HEALING THE GREAT SALT LAKE?

THANKS TO USGS:
GROUND WATER ATLAS of the UNITED STATES Arizona, Colorado, New Mexico, Utah HA 730-C

Ground Water Atlas of the United States: Segment 2, Arizona, Colorado, New Mexico, Utah

STORY OF THE PUMP!

THE SOLUTION MUST INCLUDE…

(OUR PREDISPOSINTION TO EMBRACE SUFFERING
WILL STIFLE OUR SOLUTIONS AS MUCH AS OUR AVERSION TO BEING RESPONSIBLE IN WATER USE.)

This cursory proposal to utilize Deep Saline aquifers as a medium to heal the Great Salt Lake “albeit” very superficial has support and input from some of the best and brightest professionals in their areas of expertise.

- With deep appreciation, I want to acknowledge the contribution of the United States Geological Survey and their **GROUND WATER ATLAS of the UNITED STATES** from which much of this information was taken. Principally the information on the Great Basin and the Colorado Plateau have been very helpful.
- I acknowledge to skilled efforts of the University of Utah’s EGI department, and Rich Esser, whom I have known for years and respected his work. I appreciate him being here with me today.
- I am grateful to Brian Black, Mahmood Ackmedeny, of MI-3 Petroleum Engineers Consulting, in Golden Colorado, for his work on the more granular portion of this presentation.
- The work you see today could not have been done without the herculean efforts of the Utah Geologic Survey.
- The presentation has contributors from the UofU, BYU, Colorado School of Mines, New Mexico Institute or Mining and Technology, along with scientists who ae alumni of Los Alamos National Labs and Sandia National Labs. Most of these contributing scientist and engineers have either Phds or masters degrees in their fields

- I truly appreciate their support and work. All of them see the great need to heal the GSL!

PERSPECTIVE of EVAPORATION

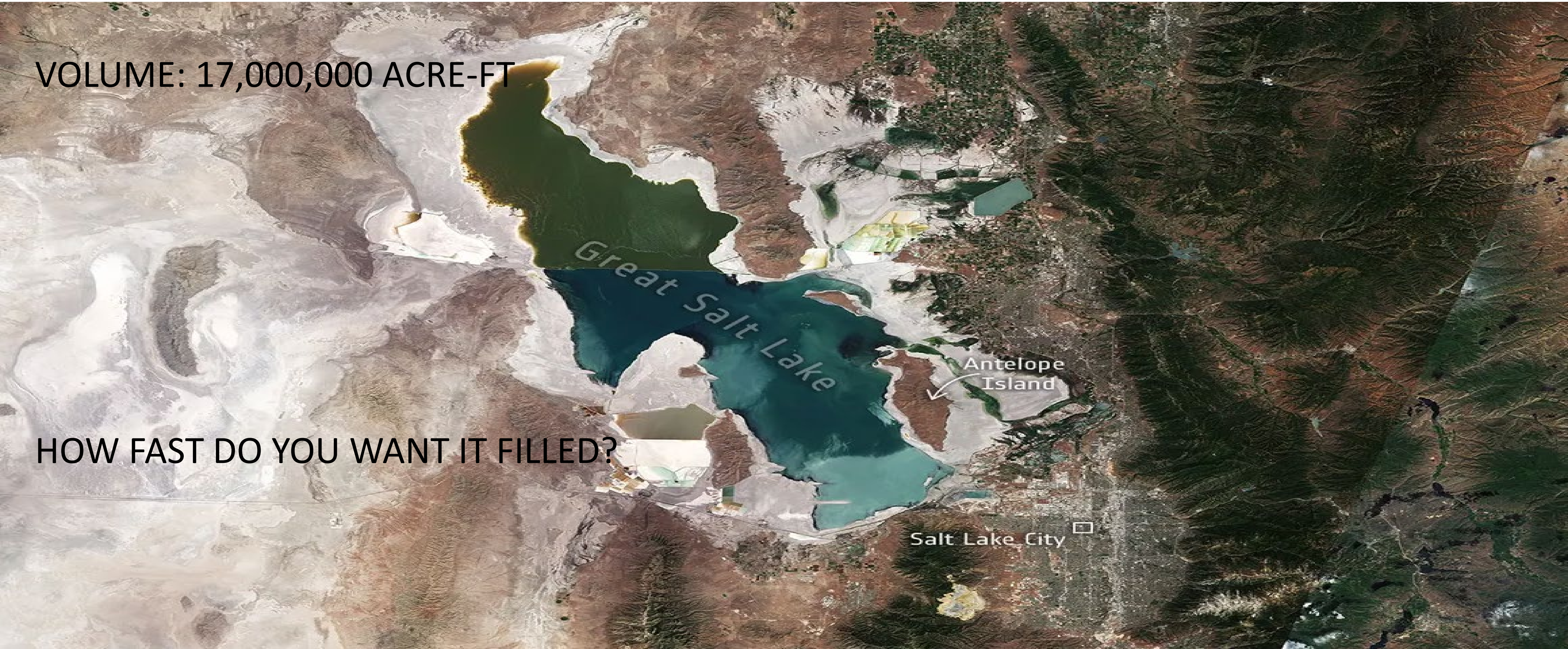
Evaporation Rate: 3,000,000 acre-ft/yr

8200 acre-ft per day

12 square miles –ft per day

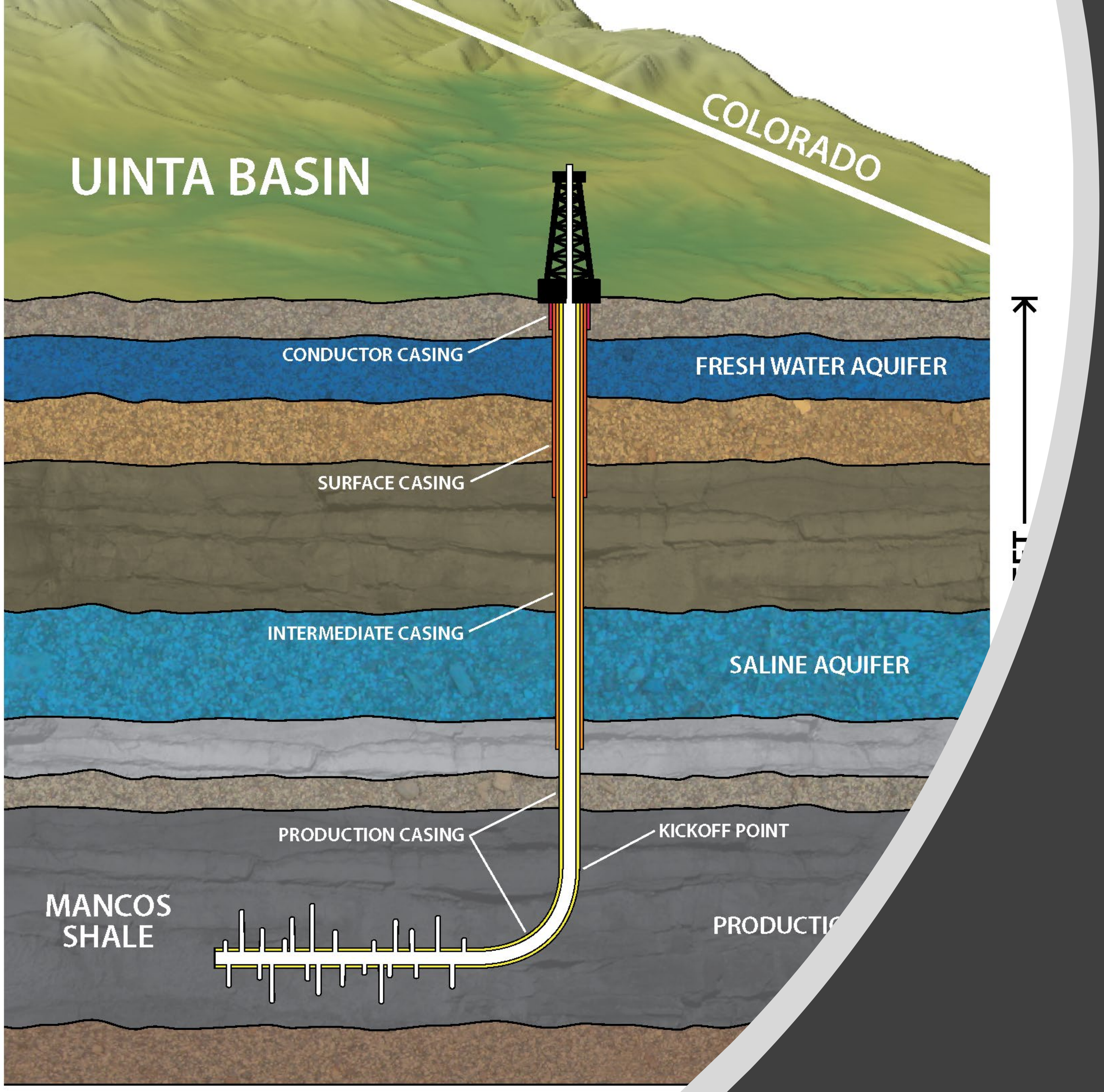
Layton Utah area: 22 square miles/day

IS THERE ENOUGH WATER IN DEEP AQUIFERS?



VOLUME: 17,000,000 ACRE-FT

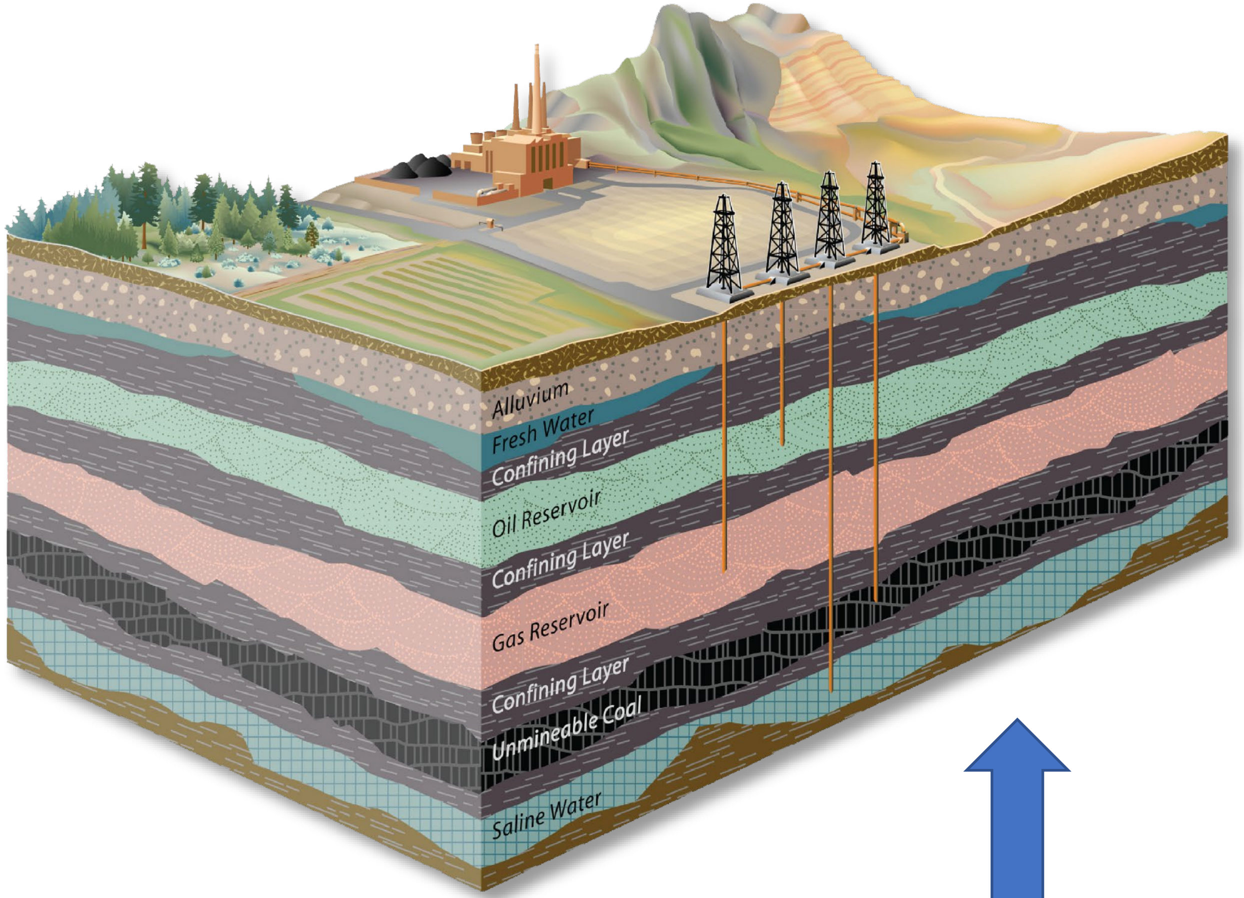
HOW FAST DO YOU WANT IT FILLED?

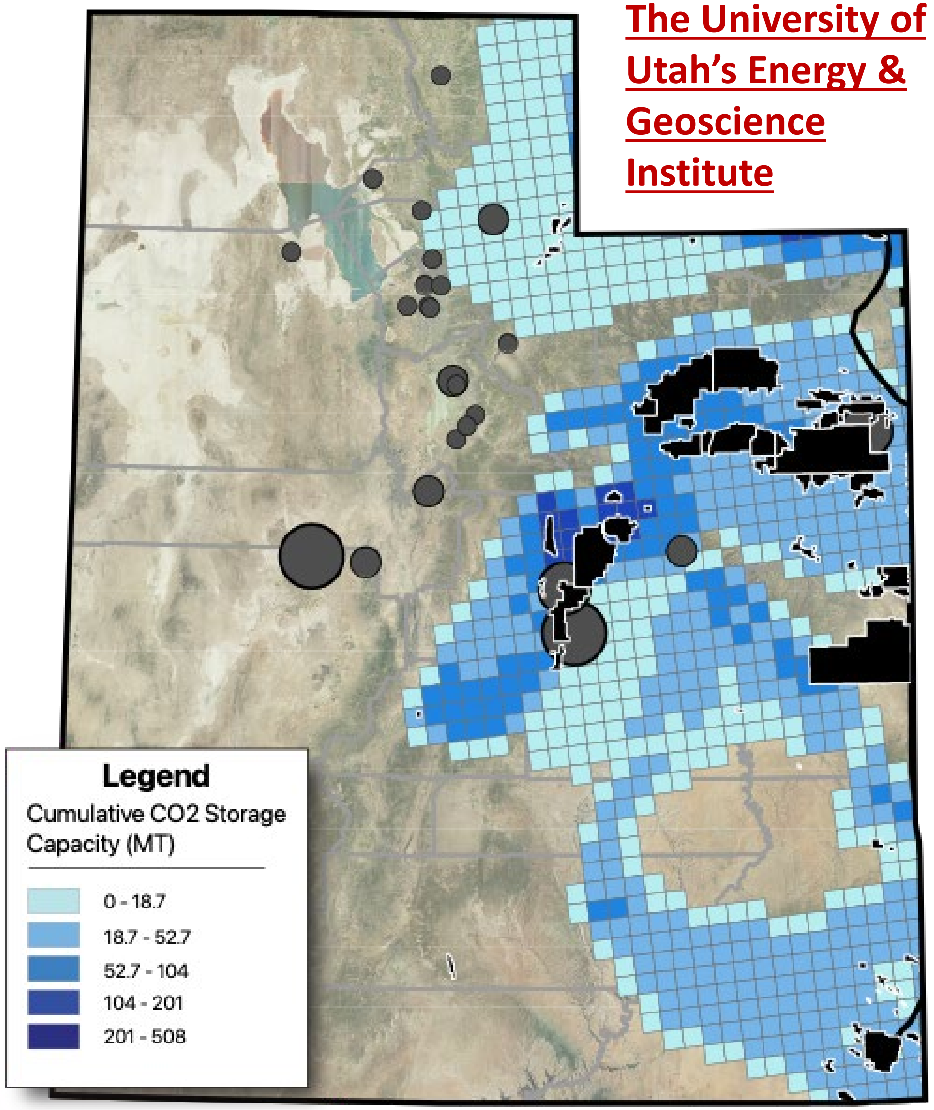


PROPOSAL TO DRILL DEEP SALINE AQUIFERS TO HEAL THE GREAT SALT LAKE

Utah’s Deep Saline Aquifers

The University of Utah’s Energy & Geoscience Institute Has Characterized Deep Saline Aquifers throughout Utah





