

# Saluda Dam Reservoir Operations Model

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# Mission Statement

“...establish a baseline of current hydrologic, hydraulic and operational conditions, and aid in analyzing and understanding the upstream and downstream effects of potential changes to project operation....”

# Operations Model Process

- 1) Determine Historic Inflow to Lake Murray
- 2) Develop Proposed Operating Conditions
  - 1) Guide Curves
    - 1) Flood Stage Curve
    - 2) Annual Target Guide Curve
    - 3) Conservation Curves
    - 4) Inactive Pool Curve
  - 2) Flow Requirements
    - 1) Reserve Calls
    - 2) Minimum Flows
    - 3) Recreational Releases
    - 4) Others
- 3) Run the Model / Tabulate Results!

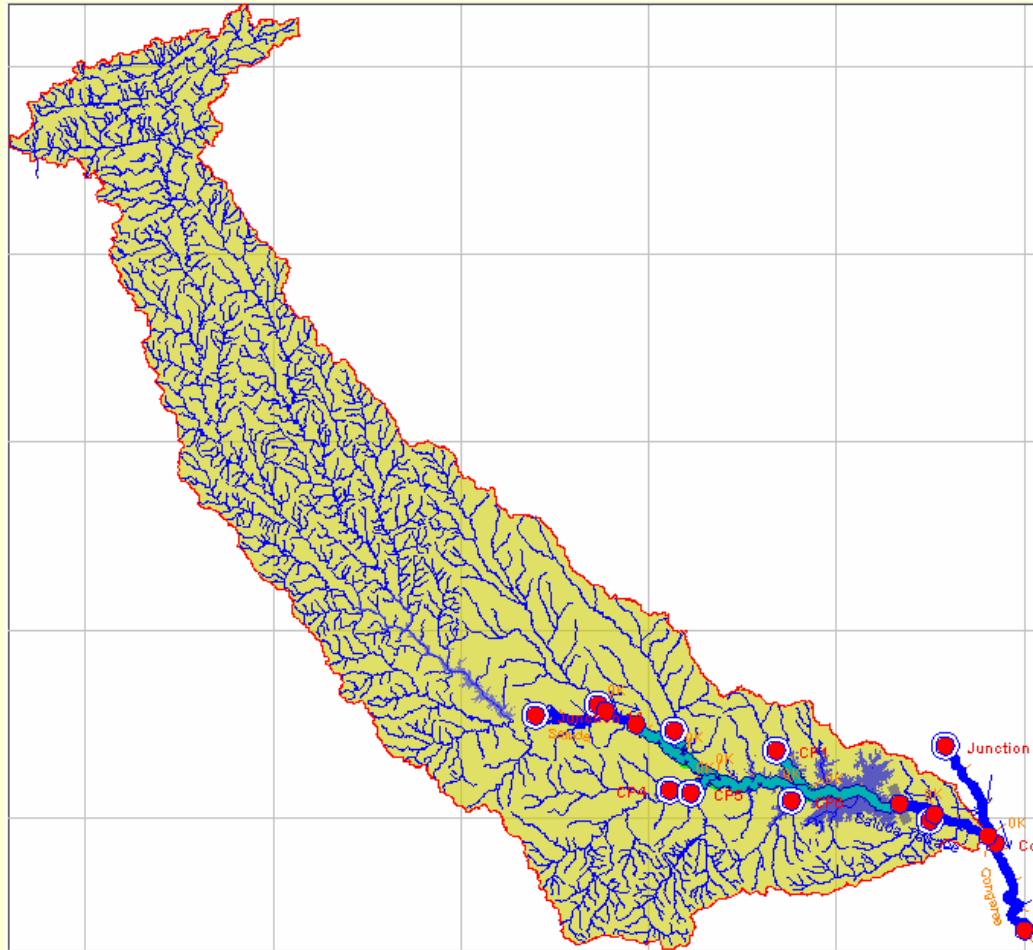
# Operations Model

- Publicly available Army Corp of Engineers software (HEC-ResSim)
- Specifically created for reservoir modeling and management
- Flexibility in managing large datasets
- Rule based decisions on daily timesteps
- Application of seasonal rules
- Ability to prioritize rules
- Use If/Then Statements



