DIKES AND CAUSEWAYS – THEIR PURPOSE AND EFFECT ON GREAT SALT LAKE

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By

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DIKE AND CAUSEWAY STRUCTURES WITHIN GREAT SALT LAKE SERVE TWO BASIC PURPOSES.

1. To serve as a support for a mode of transportation - roads and railroads.

2. As a physical means of either keeping water within or without of a certain area.

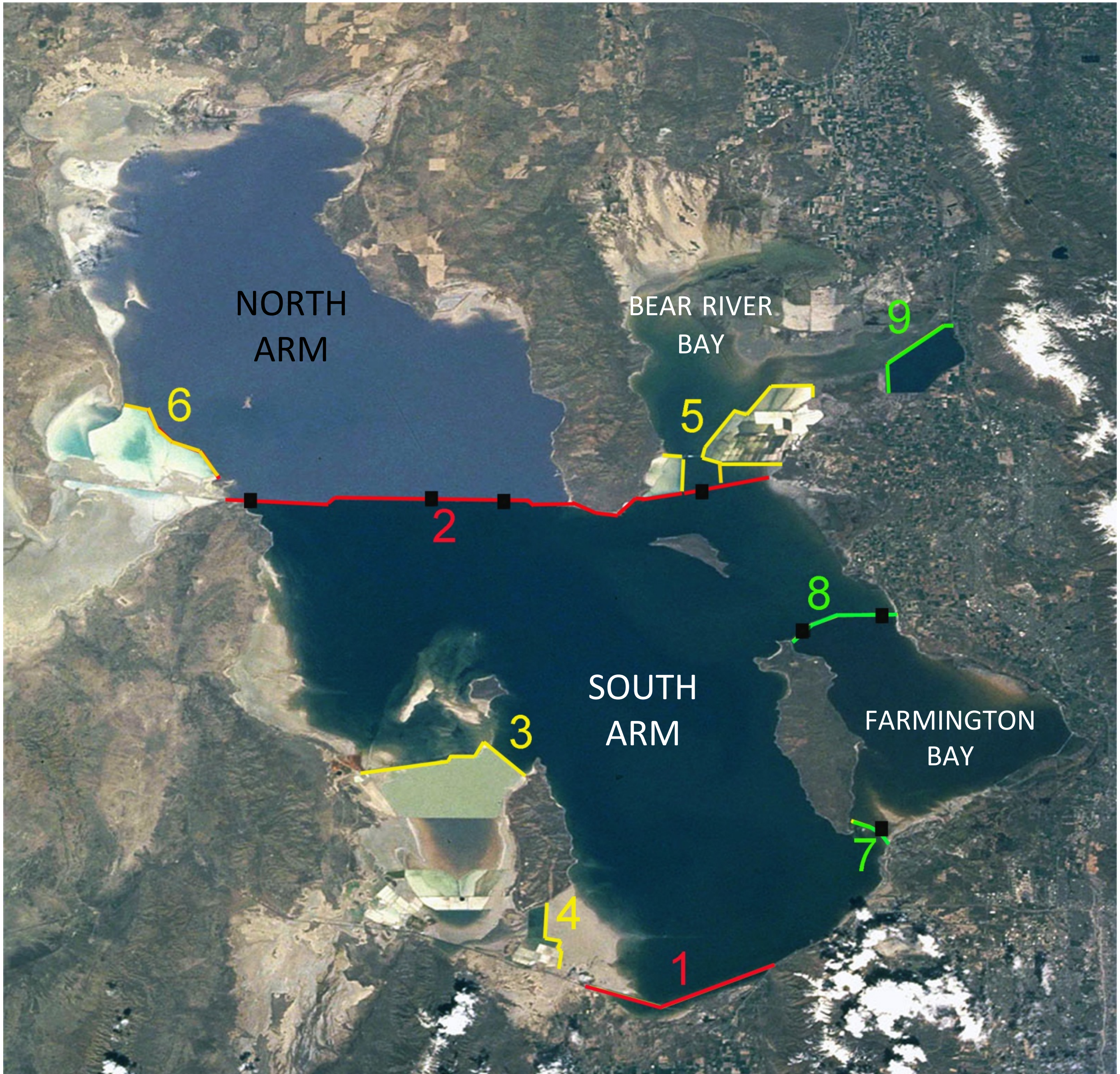
LOCATIONS OF DIKES AND CAUSEWAYS WITHIN GREAT SALT LAKE

THE NEXT SLIDE SHOWS THE LOCATIONS OF THE NINE DIKES OR DIKE SYSTEMS IN THE LAKE.

RED LINES REPRESENT RAILROADS

YELLOW LINES REPRESENT INDUSTRIES

GREEN LINES REPRESENT OTHER PURPOSES



LEGEND

1 - UPRR TRACKS

2 – UPRR CAUSEWAY

3 – US MAGNESIUM

4 – MORTON SALT

5 – GREAT SALT LAKE MINERALS

6 – GREAT SALT LAKE MINERALS

7 - FARMINGTON BAY SOUTH

8 - ANTELOPE – SYRACUSE CAUSEWAY

9 – WILLARD BAY RESERVOIR

BLACK SQUARES REPRESENT OPENINGS IN DIKES OR CAUSEWAYS

DISTRIBUTION OF THE DIKES AND CAUSEWAYS

THERE ARE OVER 90 MILES OF DIKES OR CAUSEWAY SYSTEMS WITHIN GREAT SALT LAKE. FOR THE MINERAL EXTRACTION COMPANIES, THIS DOES NOT COUNT THE MANY MILES OF INTERIOR DIKES THAT SUBDIVIDE LARGE AREAS INTO SMALLER UNITS.

FIVE ARE LOCATED WITHIN THE SOUTH ARM OF THE LAKE.

