AQUATOX Model Calibration for the LBR TP TMDL

February 26, 2014

TP TMDL TAC Meeting

Primary Model Uses for the TMDL

AQUATOX

- Estimate nutrient-periphyton relationships
- Tool for TP allocations to meet the periphyton target of 150 mg/m^2

USGS Mass Balance

- Estimate current TP loads
- Tool for TP allocations to meet the May-Sept target of 0.07 mg/L

AQUATOX Modeling Consultation

Core Group

- Ben Cope – EPA
- Bill Stewart – EPA
- Kate Harris – Boise
- Robbin Finch – Boise
- Tom Dupuis – HDR
- Michael Kasch – HDR
- Matt Gregg – Brown and Caldwell
- Jack Harrison - HyQual
- Lee Van de Bogart – Caldwell

Consultants

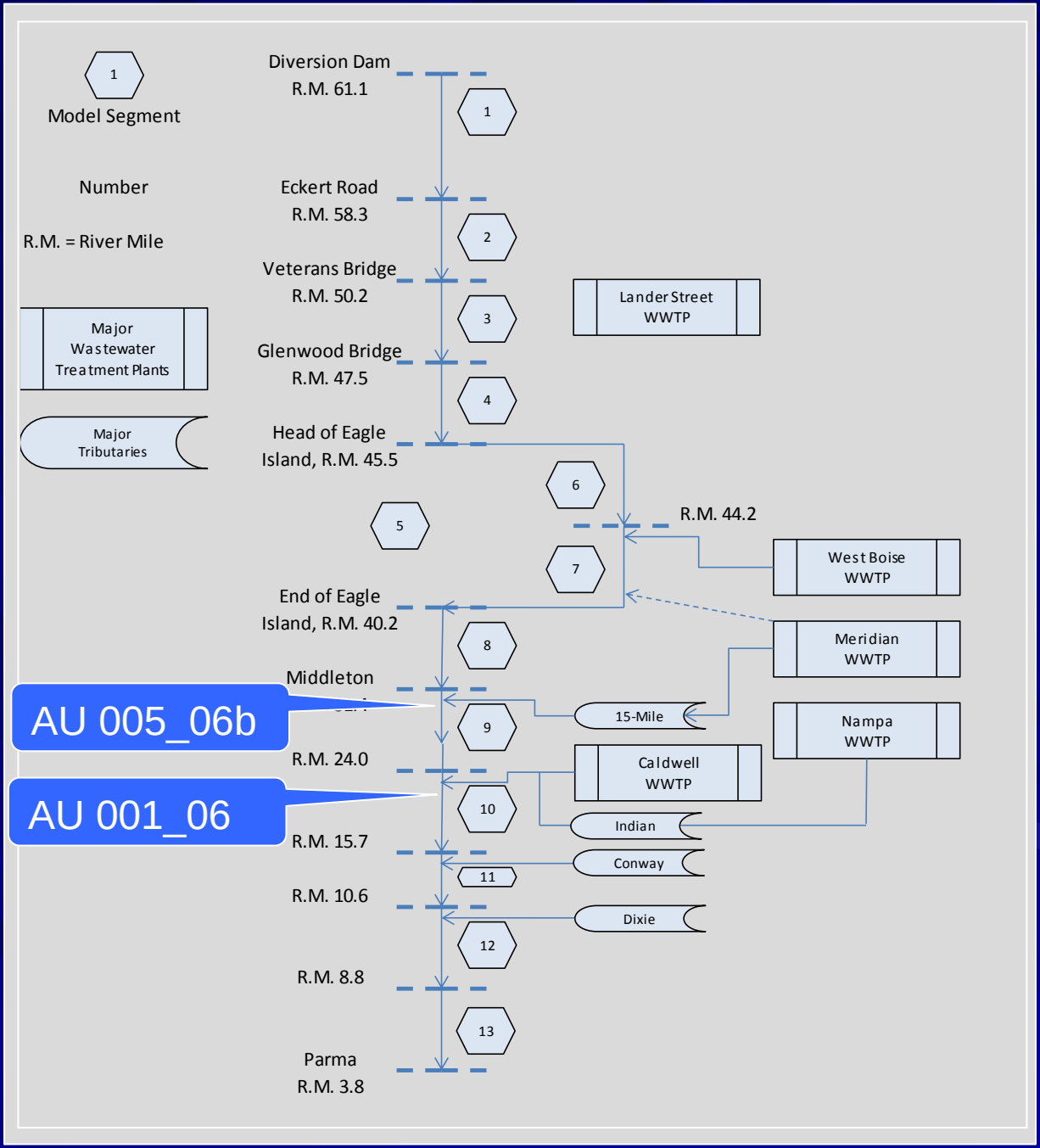
- Jonathan Clough – Warren Pinnacle Consulting
- Dick Park – Eco Modeling

