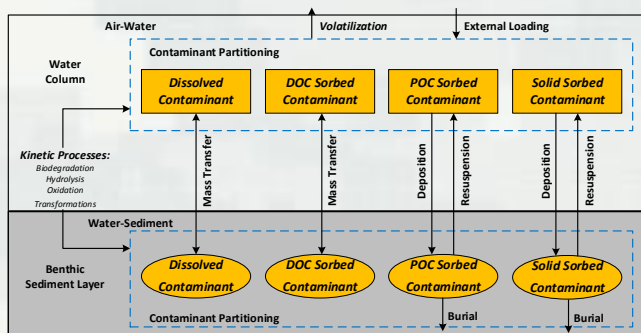
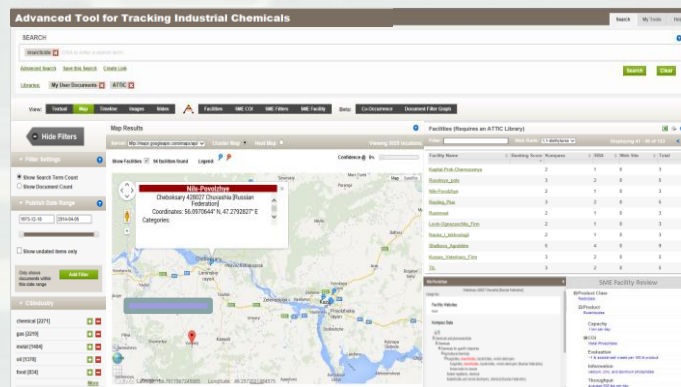
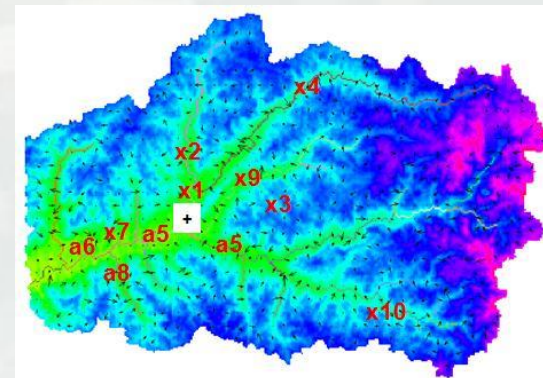


Advances in the modeling of Watershed and Riverine Fate and Transport of Contaminants

SWAT 2015 - Sardinia, Italy
June 22-26, 2015



Billy E. Johnson
Zhonglong Zhang



Discussion Items

- **Landscape Contaminant Model Development**
 - Model Conceptualization
 - Nutrient Simulation Module (NSM)
 - Contaminant Simulation Module (CSM)
- **Riverine Contaminant Model Development**
 - HEC-RAS (River Analysis System)
- **Source Zone Loading Estimation**
 - ATTIC (Advanced Tool for Tracking Industrial Chemicals)
- **Demonstration Site**
 - Calleguas Creek Watershed



EQT - Surface Water Quality Characterization in Remote Sparse Data Environments

Objective

The objective of this work is to develop a landscape contaminant modeling system capable of modeling the fate and transport of constituent parent and daughter products (chemicals and metals) over large spatial and temporal scales in a computationally efficient manner.

Benefits

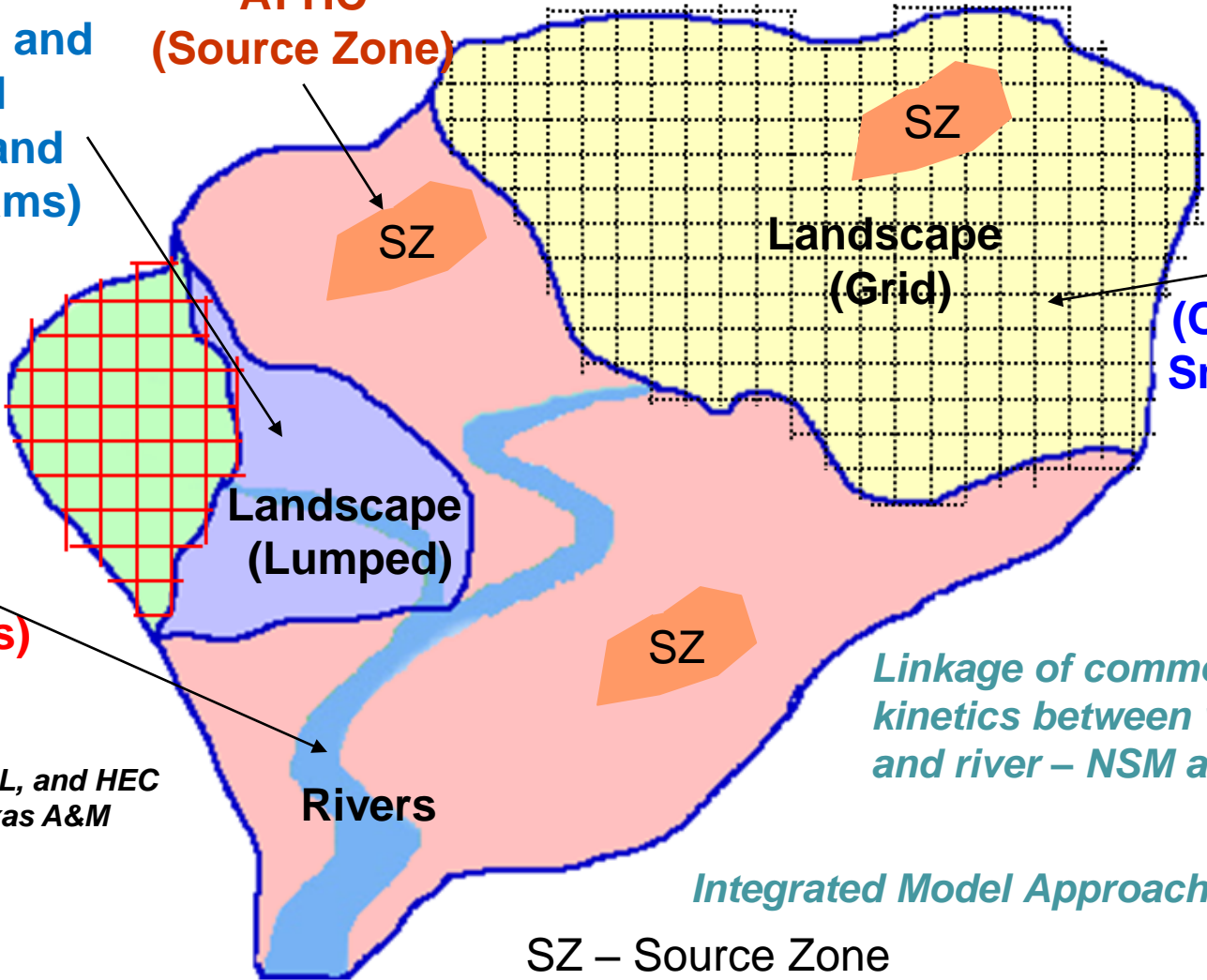
Model results will be used to characterize the water quality condition of streams and rivers based upon the intended use of the withdrawn water in addition to tracking the movement of contaminants across diverse landscapes.



