A Comparison of the Salar de Atacama and Clayton Valley Lithium Ore Deposits:
Groundwater Mining in the some of the Driest Places on Earth

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Introduction

- Water Laws in Chile
- Water situation in Chile
- Groundwater mining and lithium
- Comparison of Clayton Valley (CV) and Salar de Atacama (SDA) lithium brine mines
  - Surface water, groundwater and geology
  - Wells and Infrastructure
  - Inflows & ground water management
- Conclusion

Water Authority

- General Water Board (DGA) (DWR-US Equivalent)
  - Plan for the development of water resources and make recommendations for better management
  - Assign rights of water use, and research and measure water resources
  - Co-ordinate public sector research programs and partially publicly funded private initiatives
  - Supervise the use of public waters
  - Supervise the work of local regulatory bodies

Water laws in Chile

Water Law of 1981

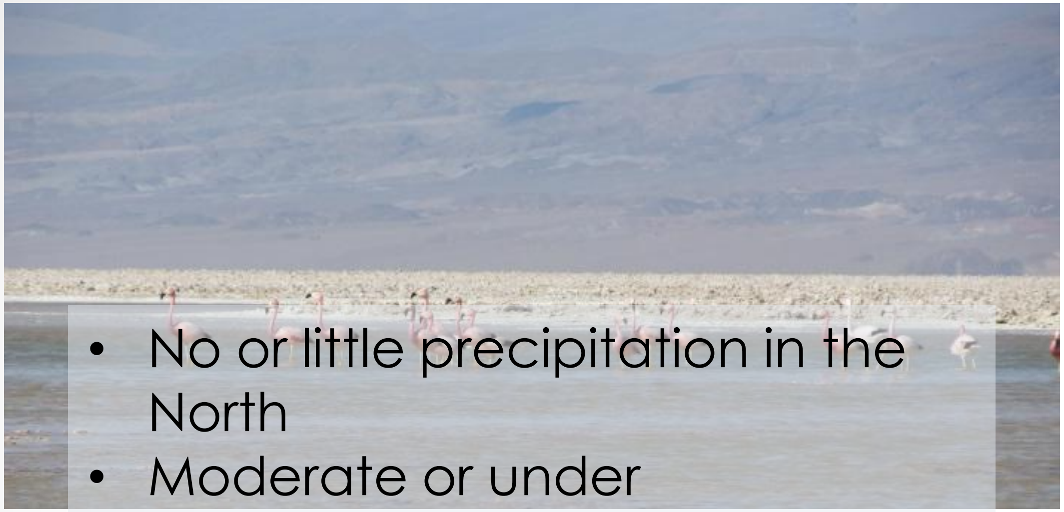
- Administered by DGA
- Established water resources as public assets
- Created a water market
- Water rights may be granted to individuals, companies
- Water rights can be sold, traded, inherited, etc…
- Limits power of State to intervene on management of the resource
- Applies to surface or groundwater

