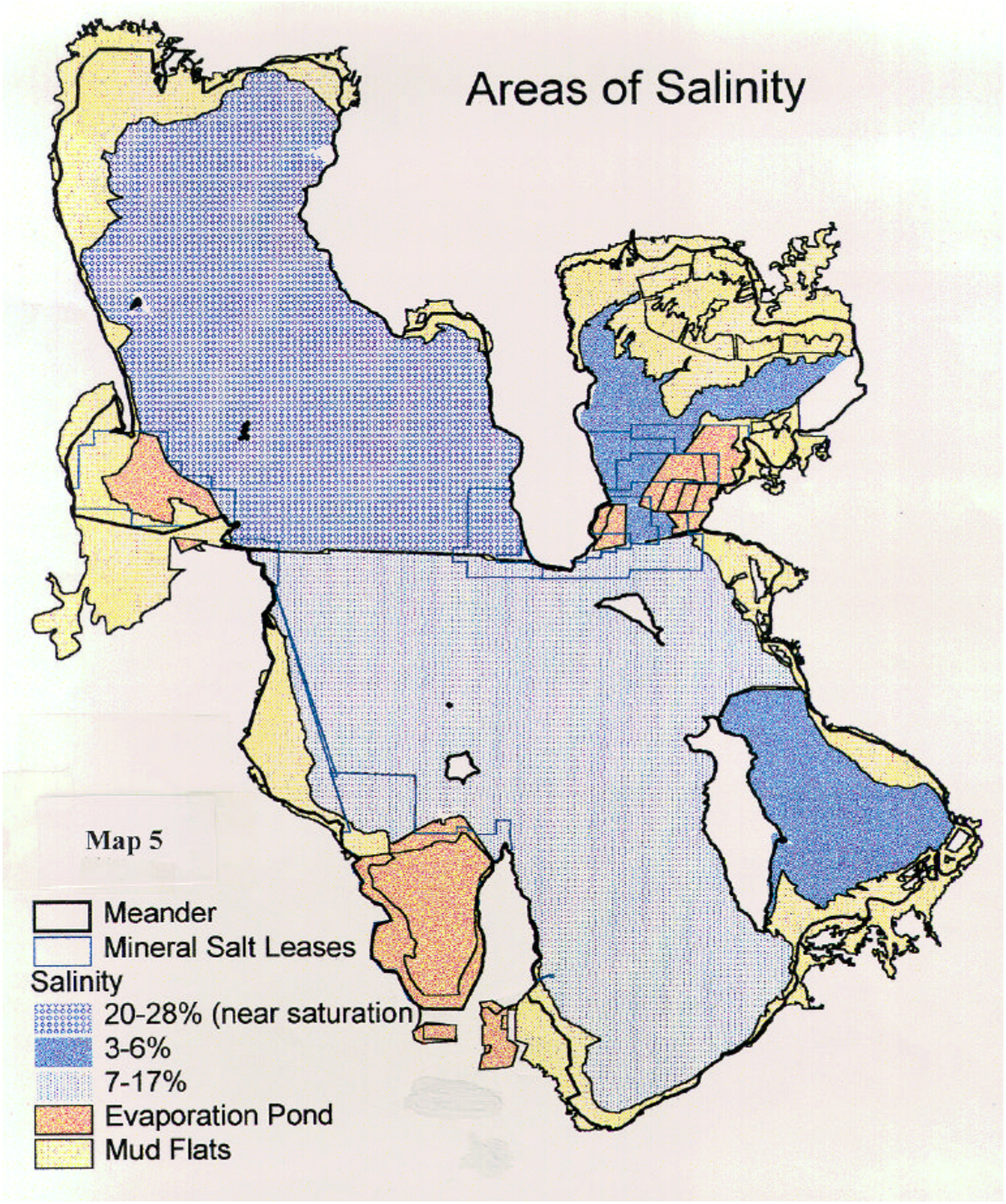
salinity conditions have developed in four main areas of Great Salt Lake. From freshest to most saline, they are; Bear River Bay, Farmington Bay, the main body of the lake (sometimes referred to as the "south arm" or Gilbert Bay), and Gunnison Bay, often referred to as the "north arm". Map 5 shows the areas of salinity in Great Salt Lake. Bear River Bay and Farmington Bay are both shown with salinities of 3 to 6%. Bear River Bay is generally fresher than Farmington Bay.

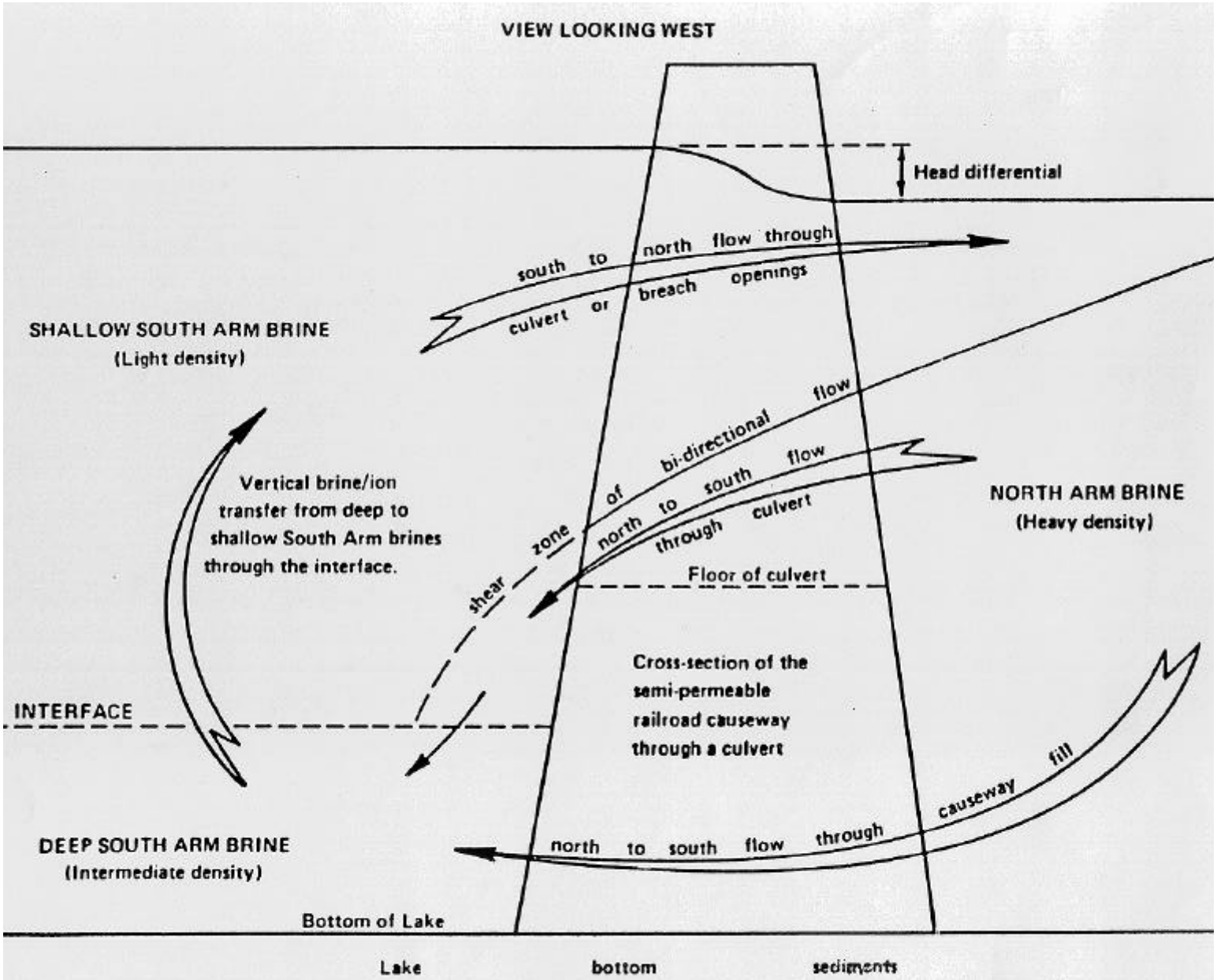
Gunnison Bay and Bear River Bay are separated from the main body of Great Salt Lake (Gilbert Bay) by a sand, gravel, and rock-fill causeway across the mid-portion of the lake, the northern railroad causeway. Construction began in 1956 and was completed in 1959. With the completion of the causeway, the main body of Great Salt Lake was now divided into two parts, the south and north arms. Even with the engineered permeability of the causeway and the incorporation of two 15-foot-wide by 20-foot-deep box culverts through the causeway, brine mixing between the two bodies of water was greatly diminished. Since 1960, the two main arms of the lake have developed different physical and chemical characteristics which vary as the lake level changes, and as changes are made to the structure.

Farmington Bay was part of the south arm of Great Salt Lake until it was isolated by the construction of two earthen causeways. The first causeway (southern) was built from the south end of Antelope Island southeastward to the mainland in 1952. This structure eliminated communication between the main body of the lake and the Bay at the south end of the island, and channeled the full flow of the Jordan River into Farmington Bay. The second causeway (Davis County), extending from the north end of Antelope Island eastward to the mainland, was constructed in 1969. With the construction of this causeway, Farmington Bay was now completely isolated from the main south arm of the lake, with the exception of one bridged opening, and mixing between the two bodies of water was severely restricted (Gwynn, 1998).

Farmington Bay

Farmington Bay is isolated from the main body of Great Salt Lake when its level is below the 4,206-foot top elevation of the Davis causeway and the fill at the south end of Antelope Island. Because of the inflow of fresh water from the Jordan River and groundwater inflows, the lake brines tend to be "flushed" from the Bay through openings in the causeway. At the same time, denser brines from the main body of the lake flow back into Farmington Bay underneath the lighter, fresher brines from the Bay. This phenomenon is known as "bi-directional flow", and prevents the waters of Farmington Bay from becoming completely fresh. Bi-directional flow occurs through the Davis causeway's bridged opening, and through a narrow culvert to the east which was installed in 1992. Bi-directional flow through these two openings is illustrated in Figure 4. When the lake's elevation is below 4,206 feet, the salinity of Farmington Bay is approximately half that of the main body because of fresh water flows of the Jordan River into the Bay. When the lake's elevation rises above the 4,208 elevation, there is free communication, and the waters of Farmington Bay and the main body are free to mix (Gwynn, 1998).


Areas of Salinity
Map 5
Meander
Mineral Salt Leases
Salinity
20-28% (near saturation)
3-6%
7-17%
Evaporation Pond
Mud Flats



Schematic of bi-directional brine movement through the causeway within the Great Salt Lake, Utah (from Gwynn and Sturm, 1987).

Figure 4

Brine returning to the Bay from bi-directional flow tends to resist mixing with the fresher water, and remains in a fairly coherent "tongue" which extends some distance to the south underneath the lighter Jordan River/brine mixture above it. This forms a stratified brine condition within the central, deeper portions of Farmington Bay. The salt content of the upper Farmington Bay waters is maintained through vertical mixing of the tongue of denser, main body brine with the fresher water above it (Gwynn, 1998).

Bear River Bay

Bear River Bay is isolated from the main body of Great Salt Lake by the segment of the Union Pacific northern railroad causeway which stretches from Little Mountain on the eastern shore of the lake, to Promontory Point. Bear River Bay is similar to Farmington Bay as a brine system. It is separated from the main body of the lake by the rock-fill causeway which contains a mid-point, bridged opening through which bi-directional flow takes place. The brine is stratified within the deeper portions of Bear River Bay. The upper layer of lighter water contains one to two percent salt. Below the upper layer of water lies a tongue of salty water which is fed into the bay by the bi-directional flow through the opening in railroad causeway.

The salinity of the lower brine tongue is similar to that of the main body of the lake. The thickness of the tongue of denser brine and that of the overlying less-saline water depends upon the rate of inflow into the Bay, and on prevailing wind conditions. South winds raise the level of the lake at the causeway, forcing the tongue of main body brine farther into the Bay, making it thicker. North winds lower the level of the south arm at the causeway, causing the brine to extend a shorter distance into the Bay, and it becomes thinner. When the tongue of main body brine thickens and extends farther into the Bay, the overlying fresher brine layer thins.

The Main Body (south arm or Gilbert Bay)

The salinity (total-dissolved-solids) of the south arm of Great Salt Lake varies inversely with lake elevation, and since 1966 has fluctuated from a high of 250 grams/liter in 1966 (approximately 21% salinity) to a low of about 50 grams/liter in 1986 (approximately 5% total salinity). The south arm of the lake receives nearly all of the fresh-water inflow to the lake, including flows from the Jordan, Weber, and Bear Rivers, and numerous, minor, east- and south-shore streams.

From 1966 until about mid-1991, the south arm of the lake was density-stratified into two brine layers. A dense, turbid, hydrogen sulfide-laden brine extended from an elevation of about 4,180 feet to the bottom of the lake. A less dense, clearer, odor-free brine extended upwards from about 4,180 feet in elevation to the surface. The two brines were separated by a relatively sharp transition zone. The deeper, denser brine layer disappeared in mid-1991, after the 1980s high-water years (1983-1987). During the 1980s, the surface elevation of the lake rose from about 4,200 feet to nearly 4,212 feet by 1986-87. The disappearance of south-arm stratification is probably due to diminished north-to-south return flow through the causeway brought about by

changes in the hydraulic conductivity in the SPRR causeway. This may have been caused by the addition of fill material used to increase the height of the causeway from 1983 through 1987 and subsequent compaction of the causeway. Since mid-1991, the brines of the south arm of the lake have been thoroughly mixed from top to bottom.

Gunnison Bay (the north arm)

The salinity of the north arm does not exhibit as direct an inverse relationship with lake elevation as does the south arm. This is because the north arm receives small quantities of fresh water inflow, and large quantities of salty water inflow from the south arm. Evaporation from the surface of the north arm is sufficient to maintain the north-arm salinity at a high concentration. From 1966 until about 1982, the salinity of the north arm remained within the 310-350 grams/liter range (25.7% to 28.4%). Due to this high salinity, a layer of sodium chloride precipitated on the lake's bottom during this time. North-arm salinity dropped to only 160-170 grams/liter in 1987 (14.5 to 15.3%), as evaporation was unable to keep up with increased, dilute inflows from the south arm. Since the high-water years, the north-arm salinity has climbed back into the 290-310 grams/liter range (24.3 to 25.7%, see Figure 5).

Brine stratification was not present in the north arm of the lake from 1966 until about 1983. When the lake began its rapid rise from about 4,200 feet in 1983 to its historic high of 4,211.85 feet in 1986-87, however, a layer of less-dense brine formed on top of the very-dense north arm brine due to: (1) increased precipitation, and (2) the enormous inflow of less-saline, south-arm water as the railroad causeway was breached in August 1984 (see later discussion), and the large, bi-directional exchange of brines between the north and south arms through the breach opening which followed. By mid-1991, the level of the lake had dropped below the 4,199.5-foot bottom elevation of the breach opening. Because of this, the constant flow of south-arm brine into the upper light-brine layer in the north arm nearly ceased, and the stratified-brine condition in the north arm soon disappeared due to vertical mixing.

♦ NET NORTHWARD MOVEMENT OF DISSOLVED SALTS FROM THE SOUTH TO NORTH ARMS OF THE LAKE

During the 1980s high-water years, flooding took place around the lake, causing millions of dollars in damage. To help alleviated the flooding, the State of Utah implemented two flood-control measures which affected the dissolved-salt distribution and the total salt load within the lake.

Breaching the Northern Railroad Causeway

In 1984 to help control flooding, the State of Utah created a breach in the northern railroad causeway consisting of a 300-foot-long opening in the causeway near Lakeside (figure 1). At the time the breach was opened, the water elevation of the south arm of the lake was about 3.5 feet higher than the north arm. As a result of the breach, great quantities of less-concentrated,

south-arm brine flowed northward into the north arm. At the same time, large quantities of dense, north-arm brine flowed southward into the depths of the south arm. As a result of this bi-directional flow, the total salt load of the south arm increased and that of the north arm decreased. Figure 5 plots the changes in salinities of the north and south arms both before and after the flooding event of the late 1980's and the breaching of the causeway.

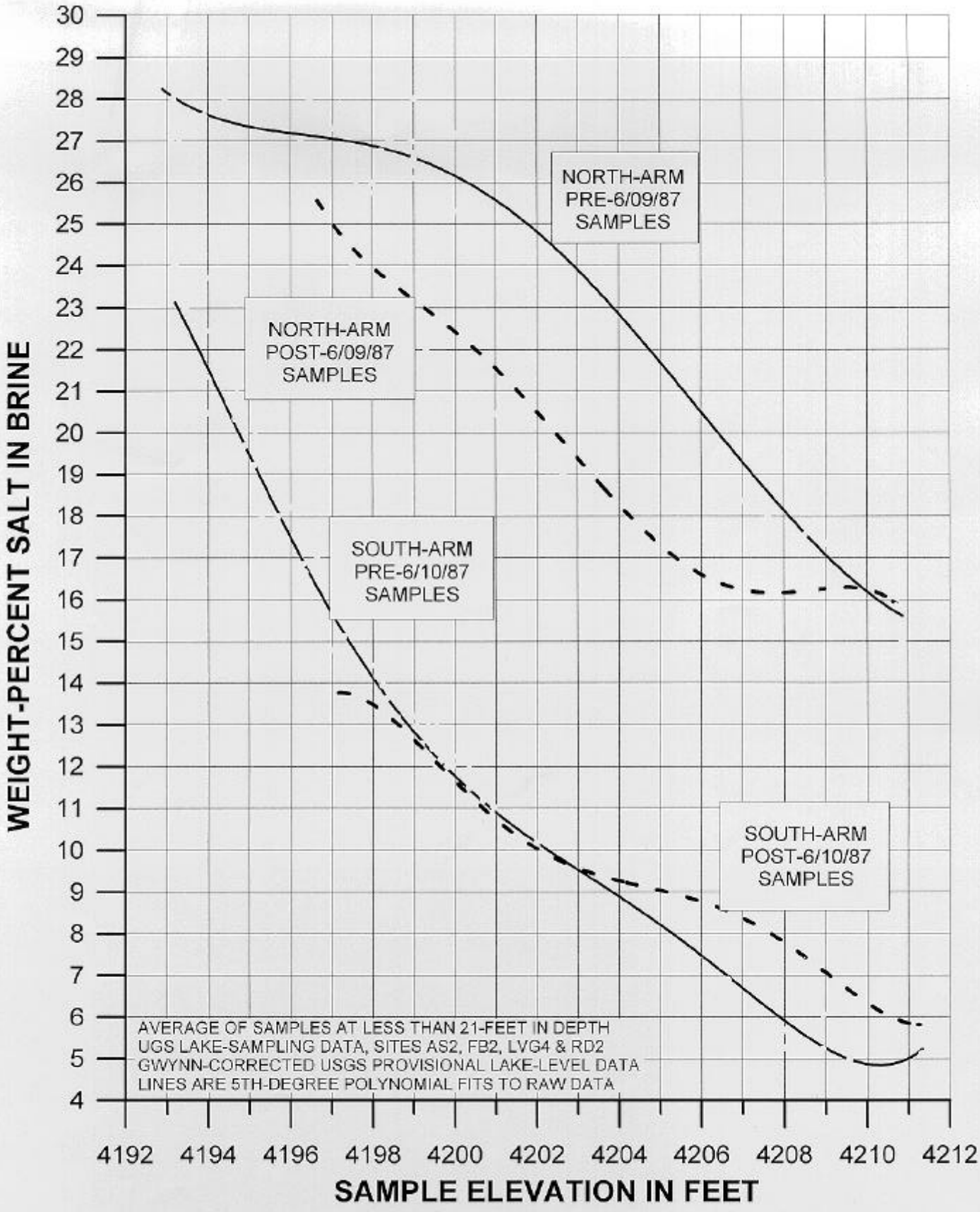
At the present time, very little bi-directional flow is taking place through the causeway, its two culverts, and the breach, and predominantly south-to-north flow is occurring through the causeway and the openings. As a result, there is a net salt movement to the brines of the north arm which are at, or near, the saturation point of sodium chloride (salt). During the summer months, salt precipitates on the floor of the north arm where it will remain until the present conditions change and the north arm salinity decreases. Meanwhile, as the north arm receives an increasing proportion of the lake's total salt load, the salinity of the brines of the south arm drops. The declining south-arm salinity is expected to continue until the overall lake elevation rises enough to allow substantial bi-directional flow through the causeway and its openings.

West-Desert Pumping

The second emergency flood-control measure was implemented after the lake continued to rise, following the opening of the breach in the SPRR causeway. This measure involved pumping water from the north arm of the lake out into the West Desert to increase the total evaporative surface area, and to physically remove water from the lake. To accomplish this, three giant pumps were installed near Hogup (about 12 miles west of Lakeside). The water was pumped from Hogup by way of a 4.1-mile canal to the West Desert where it was impounded in a 320,000-acre pond, contained by dikes (See Map 4). The West Desert pumping project was successful in helping to lower the level of the lake from 1987 to 1989, but in the process, between 400 and 600 million tons of crystalline salt, representing 10 to 14 percent of the total salt-load of the lake, were precipitated and left on the pond floor at the time the project was suspended in 1989. It is believed that some portion of the precipitated salt, approximating 180 million tons, has been returned to the lake system by redissolution by rainfall and flow to the lake. This removal of salt has had, or will in the future have, an impact on the overall salinity of the lake.

♦ ION CONCENTRATIONS IN LAKE BRINES

Unlike the lake's variable salinity (total grams of dissolved salt per liter of solution), its chemical composition (the ratio of the various dissolved ions one to another) is relatively constant throughout the north and south arms of the lake, and even within Bear River and Farmington Bays. This chemical consistency exists because: (1) chemical homogeneity existed throughout the lake prior to the construction of the railroad and other causeways, and (2) continual brine mixing, however limited, occurs among all portions of the lake. Slight, long-term changes in ion-ratios have been observed throughout the lake as a whole, however, and are discussed in more detail below. Table 1 gives an average chemical composition of the dissolved



Trends in salinity for the north and south arms of Great Salt Lake before and after the lake's 1986-1987 historic high.

Figure 5

salts in Great Salt Lake waters on a dry-weight-percent basis, as contained in the Utah Geological Survey (UGS)-Great Salt Lake (GSL) database**.** The compositions of typical ocean and Dead Sea waters are given for comparisons.

Table 1. Average chemical composition of the dissolved salts in the waters of the Great Salt Lake, Utah , typical ocean water, and Dead Sea water (dry-weight-percent basis).

Ion	GSL	Ocean	Dead Sea
Sodium	32.1	30.8	12.3
Potassium	2.3	1.1	2.3
Magnesium	3.7	3.7	12.8
Calcium	0.3	1.2	5.2
Chloride	54.0	55.5	67.1
Sulfate	7.6	7.7	0.1
Bicarbonate*	0.62		

* Value from Utah Division of Water Quality June 9, 1994 Lab Analysis Report for GSL Brine from UGS Sampling site AS2.

In addition to the main ions listed above, the UGS data base includes the three most abundant trace elements: lithium, bromine, and boron. The average levels of these elements in the south and north brines are reported as follows in units of parts per million (ppm).

Element	South Arm	North Arm
Lithium	24	45
Bromine	66	121
Boron	21	24

Table 2 shows the minor trace metals, reported in terms of micrograms per liter (ug/L), which are included in the Utah Division of Water Quality's (June 9 and 22, 1994) Lab Analysis Reports, for samples taken at UGS sampling sites AS2 (south arm) and LVG4 (north arm), respectively.

Table 2. Minor trace metals in Great Salt Lake brines (ug/L).

Metal	Site AS2	Site LVG4
Arsenic	130	218
Cadmium	<3.0	<11
Chromium	<5	<5
Iron	<220	<220
Silver	<2	<2

Zinc	<330	360
Mercury	<.2	<.2
Barium	180	170
Copper	<220	<220
Lead	<30	<12
Magnesium	<55	<55
Selenium	<12	31

(< = less than)

It has been postulated that the absolute quantities of the ions of magnesium, potassium, calcium, and sulfate in lake brines is decreasing relative to sodium and chloride. Data collected by the Utah Geological Survey since 1966 show a slight decline in the yearly average, south-arm dry weight percentages of magnesium, potassium, calcium and sulfates over time, while sodium and chloride show a slight increase. (Gwynn, 1998) During the low surface-elevation stages of the lake, from 1935 to 1945 and from 1959 to the mid 60s, sodium chloride precipitated in the main body of the lake and in Gunnison Bay (the south and north arms). Madison (1970) states that salt precipitated at lake elevations below 4195 feet, and Whelan (1973) reports that some 1.21 billion metric tons of sodium chloride precipitated throughout the lake at those low elevations.

While the precipitated salt in the south arm had redissolved by mid-1972, it took until about 1986 before all the salt in the north arm had been redissolved (Wold and others, 1996). In 1992, salt again began to precipitate on the floor of the north arm during the summer months, and it is believed that precipitation continued through 1997. Dry-weight percentages of magnesium, potassium and calcium were increased during historic low lake levels because sodium chloride is the first salt to precipitate as the concentration of lake brine increases. Conversely, the concentrations of magnesium, potassium and calcium are believed to be decreasing relative to sodium recently because of the redissolution of sodium chloride from the lake bed, particularly in the south arm. Notwithstanding slight fluctuations in relative ion ratios in lake water with changes in lake elevation, it is not believed that the overall chemistry of lake brines is changing to any significant degree.

WATER - QUALITY

Much of the earlier work on the Great Salt Lake addresses the “water quality” of the lake without distinguishing between the lake water’s natural chemistry and the presence or absence of introduced contaminants which could affect the biology of the lake or its beneficial uses. The salinity and naturally occurring constituents of the water of the Great Salt Lake are discussed in the Section entitled Water Chemistry. This section addresses only the regulation and impacts of introduced contaminants on the Great Salt Lake system.

As an aquatic system, the function and usefulness of the Great Salt Lake is highly dependent upon the chemistry and quality of the lake water. As a terminal basin, the quality of the water in the lake is highly dependent upon the quality of the water currently entering the lake, and upon the quality and nature of past inflows and discharges into the lake. A wide variety of organic and inorganic materials enter the lake by both natural and human-induced causes. The sources of potential lake water contaminants include:

- Surface and ground-water inflows to the lake;
- Permitted discharges directly to the lake;
- Unpermitted and accidental discharges to the lake;
- Lake sediments which contain non-naturally occurring contaminants; and
- Airborne particulates and precipitates.

Because of the lake's high salinity and unique aquatic biology, some contaminants which are of great concern in fresher water systems may not be as problematic in the Great Salt Lake, and some may even help support the aquatic ecosystem. Others may be rendered harmless by the lake water's high salinity, but may become more bioavailable when lake water freshens. Despite a great deal of research on the lake's water chemistry and aquatic organisms, little work has been done directly on the effects of non-natural contaminants on the Great Salt Lake ecosystem, or on the water quality effects of fluctuations in lake water chemistry.

The Water Quality element considers the presence and impacts of lake water constituents other than naturally occurring salts. Internal and external scoping identified three main areas of interest with regard to water quality; the methods by which lake water quality is managed, the potential for future changes in water quality and the degree to which lake organisms may be affected by non-salt water constituents. The team identified the following conditions and trends as relevant to lake management:

- **Discharges to the lake are managed by approval of discharge permits which are determined to be protective of primary and secondary contact recreation, aquatic wildlife and mineral extraction, and by development of non-point source management programs.**

- **The potential for changes of lake water quality through loss of wetland function, non-permitted discharges and non-point source management initiatives remain not well understood.**

- **The impacts of non-naturally occurring lake water contaminants on aquatic wildlife remain not well understood.**

♦ WATER QUALITY MANAGEMENT FOR THE GREAT SALT LAKE

The Utah Water Quality Board and the Division of Water Quality have been charged by the State Legislature to maintain, protect, and enhance the quality of Utah's surface water and groundwater resources. The statutory authorities of the Board and Division are located in Chapter 19-5 of the Utah Code. The overall program missions of the Board and the Division are to protect public health and all beneficial uses of water by maintaining and enhancing the chemical, physical, and biological integrity of Utah's waters.

Facilities in Utah that produce, treat, dispose of or otherwise discharge waste water must obtain a discharge permit from the Division of Water Quality under the Utah Pollutant Discharge Elimination System (UPDES). UPDES permits are required for all industrial, municipal and federal facilities, except those located on Indian lands. After a discharge application is received, a wasteload evaluation is developed to determine specific discharge limitations, required treatment and monitoring. Each permit includes effluent limitations and requirements for monitoring, reporting, and sludge use or disposal requirements. Permit duration is usually five years or less, with provision for renewal.

