Utah Lake – Interesting Old Place

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By Ivan Makarov


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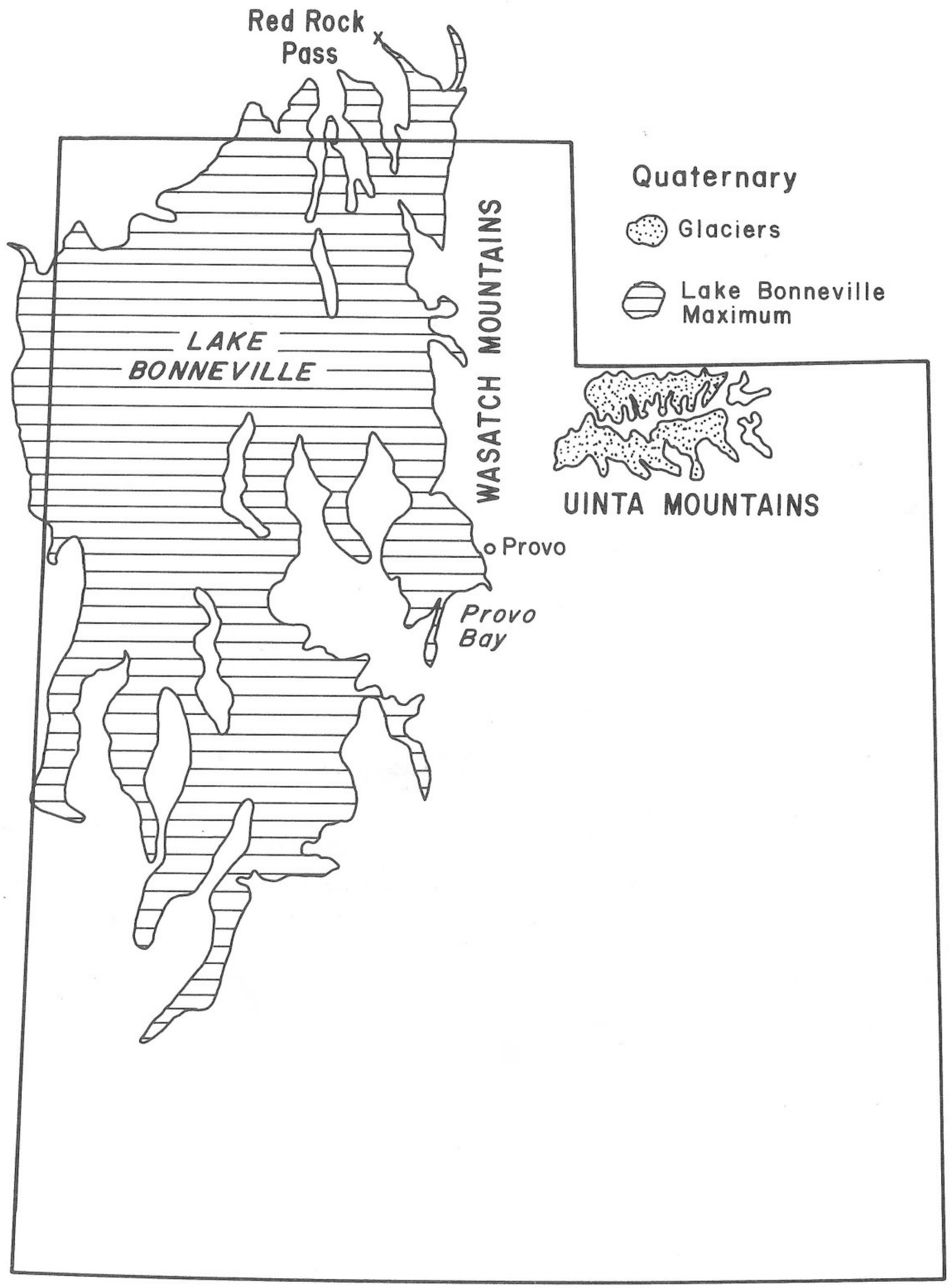
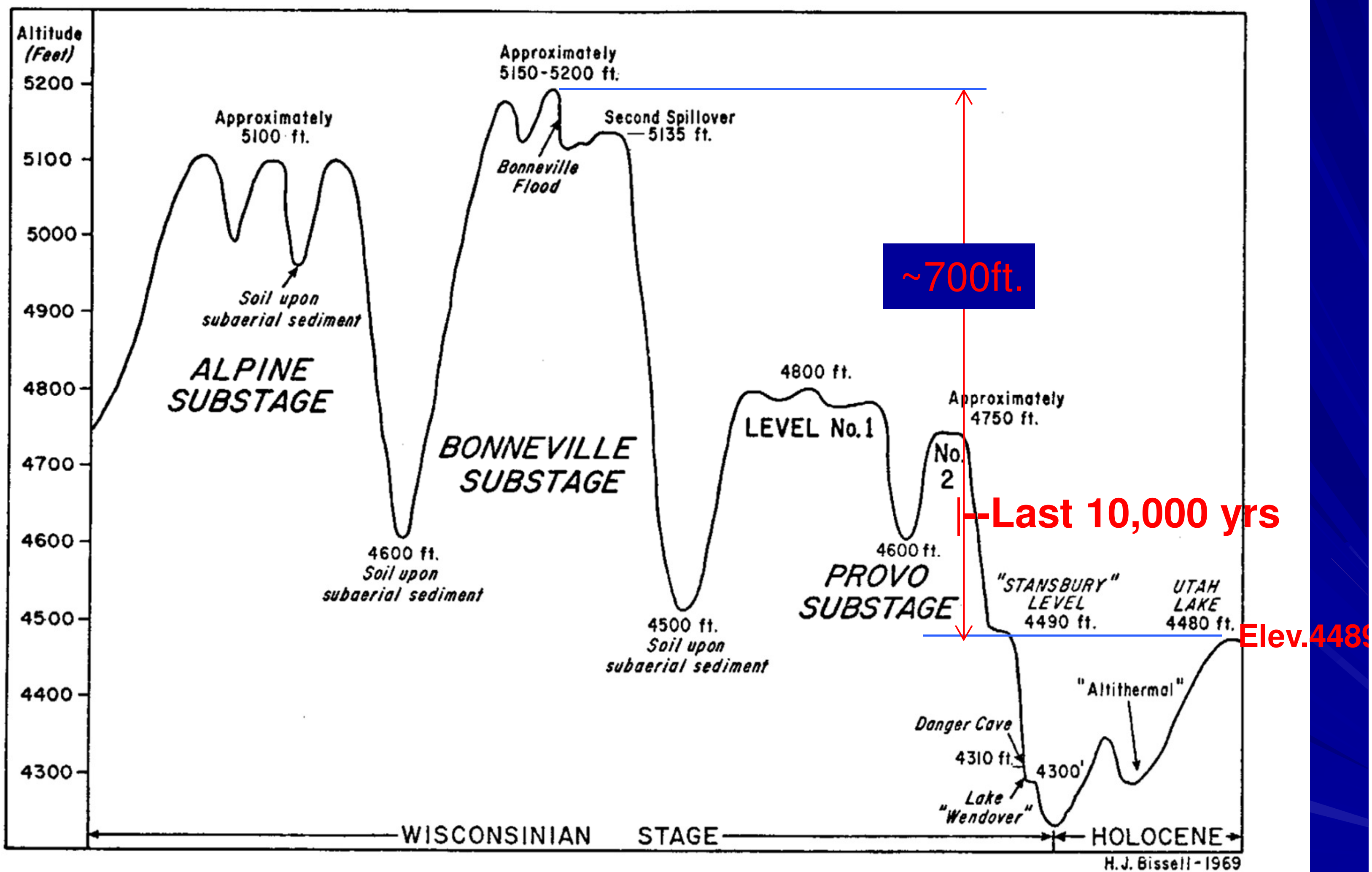