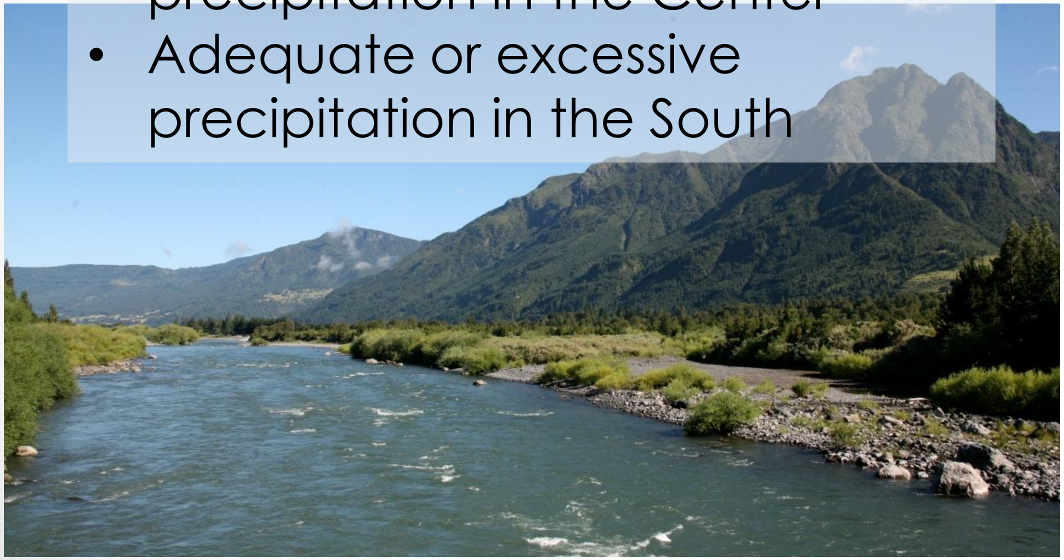
Reformation of 2005

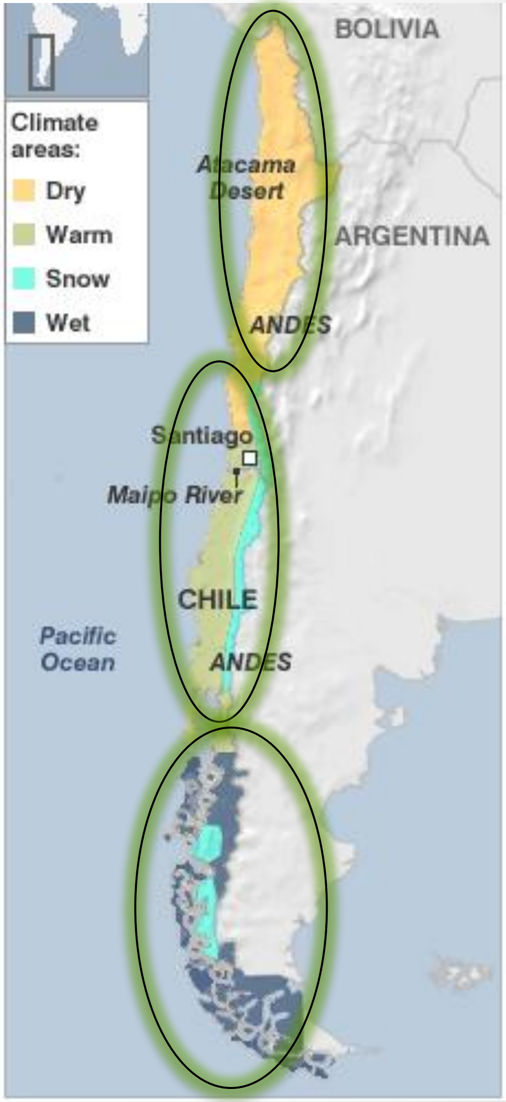
- Focused on establishing flow restrictions to an ecological minimum
- Allowed for creating a reserve, respecting need, and established a fee for non-use, and obligational reporting

Chile Water Situation

- No or little precipitation in the North
- Moderate or under precipitation in the Center
- Adequate or excessive precipitation in the South