In order to establish discharge standards, the Utah Water Quality Board has classified the waters of the state based on their beneficial uses, and has defined numerical and narrative standards for discharges to those waters to protect beneficial uses. The main water use classes are:

Class 1 - Protected for use as a raw water source for domestic water systems.
Class 2 - Protected for in-stream and recreational use and aesthetics.
Class 3 - Protected for in-stream use by aquatic wildlife.
Class 4 - Protected for agriculture uses including irrigation of crops and stock watering.
Class 5 - The Great Salt Lake. Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction.
Class 6 - Waters requiring protection when conventional uses do not apply.

Most of the main classes are subdivided into sub-classes which address specific pollutants and beneficial uses. The Great Salt Lake is in its own class (Class 5). Primary and secondary recreation, aquatic wildlife and mineral extraction are the defined beneficial uses of the lake's waters. Numerical discharge standards have not been established for Great Salt Lake, but the Division of Water Quality has established narrative standards for discharges to the lake, and permits for waste water discharges to the lake are established on a case-by-case basis. Applications for waste water discharges to the lake are reviewed and regulated by the Water Quality Board to prevent the addition of any pollutants which would be injurious to the defined uses. The current policy states that no pollutants (discharges) should be delivered to the lake in concentrations greater than those already present in the lake.

Permitted Discharges to the Great Salt Lake

Permitted discharges to Great Salt Lake fall into three major classifications; municipal wastewater treatment facility discharges, mineral extraction facility discharges, and other industrial facility discharges. Wastewater treatment facilities typically produce high levels of organic materials, which generate high Biological Oxygen Demand (BOD), and bacterial organisms. Mineral (salt) extraction industries produce bitterns or residual water from their solar evaporation ponds. These facilities withdraw water from Great Salt Lake and then use solar energy to evaporate and extract various salts from this saline water. Specific effluent guidelines and standards are applicable to discharges from salt extraction industries. The requirement is that the effluent contain only materials originally present in the intake water. Industrial discharges include effluent from the Kennecott Utah Copper mining operations and from oil refineries located in North Salt Lake. The copper mining and refining operations produce sulfates and slightly acidic effluent. Discharges from oil refineries have limitations on mass BOD, Total Suspended Solids (TSS), oil and grease, phenolic compounds, ammonia, sulfide, and chromium. A listing of existing permits for discharges into Great Salt Lake and its near-lake tributaries is attached as Appendix A.

♦ POTENTIAL FOR CHANGES TO LAKE WATER QUALITY

The overall quality of Great Salt lake water is good. From a biological standpoint, the lake's aquatic biological system is described as nitrogen limited, meaning that agricultural fertilizers, which are usually characterized as "pollutants" in fresh water aquatic system, are almost completely consumed by lake organisms and don't pose the kinds of problems in the Great Salt Lake that they otherwise can. Other factors on and near the lake, such as the wetland-marsh complexes on the east shore of the lake, are thought to be beneficial in "treating" non-point sources of potential pollution before they reach the lake itself. Among the potentials for alterations to the water quality of the lake are emergency spills and unpermitted discharges on and near the lake, possible contaminants in lake-bottom sediments, and pollutants from non-point sources near the lake and lake tributaries.

Unpermitted Discharges and Spills

In the past, de-icing fluids at Salt Lake City International Airport (SLCIA) have been controlled by disposal to a storm water collection area and then to wastewater treatment facilities. Due to a recent increase in the stringency of deicing requirements imposed by FAA regulations, the holding capacity is no longer adequate for proper containment, and overloading of local treatment facilities has resulted in operational problems, including accidental discharges. The planned development of a process to recover and recycle glycols (the main component in deicing/anti-icing fluids) to eliminate the overflow discharge of contaminated storm water should be able to handle airport storm water and contaminants of concern. Biomonitoring is required where effluent toxicity is an existing or potential concern. SLCIA is considered a minor facility and it's discharge is not likely to be toxic after the deicing/anti-icing diversion/recovery system is

fully implemented (Anticipated date of completion-January 1999) and will not require biomonitoring.

The SLCIA has developed a Best Management Practices Plan to monitor and control storm water discharges. Principal substances of concern in this plan are de-icing fluids, hydrocarbons and urea used in ground deicing. An Airport Deicing Committee was formed to discuss the status of the pretreatment system, UPDES Permit and the existing deicing practices at SLCIA. In the future, this committee will consider new requirements for discharge, new technologies as well as airport expansion. The Airport Authority has begun a monitoring program with the SLC Public Utilities Laboratory to monitor the level of Biological Oxygen demand (BOD), glycol, oil, grease and ammonia at the two outfalls and other strategic locations that will help identify the source of any potential contaminants.

Minor fuel spills involving less than 25 gallons are required to be contained by the party causing the spill. Also, in the event that fuel reaches the storm sewer it can be removed by a oil/water separators located at the discharge points to the City Drain, Surplus Canal and the influent line leading to the aeration lagoon of the storm water pretreatment system. All material entering the storm sewer passes through these separators. Fuel spills greater than 25 gallons are required to be reported to the Fire Department, State Health Department, Bureau of Water Pollution Control and the Salt Lake City County Health Department. Upon notification the responsible party will immediately begin containment of the spill and the Airport Authority Operations Division, Maintenance Division and the Airport Environmental Specialist will provide any necessary assistance.

Reporting and Cleanup of Spills

With the proximity of large industrial, transportation and sewage treatment facilities to the Great Salt Lake, accidental unpermitted discharges to the lake and the lake environs have occurred in the past and are likely to occur in the future. Emergency spill reporting and response is handled by several agencies with different jurisdictional responsibilities. The unpermitted release of any substance which may pollute surface or ground water must be reported immediately, by telephone or in person, to the Utah Department of Environmental Quality (UDEQ), followed by a written report summarizing the incident and remedial actions taken to respond. These include releases of greater than 25 gallons of used oil, damaged radiation sources, lost or stolen radioactive materials, and spills or releases of radioactive materials to the environment or other events causing significant human exposure or property damage. This reporting is required by both state and federal statutes. If an incident involves potential health or environmental effects which require immediate action by local authorities, the local emergency response access number (911) should also be called. Some spills also may require notification of the National Response Center (NRC), depending on the type and amount of the release. In addition, spills, leaks, fires and other events at oil or gas drilling or production facilities must be reported within 24 hours to the Division of Oil, Gas, and Mining followed by a written report.

Releases involving oil, causing a sheen on surface water, depositing a sludge under the surface, or releases of any substance that violates water quality standards must be reported to NRC. Any releases to the sewer system in violation of a permit must be reported to the local sewer authority. The U.S. Fish and Wildlife Service receives notification through the NRC when a spill occurs which has implications for protected fish and wildlife resources.

The UDEQ and the UDPS both require that all releases of substances or wastes which could be hazardous to human health or the environment must be cleaned up and the wastes disposed of, in accordance with applicable standards. This requirement includes releases which are below thresholds requiring notification to local, state or federal authorities. The conduct of response and cleanup of spills is governed by contingency plans developed cooperatively among the affected resource management agencies, and depend upon the type, extent and location of the spill. Federal and State agencies respond on site and consult with the on-scene coordinator (OSC).

Potential Flood Impacts on Water Quality

Lake levels above expected highs can adversely affect existing sewage treatment facilities around the lake. During the flooding years in the 1980's, several treatment plants were forced to take steps to protect their facilities from flooding. Substantial costs were incurred to protect facilities and keep them operating, preventing the discharge of millions of gallons of raw sewage into the lake. For example, the dikes of the Perry lagoons were raised, rip rap was placed on the outside of the dikes to prevent erosion, and a pump station was installed. The South Davis Sewer District built dikes around their plant and installed pumping facilities to lift the treated effluent into the lake. During the high water levels of the late 1980's (elevation 4211.85 feet), sewage treatment facilities adjacent to the lake installed protective measures so that no facility experienced a failure which adversely affected lake water quality. Although those protective structures remain in place, lakeside sewage treatment facilities should be considered to be at risk from high lake levels.

Lake Bottom Sediment Contaminants

Concerns that potential lake water contaminants may be contained in lake bottom sediments have arisen on several occasions, due to past discharges to Farmington Bay, to the south shore of the lake, and to other areas of the lake.

<u>Farmington Bay</u>

The Antelope Island Causeway, constructed in the 1960's, inhibited the free exchange of brines between Farmington Bay and the main arm of the Great Salt Lake, resulting in a gradual freshening of the brines in Farmington Bay. Because of the many years of discharge of untreated sewage into Farmington Bay, concerns emerged in the late 1960's that the freshening of the Bay might allow aerobic bacteriological decomposition of organic materials previously “fixed” by the

lake water's high salinity. In 1965, the Utah Department of Health reported "...positive evidence of sewage pollution in the [Farmington Bay] lake water to such an extent that bathing should not be approved of in any of these areas for this reason." A study completed in 1971 confirmed organics comprised up to 37% of some bottom sediment samples in the south end of the Bay, and found unacceptably high counts of E. Coli and other coliforms at salinities up to 5.5% (Carter, 1971). It was subsequently suggested that an accumulated sludge layer in the bottom of Farmington Bay could be major water quality concern if bay sediments were disturbed or if the bay water continued to freshen (Austin, Stauffer and Lin, 1974).

In 1985, Utah State University conducted an investigation to determine whether a potential for contamination of Farmington Bay water from bay sediments in different water freshening scenarios. The study suggested that the potential for contamination existed in that two sediment core samples contained freshwater soluble heavy metal accumulations. The study also concluded that more information on the potential for release of toxic metals and organic materials should be gathered before any Bay freshening proposals should be considered. It was suggested that if the salinity of Farmington Bay were lowered, the "consequences might be dramatic", and result in large algal blooms and resulting odors due to high nutrient levels. Past core sample analyses in Farmington Bay have indicated metal accumulations in bottom sediments.

Bear River Bay

An investigation by U.S. Fish & Wildlife Service near the Bear River Bird Refuge between 1989-90 discovered no indications of the presence of hazardous materials. (Department of Natural Resources, 1995 and Waddell, B. Dolling, J. Linner, S. Stephens, D. and S. Stephensen, 1990) There is currently underway a NAWQA study to determine trends in water quality using coring methods to provide information on the primary sources of contaminants found in wildlife tissues examined by the U.S. Fish & Wildlife Service during 1996-97. This will be a part of a wetlands study of chemical processes, and will include comparisons of sediment core samples taken at Red Butte Reservoir, a protected watershed, Farmington Bay, and Decker Lake, an urban flood control basin, in order to evaluate and detect peaks in pesticides, heavy metals and selected organics (U.S. Geological Survey, 1998). The results of the study are expected by March 1999. Great Salt Lake sediment core samples are also being collected for a global climate study to provide insight into Great Salt Lake Basin climate changes and evaluate environmental signals which could provide some information regarding anthropogenic influences and trends in water quality over time.

South Shore

During 1995, the U.S. Bureau of Reclamation was directed by the Environmental Protection Agency to conduct a soil and sediment sampling program to determine trace metal concentrations across the mud and alkali flats beach area of the South Arm of the Great Salt Lake. The study area was located between Black Rock and the Davis -Salt Lake County line

north of the Goggin Drain. This study was a response to concerns regarding the migration of heavy trace metals to the south arm beaches of the lake. Other possible sources of heavy metals are the Jordan River and the Goggin Drain which flow through several active and inactive landfills, junk yards and sewage treatment facilities. The purpose of this sampling program was to identify and determine the extent and the concentrations of heavy metals which might present a hazard to human health and to the ecosystem. Arsenic and lead were targeted along with 22 other elements and this group wanted to identify the source of the metals. One-hundred and twenty-five locations were sampled in a series of transects across the three main water channels, the C-7 ditch, Lee Creek and the Goggin Drain. The study concluded that concentrations of all contaminants of concern were below levels of biological concern.

Non-point Pollution Sources

A major source of pollution to all waters of the state, including Great Salt Lake, is non-point source runoff, primarily from agricultural drainage and urban runoff. Because the lake receives overland flow and inflow from streams and irrigation/drainage ditches in addition to the three major river systems feeding the lake, non-point sources of water pollution are significant, and effective management of lake water quality is dependent upon effective non-point source management upstream.

There is currently underway a Phase II implementation of the National Pollutant Discharge Elimination System (NPDES) which is focused on reducing water pollution from non-point sources. A significant aspect of Phase II is the initiative to develop Total Maximum Daily Load (TMDL) limitations in order to meet water quality standards. The TMDL is the quantity of a pollutant allowable in a water body to meet water quality standards to avoid impairment of the water body's listed beneficial uses. When TMDLs are established, the allowable pollutant loads will be allocated among the contributors to the water body in question. The Utah Department of Environmental Quality estimates that 313 existing UPDES discharge permits for 32 lakes and reservoirs and 72 stream and river segments will be re-evaluated based on TMDLs in the next 12 years.

BIOLOGY

While the term "Biology" encompasses all living things, the Biology element of the Great Salt Lake Plan focuses on the wildlife resources for which Division of Wildlife Resources is responsible, and on the physical and biological habitats which support those resources. The volume of biological information the Planning Team identified in its resource inventory is enormous. The Team has endeavored to identify and synthesize here that information which is significant and relevant to the management responsibilities of DNR divisions. While a great deal is known about many of the species present in the Great Salt Lake ecosystem, information about many species is not well known, and biological interrelationships and the effects of environmental stressors are not understood in many instances.

INTRODUCTION

The Great Salt Lake and its environs support a number of diverse plant and animal species in a unique mosaic of upland, wetland, mudflat, river delta, brackish and freshwater marshes, ephemeral ponds, and other habitat types in and around the open waters of the Great Salt Lake. In addition to some 74 species of water birds and 35 species of shorebirds, Great Salt Lake environs host 23 species or subspecies of fish which are found in impounded fresh water inflow areas, 8 species of amphibians and 64 species or subspecies of mammals. Two endangered species, the Peregrine falcon and the Bald eagle and 19 sensitive species, which include the American pelican and the Snowy plover, also occur on and around the Great Salt Lake.

At least six uniquely productive wetland and water environments exist in the Great Salt Lake ecosystem. These systems provide abundant and diverse habitat for the numerous wildlife species that use the lake system. These are:

- Open-water environments of varying salinities,
- Island and upland habitats associated with the saline system,
- Fresh-water lacustrine wetlands associated with river and stream deltas,
- Brackish-water areas of fresh and saline water interface,
- Spring-fed isolated wetlands, and
- Mudflat/playa environments.

The wetlands around the lake are unique in North America because they cover a large expanse of inland alkaline and saline wetlands located in a cold desert. About 400,000 acres of wetlands exist near the shores of Great Salt Lake, which represents almost 75 percent of all the wetlands in the State of Utah.

While habitat attention generally focuses on the Great Salt Lake's wetlands, adjacent upland areas are heavily used by wildlife and provide linking habitat types which create the highly productive saline and freshwater marsh ecosystem. Upland areas provide an extraordinary amount of food and opportunities for cover, and buffer wetlands from expanding urban and industrial developments around the south and east sides of the lake. In addition, the lake is tied to the Wasatch Mountains by ribbons of riparian habitat which, in the desert west, are critical migratory and breeding habitats for a wide variety of wildlife, especially neotropical migrant songbirds, raptors and riverine mammals. The latitude of the lake makes it a significant wintering area for a number of species. Utah's major human populations also occupy this narrow area between the mountains and the lake.

International, Hemispheric and National Significance of Great Salt Lake

The Great Salt Lake wetland ecosystem has been recognized nationally, hemispherically and globally for its importance as a vital link in a migrational corridor for water birds which

extends from South America to the Arctic. It has also been designated as a Hemispheric Reserve of the Western Hemispheric Shorebird Reserve Network (WHSRN), and has been nominated for consideration by the Ramsar Convention on Wetlands of International Significance for listing as a Wetland of International Importance.

Western Hemispheric Shorebird Reserve Network

The Western Hemisphere Shorebird Reserve Network was formed in 1985 to address serious concerns for shorebird population decline throughout North and South America. This group of government and private agencies is working together and is committed to shorebird conservation. This international cooperative program is helping to protect key shorebird sites throughout the hemisphere and has designated the greater Great Salt Lake as one of 19 WHSRN sites (Wetlands International, 1998). The designation highlights Great Salt Lake's importance as a migration corridor line for hundreds of thousands of Wilson's phalaropes, red-necked phalaropes and other shorebirds. Great Salt Lake is a significant refueling (feeding) station for shorebirds and, linked with other critical migration sites, forms a chain of such sites from northern breeding grounds in the Canadian Arctic to wintering places on remote coasts and wetlands of South America.

One reason cited for designation as a Hemispheric Reserve is the fact that the 500,000 Wilson's phalaropes known to occur here represent the world's largest known concentration of the species. Wilson's phalaropes fly over 70 hours during their migration. These shorebirds nearly double in weight while feeding at the Great Salt Lake, storing the fat needed for fuel for their long flight. Over 75 percent of the western population of Tundra Swans and 25 percent of the continental Pintail population utilizes the Great Salt Lake area. The annual production of breeding waterfowl from the marshes adjacent to the lake is estimated to exceed 750,000 birds.

The largest nesting population of California Gulls in the world is located on the lake and its environs. North America's largest staging concentrations of American Avocets and Black-necked Stilts occur at the Great Salt Lake, and the largest breeding population of White-faced Ibis occurs in the wetlands around the GSL. These are only a few examples of the importance of the lake system in terms of bird use and local, national and international recognition as an important bird area. The magnitude of the numbers of different species of birds which depend on the Great Salt lake system cannot be overstated.

Other Recognition

The Great Salt Lake and its surrounding wetlands have also been nominated for consideration by the Ramsar Convention on Wetlands of International Significance for listing as a Ramsar Wetland of International Importance. The aquaculture industry has also spotlighted Great Salt Lake due to the profitable brine shrimping industry. Brine shrimp (Artemia) are being produced, harvested or utilized on five continents, but the Great Salt Lake harvest provides the largest quantity and the best quality of the brine shrimp cysts on the international market. The

aquaculture industry is rapidly becoming a primary food source for humans and brine shrimp cysts and their nauplii (larval brine shrimp) provide the live feed and protein for marine finfish and crustacean hatcheries around the world.

AQUATIC BIOLOGY

The aquatic biology of the Great Salt Lake constitutes a relatively simple ecosystem. The interactions and relationships of the species occurring there can be complicated by environmental conditions which are constantly changing in this terminal basin lake, salinity being a very important factor. The lake has differing characteristics in each of its main bays, but the significant differences are seen contrasting Gunnison Bay to the rest of the lake.

Gunnison Bay has very little inflow relative to the rest of the lake. The earthen fill causeway which was constructed between Promontory Point and Lakeside in 1958 effectively separated this bay from Gilbert Bay. The salinity of Gunnison Bay is significantly higher than the rest of the lake, and currently is close to saturation. The species which occur there now number six. They likely include species of the bacteria *Halobacterium* and *Halococcus* (Post, 1977). Another species of algae present is *Dunaliella salina.* These species contain a pigment which gives the overall color of the water of Gunnison Bay a rose-purple hue. There are few functioning brine shrimp populations in Gunnison Bay, and none of significance. Brine shrimp and cysts are washed in from the Gilbert Bay, but the adults soon perish because of high salinities. The cysts may persist longer, but cannot hatch and grow to adults for the same reason. There may be local sites where freshwater springs discharge into the Gunnison Bay that allow a small area of the bay to sustain a brine shrimp population because the salinity is locally favorable. Gunnison Bay is essentially functioning as a solar evaporation pond for the already saline water of Gilbert Bay (Stephens, 1998). Relative to the vigorous biota of Gilbert Bay, Gunnison Bay is essentially dead.

Gilbert, Farmington and Bear River Bays receive nutrient input from drainages of the Great Salt Lake watershed. Nutrient data is available for some of these drainages, but the sampling points are located upstream from the freshwater marshes surrounding the lake. The cycling and discharge of the nutrients from these marshes to the lake has not been quantified at this time. The lake however, is a nitrogen limited system (Stephens, 1997). The nutrients in the lake water are utilized by algas and bacterias. There are more species of algae and bacteria present in these three bays of the lake than in the very saline Gunnison Bay. Identification of these species is currently underway. The numbers of species present and their abundance fluctuate with the lake salinity.

The primary consumers of the bacteria and algae are brine shrimp and two species of brine flies. The biomass of these three organisms is significant. The shrimp and shrimp eggs are eaten by birds and commercially harvested by humans. The brine flies are eaten by birds and other species in their various life stages. Dead shrimp, flies, algae, other organisms and the waste products from all, in return, are re-cycled through the system as base nutrients.

Brine Shrimp

Brine shrimp (*Artemia franciscana*) are found in all portions of Great Salt Lake. The annual life-cycle of brine shrimp begins in early spring. Fresh water inflows to the lake from snowmelt and increasing water temperatures initiate egg (cyst) hatching in late January or early February, with hatching peaking in March or early April. Decreasing lake water salinity from fresh water inflow is an important mechanism in the hatching process. The cysts survive the winter in a semi-dehydrated state. When salinities decline, the cysts rehydrate, causing the shell to swell and crack, which allows the larval shrimp, known as nauplii, to emerge. As they mature, brine shrimp molt through as many as 12 different stages before they become adults and begin reproducing.

Brine shrimp reproduce by two methods. During the spring and summer many of the females give birth to live young that are hatched from eggs within their bodies. The other reproductive mechanism involves the formation of hard-walled eggs, called cysts, which are cast into the water by the female. These cysts must then go through a period of dormancy before they hatch. Both of these mechanisms occur throughout the summer, although the birth of live young is more prevalent. In the fall, factors such as the availability of quality food, declining water temperature, decreasing day length, and increasing salinity trigger the females to start producing primarily cysts. As many as three generations of shrimp may be produced in the Great Salt Lake during a single growing season. When water temperatures decline below 5° C (42° F) live brine shrimp perish. No live brine shrimp survive the winter. The population is restarted from the cysts which persisted over winter either floating on the lake's surface or deposited on the beaches. As the lake rises in the spring due to inflow, some of the cysts which washed up on the shore during the winter may end up back in the lake.

Commercial harvesting of brine shrimp began in 1950 when adult brine shrimp were harvested for tropical fish food. Several years afterward cysts were first harvested because they could be dried, packaged, and stored for long periods of time. The eggs could then be hatched as needed. Presently, only cysts are targeted by the harvest operations but there is a small market for the adult brine shrimp bycatch. Most of the harvested cysts are used in the culture of marine organisms such as prawns and specialized fish like grouper.

Brine Flies

Often considered "noxious and insidious creatures" by the uninformed, brine flies are harmless and do not bite or transmit disease and are very important part of the overall ecology of the Great Salt Lake. Brine flies are the primary food source for many species of animals, spiders and birds living around the shores of the lake. A source of the misconception is their sheer numbers, reported to be over 370 million flies per mile of sandy beach, for a total of over 110 billion flies plus 10 billion pupae on approximately 300 miles of beaches around Great Salt Lake. Other misconceptions arise from narratives such as this one by a Great Salt Lake concessionaire:

"Almost without exception during the heart of the tourist season . . . the brine fly is multitudinous and there are times when the entire beach and picnic areas are vacated by our patrons because of this obnoxious insect . . . Not only do the bodies of the fallen insects we kill blacken our entire beach by the water's edge, but likewise the very much alive brine flies cover the Great Salt Lake waters for a good block or so our from the shore . . . On numerous occasions the air has been so thick with these insidious creatures that many of our patrons in their cars refuse to open their windows or doors and often leave our beach resort saying they will never return." (Hansen, 1969).

Brine fly abundance is variable from year to year, and depends upon changes in water chemistry and variation in the populations of other organisms in the lake which are determined, in part, by the influence of man on this environment. Wind direction and velocity seen to have a direct affect on their distribution. Brine fly numbers peak during July and August, with a decrease as temperatures begin to drop. (Vorhies, 1917) An abundance of food, limited predators, and unlimited food supplies and living space contribute to their abundance.

There are two species of brine flies; *Ephydra cinerea*, and the smallest and most abundant, *Ephydra hians*. Brine flies play an essential role in converting organic material entering the lake into food for wildlife living along the lake's shoreline. By removing over 120,000 tons of organic matter each year from Great Salt Lake, brine flies consume great quantities of algae, bacteria and organic refuse from brine shrimp and their own life processes. It would require a 78,000,000 gallon per day waste water treatment facility about the size of the Salt Lake City municipal treatment plant to remove this much organic waste from the lake. "Without brine flies or additional water treatment, lake waters would become cloudy and foul smelling, sands would be clogged with algae and decomposing organic materials, and wild animals of the lake area would be starving," according to Robert N. Winget. (No date, see Literature Cited)

The life cycle of the brine fly consists of four stages; egg, larva, pupa and adult. Each female lays approximately 75 eggs on the surface of the water or on floating debris consisting of brine fly pupal casings, dead brine shrimp or cysts. The eggs sink to the bottom of the lake before they hatch into larvae. They obtain oxygen from the water by diffusion, and feed on blue-green algae. They become free swimming after emergence, until they find suitable habitat such as algal bioherms or other stationary objects in shallow areas of the lake on which to pupate. Nearly 10 percent of the lake bottom is covered with algal bioherms. (Cohenour, 1966) Eighty eight percent of the lake's brine flies are produced on only 18% of the lake's bottom area.

Larvae and pupae have been found in water depths of between one and 20 feet, and can obtain oxygen from the water by use of tracheal gills located in a long forked anal tube. During warm weather, the larval stage also may pupate on the surface of the lake on floating masses of algae. The pupal cases split open on the back and fully develop into adult flies. Flies emerging from the bottom of the lake float to the surface in a bubble of air. The life cycle can be completed

in 21 to 30 days, and may extend longer during cooler temperatures. Adult brine flies only live 3-4 days. Brine fly populations begin to expand rapidly in numbers during the first of June, and one or two generations of flies reach maturity each year. The flies survive the winter in immature stages. Studies are inconclusive as to the effects of water salinity on fly production, but it is clear that when salinity drops, so does the abundance of flies. (Collins, 1980).

Bacteria and Algae

There are many species of bacteria that inhabit the waters of Great Salt Lake. Often, these organism assist in the decomposition of dead algae, animals and organic wastes entering the lake by stream flow and wind. It was reported in 1966 by Flowers and Evans that Great Salt Lake hosts eleven species of bacteria that tolerate moderate to high levels of salt concentrations. Gunnison Bay of the lake supports only two genera of bacteria, *Halobacterium* and *Halococcus*, which are extreme halophiles present in numbers from 1,000,000 to 100,000,000 bacteria per milliliter, and which are very evident in the pink to purple color of this part of the lake.

Blue-green algae species in Gunnison Bay include *Oscillatoria* and *Coccochloris elebans*, both of which play a role in the formation of the algal bioherms in the lake. The biology of these algae, however, is virtually unknown.

The presence of the algae *Dunalliella viridis* and *Dunalliella salina* and brine shrimp indicate a very large concentration of organic matter in lake water. However, little is known regarding the concentrations of nutrients, limiting factors and cycling in the lake. The principal food-makers are blue-green algae, including several colonial forms which produce salmon-colored gelatinous masses. Diatoms and flagellates are the food base for a very limited fauna of protozoans and invertebrates which can withstand the water salinity. There is an enormous volume of organisms in the lake, but a relatively small number of few bacteria and invertebrate species. This faunistically exclusive environment is teeming with seasonally abundant animal life (Rawley, E., B. Johnson and D. Rees, 1994). These animals are physiologically adapted to the saturated saline environment, have few or no natural predators, have an abundance of food, have competition limited to that between individuals within the same species, all of which are favorable conditions for significant increases in their numbers.

Corixids

These small bugs are also called water boatmen and are less than 12 millimeters long. They occur everywhere in the shallows of ponds, lake and streams where they spend most of their time on the bottom. Corixids show preferences to for particular habitats, and can serve as indicators of local conditions. Corixids do not breed in the open lake water, but fly to fresher side pools to breed and lay their eggs. They are predators and feed upon brine shrimp and brine fly larvae in the Great Salt Lake (Rawley, 1994). The significance of Corixids in and upon the food chain of Great Salt Lake is not known.

Fish

The salinities of Gilbert and Gunnison Bays of the Great Salt Lake are too saline to support fishes. Some fish species do occur on a temporary basis in the Bear River and Farmington Bays. Both of these bays receive substantial freshwater inputs from the Bear River and the Jordan River, respectively.

