Las Tablas Creek Watershed Assessment

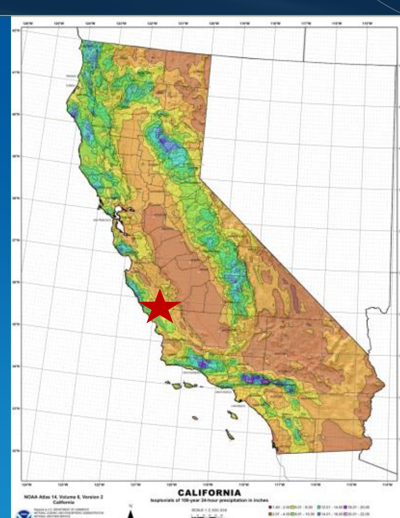
Eric Blischke, Stephen Dent, Moosub Eom and Andy Greazel, CDM Smith; Jim Sickles and John Hillenbrand, USEPA

Eric Blischke
Contaminated Sediments Specialist
CDM Smith/USA

September 23, 2015

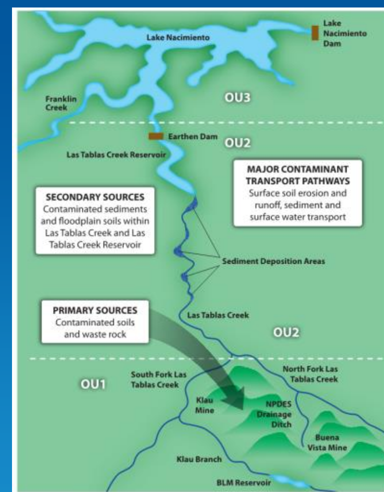
Overview

- Site is located within the Central Coast Range of California
- The watershed is contaminated with mercury due to historical mining activities
- State of California established mercury loading goals due to fish contamination
- Removal activities were completed by EPA between 2002 and 2010
- Watershed based evaluation of contaminant loading, sediment transport and mercury uptake is necessary to develop remedial solutions for the site



Conceptual Site Model

- Mercury mining and processing activities resulted in mercury contamination throughout the watershed
- Contaminant transport is dominated by particulate transport during winter precipitation events
- Mercury is methylated in reservoir sediments and accumulates in fish tissue at levels that pose a risk to human health
- Las Tablas Creek watershed represents a source of mercury contamination to Lake Nacimiento



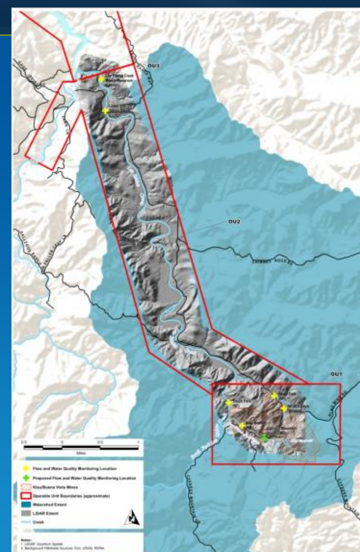
September 23, 2015

Watershed Characterization Approach

- Stream flow and water quality monitoring was conducted to develop contaminant loading estimates
  - Precipitation event and base flow monitoring
- Physical characterization to support sediment erosion and deposition analysis
  - Mercury Fractionation Study
  - Sediment traps and time series bathymetry
  - Sediment erodibility study
- Mercury methylation study
  - Sediment oxygen demand
  - Methylmercury production
  - Bioaccumulation potential
- Steam flow and sediment transport modeling