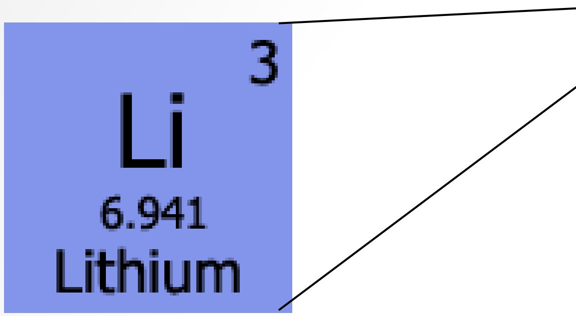


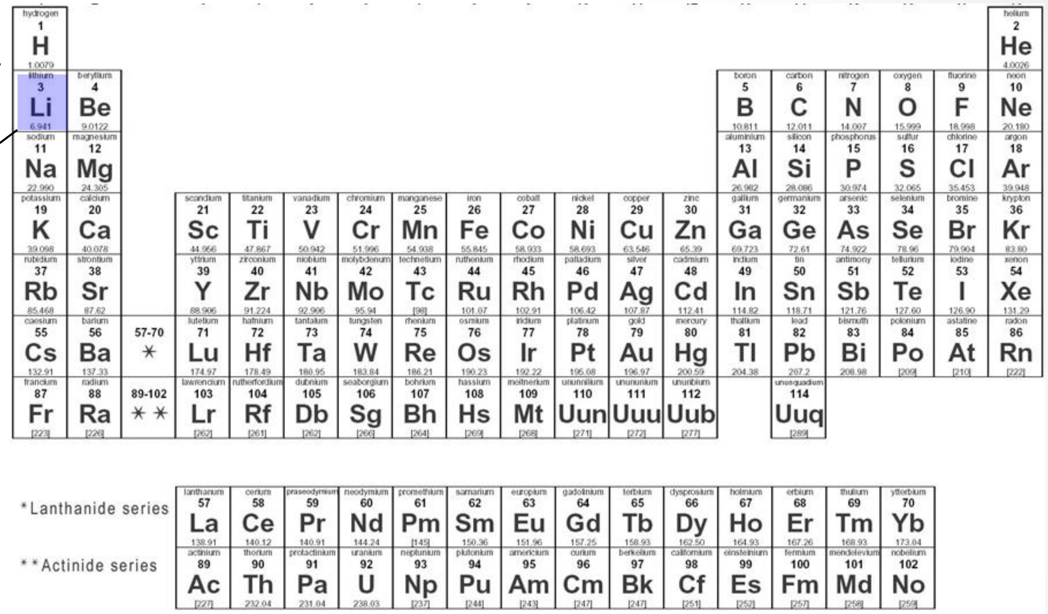




Groundwater Mining & Lithium

Lithium





What is lithium?

- Lithium is a soft, pale, white metal that belongs to the alkali metal group of chemical elements
- Lithium metal does not occur naturally in the environment
- Lithium is found as lithium chloride in aquifers of the Clayton Valley and halite aquifers of the Salar de Atacama

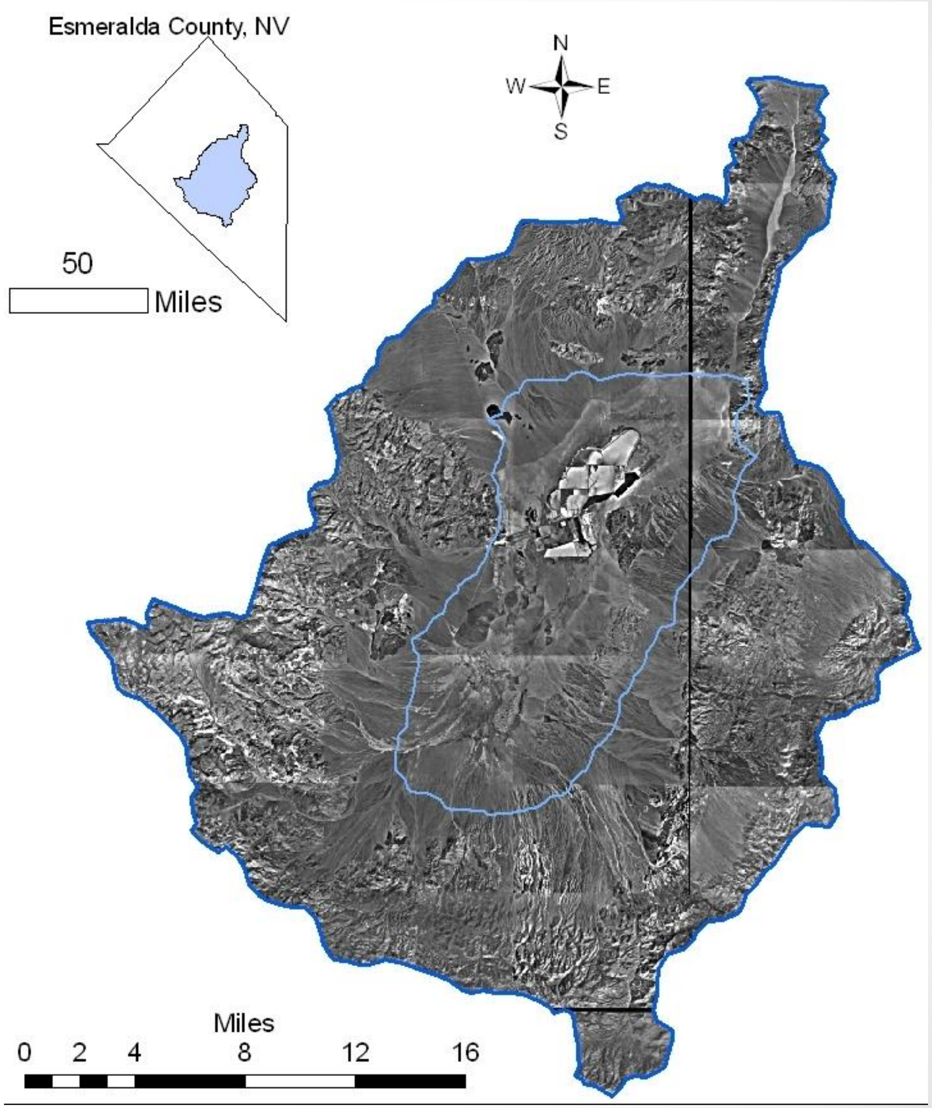
Clayton Valley Lithium brine mining

- Lithium in groundwater first discovered in1950s by Leprechaun Mining
- Foote Mineral purchased land
- 1967 First Li_2CO_3 produced
- Rockwood Lithium Inc. operates the Clayton Valley lithium brine extraction facility at Silver Peak, NV