During the spring runoff period, fishes are carried into Bear River Bay from the adjacent freshwater marshes and waterways. The salinity of this bay is very low. A tongue of saline water flows into the bay from the opening in the IMC Kalium (formerly Great Salt Lake Minerals) causeway. This layer of salt water is usually found along the bottom of the bay, and its presence and depth is influenced by south winds. There is a layer of fresher water on top of the saline layer. This fresh water can sustain fish populations over time. Carp is the species which is most abundant. Piscivorous bird species such as White pelicans, Western grebes, and Double-crested cormorants use the bay as a foraging area. A strong south wind has the ability to push saline water from the south side of the causeway up into the bay, causing significant fish kills at times.

These fish are washed out of Bear River Bay into Gilbert Bay of the Great Salt Lake. They are preserved to a degree in the saltwater, and are carried around the lake surface by winds and water currents. Observations of these fish in the main body of the lake and/or on the beaches of Fremont, Antelope and other islands leads some people to the assumption there are live fish in the main body of the lake. There are times when layers of freshwater may be temporarily found on the surface of the main body of the lake. It is hypothetically possible that fish could exist for a very short period of time within these layers, but it is unlikely.

Farmington Bay tends to be more saline than Bear River Bay, with salinities there often at 3.5%, too saline to support freshwater species of fish. The margins of the bay adjacent to the freshwater marsh outflows are sometimes fresh enough to sustain temporary populations of fish and the birds that eat them. However the winds frequently mix the water to the point that the fish cannot survive. Occasionally some fish wash out of Farmington Bay through the Davis County causeway into the main lake. This phenomenon is not as common as fish from Bear River Bay, because the populations of fish in Farmington Bay rarely are as abundant. Gunnison Bay does not support a population of fish because of the saturated solution of salts, about 26%.

TERRESTRIAL BIOLOGY

Herpetofauna

Very little serious work has been done on the amphibians and reptiles in the Great Salt Lake ecosystem. Eight amphibians, two turtles, nine lizards and eight snakes were identified in the biological resource inventory and study at the request of the Utah State Legislature prior to 1976.

Mammals

A total of 64 species or subspecies of mammals have been identified around the lake and on islands in the main body of the lake, including mice, rats, muskrats, skunks, badger, fox, bison and many others.

Plants

A great deal of work concerning plant life on the shores of the lake has been conducted by various investigators. (Flower, S. and F. R. Evans, 1966). Great Salt Lake and it environs have a unique diversity of flora, because of the interface between fresh and saline marshes and soils. Halophytic species are found along and adjacent to the beaches of Great Salt Lake. Fresh water from streams, drainage ditches and springs leaches some of the salt from the soils near the lake, and allows a greater diversity of plant species in some areas. Such areas are quite extensive in the deltas of the Jordan and the Bear Rivers, and smaller in other areas due to springs or seepage areas.

Playas are low flat depressions in the valley floor formed by bottom currents of ancient Lake Bonneville in its last stages of recession. The West Desert is a vast complex of playas laced with irregular bars and local depressions. Salt-tolerant species found on Great Salt Lake beaches are also found in some playas, depending upon soils, salt gradients and successional stage. Saline plains or uplands extend beyond the playas and beaches around the lake up to the bases of the mountains. The flora is very diverse and includes herbs and smaller scrubs. Their frequency and location depend on the character of the soil surface and rainfall. Slight depressions usually collect water in the spring and support localized changes in plant life.

Dunes are formed along the eastern shores of the lake and on the plains and foothills bordering the salt desert. Dunes near the lake are composed of white calcareous oolitic sand formed around invertebrate fecal material. Beach flora is very distinct in some areas and in others it is very mixed. Vegetation is usually restricted to the upper edge of the shoreline where wave action is less and flooding by brine laden waters is limited in frequency. Mudflats are a special aquatic site and provide important habitat for some wildlife species, such as the Snowy plover. These areas support pickleweed along the eastern shores of the lake.

Vegetation on Great Salt Lake islands is quite variable, and ranges from no vegetation to broad diversity on Antelope Island. Some islands are mere sand bars with little vegetation or cover, some have a considerable amount of vegetation including desert scrubs, and others are quite rocky and devoid of vegetation.

The eastern shoreline of the lake is dominated by marshlands or wetland type vegetation. This narrow strip of vegetation combined with shallow water is important habitat for wildlife and millions of waterfowl and shorebirds. The fact that relatively small changes in lake level inundate or expose large areas of shoreline means that the lakeshore flora are characterized by

repeated successions. The north end of the lake has extensive stands of sagebrush and is an important winter area for sheep and deer. Browse-type vegetation located in the Promotory Mountains includes Mountain mahogany, Serviceberry and Bitterbrush, which are valuable to wildlife as food and cover. These areas also have juniper growing on steep and rocky hillsides.

Perennial vegetation consists mainly of grasses and various shrubs such as sagebrush, rabbit brush, greasewood and shadscale, particularly along the west side of the lake. Upland and agricultural areas also provide important wildlife habitat and serve as critical habitat when lake levels are high.

AVIAN BIOLOGY

Dr. Joseph R. Jehl Jr., stated that "The Great Salt Lake is ornithologically the most impressive salt lake on the continent." Avifauna associated with the lake and its environs are abundant and diverse, including migratory waterfowl, shore and wading birds, and marsh associated songbirds. Over 250 different species have been identified. Several million individual birds use the lake area in spring, summer and fall migration. Some unique winter visitors occur in the area including one of the largest concentrations of Bald eagles in the 48 contiguous United States, and a single flamingo, Pink Floyd, the famous escapee from Tracy Aviary in Salt Lake City.

Water birds on Great Salt Lake

The Great Salt Lake has extensive populations of waterbirds. These species are primarily colonial nesters and can be found on the lands or marshes adjacent to the lake, or on the islands and dikes/causeways within the lake. There are three primary habitat types utilized as by these birds for nesting locations, open ground, the interface between open water and emergent vegetation, and areas of woody vegetation.

The ground nesting include California gulls, which nest on islands in the lake and on dikes or causeways that transect the lake. Egg Island and dikes at the IMC Kalium Potash operation in Bear River Bay are sites for gull colonies. White pelicans nest on Gunnison Island. The extremely remote island provides security from disturbance and predators. The pelicans fly from the island daily to forage for fish in the freshwater marshes and reservoirs, then return at the end of the day to bring food back to the rookery. Black-necked stilts and American avocets nest on flat mud playas around the lake. These sites are adjacent to their favored shallow water feeding areas. Snowy plovers select playas with little vegetation around the lake for nesting sites.

Birds which select the interface of open water areas and the beginning of the emergent vegetation (such as bulrush species) of the exterior marshes include White-faced ibis, Franklin gulls and tern species, which are often found conjunctively in nesting colonies around the lake. Eared grebes also utilize this habitat type, although they are not necessarily nesting along with the species previously mentioned. The populations of these species are substantial in magnitude.

As the lake levels fluctuate, the location of the bulrush-open water interface constantly changes. If the movement of the lake's shoreline is obstructed, if water were not allowed to become gradually shallow, or if salinities were to increase greatly, these habitats would be lost, along with the populations of birds that inhabit and rely upon them.

There is another group of species which utilize a relatively rare habitat type around the lake. This is woody vegetation in the form of trees and large shrubs. These are usually found along the waterways entering the marshes or planted along dikes and uplands by wildlife managers. All of the trees below lake elevation 4212 feet were killed by salt water and/or flooding during the mid 1980's. Some of the dead trees still persist, and new trees have been planted or have naturally re-established themselves. These trees are essential nesting sites for such species as: Great Blue herons, Snowy egrets, Black-crowned night herons and Double-crested cormorants. Other species such as raptors utilize these trees as well.

The open or pelagic areas of the lake are very important to many birds. These areas are primarily used for either foraging or resting. Eared grebes and Red-necked phalaropes feed on brine shrimp in the open waters of the lake. Gulls are observed there as well. They feed upon dead brine shrimp which collect in windrows or streaks. During the fall and winter, huge flocks of ducks are found on the open waters of the lake resting and apparently feeding on the streaks of brine shrimp eggs.

Waterfowl

The Great Salt Lake is located on the western edge of the Central Flyway and the eastern edge of the Pacific Flyway. These corridors are the major routes that different populations of birds utilize when migrating north and south. These flyways were established resultant of analyzing bird banding data over time. It was discovered that birds typically, although not exclusively, migrate in north south corridors.

There are many species of waterfowl that have been documented on and around the Great Salt Lake. Over 75% of the western population of Tundra swans utilize the lake as a stopover and foraging area during their migration. As many as 60,000 birds have been observed at peak times. They utilize the large lake areas within the Wildlife Management Areas and at Bear River Refuge. Sago pondweed grows in these units and is a preferred forage. Trumpeter swans also inhabit the area. The USF&WS has been transplanting Trumpeter swans here from areas where their populations have exceeded the food source. The goal is to broaden the range of these birds across the west.

A number of ducks are found in the marshes around the lake. These birds breed and produce young here. The habitat types used are upland areas and emergent marshes. The numbers following the species represent breeding pairs, the total numbers of individuals is double the breeding pair number: Pintail-2,000, Gadwall-40,000, Cinnamon Teal-40,000, Mallards-<65,000, Ruddy ducks-15,000, Redheads-20,000, and Shovellers-10,000. There are also about 2,000

breeding pairs of Canada geese that utilize the lake and marshes.

Waterfowl that are produced elsewhere, typically north of Utah, use the marshes and lake as a stopover point during their migration. Large numbers of two species use the lake as a staging and molting area. They fly here from other areas and use the large open water lakes for security and foraging. Waterfowl molt their flight feathers during the summer, and are flightless during this 3-4 week period. The large open water areas allow them to escape predators during this vulnerable period. Peak Pintail numbers in late summer are about 1,000,000, which is about 25% of the continental population of these birds. Green-wing teal numbers peak at 600,000 during this molting and staging period. Population numbers of the following species also utilize the lake during migration periods: Gadwall-100,000, Cinnamon Teal-80,000, Mallards-500,000, Ruddy ducks-60,000, Canada geese-50,000, Redheads-150,000, Canvasbacks-50,000, and Shovellers 100,000.

Wintering populations of waterfowl are dependent upon habitat and climatic conditions, which change from year to year. The amount of water which is not frozen and the availability of food are the primary factors governing abundance of birds during the winter. If the winter is severe and most of the marshes are frozen over and relatively deep snows cover the ground, birds migrate south until more favorable conditions are encountered.

UDWR participates with other states and the USF&WS in the management of migrating waterfowl. Birds that can move in one day from state to state or even between countries, need to have coordinated management. Utah conducts several surveys each year to determine population numbers of birds in the state. These counts are coordinated with the other states so a continental population is possible to determine. For example, the states conduct mid-winter surveys between January 1-15, to establish wintering population data.

Habitat Relationships

There are five major habitat types around the lake that are used by waterfowl species. They are:

Uplands- this habitat is found at slightly higher levels than adjacent marshes, and is usually characterized by dry ground and species of grasses, forbs and shrubs that favor this condition. Uplands are the most limited of the types of habitats around the lake. These are the areas that are best suited to development, farming and other activities of humans. Many waterfowl species prefer to nest in upland sites, then lead their broods of ducklings to the marshes to rear them.

Emergent fresh-water marsh is the next habitat frequently encountered as the elevation gets closer to the lake level. There are approximately 400,000 acres of this wetland type around the lake, principally on the east side. The major surface water inflows to the lake run through these areas. Many impoundments have been constructed by the Division of Wildlife Resources, the U.S. Fish and Wildlife Service, private land owners which include duck clubs, and the

wetlands mitigation sites of Kennecott Copper Corporation, and the Salt Lake International Airport Authority. The Nature Conservancy and the Utah Reclamation and Mitigation Commission also own emergent marsh wetlands. These areas are principally impounded water which supports marsh plants including bulrush and cattail. Other land types associated with this habitat include small ponds found within the emergent vegetation and large bodies of water where the depth precludes the establishment of these species. Dikes and small islands are also found in these marshes. They are particularly important as nesting and resting sites because, as water levels change, they usually stay dry.

Mudflats and playas are another major habitat type around the lake. These areas are characterized by a very low gradient. As the lake level fluctuates these areas become inundated, then dry out. The water levels can change due to runoff or winds. The lake is so wide and shallow that, as the wind blows across it, water is pushed to the windward side increasing water levels one foot or more due to this tide-like phenomenon. Precipitation or snow melt can also fill low spots in these areas, creating ephemeral ponds which are excellent sites for invertebrates. The vegetation on the mudflats and playas is often very sparse and composed of plant species that are very tolerant to high salinities. These include salt grass and pickleweed. Mudflats and playas are important to waterfowl for feeding and resting. The lack of vegetation provides a visual security from predators.

The fourth habitat type on the lake are the brackish-water areas. These are located where the freshwater from the marshes flows into the saline water of the Great Salt Lake. The resultant mixing of the waters provided a range of salinities that allow a diverse groups of plants, invertebrates and sometimes fishes to exist there. Water depths are often shallow and the birds use these areas extensively for feeding.

The fifth major habitat type is the open water or pelagic area of the lake itself. When the surface water is relatively calm, huge numbers of waterfowl raft in these areas. There are few disturbances and the birds are able to rest without molestation. These areas also provide important foraging opportunities. Brine flies are found on floating bits of vegetation and brine shrimp and brine shrimp cysts can be found floating on the lake surface. Huge flocks of Goldeneyes and Shovellers have been observed on the lake, presumably feeding on these resources. During the winter there are other species of maritime waterfowl that are occasionally observed on these expansive open waters. These species include Oldsquaws and Scoters.

Shorebirds

The Great Salt Lake has one of the largest shorebird concentrations in the world. Over thirty-five species of shorebirds are found in the Western Hemisphere. (Sorensen, 1997) Many of these visit the Great Salt Lake each year and include the Avocet, Black-necked stilt, Killdeer and Long-billed curlew as a few of the more common species.

Many of these birds undertake extraordinary migrations with some birds traveling up to 2-3 thousand miles. Over 50 percent of the world population of Wilson's phalaropes (500,000), the largest staging population in the world, depends on Great Salt Lake. The largest population of American avocets (250,000) and Black-necked stilts (65,000) in the Pacific flyway, and over 10 percent of all Red-necked phalaropes (280,000) stop over on Great Salt Lake. The lake also hosts the world's largest assemblage of Snowy plovers (10,000), and the only staging area for Marbled godwits (30,000) in the interior region of the United States. A single day count of Long-billed dowitcher recorded 32,000 (Shuford, 1994).

Habitat Relationships

The most significant aspect of the Great Salt Lake ecosystem is the great diversity of specific habitats created from the integration or close association of fresh and salt water systems which creates a fluctuating "mosaic" of land forms, vegetative cover, water, and salinity. Several habitat types, natural and man-made are described below to illustrate the importance of each micro-habitat. Management and conservation efforts must consider each specific habitat and the species that frequent these areas.

Fresh and salt water interfaces are created where flowing fresh water intrudes directly into the lake such as at the outflows of several small streams entering the lake from the east shore. These areas provide important foraging areas for breeding and brooding summer shorebirds and for staging shorebirds.

Riparian riverine and emergent wetland habitats occur where flowing streams enter into fresh water emergent marsh complexes, such as in managed wildlife areas and marshes. These areas, with their associated trees, are important foraging and nesting areas for fish-eating birds, provide winter perch and roost sites for Bald eagles, and migratory corridors for song birds.

Salt playas, mud flats and other lake interfaces occur at numerous locations throughout the extremely shallow Great Salt Lake basin. These environments shift seasonally and with lake level fluctuations. These areas are critical to Snowy plovers for nesting, and providing foraging and staging areas for numerous shorebirds; including tens of thousands of avocets and stilts. The associated shoreline supports a robust population of brine flies which is a significant avian food source. The transitory nature of this habitat type introduces a constant dynamic state so that emergent vegetative stands are constantly shifting between early and late serial stages as the water levels advance and recede. A rich mosaic pattern of habitat types is the result. Some examples include Farmington Bay, Howard Slough, and the areas west of existing Waterfowl Management Areas and The Nature Conservancy wetlands. There are numerous ephemeral pools that are associated with the mud flats and playas. They are resultant of slight changes in topography and precipitation, overland runoff, wind tides from the main lake and receding lake levels. These small pools create critical habitats for waterfowl, wading and water birds. They create unique places for food production of invertebrates and vegetative species.

Salinity levels vary around the main body of the lake due to geographic location and the presence of man-made structures. A corresponding variety of plants and invertebrates are dependent on these differing saline habitats. Each species has an optimum range of preferred salinity levels, and this wide spectrum of salinities provides unique and critical habitat for wildlife. Brine shrimp play a significant role in the Great Salt Lake ecosystem and, along with brine flies, are the keystone species supporting many of the water- and shorebird species that frequent the lake. A primary reason for the hemispherically important bird numbers at Great Salt Lake is the lake's capacity to produce millions of pounds of easily foraged protein at the appropriate times for staging and molting for migratory birds.

Generally, the north arm (Gunnison Bay) and the west and south shores are the most saline, and support brine shrimp at high lake elevations. The northeast, east and southeast side of the lake is less saline and support bine shrimp and other invertebrates during average and lower lake elevation years. These open lake and littoral zones are exceptionally important to phalaropes, Franklin and California gulls and Eared grebes. The east shore of the lake has many productive habitats due to the fresh water deltas of the Jordan, Weber and Bear rivers, and numerous smaller Wasatch Front streams. The historic Jordan and the Weber River deltas have been abandoned and receive little or no natural flow. These are very productive areas for waterfowl, colonial nesters and may shorebirds, including Dowitchers, Yellowlegs and Godwits.

Davis County collected information on the acreage for open water, marsh plants, upland plants and mudflats in a percent cover inventory conducted prior to 1976 as follows:

Open Water	53,123 acres
Marsh Plants	13,381 acres
Upland Plants	9,683 acres
Mudflats	20,699 acres

Total Acres: 96,886

This inventory is mentioned in The Great Salt Lake Biotic System (UDWR, 1974) and described habitat types and amounts over a relatively short time period. Managers recognize that the amounts, locations and types of habitats are directly associated with, and controlled by, climatic conditions, the water elevation of the Great Salt Lake, and variations in fresh water flows and abundance, and are constantly changing both in magnitude and quality.

Managed wetlands have created unique habitats with dikes, levies, headgate systems and diversion structures. These systems enhance the opportunities for active management by changing water depths, temperature and water dispersion patterns and by controlling nutrient flows over time. These managed wetland areas adjust to seasonal use and the needs of migrating and breeding water birds. Significant production of waterfowl also occurs in these areas.

Avian Surveys, Studies and Information

Great Salt Lake is the largest permanent saline lake in the United States, and is a major feeding station for birds. The best way to truly appreciate the sheer numbers of birds and different species is via bird surveys and census projects. The following bird surveys are, or have been, conducted on the Great Salt Lake:

Breeding Bird Survey (Annual; USFWS)
Mid-Winter Waterfowl Survey (Annual; UDWR & USFWS)
Swan Surveys (Bi-weekly Sept.-Dec.; UDWR & USFWS)
National Wildlife Federation Eagle Survey (Annual; UDWR)
Great Salt Lake Waterbird Survey (10 day intervals Apr.-Oct; UDWR)
National Audubon Christmas Bird Count (Annual; UDWR)
WMA Non-Game Surveys (Monthly; UDWR)/Replacing the GSL Waterbird Survey
South Shore Shorebird Surveys (Kennecott, SLC Airport Authority & Audubon)
Utah Latilong Survey (UDWR)
White Pelican Photo Transects (UDWR)
Peregrine Falcon Hack Tower Surveys (UDWR)

In addition, there is an enormous amount of information and research findings (published and non-published) available on the flora and fauna of Great Salt Lake. A complete literature search is currently being conducted and compiled by Utah State University and the Division of Wildlife Resources. This project is seeking research papers on brine shrimp in natural systems, limnology of saline lakes, avifauna ecology of hyper saline lakes in the Western Hemisphere, and research on the Great Salt Lake. A bibliography will be available on CD ROM in the near future.

The Utah Natural Heritage Program is a central repository for information about Utah's biodiversity including plants, animals and plant communities. This program was initiated by The Nature Conservancy in 1988, the program was handed over to the State in 1991 and is currently partially funded by the UDWR. The program's mission is to collect information about Utah species and plant communities in a standardized and easily retrievable way and provide this information for natural resource management decision-makers.

The Utah GAP analysis program is comprised of a geographic information system (GIS) that includes map layers of habitat types, vegetation, wildlife distribution and other resources. This information can be utilized to investigate spatial relationships of resources and to track changes or trends in wildlife distribution and habitat utilization. Many Master's and Doctoral dissertations have been completed on the ecology of Great Salt Lake and are kept at the various Universities where the research was originally funded. These publications will be included in the bibliography prepared by the UDWR and Utah State University (USU). Recently completed and on-going research includes the following efforts:

Pacific Flyway Shorebird Project (Point Reyes Bird Observatory)
Bear River Migratory Bird Refuge Bird Abundance Surveys (USFWS)
Canada Goose Banding (UDWR)
Pacific Flyway Duck Banding (UDWR)
Great Salt Lake Botulism Study (USU)
Mechanisms for coexistence of two swan species at varying spatial scales (USU)
Interactive pathways in wetland ecosystems (USU)
Restoring breeding bird population to Bear River Migratory Bird Refuge (USU)
Brine Shrimp Population Dynamics (USU)
Brine Shrimp Populations and Lake Limnology (UDWR & USGS)
Salinity Model/Patterns in the GSL (USGS, DNR, Tooele County)
Bioenergetics of the eared grebe (UDWR, USU)
Population Status of the eared grebe (UDWR)
Water Quality and Contaminant Research (USFWS & DFFSL)
Food Chain Ecology on the Great Salt Lake (USU)
National Wildlife Federation Eagle Count
Snowy Plover Surveys (1996-Weekly/Summer; American Birding Association)
Spatial/Temporal Avian Census of the Great Salt Lake (UDWR and cooperators)
Brine Shrimp Population and Harvest Census (UDWR)
Brine Shrimp Ecology of Great Salt Lake Beaches (UDWR)

A significant local effort is the National Audubon's Feasibility Study for the South Shore Wetlands Ecological Reserve of the Great Salt Lake (1995). This was an investigation of the potential of restoring the natural inflow of freshwater to the prehistoric river channel and delta of the Jordan River. The results of this study indicated that a state of the art ecosystem wetland habitat restoration effort would have a high likelihood of success. This is one example of an effort focusing on improving habitat for waterfowl, shorebirds and other water birds.

RESEARCH

In July, 1996 the Utah Division of Wildlife Resources (UDWR) formed the Great Salt Lake Ecosystem Project (GSLEP). The purpose of this project is to exclusively dedicate personnel to research and management of the Great Salt Lake ecosystem, focusing on the significance of the aquatic biology of the lake to resident and migratory birds. As implementation of the project began, it became apparent that no one had previously attempted to manage a naturally occurring brine shrimp population or the bird populations that rely upon it. Therefore, the methodologies and techniques had to be developed from scratch to gain the necessary data.

The Great Salt Lake Ecosystem Project is staffed by the Project Leader, an Aquatic Biologist, the Wildlife Biologist, a Wildlife Technician and various Biological Aides hired seasonally. Law Enforcement Officers conduct field operations during the harvesting season and at other times as necessary.

To address the broad ecological questions necessary to effect good management of the ecosystem, UDWR has contracted with a number of researchers. Dr. Gary Belovsky of the Department of Fisheries and Wildlife and Ecology Center at Utah State University was contracted to research factors influencing the dynamics of the brine shrimp population and develop a population model. A preliminary model was developed using available data from the lake and pertinent literature. Model components included primary and secondary production in the lake influences on brine shrimp population dynamics and standing crop of shrimp, rate of shrimp consumption by harvesters and birds, and the ultimate cycling of nutrients back to the system. Values from the literature were used in place of available Great Salt Lake data when appropriate, however in many instances, no literature values were available for the required parameters. Many of the research endeavors of the Great Salt Lake Ecosystem Project are targeted at these deficiencies. From the model it is hoped that we can predict the annual shrimp production in the lake, amount of forage required by the birds, how many cysts can be harvested, and the amount of cysts that need to be left over the following spring to restart the population.

Other research projects currently underway at Utah State University include determining the overwinter mortality of cysts within the lake, construction of a literature database on salt lake ecosystems, and a study of corixid predation on brine shrimp. A research project on Eared Grebe-brine shrimp interactions is scheduled to begin in the fall of 1998.

Dr. Doyle Stephens of United States Geological Survey (USGS) has been contracted to conduct field sampling of sites in the south arm of the Great Salt Lake and conduct laboratory analysis of these samples. This information will become an input to the management model developed by Dr. Belovsky. In addition to this work, Utah Division of Wildlife Resources has joined with other cooperators in funding data collection by the USGS necessary to refine an existing hydro-salinity model which predicts the transport of salts between the north and south arms of the lake. The USGS has also been contracted to conduct a bathymetric study of the area near the railroad causeway. Dr. Susan Kilham, a noted diatom researcher from Drexel University, Pennsylvania, will be conducting a one year sabbatical study on the dynamics of diatoms in the Great Salt Lake. It is hoped that this research will provide insights into the factors controlling algal community shifts within the Great Salt Lake.

Great Salt Lake Ecosystem Project personnel are also conducting research that assist with management directly or will enable future inputs to the brine shrimp model. Some of the objectives of Project research include:

-Understanding the role of brine shrimp cysts in the diet of wintering ducks.
-Developing sampling techniques to quantify floating cyst streaks.
-Learning more of the biology of shrimp in the lake.
-Understanding the relevance of salinity to cyst characteristics.
-Understanding nutrient loading and cycling in the lake.
-Understanding impacts of reduced water inflow to the lake over time.
-Understanding impacts of toxic substances that may be in the lake.

An avian census program has been carried out for two years with the assistance of many volunteers. The objective of this research is to quantify timing and magnitude of bird use in various habitats around the south arm of the lake, Bear River Bay, and Farmington Bay. This information will be critical as an input to the model in understanding the needs of birds as it relates to brine shrimp. Other bird conservation needs will also be addressed by this work. Additional work is underway with bird banding, specific grebe research and conservation planning. A Snowy plover research effort was partially supported by the Division of Wildlife Resources in 1997.

Other projects currently underway by GSLEP personnel include sampling in the north arm of the lake to determine the extent of the brine shrimp population in that region and estimates of the loss of shrimp and eggs from the south arm, and a project to develop the technology necessary to assess what the importance of beach deposited cysts are to the lake system. Conclusions from these studies and the annual harvest estimate will eventually be included in the population model.

EXISTING CONDITIONS AND TRENDS IN LAKE BIOLOGY

Based on the information received during internal and external scoping, the Planning team identified four major areas of management interest and concern:

- **Existing Division of Wildlife Resources management programs.**
- **Changes in lake brine salinities, with corresponding changes in aquatic and avian biology on Great Salt Lake.**
- **Potential for changes in lake water quality and impacts to aquatic and avian wildlife.**
- **Wildlife management areas within the 39 townships identified by the Utah Code for that purpose have indefinite boundaries.**

♦ EXISTING DIVISION OF WILDLIFE RESOURCES MANAGEMENT PROGRAMS

Functions of the Division of Wildlife Resources and Wildlife Board

The Utah Division of Wildlife Resources has jurisdictional responsibility for all wildlife in the state pursuant to Section 23-15-2 of the Utah Code, which provides;

> "All wildlife within this state, including but not limited to wildlife on public or private land or in public or private waters within this state, shall fall within the jurisdiction of the

Division of Wildlife Resources."

The Division is "appointed as the trustee and custodian of protected wildlife..." and, subject to the broad policy making authority of the Wildlife Board, the Division's responsibilities are to, "protect, propagate, manage, conserve, and distribute protected wildlife throughout the state." (Utah Code 23-14-1(2))

The Wildlife Board's responsibility is to, "...establish the policies best designed to accomplish the purposes, and fulfill the intent of all laws pertaining to wildlife and the preservation, protection, conservation, perpetuation, introduction, and management of wildlife." In so doing, the Wildlife Board is to rely on the Division's determinations of fact, and on the recommendations of the regional advisory councils established under Section 23-14-2.6 of the Utah Code. Under Utah law, five Regional Advisory Councils (RACs) conduct hearings to collect public input, gather information from Division staff, the public and government agencies, and make recommendations to the Wildlife Board in an advisory capacity.

On and near Great Salt Lake, the Division of Wildlife Resources' responsibilities include: research on and management of wildlife species, regulation of hunting, regulation of commercial brine shrimping, management of state wildlife and waterfowl management areas, and cooperative management of Antelope Island's large ungulates with the Division of Parks and Recreation.

