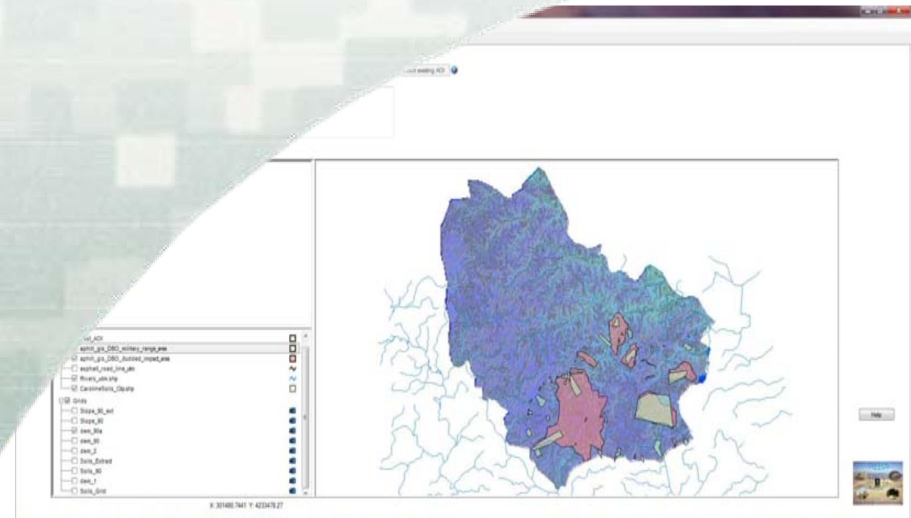
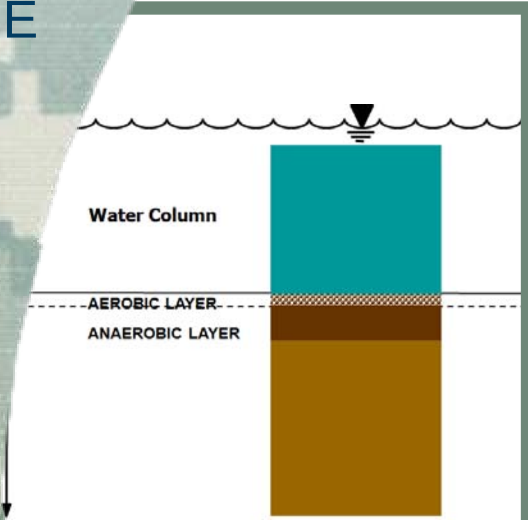
Training Range Environmental Evaluation and Characterization System (TREECS™)

Engineer Research and Development Center

Federal Remediation Technologies Roundtable (FRTR) meeting

November 14, 2013





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Discussion Items

- Training Range Environmental Evaluation and Characterization System (TREECS™)
- Case Studies

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TREECS™ Background

- *Problem*: Military firing/training ranges contain munitions constituents (MC) residue, including metals and explosives, that could migrate to surface water and groundwater off-installation, potentially threatening range sustainability.
- *Need*: An assessment tool is needed to forecast if, when, and at what level MC concentrations in off-range media (groundwater, surface water, and sediment) may exceed protective health benchmarks and to aid in assessment of compliance monitoring and management strategies.