September 23, 2015

Water Quality and Stream Flow Monitoring Locations

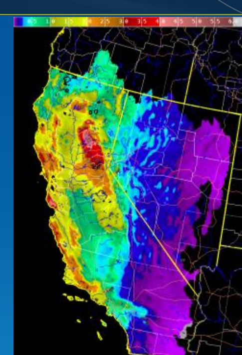


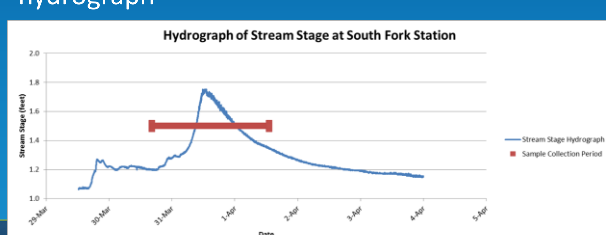
September 23, 2015

CDM Smith

Water Quality and Stream Flow Monitoring Approach

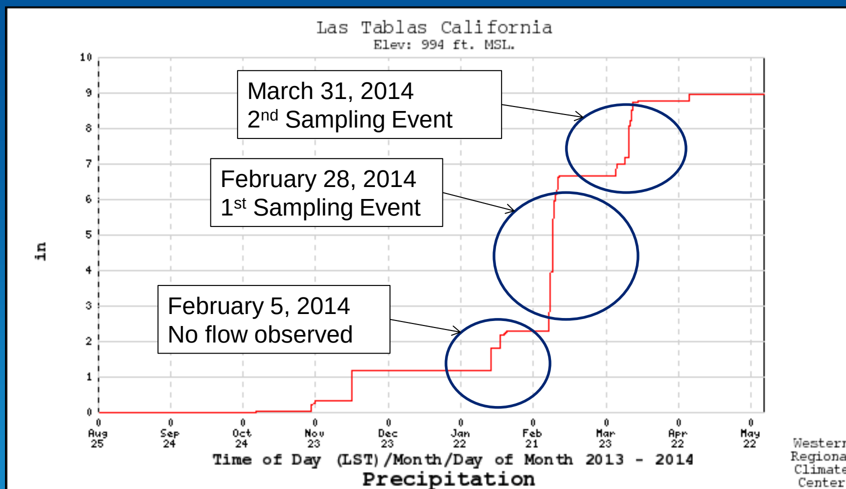
- Criteria: ½ inch of precipitation within 24 hours
  - Rainfall predictions from CNRFC
- 2013/2014
  - 2 wet weather and 1 base flow sampling events
- 2014/2015
  - 5 wet weather and 1 base flow sampling events
- Automated samplers allow sampling over the storm hydrograph