Landscape Contaminant Modeling

SWAT – Grid and Lumped (Overland and Small Streams)

ATTIC (Source Zone)



GSSHA (Overland and Small Streams)

HEC-RAS (Large Rivers)

Landscape (Lumped)

Landscape (Grid)

Rivers

Linkage of common WQ kinetics between watershed and river – NSM and CSM

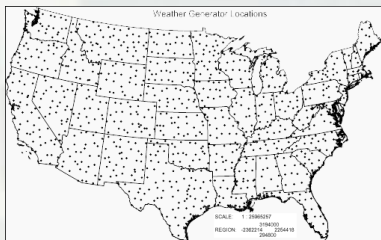
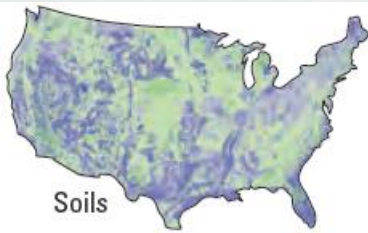
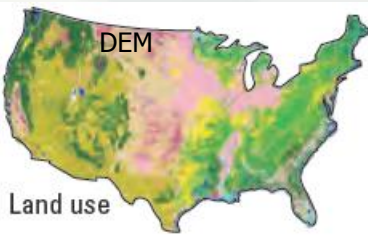
USACE – EL, CHL, and HEC
USDA-ARS / Texas A&M
ENSCO Inc.

Integrated Model Approach

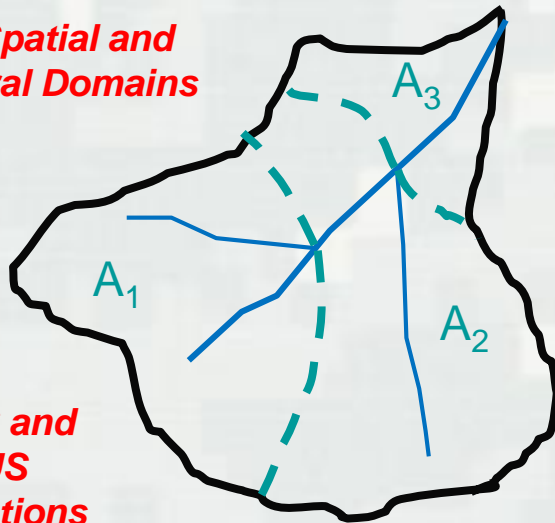
SZ – Source Zone



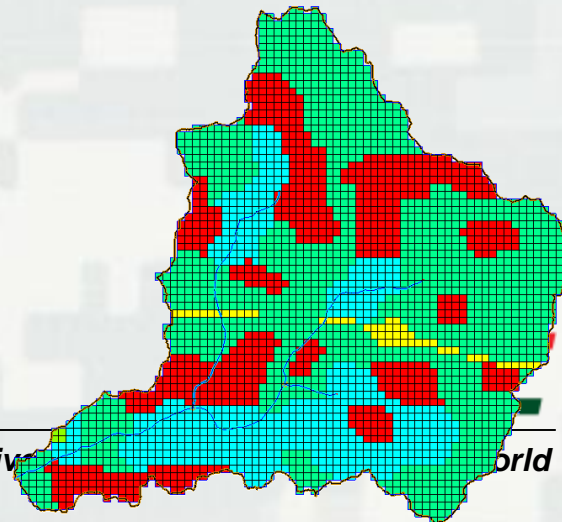
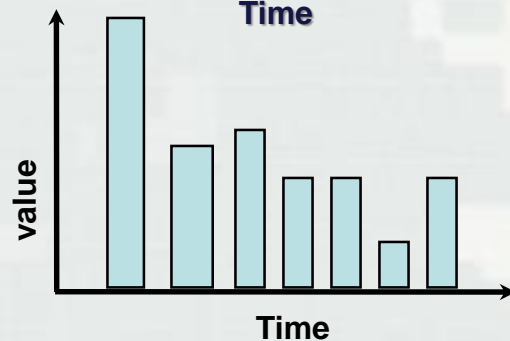
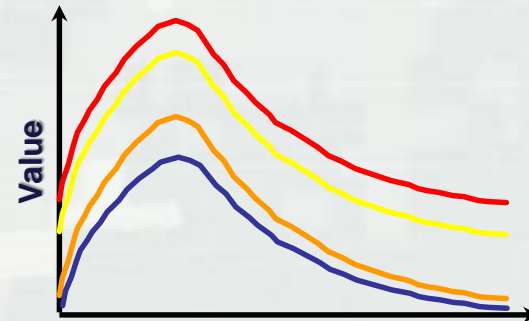
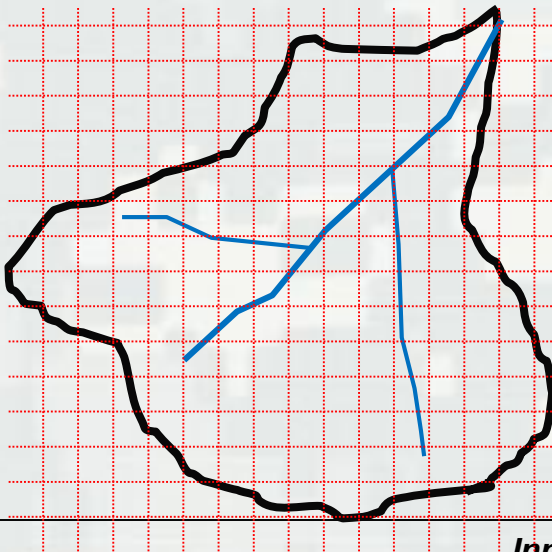
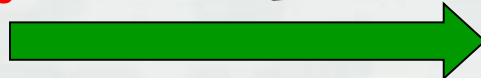
Large Basin (Landscape) Hydrology