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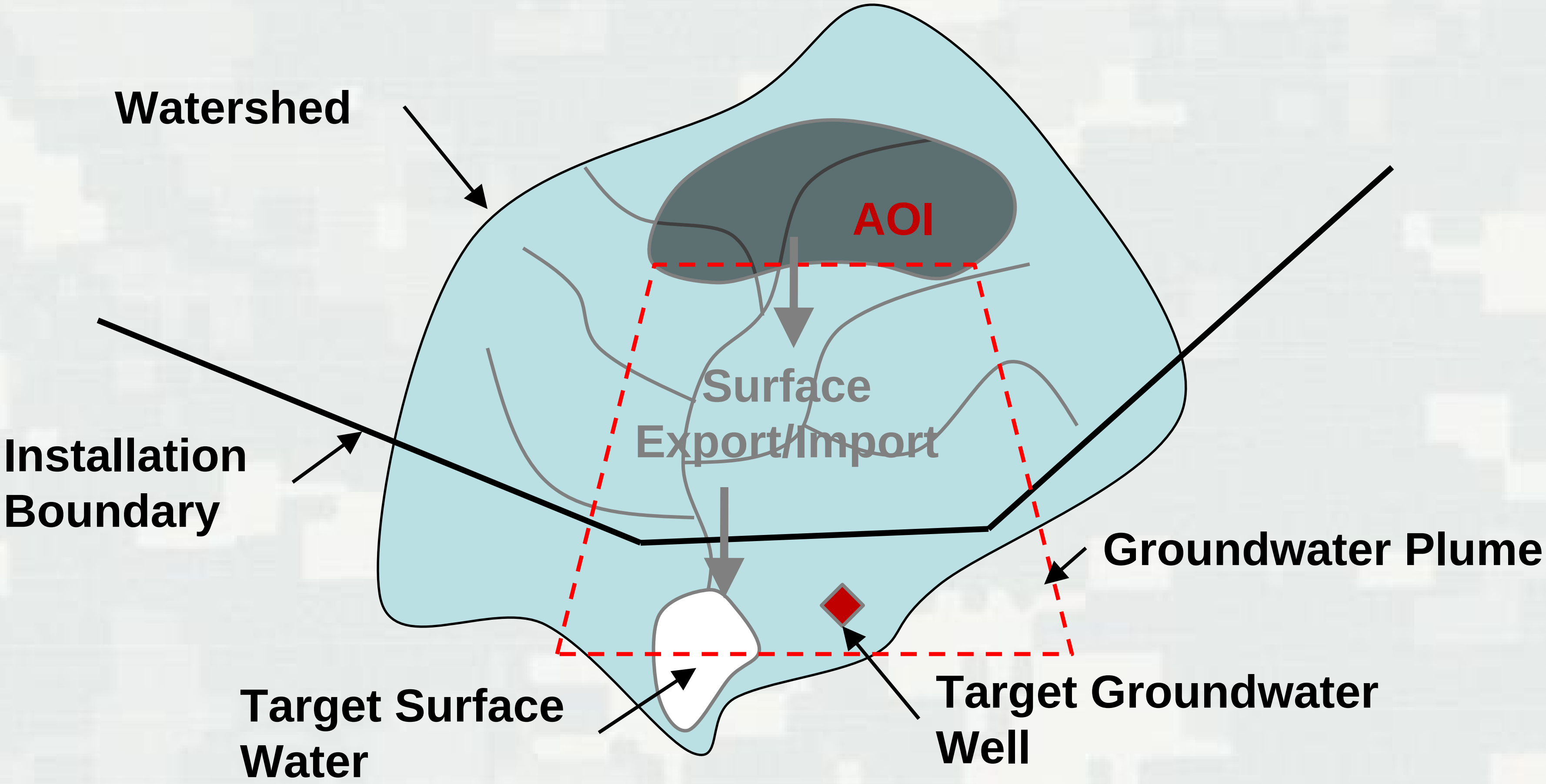
Conceptual Site Model for TREECS™ Plan View



TREECS™ Tiered Development

- Tier 1 (screening)
  - Steady-state, worse case, highly conservative
  - Requires little data
  - Can be applied very quickly
  - Indicates whether a problem could ever potentially exist; if so, proceed to Tier 2
- Tier 2 (more comprehensive)
  - Time-varying, much more realistic and accurate
  - Requires more data
  - Requires more time to set up and apply, but still can be done relatively quickly
  - Can be used to determine when benchmark exceedence may occur
  - Useful for evaluating range management strategies

Tiers 1 and 2 use models of reduced form.