Additional Assistance

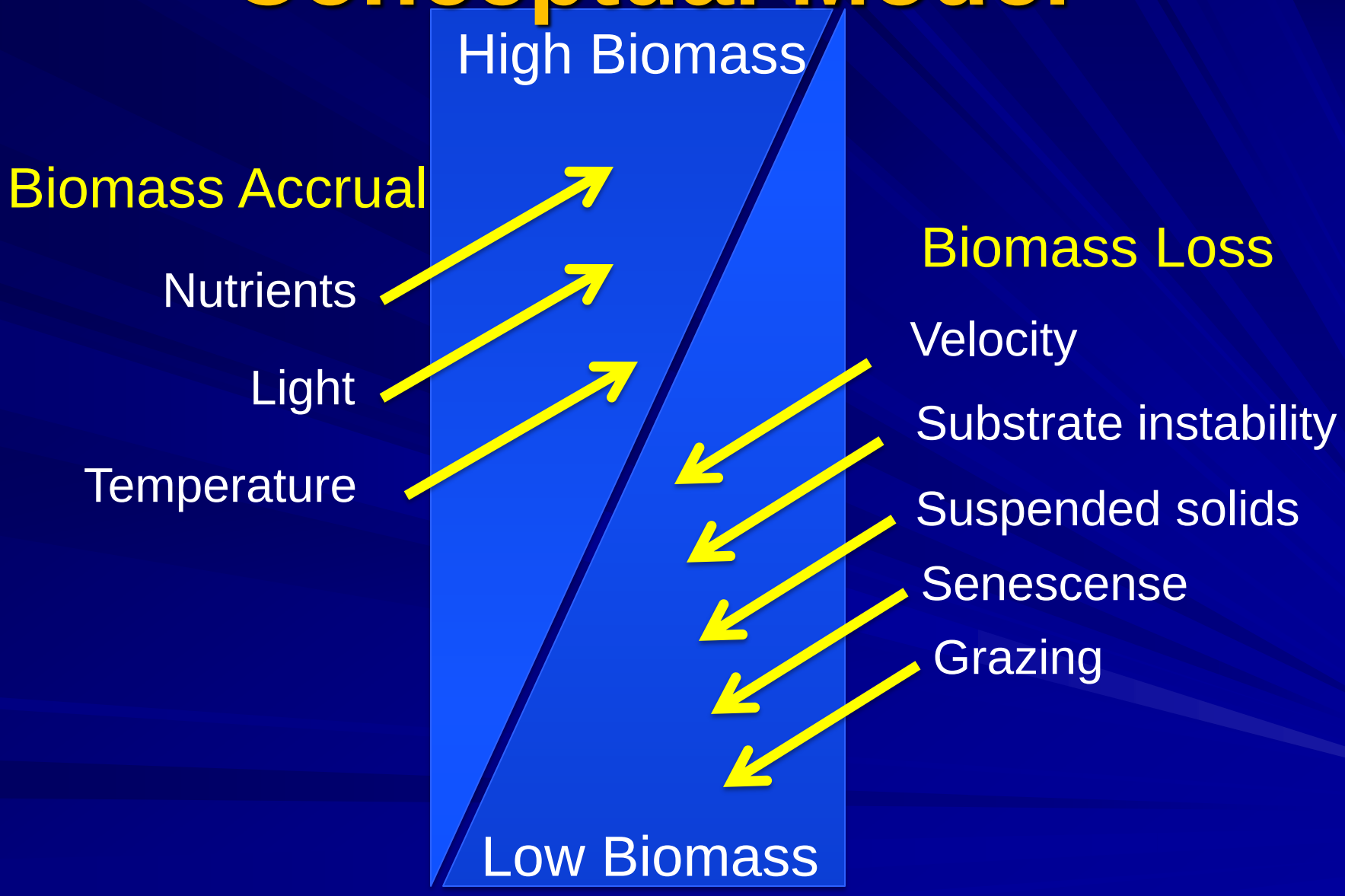
- Alex Etheridge, Dorene MacCoy, Chris Mebane – USGS
- Clifton Bell – Brown and Caldwell

