

CALIFORNIA DEPARTMENT OF WATER RESOURCES

# Improvement of Clifton Court Forebay Gate Representation in DSM2 for Planning Studies

CWEMF, May 2025

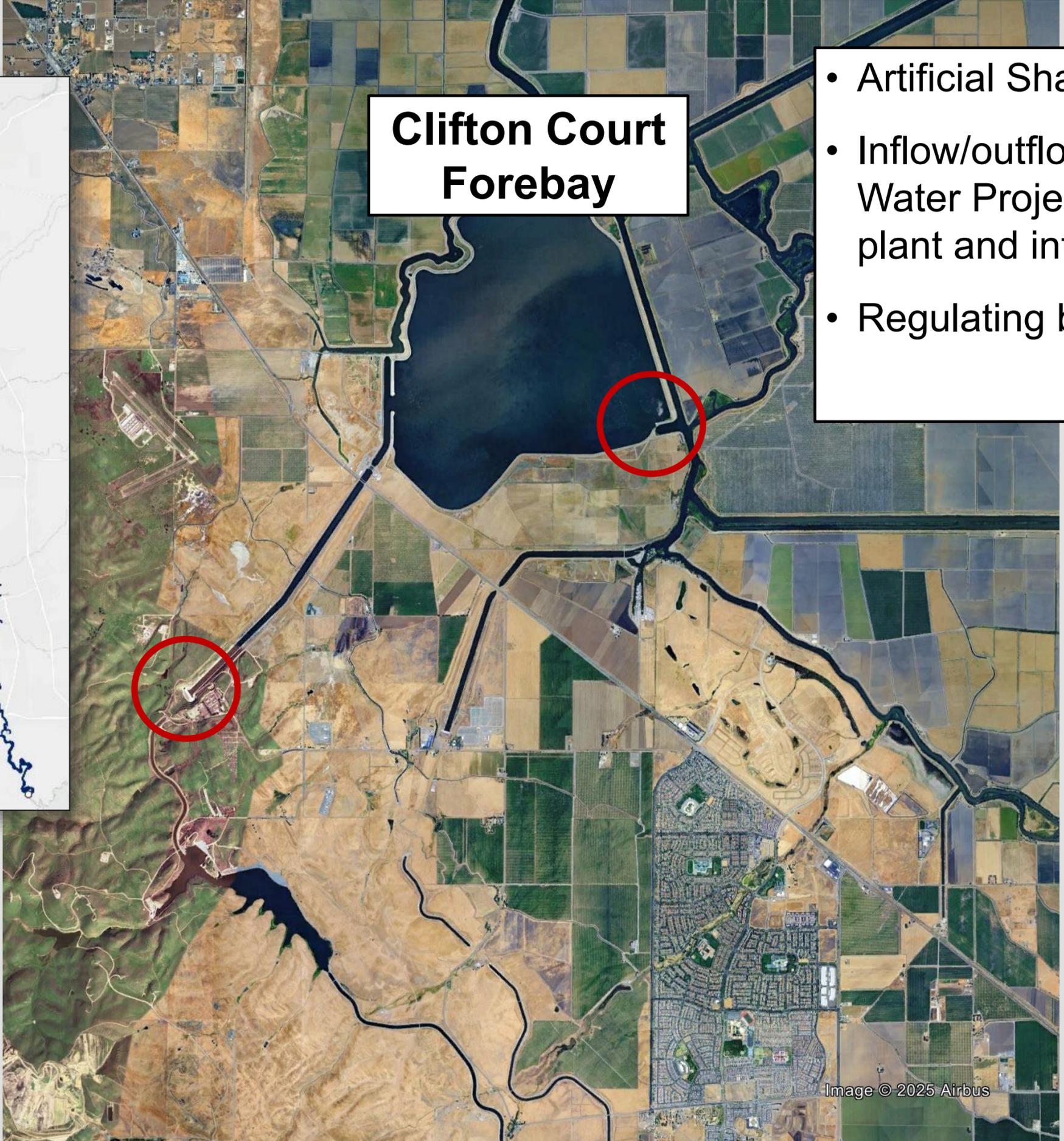
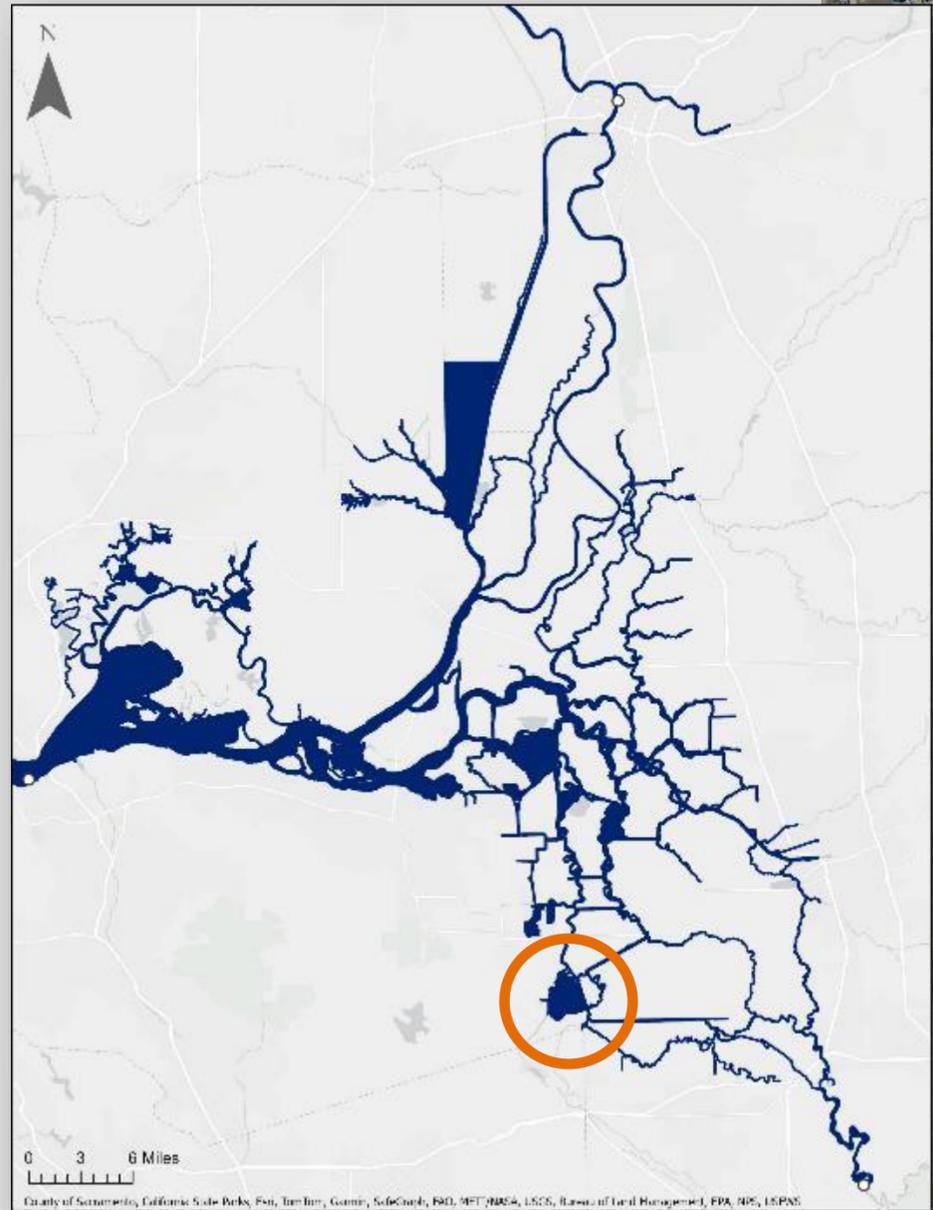


Modeling Support Office

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# Clifton Court Forebay

- Artificial Shallow reservoir
- Inflow/outflow dictated by State Water Project (SWP) pumping plant and intake radial gates
- Regulating basin/buffer





**Harvey O. Banks  
Pumping Plant**



**Clifton Court  
Forebay**

- Head of the California Aqueduct and the South Bay Aqueduct
- 244 feet of lift from the Delta to the aqueducts down to Southern California
- 11 units operated off-peak hours (not between 4pm-9pm)
- Water pumped to the canal → **EXPORTS**

