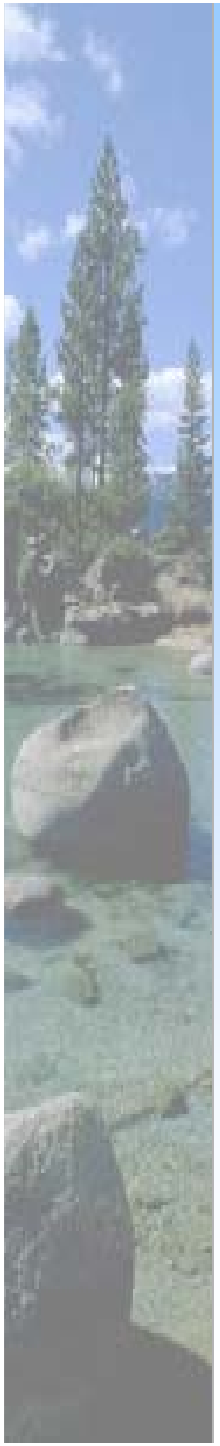
Lake Tahoe Fine Sediment and Nutrients Total Maximum Daily Load

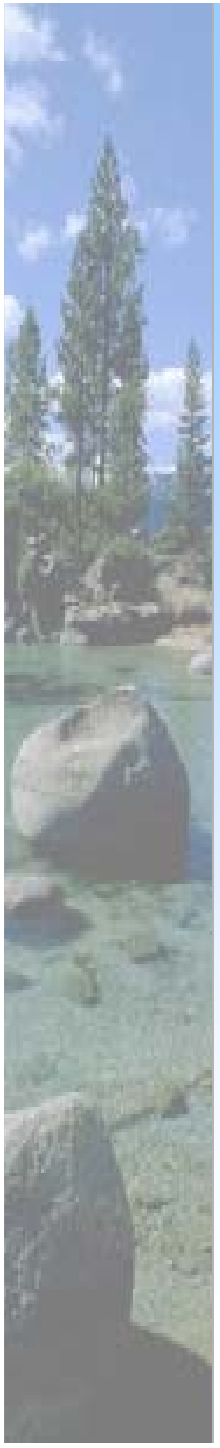
Draft Technical Report:

Summary of Findings



Technical Report designed to address the following required TMDL components:

- Problem Statement
- Numeric Target
- Source Analysis
- Linkage Analysis

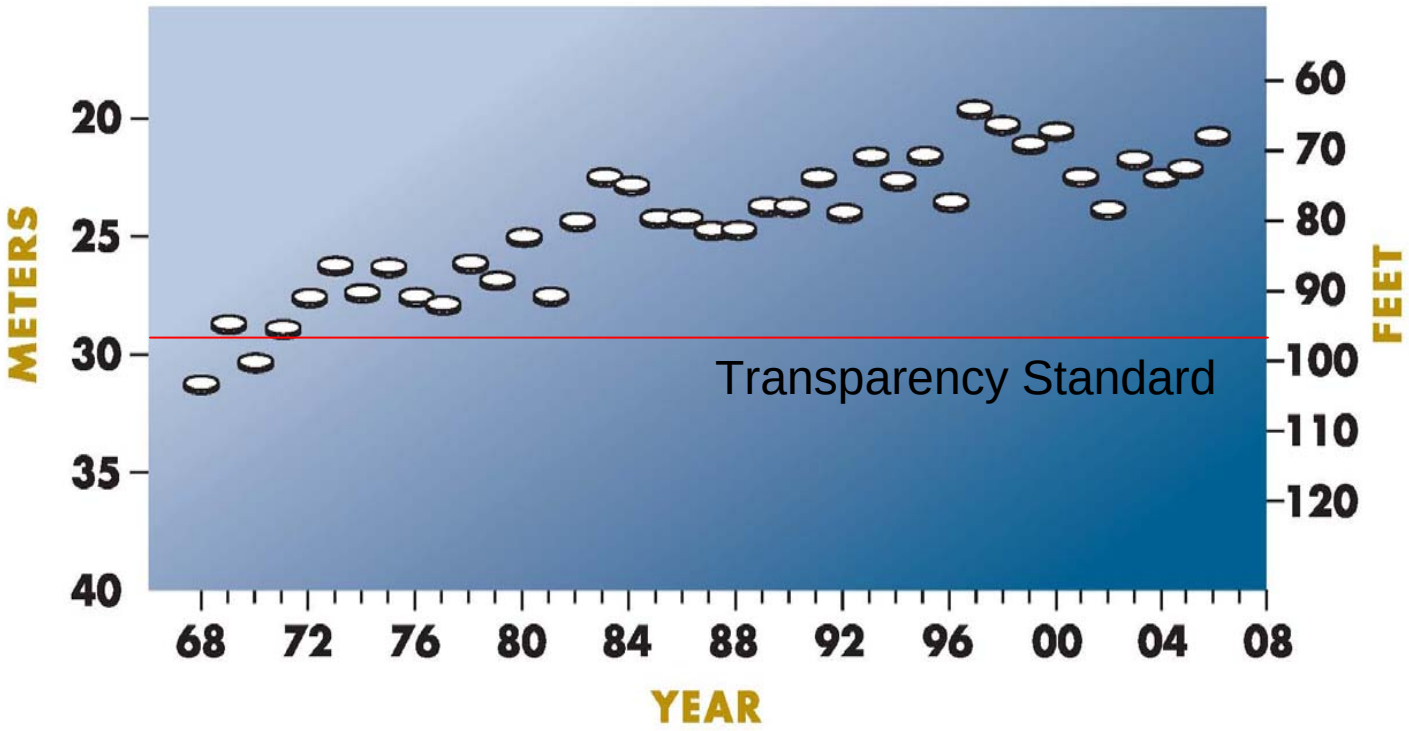


Questions Addressed in TMDL Technical Report

- What pollutants are causing Lake Tahoe's clarity loss?
- How much of each pollutant is reaching Lake Tahoe?
- How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?

Problem Statement

Monitoring data has observed declining clarity for 40 + years



Beneficial uses not being supported:

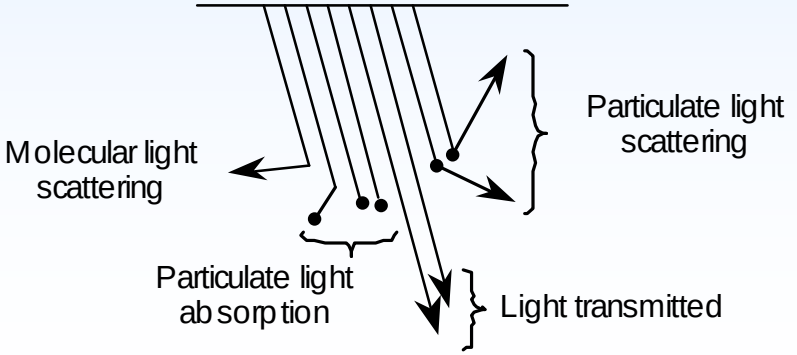
- Water of Extraordinary Aesthetic or Ecologic Value
- Recreation involving contact with the water

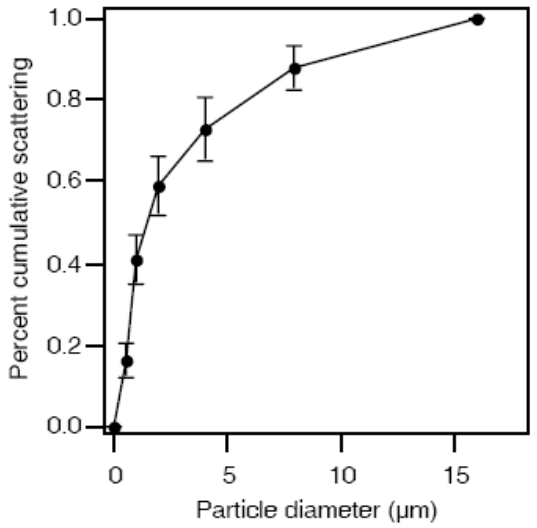
What pollutants are causing Lake Tahoe's Clarity Loss?