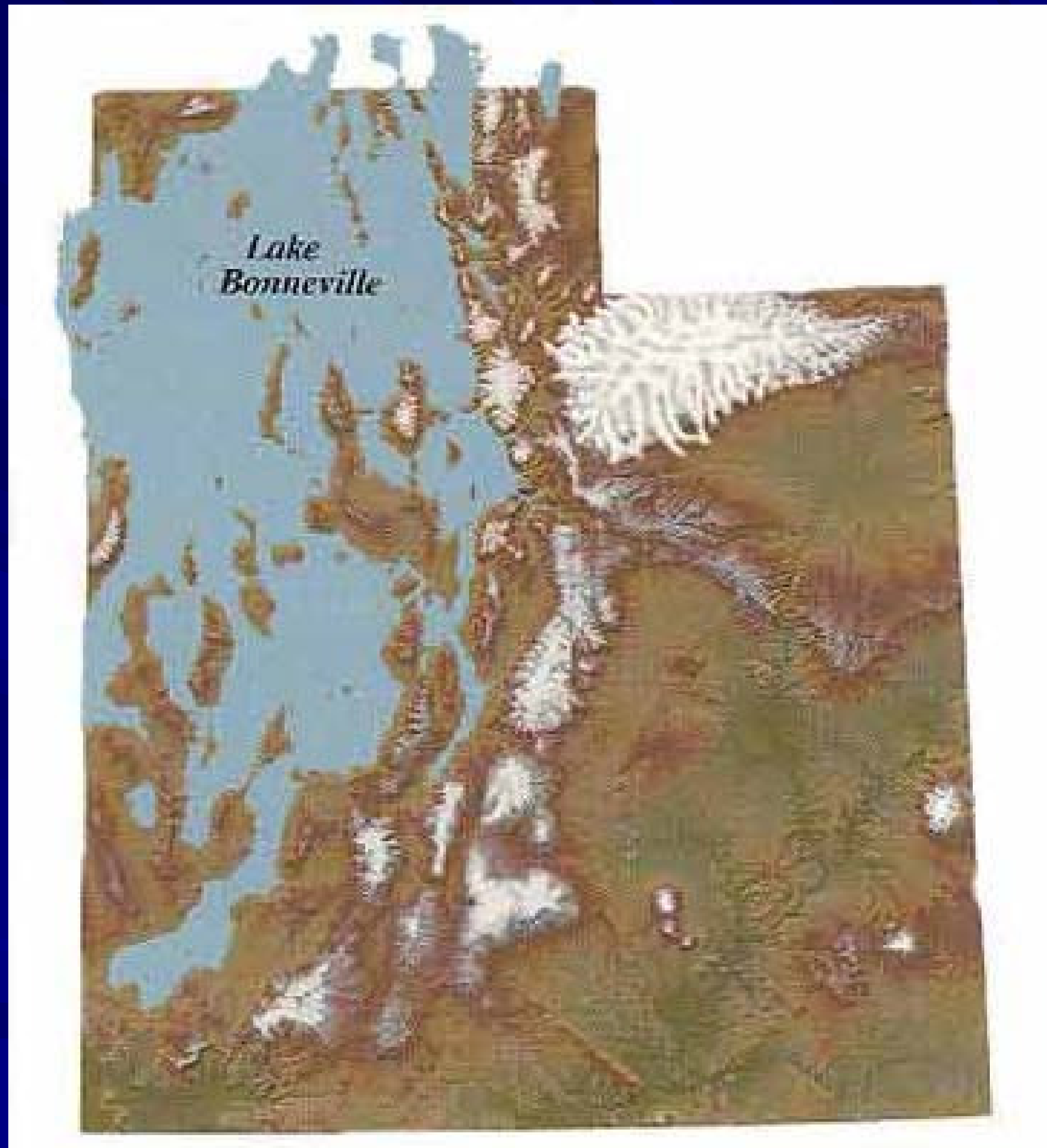
Fig. 2. The distribution of Lake Bonneville at its maximum size (adapted from Bissell 1968).

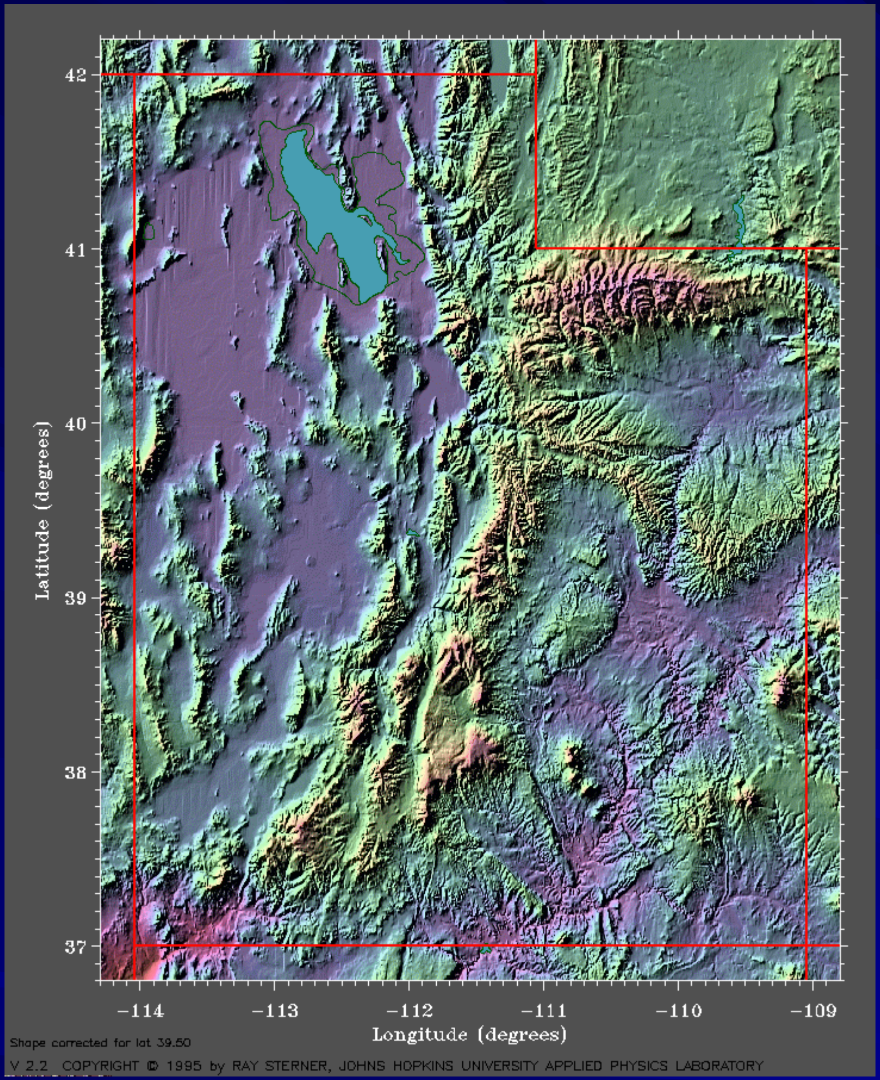
Utah Lake's Origins: Lake Bonneville.

Lake Elev. ft.



Geological Period


Lake
Bonneville


42
41
40
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Latitude (degrees)
−114
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−112
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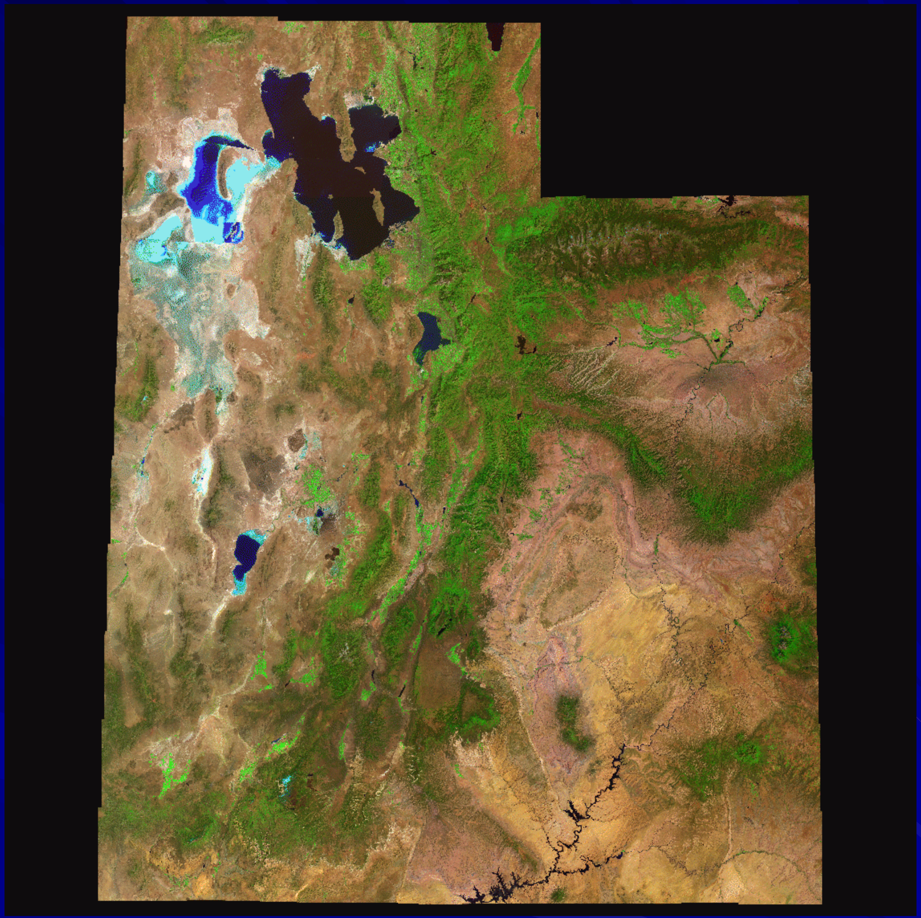
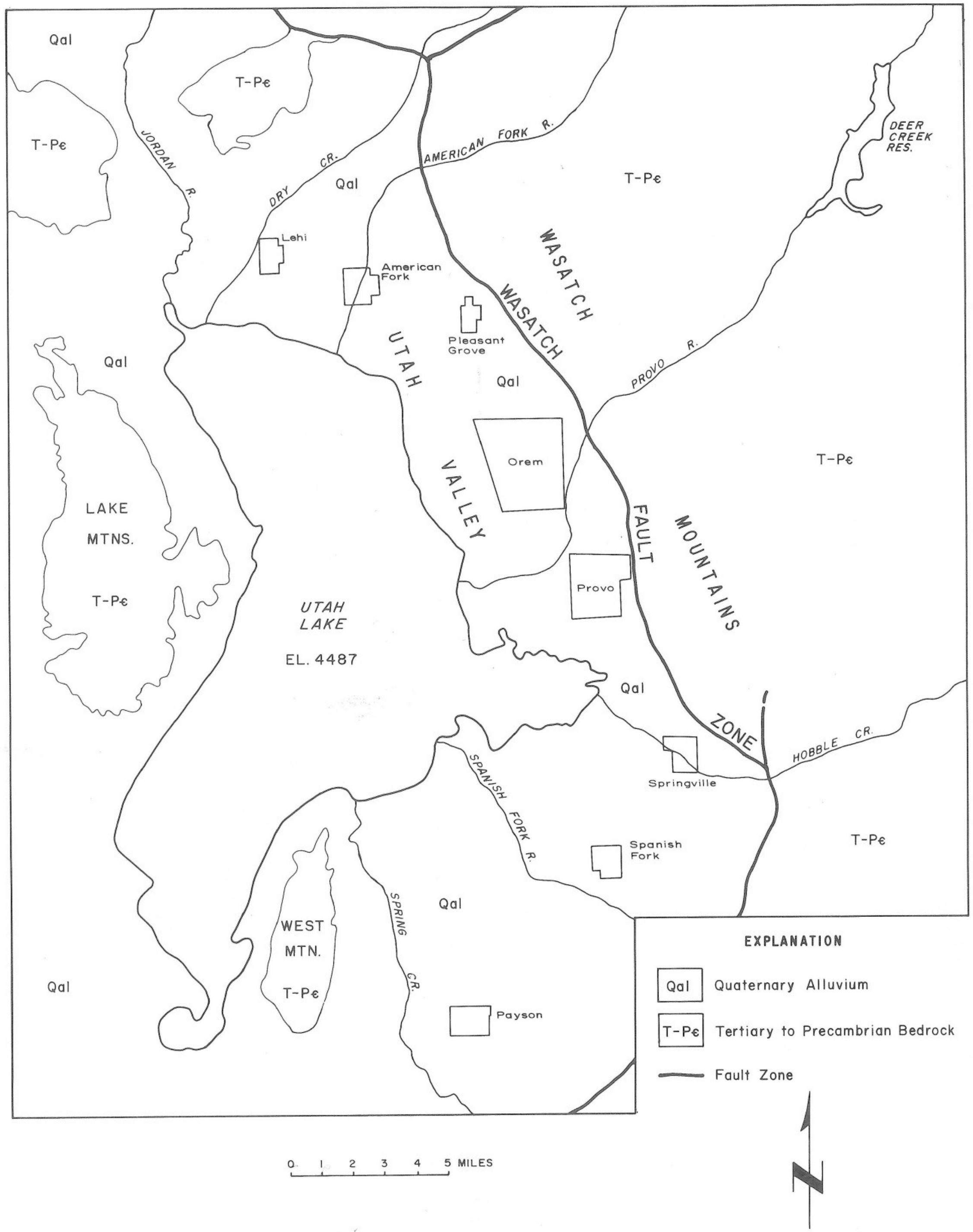
Longitude (degrees)
Shape corrected for lat 39.50
V 2.2 COPYRIGHT © 1995 by RAY STERNER, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY



