SWAT Check

A screening tool to assist users in the identification of potential model application problems

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Justification

Real need for improved quality control in modeling

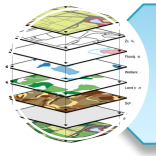
- New SWAT users
- Easier for experienced users

Prevent wasted recalibration after discovery of model problem

Aid in development of reasonable models

Lots of Things May Go Wrong

Input data errors



Initial model development problems

Improper parameter adjustment during calibration

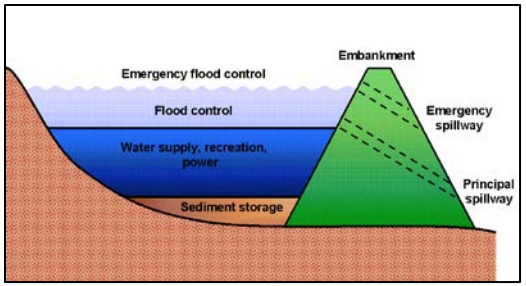
Process not properly represented

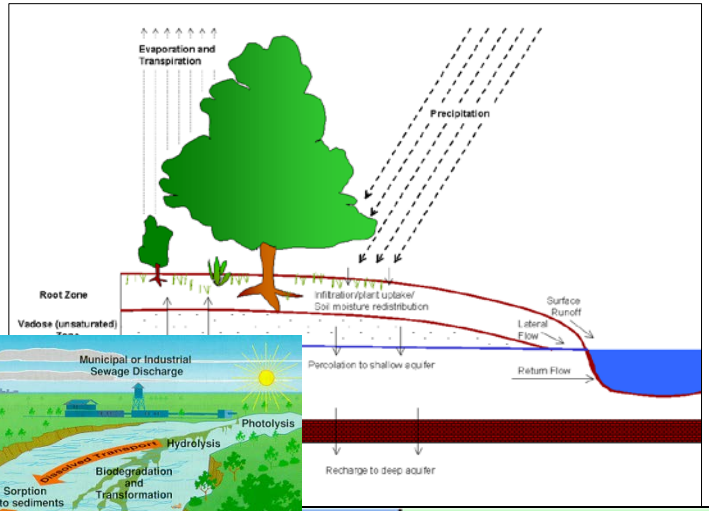
Known SWAT model application errors

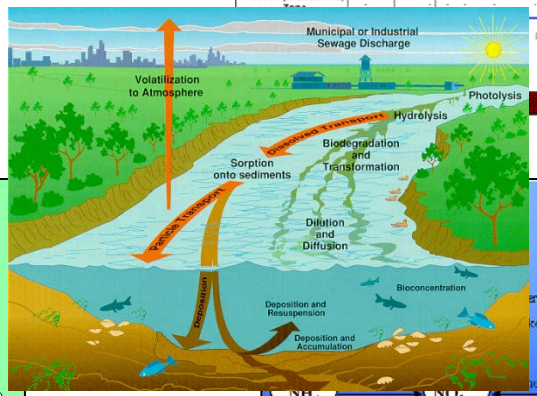
Reasonable Processes

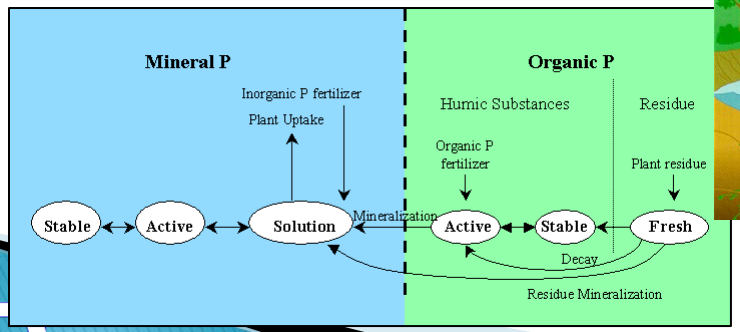
Look for unusual output values

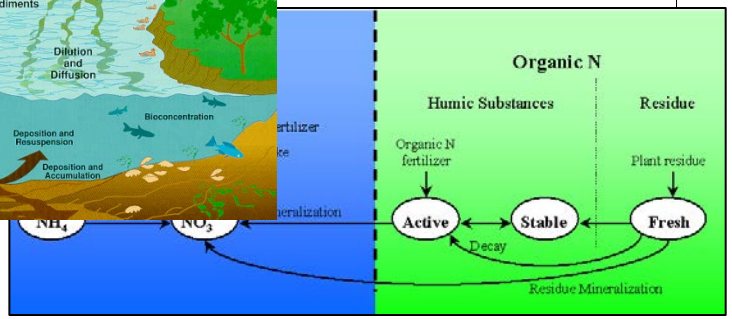
- Ranges from expert users/developers
- Ranges from literature where possible







