Great Salt Lake Integrated Water Resources Management Model (GSLIM)

Current Status and Future Work

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Utah Division of Water Resources

[Great Salt Lake Advisory Council Meeting]
March 13, 2019

The model evaluation processes: three phases (Aug 2017 to Jan 2019)

FIRST PHASE:

- **Report received**
  - **Aug 11, 2017: The model and report from Jacobs**
- **Comments on the report and model**
  - **Sep 1, 2017: DWRe shared the comments to FFSL (Utah Division of Forestry, Fire & State Lands** through Laura Vernon**)**
- **Comments discussed with Jacbos**
  - **Sept 5, 2017: Model comments were updated to the Jacob's team skype call**

SECOND PHASE:

- **Updated model and report**
  - **Jan 19, 2018**: Updated model and report from Jacobs

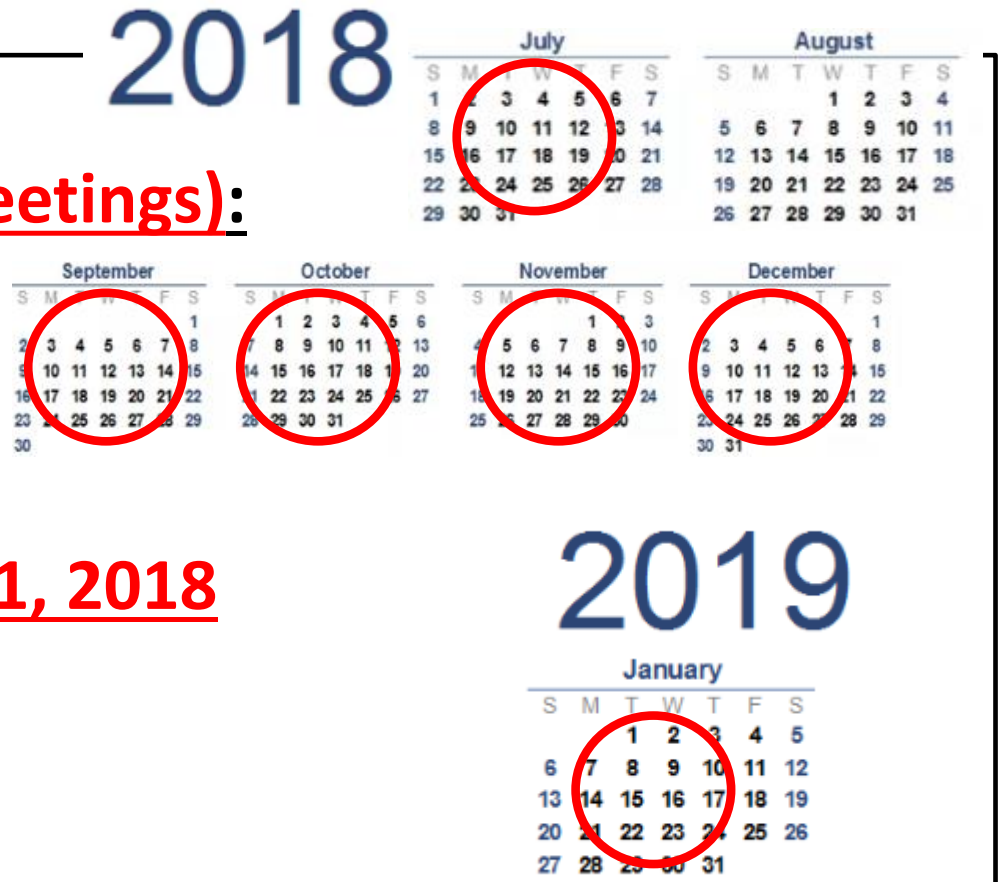
- **Internal meetings and updates**
  - **Mar 28, 2018**
  - Model errors and calibration issues were informed to DFFSL (Laura Vernon)
  - FFSL was requested to share the model and evaluate the model with other agencies and the tech. committee memebers

THIRD PHASE:

Joint evaluations with Jacobs (Six Skype Meetings):

- Started on **Jul 10, 2018**

1) **First Skype meeting:** Sept 19, 2018
2) **Second Skype meeting:** Sep 26, 2018
   - The ***updated Calibrated Model*** on **Oct 1, 2018**
3) **Third skype meeting:** Oct 17, 2018
4) **Fourth skype meeting:** Nov 2, 2018
5) **Fifth Skype meeting:** Dec 4, 2018
   - The ***extended (Dynamic) Module*** on **Dec 17, 2018**
6) **Final Skype meeting:** Jan 23, 2019
   - Discussed on **the next steps**



Acknowledgements:

JACOBS Team:

- **Jeff DenBleyker** P.E. – Salt Lake City, Office
- **Armin Munevar** P.E. – San Diego, California Office
- **Paula Silva** P.E. – San Diego, California Office
- **Kensey Daly** – San Diego, California Office

Outline:

- **Model features**
- **Model simulation results**
- **Model performances and future work**

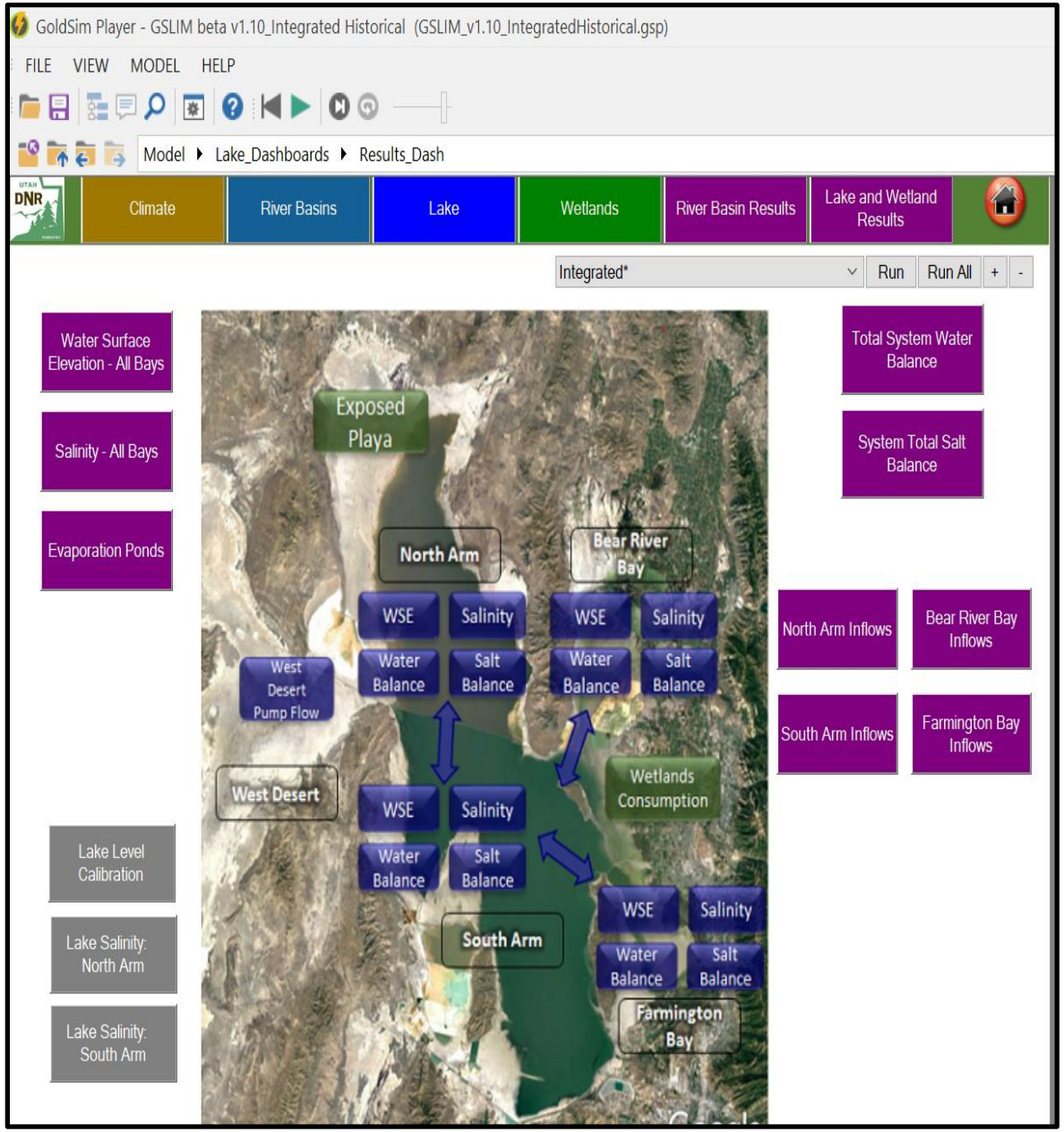
Outline:

- **Model features**
- Model simulation results
- Model performances and future work

GSLIM

- *How do changes in GSL and its watersheds impact the lake's water levels and salinity?*

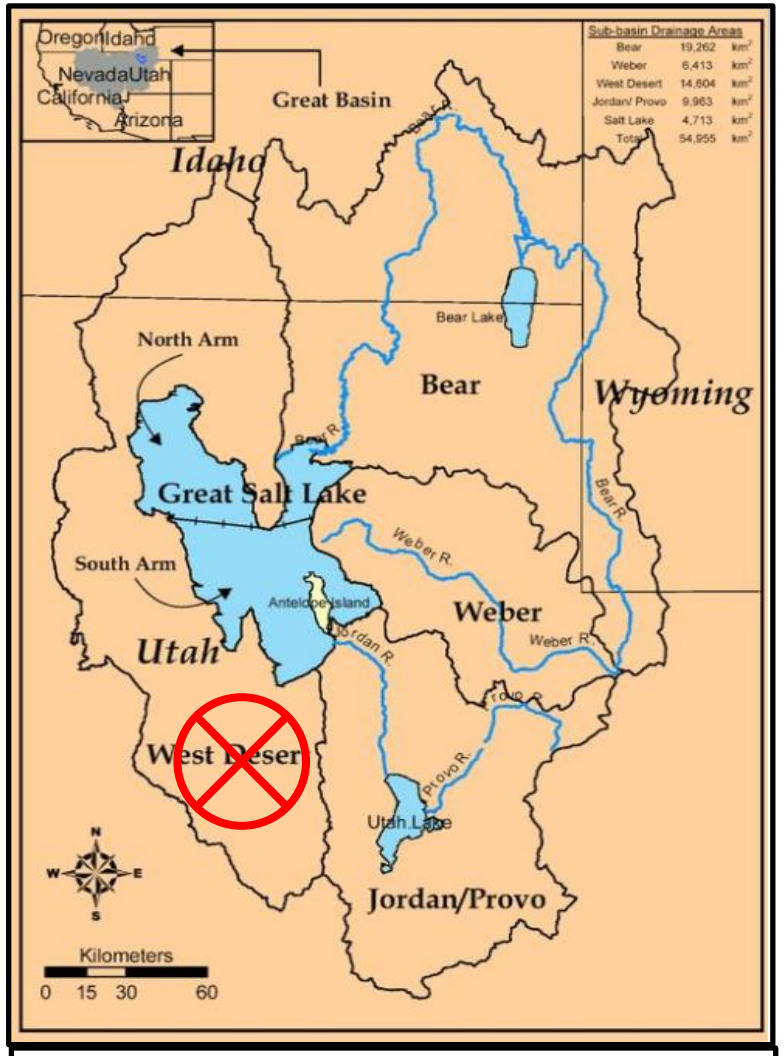
- *Modeled on the **GoldSim** Software Platform*



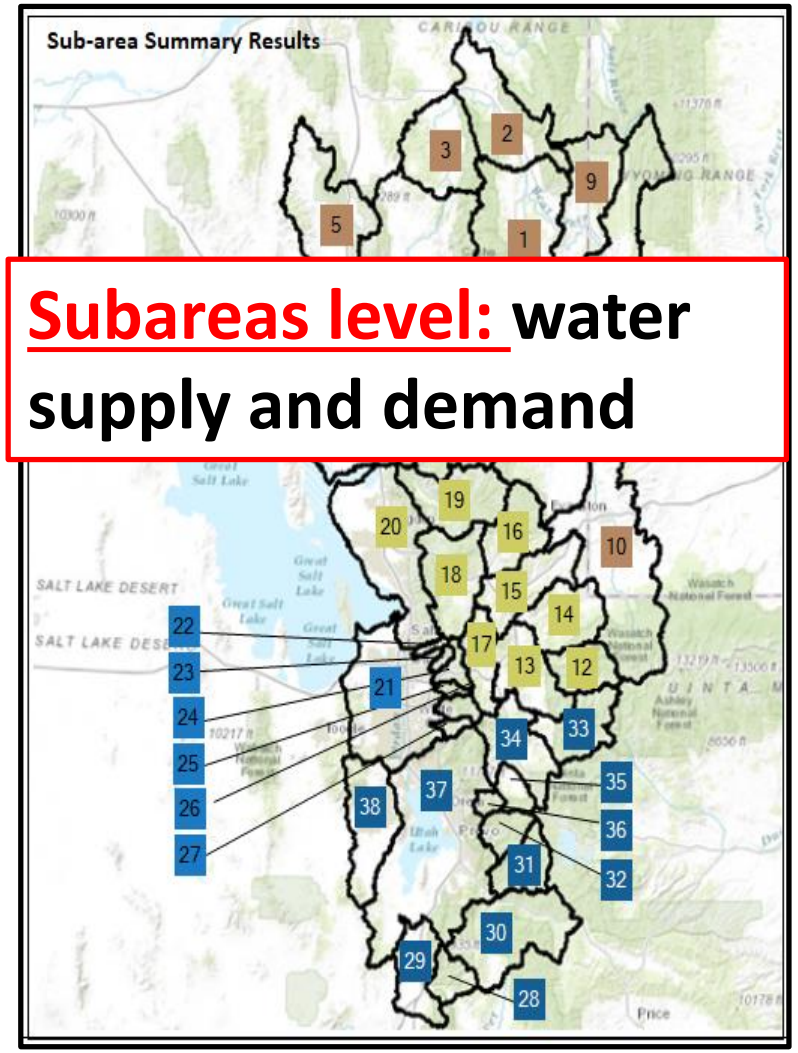
Three modules

- **River Basin (Integrated) Module**
- **Wetland and Lake (Dynamic) Module**
- **Lake (USGS Lake) Module**

