Intake Structure Siting Evaluation on the Lower Peace River Using Differing Sea Level Rise Scenarios: (*PR^3*) *Project*

Peace River Manasota Regional Water Supply Authority

Special Thanks to:

Hazen

HDR

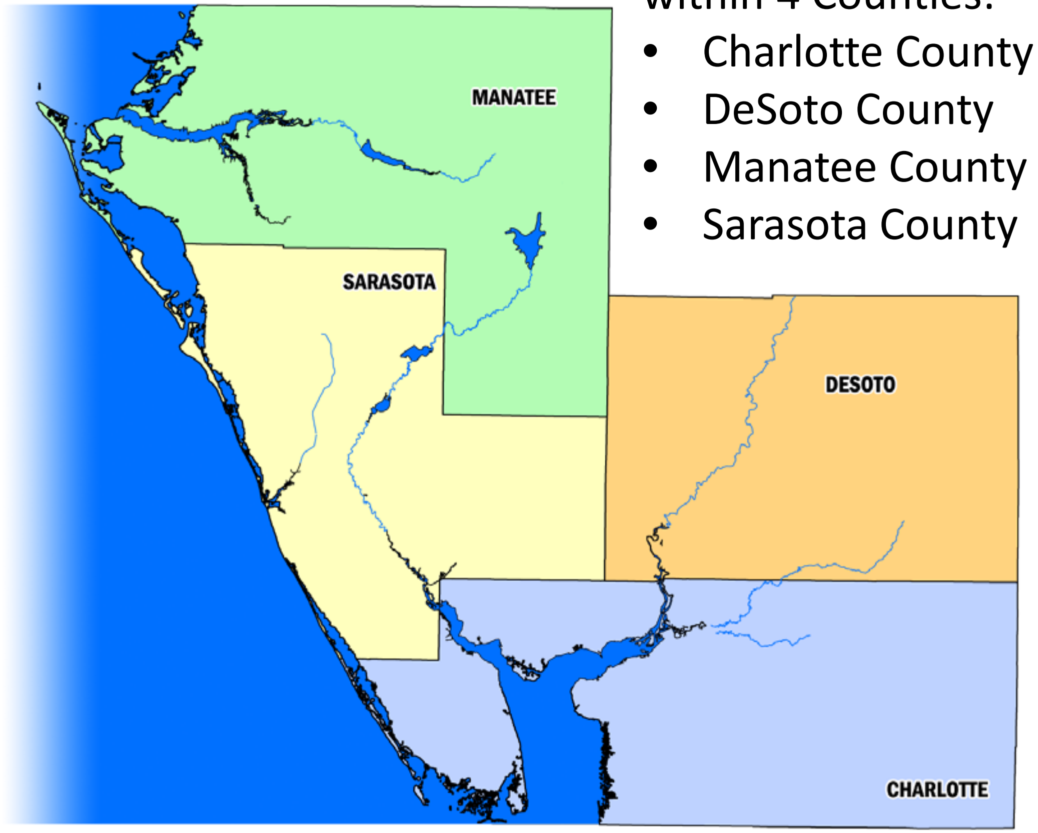
Southwest Florida Water Management District

DANIEL ROBERTS

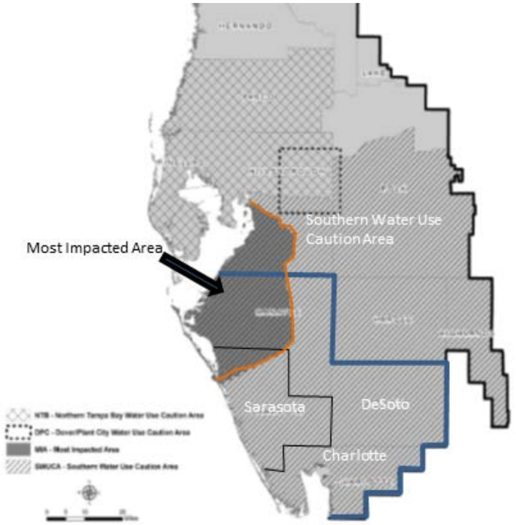
PRMRWSA – Who We Are!

Regional Wholesale provider of drinking water within 4 Counties:

- Charlotte County
- DeSoto County
- Manatee County
- Sarasota County



Included in Southern Water Use Caution Area



Created in 1981

- Interlocal Agreement (2005)
- Master Water Supply Contract (Amended 2015)
- Peace River Facility
  - Acquired from GDU in 1991
  - Expanded to 51 MGD treatment capacity
- Regional Transmission System
  - 76 Miles of large diameter pipelines
  - Emergency Interconnects