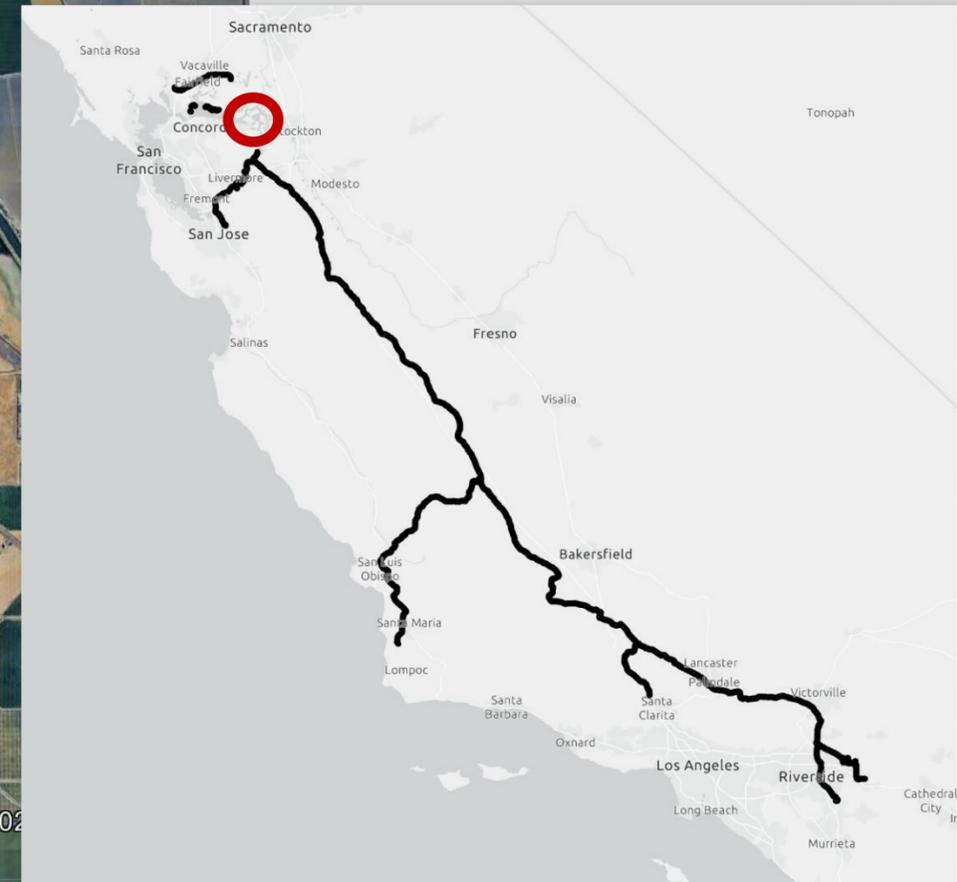
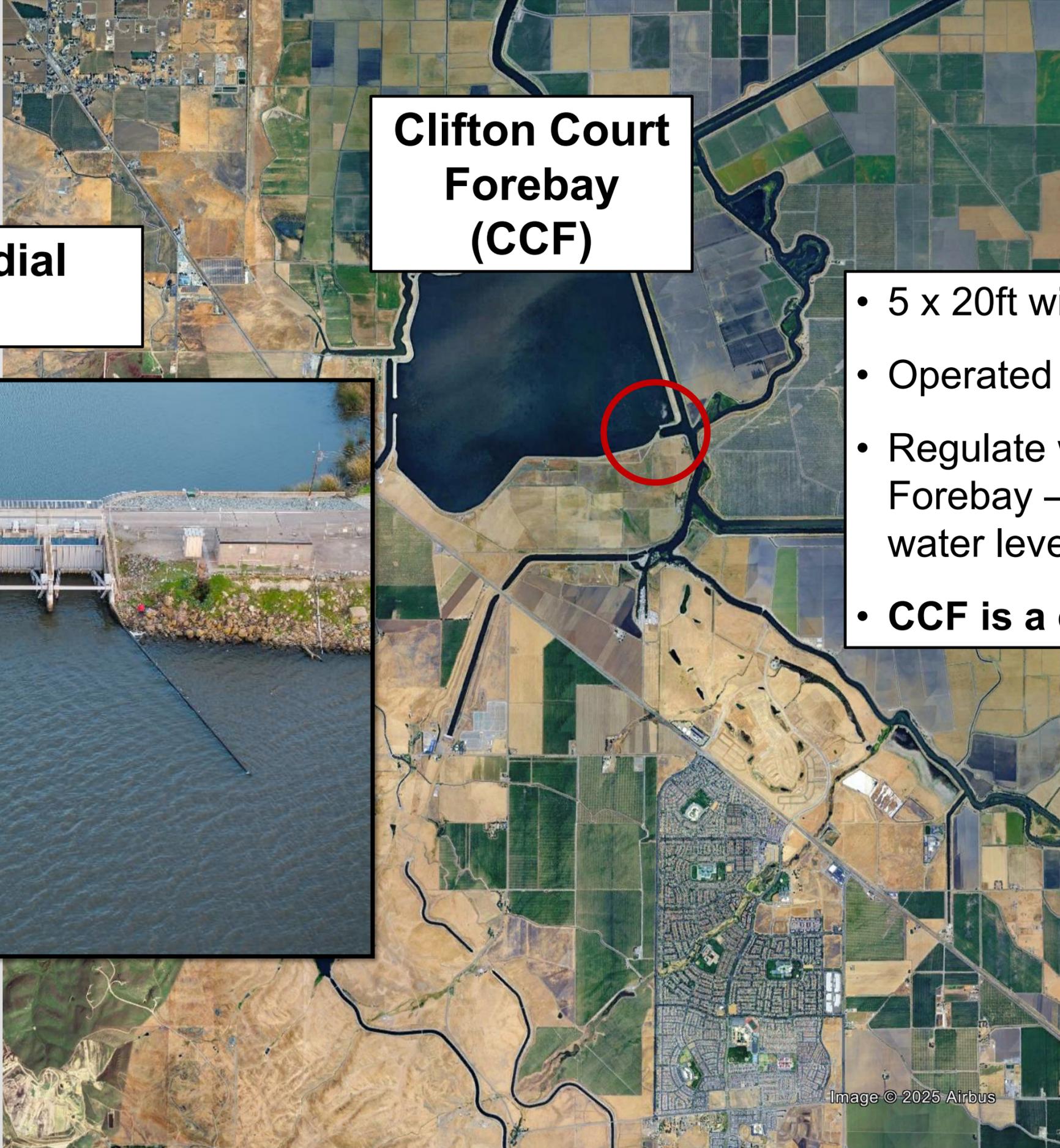


Image © 202

## Intake Radial Gates

## Clifton Court Forebay (CCF)

- 5 x 20ft wide radial gates
- Operated in tandem
- Regulate water **intake** into the Forebay – minimize the impact on water level in the Delta
- **CCF is a closed system**



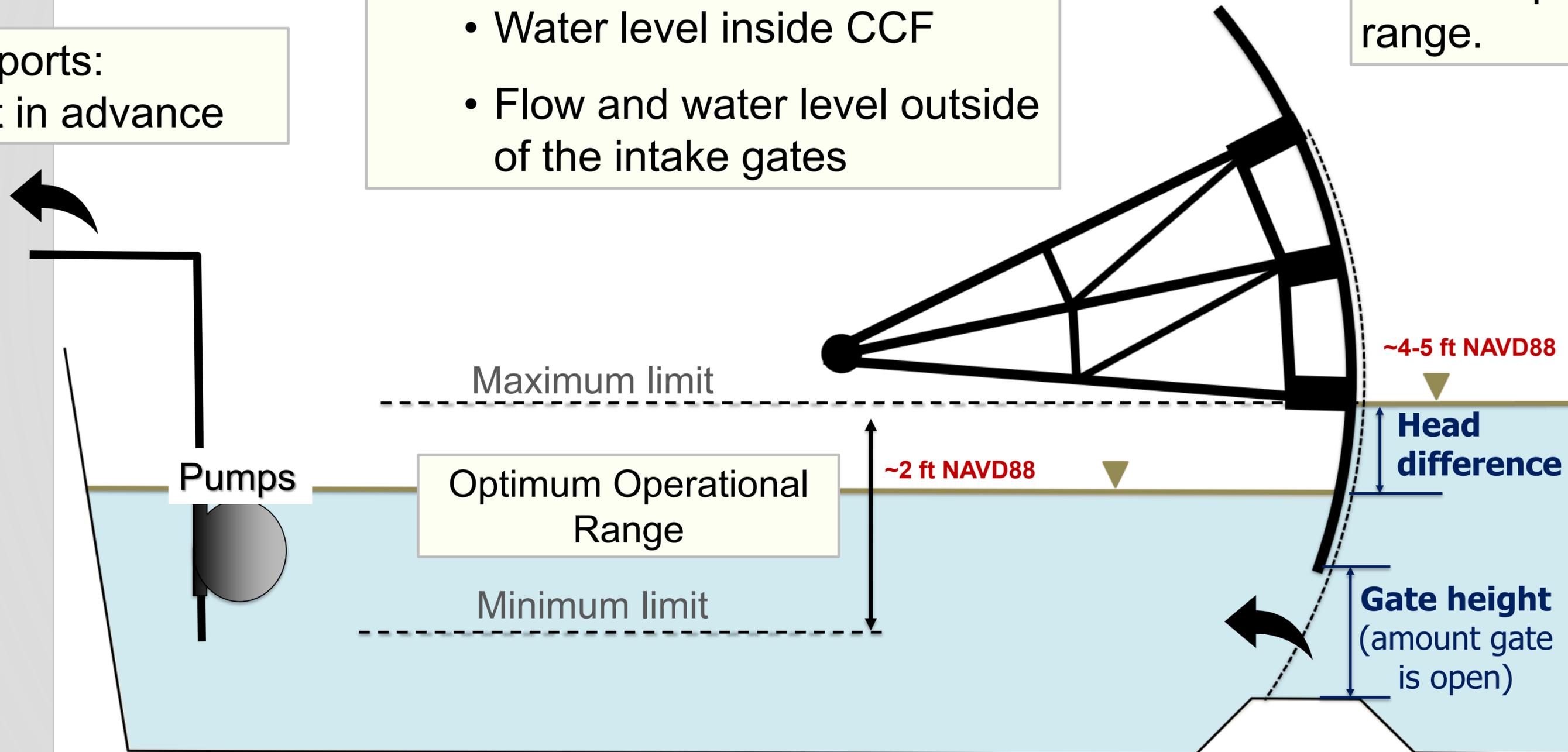
# Clifton Court Forebay- CCF

Exports:  
set in advance

Timing and gate opening impacts:

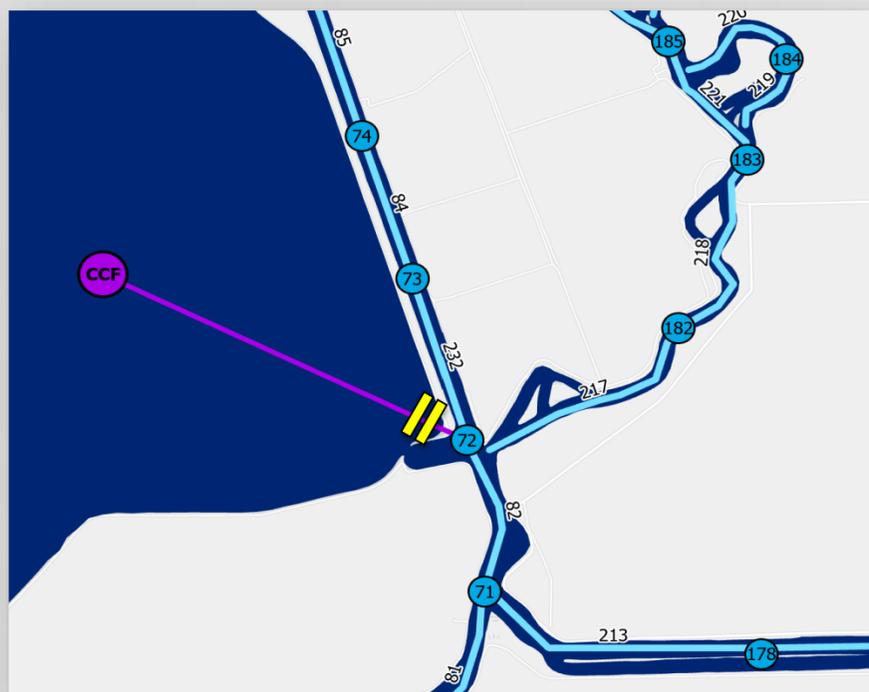
- Water level inside CCF
- Flow and water level outside of the intake gates

Intake:  
adjusted to keep water level in operational range.



# Motivation : Gate Operations in DSM2

Hindcast (Historical)	Forecast/hypothetical (Planning) Change exports
<p><b>Current Representation</b> Time series of gate heights</p> <ul style="list-style-type: none"><li>• Actual historical timing of open/close times</li></ul>	<p><b>Past Representation</b> Gates fully open during priority 3</p> <ul style="list-style-type: none"><li>• Not realistic operation</li><li>• Not realistic impact on water level and flow</li></ul>



## New Representation

### Adaptive

- Adapt to change in export
- Adapt to perturbation of water level
- Accurate water levels inside the forebay