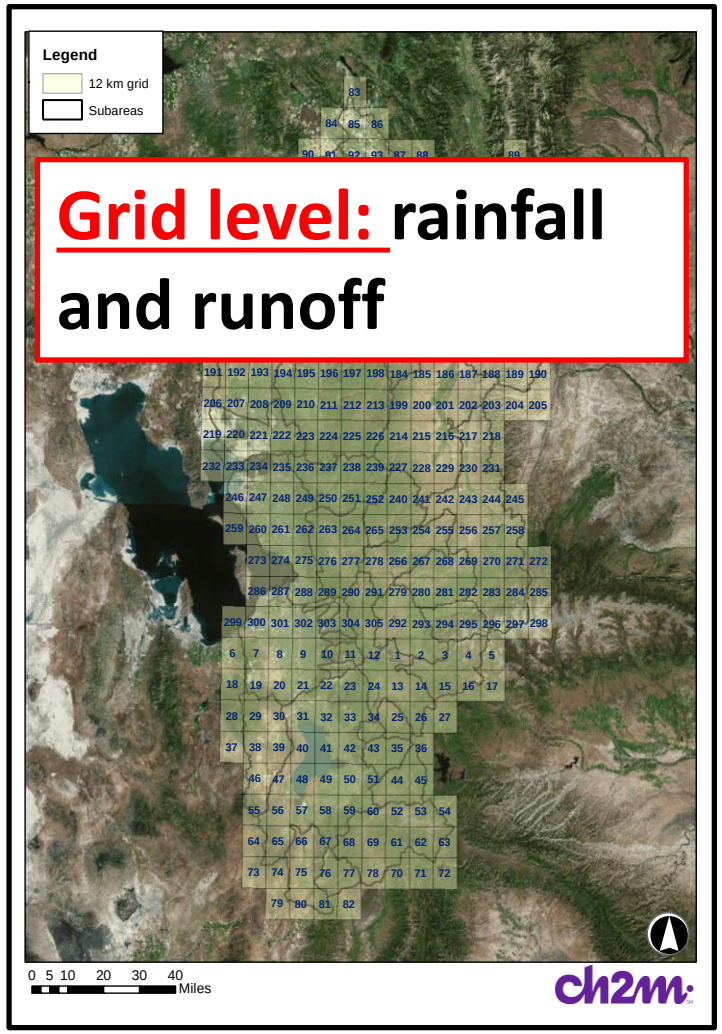
(1)River Basin Module: Basins, Subareas, & 12 km size grids



About 55000 km2

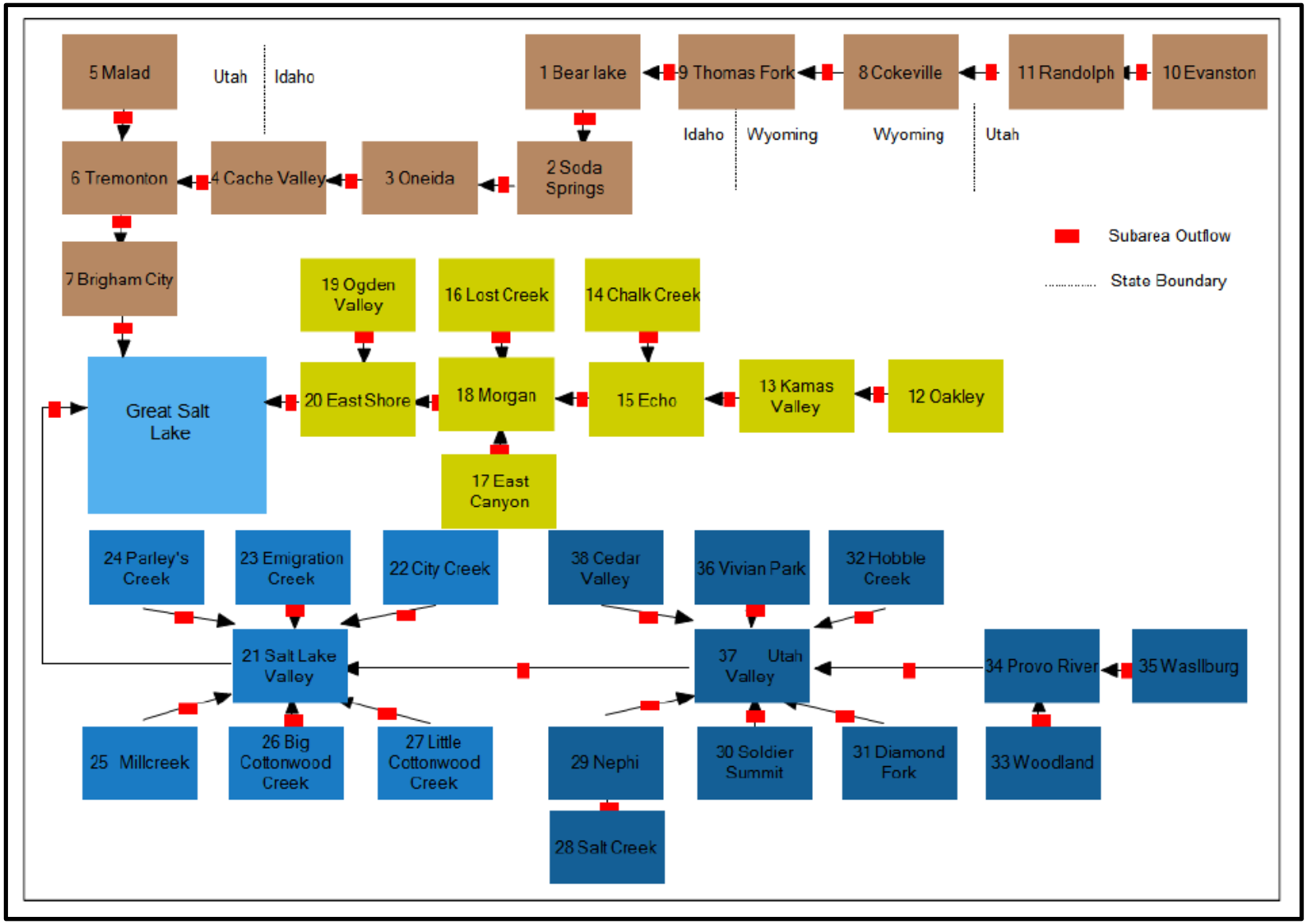


About 38 Subareas



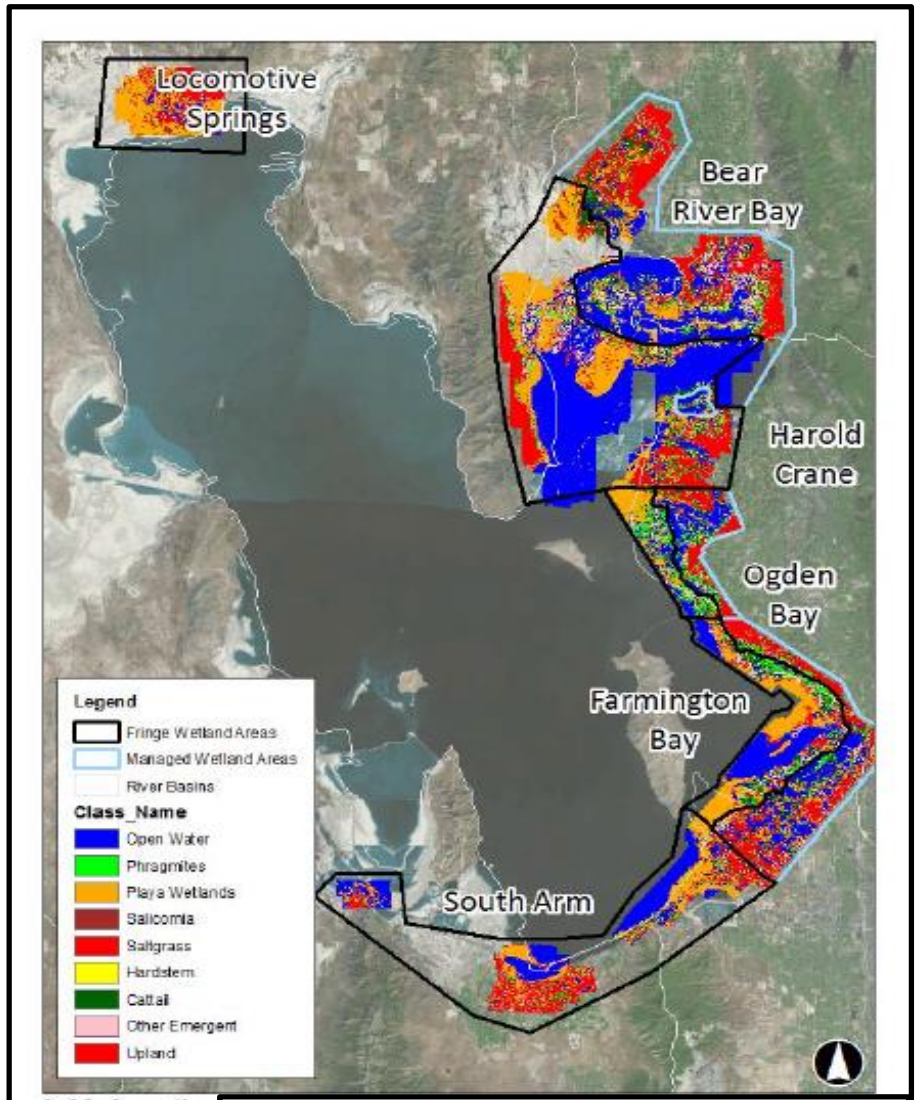
About 305 Grids of 12 km

Integrated Module: Subareas flow diagram



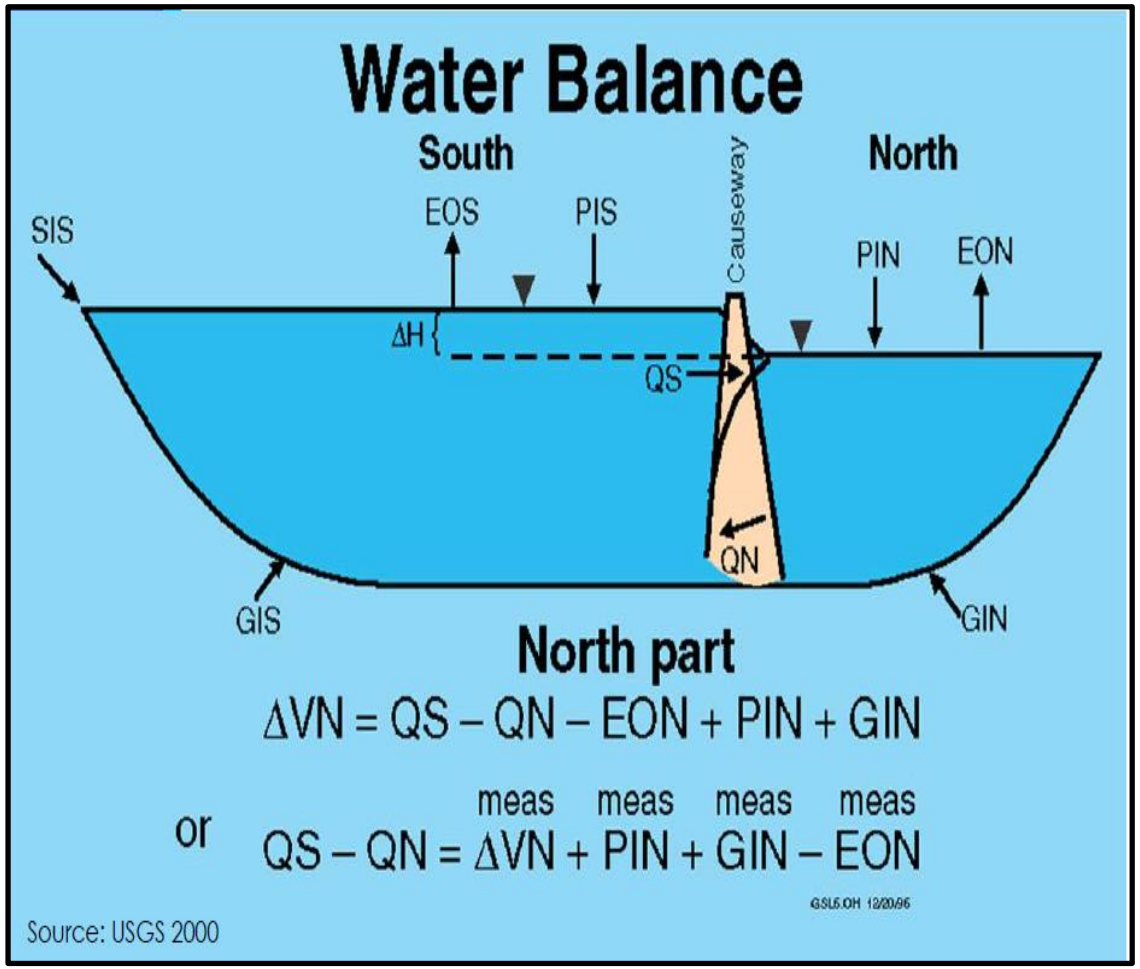
(2) Lake Module and (3) Dynamic Module (Lake and Wetland)

