Spokane River System Model

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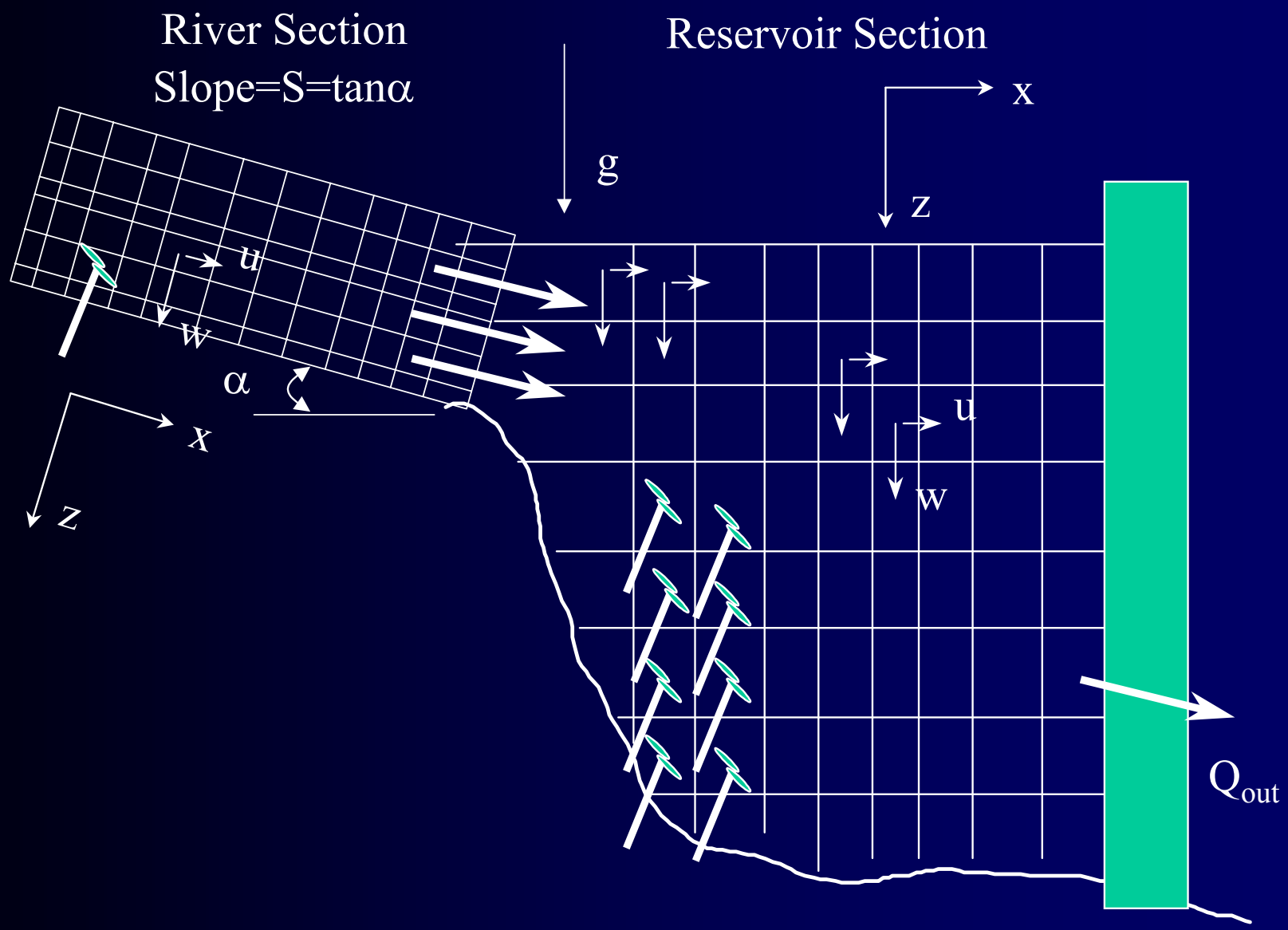
CE-QUAL-W2 Version 3



CE-QUAL-W2 Version 3

Data Requirements

Meteorological Conditions

- One meteorological file for each waterbody

Inflows

- Needed for boundary conditions, tributaries and point sources

Inflow temperature

Inflow water quality

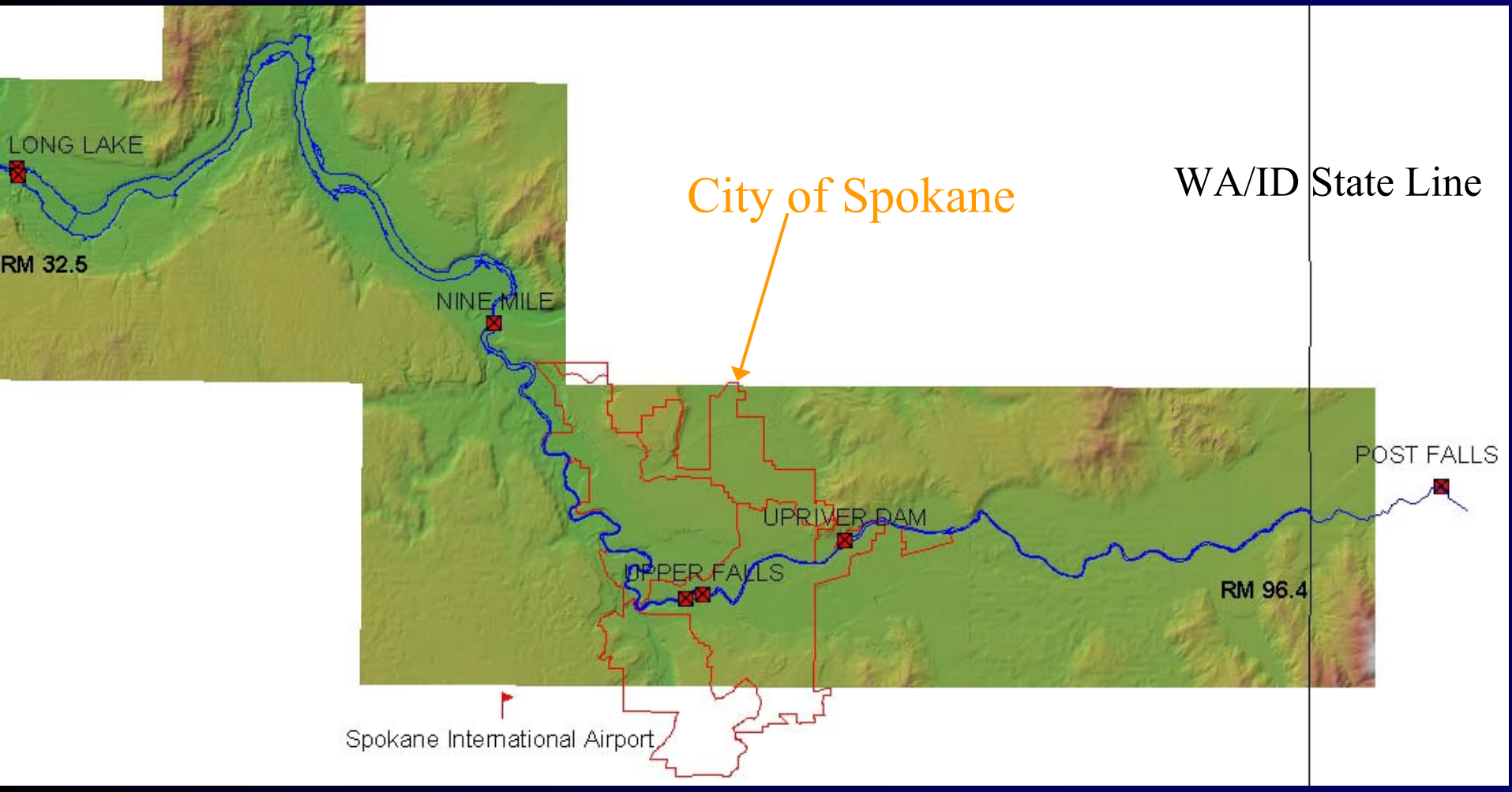
- The frequency of the data needed depends on the questions the model is being used to answer.