TWO ARE LOCATED WITHIN BEAR RIVER BAY

ONE IS LOCATED IN THE NORTH ARM

ONE DIVIDES THE LAKE INTO THE NORTH AND SOUTH ARMS

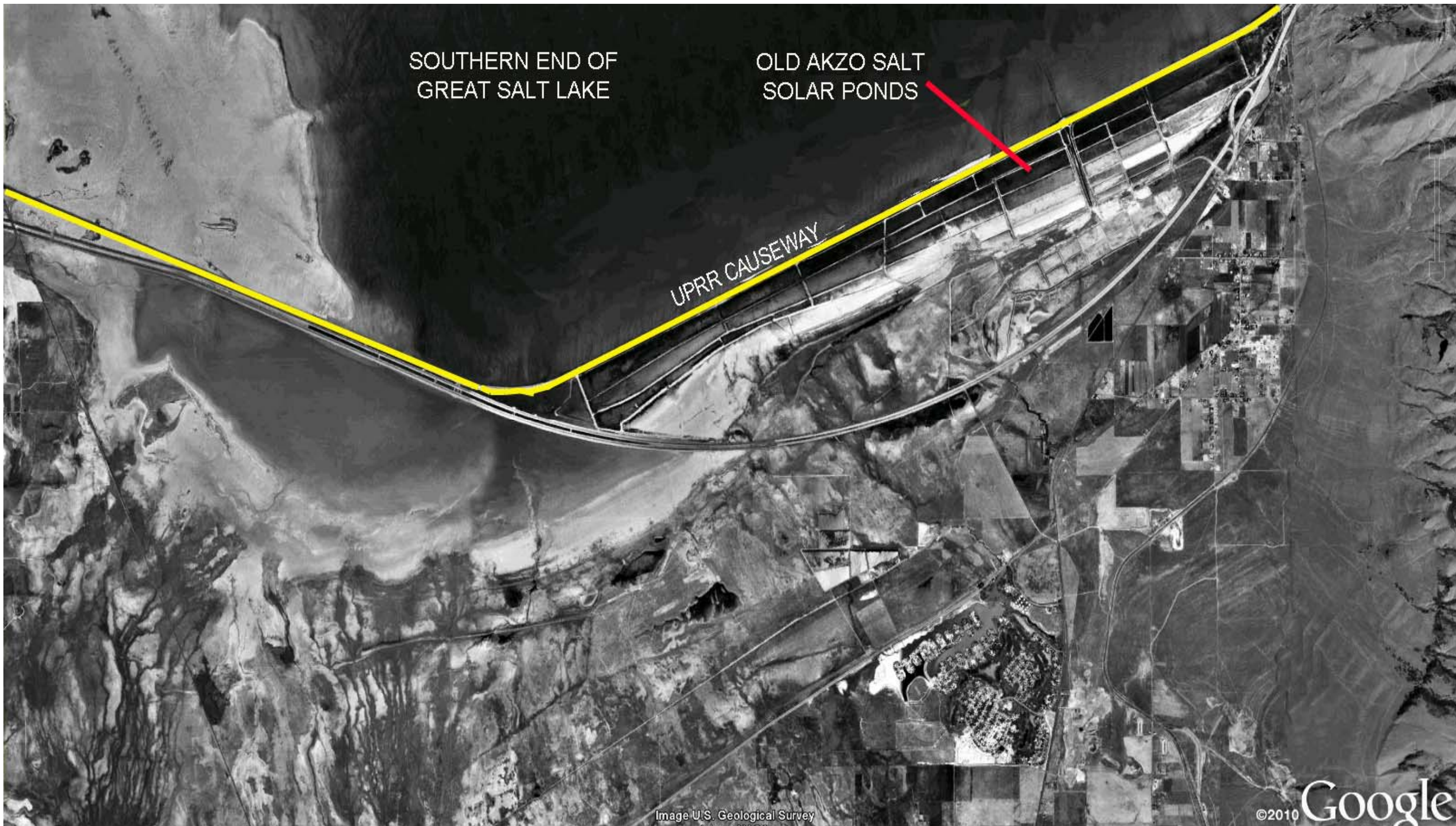
UNION PACIFIC RAILROAD TRACKS ON THE SOUTHERN END OF THE LAKE

THESE TRACKS ACCOUNT FOR MUCH OF THE MOVEMENT OF FREIGHT BOTH EAST AND WEST THROUGH THE STATE.

AN ELEVEN MILE SECTION OF THE TRACKAGE IS CARRIED ON A ROCK FILL CAUSEWAY THAT BASICALLY FORMS THE SOUTHERN END OF THE LAKE.

DURING THE 1980s FLOODING, THIS SECTION OF TRACKS HAD TO BE RAISED 11 FEET TO KEEP AHEAD OF THE RISING LAKE.