- Research indicates nutrients (Nitrogen & Phosphorous) and fine sediments are the pollutant responsible for the clarity decline

Nutrients fuel algal growth

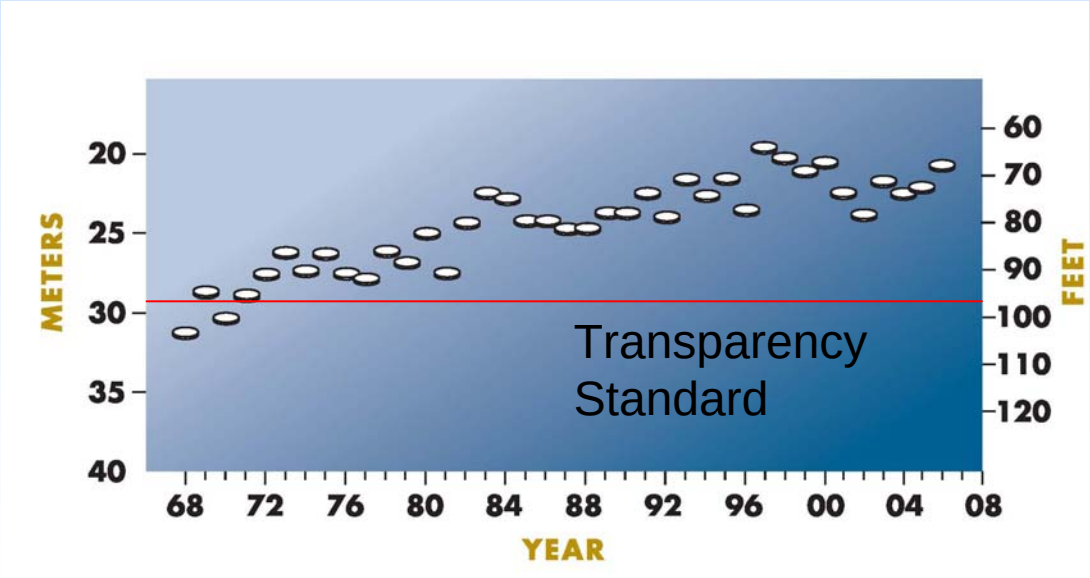
Fine sediments scatter and absorb light



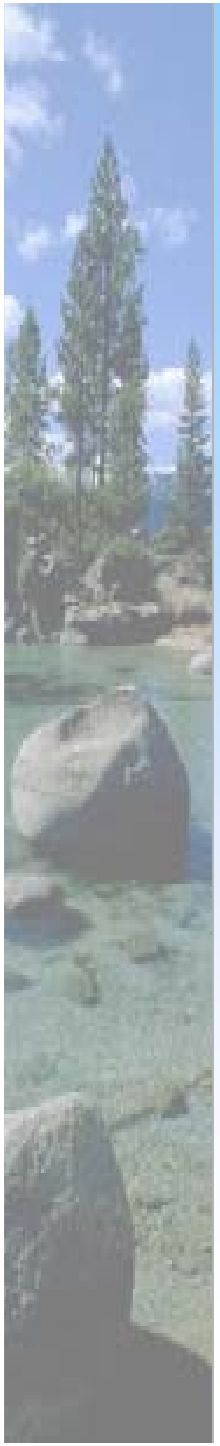


Numeric Target

- PATHWAY* Water Quality Resource Group & Forum recommendation to adopt CA transparency standard = 29.7 m annual average Secchi depth



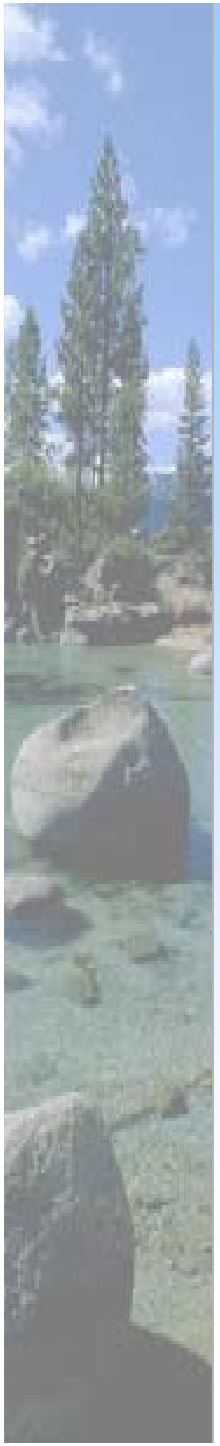
* Visit www.pathway2007.org for more information on the PATHWAY planning process and partners



Source Analysis

Research and Information Collection

- Involved more than 150 individuals
- Multimillion dollar effort of national significance
- Collaboration of State, Federal, Academic, and Private entities
- Built on impressive amount of local information and expertise
- Addressed many of the current Management Questions
- Specifically developed to provide increased adaptability
- Aimed to develop methods for estimating load reductions over time and incorporating new information to verify estimates



Source Categories

Groundwater

- US Army Corps of Engineers - Groundwater Report

Stream Channel Erosion

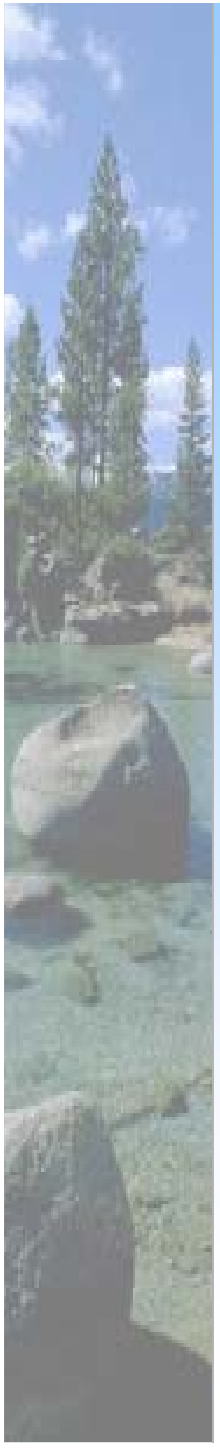
- National Sedimentation Laboratory – Basin-wide loading
- Tetra Tech – Watershed Model representation

Atmospheric

- California Air Resources Board
- Tahoe Research Group (UCD)
- Desert Research Institute (DRI)

Upland

- Tetra Tech - LSPC (Upland Hydrology and Loading)
- UCD, DRI Storm Water Monitoring Network and water quality evaluations



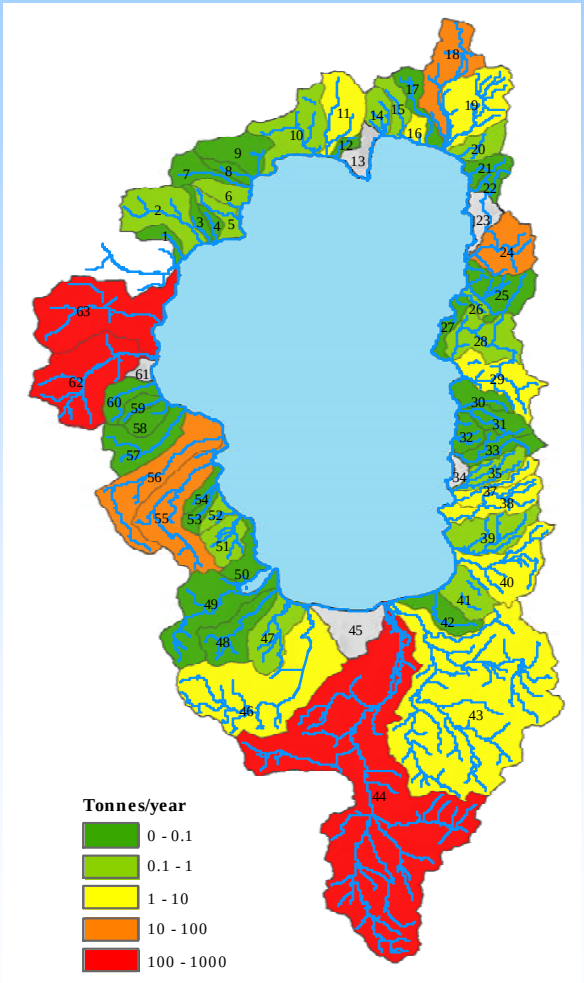
Groundwater Loading

General agreement in two studies

Constituent	**US ACOE 2003**	**Thodal 1997**
Total Dissolved Nitrogen (kg/yr)	50,000	60,000
Total Dissolved Phosphorus (kg/yr)	6,800	4,000
Discharge Rate (m^3/yr)	6.4×10^7	4.9×10^7