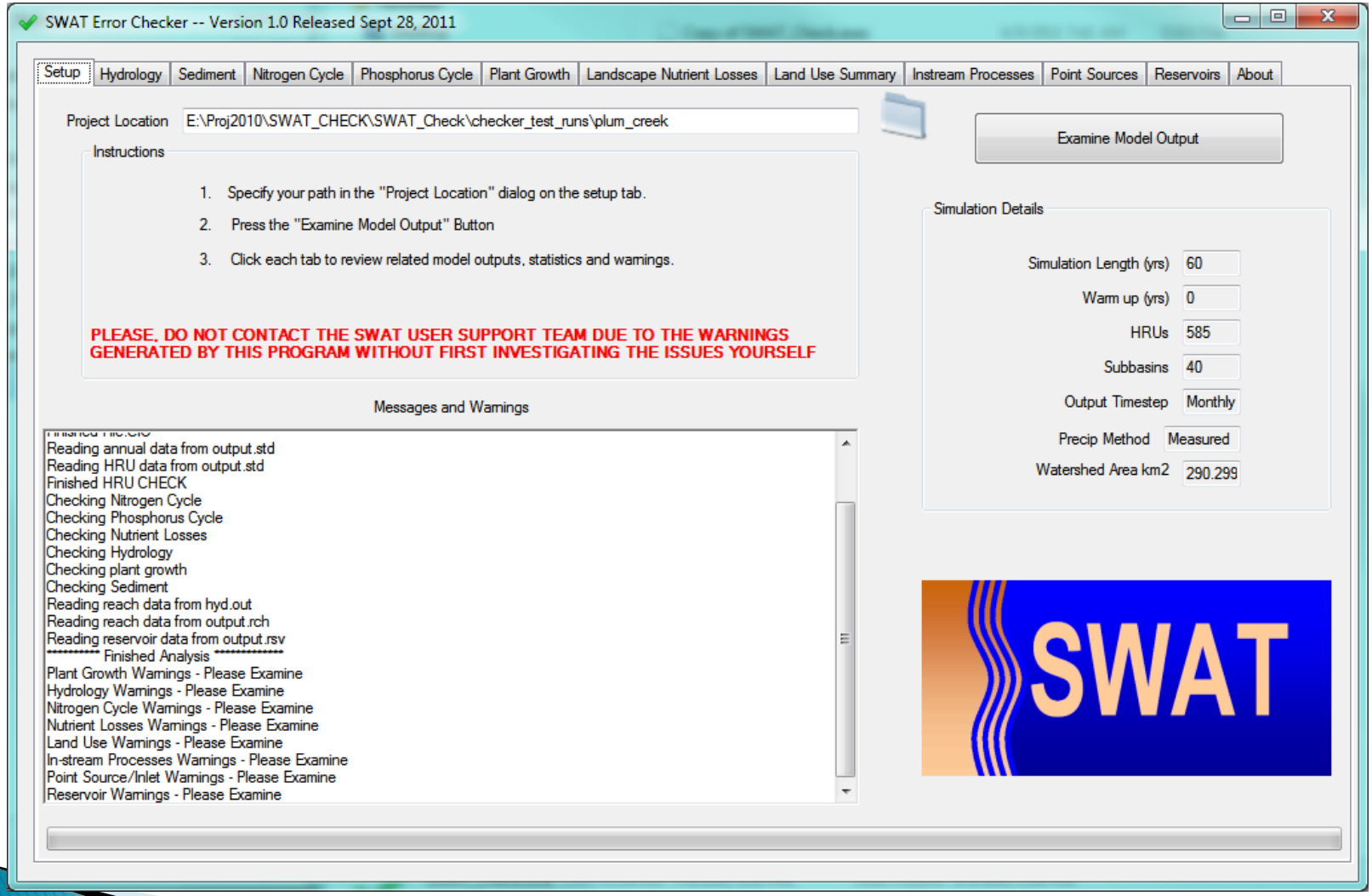


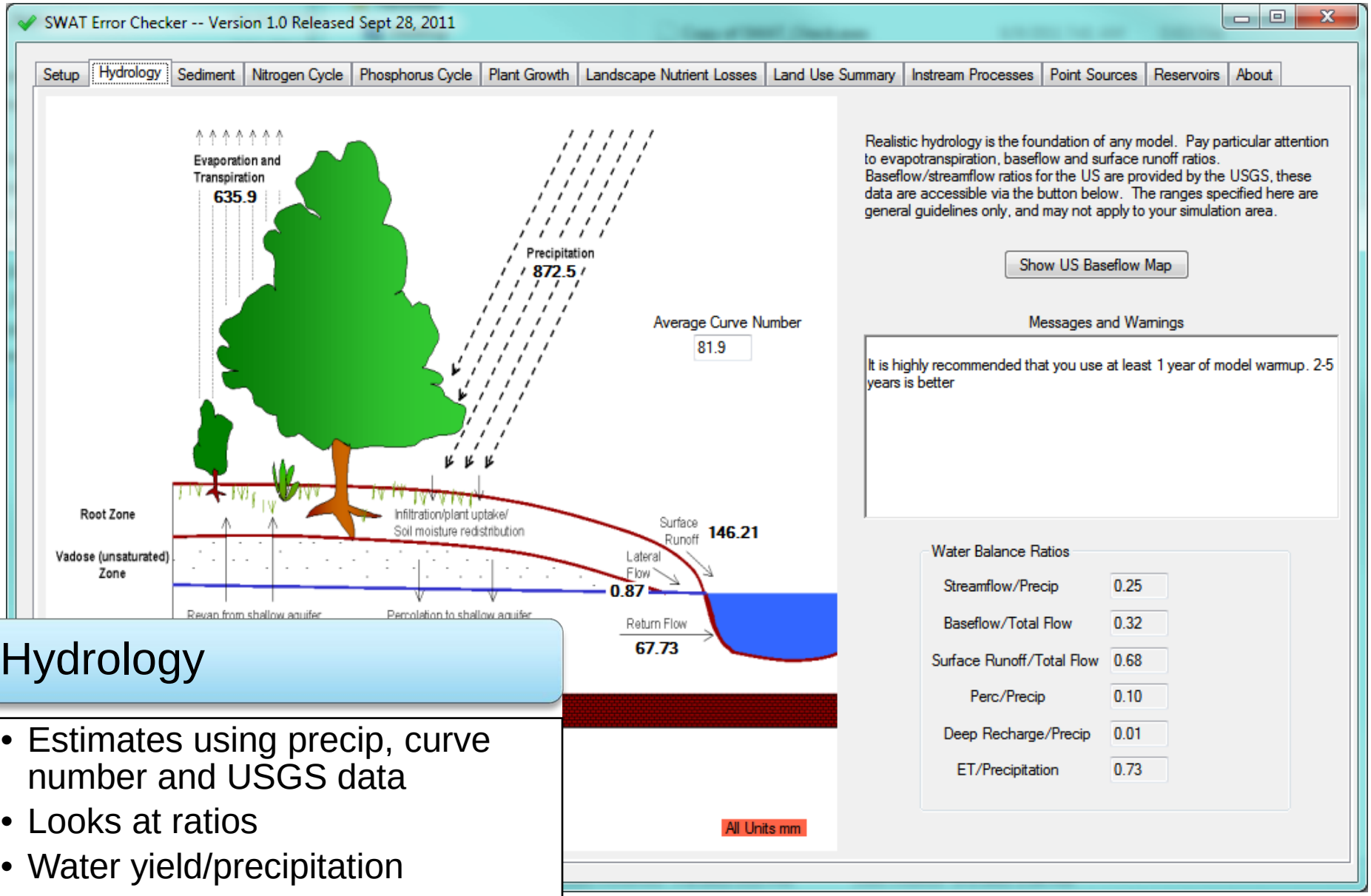


Common Known Problems

- Lack of “Warm up” period
- Reservoir issues
- Tiny HRUs
- Dramatic changes in soil nutrient status
- Poor plant growth
- Non-numeric data in output.

SWAT Check Interface





Hydrology

- Estimates using precip, curve number and USGS data
- Looks at ratios
- Water yield/precipitation
- Evapotranspiration/precipitation
- Surface runoff/water yield
- Baseflow/water yiield