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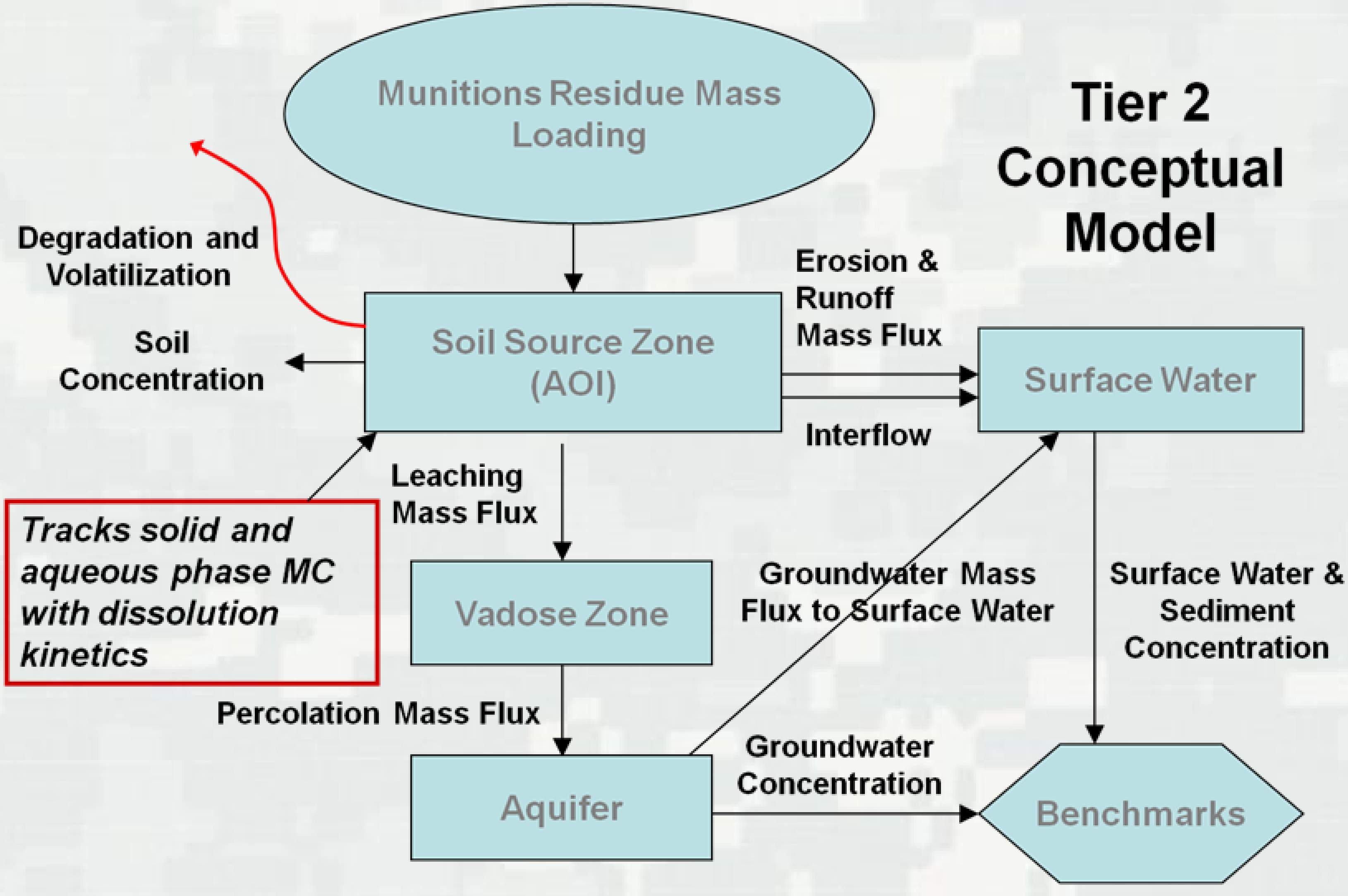
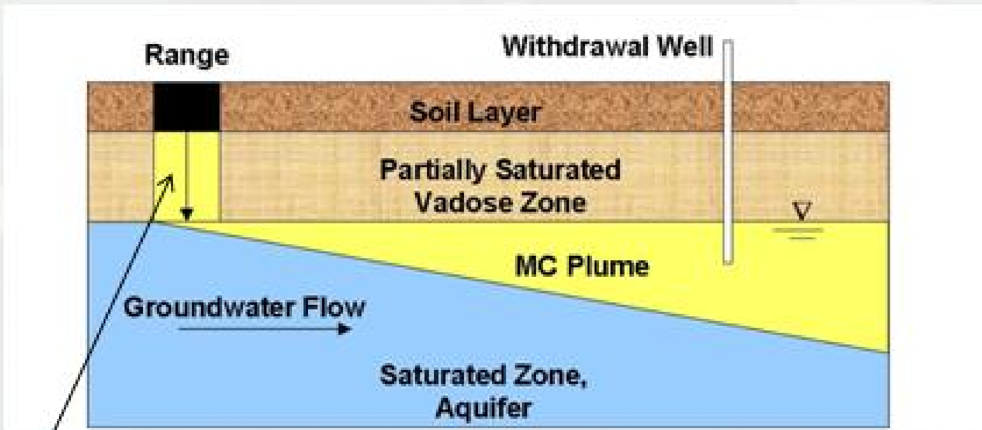
Tier 2 Conceptual Model



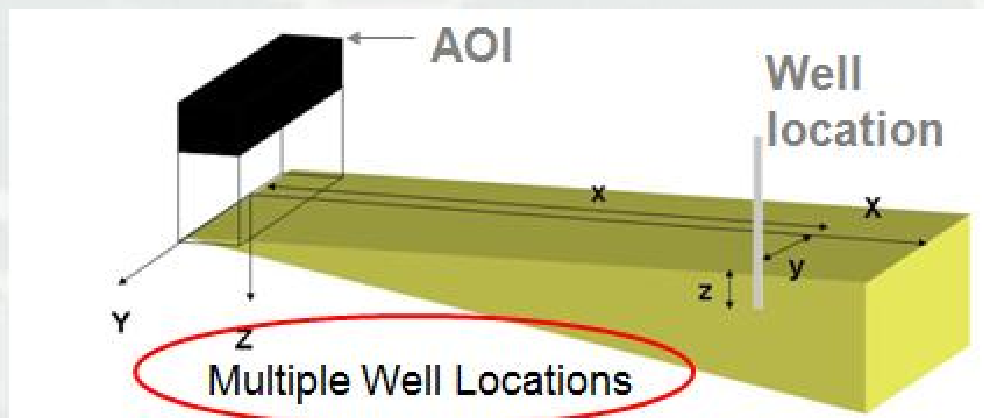
MEPAS Vadose & Aquifer Models (Tier 2)



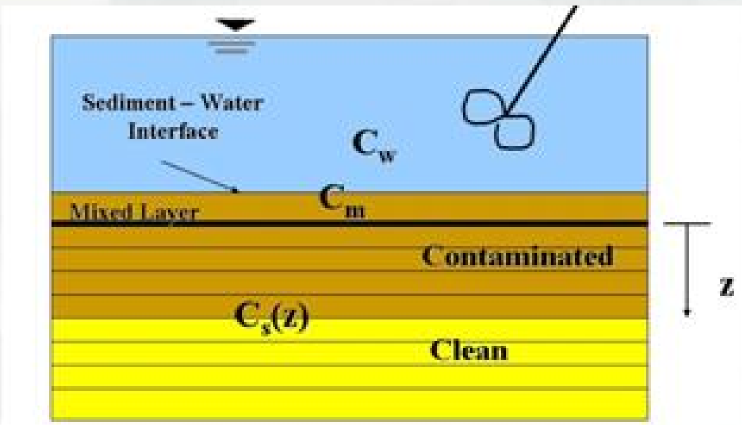
AOI length and width are input in Soil MUI