Utah Lake


Qal
T-Pє
JORDAN R.
DRY CR.
AMERICAN FORK R.
DEER CREEK RES.
Lehi
American Fork
Pleasant Grove
WASATCH
WASATCH
UTAH
VALLEY
PROVO R.
Orem
LAKE
MTNS.
UTAH
LAKE
EL. 4487
Provo
FAULT
MOUNTAINS
ZONE
HOBBLE CR.
SPANISH FORK R.
Springville
Spanish Fork
SPRING CR.
WEST
MTN.
Payson
EXPLANATION
Qal Quaternary Alluvium
T-Pє Tertiary to Precambrian Bedrock
Fault Zone
0 1 2 3 4 5 MILES

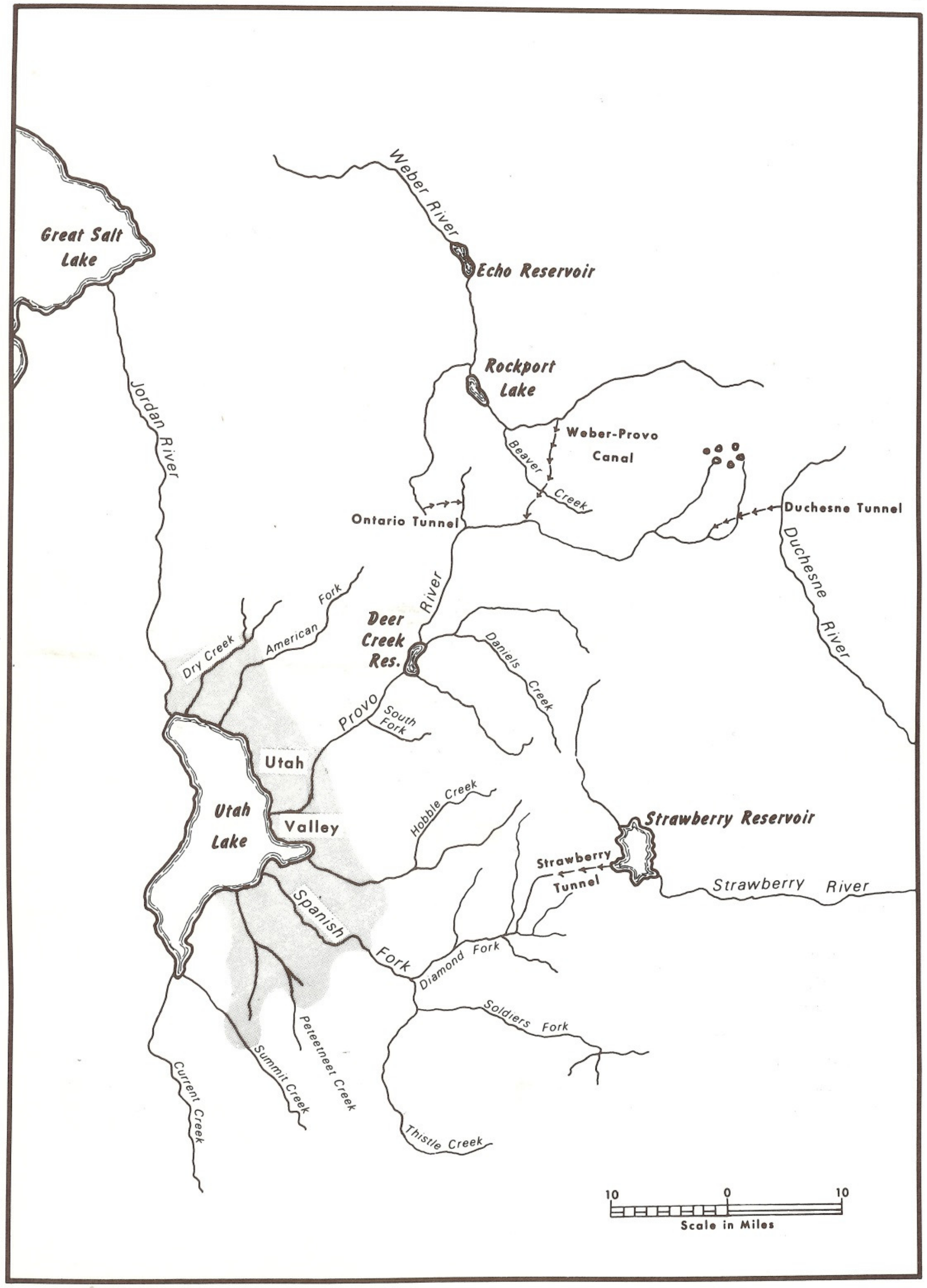


Fig. 1. Utah Lake drainage basin.

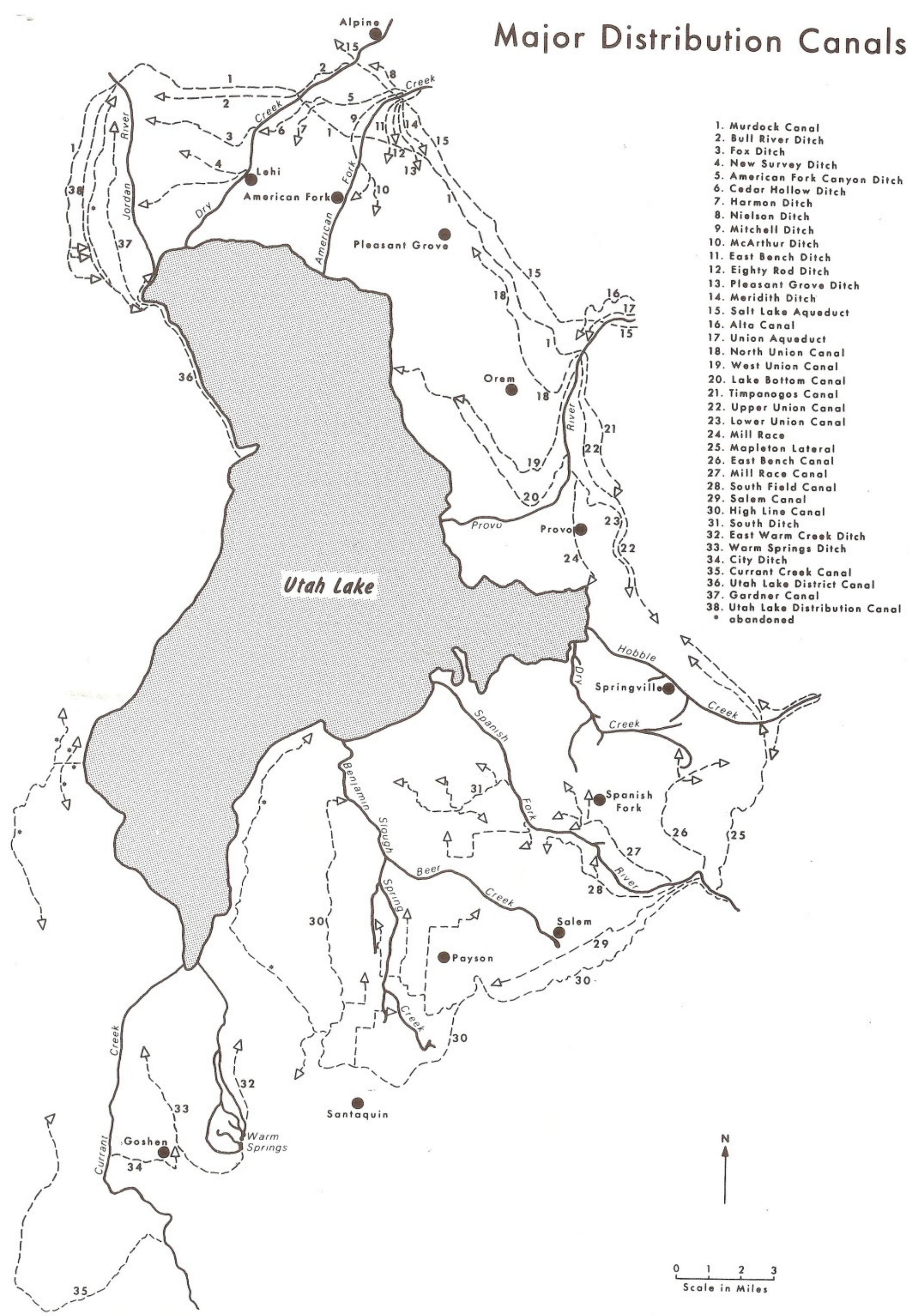


Fig. 5. Major distribution canals in the vicinity of Utah Lake.

