GROUNDWATER PROTECTION COUNCIL 2020 VIRTUAL ANNUAL FORUM

Evaluating Surface water and Groundwater Network in Red Butte Watershed, Utah

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Outline

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  - Red Butte Watershed and Red Butte Creek (RBC)
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  - Construction of Red Butte Watershed groundwater (HyperRBC) model
  - Preparation of Stream-flow Routing (SFR) package for RBC
  - Comparison of simulated and observed RBC stream flows
- **Summary**
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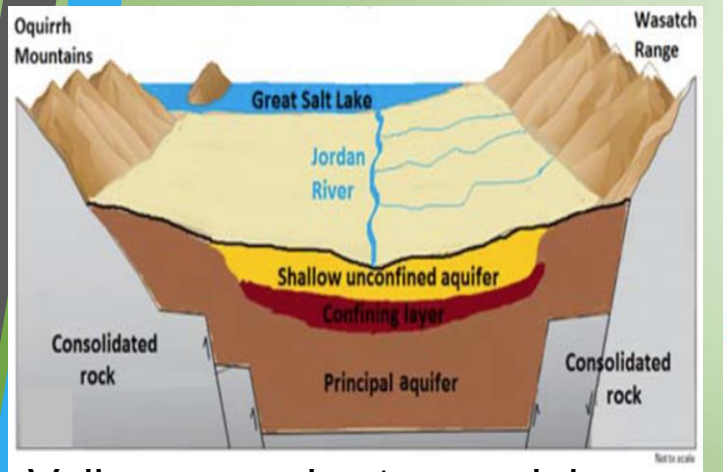
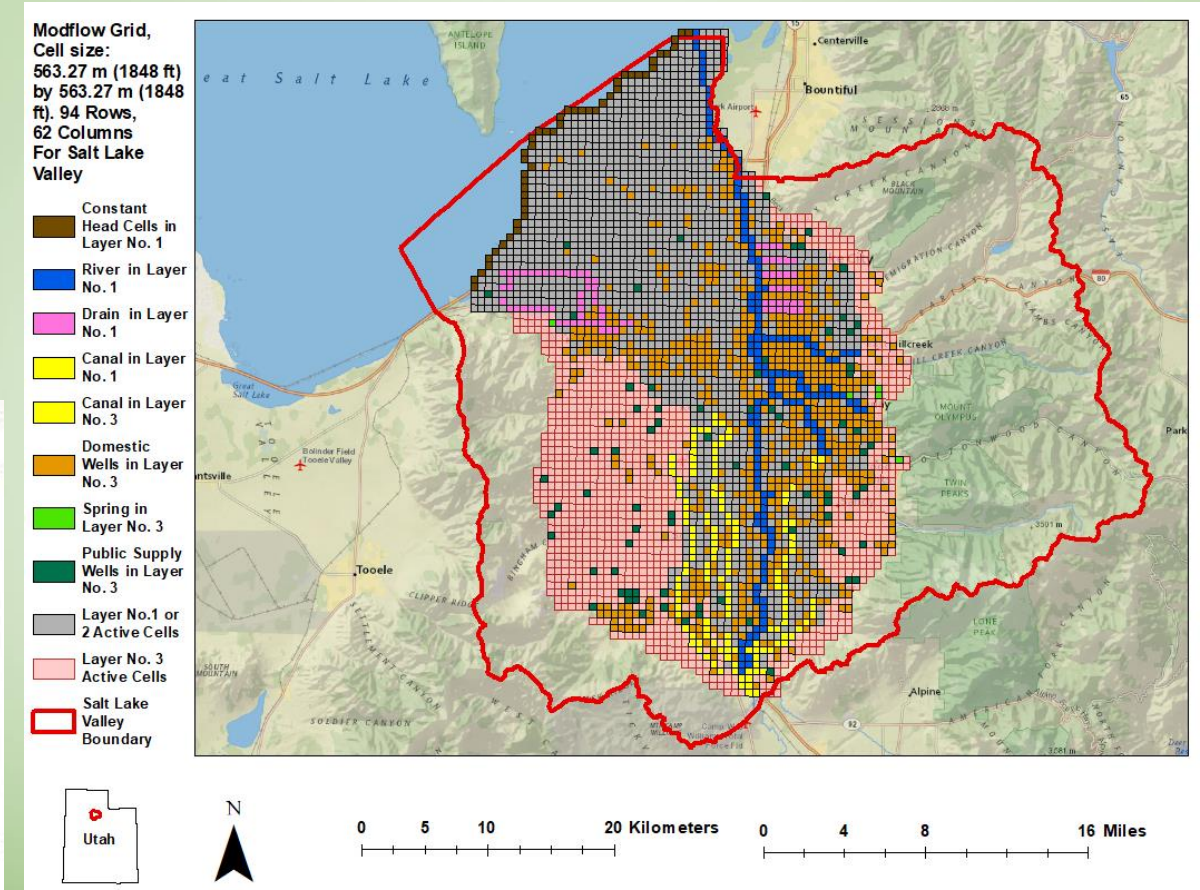
Salt Lake Valley (SLV) and USGS SLV groundwater model



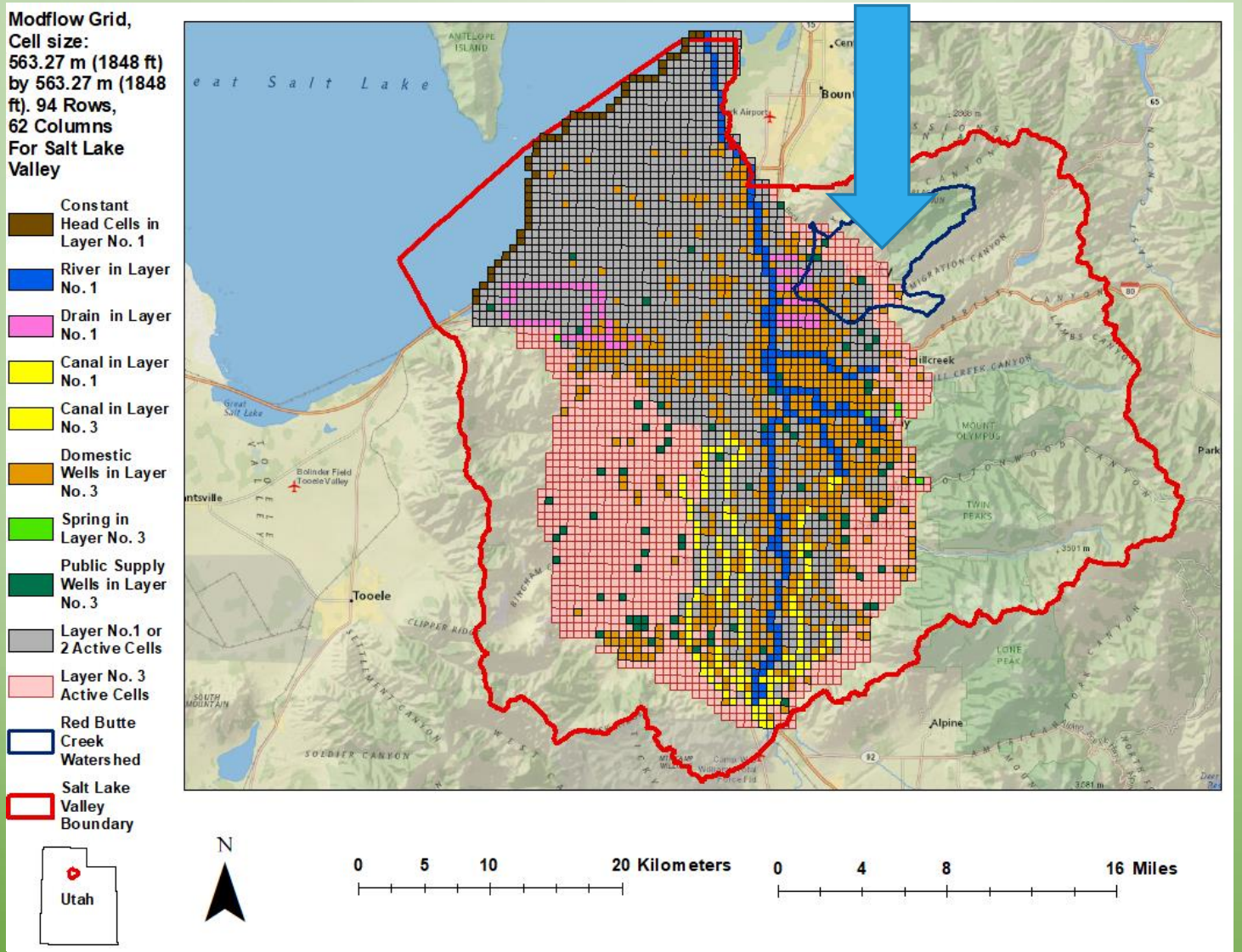
Valley groundwater model (Thiros et al., 2010): Vertically, seven layers with various boundary conditions (**Side view, No scale**)