- 4 Meetings – Model Selection
- 29 Model Work Meetings

AQUATOX Model Set-Up

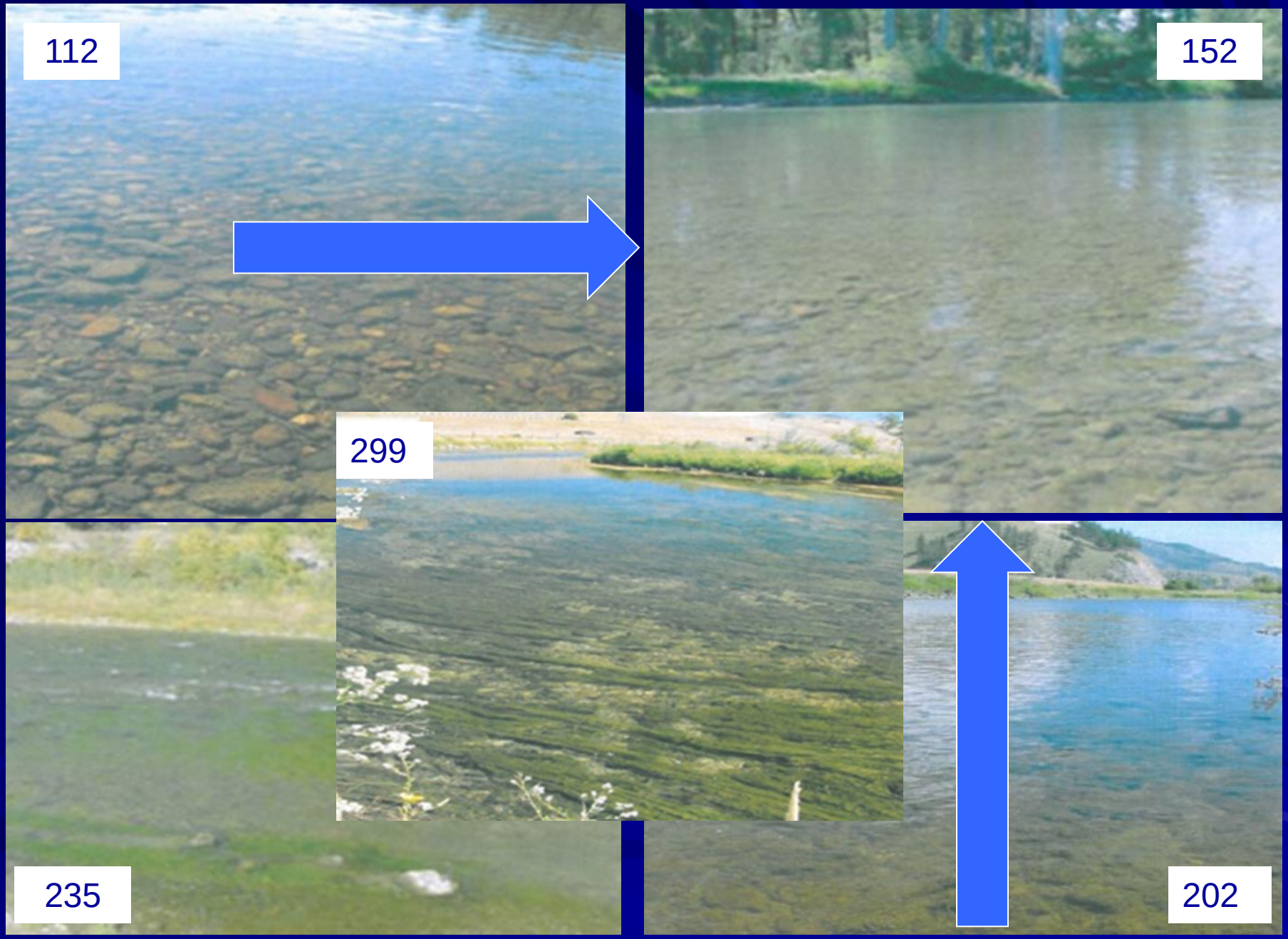


Conceptual Model



Modified from Biggs 1996

**Figure modified from Kate Harris slide 2013 (City of Boise).



Source: 2009. Suplee et al. *How green is too green? Public opinion of what constitutes undesirable algae levels in streams*. JAWRA 45(1):123 – 140.

Simulation Accuracy

Absolute Mean Error (AME)

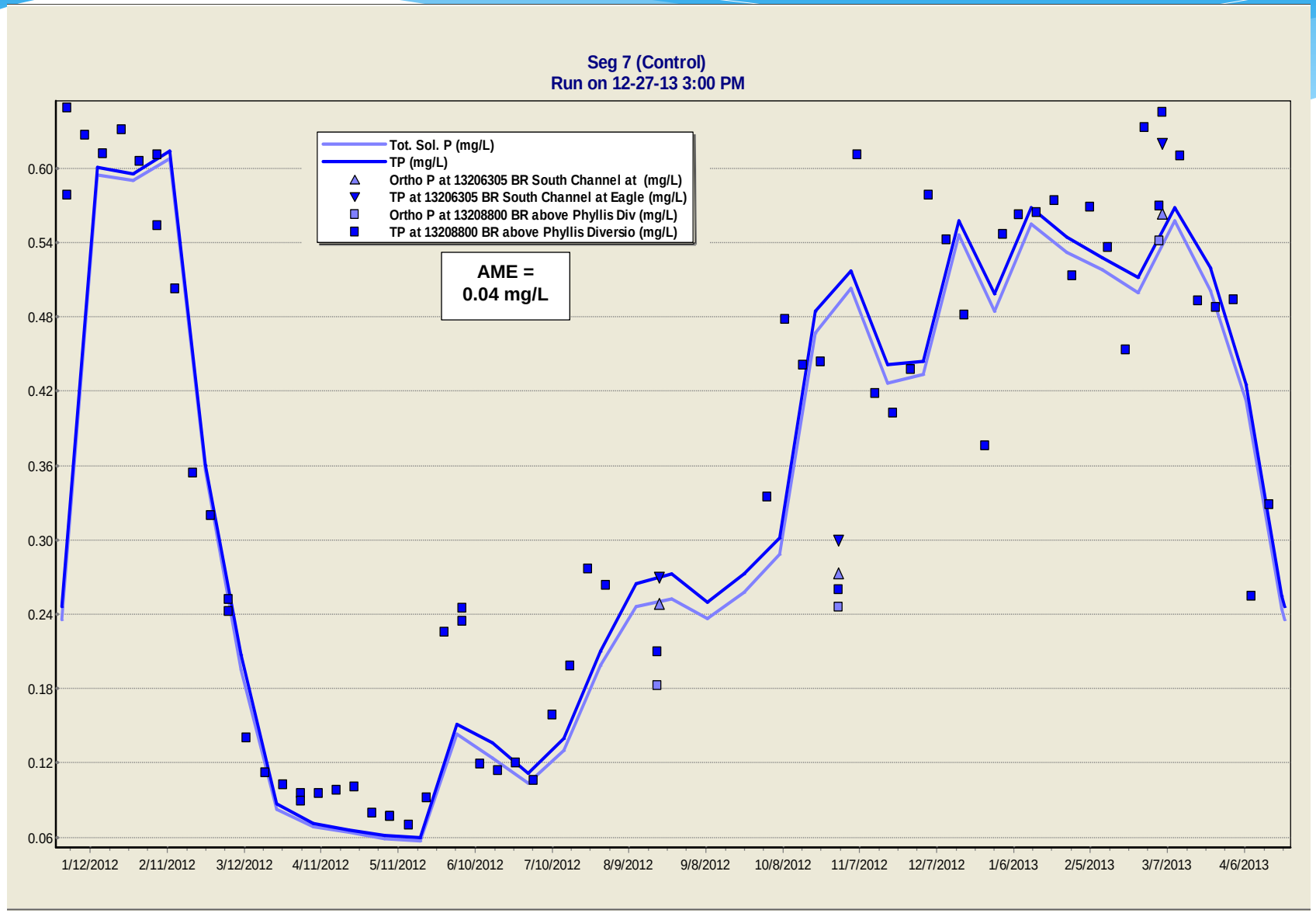
$$AME = \frac{\Sigma|x_{sim} - x_{obs}|}{n}$$