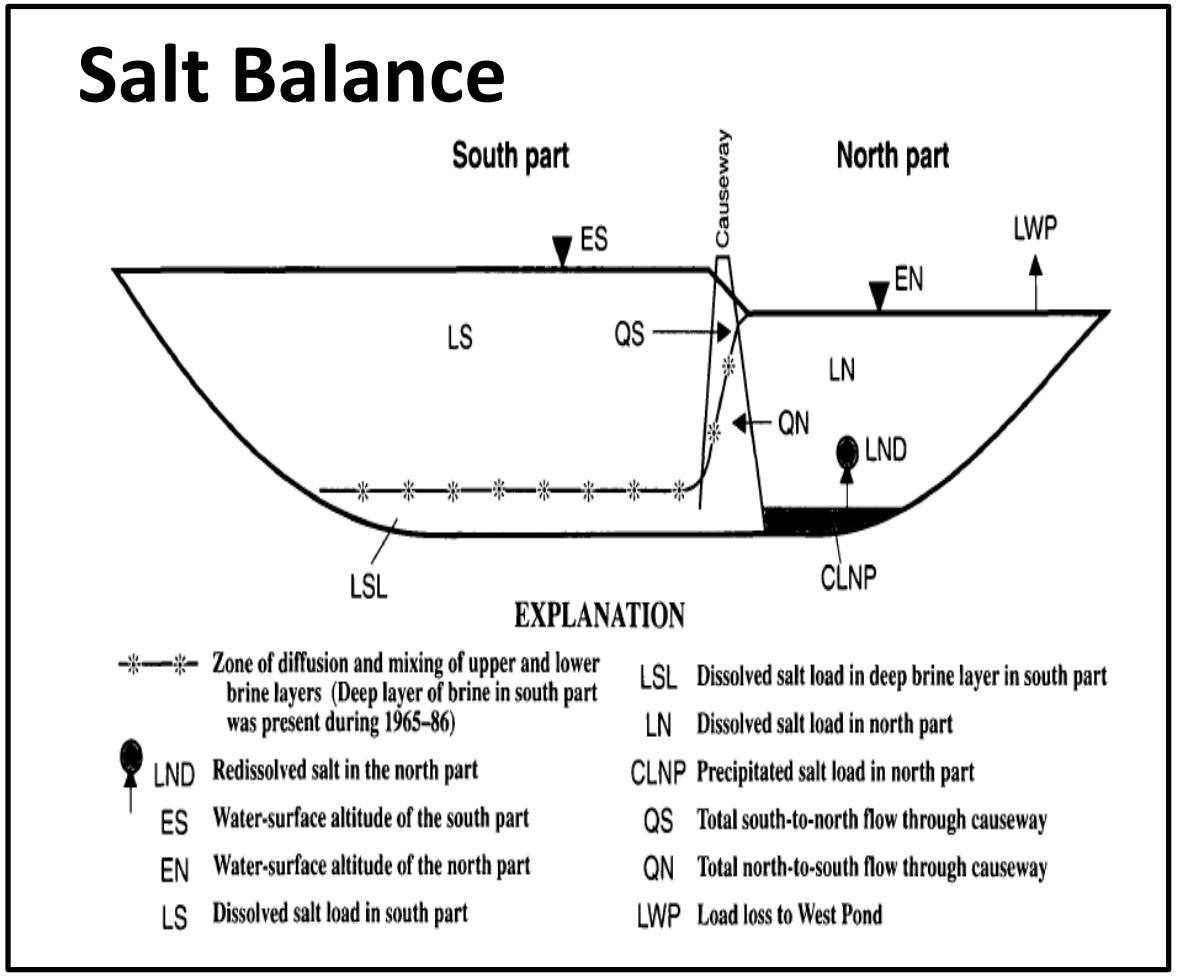
Lake Module



Dynamic Module

Both modules: Water and Salt Balance USGS equations





[USGS WRI Report: 4221]

Model Illustrations

GoldSim - GSLIM_v1.10_IntegratedHistorical

FILE EDIT VIEW GRAPHICS MODEL RUN HELP

Model ▸ Scenario_Summary_Dash

GSLIM v1.10: Great Salt Lake Integrated

Integrated

Global Settings

Simulation Settings

Climate Settings

Temperature Change (deg C) 0

Precipitation Change (%) 0 %

Climate Settings

River Basin Module Settings

River Basin Module On ☑

Population:

✔ 2010 Census Data ✖ Gove and

Water Use:

% Indoor GPCD reduction 0

Water use for agriculture and urban irrigation ✔

Lake Module Settings

Lake Module On ☑

Lake Module: additional settings

Link Inflows to: River Basin Module ✔ Input ✖

Initial Conditions Elevation Salinity

South Arm 4205.9 ft 117500 m

North Arm 4206 ft 200200 mg/l

West Desert Pump ✔ Evaporation Ponds ✔

Wetland Settings

Wetland Module On ☑

Phragmite % Coverage

Locomotive Springs 7.49 %

Bear River Bay 6.29 %

Harold Crane 6.44 %

Results Dashboards

Lake and Wetland Results

River Basin Results

Gre

GoldSim - GSLIM_v1.10_IntegratedHistorical

FILE EDIT VIEW GRAPHICS MODEL RUN HELP

Model ▸ Lake_Dashboards ▸ Causeway_Dash

Climate | River Basins | Lake | Wetlands | River Basin Results | Lake and Wetland Results

Causeway Characteristics Dashboard

Integrated | Run | Run All | + | -

UPRR Causeway

Fill Flow Correction Factor: 0.05

	Channel Bottom Elevation (NGVD29)	Channel Top Elevation (NGVD29)	Top of Trapezoidal Portion Elevation (NGVD29)	Width (ft)	Slope	Length (ft)
East UPRR Bridge	Bottom Elevation	Top Elevation	Top Elevation	Width	Slope	Length
West Breach	Bottom Elevation	Top Elevation	Top Elevation	Width	Slope	Length
West Culvert	Bottom Elevation	Top Elevation		Width	Slope	Length
East Culvert	Bottom Elevation	Top Elevation		Width	Slope	Length

Start Date of Bridge: 1/ 1/2060

☐ Close West Culvert

☐ Close East Culvert

Bear River Bay Northern Railroad Causeway

	Bottom Elevation (NGDVD29)	Top Elevation (NGDVD29)	Width (ft)
Bridge	4190	4202	550

Farmington Bay Davis County Causeway

	Bottom Elevation (NGDVD29)	Top Elevation (NGDVD29)	Width (ft)
Bridge	4193	4205	100

Back to Lake Dashboard

Great Salt Lake Integrated Model

GoldSim - GSLIM_v1.10_IntegratedHistorical

FILE EDIT VIEW GRAPHICS MODEL RUN HELP

Model ▸ Lake_Dashboards ▸ Lake_Dash

Climate | River Basins | Lake | Wetlands | River Basin Results | Lake a

Lake Module Additional Settings

Integrated

Initial Conditions

	North Arm	South Arm	Farmington Bay	Bear RiverBay
WSE (feet above NGVD29)	4206	4205.9	4205.9	4205.9
Salinity (mg/l)	200200	117500	54000	54000

USGS Elevation Data

ay Controls

Inflows

Inflow Scalars

Bear River Basin	Weber River Basin	Jordan River Basin
1	1	1

Edit Inflow Spreadsheet

Outflows

West Desert Pump ☑ Include in simulation

Pump Flow Rate (cfs) 2000

Trigger elevation (ft above NGVD29) 4205

Mineral Ponds

☑ Extraction Pond Consumptive Use in Lake Balance

	Pond_Area	ReturnFlow_Factor
NorthArm_Ponds	28317	0.28
BRB_WestPonds	19692	0.28
BRB_EastPonds	4098	0.28
SouthArm_NWPonds	51287	0.28
SouthArm_SEPonds	4406	0.28

Great Salt Lake Integrated Model

GoldSim - GSLIM_v1.10_IntegratedHistorical

FILE EDIT VIEW GRAPHICS MODEL RUN HELP

Model ▸ Lake_Dashboards ▸ Causeway_Dash

Climate | River Basins | Lake | Wetlands | River Basin Results | Lake and Wetland Results

Causeway Characteristics Dashboard

Integrated | Run | Run All | + | -

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West Breach	Bottom Elevation	Top Elevation	Top Elevation	Width	Slope	Length	
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Great Salt Lake Integrated Model

GoldSim - GSLIM_v1.10_IntegratedHistorical

FILE EDIT VIEW GRAPHICS MODEL RUN HELP

Model ▸ Scenario_Summary_Dash

GSLIM v1.10: Great Salt Lake Integrated

Integrated

Global Settings

Simulation Settings

Climate Settings

Temperature Change (deg C) 0

Precipitation Change (%) 0 %

Climate Settings

River Basin Module Settings

River Basin Module On ☑

Population:

✓ 2010 Census Data ✗ Govern and Bu

Water Use:

% Indoor GPCD reduction 0

Water use for agriculture and urban irrigation ✓

Lake Module Settings

Lake Module On ☑

Lake Module: additional settings

Link Inflows to: River Basin Module ✓ Input Spreadsheet ✗

Initial Conditions	Elevation	Salinity
South Arm	4205.9 ft	117500 mg/l
North Arm	4206 ft	200200 mg/l

West Desert Pump ✓ Evaporation Ponds ✓

Wetland Settings

Wetland Module On ☑

Phragmite % Coverage

Locomotive Springs	7.49 %	Og
Bear River Bay	6.29 %	Far
Harold Crane	6.44 %	Sou

Results Dashboards

Lake and Wetla

River Basin Results

Great

GoldSim - GSLIM_v1.10_IntegratedHistorical

FILE EDIT VIEW GRAPHICS MODEL RUN HELP

Model ▸ Lake_Dashboards ▸ Results_Dash

Climate | River Basins | Lake | Wetlands | River Basin Results | Lake and Wetland Results