Bathymetry of the system

- The more refined the data the more accurate the grid

Model Development

Meteorological Data

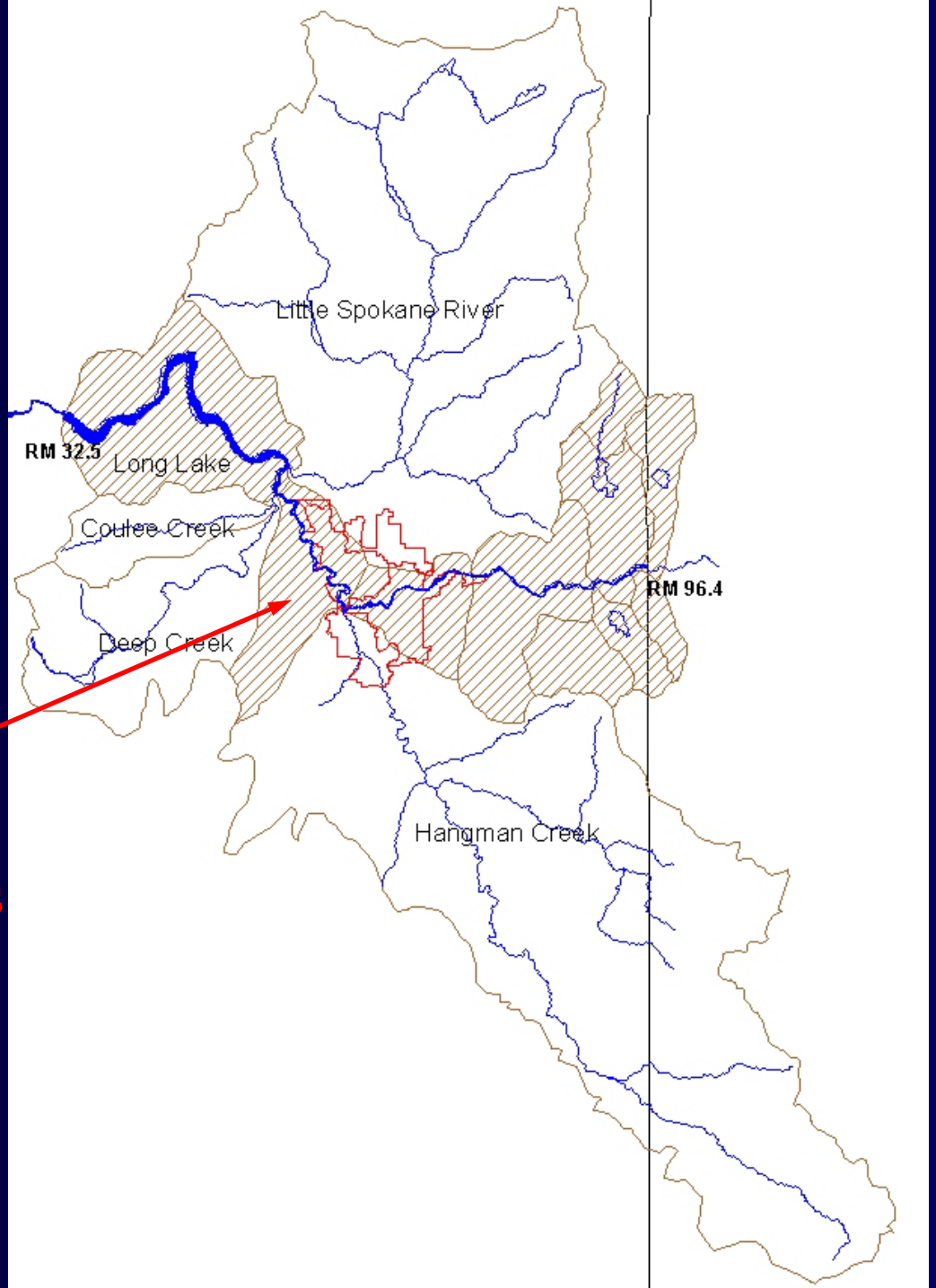


Air and Dew Point Temperature, Wind Speed and Direction, and Cloud Cover

Model Development

Inflows

Subbasin Delineation

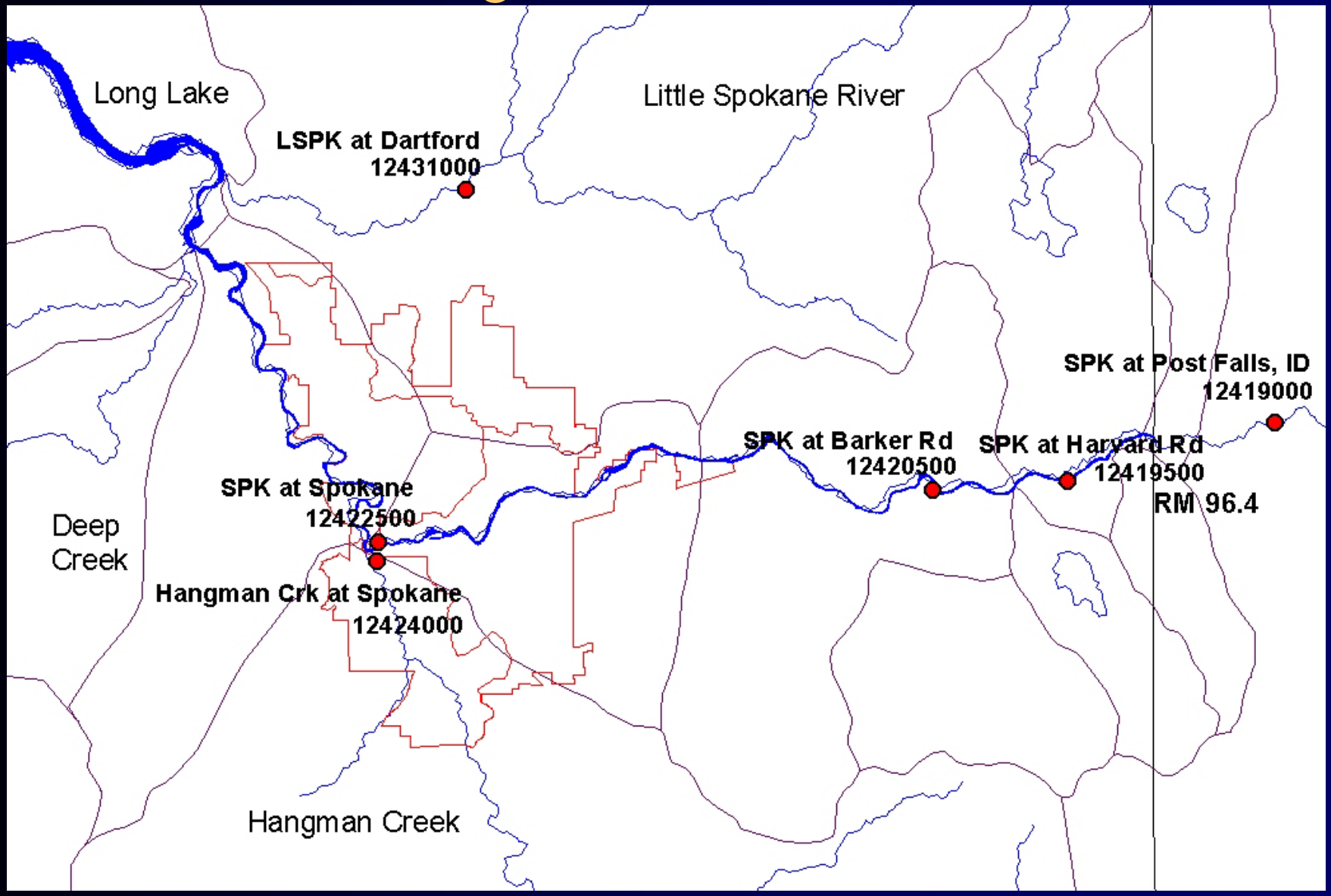


Distributed
Inflow/Outflow Areas

Model Development

Inflows

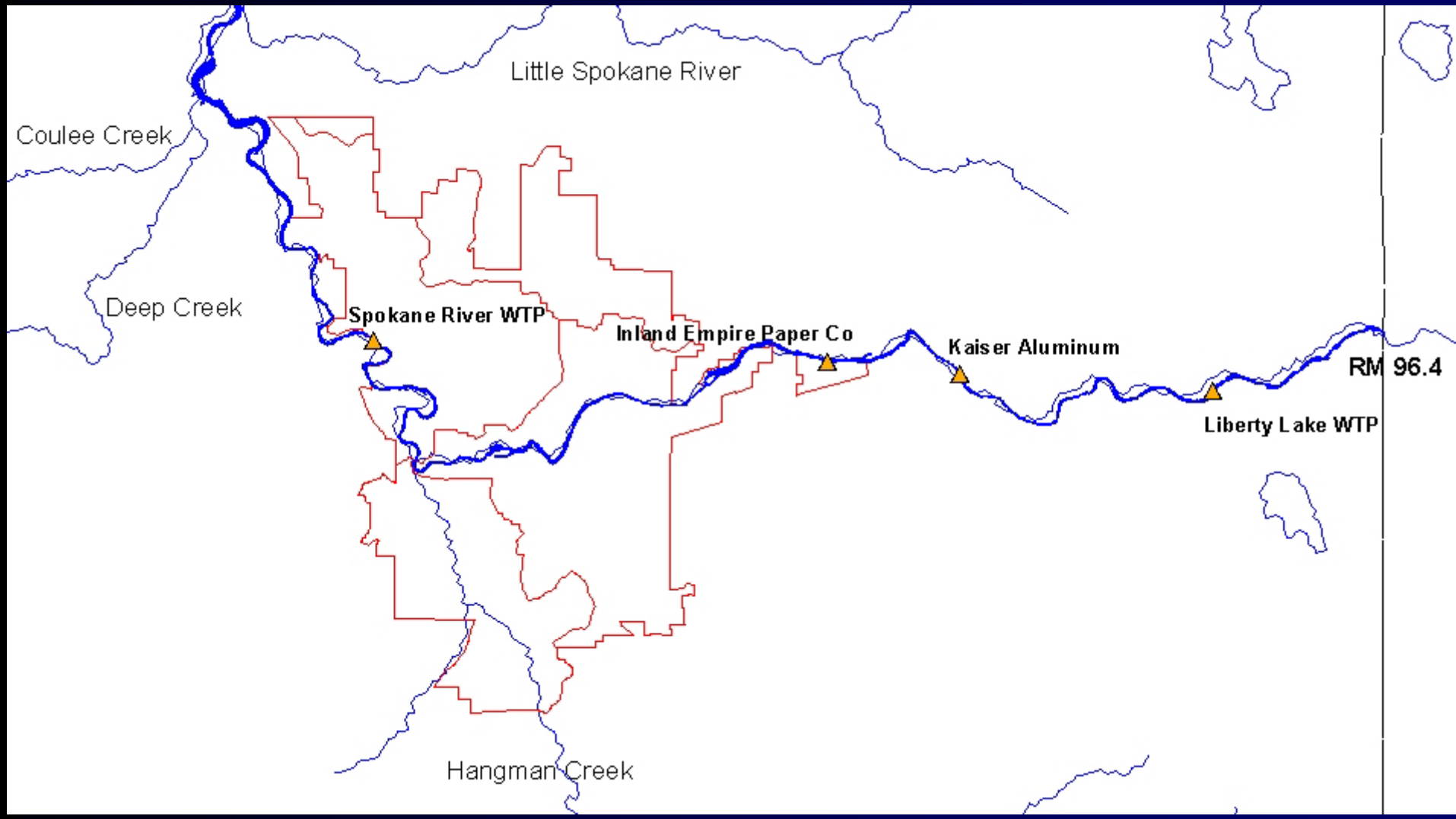
Gage Station Locations



Model Development

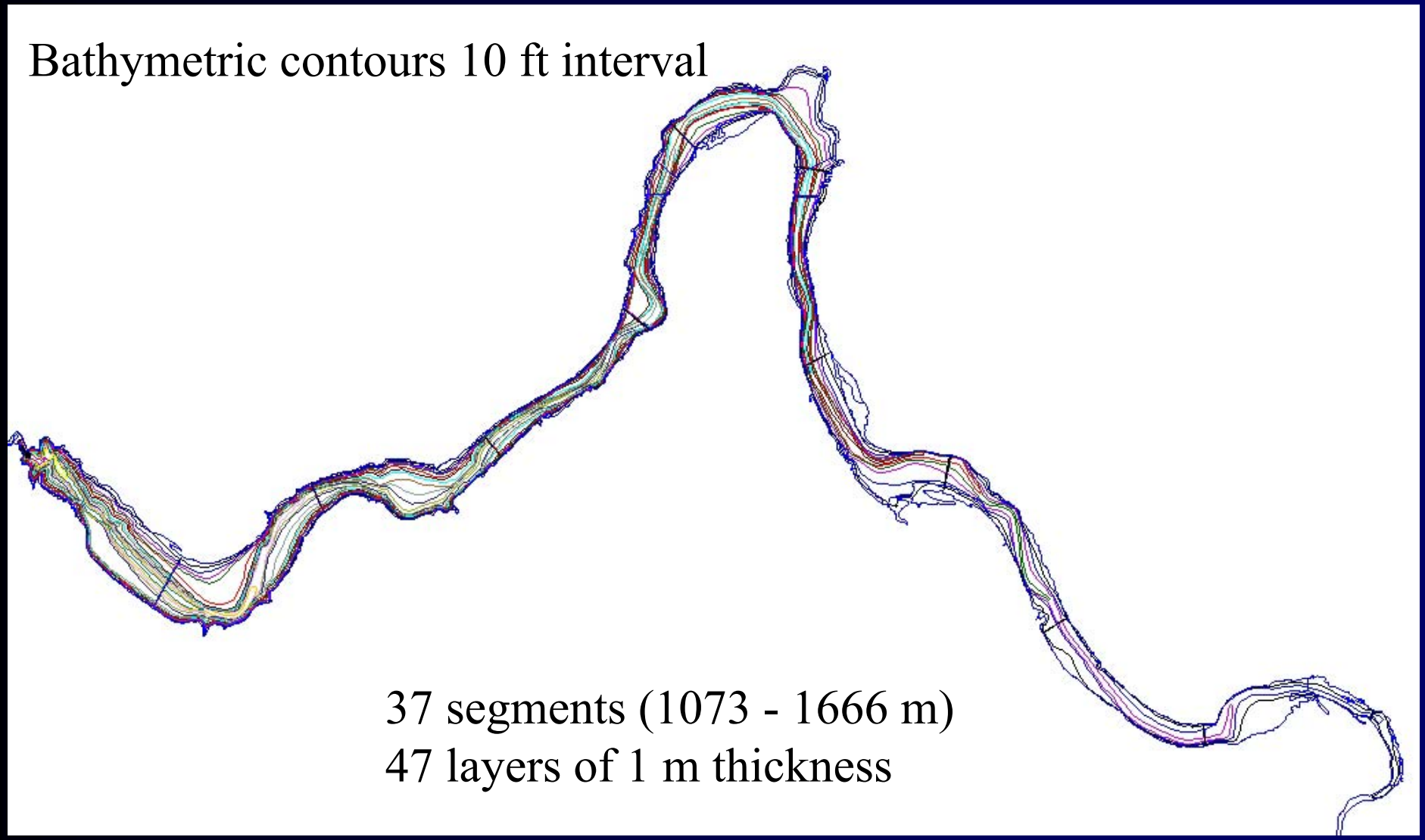
Inflows

Point Sources



Model Development

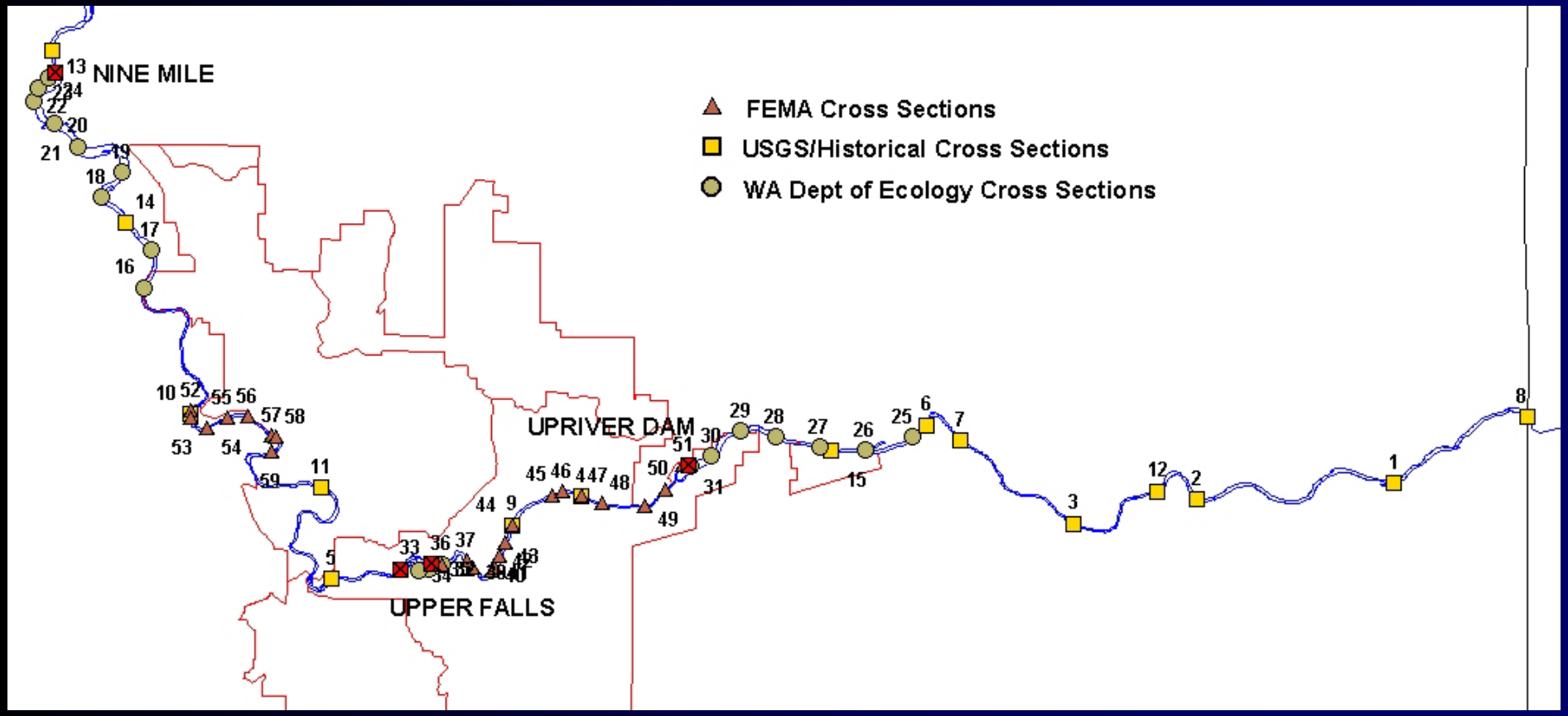
Grid Development - Long Lake



Model Development

Grid Development - Spokane River

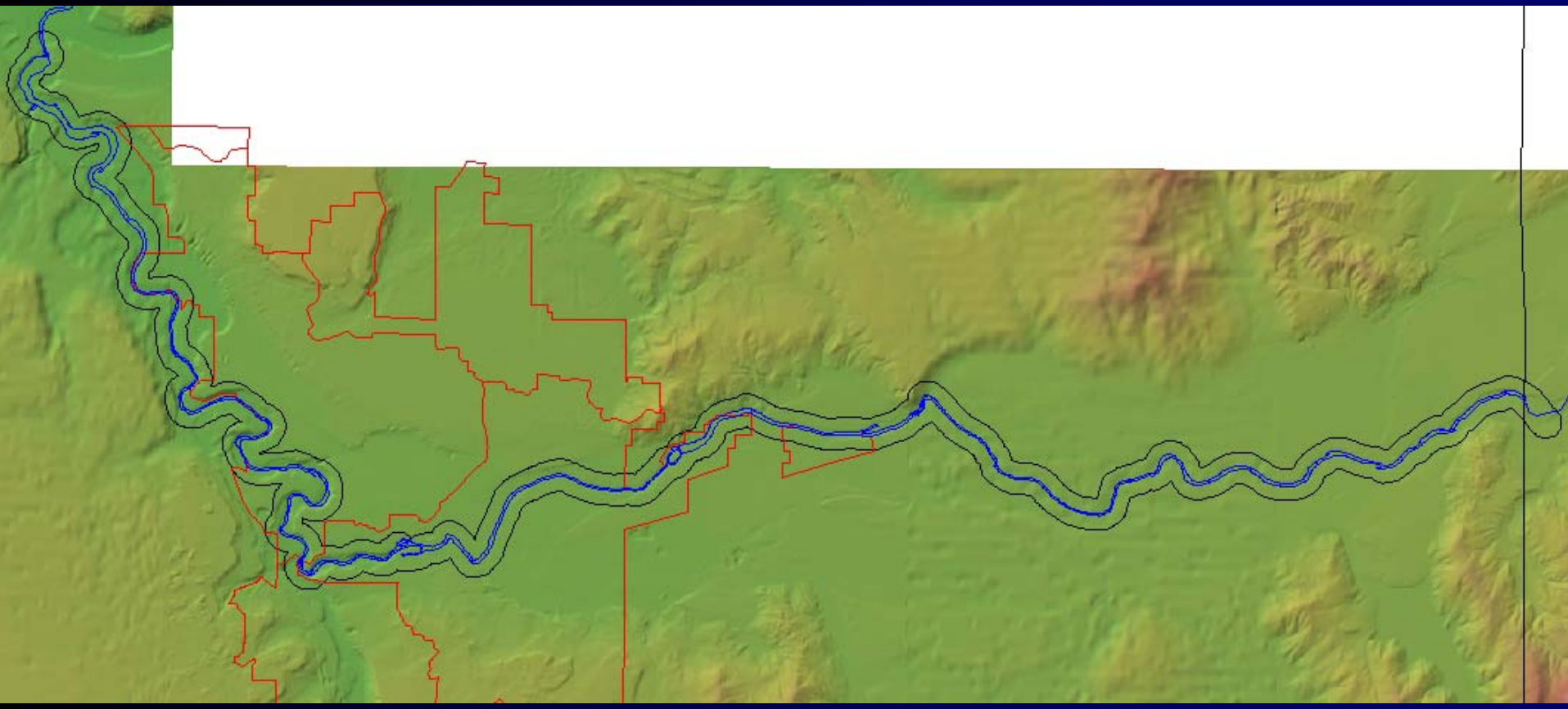
59 Cross Sections from RM 57.4 to 96.4



Model Development

Grid Development - Spokane River

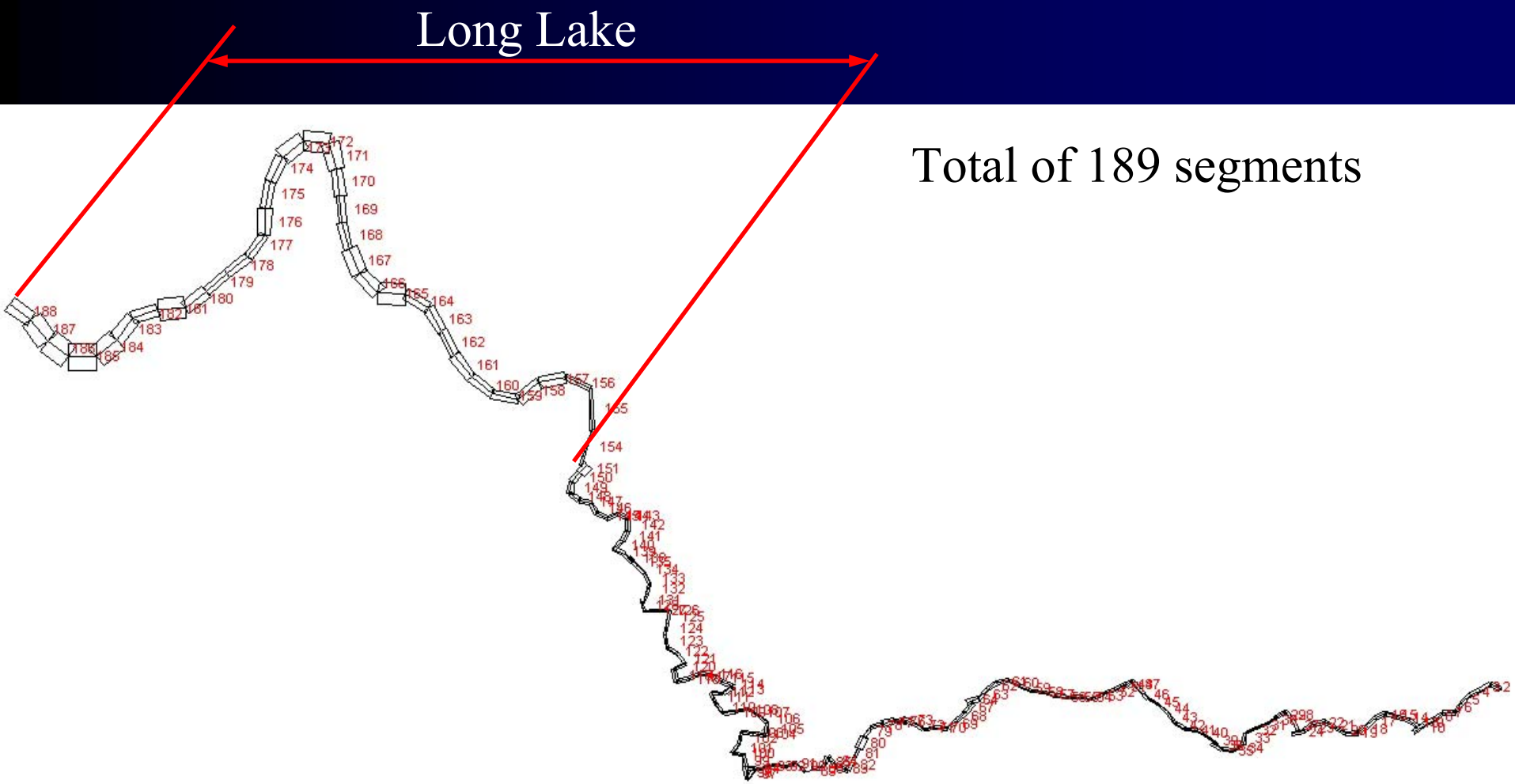
USGS DEM data: 400 m buffer around the centerline of the river