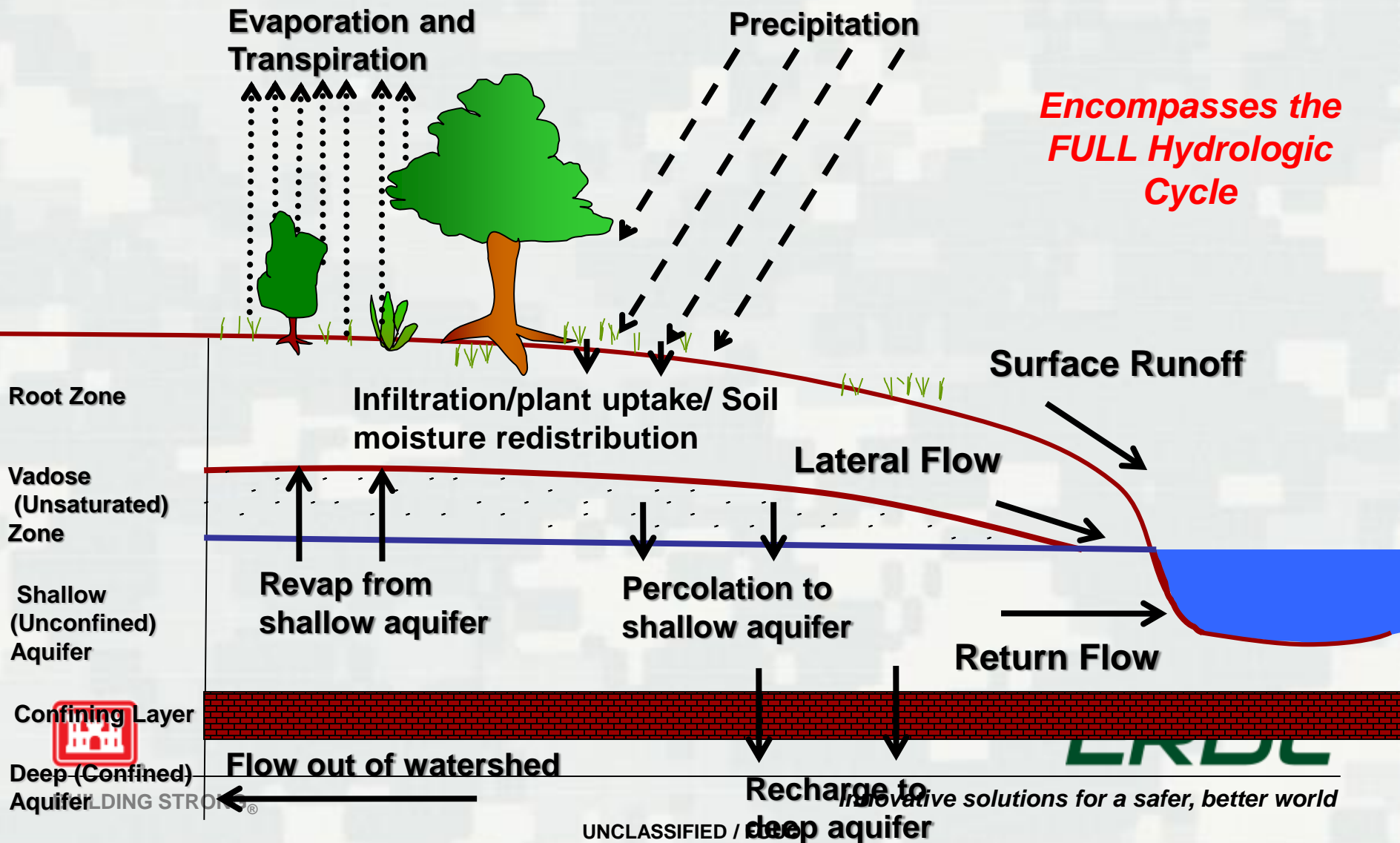
Large Spatial and Temporal Domains



CONUS and OCONUS Applications

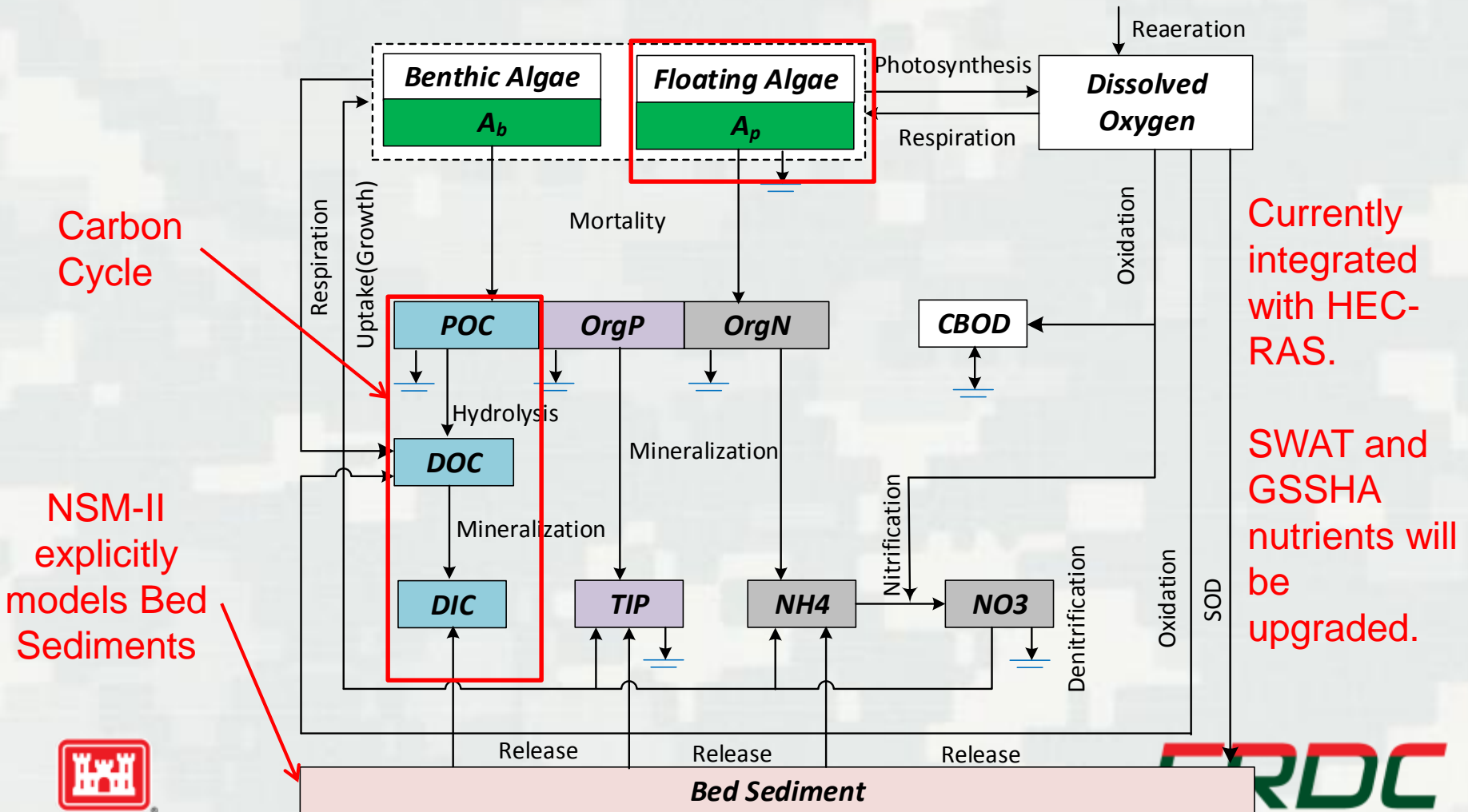


Hydrologic Processes

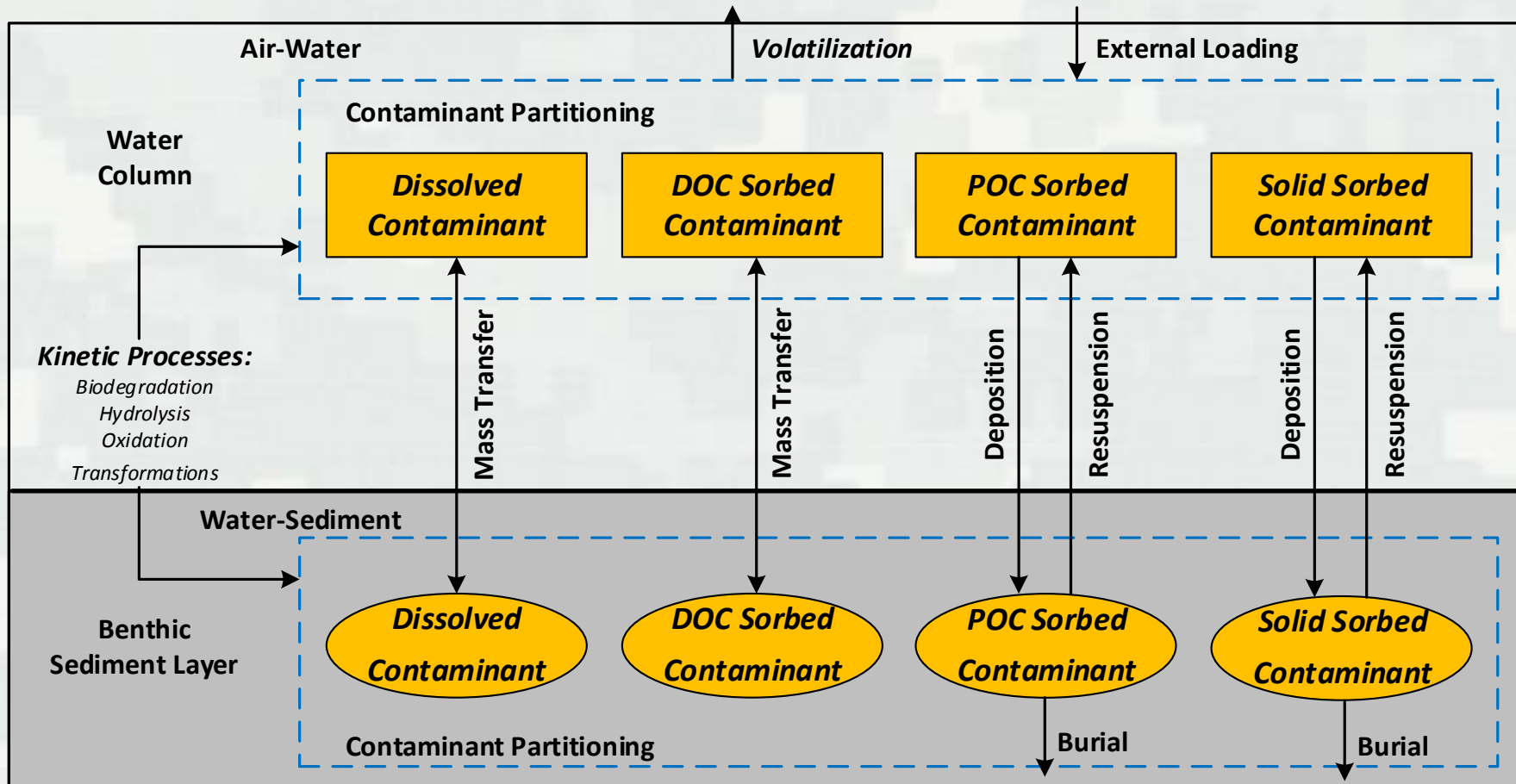


Nutrient Simulation Module (NSM-I)

Provides necessary information for the Contaminant Simulation Module



Contaminant Simulation Module (CSM)



Work currently underway to integrate with HEC-RAS, SWAT, and GSSHA



Contaminant Simulation Module (CSM)

- Multi-media physical transport processes
 - ▶ Water column
 - ▶ Bed sediments
- Multiple (4) phase partitioning of contaminants
 - ▶ Dissolved in water, Sorbed to Organic Carbon (DOC, POC), Sorbed to sediment particles
- Six (6) biochemical transformation processes
 - ▶ Ionization
 - ▶ First order biodegradation
 - ▶ Hydrolysis
 - ▶ Photolysis (Photodegradation)
 - ▶ Volatilization
 - ▶ Reaction and Transformations



Other Processes and Factors

- Sediment settling and resuspension
- Sediment-water transfer
- Air deposition
- Environmental factors
 - ▶ Water temperature
 - ▶ Inorganic sediments
 - ▶ Organic carbon (DOC, POC)
 - ▶ pH
 - ▶ Light attenuation



Riverine Hydraulics

Base Model - HEC-RAS (River Analysis Systems)

- One-Dimensional (1D) hydraulics program
- Computes river velocities, stages, profiles, and inundated areas (with GeoRAS) given streamflow and geometry
- Steady, Unsteady Flow, and Quasi-Unsteady (for Sediment analysis)
- HEC-RAS simulates sediment transport/movable beds resulting from scour and deposition
- Graphical User Interface
- Data storage/management
- Graphics, Tabular Output & Reporting
- GeoRAS – GIS pre and postprocessor
- Nationally accepted by state and local agencies, academia and Federal agencies.