CDM Smith

Year 1 Sampling Events

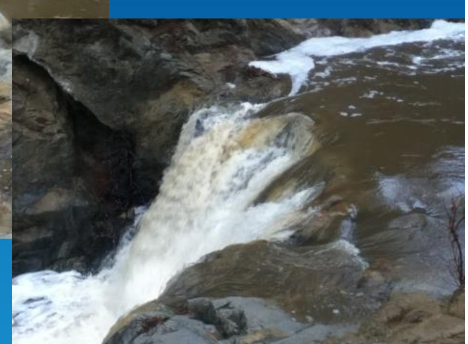


September 23, 2015

February 2014 Spillway Overflow

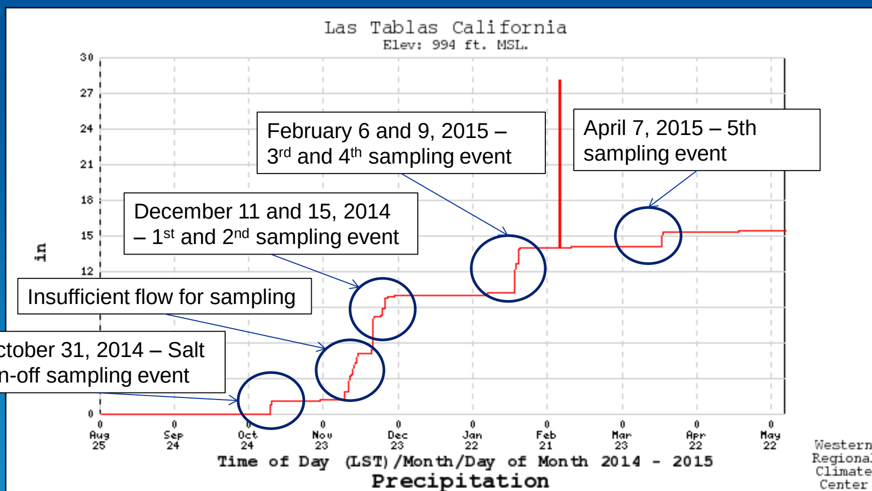
17:35

17:37



18:19

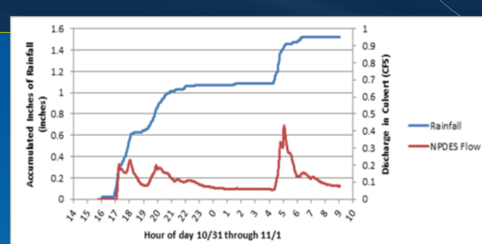
Year 2 Sampling Events

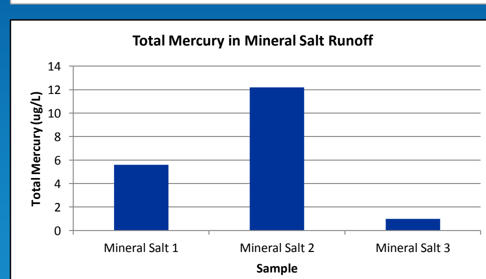


September 23, 2015

CDM Smith

Year 2 Mineral Salt Sampling

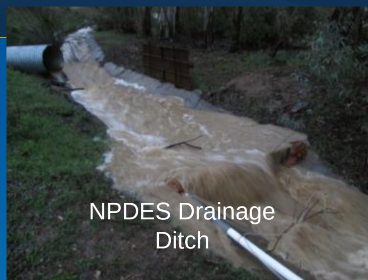


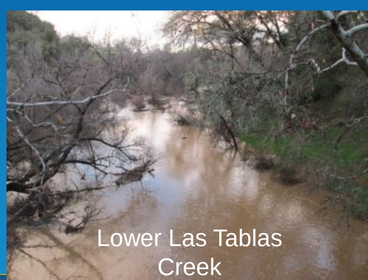


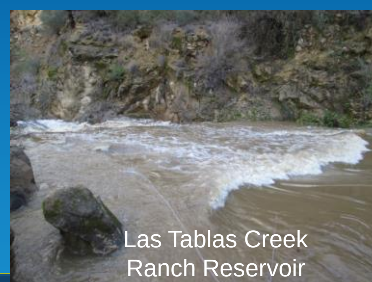
September 23, 2015

CDM Smith

February 2015 High Flow Conditions



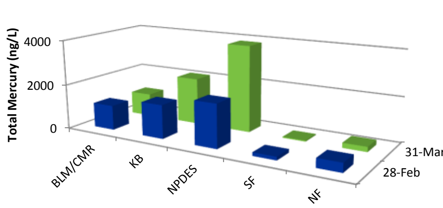




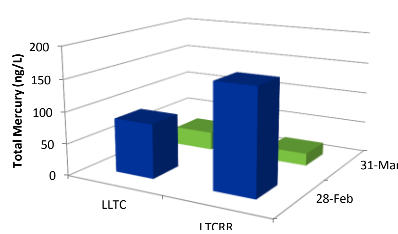
September 23, 2015

Year 1 and Year 2 Total Mercury Results

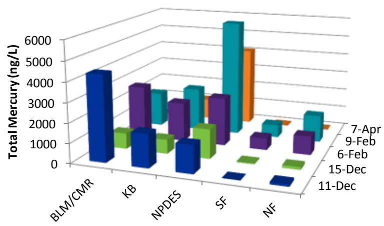
Year 1 Total Mercury - Upper Stations



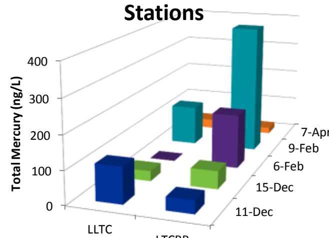
Year 1 Total Mercury - Lower Stations



Year 2 Total Mercury - Upper Stations

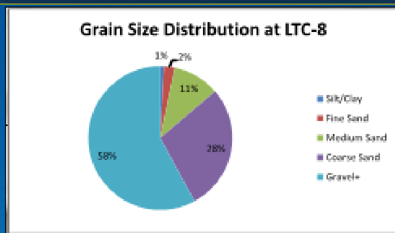


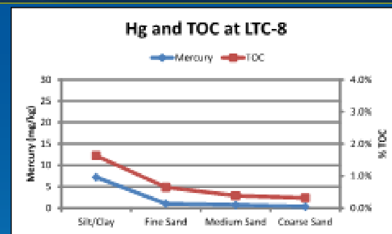
Year 2 Total Mercury - Lower Stations



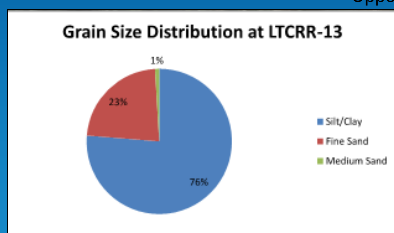
September 23, 2015

