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Fryingpan-Arkansas Storage Recovery Study

Southeastern Colorado Water Conservancy District

Phase II – Review Meeting
September 2nd, 2021

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Agenda

Agenda

1. Agenda
2. Phase II SOW Overview
3. Task 1-3 SOW & Work Summary
4. Analysis Approach
5. Review of Topographic & Bathymetric Survey Data
6. Pueblo Reservoir Sedimentation Analysis
7. Sedimentation Analysis & Storage Capacity Results
8. Next Steps & Recommendations

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Phase II SOW Overview

Phase II Scope of Work Overview

Goals & Objectives

- Assess the impacts of Pueblo Reservoir storage capacity loss on District storage and operations, storage contracts, and provides estimates as to when storage loss becomes critical to limiting Fryingpan-Arkansas operations.
- Can be used by the District and its Storage Recovery Committee and Mott MacDonald team to facilitate the development of future storage recovery tasks.
- Provides updated information for the District and its Storage Recovery Committee to communicate with stakeholders and make proactive decisions for mitigating future storage loss within Pueblo Reservoir.
- Phase II (Part 1) – *This scope of work* – addresses the first part of the Board's action. Future phases of work include obtaining an updated survey, numerical modelling, and assessing impacts from the Upper Arkansas River Basin
- Achieves its scheduled completion date.

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Tasks 1-3 Summary

Project scope of work for Tasks 1 and 2

Task Outline

1

Project Management

- **Purpose:** To successfully execute and deliver the Phase II storage recovery study on time, within budget, and in accordance with District goals and objectives.
- **Deliverables:** Updated Project Management Plan (PMP), Scheduled Progress Update Meetings Minutes (5 in total).

- **Task Start Date:** April 19, 2021 (NTP); **Task End Date:** July 23, 2021.

2

Project Initiation Workshop

- **Purpose:** For the Study Team to gain alignment with District and Committee objectives, PMP, study SOW and assumptions.
- **Deliverables:** Project Initiation Workshop Minutes and Presentation

- **Meeting Date:** May 7, 2021

Project Scope of Work for Tasks 3 – Data Collection

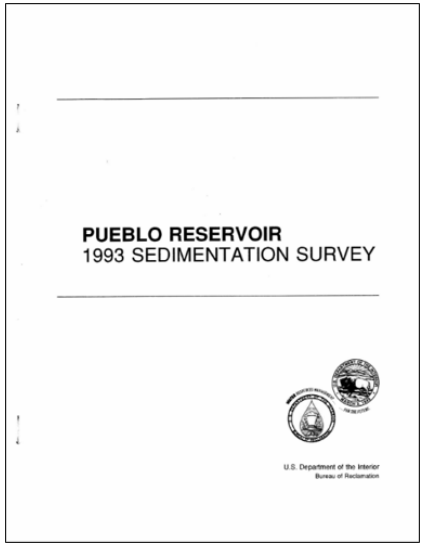
In coordination with the District, Mott MacDonald requested the following data from the Bureau:

- 1993 and 1974 survey data (Not received)
- 2012 contour data (Received)

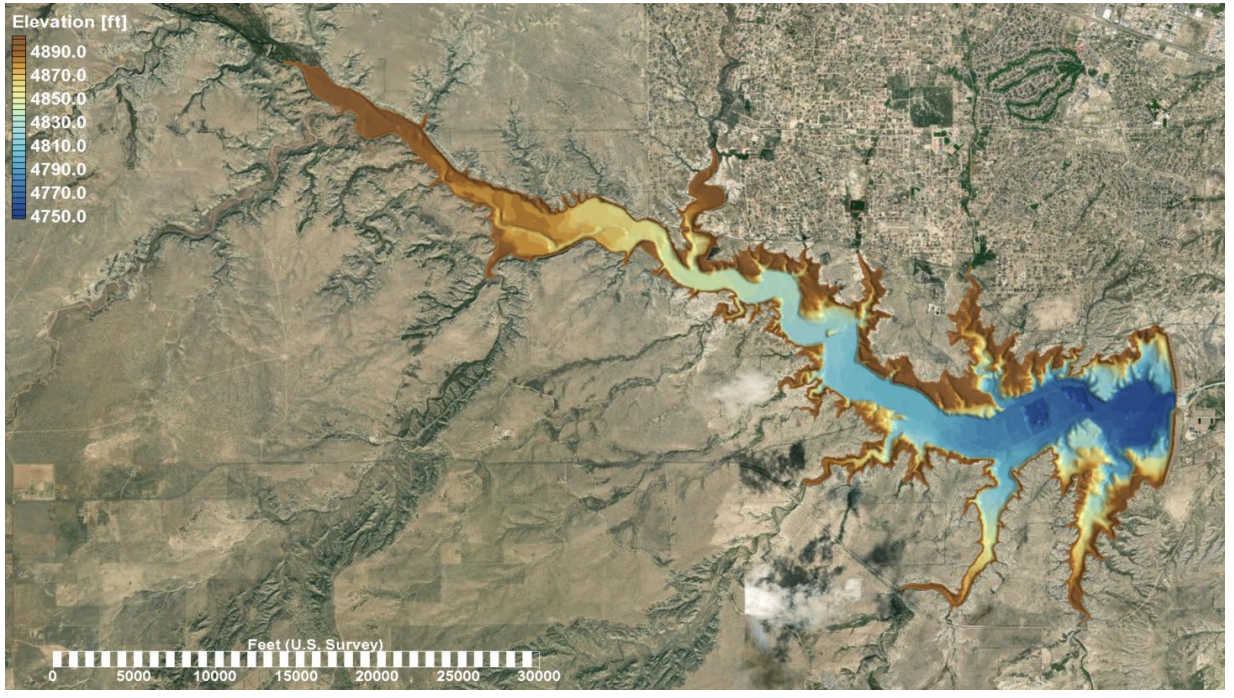
Hybrid approach taken by Mott MacDonald to develop sedimentation & storage capacity projections:

- Digitize the 1974 and 1993 transects provided in USBR, 1993. Create surfaces using smoothing, interpolation, and extrapolation to fill data gaps.
- Use digitized surveys with 2012 contour data to project future sedimentation and storage capacity losses conjunction with the operations data.
- <u>Storage loss predictions have larger confidence bands due to uncertainty in 1974 & 1993 data.</u>

1993 Sedimentation Survey Report



2012 contour data from the Bureau



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Analysis Summary

Task 4 – Engineering Assessment Work Plan

Work Items:

- **Operations**:
  - Use USBR data to develop seasonal water surface elevation elevation statistics.
  - Use this data in combination with bathymetry data to develop reservoir capacity projections.

- **Sedimentation:**
  - Use 1974 (rangeline), 1993 (rangeline), and 2012 (contours) bathymetry data to develop historical bathy elevations.
  - For years in between survey datasets, use linear interpolation to estimate bathymetry depth.

- **Storage:**
  - Using yearly bathymetry data developed in sedimentation subtask, and water level data processed in operations subtask – develop an updated historical record of reservoir storage levels.

  - Use regression curve fit to project future allocations storage allocation capacities . **This will have +/- confidence bounds that will be used in future storage projection.**

  - Compare projected available to storage contracts to identify risks for District.

Task 4 – Regression Analysis

1. Regression used to predict future sedimentation based on past reservoir elevations.

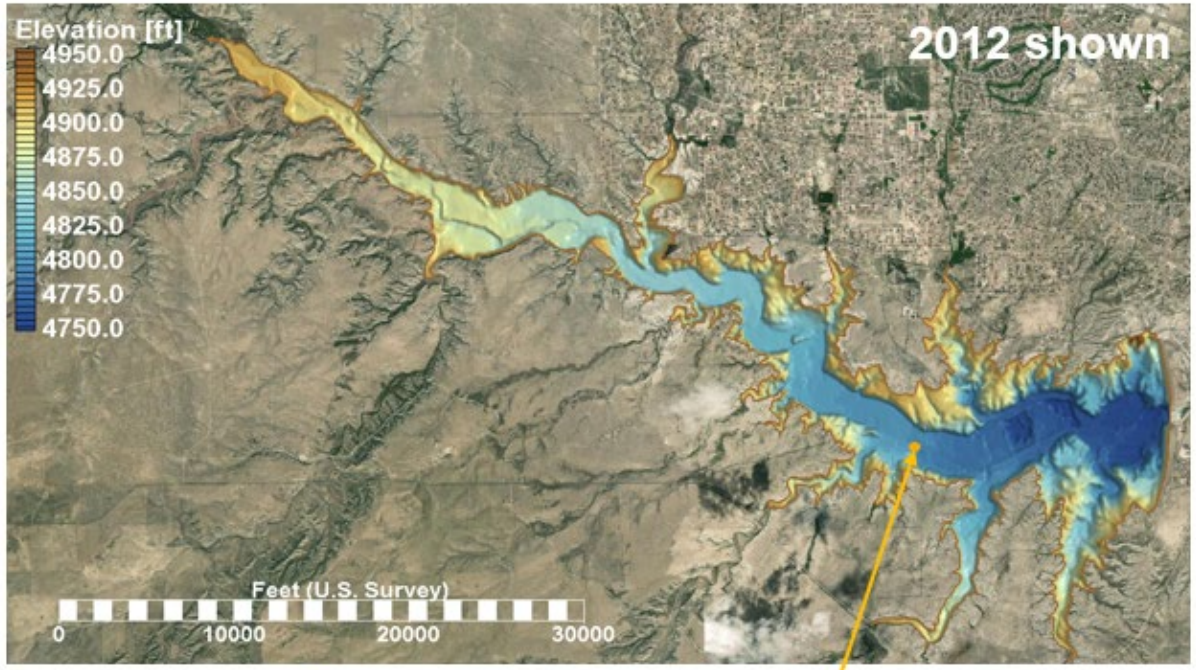
- Use 1974, 1993, and 2012 to develop linear regression fits throughout reservoir.

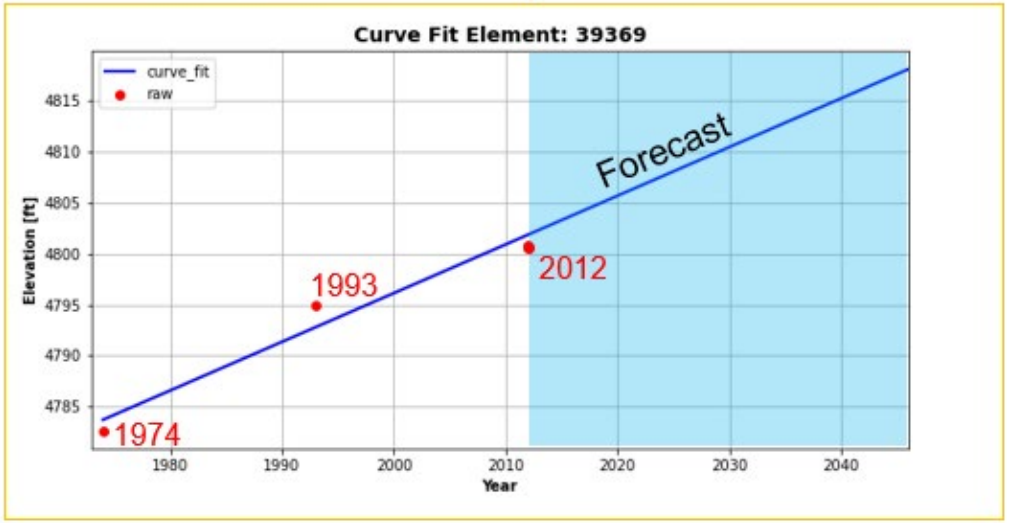
- Spatially varying results used to project future elevations throughout reservoir.

2. Use curves to project future sedimentation and reservoir elevations.

- Forecast reservoir elevations to 2046.

3. Process repeated at 74,000 points within reservoir to develop projected bottom elevations





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Survey Data Analysis

1974, 1993, and 2012

1974 & 1993 Rangeline Data

Background

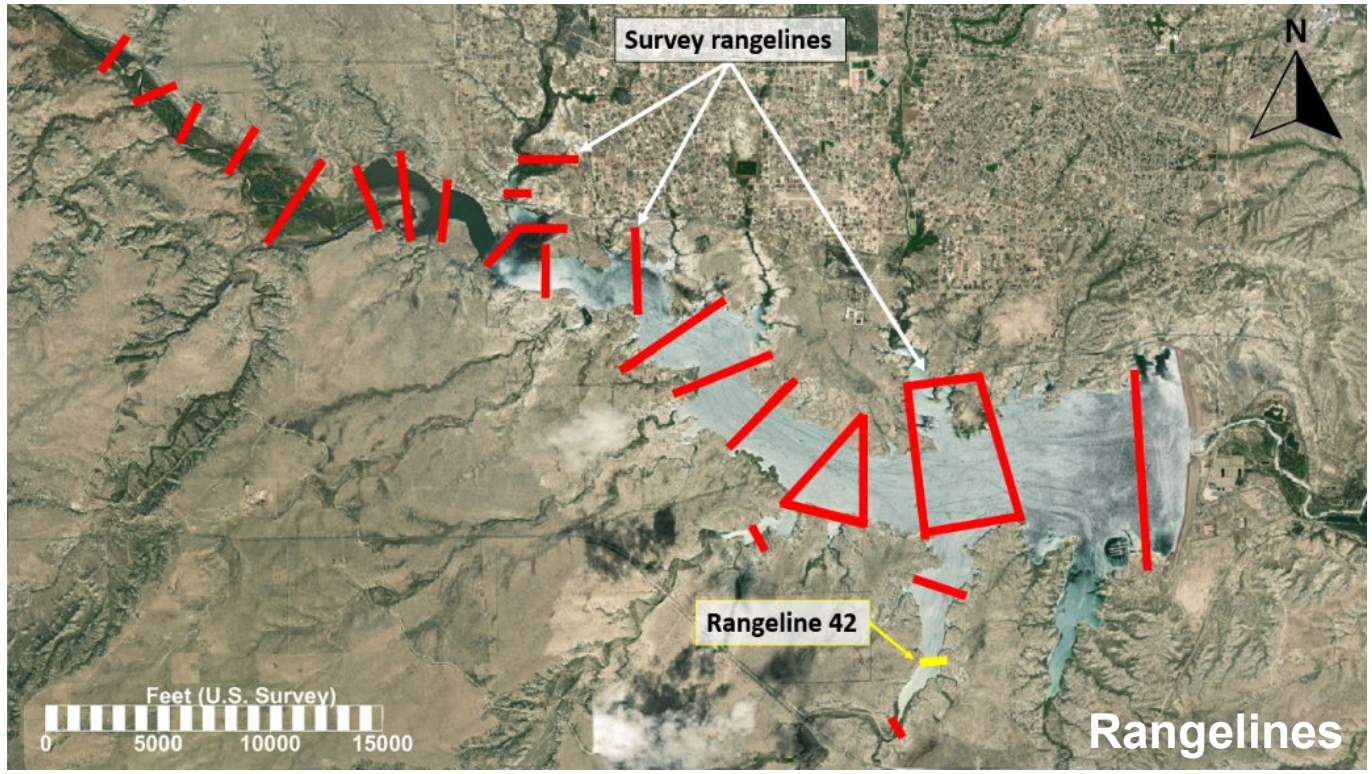
- Conducted by the Bureau of Reclamation in January 1974, and May 1993.
- Utilized to calculate area and capacity of the reservoir.