Vadose Zone included

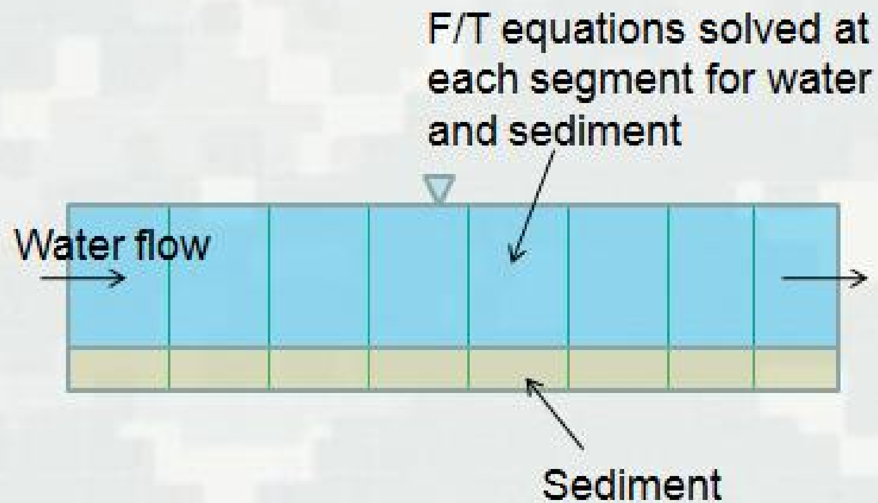
MEPAS coordinates



Surface Water Models, RECOVERY and CMS

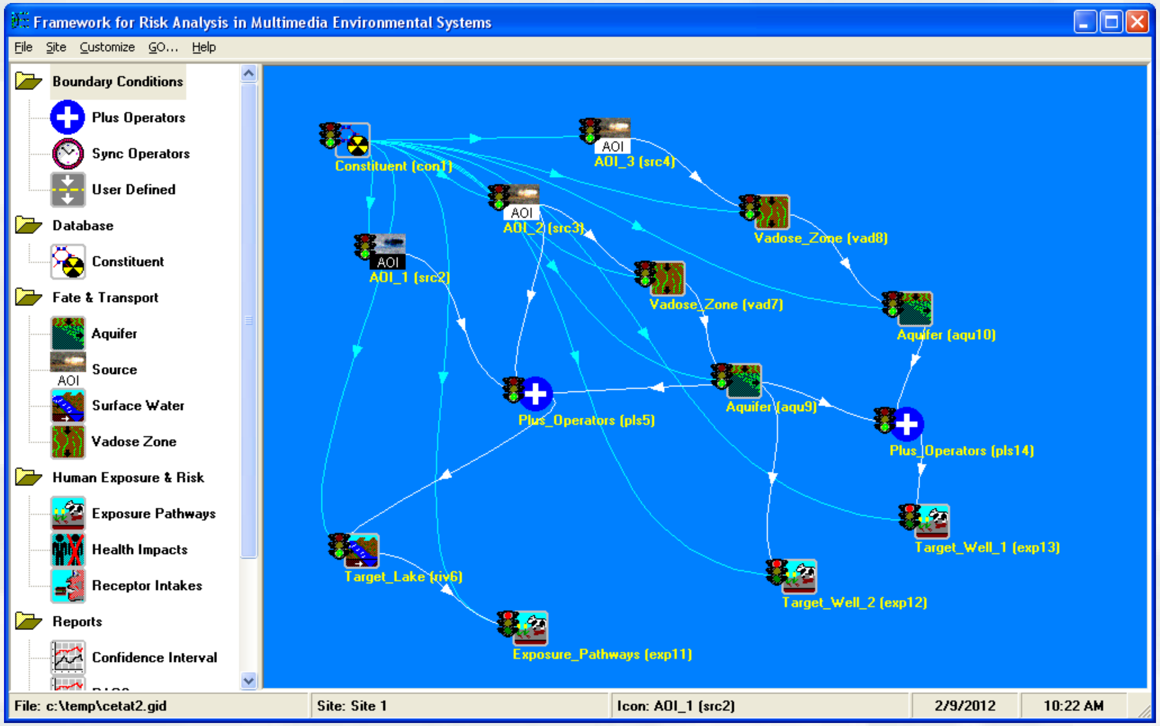


RECOVERY Model conceptualization

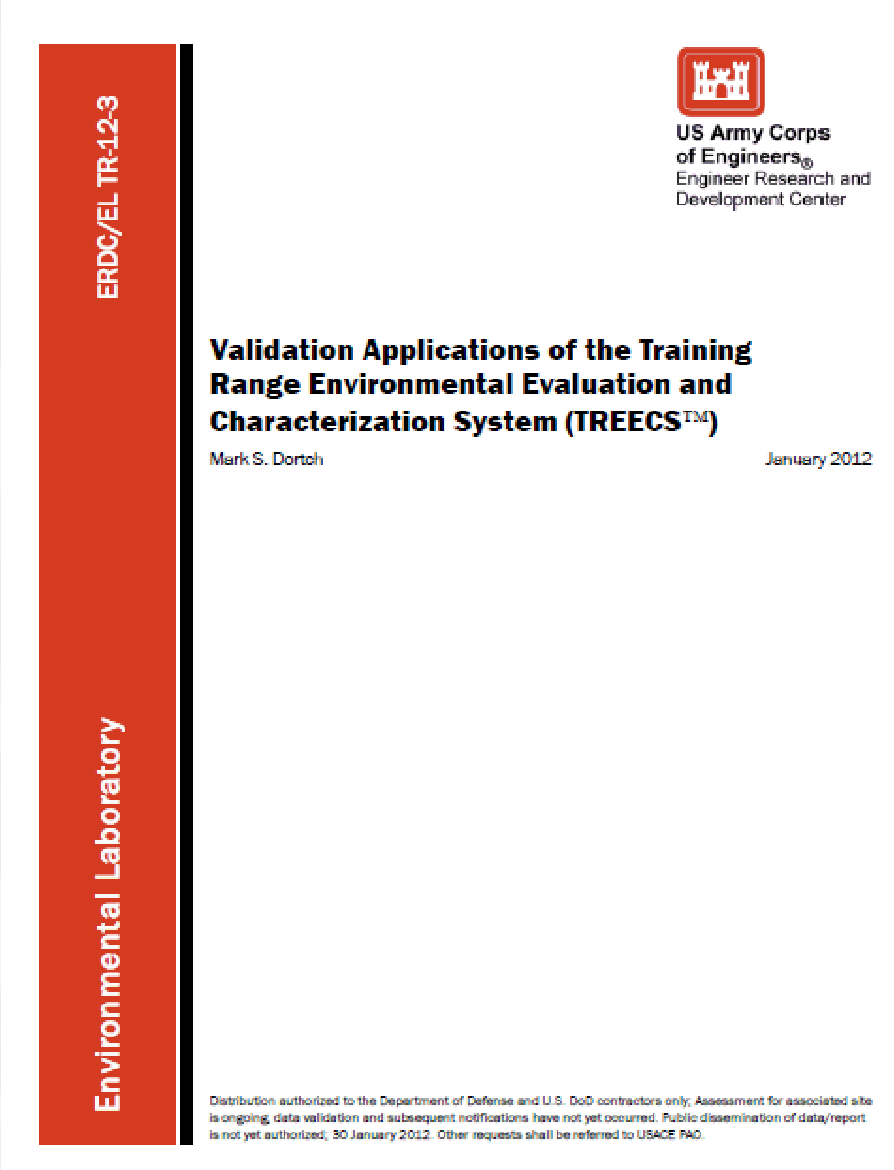


CMS conceptualization

Advanced TREECS™ Tier 2



- Multiple AOIs
- Complex Pathways
- Multiple Receptors


ERDC/EL TR-12-3

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Validation Applications of the Training Range Environmental Evaluation and Characterization System (TREECS™)

Mark S. Dortch

January 2012

Distribution authorized to the Department of Defense and U.S. DoD contractors only; Assessment for associated site is ongoing, data validation and subsequent notifications have not yet occurred. Public dissemination of data/report is not yet authorized; 30 January 2012. Other requests shall be referred to USACE PAO.

MMR: RDX in groundwater

Ft. A.P. Hill: RDX, TNT, perchlorate, lead, copper in surface water and groundwater