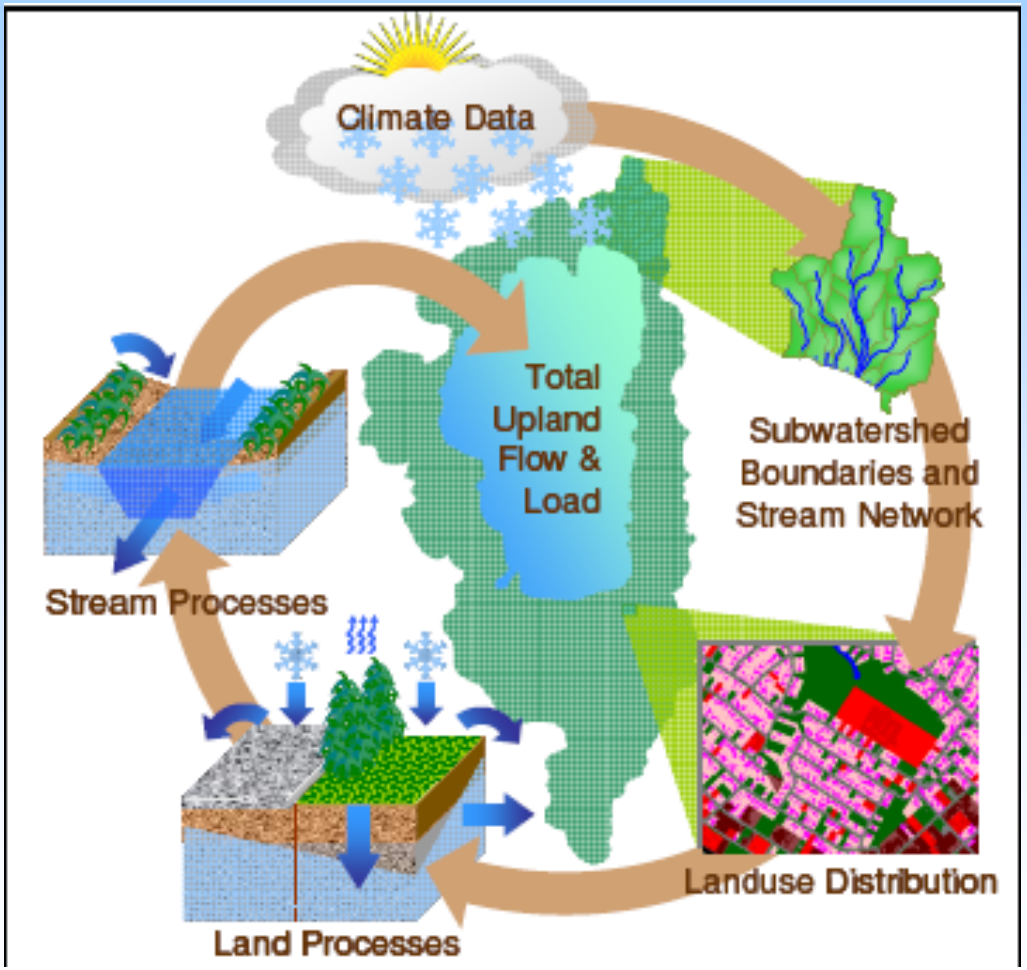
Assumes no particles > 5 microns enter via GW

Stream Channel Erosion



Field based and modeling studies to quantify sediment and fine sediment loading from stream bed and bank erosion conducted by the National Sedimentation Laboratory (2003 & 2006)

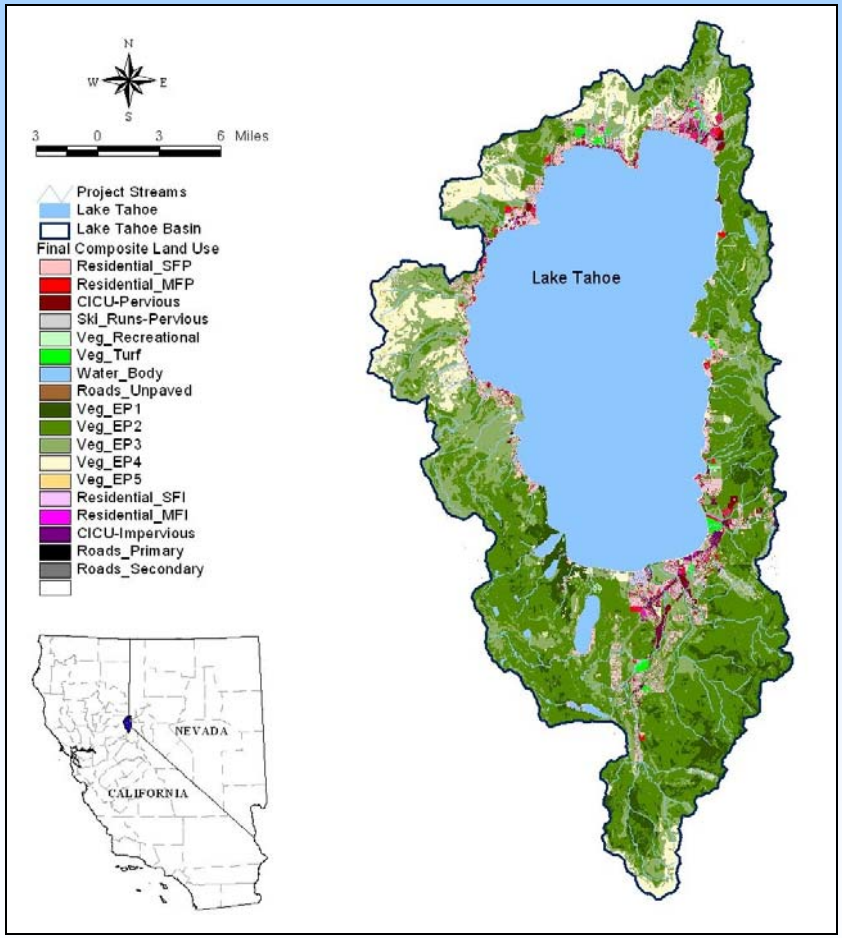
Upland Loading



LSPC Conceptual Model

Load Simulation Program C++ (LSPC) Watershed Model customized to Lake Tahoe by Tetra Tech to derive pollutant loads

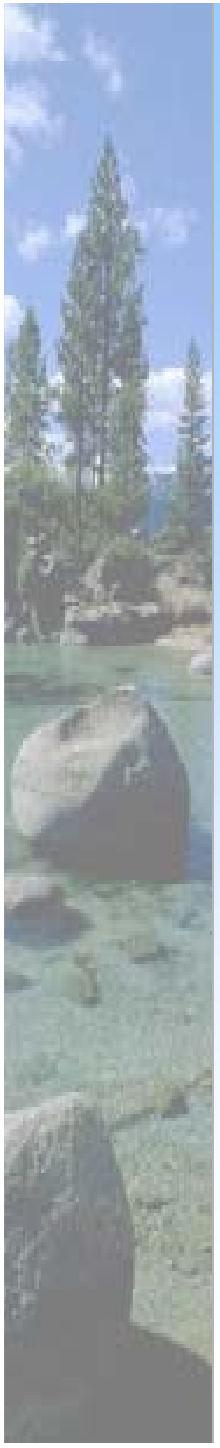
Upland Loading



LSPC population required production of reliable land use layer which took into account impervious cover

Upland Loading

- First basin-wide monitoring program for stormwater
- 16 land-use specific sites (primarily urban) over two years
- Event Mean Concentration data used as input to LSPC watershed model



Upland Loading

(1) Hourly data from 9 SNOTEL sites drives hydrology

(2) Validated well at scales of storms, monthly and annual

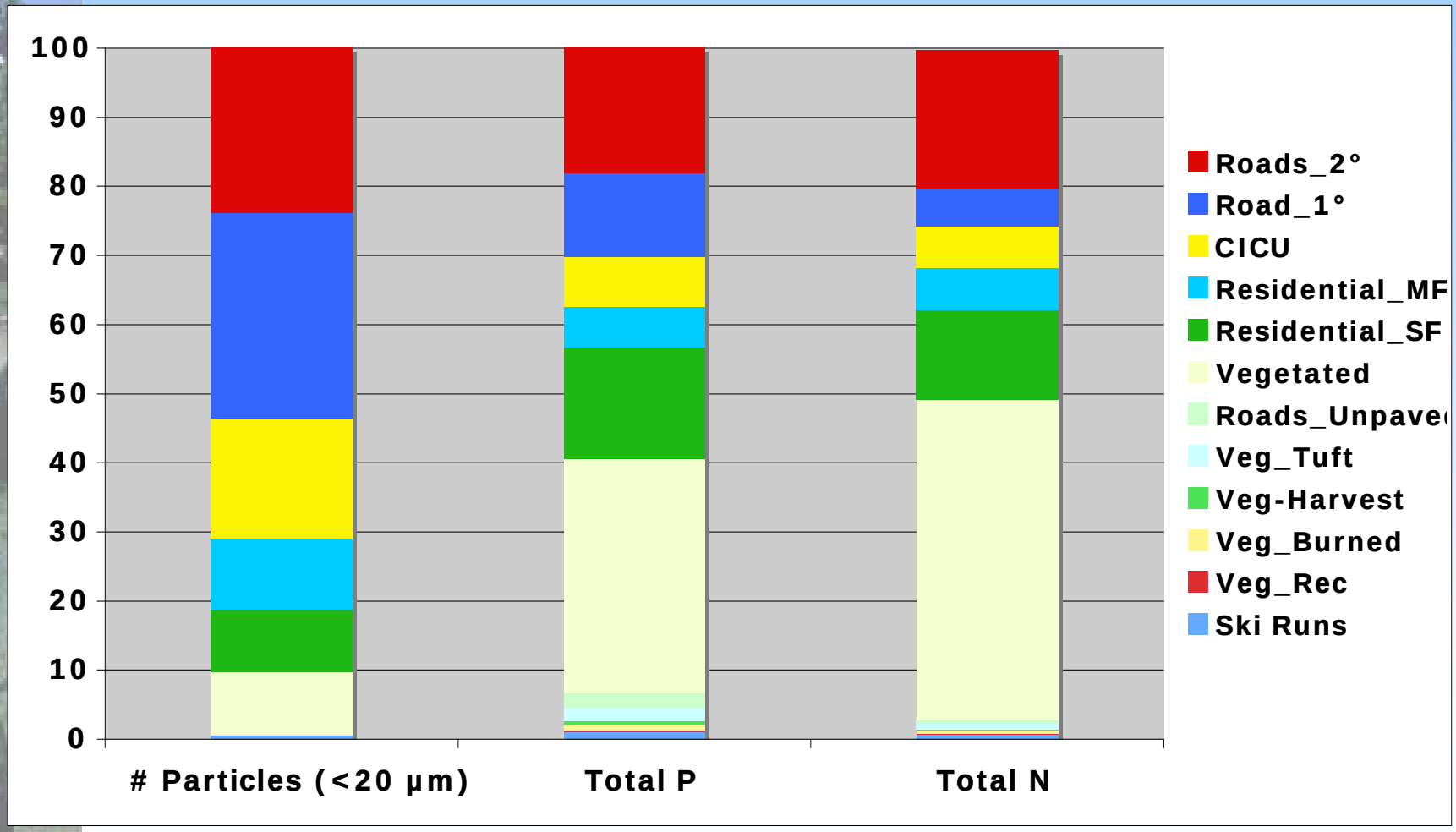
(3) Total N/P loads modeled - each partitioned using field data

