Preliminary Viability Assessment (PVA) for Lake Mendocino Forecast Informed Reservoir Operations (FIRO)

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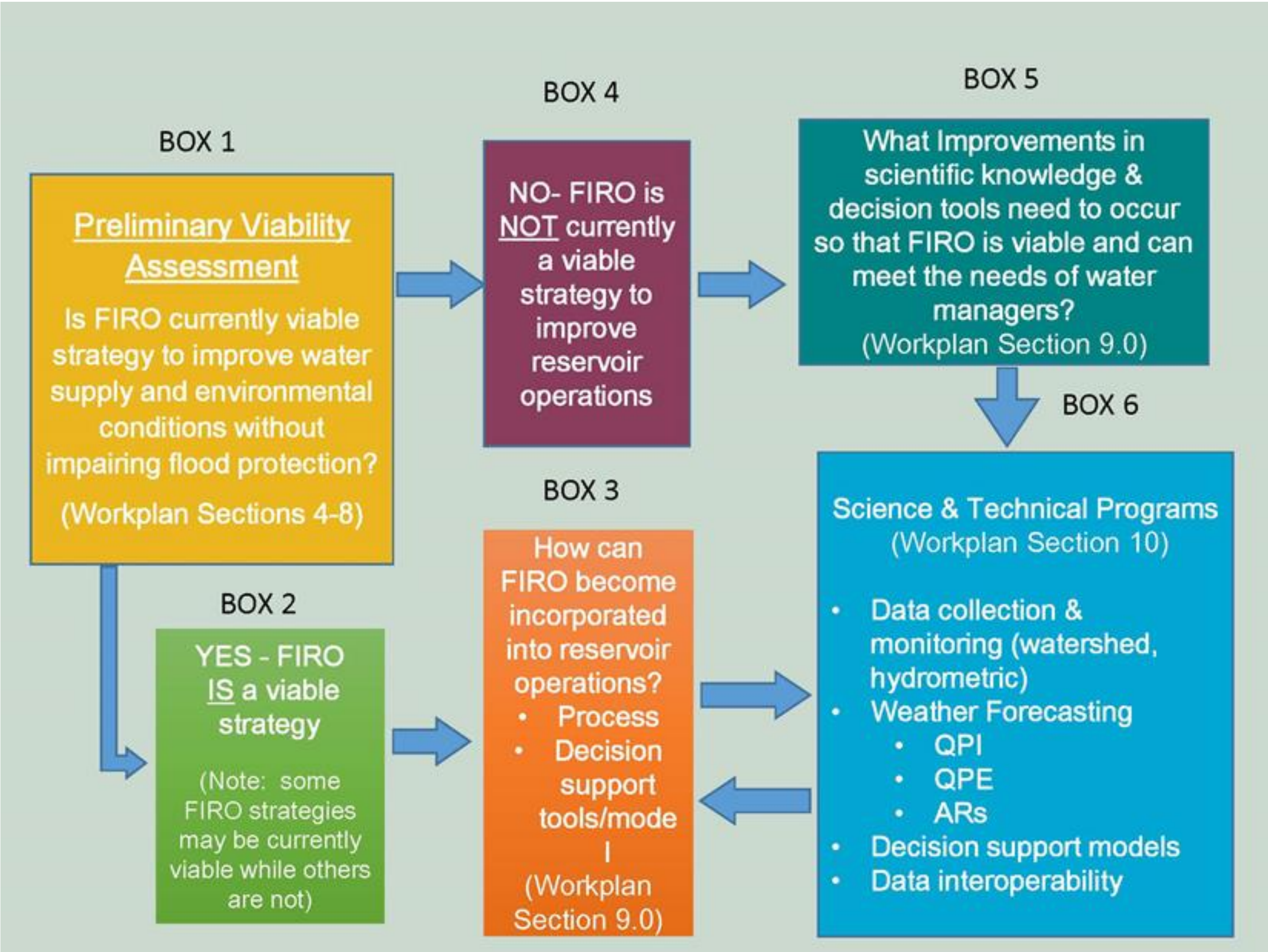
Why Conduct a PVA?



Key Questions for the PVA

1. If FIRO is implemented, will operation improve reliability in meeting water management objectives and ability to meet environmental flow requirements, and to what extent?

2. If FIRO is implemented, will operation adversely affect flood risk management in the system? If so, where and to what extent can that be mitigated?

3. What meteorological and hydrological forecast skill is required to enable FIRO to be implemented? Is current forecast skill for landfalling ARs (and their associated heavy precipitation and runoff) and other extreme precipitation events adequate to support FIRO, and what improvements would be needed to enable full implementation of FIRO for Lake Mendocino?

PVA Approach

The PRELIMINARY Viability Assessment was *not* designed to be comprehensive and conclusive.

The goal was/is to establish (to the satisfaction of the steering committee and the funding agencies) whether or not the strategy has merit for Lake Mendocino worthy of further pursuit.