Layer 1 (Shallow unconfined aquifer are gray), and

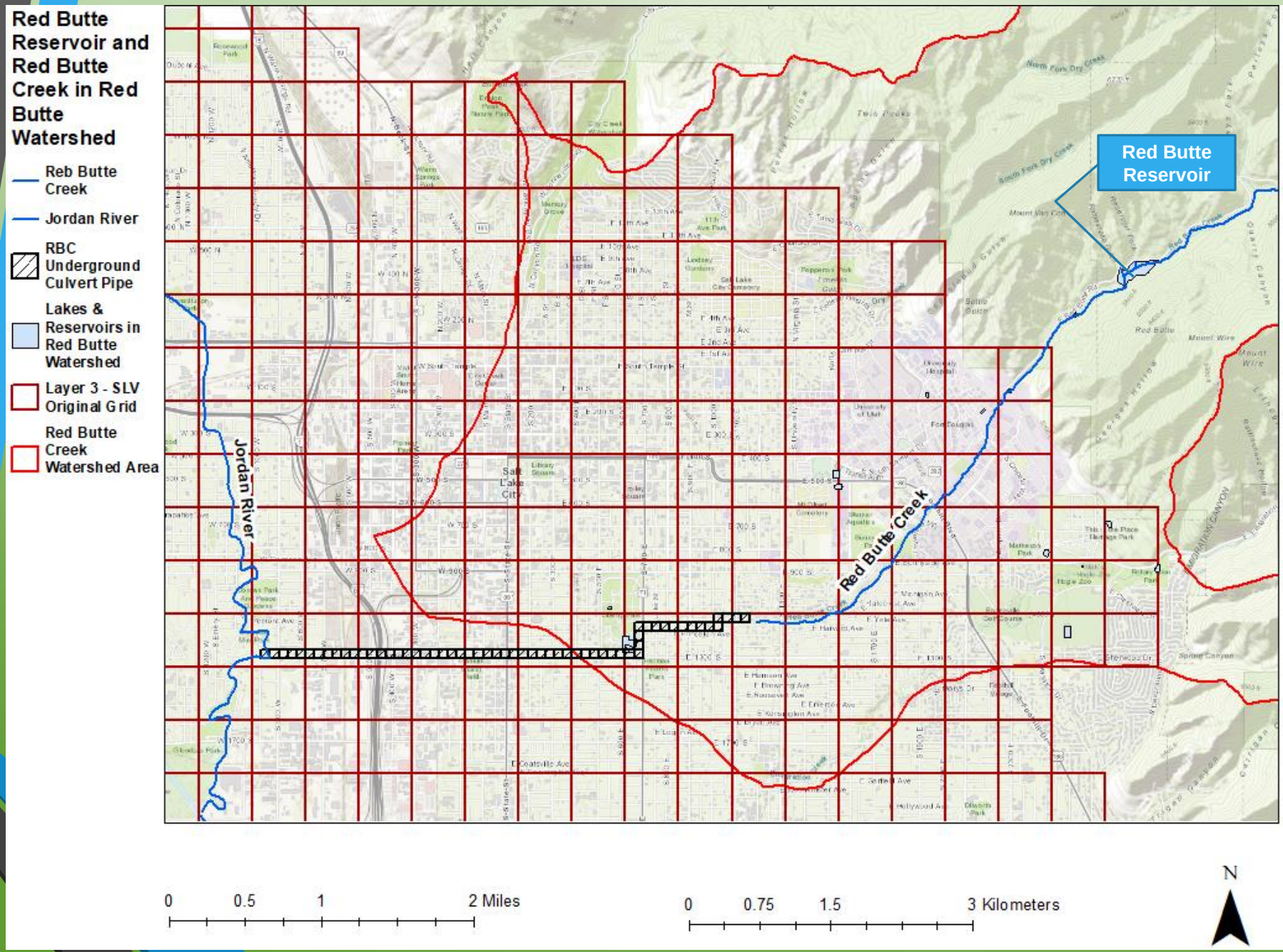
Layer 3 (Principal aquifer is pink where unconfined), of SLV groundwater model (94 rows x 62 columns with cell size of 1848 ft by 1848 ft)