US Army Corps  
of Engineers

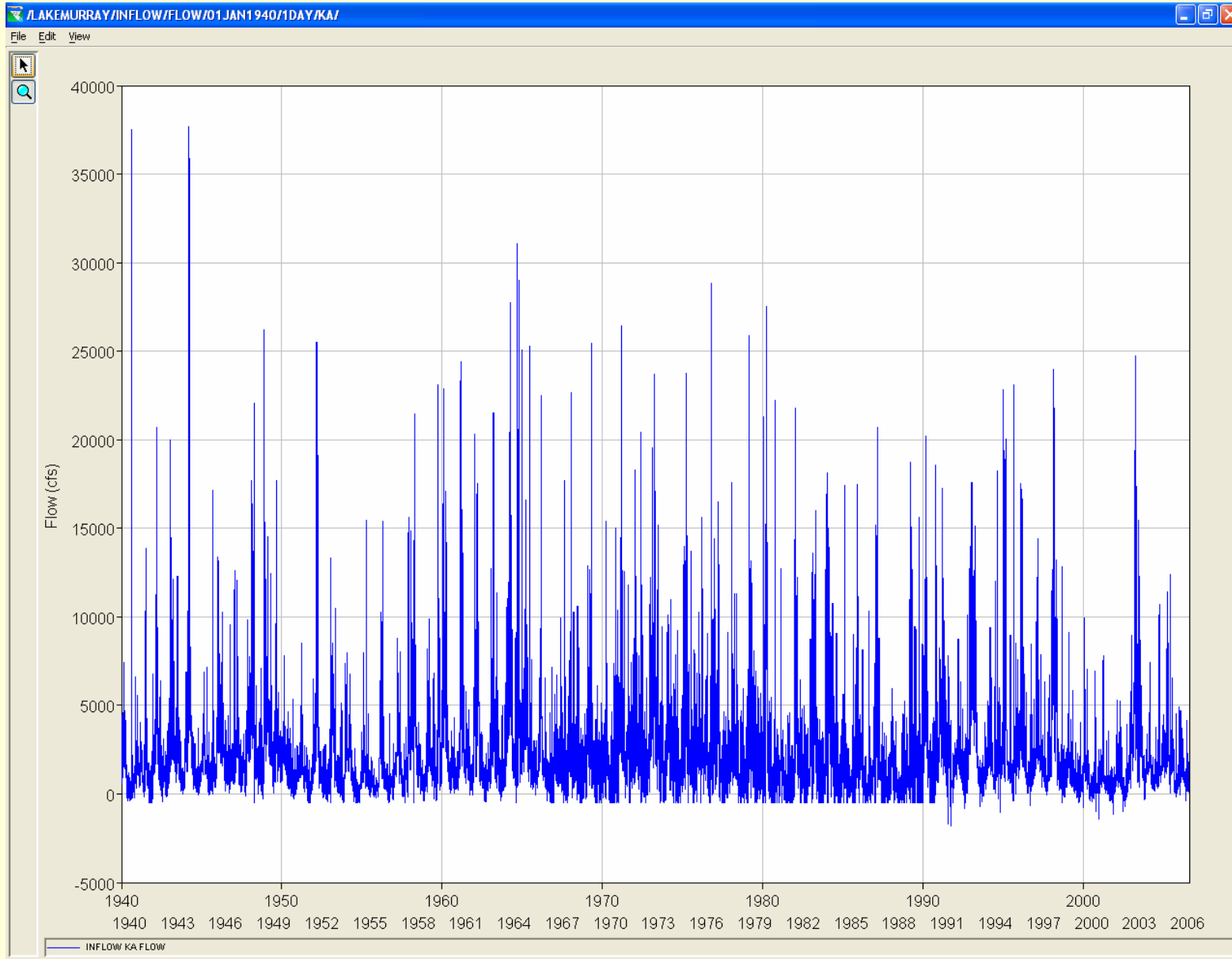
# Model Layout



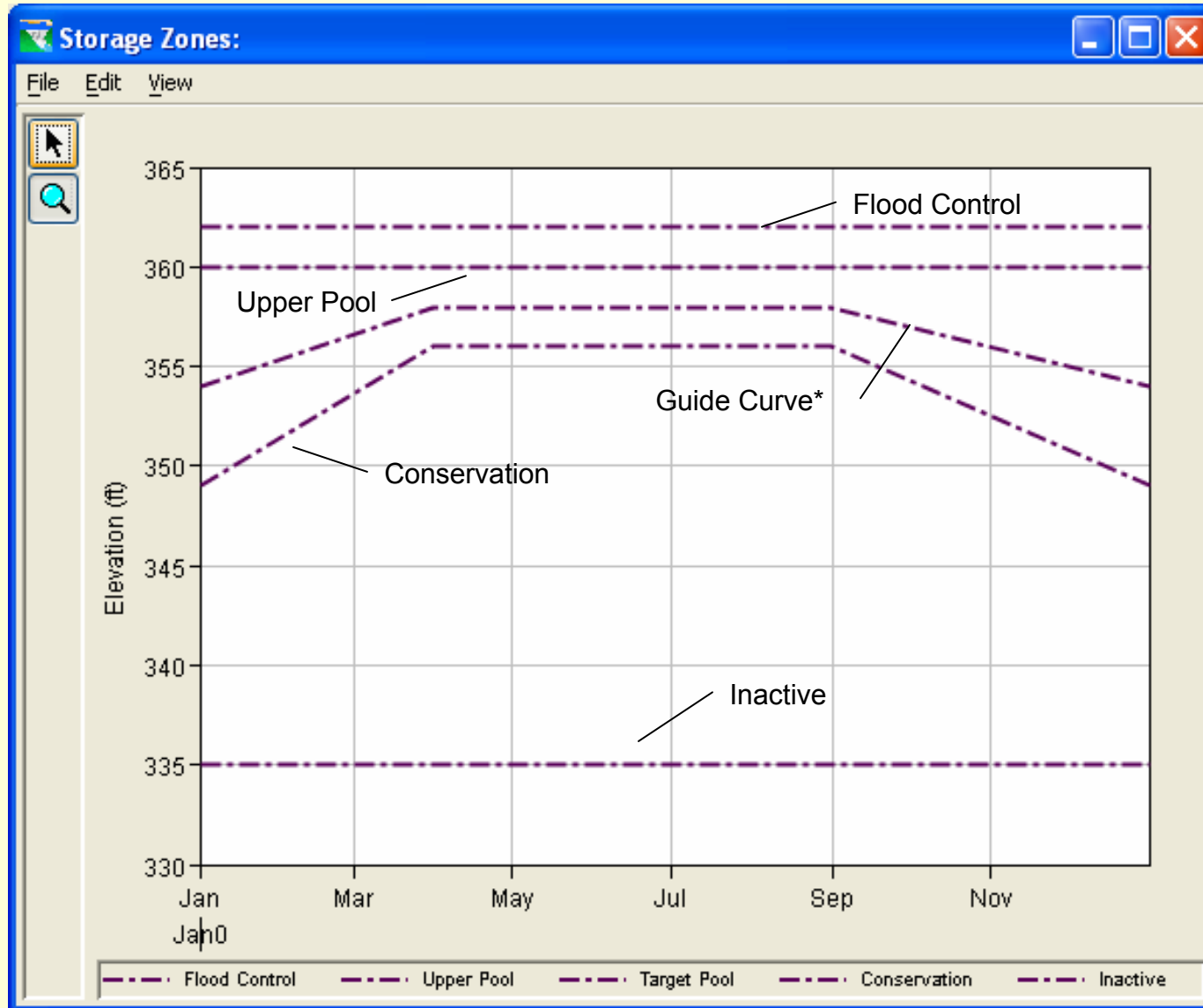
# Inflow Hydrograph

- Two Methods Tested for Developing Inflow Data:
  - 1) Upstream Gage Rating
    - Utilize available USGS gage data and adjust for ungaged areas
  - 2) Mass Balance
    - Hindcast from outflow and lake level data historical lake level data