Current Capacities

Reservoir 1 – 500 Million gallons capacity

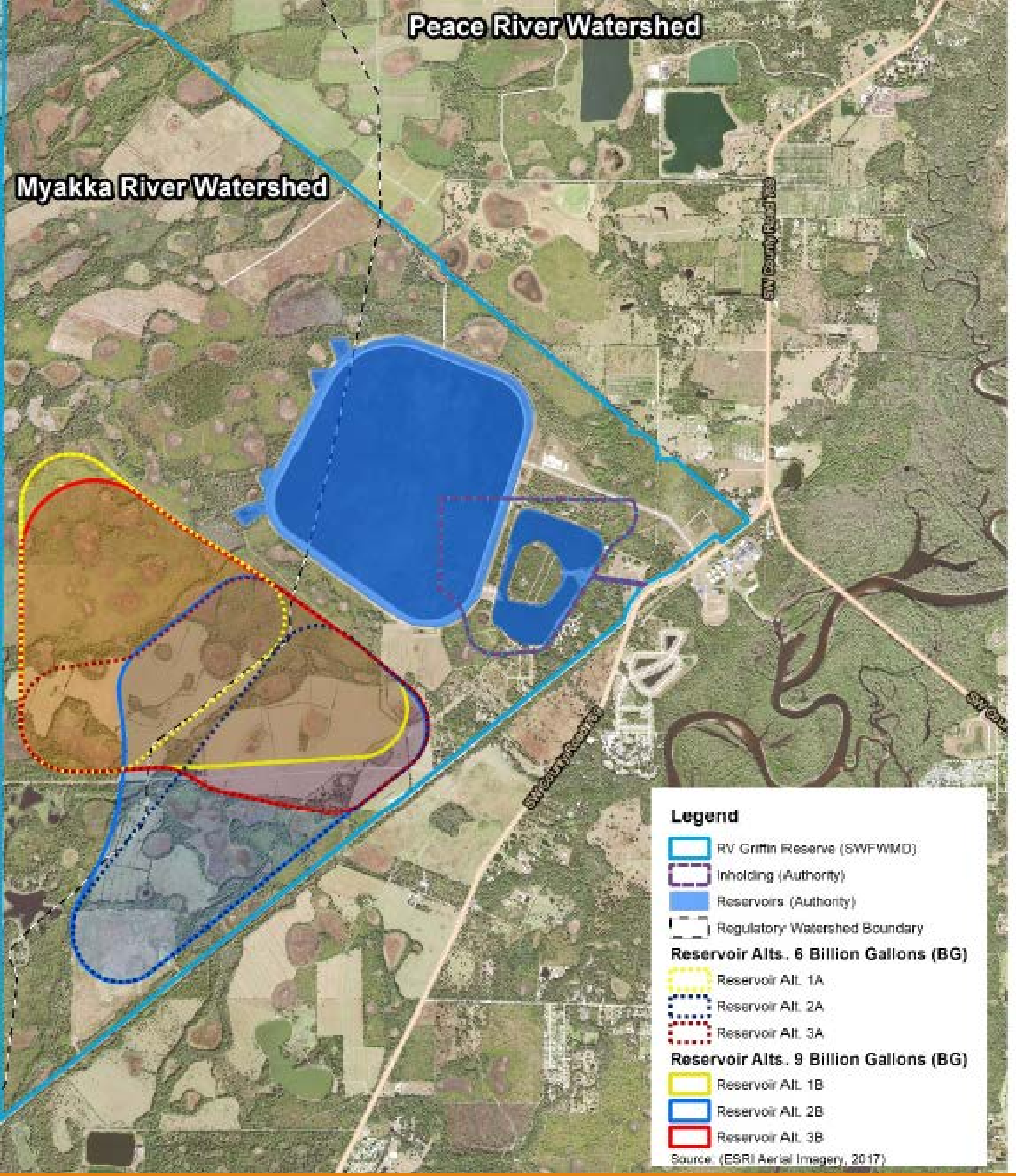
- Original reservoir constructed by General Development Utilities – avg day delivery at the time was 7 MGD

Reservoir 2 – 6 Billion gallons capacity

- Construction completed June 2009
- Reservoir filled February 2010 – avg day delivery at the time was 20 MGD

River Intake – 120 MGD pumping capacity

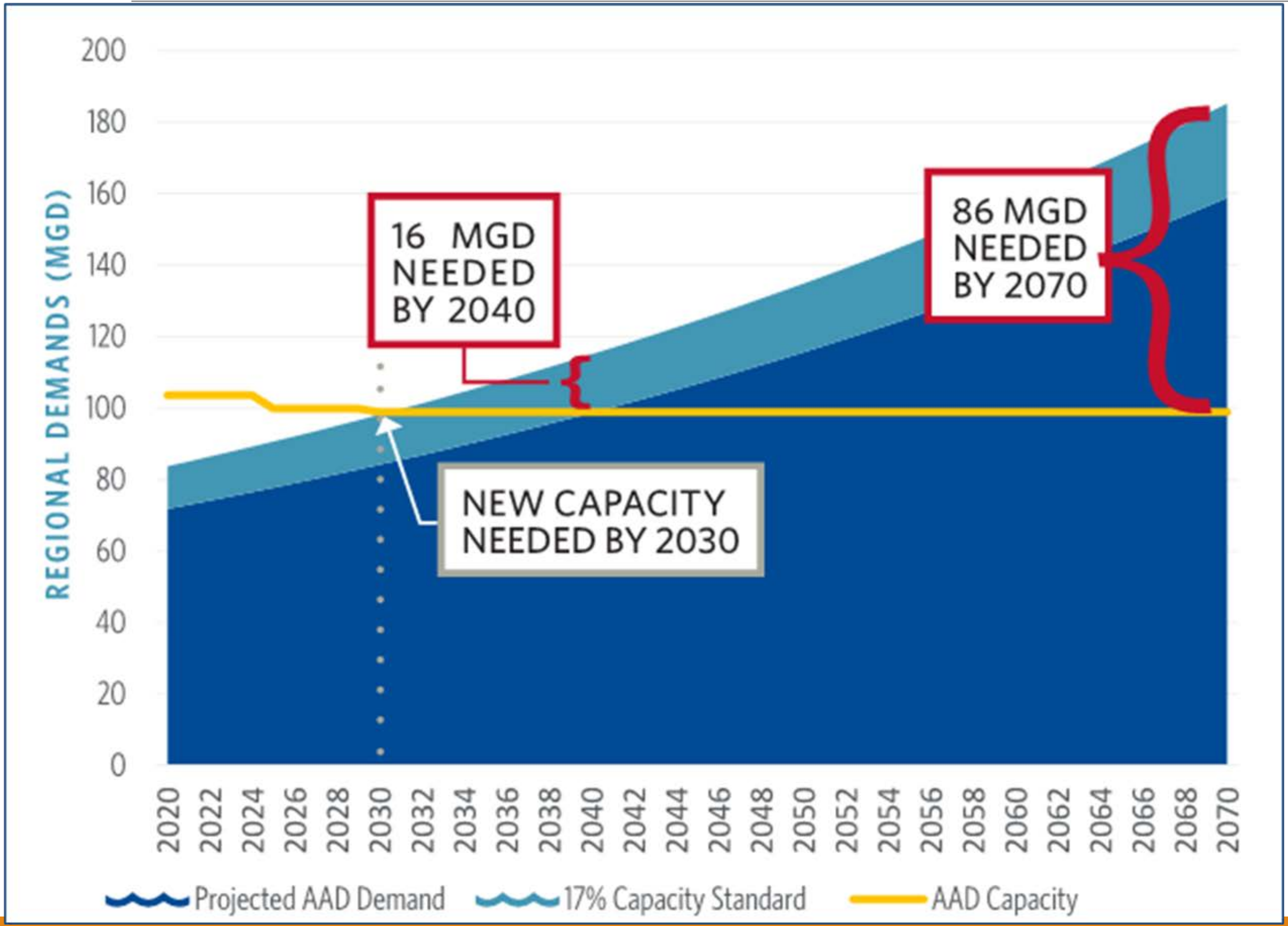
ASR system – 8 Billion gallons in storage



(PR^3) Project

- Planned construction of a new 6-9 billion-gallon surface water reservoir to double storage capacity
- **Planned construction of a second river intake and pump station located on the Lower Peace River to allow for the new maximum permitted withdrawal**
- Received new 50-year WUP allowing up to 258 MGD max and 80 MGD yearly average on a flow-based schedule.
  - Higher river flows = Higher permitted withdrawal capacity
  - Lower river flows = Reduced withdrawal capacity or no withdrawal capacity(130 cfs cut-off)

Why the expansion is needed?