Red Butte Watershed

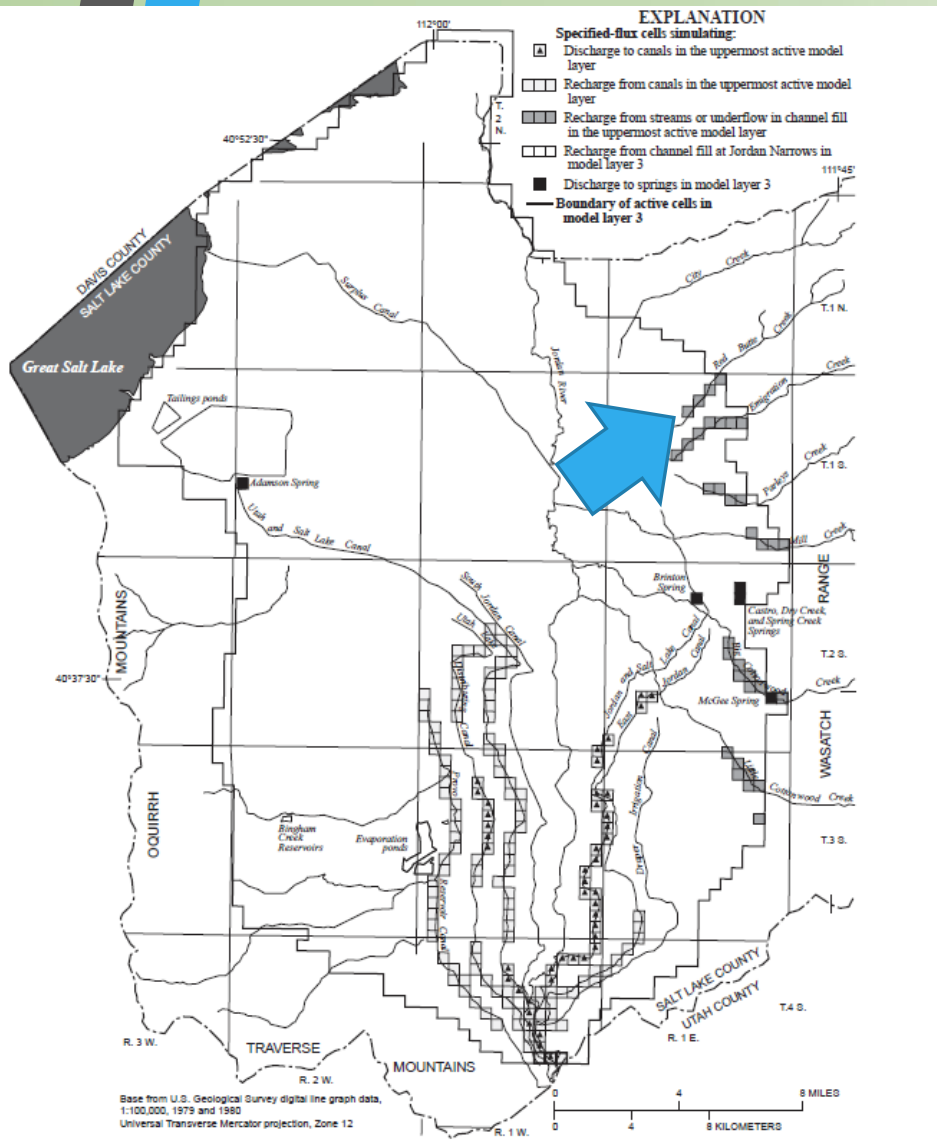


Blue arrow and outline shows Red Butte watershed.
SLV groundwater model Layer 1 (Shallow unconfined aquifer is gray) and Layer 3 (Principal aquifer is pink where unconfined);

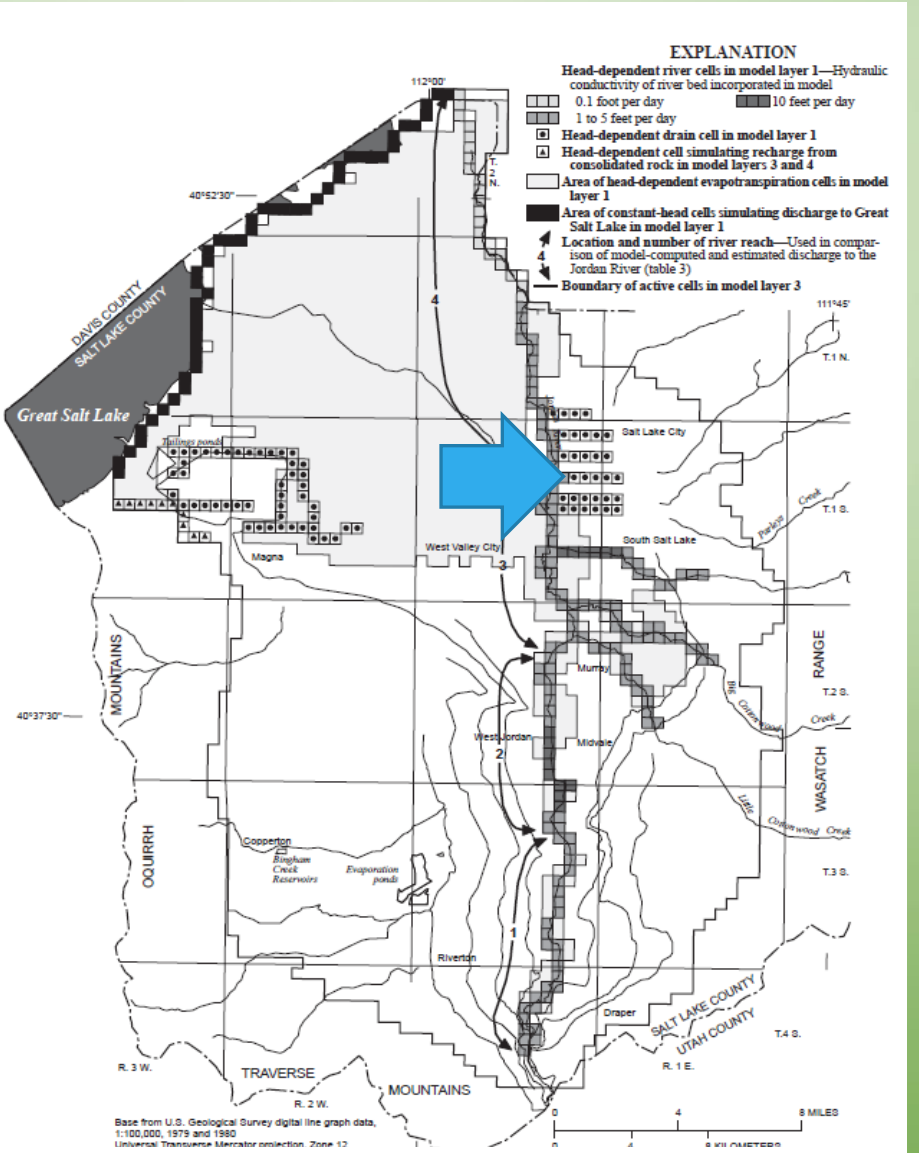
Red Butte Watershed & Red Butte Creek



Red Butte Creek (RBC) in the SLV model



Four **Recharge** cells in top layer (**Layer 3**) in SLV groundwater model for RBC (blue arrow) (**Lambert, 1995**)



Five **Drain** cells in **Layer 1** of SLV groundwater model (**Lambert, 1995**) next to Jordan river for RBC (blue arrow)

EPA-STAR project and progress

- A goal of EPA-STAR Grant# 83582401 project is to assess ways of using Red Butte Watershed stormwater runoff to increase groundwater resources:
  - Evaluate surface water and groundwater network near Red Butte Creek (RBC)
  - Evaluate use of stormwater within Aquifer Storage and Recovery (ASR) system

- Evaluation of basin scale SLV groundwater model applicability for more detailed EPA-STAR project