Segment 13			
Date	Modeled	Measured	Absolute difference
2/22/2012	0.23	0.32	0.09
4/20/2012	0.09	0.10	0.01
5/10/2012	0.07	0.12	0.05
6/21/2012	0.16	0.24	0.08
7/17/2012	0.20	0.30	0.10
8/20/2012	0.24	0.30	0.06
8/21/2012	0.24	0.29	0.05
8/22/2012	0.24	0.31	0.07
8/23/2012	0.24	0.29	0.05
8/24/2012	0.24	0.29	0.05
10/29/2012	0.38	0.28	0.09
10/30/2012	0.37	0.28	0.09
10/31/2012	0.37	0.27	0.10
11/1/2012	0.37	0.29	0.08
11/29/2012	0.37	0.27	0.10
12/11/2012	0.39	0.34	0.05
1/8/2013	0.40	0.35	0.05
2/20/2013	0.37	0.41	0.04
3/7/2013	0.36	0.34	0.02
Average absolute difference =			0.07

Phosphorus Accuracy Goal

* Phosphorus data ranges from 0.0085 to .6454
* 25% of the range of the field data is 0.16 mg/L
* Overall accuracy goal for phosphorus = 0.16 mg/L AME

Overall phosphorus calibration was within 0.05 mg/L of observed data



Periphyton Accuracy

Periphyton Accuracy Goal: 71 AME

	AME for each Model Segment					
Model Version	**1**	**3**	**8**	**9**	**13**	**Overall AME**
2001 Parameters	23.3	133.1	106.7	127.1	62.7	**90.6**
2013_0925_DDS	28.1	86.8	83.7	105.2	42.7	**69.4**
2013_1209_RAP	38.2	108.5	74.8	50.2	116.2	**77.6**
2014_0103_DDS	29.0	123.0	75.8	52.0	117.9	**79.5**
2014_0203_DDS	19.4	96.2	66.3	68.3	57.5	**61.5**

Periphyton biomass 15-day rolling mean simulation vs. measured data.

Periphyton biomass correlations (R^2):

Segment	*1*	*3*	*8*	*9*	*13*
measured	-0.0022	+0.1085	+0.1467	+0.2171	+0.1533
historical	+0.1569	+0.0204	+0.0096	+0.1650	+0.0682

Mean monthly simulated periphyton biomass, and measured and historical data:

Segment	*1*	*3*	*8*	*9*	*13*	**Overall**
measured	14	187	132	191	112	**636**
simulation	22	101	168	157	72	**520**
% difference	**57%**	**-46%**	**27%**	**-18%**	**-36%**	**-18%**
historical	10	53	78	284	158	**583**
simulation	19	59	101	149	94	**422**
% Difference	**90%**	**11%**	**29%**	**-48%**	**-41%**	**-28%**

Simulated periphyton ranges relative to measured and historical data:

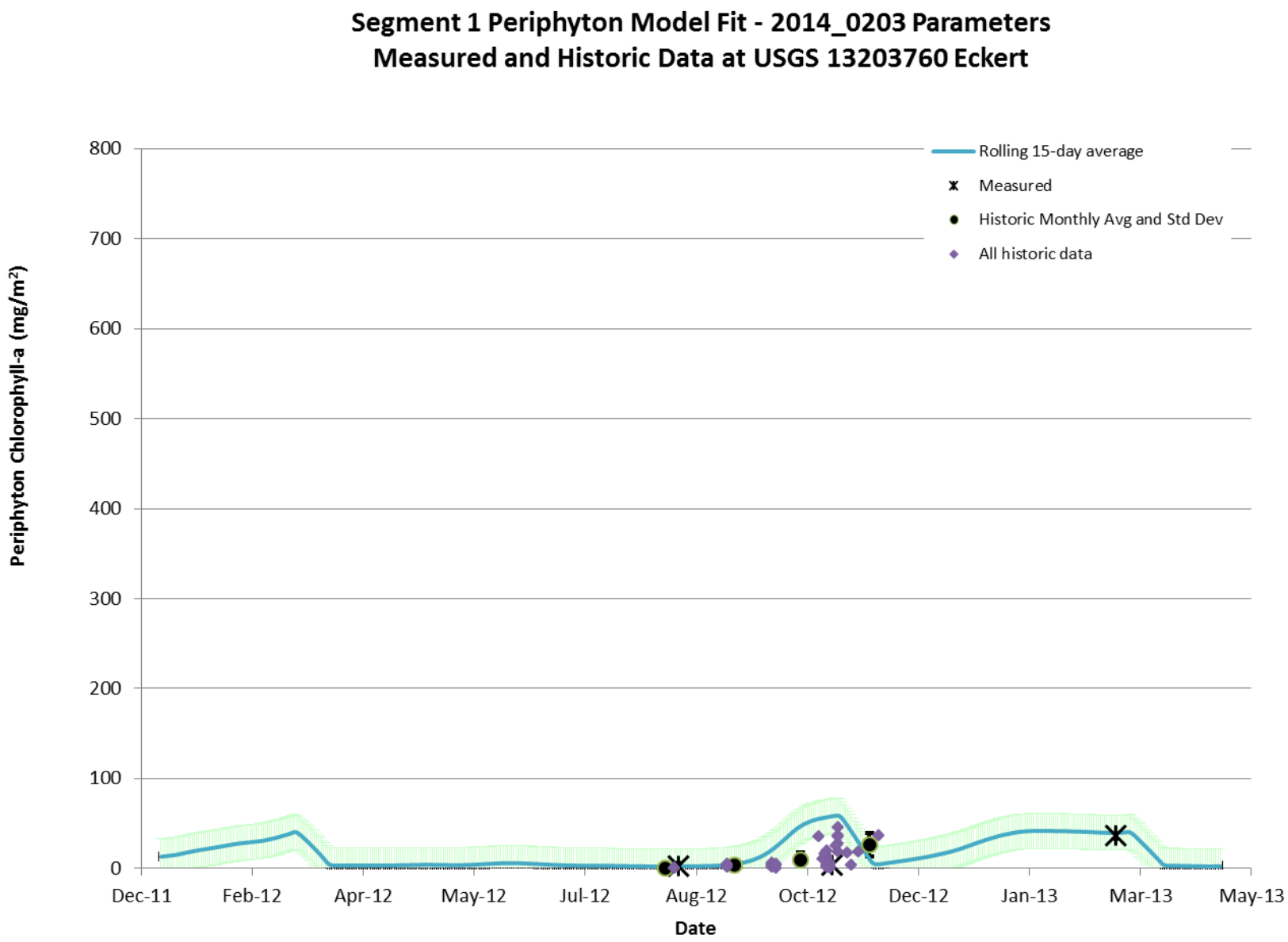
Segment	*1*	*3*	*8*	*9*	*13*
January			underpredicts		underpredicts
February		overpredicts	overpredicts	underpredicts	
March	in range	underpredicts	in range	in range	underpredicts
April		in range	in range		
May		in range	in range		
June		in range	in range		
July		in range	in range		
August	in range	in range	overpredicts	in range	in range
September	in range	in range			
October	overpredicts	in range	in range	in range	in range
November	in range	in range	in range	in range	in range
December		in range	in range		