DEEP APPRECIATION TO: The University of Utah’s Energy & Geoscience Institute

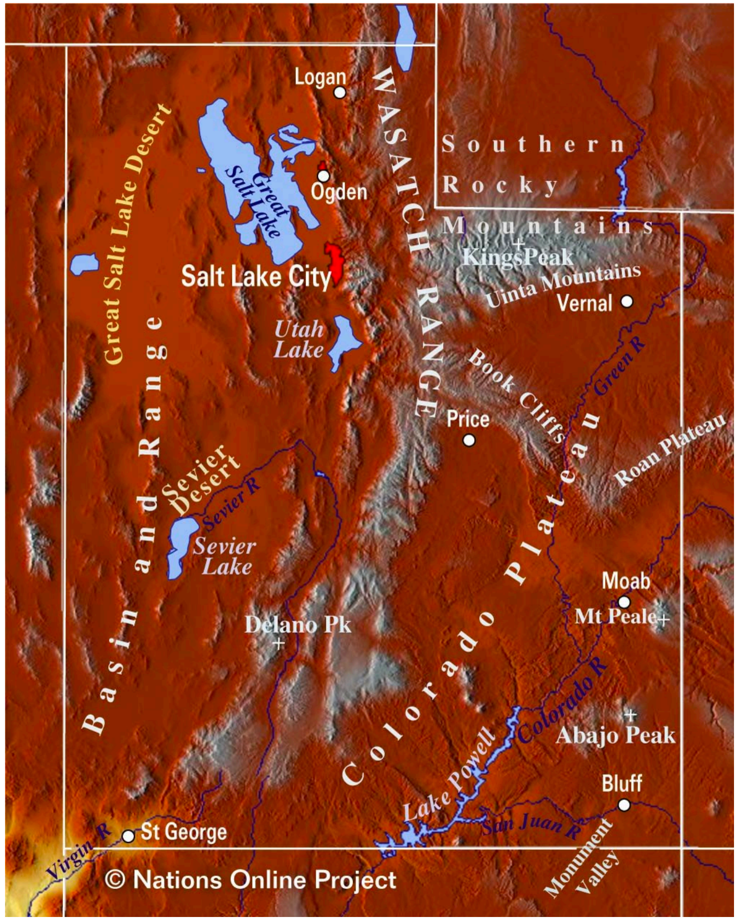
VOCABULARY

- AQUIFER: Carbonate or Sandstone formations containing ground water
- GROUND WATER: Water in an Aquifer, Precipitation or Meteoric
- METEORIC WATER: Rain or Snow
- DISCHARGE: Water taken from an aquifer
- RE-CHARGE: Water put into an aquifer
- BASIN: Area between mountain ranges (Graben)
- RANGE: Mountains bounding a basin
- BASIN AND RANGE STATE: Several States in the Western USA (Utah)
- BASIN FILL: Unconsolidated sand and gravel
- ALLUVIAL FILL: Erosional material from Ranges
- BED ROCK: Rock under a Basin and Range

THE GREAT BASIN

MAP OF UTAH SHOWING BASIN AND RANGE

A Basin and Range State consists of multiple ranges of mountains divided by Basins.
The Wasatch Mountains are significant in Utah because to the major way they divide the State into the Great Basin and the Colorado Plateau.



The Wasatch Mountains basically divide the Great Basin and the Colorado Plateau.

Both the Great Basin and the Colorado Plateau are germane to the discussion of healing the GSL.

This presentation is an attempt to provide superficial information on the relevance for both the Great Basin and the Colorado Plateau deep saline aquafers

Cross Section of a basin
Horst and Graben structure

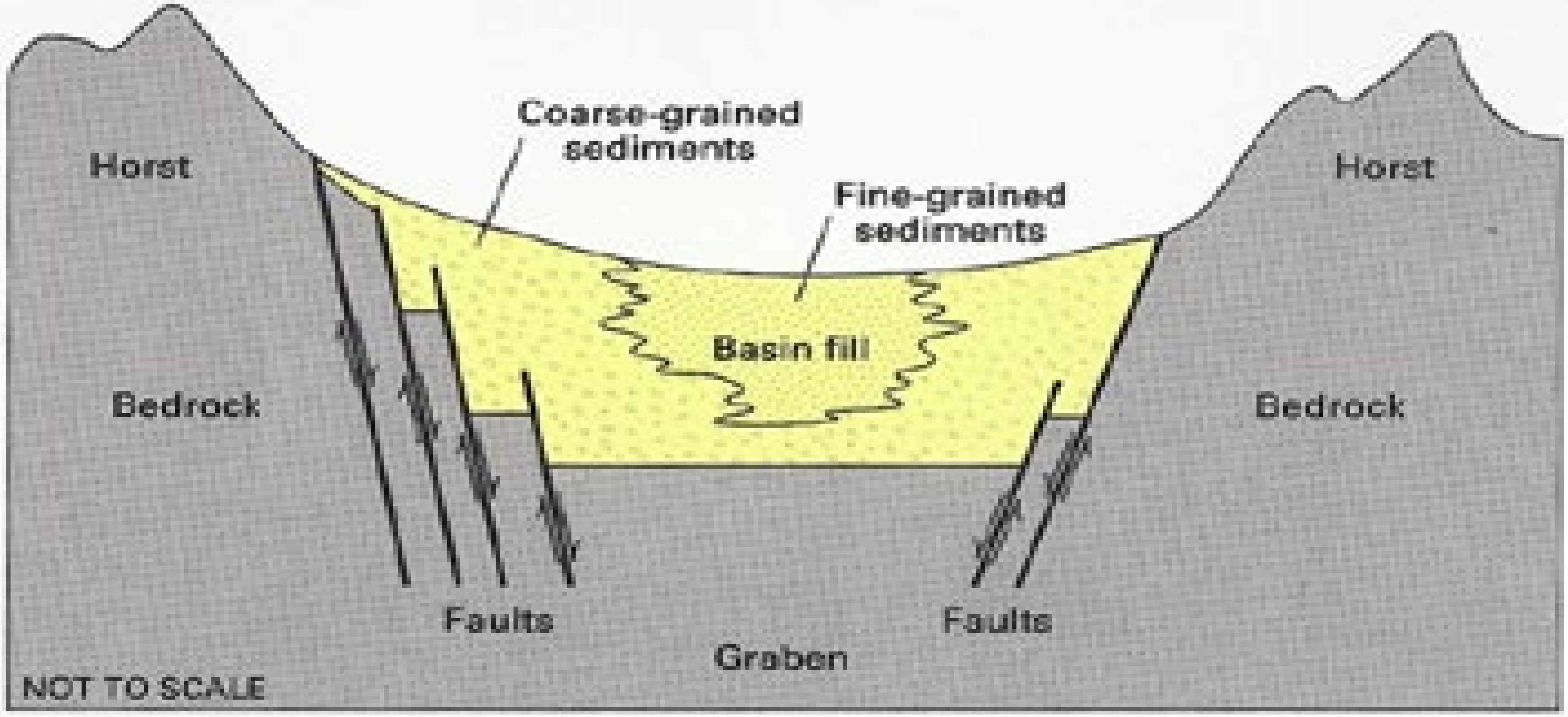


Figure 34. *Basin fill is located between bedrock mountain blocks and contains fine-grained sediments near the center of the basin. Coarse-grained sediments were deposited near the basin margins, primarily as alluvial fans.*

BASIN AND RANGE CROSS SECTION

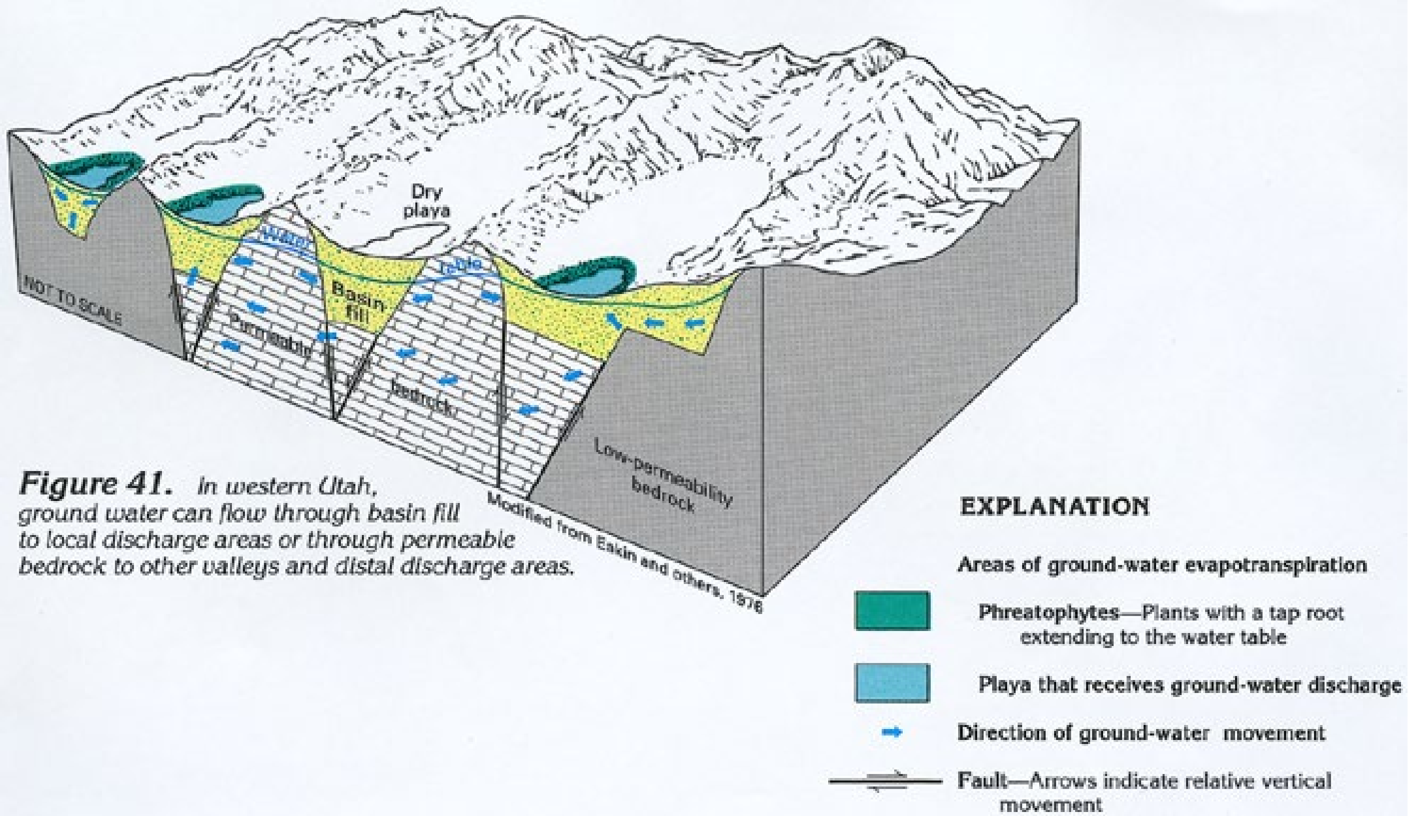


Figure 41. *In western Utah, ground water can flow through basin fill to local discharge areas or through permeable bedrock to other valleys and distal discharge areas.*

WHAT DOES AN AQUIFER LOOK LIKE?

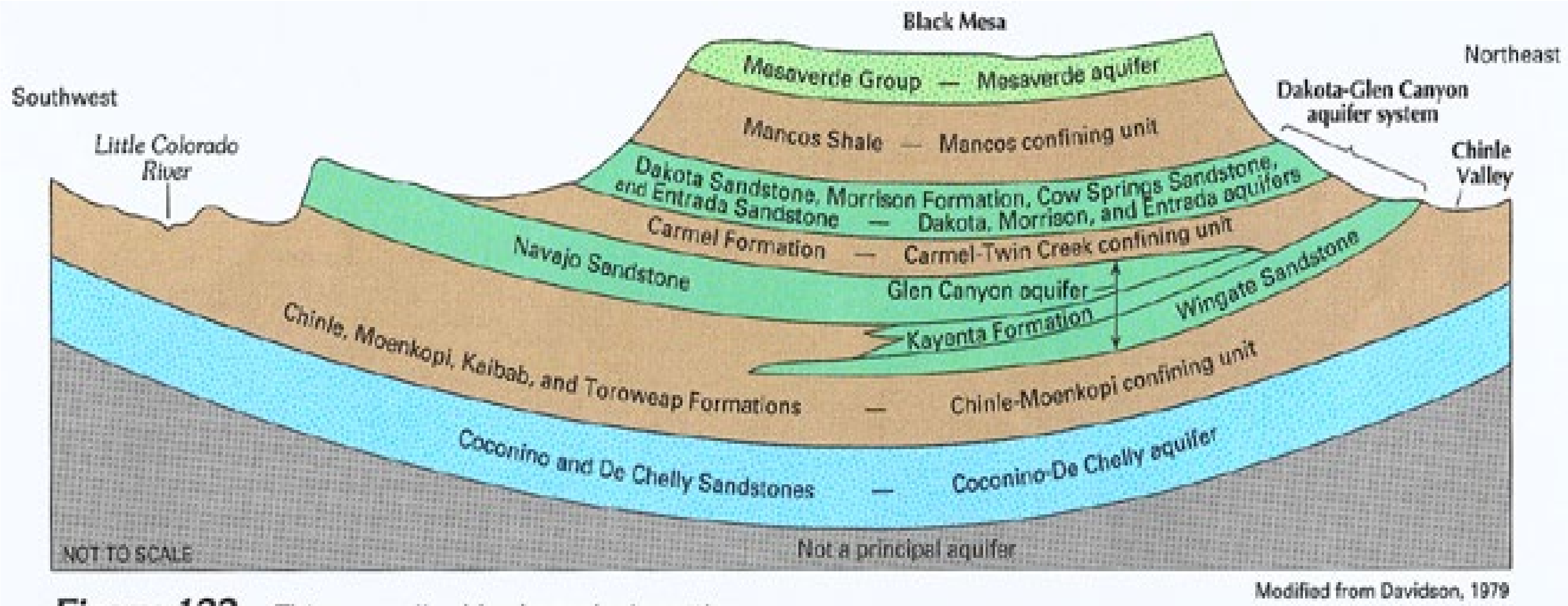


Figure 122. *This generalized hydrogeologic section through the Black Mesa Basin shows the relation of the Dakota-Glen Canyon aquifer system to the overlying and underlying hydrogeologic units.*

GREAT BASIN
ALLUVIUM FILLED BASINS

- The Basin and Range aquifers are the principal sources of ground water in western Utah and southern Arizona. **The aquifers are present in about 120 alluvium-filled basins** interspersed between ranges of mountains. About **150,000,000 acre-feet of *recoverable ground water is in storage in the upper 100 feet of the saturated sediments of these basins.**
- The principal aquifers are in thick deposits of basin fill in valleys bounded by mountain ranges formed mostly of relatively impermeable bedrock.
- *CHEEP FRESH WATER

HOW THICK IS BASIN FILL?