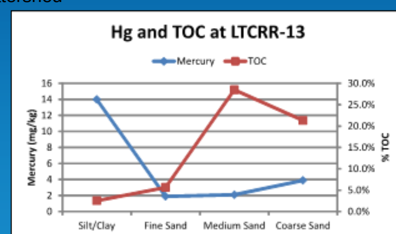
Mercury Fractionation Study





Upper Watershed





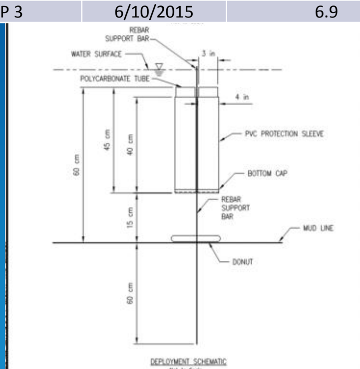
Las Tablas Creek Ranch Reservoir

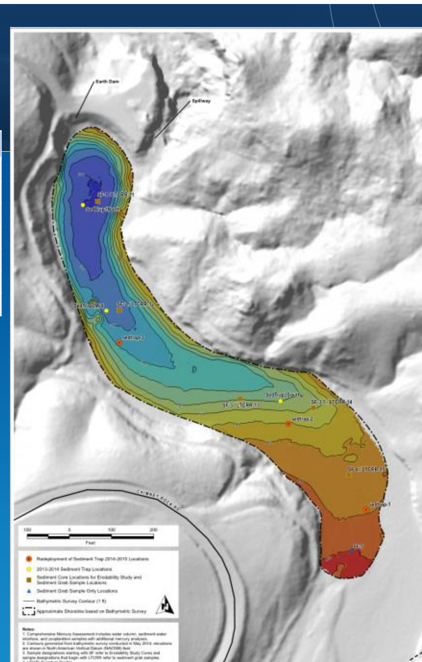
September 23, 2015

CDM Smith

Site Bathymetry and Sediment Trap Results

Location	Date	Total Mercury (mg/kg)
SEDTRAP 1	5/13/2014	5.9
SEDTRAP 2	5/13/2014	7.1
SEDTRAP 3	5/13/2014	14
SEDTRAP 1	6/4/2015	5.6
SEDTRAP 2	6/4/2015	6.3
SEDTRAP 4	6/4/2015	6.1
SEDTRAP 3	6/10/2015	6.9





September 23, 2015

CDM Smith

Sediment Erodibility Study

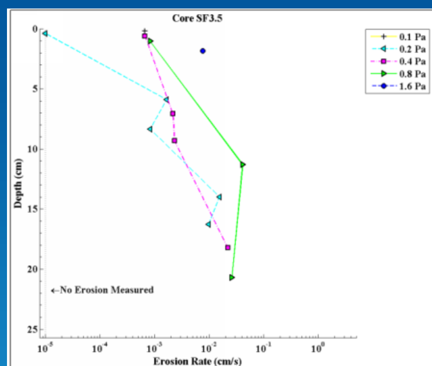


Figure 22. Down-core erosion rates for Core SF-3.5.

Upper Reservoir

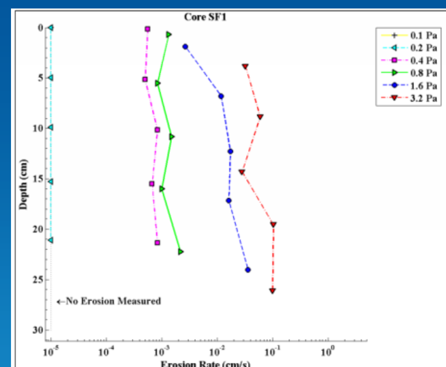


Figure 10. Down-core erosion rates for core SF-1.

Lower Reservoir

Mercury Assessment for Receiving Bodies

Tier 1: Oxygen in Bottom Water/SOD

- Does the system foster anaerobic activity?
- How fast does anaerobic activity set in?

Tier 2: MeHg Production

- Are zones of MeHg production at surface sediments

Tier 3: Zooplankton Body Burden vs MeHg in Water Column

- Are zones of MeHg production connected to aquatic food web?