**Model simulations were within range of measured and historical data during 28 of 37 (76%) month-segment combinations.*

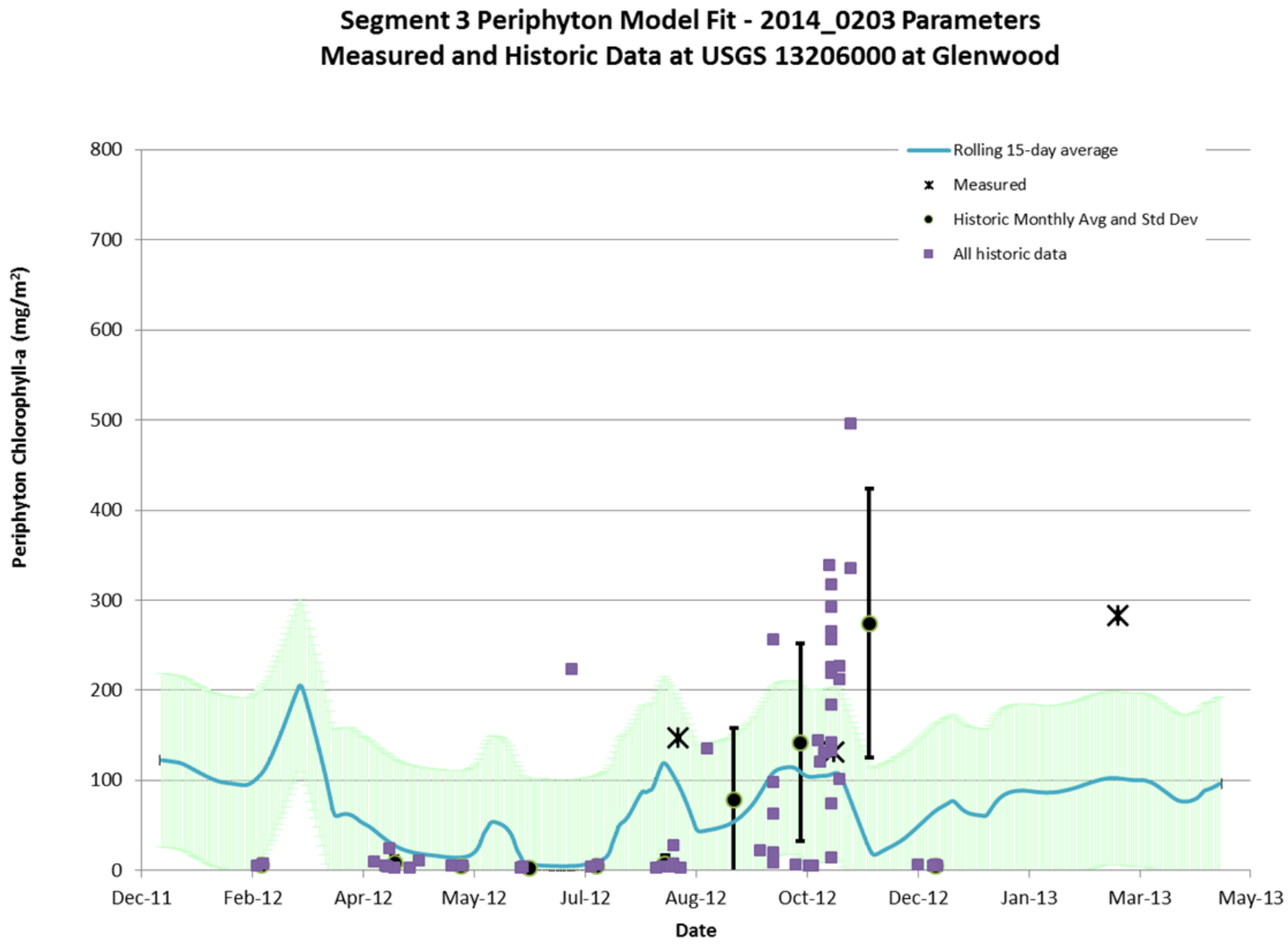
Model Workgroup Perceptions

- "…Model is really good…"
- "…Model is as good as it could be…"
- "…Tables and plots are very strong, matches data very well…"
- "…Documentation and application are transparent…"
- "…Model can provide multiple scenarios with excellent potentials for trading…"