UPRR CAUSEWAY AT SOUTH END OF THE LAKE



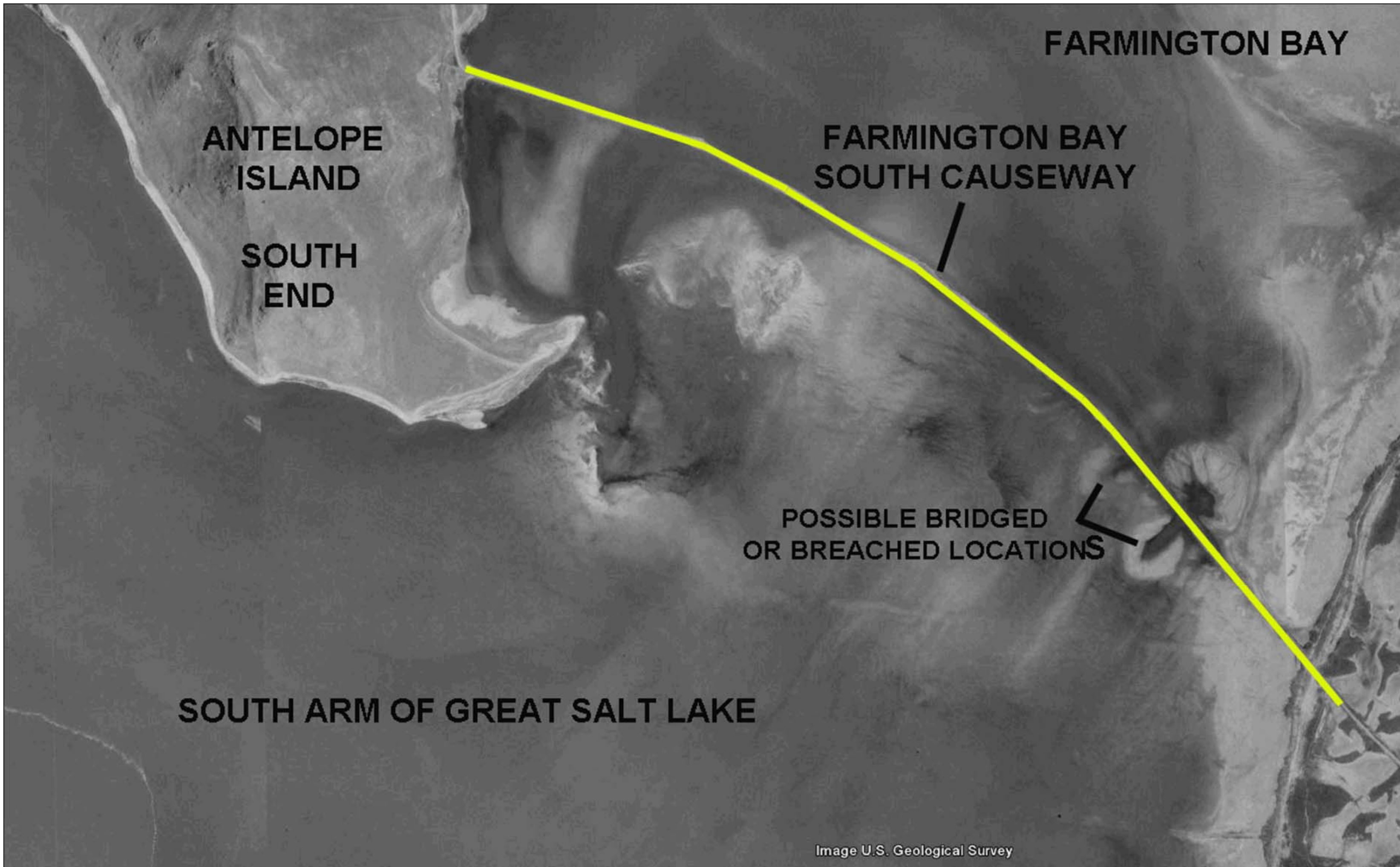
FARMINGTON BAY SOUTH CAUSEWAY

1951 TO 1952, the Southern Farmington Bay causeway was built over an existing trail on the mud flats to prevent sewage being put into the bay from getting on the southern beaches.

The top elevation of the southern causeway is estimated to be at an elevation of 4205 to 4206 feet.

In 1979, fill material was moved off Antelope Island via a 13-mile-long conveyer belt built on the causeway to construct Interstate 80 west of Salt Lake City.

SOUTHERN FARMINGTON BAY CAUSEWAY



FILL FROM THE ISLAND FOR I-80 IS MOVED ALONG CAUSEWAY

ANTELOPE ISLAND – SYRACUSE OR DAVIS COUNTY CAUSEWAY

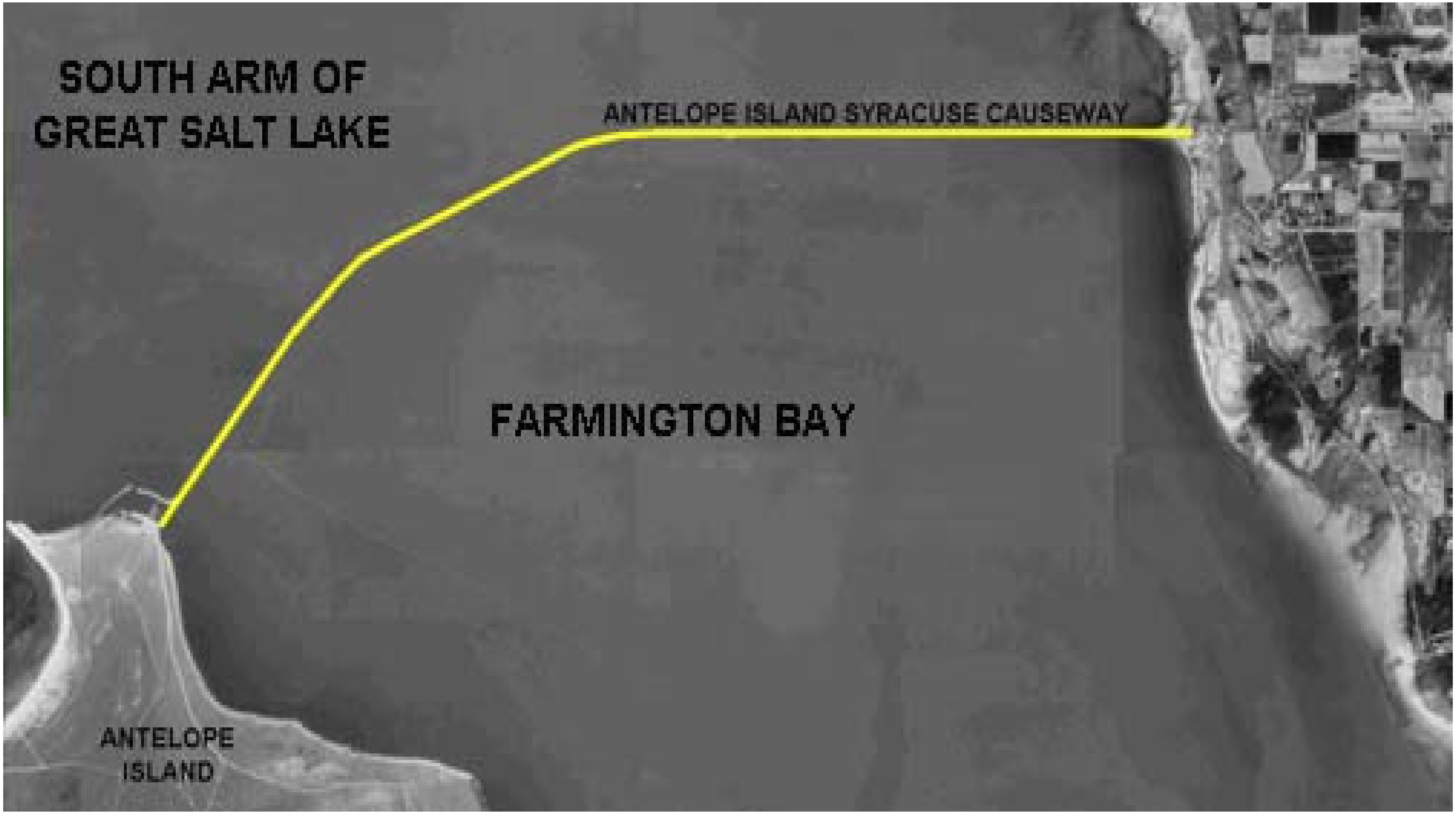
Prior to 1969 there was no northern causeway to Antelope island.