West Point (USMA): RDX and lead in surface water

Ft. Jackson: 4 metals in surface water

Military Testing Applications

Installation (No.)	AOI	MC	Target Receiving Water
MMR (1)	Demo area	RDX	Groundwater
Ft. A.P. Hill (2)	HE impact area	RDX, TNT, Pb, Cu, $KClO_4$	Groundwater, lake
USMA (3)	HE impact area SAFRs	RDX PB	Pond
Ft. Jackson (4)	SAFRs	Pb, Cu, Zn, Sb	Pond

Military Testing Results

Inst. No.	MC	Groundwater Concentration, µg/L		Surface Water Concentration, µg/L		Sediment Concentration, mg/kg	
		Computed	Measured	Computed	Measured	Computed	Measured
1	RDX	1.35	0.7 – 1.8	NA	NA	NA	NA
2	RDX	3.6E-4	ND (<0.2)	0.042	ND (<0.2)	3.8E-5	ND (<0.15)
	TNT	2.7E-3	ND (<0.2)	0.29	ND (<0.2)	3.3E-4	ND (<0.15)
	Lead	0.0	ND (<1)	1.05	0.25	3.35	6.0
	Copper	0.0	ND (<8)	0.49	0.32	1.71	2.9
	Perchlorate	1.2E-3	ND (<0.2)	2.3E-4	ND (<0.2)	2.0E-7	NM
3	RDX	NA	NA	0.035	0.023	7.7E-5	ND
	Lead	NA	NA	3.0	ND(<1000)	30.1	30.3
4	Lead	NA	NA	153	ND (<68)	1214	257
	Antimony	NA	NA	1.53	ND(<246)	3	32
	Copper	NA	NA	101	ND(<274)	88	92
	Zinc	NA	NA	31	123	105	95