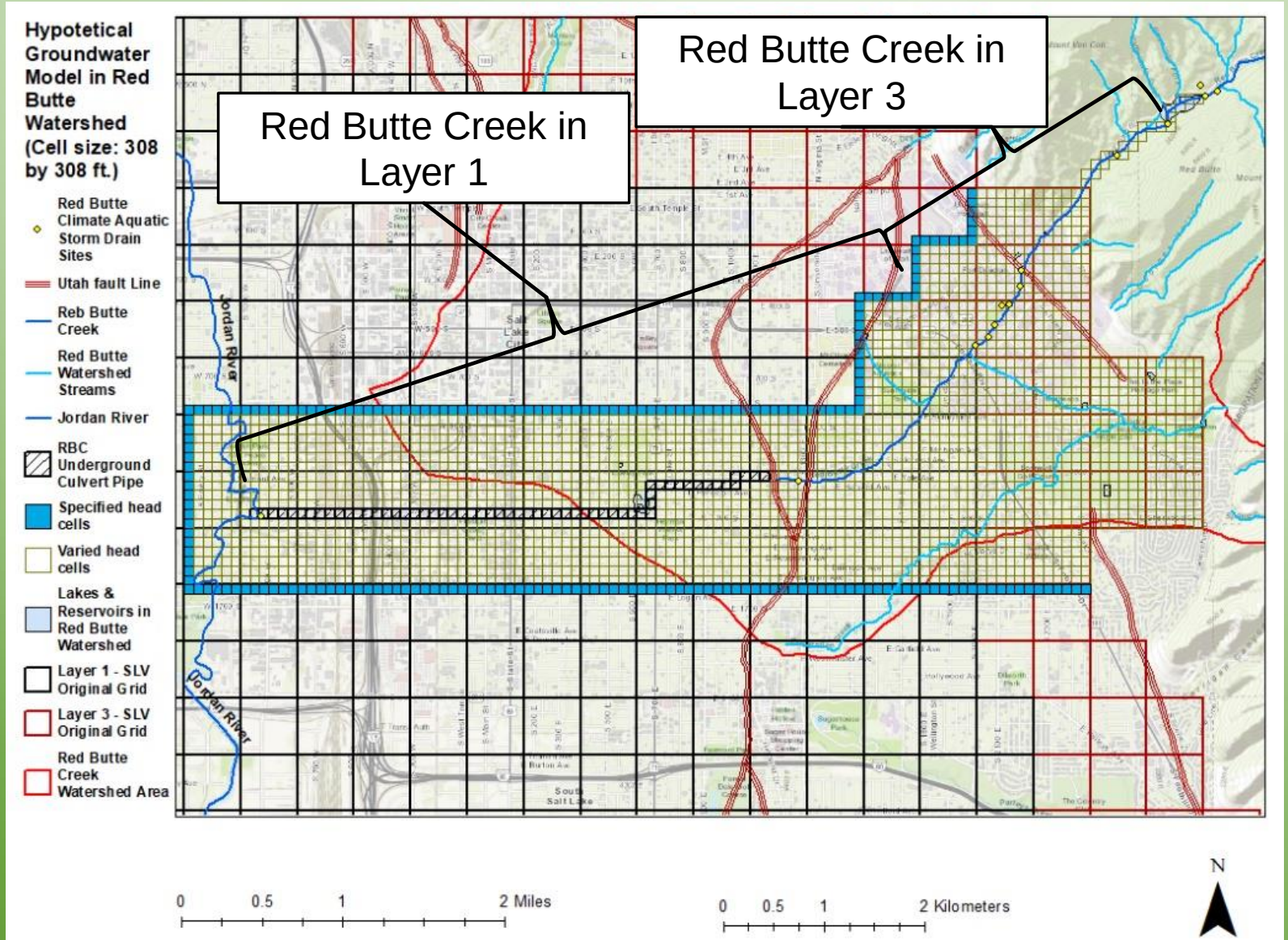
  - Cell size too large (1848 ft x 1848 ft) for demonstrating head and flow changes resulting from expected range of ASR injection rates and creek-aquifer seepage rates.

  - Boundary conditions too coarse for representing surface water-aquifer seepage between surface waters (Red Butte Reservoir and Red Butte Creek) and aquifer.

HyperRBC model Construction

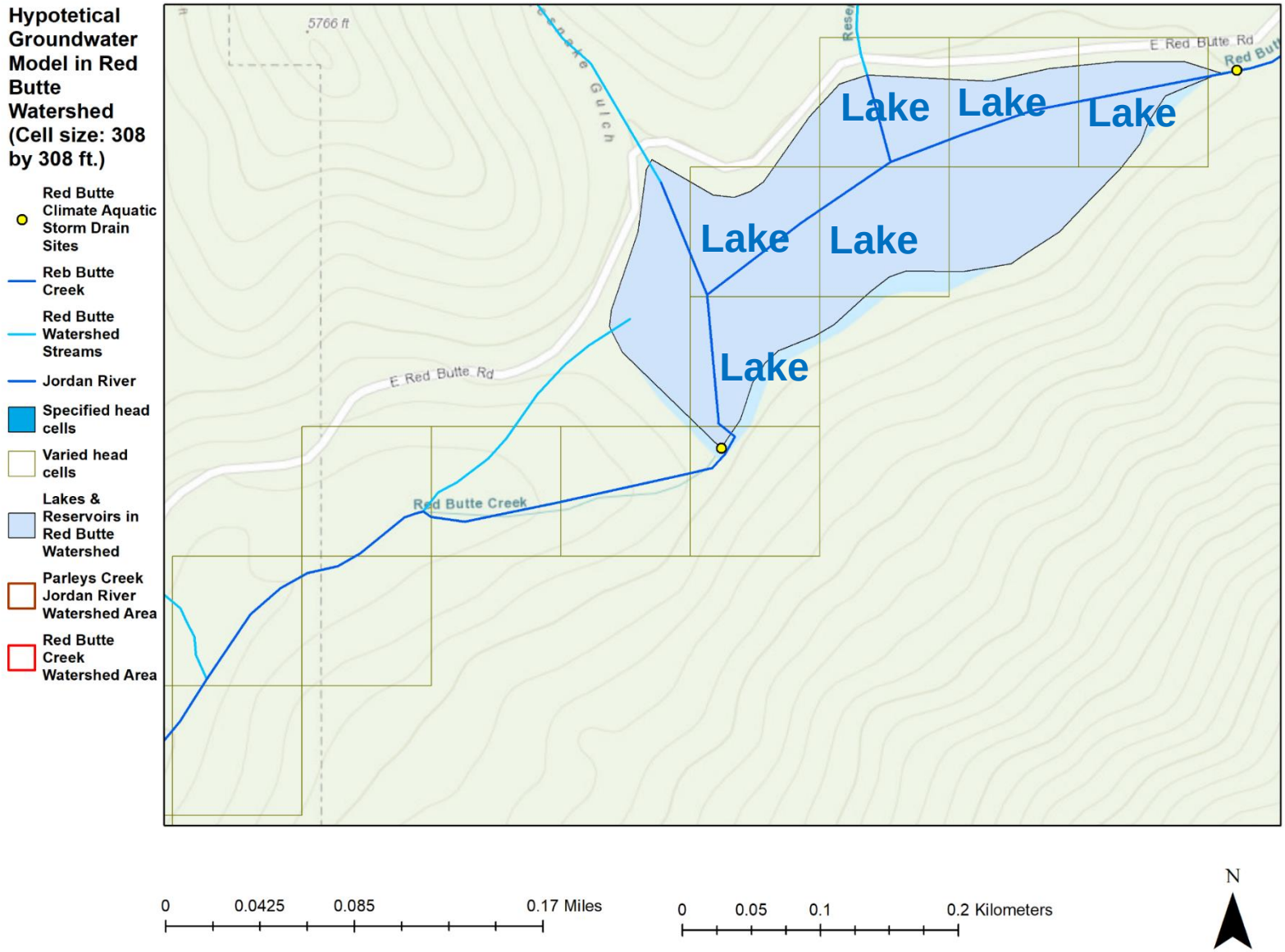
- Includes the part of Salt Lake Valley around Red Butte Creek from upstream end of Red Butte Reservoir to part of the Jordan River.
- The model has seven layers, 78 rows, 114 columns, and square **308 ft** by **308 ft** cells.
- Employs aquifer parameter data primarily from the Salt Lake Valley groundwater model (Lambert, 1995).
- Applies updated SLV stress boundary conditions for 2009 through 2016 via procedure by Forghani and Peralta (2017).
- Uses Stream Flow Routing (**SFR**) and Lake (**LAK**) boundary conditions in MODFLOW to present Red Butte Creek and Red Butte Reservoir respectively.