(4) Modeled loads usually within 10-15% of Lake Tahoe Interagency Monitoring Program (LTIMP) measurements

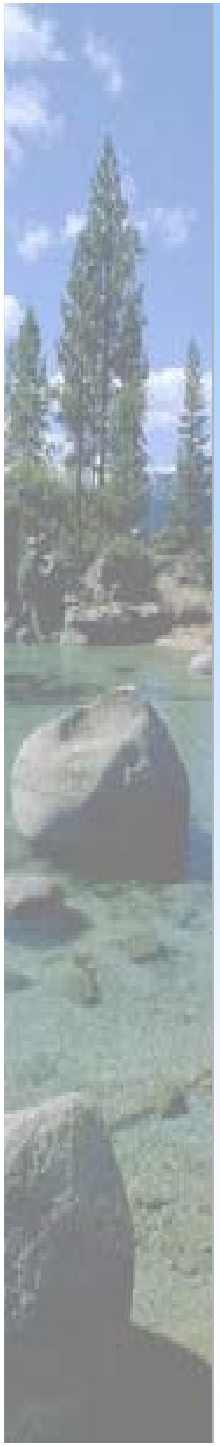
(5) Modeled TSS and mass <63 µm, but not adequate for # of particles <20 µm by size class

(6) Rabidoux & Schladow measured particles in LTIMP streams and used modeled flow to estimate load

Upland Loading



LSPC Watershed Model results



Atmospheric Deposition

Datasets utilized to quantify loading rates directly to the lake surface:

- California Air Resources Board/Desert Research Institute two year field study (2002-2003) focused on dry deposition
- UC Davis Tahoe Environmental Resources Center field measurements of wet deposition

	Dry Deposition (MT/yr)	Wet Deposition (MT/yr)
Nitrogen		
NO3	29	18
NH4	87	14
DIN	116	32
DON	31	31
TON	39	32
PN	7	<1
Total N	**155**	**63**
Phosphorus		
SRP	1.3	1.0
Total P	**3.5-5.4**	**2.6**
Particulate Matter		
Fine (<2.5 µm)	60	74
Course (>2.5-10 µm)	169	69
Large (>10 µm)	357	20
Total PM	**586**	**163**

How much of each pollutant is reaching Lake Tahoe?

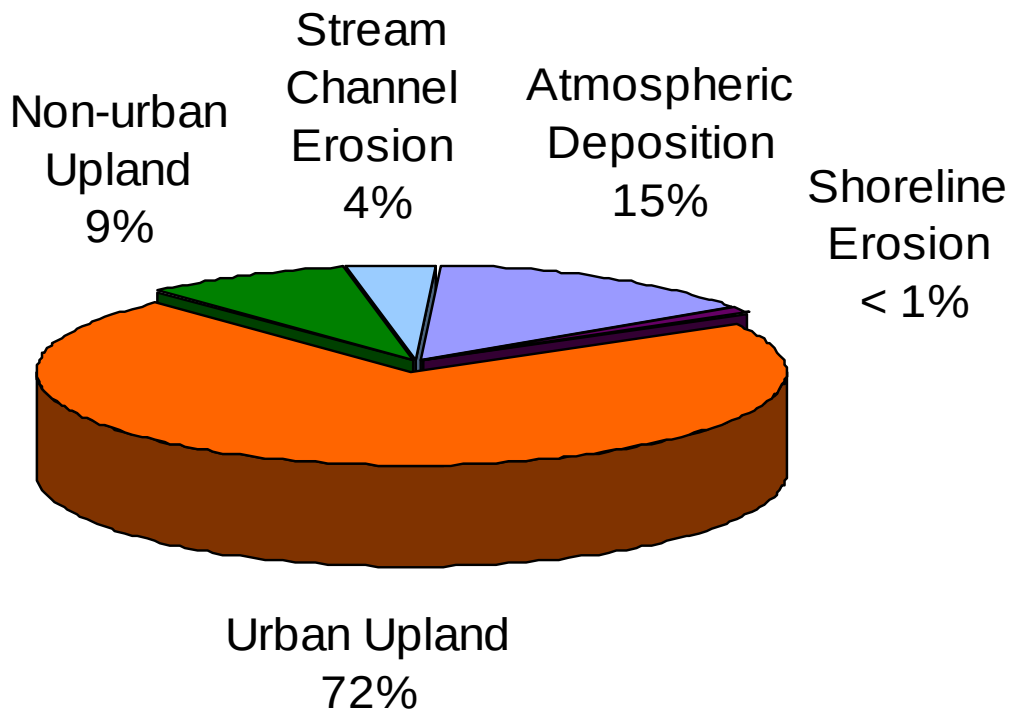
Source Category		Total Nitrogen (metric tons/year)	Total Phosphorus (metric tons/year)	Number of Fine Sediment Particles ($x10^{18}$)
Upland	Urban	63	18	348
	Non-Urban	62	12	41
Atmospheric Deposition	(wet + dry)	218	7	75
Stream Channel Erosion		2	<1	17
Groundwater		50	7	NA**
Shoreline Erosion		2	2	1
TOTAL		397	46	481

Confidence and Uncertainty Key

High	• Based on reliable and extensive field data or modeling supported by extensive field data. • Peer-reviewed studies exist specifically for the Tahoe Basin. • Weight of evidence provided by similarity to other independent studies for Lake Tahoe. • Scientific reasoning supported by TMDL Team. • Additional studies not likely to yield significantly different results.
Medium	• Estimates based on field data or modeling; however, the supporting data base is either not extensive and/or comprehensive. • Primarily non peer-reviewed studies exist for the Tahoe basin. • Weight of evidence provided by studies for Lake Tahoe is limited. • Additional studies will improve our understanding but not likely change broad-based management strategy.
Low	• Estimates based on a single study that was considered preliminary or not enough data was collected. • Additional studies are needed to support management decisions.

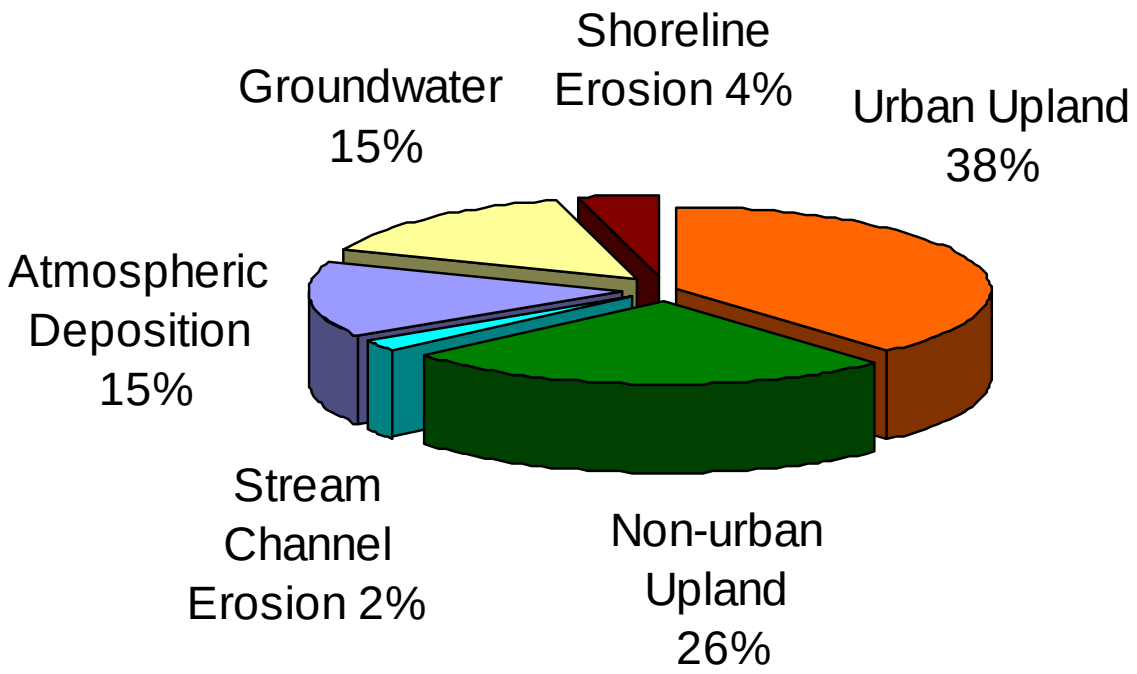
How much of each pollutant is reaching Lake Tahoe?