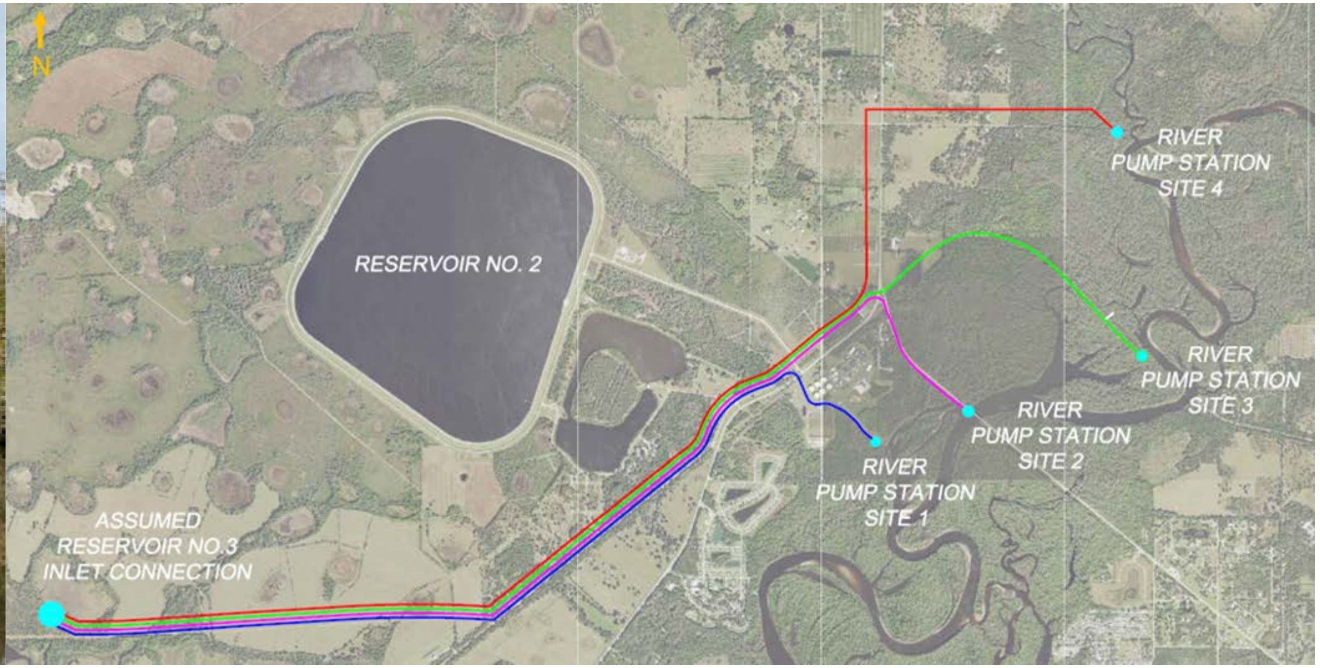


2030 – New capacity needed to meet projected demands

2040 – Projected deficit of 16 MGD

2070 – 86 MGD needed in 50 years!!!

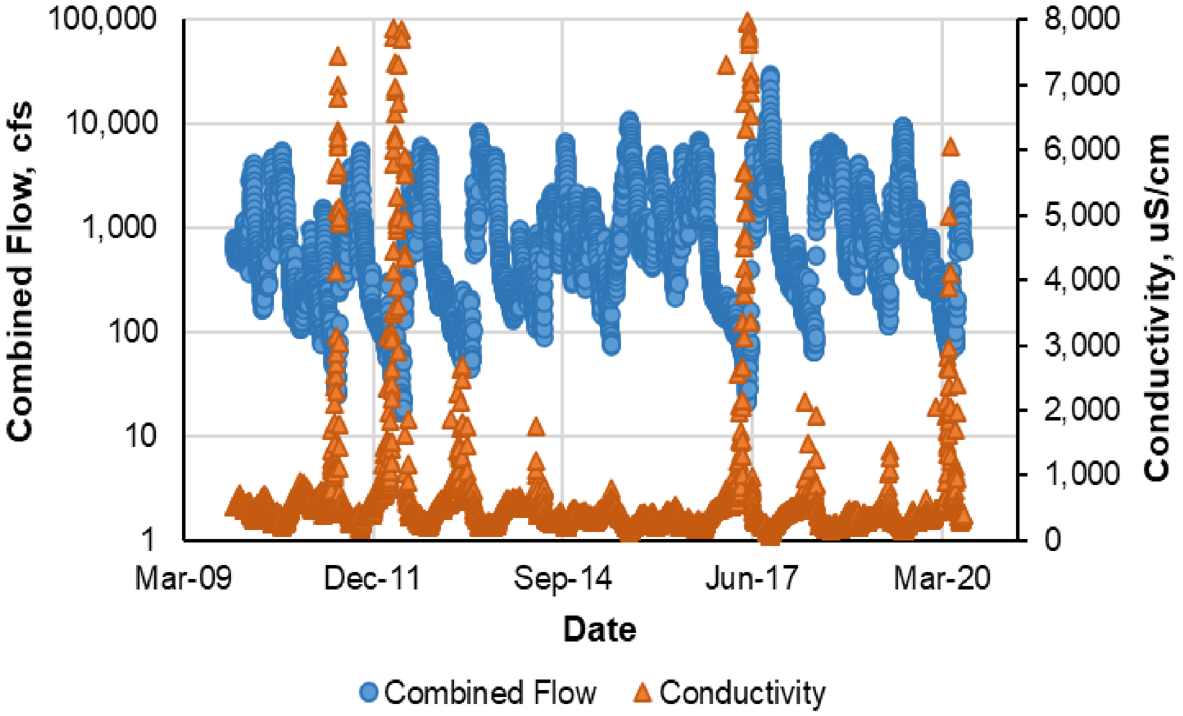
Proposed River Intake Locations



The four locations under consideration

1. Site Alternative 1 – Co-location with the Existing River Intake
2. Site Alternative 2 – CR 761
3. Site Alternative 3 – Former Railroad Corridor
4. Site Alternative 4 – Jernigan Street