HyperRBC model construction - cont'd



HyperRBC model Layer 3--Red Butte Creek exists in Layers 1 & 3

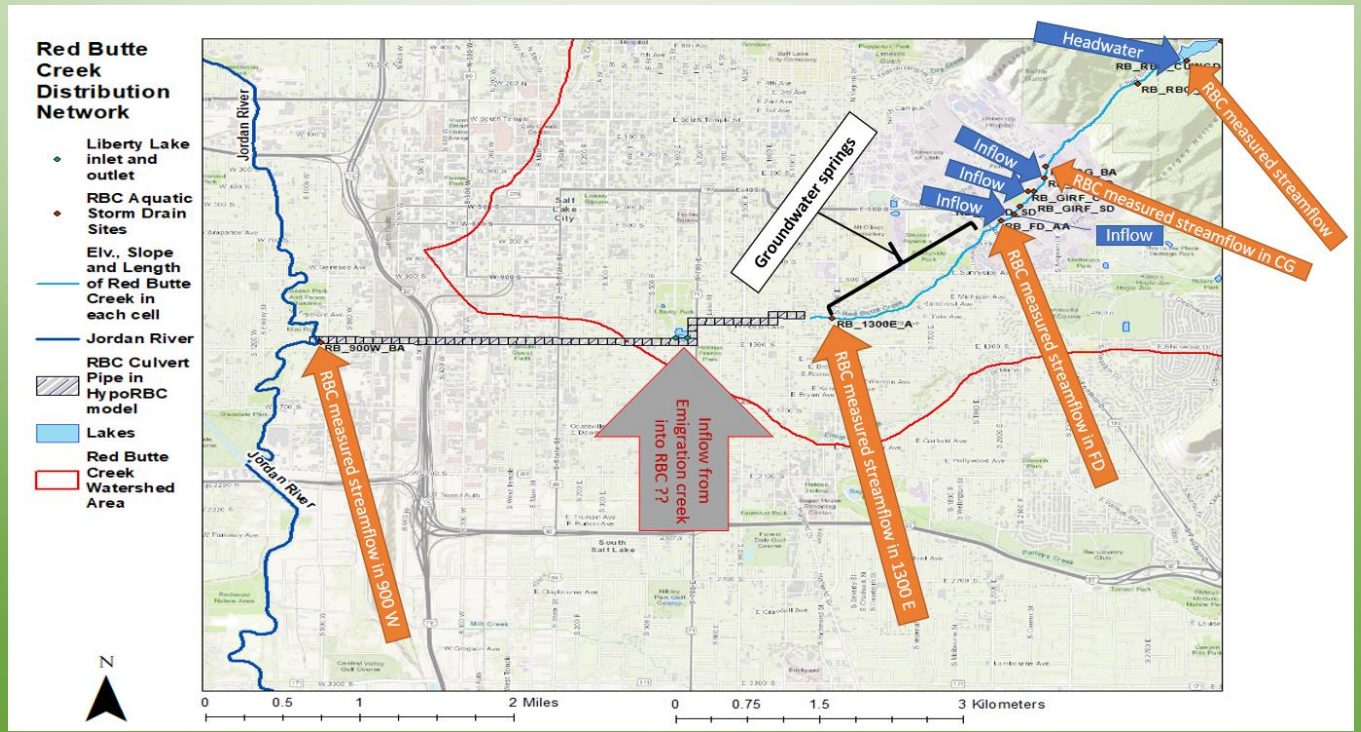
HyperRBC model construction - cont'd



Part of HyperRBC model Layer 3 Lake boundary condition cells employed for Red Butte Reservoir

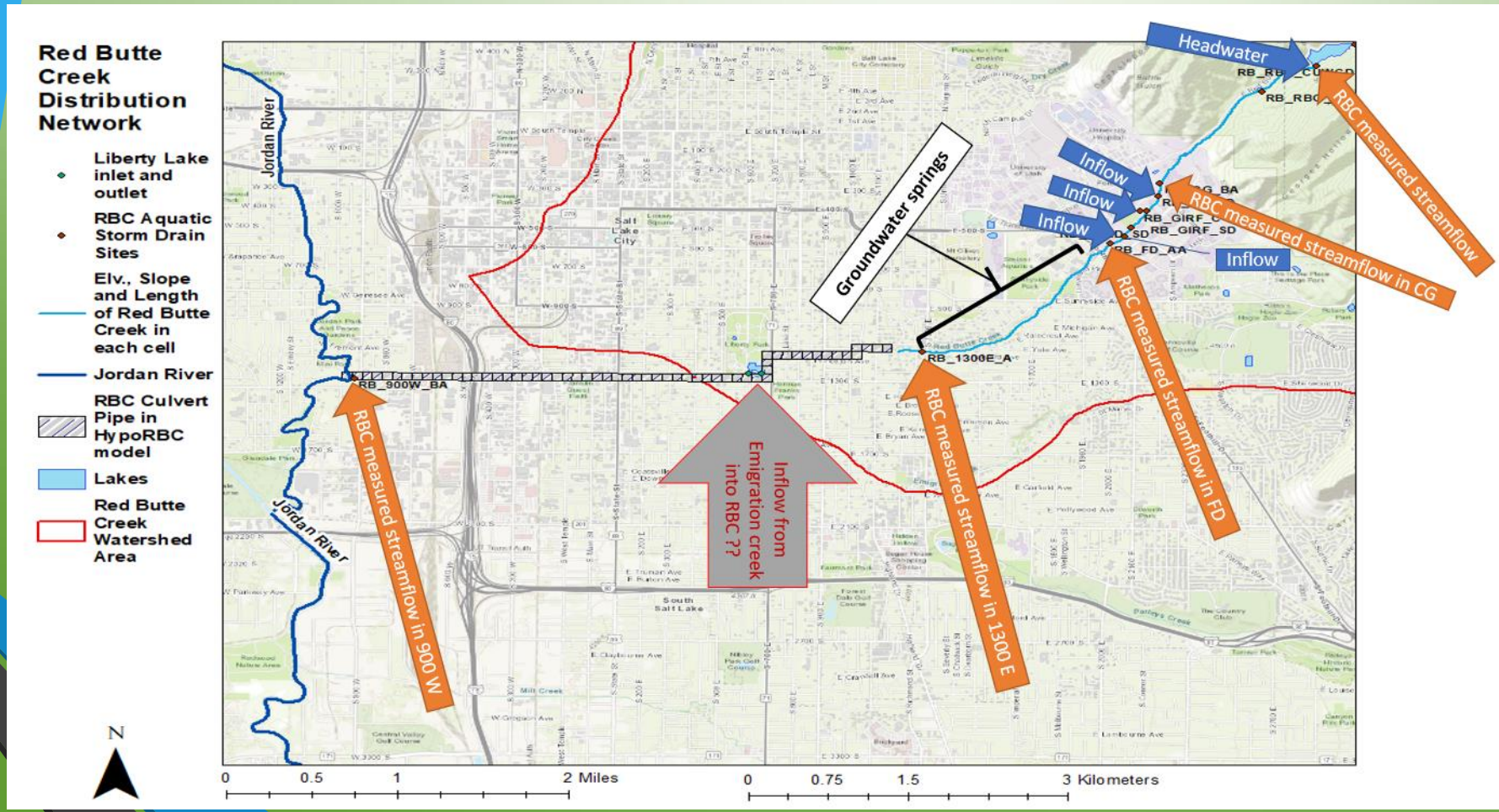
Inflows and tributaries to Red Butte Creek