**How are the  
gates operated?  
(in the field)**

**How are they  
represented in  
DSM2?  
(modeled)**

# How are the gates operated? (1/4)

In the field

Priority system

Allotment

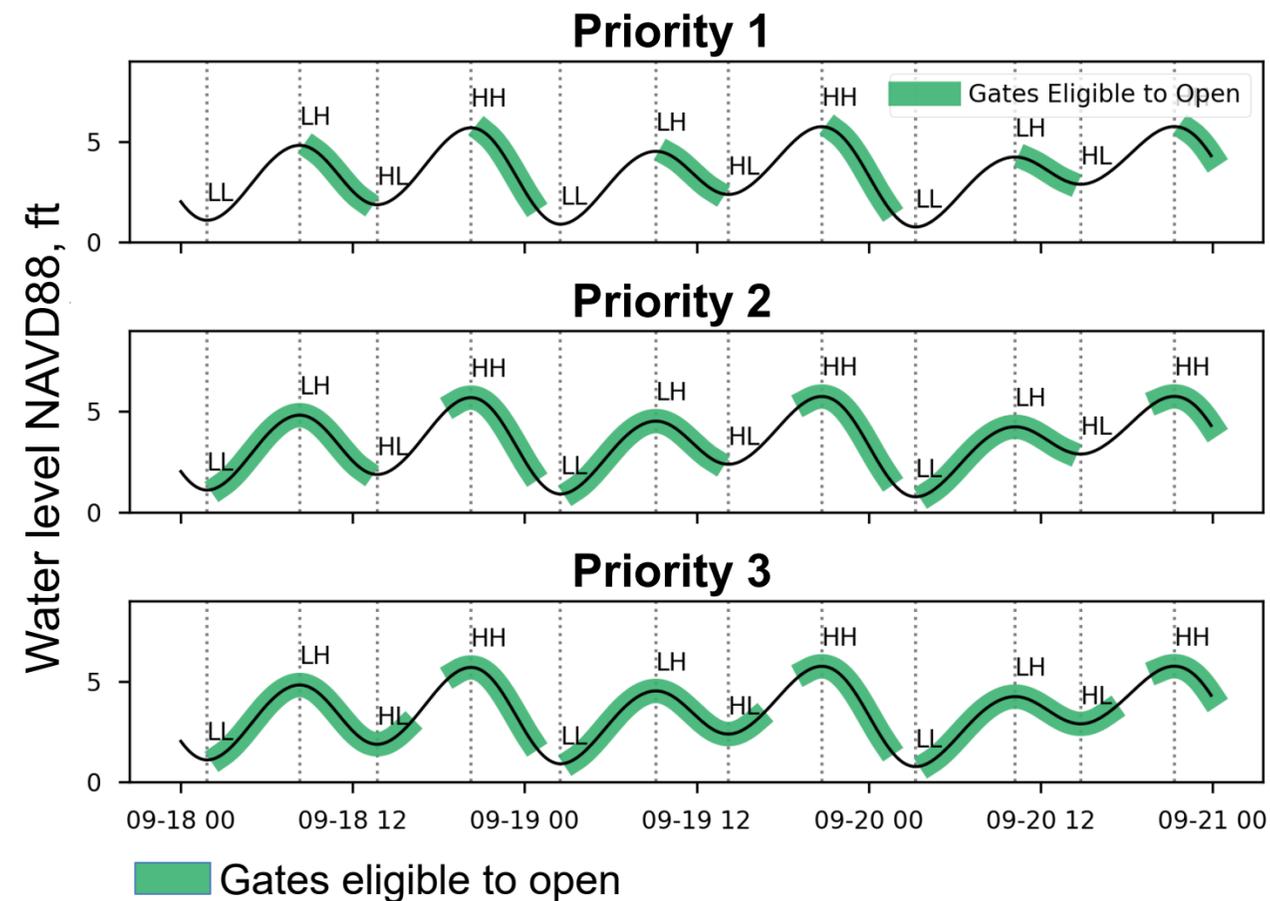
Protecting equipment

Fish

Date	CLOSE		From		To	
	From	To	From	To	From	To
04/01/24	4:30	6:45	6:15	14:00	14:00	19:00
04/02/24	6:45	7:15	8:30	15:15	15:15	20:15
04/03/24	7:15	8:15	9:30	16:30	16:30	21:15
04/04/24	8:15	9:30	10:45	17:45	17:45	22:00
04/05/24	9:30	10:45	12:00	18:00	18:00	23:45
04/06/24	1:30	16:30	3:30	11:45	11:45	15:30
04/07/24	2:00	16:30	4:15	12:30	12:30	16:15
04/08/24	2:45	8:00	5:15	13:30	13:30	18:30
04/09/24	3:00	9:00	6:15	14:30	14:30	19:30
04/10/24	3:30	9:15	7:45	15:45	15:45	20:45
04/11/24	4:45	10:15	8:15	16:45	16:45	21:30
04/12/24	5:45	10:15	9:15	17:00	17:00	22:00
04/13/24	6:45	11:15	10:15	18:15	18:15	23:00
04/14/24	7:15	12:00	11:15	19:15	19:15	20:00
04/15/24	7:45	12:45	12:15	20:00	20:00	20:45
04/16/24	8:15	12:15	13:15	21:00	21:00	21:30
04/17/24	8:30	12:45	14:15	22:00	22:00	21:30
04/18/24	8:30	9:00	13:45	18:30	18:30	15:00
04/19/24	8:30	9:15	14:30	18:30	18:30	15:45
04/20/24	1:30	9:45	15:15	16:30	16:30	16:30
04/21/24	1:30	10:00	16:00	17:30	17:30	17:30
04/22/24	2:00	10:30	16:45	18:30	18:30	18:30
04/23/24	2:30	8:00	4:15	12:45	12:45	18:30
04/24/24	2:30	8:45	5:00	13:45	13:45	18:30
04/25/24	3:00	1:45	6:00	13:45	13:45	18:30
04/26/24	3:00	2:30	6:30	13:45	13:45	18:30
04/27/24	3:00	2:45	6:30	13:45	13:45	18:30
04/28/24	3:00	2:45	6:30	13:45	13:45	18:30
04/29/24	3:00	2:45	6:30	13:45	13:45	18:30
04/30/24	3:00	2:45	6:30	13:45	13:45	18:30

NOTE: Suggested times are based on priority 1 to handle existing or anticipated tidal flow conditions.

- Which portion of the tidal cycle the gates are **eligible** to be open
- DWR Operations and Maintenance Division (O&M), develops preliminary gate schedules **a month in advance** based on tide tables.
- Local tide outside the gates – inferred using San Francisco predicted tide + 8.25hr



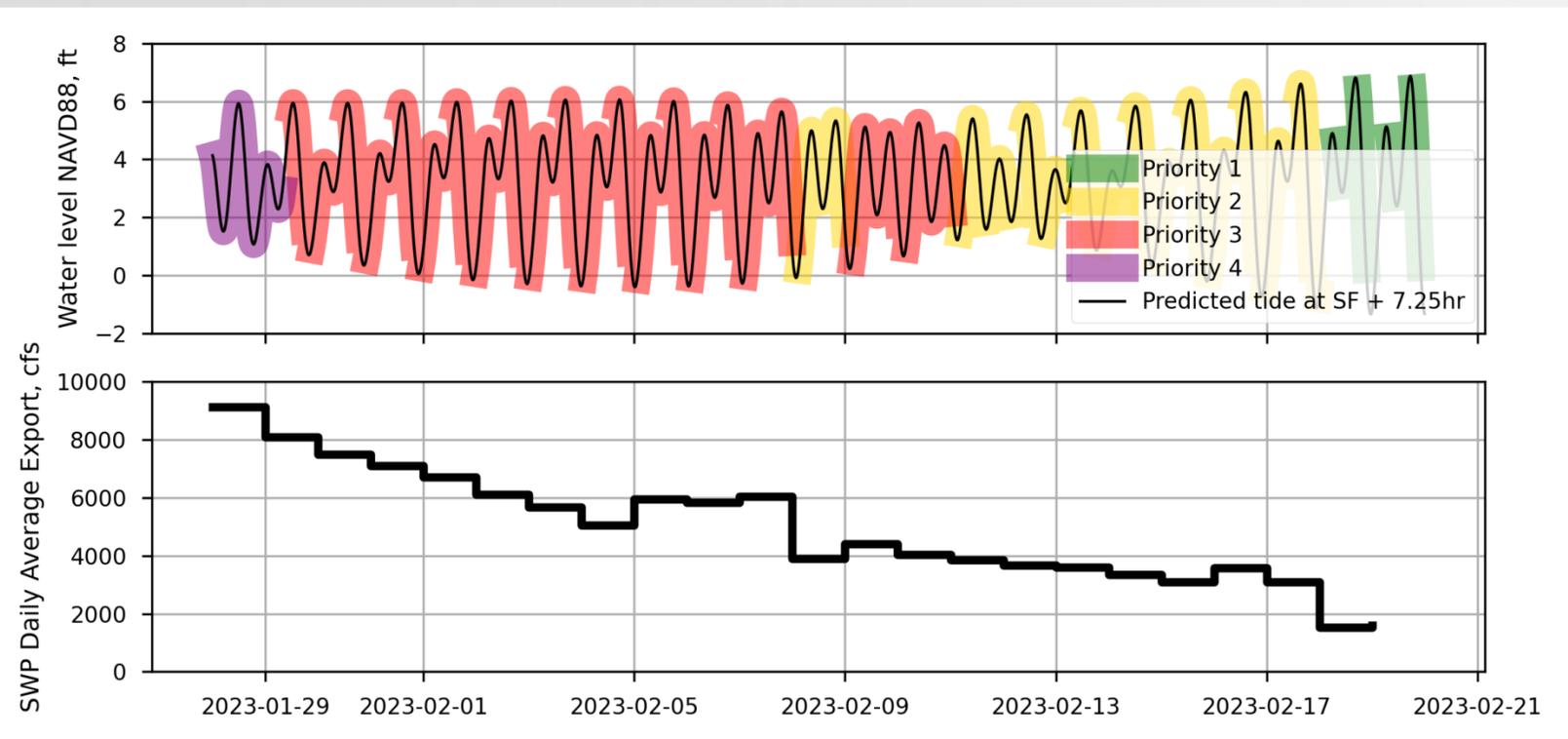
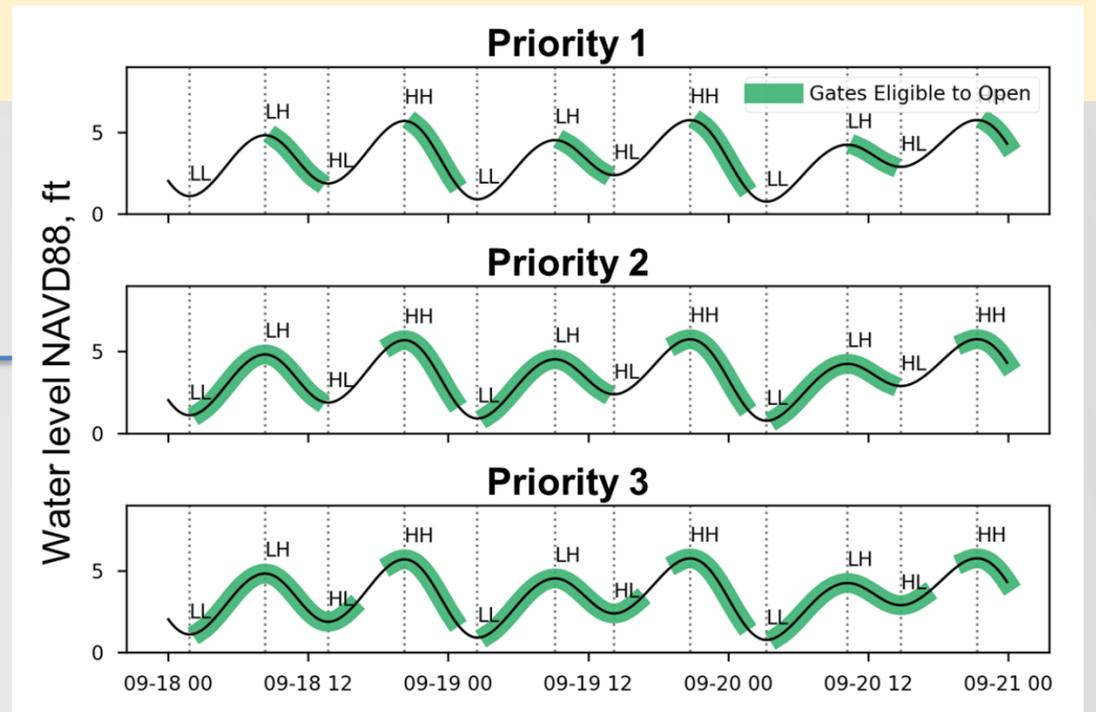
Exports 0 - 2000 cfs

