

LAKE OKEECHOBEE WATERSHED PROJECT

Modeling Sub-Team

Storage Screening
September 21, 2016

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TOPICS



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- Screening Tools and Techniques
- Overview of RESOPS screening model
- Example: Screening Techniques
- Review of Screening Outcomes for Reservoir Storage
- Review of Screening Outcomes for Reservoir Storage + Aquifer Storage & Recovery (ASR)
- Review of Screening Outcomes for Reservoir Storage + Aquifer Storage & Recovery (ASR) + Deep Injection Well (DIW)
- Summary of Key Observations



Screening Tools and Techniques



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- The detailed regional modeling tool for the LOWP is the Regional Simulation Model Basin (RSMBN) as presented at the August PDT.
- To help identify what should be analyzed with detailed modeling tools, the Reservoir Sizing and Operations Screening (RESOPS) model will be used.
- The benefit of screening is to quickly test the performance of various configurations and scenarios to identify feasible ideas for further in-depth analysis.
 - Not a replacement for the detailed regional models
 - Can reduce the burden on the more complicated regional models (RSMBN) and inform project decision making efforts.
- Optimization and inverse modeling techniques can be used to automatically evaluate thousands of operating rules and select the best performers.

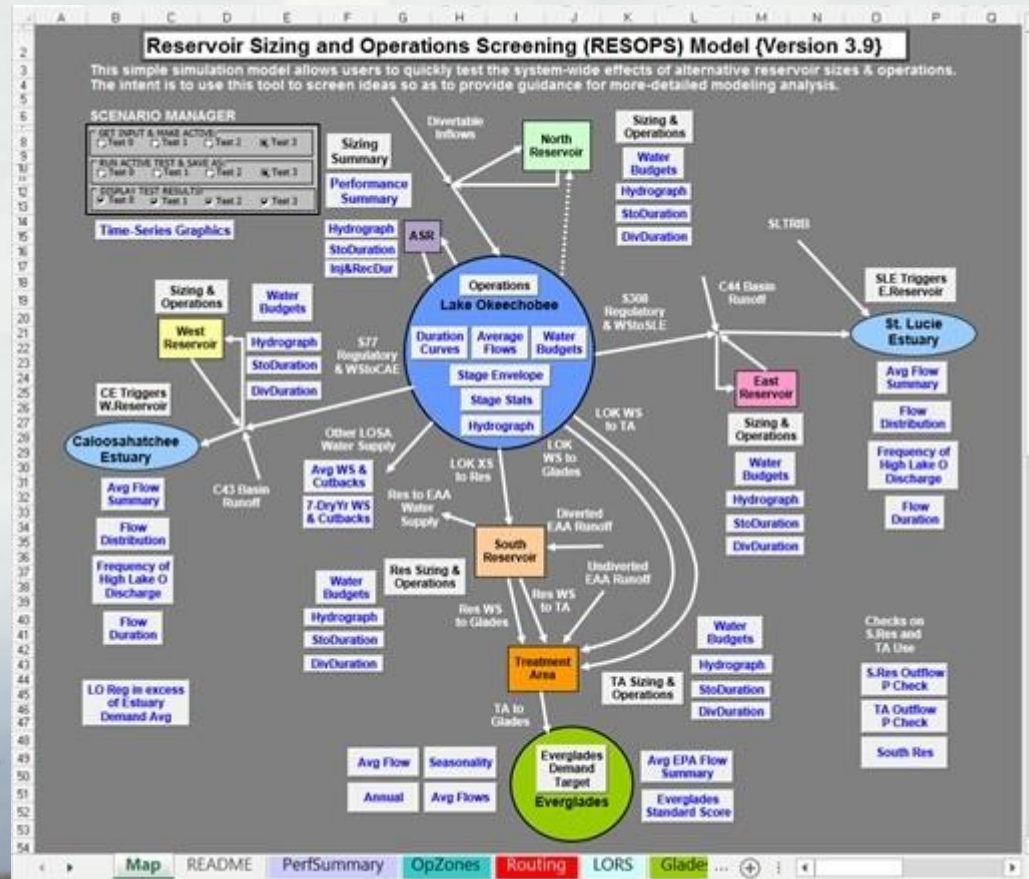


REservoir Sizing and OPerations Screening (RESOPS) Model



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- Coarse-scale Water Management Simulation Model
- Provides rapid screening-level testing of the integrated effects of reservoir sizes and proposed operating rules for...
 - Lake Okeechobee,
 - Reservoirs (EAA, C43, C44, North)
 - Aquifer Storage & Recovery (ASR)
 - Deep Injection Wells (DIW)
 - Flows to the Everglades
- Performs 41-year continuous simulations (monthly time-step) of the hydrology and operations of the water management system
- 1965-2005 rainfall years
- Runtime = ~ 10 seconds using Excel 2013





Potential Uses of Screening with RESOPS



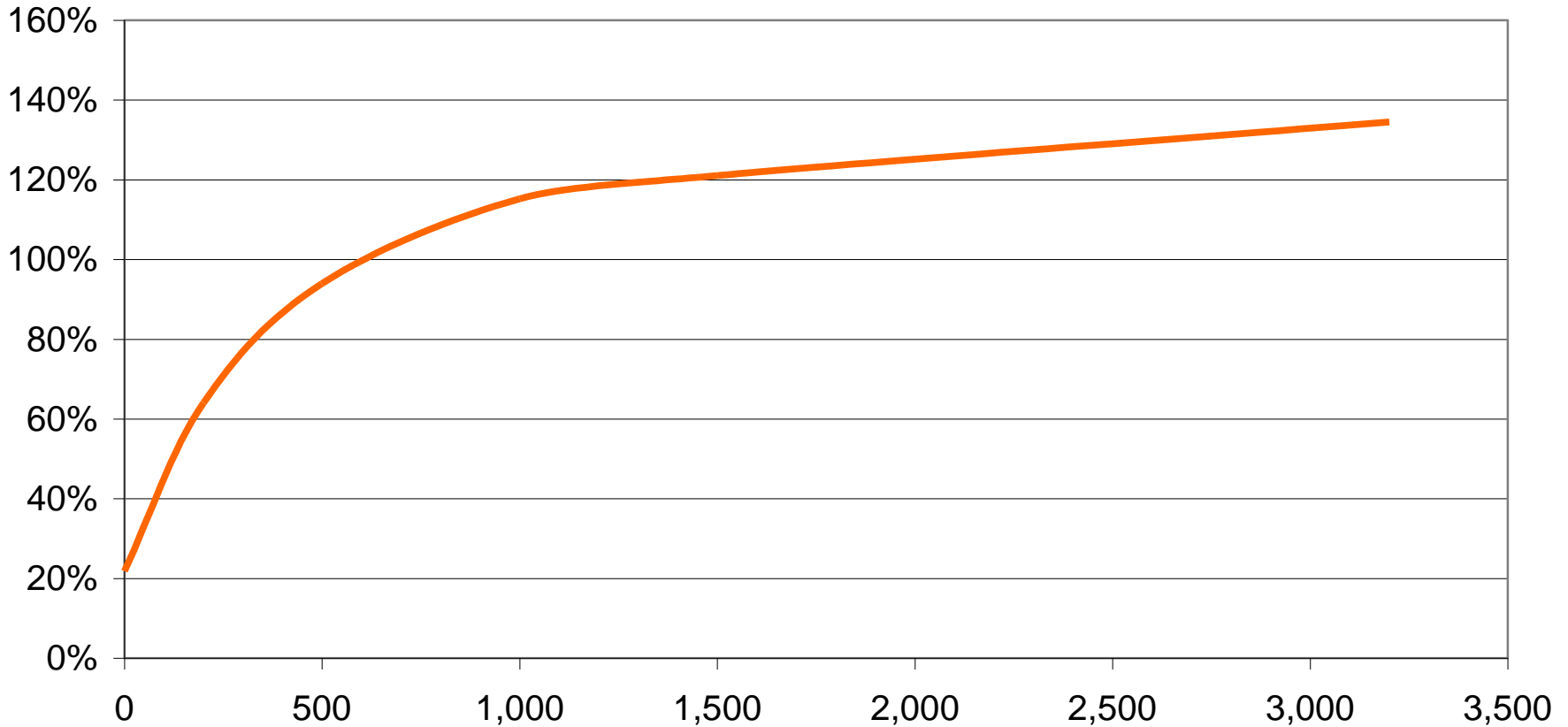
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- Help identify an overall storage goal for the LOW Project using the performance of a range of storage volumes (150Kac-ft to 350kac-ft)
- Comparing the viability of proposed management measures (e.g. reservoirs, ASR, etc...)
- Informing the discussion on what objectives are most critical to design (e.g. some Performance Measures more sensitive than others)
- Begin the process of identifying operational strategies that will work with proposed infrastructure changes