- **Headwater**: outflow of Red Butte Reservoir.
- **Four Storm Drain inflows** into Red Butte Creek (RBC).
- **Groundwater springs inflows** between Foothill Drive and 1300 E (Gabor et al., 2017).
- **Inflow** from **Emigration Creek** into **RBC** around Foothill Drive (waterrights.Utah.gov) (under investigation) ??
- **Inflow** from **Emigration Creek** into **RBC** at Liberty park, Salt Lake city (under investigation) ??
- **Inflow** from **Parley's Creek** into **RBC** after Liberty park, Salt Lake city (under investigation) ??



Outflows and streamflow measurement locations

- Outflows (Diversions):
  - **RBC** to **Mt. Olivet Cemetery** (under investigation) ??
  - **RBC** to **Jordan river**
- Four Streamflow Monitoring locations:
  - Cottams Grove (CG)
  - Foothill Drive (FD)
  - 1300 E
  - 900 W



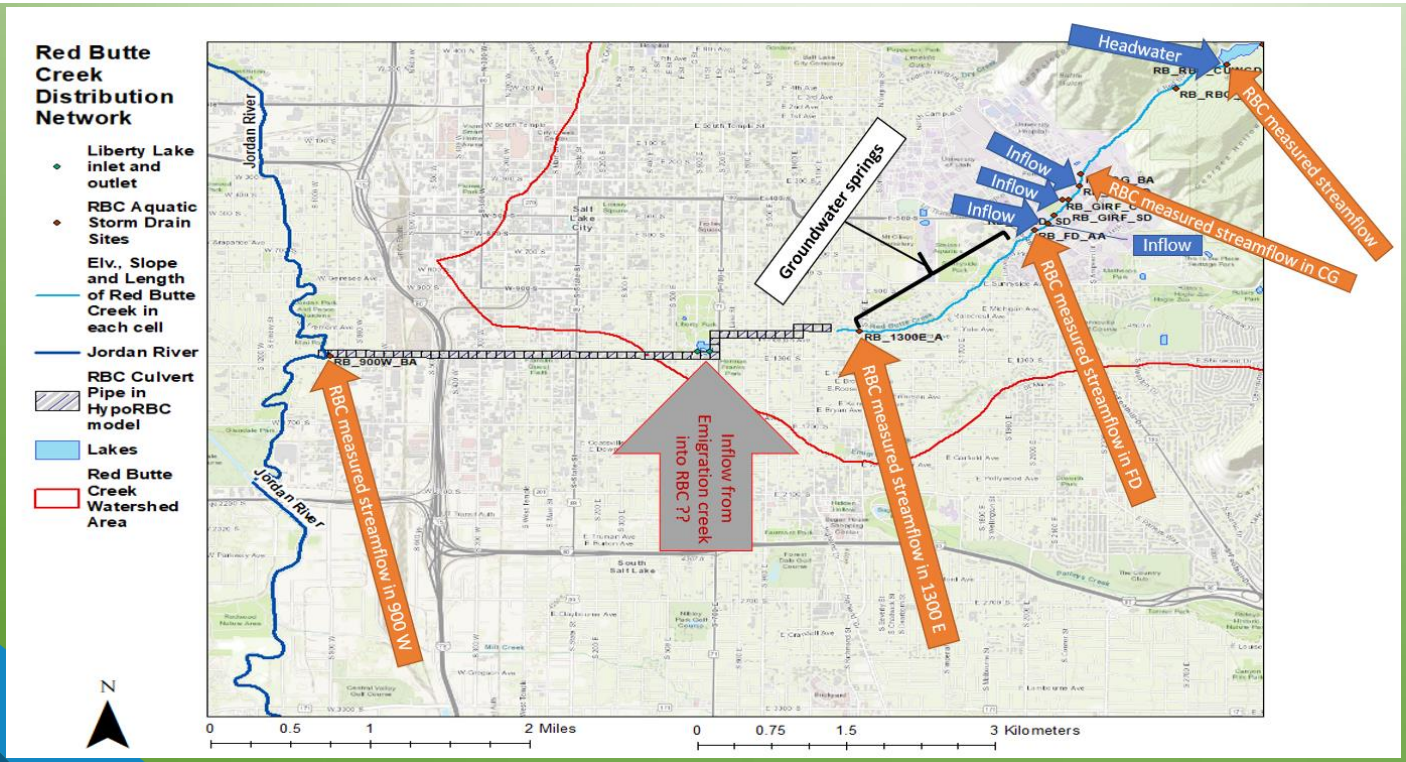
Preparation of Stream Flow Routing (SFR) package for RBC

- Use discharge data of iUtah stations including outflow of Red Butte reservoir (headwater), stream flows, and storm drains inflows.

- Provide HyperRBC steady-state models for May and June, 2016 in MODFLOW without Red Butte Reservoir via using the updated monthly averages of the stress boundary conditions of a refined version of Lambert's 1995 SLV model, and the available data (iUtah website).

Comparison of Simulated and Observed RBC stream flows

Trial 6b	Measured Streamflow in cfs at Monitoring locations from iUtah website		Simulated Streamflow in cfs via Steady-State models		(Sim. - Obs.)/Obs.		Vertical K of Streambed (ft/d)	Number of Reaches
Date / Control Locations	Avg. of May 13-14, 2016	Avg. of June 15-16, 2016	May, 2016	June, 2016	May, 2016	June, 2016		
Headwater	4.374	1.799	4.374	1.799	0	0	2.61 & 1.6	32
Cottams Grove	3.495	1.151	3.525	1.140	0.009	-0.010		
Foothill Drive	4.438	1.700	3.935	1.704	-0.113	0.002	0.08	13
1300 E		1.339					Waiting for input data	34
900 W	14.294	12.397					Waiting for input data	61



Summary

- Calibration down to Foothill Drive station yields simulated flows at that location differing from observed values by **-0.113** (**-11.3%**) for May 2016 and **0.002** (**0.2%**) for June 2016.