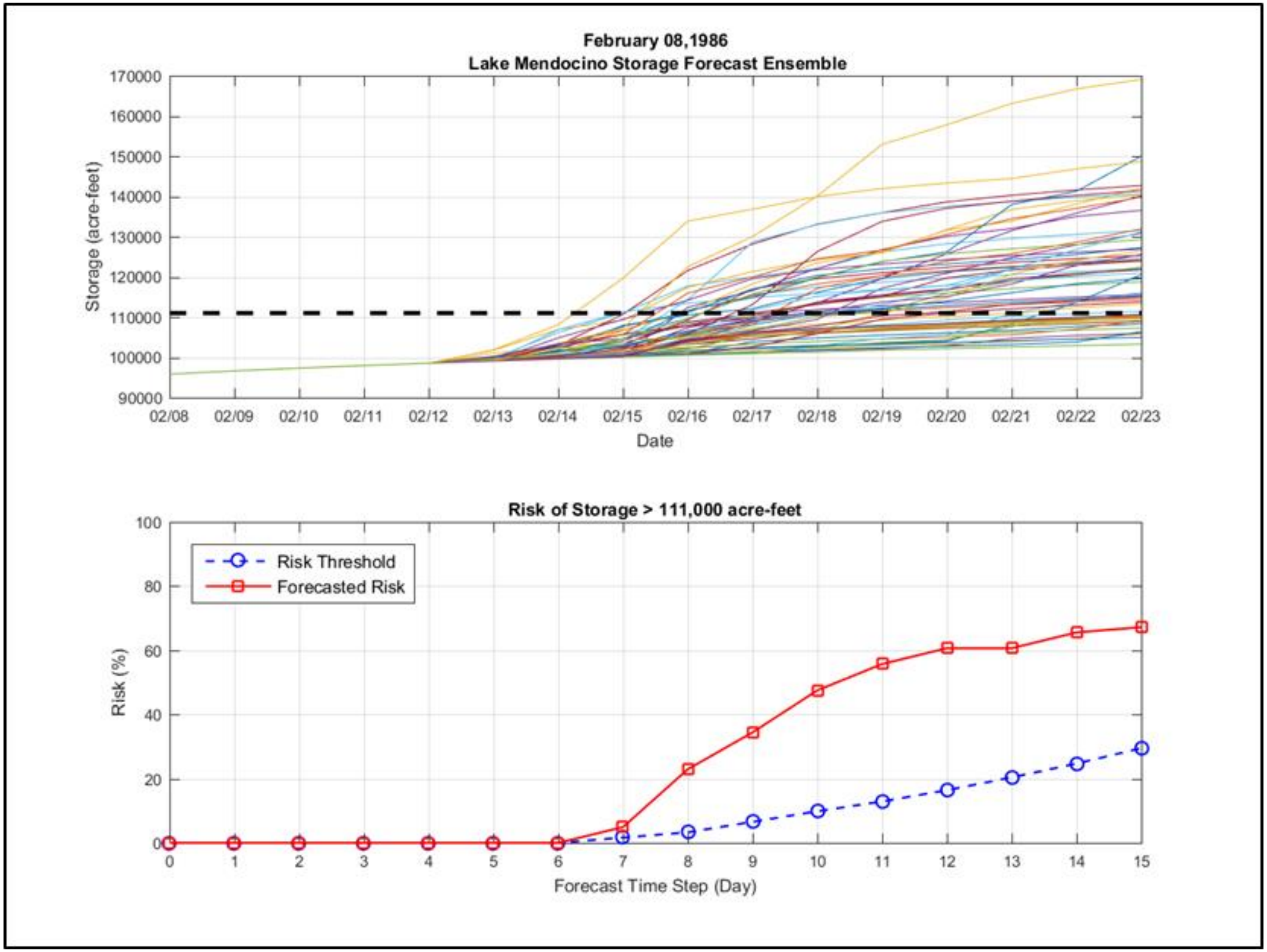
PVA Components

- A study by SCWA to assess if explicit use of forecasts can yield improved water supply reliability without impacting flood mitigation
- A study by USACE HEC to assess if using forecasts leads to compromised flood risk objectives
- A series of studies by CW3E to assess existing forecasts and their suitability for use in FIRO assessments