Example: Screening Techniques

Percentage Increase with the Addition of a Management Feature





LOWP Screening Approach



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- A range of storage options was evaluated (focused on 150 kac-ft to 350 kac-ft) in a future scenario (FWO) that assumes Central Everglades (CEPP), C43 Reservoir, C44 Reservoir, A1-A2 FEB, etc.
- For screening, storage reservoirs are assumed to be 14 ft deep.
 - Early evaluations with the model showed little sensitivity to reservoir depth.
 - Given the small modeled changes in performance at different assumed depths, considerations from the Engineering Sub-Team will be key in determining optimal reservoir depths.
- RESOPS accommodates the additional features (e.g. a storage reservoir) and modifies operations while considering the desired estuary performance in combination with desired Lake stage ranges. (Optimization)
- CEPP deliveries south were kept constant for all screening simulations.
- Sensitivity analysis to evaluate the added benefits of ASR and DIW were also performed.

Reservoir Storage Results





Performance Measure Estuary High Discharge Exceedance



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- One way of evaluating the performance of the Caloosahatchee and St Lucie Estuaries is to focus on times when regulatory discharges from S-77 and S-308 (located on Lake Okeechobee) become too large and contribute to high discharge conditions at S79 and S80 (located on the estuaries).
- This performance measure quantifies the number of months when flows from the Lake resulted in “high” discharge conditions to the estuaries.
 - Caloosahatchee Estuary: flows > 2800 cfs on average for the month at S-77
 - St. Lucie Estuary: flows > 2000 cfs on average for the month measure at S-308
- Basin runoff is a separate component of the performance measure and was not considered for screening.





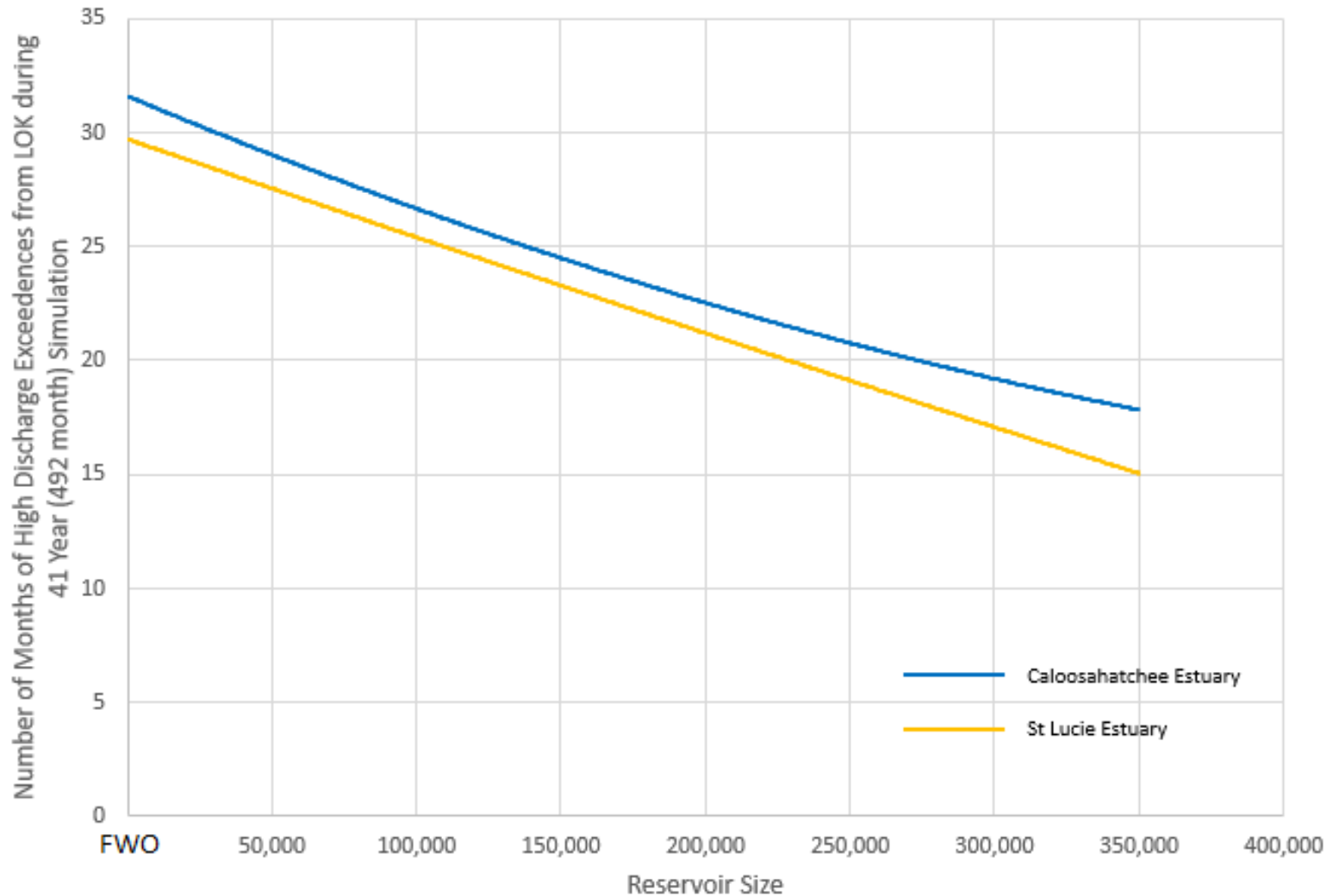
Results

Estuary High Discharge Exceedance



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Estuary High Discharge Months from Lake Okeechobee vs. Reservoir Size





Performance Measure Frequency of Estuary High Discharge Events



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- While considering the reduction in “high” discharge months resulting from Lake O. releases is critical, another way of looking at the data is to consider how frequently these type of months occur and whether LOWP can improve the length of time between years or events.
- The screening work considers a broad range of dry years (e.g. 1970’s), wet years (e.g. mid 1990’s), and years with significant hurricane activity (2003-2005).
- We will see that assumed storage provided by LOWP has the potential to improve not just the number of months, but also to reduce the number of years where high discharge months occur.