Riverine Hydraulics

- Steady flow
- Unsteady flow

Energy (momentum) Equation:

$$\frac{\partial(\alpha Q^2/A)}{\partial x} + gA\left(\frac{\partial h}{\partial x} - S_o + S_f\right) = 0$$

Continuity Equation:

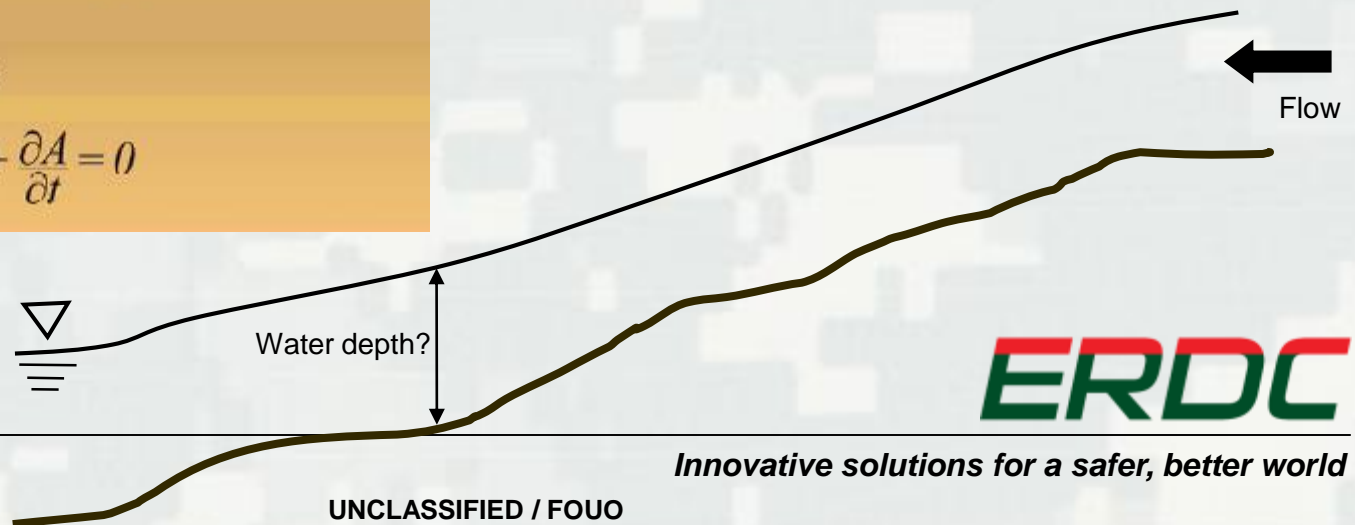
$$Q = VA$$

Momentum Equation:

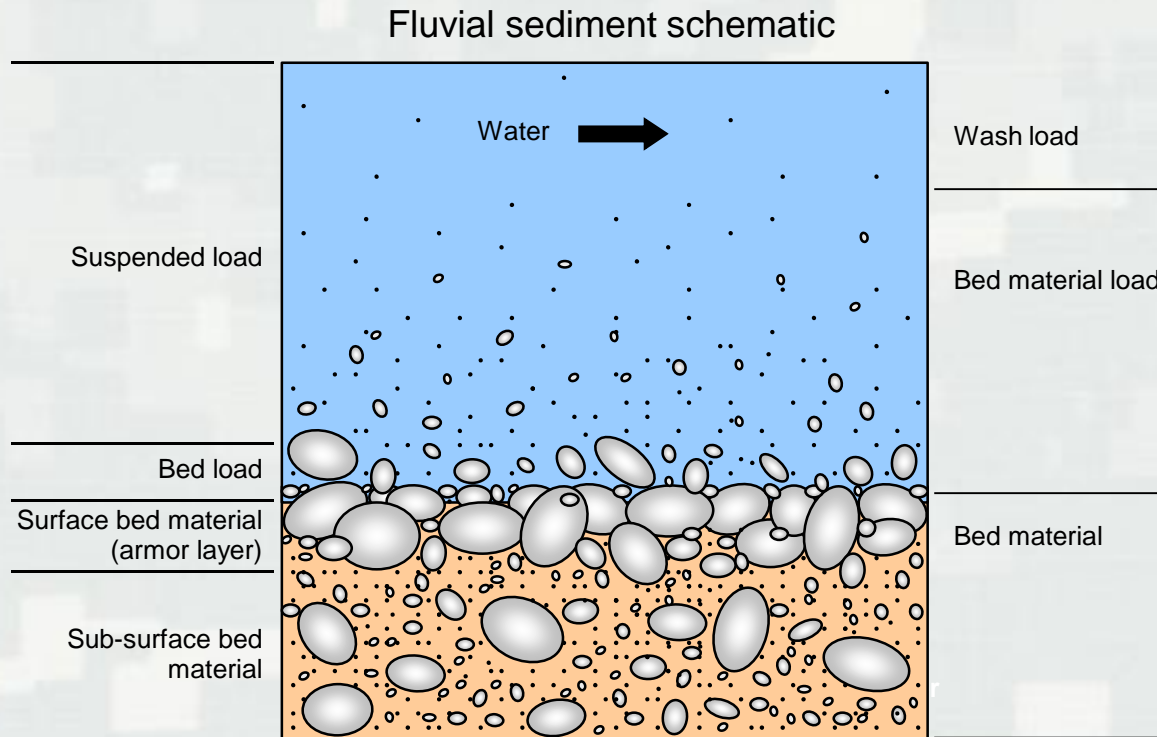
$$\frac{\partial Q}{\partial t} + \frac{\partial(\alpha Q^2/A)}{\partial x} + gA\left(\frac{\partial h}{\partial x} - S_o + S_f\right) = 0$$

Continuity Equation:

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0$$



Riverine Sediment Transport



Suspended load – sand, silt & clay

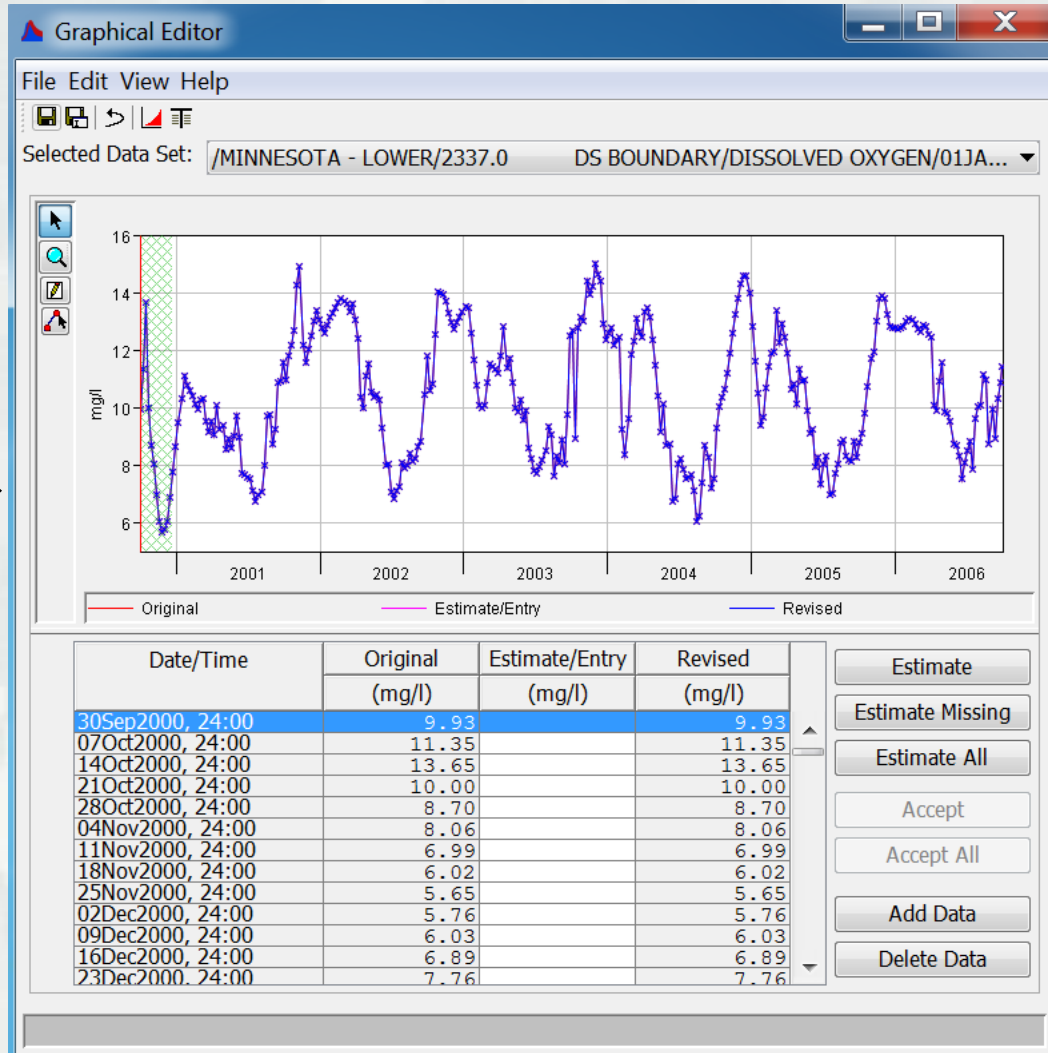
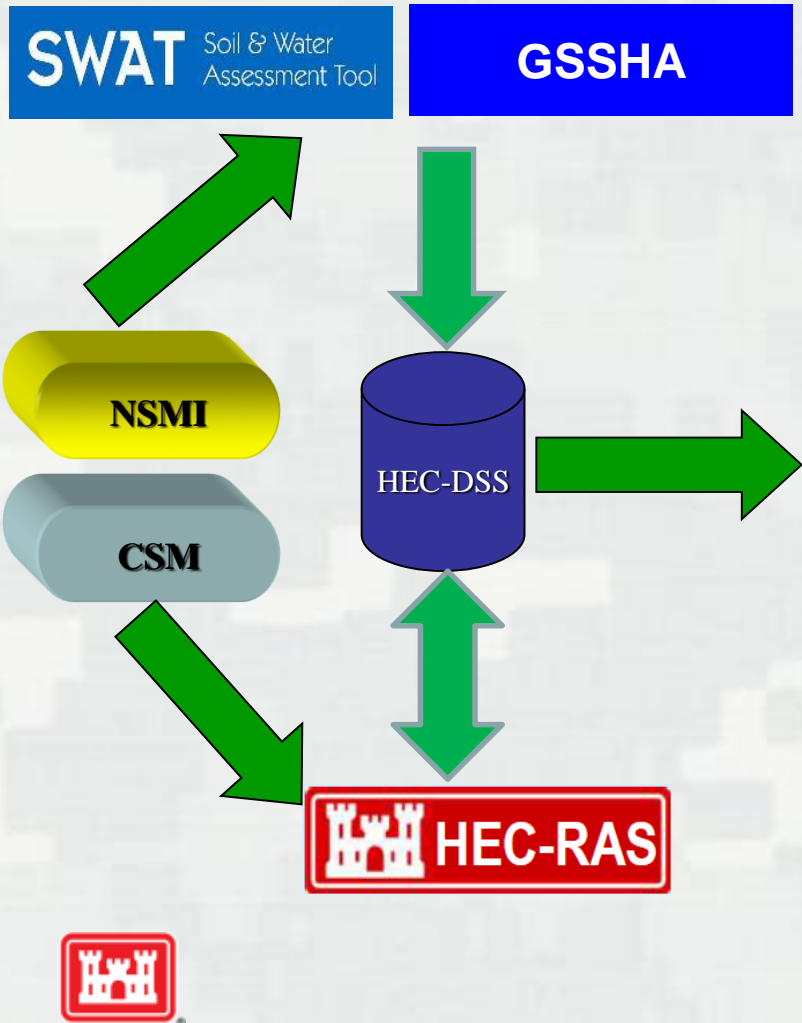
Bed load – sand, gravel, cobbles & boulders

Wash load – silt & clay

Bed material load – sand, gravel, cobbles & boulders



Landscape Contaminant Modeling System



Advanced Tool for Tracking Industrial Chemicals

- ATTIC is a semi-structured data mining and semantic processing tool that has been custom designed for navigation of chemical and industry data.
- The software framework provides users with unique graphical user interfaces (GUI) focused on each data type.
- Users may use keyword querying, meta data filters, and geographical screening to locate the data of interest.
- Designed by subject matter experts (SME) to assist and retain manual SME reviews, for eventual use in non-SME evaluations.



Used to help estimate Source Zone Loadings!