In 1969, an earth-fill causeway was constructed with a top elevation of 4206.5 feet.

In early 1984 this causeway was flooded, and remained so until mid 1989.

The causeway was rebuilt in 1992 with a top elevation of 4208.5 to 4210 feet.

ANTELOPE ISLAND-SYRACUSE CAUSEWAY



SALINITY IN FARMINGTON BAY

At lake levels below 4205, the salinity of the bay is much less than that of the South arm of the lake

Above 4205 to 4206, Farmington bay is connected to the south beach area of the lake. This connection does not affect salinity too much.

Above 4210 feet, the bay is free to mix with the south arm of the lake and its salinity if about the same as the south arm.

WILLARD BAY RESERVOIR

Willard Bay was formed by a 15.6-mile-long dike with an area of 10,000 acres. It is filled with fresh water from the Weber River, and used principally for irrigation and recreation.

Willard Bay reservoir abuts the Willard Spur, an eastern extension of Bear River Bay.

WILLARD BAY RESERVOIR

U.S. MAGNESIUM

U.S. Magnesium began operations in 1972 under the name National Lead, then NL Industries, and then AMAX. On June 7, 1986, high-water levels and a storm breached the main dike separating the solar ponds from the lake, and their entire Stansbury Basin ponding system was inundated (dropping the level of Great Salt Lake by about 5.5 inches)

AMAX continued operations by using concentrated brines from outside sources.

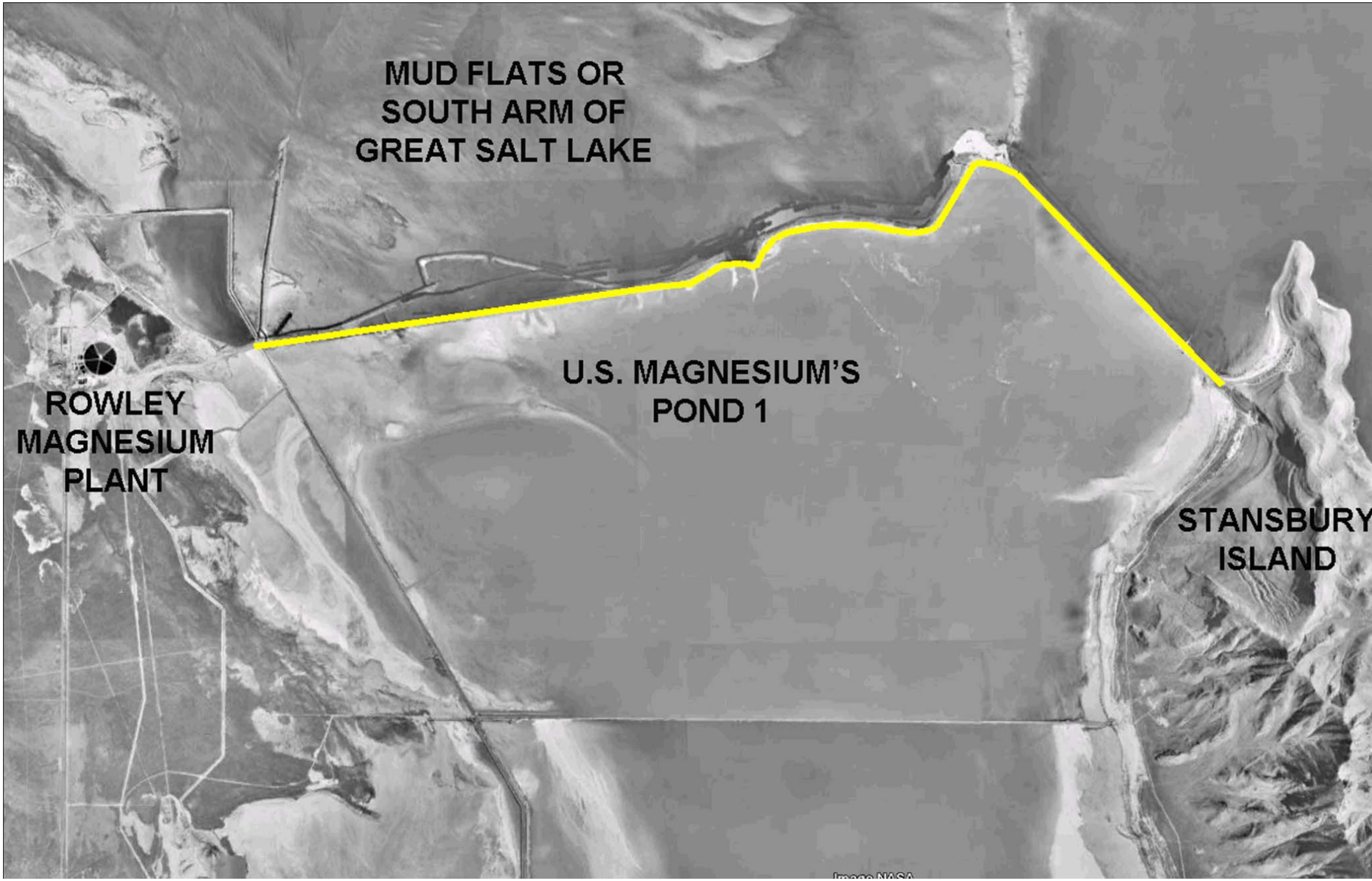
AMAX then constructed a new solar evaportion project near Knolls, capitalizing on the State's West Desert Pumping Project as a source of concentrated brine.