- The thickness of the basin fill is not well known in some basins but ranges from about 1,000 to 5,000 feet in **many basins and may exceed 10,000 in a few deep basins in Utah and south-central Arizona**.
- Extensive layers of sediments also were deposited on the bed of Lake Bonneville, a Pleistocene lake that covered about 20,000 square miles of western Utah
- Carbonate rocks predominate in a 20,000- to 30,000-foot thick sequence of Paleozoic and Lower Mesozoic rocks in an extensive area of western Utah

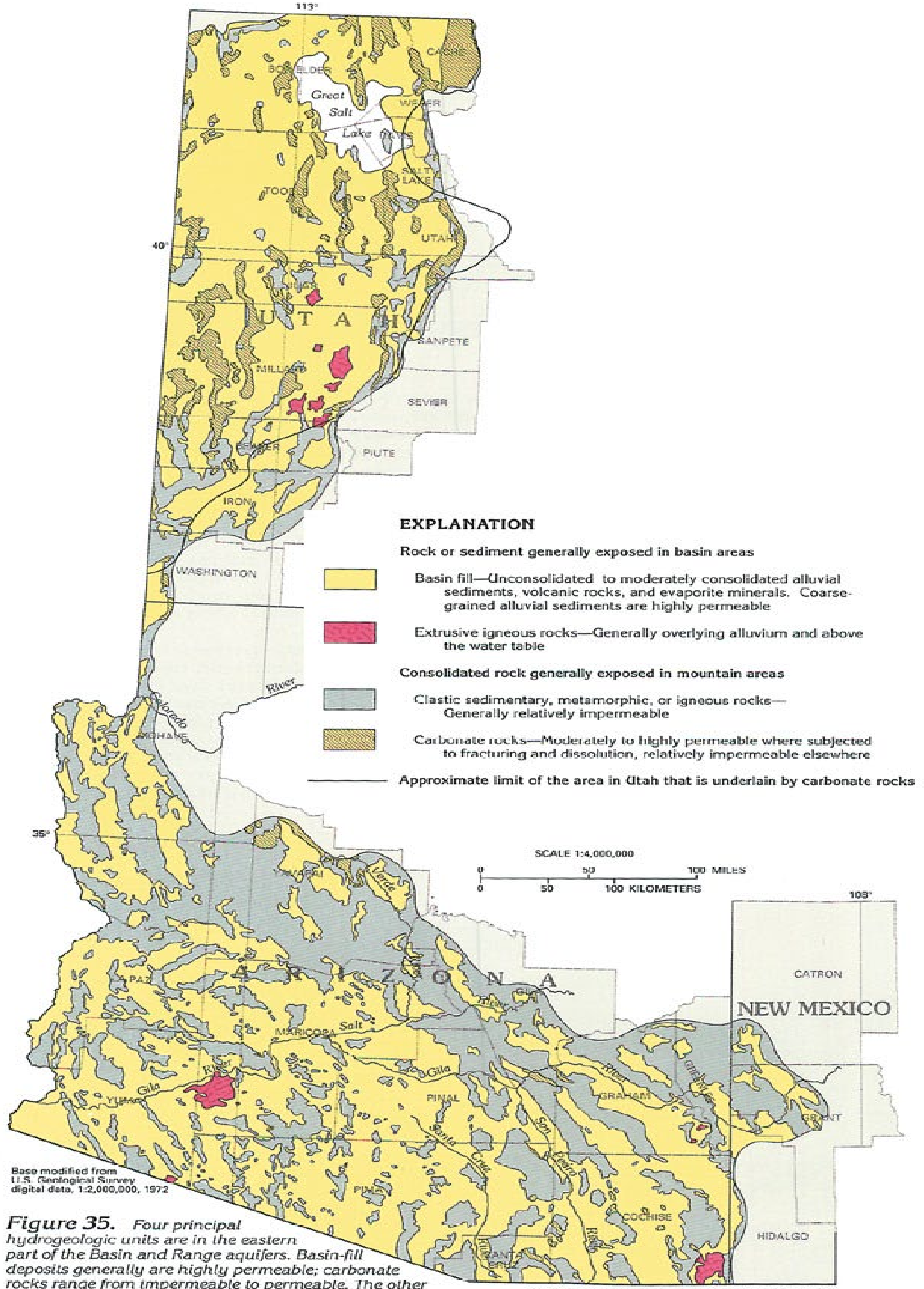


Figure 35. *Four principal hydrogeologic units are in the eastern part of the Basin and Range aquifers. Basin-fill deposits generally are highly permeable; carbonate rocks range from impermeable to permeable. The other*

LAKE BONNEVILLE AND REMANANTS GREAT SALT LAKE AND SEVIER LAKE

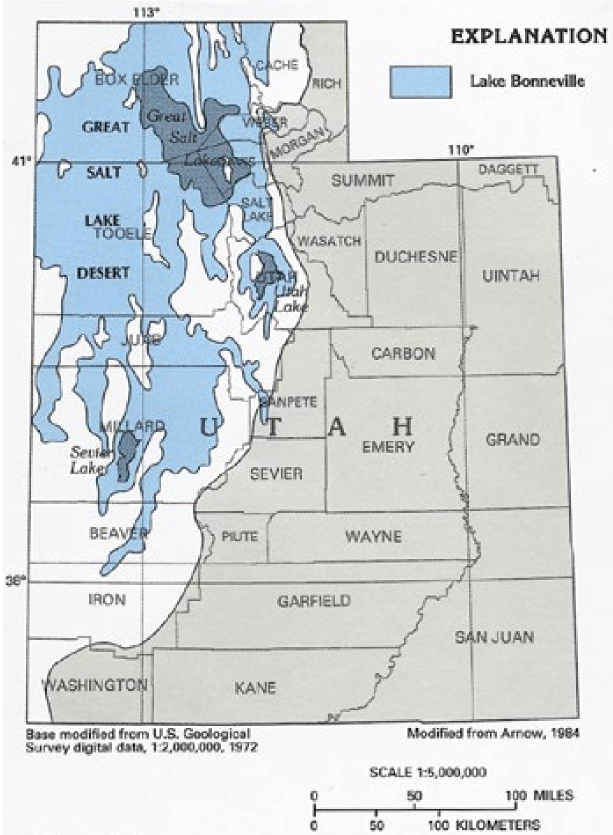


Figure 36. *The Great Salt Lake, Utah Lake, and Sevier Lake are the remnants of a much larger lake (Lake Bonneville) that covered western Utah 11,000 to 26,000 years ago.*

GROUND WATER DISCHARGE IN GREAT BASIN

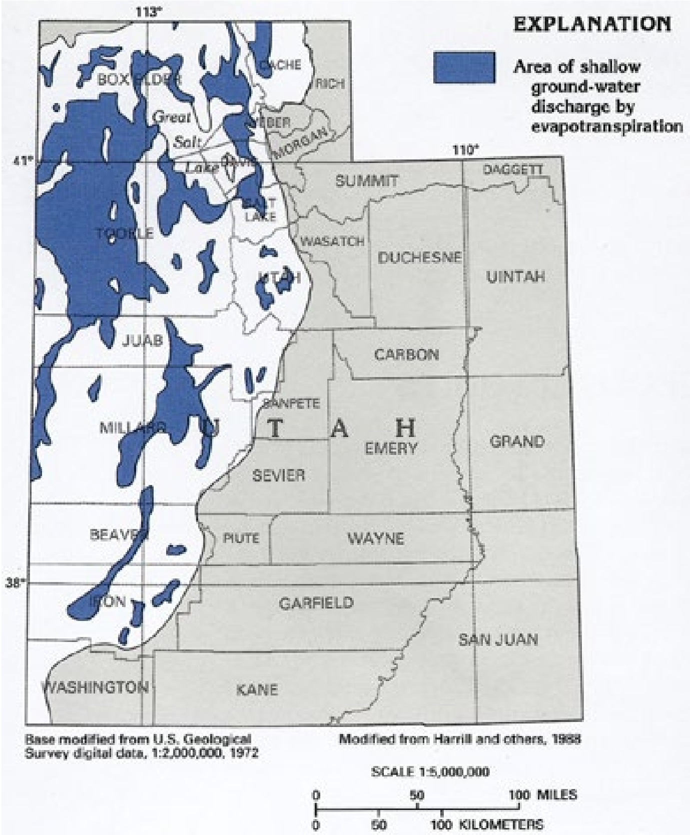


Figure 39. *Ground water is discharged by evapotranspiration in large areas of western Utah, particularly to the southwest of the Great Salt Lake.*

AQUIFER GROUND WATER RECHARGE

RECHARGE COMES FROM METORIC WATERS AND PERCIPITATIONS, STREAMS

DISCHARGE IS MAINLY THROUGH SPRINGS, WETLANDS, WELLS AND EVAPORATION

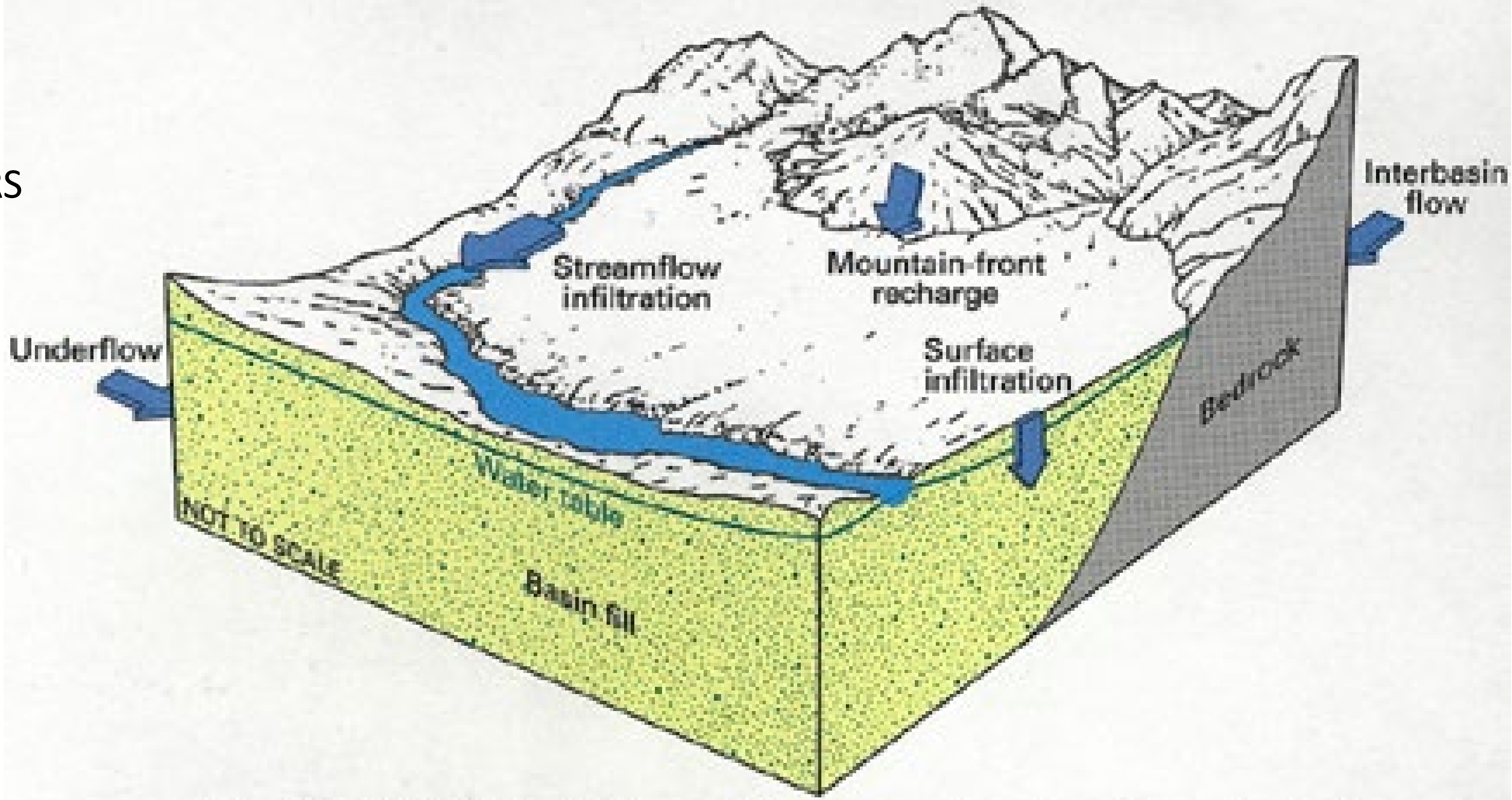


Figure 37. *The Basin and Range aquifers have five principal components of ground-water recharge. Streamflow infiltration is the largest component; mountain-front recharge is the second largest.*

WATER QUALITY IN AQUIFERS

Much of the shallow aquifer ground water is fresh and usable. Deeper water can reach hyper saline and TDS amounts of 300,000 mg/l. It's the high salinity water we are discussing today.

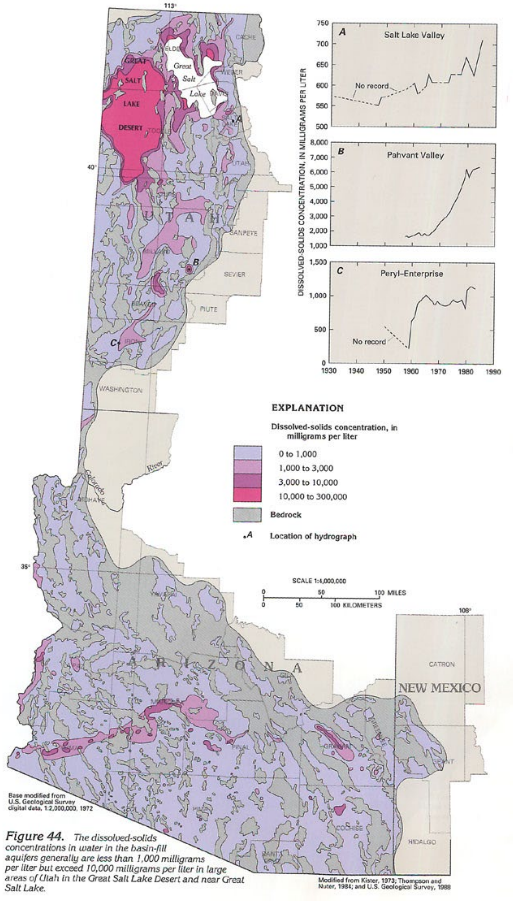


Figure 44. The dissolved-solids concentrations in water in the basin-fill aquifers generally are less than 1,000 milligrams per liter but exceed 10,000 milligrams per liter in large areas of Utah in the Great Salt Lake Desert and near Great Salt Lake.

*Dissolved-solids concentrations in ground water near surface or subsurface deposits of saline minerals can be very large; concentrations commonly exceed 200,000 milligrams per liter in parts of western Utah.