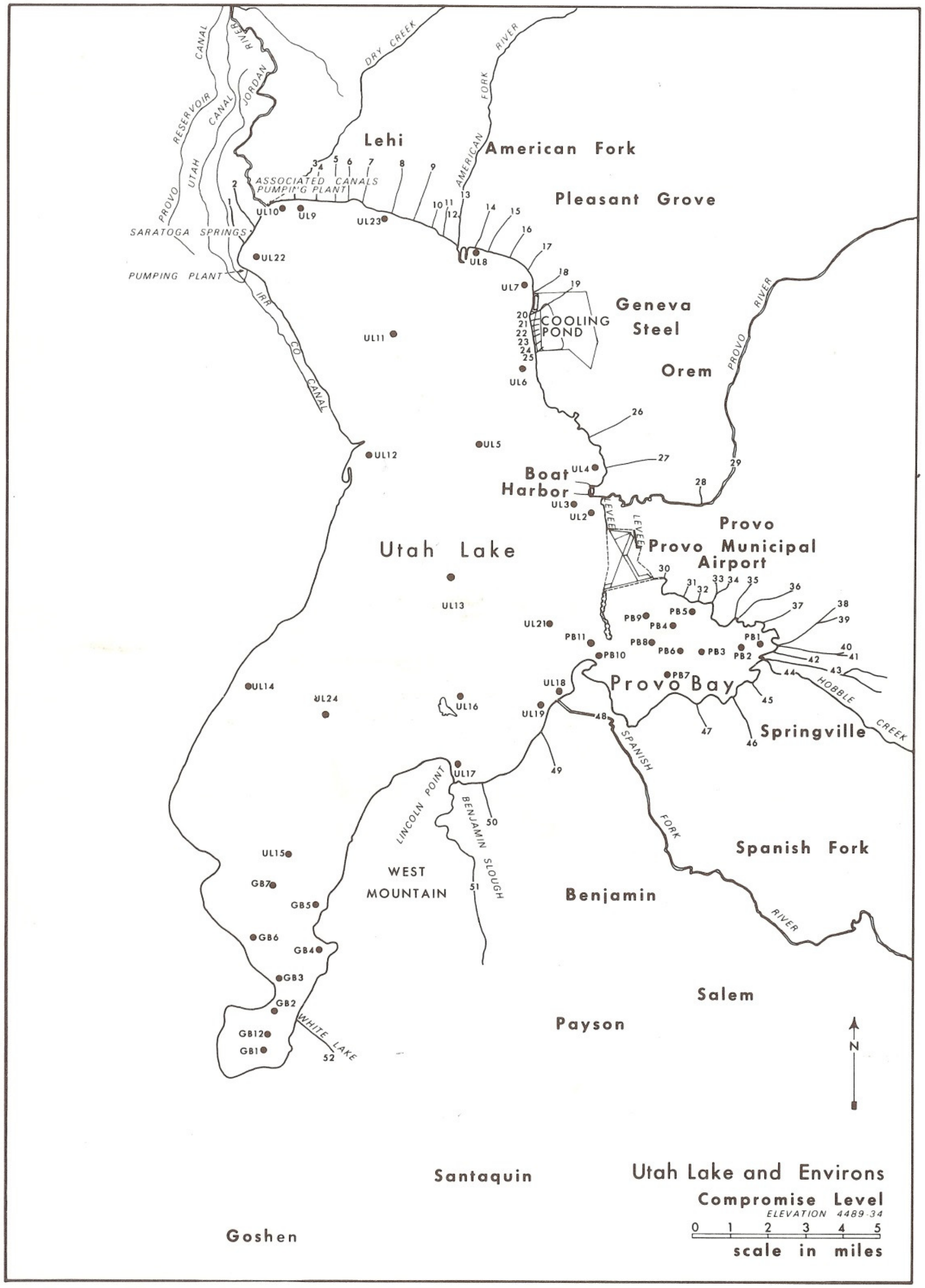


Fig. 2. Location and code numbers for Utah Lake sampling sites and code numbers of surface tributaries.

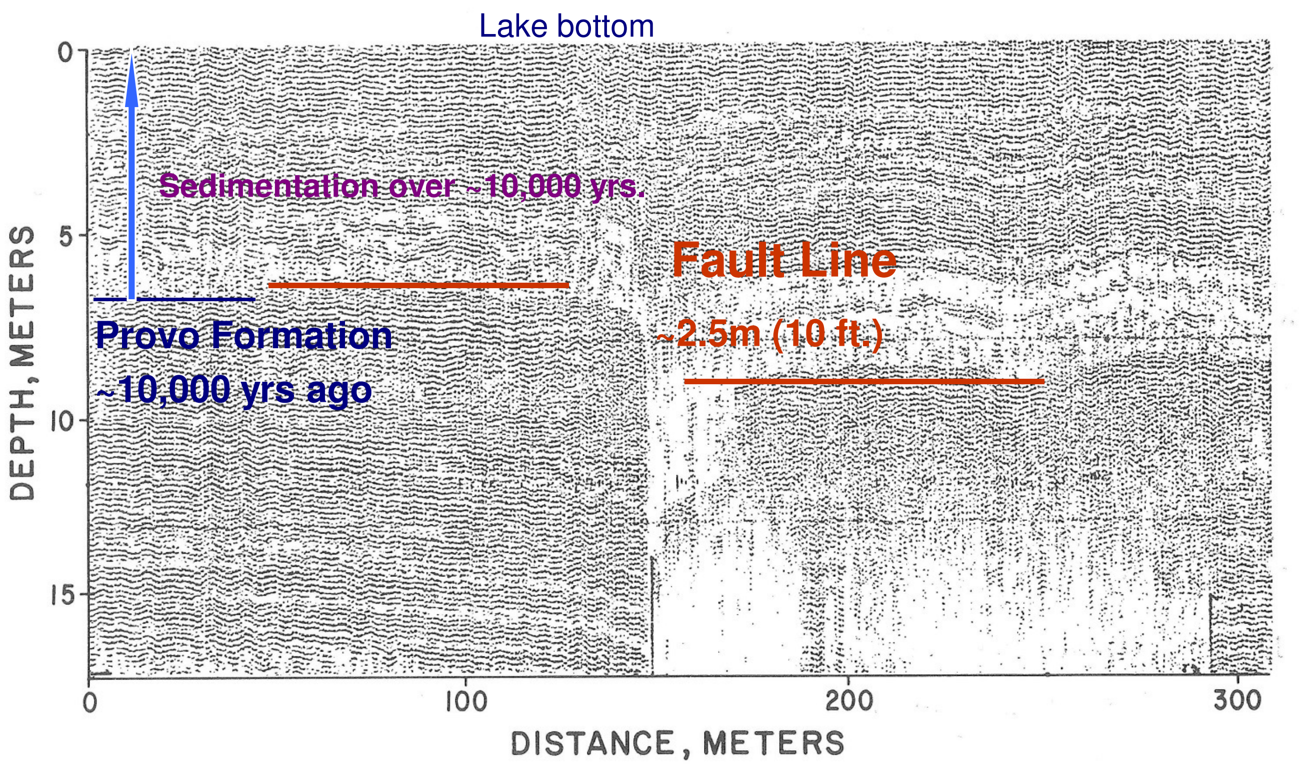


Fig. 10. A spectacular fault on the north end of West Jumbers Point Fault. The right-hand, eastern block is displaced downward about 2.5 m. The lower dark layer, between 7 and 9 m on the left side, is believed to be the clay unit of the Provo Formation.