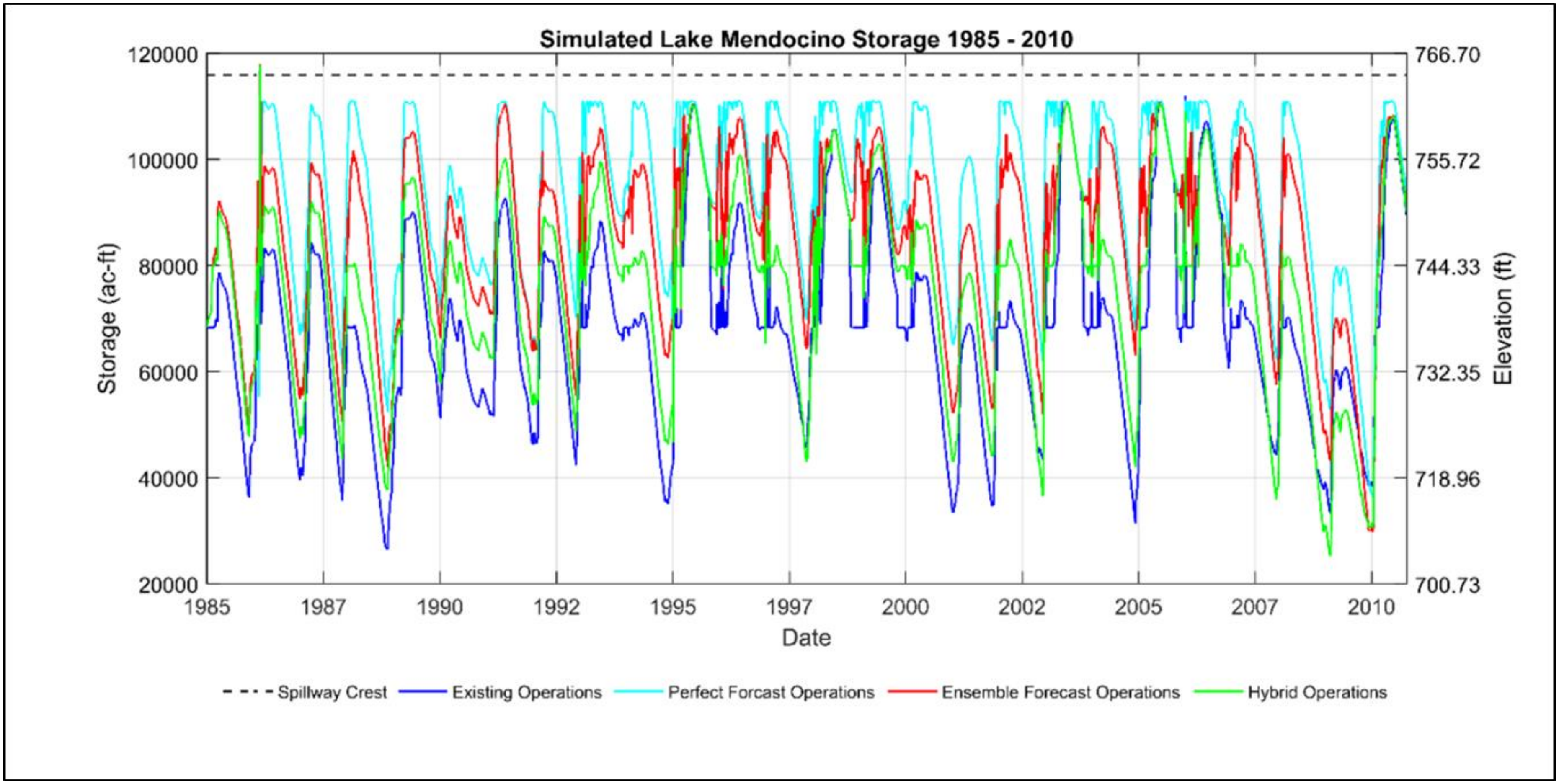
SCWA Experimental Design

- Daily time step MATLAB model
- Considers release restrictions, rate of change limits, downstream controls and objectives
- Run in 4 modes
  - Existing (rule curve) operations
  - Perfect forecast assumption
  - Ensemble Forecast Operations (EFO)
  - Hybrid EFO with elevated mid-winter conservation storage
- EFO and Hybrid EFO
  - Mitigate “risk” of reaching 111 KAF storage in Lake Menocino
  - Leverages 1985-2010 HEFS reforecast of inflow and ds locals (15-day)