Great Salt Lake Waterfowl Management Areas

There are eight State-managed Wildlife/Waterfowl Management Areas on Great Salt Lake. Six are located along the shoreline of the lake, and include Farmington Bay, Howard Slough, Ogden Bay, Harold Crane, Locomotive Springs, and Timpie Springs (See Map 1). Two other areas are located within ten miles of the lake and have a direct association with the lake environs. A total of 87,244 acres are intensively managed by the State of Utah Division of Wildlife Resources Some acres are managed under cooperative agreements with other state and federal agencies, such as Forestry, Fire and State Lands and the Bureau of Land Management. Utah Code Section 23-21-5 identifies approximately 150,000 additional acres in the lake area which are authorized for administration by the Division of Wildlife Resources for hunting, fishing and wildlife management purposes.

Each management area is in the process of developing a habitat management plan. These plans describe the management areas, identify capital improvements needs, and describe generalized management activities associated with identified goals and objectives. Management actions include wildlife habitat enhancement through water control, agricultural practices, population monitoring, law enforcement, education and information sharing to support and build an appreciation for wildlife, habitat, wetlands, wildlife management and conservation.

Wildlife management areas can be affected by high lake water levels and have many common management issues and concerns. Important issues include secure future water

supplies, access management, balancing the needs of user groups, funding to operate and maintain facilities, urban changes in the flood plain of Great Salt Lake, flooding of lower tributaries, and water pollution, including siltation.

Farmington Bay Waterfowl Management Area

Farmington Bay WMA is located west of Interstate 15 between Centerville and Farmington. This area can be easily accessed from Glovers Lane west of the interstate and south along the access road. Duck clubs, city, county and private property outline the perimeter of the WMA. Farmington Bay is one of the most popular waterfowl hunting areas in Utah and also is and outstanding birding area. It is unique in that it provides important wetland habitat and wildlife based recreation so close to an urban area. This 17,916 acre management area is one of the best places to observe the fresh water interface with Great Salt Lake. The Jordan River is the primary water source for Farmington Bay. This area is managed primarily to provide habitat for water-dependent birds.

The Farmington Bay WMA was constructed in the 1935 to provide habitat for nesting and migratory waterfowl. It includes 12,000 acres impounded by dikes and another 15,000 acres of natural estuary wetlands. Habitat types include:

4,301 acres open water	6,277 acres of marsh
6,174 acres of mud flats	600 acres of uplands

Farmington Bay Waterfowl Management Area provides opportunities for hunting, bird watching, photography and nature study. Hiking, biking and air boating are other recreation opportunities. Currently, the Division of Wildlife Resources is pursuing funding for enhanced visitor use development, which includes a Visitor Center on the north end of the management area to enhance interpretive and education efforts.

Waterfowl management areas around Great Salt Lake are sensitive to natural lake level fluctuations. The outer dikes of the Farmington Bay WMA are at an elevation of 4204 feet. At lake level elevations above 4204 feet, the WMA loses the ability to impound shallow water. Farmington Bay dikes were designed to impound and spread shallow water at a lake level elevation of 4198 feet. Lake level elevations higher than 4198 feet reduce management efficiency and increase loss of habitat units. At 4206 feet, nearly 80 percent of this WMA is inundated, and above 4210 feet all the created habitats are lost. In response to this natural dynamic, the Division of Wildlife Resources has designed portable structures for walk ways, restroom and office facilities. Approximately one million dollars was required to repair damages from the 1980's flooding event. The most significant management issue at Farmington Bay is future water quality and supply. Other important issues include providing additional access and balancing diverse user groups. Expansion of the Farmington Bay WMA has been discussed, but there appear to be a limited number of willing sellers from which to acquire additional property.

Harold Crane Waterfowl Management Area

The Harold Crane WMA is located on the south-west corner of Willard Bay Reservoir, and is approximately 11,000 acres of shallow ponds fringed by alkali bulrush and cattail. This areas was constructed in 1964 as mitigation for wetlands lost due to the construction of Willard Bay Reservoir. Additional lands acquired in 1990 doubled its size. Foot access is permitted between July 15 and March 1. The gate is open to vehicles and small boats during hunting season, but closed to motorized vehicles and boats the rest of the year. The area is closed to all trespass between March 1 to July 5 during the bird nesting season.

Howard Slough Waterfowl Management Area

Howard Slough was established as a WMA during 1958 to create wetlands from irrigation waste waters before they entered the lake. This development was the first major wetland project along GSL in over 20 years and a subsequent 1990 expansion was Utah's first North American Waterfowl Management Plan cooperative acquisition. Major redesigning and restoration occurred at this time.

Howard Slough is located south on 7100 West from 5500 South in South Hooper and includes over 3,300 acres of developed wetland habitat. This WMA is located 2 miles west and one mile south of Hooper in Davis County. This area includes a total of 3,420 acres of the following habitat types:

1,800 acres marsh	631 acres of mud flats
600 acres open water	389 acres of upland

Ogden Bay Waterfowl Management Area

The Ogden Bay WMA is located on the Weber River delta of the Great Salt Lake, and is over 21,000 acres in size, the largest state WMA in Utah, although the northwestern boundaries are indefinite. Land acquisition and development of Ogden Bay WMA started in 1937 with a cooperative project between the Division of Wildlife Resources, Weber County Wildlife Federation, The U.S. Fish and Wildlife Service, and the Civilian Conservation Corps. In 1938, following the passage of the Pittman-Robertson Act, Ogden Bay became the nation's first Federal Aid to Wildlife restoration project. It is located two miles west and one mile north of Hooper in Davis and Weber Counties. The Ogden Bay WMA contains the following habitat types (acreages are estimates):

4,998 acres open water	4,780 acres marsh
5,182 acres mud flats	3,800 acres uplands

Ogden Bay also makes significant contributions to wildlife-related recreation on Great Salt Lake. During the production period, March 1 thru August 1, approximately 15 miles of

dikes are open to non-motorized use. Throughout the rest of the year 45 miles of dikes are open to non-motorized use. Several air boat ramps and parking areas are available for public use at various lake levels during the hunting season. Ogden Bay WMA has approximately 70,000 annual visitors each year, 28,000 of which are waterfowl hunters and 60 percent other wildlife enthusiasts. The most popular activities include wildlife watching and waterfowl hunting. This area is one of the nation's most heavily hunted waterfowl management areas. Over 18,000 hunter trips harvest over 25,000 waterfowl at this WMA annually.

Ogden Bay's wetland resource values are dependent on the water levels of Great Salt Lake. Wetland habitat, wildlife use and public recreation opportunities are greatly reduced at high lake level elevations. During the 1980's flooding, wildlife and human use decreased by over 90 percent. Lake level begins to affect Ogden Bay WMA dikes at a lake level elevation of 4203, which occurred this year. Other dike elevations range from 4205-4212, with upland areas at an elevation of 4220. Over 80 percent of the area is flooded at a lake elevation of 4211. Flood damages to the diking system were close to $150,000 in the 1980's. A series of boat ramps which are useable at various lake levels improves access.

Important issues for Howard Slough and Ogden Bay WMAs include vulnerability to flooding from the Weber River and Great Salt Lake. Other management issues include additional access for air boats, visitor conflicts, water quality, and high levels of sediment entering via the Weber River. The water rights are very good since this is one of the oldest WMA's in Utah. Another concern is diminishing agricultural habitat and food sources for the White-faced ibis, waterfowl, and other agriculturally-dependent species due to residential housing development.

Timpie Springs Waterfowl Management Area

Timpie Springs WMA is located one mile north of Interstate I-80 at Rowley Junction, 15 miles northwest of Grantsville in Tooele County. This WMA is comprised of 1,440 acres. The water source is a saline spring which feeds two water impoundments created by 3.5 miles of dike. The salinity of the water source limits the vegetation of the area to Salt grass. Waterfowl, waterbirds and shorebirds utilize this area, and it is important because there are few significant marshes and sources of fresher water around the southwest quadrant of the lake. There is a half mile long road that provides access to the area from I-80. This road terminates in a parking lot where there are informational signs. Timpie Springs has approximately 400 annual visitors, of which approximately 300 are waterfowl hunters. Walking access to the area is available year around from the parking lot. Habitat types include:

350 acres open water	400 acres marsh
390 acres mud flat	300 acres upland

Locomotive Springs Waterfowl Management Area

Locomotive Springs Waterfowl Management Area is an isolated spring-fed wetland located at the north end of Great Salt Lake, east of Kelton. This 17,317 acre WMA is supported by six springs and provides a much needed oasis for wildlife in the middle of the West Desert. Habitat types include the following:

1,370 acres open water	3,250 acres marsh
9,077 acres mud flats	1,455 acres upland

The Civilian Conservation Corps created the Locomotive Springs WMA in 1931. The Division of Wildlife Resources plans to expand the WMA by 2,600 acres to include protection of playas which are Snowy plover habitat. Wildlife viewing activities include a Peregrine falcon hacking tower, waterfowl and wading shorebirds. Public vehicle access around the dikes is permissible, except during waterfowl breeding and nesting season, and during falcon hacking. Bird watching, fishing and primitive camping are allowable year around. The entire Waterfowl Management Area is accessible during hunting season. Locomotive Springs receives approximately 6,000 visitors a year, 5,000 of which enjoy hunting and fishing.

The most significant issue facing Locomotive Springs is maintaining water flow from the springs throughout the year. The aquifer which feeds Locomotive Springs is over-allocated, and since the early 1970's the spring flow has declined by 83 percent. This has diminished wetlands by 5,000 acres in this WMA. Declining water quality as a result of diminished flows is also a concern due to the high salinity of the spring and lake water.

Other Important State-Operated Wildlife Management Areas

Other wildlife and waterfowl management areas located beyond the meander line of Great Salt Lake provide a variety of different habitat types for many species that depend upon the Great Salt Lake ecosystem. These areas are directly associated with the lake environs and become critically important when high lake levels inundate otherwise available habitats at lower elevations.

Public Shooting Grounds Waterfowl Management Area

Public Shooting Grounds WMA is perhaps the first area in the nation set aside specifically for hunting, and was established in 1929. It is located 10.5 miles west of Corinne on U-83 and is directly north of the Bear River Migratory Bird Refuge. This 11,834 acre area includes cold desert upland plant species, extensive wetland vegetation, eleven developed ponds and mud flat areas which, together, provide great habitat diversity. Habitat types include:

2,305 acres open water	4,129 acres marsh
3,675 acres mud flats	1,455 acres upland

Camping, off-highway vehicle and air boat use are restricted, but permitted during the waterfowl hunting season. Wildlife viewing is limited and access is poor for vehicle traffic at the Promontory access where air boats may launch.

Bear River Access Wildlife Management Area

Bear River Access Wildlife Management Area was purchased in 1989 for fisherman access to the Bear River. This WMA is small, only five acres, but includes a parking area and a hardened launch ramp for easy access. The WMA is set in a riparian valley bottom at an elevation of 4220, and is a diverse and productive area for waterfowl and wildlife. Camping, boating and fishing are the primary and popular recreational activities available in this area. Wildlife viewing opportunities include waterfowl during spring and fall, Bald Eagles in the winter, and a variety of other species.

Salt Creek Waterfowl Management Area

Salt Creek Wildlife Management Area is located 8 miles west of Corinne on U-83 then north of Little Mountain. The Salt Creek WMA was established in 1961 and has expanded from 1,389 acres to approximately 5,236 acres. It provides semi-marsh habitat with open water ponds and extensive wetland vegetation. Elevations range between 4255 and 4270 feet. Upland areas include cold desert plant species. Habitat types in this area include the following:

1,208 acres open water	1,210 acres marsh
120 acres mud flats	2,006 acres uplands

Vehicle access is possible to Comptons Knoll throughout most of the year, but is difficult during winter months. However, all other access points are restricted except during the waterfowl hunting season.

Willard Bay Upland Game Wildlife Management Area

Willard Bay Upland Game Wildlife Management Area is located on the south side of Willard Reservoir, and consists of primarily upland habitat mixed with cultivated food plots. This provides habitat for many species of wildlife, and is particularly ideal for pheasants. Riparian wetland areas in this area are productive and attract a variety of wildlife species. Recreation activities include hunting, dog training and wildlife viewing of waterfowl and songbirds. This WMA contains 1,350 acres and is accessible along the south dike of Willard Bay just west of the south marina entrance.

Antelope Island State Park

Antelope Island provides habitat for an unusual array of wildlife. The most visible and well-known of the park's wildlife are bison. The island bison herd, which numbers over 700

after calving season, is one of the largest public herds in the nation. The herd is maintained within carrying capacity via a roundup and the sale of bison finances the park's wildlife program.

Pronghorn were reintroduced in 1993 through a cooperative effort between State Parks and Wildlife Resources. A similar cooperative effort resulted in the introduction of bighorn sheep. Antelope Island provides a disease free environment as it relates to domestic sheep, which is a key consideration for bighorns. A program goal for the island's bighorn herd is to produce a surplus to reintroduce bighorn sheep to historic ranges. Mule deer, coyotes, bobcats, badgers as well as numerous small mammals inhabit Antelope Island as well.

The island's east shore wetlands connect to the mainland marshes and provide additional waterbird habitat. The island also provides important upland habitat juxtaposed to wetlands.

The Division of Parks and Recreation established an independent outside, Wildlife Advisory Committee to review management programs pertaining to range and wildlife issues. A number of outside research projects have been funded and focus on pronghorn, bighorn sheep and bison genetics. Staff monitors range trend and condition, herd sizes and composition; and assists DWR with shorebird censusing. Future research will study recreational impacts on wildlife populations.

Important Habitat Managed by Other Entities

Many areas around the lake are managed for habitat preservation and improvement by other entities such as conservation groups, duck clubs and federal agencies.

Bear River Migratory Bird Refuge

The Bear River Migratory Bird Refuge (BRMBR) is located west of Brigham City in Box Elder County at the mouth of the Bear River. It is the largest national refuge specifically set aside for waterfowl and shorebird management. The Bear River delta is considered one of the most valuable water bird and wetland areas in the state of Utah. Waterfowl, water birds, migratory birds and wildlife depend upon the refuge as an important breeding, wintering and staging area (U.S. Fish & Wildlife Service, 1993).

The refuge was established in 1928 through an Executive Order by Herbert Hoover. Today, BRMBR encompasses approximately 65,163 acres providing contiguous and diverse habitat areas for wildlife. The primary management goals of the refuge include protecting and enhancing habitat to maintain or increase threatened and endangered species, providing suitable production and migration habitat to benefit migratory birds, and providing a biologically diverse suite of habitat types in various successional stages to maintain healthy wildlife and fish populations. Secondary management goals include providing opportunities for the public to enjoy wildlife and to better understand their role in the environment, and ensuring protection for important archaeological, historical and cultural resources. Over 43 archeological sites have

been recorded on the refuge.

A 12 mile driving or hiking tour is open year round and provides an excellent opportunities for wildlife viewing and environmental education. Hunting, trapping and warm water fishing on the main river channel are popular activities available seasonally. Over 40 percent of the refuge is open to waterfowl hunting. A 1990 study to examine the economic worth of the refuge indicated that 20,000 visitors equates to over $180,000 dollars to the local economy.

Water control structures are designed to control water flow into several management units to create diverse habitat areas to benefit wildlife. Approximately 18,937 acres of the refuge does not receive water from the Bear River. Water supplies are rarely at optimum levels. Flushing removes excess salts and drawdowns improve some habitat types. During the 1980's, Great Salt Lake flooding caused over 42 million dollars worth of flood damage including the loss of the visitor center, dikes, water control structures and roads. The outside dikes are presently at 4208.75 feet, which is a 0.75 foot increase from their pre-flooding elevation.

The BRMBR has completed a Long Range Water Management Plan in 1993, to examine existing water management, enhancing the refuge habitat and improving future water supplies and management for the maximum wildlife benefit. Important management concerns include water supply, water quality, and disease management. Water shortages are very detrimental to wetlands and wildlife. The U.S. Fish & Wildlife Service would like to augment natural flows of the Bear River during the months of July and August. A project to supplement these low flows with Willard Bay water was negotiated, but the project was not constructed. Future water development projects on the Bear River are currently under consideration include plans for the Honeyville area, but there is no authorization for this dam to date. Disease management focuses on botulism outbreaks and attempting to understand ideal conditions by linking losses with water conditions and habitat indicators. Peak avian botulism losses seem to occur during above-average water years, according to the USFWS. Water quality and sediment contamination have been investigated in the BRMBR and in proposed acquisition areas. “Soil and water analysis from this study did not identify and toxic constituents, although further sampling of soil, water and fish tissues may be warranted in the Black Slough area to determine the source(s) or extent of DDT contamination,” according to this contaminants study (Waddell, B., Dolling, J., Linner, S., Stephens, D. And S. Stephensen). Also, salts were present in high levels in both water and sediments.

Layton Wetlands Preserve

The Layton Wetlands Preserve is managed by The Nature Conservancy (TNC) and protects approximately 2000 acres of shoreline and upland habitat. One of the main goals of the preserve is to protect upland habitat to buffer State wildlife management areas located adjacent to the lake. TNC allows non-motorized access year around at the Gailey Access in Layton. Management issues include housing and infrastructure development impacts, maintaining water

quality, and the loss of agricultural land habitats. Other issues include sovereign land access and grazing trespass, mosquito abatement and ATV activities which may affect Snowy Plover habitat.

The Nature Conservancy is working with the Utah Reclamation Mitigation and Conservation Commission (URMCC) to develop education programs and interpretive signs. In the future, TNC's hopes to provide greater recreational access and resolve management conflicts, and intends to continue providing hunting access, although their primary mission is to protect wetlands.

Inland Sea Shorebird Reserve

This 4,500 acre reserve was developed by the Kennecott Utah Copper Corporation to mitigate for the tailings modernization and expansion project completed in 1993. The reserve provide a large contiguous area for nesting, and resting habitat for migratory shorebirds and waterfowl. The Inland Sea Shorebird Reserve is surrounded by private duck clubs, the Gillmor Sanctuary and the Salt Lake City International Airport (SLCIA) Mitigation Project, all of which provide wildlife habitat. The reserve has three water sources, including the Goggin Drain, Lee Creek and the North Point Canal, to circulate brackish water through marshes and mudflats to maximize invertebrate populations as food for visiting birds. A unique sand dune environment exists on State sovereign lands adjacent to the reserve.

Once the Army Corps of Engineers approves the mitigation project, expected sometime in 2002, KUC plans to allow greater public access. Important issues for the Inland Sea Shorebird Reserve include access to sovereign lands and mosquito abatement practices.

Gillmor Wildlife Sanctuary

The land for the Gillmor Wildlife Sanctuary was donated to the National Audubon Society to help preserve the natural ecosystem of Great Salt Lake. This 1425 acre property has a variety of habitat types ranging from open water to playas and upland areas. It is located north of Interstate I-80 and to the west and northwest of the new SLCIA runway, on the abandoned delta of the Jordan River. The "Feasibility Study for the South Shore Wetlands Ecological Reserve of the Great Salt Lake" was conducted with URMCC to investigate the possibility of restoration of the natural inflow of fresh water to this old river delta system. The hydrological study and analysis concluded that approximately 2,000 acres of potential wetland habitat could be developed or restored in this area to provide a mosaic of wetland and upland habitats for wildlife.

The goals of the adjacent property owners are compatible in developing a contiguous area of highly productive habitat suitable for breeding, nesting, foraging and resting for a wide range of species. Issues facing this area include acquiring additional water to restore the former Jordan River delta, and encroachment from development near the southeast shore of the lake.

Salt Lake City International Airport Mitigation Site

The Salt Lake City International Airport (SLCIA) runway expansion project required mitigation for wet meadow wetlands habitat loss. Most of this mitigation site is surrounded by private property, duck clubs and the Gillmor Sanctuary. The mitigation site includes 1500 acres of wetland habitat. The SLCIA authorities plan to focus on increasing shorebird habitat by 70 to 80 acres by enhancing marginal wetlands and uplands. Issues facing this mitigation project include flooding impacts, changes in water use from agriculture to urban, non-native species invasion and, most importantly, future supplies of fresh water entering the mitigation site.

Great Salt Lake Duck Club Properties

According to the "South Shore Duck Club Study", 13 duck clubs exist on the south shore of Great Salt Lake, with more than 16,791 acres managed as wetlands for waterfowl habitat. Many duck clubs also exist along the east and north areas around the lake. Private duck clubs develop additional habitat and actively manage and enhance existing habitat to increase wildlife use for the purpose of waterfowl hunting. Enhanced areas require active management to maintain wetland and wildlife values. These efforts also improve habitat conditions for a variety of other species and, together with the efforts of other entities, provide a considerable amount of contiguous habitat for wildlife around Great Salt Lake. The "South Shore Duck Club Study", conducted between 1994-1995, examined the feasibility of a formal protection plan and the possibility of developing public support for these privately owned and managed wetland areas. This effort identified the importance of duck clubs in providing habitat to a variety of species.

Critical issues for duck club properties managers includes securing adequate water supply, water delivery timing and reliability, and maintaining water quality. Flooding issues are significant since these properties are located at low elevations near the lake and most owners or managers rebuilt after the 1980's flooding. Other pressing issues include access, road maintenance, predator control, trespass grazing, and non-native plant species invasions which require ongoing control and expensive eradication.

Important Island Habitat Areas

In addition to established wildlife management areas and privately managed habitats, the islands of the Great Salt Lake provide isolated habitat for a variety of colonial and migratory birds. The table below was used in "Linking Communities, Wetlands and Migratory Birds" document to describe the islands of the lake, access and wildlife use.

Great Salt Lake Island Management, Acreage, Public Access and Wildlife Use Table

Island Name	Managing Agency	Acreage	Public Access	Wildlife Use
Antelope	Utah State Parks	28,240	Yes	Antelope, bison, many birds & other wildlife species
Stansbury Island	BLM/Private	22,314	Partial	
Fremont Island	Private	2,945	No	Unknown
Carrington Island	BLM/Private	1,767	Yes	
Gunnison Island	Utah DWR	163	No	Pelican rookery, gulls
Dolphin Island	Sovereign Land	60	Yes	
Bird or Hat Island	Utah DWR	22	No	Gull & heron rookery
Badger Island	Sovereign Land	6	Yes	
Cub Island	BLM	1	Yes	
Egg Island	Sovereign Land	1	Yes	Gull rookery closed (4/1-7/31)
White Rock Island	Sovereign Land	1	Yes	Gull rookery closed (4/1-7/31)

♦ CHANGES IN LAKE BRINE SALINITIES

Segregation of Great Salt Lake into Distinct Salinity Areas

The waters of the Great Salt Lake are segregated into four areas of different water chemistry and salinity. Each of them is influenced by differing water inflow and evaporation regimes, which results in changes to lake elevation and salinity. The South Arm of the lake is that portion of the lake south of the northern railroad causeway, excluding Farmington Bay and Bear River Bay. Salinities in the South Arm have ranged from 6-16% in recent times. It is this portion of the lake that currently is harvested for brine shrimp.

Farmington Bay is that portion of the lake east of Antelope Island and isolated from the rest of the lake by the Davis Causeway linking Antelope Island to the mainland. Salinities of Farmington Bay fluctuate substantially due the inflow of fresh water from the Jordan River, and the causeway-inhibited exchange of salt water from the South Arm. Salinity values have ranged from 2-6% in recent times. Commercial harvesting of brine shrimp is prohibited in this area to minimize impacts to bird populations.

Bear River Bay lies north of the northern railroad causeway, on the east side of Promontory Point. Water salinity in this bay also fluctuates substantially. There is evidence that when the Bear River flows are very low, a layer of dense brine runs northward into the Bay, especially during periods of south winds. Salinity values are being studied at the current time by the Utah Divisions of Forestry, Fire and State Lands, and Wildlife Resources, the Great Salt Lake

Ecosystem Project, the Department of Environmental Quality and IMC Kalium , Inc. (Formerly Great Salt Lake Minerals, Inc.). Commercial harvesting of brine shrimp is also prohibited in this bay to minimize impacts to birds.

The north arm of the lake (Gunnison Bay) lies north of the northern railroad causeway between Promontory Point and Lakeside. Salinities in this portion of the lake have ranged from 22-26% in recent times. There has been very little harvesting of brine shrimp in this portion of the lake. The water of the north arm is too saline to sustain viable populations of shrimp. Periodically, some shrimp and cysts wash through the breach and culverts, and there are a few locations in the lake where brine shrimp populations may occur, probably due to springs which dilute brine salinity. Commercial brine shrimp harvesting is allowed in the north arm. Bird use of the north arm of the lake has been essentially eliminated because of the lack of viable brine shrimp populations, although some foraging occurs near the causeway breach and culverts. Gunnison Island is an important White pelican rookery.

Aquatic Biota Differences Among the Areas of the Lake

Of primary concern to wildlife managers is the current degree of the difference in salinities between the north and south arms of Great Salt Lake, and the lack of brine shrimp productivity in the north arm. Because brine shrimp are the only commercially harvested aquatic species in Great Salt Lake, most of the research and attention has focused on brine shrimp. However, the same low productivity concerns extend to other aquatic species which are significant in the lake's food chain, such as algae and brine flies.

The northern railroad causeway from Promontory Point to Lakeside is inhibiting the exchange of lake brines between the north and south arms of the lake, and has caused a significant difference between the salinities of the north and south arms since its completion in the late 1950's. It is now thought, however, that the differential, which has averaged between 10% and 13%, is increasing. (See Water-Chemistry) Because the brine shrimp and brine fly productivity of the north arm has been essentially lost, substantial negative impacts on avian species are suspected. Wildlife managers are concerned about the ecological health of the Great Salt Lake system.

Brine shrimp populations flourished in the north arm of the lake during the mid-1980's, due primarily to high lake levels and resulting lower than average salinities in the north arm. It has been suggested that, at some lake levels, a differential in brine concentrations is beneficial in that when the south arm is too dilute to support a healthy brine shrimp population, the north arm may be able to. At historically high lake levels, that appears to be the case. At the present, however, the salinity difference between the north and south arms is too high to make that argument.

With the salinity differential, salinities in the south arm could diminish to the point where the brine shrimp population becomes stressed and is reduced, while salinities in the north arm

continue at concentrations high enough to prevent the establishment of a viable brine shrimp population. This circumstance will result in a minimal shrimp population in the lake with potentially disastrous impacts on bird populations and commercial harvesting of brine shrimp. Research on both the hydrology of the lake and the role of salinity in brine shrimp and other aquatic populations is continuing. One fact which is now evident is that the north arm of the lake is not productive for brine shrimp because salt levels there are toxic to brine shrimp.

♦ LAKE WATER QUALITY IMPACTS TO WILDLIFE

A discussion of Great Salt Lake water quality issues, studies and initiatives appears in the Water-Quality element of this Statement. Little is known about the impacts of water contaminants on Great Salt Lake wildlife. The Division of Wildlife Resources' Great Salt Lake Ecosystem Project is examining the roles of water contaminants in both the aquatic and avian food chains of the lake. A research project sponsored by the U.S. Fish and Wildlife Service is expected to provide information focusing on Bear River Bay in the near future. That document will represent the latest understanding of the dynamics of water contaminants, and will likely help chart the future of water quality research on Great Salt Lake.

♦ LANDS DESIGNATED FOR WILDLIFE MANAGEMENT

Section 23-21-5 of the Utah Code provides;

> "The Wildlife Board is authorized to use any and all unsurveyed state-owned lands below the 1855 meander line of the Great Salt Lake within the following townships for the creation, operation, maintenance and management of wildlife management areas, fishing waters and other recreational activities..."

The Code identifies all or part of 39 townships lying within the meander line of the lake. Some of the area within the identified townships has been formally placed within wildlife management areas by action of the Board of Wildlife Resources, but much has not. The management status and responsibility for the lands identified as available for wildlife management by statute is unclear for those which have not yet been evaluated and acted upon by the Utah Wildlife Board.

LAND

INTRODUCTION

The State of Utah owns and manages the bed of the Great Salt Lake pursuant to the Equal Footing doctrine discussed in the Introduction to this Statement of Current Conditions and Trends. The boundary line is the "meander line", a courses and distances surveyed line established by court order. The meander line follows no particular topographic contour or

elevation, but is generally located between 4,202 and 4,212 foot above sea level in most places around the lake. These lands are referred to as "sovereign lands" in this Plan element. Sovereign lands also include the unsurveyed islands in Great Salt Lake; Dolphin, Badger, Egg and White Rock Islands. Hat and Gunnison Islands are owned by the Division of Wildlife Resources. Stansbury, Fremont, Carrington and Cub Islands are federally and privately owned.

In addition to the sovereign lands owned by the State, agencies of the Department of Natural Resources have acquired lands in and around Great Salt Lake including Antelope Island (Division of Parks and Recreation), wetlands and uplands associated with wildlife management areas, and formerly private lands needed for the West Desert Pumping Project operation, all of which are managed for specific purposes.