In 1989, AMAX was sold to Renco, and became Magnesium Corporation of America (MagCorp).

In 1992 MagCorp began rebuilding the flooded solar ponds with higher stronger dikes against the lake. In 1995, the first brine from the refurbished ponds was brought to the plant.

MagCorp, through a reorganization, became U.S. Magnesium.

U.S.MAGNESIUM



GREAT SALT LAKE MINERALS

Investigations into the production of lithium, and later sulfate of potash (SOP) from Great Salt Lake were started in 1963-1964, and construction of solar ponds began in 1967. Since that time, Great Salt Lake Minerals has grown to become one of the largest mineral producers on the lake.

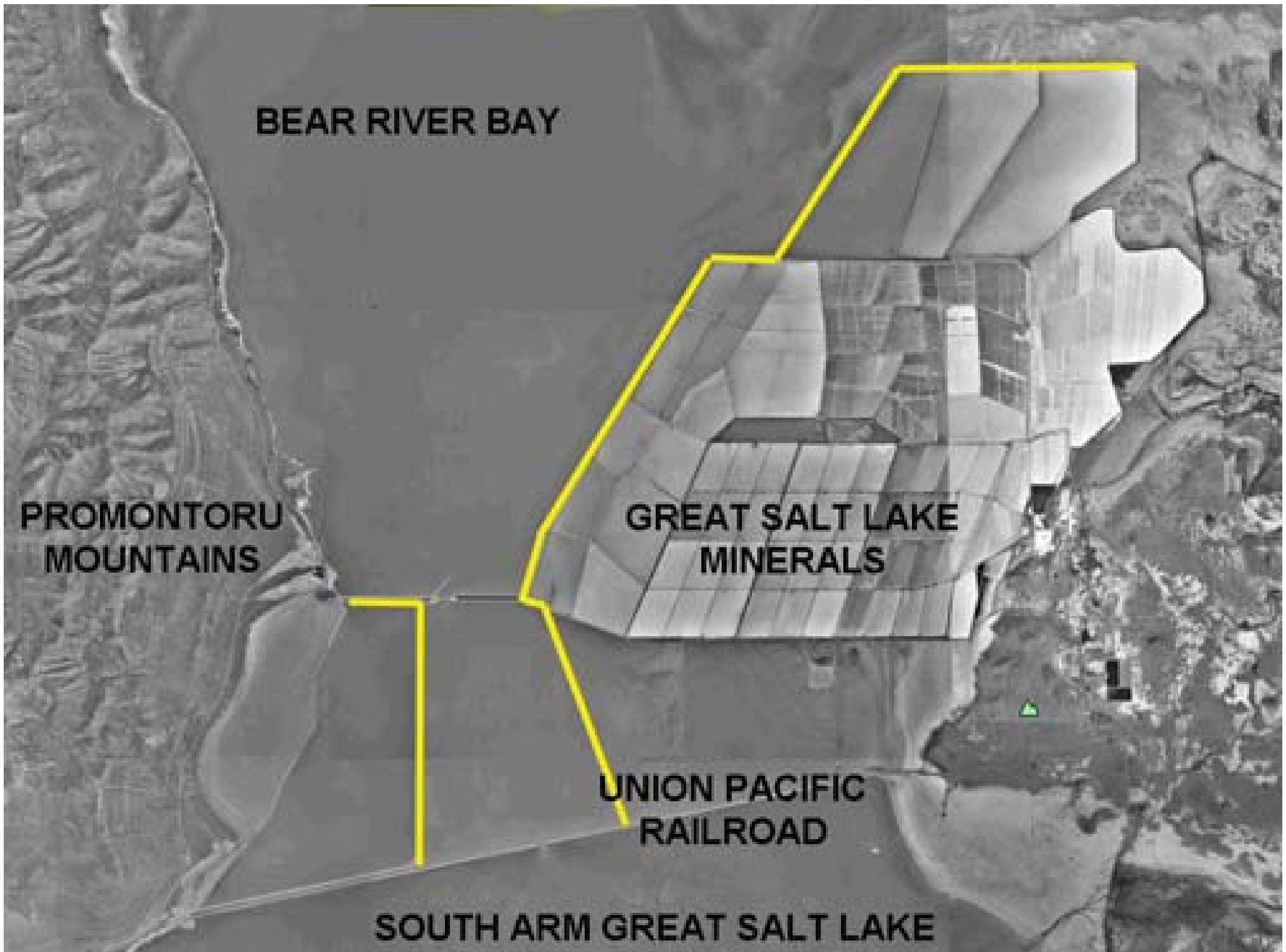
High water conditions in the early 1980s caused the breach of the dike separating their solar ponds from the lake and resulted in flooding the entire solar ponding system.

From 1984 to 1990 GSLM was unable to produce any SOP, but made repairs to their facilities.