Tidal Influences
Salt Wedge



SUMDAT
Peace River's Modeling Tool for Reliability

- System Utilization Management Decision Analysis Tool - SUMDAT
  - Decision tool used to provide guidance to the PRMRWSA in relation to threats posed by sea-level rise and climate change
  - More than 120 variables which can be adjusted to gauge system design to change
  - Uses daily time steps centering on system flow and mass balances involving total dissolved solids (TDS)
  - An embedded algorithm projects flow-dependent salinity increases in river water as a result of sea level rise and lends the model the capability of quantifying future water quality trends under a range of conditions.
  - Resiliency is quantified by calculating Quantity Reliability and Quality Reliability. The resiliency measures applicable to this work were 99.5% Quantity Reliability (ability to meet customer demands) and 95% Quality Reliability (ability to meet the secondary drinking water standard of 500 mg/L for TDS).
  - Developed by Kevin Morris for PRMRWSA
  - Historical water quality monitoring data were used to develop a model for predicting Peace River TDS time series inputs to the SUMDAT simulation model.

Model Development
Identify Data and Gaps

Develop relationship between conductivity, TDS, and flow based on historical data.

- Review current data to determine any deficiencies and/or gaps
- Additional Sondes deployed at RK 31 and 34 for continuous monitoring

Standardize data to a unified nomenclature and then plotted into a timeseries.

Data Source	Locations	Period of Record	Parameters	Depth
HBMP continuous recorders (Cfix9619, Efix9619, Hfix9619)	Peace River RK -2.4, RK 6.6, RK 8.4, RK 10.5, RK 12.7, RK 12.8, RK 15.5, RK 17.5, RK 20.1, RK 21.9, RK 23.6, RK 24.7, RK 25.9, RK 26.7, RK 29.5, RK 30.7, RK 32.3	August 1996 – December 2019	Various water quality (e.g., alkalinity, color, TOC, turbidity, TSS, temperature, conductivity, salinity, DO, pH, light depth)	Top, bottom*
HMBP Water Quality (Chem_all)	Peace River RK 2, RK 4, RK 5, RK6, RK 7, RK 8, RK 9, RK 10, RK 12, RK 14, RK 18, RK 21, RK23, RK 31, RK 32, RK 33	January 1976 – December 2019	Various water quality (e.g., alkalinity, color, TOC, turbidity, TSS, temperature, conductivity, salinity, DO, pH)	Top, bottom*
HMBP Flow (Flwd19_hbmp)	Peace River, Prairie Creek, Joshua Creek, Shell Creek, Big Slough, Myakka River, Horse Creek	January 1931 – December 2019	Discharge	N/A
HBMP "Moving" isohaline-based monitors	Various locations (RK -20 to RK 38)	Jun. 1983 – Dec. 2019	Various water quality (e.g., alkalinity, color, chlorophyll A, temperature, conductivity, salinity, DO, pH)	Top
ESA Sondes	Peace River RK 31, RK 34	December 2020 – June 2021	Temperature, conductivity, salinity	Top, bottom
HBMP Lower Peace River continuous recorders	Peace River RK 9.2, RK 12.7, RK 18.5, RK 20.8, 21.9, 23.4, 30.6, 31.7	May 2008 – August 2018	Temperature, salinity, conductivity	N/A
USGS gages	Peace River, Prairie Creek, Joshua Creek, Shell Creek, Big Slough, Myakka River, Horse Creek	October 2007 - Present	Temperature*, gage height*, discharge*, stream level*, precipitation*, conductivity*	top, bottom*
NOAA	Ft. Myers	October 2007 - Present	Tide Levels	N/A
NOAA/University of Hawaii	Naples	March 1965 – Dec. 2019	Sea level	N/A

*Only available for some gages; depth difference between top and bottom is dependent on gage and temporally variable stream level

Model Development

Regression Analysis Approach to develop time series predictions for conductivity for the SUMDAT sim period

Guided by:

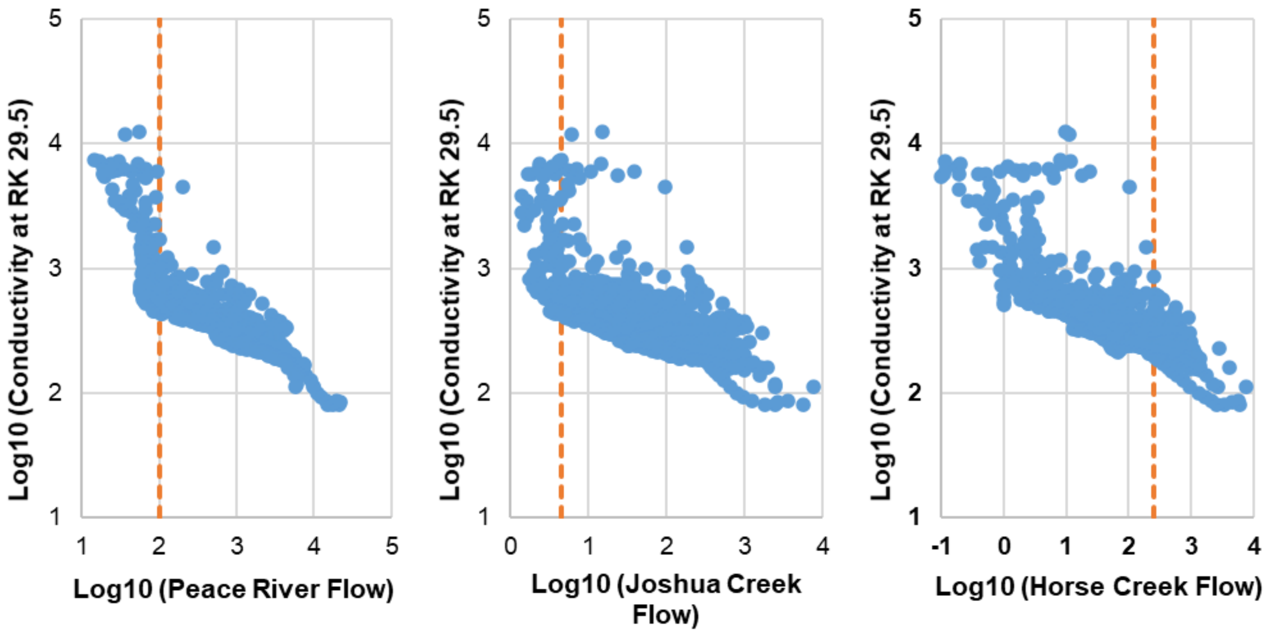
- Regression model should use predictors for which historical data are available to develop input time series for the SUMDAT simulation period (1975-2020)
- The regression model should be representative of the dynamics of an estuary system, where TDS is primarily a function of the opposing forces of freshwater inflows upstream and tidal forces downstream, and
- The regression model should consider different TDS responses for different flow regimes.