Digital Elevation Model Resolution: X&Y 30 m; Z 1 m

Model Development

Grid Layout



Total of 189 segments

Model Development

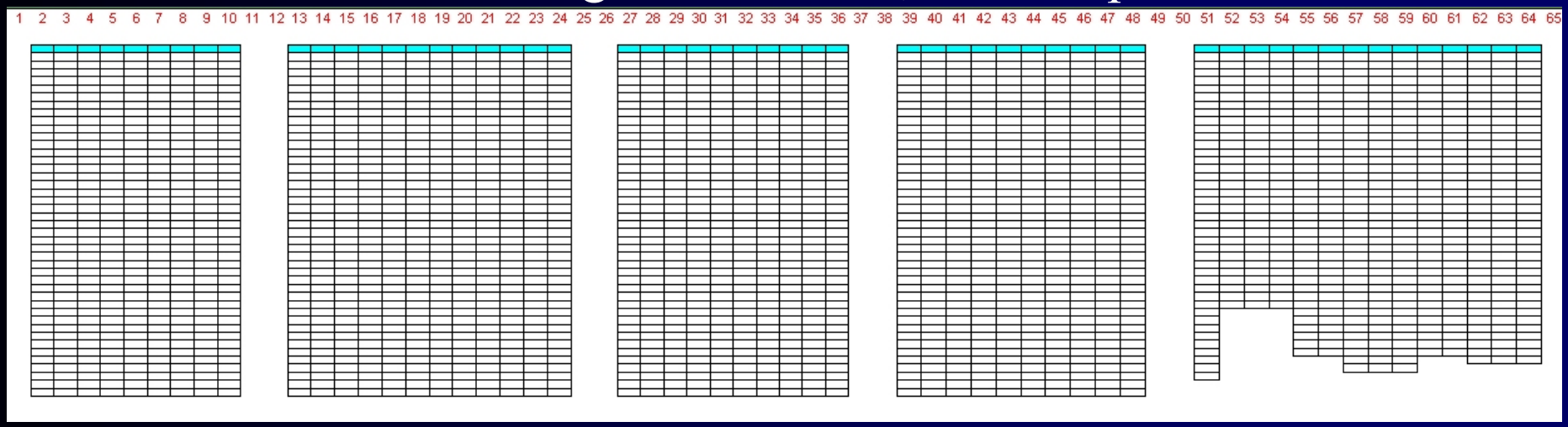
Grid Layout

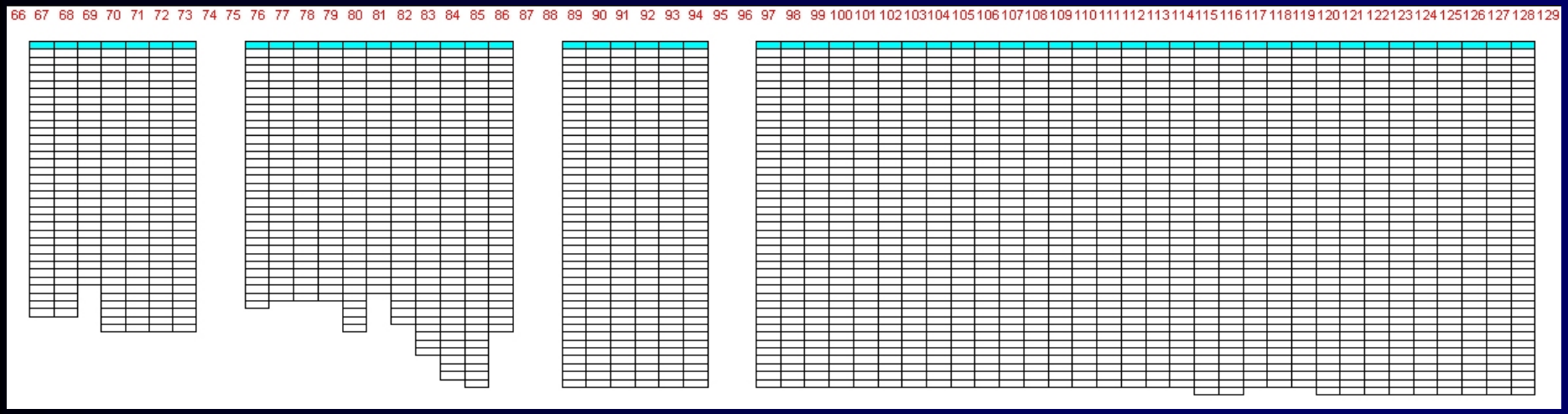
Comments	Start Branch (RM)	End Branch (RM)	Branch #	# of segments	DLX, m	Bottom Elev m, end of Branch
Post Falls USGS gage to Stateline						
Stateline to Harvard Road Bridge	96.4	93.8	1	9	461.61	608.5
Harvard Road Bridge to RM 90.34	93.8	90.3	2	12	467.37	600.0
RM 90.34 Barker Road Bridge	90.3	87.5	3	10	457.06	585.0
Barker Rd. Bridge to The Islands Foot Bridge	87.5	84.5	4	10	491.62	578.0
The Islands Foot Bridge to Upriver Dam	84.5	80.2	5	14	489.85	571.0
Upriver Dam to Green Street Bridge	80.2	78.1	6	7	478.90	560.0
Green Street Bridge to Upper Falls Dam	78.1	74.8	7	11	490.56	560.0
Upper Falls Dam to Spokane USGS gage	74.8	72.9	8	6	487.62	517.5
Spokane USGS gage to Seven Mile Bridge	72.9	63.2	9	32	489.35	485.0
Seven Mile Bridge to RM61.813	63.2	61.8	10	5	446.44	481.0
RM 61.813 to Nine Mile Dam	61.8	57.8	11	14	464.76	481.0
Nine Mile Dam to Long Lake Dam	57.8	32.5	12	37	1073.00	400.0

Model Development

Grid Layout

Segments 1 to 65, above Upriver Dam



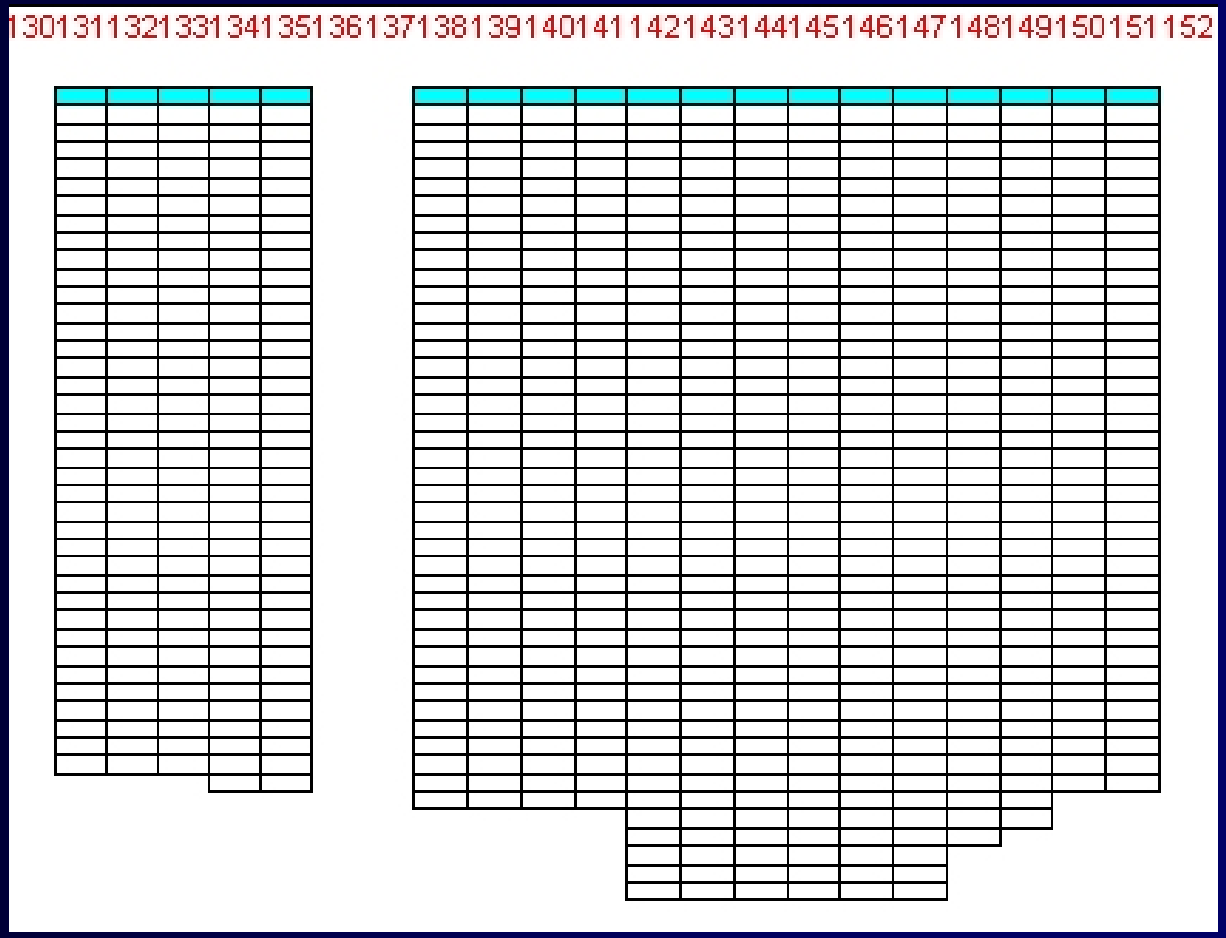


Segments 66 to 129, below Upriver Dam to Seven Mile Bridge

Model Development

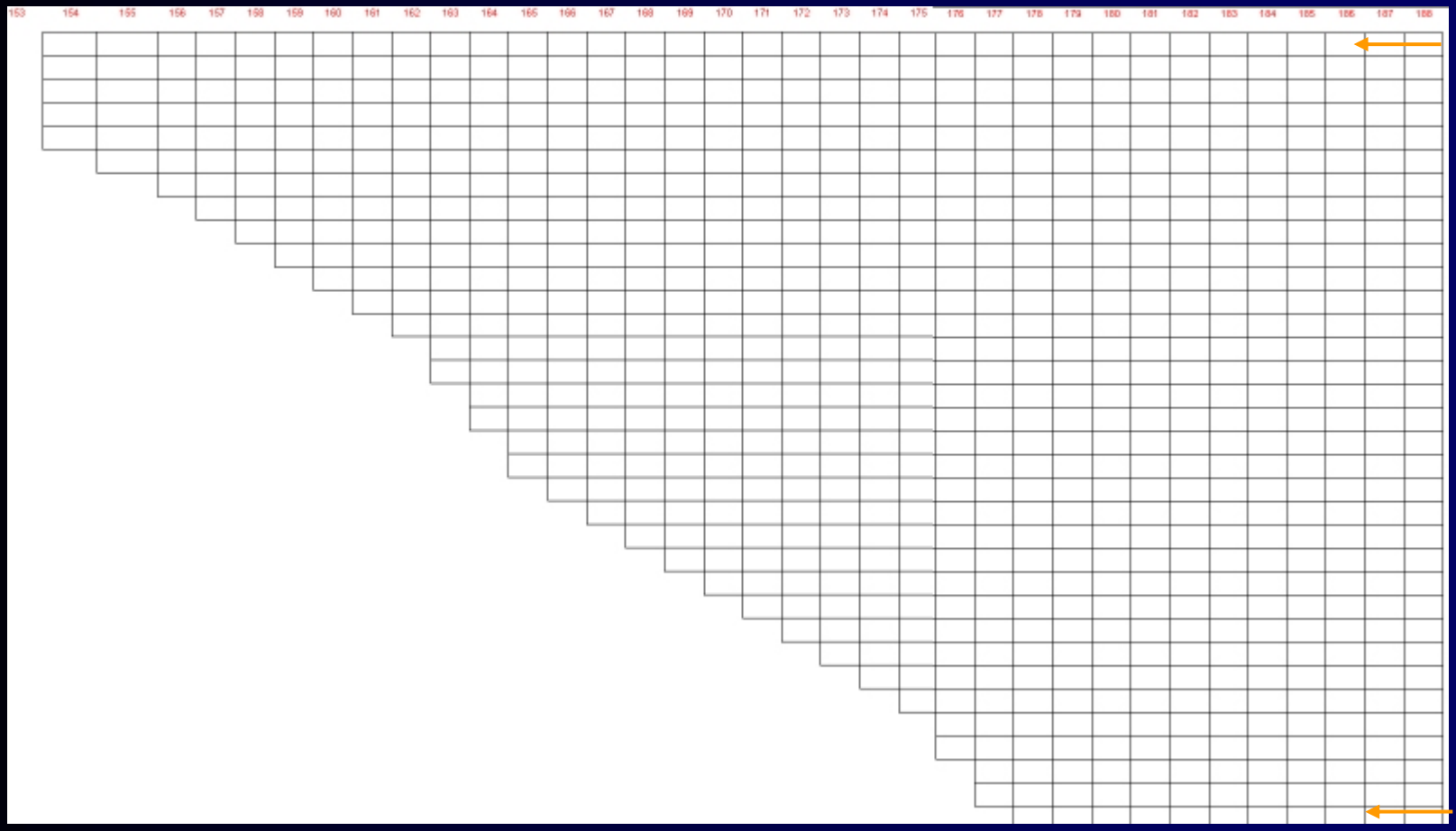
Grid Layout

Segments 130 to 152, Seven Mile Bridge to Nine Mile Dam



Model Development

Grid Layout



Bottom Layer: 47

Segments 153 - 189, Nine Mile Dam to Long Lake Dam

Model Calibration

Model Calibration time window:
February 1, 1991 to October 31, 1991
January 1, 2000 to October 31, 2000

Calibration Steps

- Hydrodynamics – water level, flow
- Temperature
- Water Quality
- Sensitivity Analysis

Hydrodynamic Calibration

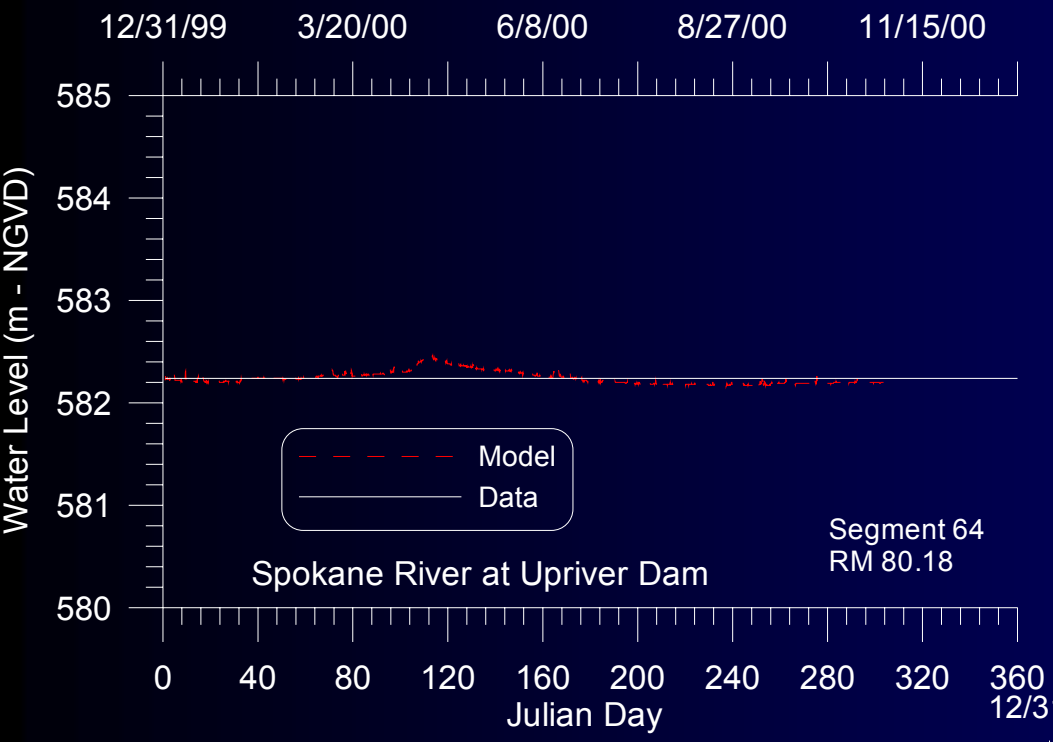
Water level data sites

Spokane River Sites	River Mile	Model Segment	Water Level Data available
Harvard Rd (USGS: 12419500)	93.8	13	2000
Barker Rd (USGS: 12420500)	90.3	24	2000
Upriver Dam	80.2	64	1991, 2000
Upper Falls Dam	74.8	86	1991, 2000
Downtown Spokane (USGS: 12422500)	72.9	97	1991, 2000
Nine Mile Dam	57.8	151	1991, 2000
Long Lake Dam	32.5	188	1991, 2000