Exports 2000 - 4000 cfs

Exports 4000 - 6680 cfs

# Past Model Implementation - Priority Schedule

Daily Average Export Flow: Historical or Planned (cfs)	Priority Number
0–2,000	1
2,000–4,000	2
4,000–9,000	3
>9,000	4 (always open to inward flow)



DSM2 Output Date / Time	CCFB GATE-OP DWR-MSS
29 Dec 2023, 18:19	1 = gate open
30 Dec 2023, 00:19	0 = gate closed
30 Dec 2023, 03:19	1
30 Dec 2023, 16:22	0
30 Dec 2023, 18:58	1
31 Dec 2023, 00:56	0
31 Dec 2023, 03:56	1
31 Dec 2023, 17:13	0
31 Dec 2023, 19:40	1
01 Jan 2024, 01:30	0
01 Jan 2024, 04:30	1
01 Jan 2024, 15:11	0
01 Jan 2024, 20:27	1
02 Jan 2024, 02:07	0

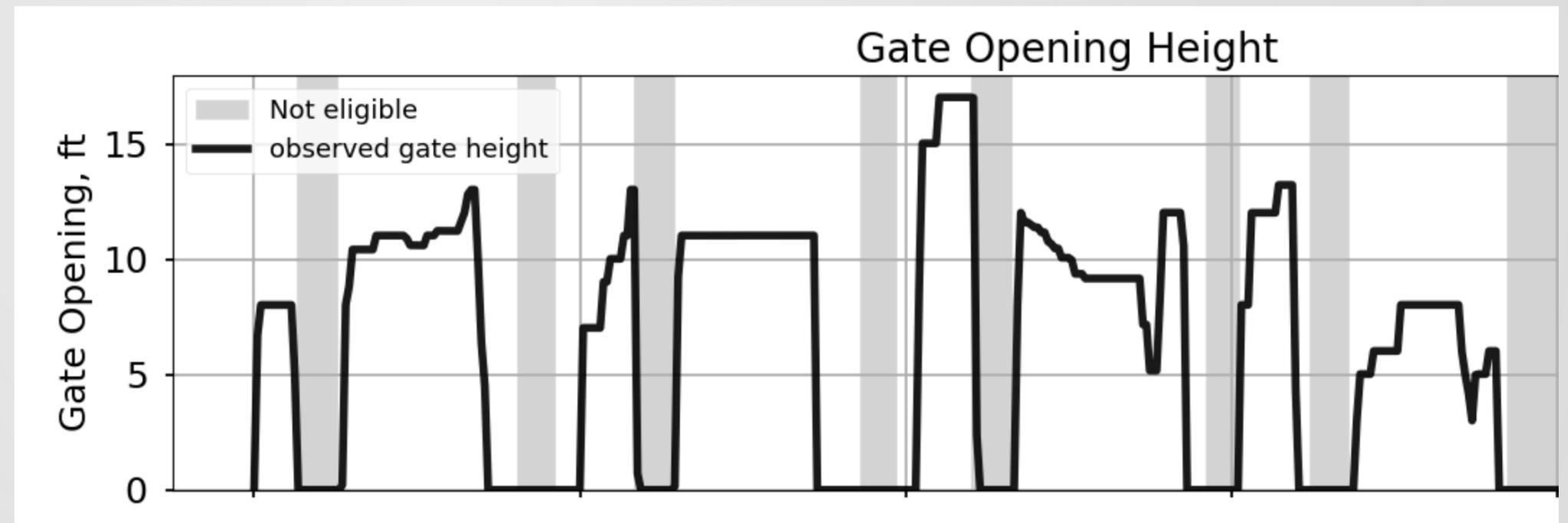
 Integrated in DSM2 Planning  
(hypothetical scenarios)

# How are the gates operated? (2/4)

In the field



- Priority system when the gates **are eligible** to be open
- In practice the gates are **closed after the day's allotment is fulfilled**



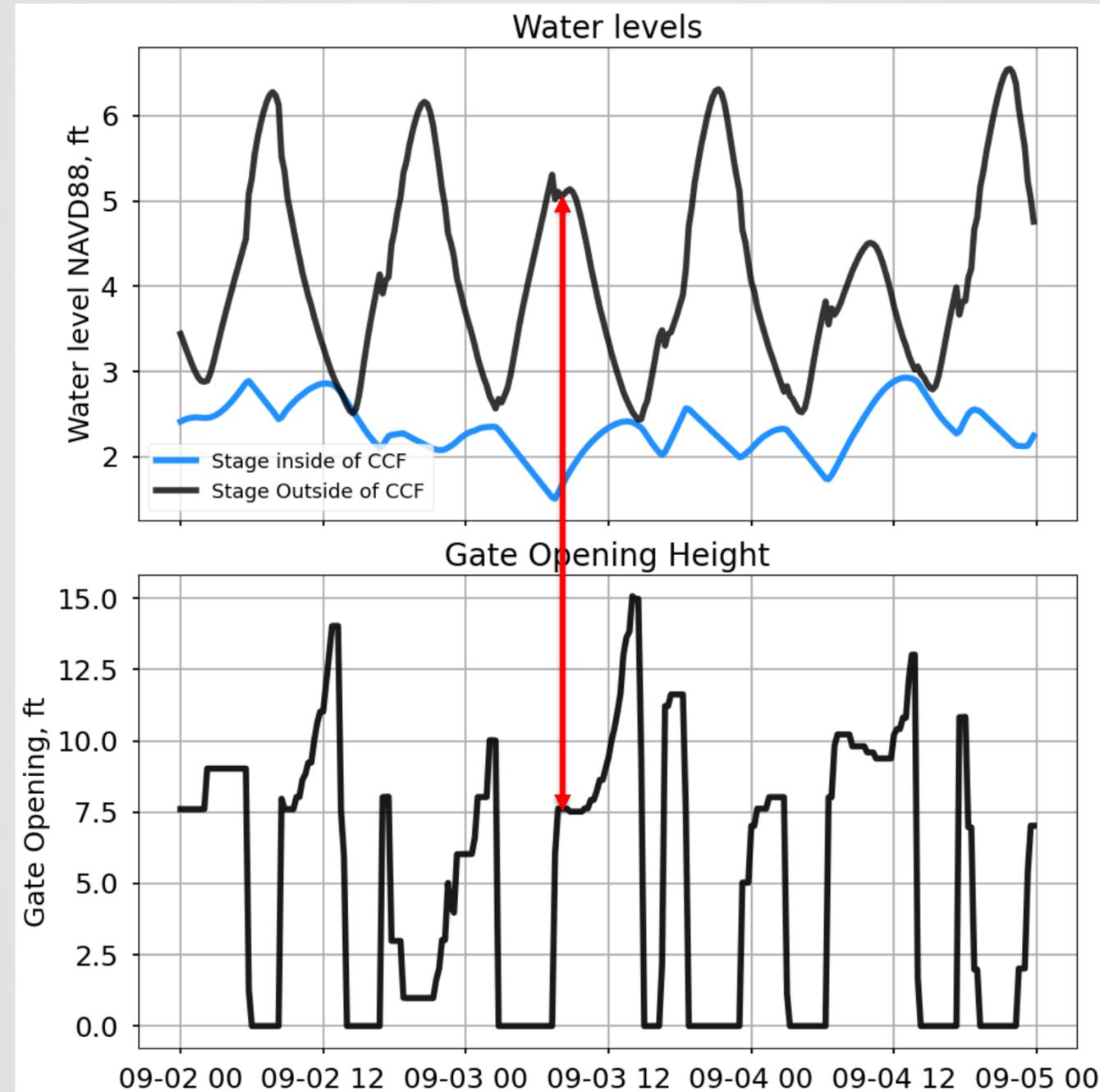
# New Model Implementation - Allotment

## Inside the Gate Operating Rule Module

- Improved gate rating equation – accurate inflow
- Keep track of inflows with ACCUMULATE function
- Close gate if enough water is available in the Forebay

# How are the gates operated? (3/4)

In the field



- **Maximum design flow rate of 12,000 cfs** – to protect the gate/prevent scour
- Gate height is modulated through the tidal cycle to reduce flow