Relationship developed between Specific Conductivity and TDS:

$$TDS\left(\frac{mg}{L}\right) = 0.42 \cdot Conductivity\ (uS/cm) + 94 \qquad (R^2 = 0.98)$$

Model Development
R Statistical Software

- Log-transformed streamflow and conductivity time series due to log-normal distribution
- A segmented or broken line linear regression model was chosen for a better fit during high conductivity values. WHY???
- Conductivity and freshwater flow relationship changes from the low freshwater flow regime to the high flow regime. Breakpoints for the three flow time series were identified based on visual inspection of data and testing with the segmented package.
- *Break point* is identified with red dotted line.



Log of Conductivity at RK 29.5 versus Log of Flow for Peace River, Joshua Creek, and Horse Creek Showing Modeled Breakpoints for Segmented Regression

Final Rule form for the linear regression equation

$Log_{10}[Conductivity] = \beta_0 + \beta_{PR1} Log_{10}[Q_{PR}] + \beta_{PR2}(Log_{10}[Q_{PR}] - Log_{10}[Q_{PR}^{Br}]) \cdot (Q_{PR} \geq Q_{PR}^{Br}) +$
$\beta_{JC1} Log_{10}[Q_{JC}] + \beta_{JC2}\left(Log_{10}[Q_{JC}] - Log_{10}[Q_{JC}^{Br}]\right) \cdot \left(Q_{JC} \geq Q_{JC}^{Br}\right) + \beta_{HC1} Log_{10}[Q_{HC}] + \beta_{HC2}\left(Log_{10}[Q_{HC}] -\right.$

Summary of Regression Model Parameters
Final Regression Model Inputs

Regression Model Parameter	Existing Intake Location (RK 29.5), Top	Existing Intake Location (RK 29.5), Bottom	Furthest Upstream Intake Siting Alternative (RK 34), Top
β_0	5.9	6.5	3.5
β_{PR1}	-1.6	-1.9	-0.40
β_{JC1}	-0.05	-0.21	0.28
β_{HC1}	0.04	0.02	-0.14
β_{PR2}	1.2	1.4	-
β_{JC2}	0.19	0.36	-
β_{HC2}	-0.20	-0.32	-
Q_{PR}^{Br}	100	100	-
Q_{JC}^{Br}	4.5	4.5	-
Q_{HC}^{Br}	250	630	-
β_{SL}	9.7×10^{-5}	1.4×10^{-4}	-
$N*$	240	192	432
$R^2\ adj**$	0.88	0.87	0.78

Segmented regression did not improve fit so a continuous linear regression was used.

Inclusion of sea level data did not significantly change regression performance so conductivity assumed to be independent of tidal influence.

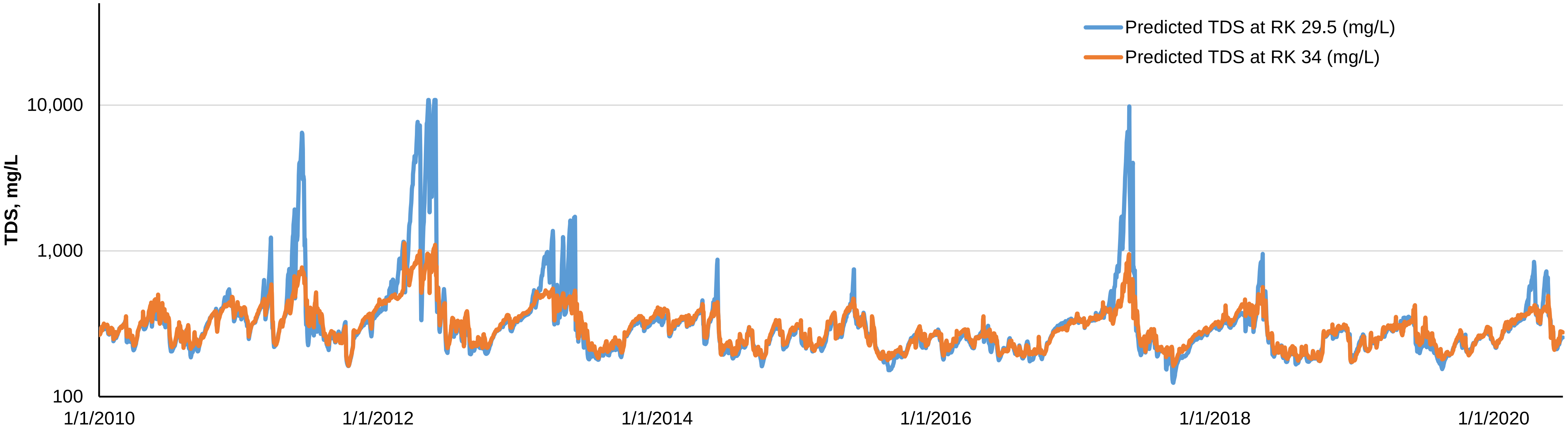
*N = number of observations

** *R2 adj* is the adjusted r-squared value that accounts for the number of variables in a regression model

Model Findings

Regressions mentioned on previous slide were used to develop time-series predictions for conductivity for the SUMDAT simulation period. Predictions were based on historical streamflows at the three upstream USGS gauging stations and assumed constant sea level conditions (1280 mm sea level).

Predictions generally match well with historical observations and the segmented regression captures conductivity peaks during low flow periods.