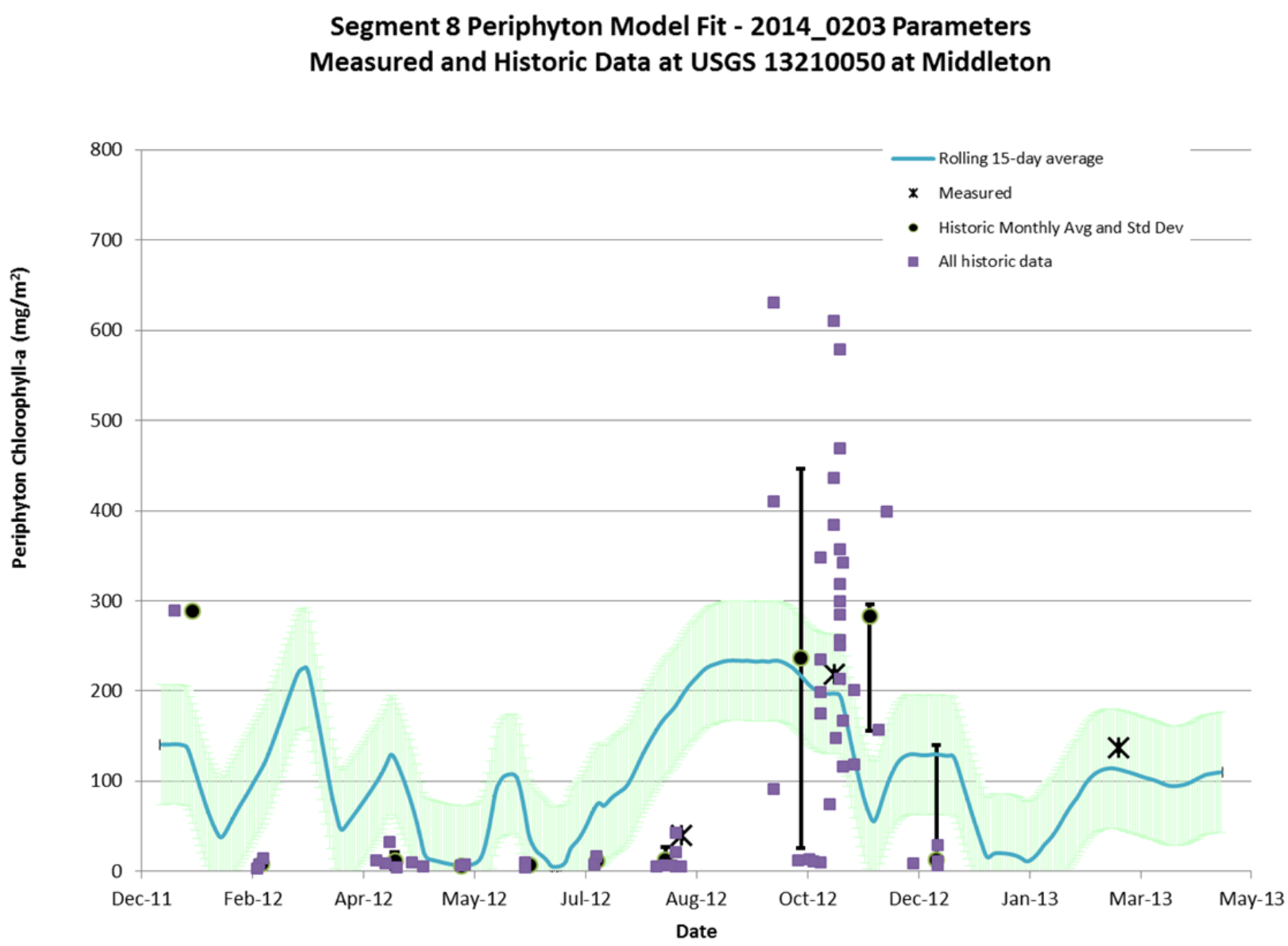
DEQ asking TAC to provide recommendations to LBWC