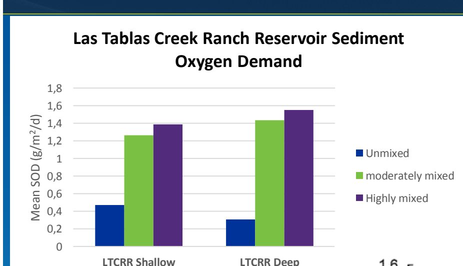
- Identify which tier to target for cost effective mitigation

Tier 1: Sediment productivity

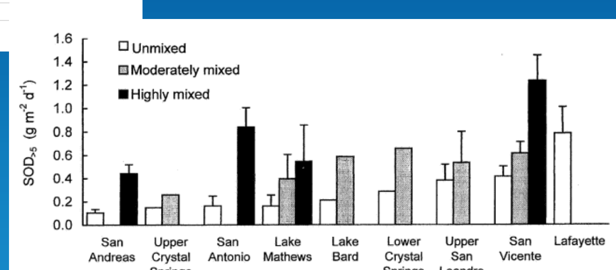
- Oxygen/mixing conditions in bottom waters
- Sediment oxygen demand/organic content
  - Nutrient budget
- Reducing conditions at sediment water interface
  - Iron and manganese enrichment in bottom waters
  - Sulfide in sediment

CDM Smith

Las Tablas Creek Ranch Reservoir Sediment Oxygen Demand



LTCRR is on the high end of SOD for waterbodies in California

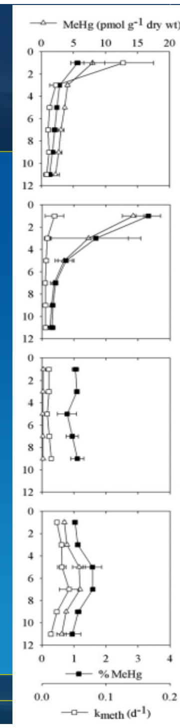


Beutel, 2003

CDM Smith

Tier 2: Methylmercury Production

- Percent MeHg of total Hg is used as a surrogate for MeHg production (Windham-Myers et al., 2009)
- Sites with highest *surface* methylation also have highest fish concentrations (Benoit et al., 2003)
- Growing database in literature to use for comparison

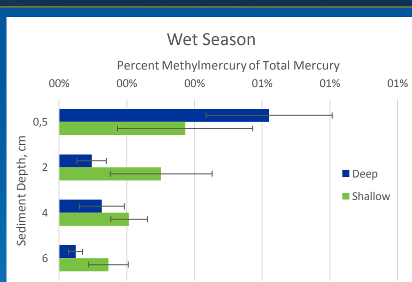


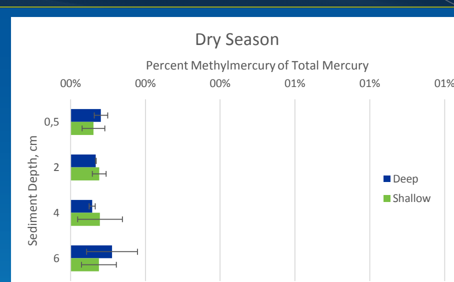
Hollweg, et al., 2009

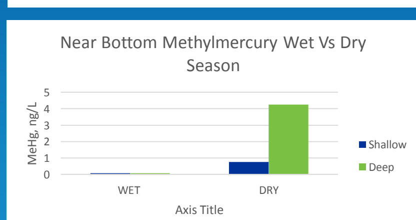
September 23, 2015

CDM Smith

Sediment Methylation and Bottom Water Enrichment: Unexpected Results





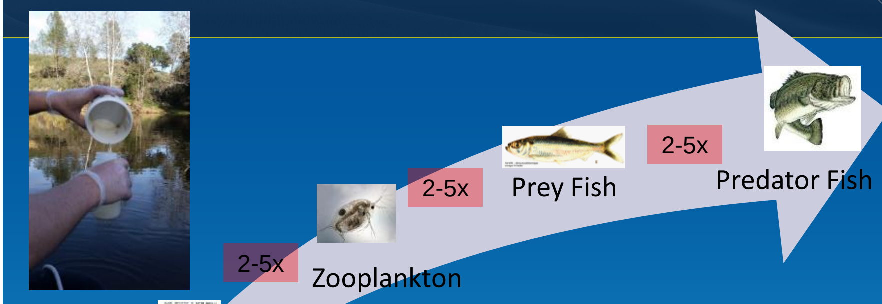


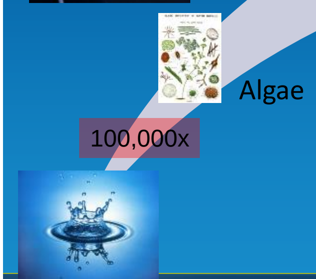
- Poor alignment with trends in sediment methylation and bottom water enrichment
- Potential for Significant In Water Methylation during Dry Season