Water in Clayton Valley

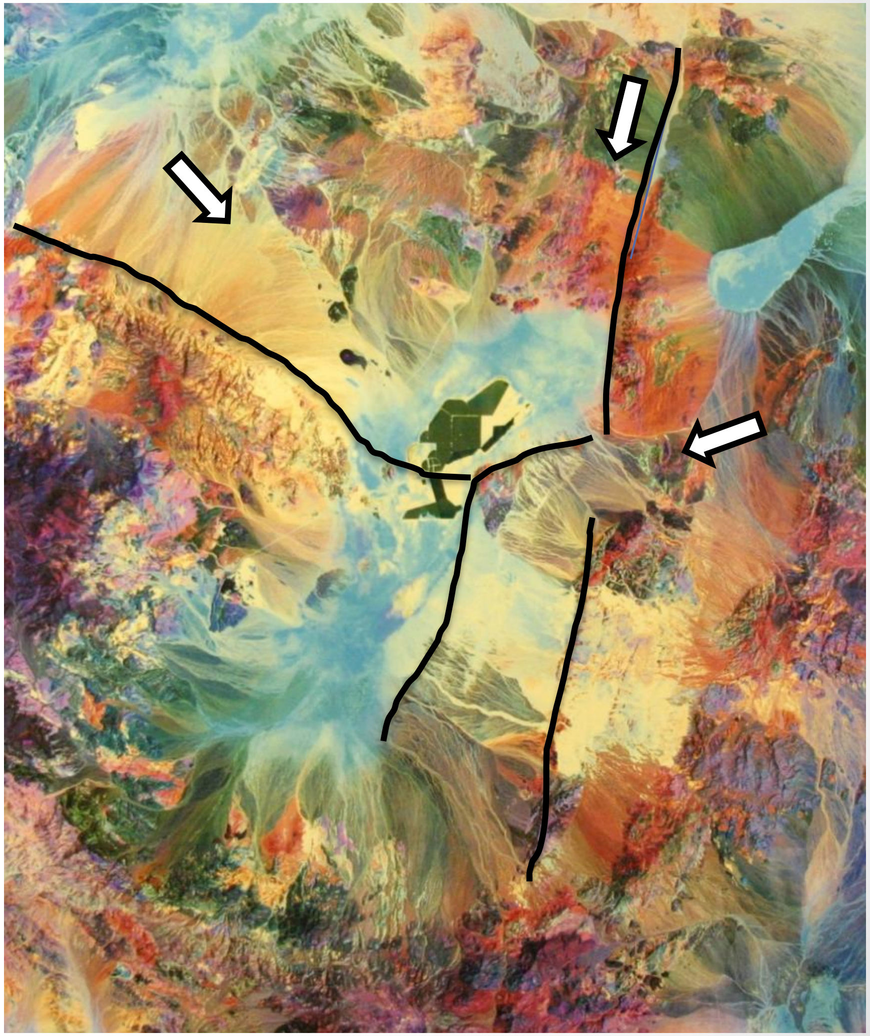
Groundwater at Clayton Valley

- Closed basin
- Basin area 1342 km^2 (518 sq mi)
- Playa area 78 km^2 (30 sq mi)
- Playa elevation 1300 m
- Arid region in rain shadow of Sierra Nevada
- Precipitation 3.6-17.5 cm Average 8.9 cm(3.5")
- Evaporation 45-161 cm Average 147 cm(58")
- Mean average temperature 10.5C (51F)



Geology & Groundwater

- Partial graben structure
- Fault bounded-controls recharge to basin
  - Paymaster Fault
  - Cross Central Fault
  - Angel Island Fault
- Main recharge from Smoky Valley - north
- Ash, gravel, halite aquifers host lithium deposit
- Evaporation and EVT at borders