- Calibrated vertical hydraulic conductivities of RBC streambed from the headwater down to Foothill Drive vary from **2.61** to **0.08 ft/d**.

- After estimating remaining RBC tributary and diversion flows for calibration periods, the vertical hydraulic conductivities for the rest of RBC will be calibrated.

Thank you

References

1. Lambert, P. M. 1995. Numerical Simulation of Ground-Water Flow in Basin-Fill Material in Salt Lake Valley, Utah. United States Geological Survey. Technical Publication No. 110-B.
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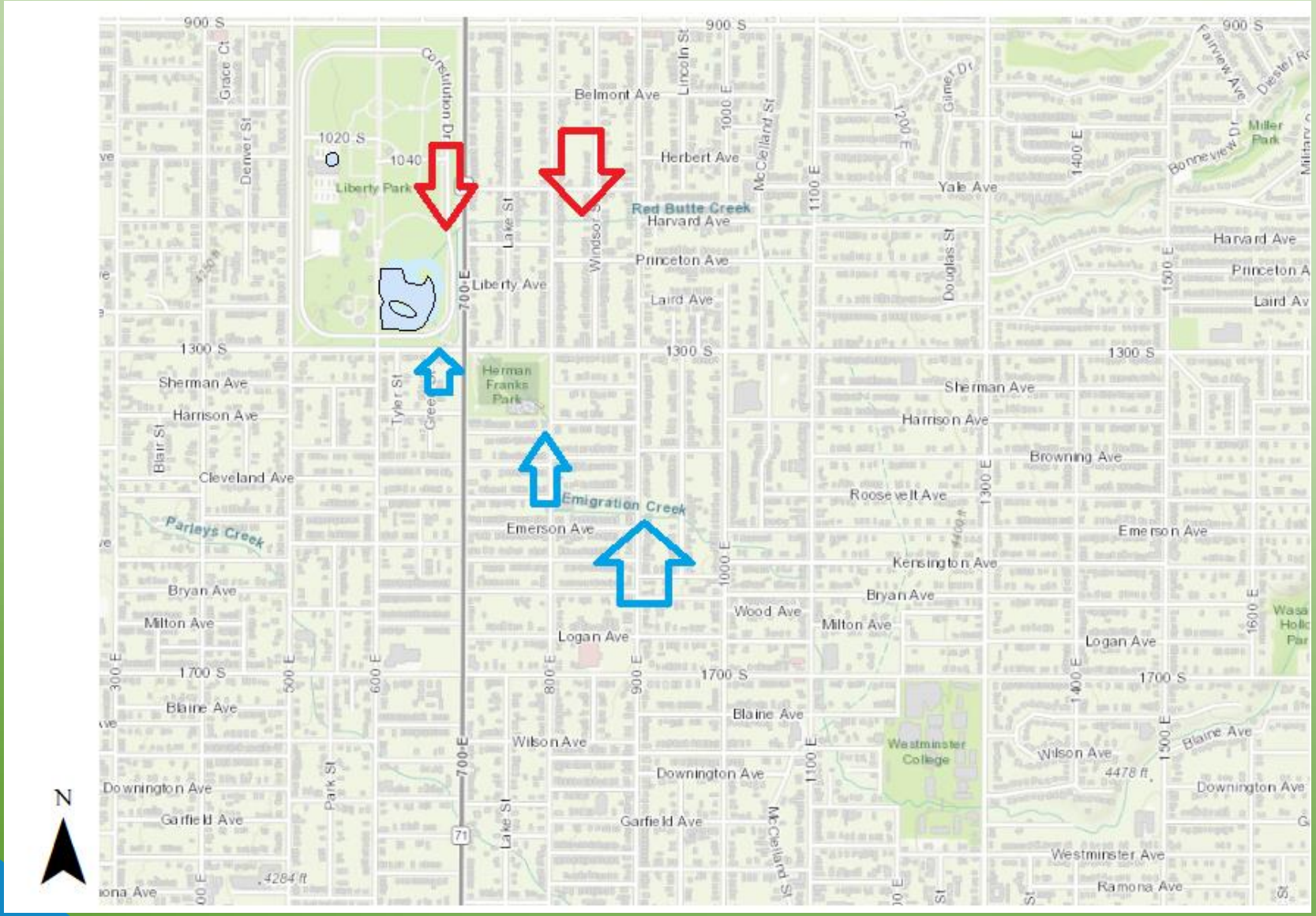
3. McDonald, M. G., and A. W. Harbaugh. 1988. A modular three-dimensional finite-difference ground-water flow model. United States Geological Survey Report, Techniques of Water-Resources Investigations 06-A1, 1988; 586 pages. https://doi.org/10.3133/twri06A1.
4. Forghani, A., and R. C. Peralta. 2018. Transport modeling and multivariate adaptive regression splines for evaluating performance of ASR systems in freshwater aquifers. Journal of Hydrology 553 (2017). Pages 540-548. https://doi.org/10.1016/j.jhydrol.2017.08.012.
5. Gabor, R. S., S. J. Hall, D. P. Eiriksson, Y. Jameel, M. Millington, T. Stout, M. L. Barnes, A. Gelderloos, H. Tennant, G. J. Bowen, B. T. Neilson, and P. D. Brooks. 2017. Persistent Urban Influence on Surface Water Quality via Impacted Groundwater. Environ. Sci. Technol. 2017, 51, 9477−9487. ACS Publications. https://pubs.acs.org/doi/10.1021/acs.est.7b00271.

Appendix

- Base map of ArcMap software around Liberty Park in Salt Lake City, Utah: Inflow from Emigration Creek into Liberty park (Blue arrows)