# Saluda Reservoir Inflow Hydrograph



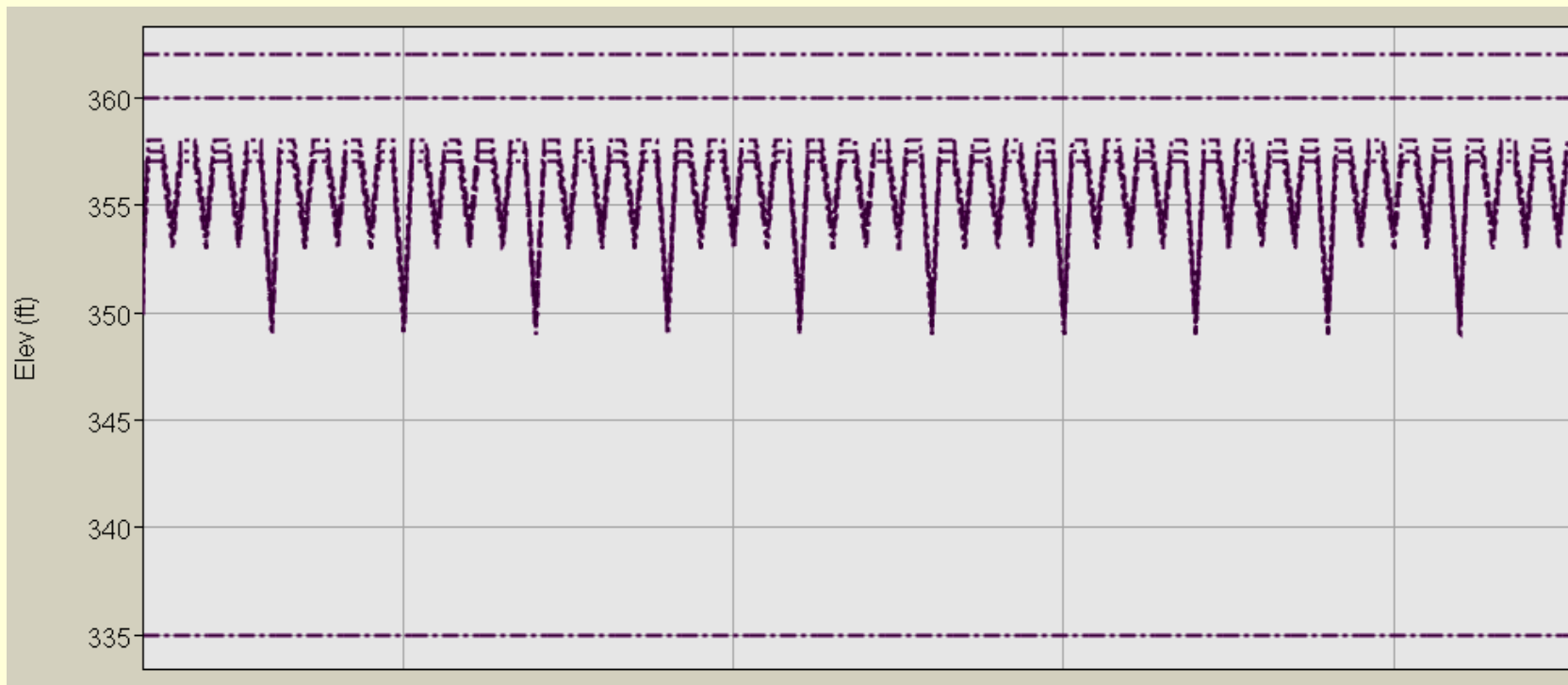
# General Guide Curve





# EI. 350' Cycles

- Two Year & Four Year Cycles
- Guide Curve lowers to EI. 350'



# Operations

- Zones vary with Time (Guide Curves)
- Operations vary with Current Zone  
(Operation Zone depends on Lake Level)

			Recreational Releases				
	Reserve Generation	Minimum Flow	Tier 0	Tier 1	Tier 2	Max Release	Min Release
<b>Flood Stage</b>	n/a	n/a	n/a	n/a	n/a	n/a	n/a
<b>Upper Pool</b>	Y	n/a	Y	Y	Y	18kcfs	MinFlow
<b>Guide Curve</b>	Y	Y	Y	Y	Y	18kcfs	MinFlow
<b>Low Pool</b>	Y	Y	Y	Y	N	18kcfs	MinFlow
<b>Conservation</b>	Y	Y	Y	N	N	18kcfs	MinFlow
<b>Drought</b>	Y	Y	Y	N	N	18kcfs	400cfs
<b>NoReserve</b>	N	Y	N	N	N	18kcfs	400cfs
<b>Inactive</b>	N	N	N	N	N	0	n/a

# Recreational Flow Requests

		Date	Day	Event	Days	Duration (hrs)	Min Flow	Rec Release	24-Hr Average (Includes Min Flow)	Priority Tier
January		1-Jan	1	Iceman Race	1	5	700	4,000	1,388	2
		3-Jan	3	Wade Fishing	1	5	700	700	700	2
		4-Jan	4	Wade Fishing	1	5	700	700	700	2
		13-Jan	13	Wade Fishing	1	5	700	700	700	2
		14-Jan	14	Wade Fishing	1	5	700	700	700	2
		21-Jan	21	MLK Day	1	5	700	700	700	2
		3-Feb	34	Wade Fishing	1	5	700	700	700	2

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		13-Jan	13	Wade Fishing	1	5	700	700	700	2
		14-Jan	14	Wade Fishing	1	5	700	700	700	2
		21-Jan	21	MLK Day	1	5	700	700	700	2