Horizontal Extents

- 31 rangelines, extending from 0.5 mi. north of dam to 12.5 mi. north of dam.
  - Rangelines were digitized and selectively merged with 2012 upland data to create a comprehensive surface.

Datum

- Horizontal – NAD27 State Plane Colorado South, ft.
- Vertical – Pueblo Reservoir Project Datum, ft.



2012 Contour Data from the Bureau

Background

- Conducted by USBR in May 2012.
- Conducted near water surface elevation 4,873 ft.
- The above-water topography was developed from high altitude aerial photography and bare earth data from 2007 near water surface elevation 4,855 (NAVD88).

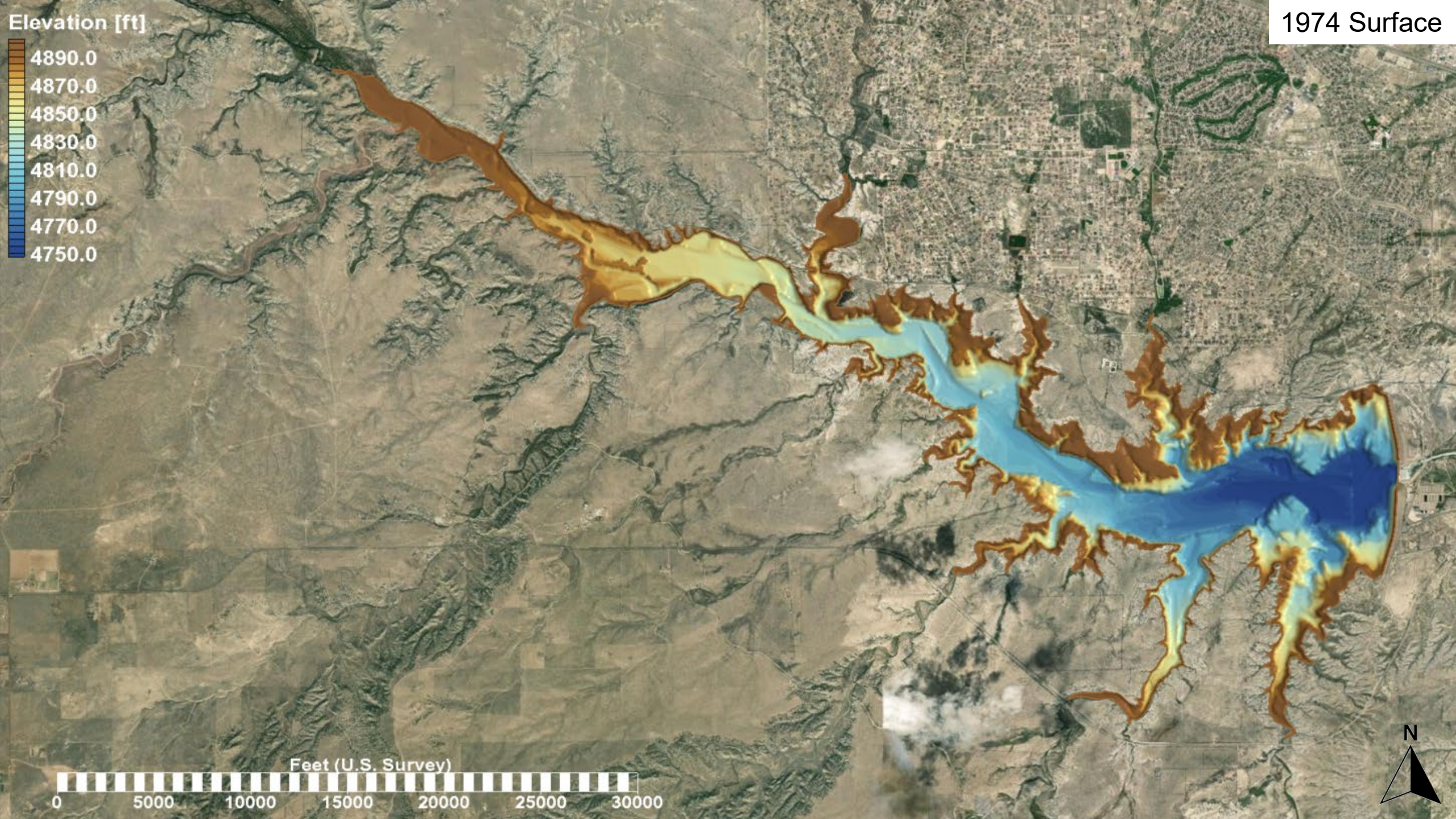
Vertical Extents

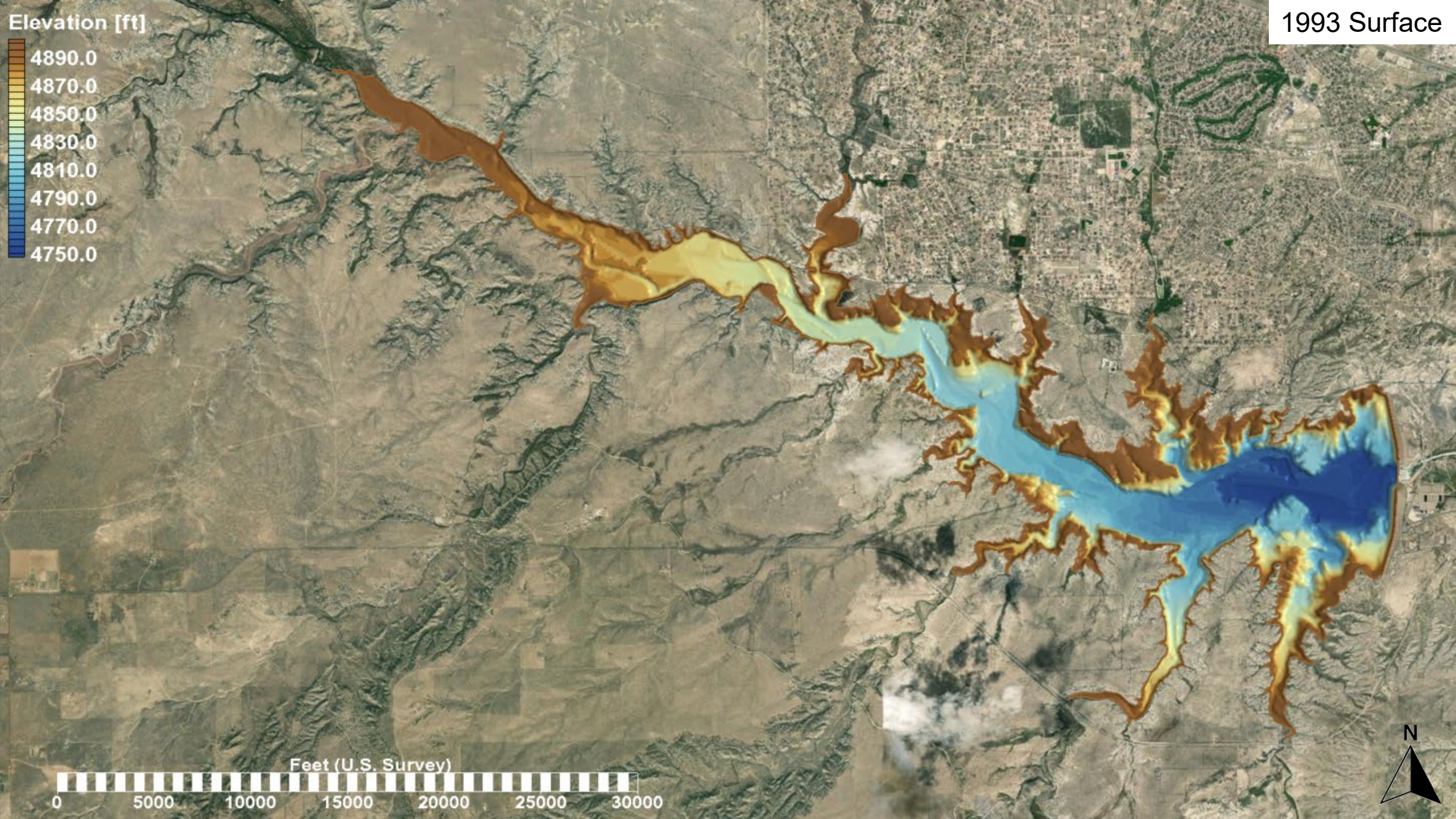
- Survey contours extend up to elevation +4,950 ft. T.O. Surcharge El. = +4,919 ft.

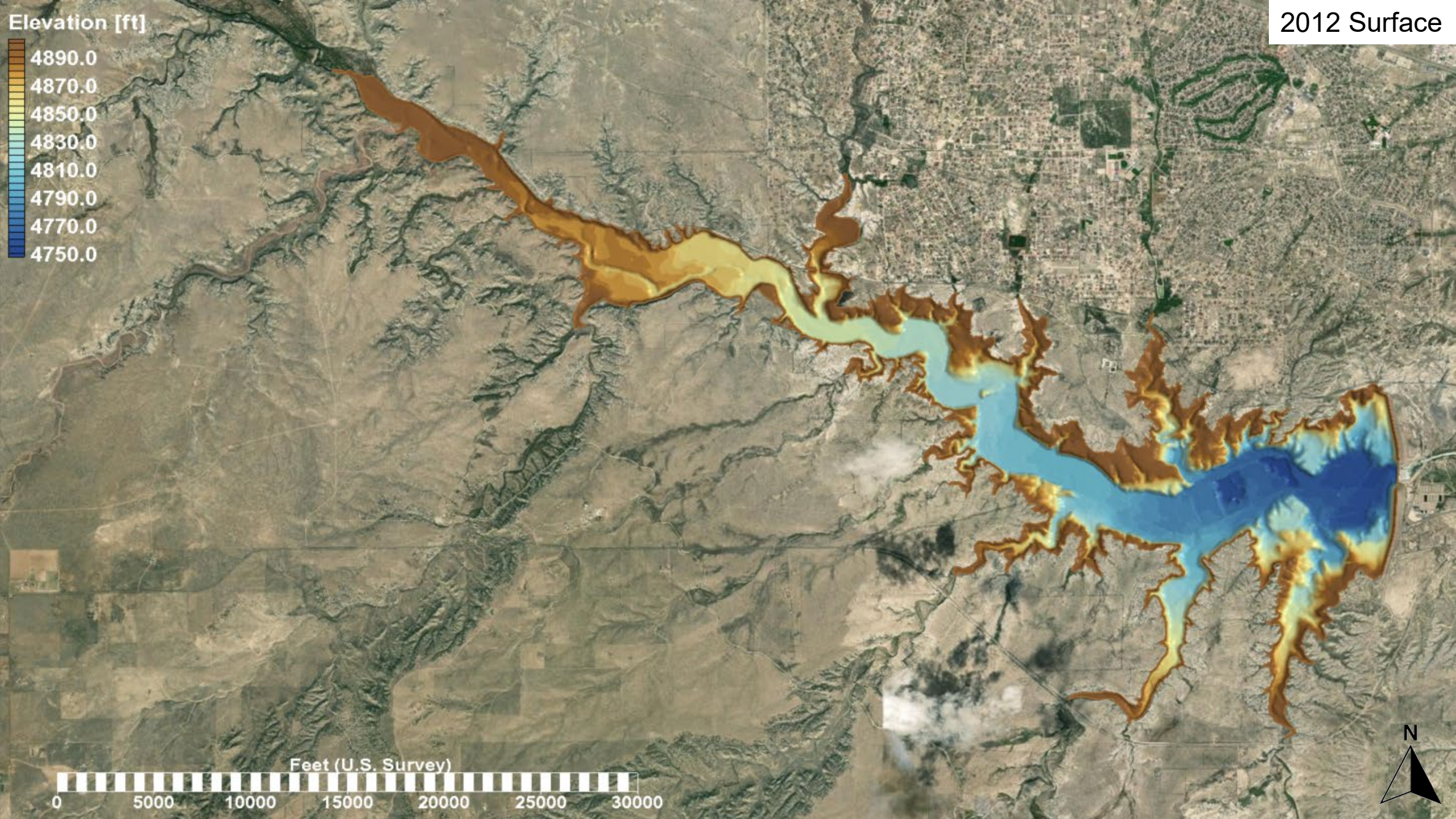
Datum

- Horizontal – State Plane Colorado South (feet).
- Vertical – NAVD88 (feet).

(NAVD88). For this study, the developed reservoir topography was tied to NAVD88 (GEOID12A) in US Survey Feet (feet) and resulting elevation versus area and capacity values were shifted down 3.2 feet to the project vertical datum.


Elevation [ft]
4890.0
4870.0
4850.0
4830.0
4810.0
4790.0
4770.0
4750.0
1974 Surface
Feet (U.S. Survey)
0
5000
10000
15000
20000
25000
30000
N