ERDC

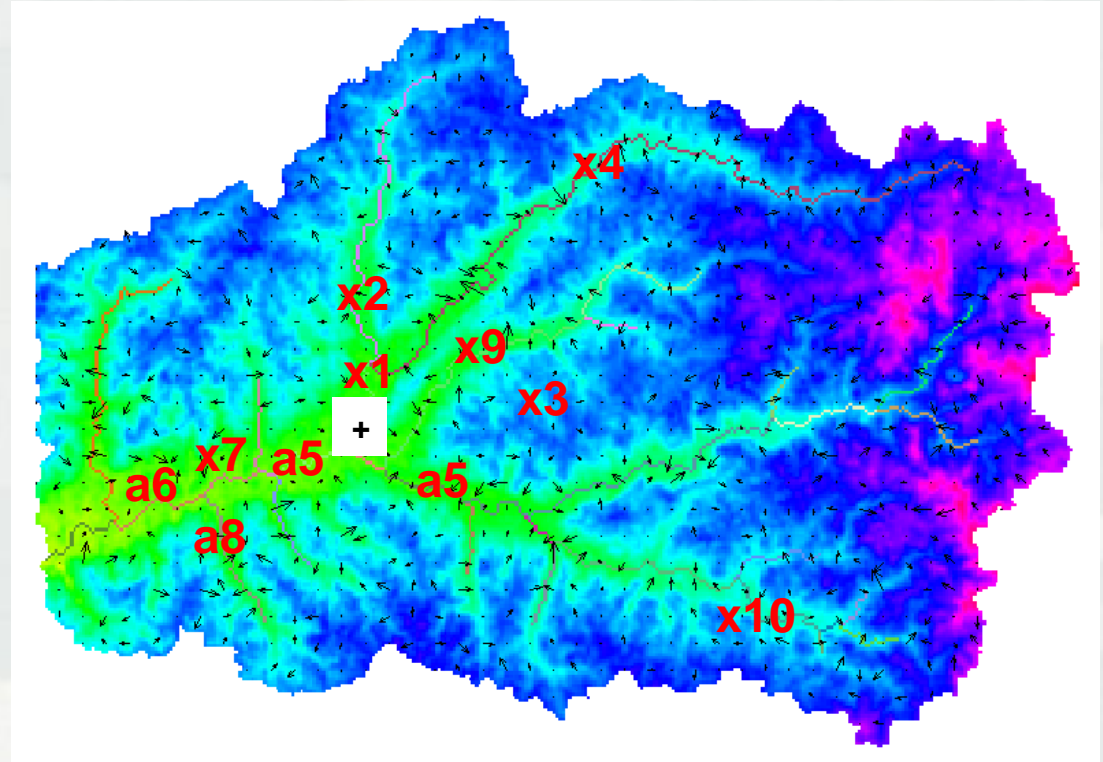
ATTIC Purpose and Uses

- Assists identification of commercial activities and products associated with specific chemicals of interest (COIs)
- Allows user to locate chemical, industrial, and medical facilities with activities or products associated with specific COIs within a target geographic region of interest (ROI)
- Contains data that allows user to manually evaluate facilities for the likelihood of being a source COI to the environment
- Allow SMEs to enhance data and create reviews for future rapid automated and/or non-SME analyses



Integrate ATTIC with Basin Hydrology

- Ability to choose a basin of interest in ATTIC
- Use GIS flow direction to pre-screen sources
- Filter ATTIC facilities and ag. sources using hydrology to provide source loading at +
- Export max and min source loading estimates to table



a#: agricultural sources

x#: industrial facility sources

+: possible site of interest



ERDC

SME Estimated Basin Loadings

- Based upon facility and agricultural zone evaluations, SMEs develop estimates for basin loadings of various classes of compounds.

Agricultural Zone Loadings			
Zone	Fertilizers (N-P-K) (kg/acre)	Inorganic Pesticides (kg/acre)	Organic Pesticides (kg/acre)
A	100 - 30 - 60	2	12.5
B	200 - 10 - 20	1	20
C	80 - 80 - 80	1	4
D	0 - 0 - 0	0	0
E	40 - 0 - 10	0	5
F	100 - 30 - 60	5	30
G	0 - 0 - 0	3	10
H	200 - 30 - 60	7	15

- Speciation of most toxic chemicals of interest may be given higher scrutiny and more detailed estimates.

Industrial Facilities Loadings			
Company	Organics (kg/day)	Inorganic Solubles (kg/day)	Insoluble Particulate
Kapital-Prok-Chernozemye	10-100	0-1	1-10
Buskoye_pole	1-10	0-1	0-1
Nils-Povolzhye	1-10	1-10	1-10
Reyting_Plus	0-1	10-100	1-10
Rusinvest	1-10	10-100	1-10
Lovin-Ognezaschita_Firm	100-1000	1-10	10-100
Nauka_i_teknologii	0-1	1-10	0-1
Shelkovo_Agrokhim	100-1000	0-1	10-100
Korpas_Veterinary_Firm	0-1	0-1	0-1
TIL	10-100	1-10	0-1



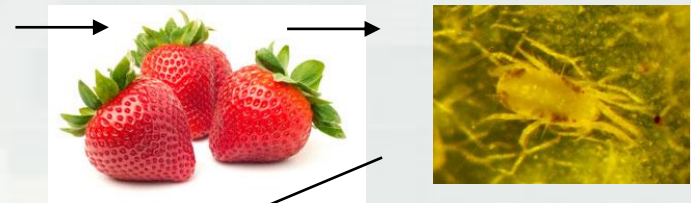
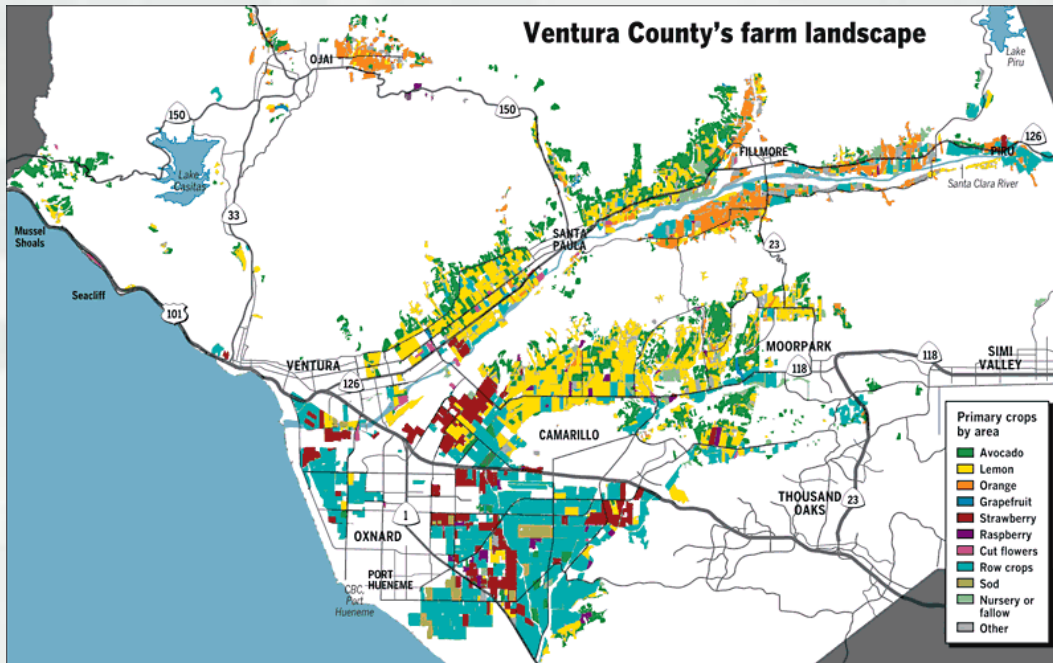
Agricultural Loading Estimation