NA = Not applicable; ND = Not detected; NM = Not measured

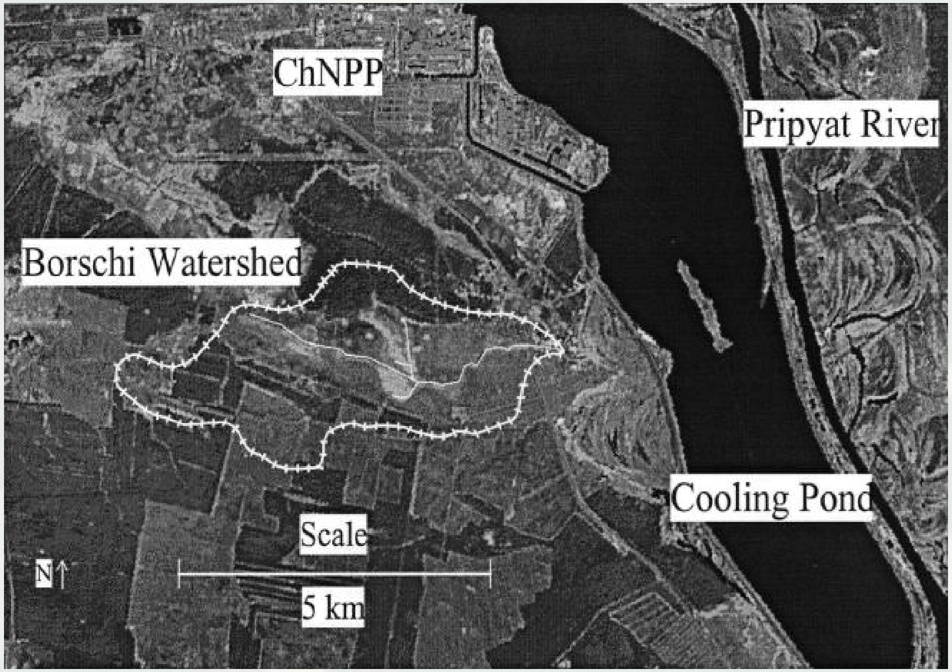
= greatest disagreement; error less than factor of 4 for others

Summary of Military Testing Results

- All model results are within an order of magnitude of measured for all validations
- Model results for HE and perchlorate were more accurate than for metals due to complexities associated with metal solubility and sorption
- Model results for lead at installation 4 did not consider possible trapping in creek leading to pond

Borschi Watershed

- Borschi Watershed (8.5 km^2) is 3 km south of the Chernobyl Power Plant
- Radio-strontium-90 (^{90}Sr) is a fission product resulting from the accident in 1986
- ^{90}Sr poses a health risk due to its high specific radio-activity (143 Ci/g) and relatively long half-life (29 years)
- In the late 1990s, soil and sediment concentrations of ^{90}Sr were surveyed and a total inventory of approximately 1.0E13 Bq was determined for the watershed
- Annual watershed export was estimated to be between 1.27E10 and 1.62E10 Bq for the period between 1999 and 2001.



- Average annual ^{90}Sr at the watershed outlet was estimated to be 1.43E10 Bq or about 0.14% of the estimated inventory.

Special thanks go to Dr. Boris Faybishenko, from Lawrence Berkeley National Laboratory (LBNL) for his assistance in gathering the required data for this demonstration study.

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Borschi Watershed

Measurements of ^{90}Sr irreversibly bound to soil and sediment varied between 0-70%, 10-40%, and 30-90% for Borschi watershed soils, wetland sediments, and channel sediments respectively.

Due to most of the land being abandoned agricultural fields, the soil concentration was reduced by 20% to account for the fraction of non-exchangeable ^{90}Sr thus resulting in a soil concentration of 6.32E-7 mg/kg available for export.

For Solid Phase modeling, weathered ^{90}Sr exists as strontium oxide (SrO), which has a specific gravity of 4.7, solubility of 6900 mg/L, and an initial particle diameter of 1.0 micron. These input parameters were used to compute dissolution. It should be noted that SrO reacts quickly and exothermally with water to form $Sr(OH)_2$ which is highly soluble.

Soil Parameters: Dry Bulk Density (1.49 g/cm3) based on loamy sand, soil moisture content (12%), and porosity (44%).

Average Annual Hydrology: Total precipitation (0.6 m/yr), Rainfall (0.47 m/yr), total runoff(0.097 m/yr), runoff due to rainfall (0.0194 m/yr)

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Borschi Watershed

Sub-surface Flow: Interflow (0.0776 m/yr) and Infiltration (0.097 m/yr)

Average number of days per year that runoff producing rain occurred is 14 days based on period of record from 1999 to 2001.

