Introduction

The state owns and manages the bed of GSL pursuant to the Equal Footing Doctrine. The boundary line of the bed of GSL is the surveyed "meander line." The meander line follows no particular topographic contour or elevation, but is generally located between 4202- 4212 (above sea level) in most places around the lake. These lands within the meander line are referred to as "sovereign lands." Sovereign lands also include the unsurveyed islands in GSL; Dolphin, Badger, Egg and White Rock Islands. Hat and Gunnison Islands are owned by DWR. Stansbury, Fremont, Carrington and Cub Islands are federally and privately owned.

In addition to the sovereign lands owned by the state, DNR has acquired lands in and around GSL including Antelope Island (DPR), wetlands and uplands associated with wildlife management areas and formerly private lands needed for the WDPP operation, all of which are managed for specific purposes.

The management of sovereign lands is the responsibility of DFFSL. One of the challenges in managing sovereign lands is that the biological and physical systems of GSL do not observe property boundaries, and management decisions on sovereign lands affect, and are affected by, uses and activities on adjoining lands.

The internal and external scoping conducted by the planning team identified these areas of interest and concern with regard to the management of sovereign and other state-owned lands on and around GSL. A listing of the existing leases and permits on sovereign lands is in Appendix B.

- **Disclosure has to be made of known geologic hazards.**
- **Impact assessment for diking proposals needs to be considered.**
- **A review of sovereign land is needed.**
- **Use of sovereign land for BRMBR expansion is a consideration.**

Land Uses Adjacent to Great Salt Lake

Land use around GSL consists of a mix of residential, commercial, agricultural, recreational and industrial uses common to population centers (Exhibit 1). 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 M&I 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 (Davis County Government et al., 1996). In addition, runoff from urban

lands introduces water contaminants different from those of agricultural lands.

BLM manages nearly 40 percent of the total GSL shoreline. Approximately 70 percent of the shoreline above meander on the west side of GSL is managed by BLM. The USAF operates the Utah Test and Training Range on the west side of GSL.

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 WMAs. In addition, approximately 10,000 acres of wetland and upland parcels are owned and managed by groups like TNC 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 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 GSL, 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 other than mineral production. Only a portion of the lake shoreline is zoned. The area on the west side of the lake 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 GSL 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 include 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,..."

(Davis County Government et al., 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 GSL in Davis County.

Centerville City abuts the eastern shoreline of the lake for about two and one-half miles immediately to the east of the Farmington Bay WMA. 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 GSL in Salt Lake County is generally unpopulated, and is zoned A-20, an agricultural zone with a 20 acre minimum lot size, or C-V, 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 GSL 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 GSL shoreline are within Weber County, and are 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.

Division rule allows for classification of sovereign lands based upon current and planned uses (R652-70-200. "Classification of Sovereign Lands" (Appendix F, Exhibit 3).

Class 1: Manage to protect existing resource development uses.

Class 2: Manage to protect potential resource development options.

Class 3: Manage as open for consideration of any use.

Class 4: Manage for resource inventory and analysis.

Class 5: Manage to protect potential resource preservation options.

Class 6: Manage to protect existing resource preservation uses.

The legislature has authorized DWR to use sovereign land in all or parts of 39 townships on GSL for the creation, operation, maintenance and management of WMAs, 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. Some of this sovereign land is included in AISP and is managed by DPR. Some of the land has been sold or exchanged.

The most current statement of use classifications for the sovereign and other state lands of GSL appears in the 1995 plan. The 1995 plan recommended application of the use classifications set forth in R652-70-200 to areas of GSL as follows (Appendix F, Exhibit 3):

Class 1, managed to protect existing resource development.

Lands under this classification include the area around Antelope Island delegated to DPR for recreation management, the area around Saltair and GSL 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 West 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, Salt Lake Base and Meridian (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 DWR to use for wildlife purposes under Section 23-21-5 (Appendix F, Exhibit 2), and a one-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 WMAs or in the island buffer zones. Elsewhere, oil and gas surface occupancy constraints shall be determined in consultation with DWR (Appendix B, Exhibit 1 for Sovereign Land Surface Leases). Mitigation strategies for developments

not related to wildlife management in these areas shall also be determined in consultation with DWR.

Class 6, managed to protect existing resource preservation uses.

This classification covers existing WMAs. 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.

Class 4, managed for resource inventory and analysis.

This is a temporary classification used while resource information is gathered pending a different classification. There are no Class 4 lands in the lake.

The mineral lease descriptions in the 1995 plan are revised by the 1996 MLP. The sovereign land mineral lease categories now in place are shown in Appendix F (Exhibits 5 and 6).

Geologic Hazards

State law requires DFFSL to disclose known geologic hazards affecting leased property. Information on known hazards is routinely provided to lessees but, in general, there is no follow-up activity.

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. Keaton (1986) suggests that displacement could be approximately five feet at the fault line. The zero-subsidence line would be about 10-12 miles west of the fault. A drop and tilt of the valley floor of this magnitude would cause (1) waters of GSL to move east, and (2) 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.