■ Data

- ▶ Open Source Regional Crop Data
- ▶ Imagery-Driven Crop Identification where Needed/Possible

■ Methodology

- ▶ Crop → Common Pests → Req'd Pesticide → Application Rate
- ▶ Crop → Soil Type → Fertilizer Requirements → Application Rate



Greenhouse-, Shadehouse-, and Field-Grown Ornamentals, Foliage Plants, Christmas Trees, and other Woody Ornamentals		
Pests	Amount of Abamectin 0.15 EC Fl. oz./100 gallons water	Notes
Mites: European Red Mite Two-spotted Spider Mite Carmine Spider Mite Southern Red Mite Spruce Spider Mite Tarsonemid Mites: Cyclamen & Broad Mites Eriophyid Mites: Rust and Bud Mites	4*	For tarsonemid mites, multiple applications to newly developing tissue may be needed to maintain effective control.
Boxwood Leafminer	8	To control mining larvae, apply when adults begin to lay eggs on to new foliage.
Liriomyza Leafminers	8*	Repeat at intervals of 7 days or as needed to maintain effective control.
Aphids, Thrips, & Whiteflies	8	Spray must contact young immatures.

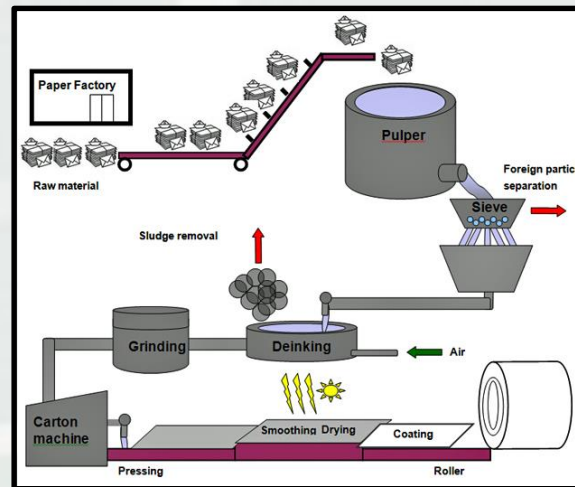
Industrial Loading Estimation

▪ Data

- ▶ Commercial Web Data
- ▶ External Database and/or Product/Industry Code Data

▪ Methodology

- ▶ Industry/Material/Product → Industrial Process → Chemicals
- ▶ Chemical x Scale Factor x Containment Factor → Effluent/Emissions/Discharge



NICB uses 100% recycled fiber. The mill receives over 100 truckloads of Old Corrugated Containers a day. Material is reduced to a slurry and re-formed to create new brown paper. We have our own wastewater treatment plant to clean and recycle wastewater.

Pulper

- Water
- NaOH
- Sulfates, Sulfides, Sulfites

De-inking

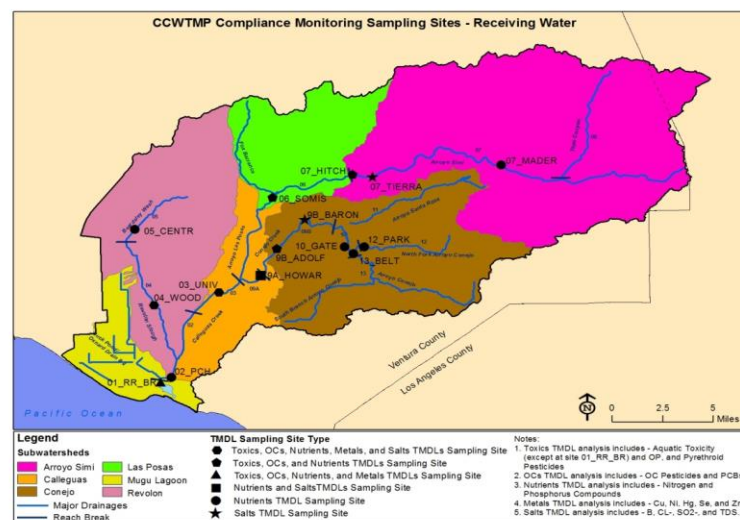
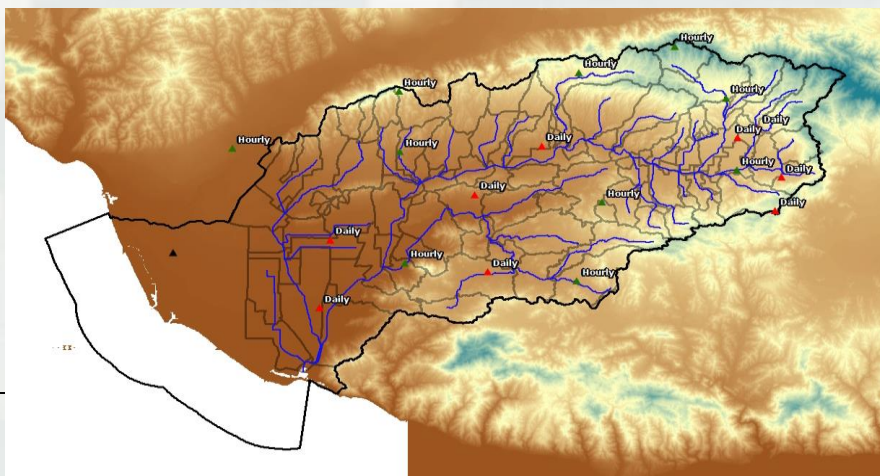
- Fatty acid soaps
- Polyethyleneoxide alkyl ethers

Innovativ

Demonstration Site

Calleguas Creek Watershed, Ventura County, California

- Drainage Area is 343 mi² (888.4 km²)
- 20 flow gages
- 20 precipitation gages (daily and hourly)
- For multiple sites, datasets (flow, sediment concentration, nutrient concentration, and contaminant concentration) spanning 20+ years (1993 to present) is available at disparate locations.
- Ranges from steep to mild slopes, urban (civil and military) to agriculture, and main stem river connects to the ocean.
- Data is being gathered and models are being set up to start flow and sediment calibration.
- Contaminant calibration will be done in Fiscal Year 2016.



Questions???



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