Soil Erosion: R=150, K=0.04, slope=0.02, L>400 ft, C=0.03, and P=1. SDR was estimated based on drainage area size, Soil Erosion Rate was computed to be 2.5E-6 m/yr.

Water Partitioning Distribution Coefficient (K_d) was measured to be 76 L/kg. Soil pH ranged between 6 and 7 for the watershed.

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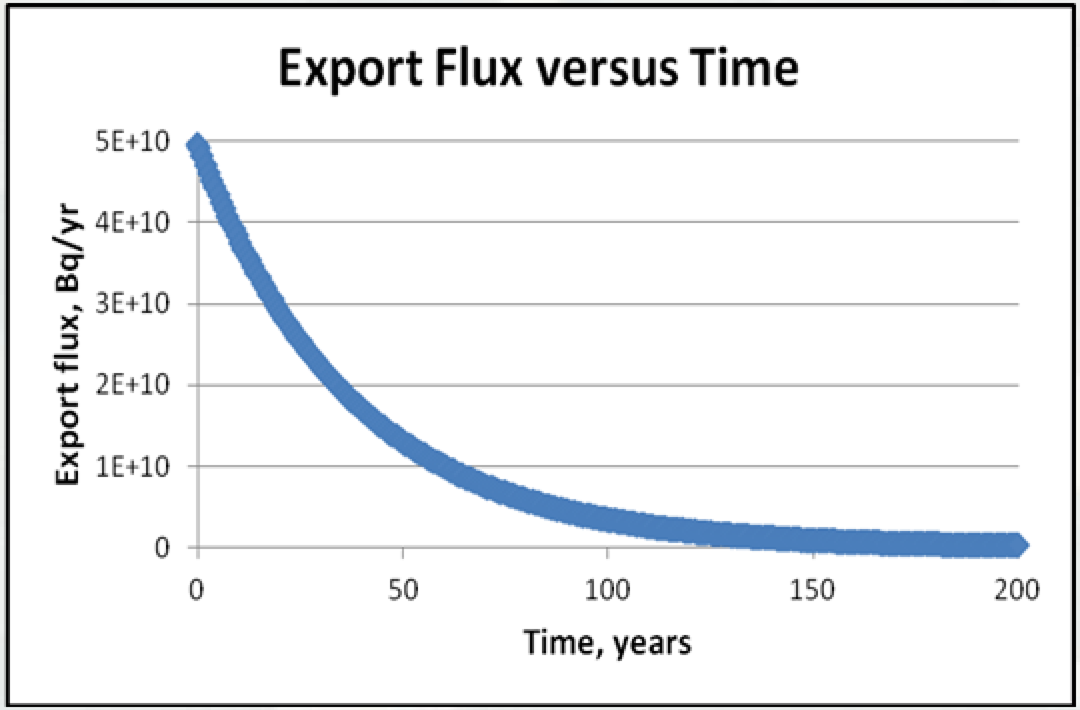
Borschi Watershed

Model Results

The computed ^{90}Sr export flux at time zero (year 2000) is 4.95E10 Bq/yr for the baseline conditions, which is 0.5% of the total inventory.

The measured export was 1.49E10 Bq/yr (0.14% of total inventory).



The ^{90}Sr concentration in the stream at the watershed outlet varied from 6 to 35 Bq/L during 1999 to 2001.

The model computed stream concentration was obtained by dividing the computed export flux of 4.95E10 Bq/yr by the average annual stream flow of 8.5E8 L/yr (computed from the product of 0.1 m/yr of runoff, 8.5 km^2 surface area, and 1E9 $L/m/km^2$), resulting in 58 Bq/L.

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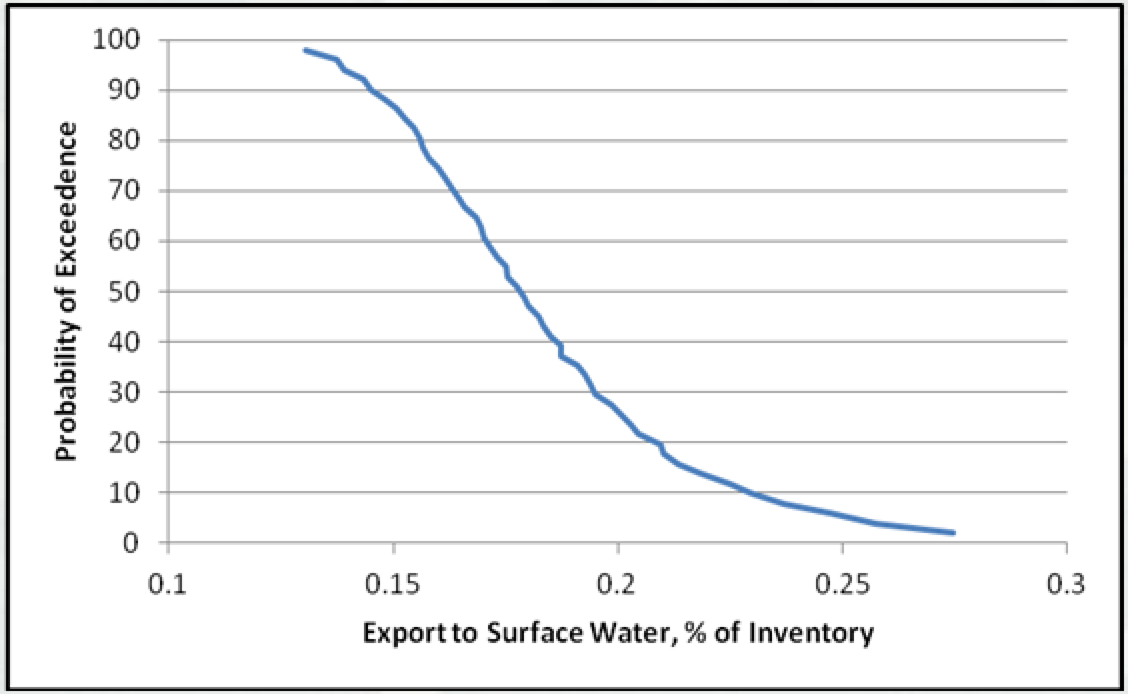
Borschi Watershed