Flow data sites

Spokane River Sites	River Mile	Model Segment	Flow Data available
Harvard Rd (USGS: 12419500)	93.8	13	2000
Barker Rd (USGS: 12420500)	90.3	24	2000
Downtown Spokane (USGS: 12422500)	72.9	97	1991, 2000

Water Level Prediction

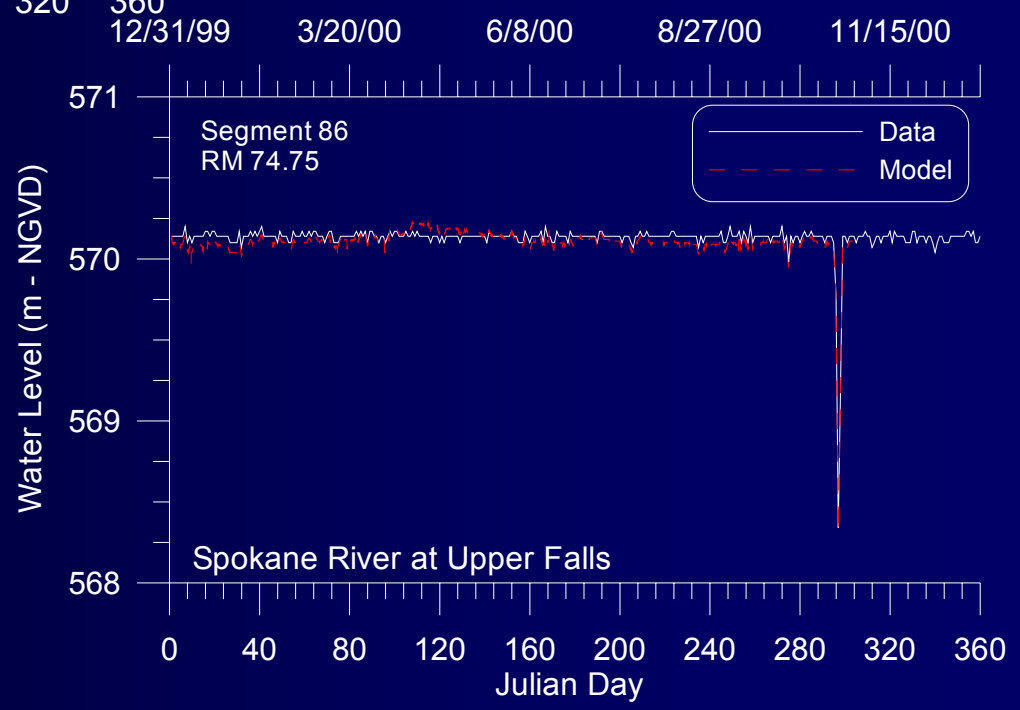


Year	n, # of data comparisons	Water level model –data error statistics	
		AME, m	RMS error, m
1991	271	0.060	0.069
2000	303	0.050	0.062

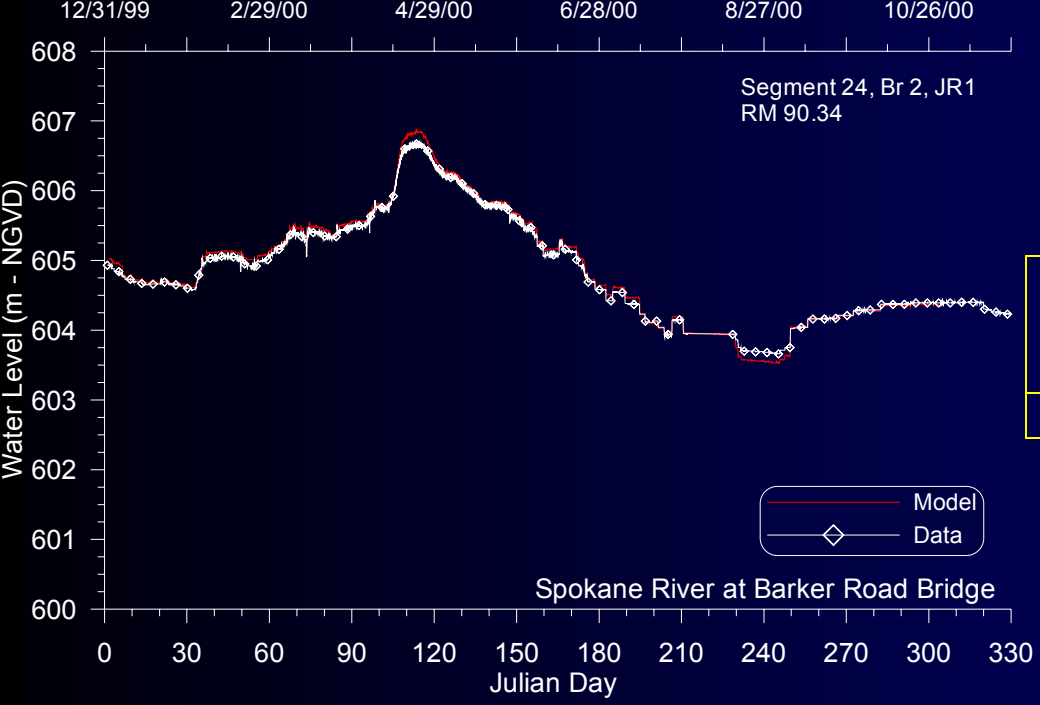
Spokane River at Upriver Dam

Year	N, # of data comparisons	Water level model –data error statistics	
		AME, m	RMS error, m
1991	271	0.044	0.057
2000	303	0.036	0.040

Spokane River at Upper Falls Dam



Water Level Prediction

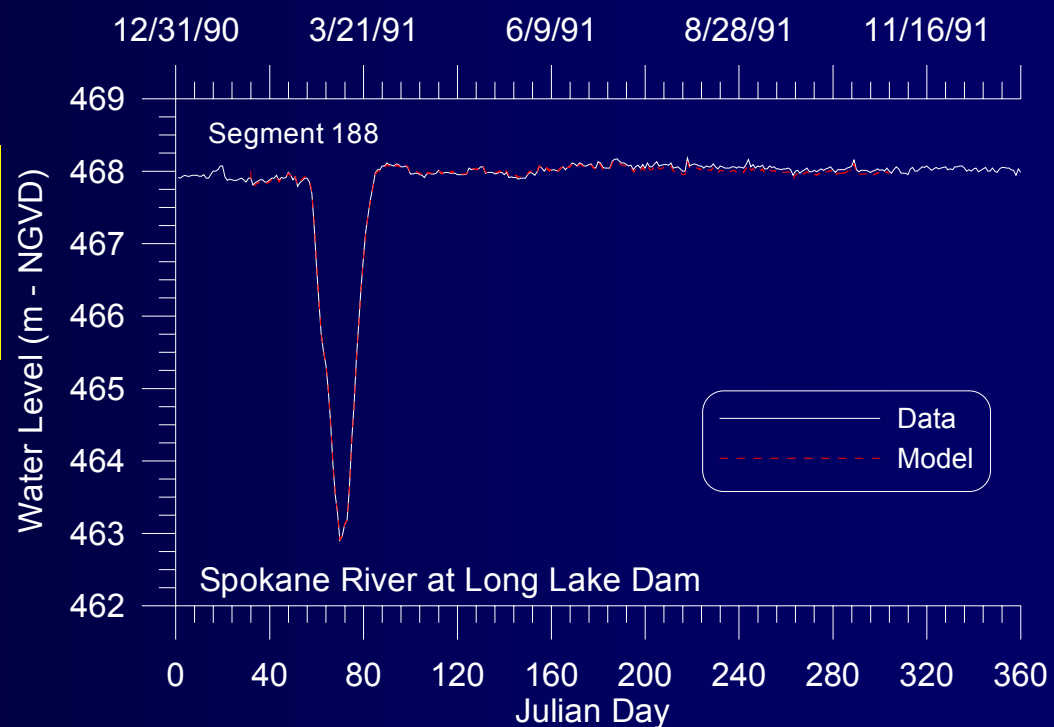


Year	N, # of data comparisons	Water level model –data error statistics	
		AME, m	RMS error, m
2000	28933	0.06	0.07

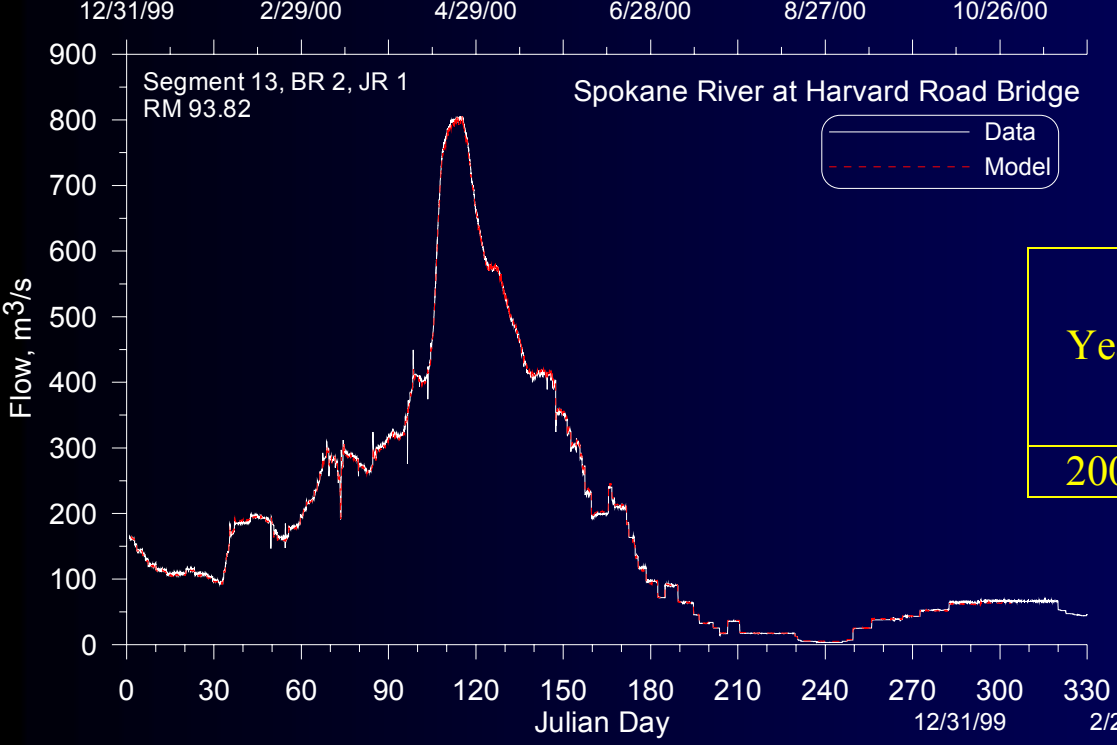
Spokane River at Barker Road

Year	N, # of data comparisons	Water level model –data error statistics	
		AME, m	RMS error, m
1991	271	0.029	0.034
2000	303	0.030	0.034

Spokane River at Long Lake Dam

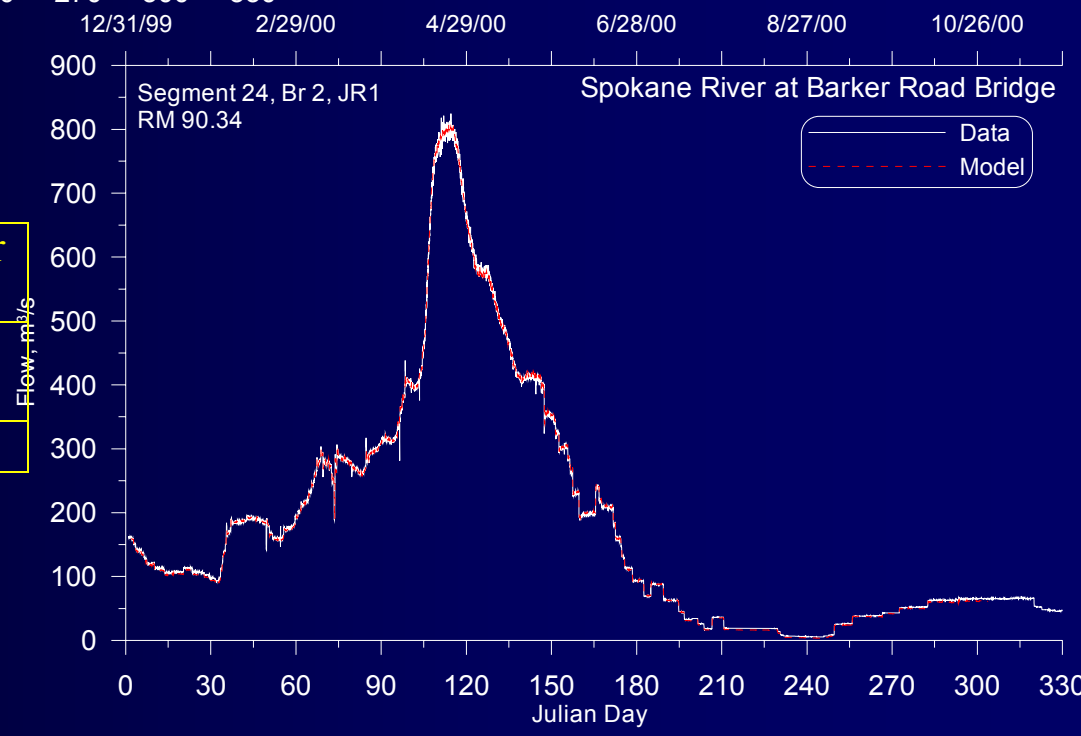


Flow Prediction



Year	N, # of data comparisons	Flow model –data error statistics	
		AME, m^3/s	RMS, m^3/s
2000	14466	2.31	3.40