EXPANSE OF THE BASIN AND RANGE AQUIFERS

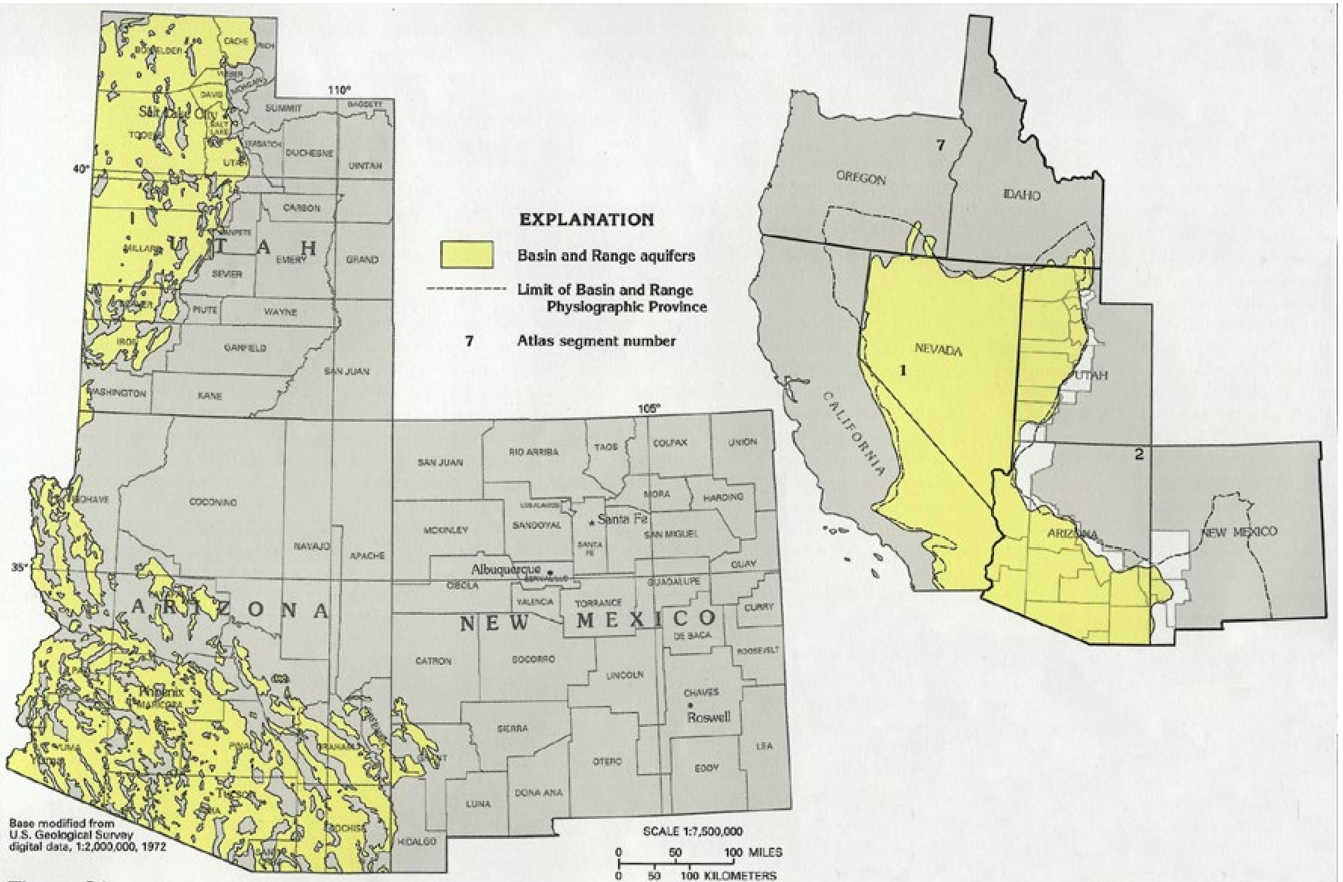
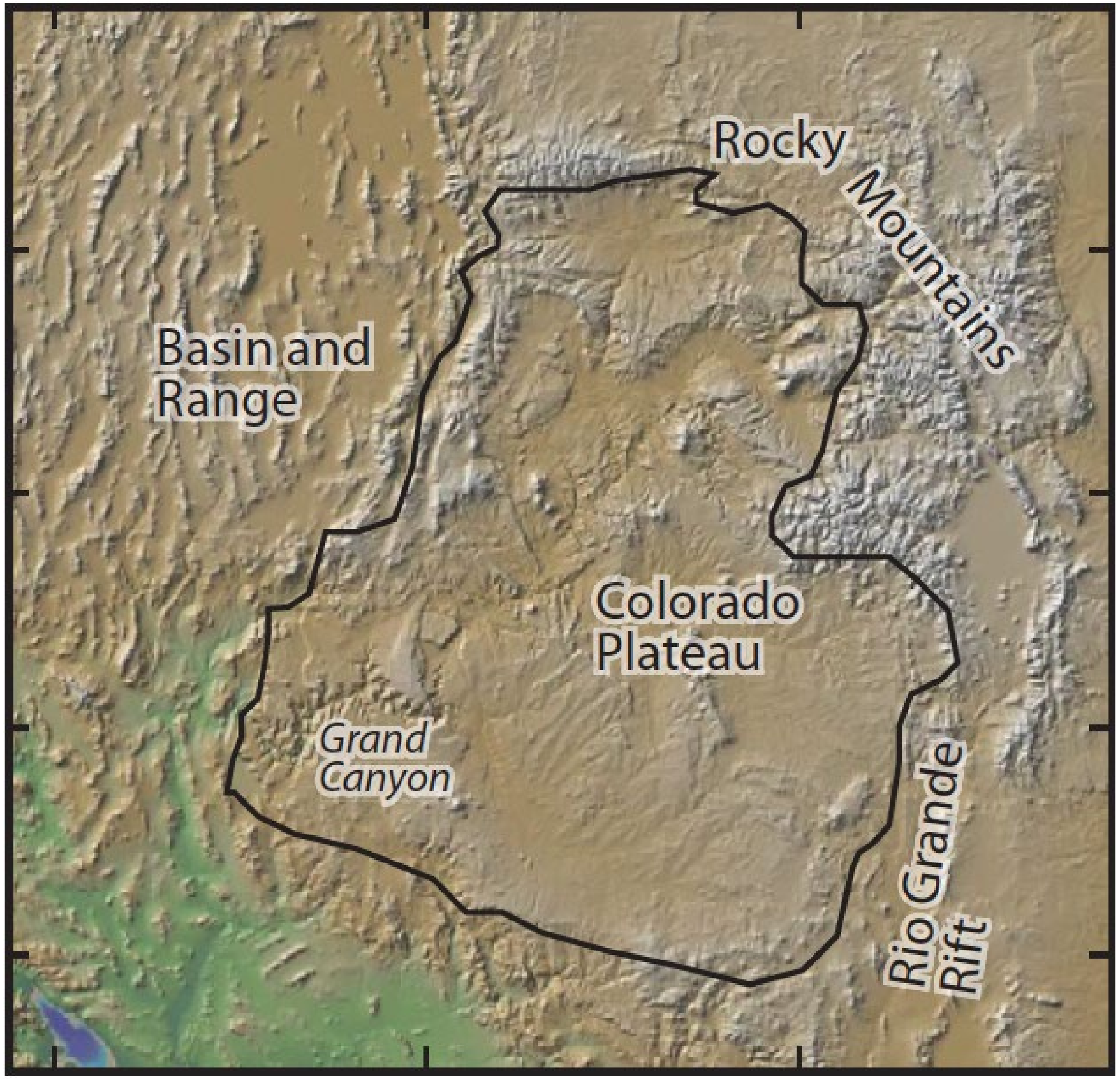


Figure 31. The Basin and Range aquifers extend through parts of seven States and are the principal sources of water in much of this desert area.

BASIN AND RANGE / COLORADO PLATEAU

NOTE BASIN AND RANGE



COLORADO PLATEAU

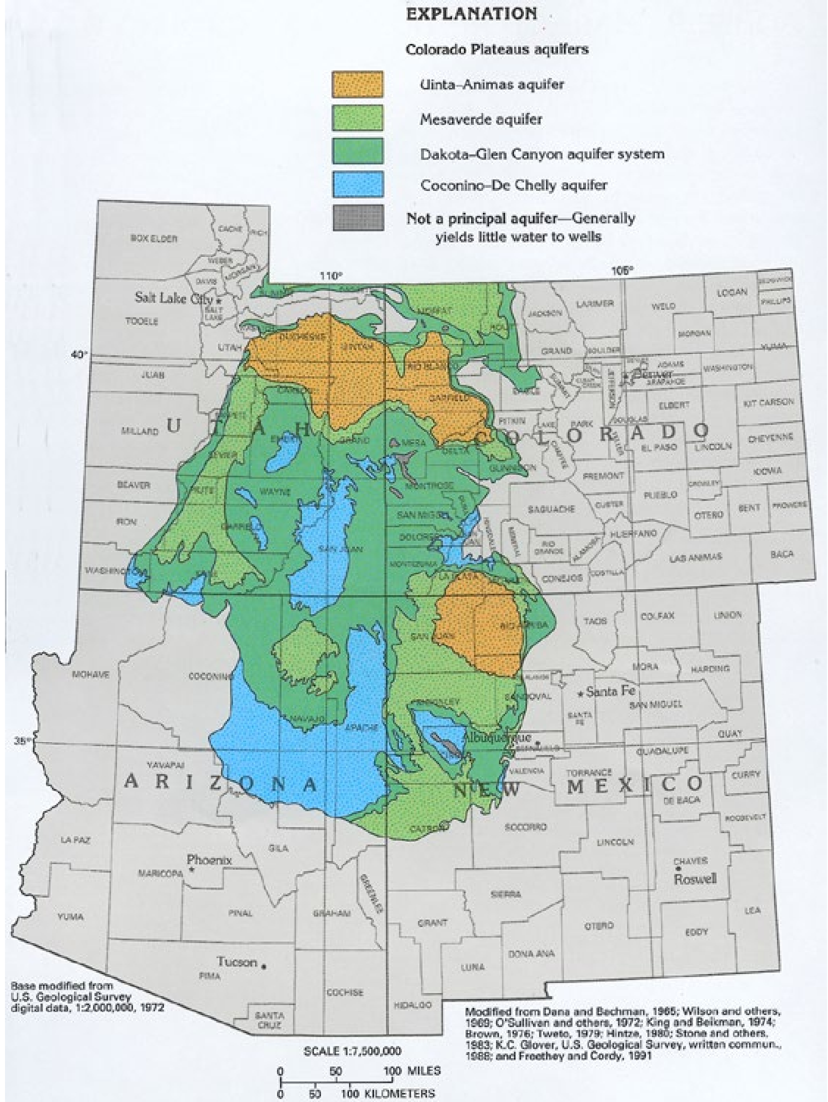


Figure 107. *The Colorado Plateaus are underlain by four principal aquifers. The areas where each aquifer is the uppermost water-yielding unit are shown here.*

COLORADO PLATEAU AND DEEP AQUIFERS

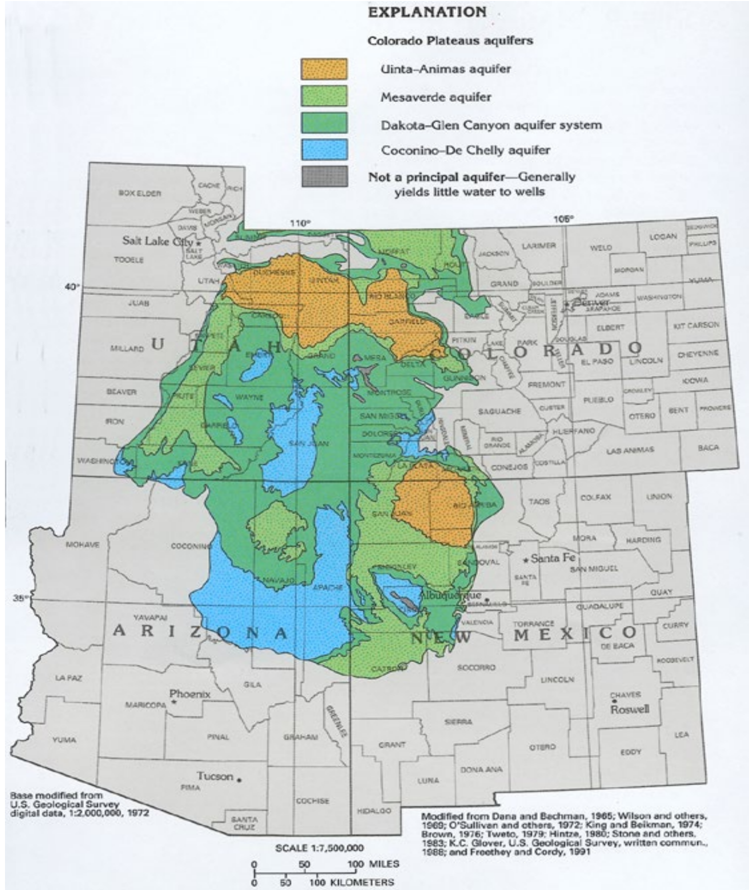


Figure 107. *The Colorado Plateaus are underlain by four principal aquifers. The areas where each aquifer is the uppermost water-yielding unit are shown here.*

AQUIFERS IN UINTA BASIN

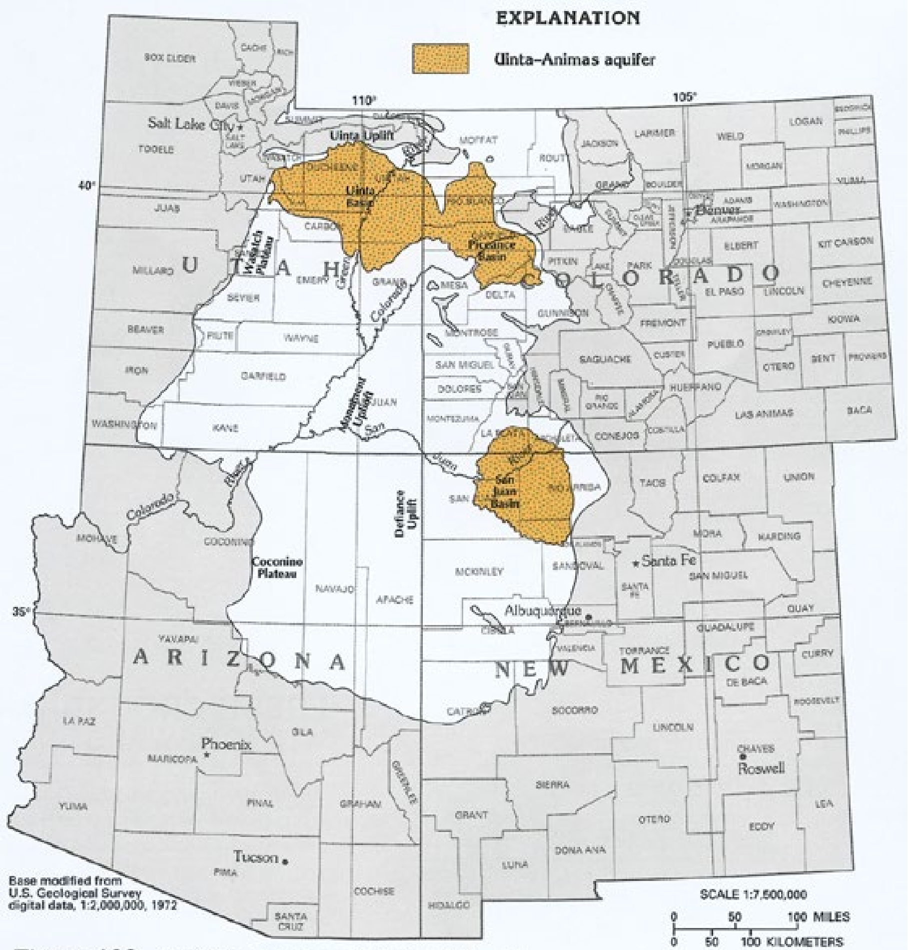


Figure 108. The Uinta–Animas aquifer is the shallowest of the Colorado Plateaus aquifers and is present in the Uinta, Piceance, and San Juan Basins.

GLEN CANYON AQUIFERS AS DEEP AS 12,000 FT

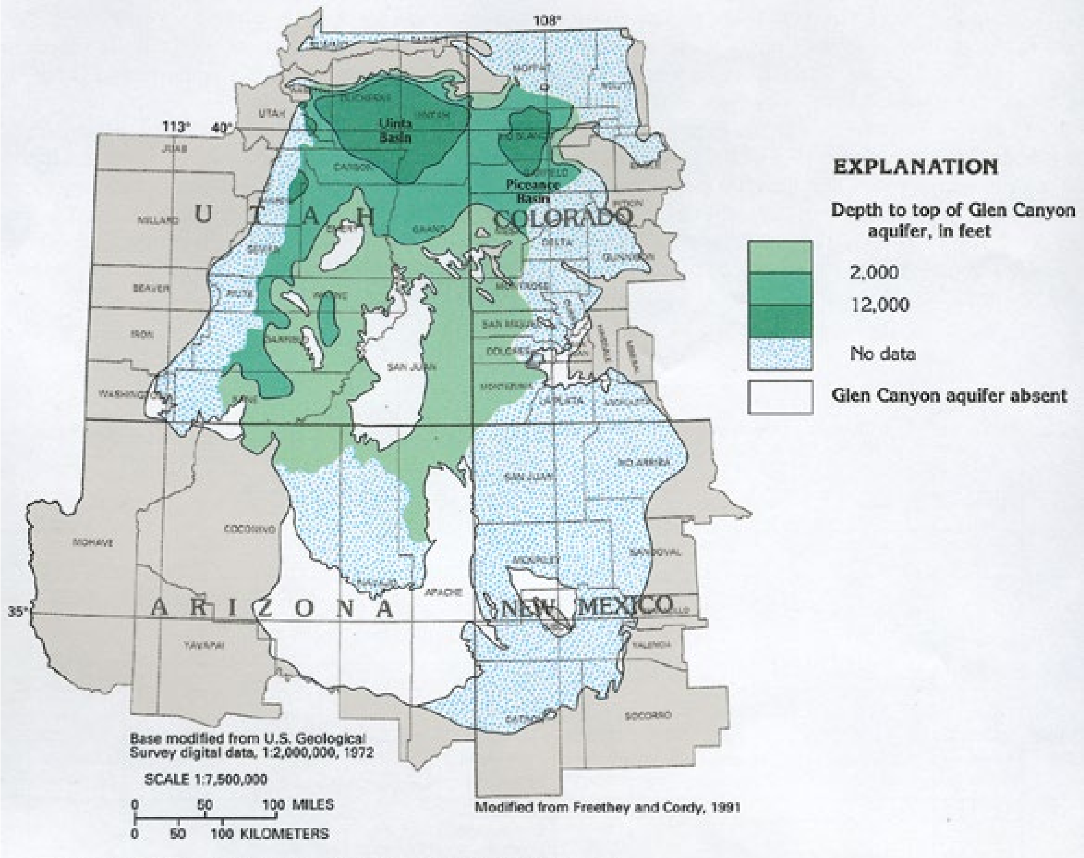


Figure 125. Depth to the top of the Glen Canyon aquifer exceeds 12,000 feet in several areas, primarily in large basins.