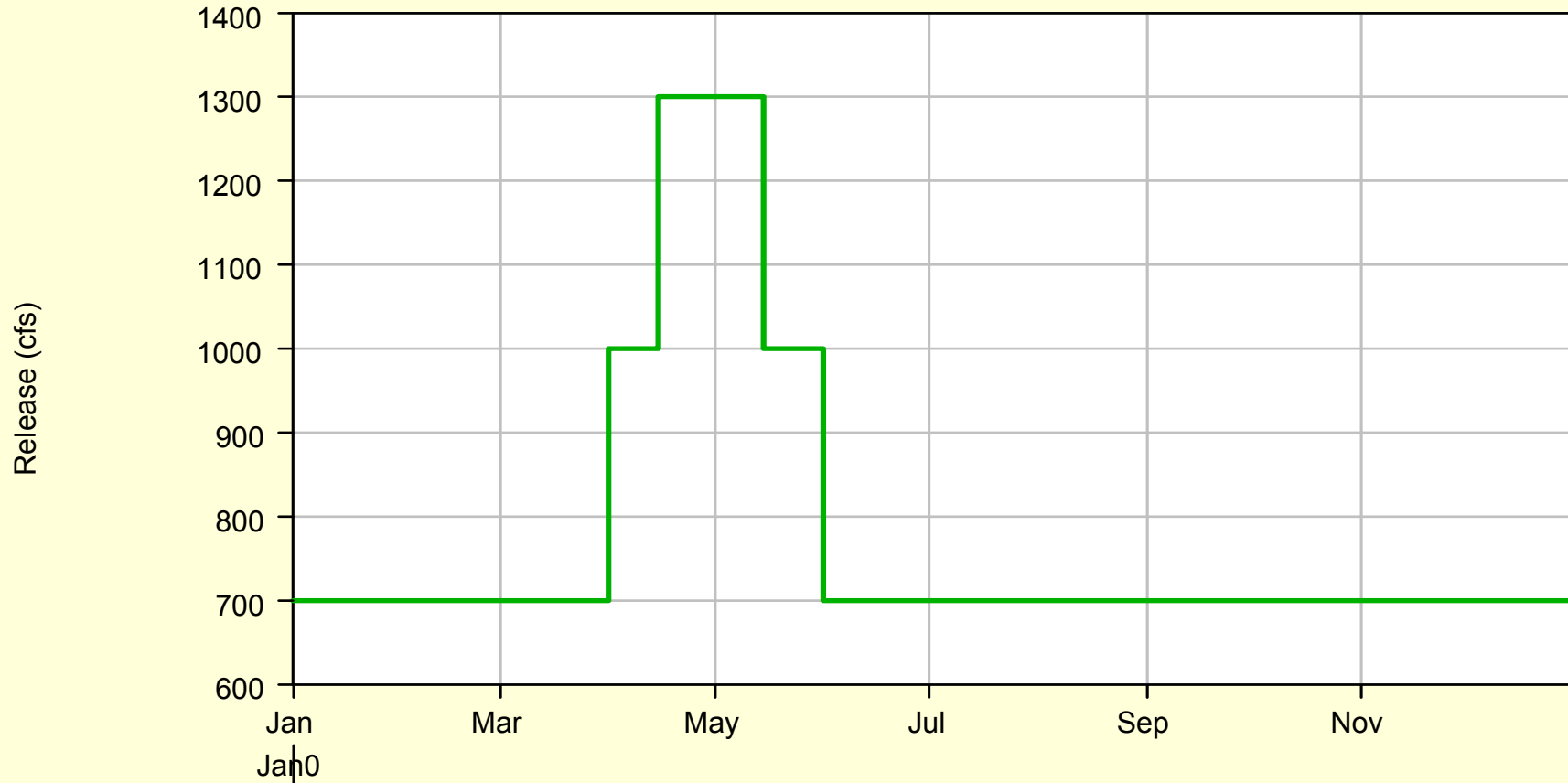
Recreational Flow Request	Date	Day	Event	Days	Duration (hrs)	Min Flow	Rec Release	24-Hr Average (Includes Min Flow)	Priority Tier	
	24-Apr	114	New Cert - Mandatory	1	14	1,300	8,000	5,208	0	
	30-Apr	120	New Cert - Available	2	9	1,300	8,000	7,625	1	
	May	1-May	121	CFK	1	9	1,300	10,000	4,563	1
		13-May	133	Wade Fishing	1	9	1,300	1,000	1,188	2
		27-May	147	Memorial Day	1	9	1,000	1,000	1,000	2
		June	1-Jun	152	Rescue Rodeo	2	9	700	2,111	2,458
	3-Jun		154	Wade Fishing	1	9	700	700	700	2
	4-Jun		155	Wade Fishing	1	9	700	700	700	2
	13-Jun		164	Wade Fishing	1	9	700	700	700	2
	14-Jun		165	Wade Fishing	1	9	700	700	700	2
	July	1-Jul	182	WW Rodeo	2	8	700	3,300	3,133	2
		4-Jul	185	Ind. Day	1	9	700	1,000	813	2
		26-Jul	207	Wade Fishing	1	9	700	700	700	2
		27-Jul	208	Wade Fishing	1	9	700	700	700	2
	August	3-Aug	215	USTWWR Prac.	2	8	700	10,000	7,600	1
		15-Aug	227	Wade Fishing	1	9	700	700	700	2
		16-Aug	228	Wade Fishing	1	9	700	700	700	2
	September	5-Sep	248	Labor Day	1	9	700	1,000	813	2
		13-Sep	256	High Boating	2	6	700	4,500	3,300	2
	October	1-Oct	274	CFK	1	6	700	2,400	1,125	1
		15-Oct	288	High Boating	2	6	700	4,500	3,300	2
22-Oct		295	ReCert-Mandatory	1	14	700	12,000	7,292	0	
23-Oct		296	ReCert-Mandatory	1	14	700	12,000	7,292	0	
24-Oct		297	ReCert-Mandatory	1	14	700	12,000	7,292	0	
November	27-Oct	300	ReCert-Available	2	6	700	4,500	3,300	1	
	5-Nov	309	Low Boating	1	6	700	2,400	1,125	2	
	25-Nov	329	High Boating	1	6	700	4,500	1,650	2	
	December	1-Dec	335	Low Boating	1	6	700	2,400	1,125	2
3-Dec		337	Wade Fishing	1	5	700	700	700	2	
4-Dec		338	Wade Fishing	1	5	700	700	700	2	
17-Dec		351	High Boating	1	5	700	700	700	2	
23-Dec		357	Wade Fishing	1	6	700	4,500	1,650	2	
24-Dec		358	Wade Fishing	1	5	700	700	700	2	



# Reserve Generation

- Past Performance  $\neq$  Future Requirements
- Average Hours of 18kcfs/month
- 10<sup>th</sup> & 20<sup>th</sup> of Every Month
- Evaluated 40, 20, 10, 0 hrs/month