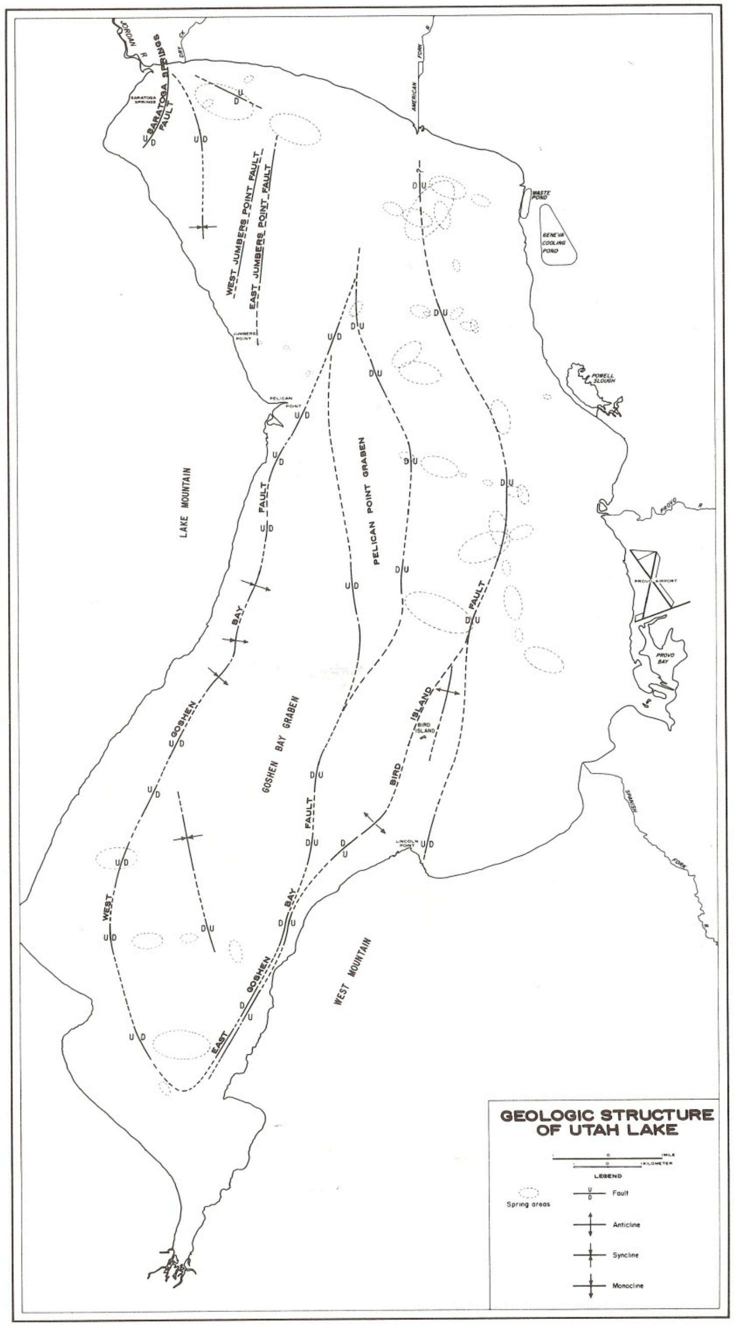
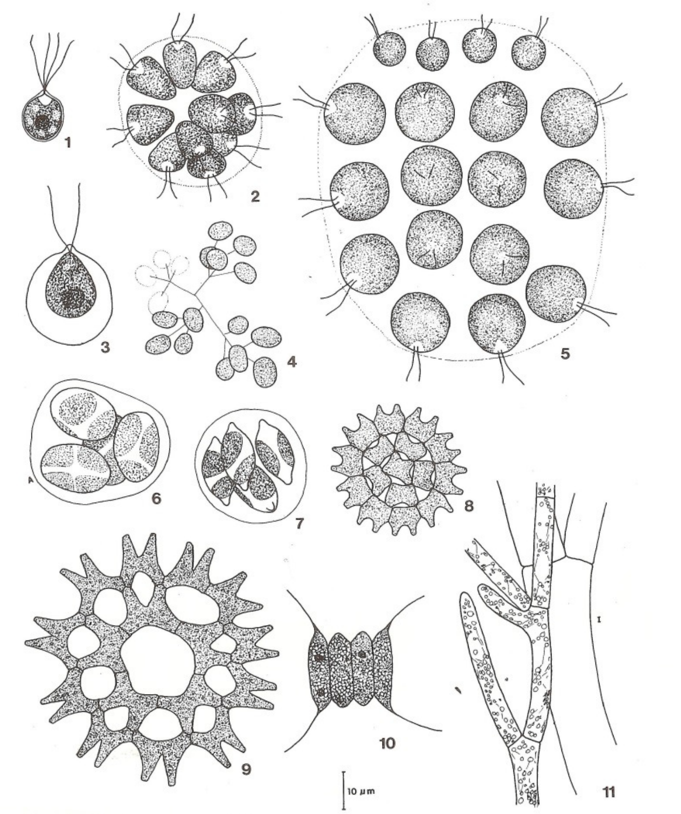
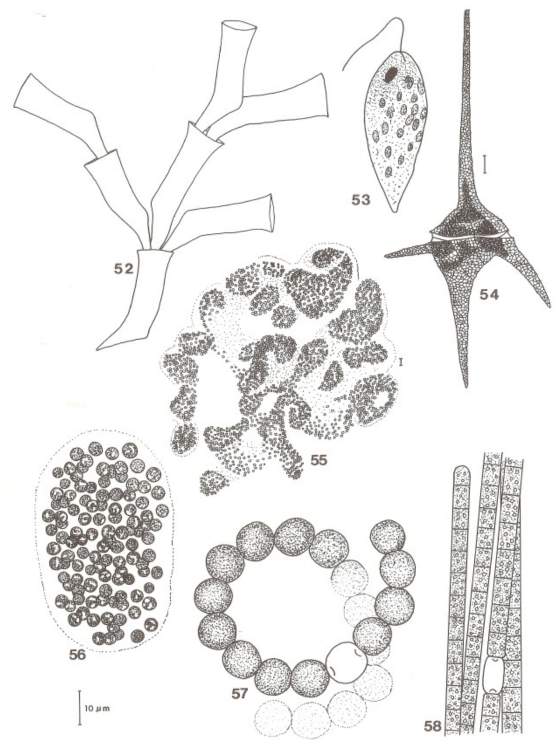


Fig. 9. The principal geologic structures present in the floor of Utah Lake, and the location of the presently known spring areas(adapted from Brimhall, Merritt, and Bassett 1976).

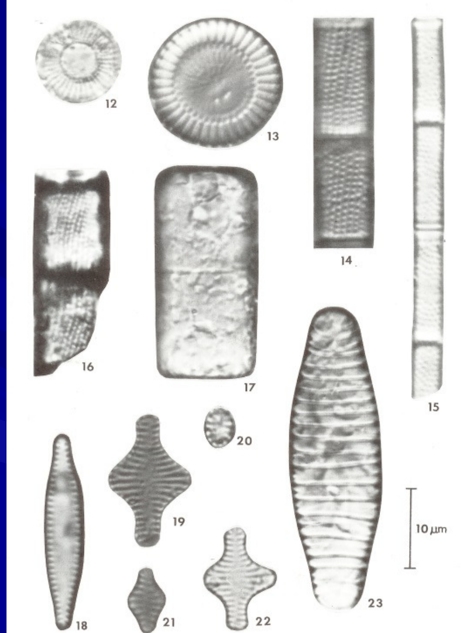

Johnson

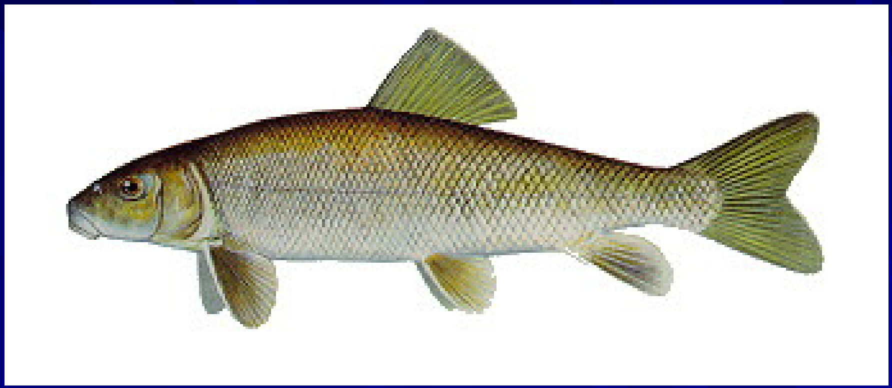
Figs. 1–11: 1, *carteria stellifera*; 2, *Pandorina morum*; 3, *Sphaerellopsis aulata*; 4, *Dictyosphaerium ehrenbergianum*; 5, *Pleodorina illinoisensis*; 6, *Oocystic borgei*; 7, *Oocystis lacustris*; 8, *Pediastrum duplex*; 9, *Pediastrum duplex* var. *gracilimum*; 10, *Scenedesmus quadricauda* var. *longispina*; 11, *Cladophora glomerata*. All figures except Fig. 11 are drawn to the same scale. Scales provided represent 10 μm.



Figs. 52–58: 52, *Dinobryon divergens*; 53, *Euglena gracilis*; 54, *Ceratium hirundinella*; 55–56, *Microcystis aeruginosa*; 57, *Anabaena spiroides* var. *crassa*; 58, *Aphanizomenon flos-aquae*. All figures except 54 and 55 are drawn to the same scale. Scales provided represent 10 μm.



Figs. 12–23: 12, *Cyclotella kutzingiana*; 13, *Cyclotella meneghiniana*; 14, *Melosira granulata*; 15, *Melosira granulata* var. *angustissima*; 16, *Melosira italica*; 17, *Melosira varians*; 18, *Fragilaria brevistriata* var. *inflata*; 19, *Fragilaria construens*; 20, *Fragilaria construens* var. *venter*; 21–22, *Fragilaria construens*; 23, *Diatoma vulgare*. All figures are printed to the same scale.