Results

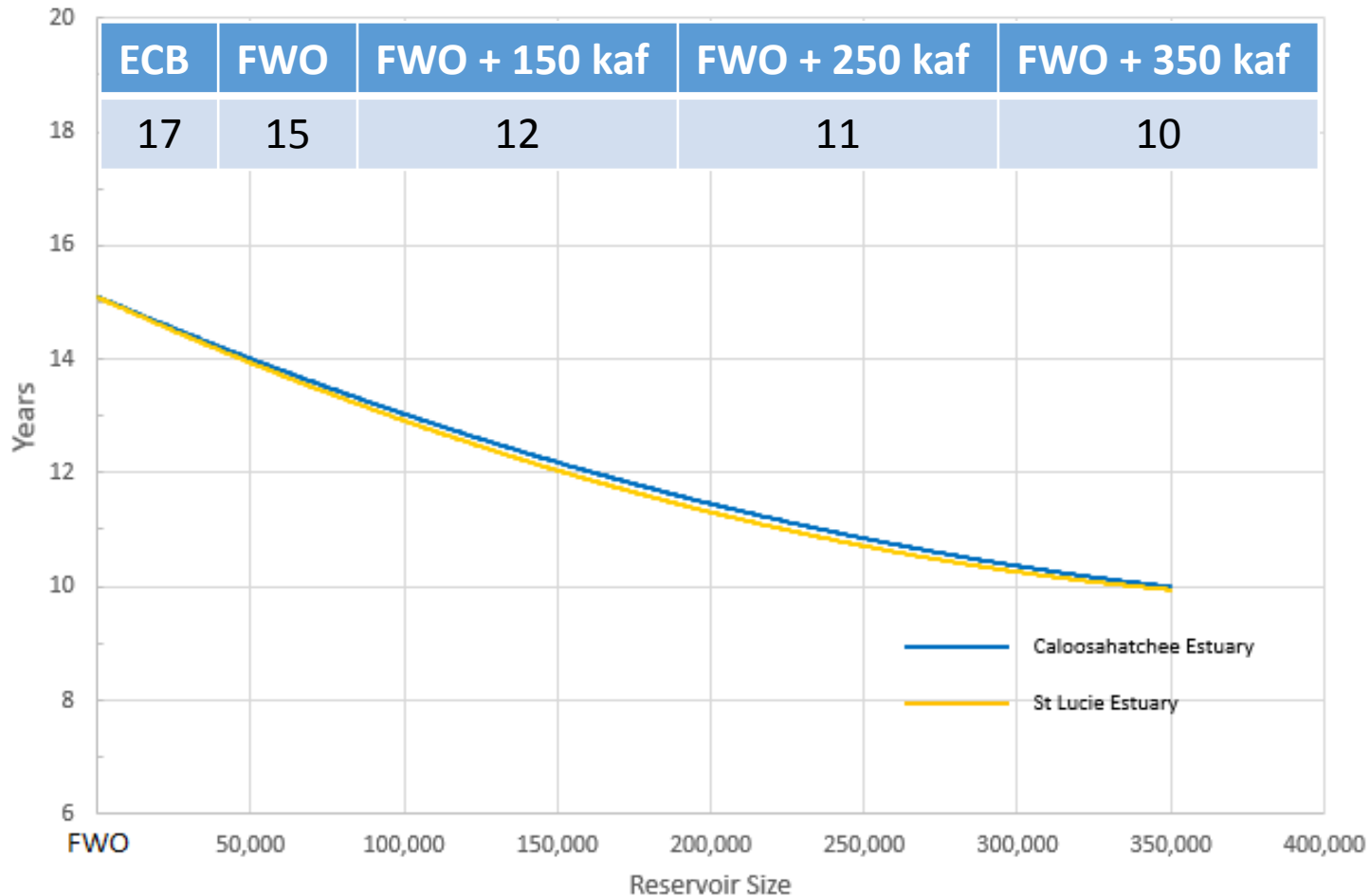
Frequency of Estuary High Discharge Events



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Modeling shows that addition of storage features reduces the annual frequency of high discharge event.

Number of Years (in 41 Years) With At Least 1 Month Having An Estuary High Discharge Event vs. Reservoir Size





Results

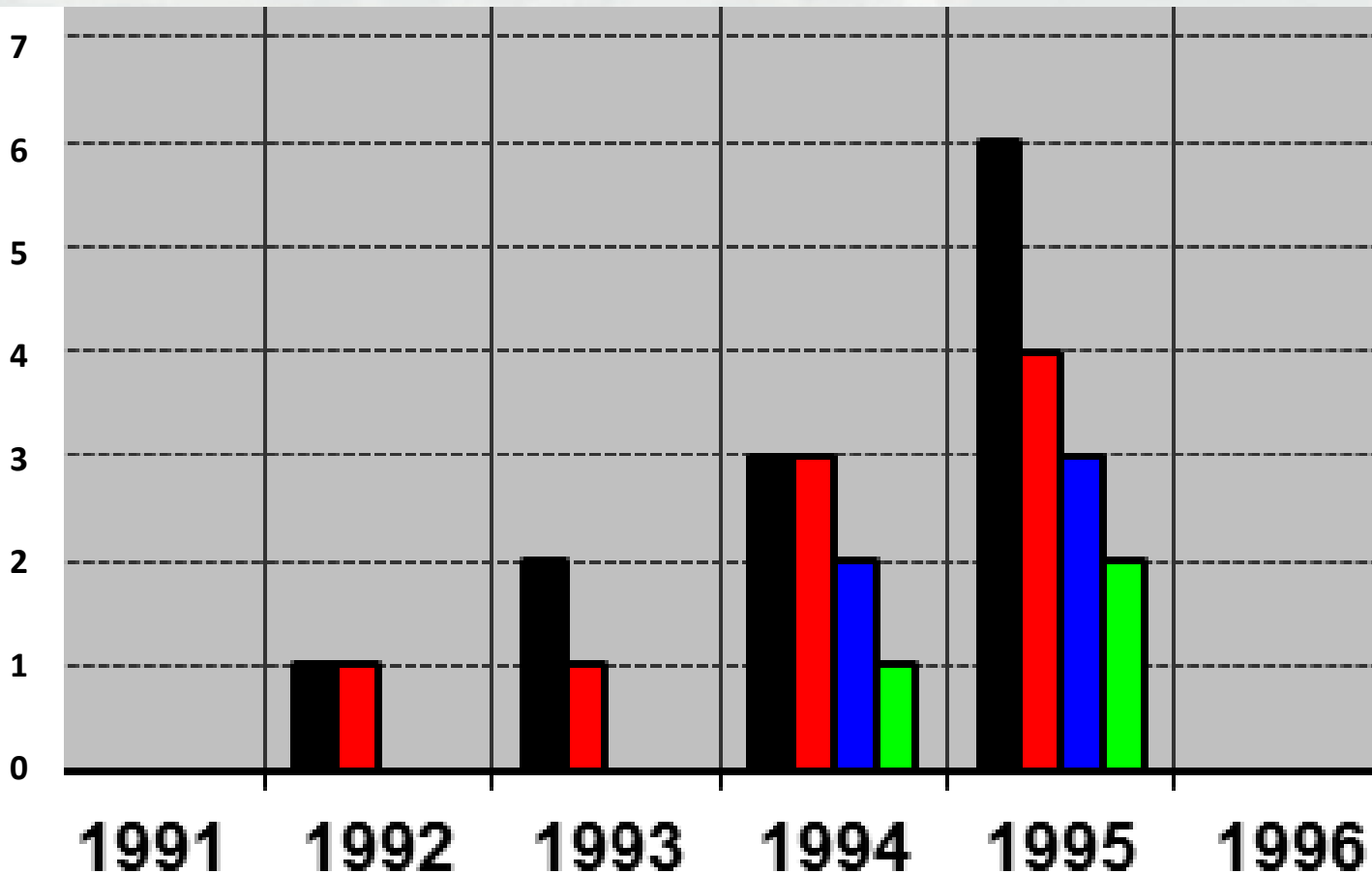
Frequency of Estuary High Discharge Events Caloosahatchee – Wet Period