DAKOTA ACQUIFER

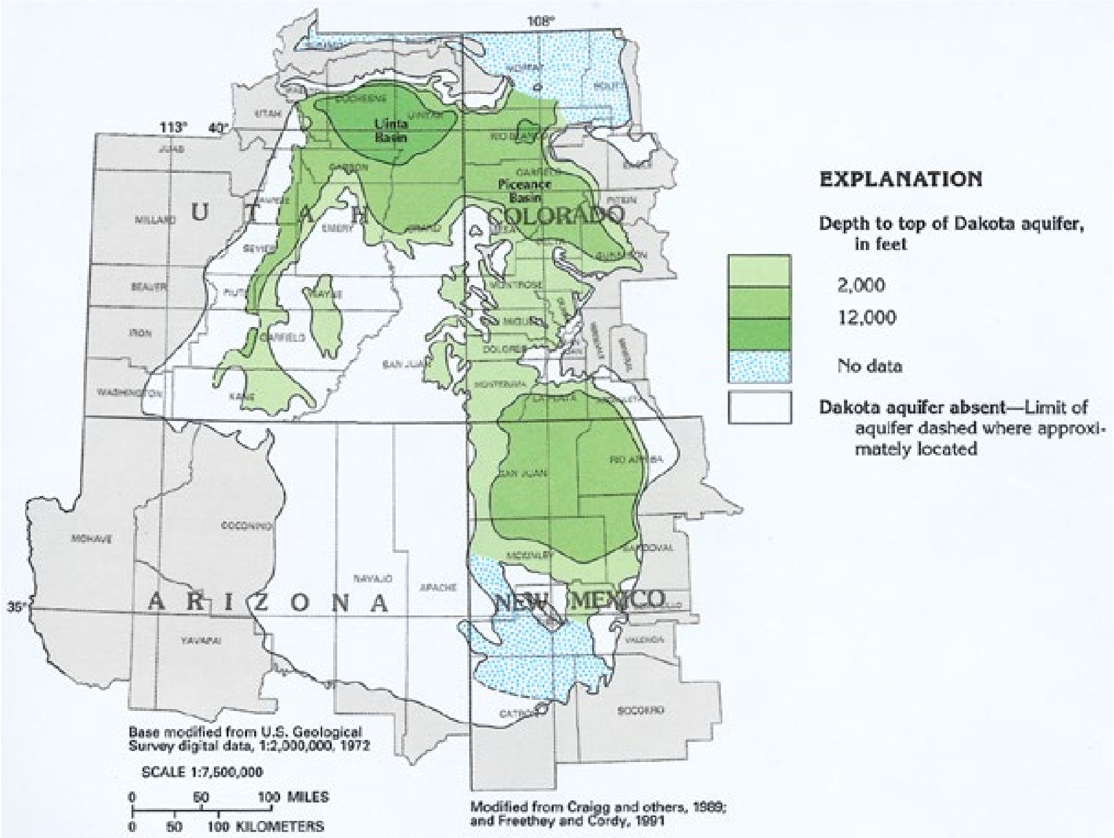


Figure 123. *Depth to the top of the Dakota aquifer is less than 2,000 feet in extensive areas of Colorado, New Mexico, and Utah.*

COCONINO – DE CHELLY AQUIFER

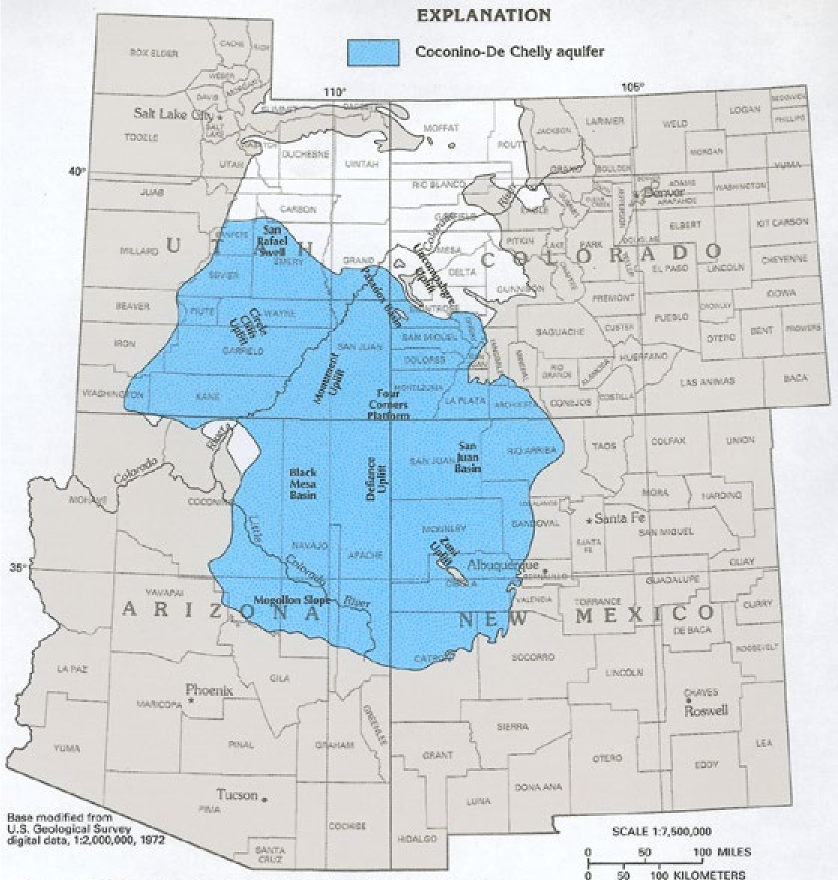


Figure 129. The Coconino–De Chelly aquifer underlies the southern part of the Colorado Plateaus.

GRAND CANYON/ COCONINO ANDDE CHELLY AQUIFERS

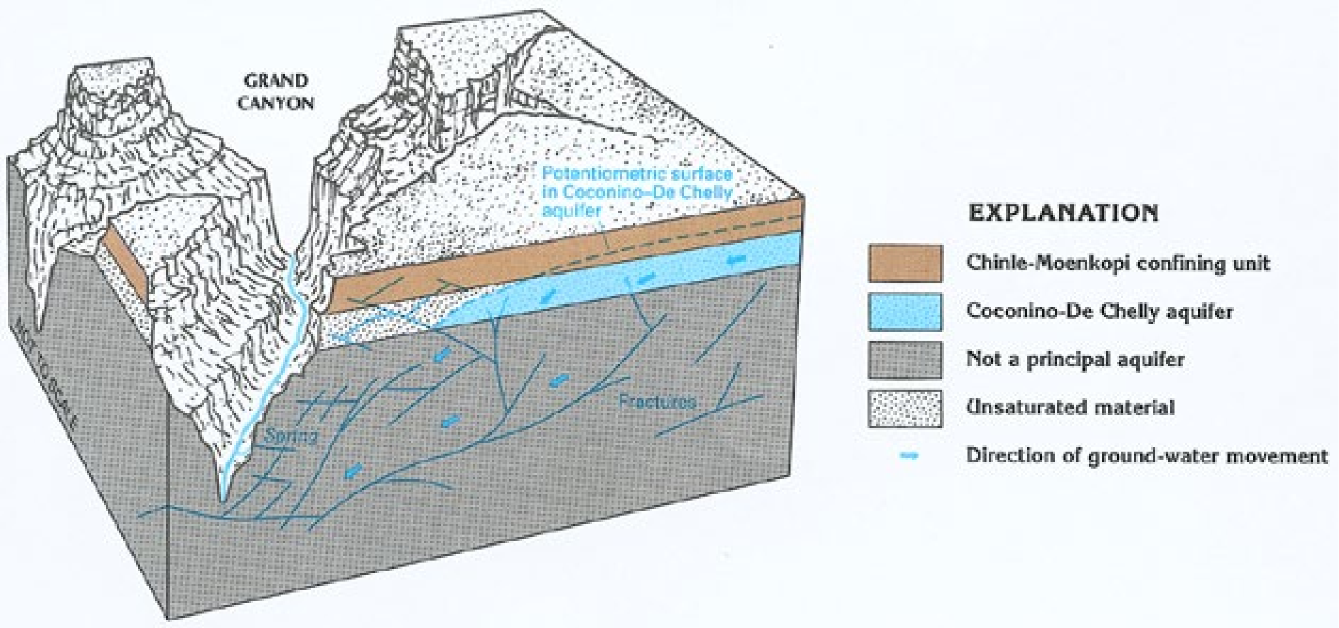


Figure 131. *Fractures in the vicinity of the Grand Canyon act as conduits that allow ground water to drain from the Coconino–De Chelly aquifer. The water emerges from underlying rocks at springs in the Grand Canyon and canyons of tributaries of the Colorado River.*

TDS AND DEEP SALINE AQUIFERS

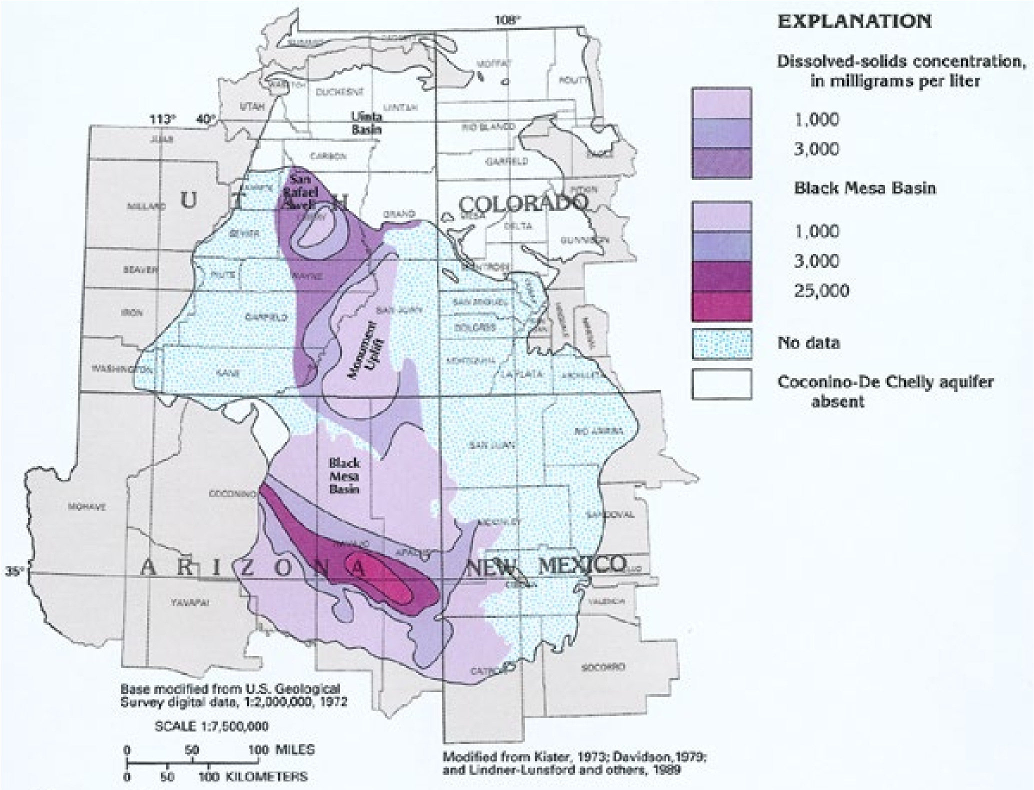


Figure 134. *The dissolved-solids concentration of water in the Coconino–De Chelly aquifer is less than 1,000 milligrams per liter in large areas of northeastern Arizona and southeastern Utah. Little is known of the dissolved-solids concentrations in some parts of the aquifer.*

SO WHERE ARE THE DEEP SALINE AQUIFERS IN UTAH?

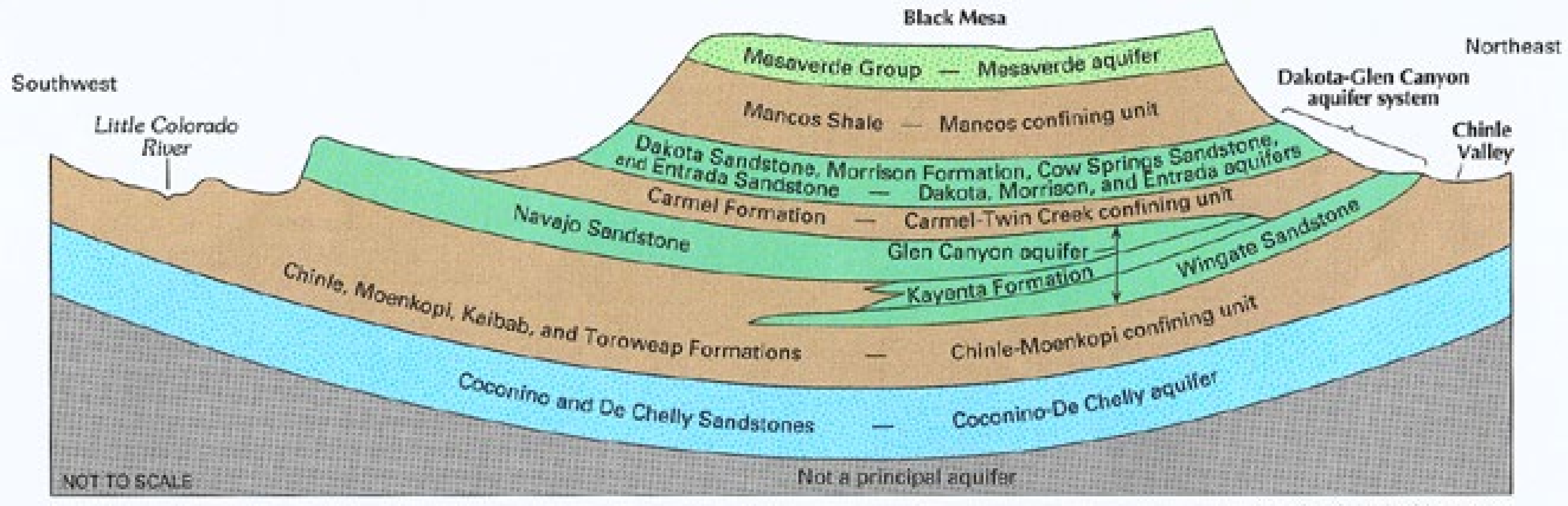


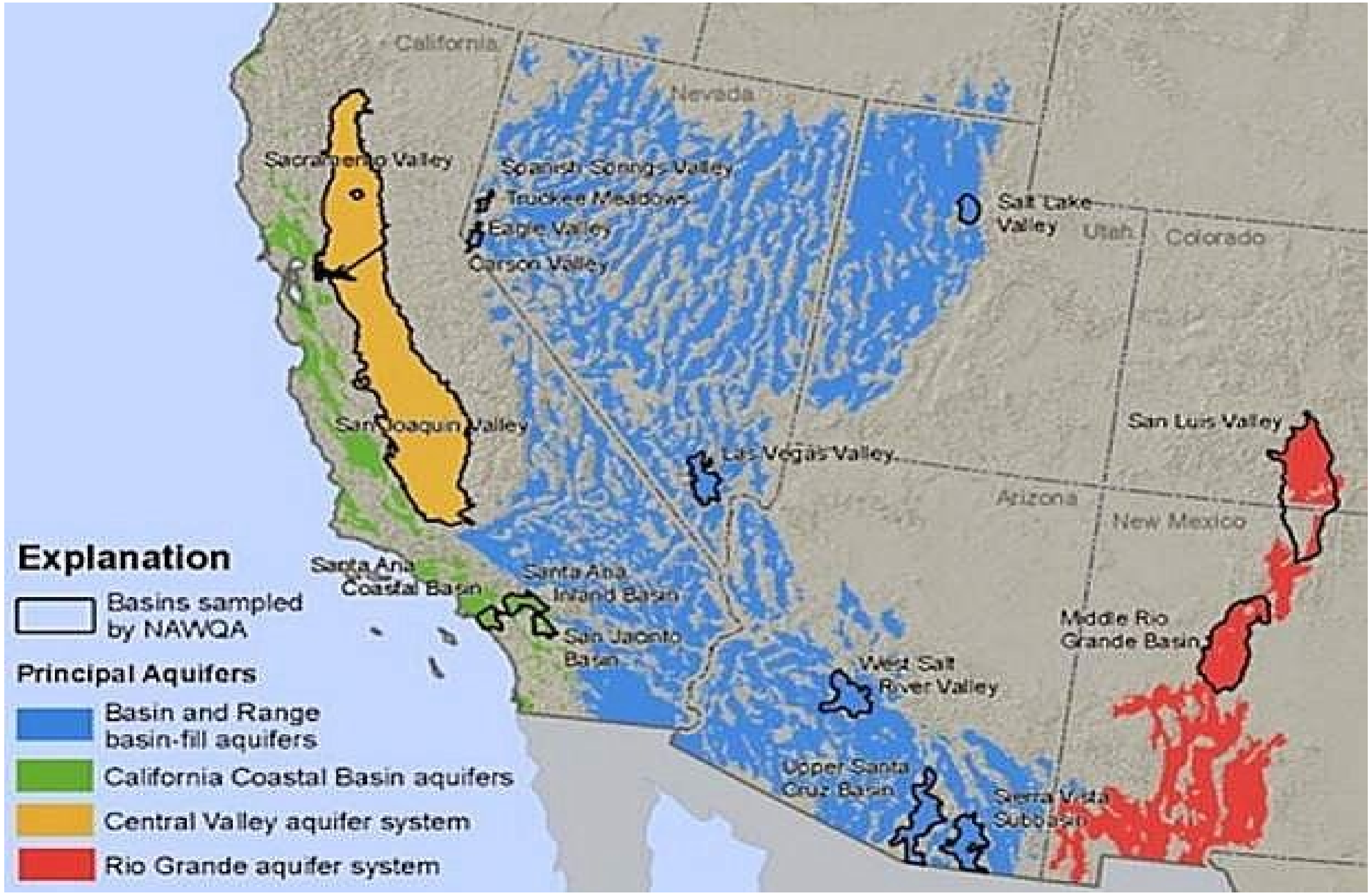
Figure 122. *This generalized hydrogeologic section through the Black Mesa Basin shows the relation of the Dakota-Glen Canyon aquifer system to the overlying and underlying hydrogeologic units.*