Elevation [ft]
4890.0
4870.0
4850.0
4830.0
4810.0
4790.0
4770.0
4750.0
1993 Surface
Feet (U.S. Survey)
0
5000
10000
15000
20000
25000
30000
N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4810.0
4790.0
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4750.0
2012 Surface
Feet (U.S. Survey)
0
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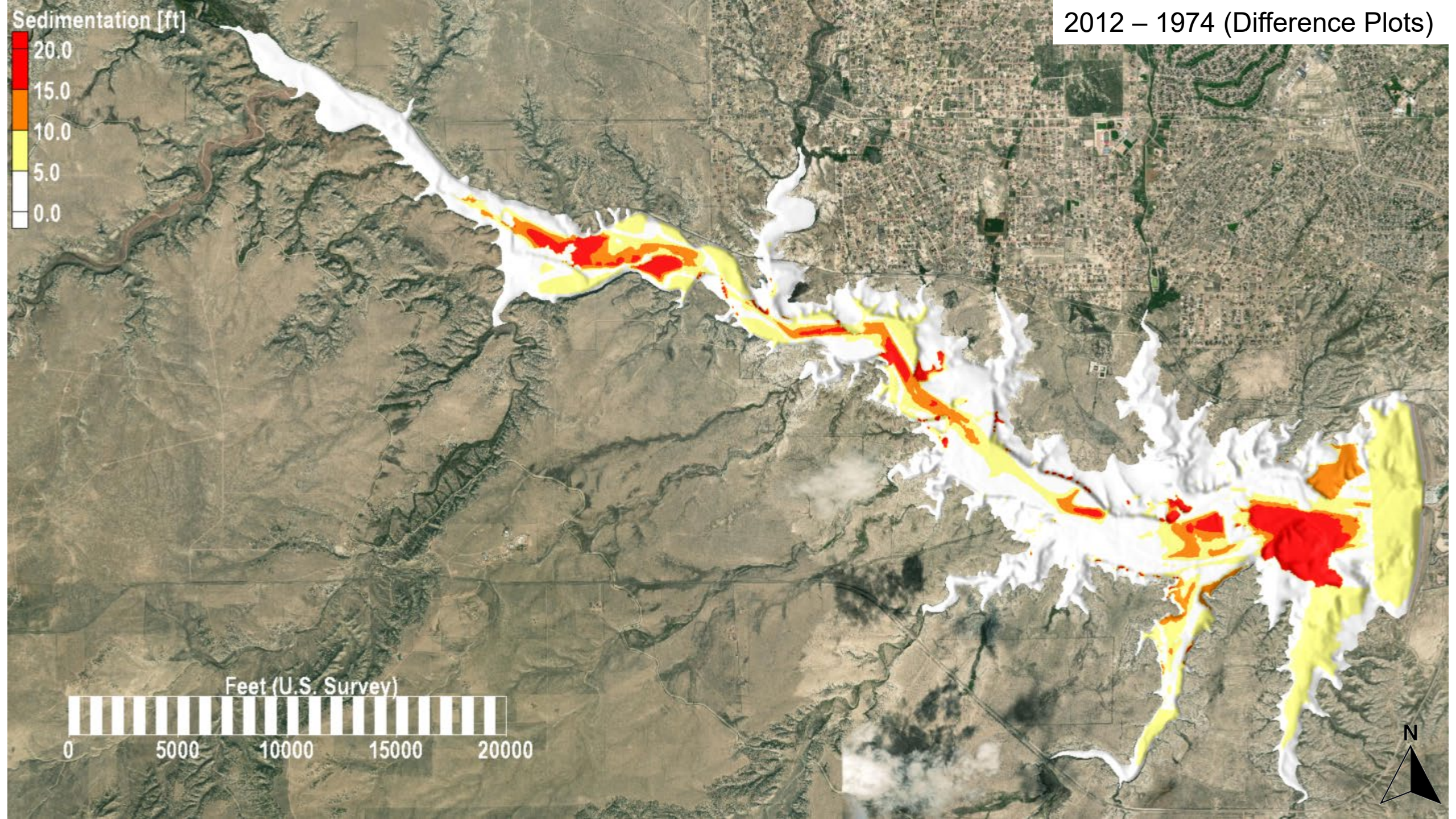
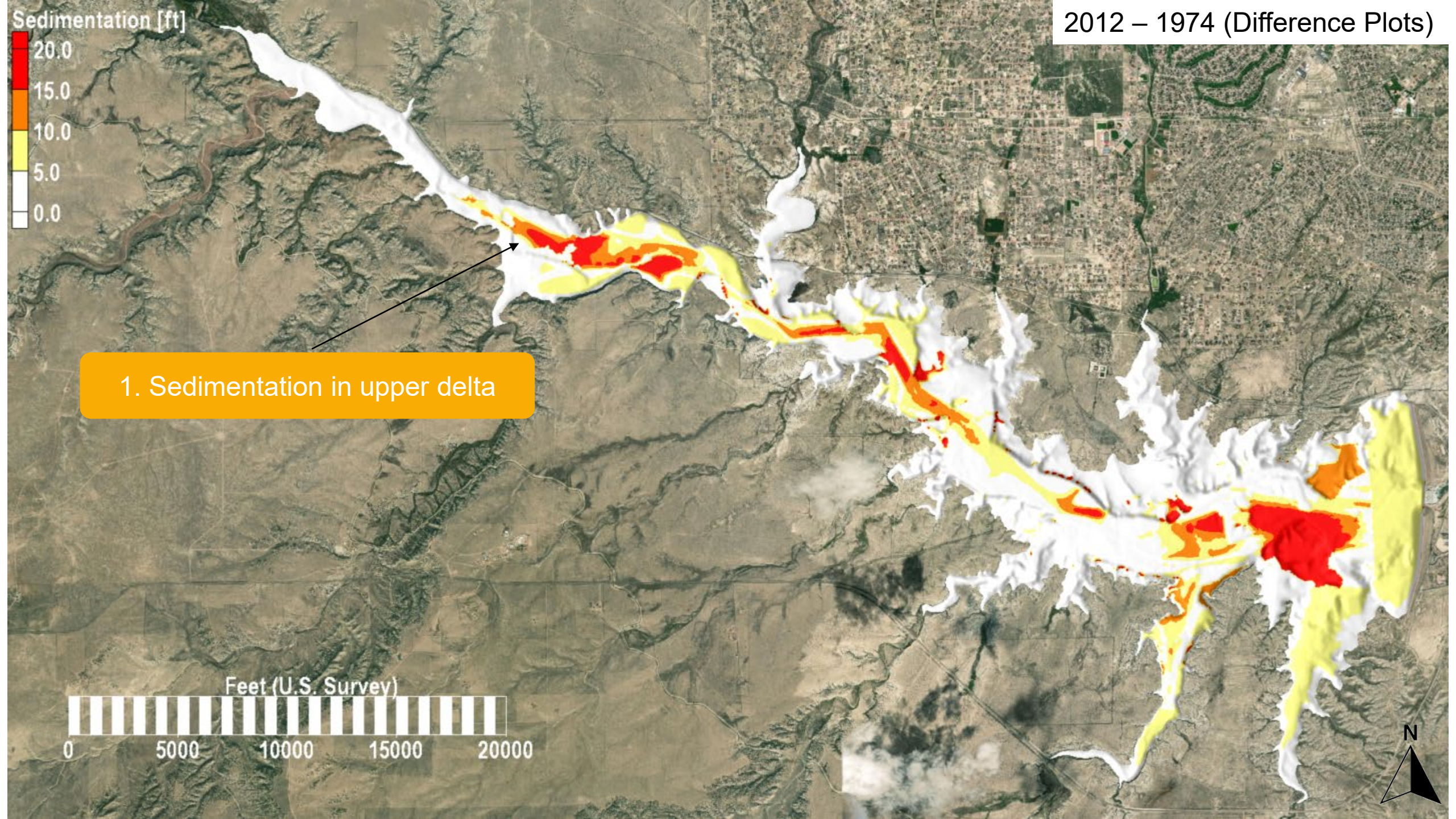
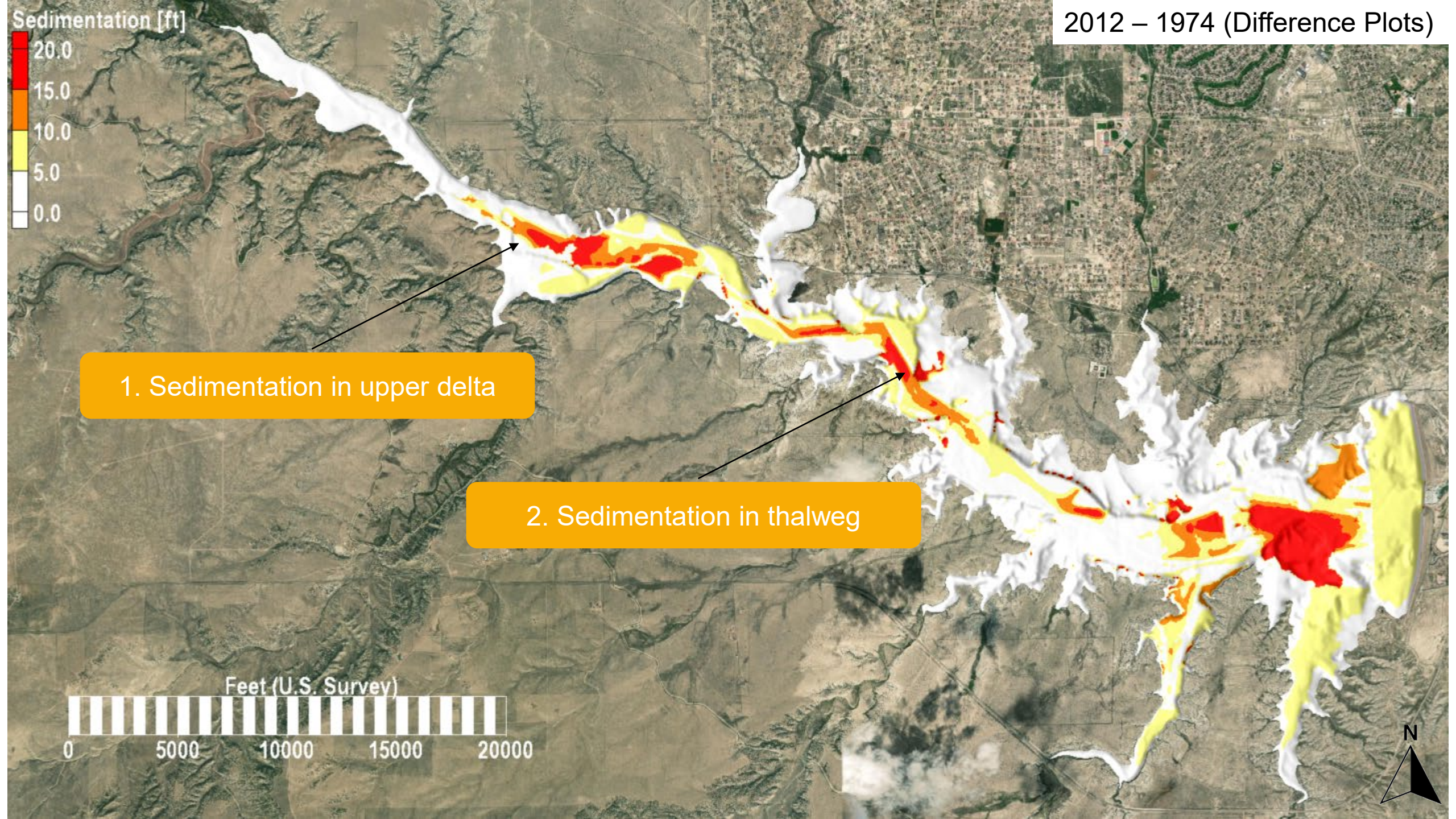
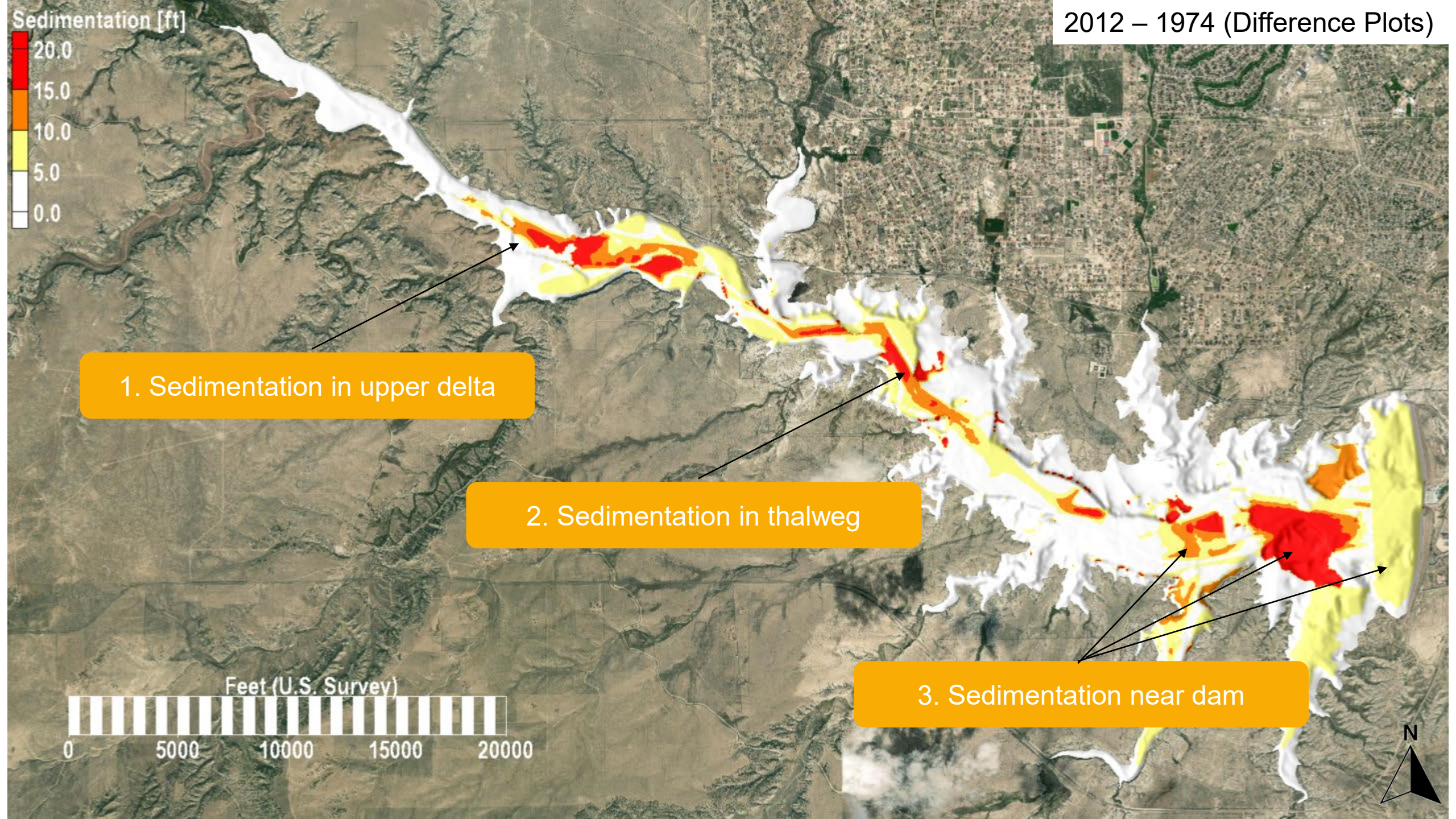
N


2012 – 1974 (Difference Plots)
Sedimentation [ft]
20.0
15.0
10.0
5.0
0.0
Feet (U.S. Survey)
0
5000
10000
15000
20000
N


2012 – 1974 (Difference Plots)
Sedimentation [ft]
20.0
15.0
10.0
5.0
0.0
1. Sedimentation in upper delta
Feet (U.S. Survey)
0
5000
10000
15000
20000
N


2012 – 1974 (Difference Plots)
Sedimentation [ft]
20.0
15.0
10.0
5.0
0.0
1. Sedimentation in upper delta
2. Sedimentation in thalweg
Feet (U.S. Survey)
0
5000
10000
15000
20000
N


2012 – 1974 (Difference Plots)
Sedimentation [ft]
20.0
15.0
10.0
5.0
0.0
1. Sedimentation in upper delta
2. Sedimentation in thalweg
3. Sedimentation near dam
Feet (U.S. Survey)
0
5000
10000
15000
20000
N

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Sedimentation Analysis

USBR Comparison & Forecasting Methodology

USBR Storage Comparison

Difference likely due to area of analysis

Storage Allocation	Top of Pool Elevation (Feet)	1974 USBR Capacity (AF)	1974 MM Capacity [AF]	1974 Difference [MM - USBR]	1993 USBR Capacity (AF)	1993 MM Capacity [AF]	1993 Difference [MM - USBR]	2012 USBR Capacity (AF)[2]	2012 MM Capacity [AF]	2012 Difference [MM - USBR]
Surcharge	4,919.0	131,054	128,930	-2,124	131,054	128,920	-2,134	131,054	128,951	-2,103
Flood Control	4,898.7	26,992	26,456	-536	27,044	26,443	-601	26,990	26,439	-551
Joint Use	4,893.8	66,266	65,145	-1,121	65,716	64,998	-718	66,011	64,704	-1,307
Active Conservation	4,880.5	234,210	238,957	4,747	229,059	230,438	1,379	219,772	218,850	-922
Inactive Pool	4,796.7	26,895	28,252	1,357	25,792	25,673	-119	23,706	23,469	-237
Dead	4,764.0	3,758	5,537	1,779	2,329	4,327	1,998	1,895	1,796	-99
	Total[1]	358,121	364,347	6,226	349,940	351,878	1,938	338,374	335,258	-3,116

Notes: 1. Calculated below the top of Flood Control pool, el. 4,898.7 feet. Does NOT include surcharge volumes
2. USBR, 2015 recalculation of capacity