Surface Faulting

Surface faulting may accompany large earthquakes (greater than magnitude 6.0-6.5) on active faults in the bed of GSL. One fault trends northwest along the west side of the Promontory Mountains and Antelope Island. Other faults are present elsewhere beneath GSL, particularly in the north arm (Hecker, 1993). Because faults in GSL do not trend onshore, surface faulting resulting from an earthquake on one of these faults would not directly affect structures along the shoreline. However, surface faulting beneath the lake may rupture dikes or in-lake structures that straddle the faults, and may generate seiches which could indirectly damage both in-lake and shoreline structures by flooding. Little is known of the earthquake history of the faults in GSL, but evidence indicates some have been active in Holocene time.

Liquefaction and Ground Failure in Sensitive Clays

Lowe (1990a) 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. These areas adjacent to the lake have sensitive clay soils susceptible to liquefaction. Regarding flooding related to local and distant earthquakes, liquefaction, and wind tides, Atwood and Mabey (1990) point out the following: "Engineered structures (such as dikes and causeway embankments) founded on the lakebed, particularly those designed to provide protection from the lake water, pose special engineering-geology problems." These problems include settling, flooding, soil compaction and erosion.

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. Ground water is considered shallow when it occurs at depths less than 30 feet. Lowe (1990a and 1990b) suggests that ground water adjacent to the lake, at depths less than 10 feet, may cause flooding of basements and other related problems. In the vicinity of GSL, 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.

Wind Tides and Seiches

Sustained winds blowing across the surface of GSL push the water to the shore or dike and causeway where it "piles up," forming what is known as a wind tide or wind setup. The height or magnitude of the setup depends on the speed, direction, fetch, depth of lake at that point and duration of the wind. Wind setup exceeding two feet is not uncommon, and can cause localized increased flooding and damage. The combined effects of wind setup and high waves (wave runup) can produce adverse impacts to elevations five to seven feet above the static lake elevation and locally even higher. 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 a 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

in the south arm (Lin, 1976, and Lin and Wang, 1978b) and shorter in the north arm. Earthquakes also have the potential to cause large-scale surges and seiches in the lake. During such surges and seiches, the elevated water may cause repeated, short-term flooding around the lake. The heights of earthquake-induced surges and seiches are unknown, but may well exceed the heights of wind tides and seiches. A 1909 earthquake is reported to have generated a surge that sent water over the railroad causeway and the pier at Saltair. The extent of flood damage in an earthquake affecting the lake will depend on the level of the lake at the time of the event.

Wind-Blown Ice

During the cold winter months, freshwater from the major tributaries to the lake flows out and over the heavier saline water of the south arm and also in Bear River Bay. 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 Comprehensive Management Plan-Planning Process and Matrix* (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 wind-blown ice in the southern part of the lake.

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 on geologic hazards and mitigation measures should be provided to applicable county planning, zoning and permitting agencies. UGS suggests that general hazard maps be made available to city and county planning, zoning and permitting agencies to identify where further 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 contour (or high elevation if required by the permitting agency). These studies should be reviewed for adequacy by the local government or their consultants (UGS performs such reviews), and steps should be taken by local government to ensure that recommended mitigation measures are implemented.

Sovereign Lands Boundaries

Uncertainties and Disputes

The meander line, which is the legal boundary between sovereign lands and adjacent lands, was established by a series of surveys over a period of years, and does not follow a topographical contour line around GSL. 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 (Appendix B, Exhibit 2 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 BRMBR
Lands below the meander line between Willard Bay and BRMBR

Boundary Resolution Strategies

Section 65A-10-3 requires DFFSL 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 2000 if the records search identifies potentially legitimate private ownership claims below meander.

Dikes and Causeways

Dikes and causeways in and around GSL serve a variety of purposes. Dikes are used to impound freshwater (e.g., BRMBR, WMAs, Willard Bay Reservoir), impound brine pumped from the lake or trap brine in the lake for brine extraction (e.g., Magcorp, IMC Kalium Ogden Corp., Morton) and protect facilities from high lake levels (wastewater treatment plants, sewage lagoons, power lines). Causeways are also used for transportation facilities along the shore or across the lake (I-80, northern and southern railroad causeways, Davis County Causeway).

Dikes and causeways influence lake level, salinity, habitat and the surface area of the lake. The influence of causeways on salinity is evident. Where dikes or causeways constrain the area over which the lake could expand in high water periods, the water depth along shores may be too deep for shorebird habitat. Similarly, the formation of wetlands along shoreline areas may be affected. Some dikes and causeways constrict lake hydrodynamics and tributary flows as the water moves toward the lake, thereby exacerbating local flooding.

With the exception of studies regarding proposed large freshwater impoundments (e.g., inter-island diking, Lake Davis, Lake Wasatch), assessments of effects have focused on the intended purposes of dikes and causeways. Effects beyond the immediate vicinity have received little attention in project planning.