Integrated | Run | Run All | + | -

Water Surface Elevation - All Bays

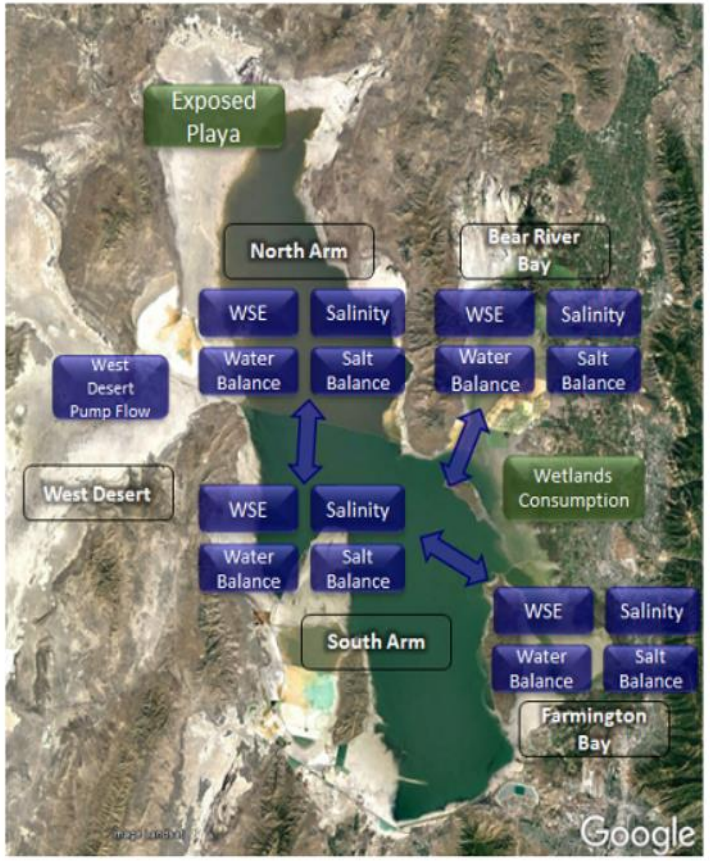
Salinity - All Bays

Evaporation Ponds

Lake Level Calibration

Lake Salinity: North Arm

Lake Salinity: South Arm



Total System Water Balance

System Total Salt Balance

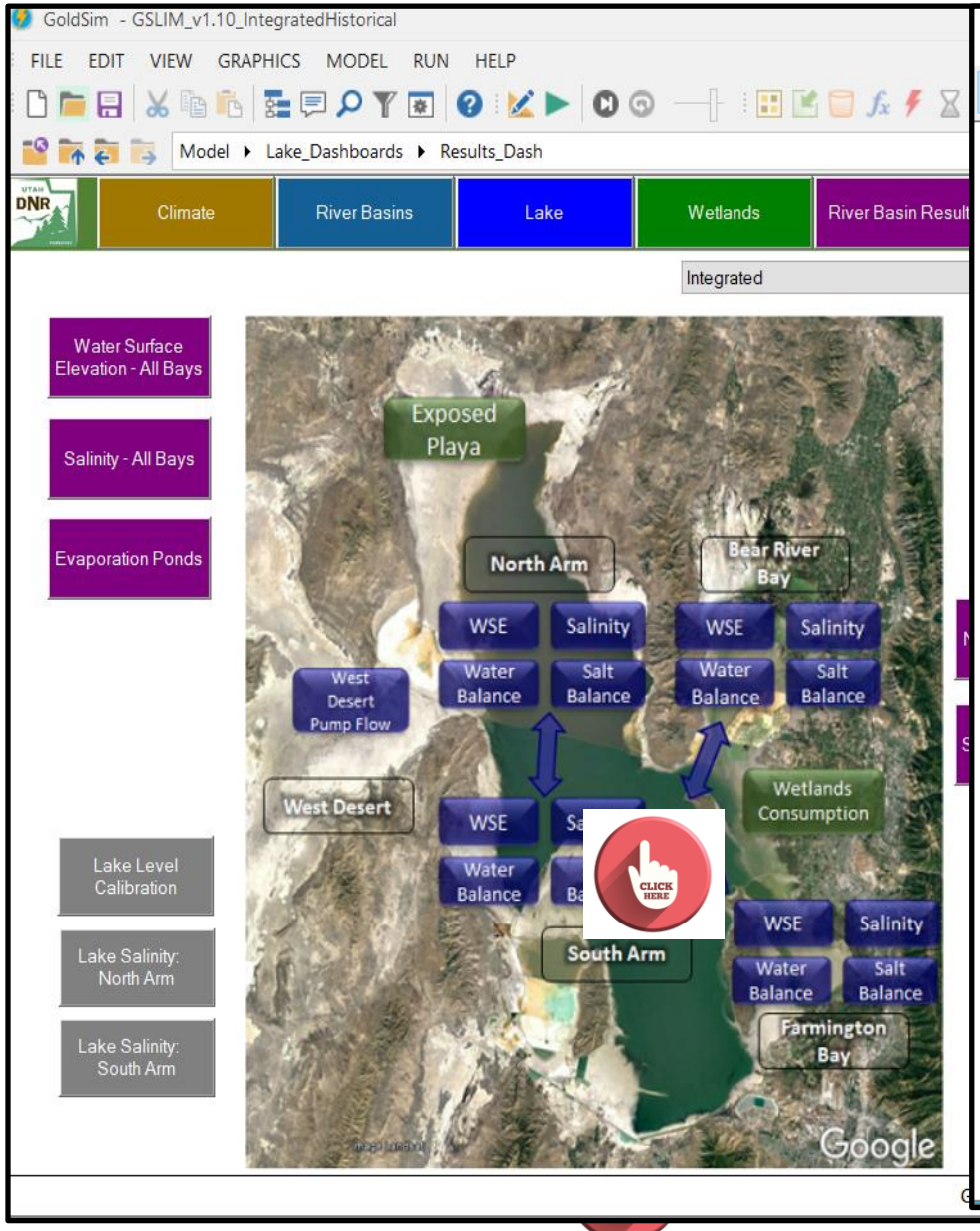
North Arm Inflows

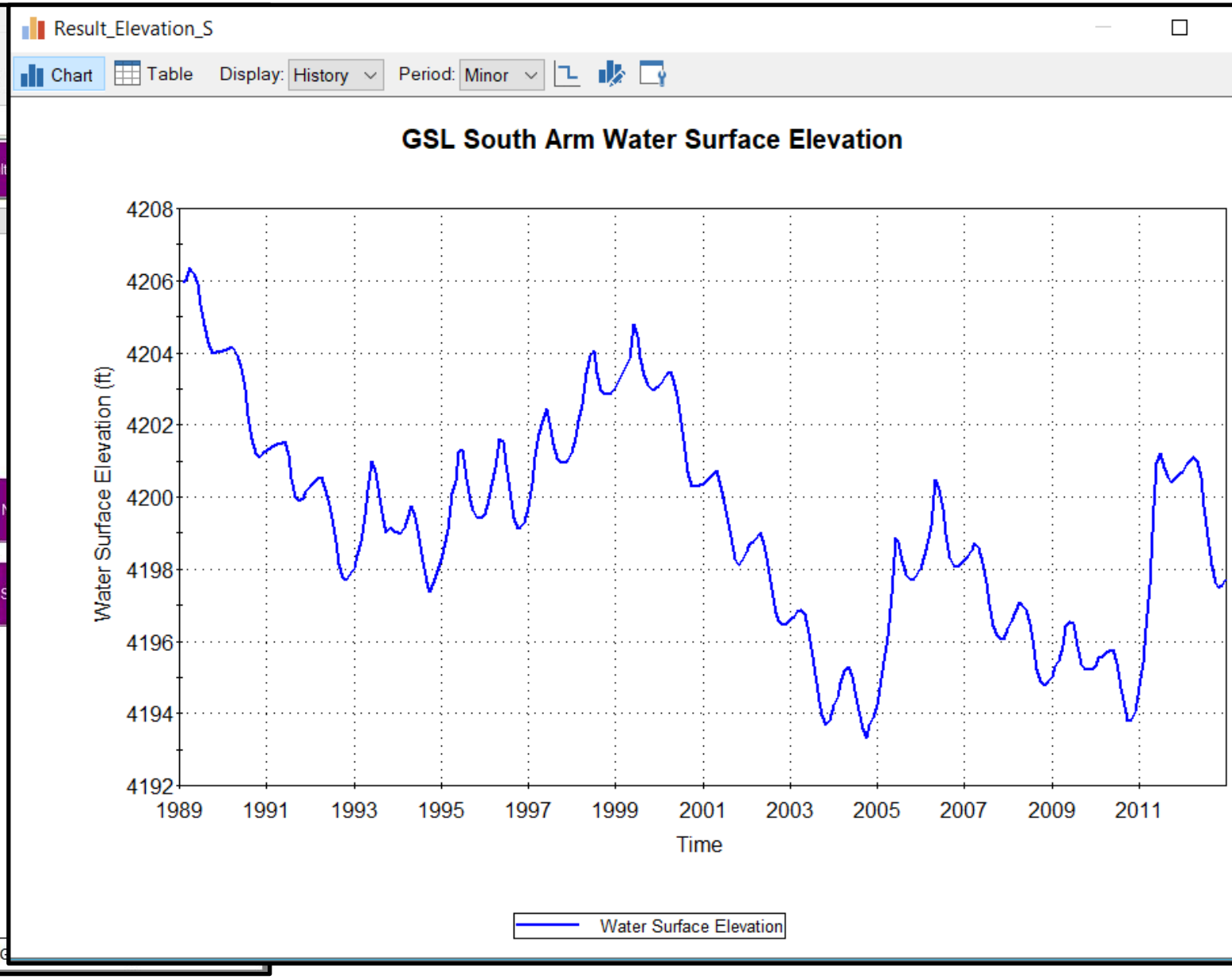
Bear River Bay Inflows

South Arm Inflows

Farmington Bay Inflows

Great Salt Lake Integrated Model


GoldSim - GSLIM_v1.10_IntegratedHistorical
FILE EDIT VIEW GRAPHICS MODEL RUN HELP
Model ▸ Lake_Dashboards ▸ Results_Dash
Climate
River Basins
Lake
Wetlands
River Basin Result
Integrated
Water Surface Elevation - All Bays
Salinity - All Bays
Evaporation Ponds
Exposed Playa
North Arm
Bear River Bay
WSE
Salinity
Water Balance
Salt Balance
West Desert Pump Flow
West Desert
Wetlands Consumption
South Arm
Farmington Bay
Lake Level Calibration
Lake Salinity: North Arm
Lake Salinity: South Arm
Google


Result_Elevation_S
Chart
Table
Display: History
Period: Minor
GSL South Arm Water Surface Elevation
Water Surface Elevation (ft)
4208
4206
4204
4202
4200
4198
4196
4194
4192
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Time
Water Surface Elevation

Outline:

- Model features
- **Model simulation results**
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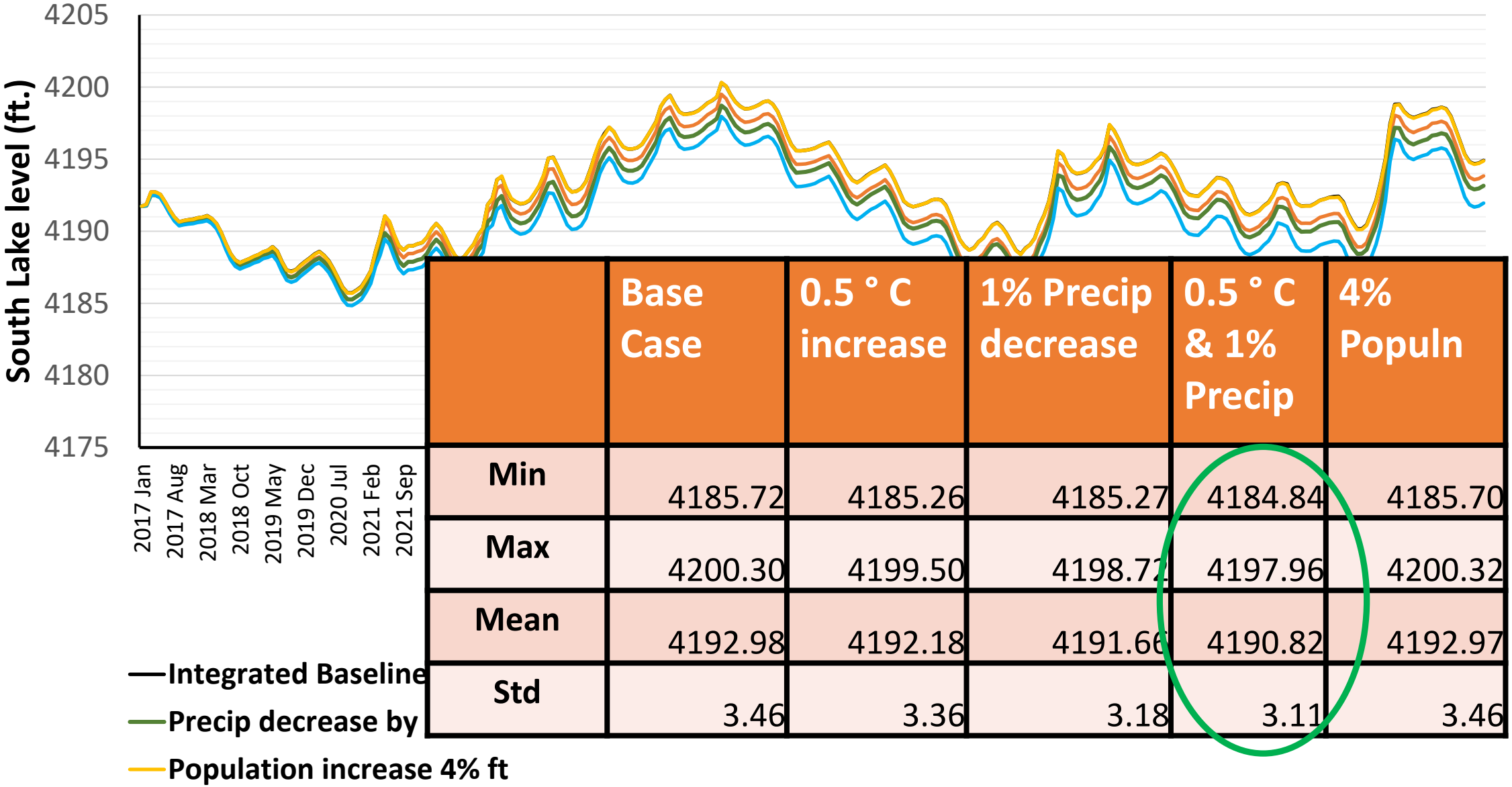
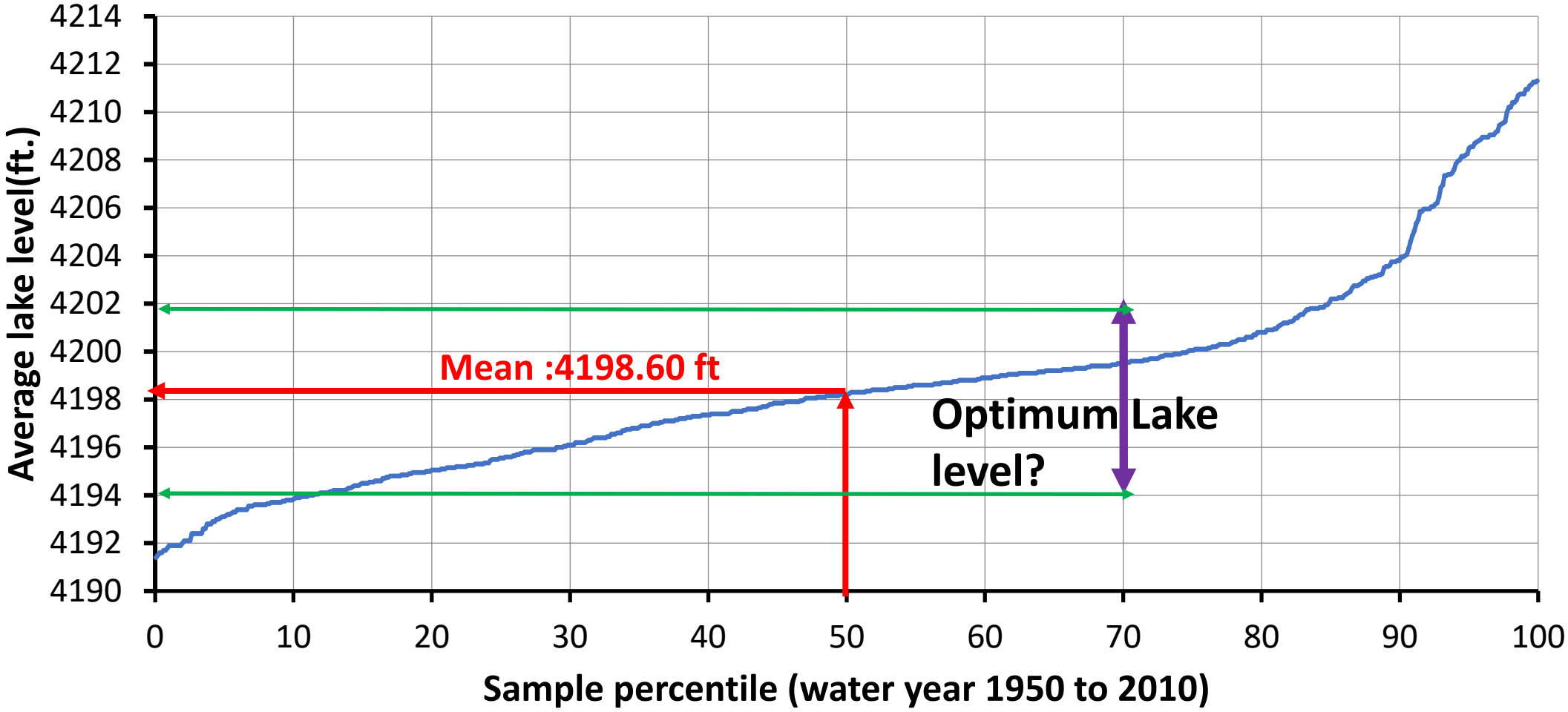
Five Scenarios Run (Hypothetical): How will lake levels and salinity change in the future (2017 to 2040)?