Fine Sediment Particle Number Estimates (particles less than 20 micrometers): Percent Contribution per Source Category



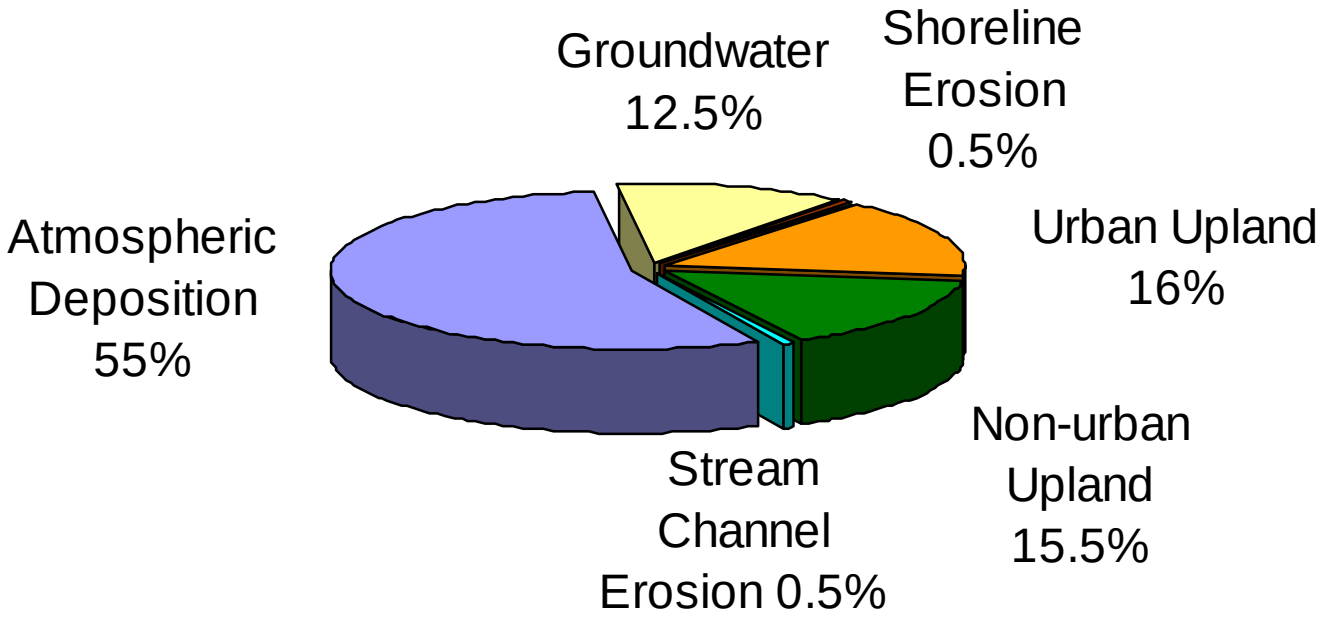
How much of each pollutant is reaching Lake Tahoe?

Total Phosphorus Estimates:
Percent Contribution per Source Category

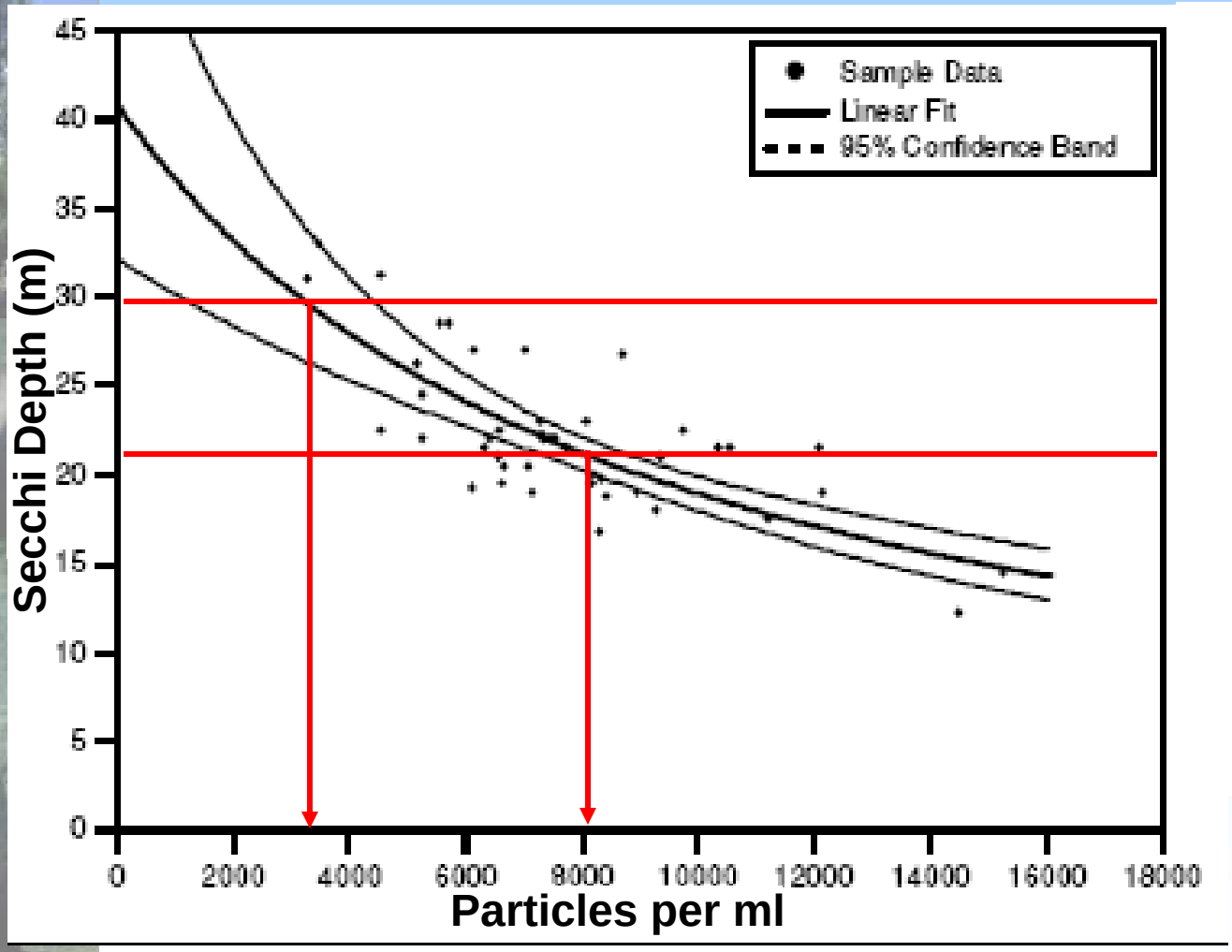


How much of each pollutant is reaching Lake Tahoe?