USBR Storage Comparison

Storage Allocation	Top of Pool Elevation (Feet)	1974 USBR Capacity (AF)	1974 MM Capacity [AF]	1974 Difference [MM - USBR]	1993 USBR Capacity (AF)	1993 MM Capacity [AF]	1993 Difference [MM - USBR]	2012 USBR Capacity (AF)[2]	2012 MM Capacity [AF]	2012 Difference [MM - USBR]
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Notes: 1. Calculated below the top of Flood Control pool, el. 4,898.7 feet. Does NOT include surcharge volumes
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Forecasting methodology (1)

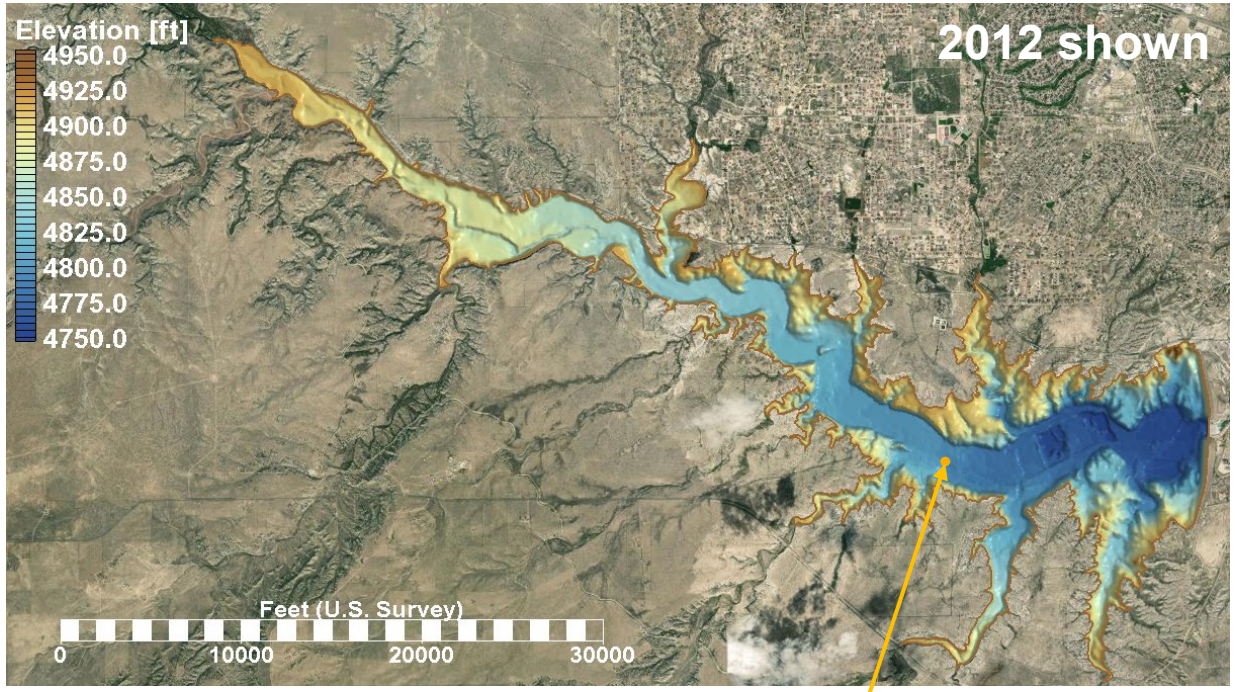
1. Develop forecasting curves at each point in surface.

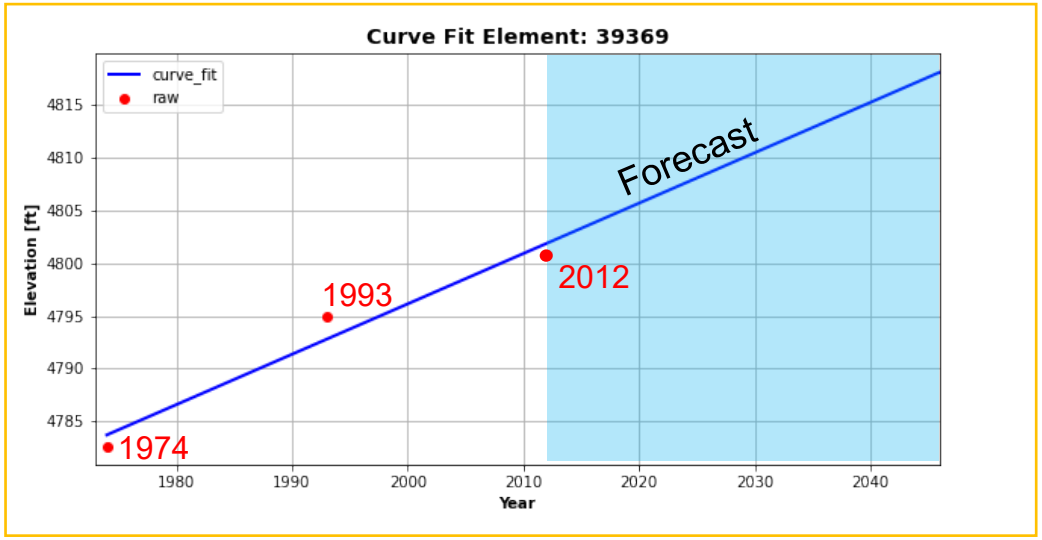
- Use 1974, 1993, and 2012 to develop linear regression fits throughout reservoir.
- Spatially varying results used to project future elevations throughout reservoir.

2. Use curves to project future sedimentation and reservoir elevations.

- Forecast reservoir elevations to 2046.

3. Use historical water surface elevation data & future sedimentation to develop a range of future capacities





Forecasting methodology (1)

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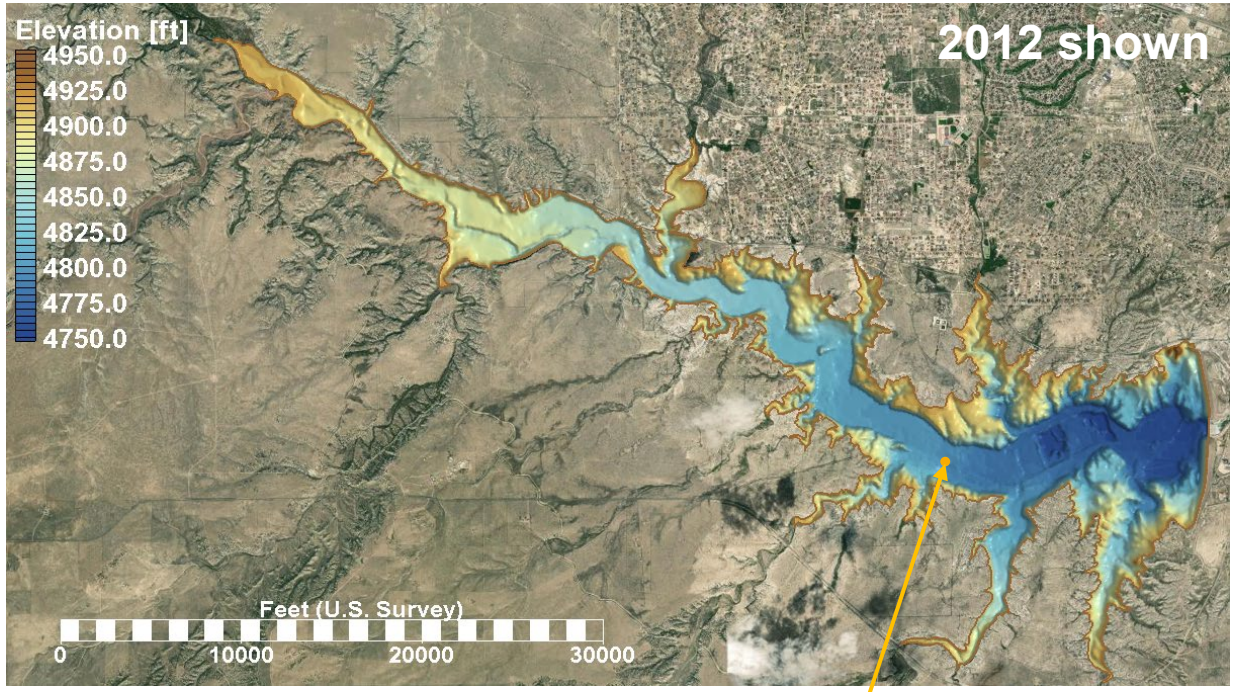
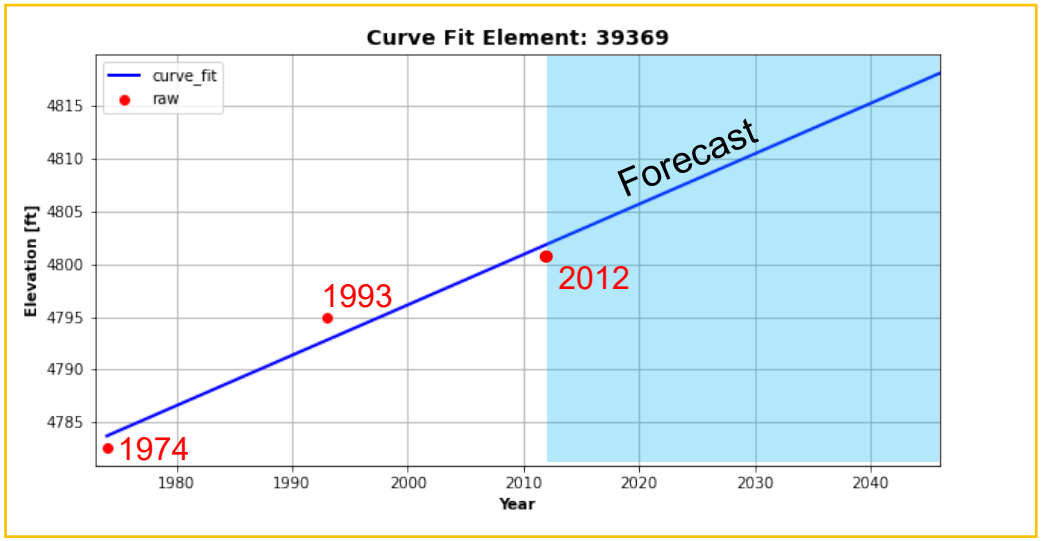
- Forecast reservoir elevations to 2045.

3. Use historical water surface elevation data & future sedimentation to develop a range of future capacities





Analysis is based on long term averages of sedimentation rates.

Numerical model simulation recommended in future phases to refine these projections, conduct event-based analysis, and assess dredging alternative.

Forecasting methodology (2)

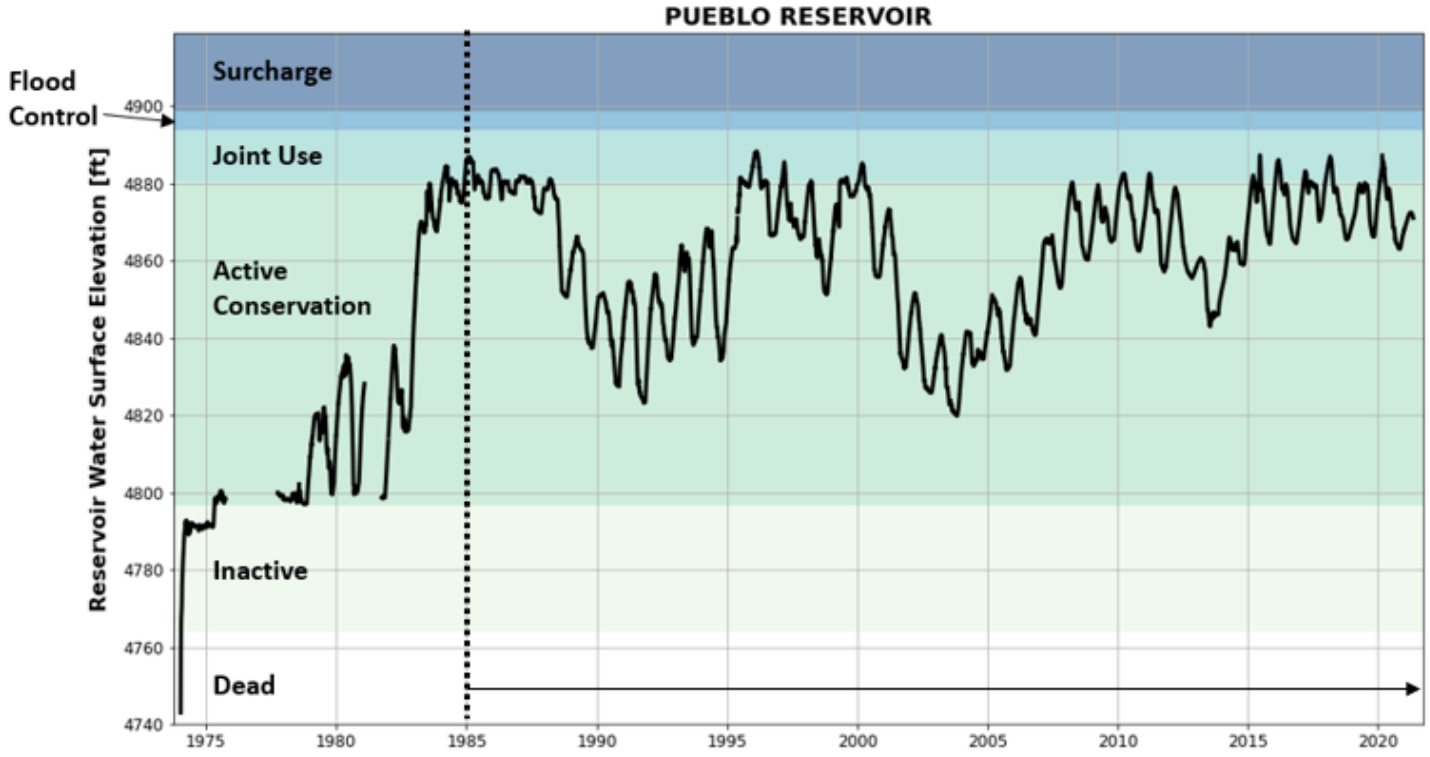
1. Develop forecasting curves at each point in surface.

- Use 1974, 1993, and 2012 to develop linear regression fits throughout reservoir.
- Spatially varying results used to project future elevations throughout reservoir.

2. Use curves to project future sedimentation and reservoir elevations.

- Forecast reservoir elevations to 2045.