1. **Base scenario:** Assuming same historical climatic and water uses observed from 1989 to 2012, and lake levels and salinity recorded on Jan 1st, 2017
2. **Temperature increases by 0.50°C**
3. **Precip. decreases by 1%**
4. **Temperature increases by 0.50°C & precip. decreases by 1%**
5. **Population growth @4% of 2010**



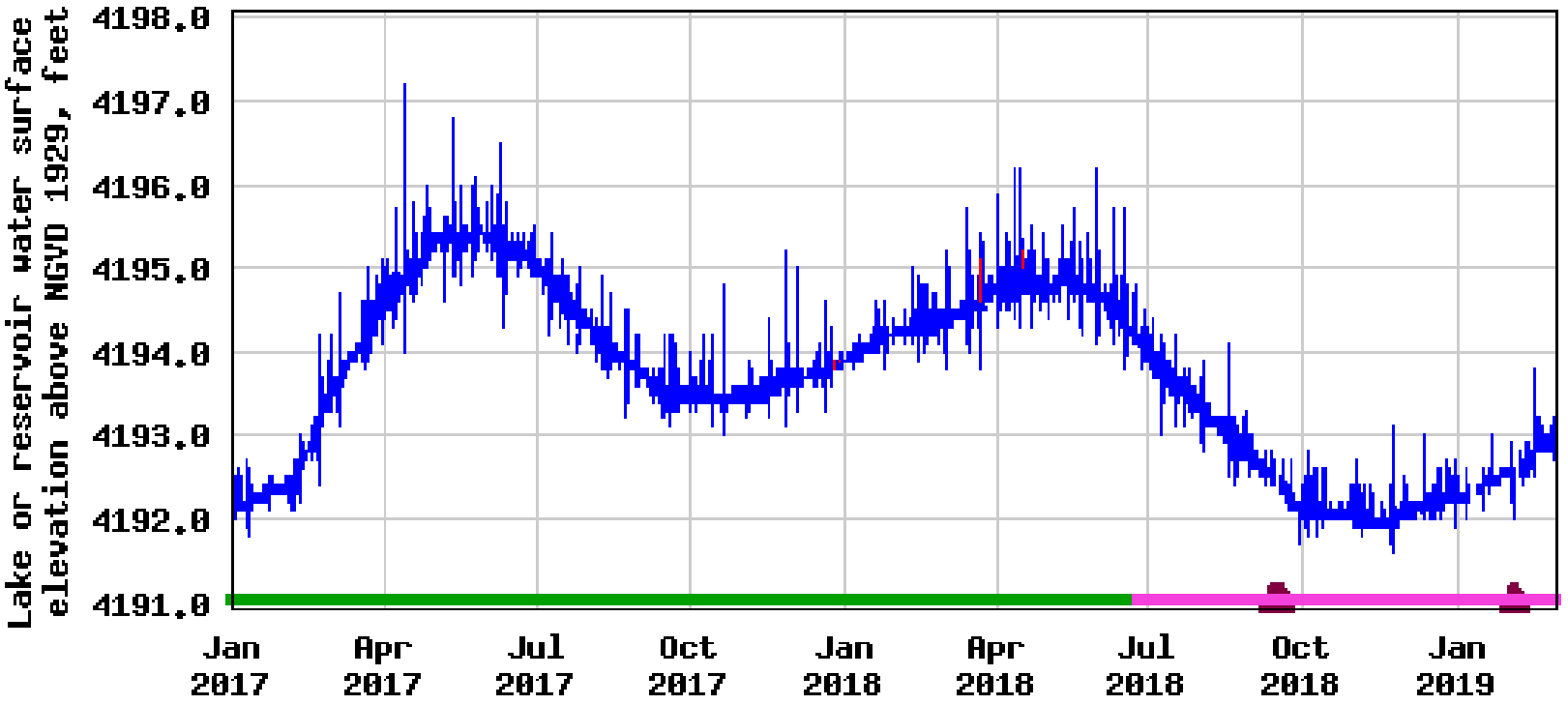
	Base Case	0.5 ° C increase	1% Precip decrease	0.5 ° C & 1% Precip	4% Populn
Min	4185.72	4185.26	4185.27	4184.84	4185.70
Max	4200.30	4199.50	4198.72	4197.96	4200.32
Mean	4192.98	4192.18	4191.66	4190.82	4192.97
Std	3.46	3.36	3.18	3.11	3.46

Normal Probability Plot (Observed data 1950 to 2010)

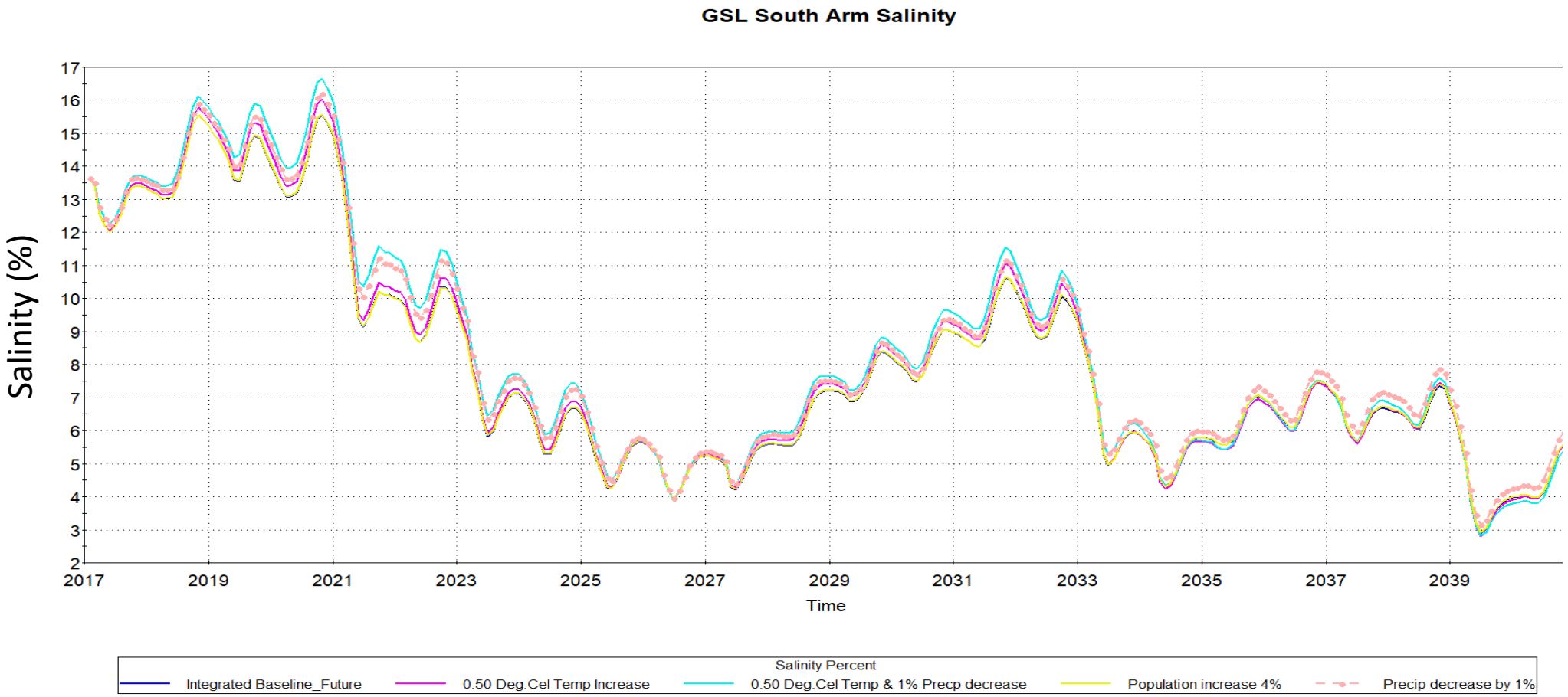


USGS

USGS 10010000 GREAT SALT LAKE AT SALTAIR BOAT HARBOR, UT



Lake or reservoir water surface elevation above ngvd 1929
Estimated lake or reservoir water surface elevation above ngvd 1929
Period of approved data
Value affected by equipment malfunction.
Period of provisional data