# New Model Implementation – Modulate Gate height

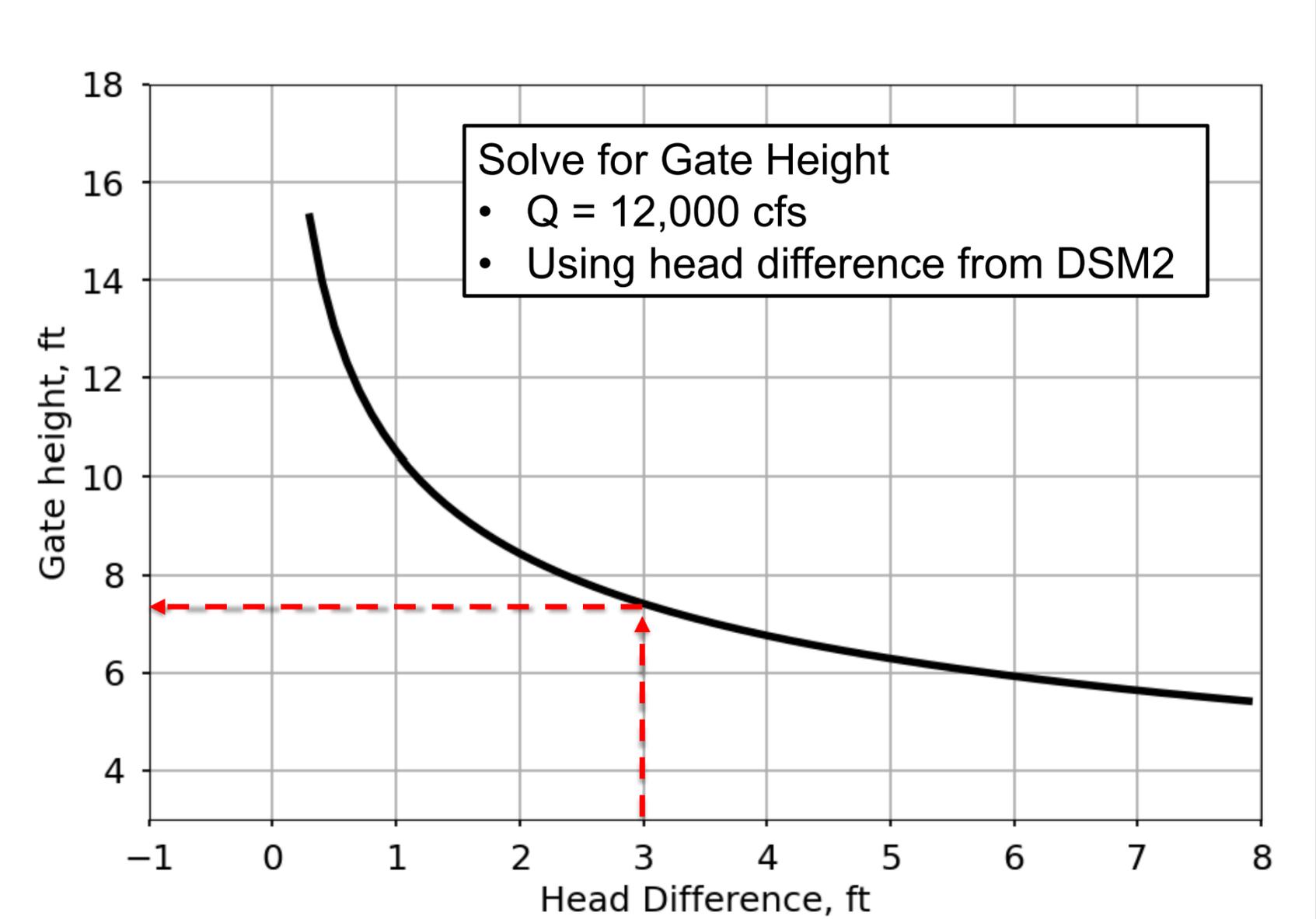
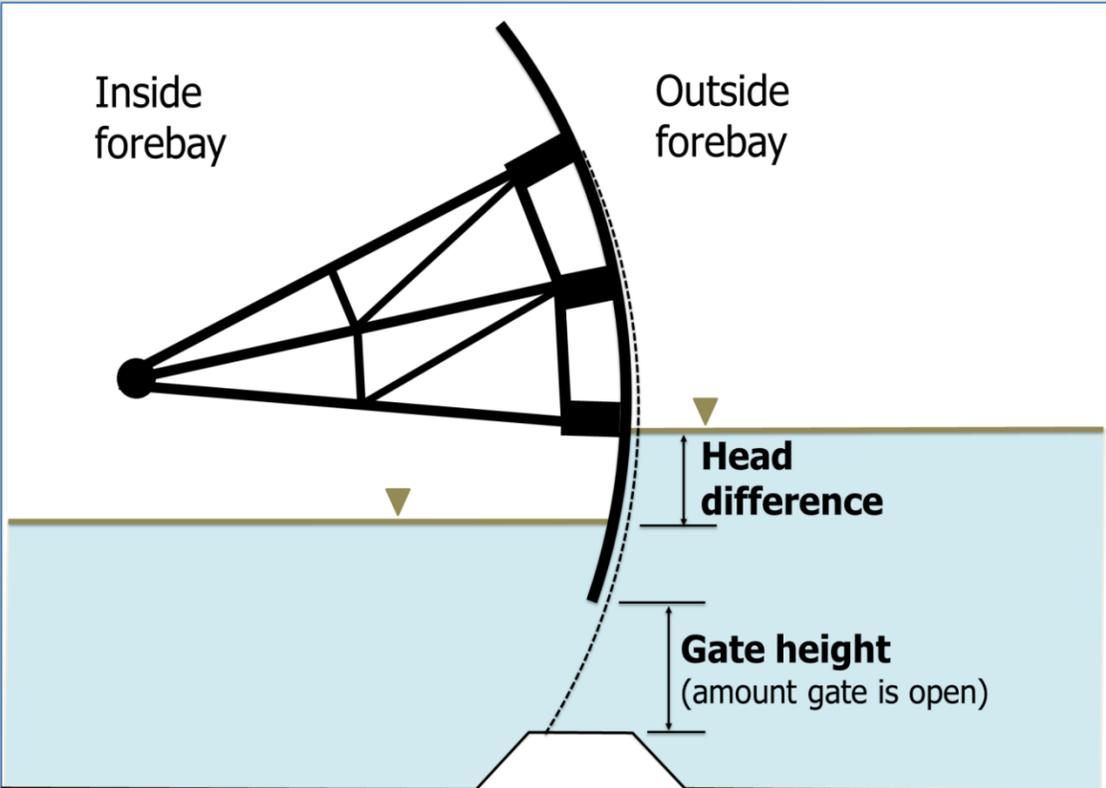
Generic form of Gate Equation

$$Q = nCA \sqrt{(2g)(z_{up} - z_{down})}$$

Head difference

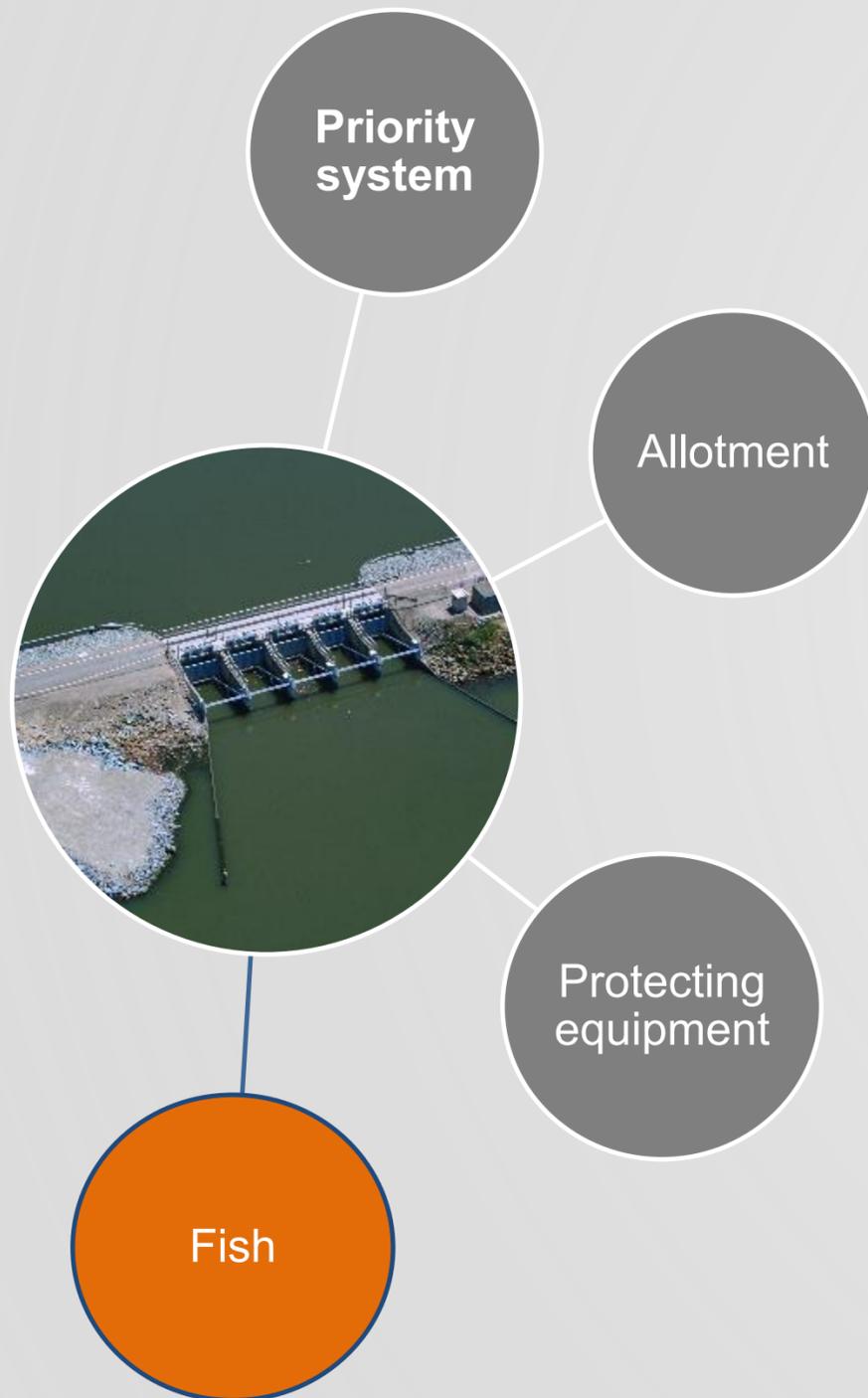
A = Gate Height \* Width

C = Gate Coeff, f(Gate Height)



# Model Implementation - Sipping

- Sipping: gates lower for longer
- Gulping: gate open to max

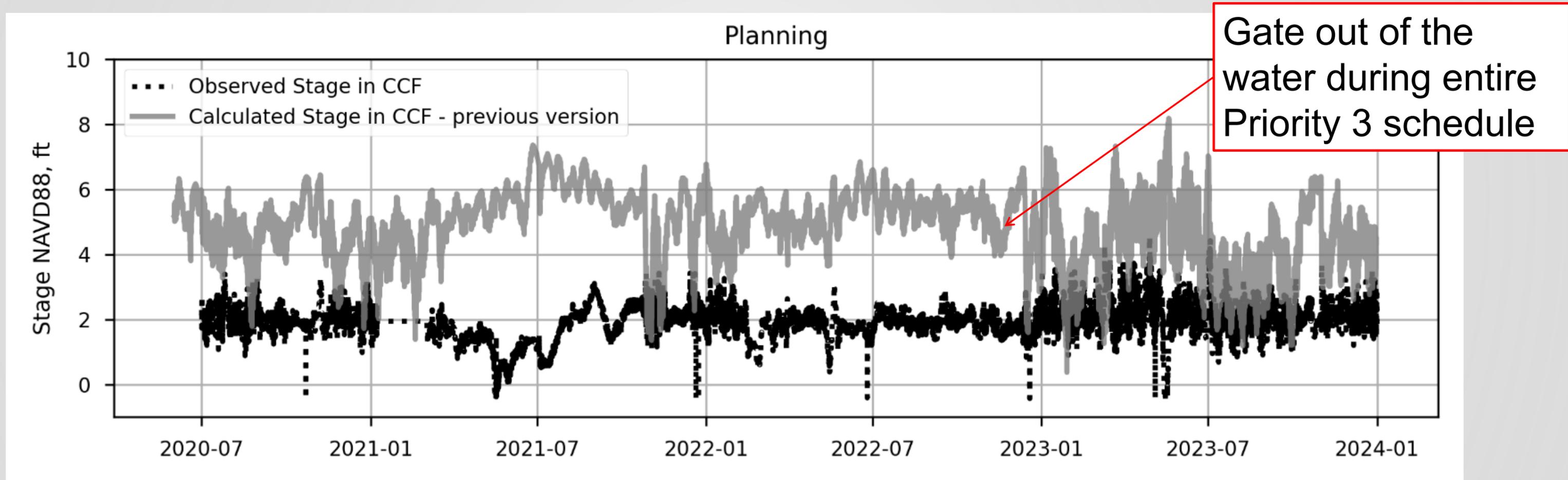


Daily Average Export Flow: Historical or Planned (cubic square feet)	Maximum Gate Height (feet)
0-400	3 Sipping
400-1,200	5
1,200-3,000	8
3,000-4,000	10
>4,000	16 Gulping