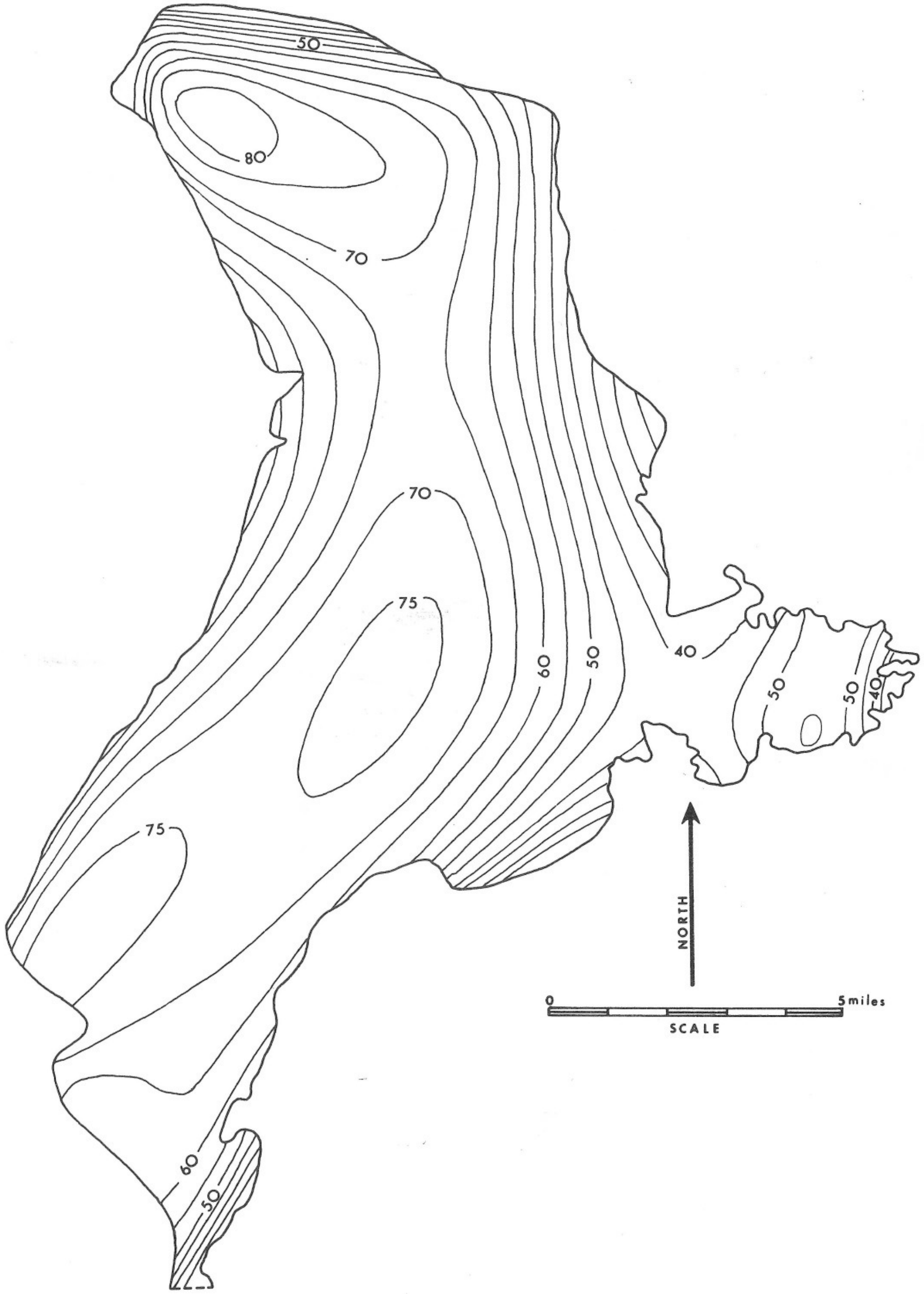


Fig. 7. Sixth degree trend surface map of calcite concentrations in Utah Lake sediments. Contours are in weight percent, dry sediment (adapted from Sonerholm 1973).

LKSIM—A water and salt balance model

--Operates on a monthly basis

--Based on the assumption that all of the water and "conservative" salts are tracked on a monthly basis

- Inflows—
  – Monthly flows for Provo River, Spanish Fork River and Jordan River
  – Annual flows for 50+ other tributaries including
  – Fresh groundwater
  – Mineral springs
  – Surface wash
  – Wastewater Treatment Plants

- Precipitation
  – Monthly values from Theissen Polygon evaluation

- Evaporation—
  – Calculations from the Morton model

LKSIM—A water and salt balance model

- Water Quality
  - Major ions (salts): TDS,Ca, Mg, Na, K, HCO3, Cl, SO4
  - & Phosphorus and Nitrogen

- Correlations with flowrate and seasons, but most are just average values for all of the available data.

Average Water and Salt Quantities for **1950-1999** (50 yr-CUWCD) Utah Lake Historical Simulation.

I. INFLOW

		af/yr	%1	%2	Salts---Percent of the Total Input							
					TDS	Na	Ca	Mg	K	Cl	HCO3	SO4
1.	**Surface Inflow**											
a.	Mountain Streams	254001.	42.5	35.9	24.4	11.4	33.7	28.9	13.0	8.8	35.7	21.7
b.	Wastewater Trt Plants	30008.	5.0	4.2	4.2	3.7	4.8	3.8	5.7	3.5	6.1	3.
c.	Other—Main Lake	122327.	20.5	17.3	21.0	16.0	20.9	27.9	22.4	11.9	25.7	23.
	d. Other—Provo Bay	62817.	10.5	8.9	9.9	6.1	12.9	11.4	7.8	4.3	12.4	12.8
e.	Other—Goshen Bay	6077.	1.0	0.9	5.4	10.2	1.0	3.7	6.0	11.0	1.4	5.7
	1. Sub-Total	**475230.**	**79.5**	**67.2**	**64.9**	**47.4**	**74.3**	**75.8**	**55.0**	**39.6**	**81.3**	**66.4**
	2. Fresh Groundwater											
a.	Main Lake	54124.	9.1									
b.	Goshen Bay	42276.	7.1									
	2. **Sub-Total**	**96400.**	**16.1**	**13.6**	**9.6**	**8.6**	**9.9**	**13.0**	**11.7**	**8.4**	**11.9**	**9.5**
	3. **Thermal/Mineral Groundwater**											
	a. Main Lake	24190.	4.1		25.0	42.9	15.6	11.0	32.8	51.2	6.7	23.4
	b. Goshen Bay	1363.	0.2		0.5	1.0	0.2	0.2	0.6	0.8	0.2	0.6
	3. **Sub-Total**	**25553.**	**4.3**	**3.2**	**25.5**	**43.9**	**15.8**	**11.2**	**33.4**	**52.0**	**6.9**	**24.0**
	1 + 2 + 3 Sub-Total	**597183.**	100.0		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	4. **Precipitation**											
	a. Main Lake	73191.										
	b. Provo Bay	6971.										
	c. Goshen Bay	29310.										
	Sub-Total	109472.		15.5								
	Inflow Total:	**706655.**		100.0								

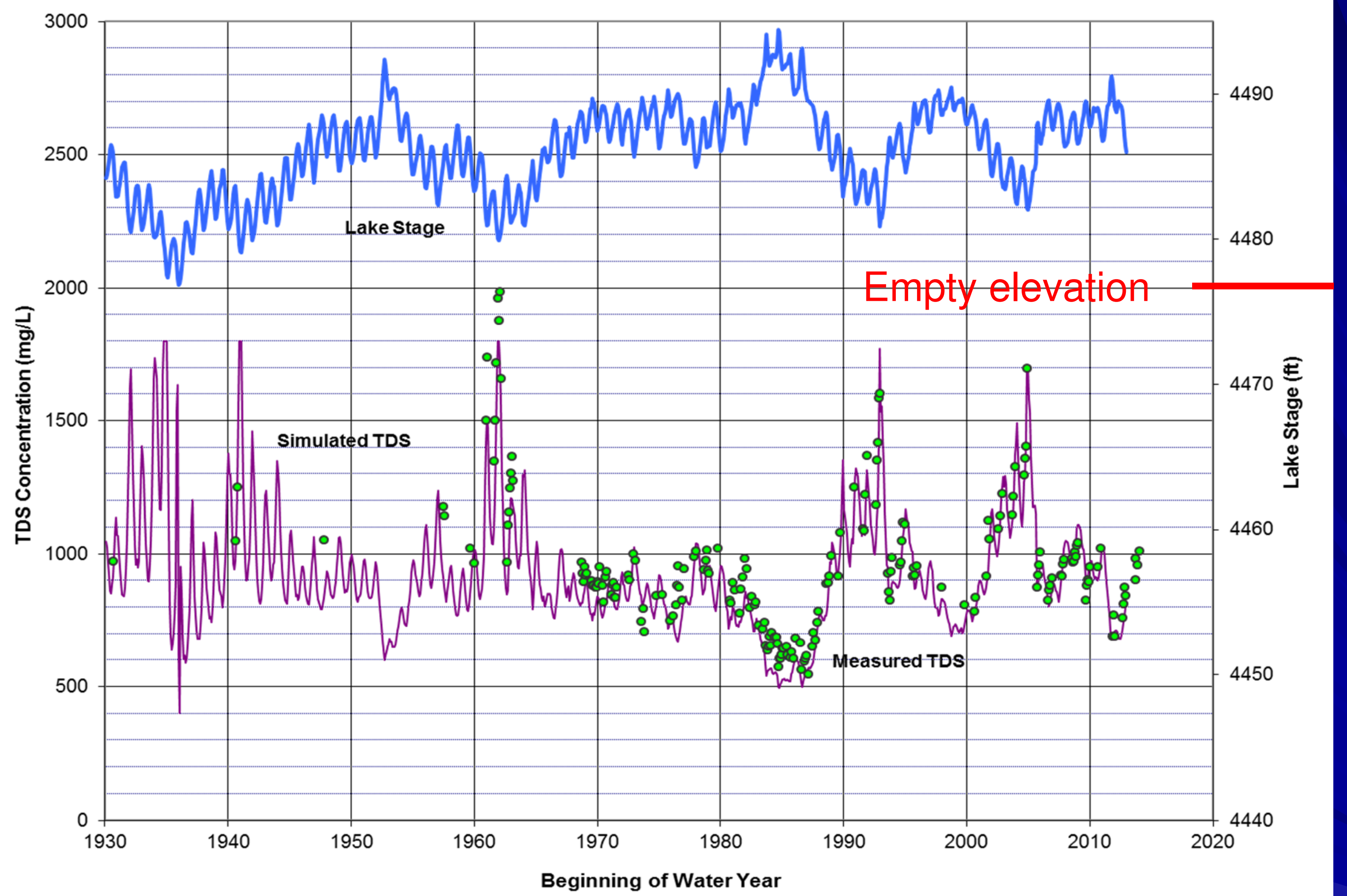
II. Outflow

		af/yr	%
	1. **Jordan River**	**359189.**	**51.2**
2.	**Evaporation**		
a.	Main Lake	228793.	32.6
	b. Provo Bay	19313.	2.8
	c. Goshen Bay	94566.	13.4
	2. **Sub-Total:**	**342672.**	**48.8**
	Outflow Total:	**701861.**	100.0

	TDS	Na	Ca	Mg	K	Cl	HCO3	SO4
Ratio: Total Salts Out/Salts In (%)	**76.0**	**99.7**	**45.0**	**99.6**	**100.0**	**99.8**	**52.8**	**100.0**

1 Based on Total w/o precipitation, 2 Based on Total Including precipitation

Utah Lake



Historical Total Dissolved Solids and Water Levels in Utah Lake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What is Utah Lake's natural setting?