Full capacity is about
17,000,000 acre-feet

Estimated Deep Saline Reserves
900,000,000 Acre-Ft

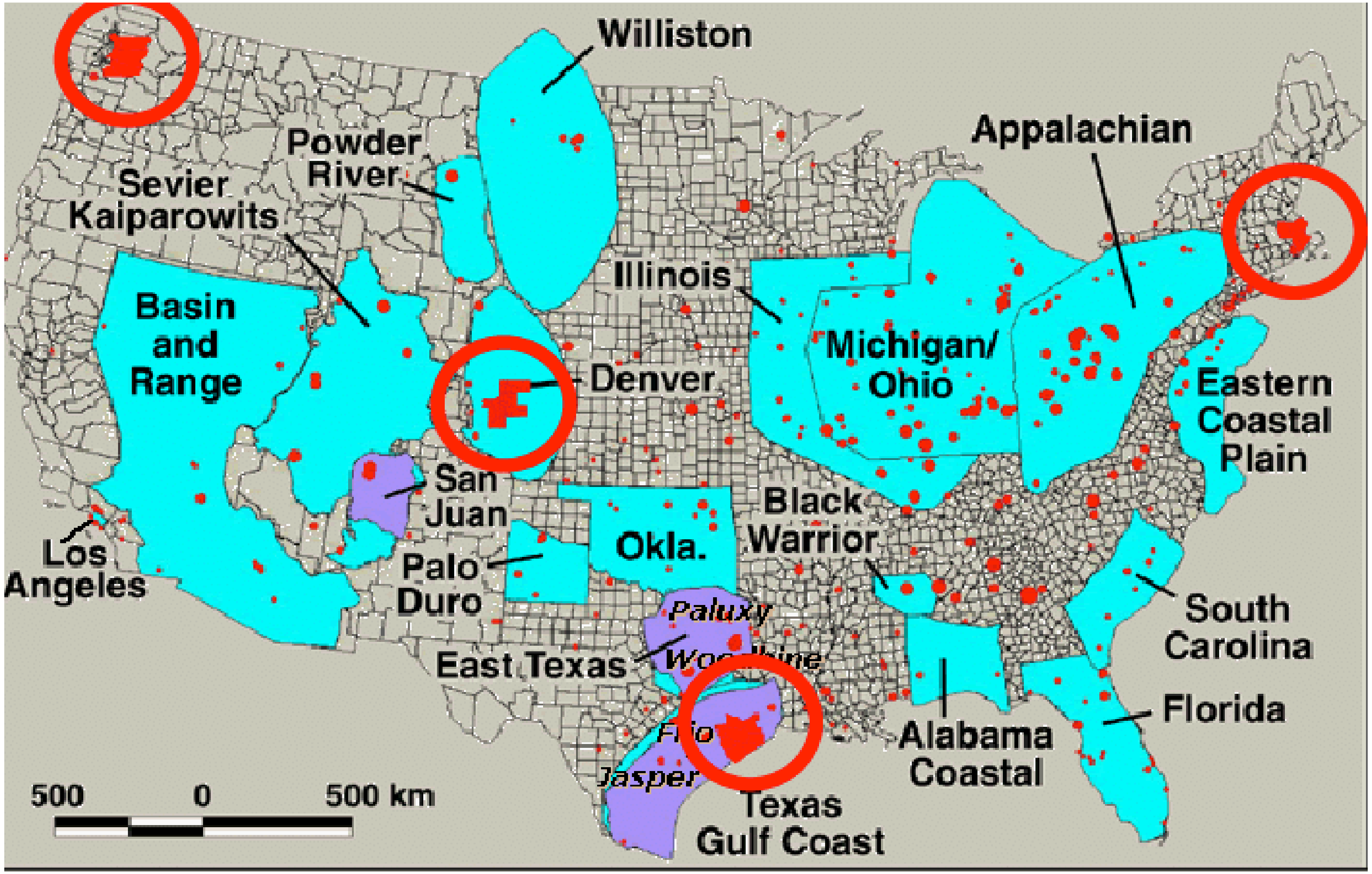
Where are these aquifers?

PRINCIPLE AQUIFERS IN BASIN AND RANGE PROVINCE



Where are the Deep Saline Aquifers in the United States?

Basin & Range Aquifers extend about 200,000 square miles From California to Utah.



Evidence of Potential Deep Brine Reservoirs: Great Basin, Western Utah

DEEP APPRECIATION TO

MI3 Petroleum Engineering

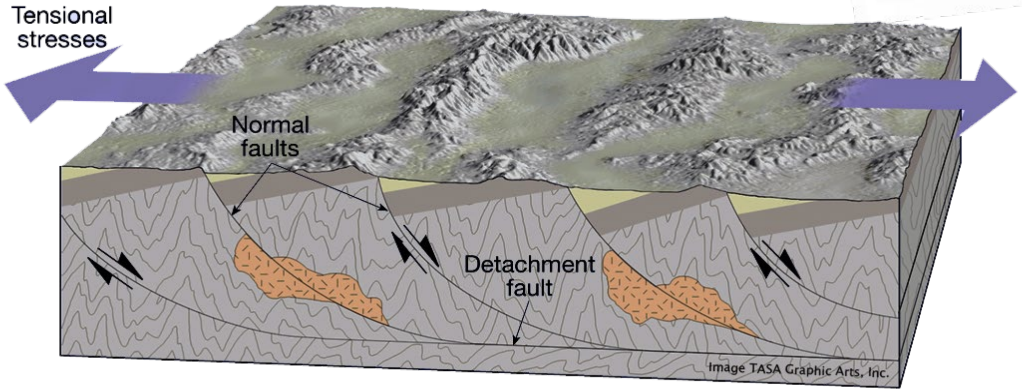
Golden, Colorado

SEPTEMBER 2022

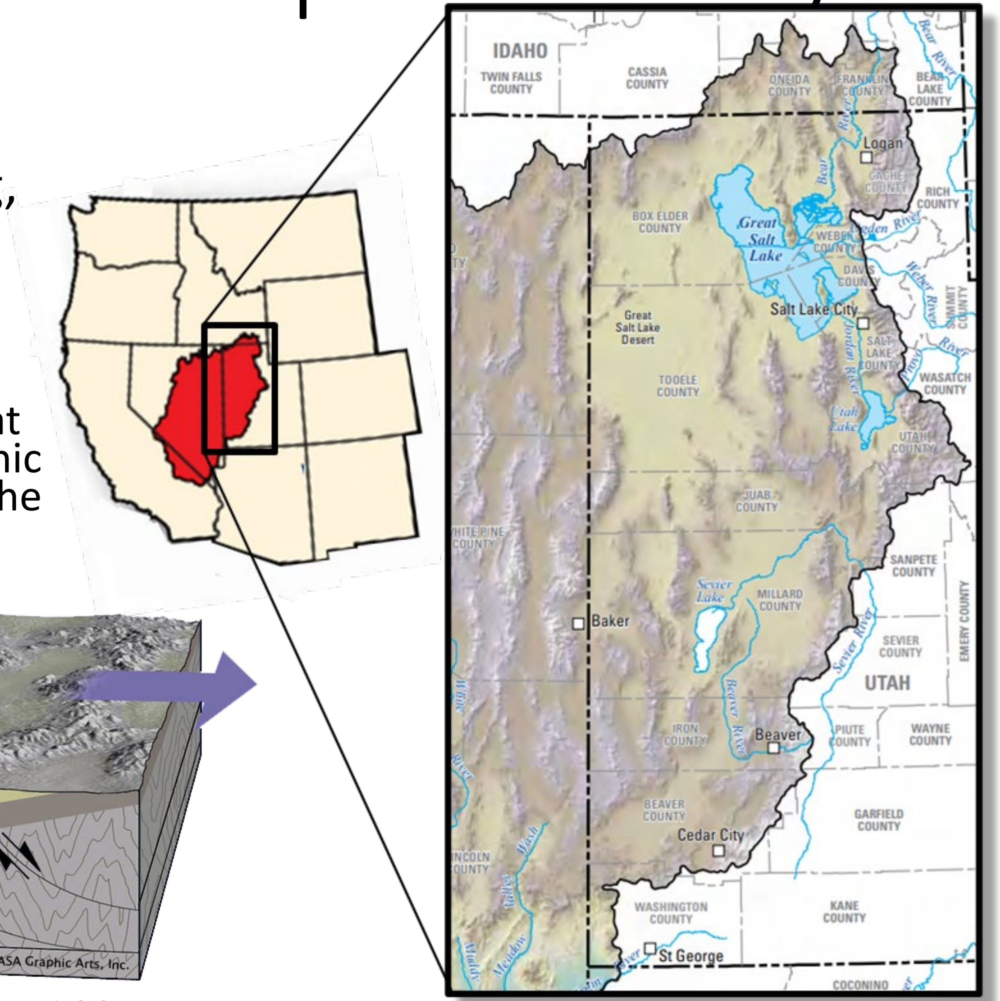
Great Basin Geology – Complex History

The rocks in the Basin have been deformed over time, originally through multiple phases of compressional folding and faulting, and by a subsequent phase of extension.

- The basins and ranges consist of many subparallel fault blocks that are created as extensional tectonic forces have slowly pulled apart the landscape over millions of years.



Source: https://www.chegg.com/flashcards/national-parks-exam-1-89d3f2f8-d990-4321-867d-aaee7516cc64/deck



Modified from USGS Scientific Investigations Report 2010-5193

Stratigraphic Column – Oquirrh Mtns

Great Basin rocks typically include:

- Precambrian Metamorphic and Granitic rocks.
- Paleozoic aged Sedimentary rocks (Limestone, Dolomite, Sandstone, Siltstone, Shale, Conglomerate, etc.).
- Localized deposits of Neogene Igneous rocks (Volcanic Tuff, Andesite, Rhyolite, Basalt, Intrusive Granitic rocks).
- Quaternary alluvium and Lake Bonneville sediments.

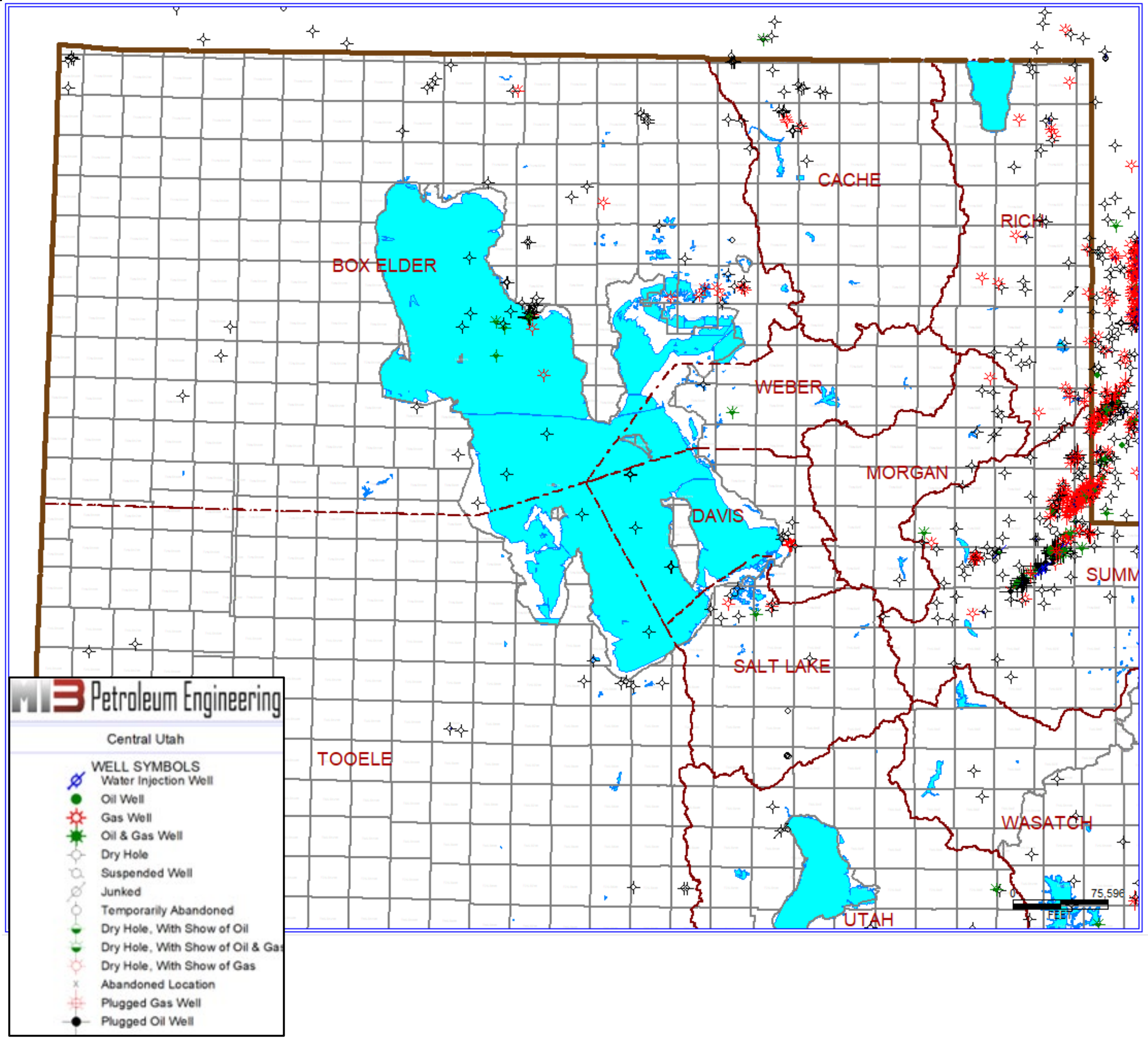
Period /Epoch	Groups, Formations & Members		Thick-ness (ft)	Rock Type
Q Quaternary	Alluvium & Lake Bonne- ville sediments		0-1000	
Q Quaternary	Valley fill in Cedar Valley		0-2000	
Neogene	Tickville rhyolite flows		0-300	
	Rhyolite plug near Mercur		?	
	Latite flows & lahars		500-1000	
	Nepheline basalt		0-100	
Permian (P)	post-thrusting conglomerate		0-200	
	Park City Group		200	
	Diamond Creek Ss		2300	
	Kirkman Limestone		100	
	Freeman Peak Formation		1900	
	Curry Peak Formation		3100	
Carboniferous	Bingham Mine Formation	Main Body	6500	
		Commercial Ls	20-200	
		Jordan Ls Mbr	50-300	
	Butterfield Peaks Formation (Bissell's 1959 Pole Canyon Lewiston Peak Cedar Fort & Meadow Canyon members are all part of this formation)		8500	
	West Canyon Limestone		900-1200	

Period /Epoch	Groups, Formations & Members		Thick-ness (ft)	Rock Type
Carboniferous	Manning Canyon Shale		1330 - 1610	
	Great Blue Limestone	Upper limestone member	1950	
		Long Trail Sh. M.	90	
		Lower ls mbr	550	
	Humbug Formation		640	
	Deseret Limestone		580-730	
	Gardison Limestone		720	
Dev (D)	Fitchville Dolomite		180-340	
	Stansbury Fm		10-200	
Cambrian (€)	Opex Dolomite		180	
	Cole Canyon Dolomite		210	
	Bluebird Dolomite		310	
	Bowman Limestone		250	
	Herkimer Limestone		470	
	Teutonic Limestone		280	
	Ophir Formation		300	
	Pioche Formation		300	
	Tintic Quartzite		?	