Total Nitrogen Estimates:
Percent Contribution per Source Category



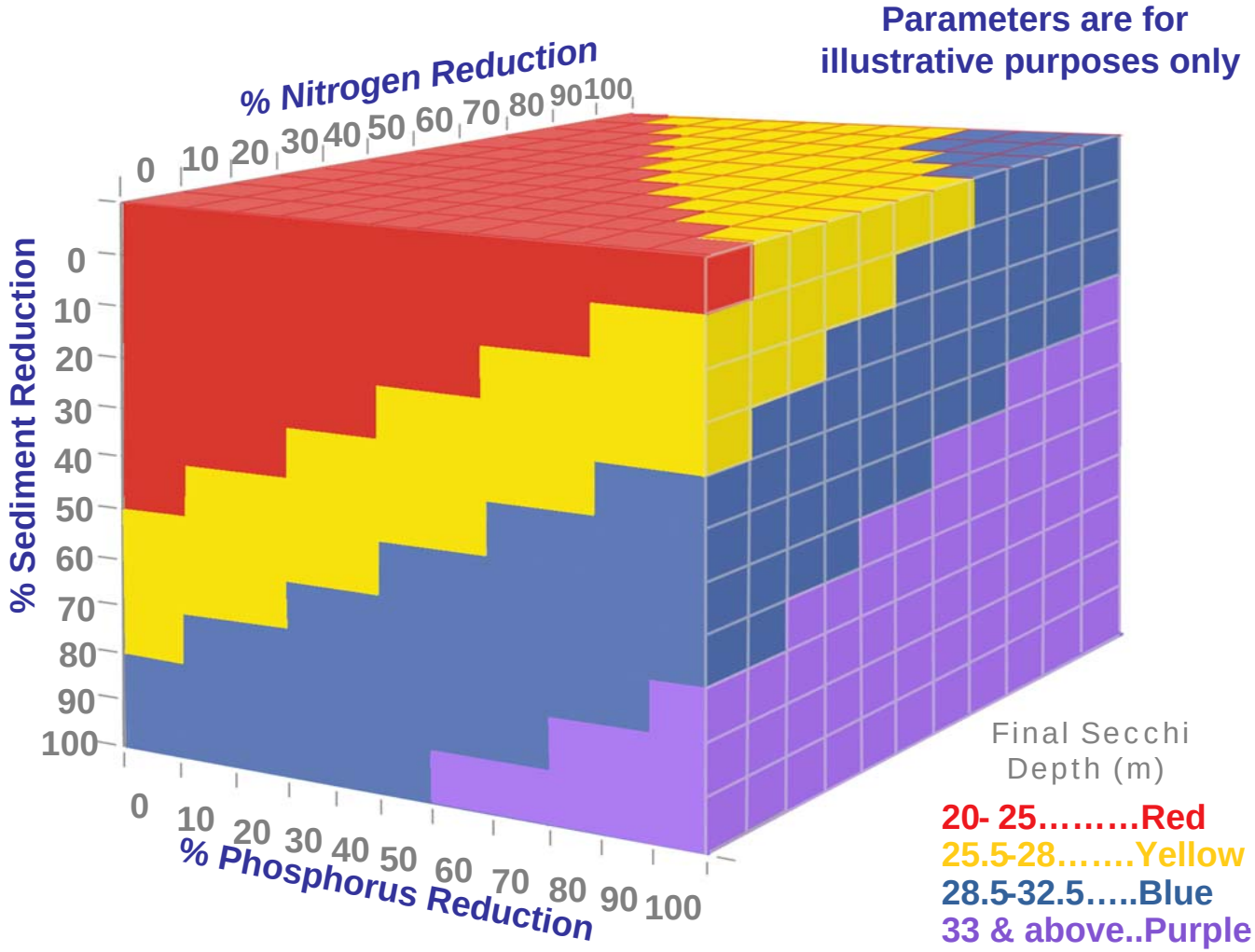
Linkage Analysis



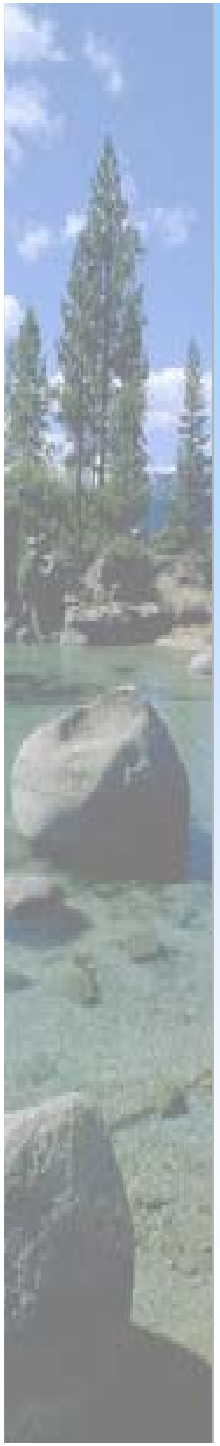
Direct measurements from Lake Tahoe that show the relationship between number of in-lake particles (not loads) and Secchi depth. **A reduction of in-lake particles by 65% is would be needed to achieve 30 m…**

modified from Swift (2004)

Linkage Analysis



However, clarity is controlled by three pollutants. Thus, there are numerous combinations of load reductions that are each capable of reaching the clarity objective, as illustrated by this conceptual clarity cube. Therefore, a tool that evaluates the lake response to various management actions would be really helpful…



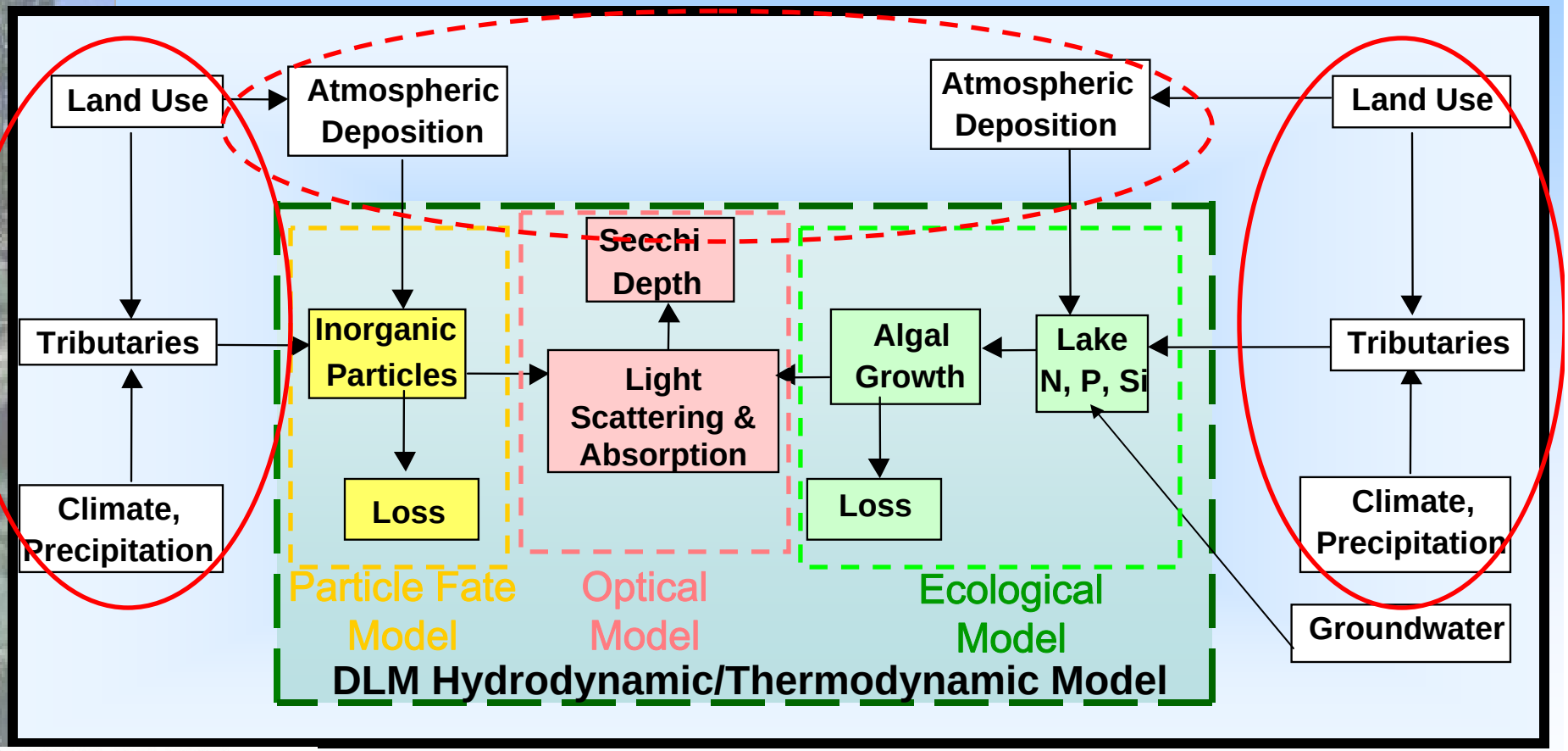
Lake Tahoe Clarity Model

A PROCESS-BASED NUMERICAL MODEL

SEVERAL MODELS COMBINED INTO ONE:
- HYDRODYNAMIC/THERMODYNAMIC MODEL
- WATER QUALITY (ECOLOGICAL) MODEL
- PARTICLE FATE MODEL
- OPTICAL MODEL