ESTUARY PERFORMANCE IMPROVES WITH LARGER NORTHERN RESERVOIRS

- **ECB** and **FWO** show four consecutive years with at least one month
- **250k** reduces 4 consecutive years to 2 consecutive years (5 months)
- **350k** reduces 4 consecutive years to 2 consecutive years (3 months)

Number of Months





Performance Measure Lake Okeechobee Stage Envelope Standard Scores



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- Stage envelope standard scores measure the departure of the lake stage from the LORS defined upper and lower lake stage limits.
 - **Standard score above** measures the departures of the lake stage above the upper lake stage limit.
 - **Standard score below** measures the departures of the lake stage below the lower lake stage limit.
- A higher score means fewer departures and better in-Lake habitat and ecology.



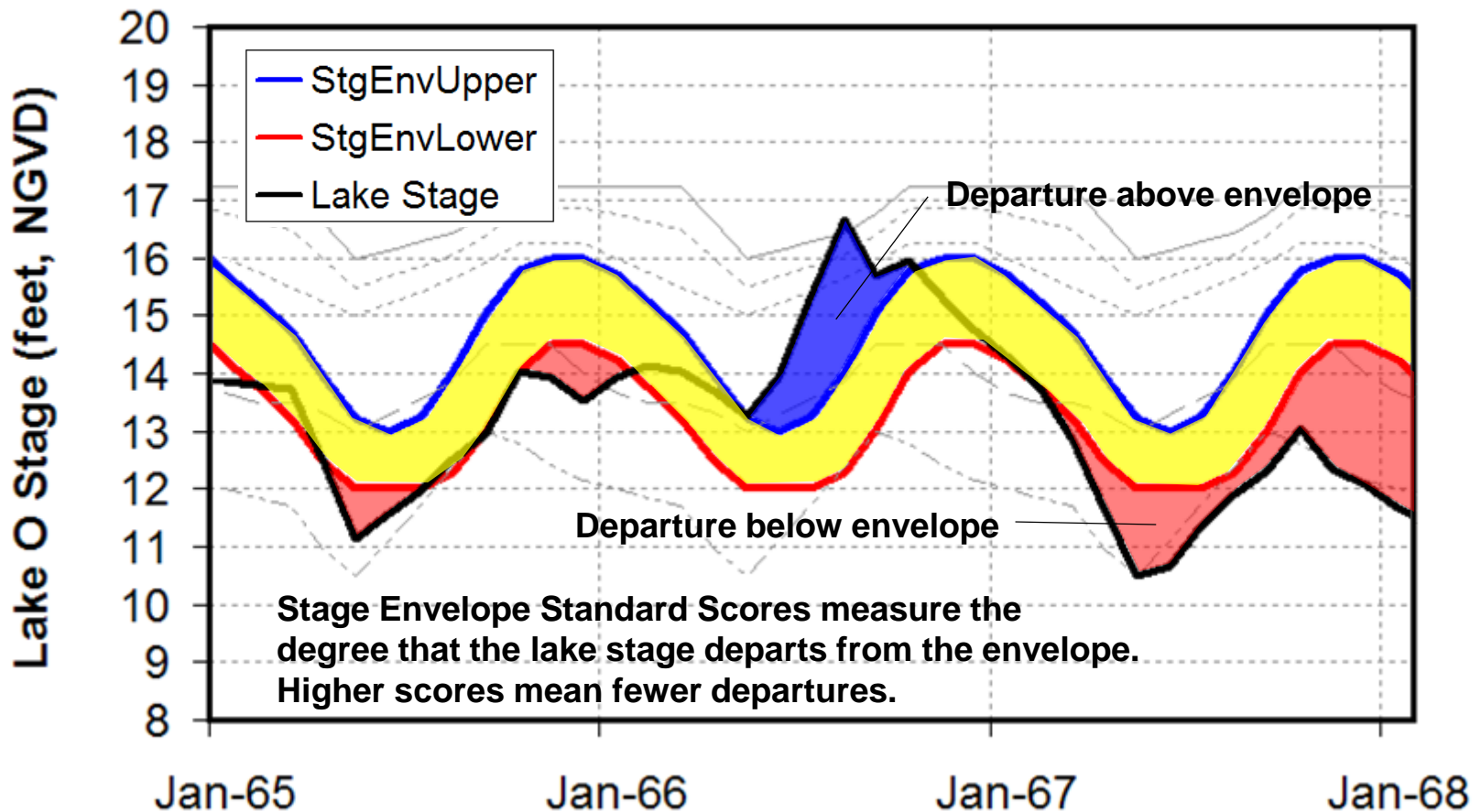


Performance Measure Stage Envelope Standard Scores



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Lake Okeechobee Stage Hydrograph and Envelope