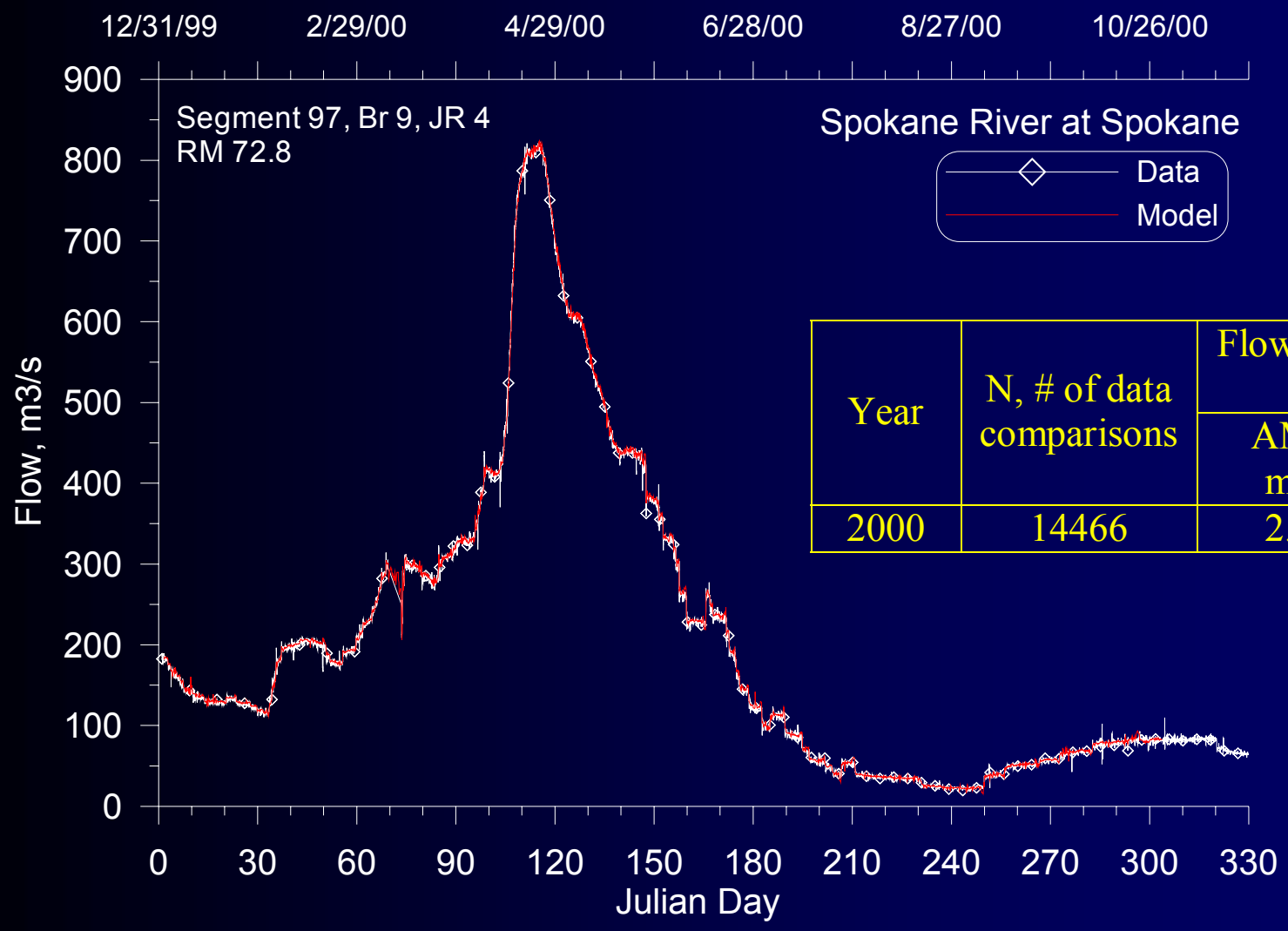
Spokane River at Harvard Rd Bridge



Year	N, # of data comparisons	Flow model –data error statistics	
		AME, m^3/s	RMS, m^3/s
2000	14466	2.51	3.79

Spokane River at Barker Rd Bridge

Flow Prediction



Year	N, # of data comparisons	Flow model –data error statistics	
		AME, m^3/s	RMS, m^3/s
2000	14466	2.97	4.31

Spokane River at Spokane

Temperature Calibration

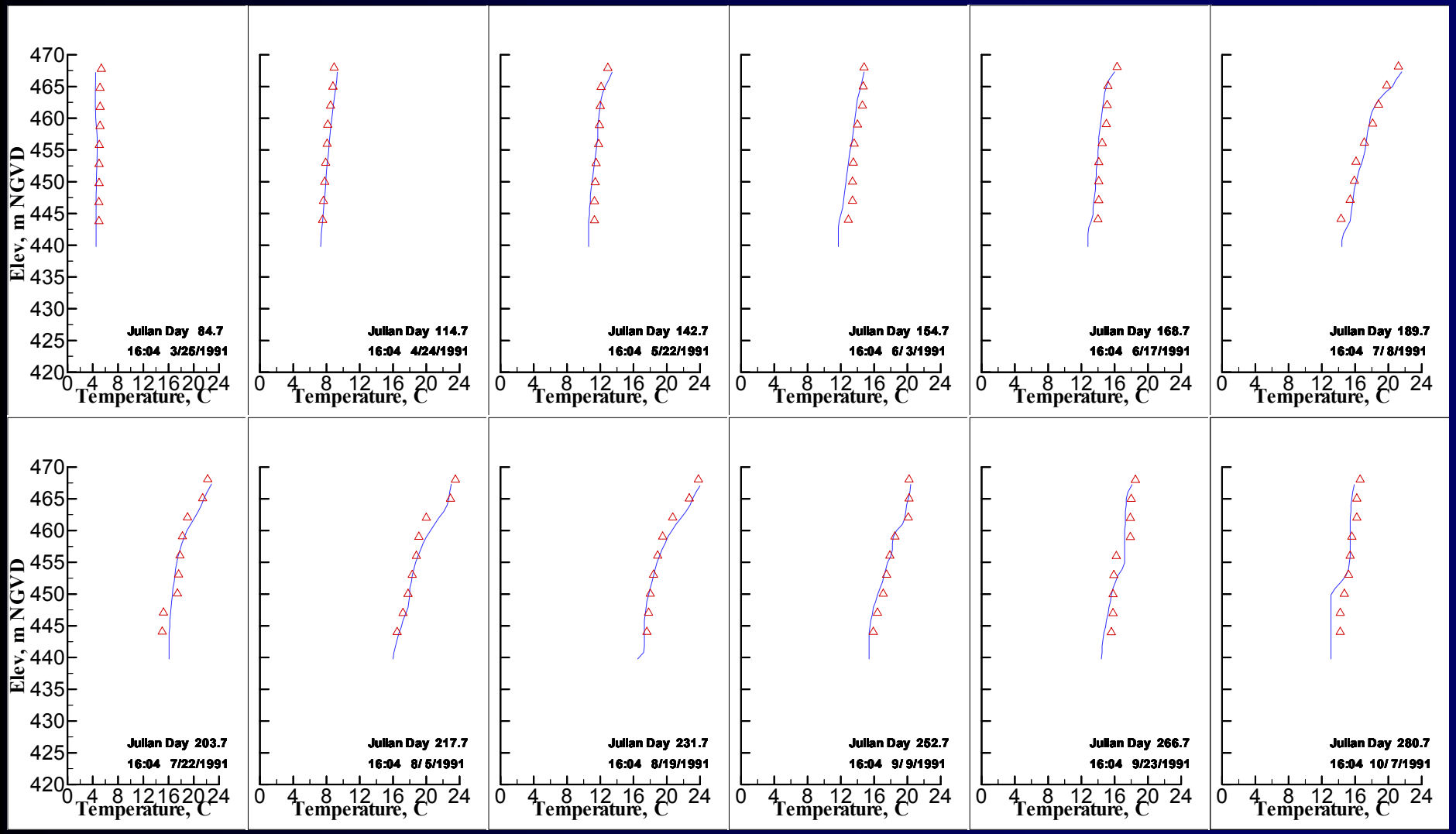
Vertical Profile Data

Site ID	Description	Segment Number	River Mile	Year
LL0	Long Lake @ Station 0 (near dam)	187	32.66	1991, 2000
LL0.5	Long Lake @ Station 0.5	183	35.90	2000
LL1	Long Lake @ Station 1	180	37.62	1991, 2000
LL2	Long Lake @ Station 2	174	42.06	1991, 2000
LL3	Long Lake @ Station 3	168	46.42	1991, 2000
LL4	Long Lake @ Station 4	161	51.47	1991, 2000
LL5	Long Lake @ Station 5	157	54.20	2000
SPK58.3	0.2 miles upstream of Nine mile Dam	150	58.30	2000
SPK58.9	0.8 miles upstream of Nine mile Dam	147	58.90	2000
SPK60.2	2.1 miles upstream of Nine mile Dam	143	60.20	2000
SPK60.9	2.8 miles upstream of Nine mile Dam	141	60.90	2000
SPK61.4	3.3 miles upstream of Nine mile Dam	139	61.40	2000
SPK61.9	3.8 miles upstream of Nine mile Dam	135	61.90	2000
SPK80.2	0.4 miles upstream of Upriver Dam	64	80.20	2000
SPK81.0	1.2 miles upstream of Upriver Dam	62	81.00	2000
SPK81.6	1.8 miles upstream of Upriver Dam	60	81.60	2000
SPK82.5	2.7 miles upstream of Upriver Dam	57	82.50	2000

Time Series Data

Site ID	Description	Segment Number	River Mile	Year
SPK58.1	Just d/s of Nine Mile Dam at the Charles road bridge	154	58.10	2000
SPK62.0	Spokane R @ Seven Mile Br	135	62.00	1991, 2000
SPK66.0	Spokane R @ Riverside State Park	119	66.00	1991, 2000
SPK69.8	Spokane R near Fort Wright Bridge	106	69.80	1991, 2000
SPK72.8	USGS gauging station, Spokane River at Spokane	97	72.80	1991, 2000
SPK96.0	Spokane R @ Stateline Bridge	2	96.00	1991, 2000

Temperature Prediction – Long Lake, 1991

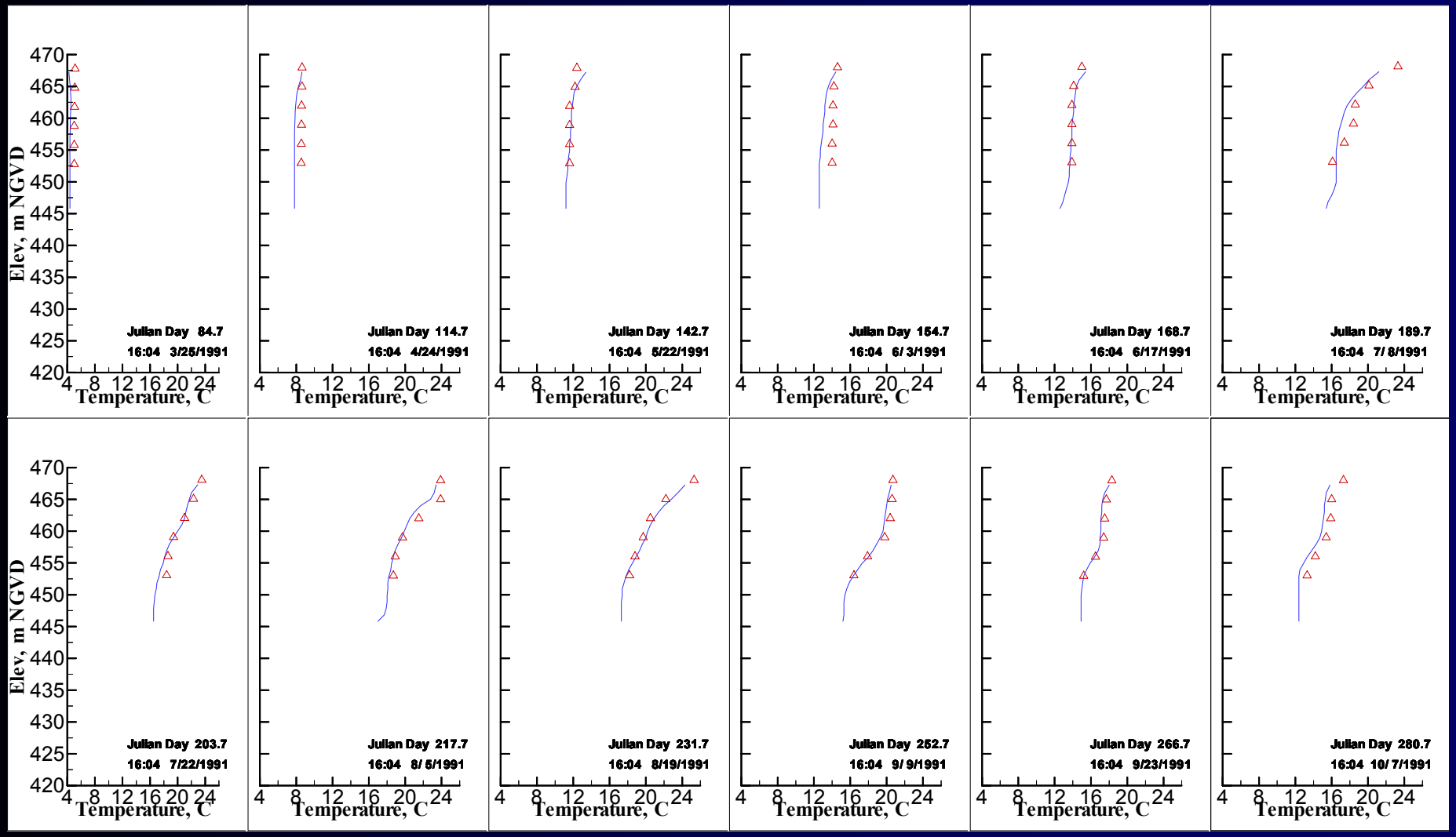


(LL2, segment 174)

AME: 0.57 ^{o}C RMS: 0.67 ^{o}C

Open triangles are data and the line is the model

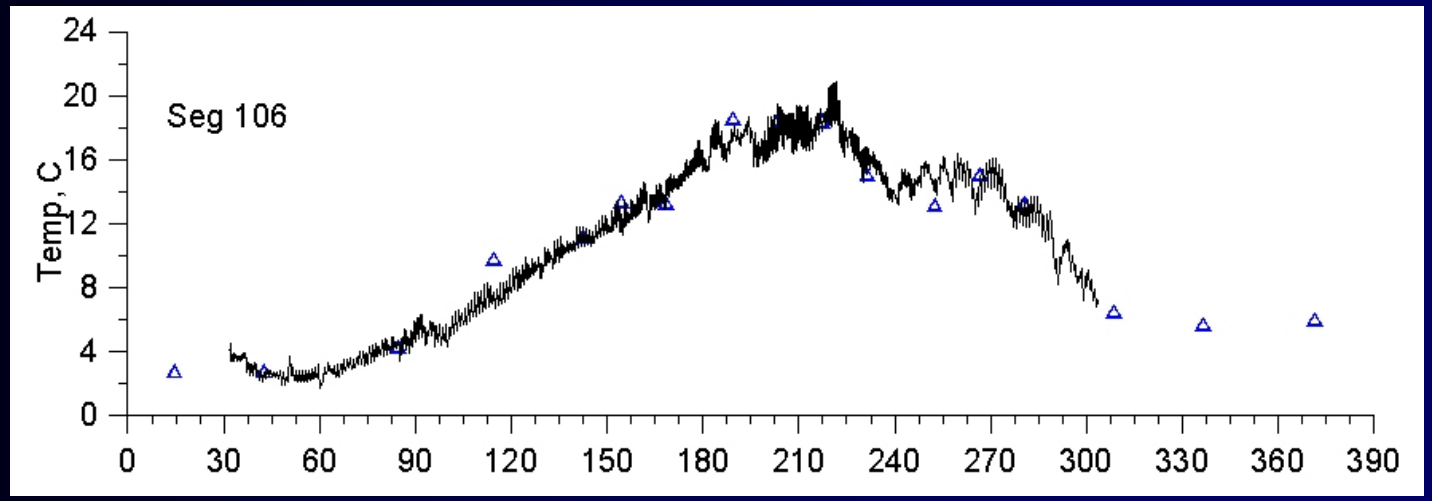
Temperature Prediction – Long Lake, 1991



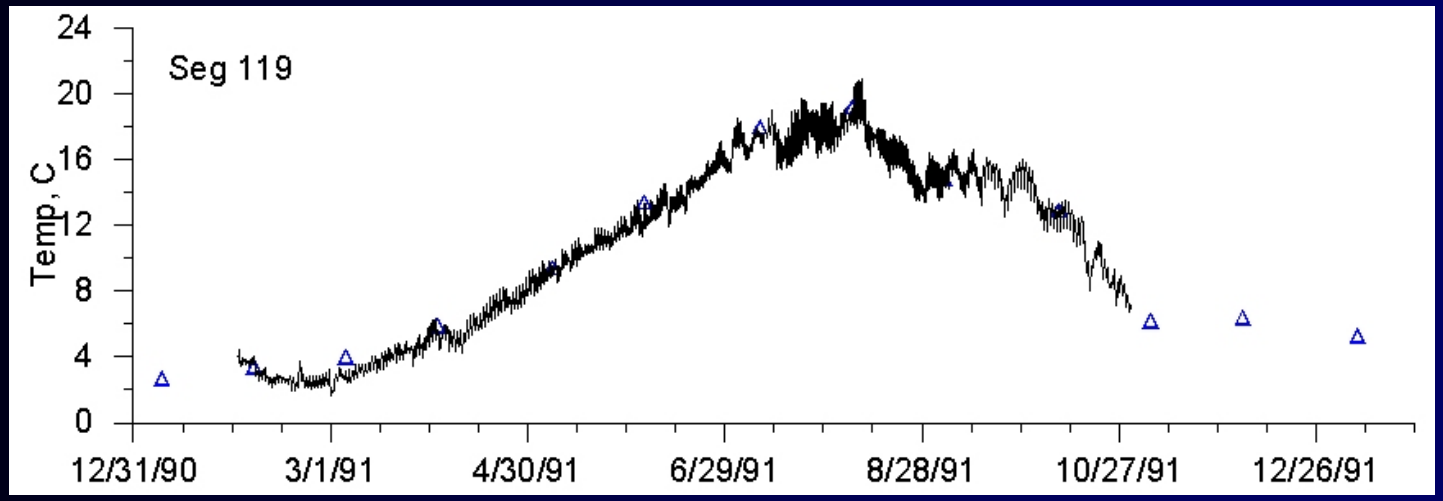
(Site LL3, segment 168)