SDA Lithium Brine Mining

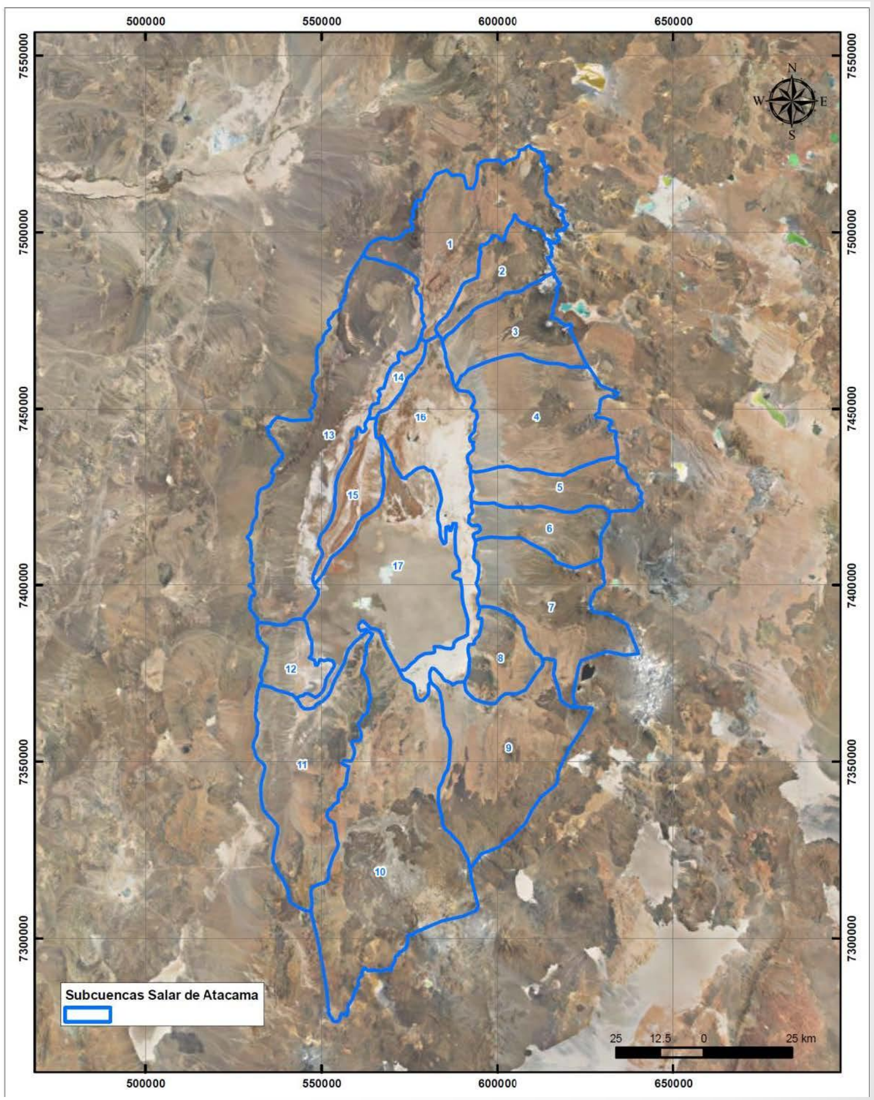
- Lithium discovered in 1970s
- Sociedad Chilena de Litio company was constituted 1980
- The first concentrated brine production was in 1984
- La Negra production facility first produced lithium carbonate in