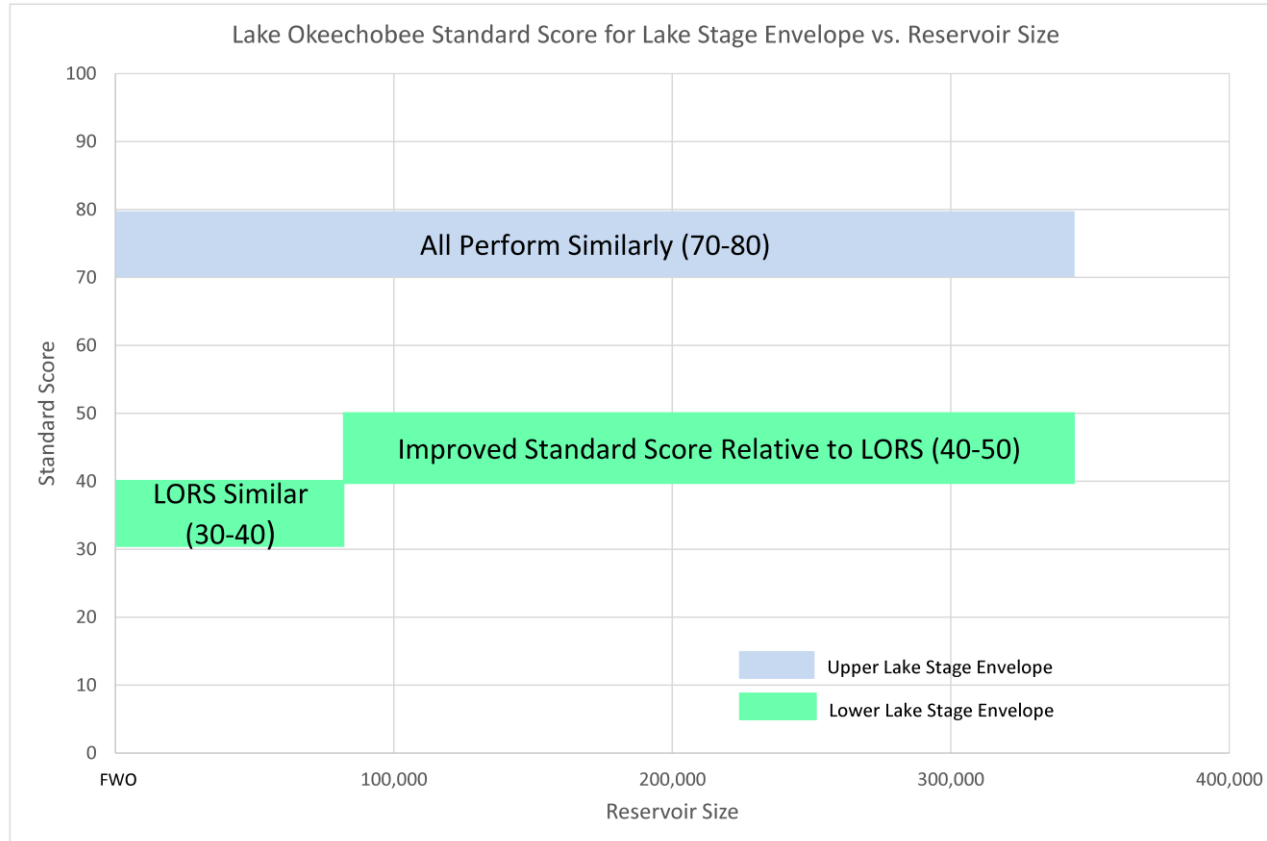


Results

Lake Okeechobee – Stage Envelope Standard Scores



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- Improved lower standard score identifies a potential benefit lake ecology and/or more volume that could be sent to the Western Everglades Restoration Project.
- There is a benefit observed, but results are relatively insensitive to reservoir size.

Reservoir Storage + ASR Results





ASR Management Measure



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- Four ASR sensitivity simulations using a feasible range as identified by the PDT:

ASR Sensitivity Run	Number of ASR Wells	Injection/Recovery Limit (MGD)	Injection/Recovery Limit (ac-ft/mo)	Injection/Recovery Limit (cfs)
1	20	100	9,341	186
2	40	200	18,682	372
3	60	300	28,023	557
4	80	400	37,364	743

- Screening assumed a 70% recovery efficiency which is consistent with the original RESTUDY (CERP) assumption. Sensitivity analysis indicates 70% recovery efficiency may be a reasonable and conservative planning assumption.
- In the modeling, ASR is connected to Lake Okeechobee for inflow/outflow (similar to assuming ASR would be located near a reservoir or near Lake Okeechobee for accessing lake water).
- “Proactive” operations are critical to maximize the efficiency of ASR due to its limited injection/recovery capacity.

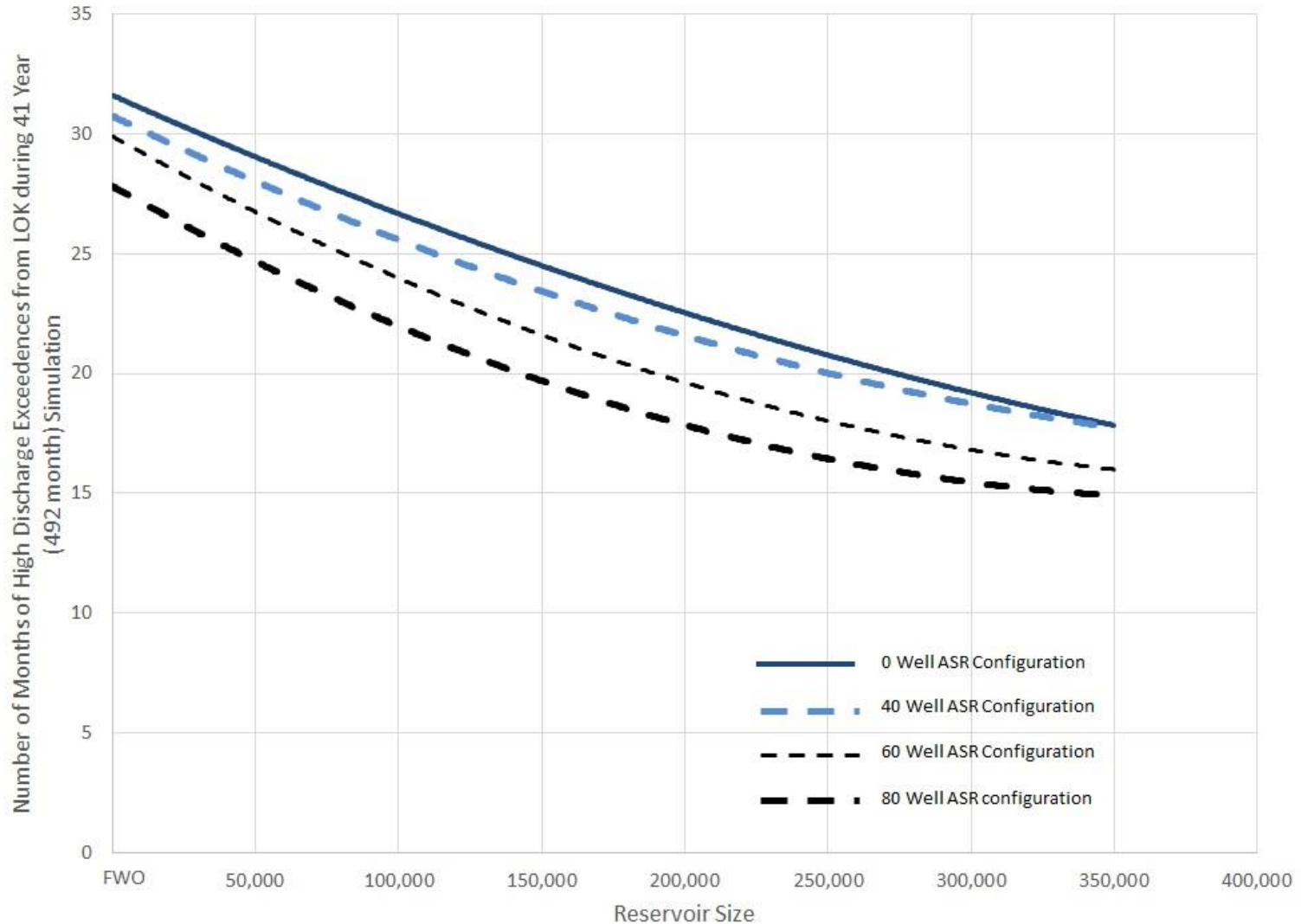


ASR Results – Caloosahatchee Estuary



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Caloosahatchee Estuary High Discharge Months from Lake Okeechobee vs. Reservoir Size