3. Use historical water surface elevation data & future sedimentation to develop a range of future capacities



Historical Reservoir Water Surface Elevations from USBR

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Sedimentation & Storage Capacity Results

Results

Results (1) – Yearly Sedimentation Movie

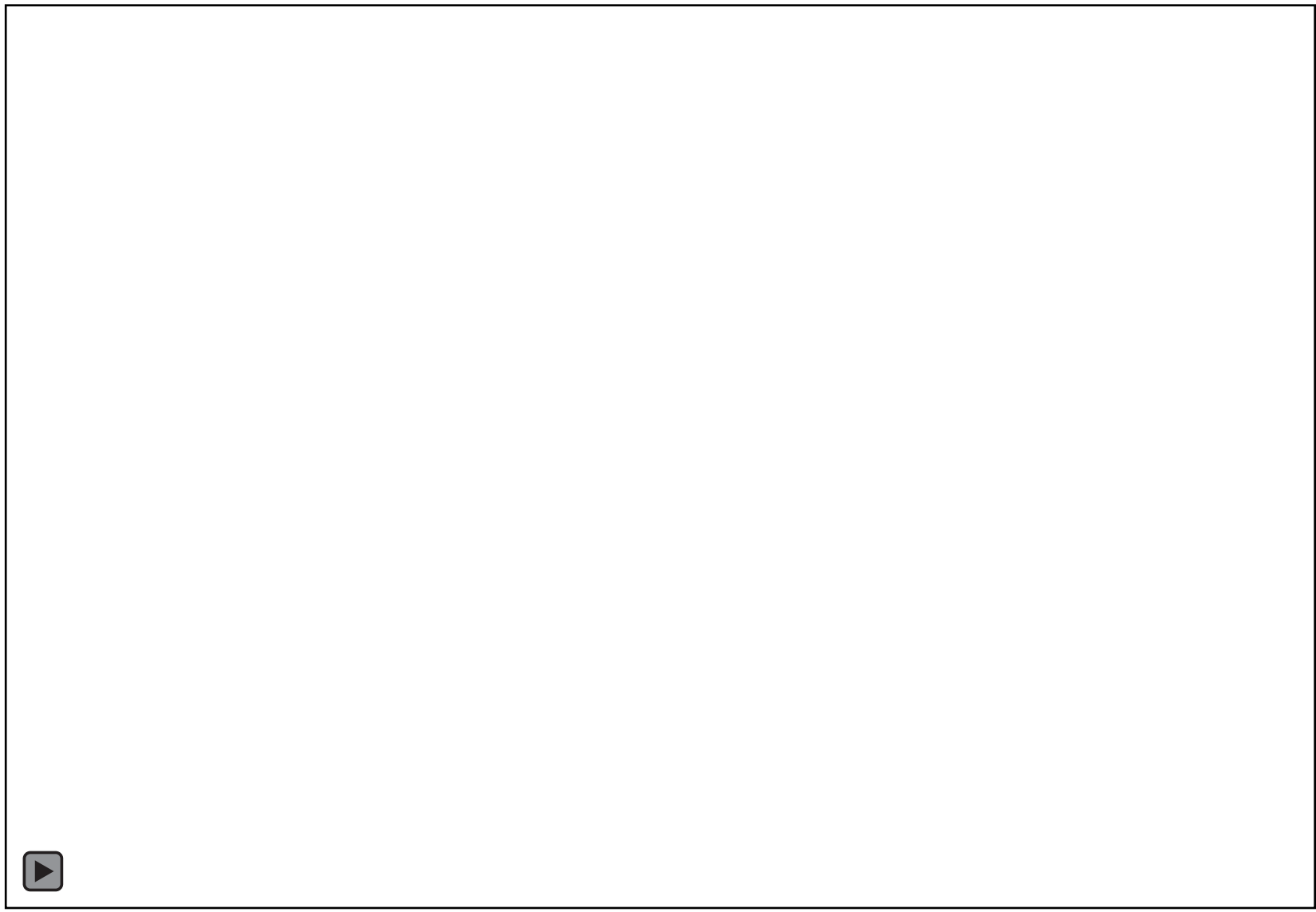
1. **Spatial reservoir elevations over time**

2. Distribution of water levels (1985-2021) used to bound future capacity estimates.

3. Capacity estimates show 10%, 50%, and 90% non-exceedance values.

Note: Sedimentation Results from regression analysis described on previous slides.

Numerical model simulation recommended in future phases to refine these projections.



Results (1) – Projected Sedimentation

1. **Spatial reservoir elevations over time**

2. **Distribution of water levels (1985-2021) used to bound future capacity estimates.**

3. **Capacity estimates show 10%, 50%, and 90% non-exceedance values.**

Note: Sedimentation Results from regression analysis described on previous slides.

Numerical model simulation recommended in future phases to refine these projections.

Allocation	Projected Annual Future Capacity Loss [AF/YR]
Joint Use	50-180
Active Conservation	350-625
Inactive Pool	125-200
Dead Pool	5-55
Total	530-1,060

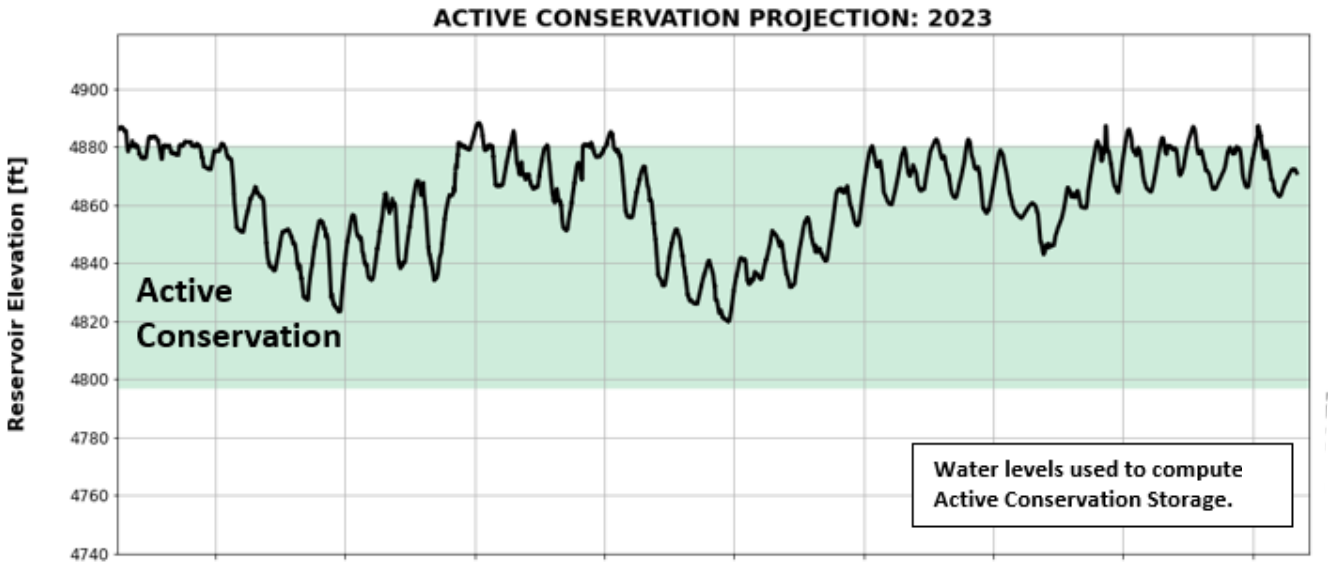
Notes and References

[1] The Bureau provides estimates in U.S. Bureau of Reclamation, 2015 on sedimentation in the Active Conservation through Dead Pool Allocations.

[2] U.S. Bureau of Reclamation, 2015 estimate a historical average annual rate of 496.1 AF/yr. This matches general range of estimated sedimentation calculated by Mott MacDonald in the Active Conservation through Dead Pool Allocations of 480-880 AF/yr.

[3] Additional surveys are needed to refine the sedimentation projections.

Results (2a) – Historical Reservoir WSE Timeseries

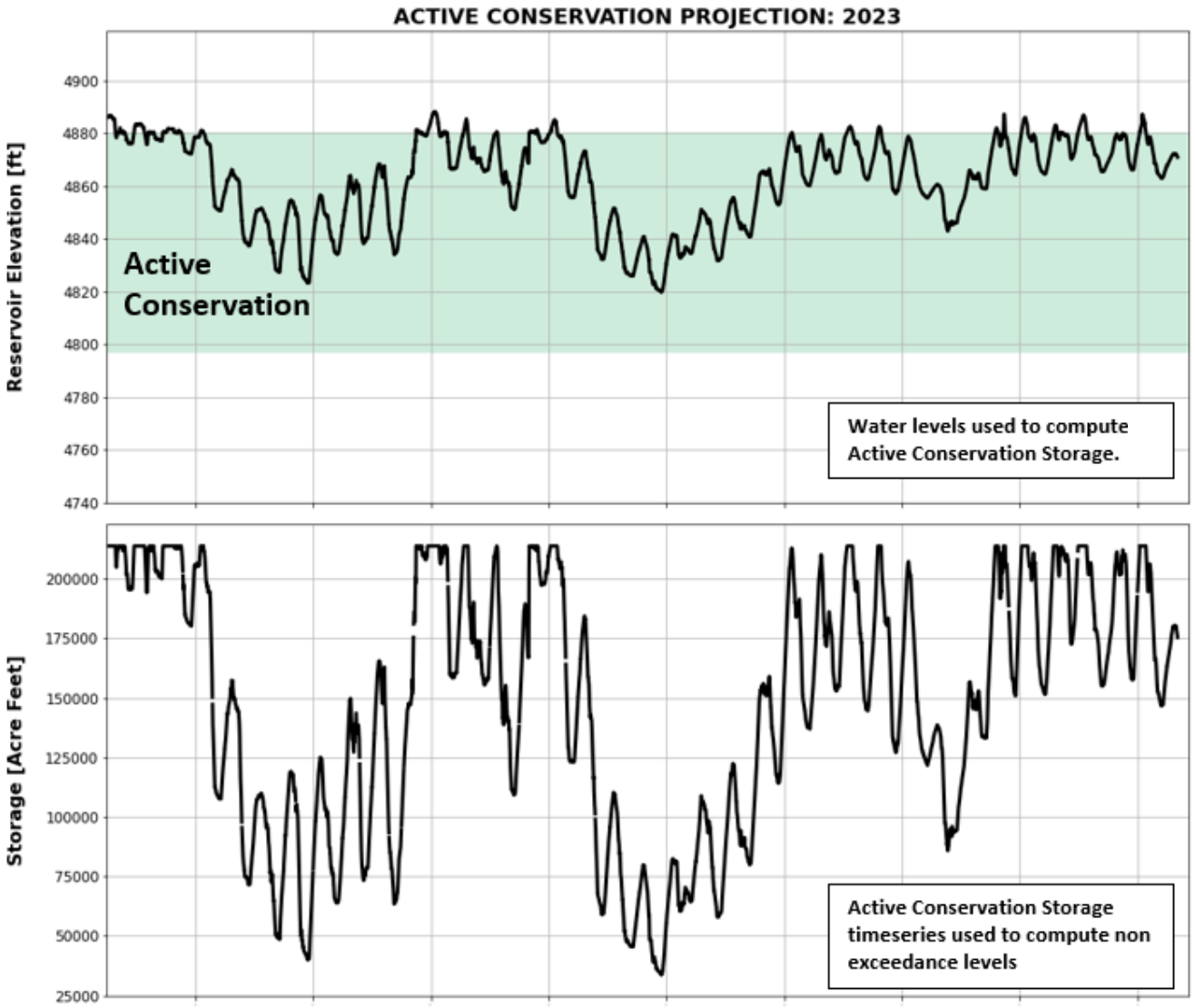


Operations Data:

1. Historical timeseries of water surface elevations post 1985 used.

2. Water levels relative to Active Conservation Pool limits shown in plot

Results (2b) – Capacity Calculation Timseries



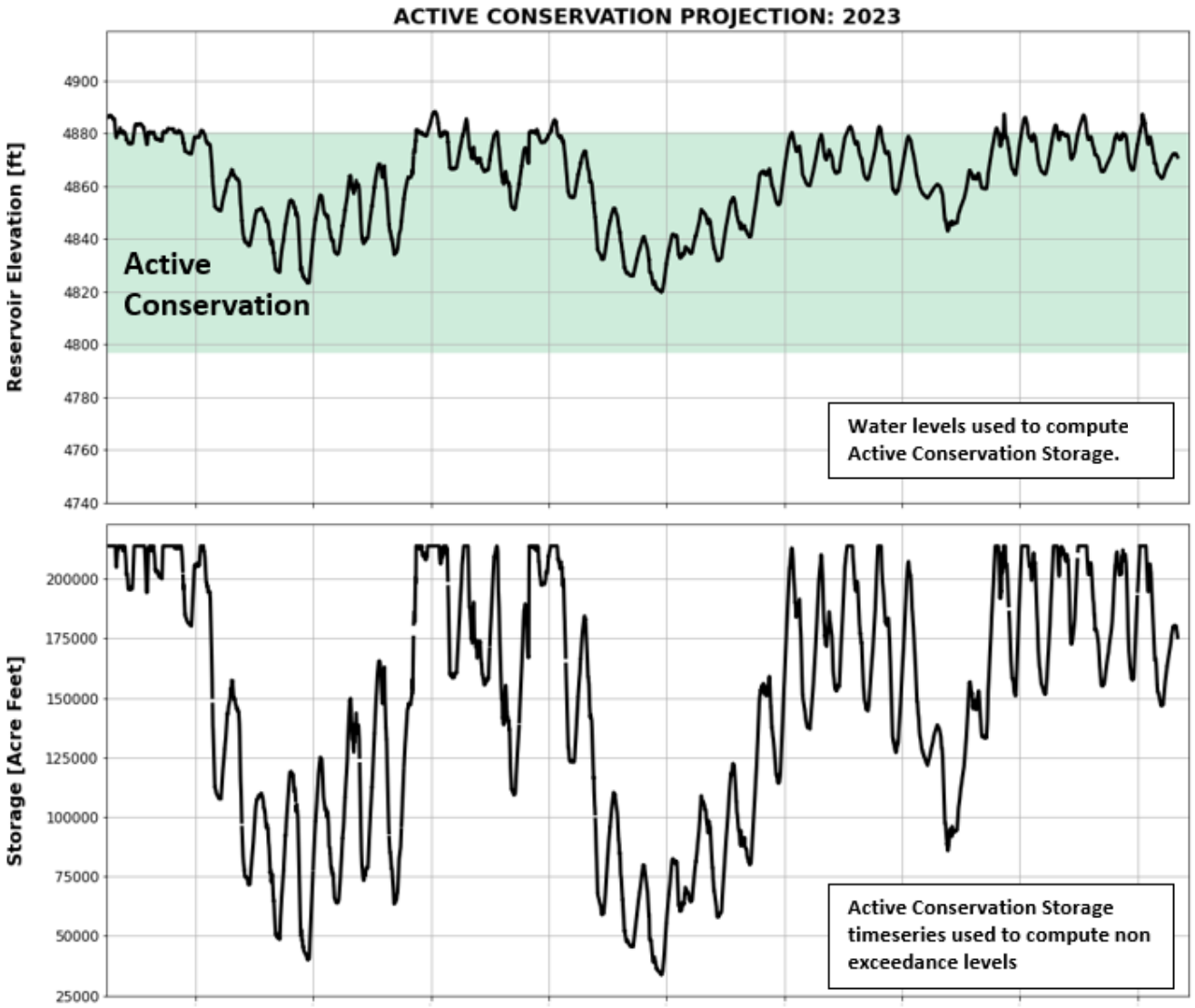
Capacity Timeseries Calculation:

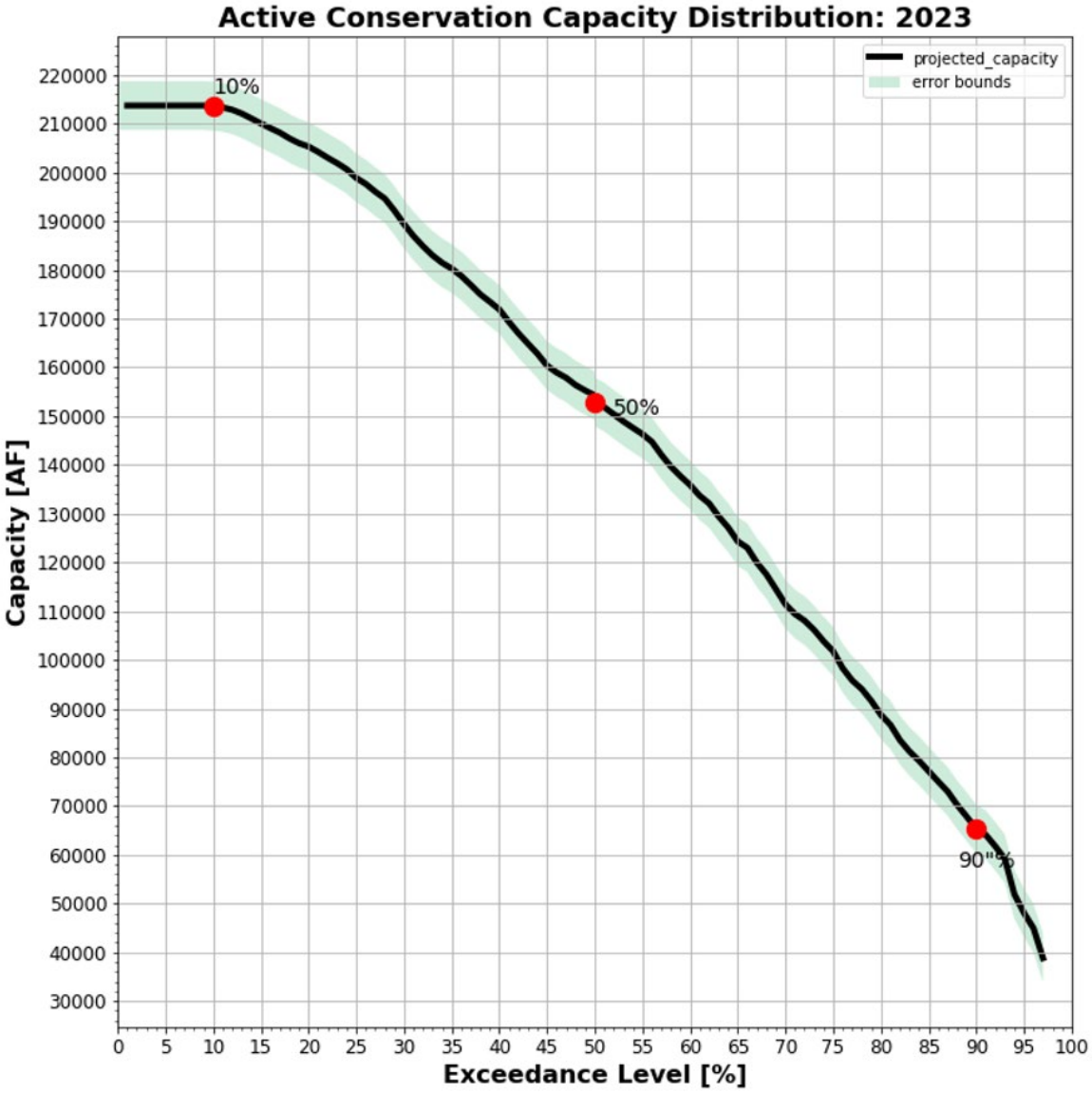
1. Water level data used in conjunction with projected reservoir depths from sedimentation analysis.

2. Together – these produce a timeseries of reservoir capacities.

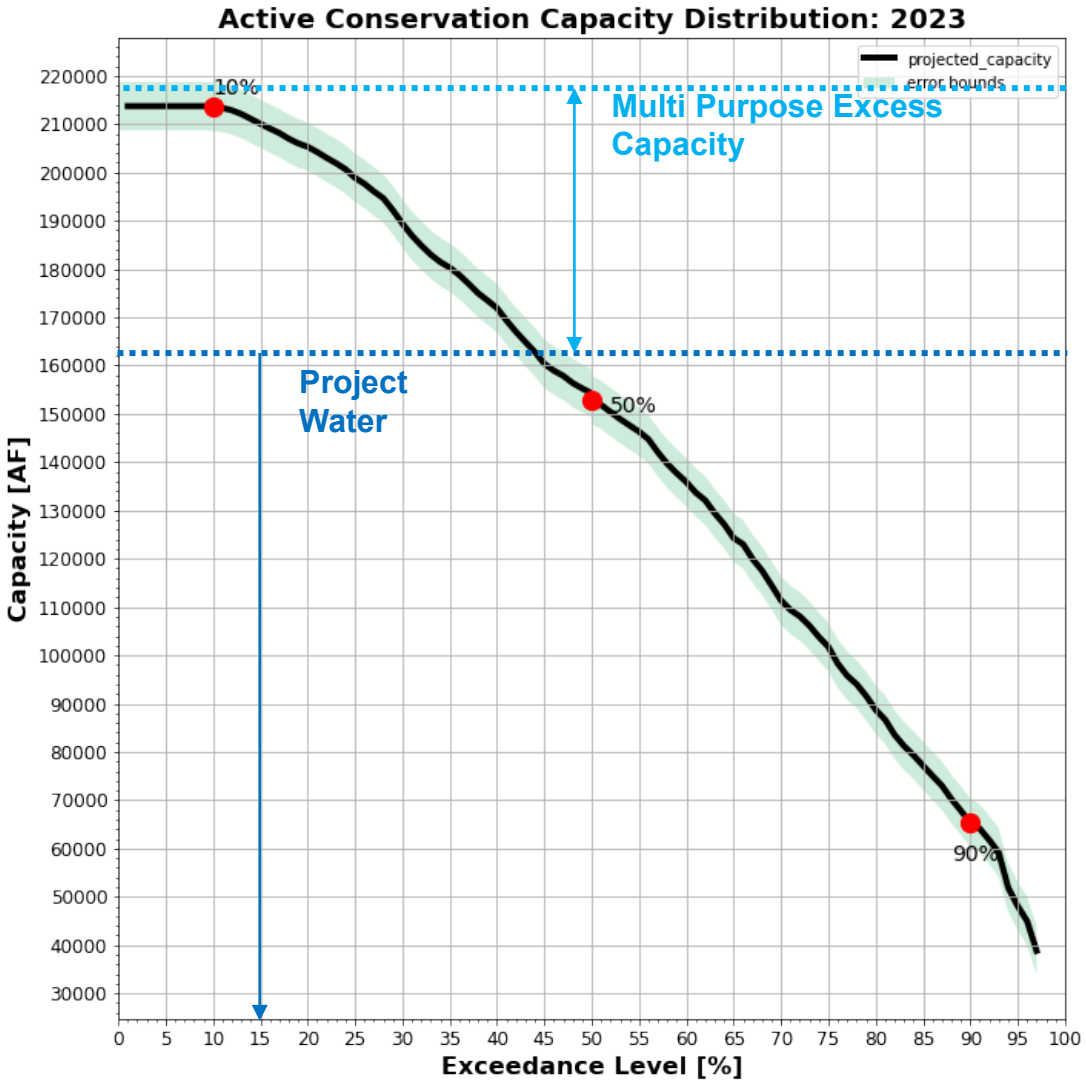
Results (2c) – Capacity Stats

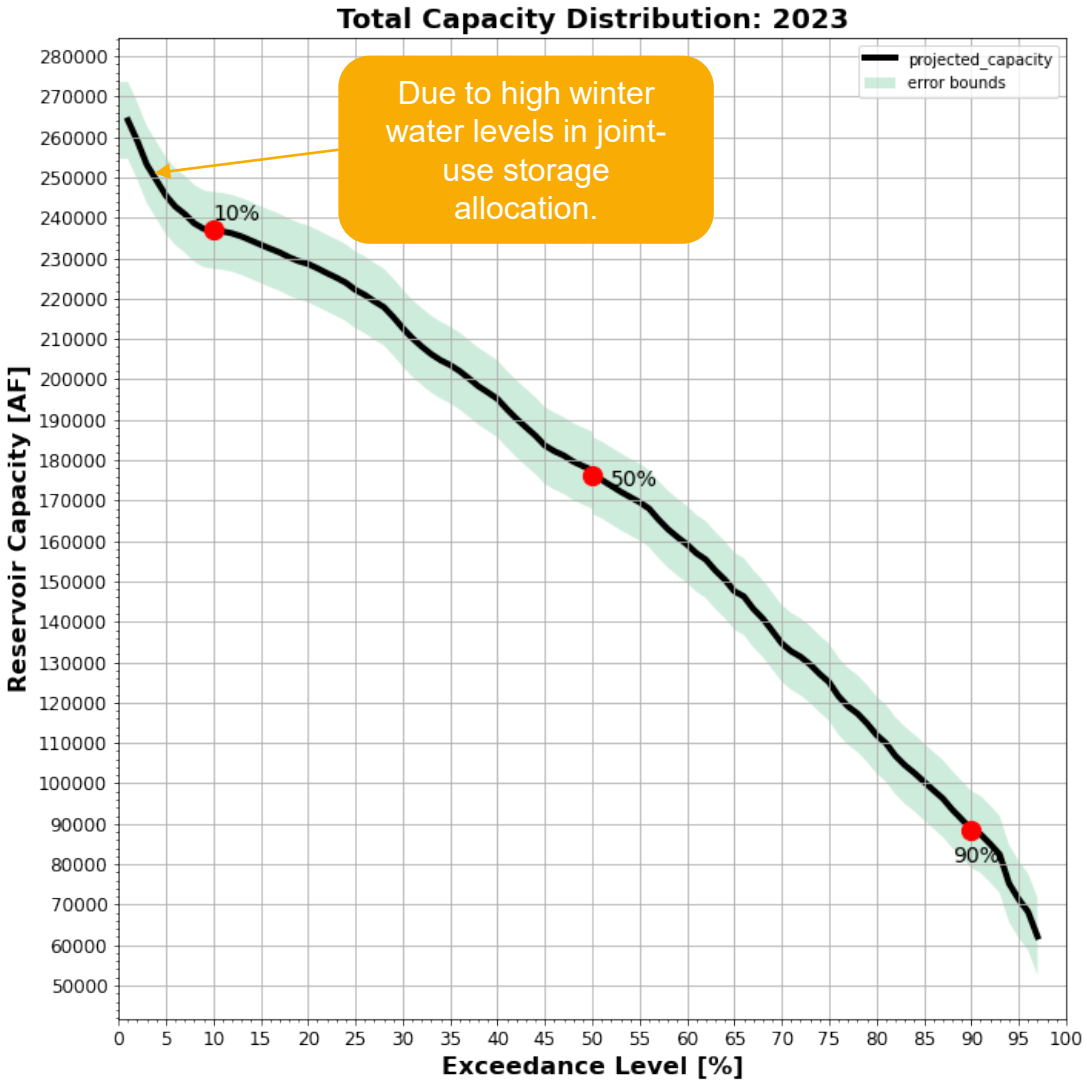
1. Finally – statistics of reservoir capacities are developed.
2. **This process is repeated each year with the projected updated bottom elevations from our sedimentation analysis.**