Sources: UtahGeology.com, Hintze, 1988

Deep Wells Drilled (Mostly Oil Gas Exploration)

- Due to a paucity of oil and gas discoveries in the Great Basin, very few deep exploratory wells have been drilled in Northwestern Utah
    - Depths from surface to Paleozoic rocks vary significantly due to faulting and thicknesses of valley fill sediments.
    - Very little data exists in these wells for capability of rocks to produce brine water.
    - Best source of information is from borehole wireline logs.

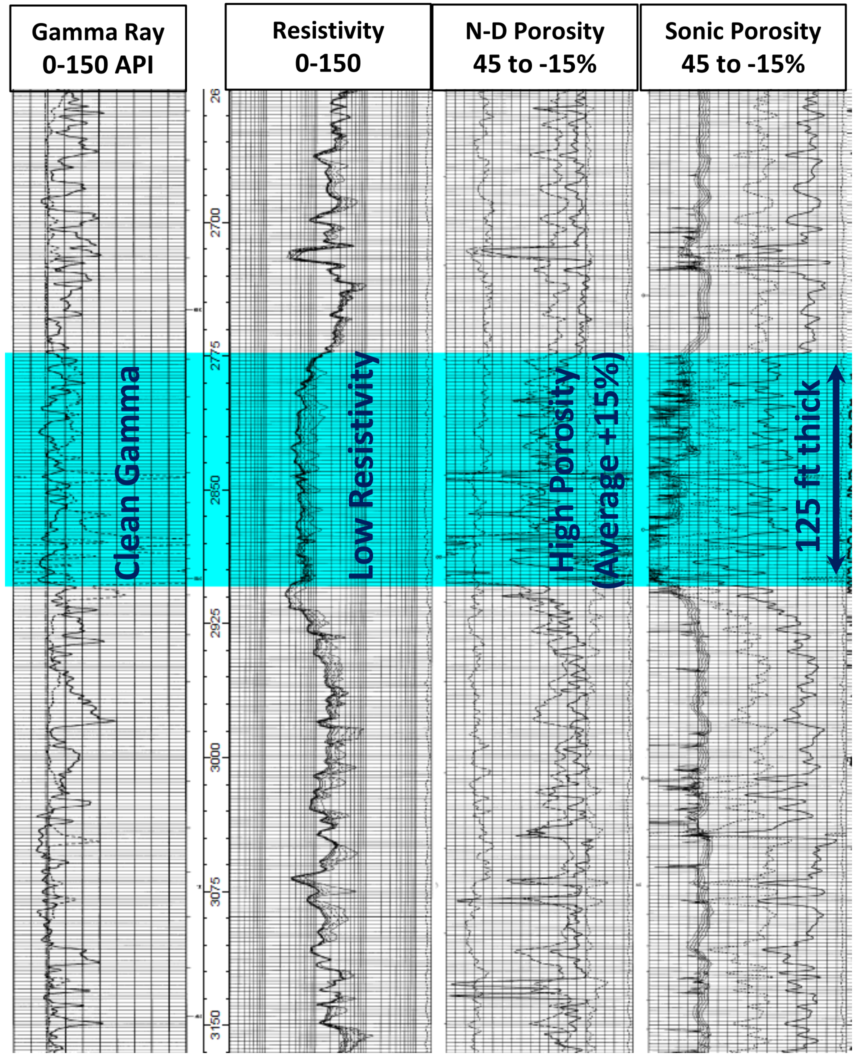


Methodology

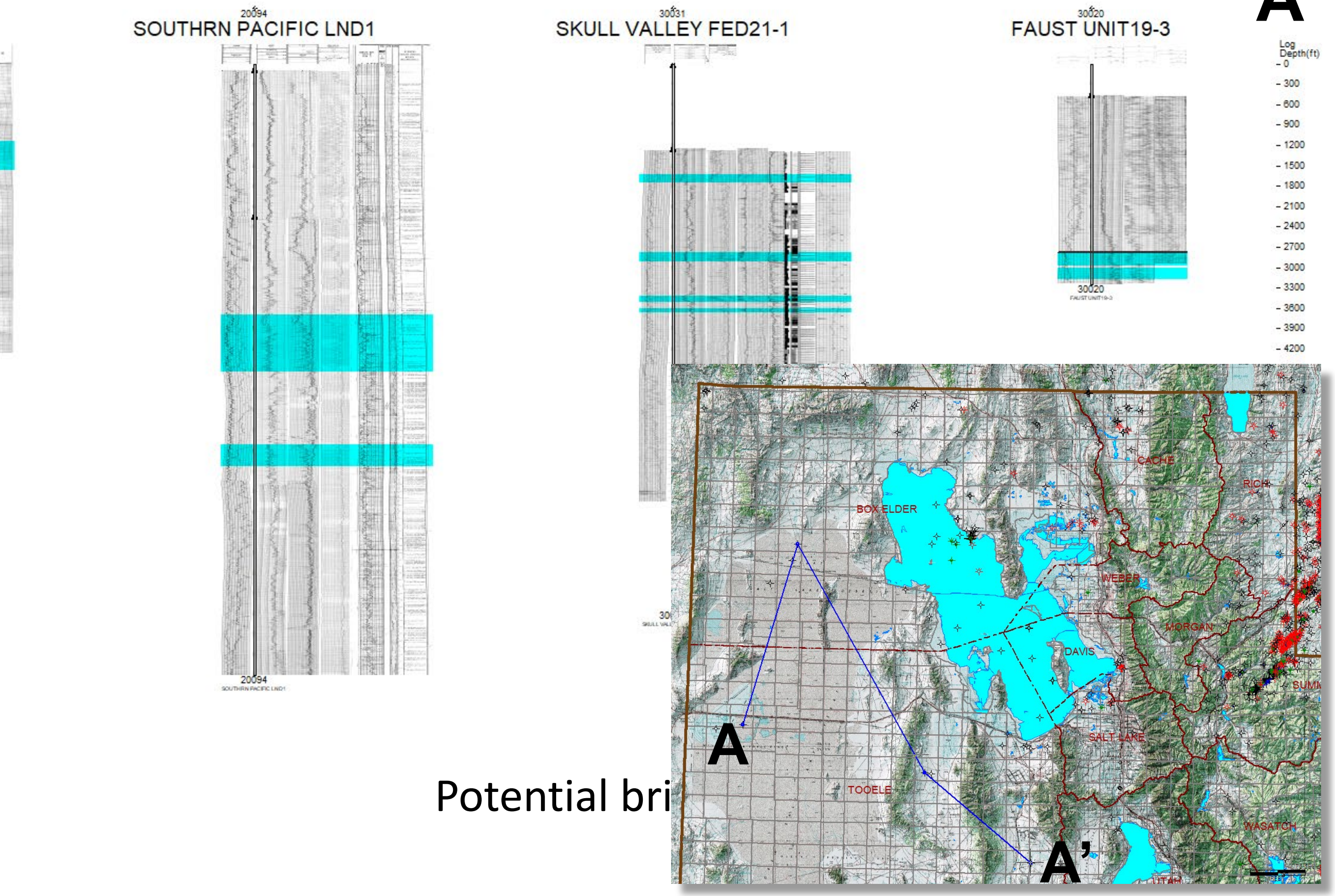
- Quick-scan analysis of well logs has identified that the potential exists for areas of productive brine water extraction wells.

  - These techniques identify zones of clean reservoir rock, low resistivity, and high porosity.
  - Where present, these zones could be potential target zones for production wells.
  - Due to nearby faulting and the regional active tectonic regime in the area, it is highly likely that reservoir rocks will be fractured and will have enhanced permeability.
  - No flow test or pressure has been found, but wells drilled in the nearby Covenant Oil Field in Central Utah show that there is a potential for strong aquifer support, particularly near mountain ranges.

SKULL VALLEY FED 21-1



Cross Section of Well Logs in NW Utah



Potential bri

Well data from Utah Division of Oil, Gas, and Mining

Conclusions

- The Great Basin of Western Utah and Eastern Nevada contains sedimentary and volcanic formations that are capable of storing vast amounts of brine water at depths ranging from 2,000 as deep as 10,000 ft below the surface.
- Zones in Paleozoic Sandstone, Limestone, and Dolomites were identified that contain good reservoir properties that can support high brine-water production.
- The size of the aquifers, potential flow rates, and long-term productivity is not possible to determine with the data that was available for the wells reviewed.
- A detailed study will be required to review more wells and to look at all data that has been recorded for wells in the region and understand local recharge and any possible hydraulic connections to shallow aquifers.
- It may be necessary to drill several new wells with the objective of capturing new data and tests specific to evaluating brine zone production.

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- Well data from Utah Division of Oil, Gas, and Mining, https://oilgas.ogm.utah.gov/oilgasweb/live-data-search/lds-well/well-main.xhtml, accessed 9/15/2022

What about a pipeline from the Pacific

- 24” pipe capacity is 18,000 gal/min
- ((18000 g/m/7.48 g/cft)*60min/hr*24hr/d*360d/y)/43560 cft/acre=

  29,000 acres-ft/year/pipeline
- Full pool 17,000,000 acre-ft/29,000 acre-ft/year= 586 years
- Average evaporation rate: 3,000,000 Acre-ft: 3,000,000/29000 acre-ft/pipeline=

  103 pipelines to account for evaporation
- If only 10% of full pool is needed is 59 years
- Looped line 30 years
- 3 loops: 20 years
- What do you do with the pipeline when it isn’t being used?

Coos Bay to GSL: 900 miles need to add elevation to that

Evaporation rate of GSL

- Average evaporation rate of the Great Salt Lake: 3,000,000 acre-ft/yr
- Assume a pipeline that could provide 10% of the water lost to evaporation: 300,000 acre-ft/yr
- Assumed a slope of fall from maximum elevation of a pipeline to the Great Salt Lake: 1-6%. Best case scenario (deepest slope) 6%
- Pipeline diameter: 72”
- This is consistent with the Lake Powell pipeline design.
- This pipeline would only account for 10% of the evaporation rate on the GSL
- This pipeline would not keep up with jus the water lost to evaporation.
- The assumption is that the natural tributaries

that feed the GSL would account for the remaining 90% of the water lost to evaporation. This does not account for any additional water to fill the pool

Cost of a pipeline
assume this pipeline covers 10% of evaporation

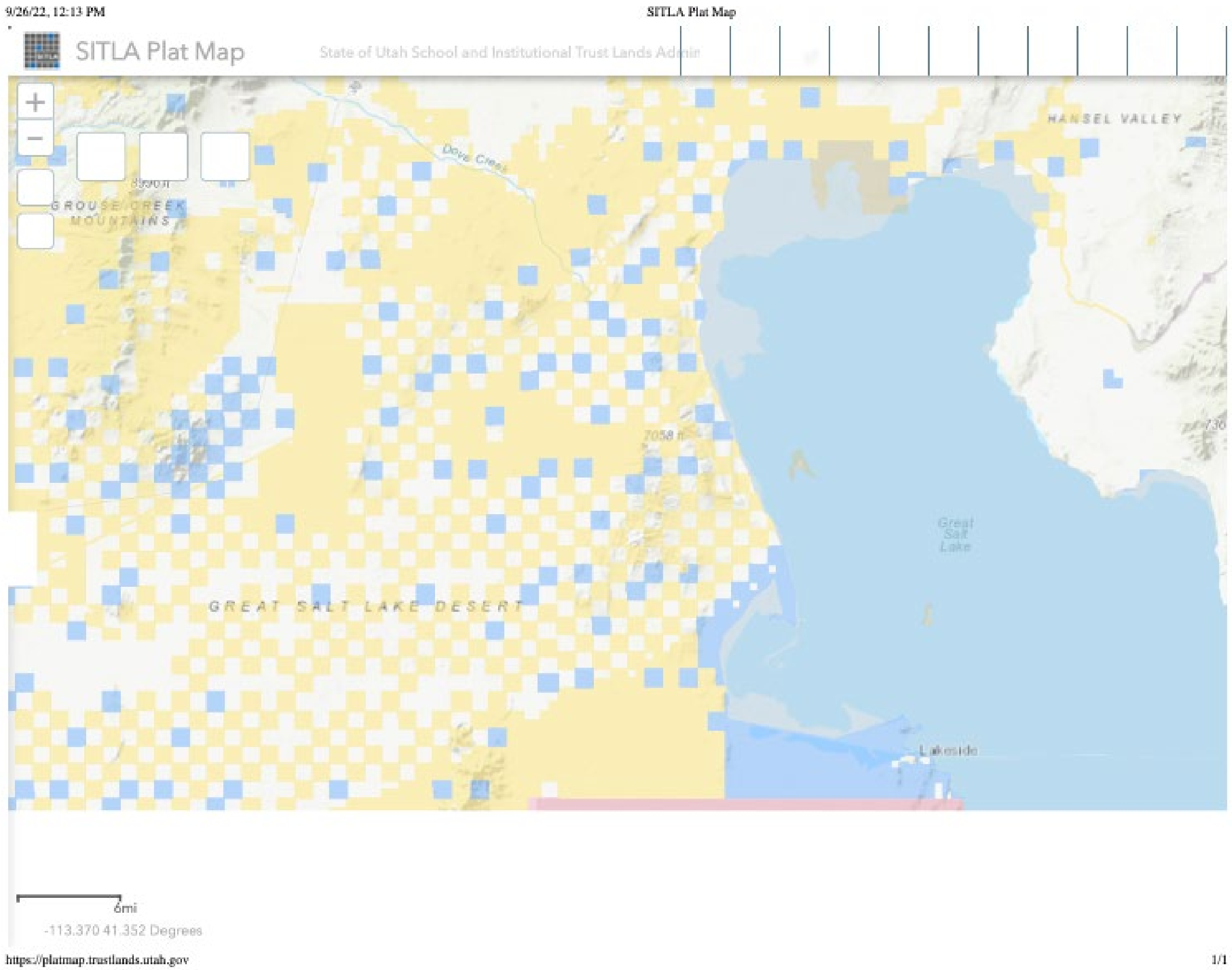
- Its difficult to estimate the cost of a pipeline from southern California to the GSL
- Assumptions
  - 1000 miles
  - $75,000/inch /mile
  - 1000 miles X $100,000/inch/mile X 72 inches =. $7,200,000,000
  - Just to lay the pipeline
  - Additional Infrastructure $15,000,000,000
  - My estimated total for. 72” (6 ft) diameter pipe $22,200,000,000
  - Energy for pumping stations, pressure control stations, cathodic protection is additional
  - This project will exceed 80 billion
  - Rough estimations assume $300,000 per inch per mile, this is the inexpensive portion of a pipeline.
  - Operating Expense: Daily on-going costs…. Whether the pipeline is in use your not

NEXT STEP: MODULAR MOLTEN SALT REACTORS

THIS NUCLEAR MODULAR MOLTEN SALT REACTOR IS ALSO A DE-SALINATION PLANT

- The modular nuclear molten salt reactor is scalable and capable of operating in tandem with other modules.
- Coupling these modular reactors together in a train of 89 will produce 25,000,000 acre-ft of de-saliated water in 14 months.
- The only way to get the volumes of water needed to heal the GSL is to access the deep saline aquifers. USGS estimates the deep saline aquifers in the Great Basin to be near 900,000,000 acre-ft.

WHERE TO LOCATE, DRILLING & DESALINATION PLANT?



WEST DESERT PUMPING PROJECT

COMMON YET UNIMAGINATIVE POPULAR THOUGHT

- Utah's Expensive Flooding Quick-Fix: The 1987 Bangerter Pumps
- Description
- **Out in Utah's West Desert is a massive $60 million infrastructure project that hasn't been used in over thirty years. Can you guess what it is and why it was made?**
  In the 1980's, a flooding Great Salt Lake threatened transportation, industry, and the economy in Utah. Under the leadership of Utah governor Norm Bangerter, the emergency was solved by installing three huge pumps on the lake's western shore that would pull water away from urban areas out to the desert to evaporate. After only two years of use, the pumps were moth-balled. Thirty years later, this $60 million project still sits out in the West Desert, waiting for another flood.
- As expected, over the next two years the lake level lowered. The project won the Outstanding Civil Engineering Achievement Award from the American Society of Civil Engineers. But, others noted the futility of creating a massive infrastructure project for a problem that now seems so temporary. With Utah's waters diverted away from Great Salt Lake at an increasing rate to support our growing population, it is uncertain whether the pumps will ever be used again.
- Creator
- By Megan Weiss for Utah Humanities © 2021

WEST DESERT PUMPING PROJECT

- SALT LAKE CITY (KUTV) — Silent for 32 years and left high and dry by the drought, pumps at the Great Salt Lake are ready to start up again if needed.
- The drought has taken a big toll on the lake. It's now near its lowest level since 1963, but in the 1980s, record snowmelt poured into the lake. Flood waters took over Saltair, shoreline businesses, farmland, roads, even threatened the airport.
- The pumps would probably take approximately six months of actual work time to get them going.
  The state declared an emergency, and in a highly-controversial move rushed to build a giant $60 million pump station – and they did it in less than a year.