- Over hundreds of thousands of years, a huge lake comes and goes sometimes accompanied by massive glaciers—with dry valley land and habitable conditions occurring occasionally between these inhospitable periods.
- Exists because of geologic fault movements—these cause earthquakes. About 10,000 years one deepened the Lake—making it some 20 feet deeper in some areas, but only 3 to 10 feet deeper in most areas.
- Over last ~10,000 yrs 15 to 20 feet of sediments have been deposited on the Lake bottom. If the fault movement hadn't occurred, the Lake would now just be a swampy pond—or not exist at all.
- A shallow, basin-bottom lake in a semi-arid area.
- Naturally turbid, slightly saline--eutrophic.
- It's water quality probably hasn't changed dramatically since its ecosystem stabilized after being formed as Lake Bonneville last receded about ten thousand years ago--at the end of the last ice age, well into the current cyclic global-warming period.
- Water quality about as at pioneer settlement about 150 years ago.

Utah Lake—A Few Considerations:

Why does the Lake level vary so much?

- It has a restricted outlet as do most natural lakes--spring runoff then drier summer/fall—outflow functions like a weir: $Q = CLH^{1.5}$

- Under "natural" conditions, levels varied some 4 to 6 feet within a year—4 feet of represents about 300,000 acre feet of water, or about 1/3 of the lakes volume.

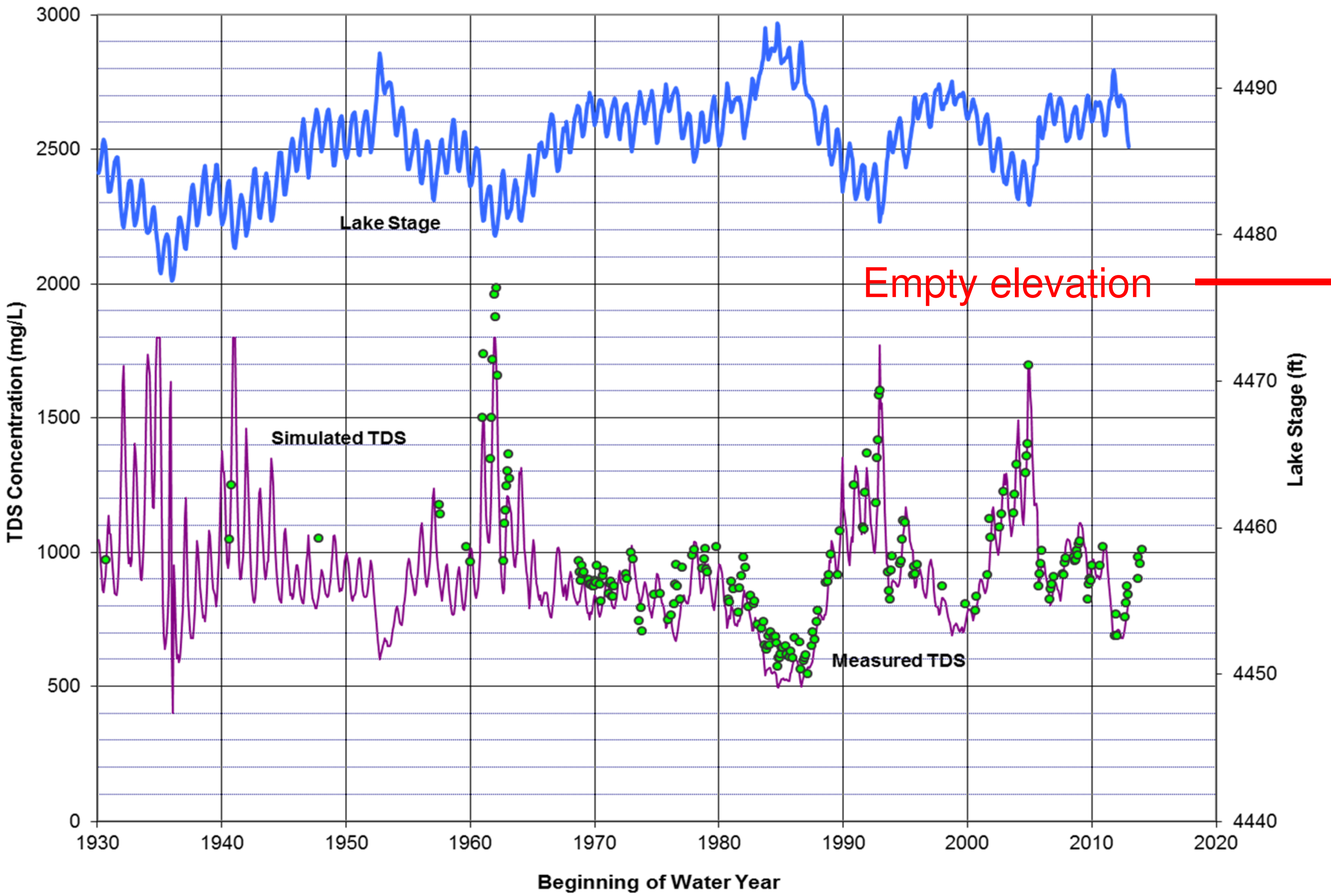
- Over several-year-long, wet and dry cycles a 15 foot, or so, depth change occurs.

- In a major drought, it becomes a pond only 3 or 4 feet deep with no natural outflow.

- Wet-dry cycles vary in magnitude and length, but currently fairly large drought cycles seem to be occurring about every 20 to 30 years.

- Since pioneer settlement, use of the Lake as a reservoir and diversion of tributary waters changes lake levels another 2 or 3 feet—usually increasing, but sometimes decreasing "natural" depth fluctuations.

Utah Lake



Historical Total Dissolved Solids and Water Levels in Utah Lake

Utah Lake—A Few Considerations:

Why aren’t there additional developed boat launch and recreation areas in the Lake?

- Much of the near-shore bottom slope is 1 to 2 feet per 1000 feet--so the shoreline moves large distances with relatively small changes in depth. A facility might face a mile or more to launch boats during a dry cycle—then face water 5 or 6 feet higher than wanted during a wet cycle.
- These cycles will continue--environmental/ ecology needs and water rights/storage rights, combined with ongoing wet and dry cycles, will cause depth variations about the same as in the past—a difficult challenge to shoreline recreational facilities.

Is Utah Lake polluted?

- Utah Lake has good overall water quality, given its basin-bottom location and its "rich" biological nature.
- But it can never be a clear mountain lake due to its shallow, biologically rich, wave-stirred nature.
- The Lake has an excellent natural capacity for stabilizing both natural and man-caused "pollutants." Its high oxygen levels, along with naturally high pH levels, are favorable for stabilizing/ binding many pollutants.
- Water quality has not changed much over the recent 40 year period, and in some ways quality has significantly improved—remember that just 50 years ago, most sewage and industrial wastes flowed untreated into the Lake.
- Nevertheless, since the Lake is "downstream" of many everyday activities, too frequently its tributaries are used as "convenient" dumps for unwanted chemicals and other garbage and trash; some of which is carried into the Lake.

Cont.

Is Utah Lake polluted? *Cont.*

- We have cleaned up many discharges via better treatment and management and greatly reduced many pollutants in the lake.
- But not all problems are solved. Eg., the States recent (2007) study on Polychlorinated Biphenyl (PCB) in fish in Utah Lake,--found some violations of allowable PCB levels in some fish species (Carp and Channel Catfish).
- Prevention and elimination of pollution is a wise approach—For most of the exotic pollutants of concern today, cleanup and restoration are usually monumentally more costly than the cost of proper disposal/prevention at the source.

Why is Utah Lake so dirty and muddy, and sometimes stinky?

- Utah Lake is naturally turbid (opaque/cloudy)—largely due to fine Calcium Carbonate, mingled with other mineral precipitates and organic matter.
- These flocculent bottom sediments are frequently stirred up by wind-driven waves in this shallow lake, giving it a milky grey-brown to milky grey-brown-green appearance much of the time.
- On the average, sedimentation is filling in the Lake about 2 inches every 100 years. Utah Lake is very productive biologically—growth and decay of all of its plant and animal life sometimes results in “swampy” conditions.
- Some observers have speculated that the increased turbidity caused by Carp might be a good thing—to help increase the turbidity—more light-limitation to algae growth. This is likely a minor factor in this case.

Why is Utah Lake slightly salty at times--is this a problem?