Sea Level Rise

Four Scenarios 2010-2020

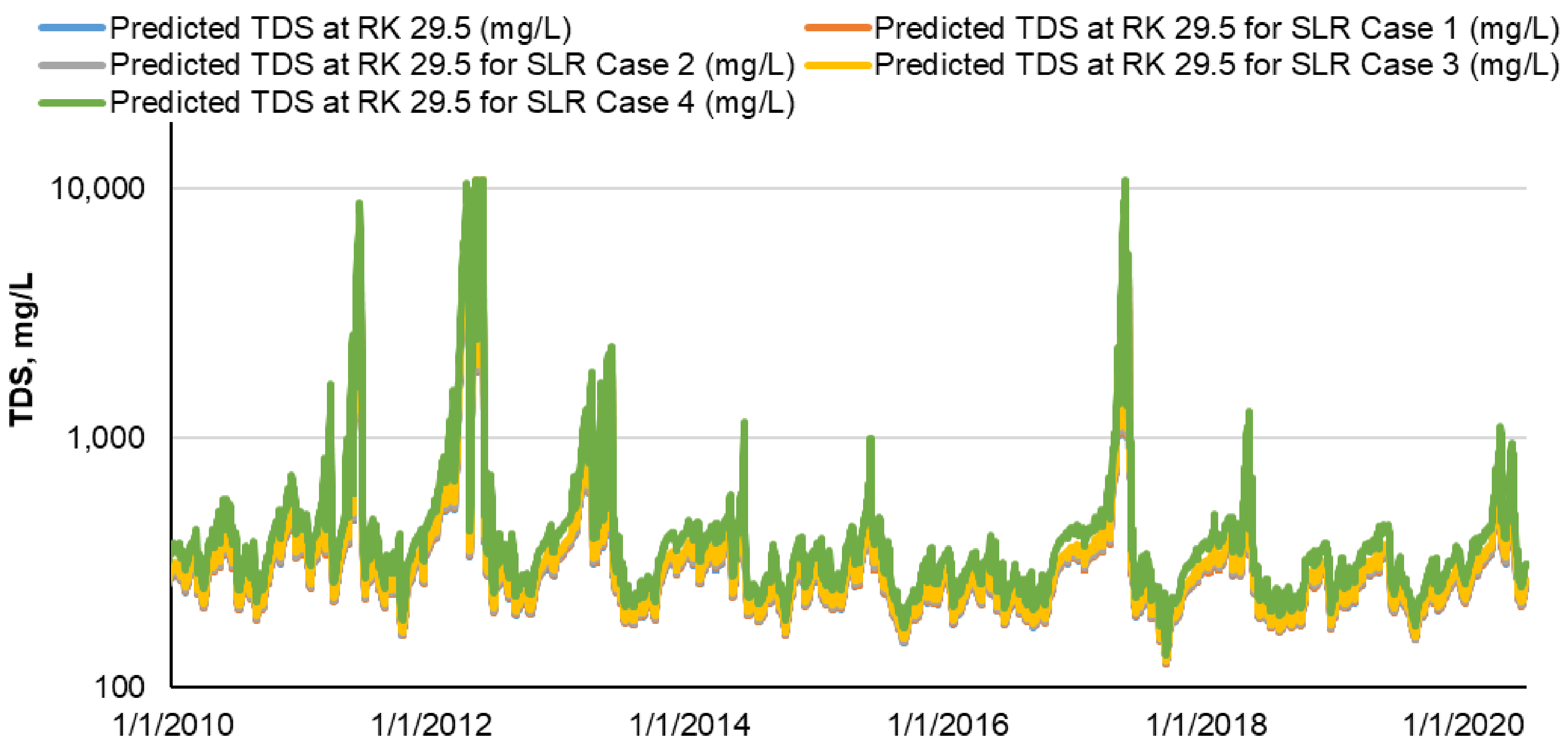
Baseline
Case 1: 2.4” SLR
Case 2: 3.96” SLR
Case 3: 9.12” SLR
Case 4: 36” SLR (2100)

Case 1: minor

Case 2: minor

Case 3: 5% average increase

Case 4: 25% average increase



• Sea Level Rise
Four Scenarios 2020 Only

Baseline
Case 1: 2.4” SLR
Case 2: 3.96” SLR
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Case 4: 36” SLR (2100)