The management of sovereign lands is the responsibility of the Division of Forestry, Fire and State Lands. One of the challenges in managing sovereign lands is that the biological and physical systems of the Great Salt Lake do not observe property boundaries, and management decisions on sovereign lands affect, and are affected by, uses and activities on adjoining lands.

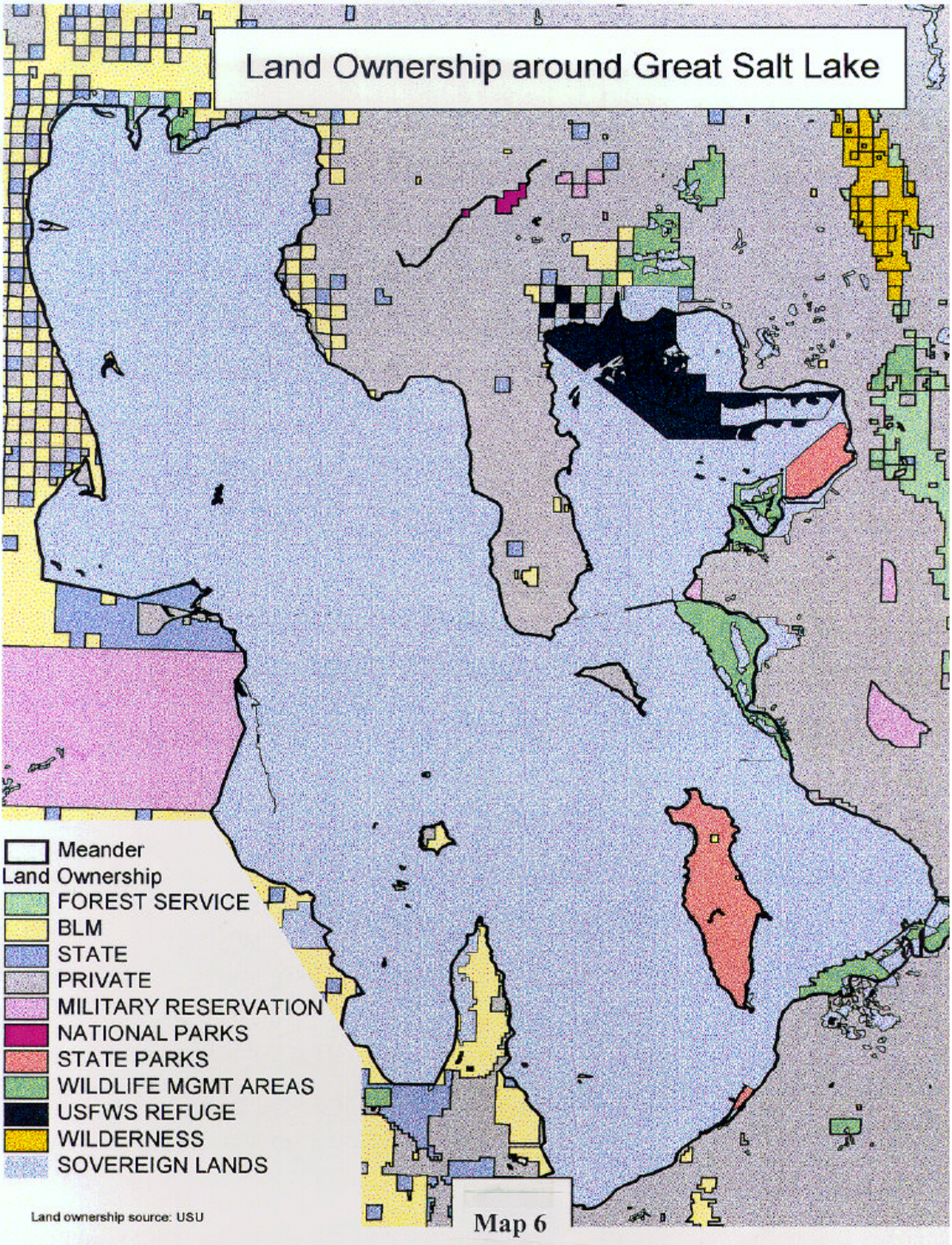
LAND USES ADJACENT TO GREAT SALT LAKE

Land use around Great Salt Lake consists of a mix of residential, commercial, agricultural, recreational and industrial uses common to population centers (See Map 6). The east side of the lake has the higher concentration and diversity of land uses. Population growth in Weber, Davis and Salt Lake counties is resulting in the conversion of agricultural land to residential and commercial uses. Associated with this changing land use is a shift in water use from agriculture to municipal and industrial uses, with a resulting reduction in sub-irrigation ground water and return flows to lands adjacent to the lake. As development moves lakeward, the uplands no longer provide a buffer to the lake wetlands, and diminishing irrigation return flows affect the wetland ecosystem.[6] In addition, runoff from urban lands introduces water contaminants different from those of agricultural lands.

A number of landowners adjacent to the lake are managing their holdings primarily for habitat protection. Approximately 150,000 acres of adjacent lands are within state and federal wildlife management areas. In addition, approximately 10,000 acres of wetland and upland parcels are owned and managed by groups like the Nature Conservancy and the National Audubon Society for habitat preservation. Private hunting clubs own and manage over 50,000 additional acres on the east side of the lake, primarily adjacent to Bear River Bay and south of Farmington Bay.

Elsewhere around the east side of the lake agricultural uses predominate. Grazing and crop production from dry and irrigated acreage are the most common land uses around the north

[6] Davis County Wetlands Conservation Plan, December 1996, p.4.


Land Ownership around Great Salt Lake
Meander
Land Ownership
FOREST SERVICE
BLM
STATE
PRIVATE
MILITARY RESERVATION
NATIONAL PARKS
STATE PARKS
WILDLIFE MGMT AREAS
USFWS REFUGE
WILDERNESS
SOVEREIGN LANDS
Land ownership source: USU

Map 6

and west sides of the lake. The notable exceptions are the mineral evaporation ponds of Bear River and Clyman Bays and the south shore, and the bombing and gunnery range which lies on the western shore of the lake.

COUNTY ZONING ADJACENT TO GREAT SALT LAKE

Box Elder County

Box Elder County covers approximately 800 square miles of the Great Salt Lake, the largest area and the longest shoreline of the five counties adjoining the lake. Several abandoned industrial ventures abut the lake, but brine shrimping is the only current lakeshore commercial activity. Only a portion of the lake shoreline is zoned. The area from Kelton to the southern County line is zoned M-160, multiple uses with 160 acre minimum lot size. The balance of the shoreline is not zoned.

Davis County

Zoning along the Great Salt Lake shoreline in Davis County is controlled by three governmental entities; Davis County, Kaysville City and Centerville City. Most of the county-controlled land adjacent to the lake is zoned A-5 for "Agriculture and Farm Industry" with a five acre minimum lot size. The A-5 zone is intended to promote and preserve agricultural uses and to maintain greenbelt open spaces. Primary uses include single family dwellings, farm industry and agriculture. Several conditional uses are stables and dog kennels. Kaysville City abuts the lake for only a few hundred feet, and is also zoned A-5 with similar uses.

Davis County, and others, sponsored the development of the Davis County Wetlands Conservation Plan, published in December, 1996, as a non-regulatory, multi-faceted program, "To conserve and enhance the integrity of Great Salt Lake wetland ecosystems in Davis County,..." (Wetlands Conservation Plan, 1996). The purposes of the Plan are to define a Davis County conservation zone adjacent to the lake, "...incorporating provisions for appropriate development, infrastructure needs, resident livelihoods and quality of life, while ensuring perpetuation of these important natural resources;..." While many of the Plan implementation steps remain to be completed, the Conservation Plan establishes a blueprint for land management and use adjacent to Great Salt Lake in Davis County.

Centerville City abuts the eastern shoreline of the lake for about 2 ½ miles immediately to the east of the Farmington Bay Waterfowl Management Area. City zoning in this area is A-1 agricultural, or I-D, industrial development. The A-1 zone allows both standard agricultural activities and single-family dwellings on one-half acre lots. The I-D zone allows for a wide array of industrial and commercial uses.

Salt Lake County

The shoreline of Great Salt Lake in Salt Lake County is generally unpopulated, and is zoned A-20, an agricultural zone with a 20 acre minimum lot size, or CV, a commercial visitor zone. The A-20 zone provides for standard agricultural uses, but also allows solar evaporation ponds. It typically acts as a large-acre holding zone until a specific use is proposed, which can result in re-zoning for the use proposed. The C-V zone allows for commercial uses to accommodate the needs of visitors and travelers.

Tooele County

The shoreline of Great Salt Lake is not specifically zoned in Tooele County, with land uses reviewed and approved on a case-by-case basis as conditional uses. Current uses include agricultural operations, brine mineral extraction and brine shrimping operations.

Weber County

Fifteen miles of Great Salt Lake shoreline are within Weber County, and is zoned S-1, farming and recreation. Lands around Little Mountain are zoned M-3, manufacturing. The M-3 zone allows for the manufacture and testing of jet and missile engines, aircraft and spacecraft parts and similar heavy industry, and for the extraction and processing of brine minerals. Bordering the S-1 and M-3 zones on the east are agricultural zones A-1, A-2 and A-3.

LAND USES ON SOVEREIGN LANDS

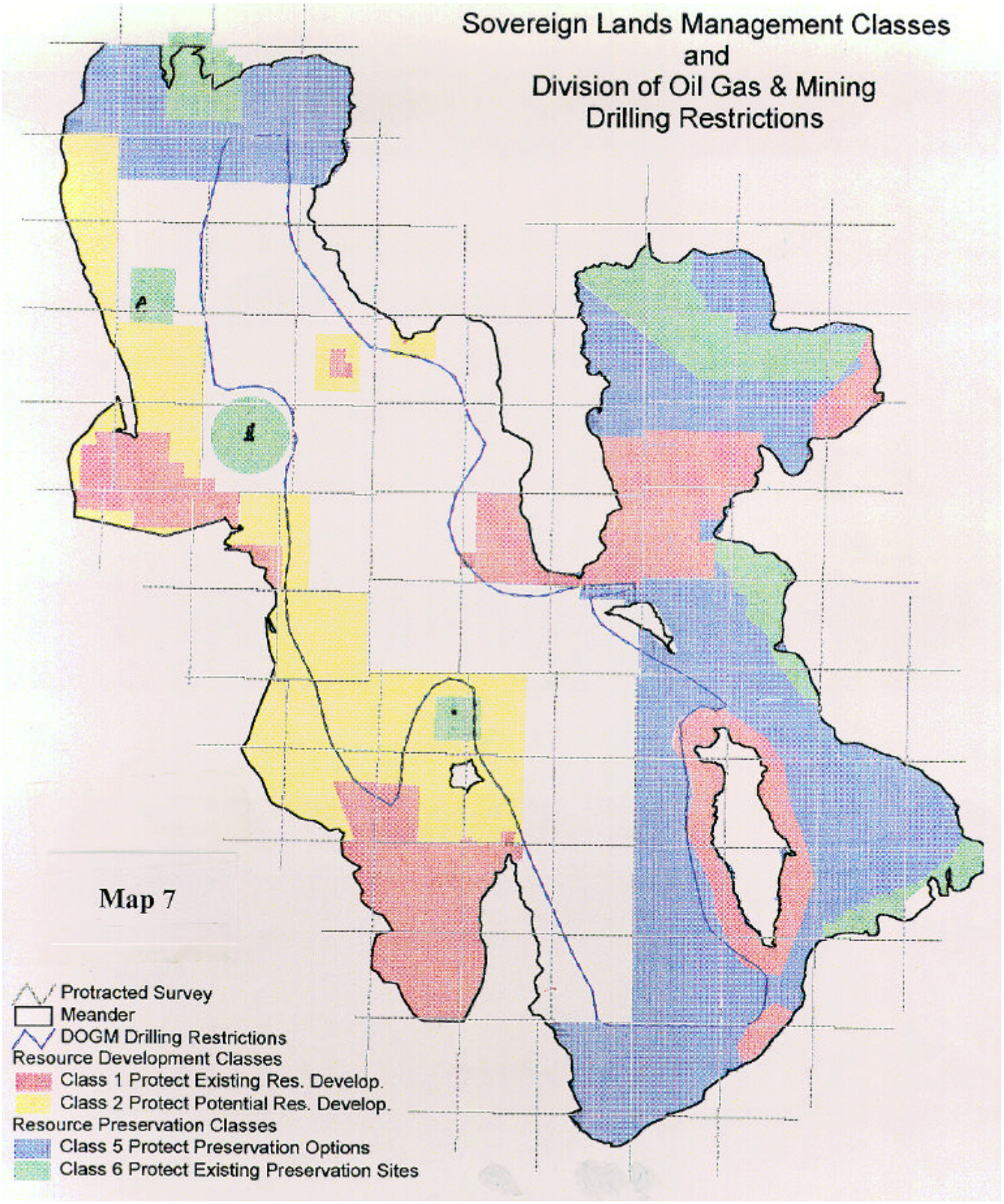
The framework for sovereign land management is found in the Utah Constitution (Article XX), State statute (primarily Chapter 65A-10), and administrative rule (R652). Commercial uses are allowed on sovereign lands only by permit. The permitting processes of the Division of Forestry, Fire and State Lands provide for application, review and public comment on proposed sovereign land uses, and provide an appeals process for aggrieved applicants and commentors.

Division rule allows for classification of sovereign lands based upon current and planned uses. R652-70-200. Classification of Sovereign Lands. [7] Class descriptions and examples of applicable uses around the Great Salt Lake are (See Map 7):

> **Class 1: Manage to protect existing resource development uses.** The Utah State Park Marinas and evaporative mineral developments are areas where the current development use is emphasized.

[7] Rules Governing The Management of State Lands and Forestry and Fire Control Activities In Utah, 2nd Edition, July 1997.

Sovereign Lands Management Classes and Division of Oil Gas & Mining Drilling Restrictions



Map 7

Protracted Survey
Meander
DOGM Drilling Restrictions

Resource Development Classes
Class 1 Protect Existing Res. Develop.
Class 2 Protect Potential Res. Develop.

Resource Preservation Classes
Class 5 Protect Preservation Options
Class 6 Protect Existing Preservation Sites

Class 2: Manage to protect potential resource development options. Examples would include areas adjacent to Class 1 areas which have the potential to be developed.

Class 3: Manage as open for consideration of any use. This might include areas which do not currently show development potential, but which are not now, or in the foreseeable future, needed for protection or preservation of resources.

Class 4: Manage for resource inventory and analysis. This is a temporary classification which allows the Division to gather the necessary resource information to make a responsible future classification decision.

Class 5: Manage to protect potential resource preservation options. Areas of important wildlife habitat would fall into this class.

Class 6: Manage to protect existing resource preservation uses. Areas which have been designated for resource protection, such as wildlife management areas, fall into this class.

The legislature has authorized the Division of Wildlife Resources to use sovereign land in all or parts of 39 townships on Great Salt Lake for the creation, operation, maintenance and management of wildlife management areas, fishing waters and other recreational activities. This geographic area covers Bear River Bay, Ogden Bay, Farmington Bay, portions of the south shore area, and the north end of Spring Bay. This statutory authorization is interpreted as establishing wildlife management and wildlife-related recreation as the primary intended land use, except for areas identified for other uses through a planning process. Land uses with significant adverse impacts on wildlife and recreation values may be prohibited, even though mitigation strategies are available.

GEOLOGIC HAZARDS

Tectonic Subsidence

In the event of an earthquake within the Salt Lake Valley, the potential exists for the valley floor to drop relative to the adjacent Wasatch Range. Such movement would likely occur along the multi-segmented Wasatch fault zone, which generally follows the mountain-valley floor downward toward the east. Keaton (1986) suggests that displacement could be approximately five feet at the fault line. The zero-subsidence line would be about 10 to 12 miles west of the fault. A drop and tilt of the valley floor of this magnitude would cause (a) waters of Great Salt Lake to move east, and (b) a rise in the water table in low areas near the fault. These effects could vary depending on the surface elevation of the lake at the time and the amount of displacement along the fault.

Earthquakes could also cause movement along the numerous north-south faults within and adjacent to the lake. Such movement could cause damage to highways, railroads, dikes and other existing or proposed structures in and around the lake.

Liquefaction and Ground Failure in Sensitive Clays

Lowe (1990) states that "ground shaking tends to increase the pressure in the pore water between silt grains, which decreases the stresses between the grains. The loss of intergranular stress can cause the strength of some soils to decrease nearly to zero. When this happens, the soil behaves like a liquid, and therefore is said to have liquefied." Four types of ground failure can occur during liquefaction: loss of bearing strength, ground oscillation, lateral-spread landslides, and flow landslides. The type and severity of the failure depends greatly on the surface slope. Under some conditions, clays can become unstable by leaching salts. These are referred to as sensitive clays. During earthquakes they can lose their strength, resulting in ground failures similar to those occurring during liquefaction.

Anderson and others (1982, 1986 and 1990) and Lowe (1990a and 1990b) suggest that large areas within Salt Lake, Davis and Weber Counties east of the lake have a moderate to high potential for liquefaction during earthquakes. Areas adjacent to the lake containing sensitive clays also occur there. In flooding related to local and distant earthquakes, liquefaction and wind tides, ect., Atwood and Mabey (1990) point out the following: "Engineered structures (such as dikes and causeway embankments) founded on the lake-bed, particularly those designed to provide protection from the lake water, pose special engineering-geology problems." These problems include prevention of settling, rupture, and erosion. (rotation?)

Shallow Ground Water

Ground water is, by definition, water beneath the surface of the ground which fills fractures and pore spaces in rocks and the voids between grains in unconsolidated sediments. Shallow ground water occurs at depths less than 30 feet. Lowe (1990a and 1990b) suggests that ground water adjacent to the lake, at depths less than ten feet, may cause flooding of basements and other related problems. In the vicinity of Great Salt Lake, the water table, or the top of the saturated ground, fluctuates in response to the level of the lake. During times of high-lake levels, the water table is higher than during times of low-lake levels, and larger areas around the lake will be affected.

The 1995 Comprehensive Management Plan Planning Process and Matrix (the 1995 Plan) recommended that site-specific studies be conducted, prior to development of proposed structures in and near the lake, to identify sensitive clays, soils susceptible to liquefaction, areas susceptible to earthquake-induced flooding, and shallow ground water. In addition, the plan recommended that advice should be provided to applicable county planning, zoning, and permitting agencies of liquefaction and sensitive-clay hazards, detailed technical information on

such hazard areas and the appropriate mitigation measures. Utah Geological Survey also suggests that general hazard maps be made available to city and county planning, zoning and permitting agencies to identify where site-specific studies are needed. Where such maps are not available, studies addressing all these potential hazards should be required for any development between the lake and the 4217 foot contour. These studies should be reviewed for adequacy by the local government or their consultants (UGS performs such reviews), and steps must be taken by local government to ensure that recommended mitigation measure are implemented.

Wind Tides and Seiches

Sustained winds blowing across the surface of Great Salt Lake push the water to one end of the lake or the other where it "piles up", forming what is known as a wind tide. The height or magnitude of the tide depends on the speed, direction, and duration of the wind. Wind tides exceeding two feet are not uncommon, and can cause localized increased flooding and damage while they are in effect. The combined effects of wind tides and high waves can produce adverse impacts to elevations five to seven feet above the static lake elevation. As these winds cease or diminish, the water begins to oscillate back and forth in the lake, similar to water sloshing from end to end in the bathtub. This movement is referred to as a seiche. The period of the oscillation, or the time it takes to move from high to low and back to high, is about six hours (Lin, 1976). Earthquakes also have the potential of causing large-scale seiches in the lake. During such seiches, the elevated water may cause repeated, short-term flooding around the lake. The heights of earthquake-induced seiches are unknown, but may well exceed the heights of wind seiches.

Wind-blown Ice

During the cold winter months, fresh water from the major tributaries to the lake flows out and over the heavier saline water of the south arm. If this water is not mixed, it freezes and can form large sheets of ice. As the winds blow, these sheets of ice are pushed around the lake and can destroy stationary objects within the lake and at its margins.

The 1995 Plan recommended that all five counties on the lake should establish ordinances requiring that all structures built in and around the lake be designed for additional short-term lake elevations due to wind-tides (and subsequent seiches), earthquake-induced seiches, and waves. Wind-tides can raise the lake an additional two to four feet. Structures should be built to withstand ice flows in the southern part of the lake.

CURRENT CONDITIONS AND TRENDS IN LAND USE ON GREAT SALT LAKE

The internal and external scoping conducted by the Planning Team identified two main areas of interest and concern with regard to the management of Sovereign and other State-owned lands on and around Great Salt Lake, existing uses and classifications, and boundary uncertainties and disputes. A listing of the existing leases and permits on sovereign lands is

attached here as Appendix B.

- **Existing use classifications and application procedures for permitting and construction on sovereign lands.**

- **Resolution of sovereign land boundary uncertainties and disputes.**

♦ EXISTING USE CLASSIFICATIONS AND PERMITTING PROCEDURES

Recommended Land Classifications

The most current statement of use classifications for the sovereign and other state lands of the Great Salt Lake appears in the 1995 Great Salt Lake Comprehensive Management Plan - Planning Process and Matrix. The 1995 Plan recommended application of the use classifications set forth in R652-70-200 to areas of the Great Salt Lake as follows (See Map 6):

Class 1, managed to protect existing resource development.

Lands under this classification include the area around Antelope Island delegated to the Division of Parks and Recreation for recreation management, the area around Saltair and Great Salt Lake Marina, existing mineral extraction lease areas, and areas under special use lease for brine shrimp cyst harvest activities. These lands would be open to oil and gas leasing, but no surface occupancy will be allowed in the recreation areas.

Class 2, managed to protect potential resource development options.

This area includes the Rozel oil field and shoreline areas from the north end of Stansbury Island south along the west side of the island and then north along the west side of the lake to the south line of Township 11 North, SLB&M. This area will be open to mineral leasing, developed recreation and other kinds of developments.

Class 5, managed to protect potential resource preservation options.

This classification includes lands which the legislature has authorized the DWR to use for wildlife purposes under Section 23-21-5, and a 1 mile buffer zone around islands in the north arm of the lake. No surface occupancy for oil and gas exploration will be allowed in established wildlife management areas or in the island buffer zones. Elsewhere, oil and gas surface occupancy constraints shall be determined in consultation with the DWR. Mitigation strategies for developments not related to wildlife management in these areas shall also be determined in consultation with the DWR.

Class 6, managed to protect existing resource preservation uses.

This classification covers existing wildlife management areas. Lands will be available for oil and gas leasing with no surface occupancy.

Class 3, managed as open for consideration of any use.

The remainder of the lake is recommended to be placed in Class 3.[8]

Permitting and Classification Processes

Land use authorizations issued by the Division of Forestry, Fire and State Lands include materials permits (usually sand and gravel), mineral leases, special use leases (classified as commercial, industrial, agricultural or recreational) easements, rights of entry, grazing permits, general permits and exchanges. Permits, leases and other authorizations are issued following two general procedures. The first is over-the-counter transactions which are largely administerial in nature. Grazing, rights-of-entry and burning permits are examples. Other actions like easements, special use leases and exchanges trigger a site-specific planning process and the preparation of a record of decision.

In site-specific planning, the Division provides notice that the process is under way to affected parties, usually adjoining landowners and lessees and permittees of record for the affected land, and to the Office of Planning and Budget for inclusion in the RDCC agenda packet and the weekly status report. In some cases notice in newspapers of general circulation in the local county is required. The Division relies upon the RDCC process as the primary method through which the public is apprised of proposed actions and given the opportunity to provide comments to the Division.

The Division is required to respond to all commenting parties and give the rationale for acceptance or nonacceptance of the comments. Records of decision are subject to a 20-day review period. Within 20 days of any Division action any party aggrieved by the action may petition the executive director of the Department of Natural Resources to review the action for consistency with statutes, rules and policy.

♦ SOVEREIGN LANDS BOUNDARIES

Uncertainties and Disputes

The meander line which is the legal boundary between sovereign lands and adjacent lands

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[8] Great Salt Lake Comprehensive Management Plan Planning Process and Matrix, September 1995.

was established by a series of surveys over a period of years, and does not follow a topographical contour line around Great Salt Lake. A number of the original survey markers and monuments have been obliterated, and the exact location of the sovereign/private boundary is uncertain in many areas. Specific areas of uncertainty and/or dispute include (See Map 2 to Appendix A for locations):

-Bear River Duck Club (E1). Ownership questions below meander need to be resolved.
-Chesapeake Duck Club (E2). Ownership questions below meander need to be resolved.
-Canadian Goose Club (E3). Ownership questions below meander need to be resolved.
-Lands below the meander line in the proposed expansion of Bear River Migratory Bird Refuge.
-Lands below the meander line between Willard Bay and Bear River Migratory Bird Refuge.

Boundary Resolution Strategies

Section 65A-10-3 requires the Division to consult with the attorney general and affected state agencies to develop plans for the resolution of disputes over the location of sovereign land boundaries. With respect to the areas identified above, the Division has not yet prepared such a plan, but anticipates doing so in 1999.

MINERALS AND HYDROCARBONS

INTRODUCTION

The State of Utah owns the minerals located in the bed and waters of the Great Salt Lake as public trust resources. The responsibility to manage the minerals of the lake, and of all sovereign state lands, has been assigned to the Division of Forestry, Fire and State Lands by statute. The Division has specific management responsibilities for minerals of the Great Salt Lake pursuant to Section 65A-10-18 of the Utah Code.

Although the Great Salt Lake is renowned for its “salt”, its waters actually contain a variety of “salts” and ions. The Great Salt Lake contains salt from a variety of sources. Rain and snow in the mountains leached saline materials from soils and rocks and carried it in solution to streams that eventually flow into the lake (Miller, 1949). The Great Salt Lake may be as salty as it is because much of the salt was originally in the waters of Lake Bonneville and was concentrated as those waters evaporated (Trimmer, 1998). In addition, some believe that the lake’s salts were leached from deposits of oceanic salt of Jurassic age which crop out extensively in Sanpete Valley within the Great Salt Lake Drainage Basin (Eardley, 1938). Due to the terminal nature of the Great Salt Lake, all salt carried to it remains in the lake. Water entering the Great Salt Lake escapes by evaporation only. It is thought that the Great Salt Lake contains 4.9 billion tons of salt in its system (Trimmer, 1998). That system includes precipitated salts on

the lake bed, the West Pond and elsewhere, as well as the salts in solution in lake water.

Less well know are the hydrocarbon and oolitic sand resources of the lake. Naturally oozing tars have been collected from areas near Rozel Point, probably since pre-settlement times. An extensive offshore oil exploration program was conducted on the lake in the 1970's, ultimately without much success. The hydrocarbons are present, in large quantities, but have not yet been shown to be commercially producible. Oolites, which are sands with almost spherical grains, have several limited, specialized uses and have been collected commercially on an intermittent basis.

Mineral Industry Overview

Salt extraction is one of Utah's oldest industries and salt has been harvested from the waters of the Great Salt Lake for over 100 years (Miller, 1949). In addition, magnesium metal and potassium salts are harvested through extraction processes. These newer industries began in the 1970s. Currently, all major ions contained in the lake water are extracted by solar evaporation in large pond systems (Trimmer, 1998).

There are currently 6 companies extracting minerals from the waters of Great Salt Lake. These include IMC Kalium Ogden Corp., Magnesium Corporation of America (MagCorp), Cargill Salt, Morton Salt, IMC Salt and North Shore Limited (See Maps 3 and 5). In 1997, existing aggregate data from the Utah Division of Water Rights indicates that in excess of 31 billion gallons of water was pumped from the Great Salt Lake by mineral harvesting companies (Hudon, 1998). Sodium chloride (NaCl, or table salt) is the first salt to be precipitated out as lake brines are concentrated, and it is either sold or is a waste product, depending on the focus of each company (Trimmer, 1998 and U.S.Bureau of Mines, 1996).

MagCorp produces magnesium metal at its electrolytic plant in Tooele County from lake water. Chlorine gas is also produced. The plant has a capacity to produce 41,000 tons of magnesium metal at 99.9% purity annually and is the fourth largest magnesium plant in the world as of 1996. MagCorp sells some potassium and magnesium salts to IMC Kalium Ogden Corp.