AME: 0.52 ^{o}C RMS: 0.57 ^{o}C

Temperature Prediction Time Series, 1991



(Spokane River near Fort Wright Bridge, segment 106)



(Spokane River at Riverside State Park, segment 119)

Water Quality Calibration

Vertical Profile Data

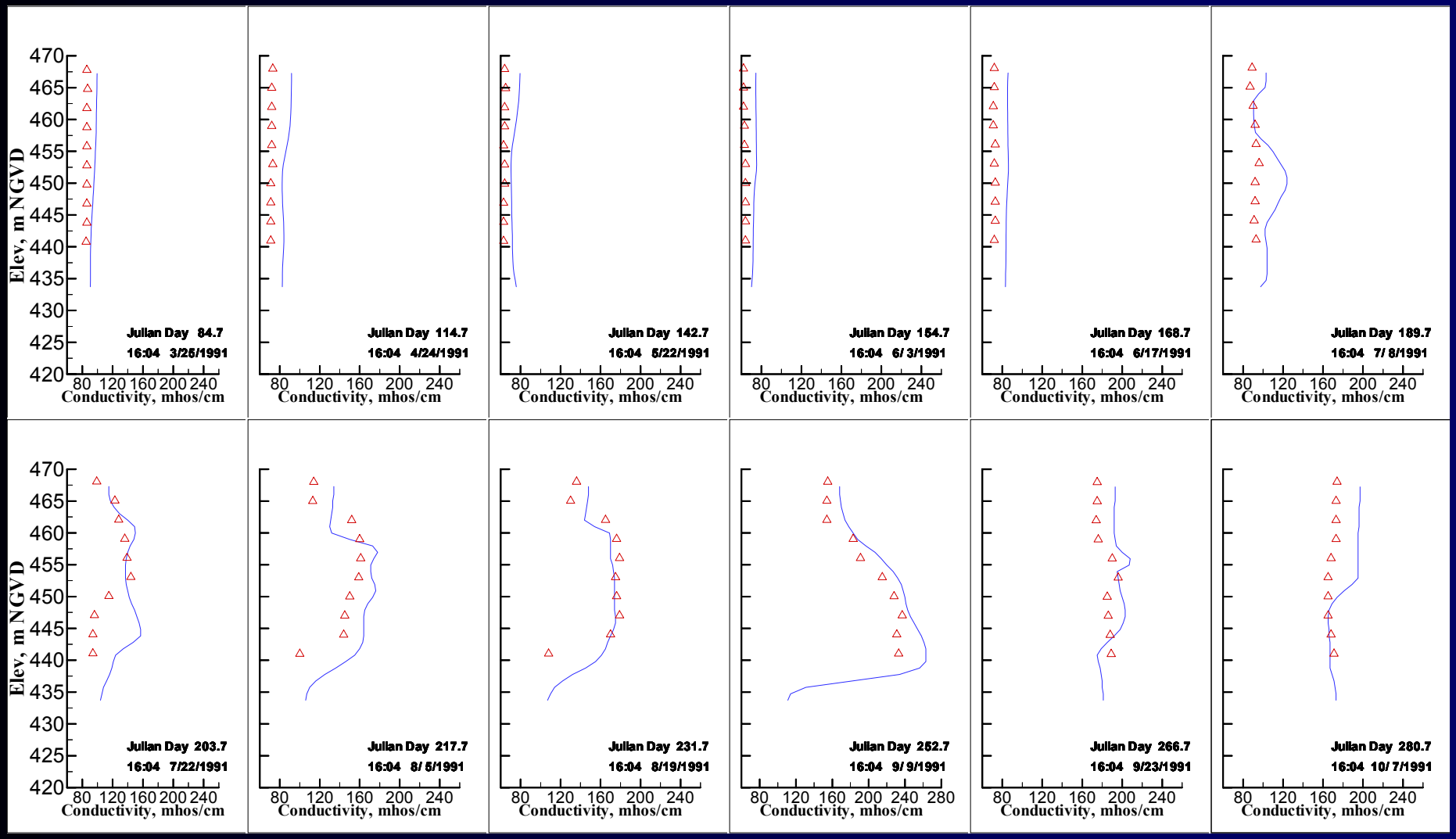
SiteID	Description	Seg	RM	1991 Vert. profile	2000 Vert. profile
LL0	Long Lake @ Station 0 (near dam)	187	32.66	YES	YES
LL0.5	Long Lake @ Station 0.5	183	35.90		YES
LL1	Long Lake @ Station 1	180	37.62	YES	YES
LL2	Long Lake @ Station 2	174	42.06	YES	YES
LL3	Long Lake @ Station 3	168	46.42	YES	YES
LL4	Long Lake @ Station 4	161	51.47	YES	YES
LL5	Long Lake @ Station 5	157	54.20		YES
SPK58.3	0.2 miles upstream of Nine mile Dam	150	58.30		YES
SPK58.9	0.8 miles upstream of Nine mile Dam	147	58.90		YES
SPK60.2	2.1 miles upstream of Nine mile Dam	143	60.20		YES
SPK60.9	2.8 miles upstream of Nine mile Dam	141	60.90		YES
SPK61.4	3.3 miles upstream of Nine mile Dam	139	61.40		YES
SPK61.9	3.8 miles upstream of Nine mile Dam	135	61.90		YES
SPK80.2	0.4 miles upstream of Upriver Dam	64	80.20		YES
SPK81.0	1.2 miles upstream of Upriver Dam	62	81.00		YES
SPK81.6	1.8 miles upstream of Upriver Dam	60	81.60		YES
SPK82.5	2.7 miles upstream of Upriver Dam	57	82.50		YES

Water Quality Calibration

Time Series Data

SiteID	Description	Seg	RM	1991 Time Series	2000 Time Series
LL0	Long Lake @ Station 0 (near dam)	187	32.66	YES	
LL1	Long Lake @ Station 1	180	37.62	YES	
LL2	Long Lake @ Station 2	174	42.06	YES	
LL3	Long Lake @ Station 3	168	46.42	YES	
LL4	Long Lake @ Station 4	161	51.47	YES	
SPK57.1-A&B	1 mile downstream of Nine Mile Dam.	155	57.10		YES
SPK58.1	Just d/s of Nine Mile Dam at the road bridge	154	58.10	YES	YES
SPK58.3	0.2 miles upstream of Nine mile Dam	150	58.30		YES
SPK60.9	2.8 miles upstream of Nine mile Dam	141	60.90		YES
SPK62.0	Spokane R @ Seven Mile Br	135	62.00	YES	YES
SPK66.0	Spokane R @ Riverside State Park	119	66.00	YES	YES
SPK67.6	Spokane R Upstream Spokane WTP	114	67.60		YES
SPK69.8	Spokane R near Fort Wright Bridge	106	69.80	YES	YES
SPK72.5	Spokane R Upstream of Hangman Cr.	97	72.50		YES
SPK72.8	USGS gauging station, Spokane River at Spokane	97	72.80	YES	
SPK74.4	Spokane River @ Walkbridge behind Spokane Center	89	74.40		YES
SPK78.0	Spokane R @ Green St. Bridge	73	78.00		YES
SPK79.8	Spokane R Upstream Upriver Dam Powerhouse	67	79.80		YES
SPK79.9	0.1 miles upstream of Upriver Dam	64	79.90		YES
SPK84.7	Spokane R Foot Bridge @ Plante Ferry Park	48	84.70		YES
SPK87.8	Spokane R @ Sullivan Rd. Bridge	36	87.80		YES
SPK90.4	Spokane R @ Barker Rd. Bridge	24	90.40		YES
SPK93.0	Spokane R @ Harvard Rd. Bridge	17	93.00		YES
SPK96.0	Spokane R @ Stateline Bridge	2	96.00	YES	YES

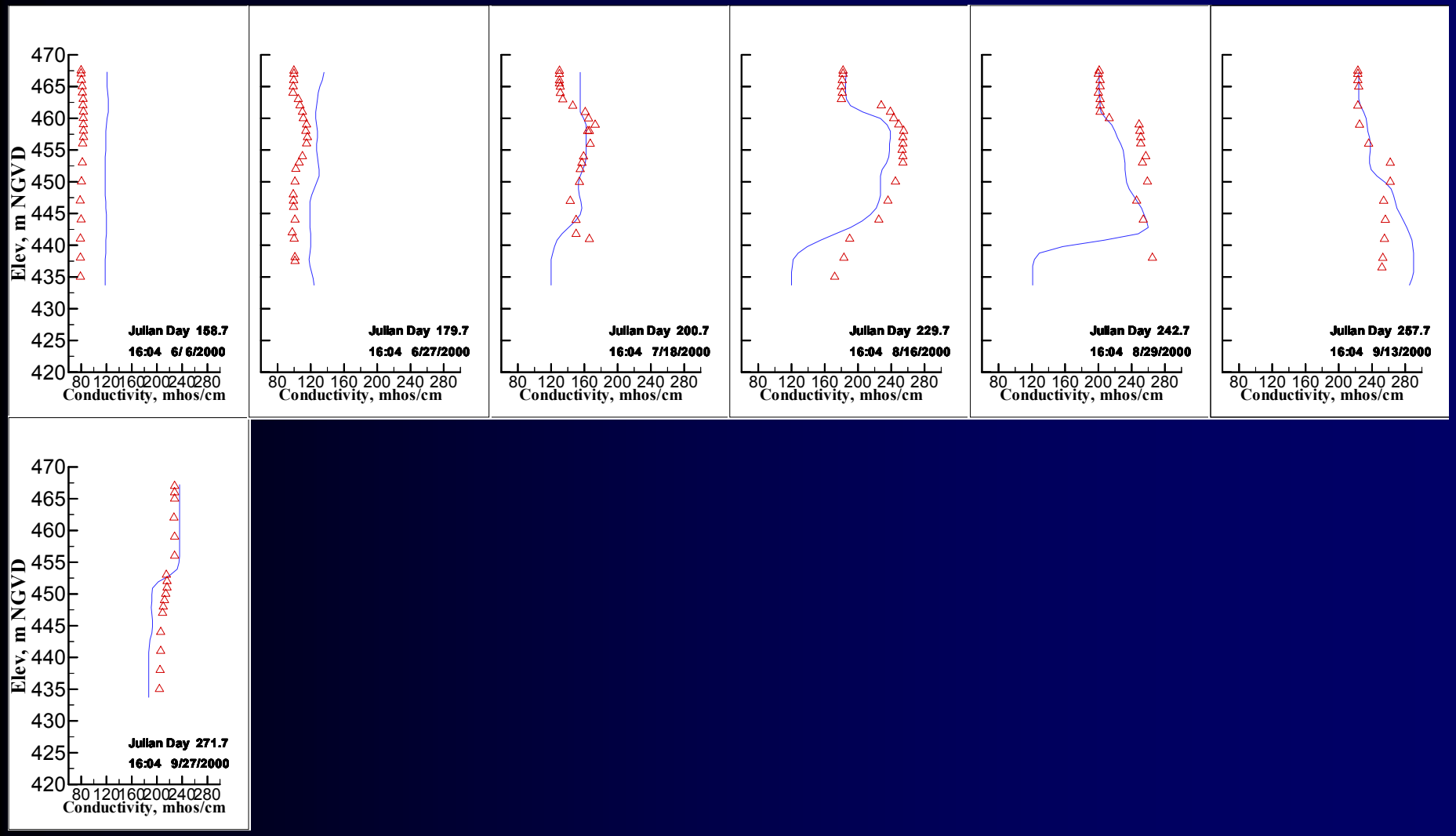
Conductivity Prediction – Long Lake, 1991



(Site LL1, segment 180)

AME: 14.7 mhos/cm RMS: 17.2 mhos/cm

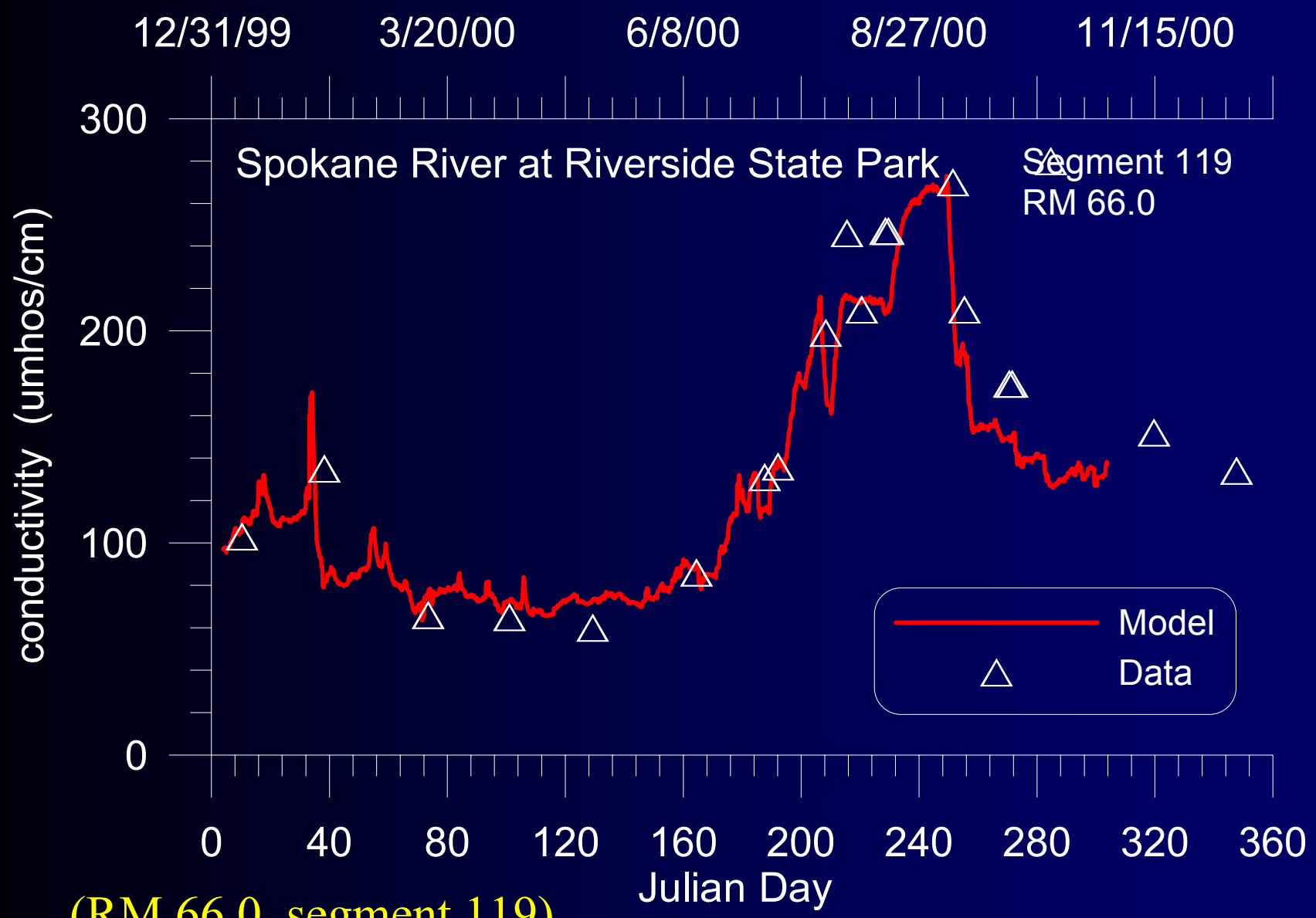
Conductivity Prediction – Long Lake, 2000



(Site LL1, segment 180)