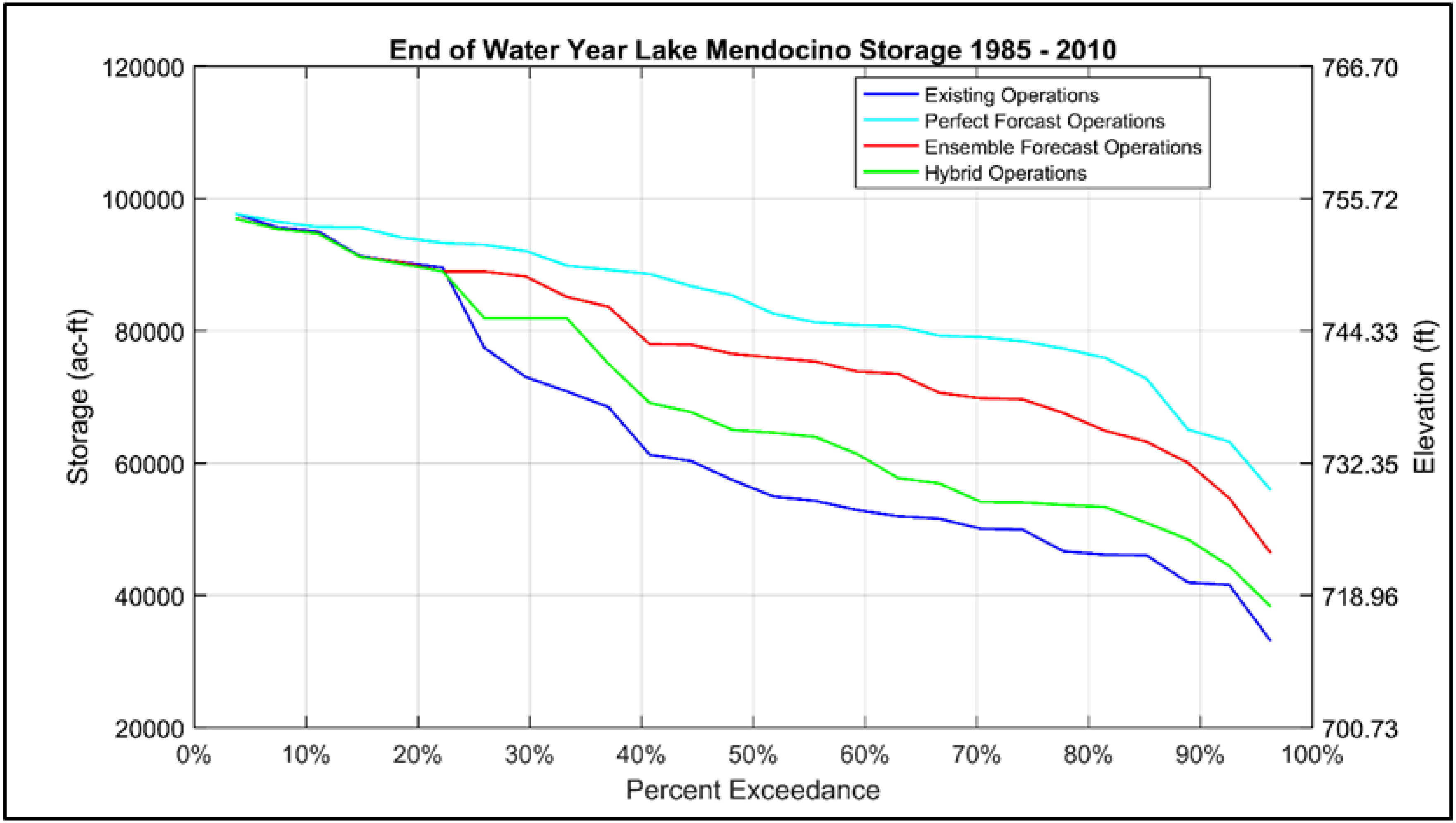
SCWA EFO Process



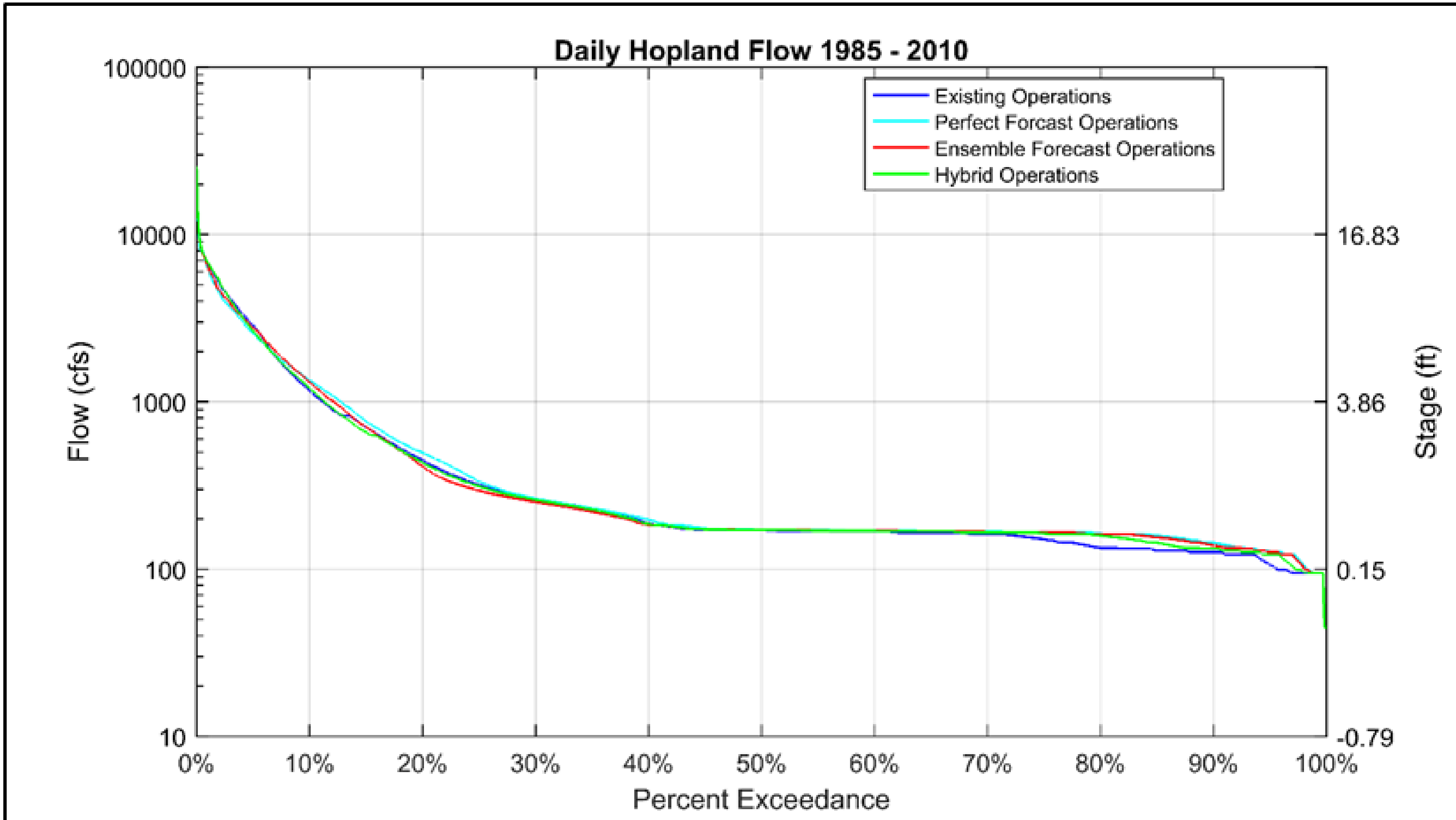
SCWA Results



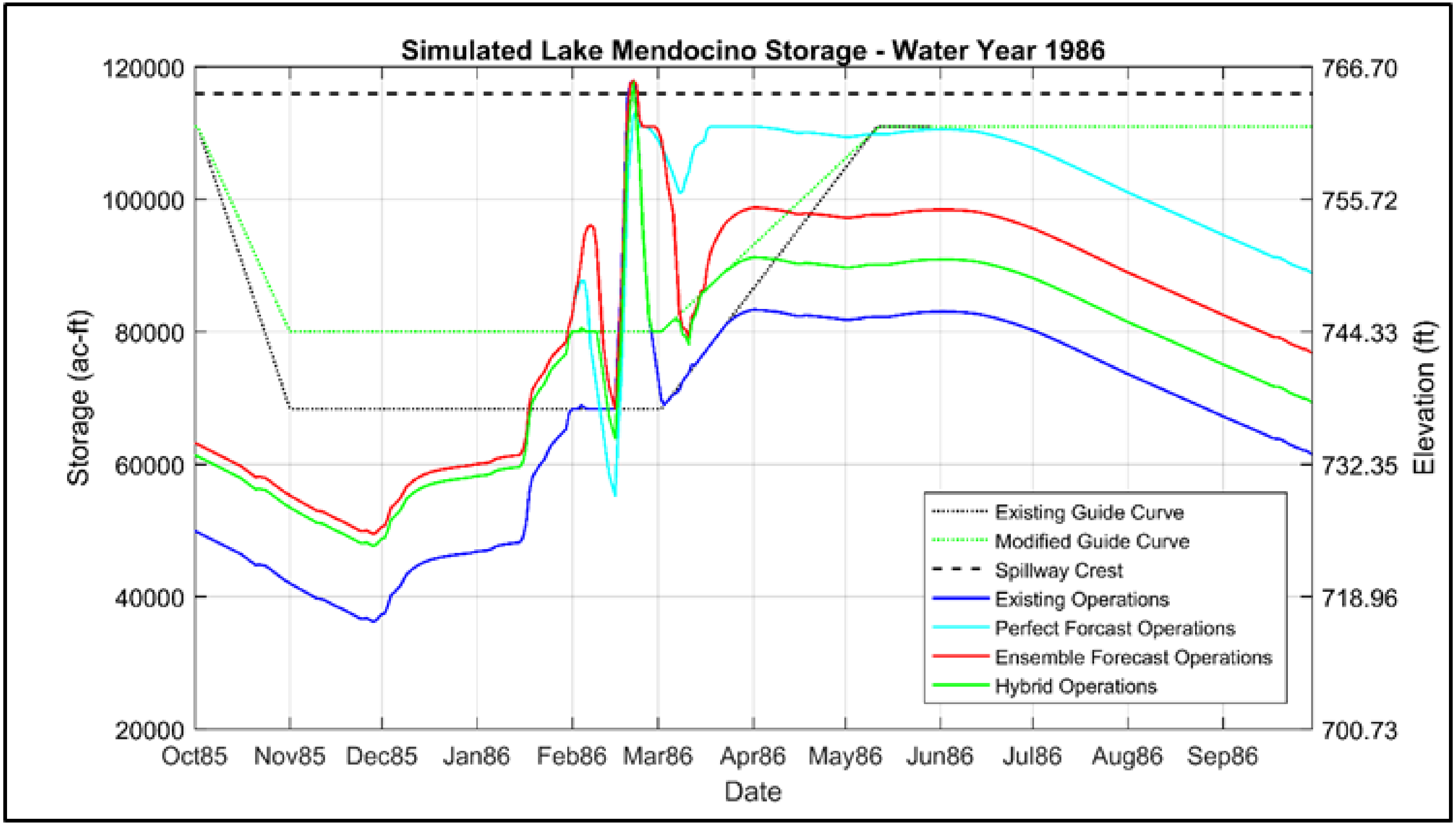
SCWA Results



SCWA Results



SCWA Results



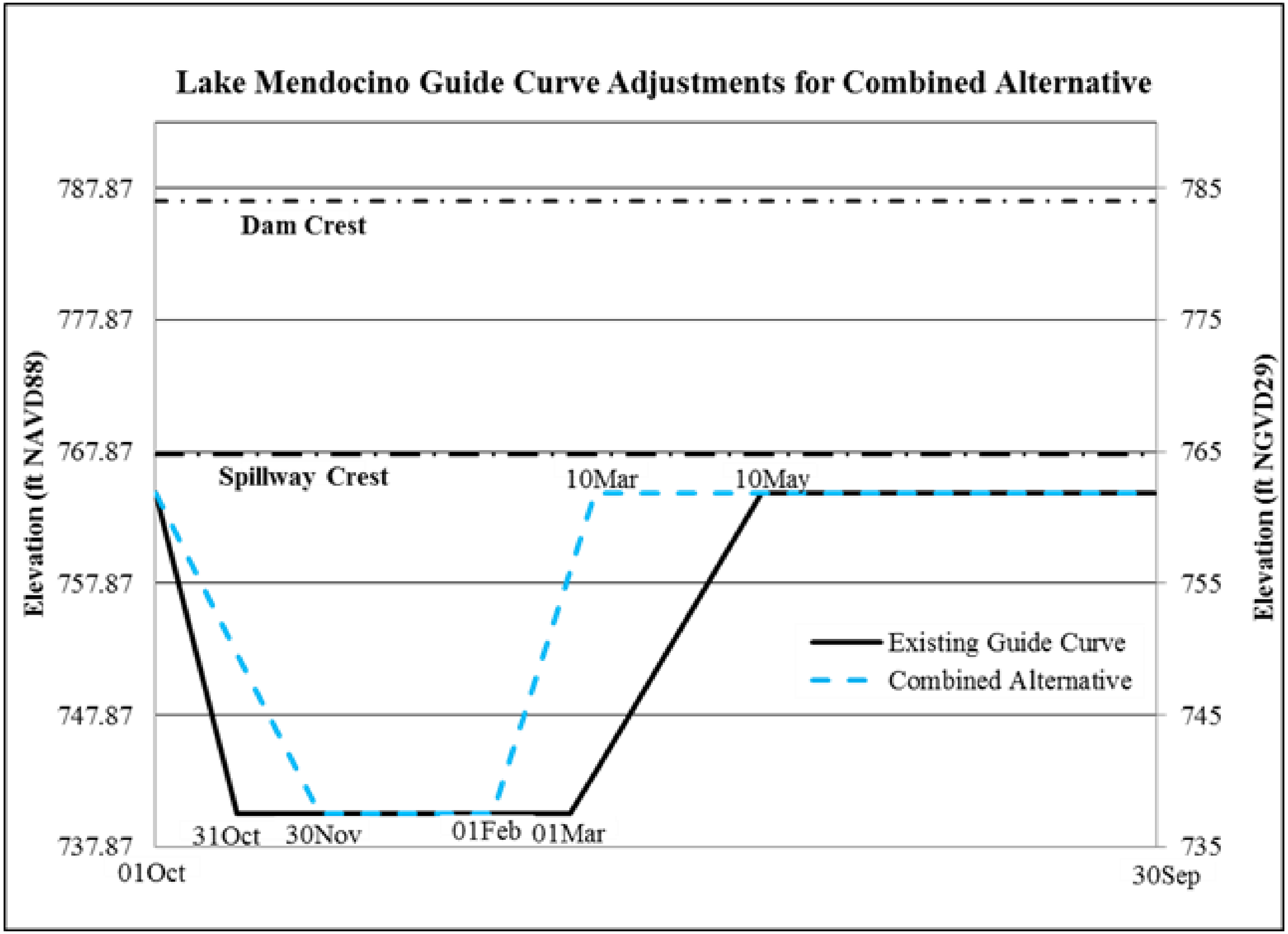
HEC Experimental Design

- Assess
  - Flood hazard (frequency and magnitude of flows)
  - Performance of CVD to reduce flood hazard
  - Consequence (damages) of excessive flows
- System Modeling
  - HEC HMS (watershed response)
  - HEC ResSim (reservoir operations)
  - HEC RAS (routing)
  - HEC FIA (risk analysis and impacts)
- Rainfall sequences
  - Statistically derived
  - Historical (1950-2010)

HEC Experimental Design

- Metrics
  - Average Annual Damage (AAD)
  - Expected Annual Damage (EAD)
  - WSEL and flow at CVD and downstream locations (stage frequency curves)
  - Available CVD storage for conservation
- Alternatives Considered
  - Existing operations
  - Encroach – Perfect Forecasts
  - EncroachWIF – Imperfect Forecasts
  - Combined hybrid operations