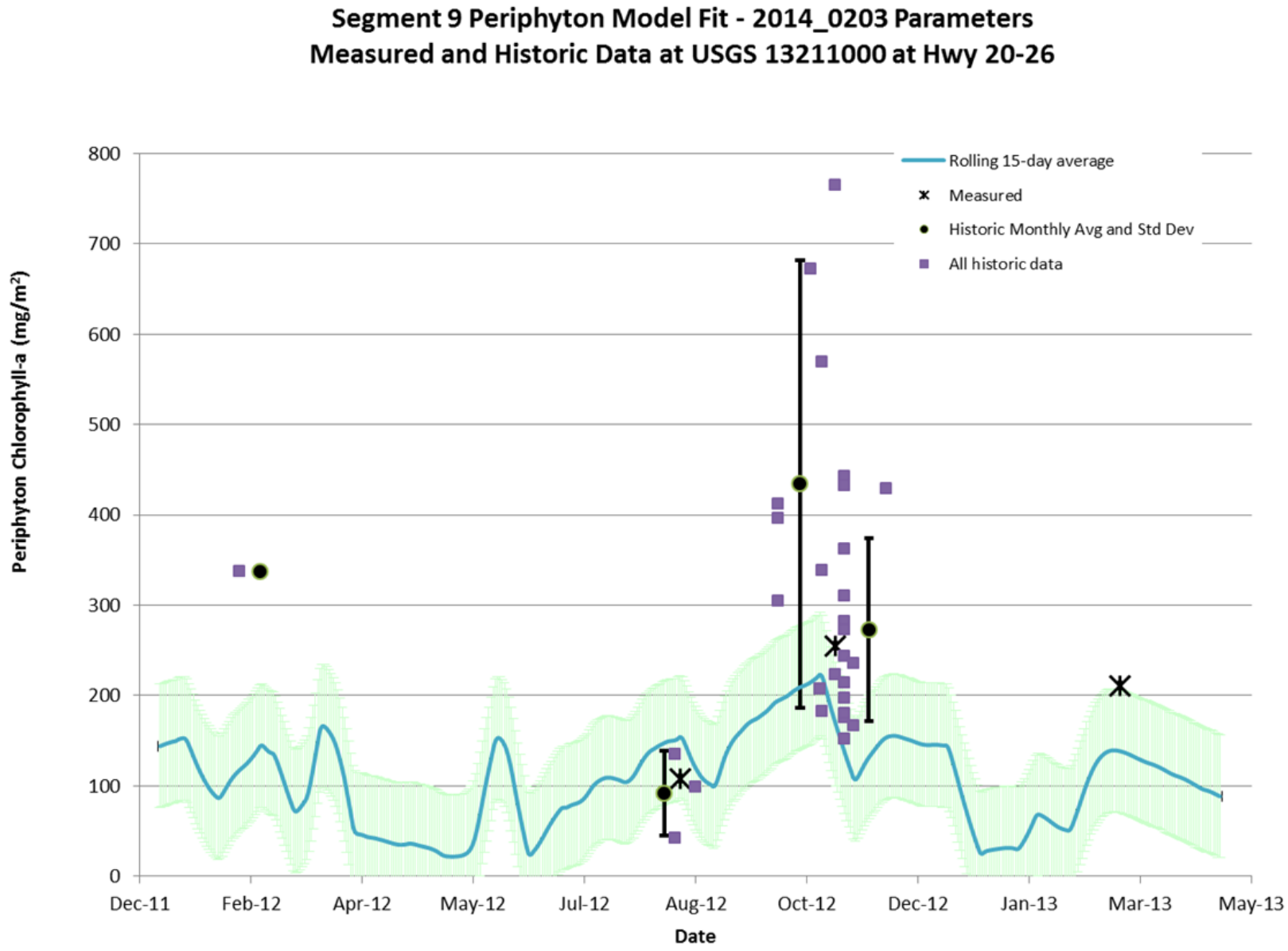
15-day rolling mean simulation bound with AME error bars = 19.4



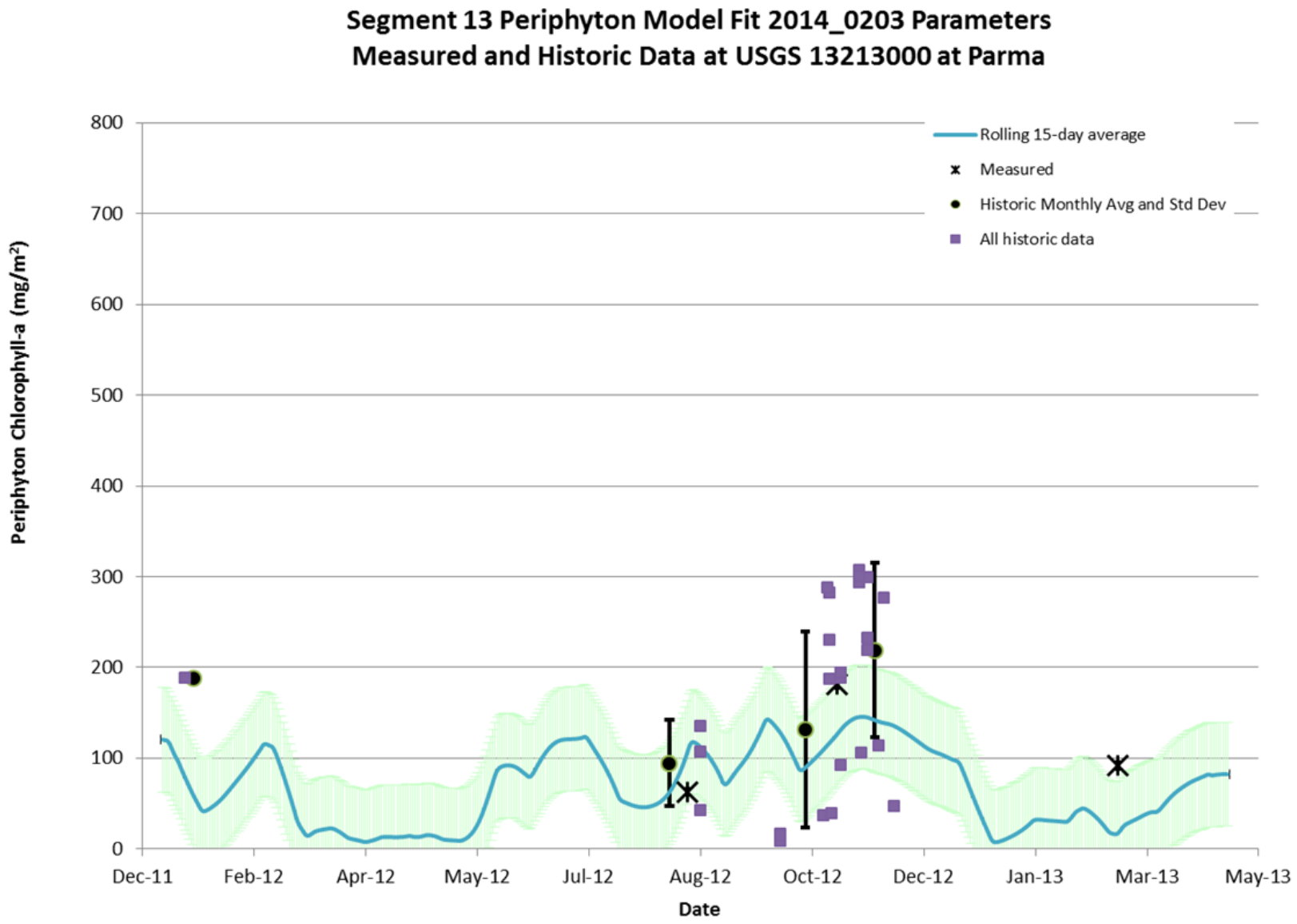
15-day rolling mean simulation bound with AME error bars = 96.2