Integrated Baseline_Future ft

0.50 Deg.Cel Temp Increase ft

Precip decrease by 1% ft

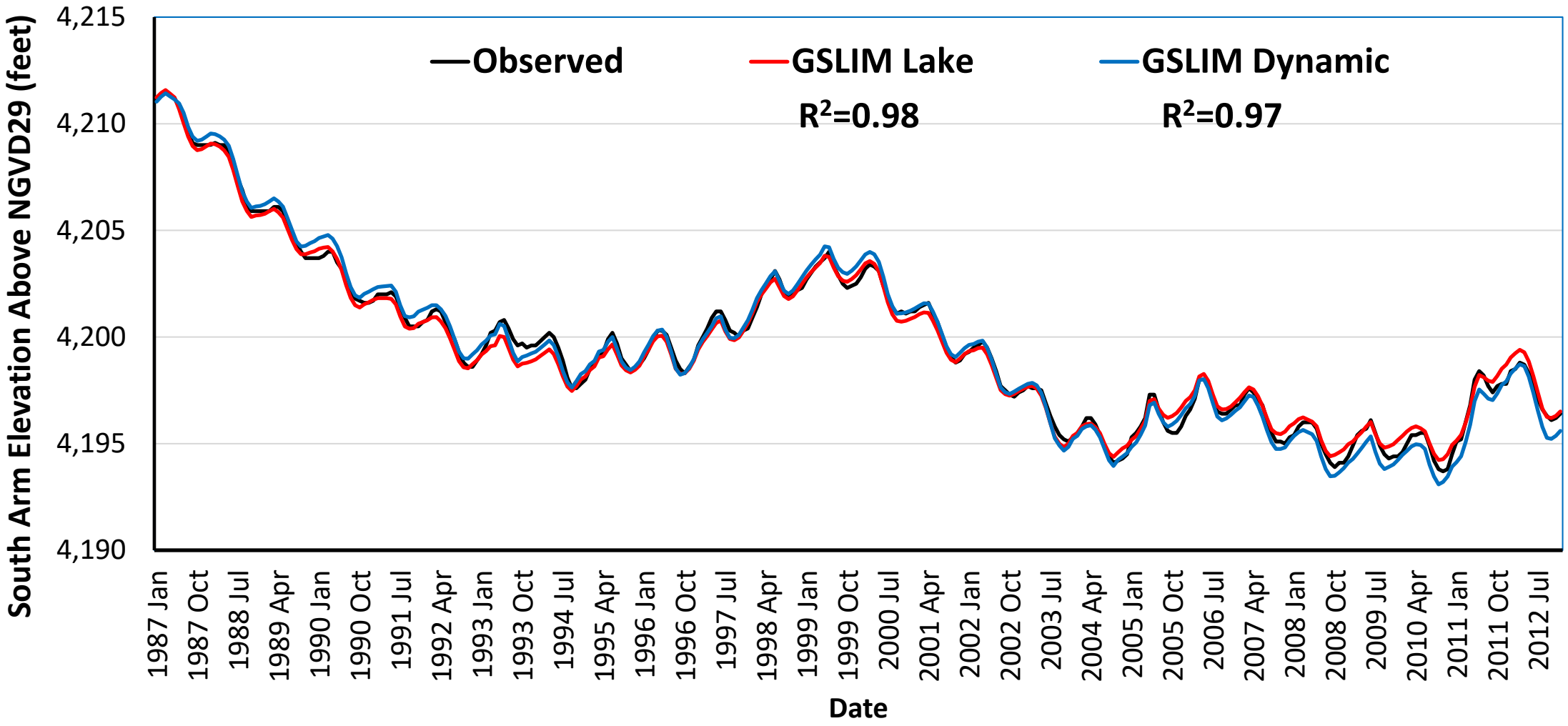
0.50 Deg.Cel Temp & 1% Precp decrease ft

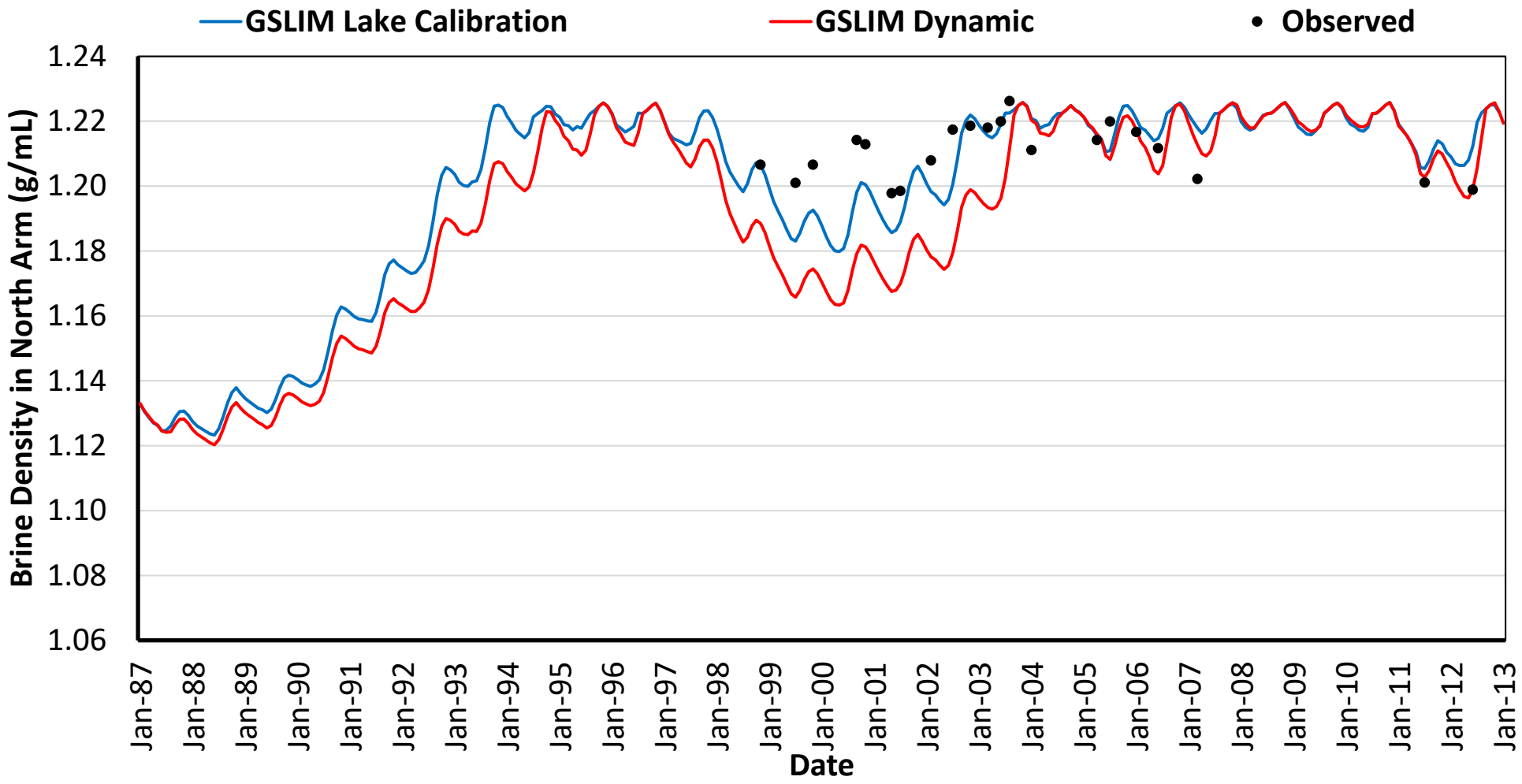
Population increase 4% ft

Outline:

- Model features
- Model simulation results
- **Model performances and future work**

Lake and dynamics modules




GSLIM Lake Calibration
GSLIM Dynamic
Observed
Brine Density in North Arm (g/mL)
1.24
1.22
1.20
1.18
1.16
1.14
1.12
1.10
1.08
1.06
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
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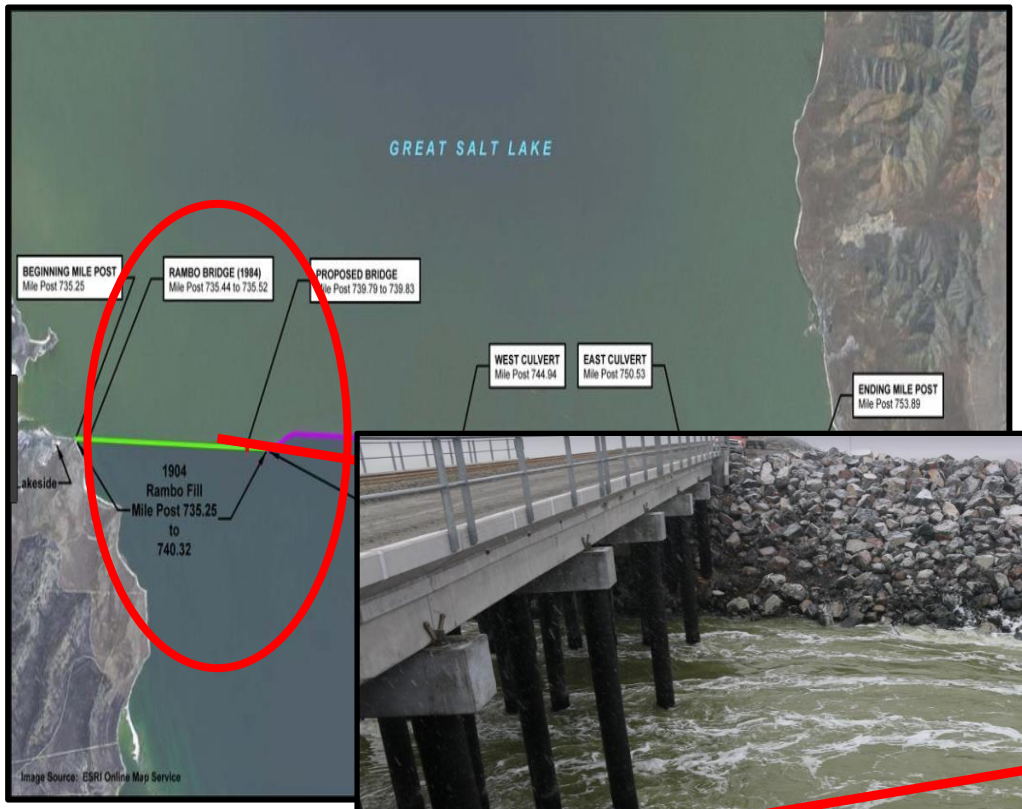
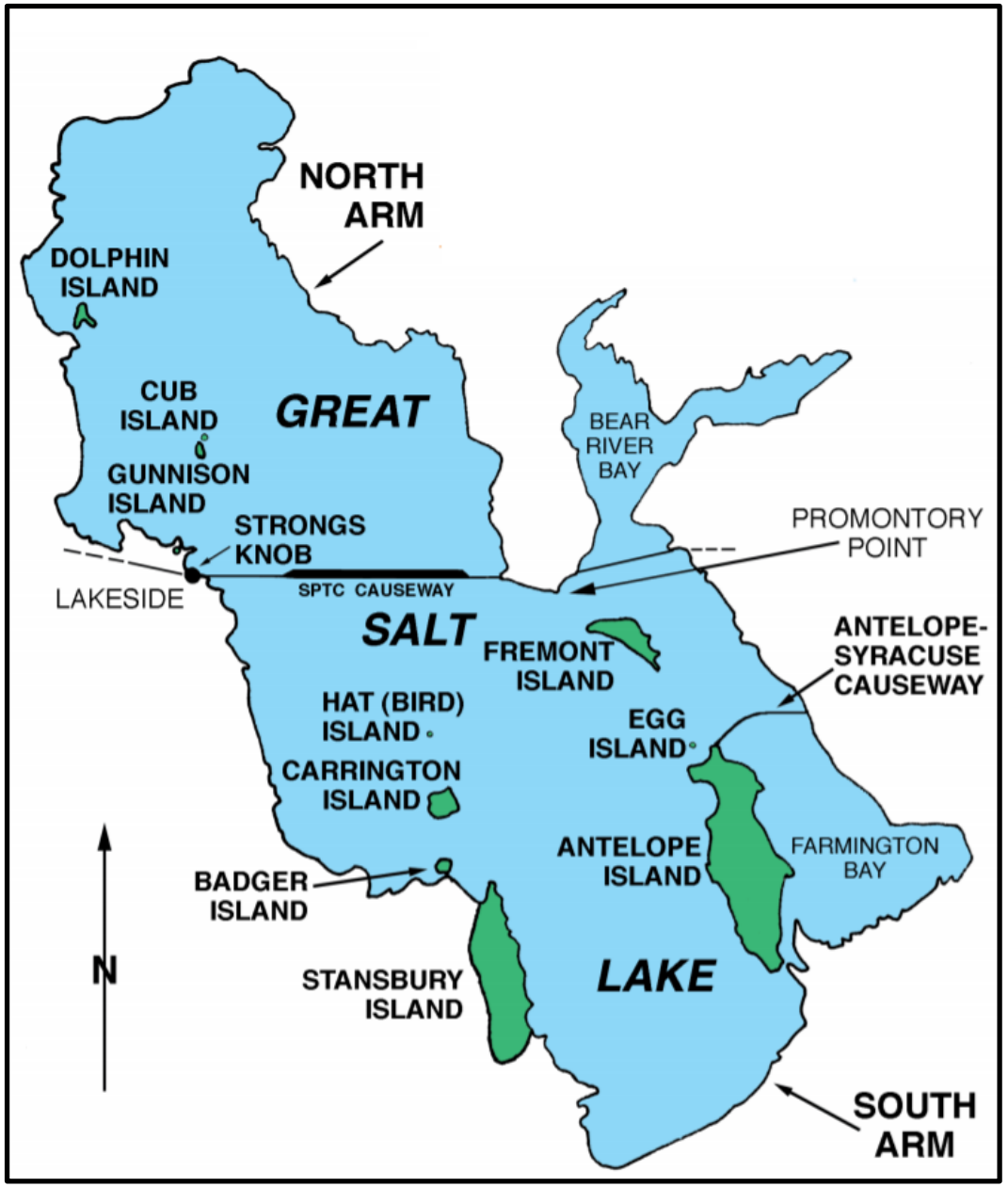
Jan-11
Jan-12
Jan-13
Date