Water in Atacama



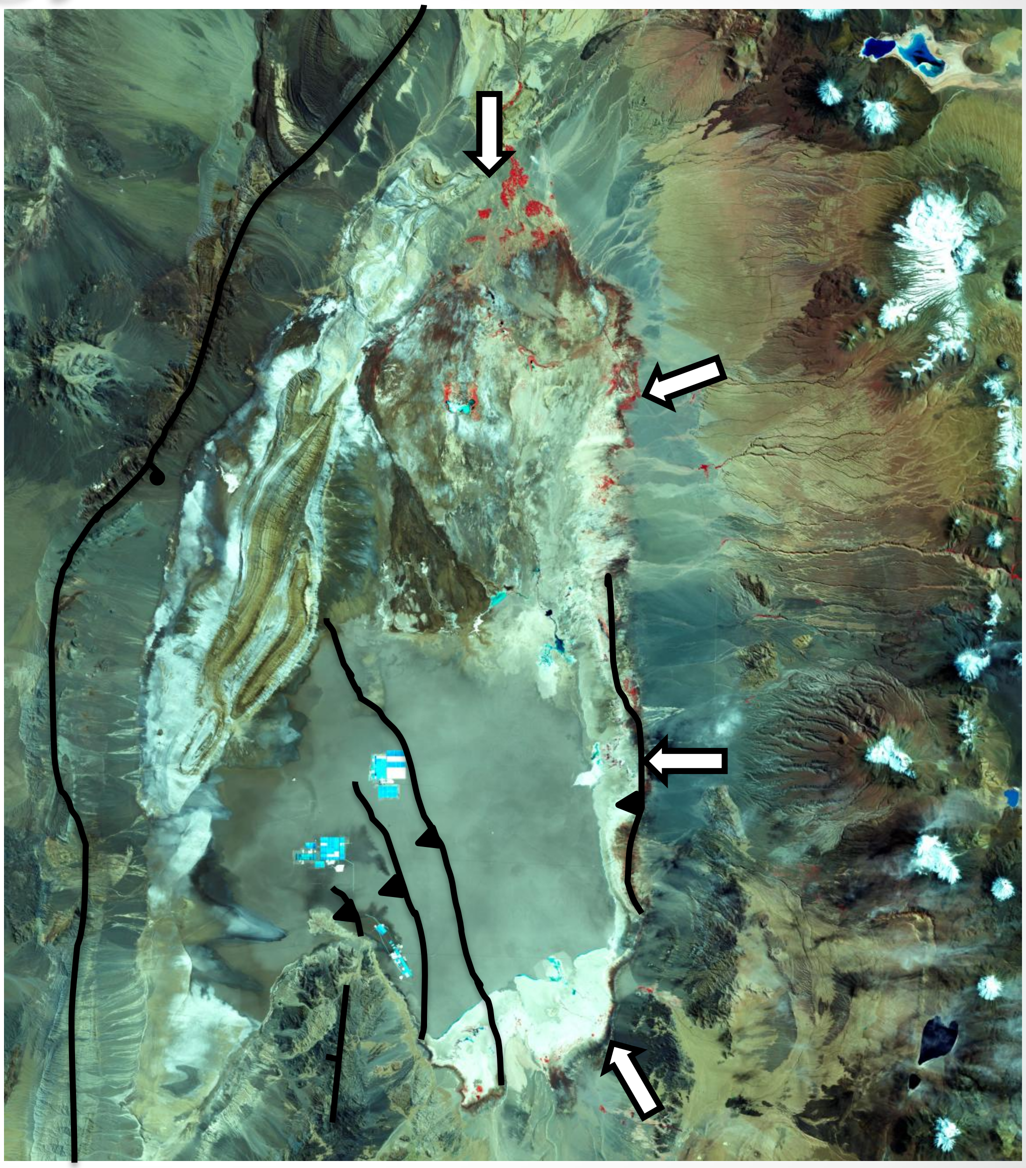

Groundwater at SDA

- Closed basin with multiple sub basins
- Basin area 18,100 km^2 (7000 sq mi)
- Playa area 2,017 km^2 (779 sq mi)
- Salar elevation 2300 m
- Hyper arid region
- Precipitation 0 to 20 mm/y
- Evaporation 70-200 cm/y
- Mean temperature 14C (57F)
- Recharge rate 125,000AF/y
- Groundwater pumping
- Water rights over-extended