15-day rolling mean simulation bound with AME error bars = 66.3



15-day rolling mean simulation bound with AME error bars = 68.3



15-day rolling mean simulation bound with AME error bars = 57.5

Sensitivity analysis summary

* Optimal temperature has the greatest effect on green algae and secondarily on high-nutrient diatoms
* Critical force and light extinction coefficient have the greatest effect on high-nutrient diatoms
* Sloughing has the largest effect on low-nutrient diatoms and high-nutrient diatoms
* Maximum photosynthetic rate has the greatest effect on green algae and a lesser effect on high-nutrient diatoms

USGS Mass Balance Model v. AQUATOX Model (Table 9 Summary of Results)

Scenario	NC	1	2	3	4	5	6	7	8	8+	9	10	11	12	12+
Point Sources		0.30	0.07	NC	NC	0.30	0.30	0.30	0.30	0.30	0.07	0.07	0.07	0.07	0.07
Nonpoint Sources		NC	NC	0.10	0.07	0.10	0.07	0.10	0.07	0.07	0.10	0.07	0.10	0.07	0.07
Unmeasured		NC	NC	NC	NC	0.15	0.15	0.07	0.07	0.07	0.15	0.15	0.07	0.07	0.07
August	NC	1	2	3	4	5	6	7	8	8+	9	10	11	12	12+
u/s Phyllis Canal	0.22	0.04	0.03	0.22	0.22	0.04	0.04	0.03	0.03		0.02	0.02	0.02	0.02	
Segment 7	0.27	0.03	0.02	0.27	0.27	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
at Parma	0.30	0.27	0.27	0.17	0.15	0.11	0.10	0.09	**0.07**		0.11	0.09	0.08	**0.07**	
Segment 13	0.25	0.23	0.23	0.17	0.15	0.13	0.11	0.10	0.08	0.08	0.13	0.11	0.10	0.08	**0.07**
October	NC	1	2	3	4	5	6	7	8	8+	9	10	11	12	12+
u/s Phyllis Canal	0.44	0.06	0.02	0.44	0.43	0.06	0.06	0.05	0.05		0.02	0.02	0.02	0.02	
Segment 7	0.46	0.05	0.02	0.46	0.46	0.05	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02	0.02
at Parma	0.31	0.21	0.20	0.20	0.18	0.09	**0.07**	0.08	**0.07**		0.08	**0.06**	**0.07**	**0.05**	
Segment 13	0.36	0.27	0.27	0.20	0.17	0.11	0.09	0.10	0.08	0.08	0.11	0.09	0.09	0.08	**0.07**
March	NC	1	2	3	4	5	6	7	8	8+	9	10	11	12	12+
u/s Phyllis Canal	0.53	0.05	0.02	0.53	0.53	0.05	0.05	0.05	0.05		0.02	0.02	0.02	0.02	
Segment 7	0.52	0.06	0.03	0.53	0.53	0.06	0.06	0.06	0.06	0.06	0.03	0.03	0.03	0.03	0.02
at Parma	0.35	0.19	0.18	0.27	0.25	0.09	0.08	0.08	**0.06**		0.08	**0.07**	**0.06**	**0.05**	
Segment 13	0.38	0.20	0.19	0.28	0.26	0.10	0.09	0.10	0.08	0.08	0.09	**0.07**	0.09	**0.07**	**0.07**
+Total Sediment Reduction of 37%															

USGS Table 9 Evaluation of Total Phosphorus Mass Balance in the Lower Boise River, Southwestern Idaho
Idaho DEQ Final Calibrated AQUATOX Model
HDR AQUATOX Model Scenarios

Continued Consultation

- Refine target duration, location, frequency
- Other adjustments
  - Parma TP load $\leq$ 0.07 mg/L, May – Sept
  - Reduce sediment (37%)?
  - Critical conditions? Flow tiers?
- Model is a tool among multiple lines of evidence
- Modeling-Techno-Policy group to continue advising on model-TMDL application

LBWC Vote

- March 13, DEQ to ask LBWC to vote on current AQUATOX model calibration
  - As an acceptable tool for use in developing scenarios and TP allocations in the TMDL

Model Calibration Summary

- Accuracy goals achieved (AME)
- Additional measures of model fit identified
- Broad support from Model Workgroup
- Consistent with USGS Mass Balance
- Tool to help develop scenarios and allocations among multiple lines of evidence
- DEQ asking TAC to provide recommendations to LBWC
- DEQ asking LBWC to vote on model calibration

Contact Information

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