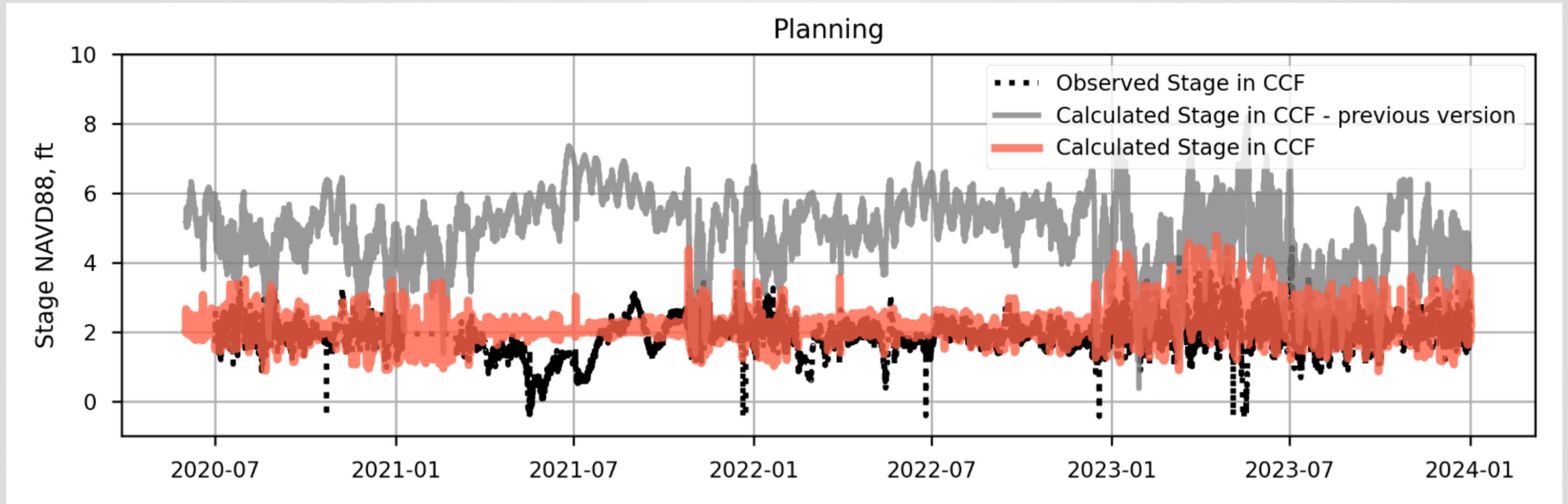
1. Gate Modulation

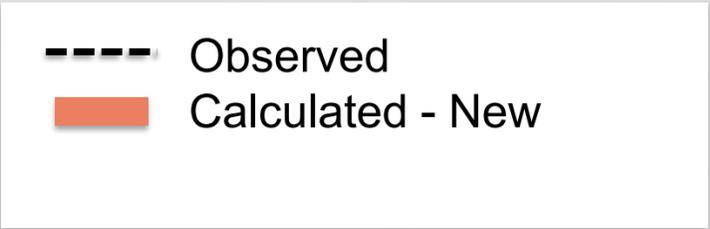
2. Adjust for sipping

# Calculated water level in Clifton Court Forebay

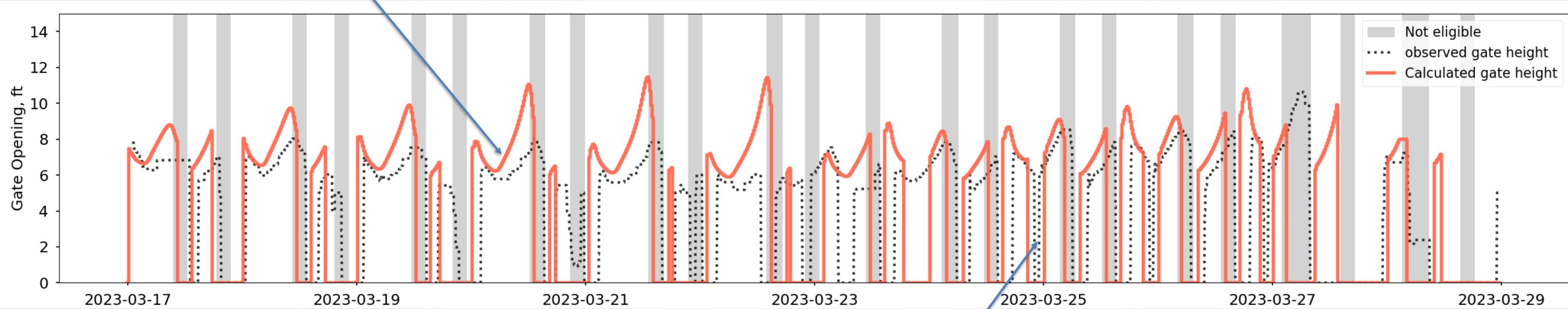


# Calculated water level in Clifton Court Forebay



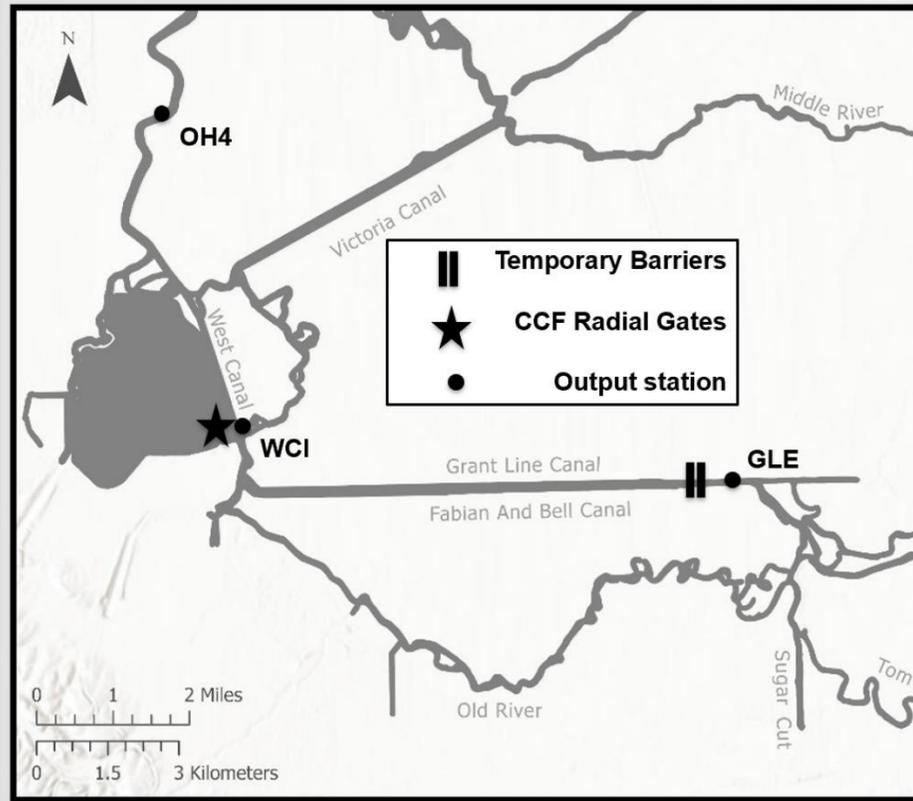


Emulate the change in gate height in response to head difference.

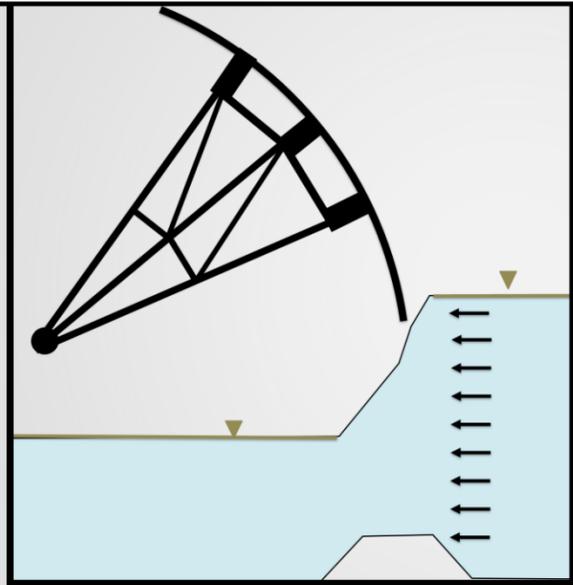


Early closing due to allotment

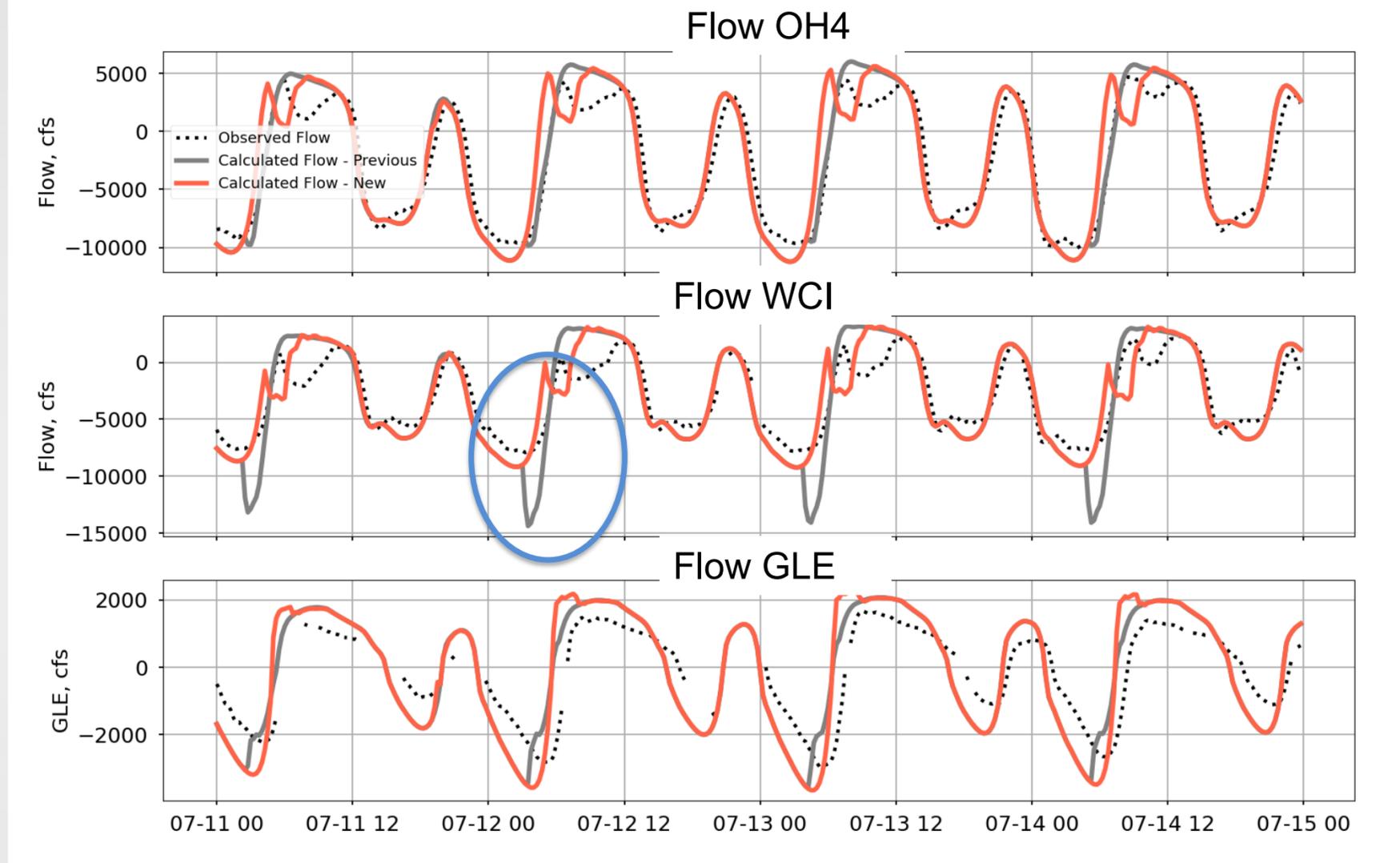
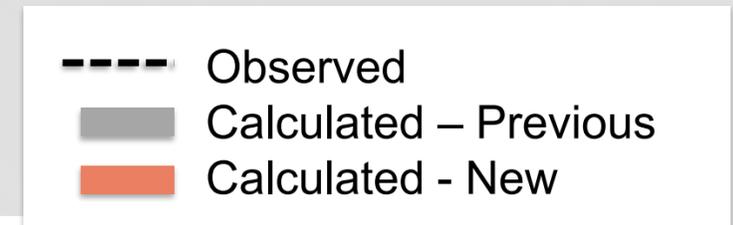
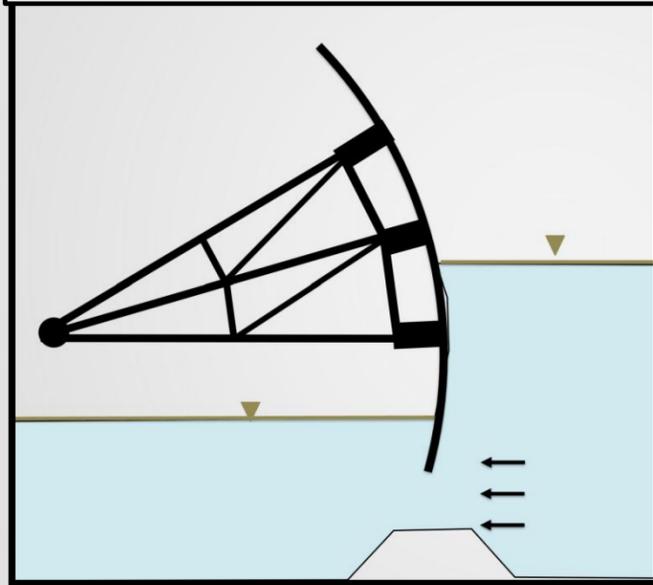
# Effect on Flow