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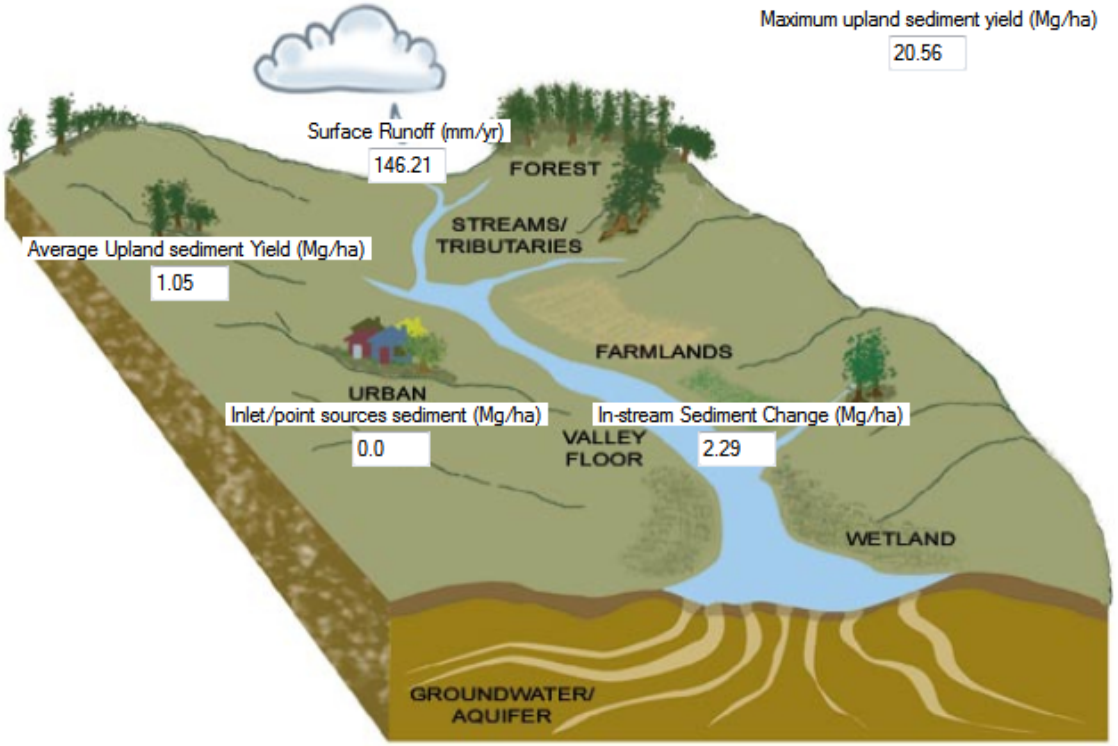
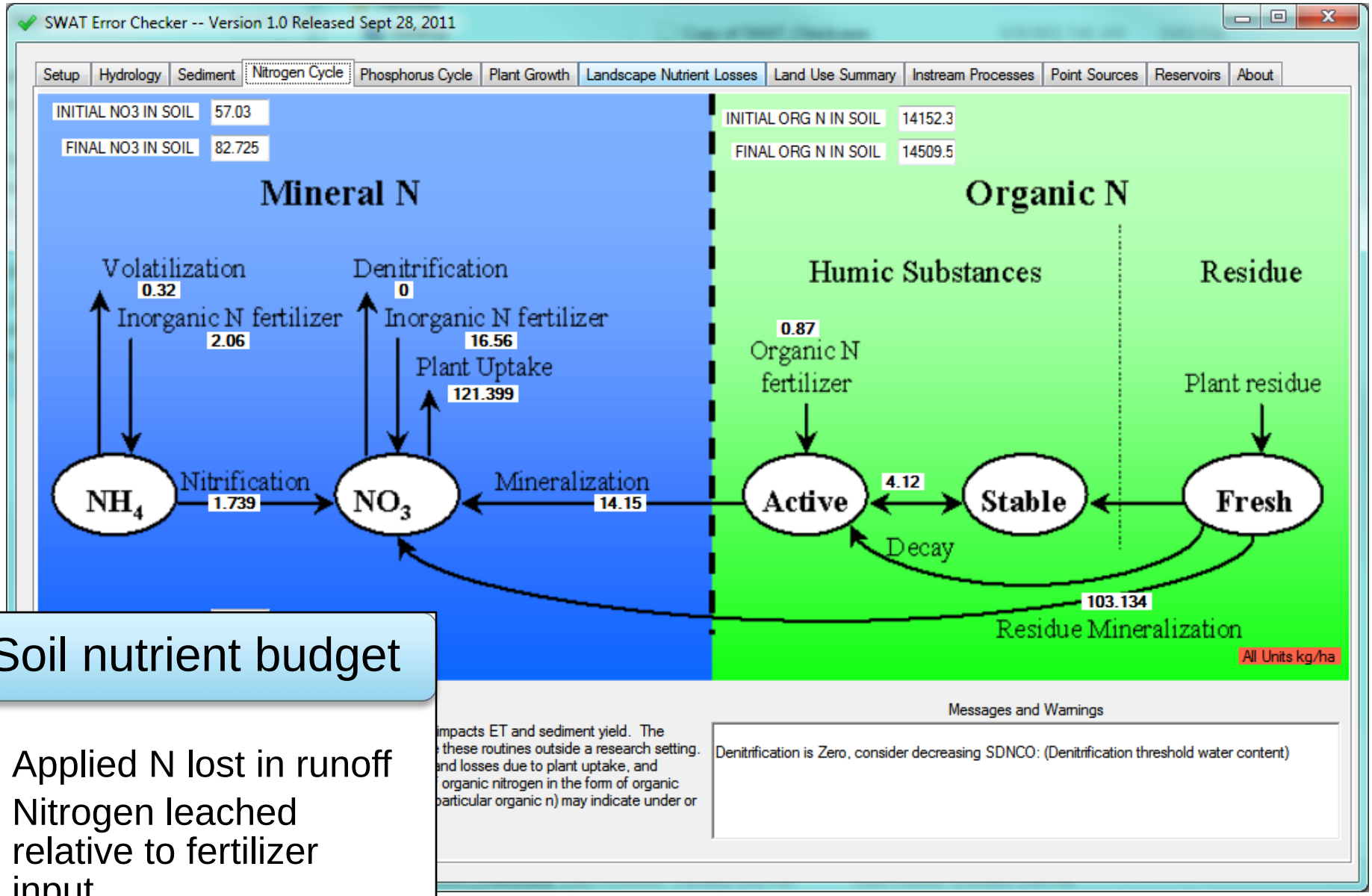
Setup | Hydrology | Sediment | Nitrogen Cycle | Phosphorus Cycle | Plant Growth | Landscape Nutrient Losses | Land Use Summary | Instream Processes | Point Sources | Reservoirs | About



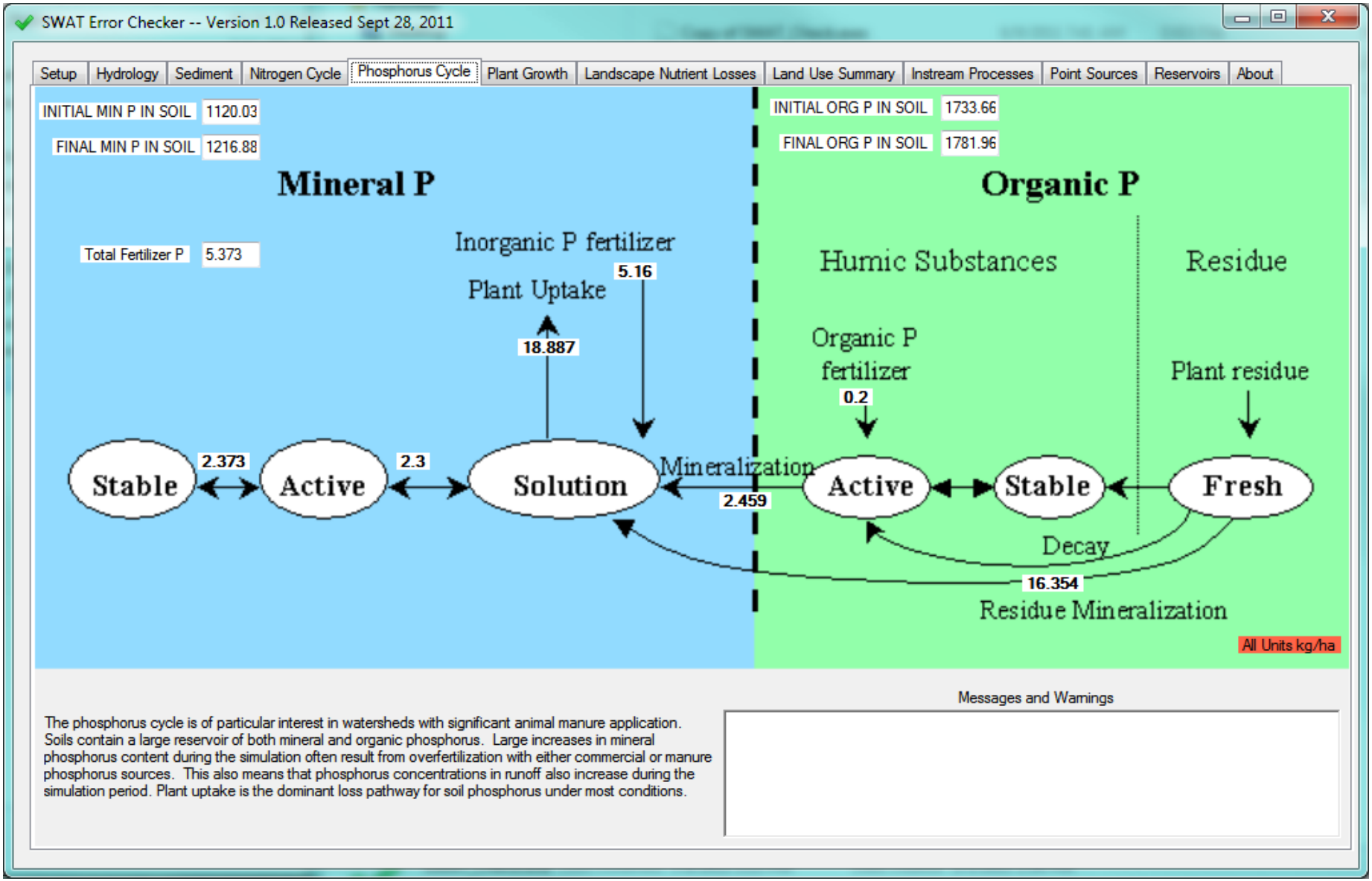
Sediment loss form the landscape is dependent upon many factors. Sediment overestimation in SWAT is most commonly due to inadequate biomass production. This often occurs on specific land uses. If your maximum upland sediment yield is excessive, use the landuse summary tab to identify the problem land use.
SWAT also modifies sediments to account for in-stream deposition and erosion of stream banks and channels. Often there is little or no measured data to differentiate between upland sediment and in-stream sediment changes. Streams may be either a net source of sediment, or a sink. In-stream sediment modification is impacted by physical channel characteristic's (slope, width, depth, channel cover, and substrate characteristics) and the quantity of sediment and flow from upstream.