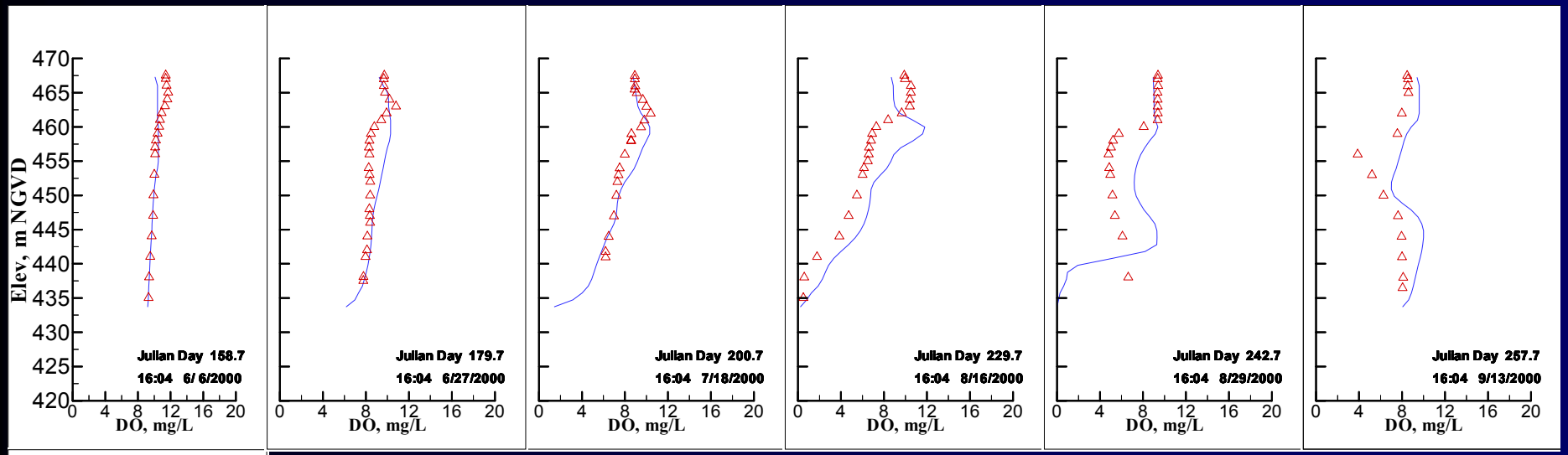
AME: 24.9 mhos/cm RMS: 16.4 mhos/cm

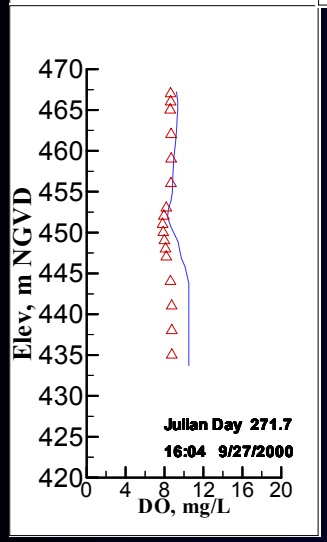
Conductivity – Riverside State Park



(RM 66.0, segment 119)

Dissolved Oxygen – Long Lake, 2000

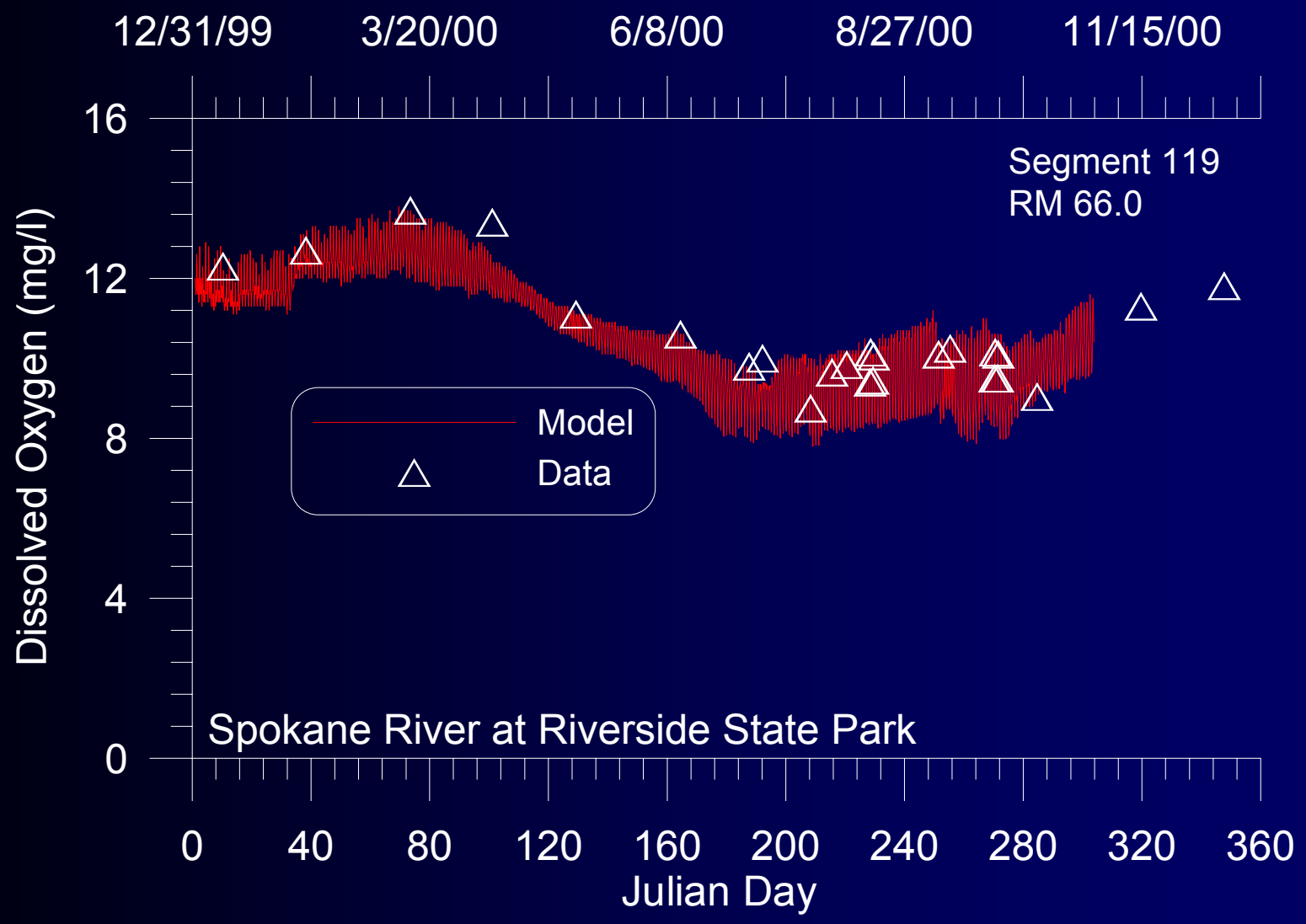




AME: 1.2 mg/L RMS: 1.5 mg/L

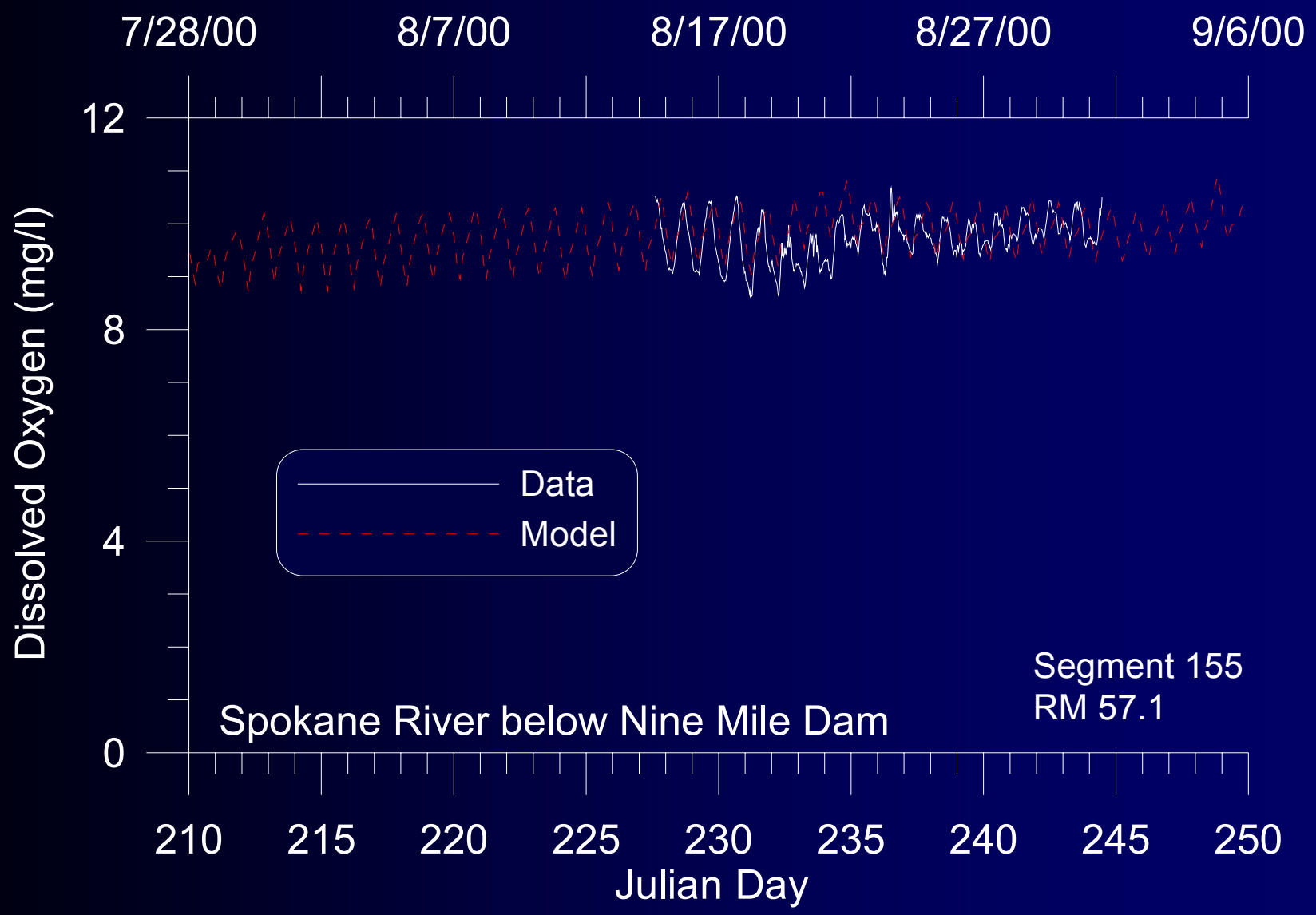
(Site LL1, segment 180)

Dissolved Oxygen – Riverside State Park, 2000



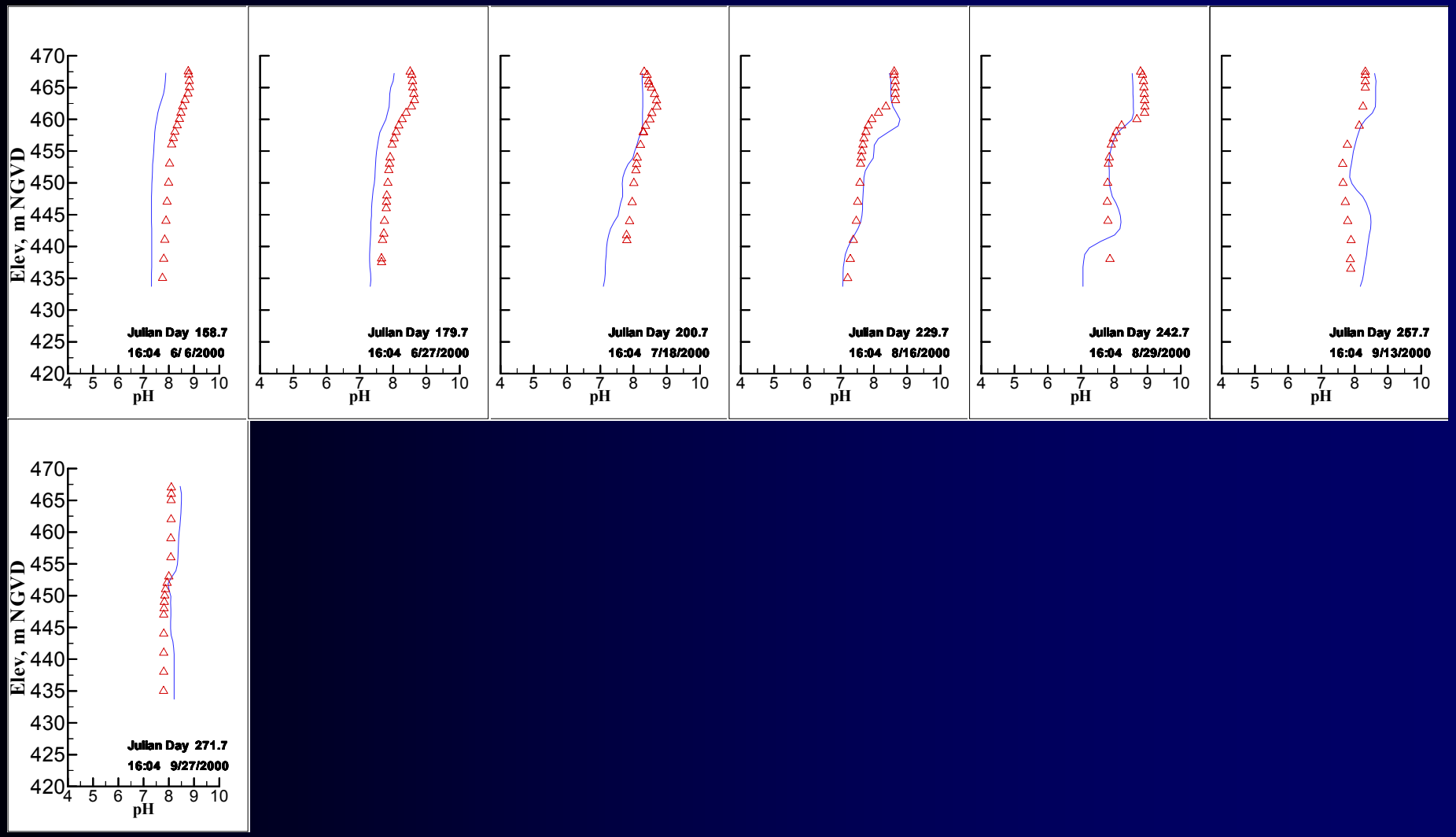
(RM 66.0, segment 119)

Dissolved Oxygen below Nine Mile Dam, 2000



(RM 57.1, segment 155)

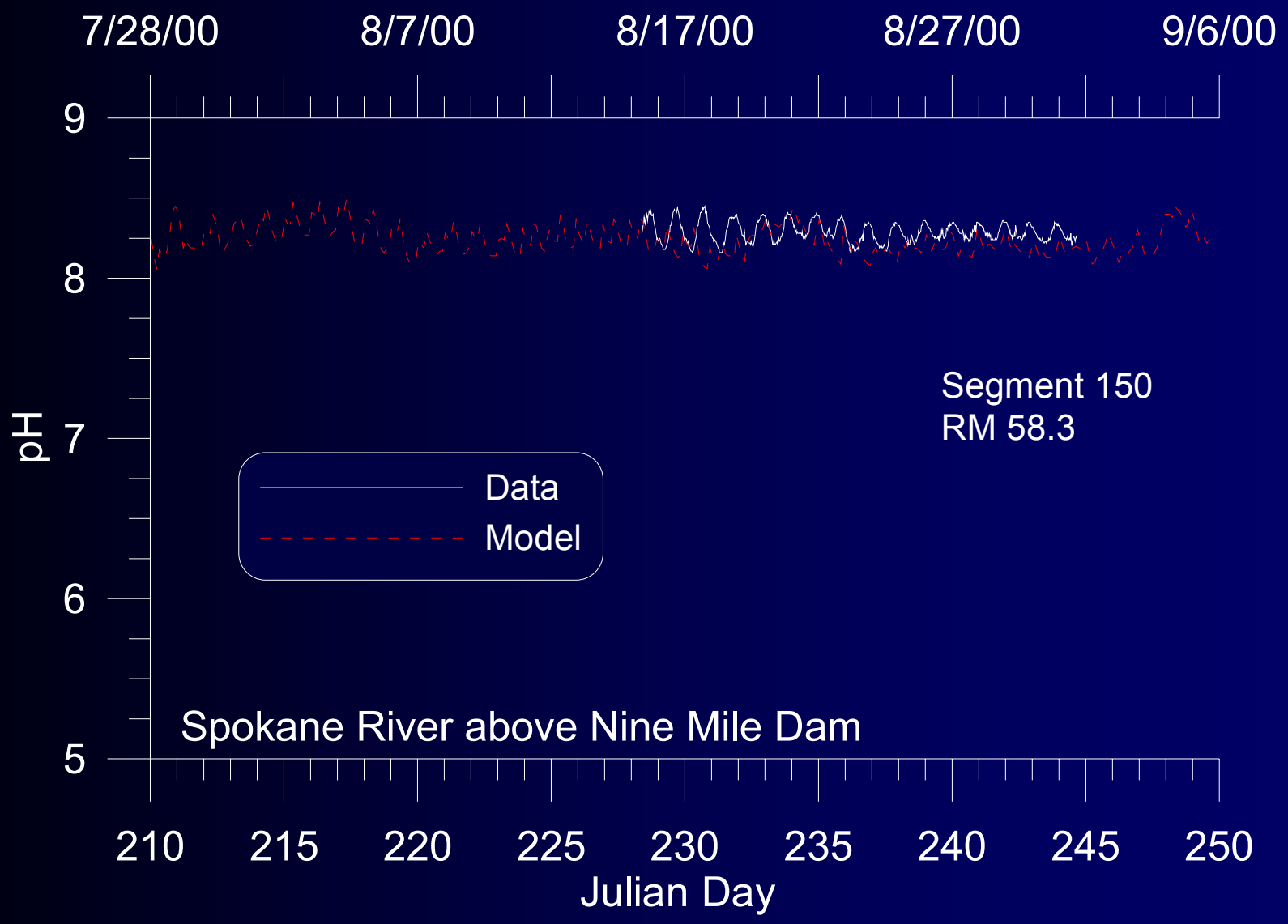
pH – Long Lake, 2000



(Site LL1, segment 180)

