Runoff of Mercury from UCD/DOE LEHR Superfund Site – Putah Creek Mercury Issues G. Fred Lee, PhD, PE, BCEE & Anne Jones-Lee, PhD G. Fred Lee & Associates El Macero, CA 530-753-9630 gfredlee@aol.com (\*) www.gfredlee.com

- Putah Creek Fish Contain Excessive Hg Compared to Human Health Guidelines
- Monitoring at UCD/DOE LEHR Superfund Site Revealed More Than 500 ng/L Hg in Some Stormwater Runoff
- Presentation Will Review These Findings as Well as Sources & Control of Hg in Putah Creek as Well at LEHR

Presented to Delta Mercury Tributary Council, December 2, (2008)



#### **Putah Creek History**

Before ~ 1900s

- Free-Flowing Stream
- Large Floods in Winter & Spring

**~** 1870

- Channelization Began
- Diverted Putah Creek to South Fork in Davis
- World War II Era
  - US Army Corps of Engineers Conducted Putah Creek Project to Contain 100-yr Flood
    - Removed Vegetation
    - Constructed High Levees

**1957** 

Monticello Dam Constructed Creating Lake Berryessa

## **LEHR Superfund Site**

- LEHR: Laboratory for Energy-Related Health Research
- 1958 1988: Atomic Energy Commission (AEC) Funded University of California, Davis (UCD) to Study Impacts on Beagle dogs' Health of Feeding/Injecting Them with Low Levels of Strontium-90 & Radium-226
  - ~ 1,000 Dogs Involved
- UCD Made Land Available for LEHR on Its South Campus
  - A Number of Campus Landfills Already in the Area
- AEC became the Department of Energy (DOE)
  - AEC/.DOE Had Legal Responsibility for Oversight of LEHR Site Activities

## **LEHR Site & Environs**



# **LEHR Project Area**



Source: Weiss Associates, Emeryville, CA

## **LEHR Becomes Superfund Site**

Mid-1980s: Significant Pollution of Groundwater & Other Areas Found at LEHR
Caused US EPA to List LEHR on National Priority List (NPL) of Superfund Sites
LEHR Officially Listed in 1994

#### **Public Action & Support**

#### DSCSOC

(Davis South Campus Superfund Oversight Committee)
Formed to Represent Interests of Public in Site Investigation & Remediation at LEHR
Superfund Provides Funds (through Technical Assistance Grant (TAG)) to Public Groups to Hire Technical Advisor
1995 – DSCSOC Hired Dr. G. Fred Lee as TAG Advisor

## Activities of GFL as TAG Advisor

- Reviews All Documents Developed by UCD & DOE Contractors
- Attends RPM Meetings
- Provides Comments on Adequacy of Site Investigation & Remediation Plans & Activities for Protecting Public Health & Environmental Quality
- Addresses Issues at Public Meetings
- Maintains DSCSOC Website
  - http://www.gfredlee.com/DSCSOC/DSCSOC.htm
  - GFL Reports Available for Download

#### Site Detail Map



## **Conceptual Site Model**



#### **Superfund Process**

**Remedial Response Process** 



Source: Weiss Associates, Emeryville, CA

# Superfund Site Investigation/Remediation

 Current Guidance Typically Focuses on:

 Waste Disposal Area
 Surface Soil
 Groundwater Contamination

 Investigation of Stormwater Runoff Impacts at Many Hazardous Chemical (Superfund) Sites Grossly Inadequate
 Especially Regarding Bioaccumulation of Hazardous Chemicals in Edible Fish

This Is the Case at LEHR Superfund Site

Portions of Upper Putah Creek Watershed Showing Primary Abandoned Mercury Mines

Source: Slotton et al. (1999)



# Mercury Mines in Putah Creek Watershed

- Several Large, Abandoned Hg Mines in Putah Creek
   Watershed above Lake Berryessa
- Before Construction of Monticello Dam (Lake Berryessa) in 1957, Storms Transported Hg Attached to Mine Wastes down Putah Creek to Yolo Bypass/Sacramento River
- With Monticello Dam, Mine Waste Erosion & Associated Hg Trapped in Lake
- Lake Berryessa Hydraulic Residence Time (Filling Time)
  - 5 10 yrs Depending on Flow

 1995: DSCSOC GFL Could Find No Information on Pollutants in Putah Creek Fish near LEHR
 ATSDR (Agency for Toxic Substances & Disease Registry)
 Funded by Superfund to Develop Public Health Assessments at Superfund Sites
 DSCSOC Convinced ATSDR & US EPA to
 Sample Fish from Putah Creek
 Analyze Fish for OCI Pesticides & Hg

- 1996: Excessive Hg Found in Fish Taken from Putah Creek near LEHR
  - Largemouth Bass 0.11 to 0.81 mg/kg Hg in Fish
- No Flow in Putah Creek above UCD WWTP Discharge
  - UCD WWTP Provided Poor Wastewater Treatment
  - Promoted Methylation of Hg
- Radioactive Hg Found in Fish UCD Lab Use?