Messages and Warnings



Soil nutrient budget

- Applied N lost in runoff
- Nitrogen leached relative to fertilizer input
- Denitrification
- Ammonia volatilization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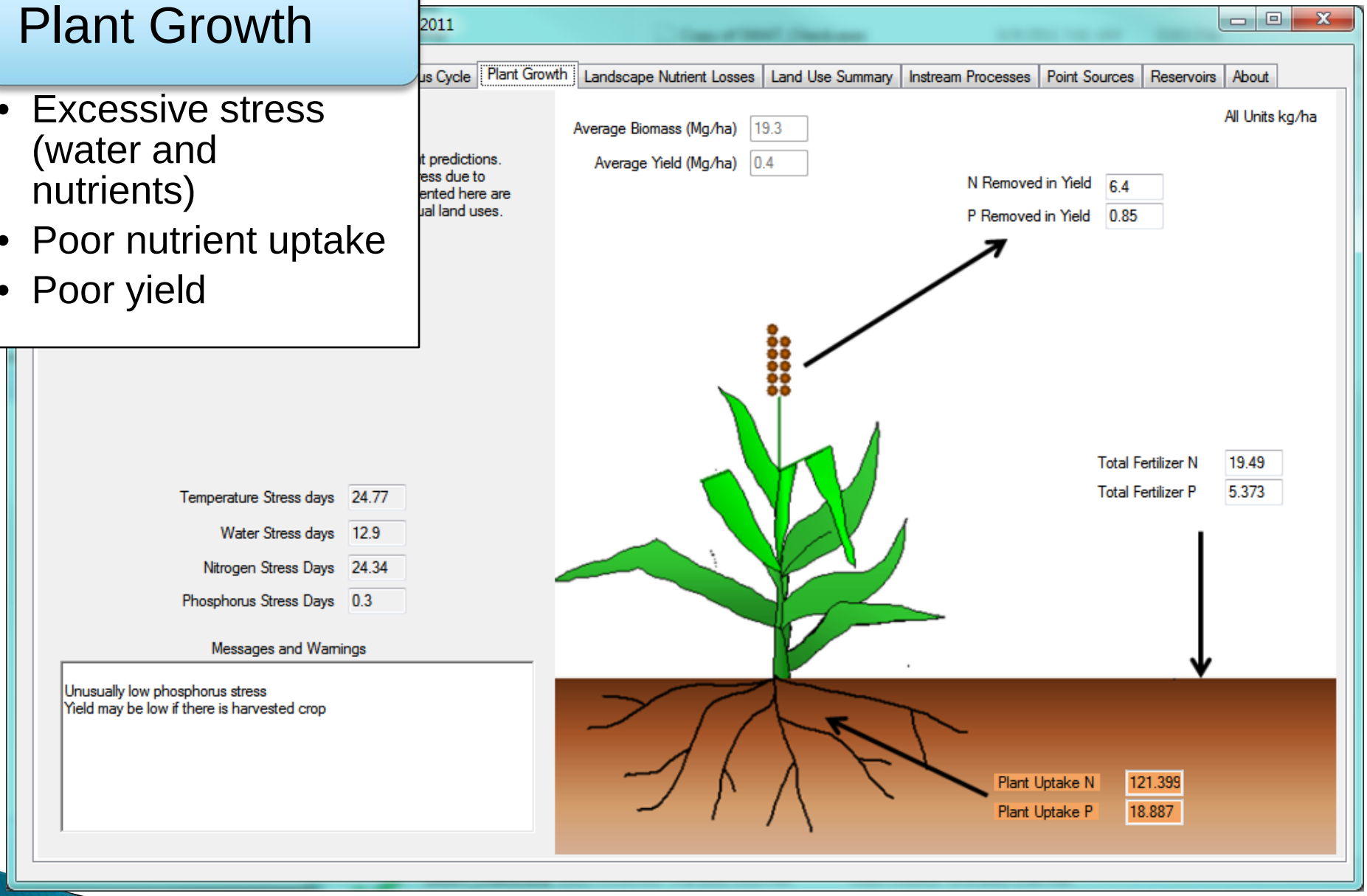
Setup
Hydrology
Sediment
Nitrogen Cycle
Phosphorus Cycle
Plant Growth
Landscape Nutrient Losses
Land Use Summary
Instream Processes
Point Sources
Reservoirs
About
INITIAL MIN P IN SOIL 1120.03
FINAL MIN P IN SOIL 1216.88
Mineral P
Total Fertilizer P 5.373
Inorganic P fertilizer
5.16
Plant Uptake
18.887
Stable
2.373
Active
2.3
Solution
Mineralization
2.459
INITIAL ORG P IN SOIL 1733.66
FINAL ORG P IN SOIL 1781.96
Organic P
Humic Substances
Residue
Organic P fertilizer
0.2
Plant residue
Active
Stable
Fresh
Decay
16.354
Residue Mineralization
All Units kg/ha
Messages and Warnings
The phosphorus cycle is of particular interest in watersheds with significant animal manure application. Soils contain a large reservoir of both mineral and organic phosphorus. Large increases in mineral phosphorus content during the simulation often result from overfertilization with either commercial or manure phosphorus sources. This also means that phosphorus concentrations in runoff also increase during the simulation period. Plant uptake is the dominant loss pathway for soil phosphorus under most conditions.