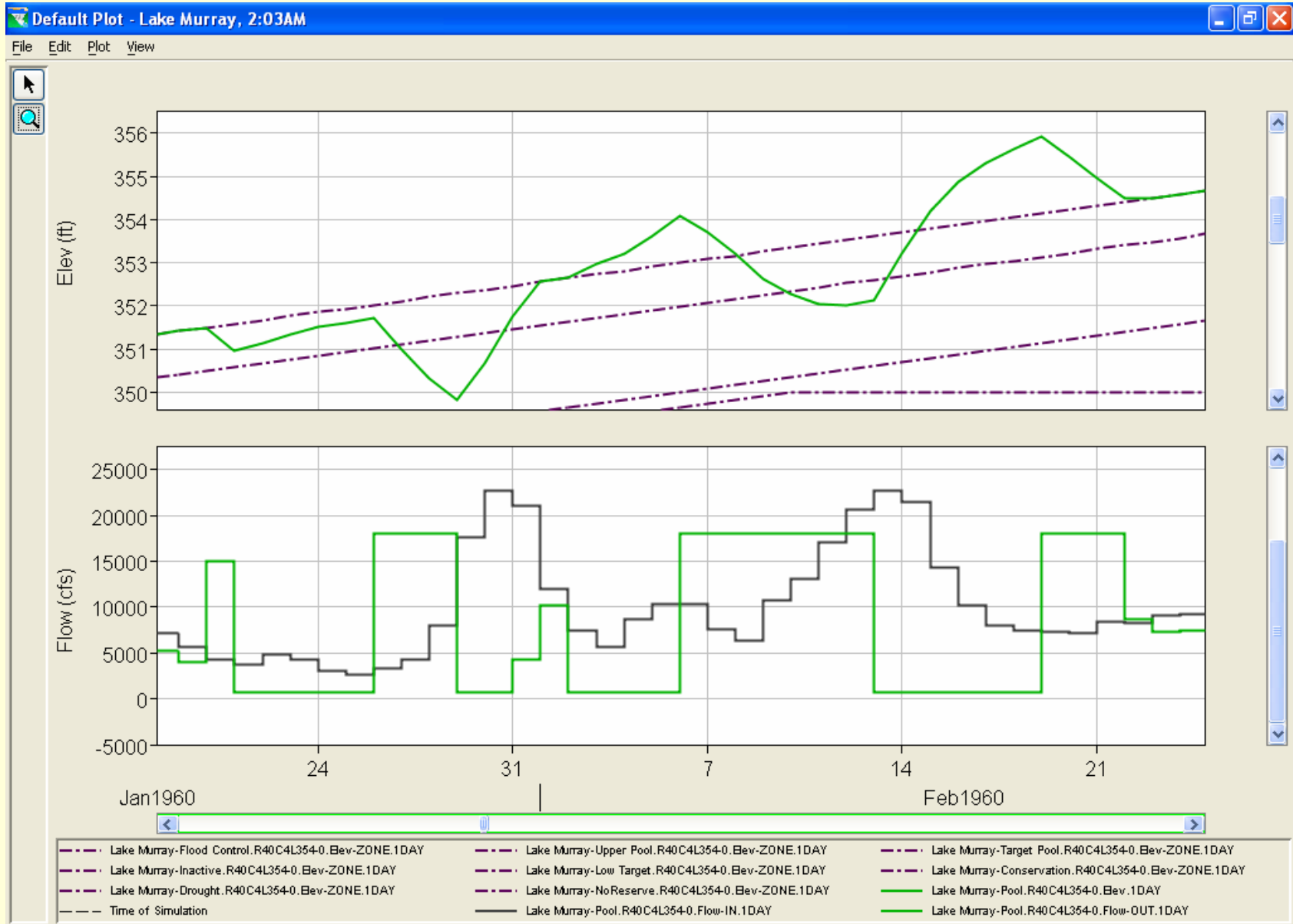
# Minimum Flows



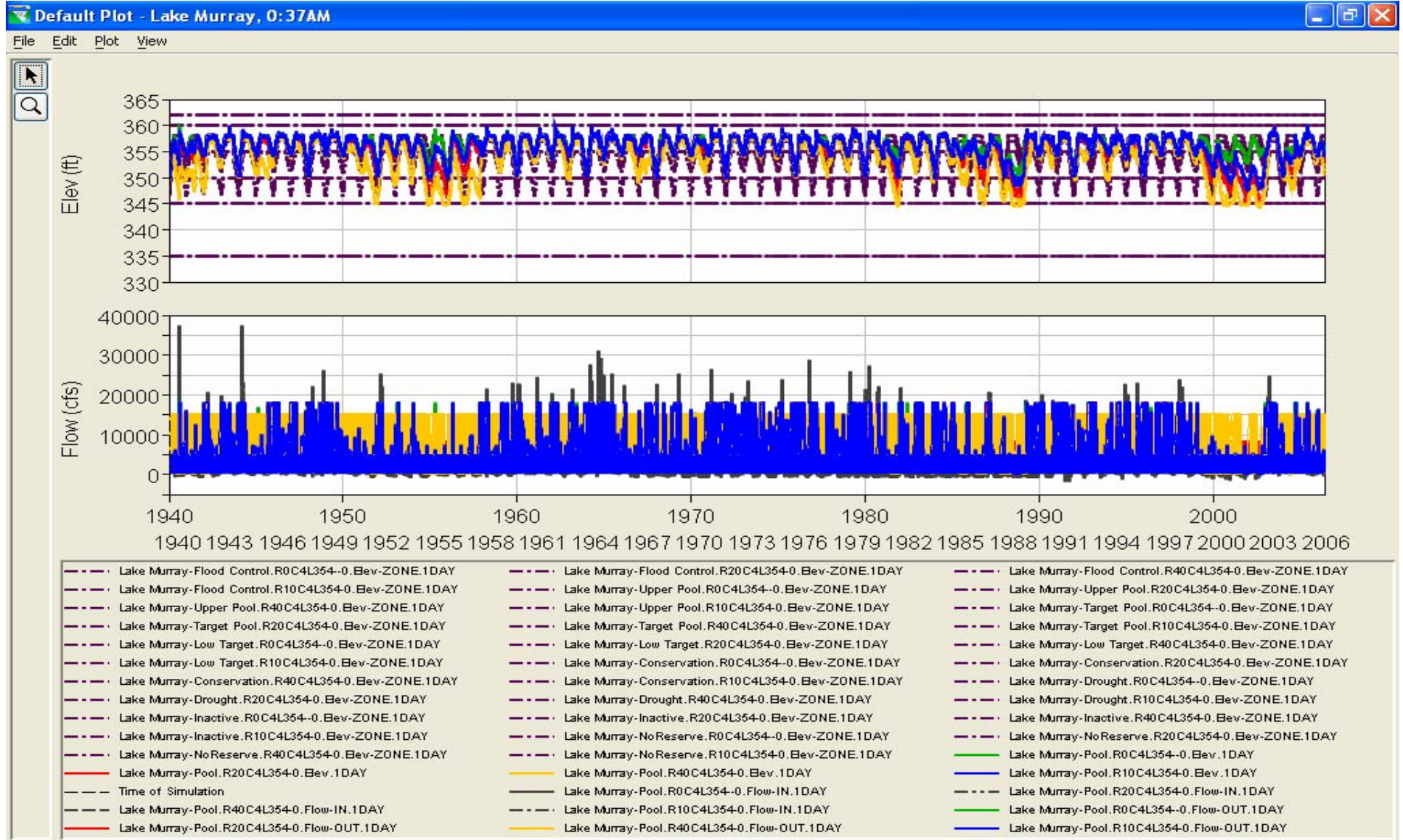
Function of: Date



# Flood Forecast

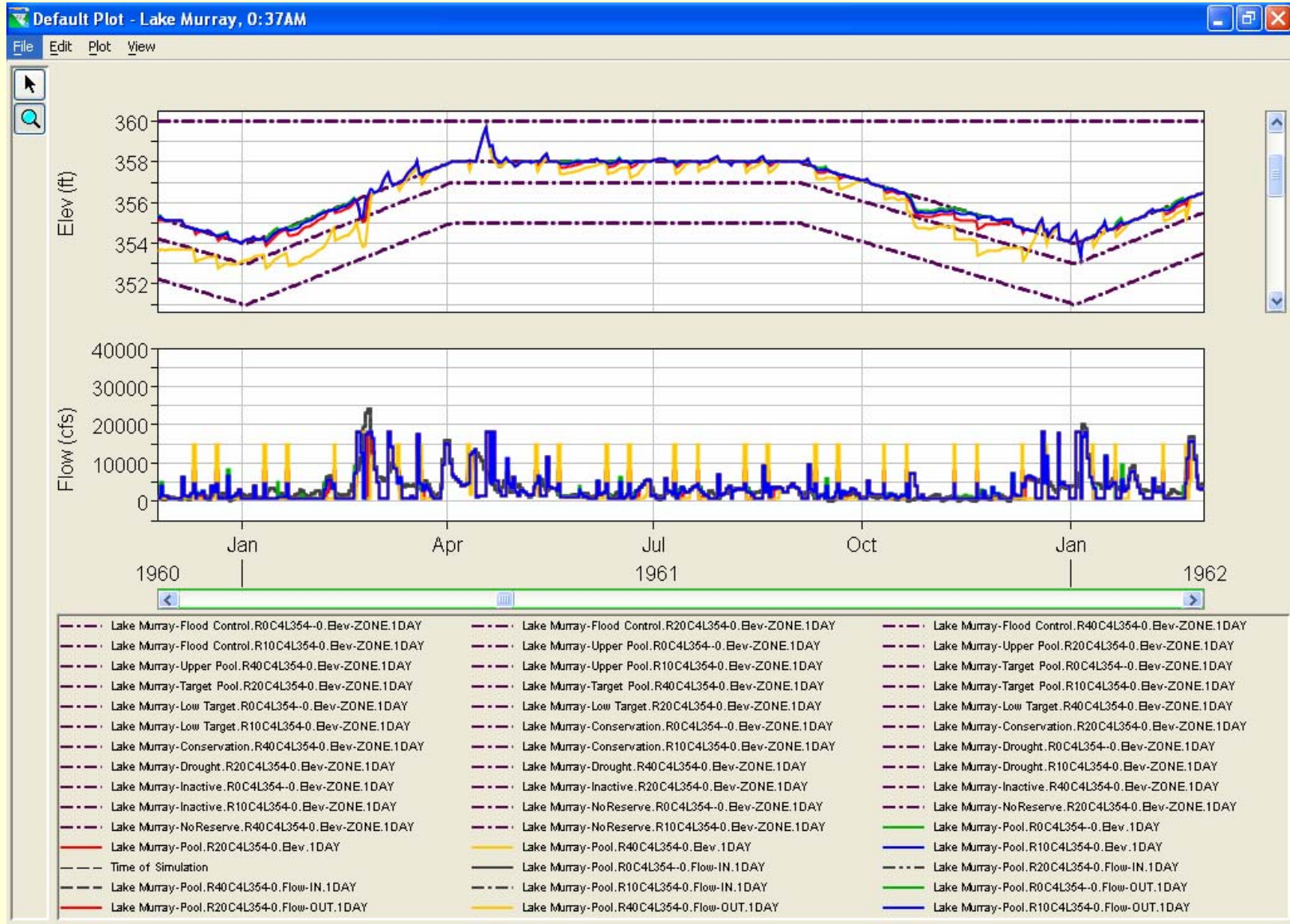


# 66 Year Results



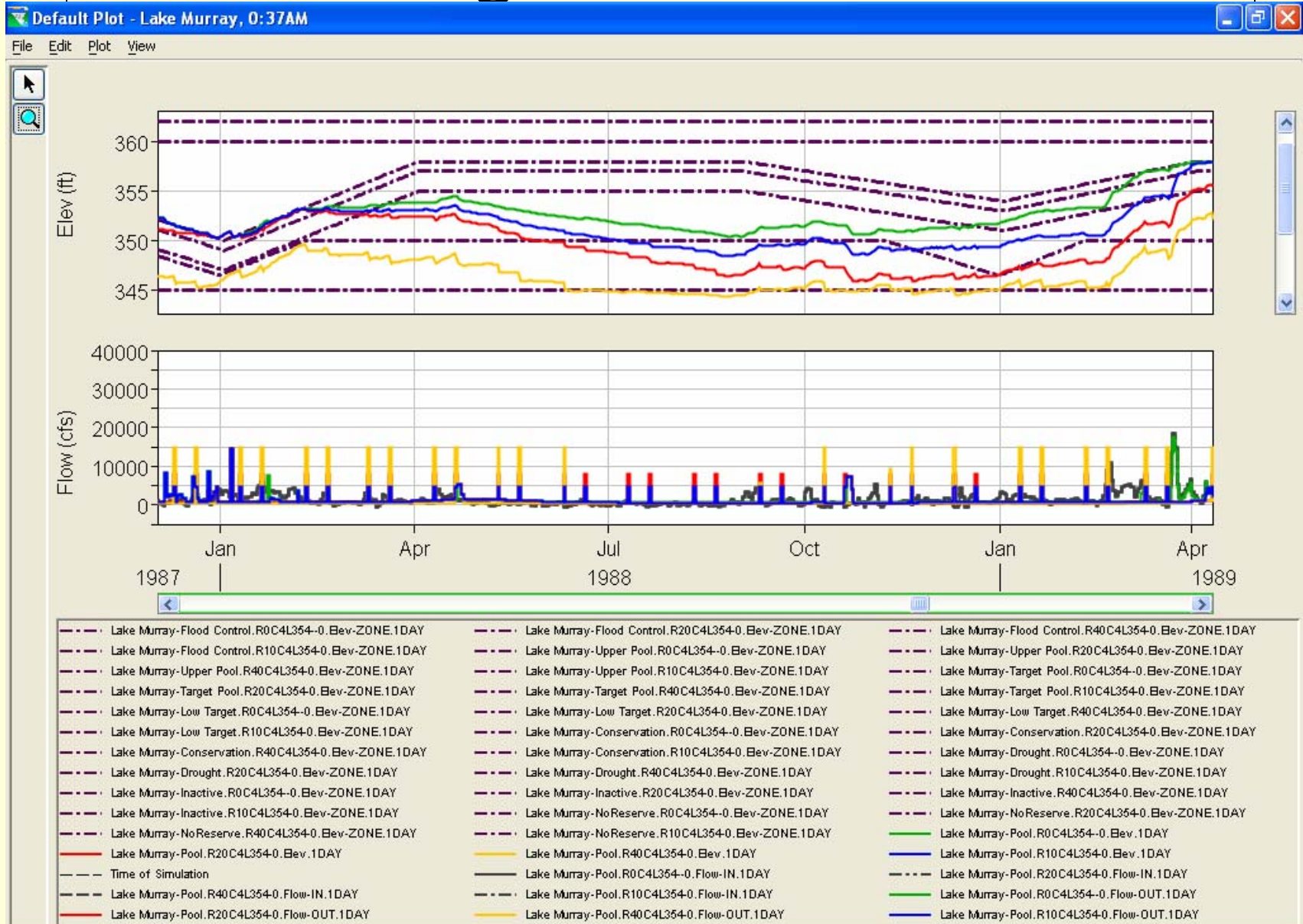


# Typical Wet-Year Operations



*Huda*