Morton and Cargill produce only sodium chloride and return bitterns, the concentrated brine that remains after sodium chloride has crystallized, to the lake. IMC Salt is the largest salt producer on the lake and buys salt from IMC Kalium Ogden Corp. IMC produces magnesium and potassium salts, primarily sulfate of potash (K_2SO_4) rather than muriate of potash (KCl). Sulfate of potash is a higher value product than KCl. IMC Kalium Ogden Corp. produces minerals such as kainite, schoenite and carnallite in its solar ponds which are then processed to remove magnesium, chloride and sodium ions, leaving potassium sulfate. Also, under certain conditions, potassium chloride is added directly to the process where it undergoes a base conversion into potassium sulfate. A significant portion of the sulfate of potash is exported to other countries. This company retains and sells the magnesium chloride brine, but flushes excess

sodium chloride and some of the low-grade magnesium and potassium salts back into the lake. Sodium chloride build-up on evaporation pond floors is a problem for both IMC Kalium Ogden Corp. and MagCorp, although IMC is able to return some waste salts to the lake (Trimmer, 1998 and Gwynn, 1998).

North Shore Limited produces magnesium chloride brines through solar evaporation. This product is sold for nutritional supplements (Trimmer, 1998).

Company	**Production**
IMC Kalium Ogden Corp.	Magnesium and Potassium Salts ($MgCl_2$, K_2SO_4)
Magnesium Corporation of America	Magnesium Metal (Mg), Chlorine Gas (Cl)
Cargill Salt	Salt (NaCl)
Morton Salt	Salt (NaCl)
IMC Salt	Salt (NaCl)
North Shore Limited	Magnesium Brines ($MgCl_2$)

(Trimmer, 1998 and Gwynn, 1998)

Production Trends

The salt industry is characterized by high tonnage volumes at relatively low unit values and a product which is harvested far from markets. These products face intense competition within the industry both nationally and internationally (Great Salt Lake Technical Team and Utah Division of Sovereign Lands and Forestry, 1995). Potassium sulfate is produced at a relatively high volume with higher value per ton, while magnesium metal is produced at a relatively low volume with a high value per ton (Trimmer, 1998). The estimated average price per metric ton of K_2O in 1997 is $140 (Searls, 1998). The estimate average price per metric ton of magnesium metal in 1997 is $2,700 (Kramer, 1998a).

Harvesting is also vulnerable to weather conditions. Both low and high lake levels create problems for the mineral extraction industries. When lake levels are low, intake canals to pumps must be dredged and the pumps may need to be repositioned into deeper water. High lake levels, as experienced in the mid-1980s, are much more critical to the salt industries than low levels, due to the dilution of feed brines. The economic impact of increased erosion of dikes, dike failure and rebuilding or reinforcing of dikes at high lake levels can also cost millions of dollars.

As the lake level rises and falls, the strength of the brine falls and rises. This inverse relationship is a result of a relatively fixed amount of dissolved solids within the lake coupled with a fluctuating amount of water. When inflow exceeds evaporation, the lake level rises and the extra water dilutes the lake brine. Dilute brine conditions require larger pond areas for a given tonnage of salt. With a low lake level, brine strength is higher and therefore pumping and pond area requirements are lower for a given tonnage of salt, therefore producing a greater yield. This inverse relationship is particularly applicable to the south arm of the lake (Great Salt Lake Technical Team and Utah Division of Sovereign Lands and Forestry, 1995).

Salt and brine-derived products are the largest contributors to the value of industrial minerals in Utah. The production of salt and brine-derived products is expected to continue to expand over the next several years (U.S. Bureau of Mines, 1996). For instance, IMC Kalium Ogden Corp., the largest potassium sulfate producer in North America, plans to double current production (Warnick, 1998).

Value of Production

Because there are only six companies on the lake which harvest minerals, and only five mineral commodities are harvested, data on extraction must be presented in aggregate form. Therefore instead of reporting a unit value of the product, this section emphasizes the overall value of production of the minerals harvested. Although the dollar amounts of value of production of minerals extracted is held in confidence by the Division of Forestry, Fire and State Lands, general trends can be noted.

Overall, the value of production of potassium and magnesium salts has increased more than 12-fold since production began in 1973. The value of production of magnesium metal has increased 31-fold since production began in 1974, and the value of production of salt has increased 17-fold since 1970. These increases have not been steady however, as the value of production in all three categories declined periodically, particularly from 1986 to 1989 due to years of flooding. In total, minerals extraction from the Great Salt Lake amounted to a value of production of $231,611,752 in 1997 (See Figure 6) (Trimmer, 1998).

Solar salt produced from Great Salt Lake represents a significant and increasing share of total domestic solar salt production. The remainder of solar salt produced in the U.S. is primarily from California with some production from New Mexico. Solar salt competes in regional markets with rock salt for chemical and industrial, water conditioning and agricultural uses. Nationwide, the consumption of rock salt is four times that of solar salt. However, USGS data show that these markets are regional and, with respect to road salt, local. Solar salt dominates in western markets and appears to be increasing in certain Midwestern markets for certain end uses. The Division of Forestry, Fire and State Lands believes that the growth of regional solar salt markets, in which Utah producers compete, could continue to grow at 3% per year over the next 5 years. This amounts to approximately 50,000 tons per year (Trimmer, 1996).

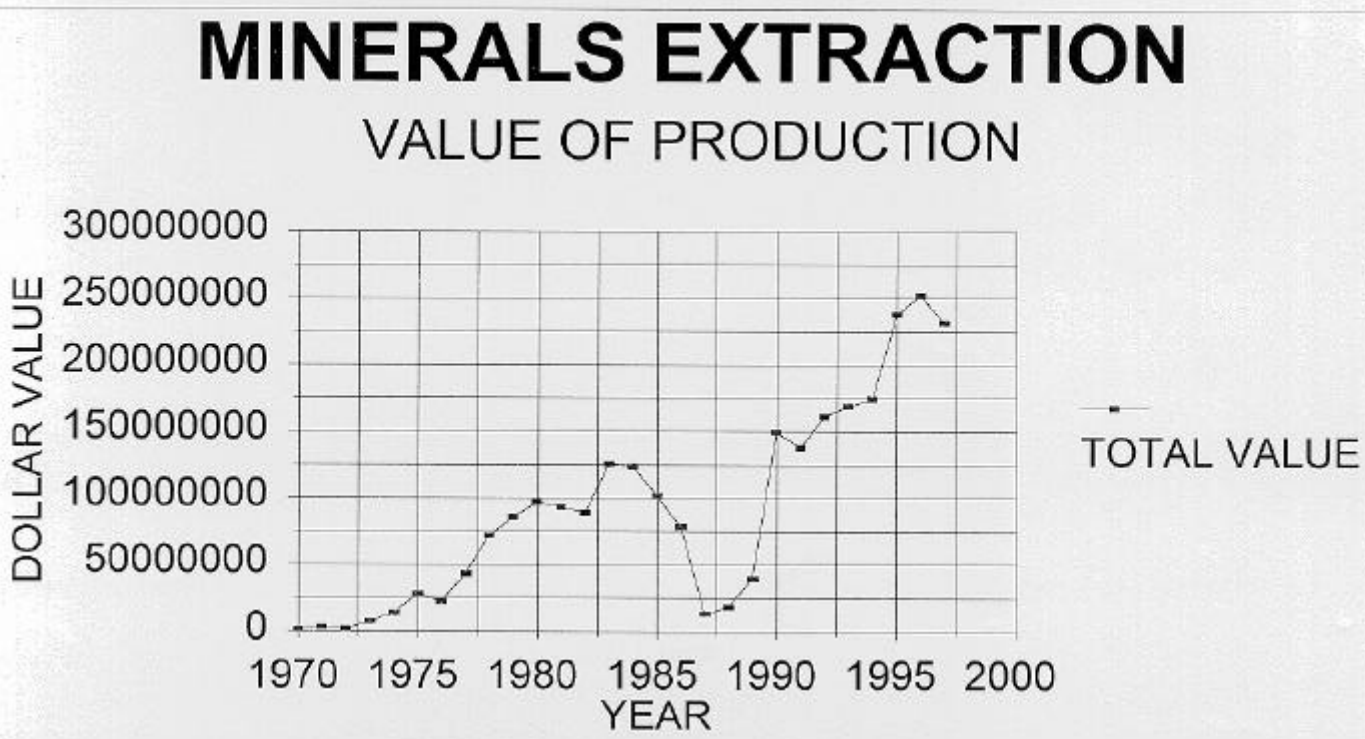


Figure 6 Minerals Extraction-Value of Production
Source Utah Division of Forestry, Fire & State Lands

Production of magnesium metal in the United States declined by 6% in 1996 from 1995. World magnesium oversupply and high prices were primarily responsible. For the first time in 20 years, the U.S. imported more magnesium than it exported. However, the U.S. continued to lead the world in production and production capacity of primary magnesium (Kramer, 1998a). Utah magnesium production remained steady in 1996 while prices declined, primarily due to increased foreign competition (U.S. Bureau of Mines, 1996). Magnesium metal is used for aluminum alloying, diecasting, and automotive applications. However, demand for magnesium used in aluminum alloying dropped in 1996 and several U.S. auto manufacturers canceled some programs to incorporate more magnesium diecastings into domestic passenger vehicles due to rapidly changing magnesium costs (Kramer, 1998a).

The outlook for global use of magnesium diecastings in automotive applications is expected to continue to grow at 15% to 20% average annual growth rate. North America and Europe are expected to be the areas with largest growth. Although magnesium prices declined in 1996 through June 1997, they began to increase slowly from mid-year. Price fluctuations were not as widely varied as in recent history. From 1993 to 1995, prices fluctuated from $2,260 to $4,138 per metric ton (Kramer, 1998a). U.S. production of magnesium compounds increased in 1996. Magnesium chloride was used mainly as a chemical intermediate. Magnesium chloride brines were used principally for road dust and ice control. $MgCl_2$ was used in agricultural, chemical, construction, environmental and industrial applications. Year-end magnesium compound prices in 1996 did not change from those at year-end 1995 (Kramer, 1998b).

The term potash denotes a variety of mined and manufactured salts, all containing the element potassium in water soluble form. The general term potash also includes potassium sulfate (K_2SO_4), which is produced in Utah (Searls, 1998 and Trimmer, 1998). Domestic potash production comes from New Mexico, Utah and California. Because it is a source of soluble potassium, potash is used primarily as an agricultural fertilizer. U.S. potash sales were approximately 88% to the fertilizer industry and approximately 12% to the chemical industry. Production of all types and grades of potash in the U.S. declined in 1996. Sales of all types and grades of U.S.-produced potash were unchanged from 1995 to 1996. Potash consumption was only slightly above the 1995 level in 1996 (Searls, 1998).

Royalties on State Minerals

Prior to February 1997, Cargill and Morton paid a $0.10 per ton royalty to the Division of Forestry, Fire and State Lands on salt extraction, while IMC's predecessor paid an ad valorem royalty of approximately 2% of the value of the salt. Currently, Cargill and Morton pay a $0.10 per ton royalty to the Division of Forestry, Fire and State Lands, with an additional amount paid into an escrow account which is controlled by the companies. The Division of Forestry, Fire and State Lands, which administers mineral leasing on the Great Salt Lake, is attempting to adjust the royalty rate to $0.50 per ton over the next 5-8 years. Implementation of this increased royalty rate is pending litigation (Trimmer, 1998).

IMC Kalium Ogden Corp. pays an ad valorem royalty rate of 1.5% to 5%, increasing over time, on magnesium chloride and potassium sulfate. MagCorp pays a royalty rate of 0.1259% to 0.41967%, increasing over time, on sales of magnesium metal and chlorine gas. In 1986, these companies were allowed to roll-back the royalty rate to year one due to flood damage. The royalty rate has continued to advance from this base rate since that time. North Shore Limited pays a royalty of 5% on the value of the brine with a $5,000 minimum royalty (Trimmer, 1998).

All of the above-listed royalties are put into the restricted Sovereign Lands Management Account. This money must be appropriated by the Legislature for any use. To date, these funds have been used for the Division of Forestry, Fire and State Lands' operating costs associated with sovereign lands management and various sovereign lands projects such as the cooperative causeway salinity study with U.S. Geological Survey and work related to Utah Lake, the Jordan River Corridor, Bear Lake and the Colorado River (Baker, 1998 and Kappe, 1998).

Royalty Revenues

Royalties paid to the state amounted to $1,056,367 in 1997. The percent of total value of production paid as royalties declined from 1970 to 1997 with the exception of the period from 1986-1987. Currently, approximately 0.61% of total production value is paid in royalties. For those companies that pay a fixed rate on salt harvesting, the percent of total value paid as royalties primarily declined during this time because the selling price increased (Trimmer, 1998).

CURRENT CONDITIONS AND TRENDS IN MINERALS MANAGEMENT

The internal and external scoping conducted by the Planning Team focused on two main topics:

- **The Forestry, Fire and State Lands Mineral Leasing Plan.**
- **The lack of accounting for salts and brines sequestered by mineral operators.** (The accounting matter is discussed in the Water-Chemistry element of this Statement)

♦ MINERAL LEASING PLAN

On June, 27, 1996, the Division of Forestry, Fire and State Lands published its Mineral Leasing Plan - Great Salt Lake. Development of a mineral leasing plan was one of the key recommendations of the 1995 Great Salt Lake Comprehensive Management Plan. The Goals section of the Mineral Leasing Plan recites:

> "The purpose of the mineral leasing plan for the Great Salt Lake is to guide DSLF [now the Division of Forestry, Fire and State Lands] in accomplishing the following goals:

Integrate minerals resource planning with other resource planning
- To create a framework for long-term policy direction for minerals management which also has flexibility to respond to the dynamic character of Great Salt Lake;
- To integrate management of Great Salt Lake's mineral resources with the lake's other resources so that all resources are managed for the health and integrity of Great Salt Lake ecosystem;
- To identify compatible uses and conflicts among mineral resource development and other resources on Great Salt Lake and to provide for resolution of conflicts;
- To monitor impacts of minerals operations and to collect, analyze and use data to maintain health and integrity of the ecosystem, including its mineral resources;
- To monitor impacts of all diversion, dredging, causeway and diking operations and to collect, analyze and use data to maintain health and integrity of the ecosystem, including its mineral resources;

Plan for leasing and efficient development of mineral resources
- To inventory and monitor Great Salt Lake's mineral resources;
- To assure wise and diligent development of mineral resources within Great Salt Lake's boundaries;
- To provide for the orderly leasing of mineral resources to existing and potential mineral lessees;
- To receive fair compensation for development and extraction of Great Salt Lake's various mineral resources;

Assert the role of DSLF as a manager of state-owned lands
- To clearly define sovereign lands for resource users, the public and other resource management agencies."

The Mineral Leasing Plan identifies and evaluates the mineral resources of Great Salt Lake, impacts of diking and causeways, evaporative pond impacts and constraints, issues and conflicts, and the relationships of mineral operations to the other trust resources present on Great Salt Lake. The Plan identifies areas of potential resource conflicts and addresses them by establishing leasing "zones" in the lake and creating mitigation strategies. The Plan is the result of a multi-interest, public process over many months, and is viewed by the Division of Forestry, Fire and State Lands as the minerals element of what will become the Great Salt Lake Management Plan.

At this time, neither the Division of Forestry, Fire and State Lands nor the Department of Natural Resources is aware of specific concerns with the Mineral Leasing Plan, but all aspects of the Plan are open for comment, suggestion and criticism as part of the current planning effort.

RECREATION, TOURISM AND CULTURAL RESOURCES

Perceptions of Great Salt Lake vary among local residents. Some residents find that the lake offers great beauty and quality recreation, and that the lake significantly enhances the quality of their lives. Others view the lake negatively and find little value in Great Salt Lake. Out-of-state tourists often view Great Salt Lake as one of the most well-known of Utah's natural resources, and aspire to visit the lake while visiting northern Utah. The tourism industry and local residents alike desire greater access to Great Salt Lake. While greater access is desired, studies to date suggest that the public wishes access to be provided in a manner that does not impair the resources of the lake (Antelope Island Resource Management Plan).

The demand for recreational uses of Great Salt Lake's resources is expected to grow in the future. The lake's extraordinary numbers of water birds, magnificent sunsets and vistas, no-sink swimming, the trails-wildlife- historic resources and development of Antelope Island, and open space next to a growing metropolitan area all point to growing interest in visiting and recreating at Great Salt Lake.

Based on internal and external scoping, the Planning Team identified a number of matters of interest and concern with regard to management of Great Salt Lake's recreation resources, including:

- **Capacities and uses of existing recreational sites, marinas and other facilities.**
- **Management of Antelope Island State Park.**
- **Cultural resource protection.**
- **Resource education and interpretation.**
- **Recreational boat navigation through existing causeways.**
- **Hunting, birdwatching and wildlife management area access and opportunities.**
- **Camping, hiking, biking, trail, automobile touring, and picnicking opportunities.**
- **A centralized south shore visitors/activities area.**
- **Hunting and Park use conflicts.**
- **Recreational OHV use on sovereign lands.**

Although a large number of specific recreation related concerns and issues were raised during internal and external scoping, the general themes of the concerns related to the numbers

and types of recreational opportunities available on Great Salt Lake, user conflicts, the environmental impacts of recreational uses, and educational and interpretive opportunities. Rather than devote discrete sections to discussion of each issue, this Statement provides a description of the kinds, locations and uses of recreational facilities and opportunities on Great Salt Lake, existing interpretive and educational opportunities and programs, and cultural resource protection and interpretation.

RECREATION SITES AND OPPORTUNITIES ON GREAT SALT LAKE

Antelope Island (Utah State Parks)

The largest island in Great Salt Lake is Utah's largest state park. Reopened in July 1993, Antelope Island's annual visitation (currently at 300,000) has grown steadily, and the island has been identified by the Utah Travel Council as one of Utah's fastest growing tourist attractions. The Division of Forestry, Fire & State Lands has signed a Memorandum of Understanding with State Parks to allow Antelope Island State Park to manage sovereign lands surrounding the island as a buffer zone.

Antelope Island has been called the best place to see and experience Great Salt Lake, given the island's sandy beaches, lofty overlooks and amenities. Antelope Island has a unique array of wildlife - abundant large mammals juxtaposed to concentrations of water birds of hemispheric importance. Ungulate species on Antelope Island include the third largest publicly owned bison herd in the nation, pronghorn, big horn sheep and mule deer. The island's east shore is dominated by fresh water seeps and wetlands and is connected to the mainland marshes by playas off the south end of the island. This array of wildlife, accompanied by easy access provides outstanding wildlife viewing opportunities.

Antelope Island has important cultural sites, most significant of which is the Garr Ranch. The Garr Ranch contains some of the oldest anglo-constructed buildings in Utah and was the home ranch of some of Utah's largest ranching operations from 1848-1981. The site's interpretive focus is on the length of occupation and the evolution of large scale western ranching from pre-mechanization to mechanization. Recreational opportunities and development includes, scenic drives with bicycle lanes, a back country trail system, campgrounds and picnic areas, interpretive information and programs, a swimming beach and a marina. Three private concession businesses are located on the island; food and souvenirs, a tour boat with a dining area and guided horseback rides.

Significant educational opportunities are available on Antelope Island. Utah State Parks, in partnership with Davis County, developed a 5200 square foot Visitor Center overlooking the lake. Interpretive exhibits and programs center on the resources of Great Salt Lake and the island. The Garr Ranch, scheduled to open on a daily basis in Spring of 1999 will be another important interpretive venue. Opportunities for self-directed interpretation are available with nature trails, wayside exhibits and publications. An outdoor amphitheater, located at the Visitor

Center, is under construction and will enhance the park's ability to provide personal programs. The park provides educational talks to thousands of school children per year. The park's proximity to universities and significance of resources allows for a number of outside research projects each year.

Challenging issues confront Antelope Island State Park. Foremost is to provide greater access while still protecting the park's resources. Park staff have identified critical habitat which is inappropriate for access and development. Managing the back country trail system is a particular challenge and management has instituted a program of area and time of use limitations. The park has an independent, outside Wildlife Committee to advise management on resource based issues. The park is initiating a social carrying capacity study in an attempt to quantify and safeguard the quality of visitor experience. Other significant issues facing the park is the potential development of a southern road access to the island, separation of waterfowl hunters from traditional park visitors, overflights from aircraft and increasing visitation and use.

Davis County Causeway (Davis County)

In return for maintaining the causeway from Syracuse to Antelope Island, the State of Utah deeded the roadway to Davis County. Davis County now manages the causeway in cooperation with Utah State Parks. The Davis County causeway is one of the most scenic drives around Great Salt Lake, and is an outstanding birding area. The bike lanes provide one of the most popular cycling tours in northern Utah and, when combined with the new east side road on Antelope Island, offer a 36 mile round trip. Davis County has developed a trail head parking lot for cyclists and another area with interpretive information regarding Great Salt Lake.

The number one issue facing the causeway is maintaining the roadway at high lake levels. The causeway was constructed at elevation 4208.75. The causeway is essentially a toll road, and $2.00 per vehicle collected by Antelope Island State Park is returned to Davis County. Davis County utilizes these funds to maintain the causeway. There has also been some concern that the causeway restricts water flow from Farmington Bay to the south arm of the lake and inhibits brine exchange between the Bay and the main body of the lake, with a resulting freshening of Farmington Bay relative to the rest of the lake. This issue is discussed more completely in the Hydrology section.

Bear River Migratory Bird Refuge (U.S. Fish & Wildlife Service)

At 74,000 acres, the Bear River Migratory Bird Refuge is considered one of the premier birding sites in the nation. Given the Refuge's beautiful scenic background, isolated nature, and sheer abundance of water birds, its complex of fresh water impoundments has long attracted birders from around the country and is one of the best places to experience the fresh water marshes of Great Salt Lake. The Refuge is recognized internationally and was integral to Great Salt Lake's designation as a Western Hemispheric Shorebird Reserve. The Refuge is also one of the finest waterfowl hunting areas in Utah. Currently the Refuge is visited by 36,000 people

annually, with 11,660 being waterfowl hunters. In addition, annual visitation includes 21,000 auto tour route visits, 1,155 fishermen, and 2,185 others. (Ann Bull, Bear River Migratory Bird Refuge)

The Refuge was damaged extensively during the 1980s flooding, and has been rebuilding ever since. Currently the refuge offers a 12 mile scenic drive that is popular for birding and bicycling, interpretive information, an air boat ramp that is open during hunting season, and expanded access during hunting season. Fishing is allowed in the Bear River channel. The U.S. Fish & Wildlife Service is developing plans for a Visitor Center to be constructed near Brigham City. This Visitor Center will dramatically expand interpretation of Great Salt Lake's concentration of water birds. The Visitor Center is scheduled for completion by 2002. Currently the Refuge offers educational tours by reservation. Management is working on a plan that will allow expanded fishing access, foot trails and a short canoe trip.

Given the U.S. Fish & Wildlife Service's dual mandate of protecting migrating birds and providing opportunities for hunting, the Refuge follows a management mandate practiced throughout the agency. That is, 60% of the refuge is closed throughout the year, 20% is open throughout the year and an additional 20% is opened only during hunting season.

Issues facing Bear River Migratory Bird Refuge include; safeguarding a dependable fresh water flow throughout the year, balancing hunting with birding, and protection from industrial encroachment along the southern boundary and utilizing sovereign lands for refuge expansion.

Great Salt Lake Marina (Utah State Parks)

The Great Salt Lake Marina is the most popular launching and mooring site on the lake. The marina is a highly developed, attractive and safe mooring site for approximately 300 sail boats. Given the marina's proximity to Salt Lake City and level of development the marina is generally filled to capacity. The marina also provides access to the lake for boaters who do not moor their vessels at the site. The tour boat based at Antelope Island also offers tours departing from the Great Salt Lake Marina on occasion. The park staff offers educational talks by reservation. Visitation to Great Salt Lake Marina in 1997 is estimated at 461,000.

Saltair/South Shore (Utah Forestry, Fire & State Lands)

This recreational complex consists of south shore beach areas and the Saltair Resort. This site offers access to the lake and has an attractive visual impact, with its open expanse, islands and beautiful sunsets. Birding opportunities are also significant. Saltair Resort provides interpretive information, food and souvenirs, is an historic site, and offers special events ranging from concerts to beach fests. This site provides the quickest and easiest access to the lake from downtown Salt Lake City. This site was formerly managed (along with the marina) by Utah State Parks as Great Salt Lake State Park, but management was returned to Utah Forestry, Fire & State Lands in 1997. At that time over 600,000 people visited Great Salt Lake State Park.

There are a number of challenges inherent to the site; fluctuating water levels, odors and proximity to the Kennecott Copper Smelter.

Farmington Bay Waterfowl Management Area (Utah Division of Wildlife Resources)

This 17,916 acre management area is one of the most popular waterfowl hunting areas in Utah and also is an outstanding birding area. Farmington Bay Waterfowl Management Area is unique in that it provides important wetland habitat and wildlife based recreation so close to an urban area. The management area is also one of the best places to observe the fresh water interface with Great Salt Lake. The Division of Wildlife Resources manages their Waterfowl Management Areas to provide habitat for water dependent birds.

Currently the Farmington Bay WMA receives 48,644 visitors annually. Of this, 20,644 is from waterfowl hunters and the rest is from birding or other recreationists. Staff has identified March 1 through August 1 as a critical wildlife production period. During the critical production period a 1.5 mile road is open, with an overlook and interpretive signing and an additional 2.5 miles is open non-motorized use. During the non-critical production period another 26 miles of dikes are open for non-motorized use. An air boat ramp is open from two weeks prior to hunting season through the hunting season. Division of Wildlife Resources is pursuing funding for enhanced visitor use development, possibly including a Visitor Center on the north end of the management area to enhance lakewide interpretive and education efforts.

A number of critical issues confront the Farmington Bay WMA. These include potential impacts from the proposed Legacy Highway, maintaining adequate water and water quality from the Jordan River, flooding from Great Salt Lake, and urban development on the boundary of the management area.

Ogden Bay Waterfowl Management Area/Howard Slough (Utah Division of Wildlife Resources)

The Ogden Bay Waterfowl Management Area is over 21,000 acres in size and is the largest state WMA in Utah. The Ogden Bay WMA has documented some of the highest densities of nesting waterfowl in the United States. The Ogden Bay WMA makes significant contributions to recreation on Great Salt Lake . During the production period (March 1 thru August 1) 15 miles of dikes are open to non-motorized use. During the non-production period 45 miles of dikes are open to non-motorized use. The WMA has an air boat ramp open during the hunting season. Ogden Bay WMA has approximately 70,000 annual visitors, of which 28,000 are waterfowl hunters.

Ogden Bay WMA critical issues have to do with water control. The WMA is vulnerable to flooding, both from the Weber River and Great Salt Lake. The Ogden Bay WMA is one of the oldest WMAs in Utah and has high priority water rights.

Stansbury Island (Bureau of Land Management/Private)

Only a small area on the south end of Stansbury Island is opened to the public and readily accessible. Development consists of an access road and a nine mile trail open for non-motorized use. Stansbury Island is comprised of some of the most striking rock formations surrounding Great Salt Lake. The island's vistas of lake, mountain ranges and islands are dramatic. Currently the south end of Stansbury Island is utilized for dispersed recreation including the non-motorized trail, camping, some off-highway vehicle (OHV) use and chukar hunting.

There has been a great deal of local interest in securing greater public access to Stansbury Island, for both motorized and non-motorized recreation. Given the island's size, location and resources, greater public access would significantly expand recreational opportunities surrounding Great Salt Lake. The legality of the west side road closure is uncertain. The Bureau of Land Management has been striving to secure greater public access to Stansbury Island. The greatest challenge will be to secure greater public access from private land owners and then appropriately manage that visitation if made accessible.

Locomotive Springs (Utah Division of Wildlife Resources)

Locomotive Springs Waterfowl Management Area is an isolated wetland at the north end of Great Salt Lake. This 17,317 acre Wildlife Management Area is an oasis for wildlife in the middle of the West Desert. Currently, the staff is able to flood approximately 1,200 acres and the rest of the area is comprised of playas and upland habitat. Locomotive springs provides year around fishing and primitive camping. Public access is limited to three miles of roads. During hunting season the entire Waterfowl Management Area is accessible. Locomotive Springs receives approximately 6,000 visitors a year, of which 5,000 are hunters and fisherman. Future plans include expanding the Waterfowl Management Area by 2,600 acres to include protection of playas which are Snowy plover habitat.

The most critical issue facing Locomotive Springs is maintaining water flow. The aquifer which feeds the springs is over-allocated, and since the early 1970's the spring flow has declined by 83%. The decreasing water flow has diminished wetlands by 5,000 acres in the Waterfowl Management Area. Because of decreased head pressure from the aquifer, potential salt water intrusion is another concern facing this WMA.