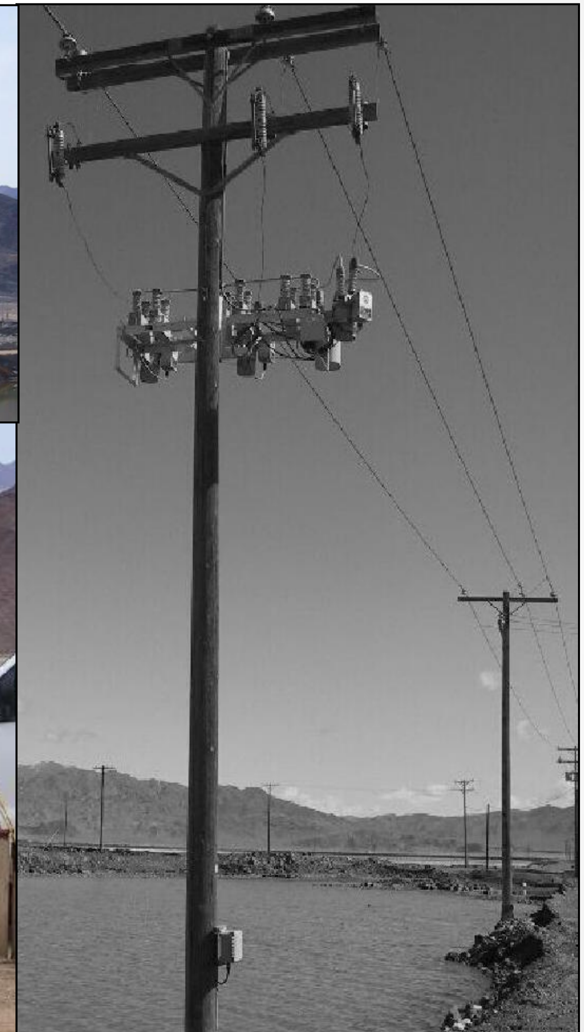


SDA Geology & Groundwater

- Active faulting
- Compressional basin
- Rio San Pedro to North
- Main inputs on east side
- Halite aquifer hosts lithium deposit
- Climate controlled recharge
- Recharge reaches periphery and dissolves halite
- Evaporation and EVT at borders