# Drought in Late 80's

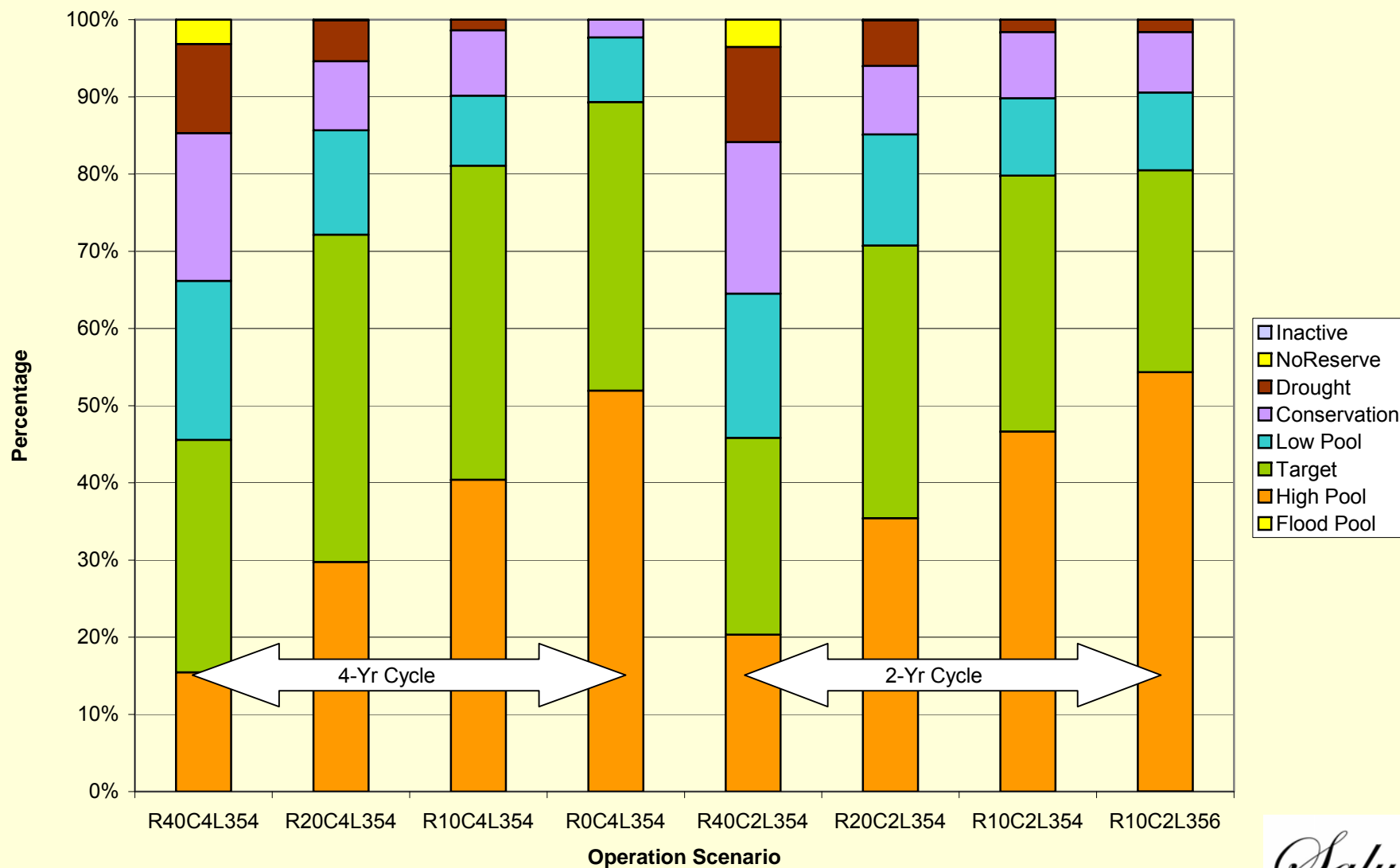


# Zone Frequencies

		Flood Pool	High Pool	Target	Low Pool	Conservation	Drought	NoReserve	Inactive
4-Year Cycle	R40C4L354	0.0%	15.4%	30.1%	20.6%	19.1%	11.5%	3.2%	0.0%
	R20C4L354	0.0%	29.8%	42.4%	13.5%	9.0%	5.3%	0.1%	0.0%
	R10C4L354	0.0%	40.4%	40.7%	9.1%	8.5%	1.4%	0.0%	0.0%
	R0C4L354	0.0%	52.0%	37.4%	8.4%	2.3%	0.0%	0.0%	0.0%
2-Year Cycle	R40C2L354	0.0%	20.3%	25.5%	18.7%	19.6%	12.3%	3.5%	0.0%
	R20C2L354	0.0%	35.4%	35.3%	14.4%	8.9%	5.9%	0.1%	0.0%
	R10C2L354	0.0%	46.7%	33.1%	10.0%	8.6%	1.6%	0.0%	0.0%
	R10C2L356	0.0%	54.3%	26.2%	10.1%	7.8%	1.6%	0.0%	0.0%