Sensitivity

For high solubility (6900 mg/L) it did not matter if ^{90}Sr was in solid form or dissolved form due to the high rate of dissolution and the small particle size.

A model run was made with a low solubility (100 mg/L) but the high dissolution rate produced identical results as the high solubility run.



Soil erosion and infiltration rates were tested but did not sufficiently change the baseline results thus leaving only K_d as the most sensitive model parameter.

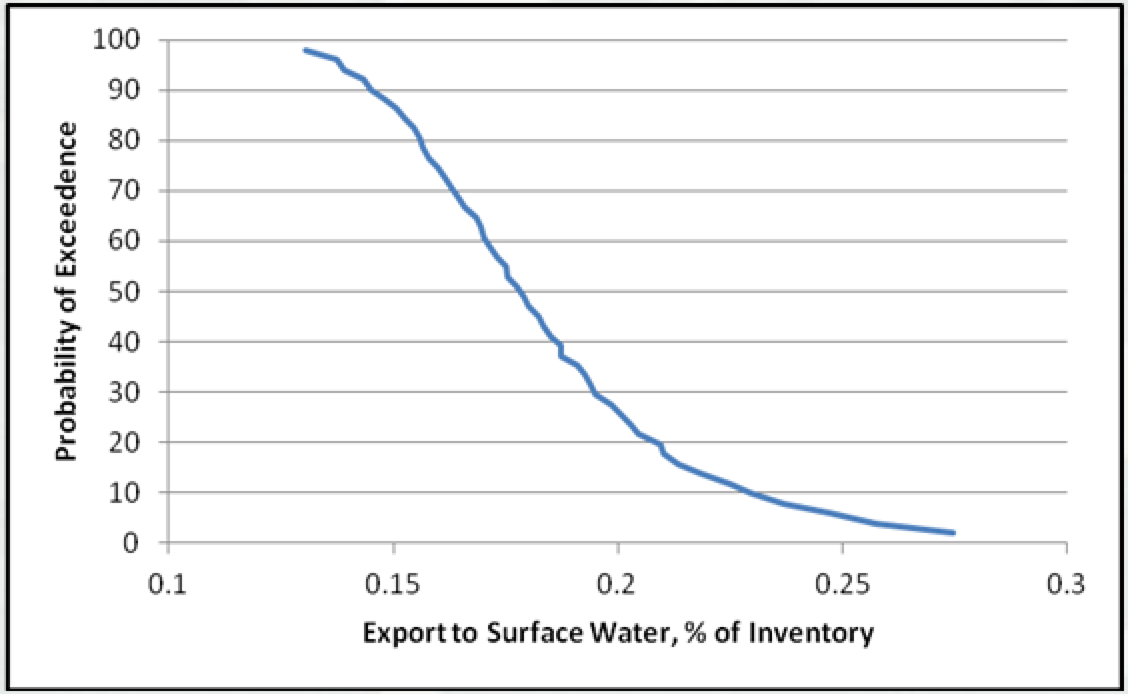
Borschi Watershed

Uncertainty

The S/U feature within TREECS uses Monte Carlo simulation with Latin Hypercube sampling for improved efficiency.

Minimum and maximum K_d was set to 100 and 300 L/kg respectively.

A Normal Distribution was assumed with a mean of 200 L/kg and a Standard Deviation of 33 L/kg. The range in K_d was based on results from an EPA study for a wide range of soils.



The 50% exceedence probability for export as a percent of inventory in year 2000 is show to be 0.18% with a range based on uncertainty to be 0.13 to 0.27%. The estimated export based on field measurements was found to be 0.14%.

Benefits of using TREECS™

- Allows the user to project future conditions
  - Answers the question of whether there will be a problem in the future
- Can be used to develop and assess mitigation scenarios
- Can be used to help optimize and prioritize data collection sites for future assessment activities

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