- About half of inflowing water evaporates—about 4 feet annually. Precipitation averages 1 foot, so net evaporation is 3 ft—about 230,000 acre feet a year.
- Enough water to supply a city of about one million people, or to irrigate about 70,000 acres.
- Evaporation nearly doubles TDS compared to avg inflowing water.
- Numerous mineral springs also flow into the Lake; these thermal, slightly salty springs range in TDS--typically 1500 mg/l to 7000 mg/l. These springs supply only about 4% of the water but carry in 25% of the salts.
- The net result is that TDS in the Lake is about 2 or 3 times higher than average inflowing waters.
- Cycles result in the TDS varying markedly over time, between about 500 mg/l and 2000 mg/l.

Cont.

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Cont.

Why is Utah Lake slightly salty at times--is this a problem?

- Water spends 1 to 4 years in the Lake--time varying with wet and dry cycles. The lake's plant and animal communities seem to be adapted to this natural salt range and these salt fluctuations don't seem to be a significant threat to them.

- Modeling simulations indicates TDS is some 35% to 45% higher as compared to pre-settlement conditions about 150 years ago.

- TDS levels in the Lake make its waters marginally acceptable-unacceptable as a source of drinking water, particularly during dry cycles when it would be needed the most. Biological residues also treatment problem.

- Advanced treatment likely cost 2 to 3 times more than current treatment plants using higher quality source waters. Jordan Valley regional water agency reports--cost of advanced treatment (Reverse Osmosis) is not much above the cost of developing large new, higher quality water sources.

- For traditional irrigation, most Utah soils/crops don't experience significant salt damage from irrigation water until its TDS is above about 1,500 mg/l. The 1,200 mg/l "standard" level is occasionally exceeded in Utah Lake during prolonged droughts.

Are algae in Utah Lake bad?

- Algae are a natural and vital part (base) in aquatic food chains—excessive algae growth causes water quality and habitat quality problems. Some types of algae found seasonally in the Lake, primarily the cynobacteria (blue-greens), can be particularly troublesome and even toxic at times.

- Diatom algae shells are an indicator of past conditions in the Lake--Studies of sediment cores taken from Utah Lake indicate that the types and relative amounts of diatom algae have not changed substantially over the last few hundred years—this consistency indicates that environmental and water quality factors have likewise been fairly constant over this time period.

- **Is Phosphorus a pollution problem in the Lake?**

- Very high levels of Phosphorus, Nitrogen and other nutrients occur in Utah Lake—even naturally. Even if man-caused sources were controlled/ removed--very high nutrient levels would still be found in the Lake.

- However, the amount of these nutrients likely a mute point since overall algal growth appears to be largely limited by the lake's natural turbidity (light limitation).

- This being the case, the high levels of Phosphorus, Nitrogen and other nutrients found in the Lake are of less concern.

- In tributary waters and Lake bay areas, high nutrient levels may or may not cause excessive algae growth and "pollution" problems, depending on specific conditions found in those waters.

Cont.

Is Phosphorus a pollution problem in the Lake? *Cont.*

- Phosphorus and Nitrogen are not directly toxic or poisonous to man and higher animals until much, much higher than the concentrations of concern relative to the stimulation of algae growth.

- Another interesting point--many lakes in Utah are Nitrogen-limited rather than Phosphorus-limited—this is likely the case with Utah Lake

- Practices to control nutrients coming from agriculture, land erosion, storm runoff, etc, commonly concurrently reduce levels of both Nitrogen and Phosphorus. But treatment systems for sewage and many industrial wastewaters must be targeted at the specific nutrients

Why aren't trout abundant in Utah Lake anymore?

- The Bonneville cutthroat trout was abundant in the Lake until the late 1800s. --many weighed more than 10 lbs.

  --Over-fishing, competition from introduced fish species, and interferences with stream spawning and migration cycles caused by dams and diversions for irrigation, resulted in low trout numbers by 1900.

  --the 1930s drought when they encountered extremely low and warm water in both the Lake and its tributaries—eliminated them.

  --Many of these factors continue to severely challenge some other native species in the Lake, particularly the endangered June Sucker.

- Lake supports a premier warm water fishery with very high levels of fish production--greatly underused.

Cont.

- **Why aren't trout abundant in Utah Lake anymore?** *Cont.*
- The June Sucker listed as an endangered species.
- Restoration plans include large reduction of Carp--some 6 to 8 million adult carp are in the Lake.
- The huge Carp population has devastated the rooted aquatic vegetation.
- Contributed to significant deterioration of the aquatic ecosystem, particularly in the lake's shallows, inlets and bays.
- A large reduction in Carp will not change water quality much in the main lake, but should result in major improvements in the lake's ecosystem,

  --More vegetation needed--many areas now largely devoid of aquatic and shoreline vegetation.

If the Lake were deeper would it be clearer?

- Yes—during early spring and late fall, but likely no during the summer and early fall.
- If the Lake were deeper, wave energy less to stir up flocculent bottom sediments--Problem: increased transparency would trigger more algae growth--many more “algae blooms” would occur.
- Seasonal stratification would likely occur where the Lake was deeper than about 15 feet. In this climatic region, more turbid lakes, persistent summer stratification might occur in water as shallow as 10 to 15 feet deep.

What maximum dredged depth might work for Utah Lake?

- Difficulties in dredging aside—lake depths of about 15 to 17 feet in the late Spring, going to 12 to 14 foot depths during the Summer and Fall would likely result in noticeably lower turbidity except—
- During the maximum algae growth period from mid-summer into mid-fall, large increases in algae blooms would likely occur.
- Large scale dredging may not be feasible for a variety of ecological, engineering and economic reasons. For example, dredged bottom sediments are a clayey material—when exposed to the air, they shrink, crack and become very hard when dry, or become swollen and mucky when wet.

Could a road causeway or bridge be built across Utah Lake?

- Yes, but huge environmental, engineering and financing problems exist, very difficult and expensive!
- The bottom of Utah Lake is a very poor foundation. A fill causeway would need a very wide base (several hundred feet wide) or be on support piles—the roadway at least 6 to 8 feet above the highest lake level .
- Settlement of at least several inches a year would occur under the causeway. A couple of bridges and likely many very large culverts would be needed to allow for good water and aquatic biota circulation through the causeway--to minimize impacts on the lake's ecosystem.
- If built, likely the best solution, both structurally and environmentally, would be a low bridge-type roadway built on pilings driven into the Lake bottom At one or two locations, spanning bridges would be needed to allow boat passage.
- A bridge structure would be even more expensive.

How about a residential/recreational Island(s) in Utah Lake?

- The concept of constructing at least a few hundred acres of residential and recreational islands in the Lake is appealing to many people—perhaps linked together by a causeway or bridge across the Lake.

- Sale of the “reclaimed” land for residential and commercial use might provide hundreds of millions of dollars to fund the island-building project and perhaps other development, recreational and enhancement projects.

- Lake-bottom sediments adjacent to islands could be dredged from the Lake to provide much of the needed fill material. A few years of settlement would be necessary before utility and building construction could begin.

Why not just dike or fill in much of Utah Lake and use it for agricultural lands/other developments/constructed wildlife habitat?

- At this point in our National experience, lake and marshland areas are considered too valuable to allow further significant encroachment /destruction of them.

- Though “reclamation” diking very unlikely--only the Provo Bay area has bottom sediments/soils that could be readily farmed/cultivated/developed-- The rest of the Lake has largely the clayey Calcium Carbonate type sediments that are not suitable for farming nor development without major stabilization work.

- Major environmental issues would be encountered with large scale diking. The stabilized level would probably need to support large marsh and wetland areas and result in little, if any, additional land acreage for farming or development. Also, the diked area would likely suffer from several feet of flooding for a few months about every 30 years or so.

Are major improvements in the Utah Lake ecosystem feasible?

- This issue is very complex. Major ecosystem improvements or restorations tend to be difficult to formulate and very expensive to implement, both in direct costs and lost opportunity costs for competing uses.
- Many of the pressures on bird and animal populations are not associated directly with water quality or the lake's existing habitat, but on tributary and watershed issues.
- Shoreline vegetation and habitat will likely benefit from current water development plans and projects of the Central Utah Project which will reduce the magnitude and frequency of extremely high and low lake levels.
- With reasonable attention to ecosystem preservation and enhancement, where feasible, the Lake can continue to support very rich and diverse plant and animal communities.
- Appropriate emphasis on the preserving and enhancing the ecology of Utah Lake doesn't preclude additional "development" on and near the Lake, but environmental sensitivity will be extremely important.

Utah Lake—A Few Considerations:

What will Utah Lake be like in the future?

- Water quality in the Lake is not likely to change significantly for the foreseeable future, as long as wastewater treatment, agricultural pollution control and other pollution control requirements all ready in force are continued.

- A State “Total Maximum Daily Load” (TMDL) water quality study currently underway is charged with determining whether additional control is needed to actually protect stated lake beneficial uses; this study targets the occasional violation of the Phosphorus and TDS limits under the use classifications assigned to the Lake. It is unlikely that significant new restrictions will be implemented since it doesn’t appear that any significant problems are actually associated with occasional exceedences of these two water quality parameters.

Cont.

What will Utah Lake be like in the future? *Cont.*

- Regardless, Utah Lake will not be clear, or deep, or bordered by expansive clean, sandy beaches—although some exist and others can be expanded.
- It will continue to be a shallow, turbid, slightly saline, eutrophic lake, largely bordered by marshy wetland areas—yet still tremendous water, recreational and ecological resource.
- Natural flooding, wetland protection laws, threatened native species and/or environmental impacts will limit development near the shoreline. A causeway(s), bridge(s) or dike(s) will probably be built across the Lake sometime in the future.
- The Utah Lake Commission that was formed recently, at last establishes an authorized, recognized, representative body, which will give long term continuity in addressing lake issues and hopefully be pivotal in generating wise consensus on lake use and management issues.


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