September 23, 2015

CDM Smith

Tier 3: Methylmercury Accumulation in the Food Web



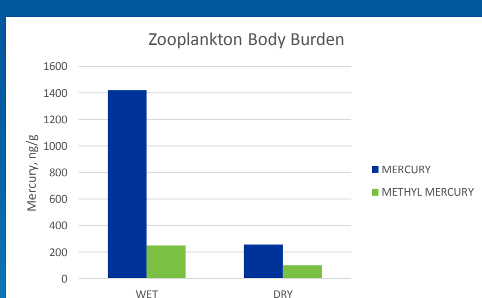


- Life cycle (zooplankton vs fish)
  - Daphnia – Females ~ 2 months (E. Bethesda, 2005)
  - Bass/Trout– 5 to 20 years
    (http://dnr.wi.gov/topic/fishing/documents/species/lmbass.pdf)

September 23, 2015

CDM Smith

Zooplankton Body Burden: Unexpected Patterns



	Wet Season		Dry Season	
Order	Shallow	Deep	Shallow	Deep
Ploima (#/m3)	0	0	475	5570
Cyclopoida (#/m3)	728	398	0	6730
Calanoida (#/m3)	0	0	2848	11372
Cladocera (#/m3)	380	995	538	6730
Total Zoop (#/m3)	1108	1392	3861	30401

- Higher levels of mercury in in zooplankton during the wet season are likely the result of storm runoff load
- Poor linkage between base of the food web and in-water methylmercury concentration
- Biodilution explains as least part of the disconnect between food web and water concentration

CDM Smith

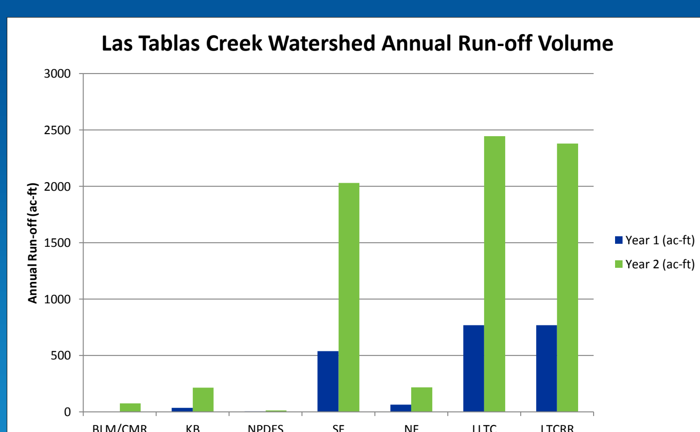
Modeling Approach

- Hydrological Modeling System (HEC HMS)
  - Developed by U.S. Army Corps of Engineers
  - Simulates hydrologic processes of watershed systems
  - Simulated hydrographs were developed based on measured precipitation to compensate for limitations in flow data
  - Model was calibrated to year 2 stream stage and flow data
  - Modeled annual run-off volumes were used in conjunction with water quality data to develop loading estimates
- HEC 6
  - One-dimensional model that simulates sediment erosion and deposition within watershed
  - Modeling effort focused on long-term estimates of sediment transport is still underway