HEC Experimental Design



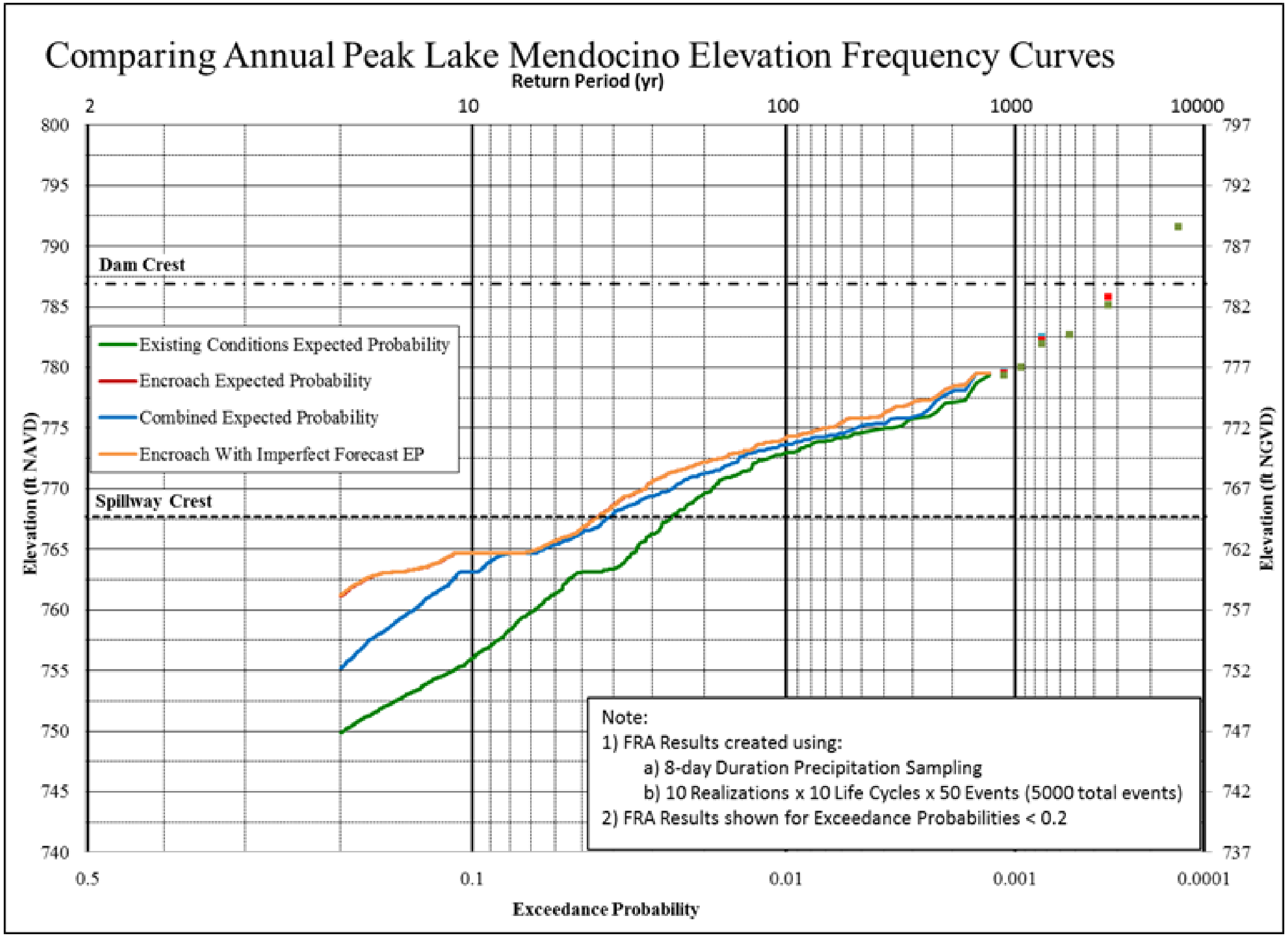
HEC Results

Table 10. Summary of flood risk assessment results

Alternative (1)	POR compute (60 years, 1951-2010) AAD ($ million) (2)	POR compute (60 years, 1951-2010) Increase in AAD from existing[1] ($ million) (3)	FRA compute (5,000 events) EAD ($ million) (4)	FRA compute (5,000 events) Increase in EAD from existing[2] ($ million) (5)
Existing Conditions	6.10	—	10.40	—
Combined (complex, perfect forecast)	6.10	0	10.40	0
Encroach (simple, perfect forecast)	6.10	0	10.50	0.10
EncroachWIF (simple, imperfect forecast)	6.10	0	10.50	0.10

1. Increase = FIRO alternative - Existing Condition.

HEC Results



Comparing Annual Peak Lake Mendocino Elevation Frequency Curves
Return Period (yr)
2
10
100
1000
10000
Dam Crest
Spillway Crest
Existing Conditions Expected Probability
Encroach Expected Probability
Combined Expected Probability
Encroach With Imperfect Forecast EP
Elevation (ft NAVD)
Elevation (ft NGVD)
800
795
790
785
780
775
770
765
760
755
750
745
740
797
792
787
782
777
772
767
762
757
752
747
742
737
0.5
0.1
0.01
0.001
0.0001
Exceedance Probability
Note:
1) FRA Results created using:
a) 8-day Duration Precipitation Sampling
b) 10 Realizations x 10 Life Cycles x 50 Events (5000 total events)
2) FRA Results shown for Exceedance Probabilities < 0.2

HEC Results