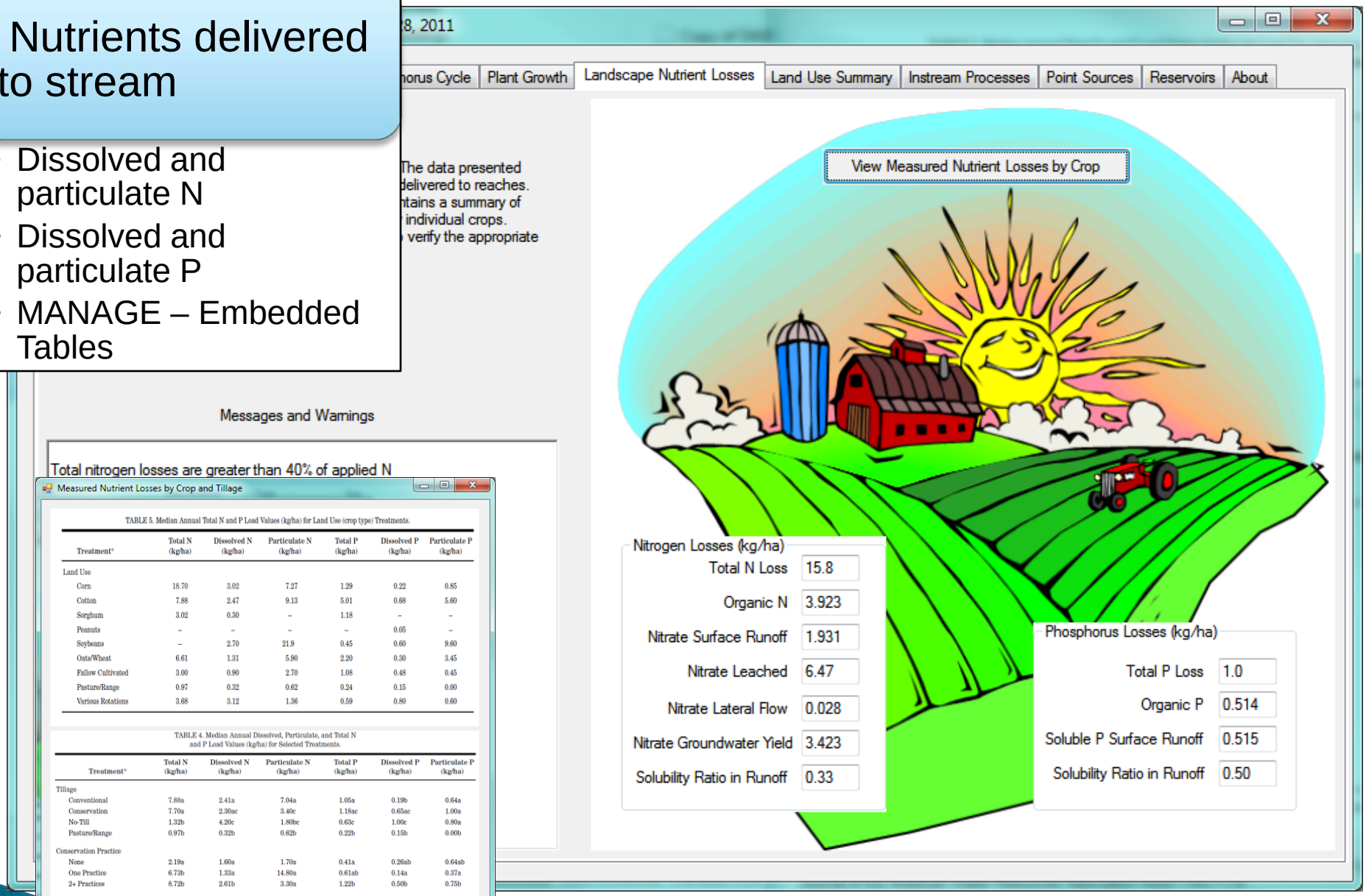
Plant Growth

- Excessive stress (water and nutrients)
- Poor nutrient uptake
- Poor yield



Nutrients delivered to stream

- Dissolved and particulate N
- Dissolved and particulate P
- MANAGE – Embedded Tables



Measured Nutrient Losses by Crop and Tillage

TABLE 5. Median Annual Total N and P Load Values (kg/ha) for Land Use (crop type) Treatments.

Treatment*	Total N (kg/ha)	Dissolved N (kg/ha)	Particulate N (kg/ha)	Total P (kg/ha)	Dissolved P (kg/ha)	Particulate P (kg/ha)
Land Use						
Corn	18.70	3.02	7.27	1.29	0.22	0.85
Cotton	7.88	2.47	9.13	5.01	0.68	5.60
Sorghum	3.02	0.30	–	1.18	–	–
Peanuts	–	–	–	–	0.05	–
Soybeans	–	2.70	21.9	0.45	0.60	9.60
Oats/Wheat	6.61	1.31	5.90	2.20	0.30	3.45
Fallow Cultivated	3.00	0.90	2.70	1.08	0.48	0.45
Pasture/Range	0.97	0.32	0.62	0.24	0.15	0.00
Various Rotations	3.68	3.12	1.36	0.59	0.80	0.60

TABLE 4. Median Annual Dissolved, Particulate, and Total N and P Load Values (kg/ha) for Selected Treatments.

Treatment*	Total N (kg/ha)	Dissolved N (kg/ha)	Particulate N (kg/ha)	Total P (kg/ha)	Dissolved P (kg/ha)	Particulate P (kg/ha)
Tillage						
Conventional	7.88a	2.41a	7.04a	1.05a	0.19b	0.64a
Conservation	7.70a	2.30ac	3.40c	1.18ac	0.65ac	1.00a
No-Till	1.32b	4.20c	1.80bc	0.63c	1.00c	0.80a
Pasture/Range	0.97b	0.32b	0.62b	0.22b	0.15b	0.00b
Conservation Practice						
None	2.19a	1.60a	1.70a	0.41a	0.26ab	0.64ab
One Practice	6.73b	1.33a	14.80a	0.61ab	0.14a	0.37a
2+ Practices	8.72b	2.61b	3.30a	1.22b	0.50b	0.75b
Soil Texture						
Clay	4.93a	4.47a	2.00a	0.92a	0.50a	0.55a
Loam	4.05a	1.64b	5.78b	0.41b	0.18b	0.93a
Sand	2.74a	1.70ab	–**	1.50ab	0.07ab	–**

*For each nutrient form within a treatment, medians followed by a different letter are significantly different (α = 0.05).
**No particulate N or P data were available for sandy soils.

From Harmel, D., et al. 2006 Compilation of Measured Nutrient Load Data for Agricultural Land Uses in the United States. Journal of the American Water Resources Association 42(5):1163-1178.

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Setup | Hydrology | Sediment | Nitrogen Cycle | Phosphorus Cycle | Plant Growth | Landscape Nutrient Losses | Land Use Summary | Instream Processes | Point Sources | Reservoirs | About

Summary By Reported Landuse

LULC	AREAkm2	CN	AWCmm	USLE_LS	IRRmm	PRECmm	SURQmm	GWQmm	ETmm	SEDth	NO3kgh	ORGNkgh	BIOMth	YLDth
RNGB	140.7	79.59	220.67	0.56	0.00	872.02	126.97	104.88	609.77	0.22	0.96	1.39	15.48	0.00
PAST	44.7	83.90	213.63	0.55	0.00	870.23	176.06	9.86	674.96	0.48	7.00	4.74	22.82	0.16
RNGE	76.9	83.33	225.09	0.55	0.00	876.36	154.73	55.64	642.05	0.30	1.07	1.69	15.42	0.00
FRSD	9.1	82.83	212.00	0.57	0.00	862.44	141.53	15.99	691.94	0.10	0.64	0.44	53.65	0.00
WETF	1.2	83.00	210.56	0.61	0.00	858.54	140.05	142.77	533.03	0.11	0.37	0.46	349.61	0.00
WATR	0.7	92.00	24.81	0.55	0.00	872.76	0.00	0.00	1574.87	0.00	0.00	0.00	0.00	0.00
CORN	16.8	88.34	256.39	0.35	0.00	871.53	197.84	6.31	660.32	13.70	1.89	35.49	16.82	6.01

View HRU Level Warnings

Model errors are often isolated to a particular land use type. If the land use is relatively minor, these issues may go unnoticed at the basin outlet during calibration. Often, these minor land uses are the focus of scenario development, and errors become apparent after the investment of much calibration effort. The table above contains a few important predictions summarized by land use. These should be reviewed carefully. The button to the right provides HRU level warnings, these data are provided only to help isolate problem HRUs within a particular land use. We do not recommend that these data be used during routine checking of model output.