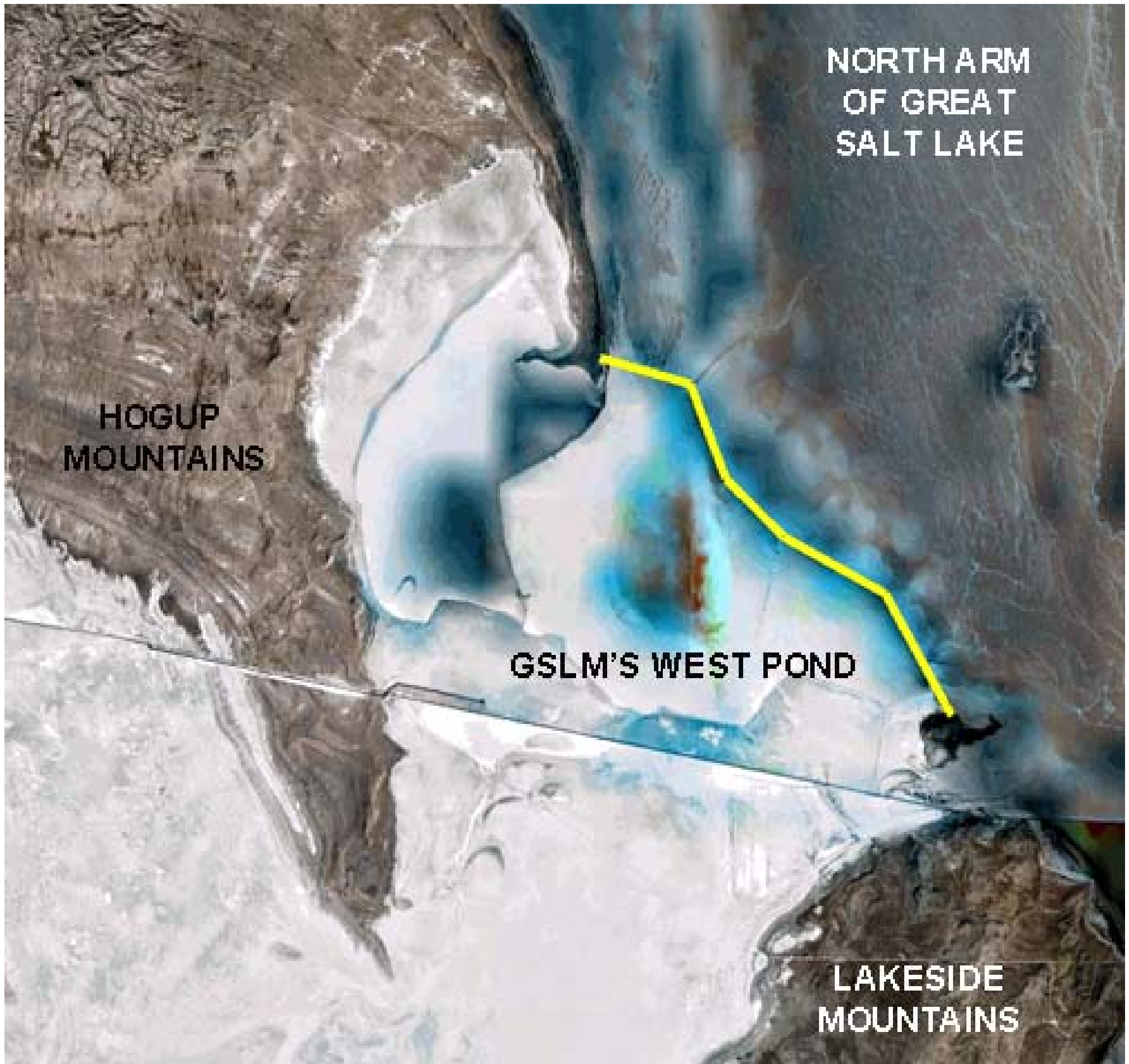
In the early 1990s, additional solar ponds were constructed on the west side of the lake. The concentrated brine produced there was conveyed to the main solar ponds via a 21-mile-long, open, underwater canal referred to as the Behren’s trench.

GSLM has proposed plans to add several thousand more acres of solar ponds north of the area shown on the previous slide on the west side of the lake.

GREA SALT LAKE MINERALS MAIN PONDING SYSTEM



GSLM'S SOLAR PONDS ON THE WEST SIDE OF THE LAKE



SPRR/UPRR CAUSEWAY

The driving of the golden spike at Promontory in 1869 marked the completion of the nation's first transcontinental railroad.

Because of steep grades and many degrees of curvature that accompanied the route around the north end of the lake, a route across Great Salt Lake was investigated, to be called the Lucin Cutoff.

Work on the Lucin Cutoff was started in 1902 and completed in 1904.

- Construction across the main body of the lake, could not be completed as solid, rock-fill causeway because of soft-bottom conditions.
- The central 13-mile-long portion of the cutoff was constructed as an open-trestle structure.
- The open-trestle structure allowed for the free mixing of the lake from north to south.

OPEN-TRESTLE STRUCTURE – CENTRAL 13-MILE-LONG PORTION OF CAUSESAY

By the 1950s, the trestle portion of the causeway began to be unsafe, and plans were made to replace it with a solid, rock-fill structure, located parallel to and 1500 feet to the north.

Work began on the new fill in 1956 and was completed in 1959. The Morrison-Knudsen Company of Boise, Idaho was awarded the contract to build the causeway at a cost of about 53 million dollars.

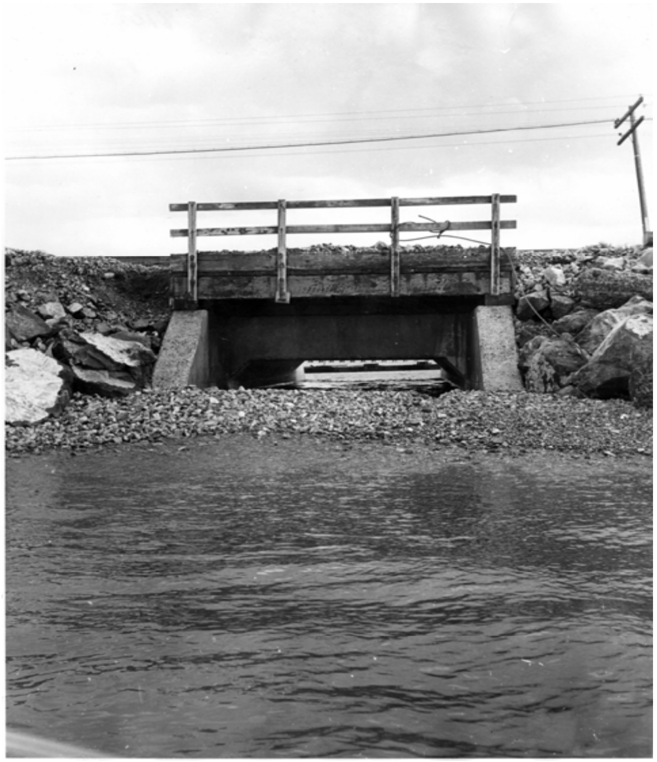
CULVERTS IN THE CAUSEWAY AND THEIR EFFECT ON LAKE SALINITY

During construction of the causeway, two 15’ wide by 20’ deep culverts were constructed on shore and floated out and put in place.