September 23, 2015

CDM Smith

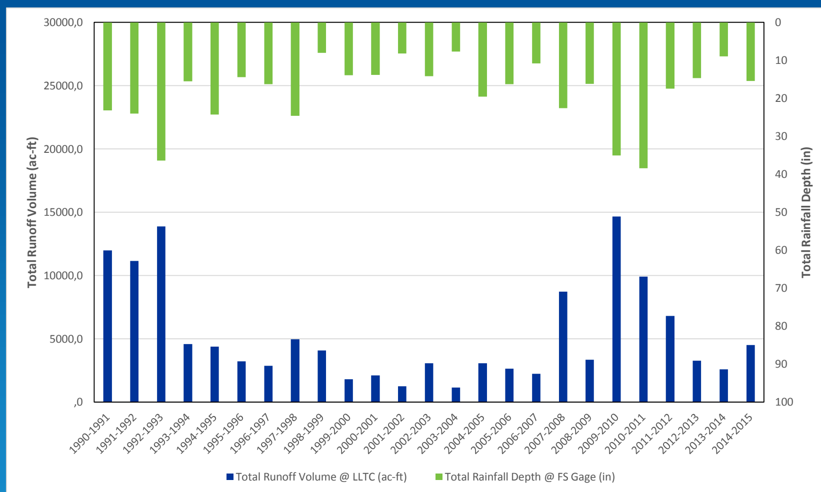
Modeling Results – Annual Run-off Volume



September 23, 2015

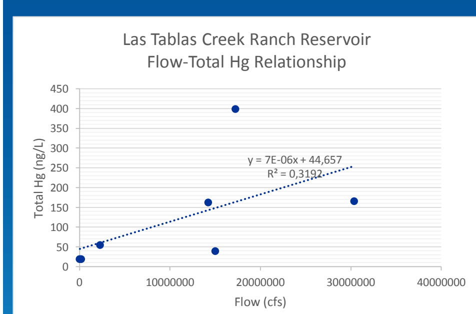
CDM Smith

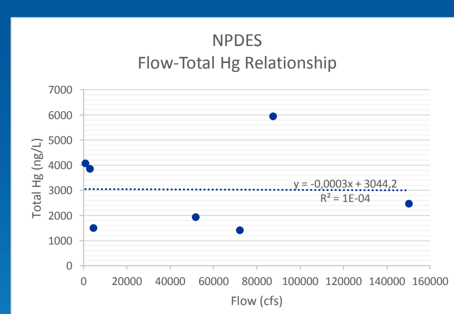
Long-Term Simulation of Run-Off Volume



September 23, 2015

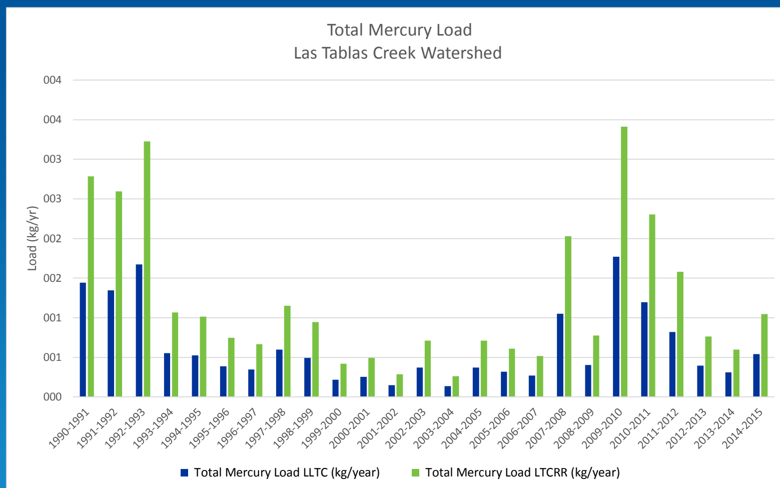
Assigning Total Mercury Concentration to Flow





- Mixed results in relationship between flow and total mercury concentration
- Precipitation event mean underestimates contribution from high flow events
- Flow weighted average used to develop loading estimates

Long-Term Simulation of Mercury Load within Las Tablas Creek Watershed



Watershed Assessment Summary

- Episodic precipitation events in a remote location were successfully monitored to estimate source area runoff and in-stream contaminant levels
- Difficulties encountered in measuring stream flow were overcome through the use of the HEC-HMS model to estimate stream flow
- Dry season reservoir assessment suggests near bottom water rather than surface sediments are the source of methyl mercury
- Incoming sediment particle concentrations range from 6 to 14 mg/kg with long-term mercury loading estimates to Lake Nacimiento ranging from 0.3 to 3.4 kg/year
- Erodibility measurements and loading estimates indicate that contaminated sediments with Las Tablas Creek Ranch Reservoir are a significant source of mercury contamination to Lake Nacimiento