# Zone Frequencies

Percentage Model Operating Zones

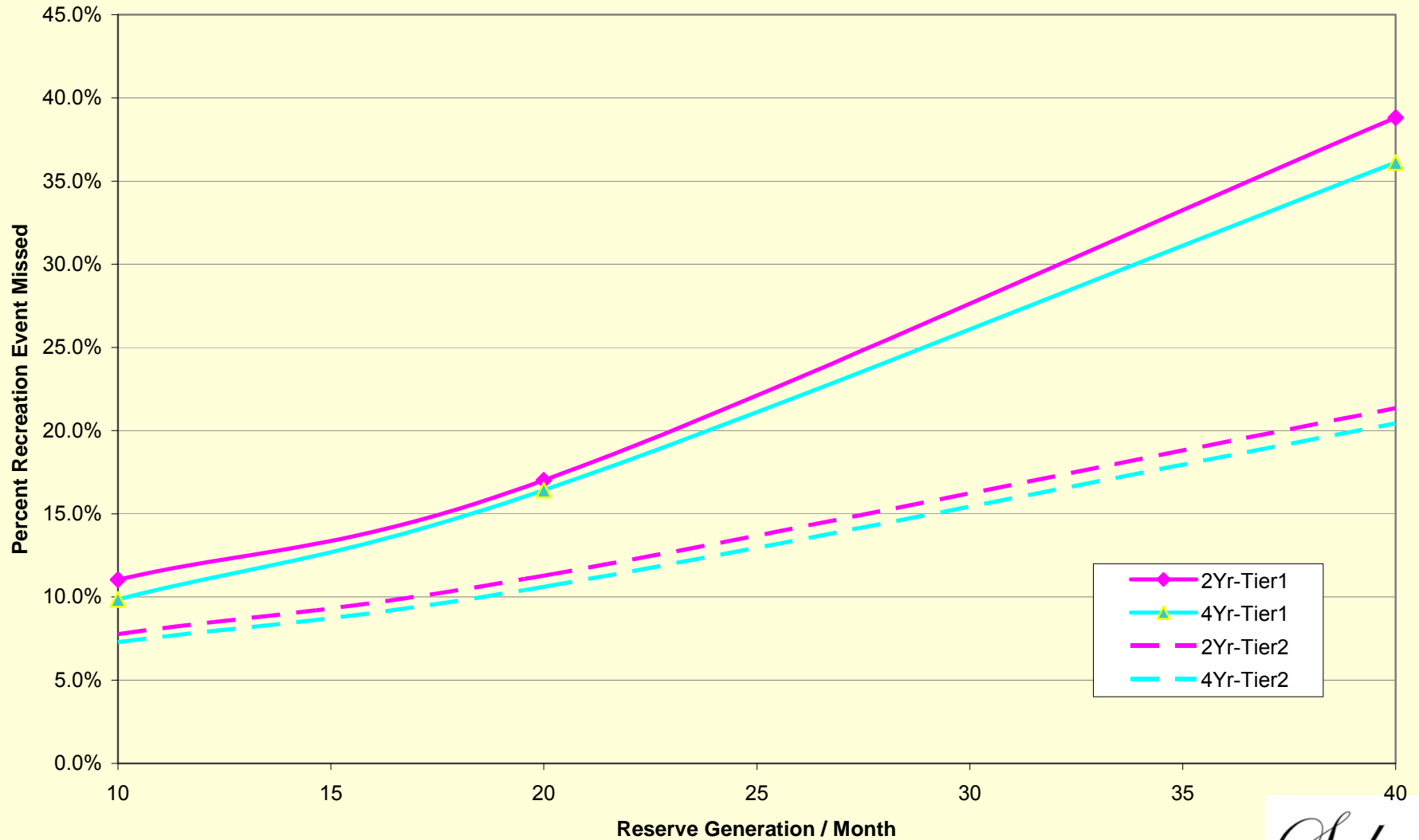


# Missed Recreation Days

		Missed Rec		
			Days	% Missed
4-Year Cycle	R40C4L354	Tier 1	121	36.1%
		Tier 2	589	20.4%
	R20C4L354	Tier 1	55	16.4%
		Tier 2	306	10.6%
	R10C4L354	Tier 1	33	9.9%
		Tier 2	210	7.3%
	R0C4L354	Tier 1	13	3.9%
		Tier 2	119	4.1%
2-Year Cycle	R40C2L354	Tier 1	130	38.8%
		Tier 2	615	21.3%
	R20C2L354	Tier 1	57	17.0%
		Tier 2	325	11.3%
	R10C2L354	Tier 1	37	11.0%
		Tier 2	224	7.8%
	R10C2L356	Tier 1	34	10.1%
		Tier 2	218	7.6%

# Recreational Violations

Reserve Generation and Lake Level Cycling  
Impacts to Recreational Releases



# Periods Below EI.354' & EI.345'

		<354'	<345'
<b>4-Year Cycle</b>	<b>R40C4L354</b>	42.2%	3.2%
	<b>R20C4L354</b>	21.9%	0.1%
	<b>R10C4L354</b>	16.7%	0.0%
	<b>R0C4L354</b>	10.7%	0.0%
<b>2-Year Cycle</b>	<b>R40C2L354</b>	49.1%	3.5%
	<b>R20C2L354</b>	29.6%	0.1%
	<b>R10C2L354</b>	24.5%	0.0%
	<b>R10C2L356</b>	23.9%	0.0%
		7.2%	

# Next Steps

- Finalize Model Inputs
- Summarize Duration & Magnitude of Violations
- Evaluate March 1<sup>st</sup> El.358' (vs. April 1<sup>st</sup>)
- Present Final Model Results



Questions?