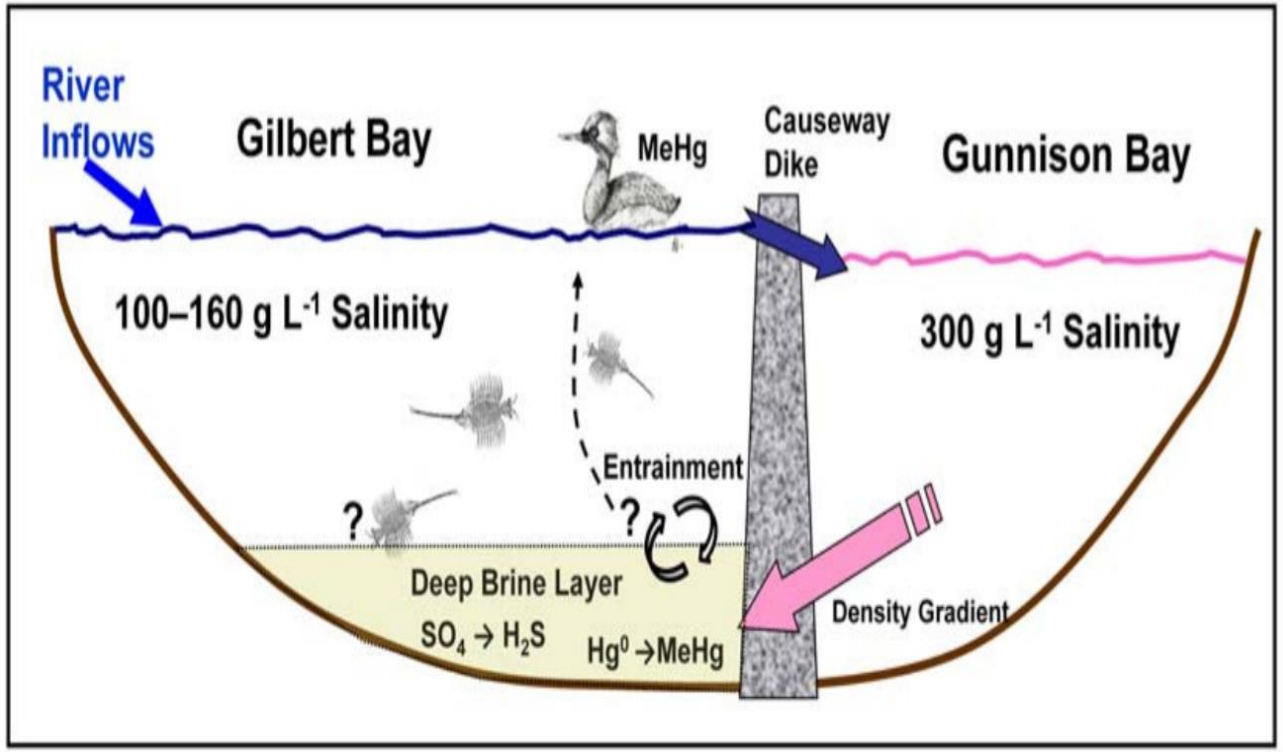


- Update New Bridge hydraulics using data collected since 2017

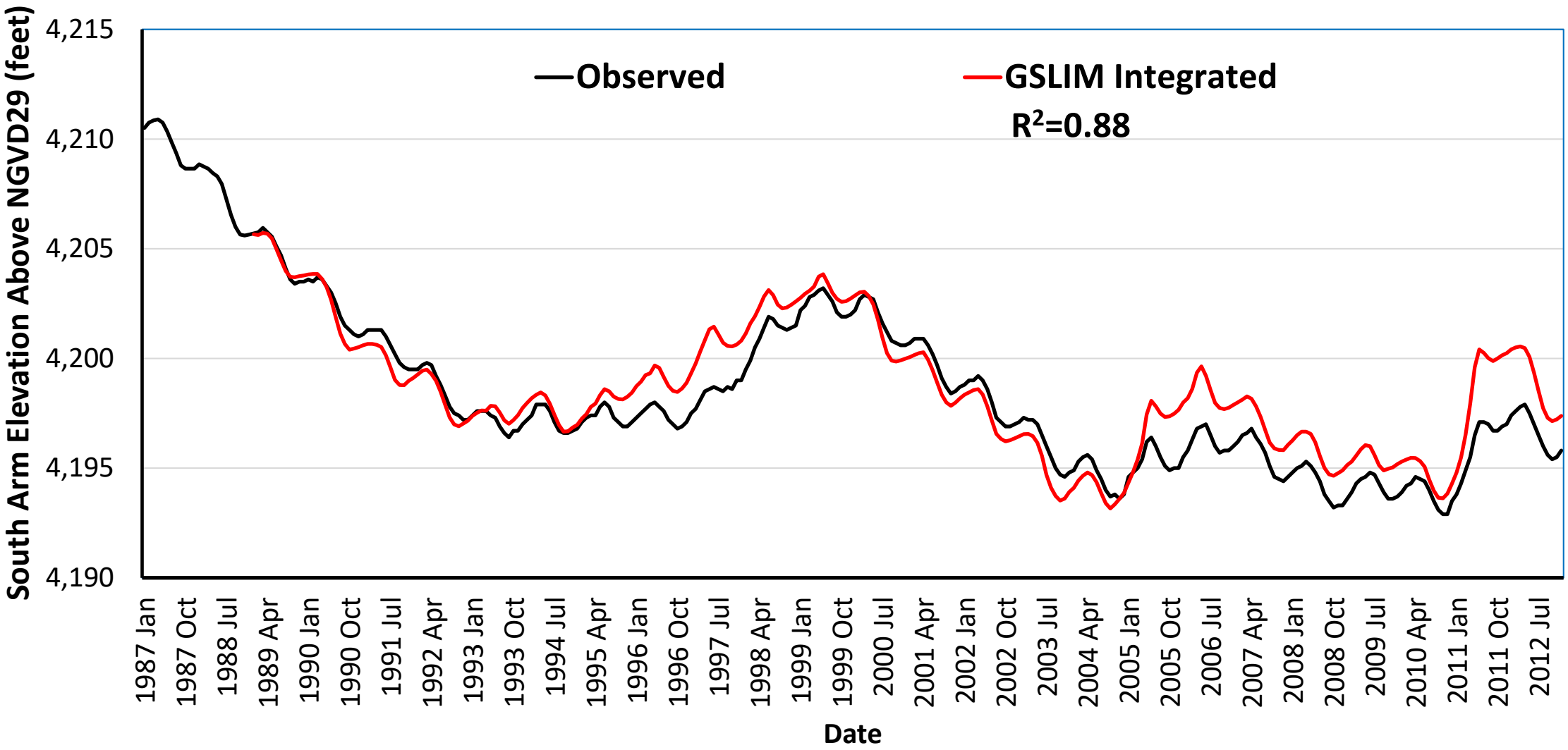
- **Update scenarios: industrial water uses**