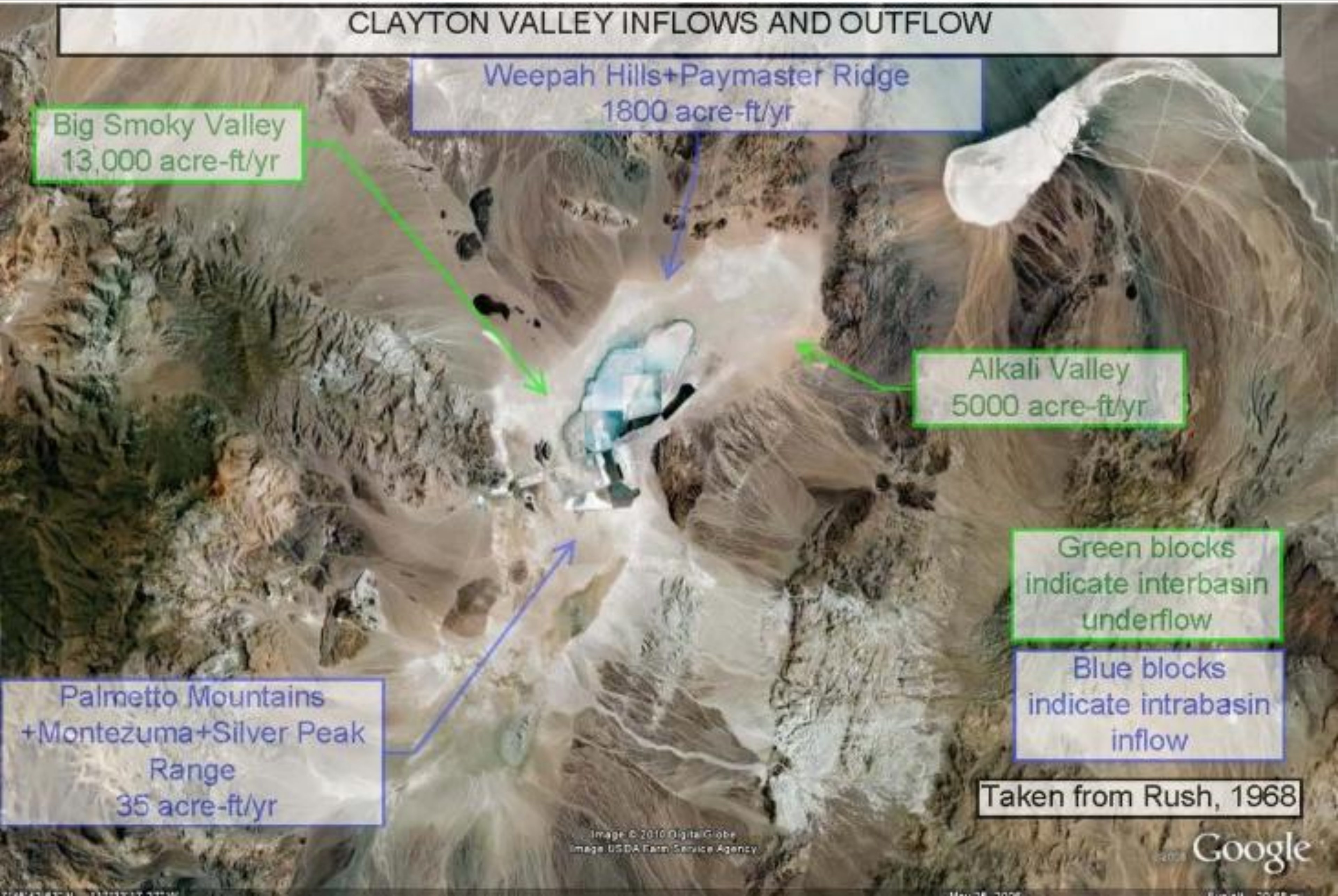


CV Wells & Infrastructure

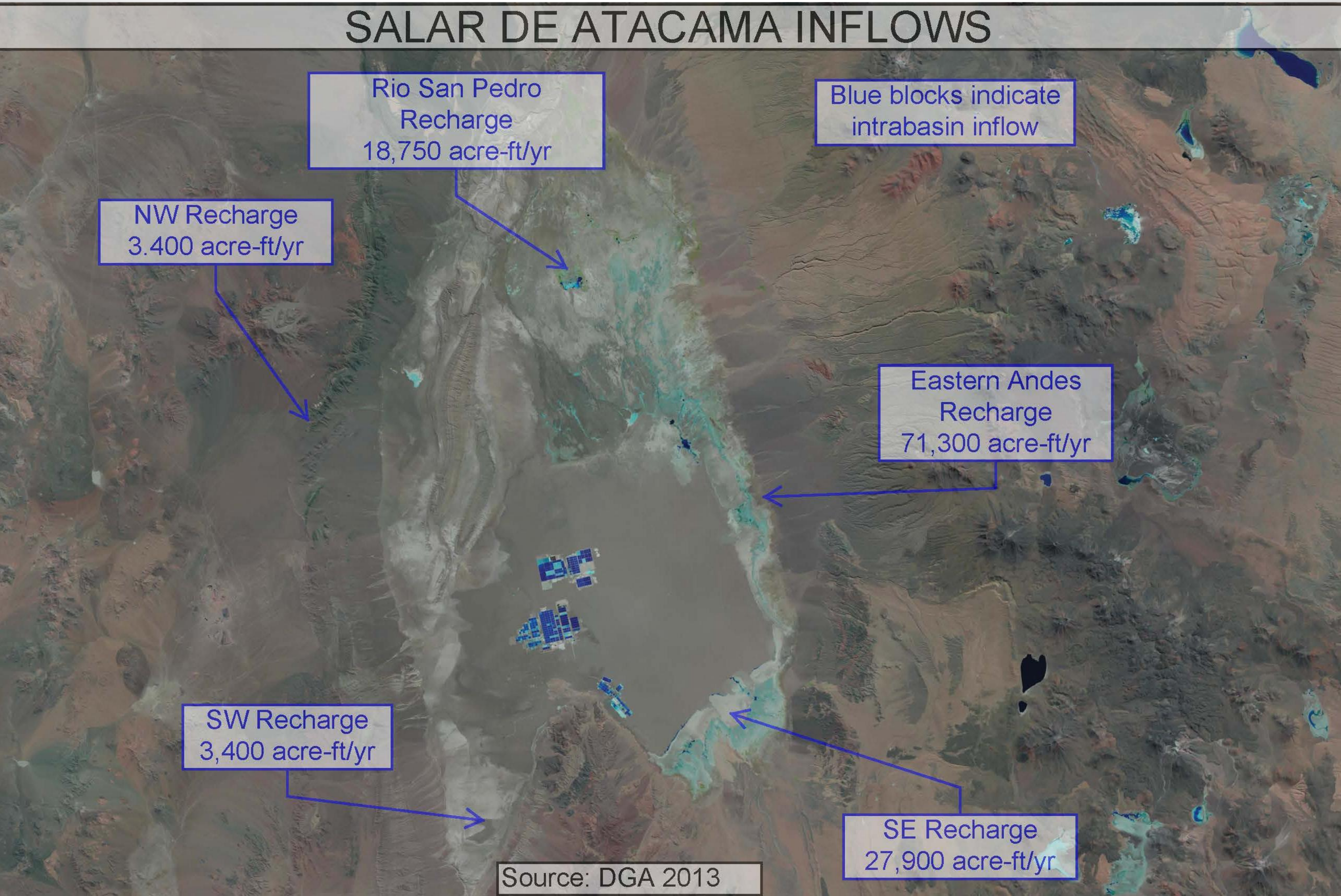


SDA Wells & Infrastructure

Theoretical Basin Inflows



Theoretical Basin Inflows



Conclusion

Comparison of Clayton Valley (CV) and Salar de Atacama (SDA)

- Similarities
  - Closed basins, high altitude, non-potable water
  - Low precipitation, high evaporation, moderate temperatures
  - Methodology and process time
- Differences
  - Size and scale
  - Recharge rate rates
  - Infrastructure and logistics
  - Management strategies