IN ADDITION, IT HAS "INPUTS" FROM OTHER MODELS
- WATERSHED MODEL
- METEOROLOGY MODEL
- ATMOSPHERIC MODEL

Lake Tahoe Clarity Model



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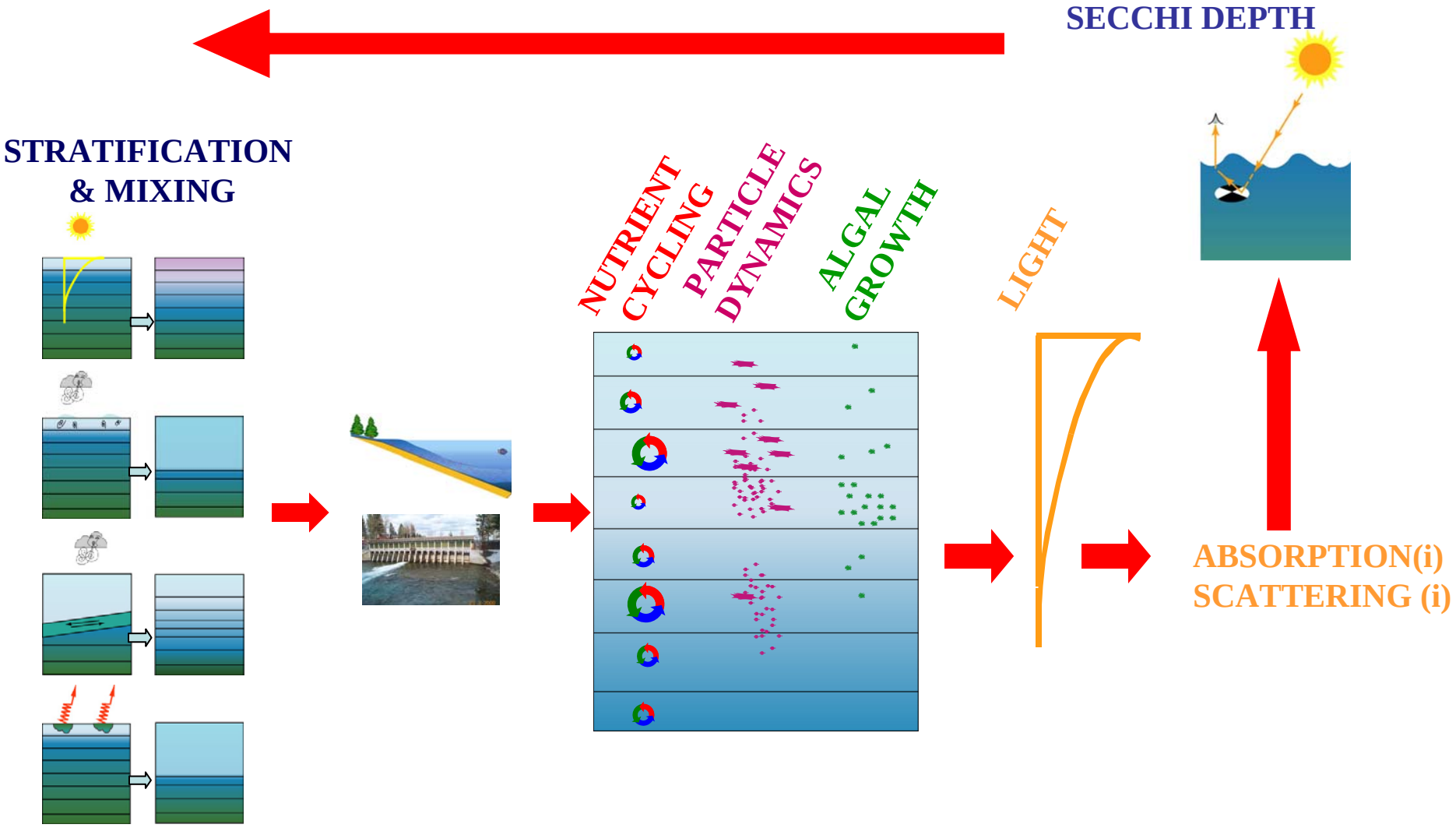
This is the tool utilized to conduct linkage analysis.

Clarity Model



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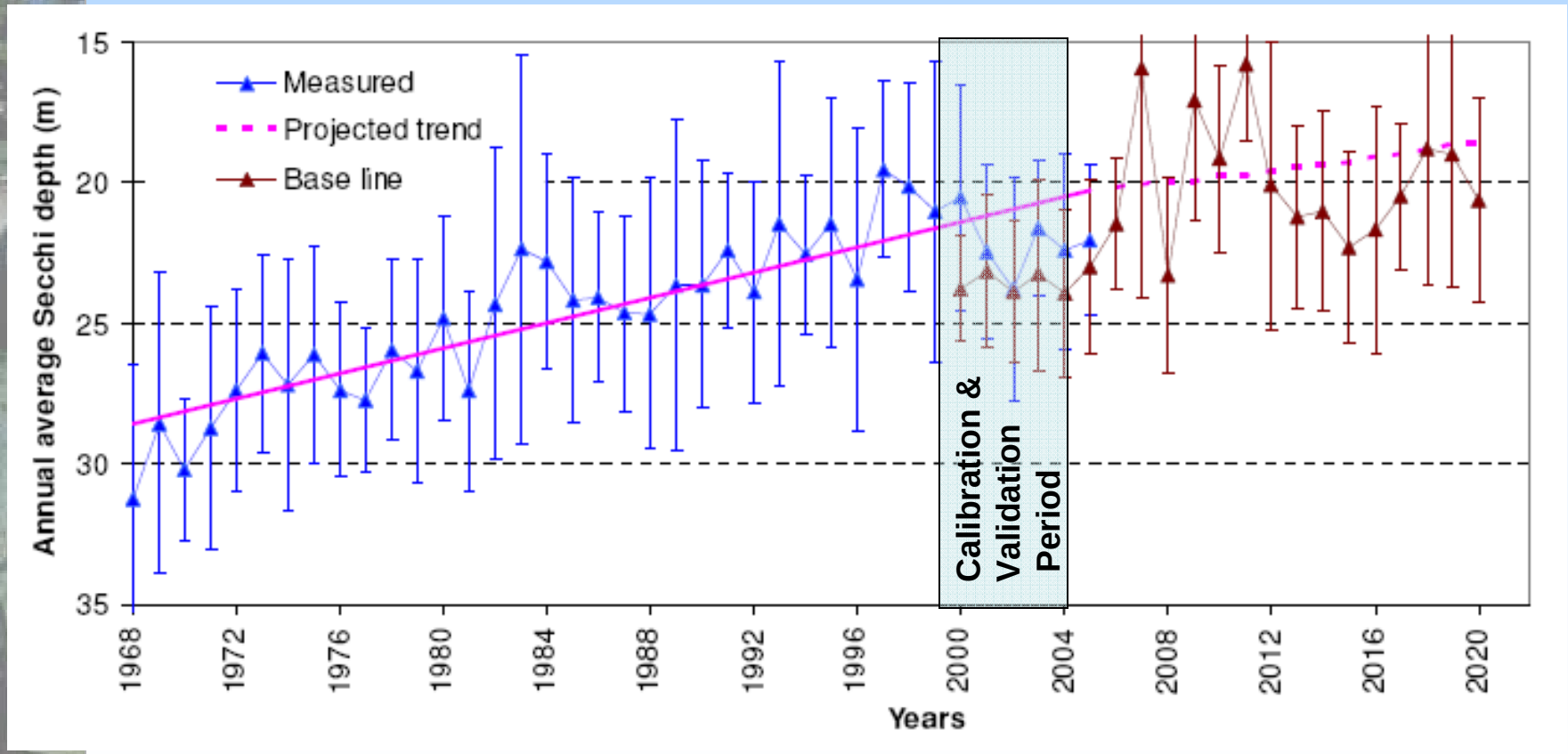
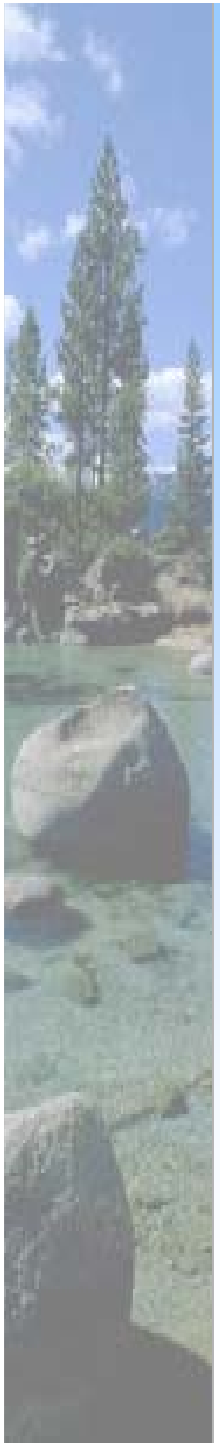
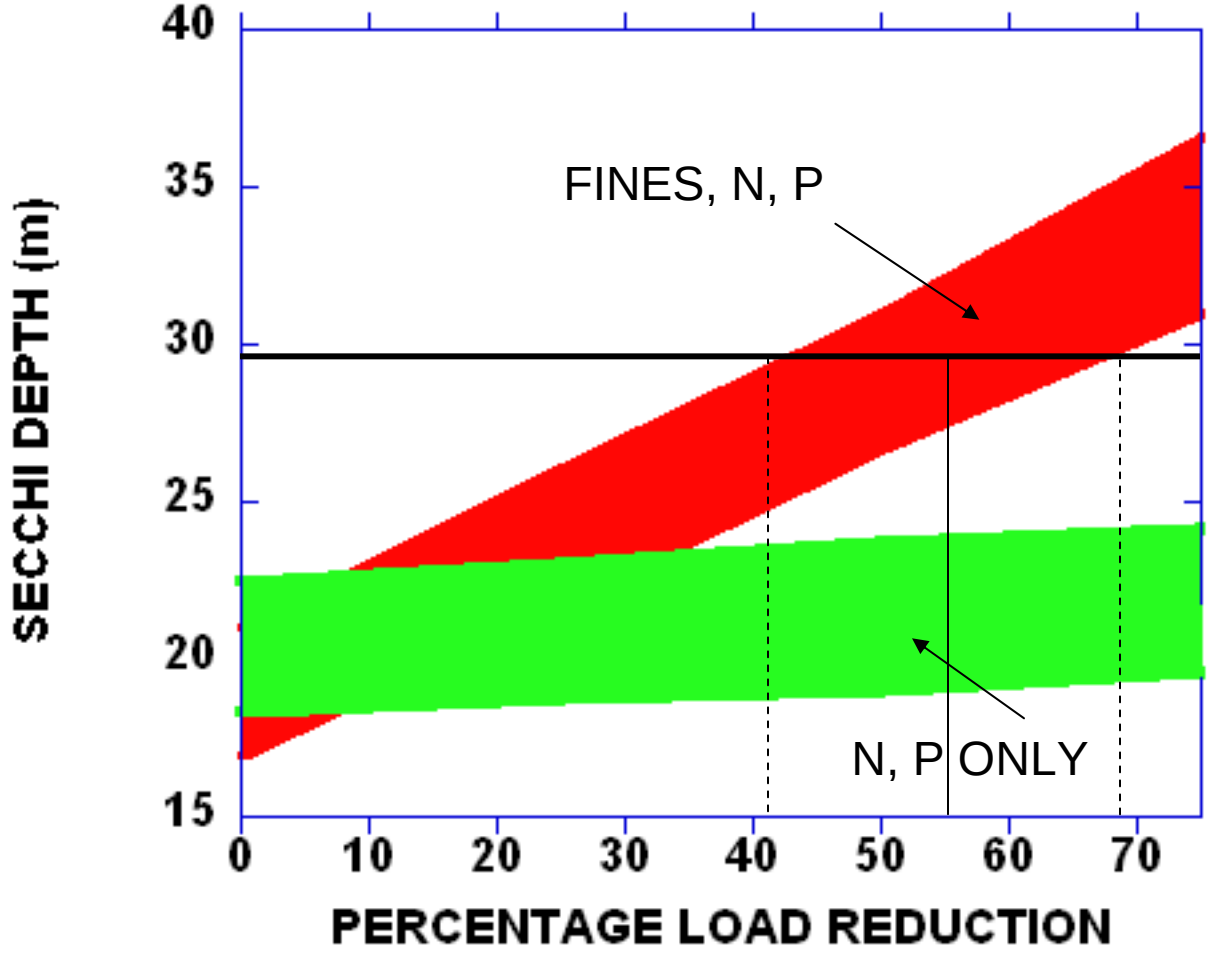
Results – Test Case 1