Even with the two culverts in place and the natural seepage through the rock fill, there was limited mixing of the brine between the south and north portions of the lake. A salinity difference began to build between the two arms of the lake.

When hydraulic conditions are right, there is north to south return flow as well as south to north flow through the two culverts.

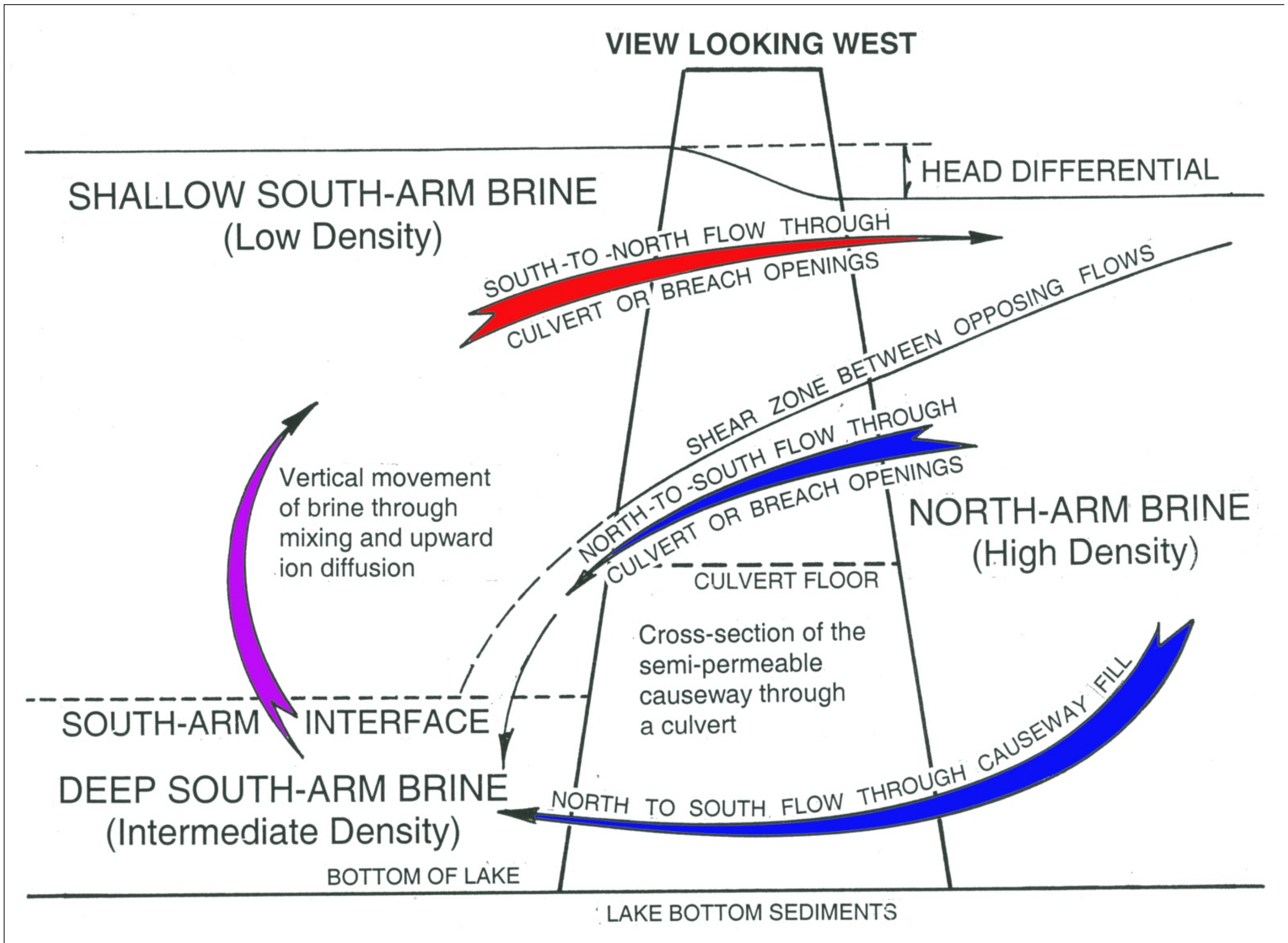
VIEWS OF THE CULVERTS



View looking north to south. Note, culvert has been filled with gravel during a recent storm.

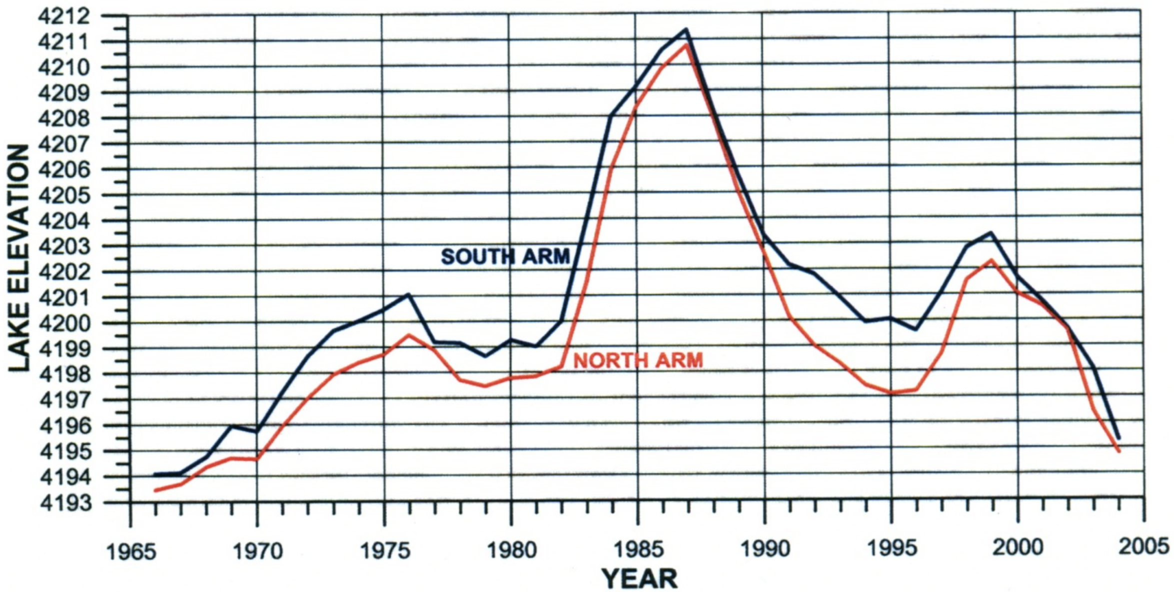
Culvert is nearly under water.