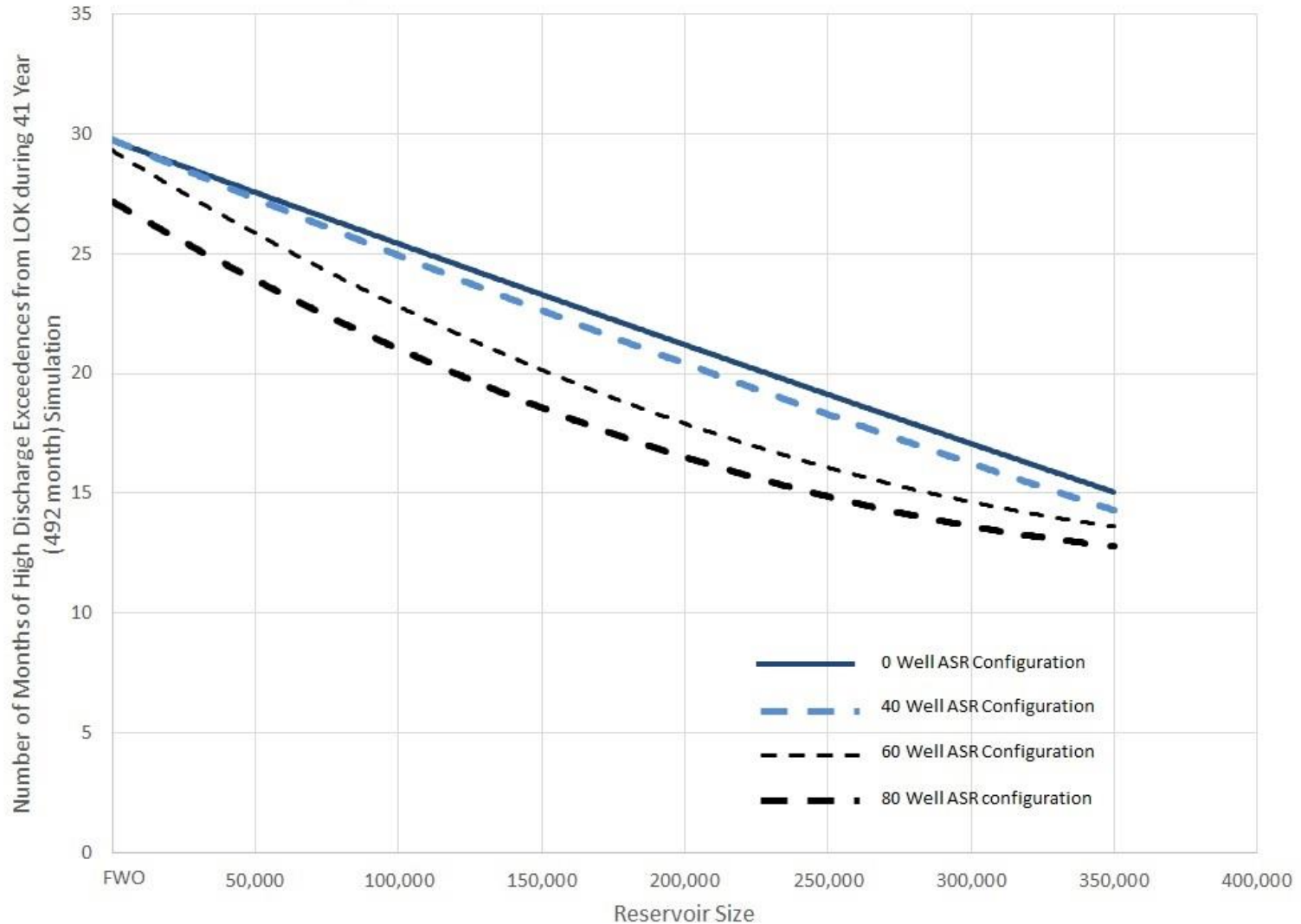


ASR Results – St Lucie Estuary



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St Lucie Estuary High Discharge Months from Lake Okeechobee vs. Reservoir Size