Previous Representation



New Representation



# Implementation for SCHISM

- No capability for sophisticated gate operation
- Use DSM2 to get gate heights and timing for scenarios perturbed exports
- Now use “Offline” calculator (Jon Shu)
  - Water level predictor based on local tide prediction and drawdown from pumps.
  - Re-package all the gate height calculations to be used offline without deploying DSM2 model.

# Summary

- Provide more realistic representation of gate operation
- Operation is adaptive – adjust with export and water level (Planning or Historical Scenarios)
- Prevent error with CCF drying due to imbalance in export and intake
- Available in future DSM2 release or upon request

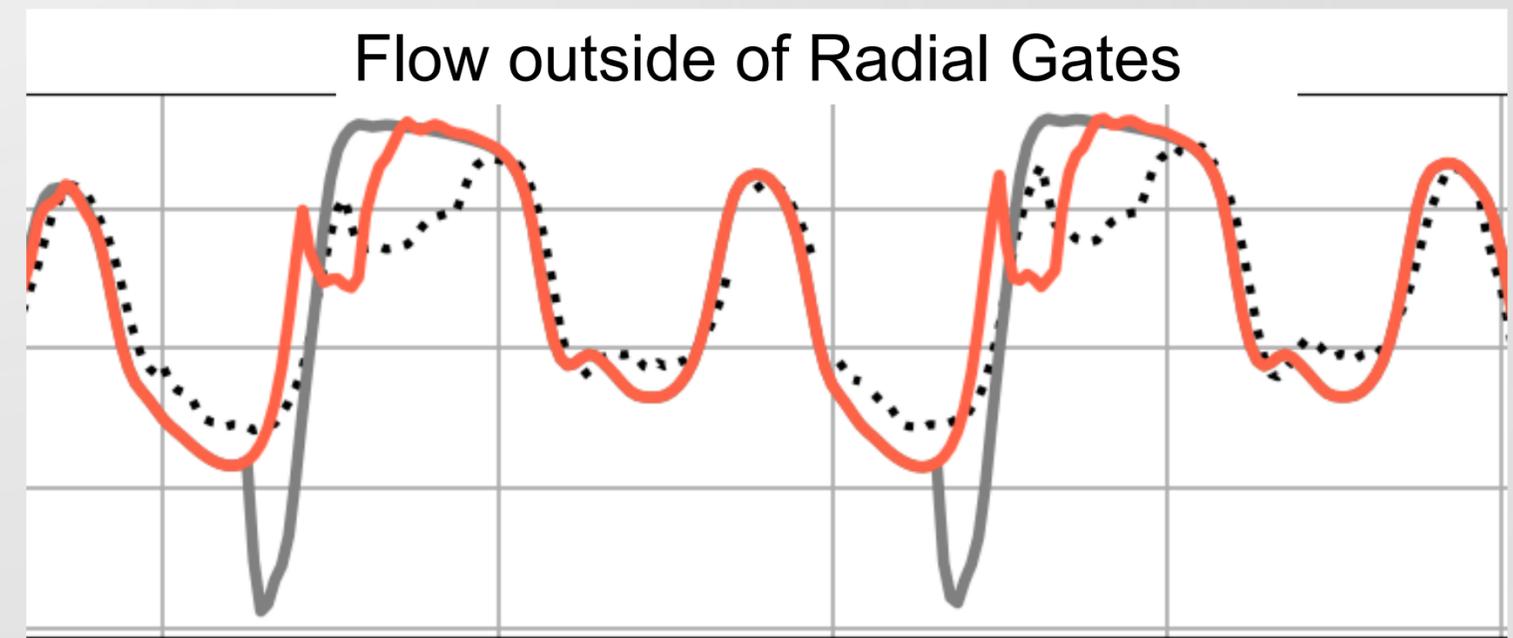
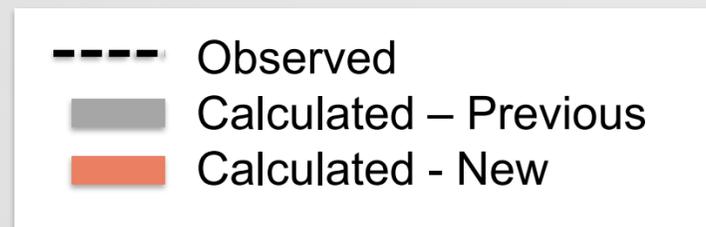
# QUESTIONS