Messages and Warnings

Crop: PAST LESS THAN 22% OF WATER YIELD IS BASEFLOW
Crop: FRSD BIOMASS MAY BE TOO HIGH 53.6 Mg/Ha
Crop: FRSD LESS THAN 22% OF WATER YIELD IS BASEFLOW
Crop: WETF BIOMASS MAY BE TOO HIGH 349.6 Mg/Ha
Crop: CORN LESS THAN 22% OF WATER YIELD IS BASEFLOW

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In-stream processes may have a large impact on sediment and nutrient loads. It is difficult to gage appropriate values for these outputs. In-stream sediment change can be either positive or negative. Typically streams are a net sink for nutrients. Channel geomorphology can provide some guidance as to the net contribution of in-stream processes.

Show Detailed Reach Table

More than 50% of sediment is

Sediment Budget

Upland Sediment Yield (Mg/ha)	1.05
Instream Sediment Change (Mg/ha)	2.29
Channel Erosion (%)	68.58
Channel Deposition (%)	

Instream Nutrient Modification (%)

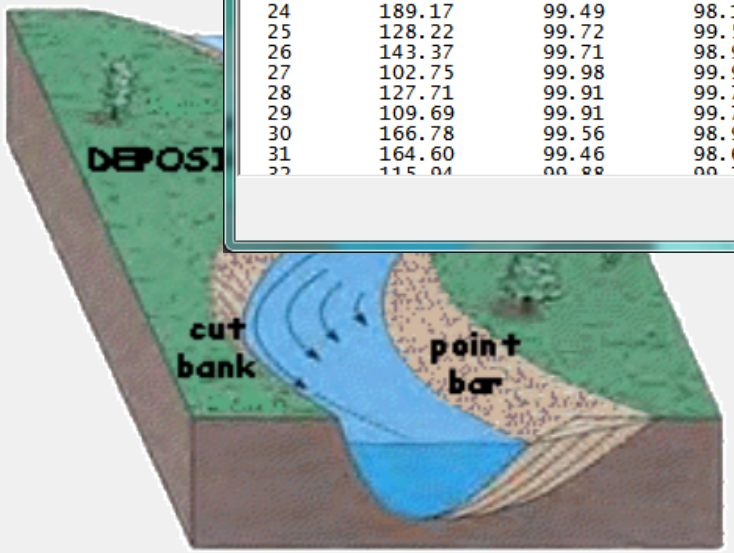
Total Nitrogen	-4.30
Total Phosphorus	-0.69

Instream Water Budget

Total Streamflow Losses (%)	2.29
	2.29
	0.00

Detailed Reach Report

RCH#	Delivery Ratio fo Segment (%) Sed.	Phos.	Nit.
1	101.49	99.99	99.97
2	133.42	99.73	99.38
3	100.00	97.72	94.04
4	99.98	99.64	97.93
5	153.78	99.66	98.86
6	100.00	99.07	94.48
7	99.91	99.10	95.47
8	100.00	94.90	74.36
9	99.94	99.28	97.31
10	126.04	99.83	99.36
11	100.00	99.21	92.55
12	100.00	99.06	81.46
13	115.10	99.89	99.74
14	99.99	98.70	95.35
15	165.63	99.59	99.13
16	348.80	99.49	98.60
17	99.93	98.40	95.53
18	100.00	99.20	94.91
19	100.00	99.35	95.82
20	99.95	99.31	97.02
21	99.64	98.69	95.67
22	137.73	99.53	98.69
23	138.29	99.71	99.33
24	189.17	99.49	98.18
25	128.22	99.72	99.51
26	143.37	99.71	98.90
27	102.75	99.98	99.95
28	127.71	99.91	99.72
29	109.69	99.91	99.74
30	166.78	99.56	98.98
31	164.60	99.46	98.69



In-stream Processes

- Sediment and Nutrients
- Delivery Ratio

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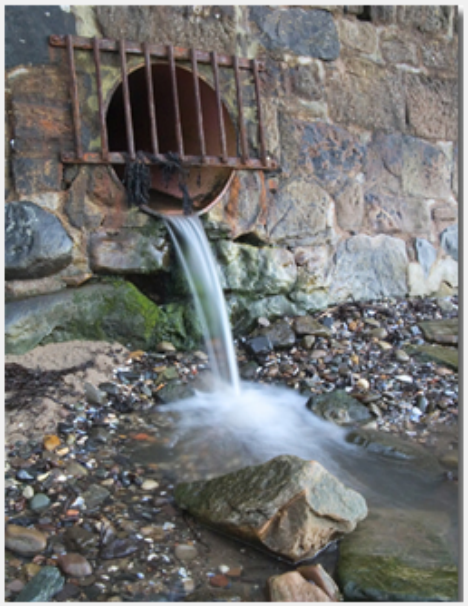
Point sources constantly discharge pollutants to streams. These are an optional feature in SWAT. These summaries are presented so that the relative contribution of these sources can be verified. Point sources contributions are so varied that there is no reasonable range which can be applied to all basins.



Total Subbasin Load	
Flow (cms)	1.96
Sediment (Mg/yr)	30687.6
Nitrogen (kg/yr)	270185.0
Phosphorus (kg/yr)	49847.8

Total Point Source + Inlet Load	
Flow (cms)	0.00
Sediment (Mg/yr)	0.0
Nitrogen (kg/yr)	0.0
Phosphorus (kg/yr)	0.0

Load From Inlet+PS (%)	
Flow (cms)	0.00
Sediment (Mg/yr)	0.00
Nitrogen (kg/yr)	0.00
Phosphorus (kg/yr)	0.00

Messages and Warnings

Inlets/point source not present.

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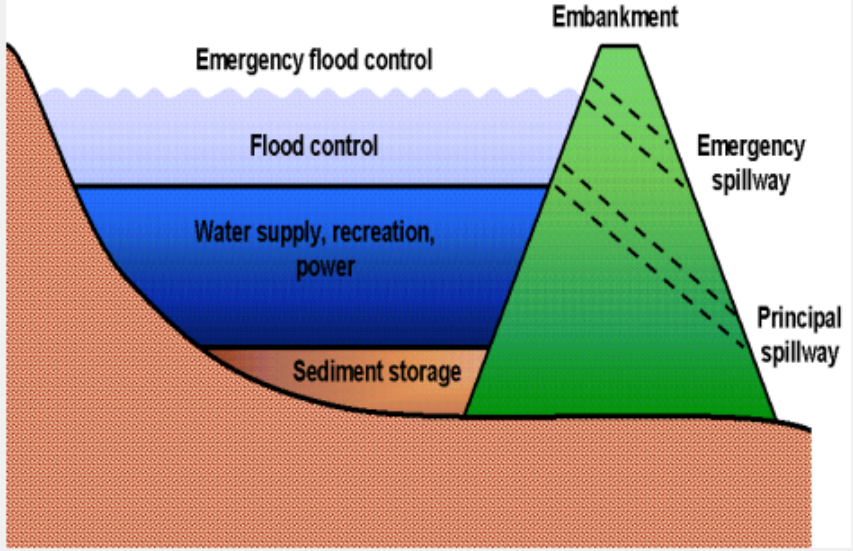
Reservoirs are an option feature in SWAT. The hydrology of basins with large reservoirs may be completely dominated by reservoir processes and release rates. The data presented here is an average of all reservoirs; data for individual reservoir is available via the "Show Reservoir Table" button. The statistics presented here are designed to identify common reservoir issues. The use of user specified release rate may cause a reservoir to grow continuously or run completely dry. These common issues can be detected via the "Final/Initial Volume" ratio and "Fraction of Period Empty" statistics.