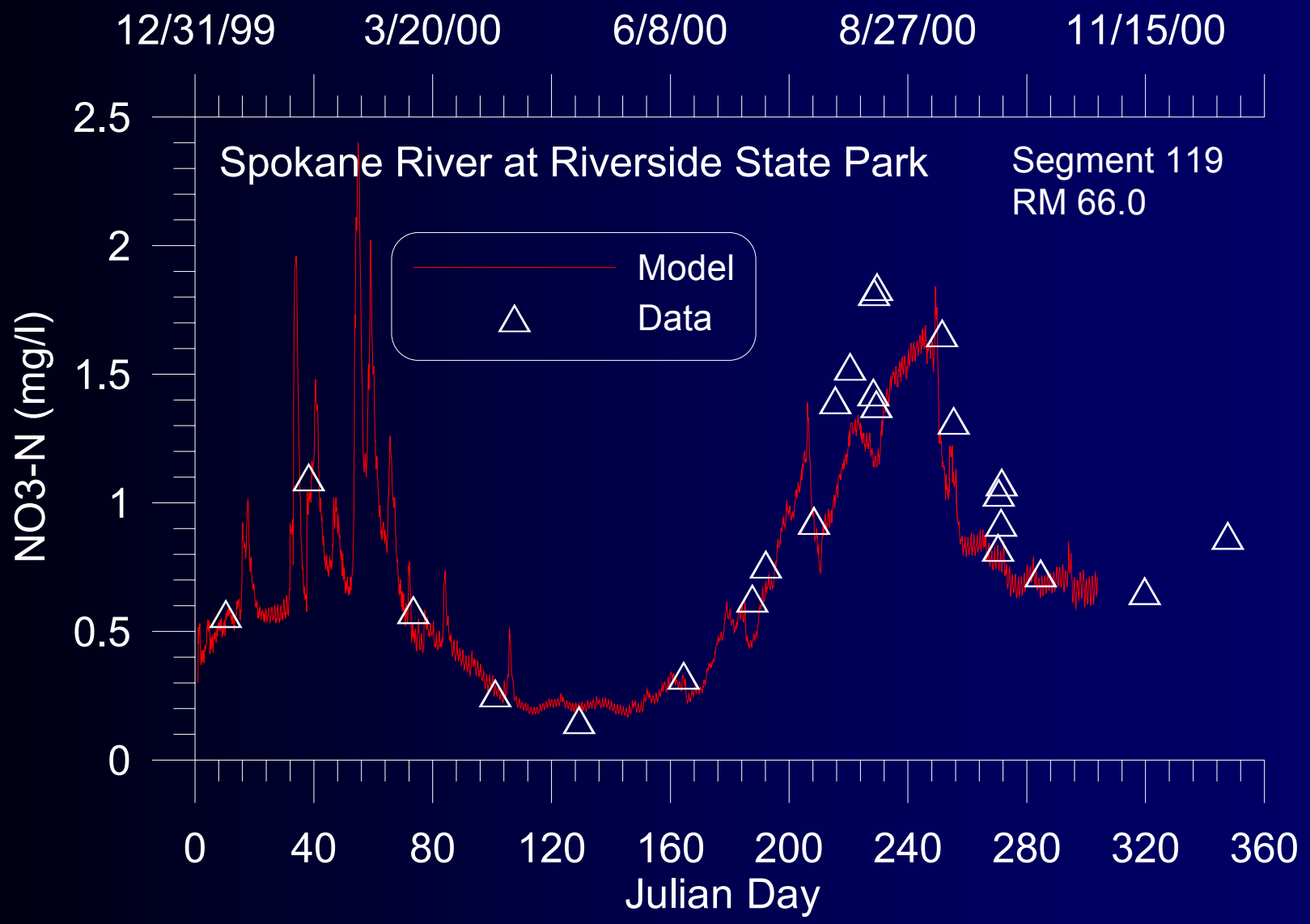
AME: 0.39 RMS: 0.43

pH above Nine Mile Dam, 2000



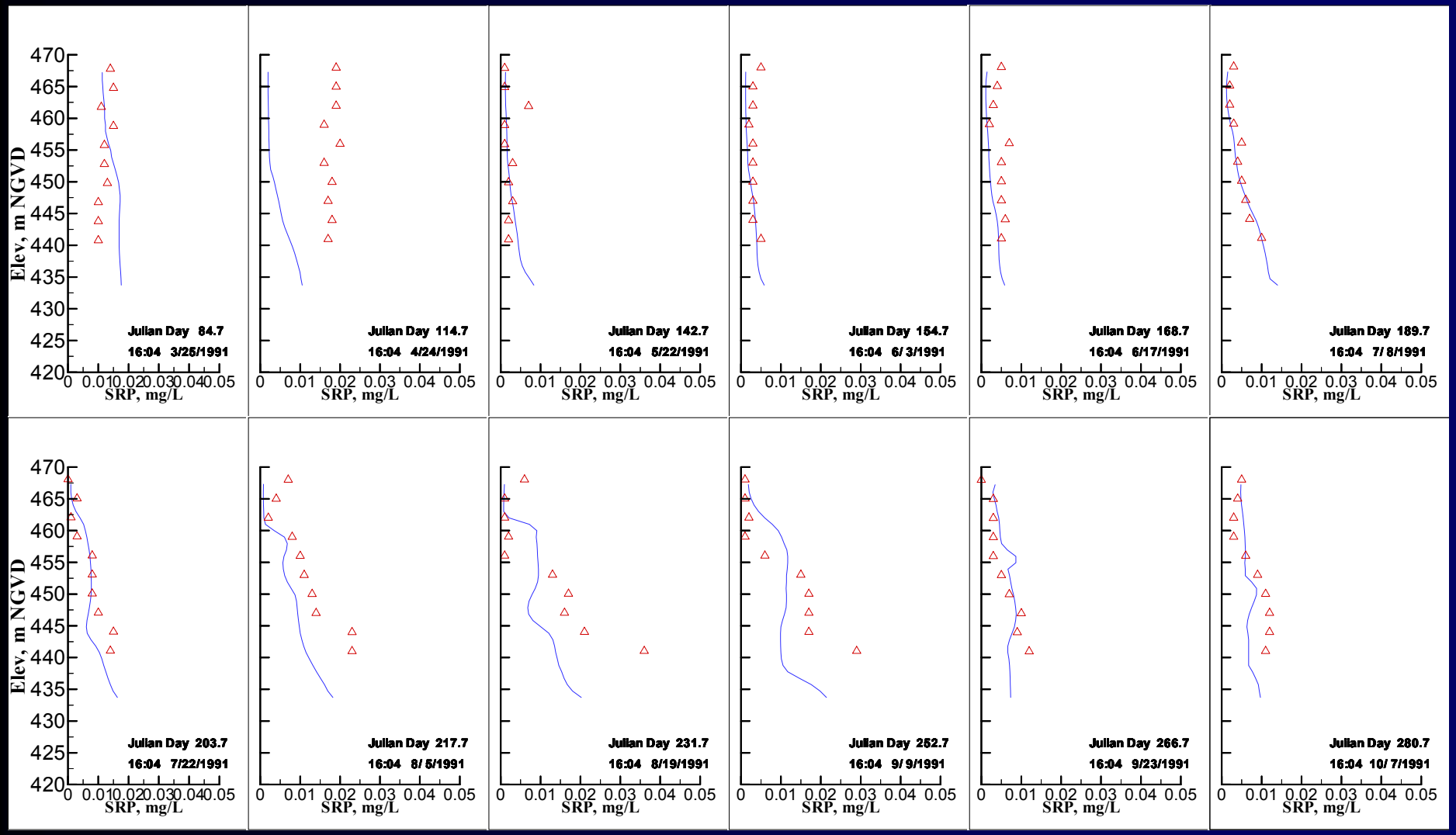
(RM 58.3, segment 150)

Nitrate – Riverside State Park, 2000



(RM 66.0, segment 119)

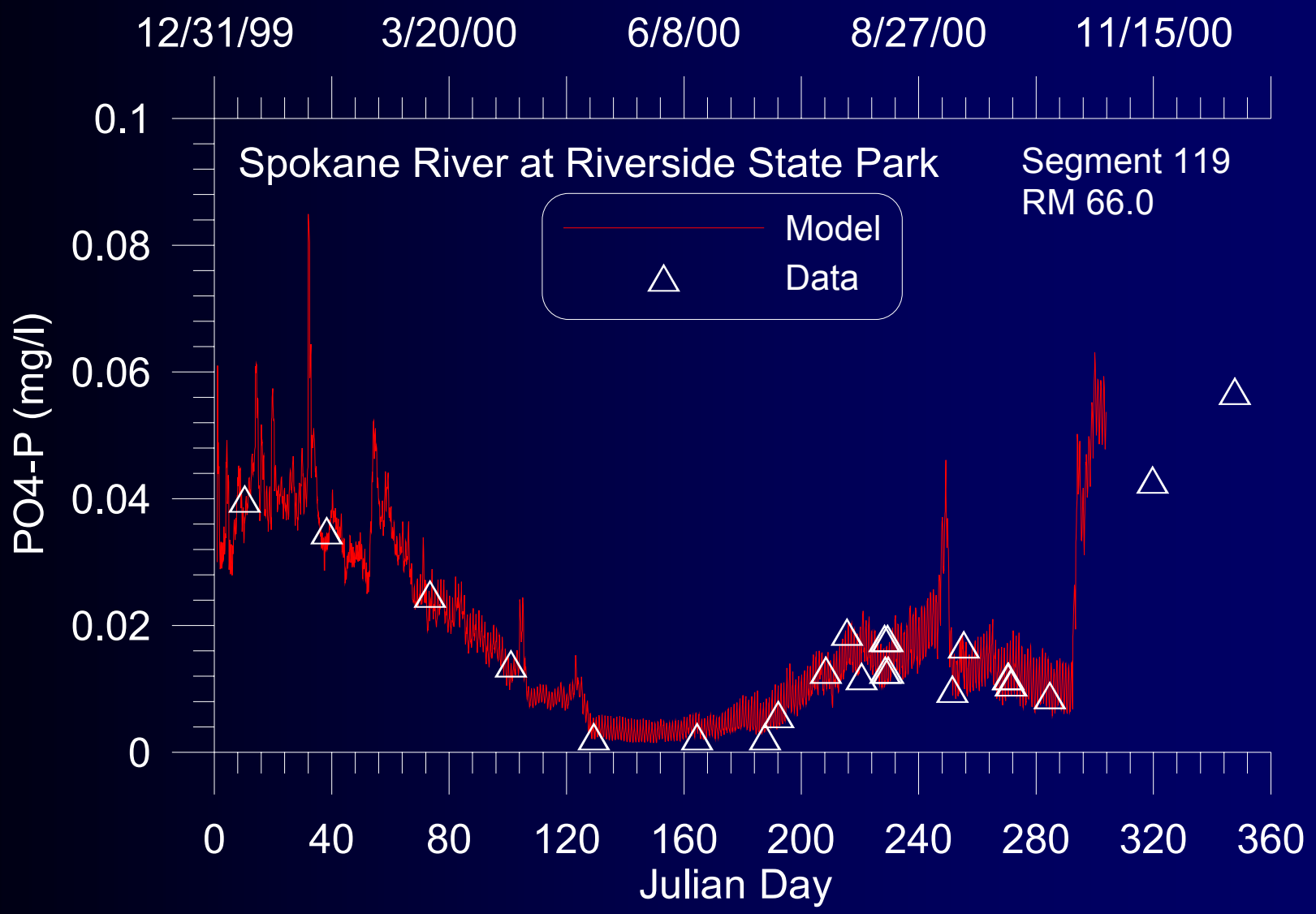
Ortho-Phosphate – Long Lake, 1991



(Site LL1, segment 180)

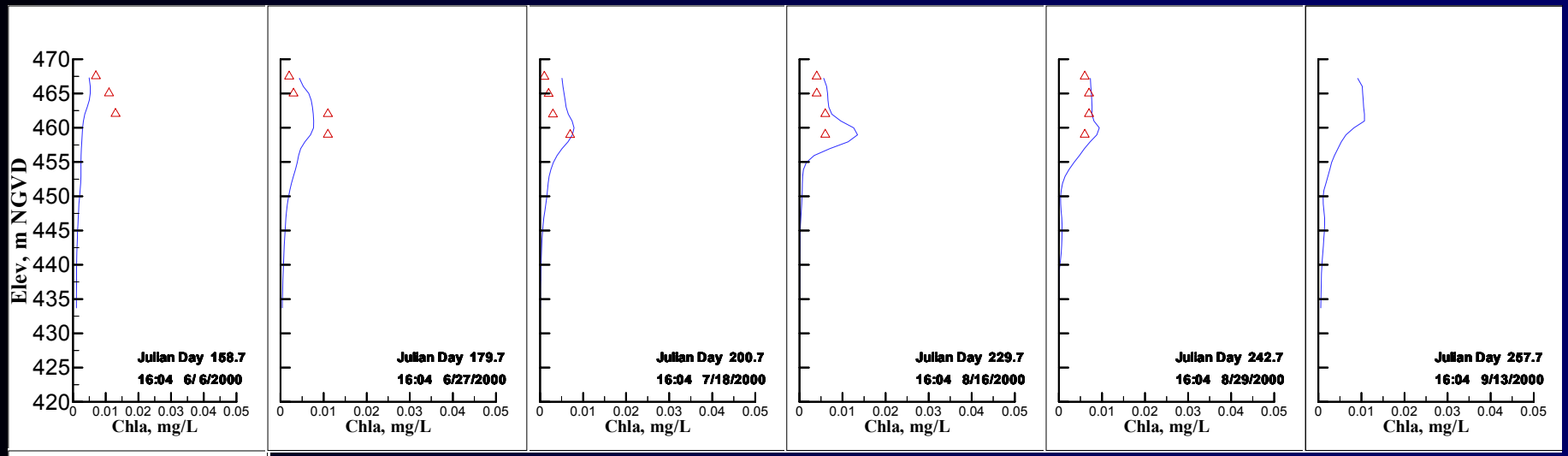
AME: 0.004 mg/L RMS: 0.005 mg/L

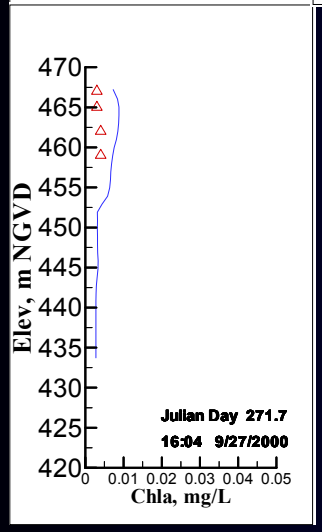
Ortho-Phosphate – Riverside State Park, 2000



(RM 66.0, segment 119)

Chlorophyll a – Long Lake, 2000





AME: 0.004 mg/L RMS: 0.005 mg/L

(Site LL1, segment 180)

Sensitivity Analysis

Sensitivity of model predictions of dissolved oxygen, temperature, chlorophyll a, and periphyton biomass to changes in model model parameter values

Long Lake

Match 27 to September 30, 2000

- Meteorological Data
- Reaeration Formulation
- Wind Sheltering
- Wind Direction
- Algal Growth Rate
- Algal half-saturation for phosphorus limited growth

Spokane River

Upper Falls dam to headwaters of Nine-Mile Dam pool (RM 77.5 to 66.0)

August 7 to September 6, 2000

- Meteorological Data
- Reaeration Formulation
- Wind Sheltering
- Wind Direction
- Periphyton Growth Rate
- Periphyton half-saturation for phosphorus limited growth

Next Steps

- Extend calibration time period to include 2001
- Extend the model upstream to Lake Coeur d'Alene