Timpie Springs (Utah Division of Wildlife Resources)

Timpie Springs Waterfowl Management Area is a 1,440 wetland located near the southwest corner of the lake. Timpie Springs WMA contains two water impoundments, 3.5 miles of dikes, a half mile road and parking lot and some information signs. Timpie Springs has around 400 annual visitors of which, approximately 300 are waterfowl hunters.

Monument Point (BLM/Utah Forestry, Fire & State Lands)

This area currently offers the only OHV riding in proximity to Great Salt Lake. The Monument Point area offers pedestrian access to the north arm of the lake, a stunning vista of the lake at it's remotest reaches and is nearby interesting historic sites. The BLM has worked towards developing trail opportunities in this area and has added interpretive information. The BLM is concerned with OHV access to the wetlands of Salt Well Flat and have identified this as an Area of Critical Environmental Concern. The key challenge is managing a growing level of dispersed recreation in a remote area. Another challenge is that a large portion of OHV use occurs on private land. The BLM is also concerned with OHV use in the wetlands between Locomotive Springs and Crocodile Mountain. The BLM is interested in securing a land trade that would allow the agency to develop a recreation area.

Rozel Point (Utah Forestry, Fire & State Lands)

Rozel Point is the site of the spiral jetty. This earth sculpture has national recognition. Rozel Point is also one of the only access points to the North Arm of the lake. Access is through the Golden Spike National Historic Site and visitors can obtain a map at the Visitor Center. There are no facilities at Rozel Point and the site has suffered from unauthorized dumping and construction which detracts from the beauty of the location. Utah Forestry, Fire & State Lands is working to restore the site. The spiral jetty is only visible at low lake elevations.

Layton Wetlands Preserve (The Nature Conservancy)

The Layton Wetlands Preserve protects approximately 2000 acres of shoreline and upland habitat. One of the goals of the Preserve is to protect upland habitat to buffer State Sovereign Lands below the Preserve. Nature Conservancy staff strive to facilitate research and can provide educational tours by appointment. There is year-around, non-motorized access to the Preserve at the Gailey Access in Layton. The Nature Conservancy is working with the Utah Reclamation Mitigation and Conservation Commission to develop education programs and interpretive signs at the Preserve. As part of their planning process, The Nature Conservancy hopes to provide greater recreational access, but stipulates that their primary mission at the Preserve is to protect wetlands. The Preserve plan will continue to guarantee hunting access.

Critical issues facing the Preserve include potential impacts from the Legacy Highway, the development of agricultural lands to for residential housing, and maintaining water quality and flow to the Preserve.

Inland Sea Shorebird Reserve (Kennecott Utah Copper)

This 4,500 acre reserve was developed by the Kennecott Utah Copper Corporation to mitigate for the tailings modernization and expansion project. The Reserve features a relatively large contiguous acreage to provide nesting and resting habitat for migratory shorebirds and

waterfowl. The Reserve utilizes brackish water with mudflats and marshes to maximize invertebrate populations as food sources for birds.

Currently there is no public access to the Reserve, though staff provides educational tours by appointment. Once mitigation has proven successful and the Army Corps of Engineers accepts the mitigation results (scheduled for 2002), Kennecott could potentially open the Reserve for greater public access. The most significant issue to the Inland Sea Shorebird Reserve would be encroachment from a potential southern road access to Antelope Island.

Gillmor Wildlife Sanctuary (National Audubon Society)

This 1425 acre sanctuary was donated to the National Audubon Society to preserve the natural ecosystem of Great Salt Lake. The Audubon Society places value on all components, both biotic and abiotic, of the ecosystem. The Sanctuary is comprised of a variety of habitats, from open water to playas and upland areas. The Sanctuary is situated on the former Jordan River delta, which is considered to be the best preserved river delta on Great Salt Lake.

The Audubon Society is working with the Utah Reclamation Mitigation and Conservation Commission to develop a hydrological engineering plan to restore water to the natural waterways of the Jordan River delta. The plan will encompass the South Shore Wetland Ecological Reserve, which is comprised of the Gillmor Wildlife Sanctuary and parcels of land owned by several other private land owners. Currently, public access is not available to the Sanctuary as it is surrounded by private land. The National Audubon Society is working on a management plan that will address the public access issue. The most significant issue facing the Gillmor Wildlife Sanctuary is a potential southern road access to Antelope Island.

Promontory Point (Various Private Land Owners)

Promontory Point offers a striking vista and is the only location that could provide access to both the South and North arms of Great Salt Lake. The site is currently accessible via a public road, but the surrounding lands are almost exclusively in private ownership. There has been interest in acquiring greater public access to this interesting and dramatic location. Multiple private land owners surrounding this site will make any expansion of public access difficult.

Willard Bay State Park (Utah Division of Parks and Recreation)

The Willard Bay Reservoir is a U.S. Bureau of Reclamation project which provides water for irrigation, M&I use, generation of electric power, flood control, recreation, fish and wildlife purposes. The dike that separates Willard Bay from Great Salt Lake is 36 feet high and 14.5 miles long. When the reservoir is full, it exceeds the elevation of Great Salt Lake. When reservoir water levels are low, the old meander line of the shore of the lake is exposed on the south and southeast side of the reservoir. The Utah Division of Parks and Recreations manages

the recreation resources and facilities, and the Division of Wildlife Resources manages the fish and wildlife.

Visitation to Willard Bay State Park in 1997 was 276,059. This level of use is causing some user conflicts and degradation of the Park facilities. In September of 1997, the first phase of a Bureau of Reclamation-sponsored Resource Management Plan (RMP) was completed. The RMP effort is to identify management goals and objectives for the reservoir. Some important issues which have emerged include improving coordination with other entities, resolving user conflicts, and expanding educational and interpretive opportunities. Water quality, management of concession services, visitor needs for additional recreational facilities to reduce congestion, improved safety and resource protection are other issues to be addressed in the RMP.

RECREATIONAL ACTIVITIES ON GREAT SALT LAKE

Most of the recreation that occurs on Great Salt Lake is dispersed in nature and visitor counts are not well quantified.

Boating

There are two public boat ramps open year-around on the South arm; Great Salt Lake Marina and Antelope Island. Both of these marinas offer safe mooring sites and are developed. These marinas are utilized almost exclusively by sail boats. Great Salt Lake Marina sponsors a large number of sailing races and festivals in conjunction with the Great Salt Lake Yacht Club. Motor boating is feasible but not popular. The salinity demands extra care and rinsing of engines and equipment. Navigation in the lake demands a high level of expertise, there is no fishing, and water skiing is not popular. These factors have prevented Great Salt Lake from becoming very popular for motor boating. Approximately 300 sail boats are moored at the Great Salt Lake Marina and an additional 25 at the Antelope Island Marina.

Farmington Bay Waterfowl Management Area has the only public boat ramp in Farmington Bay. This ramp is suitable for air boats and small vessels only. The ramp is open from two weeks prior to hunting season through hunting season. Ogden Bay Waterfowl Management Area, Bear River Migratory Bird Refuge and Willard Spur all have boat ramps suitable for small vessels and air boats. The north arm does not have a public boat ramp.

Non-Motorized Recreation

Antelope Island State Park has an extensive back country trail system (20 miles) that will be expanding significantly in the coming years. Currently, nearly 10,000 people a year utilize the Antelope Island back country trail system. Stansbury Island has a nine mile trail. The Division of Wildlife Resources waterfowl management areas have extensive dike systems open for cycling. Bear River Migratory Bird Refuge has a twelve mile graveled auto tour open for

cycling. The Davis County causeway is seven miles long with bike lanes in both directions.

Camping

The developed campgrounds of Antelope Island are used by approximately 25,000 campers per year. There is dispersed camping on BLM lands on Stansbury Island and in the area of Monument Point. Locomotive Springs allows camping.

Off - Highway Vehicles

The only OHV use permitted in the vicinity of Great Salt Lake is the Monument Point area. Sovereign lands surrounding Great Salt Lake are not open to recreational use by OHVs. Through participation on the West Box Elder Access Management Team, the Division of Forestry, Fire and State Lands is considering opening limited sovereign lands in the vicinity of Kelton to OHV use.

Birdwatching

Great Salt Lake is one the most renowned birding areas in the United States. Nearly all the recreation areas identified above have outstanding opportunities for birding.

Hunting

Great Salt Lake is the most important waterfowl hunting area in Utah. It is estimated that 63% of Utah's total waterfowl hunting occurs at Great Salt Lake, with 80-85% of all waterfowl harvested in Utah coming from the Great Salt Lake area. The State Waterfowl Management Areas and the Bear River Migratory Bird Refuge were purchased and are maintained by revenues and taxes from hunting. The State Waterfowl Management Areas, Bear River Migratory Bird Refuge and the Sovereign Lands are open for hunting. The estimated number of waterfowl hunters utilizing the Great Salt Lake and environs in 1996 was 22,700. The estimated number of hunter days on state-managed areas around the lake in 1996 was 53,700.
(Tom Aldrich, Utah Division of Wildlife Resources)

Sightseeing (auto tours)

Antelope Island State Park and the Davis County causeway combined offer a 42 mile round trip auto tour. The Bear River Migratory Bird Refuge has a twelve mile auto tour. The Monument Point area and surrounding lands have many miles of remote dirt roads for auto touring. The lack of a public thoroughfare between Lakeside and Hogup Ridge on the lake's western shore precludes circumnavigation of the lake by automobile.

INTERPRETIVE AND EDUCATIONAL OPPORTUNITIES AT GREAT SALT LAKE

Interpretive and educational programs have been significantly enhanced in recent years. Antelope Island has developed a Visitor Center on Lady Finger Point. The Garr Ranch is scheduled to open in 1999. The park has added wayside exhibits, nature trails and educational tours. The Salt Lake Convention and Visitors Bureau is opening a Visitor Center focusing on Great Salt Lake. The Visitor Center will be located at the 7200 west exit on I-80. The Bureau plans to add an observation deck and nature trails in the ensuing years.

The Bear River Migratory Bird Refuge breaks ground on a new visitor center in 1999. Completion is scheduled for 2002. Farmington Bay Waterfowl Management Area is initiating an effort to significantly expand interpretive development and visitor services for their North end. The Utah Reclamation Mitigation and Conservation Commission (URMCC) completed a Needs Assessment and Conceptual Plan for Interpretive Recreation and Education for the Greater Great Salt Lake Wetlands Ecosystem. One of the Commission's key objectives of the plan is to: "Create an umbrella concept under which all local projects play a role; the entire scheme should be a non-repetitive delivery of messages, each site carrying appropriate messages for that site and complementing efforts at other sites, thereby encouraging people to visit another location." The URMCC is working closely with private land management organizations to provide interpretive programming.

Layton Wetland Preserve is working on a plan to implement an interpretive program at the preserve. Most of the Great Salt Lake attractions offer educational tours by reservations or appointment. Friends of Great Salt Lake has a hour long interpretive slide show, called The Lake Affect, Living on the Shores of Something Great, and outreach programs designed to educate people to the resources and issues confronting the lake.

The 1996 Mineral Leasing Plan for Great Salt Lake specifies the Division of Forestry, Fire and State Lands will work with mineral lessees to provide interpretive displays of mineral development sites with particular emphasis on contributions to Utah's economy and recognizing effective mitigation efforts on the lake.

CULTURAL RESOURCES ON GREAT SALT LAKE

Similar to the watershed flowing into Great Salt Lake, human activity in the region has been drawn to the lake shore. Prehistoric cultures centered their activity around the lake for thousands of years. Hundreds of prehistoric cultural sites have been documented and researched in lake wetlands. Several of the oldest documented cultural sites in the mainland United States are in the lake environment, Danger and Hogup Caves.

Anglo activity has also been drawn to the lake. Jim Bridger is credited with the Anglo discovery of the lake. The lake was the focus of early mountain man expeditions, government

expeditions and wagon trains crossed closed to the shore, sometimes with ill-fated results. With the arrival of the Mormon pioneers, resorts and other economic enterprises sprang up along the lake shore.

Cultural resources of Great Salt Lake have been the subject of much research and writing, primarily by agencies and institutions external to DNR. State agencies are responsible to consult with the Division of State History prior to the initiation of any project which may disturb cultural resources.

Prehistoric Resources

Use of Great Salt Lake wetlands started with Archaic cultures as long as 10,000 years before present. Archaic cultures primarily utilized sites immediately adjacent to wetlands. The majority of human interactions with the lake is recorded in the camp sites of the Fremont Culture which flourished in the Great Salt Lake valley from 500 - 2000 years before present. Fremont remains are found connected to nearly every wetland around the lake. Subsequent cultures, the late prehistoric and historical tribes also made extensive use of Great Salt Lake wetlands. Primarily, native cultures made seasonal use of wetlands for hunting and gathering. To a greater extent, the Fremont Culture made permanent use of wetland sites, including farming. Today, there are nearly 400,000 acres of wetlands on Great Salt Lake, many of which have yielded prehistoric artifacts. Several hundred Native American archaeological sites have been identified in Great Salt Lake wetlands.

Well known sites such as Danger Cave and Hogup Cave are situated near wetlands of former Lake Bonneville. Cultural deposits along Great Salt Lake have supplied valuable information about prehistoric cultures. Currently, most protection of cultural resources is done through state and federal agencies, to ensure development complies with state and federal law. Cultural deposits in Great Salt Lake wetlands are often difficult to locate. They are usually buried under the surface or obscured by vegetation. Often erosional events, such as wave action associated with high lake levels are required to bring the cultural materials to the surface.

The most immediate threat to prehistoric cultural resources is construction activity adjacent to the east side of the lake, such as the proposed Legacy Highway. The Division of State History is confident that when surveying and construction is undertaken in these areas, numerous Fremont camp sites and human burials will be discovered in affected wetlands. This will necessitate archaeological surveys and compliance with the Native American Graves Protection and Repatriation Act (NAGPRA). If these human remains are treated in the same manner as those which were exposed after the 1980's floods, they will be deposited in the Native American Remains vault at This Is The Place State Park.

Unique prehistoric and historical cultural resources of high significance have been identified on Fremont Island. A number of prehistoric sites, including rock art, have been discovered on Stansbury Island. Antelope Island contains a number of prehistoric sites, and

active cultural surveying will continue into the future. Cultural resource management on state lands along the east shore is conducted on a case-by-case basis as projects are undertaken or discoveries made. Some archeologists think the State should conduct regular monitoring of sensitive areas.

Historical Resources

More recent cultural deposits contain a record of Anglo activities on and around Great Salt Lake. The islands of the lake were the focus of several early survey and exploration parties. Explorers such as Kit Carson, Howard Stansbury, John C. Fremont and others left marks on these islands in the form of camp sites, survey stations and markers, temporary dwellings and graffiti. Others left no physical mark, but their presence has been well documented. An old mountaineer named Daddy Stump is documented as having a small homestead on Antelope Island, perhaps prior to the Mormon arrival in the valley. Today, there are no remains of this homestead. Similarly, around the shores of Great Salt Lake, early settlers left remains of greater or lesser permanence. The Garr Ranch on Antelope Island is a significant site that will be open to the public in 1999. Another significant site on Antelope Island, the George Frary homestead will be open in 2000. The once famous Saltair Resort and the remnants of a handful of other historical resorts are located on sovereign lands.

Many of the cultural resources around Great Salt Lake, both historical and prehistoric, are located on private property. These land owners are under no obligation to protect or conserve the cultural resources on their property. Many of these land owners are unaware that such resources are found on their property, or that these resources have scientific or academic value. Cultural remains which are located on state or federal lands are protected by state and federal law. Any activity which may possibly threaten these resources must be reported to the Division of State History, and consultation for these activities must occur. Often, it is determined the activity will not threaten the resource. In other cases, an archaeological survey must be conducted. These statutes apply to any cultural remains which are older than fifty years.

SOCIOLOGICAL TRENDS

There has never been a study to predict visitation to Great Salt Lake as a whole. A study performed at Antelope Island indicated that population growth is the number one factor driving increased visitation to sites. Population growth within Utah, and particularly on the Wasatch Front, will create a comparable proportional increase in the Utah resident component of visitation to Great Salt Lake recreation sites. The State Office of Planning and Budget estimates population along the Wasatch Front will grow at 2.1% annually in the ensuing years. Therefore, one can predict a base visitation increase of 2.1% annually to Great Salt Lake recreation sites. Any development to the individual recreation sites will further expand visitation.

Out-of-state tourism is very difficult to predict as it is dependent on a number of variables. Several of these variables include level of development, tourism promotion and local

amenities. Utah State Park visitation data indicates 33% of visitation to Antelope Island and the old Great Salt Lake State Park is from out-of state. The Utah Travel Council indicates that traffic through Salt Lake International Airport has grown steadily at an average of 9% per year. State and local tourism agencies and the private tourism industry will continue to promote area attractions. The 2002 Olympic Games may have a significant and lasting influence on tourism to Great Salt Lake. It is safe to project a growing number of out-of-state tourists to Great Salt Lake attractions, particularly to sites of national significance or easy access from the Interstates.

COMMERCIAL, INDUSTRIAL AND AGRICULTURAL USES

The sovereign lands and resources of the Great Salt Lake are utilized for a variety of commercial, industrial and agricultural purposes. The most extensive use, mineral salt extraction from the lake's brines, is discussed separately under the Minerals and Hydrocarbons element of this Statement. The second most extensive in terms of numbers of employees involved and the value of products produced is brine shrimp harvesting, which is discussed here. Other existing uses include recreation-oriented commercial concessions (Saltair and Antelope Island), industrial uses (Thiokol), military uses (the U.S. Air Force), art (the Spiral Jetty), and grazing. Recreation-oriented commercial activity is discussed in the Recreation, Tourism and Cultural Resources element. The lone non-mineral industrial activity is long-standing, and is limited to periodic closure of roads in the area and retrieval of "errant hardware".

The economic significance of commercial and industrial activities which are dependent on sovereign lands and resources is substantial. The direct economic benefits of extractive industries are discussed in the section on Mineral and Hydrocarbons, and brine shrimping is discussed here. Indirect benefits also accrue. It has been estimated that there are 1,325 jobs provided by the minerals extraction, brine shrimp harvesting and recreation industries operating on the lake. Of these, 1,290 are confirmed jobs and 35 are estimated for small firms on which no data is available (Newman, 1998).

Scoping disclosed interest in two broad areas of commercial and industrial activity on sovereign lands of Great Salt Lake:

- **Existing levels and types of commercial and industrial activities on Great Salt Lake.**
- **Policies with regard to future commercial and industrial activities.**

BRINE SHRIMP HARVESTING ON THE GREAT SALT LAKE

Industry Overview

The presence of brine shrimp in the Great Salt Lake is noted as early as 1900 even though at that time, the "popular literature of the day persists in asserting that no living thing exists or

can exist in the dense brine of the Great Salt Lake." (Talmage, 1900) Brine shrimp cysts are harvested from the lake's surface in the fall. The cysts, which are a form of egg, are used by commercial aquaculture operations around the world. Cysts are hatched, and the young brine shrimp are used as feed for fish and shrimp for human consumption. There are currently 32 companies permitted to harvest brine shrimp on the Great Salt Lake (Bath, 1998). It is estimated by Howard Newman of INVE AQUACULTURE, Inc. that over 1,000 year-around jobs are related to brine shrimp harvesting on the Great Salt Lake (Newman, 1998b).

Brine shrimp cysts harvested from the Great Salt Lake provide 90% of the world's supply of cysts used for feeds for aquaculture and ornamental fish. Great Salt Lake cysts are known for their consistency, small nauplii (the young brine shrimp), low contamination and competitive price. The majority of cysts sold (80%) are used in Thailand, China, Indonesia and Ecuador in panaeid shrimp hatcheries. Panaeid shrimp are those cultivated for human consumption. The rest are consumed in shrimp operations in other parts of the world as well as by marine finfish, primarily in Europe, Korea, Japan, China and Taiwan (Newman, 1998b).

The following chart denotes harvesting trends from the 1985-1986 harvest season to the 1997-1998 harvest season. The harvest numbers are as reported by the harvest companies to the Utah Division of Wildlife Resources (See Figure 7). Note that many variables influence the total number of pounds harvested. These variables include 1) legal harvest season rules; 2) number of harvesters; 3) shrimp populations; 4) market demand; 5) processing, selling and inventory needs; and 6) area of the lake being harvested (Perschon, 1998).

Harvest Year	**# of Companies**	**# of Certificates of Registration (COR)**	**(Total Harvest (lbs.)***
1985-1986	4		298,035
1986-1987	4		1,887,300
1987-1988	4		7,012,775
1988-1989	9		6,806,415
1989-1990	12		10,268,232
1990-1991	11		8,927,818
1991-1992	11	26	13,532,797
1992-1993	12	20	10,172,399
1993-1994	12	18	8,864,092
1994-1995	14	25	6,485,954

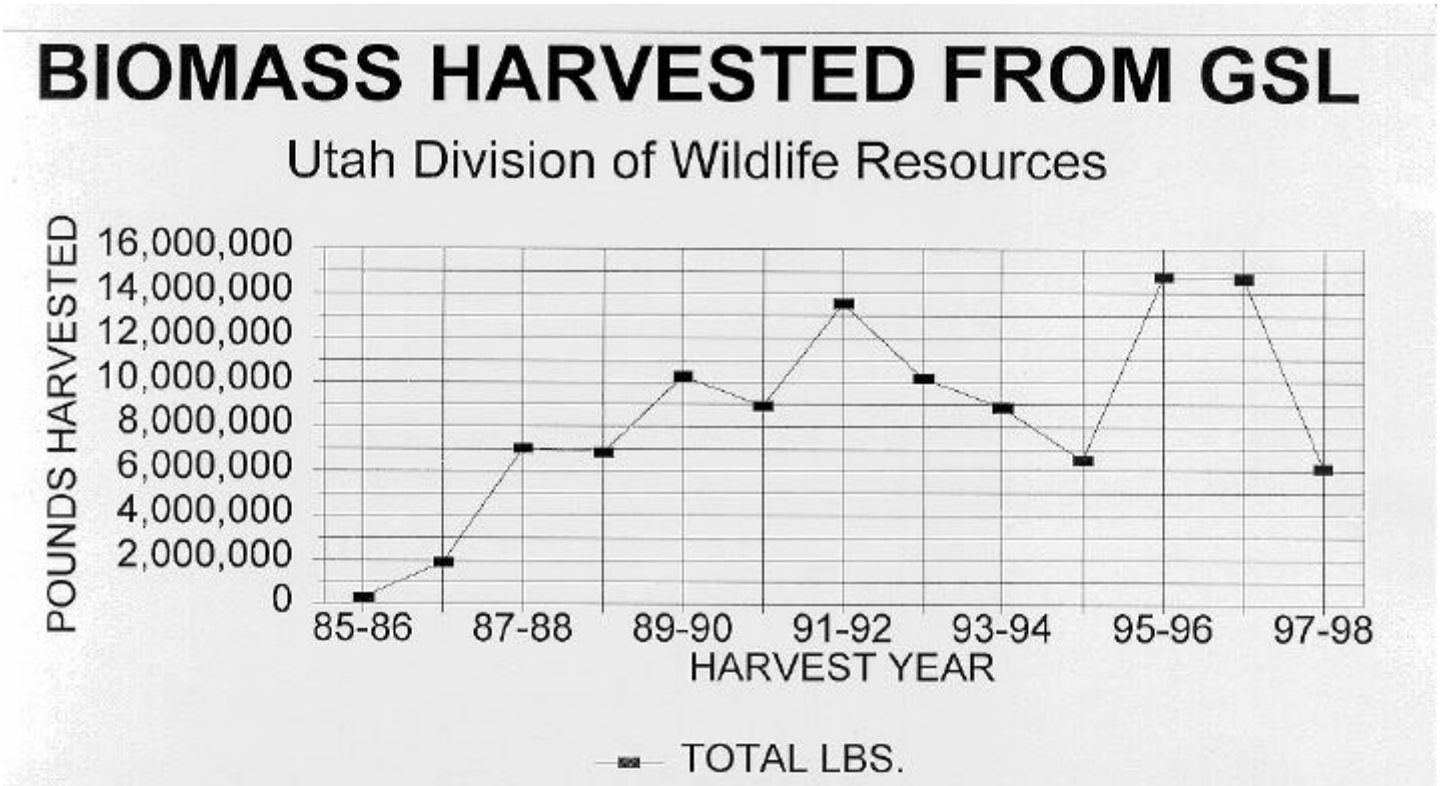


Figure 7 Biomass Harvested From Great Salt Lake
Source Utah Division of Wildlife Resources

1995-1996	21	63	14,749,596
1996-1997	32	79	14,679,498
1997-1998	32	79	6,113,695

*Denotes the total pounds (unprocessed) of biomass harvested that year as reported to the Utah Division of Wildlife Resources. (Biomass includes cysts, cyst shells, shrimp, brine fly pupal chambers, algae, etc., Perschon, 1998).

"If the shrimps could be caught and preserved in quantity, I doubt not they would soon be classed as an epicurean delicacy." (Talmage, 1900) Although this prediction from James E. Talmage in 1900 did not turn out to be true for humans, brine shrimp have become an important food for aquacultured animals. Because brine shrimp cysts are sold primarily as a food source for aquaculture, it is important to note trends in the aquaculture industry as they directly affect the demand for cysts. The global production of fish, crustaceans and molluscs equaled 18.5 million metric tons in 1994, a figure 140% higher than the 1985 total. Asian production is the dominant proportion of global aquaculture production. The total value of all global aquaculture products in 1994 exceeded US $33.5 billion (New, 1997).

As mentioned previously, the majority of brine shrimp cysts are sold to panaeid shrimp hatcheries. Panaeid shrimp can be aquacultured in either freshwater or marine environments (Perschon, 1998). Production of farmed marine shrimp increased by 332% from 1985 to 1994. Although output from freshwater crustacean culture only expanded by a factor of 1.5 from 1985 to 1994, production from freshwater prawn culture expanded by 252% (New, 1997).

Value of Production

A total of 109,798,606 pounds of biomass have been harvested from the Great Salt Lake since 1985. In the 1997-98 harvest season, 6,113,695 pounds of biomass were harvested by 32 companies that hold 79 certificates of registration (CORs). The Division of Wildlife Resources charges a registration fee of $10,000 per COR per year. More than one COR can be held by a company, and COR registration ranges from 1-9 per company (Perschon, 1998).

As part of implementation of the regulations requiring payment of royalties on brine shrimp harvested, the Utah Tax Commission establishes a unit price for unprocessed brine shrimp eggs harvested during the current season to ascertain a royalty value. In the 1997-1998 season, the first year the royalty was imposed, the unit price equaled $0.4453 per pound for raw, wet, unprocessed cysts. The Tax Commission also assumes that 40% of the biomass harvested is debris (dead shrimp, algae, bird feathers, floating wood, etc.) (Bath, 1998). Multiplying the assumed net weight of 3,668,217 lbs. by the unit value of $0.4453 yields a total value of $1,633,457 (in a raw, wet, unprocessed state).

The market value for the processed cysts is substantially higher than the estimated unit value of unprocessed cysts as determined by the Tax Commission. The market value of the cysts varies based on cyst quality (the percentage hatch rate), availability and other factors. It should be noted that processed cysts are a value-added product. The Tax Commission charges the royalty rate only for the resource being used, which it deems to be the unprocessed cyst (Bath, 1998).

It is currently difficult to ascertain the value of the 1997-98 harvest. Since the most recent season ended in October 1997 due to early closure by the Utah Division of Wildlife Resources, most of these cysts have not yet been marketed. Also, some stockpiling exists whereby cysts are carried over from one year to the next. Don Leonard, Utah Artemia Association, estimates that the 1997-98 harvest season sales will amount to $12-20 million Leonard, 1998).

The current value for processed cysts is hard to determine. Prices vary according to season sold, quality, global supply and demand, etc. These variables and others create high price volatility. Estimates from three individuals involved in the brine shrimp industry for the average value per pound of the cysts in 1998 ranged from $7-$25. According to Bob Valentine, Utah Brine Shrimp Industry Council, the current value for processed cysts ranges from $5/lb. for low quality to $35-40/lb. for high quality with $7-8/lb. being average (Valentine, 1998). Don Leonard believes that $12/lb. is the average value for 1998 (Leonard, 1998). According to Bud Insalata, whose company processes cysts from up to 6 companies harvesting off the Great Salt Lake, processed cysts sold for approximately $10-$25/lb. based on a container lot rate (large purchase, wholesale, mid-year prices) in 1998 (Insalata, 1998).

According to representatives of the brine shrimp coalitions, at least 85% of the Great Salt Lake cysts are processed in state (Valentine, 1998 and Leonard, 1998). Some Utah companies import cysts from outside the state for processing in Utah. Approximately half of the companies currently harvesting off the lake also process cysts. The other half sell the product for processing or maintain an interest in the final product value. In the latter case, the buyer gives the seller an up-front payment and then the two agree to an additional payment when the cysts are sold based on a percentage of the final sales revenues (Leonard, 1998).