Results (3) – Results: 2023 Active Conservation Capacity





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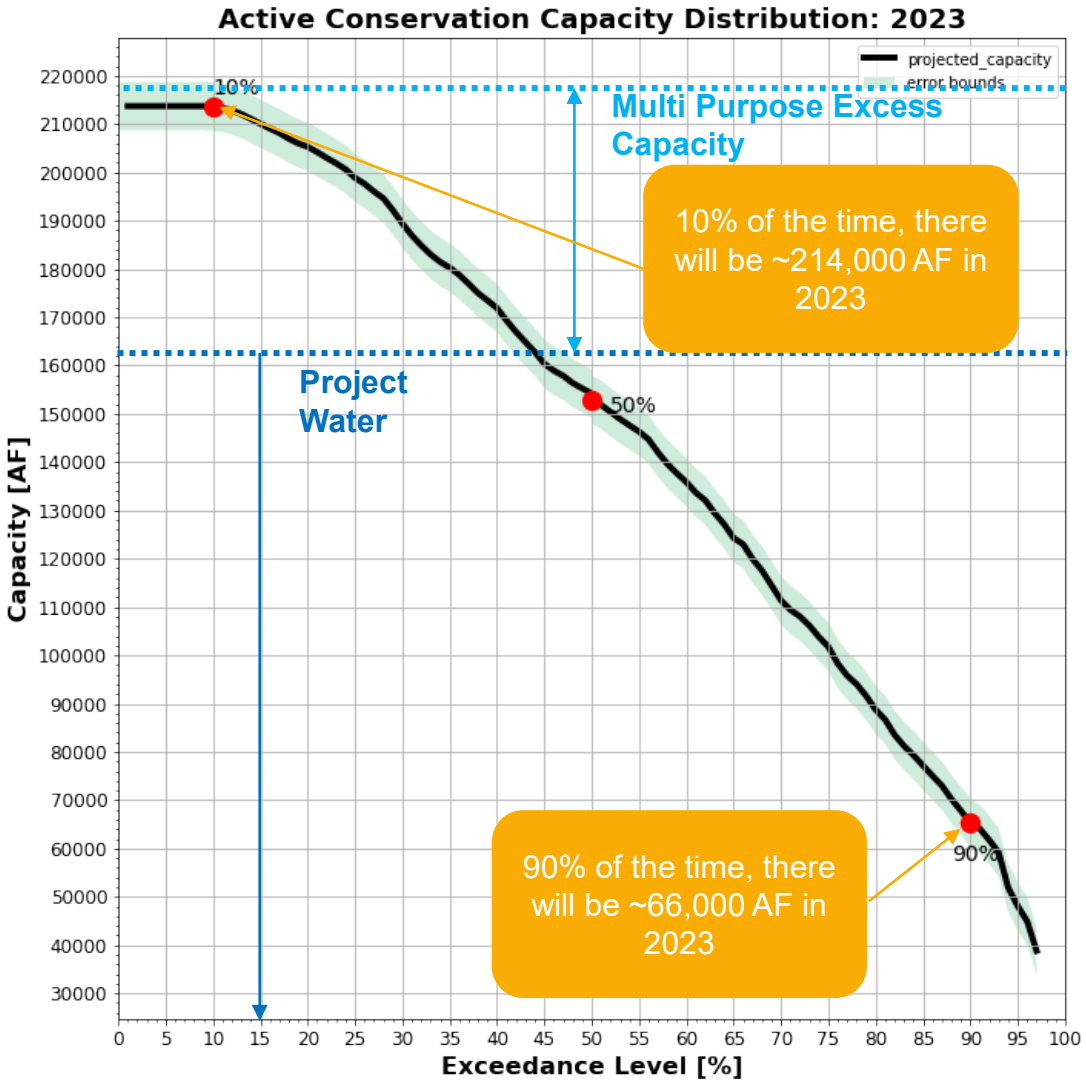
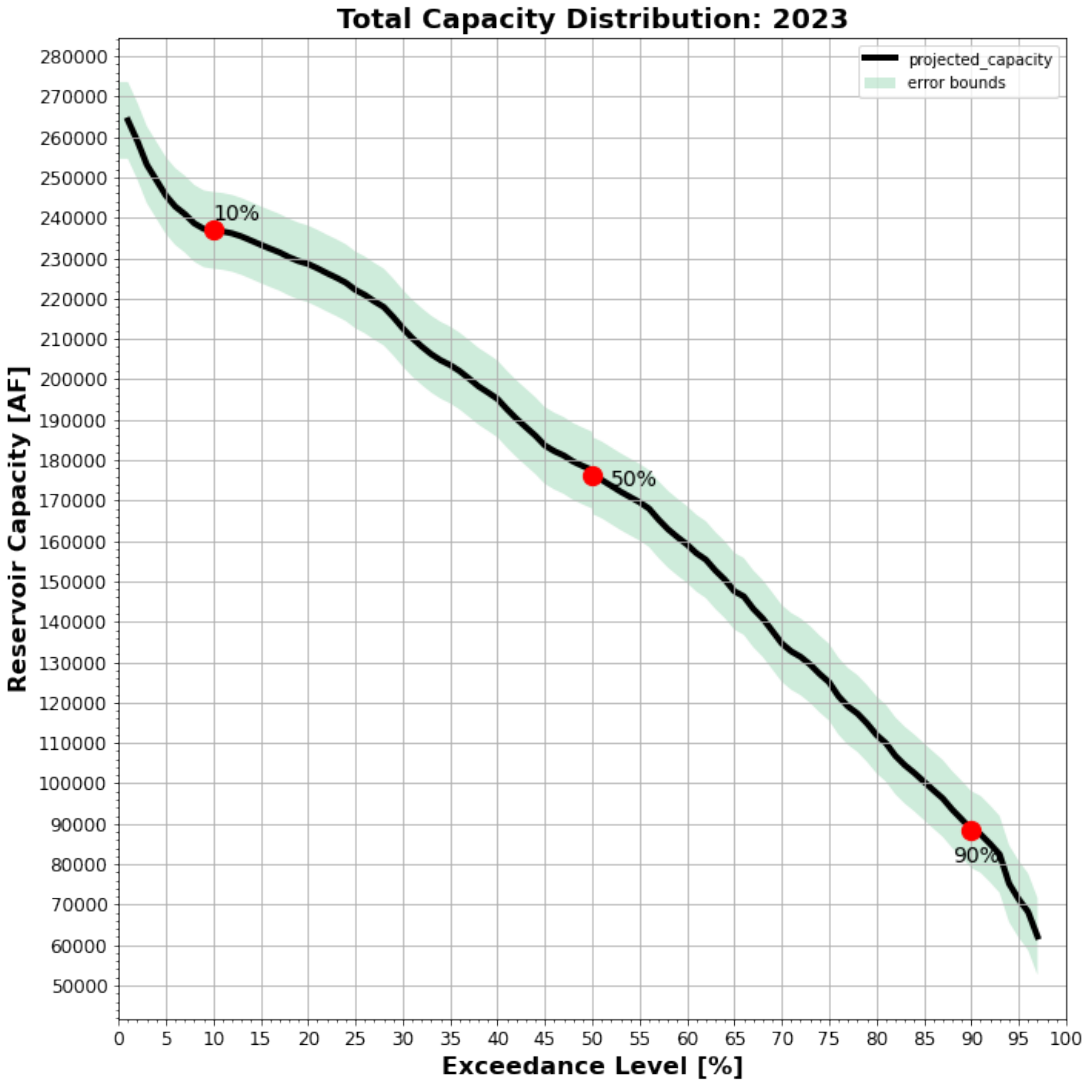
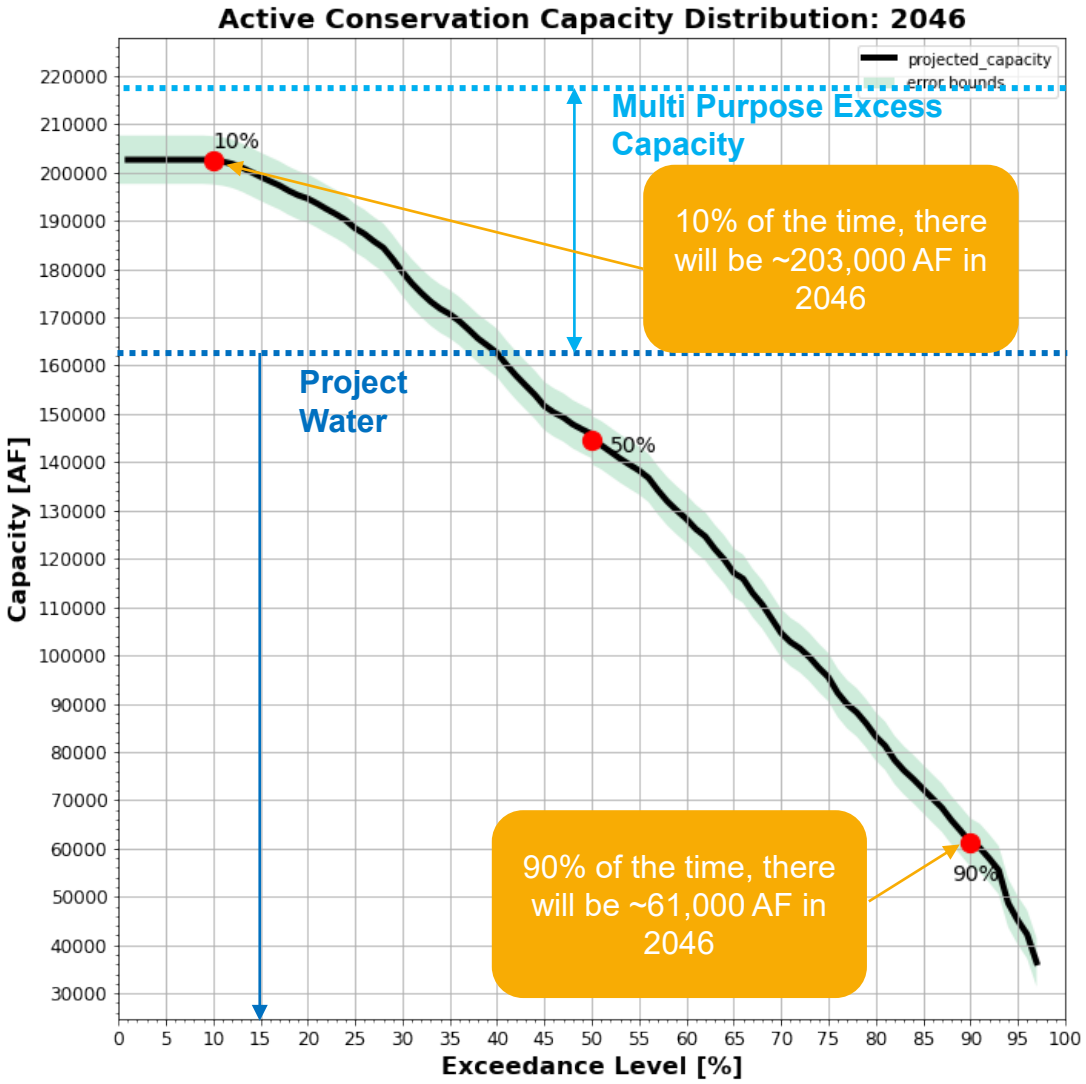
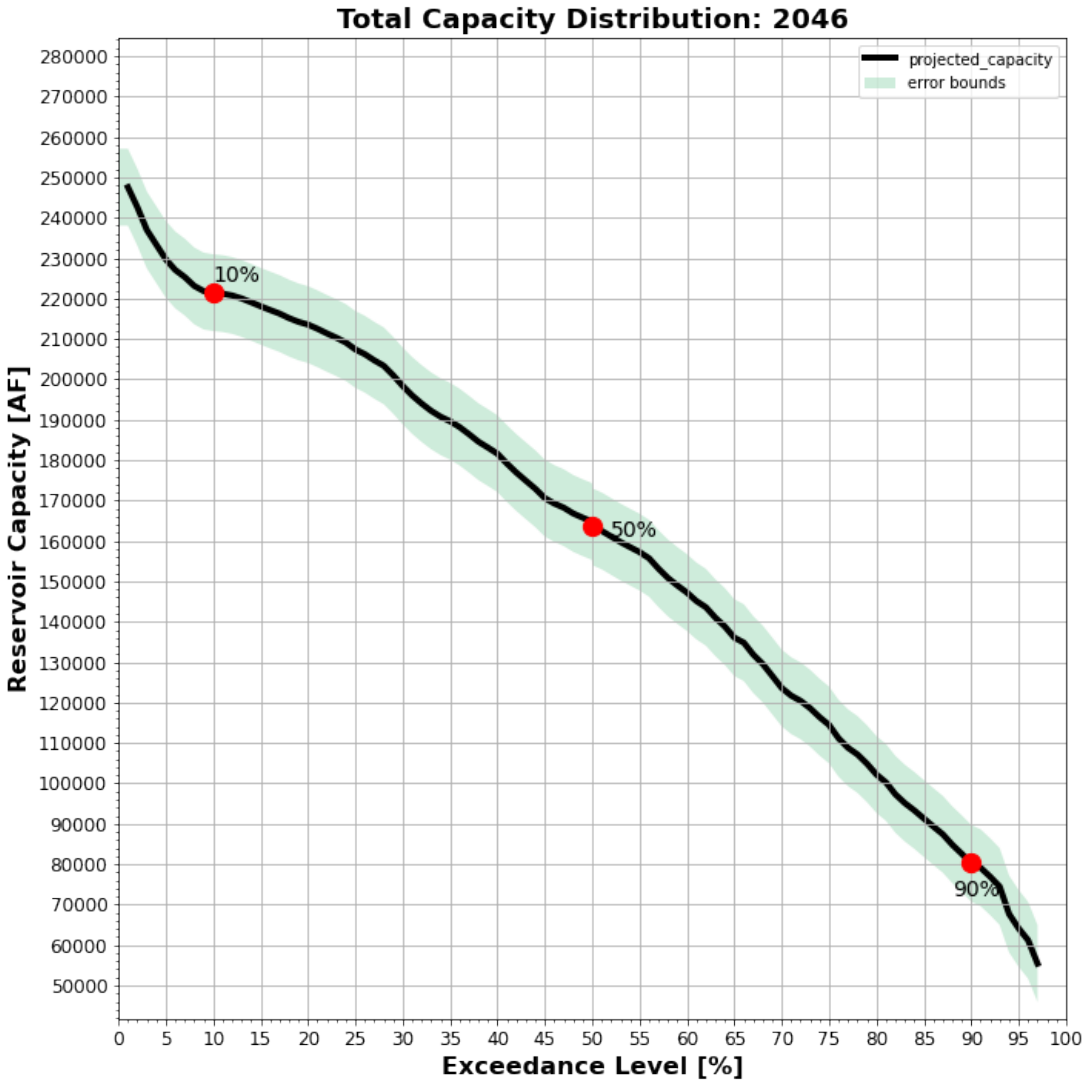