Do nothing more in an unchanging world



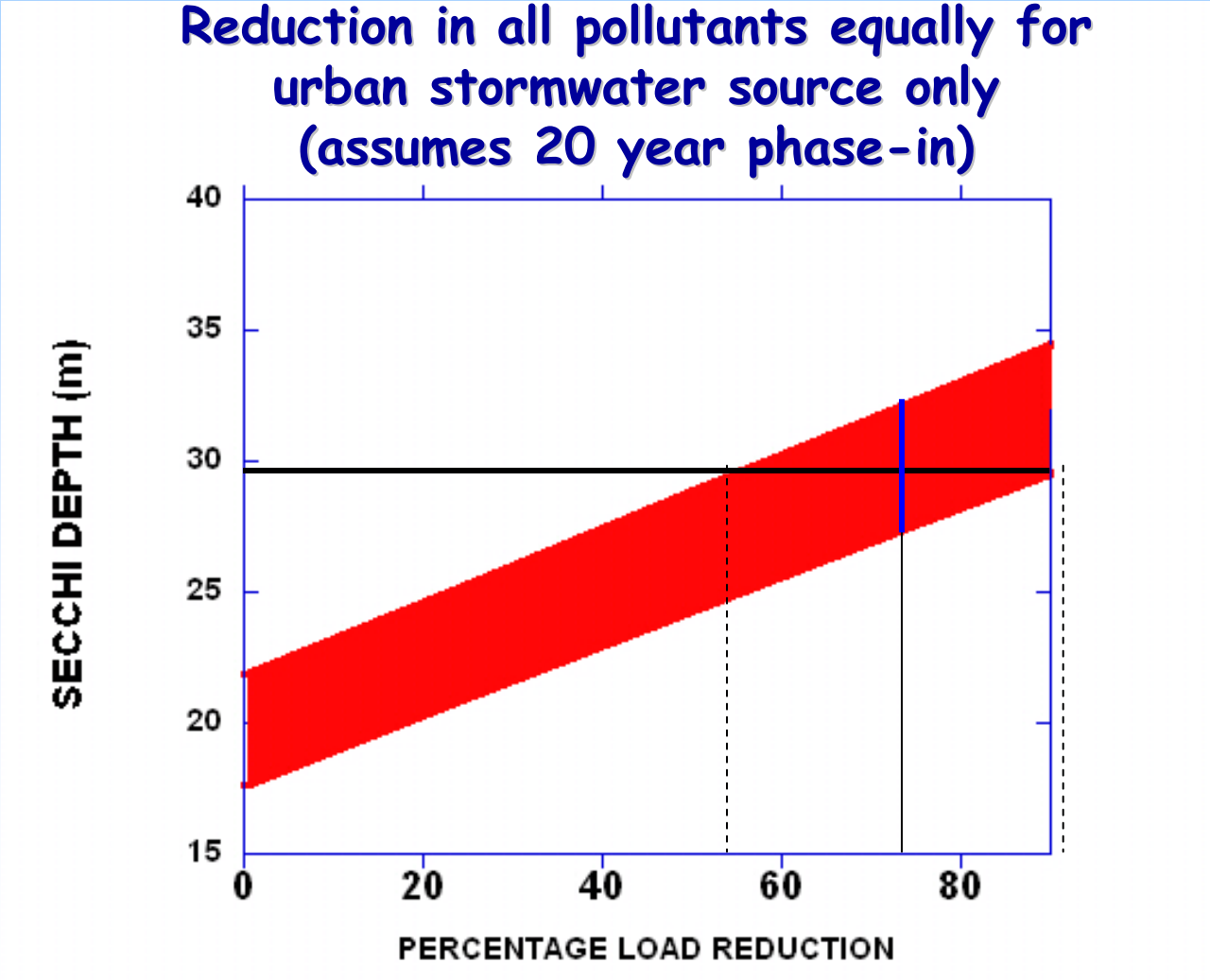
Results – Test Case 2

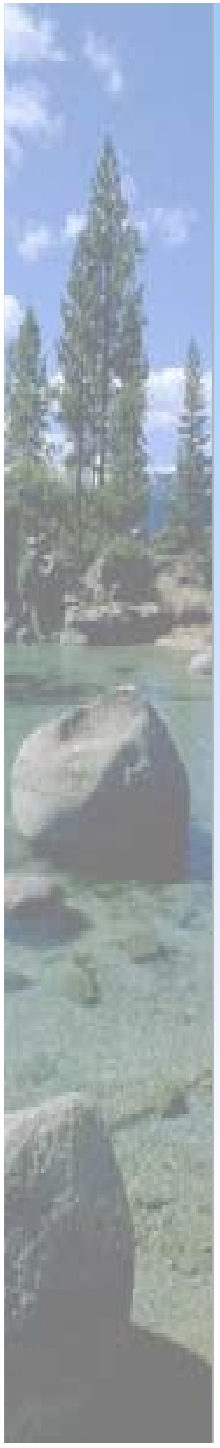




Note: that clarity is more responsive to fine sediment reductions! Results suggest fine sediments account for 2/3 of clarity condition.

Results – Test Case 3





Conclusions

- Lake Tahoe Clarity Model is a process-based model built on an established and peer reviewed framework that allows examination of the entire range of management, climate, disaster, growth etc. scenarios
- Results of the linkage analysis suggest that significant reductions will be needed in order to achieve clarity objectives
- There are countless ways in which the desired load reductions can be achieved. The model can test them and provide support for the agencies and stakeholders to decide upon a recommended implementation strategy.