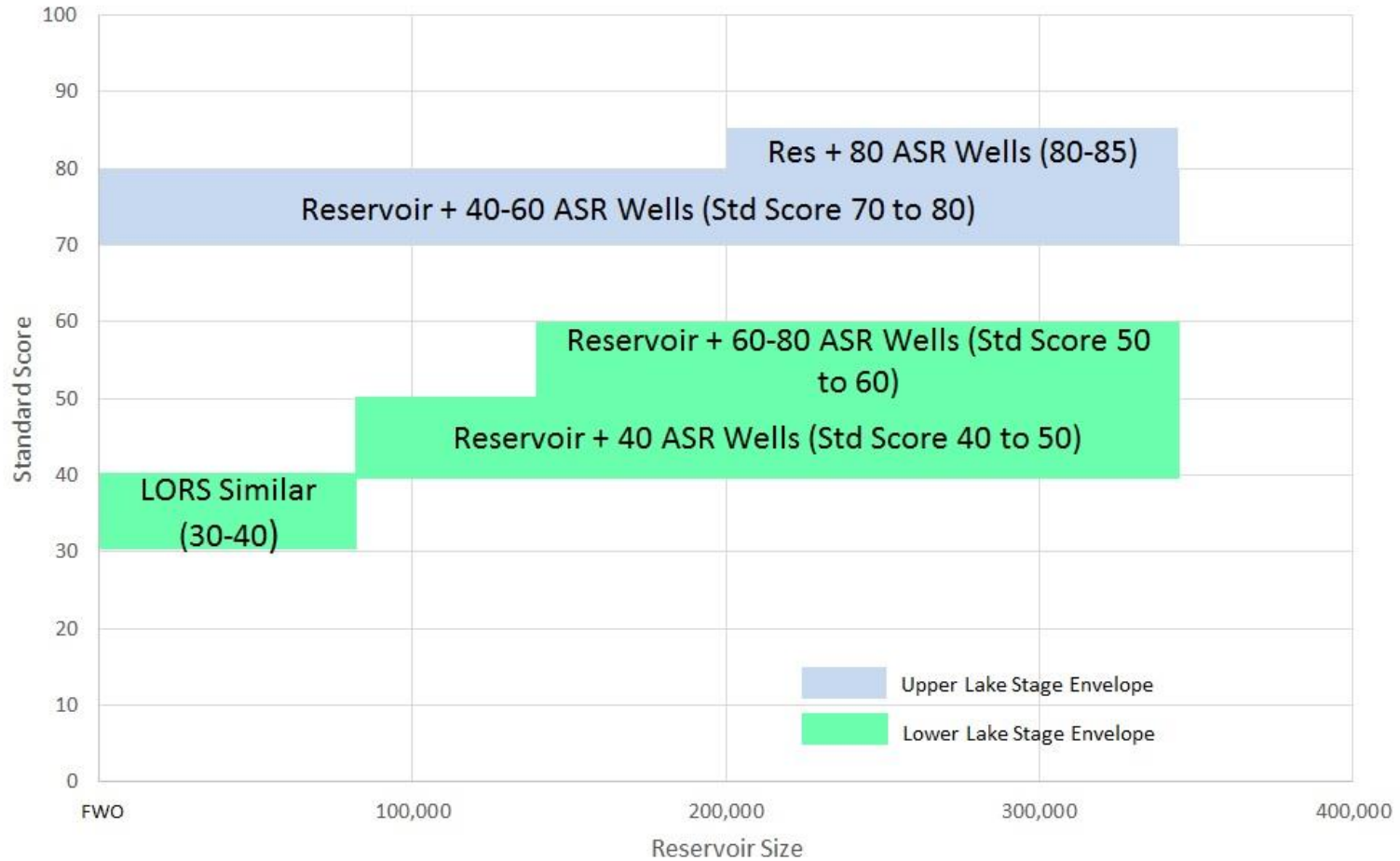


Results

Lake Okeechobee – Stage Envelope Standard Scores



Lake Okeechobee Standard Score for Lake Stage Envelope vs. Reservoir Size



- ASR improved the standard score. This identifies a potential benefit lake ecology and/or more volume that could be sent to the Western Everglades Restoration Project.



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Reservoir Storage + ASR + DIW Results

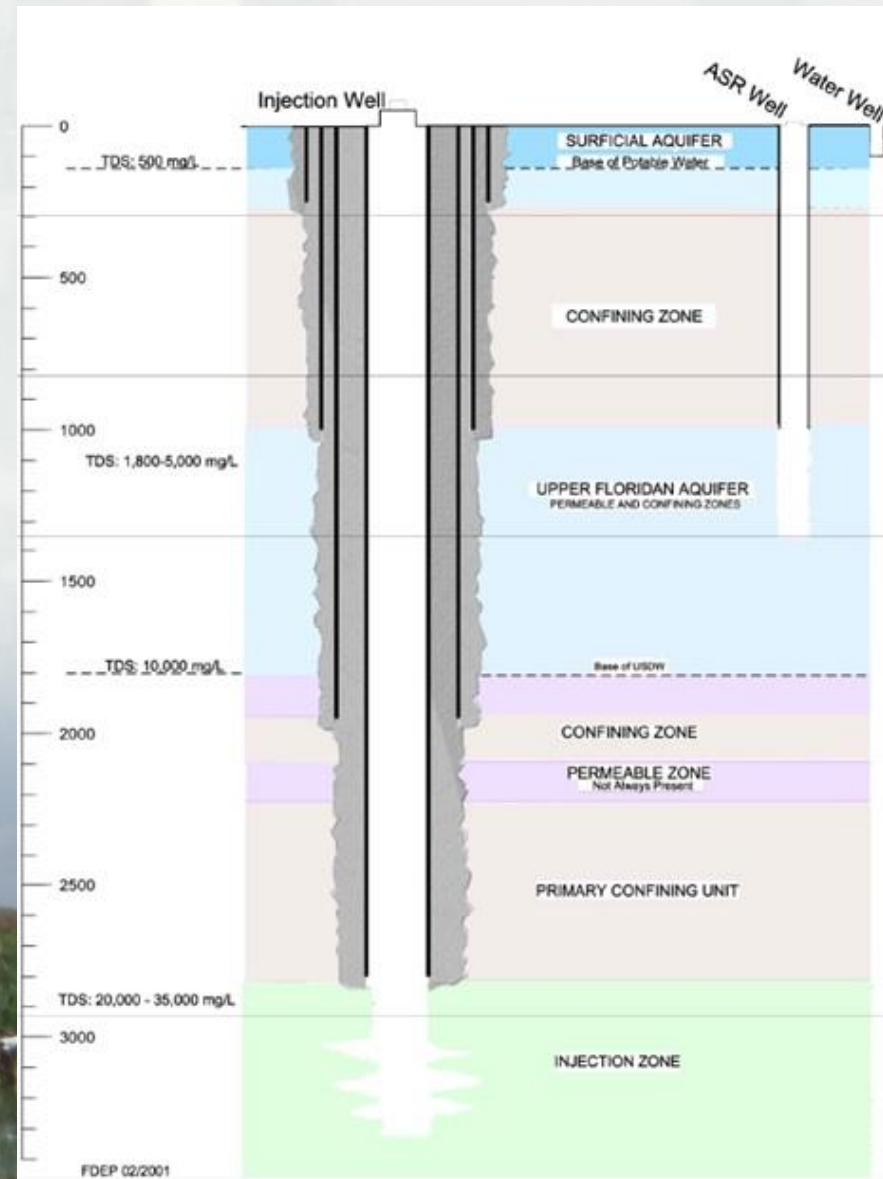




Deep Injection Wells



- A management feature that will provide extra capacity to lower the Lake level before a high discharge event impacts the estuary.
 - Only inject when there would be regulatory releases in excess of Estuary needs (e.g. flows that would otherwise go to tide).
- DIW are high capacity that inject water into a confined aquifer that's 3,000 ft deep.
- For RESOPS, 30 DIW's each with a capacity of 4,048 ac-ft/mo [67 cfs] totaling 121,400 ac-ft/mo [2,010 cfs] were assumed.