Table 12. Comparison of spillway flow durations for 1951-2010 simulations

Alternative (1)	Total hours of spillway flow (2)	Maximum level (NAVD ft) (3)	Maximum level (NGVD ft) (4)
Existing Conditions	204	771.79	768.92
Combined (complex, perfect forecast)	180	771.74	768.87
Encroach (simple, perfect forecast)	324	773.85	770.98
EncroachWIF (simple, imperfect forecast)	324	774.00	771.13

HEC Results

Table 13. Comparison of key frequencies at Russian River near Hopland gage - USGS 11462500/NWS HOPC1/RM 84.78

Alternative (1)	**Event with 1% ACE**			**AEP of flood stage (Gage 21.00/ NAVD 521.46 ft) (5)**
	Discharge (cfs) (2)	**WSEL (NAVD ft) (3)**	**Gage height (ft) (4)**	
Existing Conditions	66,200	531.74	31.28	0.509
Combined (complex, perfect forecast)	66,300	531.75	31.29	0.509
Encroach (simple, perfect forecast)	66,300	531.75	31.29	0.506
EncroachWIF (simple, imperfect forecast)	66,300	531.75	31.29	0.509

Table 16. Hopland rule compliance comparison

Alternative (1)	**Hours with flow greater than 8,000 cfs (60-year simulation, 1951-2010) (2)**
Existing Conditions	3,828
Encroach (simple, perfect forecast)	3,438
Combined (complex, perfect forecast)	3,552
EncroachWIF (simple, imperfect forecast)	3,522

HEC Results

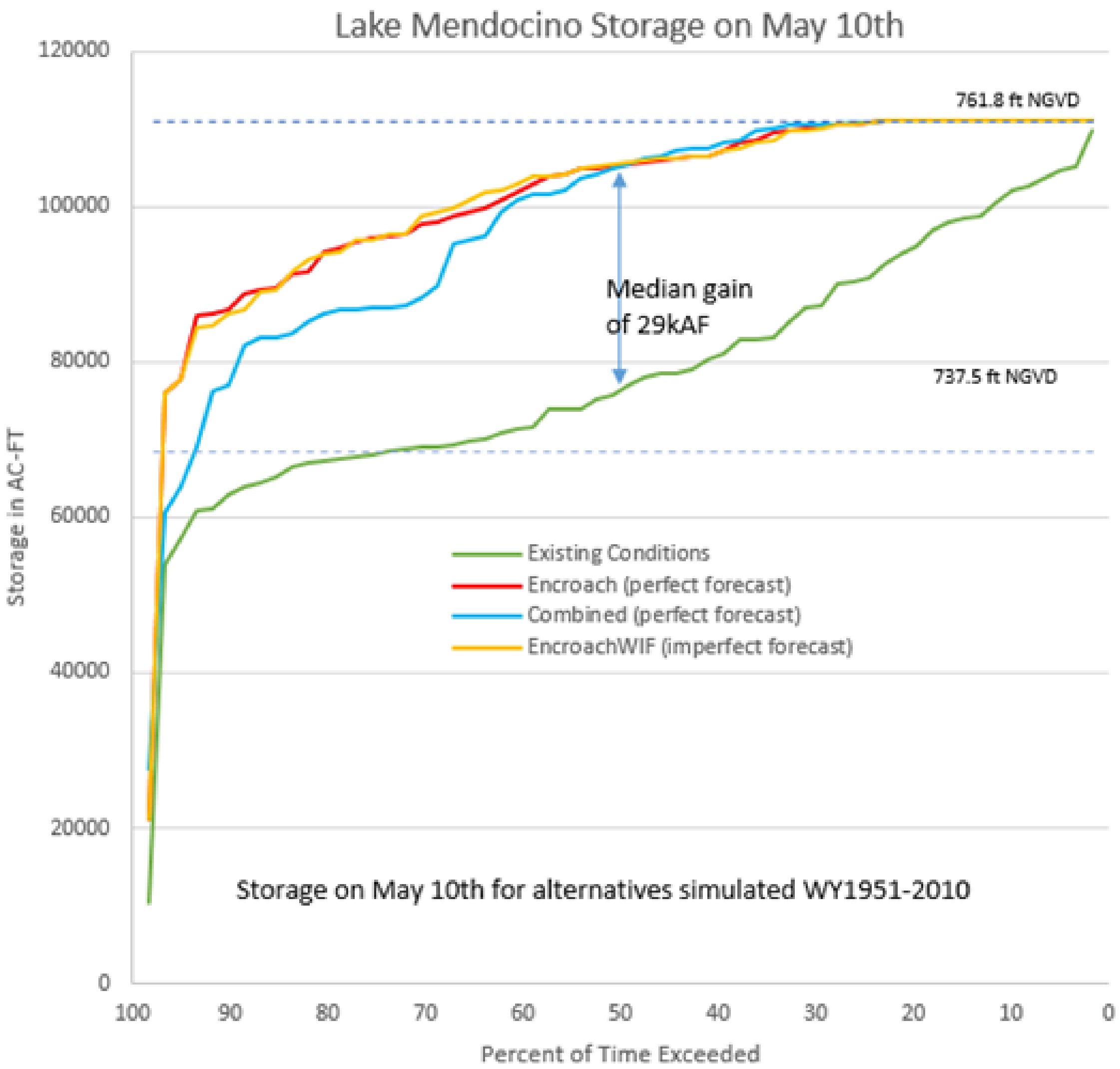
Table 14. Comparison of key frequencies at Russian River near Healdsburg gage - USGS 11464000/NWS HEAC1/RM 35.42