Royalties

In 1997, the state decided that a royalty should be paid by the brine shrimp harvesters to compensate the state for the use of brine shrimp eggs.

> "It is the policy of the state than when its natural resources are used, a royalty should be paid to compensate the state for the use of the natural resource. The state receives royalties on minerals extracted from the Great Salt Lake. A market has developed for brine shrimp eggs; therefore, the state should be compensated for the use of this natural resource." (Section 59-23-2, Utah Code).

The brine shrimp royalty equals 0.035 of the value of unprocessed brine shrimp eggs (Section 59-23, Utah Code). The Tax Commission annually determines the value of unprocessed brine shrimp eggs. All revenue generated by the brine shrimp royalty is deposited in the Species Protection Account. These funds can then be appropriated by the Legislature for actions to protect any plant or animal species identified as sensitive by the state or as threatened or endangered under the Endangered Species Act of 1973, U.S.C. 16, Sec. 1531 et seq. (Section 63-34-14, Utah Code).

According to brine shrimp harvesters, 40% of the total harvest consists of debris. The remaining 60%, which is referred to by the Tax Commission as "Net Weight," is multiplied by the unit price established by the Tax Commission for unprocessed brine shrimp eggs harvested during the current season to ascertain the royalty value. In the 1997-1998 season, the unit price equaled $0.4453 per pound. The royalty value is then multiplied by the royalty rate, which is equal to 3.5%. Brine shrimp harvesters paid $60,790.81 in royalties for the 1997-1998 season. It should be noted that since the statute regarding the royalty first came into effect in this season, the data reported by the companies regarding gross proceeds reflected only proceeds accrued as of January 31, 1998 (Bath, 1998).

Access and Impacts

Commercial brine shrimping is regulated by the Division of Wildlife Resources and the Wildlife Board to guard against over-harvesting and ensure compliance with operational rules. The shrimping season generally begins on October 1st of each year, and continues until January 31st of the following year by rule. However, the Division may close the season early if it determines that the harvestable surplus of brine shrimp cysts has been collected. A sufficient number of cysts are left unharvested to leave an overwintering supply to ensure a viable brine shrimp population in Great Salt Lake the following spring, and to provide forage for birds. Ongoing research by the Division is focused on developing a better understanding of the life cycles of, and environmental stressors on, brine shrimp.

The conduct of commercial brine shrimping requires both access to navigable harbors on the lake, and area for staging, maintenance and storage of materials. Current access is from both the public marina at Antelope Island and a number of privately constructed and operated harbors around the lake. The policy of the Division of Forestry, Fire and State Lands is that new harbor facilities constructed on sovereign land must be made available to all users. Current plans are to provide access to Great Salt Lake at dispersed strategic locations where water depth is suitable, access is reasonably available and conflicts with other public trust resources are minimized. The South Arm sites determined to satisfy these criteria are Black Rock, Stansbury Island/MagCorp dike, Lakeside, Promontory Point and Antelope Island. The Antelope Island marina will be available for commercial uses until the Division of Parks and Recreation determines commercial use to be in significant conflict with recreational use of the marina, and that adequate alternative access for brine shrimping exists.

AGRICULTURE

The only current agricultural use of sovereign lands is grazing. There exist nine active grazing permits on sovereign lands west of Kaysville and Layton, adjacent the Layton-Kaysville marshes on Farmington Bay. The permits cover 1,584 acres, and are held by landowners adjacent to sovereign lands who utilize sovereign land in conjunction with grazing on private land. Grazing use on sovereign lands is declining, perhaps due to the flooding of the late 1980's and current high lake water levels.

TRANSPORTATION

Existing transportation uses on sovereign lands include the northern and southern railroad causeways, portions of Interstate 80 along the south shore of the lake, and the Davis County causeway. Both railroad causeways are located on easements granted by the predecessor to the Division of Forestry, Fire and State Lands or the Legislature for those purposes. The causeway easements are vary in width between 200 and 2,900 feet, and allow for construction, operation and maintenance of structures within the easement to support and facilitate the transportation uses. The Davis County causeway is a County road right of way.

The impacts of and to the existing transportation facilities at Great Salt Lake are discussed in other elements of this Statement, including Water-Chemistry. Access to and on sovereign lands is discussed in the elements which address the uses for which access is provided.

LAW ENFORCEMENT, SEARCH & RESCUE

Given the fact that Great Salt Lake is divided by causeways and under the jurisdiction of five counties, coordination of search and rescue operations is a key challenge. Coordination is accomplished through the local County Sheriff jurisdiction but more often through two or more counties, since emergency response usually covers more than one county on the Great Salt Lake. Every major search and rescue effort follows an established five county operational pre-plan for the lake. The purpose of the pre-plan is to bring together all agencies with search and rescue responsibilities. The objective is to coordinate search and rescue activities in a timely and professional manner with all five counties and Utah State Parks. Coordination is to be accomplished by inter-local agreements and a coordinating council comprised of representatives of each jurisdiction. A coordinated training effort is accomplished at least yearly on the lake along with yearly meetings.

Two state parks on the Great Salt Lake provide equipment and expertise for search and rescue: Saltair Marina provides 24 hour service with a 36' Boston Whaler. Antelope Island provides 24 hour service with a 25' and 27' Boston Whaler an 18' Air boat and 16' Pram. The initial information collected by agencies receiving emergency messages will dictate what boat or boats will respond to the incident. Currently resources are not available to respond adequately to

an airliner crashing on approach or departure from Salt Lake International Airport. The flight paths direct aircraft over Bear River Bay; Ogden Bay and Farmington Bay. These shallow areas are hard to place rescue equipment into, and usually the response will be by air boat only. The Division of Parks and Recreation has an air boat assigned to Willard Bay and one on Antelope Island. If an airliner goes down, other sources of boats will be Division of Wildlife Resources and the Utah Air Boat Association. This association had offered their help at anytime when requested. Air boats can generally only carry four passengers safely.

Response time to 90% of search and rescues requests is usually thirty minutes or less, depending on the time of day. Response time to outlying areas such as the Bear River Bay or the north arm can take over two hours, since boats must be trailered to other locations and launched. The only boat ramp (Little Valley Harbor) available for rescues on the north arm is of poor quality. The poor quality and relative inaccessibility (across private land) of the Little Valley Harbor ramp complicates rescues on the north arm.

Utah Parks and Recreation staff will most likely get involved on all emergencies due to location, expertise and equipment. All five counties have assorted equipment and volunteer search and rescue teams to assist with various types of emergencies. The future needs for this lake are five to ten passenger Hovercrafts which would be ideal, in most conditions, for shallow water rescues.

LITERATURE CITED

This information will be available the week of November 2 - 6, 1998. If you need this information right away please contact Brenda Landureth at 801-538-5273.

Sorry for any inconvenience this may cause.

APPENDIX A

WATER DISCHARGE PERMITS ON THE GREAT SALT LAKE

Sewage Treatment Facilities

South Davis County North Wastewater Treatment Plant - Permit Number UT0021636 The plant is located at 1800 West 1200 North in West Bountiful, Utah with the outfall(s) located at latitude 40 degrees 56' 94'' to its receiving waters, the State Canal (Class 6) which flows into Farmington Bay Bird Refuge (Class 3C & 3D) and then to the Great Salt Lake. This facility serves the cities of Centerville, West Bountiful, Woods Cross and parts of Bountiful. During 1991, this plant completed its expansion and rehabilitation improvements.

South Davis County South Wastewater Treatment Plant - Permit Number UT0021628 - The plant is located at 2500 West Center Street in North Salt Lake City in Davis County. The outfall is located at latitude 40 degrees 50' 33" and longitude 111 degrees 56' 30" to discharge into the Jordan River (Class 2B, 3B, 3D, and 4) and to the Great Salt Lake after a partial diversion into a canal that waters the Farmington Bay Waterfowl Management Area (Class 3C and 3D) and adjacent wetlands. This facility was established in 1962, but was expanded and upgraded in 1994. It services Bountiful, North Salt Lake and Woods Cross with a service population over 46,000.

North Davis County Sewer District - Permit Number UT0021741 - The plant is located at West 2200 South, Syracuse, Utah with outfalls located at latitude 41 degrees 05' 04" and longitude 112 degrees 06' 30" at 4252 which empties into an unnamed irrigation return drainage ditch with flows into the Great Salt Lake. This district serves the municipalities of Clearfield, Clinton, Layton, Roy, Sunset, Syracuse and West Point and portions of unincorporated Davis County in addition to Hill Air Force Base and the Freeport Center with a total population of approximately 125,000 people. The facility completed its most recent upgrade during 1990. This plant generates over 3200 dry tons of digested sludge in 1997 which is stored for at least one year and then is transported to the East Carbon Landfill.

Central Davis County Sewer District - Permit Number UT0020974 - The plant is located approximately two miles south of Kaysville, Utah in Section 15, Township 3 North, Range 1 West. This facility empties into an unnamed irrigation ditch south of the plant into outfall 001 and to another unnamed irrigation ditch west of the treatment plant from outfall 003 both of which terminate in the Great Salt Lake.

Central Weber Sewer Improvement District - Permit Number UT0021911- The plant is located at latitude 41 degrees 16' 18" and longitude 112 degrees 02" 49" and discharges into the Warren Canal (Class 4), thence to the Weber River (Class 2B, 3C, 3D, and 4) and finally empties into the Great Salt Lake. This facility serves Farr West, Harrisville, North Ogden, Ogden, Pleasant View, Riverdale, South Ogden and Washington Terrace with a population of over 150,000.

Mineral Extraction Industries

Magnesium Corporation of America - Permit Number: UT0000779 - MagCorp manufactures chlorine and calcium chloride. The plant is located on the west side of the lake in Rowley, Utah at approximately latitude 40 degrees 56' 43' and longitude 112 degrees 42' 20". MagCorp has a no discharge permit and discharge from or bypass of the holding pond is specifically prohibited for this facility, however they are required to monitor calcium, TDS, iron and pH on a quarterly basis by grab sample at a test well and on standing water between the wastewater pond dikes and the Great Salt Lake. A pH lower than 6.5 requires State and EPA notification. If this data suggests any seepage from Magcorp's wastewater pond Magcorp must develop and implement a control plan. The plant discharges 2 million gallons of low pH wastewater per day into a total containment pond and a portion is reacted with calcium carbonate to produce calcium chloride which raises the pH of the acid wastewater. Two incidents of seepage have been detected since November, 1989 and neither of these qualify as outfalls because they did not result in a discharge into waters of the United States (as of a 1993 letter-checking with Gayle Smith-DEQ).

Great Salt Lake Minerals (IMC Kalium Corporation) - Permit Number: UT0000647 - Great Salt Lake Minerals Corporation is located in Ogden, Utah and produces potassium sulfate (potash), sodium chloride and magnesium chloride. The wastewater from the processing of potash with lignosulfonates which are used as a binder in the compaction process which produces dust which is controlled by a wt scrubber. Wastewater from the scrubber is discharged back to the Great Salt Lake with bitterns. The discharge point is located at approximately latitude 41 degrees 17' 0" and longitude of 112 degrees 13' 45" and the average flow is 4.5 million gallons per day. Wash water is taken from the Willard Bay Reservoir. The average concentration of Total Suspended Solids (TSS) is greater in the influent than in the effluent (more solids are brought into the system than are discharged) and this makes it difficult for GSL Minerals to meet its TSS limits. GSL Minerals is also required to develop a spill prevention control and countermeasure plan for those areas where lignonsulfonate is stored and shall only use lignosulfonate produced without the use of chlorine. A new proposal to discharge is under consideration and involves pushing salt off the western edge of the dikes on their evaporation ponds into the Bear River Bay. Salt is currently disposed of by flushing the evaporation ponds with water from Bear River Bay and delivering it into the main body of the lake and Bear River Bay. USFWS, DNR, DEQ and GSL Minerals are working together to conduct a monitoring program to determine potential impacts if any to Bear River Bay.

Akzo Salt Incorporated - Permit Number UT0000639 - There are two points of discharge, one at Lake Point and the other at Timpie Springs. The Lake Point facility discharges process scrub and wash water which is used to clean the salt and is then directed into their solar ponds which eventually empty into the Great Salt Lake. The Lake Point outfall is located at latitude 40 degrees 41' 14" and a longitude of 112 degrees 16' 43". The Timpie Springs outfall is located at latitude 40 degrees 45' 0" and discharges bitterns and some wash water into the lake.

Morton/Grantsville Salt - Permit Number UT0000523 **-** Morton returns bitterns to the lake via discharge 001, which is located at a latitude of 40 degrees 45' 7" and a longitude of 112 degrees 30' 00". The salt is washed with lake water which is also used to operate a dust collector. One well on the property is used for fire control. Drinking water is hauled in from Grantsville and office wastewater is disposed of in a septic tank and drain field.

Salt Lake City International Airport

This facility is public transportation airport which leases space and services to airline companies and other providing support services. SLIA is located at 776 North Terminal Drive in Salt Lake City, Utah and has three outfalls located at outfall 001-latitude 40 degrees 47' 23", longitude 111 degrees 57' 28"; outfall 002-latitude 40 degrees 46' 22", longitude 111 degrees 58' 39" and outfall 003-latitude 40 degrees 47' 29", longitude 112 degrees 00' 03". Outfall #001 is a storm water runoff discharge which flows to the City Drain (Class 6). Outfalls 002 and 003 discharge into the Surplus Canal (Class 3B, Class 3D and Class 4) which empties into the Great Salt Lake. The north end portion of the SLCIA property drains northward over a natural gradient through grass and marsh towards the Great Salt lake and is not regulated by this permit because it is considered a non-point discharge. Possible contaminants discharged with storm water or conveyed to the sanitary sewer at the airport include airport deicing/anti-icing fluids, spills of fuel oil, hydraulic oil, solvents, solids, detergents, metals, fire fighting fluids, and lavatory waste.

Mining and Oil Refining Industries

Kennecott Utah Copper - Permit Number UT0000051 - The Kennecott Utah Copper (KUC) operations include a large open-pit mine and main concentrator facilities near Copperton, and a second concentrator, tailings impoundment, power plant, smelter, and a refinery complex located near Magna, both in western Salt Lake County. The process water system includes a leach water collection system and the double lined Small Bingham Reservoir, which is protected from overflow by the Large Bingham Reservoir. The mining and processing facilities have discharge outfalls at four points of discharge to the C-7 ditch (Class 6), one to the Jordan River and Little Valley Wash, two in Pine Canyon Creek, and one in Butterfield Creek. Until recently, tailings pond discharges were routed to the C-7 ditch, which emptied directly into the Great Salt Lake. The C-7 ditch has been rerouted to discharge into Lee Creek for the duration of a tailings impoundment expansion project, but will be relocated to its original point of discharge to the lake when the project is complete. Lee Creek discharges into the Great Salt Lake. A new facilities sewage treatment plant will discharge to the West C-7 ditch (Class 6), or effluent will be recycled to the process water circuit. Storm water from the smelter area flows into an unnamed drainage and then into the Great Salt Lake. Active mine drainage can be discharged to the Jordan River, and inactive mine tunnels discharge to Butterfield Creek, a tributary to the Jordan River, and into Pine Canyon Creek, which is an ephemeral stream in Tooele County. Storm water from an area located to the Southest of the north concentrator complex may flow into Little Valley Wash, which is usually dry.

Chevron USA Inc. - Permit Number UT0000175 - Chevron operates a petroleum refinery facility located at 2351 North 1100 West in Salt Lake City, at a latitude of 40 degrees 49' 39" and longitude 111 degrees 55' 50". The waste water treatment system (WWTS) was modified between 1994-95. The five aerobic treatment lagoons were eliminated and replaced by a biological/mechanical system. The discharge flows into the Oil Drain Canal (Class 6) and eventually into the Great Salt Lake. The average discharge flow is 0.85 million gallons per day and all refinery, pipeline, marketing operations, wastewater and storm water is treated by this improved WWTS.

APPENDIX B

SOVEREIGN LAND LEASES, USES AND APPLICATIONS

Existing Uses, Leases and Permits

Grazing Permits and Easements

There are nine active grazing permits on sovereign land the west Kaysville and west Layton marshes in Davis County. Sovereign land grazing permits may be terminated on short notice. Easements on sovereign land include two railroad crossings, Antelope Island access (north and south), power lines and mineral-related developments (e.g. brine intake canals, the Behrens Trench).

Sovereign Land Surface Leases (with Map 1 reference)

Military Buffer Zone, Special Use Lease 451 (A1).
This lease covers the lakeward extension of the Hill Air Force Bombing and Gunnery Range. The lease grants exclusive rights to the surface use of the land whether inundated or not. The primary purpose is to provide a buffer around live fire target areas. Because the area was used for bombing practice during World War II, and since errant projectiles occasionally land on the property under the present use, unexploded ordnance likely exists on sovereign land.

Lake Front Duck Club, Special Use Lease 630 (A2).
This lease is part of a negotiated settlement of a land ownership dispute in the area. The lease authorizes maintenance of waterfowl habitat, waterfowl propagation, recreation and activities relating to waterfowl hunting by club members. Except for the creation of waterfowl habitat, the sovereign land is to remain in a natural state.

Spiral Jetty, Special Use Lease 889 (A3).
The Spiral Jetty is Utah's most famous international work of art. It is an "earthwork sculpture" on sovereign land off Rozel Point in the north arm of Great Salt Lake. The jetty was constructed in 1970 by Robert Smithson. In the years following its creation it received a wealth of publicity in the national press, photographs in every major art periodical, in surveys of 20th century art, and magazines of more general circulation. The Spiral Jetty is among the classics of modern sculpture and has been viewed by many international visitors.

The spiral, built of basalt rock, is about 1500 feet in length inside an area approximately 300 feet long and 150 feet wide. The site is accessible via roads that lead to Rozel Point from Golden Spike National Historic Site. Originally created for visual enjoyment from the air, shore and on the jetty itself, it may be very difficult to see. During construction the north arm elevation was around 4195 feet and the jetty extended generally less than two feet above the water. The jetty now lies under water but is exposed from time to time.

Boat Harbor, Special Use Lease 964 (A4).
This lease provides a private harbor for brine shrimp harvesting.

Industrial Buffer Zone, Special Use Lease 980 (A5).
This lease provides a buffer zone around Thiokol's illumination flare test site. Permitted activities in the buffer zone include infrequent (two to three hours per day, several days per month) control of public access, use of off highway vehicles and retrieval of errant hardware.

Boat Harbor, Special Use Lease 1017 (A6).
This lease provides a private harbor for brine shrimp harvesting. The harbor also is used by Trestlewood for the salvage of the old railroad trestle.

Saltair, Special Use Lease 30000008 (A7).
This lease is for the purpose of developing and operating recreation-oriented concessions. Saltair Resort is located here.

Sovereign Land Mineral Leases (with Map 1 reference**)**

IMC Kalium Ogden Corp. holds nine separate leases covering approximately 100,000 acres. Major developments include evaporation ponds in Bear River Bay (B1), Clyman Bay (B2) and a pumping facility on the west side of Promontory Point (B3). Concentrated brine from the Clyman Bay pond is transported to the pumping facility via the "Behrens Trench", an underwater canal in the north arm.

Morton International holds an 83 acre lease for a brine intake canal (B4) east of Stansbury Island. Morton's evaporative pond system (B13) is on private and school trust land.

MagCorp holds a 75,610 acre lease on the west side of the lake. The lease includes the Stansbury Basin (B5), acreage at Lakeside (B15), and acreage for a brine canal between these two areas. The major development on sovereign land is the evaporation basin formed by a dike running from Stansbury Island to Badger Island to the plant at Rowley. Some brine shrimp companies have constructed harbor facilities off the MagCorp dike.

Cargill holds no sovereign land leases. Brine is supplied to Cargill under an agreement with MagCorp. Cargill's ponds (B14) are on private and school trust land.

Oil, gas and hydrocarbon leases. There are six active leases on the lake. Two of the leases are at Rozel Point (B6, B7), two in the West Rozel oil field (B8, B9), and two off Antelope Island at Sea Gull Point (B10, B11). None are producing at this time.

North Shore Limited (B12) holds an easement for a brine intake canal and a royalty agreement for production of concentrated brine from ponds on private land.

Wildlife and Waterfowl Management Areas, Refuges and Sanctuaries (with Map 2 reference)

Locomotive Springs Waterfowl Management Area (D1).
Managed by the Division of Wildlife Resources on state land.

Public Shooting Grounds Waterfowl Management Area (D3).
Managed by the Division of Wildlife Resources on federal, state and school trust land.

Harold Crane Waterfowl Management Area (D4).
Managed by the Division of Wildlife Resources on state land.

Ogden Bay Waterfowl Management Area (D5).
Managed by the Division of Wildlife Resources on state land.

Howard Slough Waterfowl Management Area (D6).
Managed by the Division of Wildlife Resources on state land.

Layton-Kaysville Marsh Wildlife Management Area (D7).
Managed by the Division of Wildlife Resources on state land.

Farmington Bay Waterfowl Management Area (D8).
Managed by the Division of Wildlife Resources on state land.

Parks and Marinas (with Map 2 reference)

Willard Bay State Park (F1).
Managed by the Division of Parks and Recreation on federal land.

Antelope Island State Park (F2).
Managed by the Division of Parks and Recreation on state land.

Great Salt Lake Marina (F3).
Managed by the Division of Parks and Recreation on state land.

Pending Lease Applications

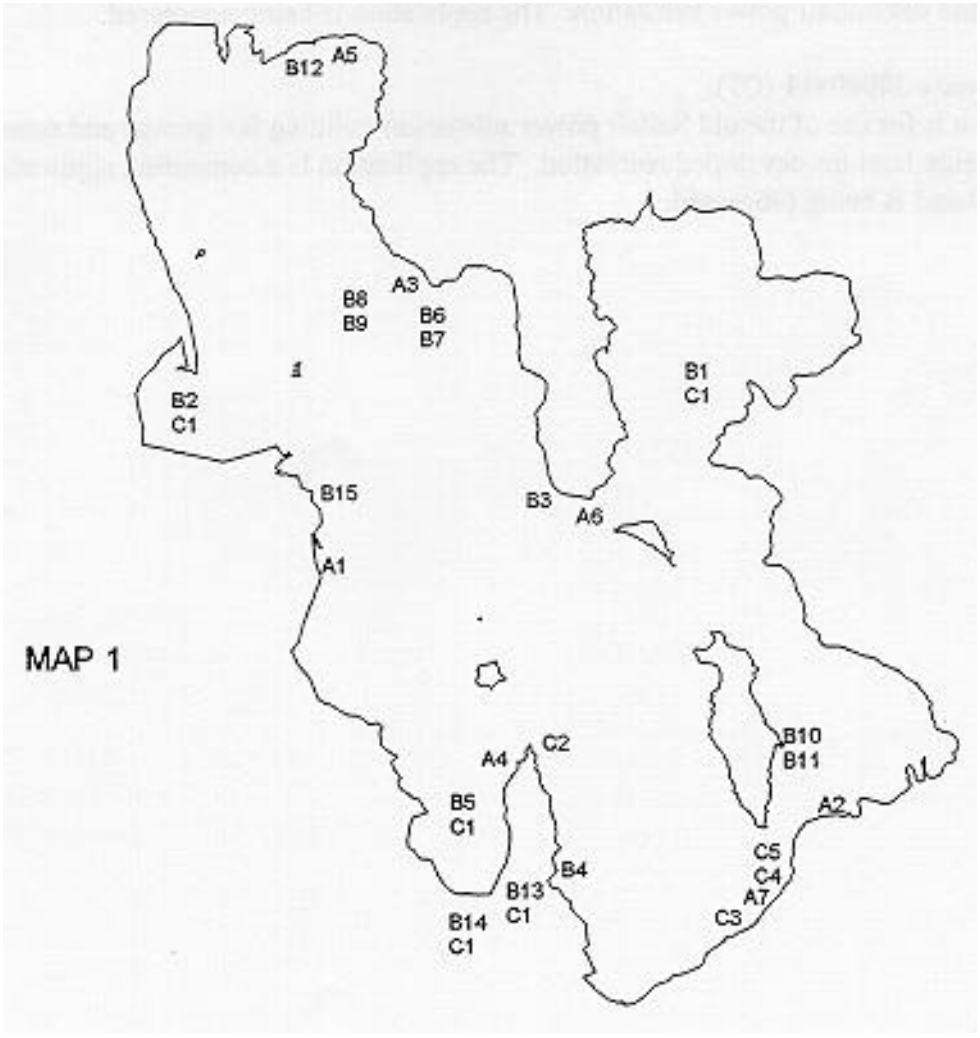
Special Use Lease 973 (C1).
This application is for commercial harvest of algae from existing evaporative ponds. A record of decision has been issued. Lease negotiations continue.

Special Use Lease 995 (C2).
This application is for the development and operation of a commercial boat harbor. The application is being processed.

Special Use Lease 30000006 (C3).
This application is for the development and operation of a commercial boat harbor. A record of decision has been issued. Lease negotiations continue.

Special Use Lease 30000010 (C4).
This application is for developed recreation facilities along the beach area east from Saltair to and including the old Saltair power substation. The application is being processed.

Special Use Lease 30000011 (C5).
This application is for use of the old Saltair power substation building for storage and some adjacent sovereign land for developed recreation. The application is a competing application with 30000010 and is being processed.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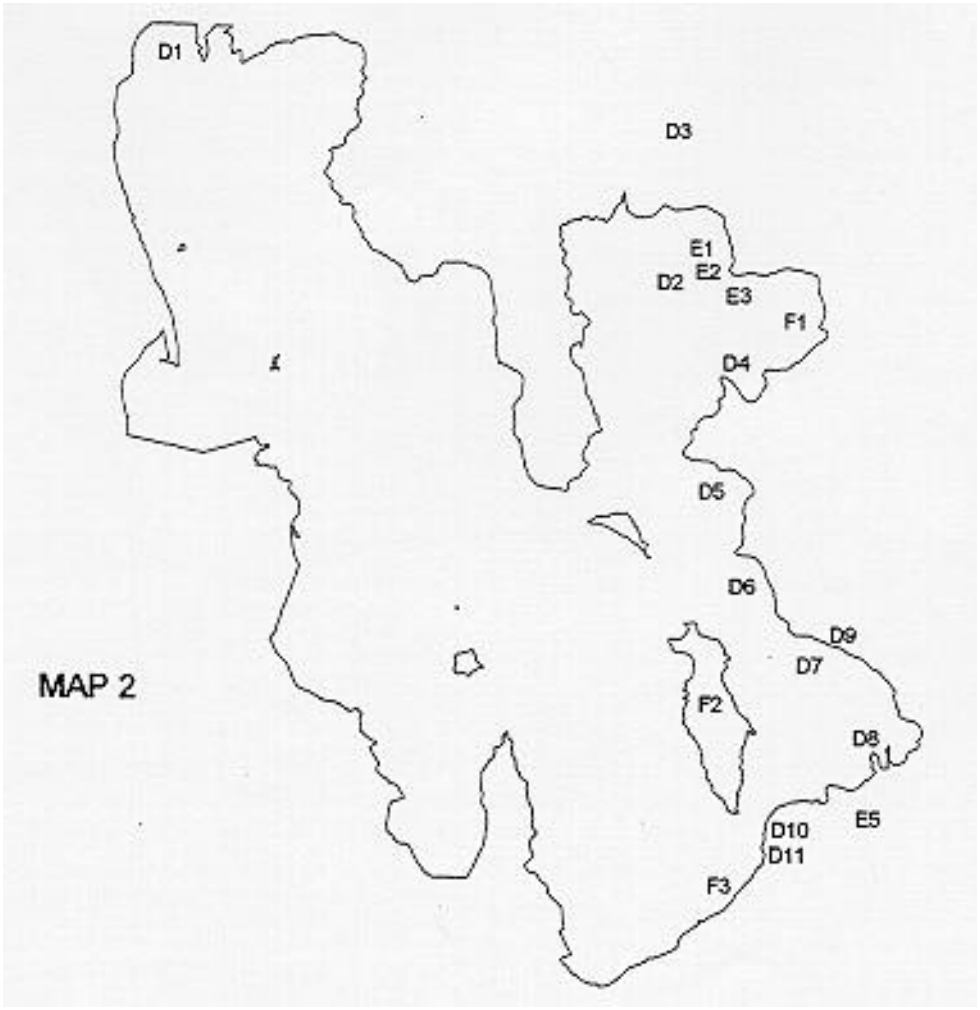
MAP 1



MAP 2