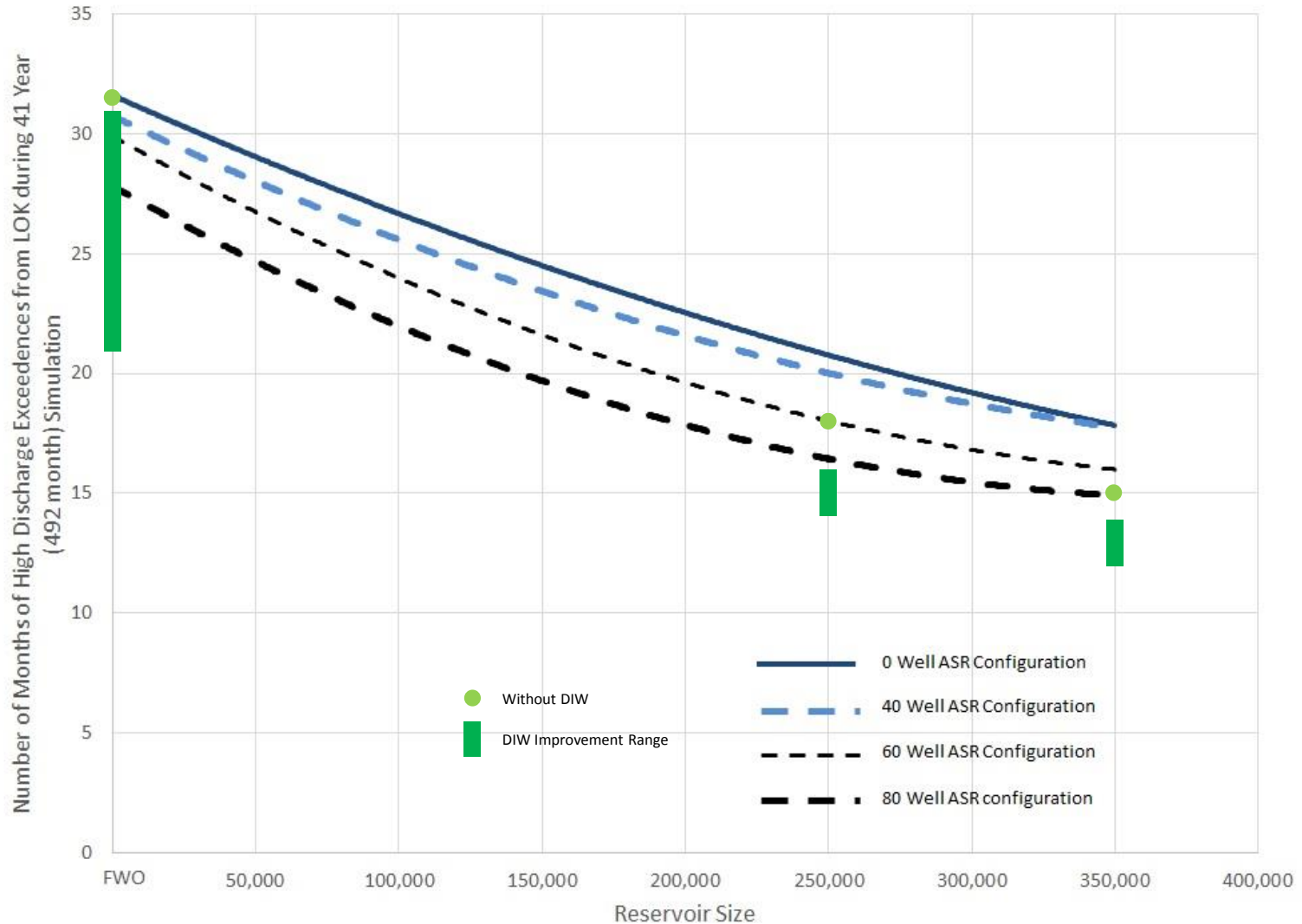


Reservoir + ASR + DIW Results Caloosahatchee Estuary



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Caloosahatchee Estuary High Discharge Months from Lake Okeechobee vs. Reservoir Size



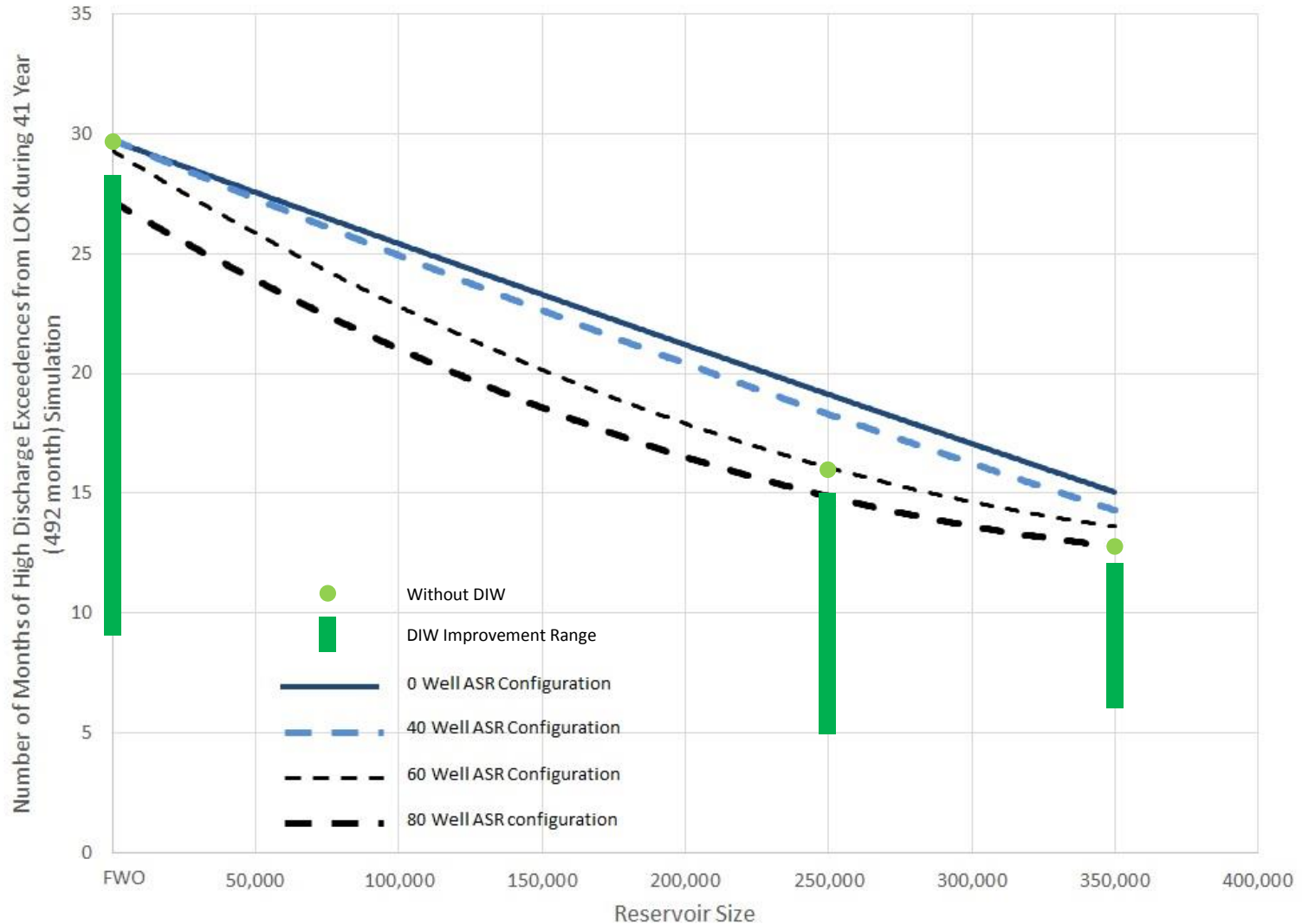


Reservoir + ASR + DIW Results St Lucie Estuary



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St Lucie Estuary High Discharge Months from Lake Okeechobee vs. Reservoir Size





Summary of Key Observations



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Estuary Performance

- Screening shows an increase in performance (e.g. fewer high discharges is better) with increasing reservoir size. These trends can be further improved with the addition of ASR or DIW.
- The LOWP is capable of producing significant benefits by demonstrating up to 50% reduction in high discharge releases (from 30+ months to ~15 months).
- These potential benefits are reinforced by observing that the number of years with at least of 1 month of a high discharges could be substantially reduced (e.g. 15 years to 11 years with 250,000 ac-ft reservoir storage) .

Lake Okeechobee Performance

- Screening shows that the LOWP has the potential to create an increase in low Lake stage performance. Reservoir, ASR, and DIW can achieve these outcomes.