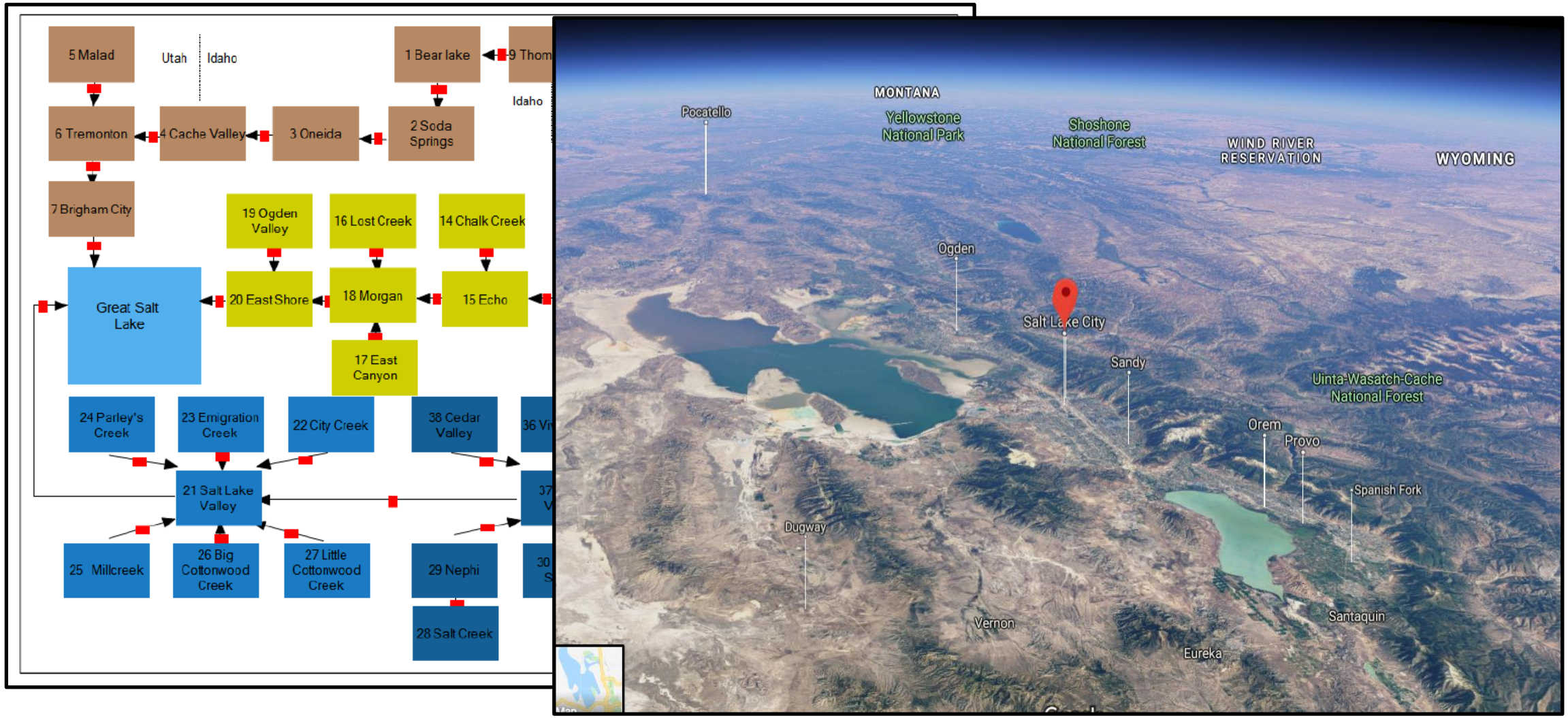


- Model other water quality parameters and deep brine layers

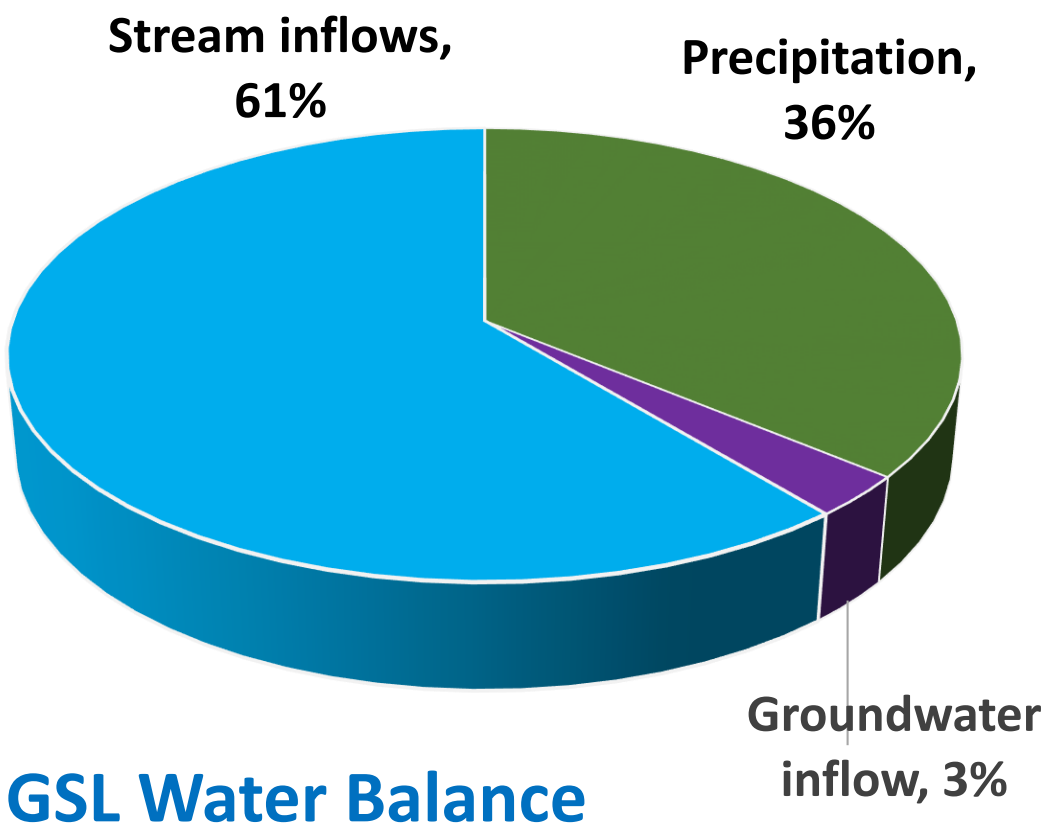


River Basin (Integrated) Module

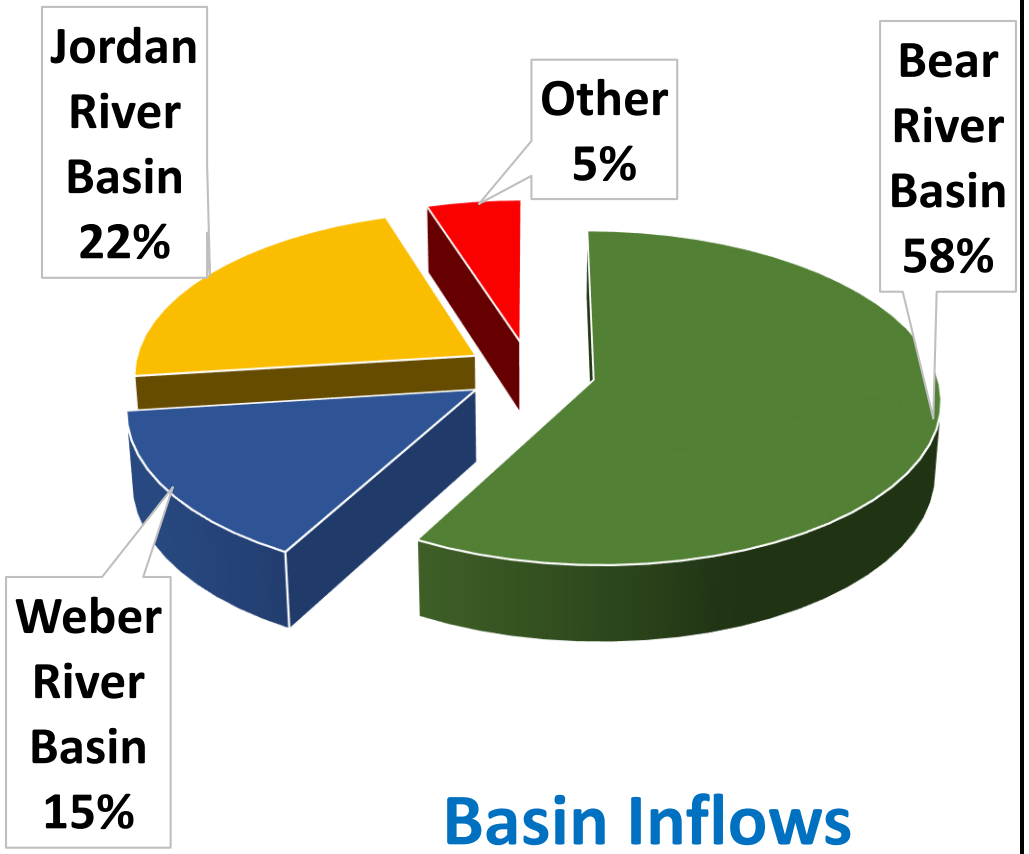




- Verify water balance in subareas level incorporating reservoirs, snowmelt and river routing



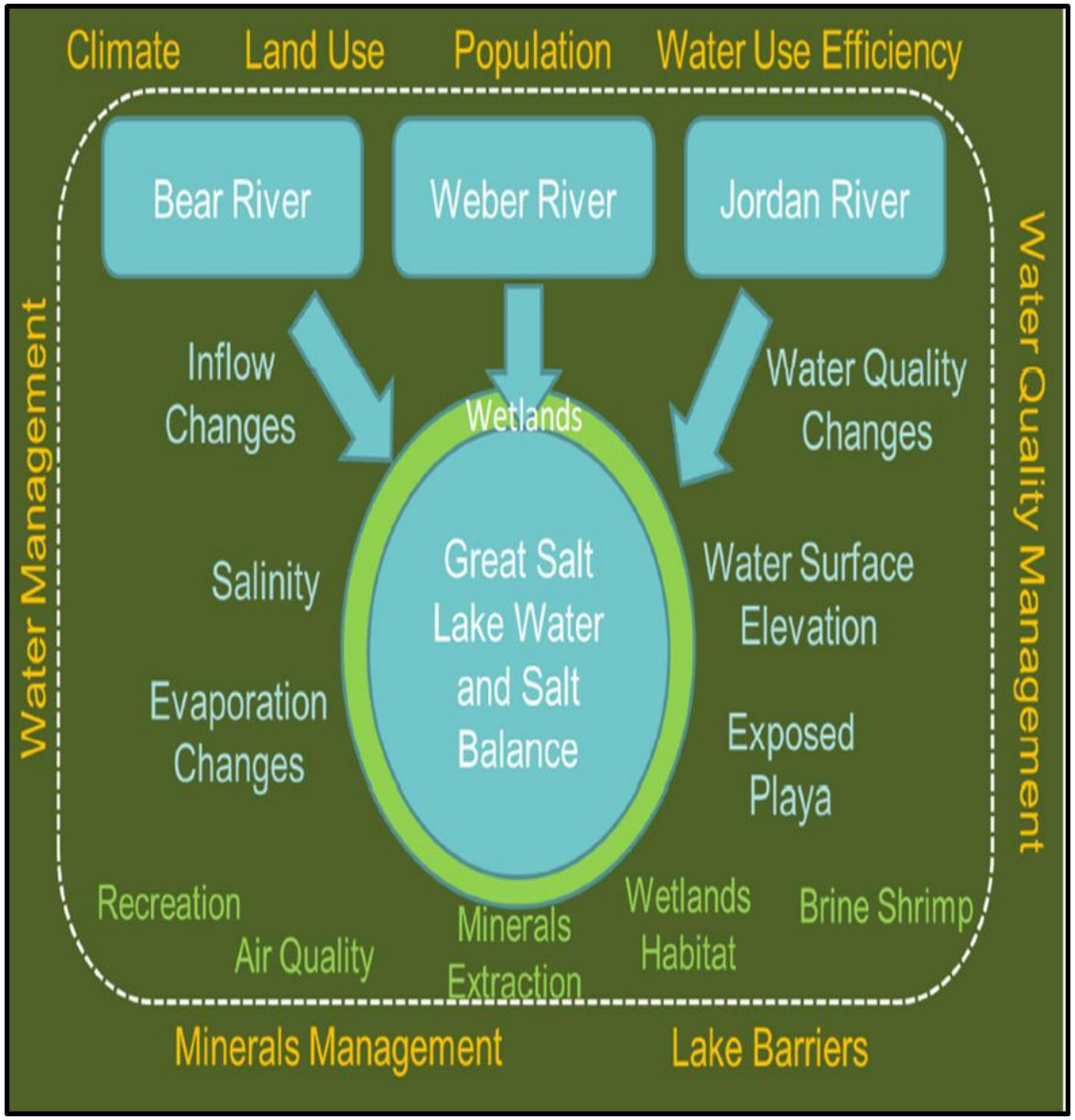
GSL Water Balance (UPRR, 2014)



Basin Inflows (Tarboton et al., 2012)

- Update input data (e.g. climate, population growth, and land use changes)

- Update scenarios incorporating important diversions in river basins (e.g. Bear River)



Summary

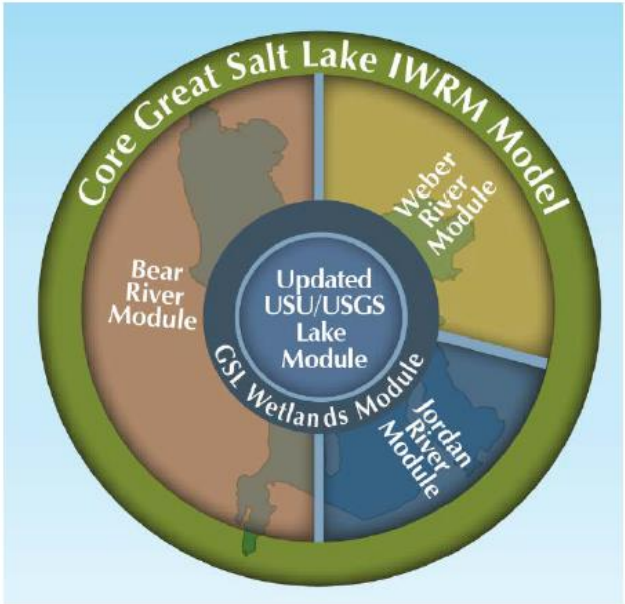
Lake and Dynamic Module: Good performances

1. Future climate parameters
2. Bridge hydraulics and bidirectional flows
3. Deep brine layer
4. Sensitivity analyses
5. Scenarios update

River Basin Module: Needs improvement

1. Reservoir operation rules, snowpack, and snowmelt analyses
2. Subareas water balance analyses and verification
3. Sensitivity and errors analyses
4. Routing module
5. Scenarios update[e.g. Bear River diversion]

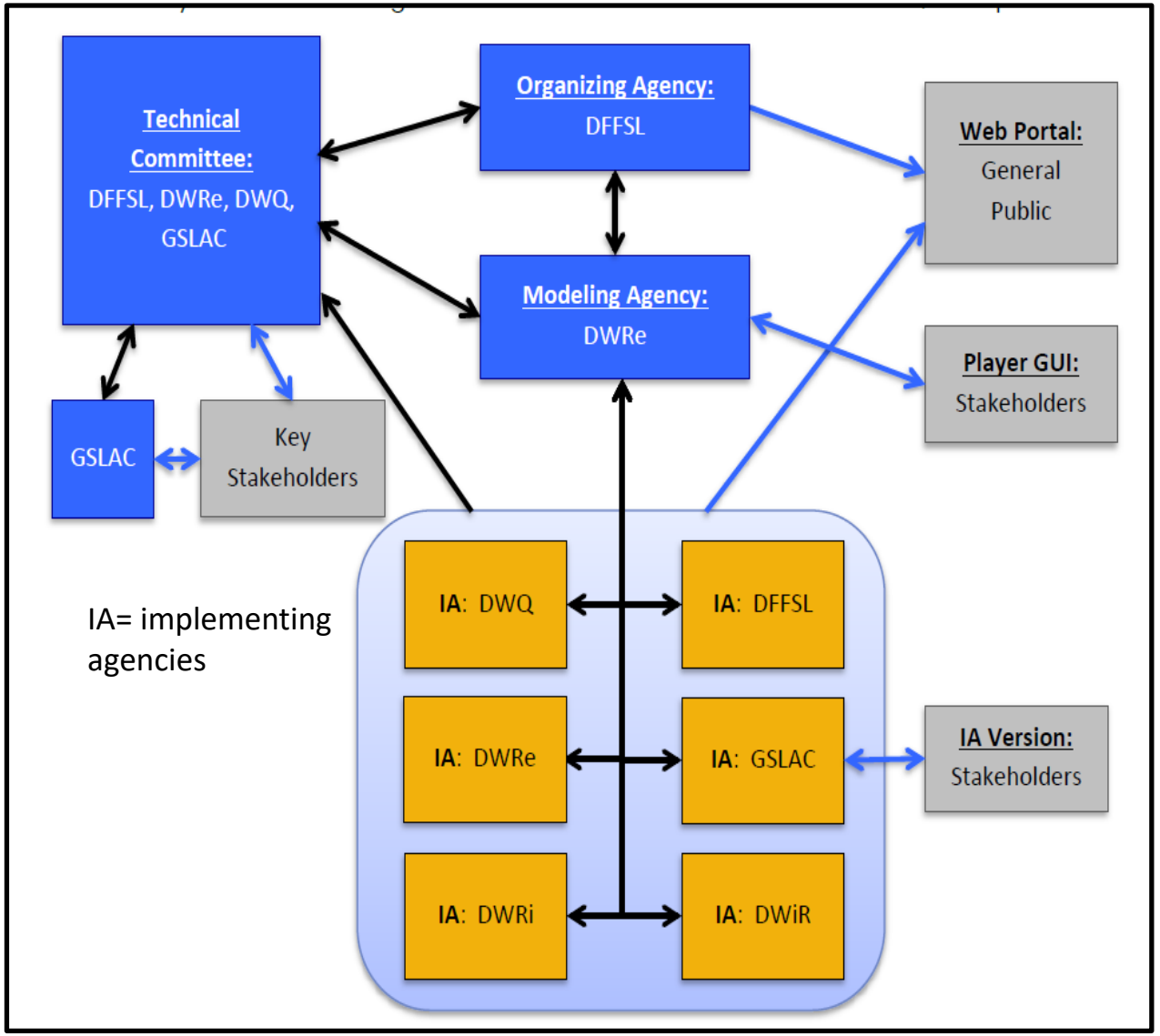
Organization supporting the GSLIM



Supporting Organizational Infrastructure Guidelines

FOR THE GREAT SALT LAKE INTEGRATED WATER RESOURCE MANAGEMENT MODEL

Created by Carter Borden, Ph.D., Sarah Borden, and Jeff DenBleyker
December 2016



(CH2M , 2017)

Thank you!

Any questions/comments/suggestions?

Craig Miller, P.E.
Manager,
Hydrology and Modeling

Candice Hasenyager, P.E.
Asst. Director

Todd Adams, P.E.
Deputy Director