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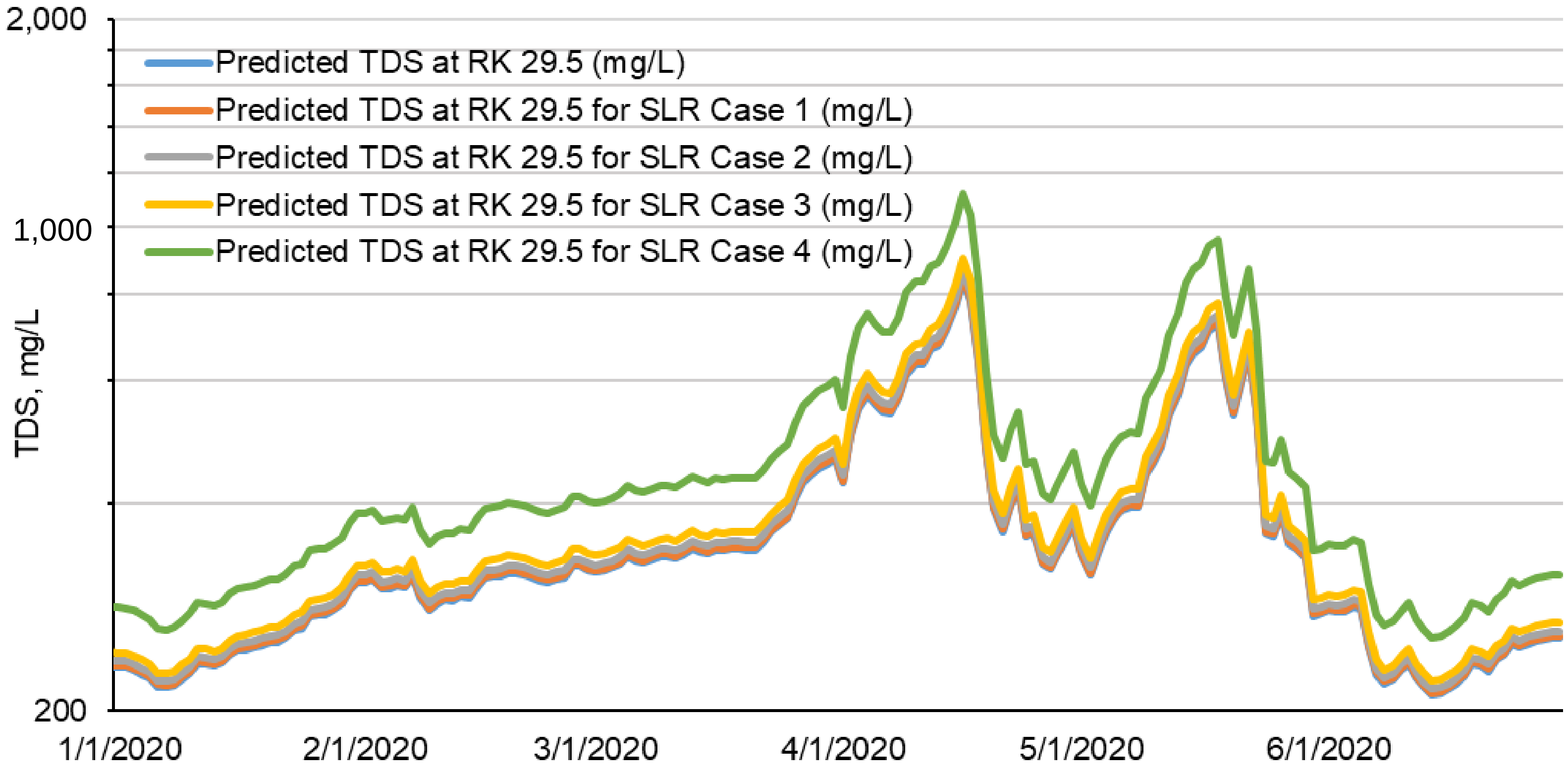
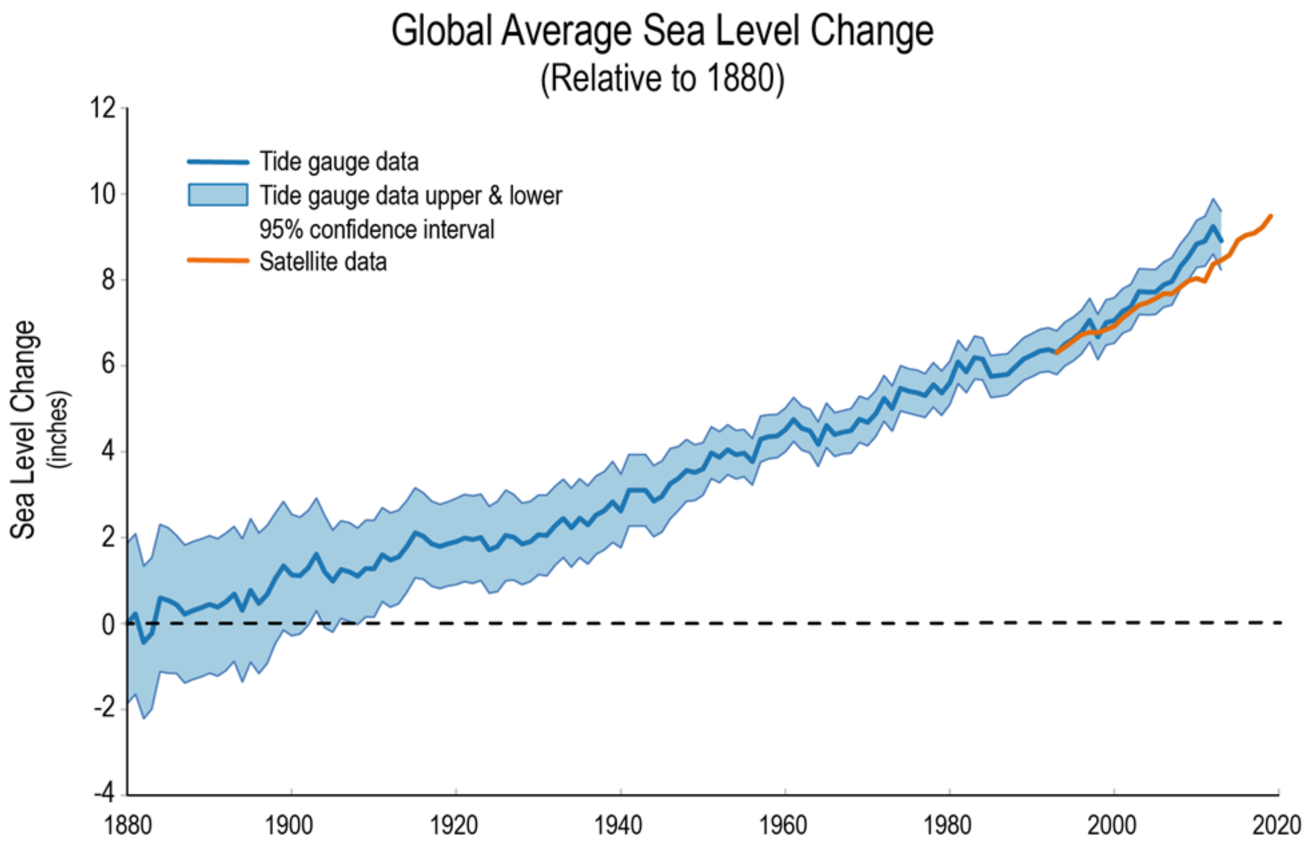


SUMDAT Model Inputs
Constants

- Max river diversion – 258 mgd to reflect current WUP,
- Storage capacity of Reservoir No. 2 assumed to be 6 BG,
- Starting TDS concentration of stored water assumed to be 225 mg/L
- No water loss assumed to occur(evaporation/seepage)
- WTP treatment capacity increased to 112 mgd.

Model Inputs
Variables

Input Variable	Options
Regional Demand	45 to 80 mgd
Reservoir No. 3 Volume	6 BG, 9 BG
Intake Location	Existing site, Furthest upstream site (confluence with Horse Creek)
Sea Level	Baseline, 1.2 in SLR, 4.0 in SLR, 9.1 in SLR, 36 in SLR
TDS Limit on River Water Withdrawals	425 mg/L, No limit
Precipitation Stressor	No stressor, 5% stressor