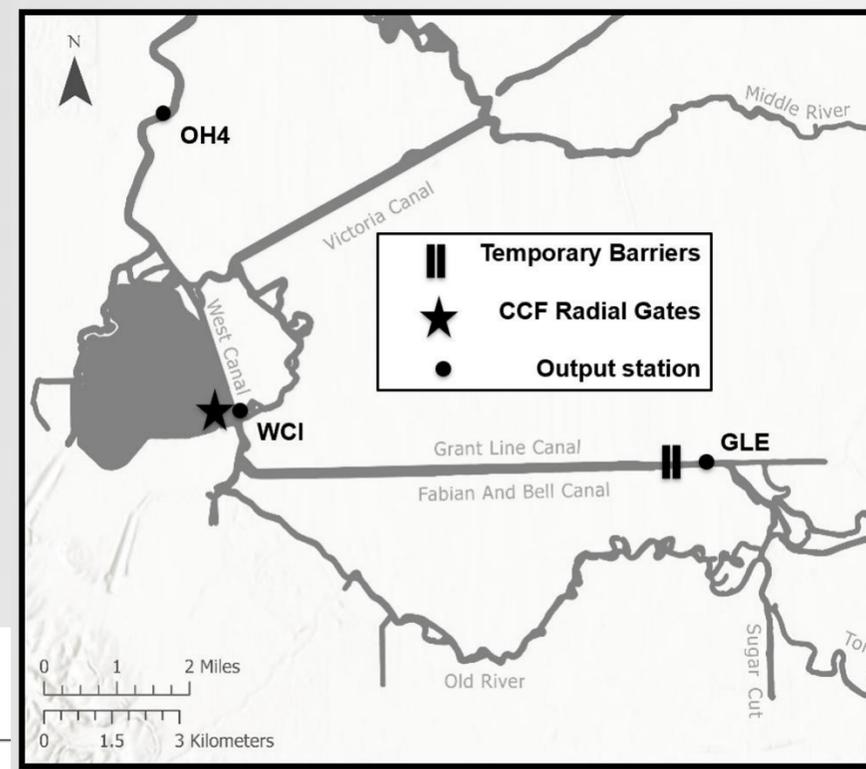
# Extras

# Summary of Improvements

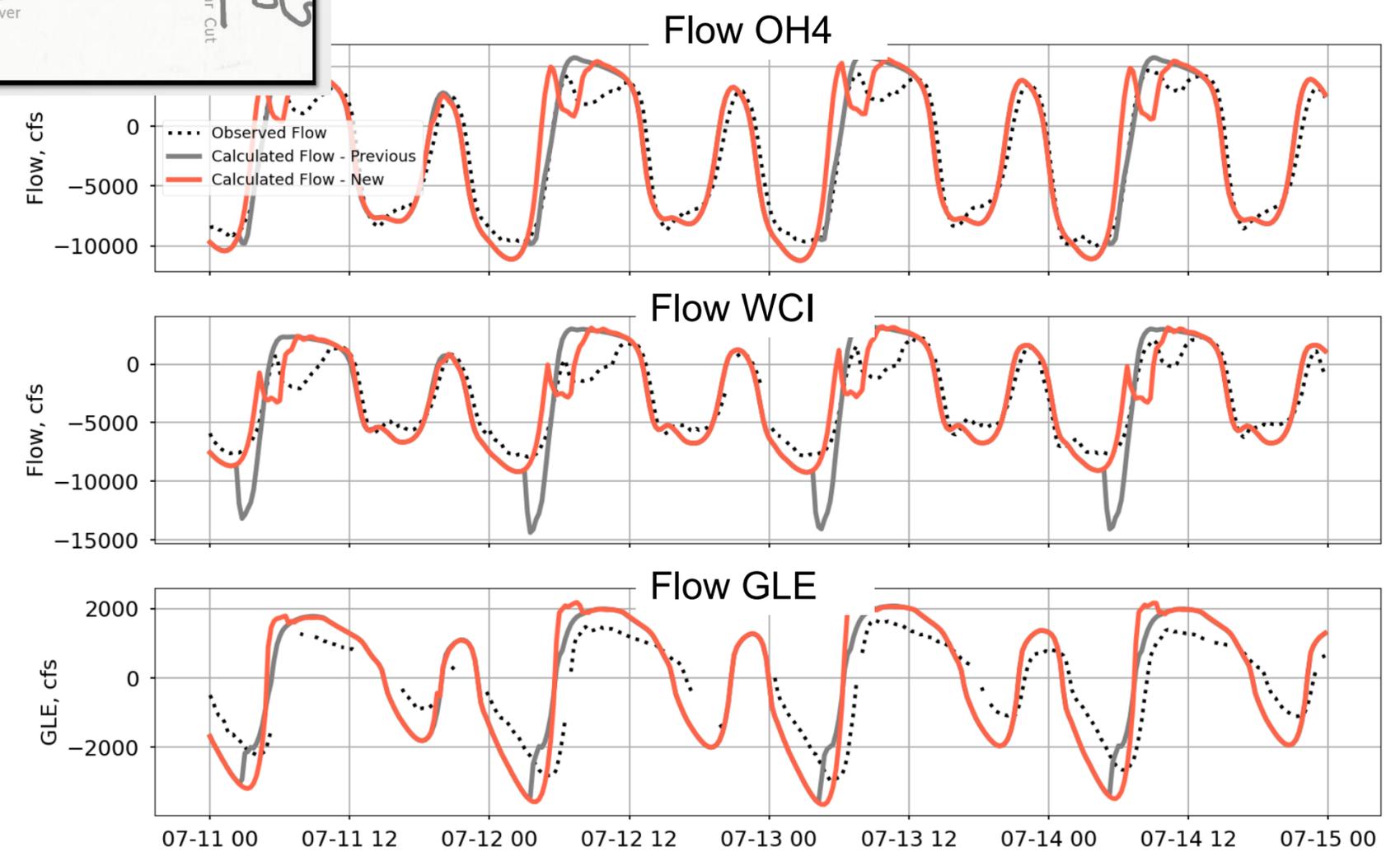
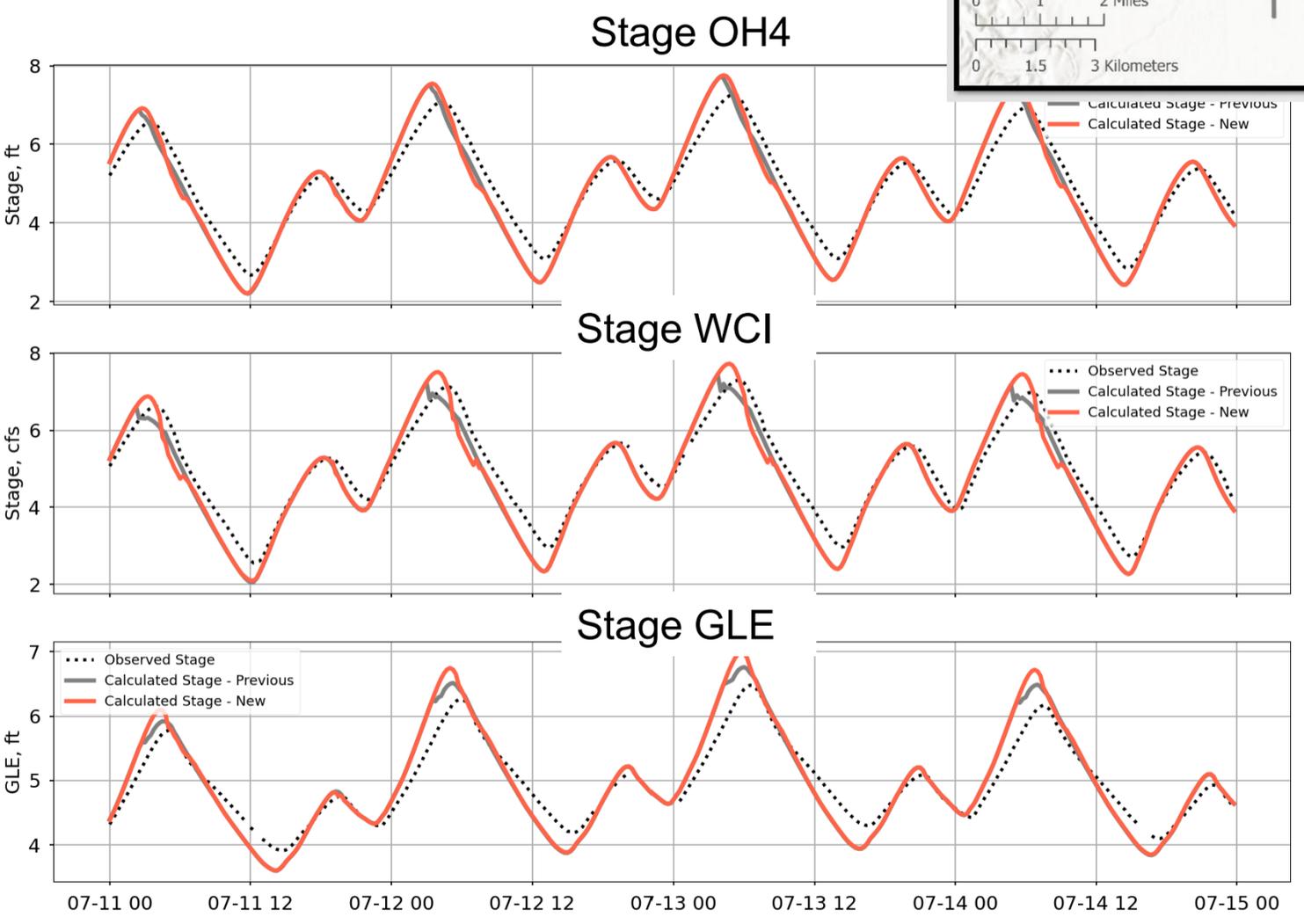
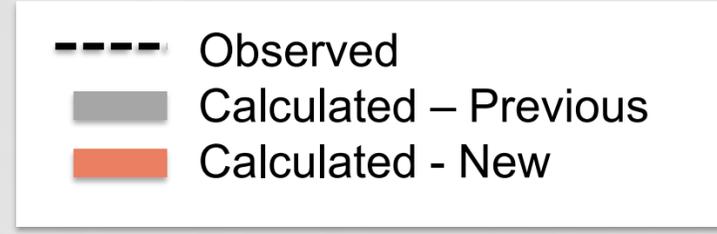
- Operation is adaptive – adjust with export and water level
- Avoid Clifton Court Forebay drying (Error)
- More gradual change in calculated stage in falling tide
- Prevent large artificial flow reversal near the intake



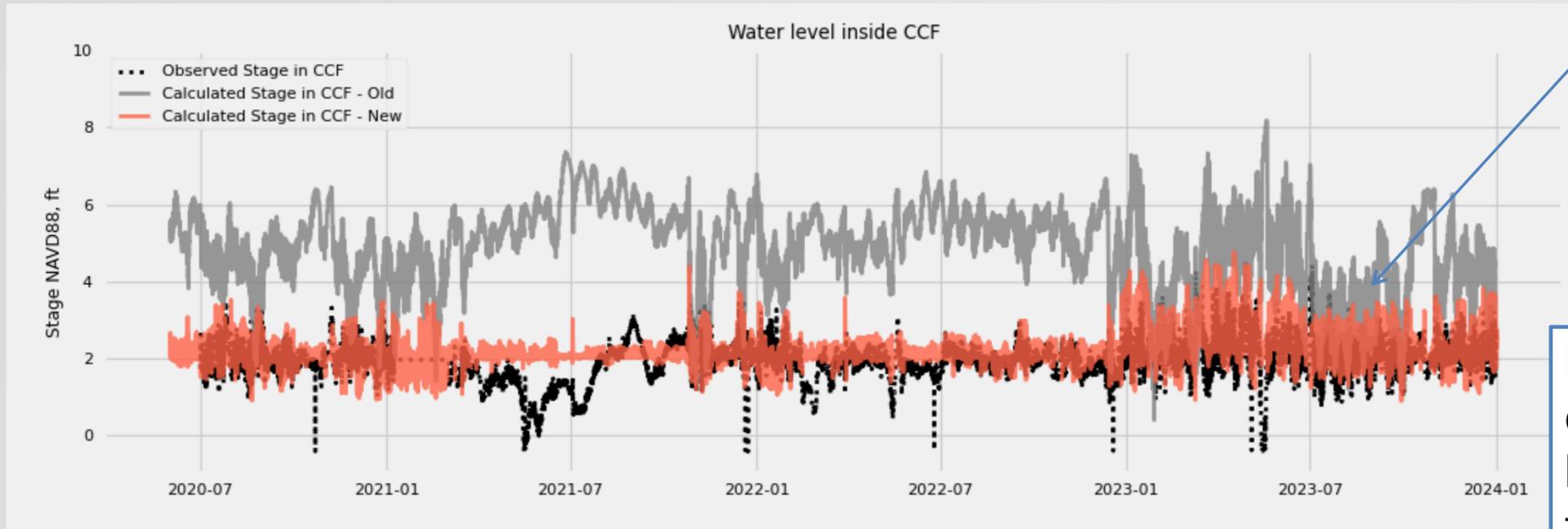
# Effect on Stage



# Effect on Flow



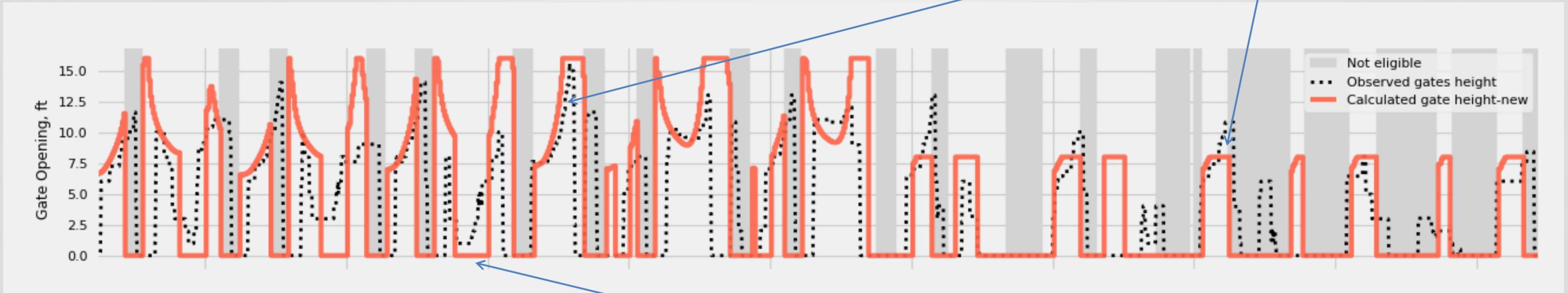
# Model Results



Model able to maintain correct water level.

Maximizing eligible period at low exports

Emulate the change in gate height in response to head difference.



Adaptative opening/closing.

# Monthly Minimum (1% Quantile) Stage 2023

Station = OH4

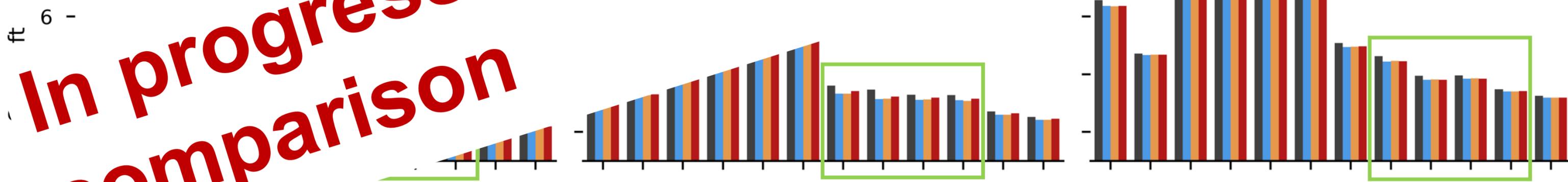
Station = GLC



**In progress – Planning Study**  
**comparison**

Station = ODM

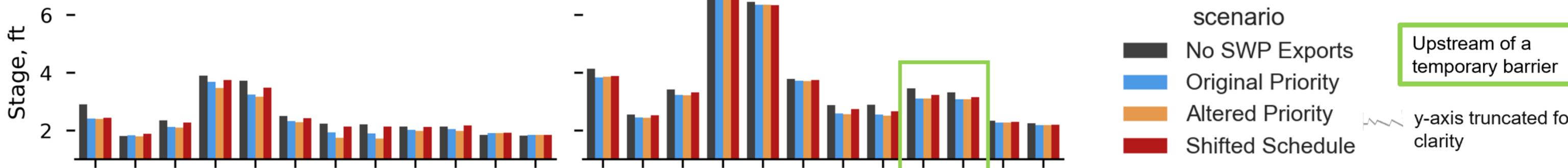
Station = OH1



Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec  
Months

Station = ODM

Station = OLD



Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec  
Months

scenario

- No SWP Exports
- Original Priority
- Altered Priority
- Shifted Schedule

Upstream of a temporary barrier

y-axis truncated for clarity