Average Trapping Efficiency (%)

Sediment	55.0
Nitrogen	25.5
Phosphorus	29.3

Average Water Losses (%)

Total Removed + Losses	6.7
Evaporation	7.6
Seepage	7.4

Average Resevoir Trends

Number of Resevoirs	17
Final/Initial Volume (max)	9.02
Final/Initial Volume (min)	0.54
Fraction of Period Empty (max)	0.00

Show Reservoir Table

Messages and Warnings

At least one of your reservoirs ends the simulation with at least 500% more volume that it begins with. Check your release parameters.
At least one of your reservoirs ends the simulation with less than 20% volume that it begins with. Check your release parameters.
Sediment trapping efficiency less than 40% at one or more reservoirs.

Reservoirs

- Sediment retention
- Nutrient retention
- Evaporation
- Seepage rates

Application Notes

A warning does not mean there is a problem

- SWAT Check identifies potential problems only
- User decides if problem is real or not

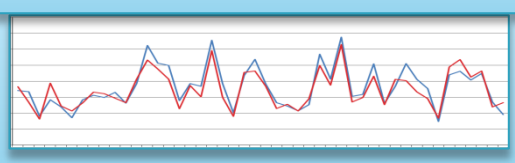
A lack of warnings does not prove a valid model

- Just an indicator, one step in the quality control process
- Good calibration/validation statistics are also a good indicator

More important to properly represent processes than to mimic “measured” data

Statistics May Not be Enough

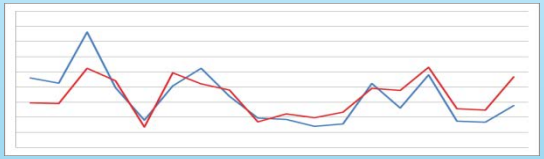
Model Calibrated for Flow
Pbias = 2% NSE =0.84



Model #1 (Up)

Calibrated for sediment using mostly upland parameters

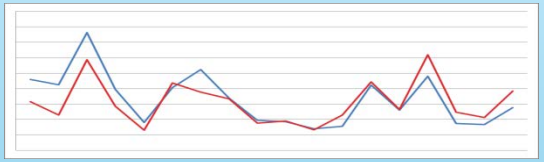
Pbias = 2% NSE =0.58



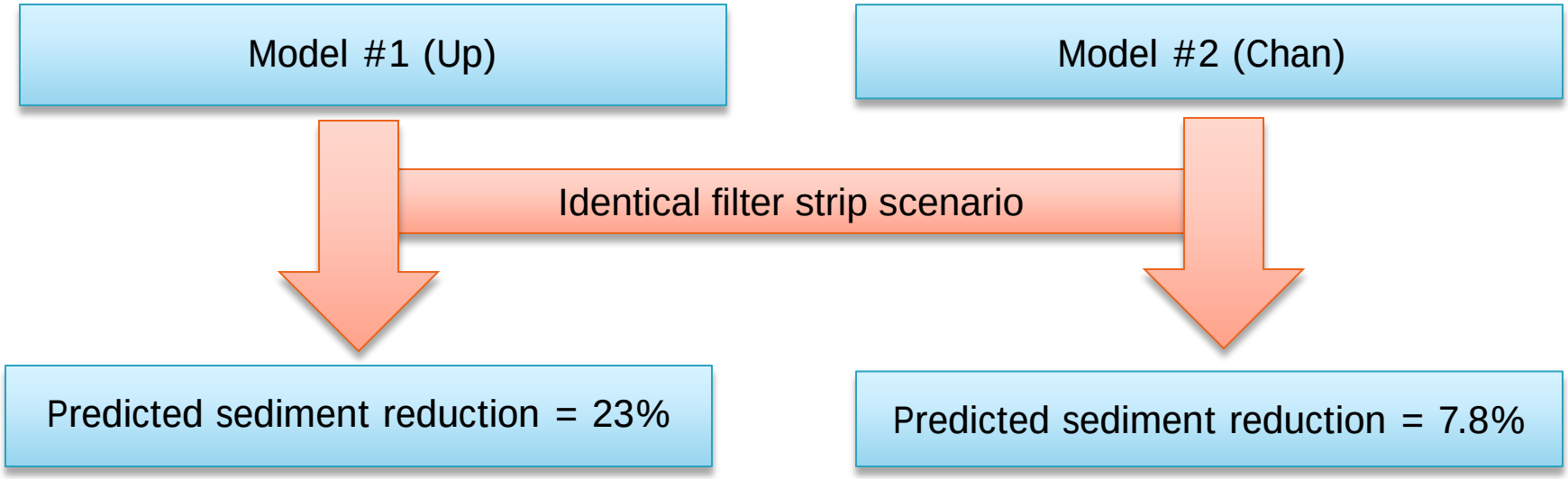
Model #2 (Chan)

Calibrated for sediment using mostly in-stream parameters

Pbias = 6% NSE =0.62



How well do these model predict?



Which one is better?

How well do these model predict?

Model #1 (Up)

Model #2 (Chan)

SWAT Check

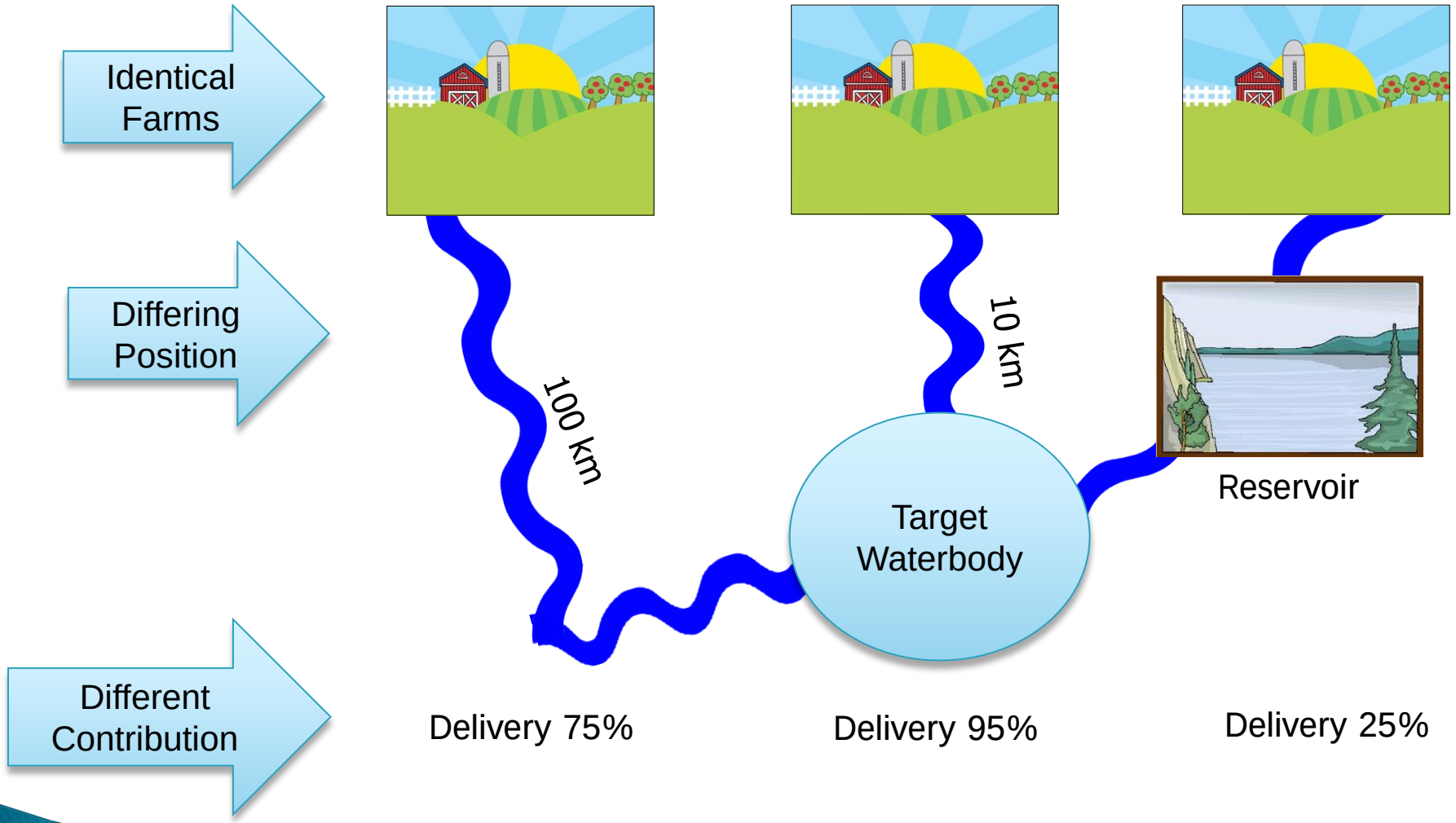
Sediment Warning:
Max sediment yield is greater than 50 metric ton per ha in at least one HRU.
Upland Sediment Yield = 0.52 Mg/ha