Alternative (1)	Event with 1% ACE			AEP of flood stage (Gage 23.00/ NAVD 102.87 ft) (5)
	Discharge (cfs) (2)	WSEL (NAVD ft) (3)	Gage height (ft) (4)	
Existing Conditions	118,600	108.18	28.31	0.052
Combined (complex, perfect forecast)	118,600	108.18	28.31	0.052
Encroach (simple, perfect forecast)	118,600	108.18	28.31	0.052
EncroachWIF (simple, imperfect forecast)	118,600	108.18	28.31	0.052

Table 15. Comparison of key frequencies at Russian River near Guerneville (Hacienda) gage - USGS 11467000/NWS RIOC1/RM 21.29

Alternative (1)	Event with 1% ACE			AEP of action stage (Gage 31.00/ NAVD 54.02) (5)
	Discharge (cfs) (2)	WSEL (NAVD ft) (3)	Gage height (ft) (4)	
Existing Conditions	120,100	72.76	49.74	-
Combined (complex, perfect forecast)	120,000	72.76	49.74	-
Encroach (simple, perfect forecast)	120,500	72.78	49.76	-
EncroachWIF (simple, imperfect forecast)	120,500	72.78	49.76	-

HEC Results



Lake Mendocino Storage on May 10th
120000
100000
80000
60000
40000
20000
0
Storage in AC-FT
100
90
80
70
60
50
40
30
20
10
0
Percent of Time Exceeded
761.8 ft NGVD
737.5 ft NGVD
Median gain
of 29kAF
Existing Conditions
Encroach (perfect forecast)
Combined (perfect forecast)
EncroachWIF (imperfect forecast)
Storage on May 10th for alternatives simulated WY1951-2010

CW3E Inquiries

1. What is the required forecast lead time?
2. What are the forecast requirements for extreme rainfall events?
3. What is the current forecast skill level for rainfall that has an impact on Lake Mendocino operation?
4. What is the current skill in forecasting no significant rainfall (AR landfall)?
5. Will current streamflow forecasts support FIRO for Lake Mendocino?

CW3E Inquiries

6. Are the ensemble precipitation forecasts suitable for testing and evaluating FIRO strategies as SCWA did?
7. How important are extreme rainfall events to annual precipitation in the Russian River watershed?
8. What is the relationship of upslope water vapor flux and rainfall for land-falling ARs?
9. What is the impact of frontal waves along ARs on flood forecasting in the Russian River Basin?

CW3E Results

- Detailed analysis provided in PVA Appendix 3.

- Bottom line…
  - Existing forecasts (precipitation and streamflow are skillful and suitable for assessing FIRO alternatives
  - Forecast skill for low-frequency, high intensity AR events is lower and requires additional research
  - Skill is best for forecasting extended dry periods

Preliminary Conclusions

1. Elements of FIRO are currently viable, and can improve reliability in meeting water management objectives and ecosystem conditions without impairing flood protection

2. Major deviation requests should be developed and submitted to USACE for consideration for winter 2017/18 and beyond

3. Additional improvements in forecast skill have the potential to further enhance reservoir operations

4. Research into integrated hydrometeorological modeling and monitoring with incorporation into decision support systems is required to realize the full potential of FIRO including for enhanced reliability in meeting water management objectives, flood mitigation, and ecosystem services

PVA Status

- Draft has been reviewed by the LM Steering Committee
- Comments from 2 of 3 External Reviewers have been received
- Final report is expected before the FIRO Workshop this summer

Anticipated Next Steps

- Project team will pivot toward a “Full Viability Assessment”
- Task groups
  - Deviations and policy
  - Modeling (refinements of SCWA model)
  - Science
  - Communications