BI-DIRECTIONAL FLOW THROUGH ONE OF THE CULVERTS

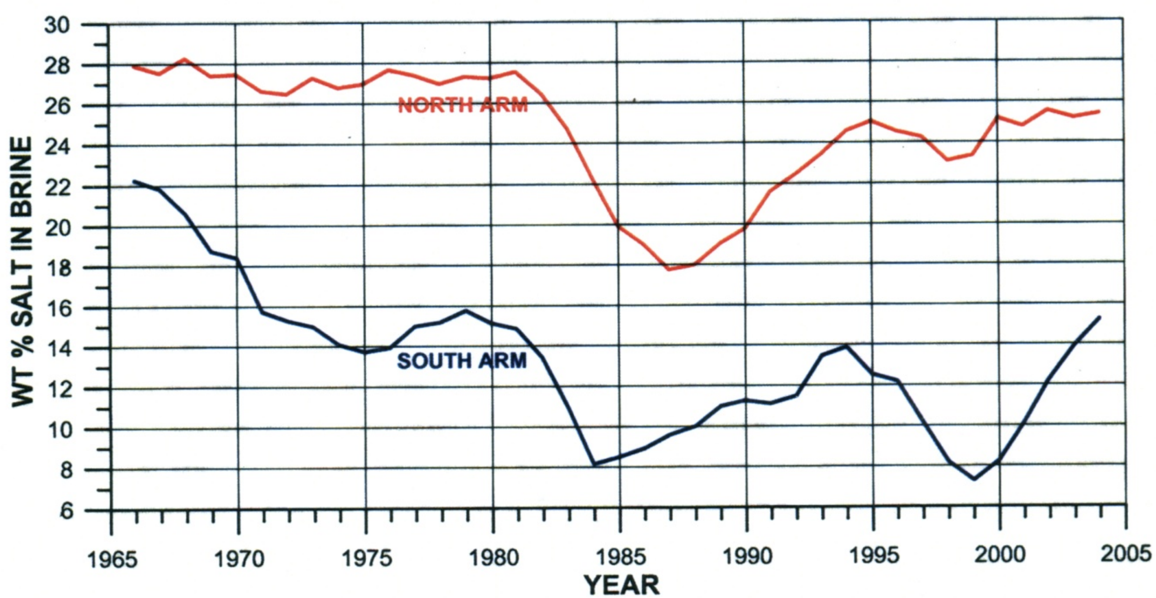


When there is insufficient return flow from north to south, there is a net movement of salt from the south arm into the north arm. This results in a lower and lower salt content or salinity in the south arm of the lake. The north arm brines becomes saturated and salt precipitates on the lake's bottom

When this happens, the north arm remains at or near saturation while the south arm fluctuates as a balance between fresh water inflow and evaporation. This condition will persist until some event, like the 1980s flooding, takes place.



North and south-arm lake levels over time



Salinities of north and south arm brines over time.

THE 1980s FLOODING PERIOD

From 1982 until 1987, the lake rose nearly 12 feet, causing extensive flooding of many transportation, industrial, and other structures around the lake.

In 1984, the State of Utah looked at numerous ways to halt or slow the lake's rise, and determined that breaching the causeway would help to alleviate the 3.5-foot head differential that had developed between the north and south arms of thee lake – The south arm being the highest and causing the most damage.

The State undertook financing the breach or opening in the causeway at a cost of about 3.5 million dollars.

VIEWS OF THE CAUSEWAY BREACH

When the breach was opened, a great exchange of brine took place between the north and south arms.

The south-arm brine making up the 3.5-foot head differential flowed to the north forming a two-layer condition for a period of time.

At the same time, large volumes of heavy north-arm water, as return flow, flowed into the depths of the south arm forming a thick layer of deep, dense brine.

BUILDING UP THE CAUSEWAY DURING THE FLOODING YEARS

- During the flooding years, the causeway had to be built up to keep ahead of the rising water.
- Millions of tons of rock and fine material were added to the top of the causeway.
- The addition of this material reduced the porosity and permeability of the causeway which greatly reduced the return flow of north arm brine to the south arm.
- There is continual south-to-north flow through the breach, but north-to-south return flows only occurs during high-water years.

- These two factors, in part, have caused a continual reduction of the total salt load in the south arm of the lake.
- At the same time, the north arm brines remain at or near to saturation with salt precipitating on the bottom during the low-water years.

UPRR's PLAN TO CONSTRUCT A BRIDGED OPENING IN THE CAUSEWAY

The two concrete box culverts in the causeway are failing.

Plans are to replace the two culverts with one 150-foot-long bridged opening which would, at a minimum, allow the same bidirectional flow as is now moving through the culverts.

Parties wishing to return the lake to a more natural condition prefer an opening much larger that will allow for a much greater exchange of brine in both directions.

Parties that feel the current conditions are ideal for their purposes, or fear that rapid changes in lake conditions may be harmful to the ecology, are opposed to making the bridged opening larger.

The Union Pacific may take the position that they are not obligated to do more than replace an equal flow volume of brine. Or, they may opt to make some compromise and increase the size of the bridged opening and thus the flow volume of brine.