WEST DESERT PUMPING PROJECT

GOVERNOR BANGERTER WASN'T WRONG;
HE WAS AHEAD OF HIS TIME

WEST DESERT PUMPING PROJECT

GOVERNOR BANGERTER WASN'T WRONG;
HE WAS AHEAD OF HIS TIME

- PUMP SPECS (3)
  - Impellars: 10 ft
  - Engines: (3) 3500 hp each
    - HP: 3500 hp each
    - Overall size: 28'X12'X18"

  - Pump Capacity:4500 gpm each
  - Total Pump Capacity: 13,500 gpm

    13,500 gal/min X 60 min/hr = 810,000 g/hr X 24 hrs=19,440,000 gal/day X 360 d/yr = 7,000,000,000 gal/yr / 7.488 gal/cuft = 947,600,000 cuft/yr / 43,560 cu ft/acre = 21,800 acre-ft/yr/pump station

    To achieve recommended new augmented capacity of 450,000 acre-ft:

    450,000 acre-ft/21,800 acre-ft/yr =20 yrs with one pump

    4 years with 5 pumps

    The regret is not that we have one pump station at $60,000,000

    Its that we didn't get 10 pump stations at $600,000,000 when they were cheap!

NEED FOR EVAPORATION
A Function of PVT and Salinity

- Evaporation rate:
- assumptions: 3,000,000 acre-ft/yr

  - AT PRESENT
  - AREA 950 SQ MILES
  - 608,000 ACRES

  - AVERAGE POOL
  - 1700 square miles
  - Depth: 14 ft

  - FULL POOL
  - Area: 3300 sq miles
  - Depth 35 ft

  l

- PVT is Pressure Volume = Temperature
  - As Temperature increases and Pressure decreases Volume increases
  - Hence Evaporation increases

  - Salinity affects the PVT based on Saline concentrations

  - As salinity increases evaporation at STP decreases
    - Example:
      - to boil potatoes at sea level: 100 deg C
      - At 4200 feet using fresh water <100 deg C
      - At 5280 <<100 deg C
      - Conclusion; your potatoes will not cook in fresh water at high elevations as fast as they will at sea level, unless you change the salinity.
      - Increasing the salinity reduces the evaporation rate of the boiling water by elevating the boiling point

NEED FOR EVAPORATION Perspective

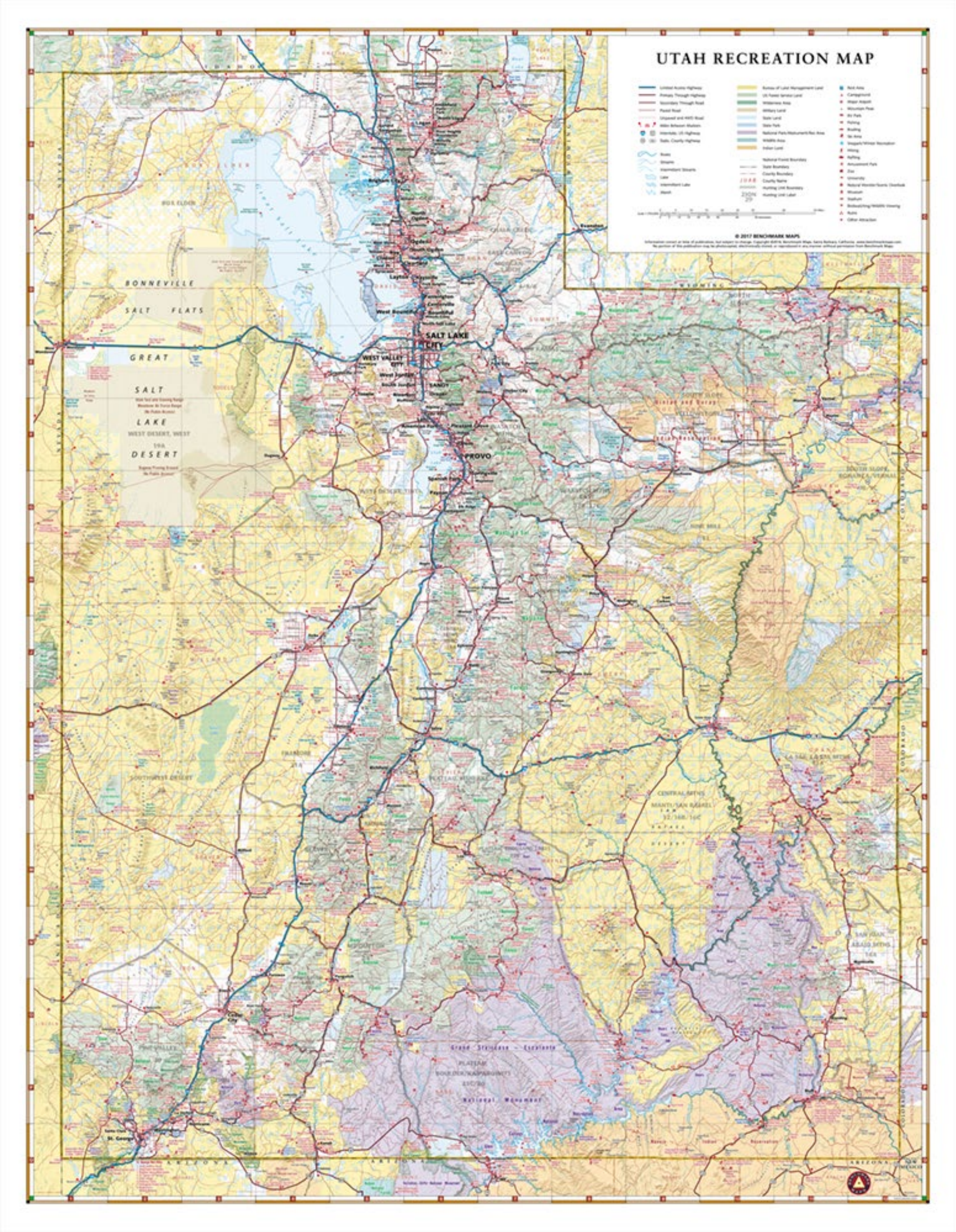
- Assume Evaporation rate of GSL: 3,000,000 acre-ft/yr

  - At a depth of 10’ the area is 300,000 acres
  - Assume a person can stand comfortably in a 6 sq-ft box
  - 300,000 acres X 43,560 sq-ft/acre = 13,000,000,000 sq-ft / 6 sq-ft/person
  - 2,178,000,000 people standing in an area with 10 feet of water over their heads
  - This illustrates the enormity of the need for evaporation. I believe. That much of our drought is caused by a lack of evaporation. Simply slowing the flow will not over come the critical state of the State of Utah. This problem is systemic with all terminal lakes in the west.
  - We need evaporation
  - To achieve the equilibrium of the ecosystem we need to thrive we need to maintain the salinity of the GSL and not simply dump more salt water in the terminal lake.

NEED FOR DESALINATION

- If the water to used to bring the GSL back to health is saline it will increase the salinity and reduce the evaporation rates. If we decrease the evaporation rates we reduce the meteoric precipitations that falls in the mountains and on the valley floor.
- While we are working on the health of the GSL we also need to consider the causeway and how to bring the salinity back to equilibrium on both sides.
- Its not a big question why the levels vary.

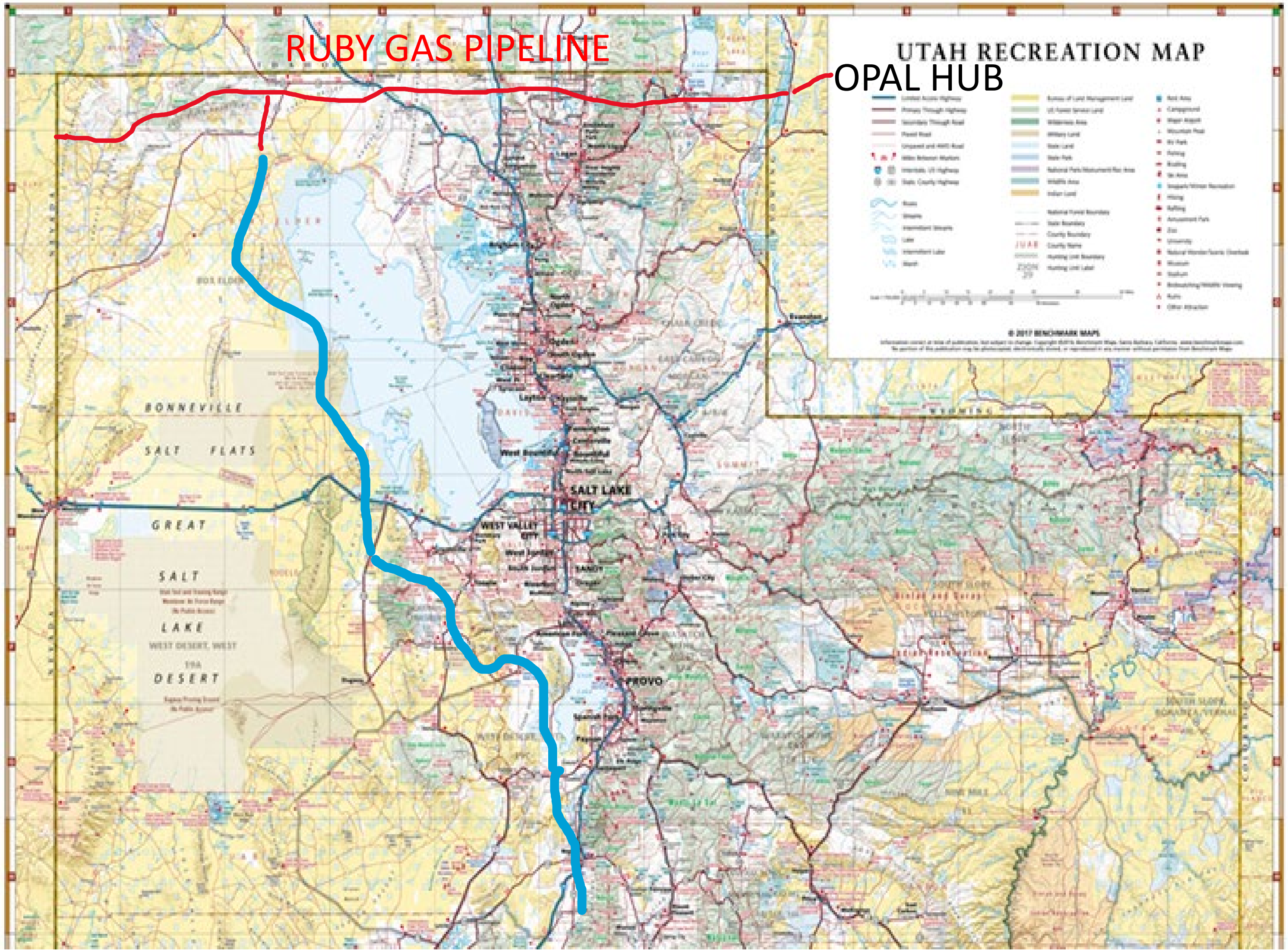
UTAH ROADS


UTAH RECREATION MAP
BONNEVILLE
SALT FLATS
GREAT
SALT
LAKE
DESERT
SALT LAKE CITY
WEST VALLEY CITY
PROVO

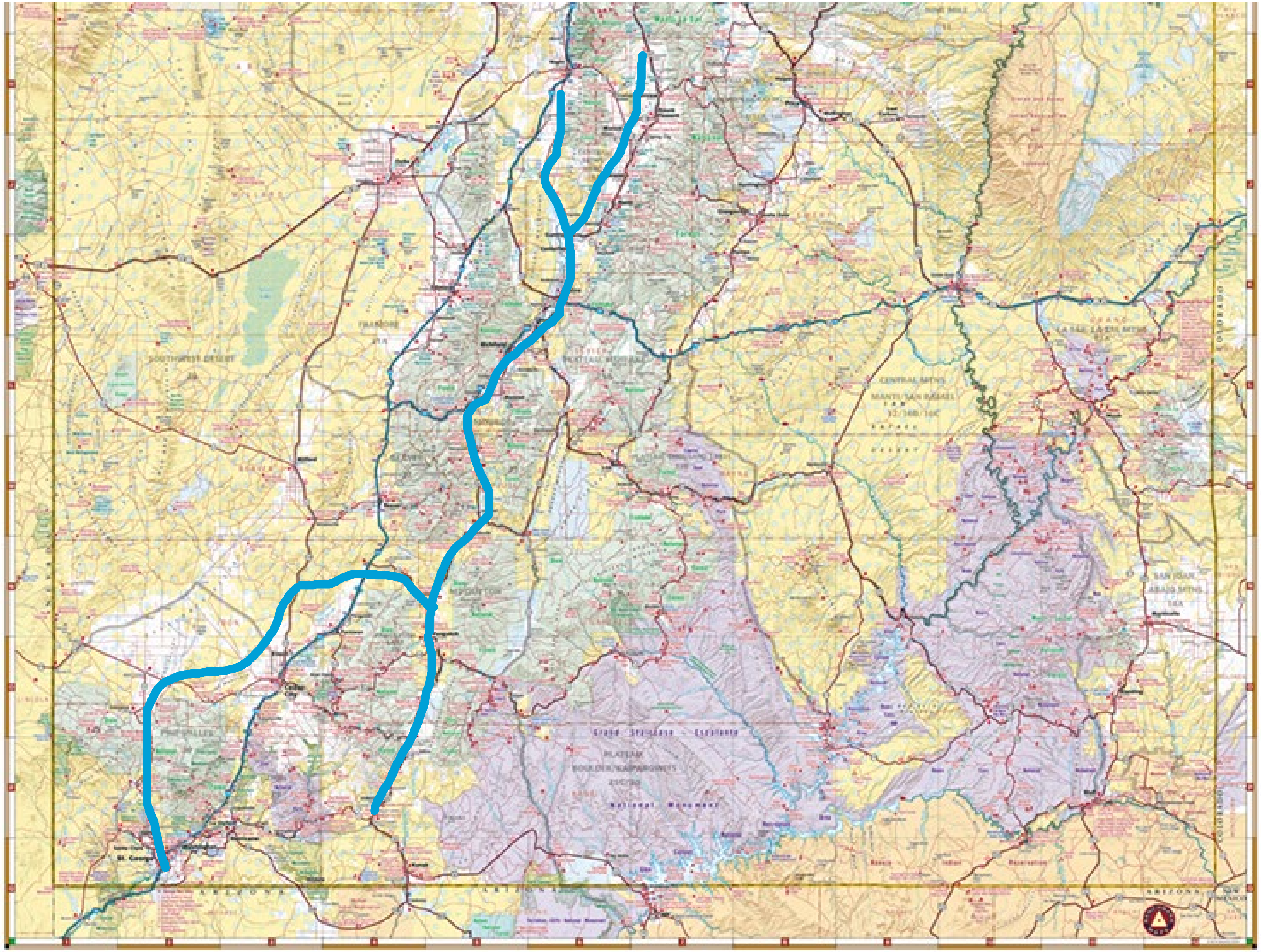
NORTHERN UTAH PIPELINE ROUTES

Why is the Ruby Gas Pipeline important to the future of the State of Utah and the GSL?

HYDROGEN



SOUTHERN UTAH PIPELINE ROUTES



PIPELINE ROUTE

WHY THIS TYPE OF PROJECT?

- Having the ability to SCALE and throttle flow into the GSL and throughout the State of Utah, based on drought conditions is something we have never had. Israel comes close.
- Producing the water from within the Utah boundaries reduces the complexities of dealing with other states and nations on water issues. See Colorado Compact for example.
- Being able to recover the REE and CM from our own water reduces the need to compensate outside interests provides revenue stream
- Opens up a badly needed Energy and Utilities Corridor running North and South in the States