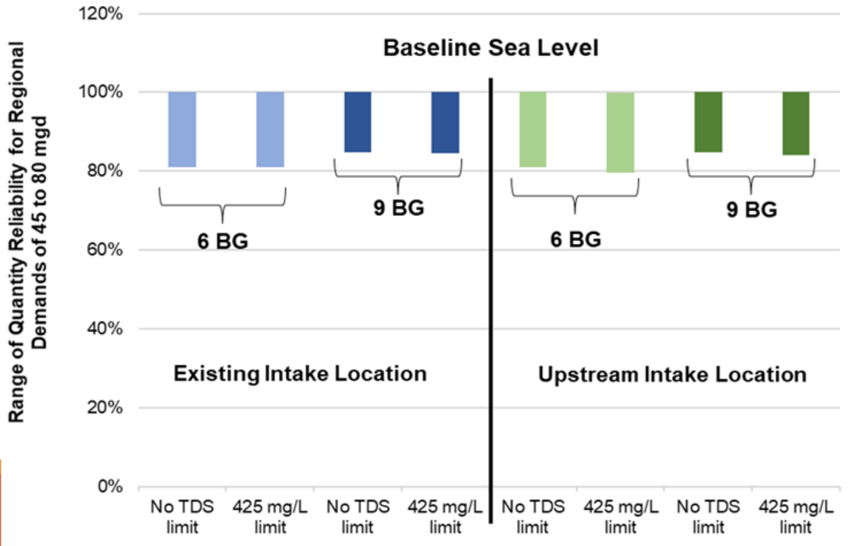


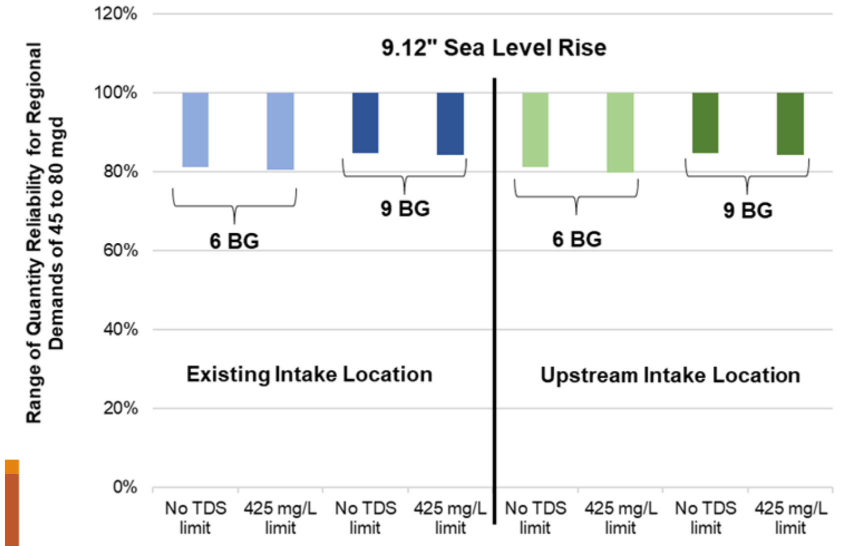
Model Output Variables

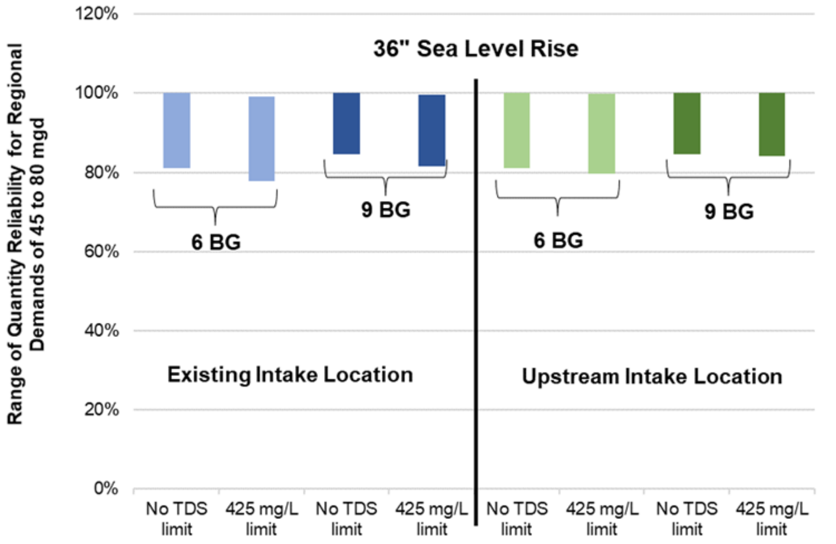
Output Variable	Range	Notes
Quantity Reliability	0 to 100%	Percentage of modeled days in which the evaluated configuration met the assumed regional demand.
Consecutive Days of Quantity Failure	0 to 16,618 days	Maximum number of consecutive modeled days in which the assumed annual average regional demand could not be met.
Quality Reliability	0 to 100%	Percentage of days in which the secondary drinking water standard for TDS of 500 mg/L (maximum) is anticipated to be met out of the days in which regional demand is met.
Number of Days with TDS > 500 mg/L	0 to 16,618 days	Number of modeled days in which the regional demand could be met, but the secondary maximum contaminant level for TDS of 500 mg/L could not be met.
Number of Days with TDS > 800 mg/L	0 to 16,618 days	Number of modeled days in which the regional demand could be met, but the finished water TDS concentration was estimated to be greater than 800 mg/L.
Safe Yield	45 to 80 mgd	The annual average regional demand at which a quantity and quality reliability of 99.5% and 95%, respectively, can be achieved. The safe yield is expressed as "< X mgd", with X being the regional demand at which the quantity and/or quality reliability requirement is broken for regional demand increments of 5 mgd ranging from 45 to 80 mgd.

Findings

Intake Location	Sea Level Condition	Range of Quantity Reliability (45 – 80 mgd Demand)	Safe Yield Based on Quantity Reliability (> 99.5%)	Range of Quality Reliability (45 – 80 mgd Demand)	Safe Yield Based on Quality Reliability (> 95%)
Existing Intake Location	Baseline	84 – 100%	< 55 mgd	81 – 89%	< 65 mgd
	1.2” SLR	84 – 100%	< 55 mgd	81 – 89%	< 65 mgd
	4.0” SLR	84 – 100%	< 55 mgd	81 – 89%	< 65 mgd
	9.1” SLR	84 – 100%	< 55 mgd	80 – 89%	< 65 mgd
	36” SLR	82 – 100%	< 50 mgd	76 – 97%	< 60 mgd
Upstream Intake Location	Baseline	84 – 100%	< 55 mgd	80 – 98%	< 65 mgd







Conclusions

SUMDAT results demonstrate:

- Increase in systemwide reliability benefits of a 9 BG Reservoir No 3 relative to a 6 BG Reservoir 3
- Minimal systemwide reliability impact of an upstream intake location relative to the existing intake location
- No real effect until 36” SLR scenario

These “reservoir size” related results may be explained by ability to harvest and store river water during high flows with additional off-line storage. The minimal impact of intake siting on system reliability is due to predicted WQ differences at sites largely occurring only when river flows are low and thus unavailable due to WUP flow-based constraints.