Instream Process Warning:
Very little in-stream sediment modification (< +-2%). This is unusual.

Instream Process Warning:
More than 50% of sediment is from instream processes.
Channel Erosion = 71%
Upland Sediment Yield = 0.18 Mg/ha

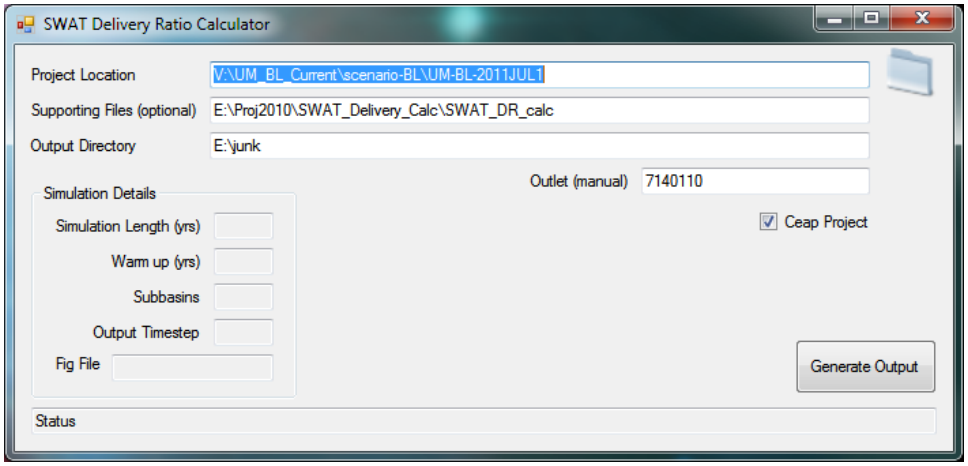
Delivery Tool

Spatial Connectivity and Delivery

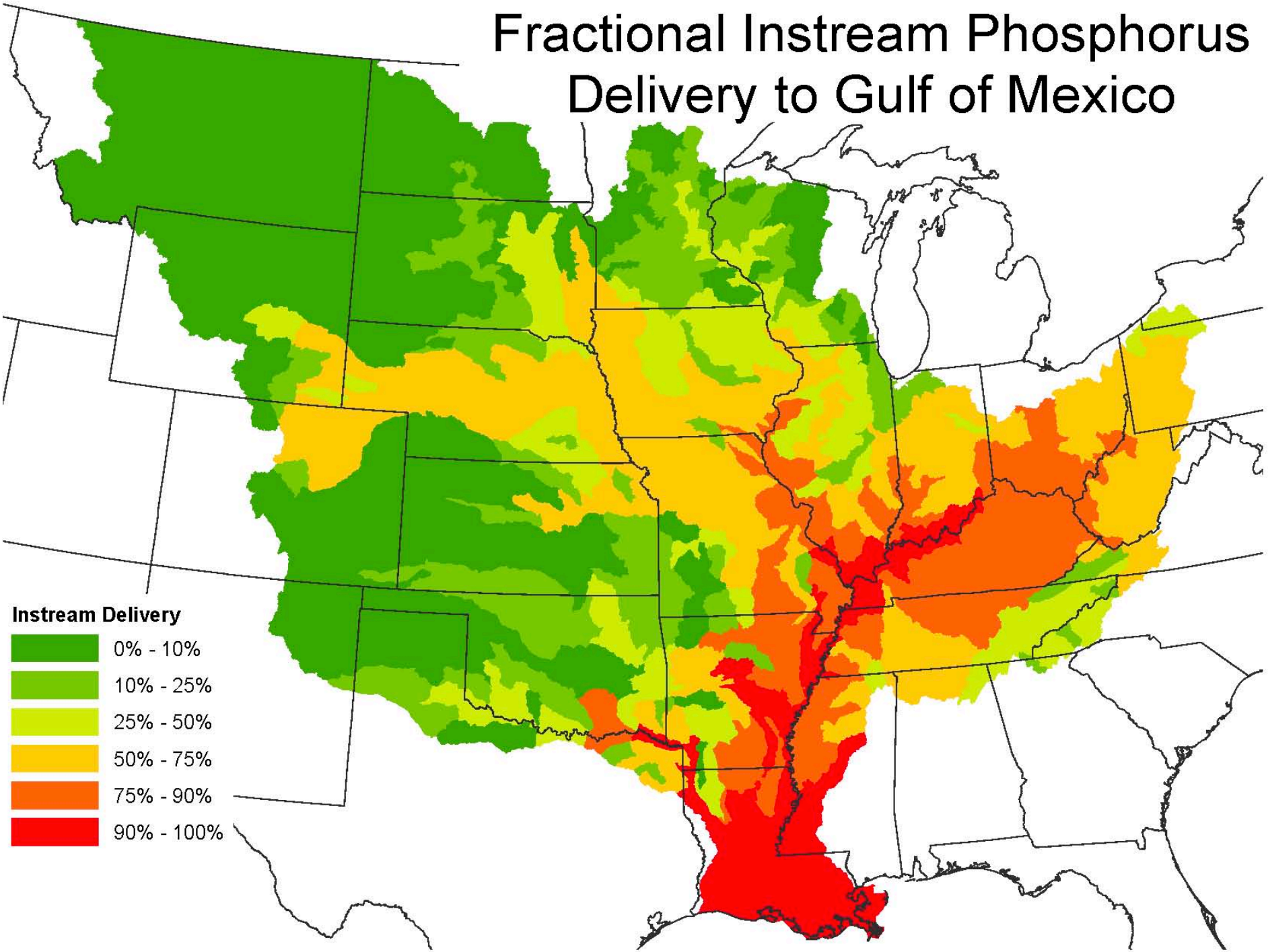


Delivery Ratio Tool

- Calculated delivery for every reach and reservoir
- Analyzes watershed configuration “Fig” file for connectivity
- Calculates cumulative delivery for each subbasin



Fractional Instream Phosphorus Delivery to Gulf of Mexico



Questions and Comments?