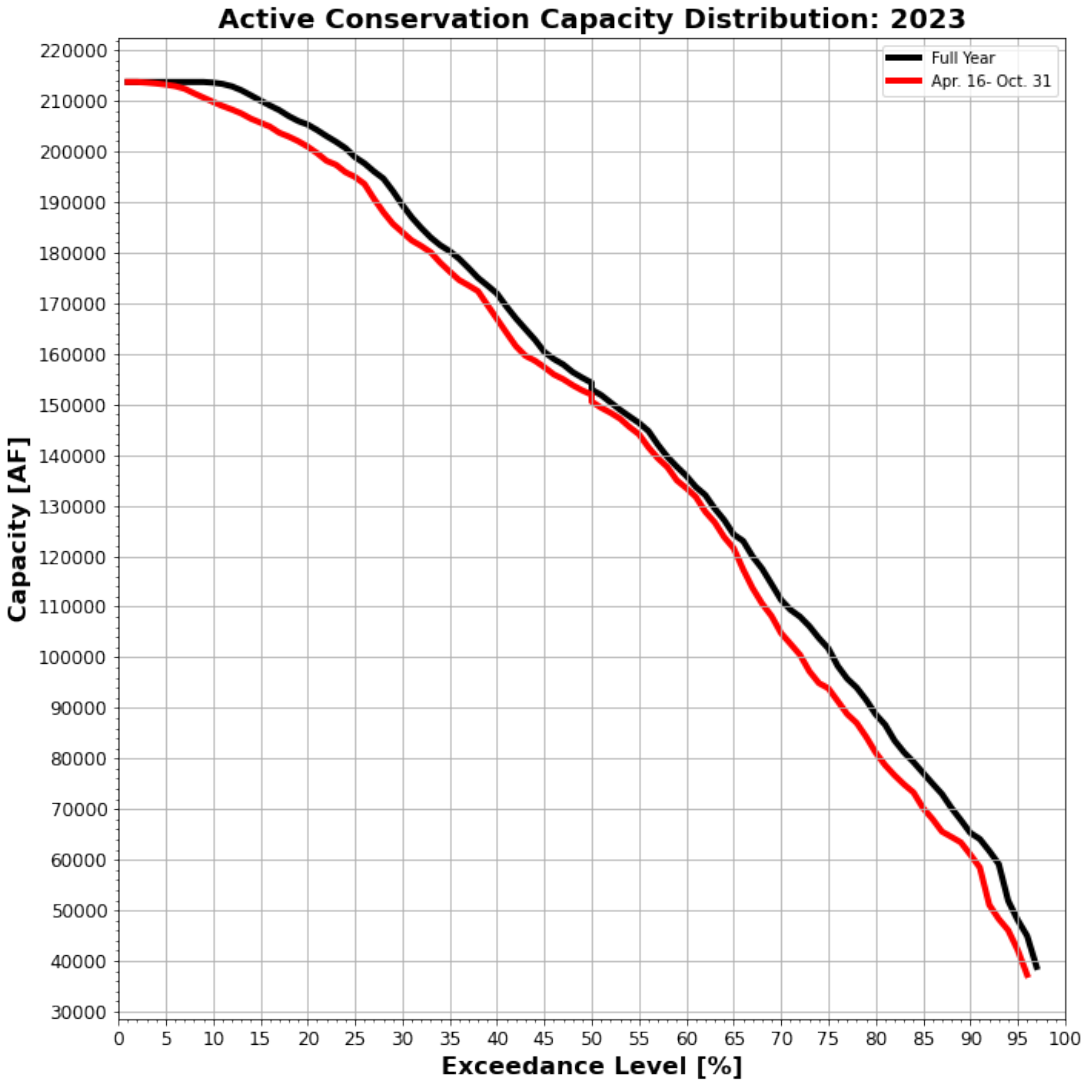


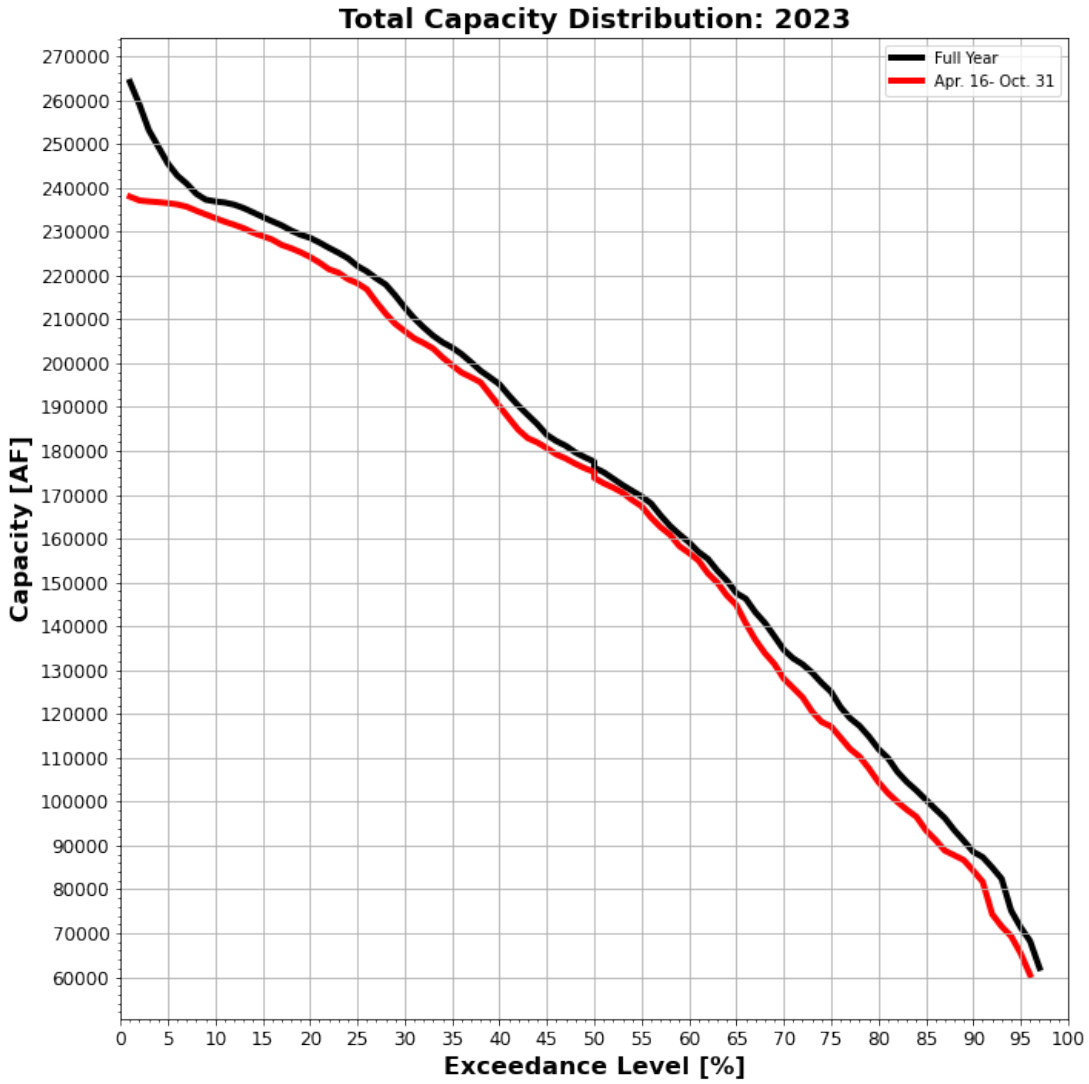
Results (3) – Results: 2046 Active Conservation Capacity





Results (3a) – Water Year Comparison





Results (3) – Projected Storage Capacity Results

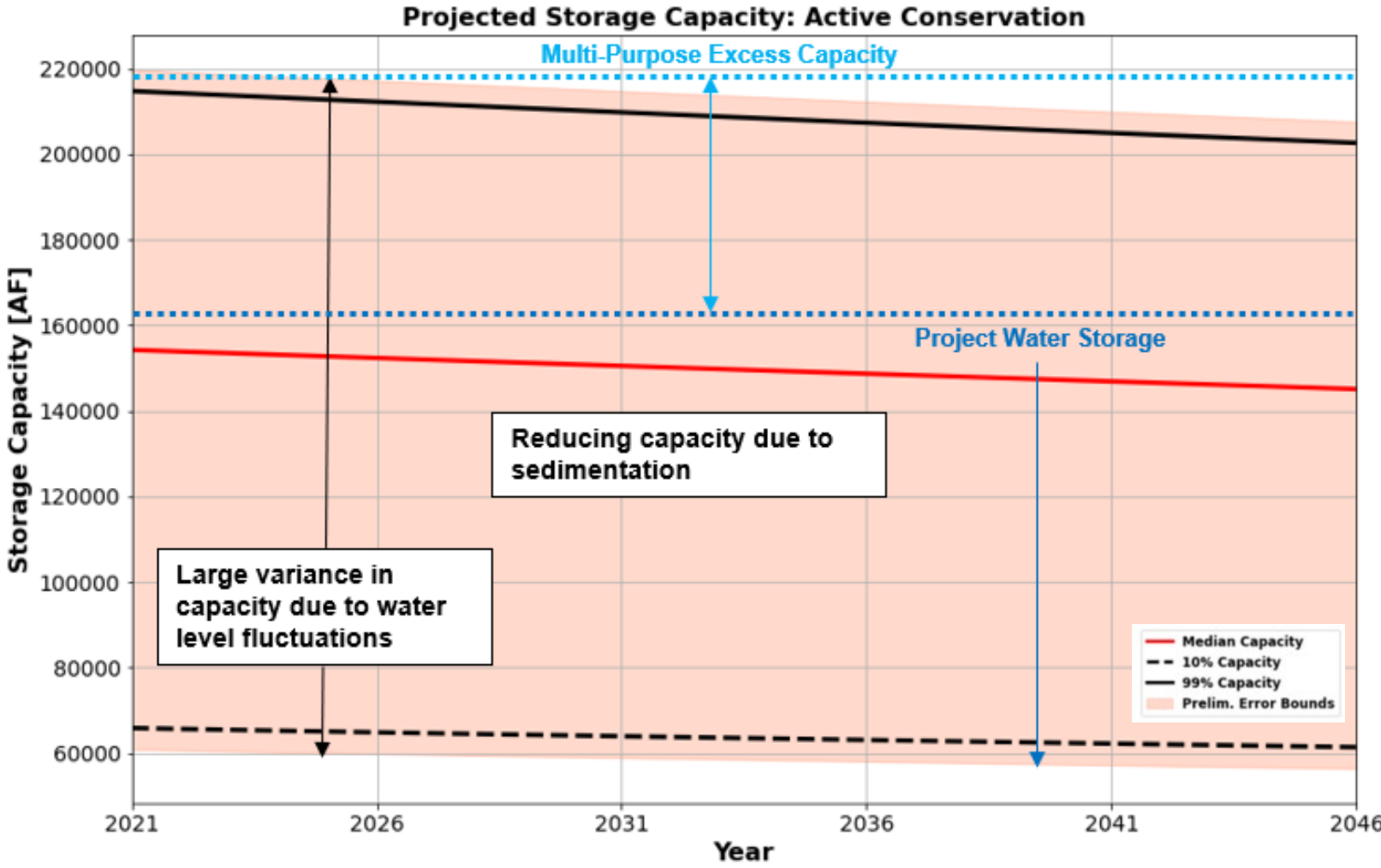
1. Spatial reservoir elevations over time

2. Distribution of water levels (1985-2021) used to bound future capacity estimates.

3. Capacity estimates show 10%, 50%, and 90% non-exceedance values.

Note: Sedimentation Results from regression analysis described on previous slides.

Numerical model simulation recommended in future phases to refine the these projections.



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Next Steps & Recommendations

Next Steps & Recommendations

1

Updated Bathymetric & Topographic Surveys: Q4 2021 - Q1 2022

- **Purpose:** Critical to conduct updated bathymetric and topographic surveying programs:
- **Uses:** Used to refine storage allocation estimates & conduct numerical modeling assessments (See recommendation 2)

2

Numerical Modeling: Q4 2021 – Q1 2022

- **Purpose:** Numerical modeling recommended to refine the storage capacity estimates provided in this document.
- **Uses:** Refine storage allocation projections & optimize any storage recovery (dredging) designs to minimize future sedimentation and prolong the useful life of the dredging project.

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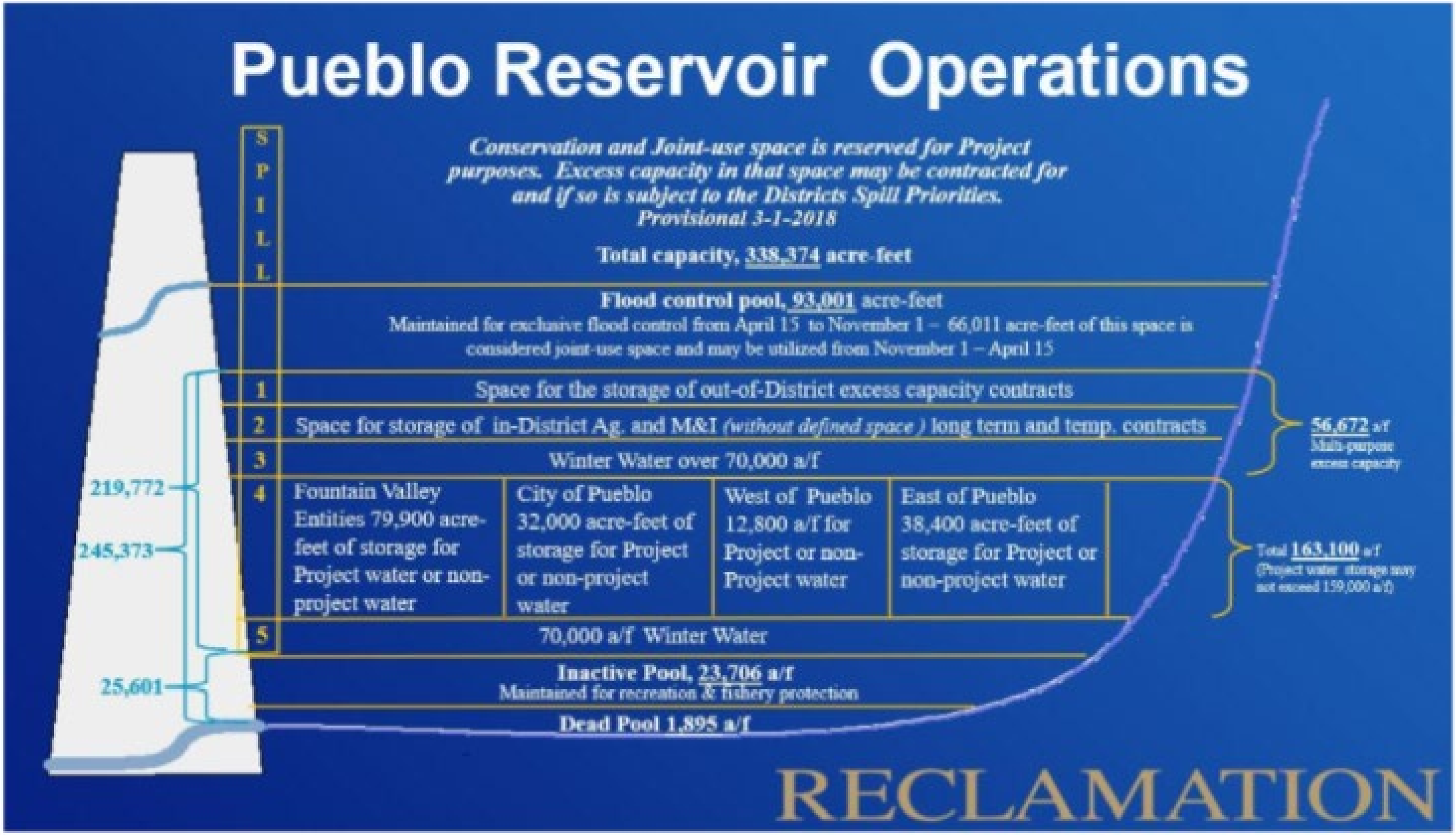
Upper Arkansas River Basin Hydrology & Geomorphology Assessment Q1 2022 – Q2 2022

- **Purpose:** Quantify sediment load from unregulated tributaries upstream of the Pueblo Reservoir.
- **Uses:** Used to identify “problem” tributaries and develop sediment sustainability measures

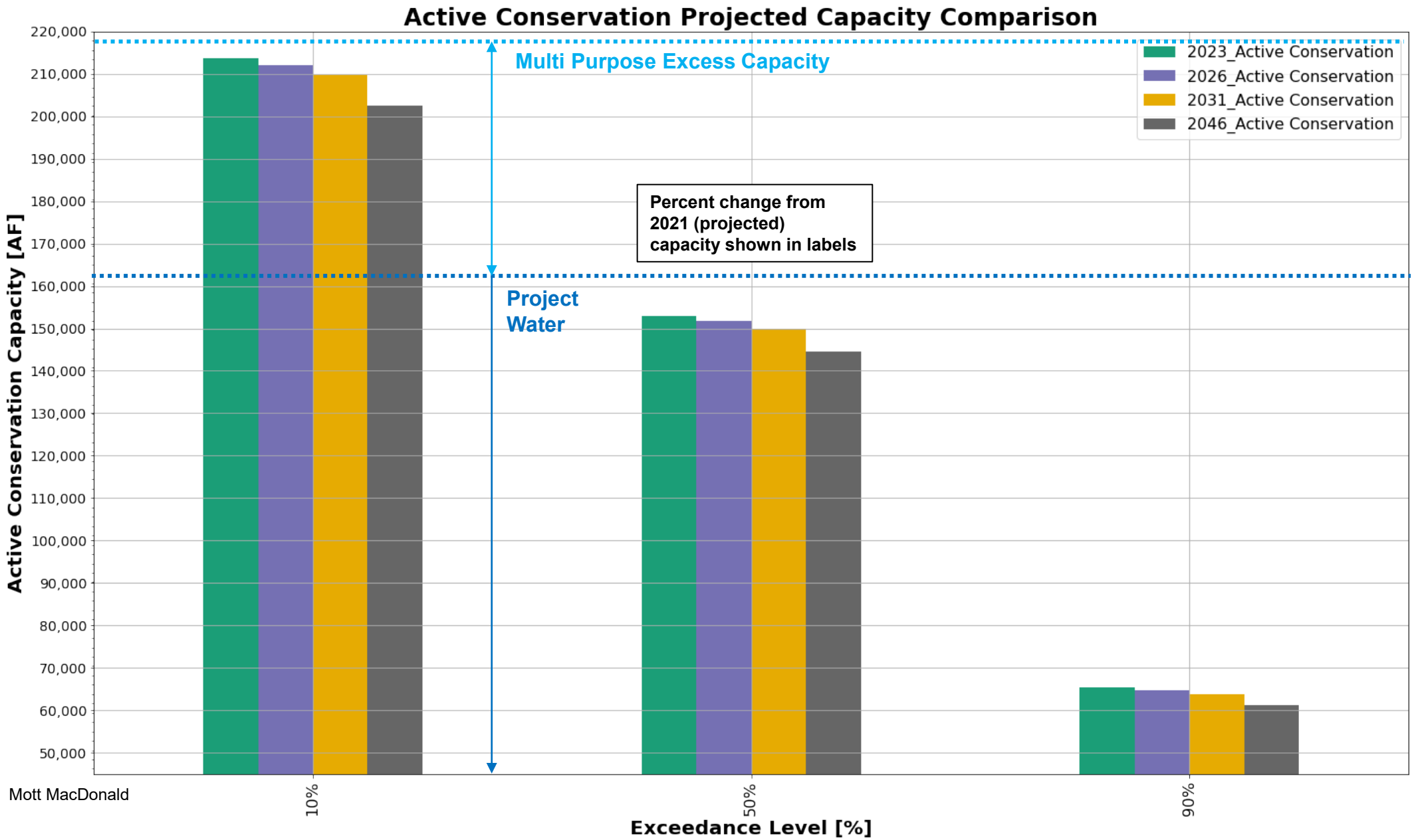
MOTT MACDONALD

Thank you

Pueblo Reservoir Operations



Results (3) – Selected Capacity Projections in Distribution



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