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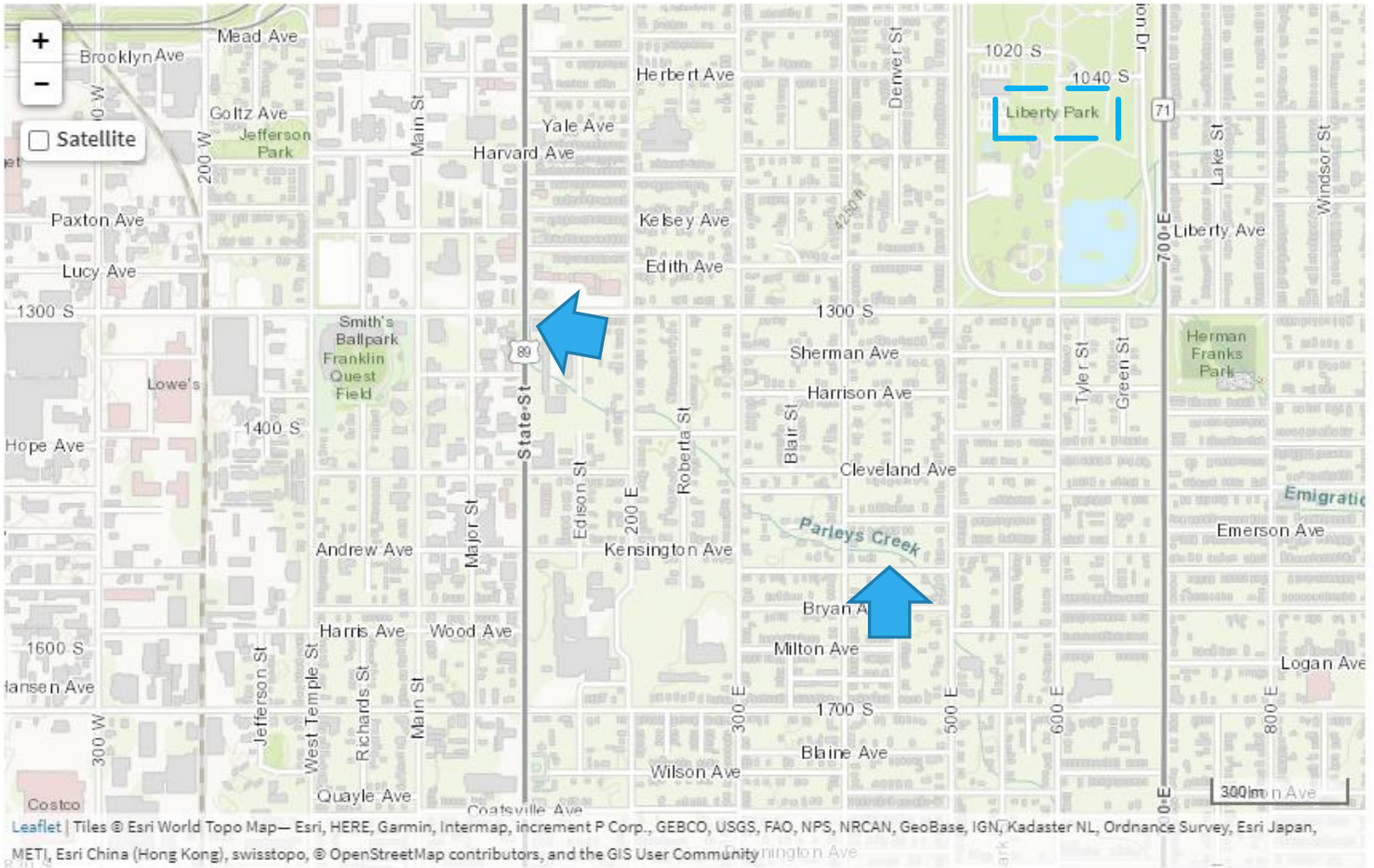
Inflow from Parley's Creek into RBC around Liberty Park in Salt Lake City, Utah



This map depicts the spatial layout of this field site. Please note that some locations may have moved over time due to logistics, safety and science requirements. This map was updated on March 03, 2020

Reference: https://www.neonscience.org/field-sites/field-sites-map/REDB

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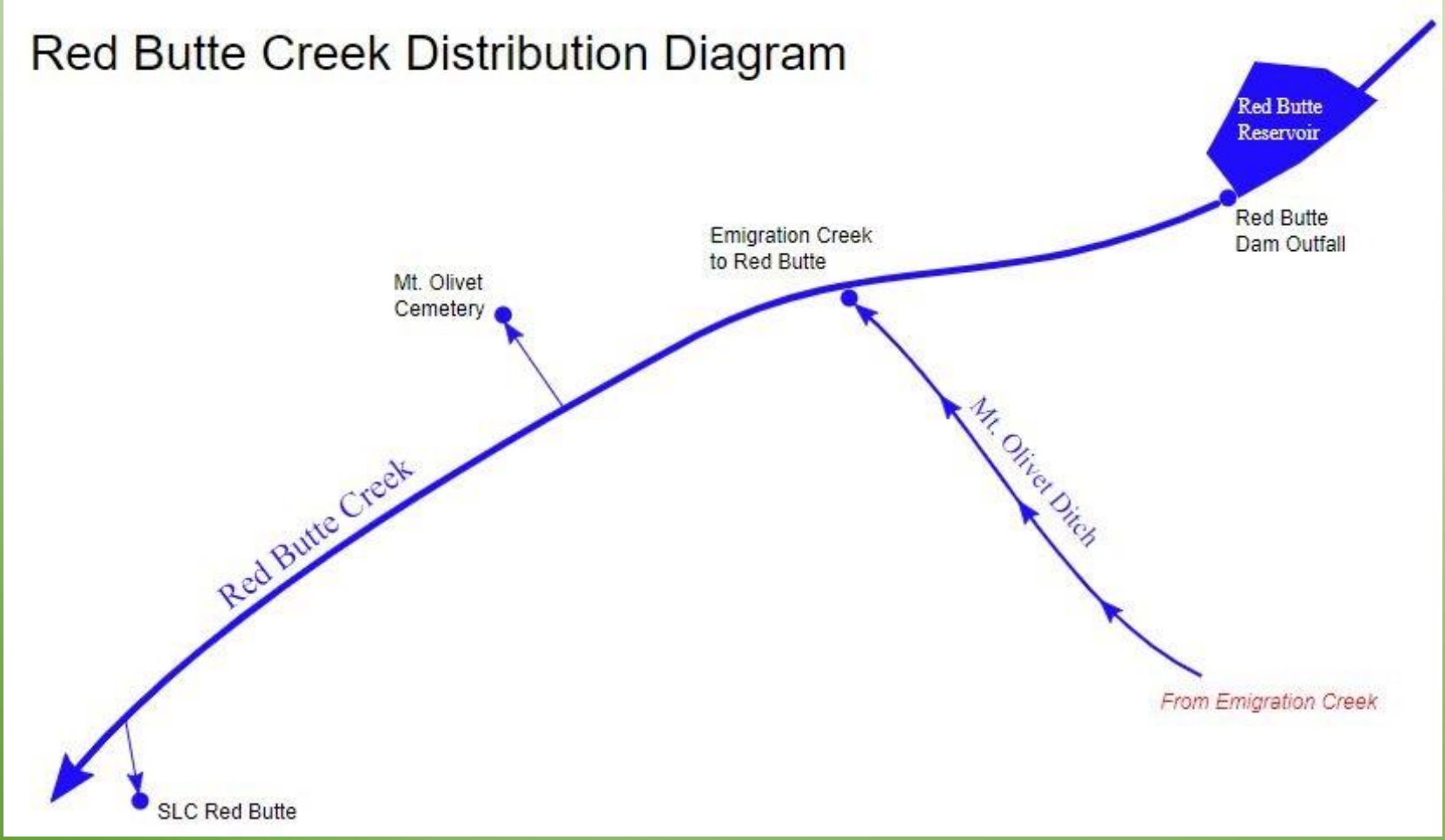
RBC Distribution Network



Reference:
https://www.waterrights.utah.gov/distribution/diagrams/redbutte.svg

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