1997: ATSDR's Second Fish Sampling
 Confirmed Excessive Hg in Creek Fish
 Flow in Creek above UCD WWTP Discharge
 Upstream Fish Also Contained Excessive Hg

Mercury Concentration in Largemouth Bass from Putah Creek – Oct/Nov 1997			
Fish Size	Mean ± SD (mg Hg/kg)		
Small (< 415 g)	0.17 ± 0.06		
Medium (540 – 730 g)	0.32 ± 0.14		

ATSDR Recommendation:

 Putah Creek Should Be Listed as "Unsafe" as Source of Fish for Consumption by Pregnant Women

No Action Taken Pursuant to ATSDR Recommendation

 1998/1999: UCD Had D. Slotton Survey Fish throughout Putah Creek below Lake Berryessa
 Found Fish with Excessive Hg throughout Creek LOWER PUTAH CREEK 1997-1998 MERCURY BIOLOGICAL DISTRIBUTION STUDY

February 1999

CONDUCTED FOR: The Department of Environmental Health and Safety, University of California, Davis



STUDY AND REPORT BY:

DARELL G. SLOTTON \* SHAUN M. AYERS JOHN E. REUTER CHARLES R. GOLDMAN

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#### POPE CREEK WATERSHED 1998 BIOLOGICAL MERCURY ASSESSMENT

June 1999

CONDUCTED FOR: PUBLIC RESOURCE ASSOCIATES San Francisco CA, Reno NV



DARELL G. SLOTTON, Ph.D. \*

and

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## Mercury Concentrations in Putah Creek Fish 1998—1999 (Slotton & Ayers, 1999)

Fish Type & Location	Mean ± SD (mg Hg/kg) [no. fish]
Trout – near Lake Berryessa	0.85 ± 0.03 [11]
Bluegill – Upstream of UCD	0.21 ± 0.06 [7]
Bluegill – Downstream of UCD	0.2 ± 0.08 [5]
Largemouth Bass – Downstream of UCD	0.46 ± 0.23 [6]
Roach – Upstream of Lake Berryessa (only small fish)	Range: 0.08 – 0.17

## **Putah Creek CWA–Listed**

DSCSOC Prepared Request to CVRWQCB (Central Valley Regional Water Quality Control Board) to List Putah Creek as CWA Section 303(d) "Impaired"

 Because of Excessive Hg in Tissue of Some Fish

Putah Creek Listed in 2003 by CVRWQCB/ SWRCB/ USEPA as "Impaired" Due to Excessive Hg in Fish

#### **Mercury Guidelines**

(from personal communication with C. Foe, CVRWQCB)

- "Fred, our proposed basin plan amendment tissue objective for large trophic level 3 and 4 fish are 0.08 and 0.24 ppm wet weight. This will allow people to safely eat a meal a week.
- We are also proposing a small fish (up to 50 mm length) tissue objective of 0.03 ppm wet weight. This is to protect fish eating wildlife. the small fish number comes from recommendations by the US FWS to protect, among other animals, least terns. There is a least tern nest colony near Antioch.
- You can read the details in our TMDL report to the US EPA. The unfiltered methyl mercury concentration needed to met these tissue numbers are site specific. The value for the Delta appears to be around 0.06 ng/l.
- details are in the TMDL report. Chris Foe "

#### Summary Mean Hg Concentrations for Legal &/or Edible-Size Fish & Shellfish from Putah Creek (OEHHA, 2006)

Species	Hg (ppm)	Species	Hg (ppm)
Channel Catfish	0.15	Carp	0.18
White Catfish	0.14	Rainbow Trout	80.0
Catfish	0.14	Brown Trout	0.06
Largemouth Bass	0.46	Trout	0.07
Sacramento Blackfish	0.09	White Crappie	0.28
Sacramento Sucker	0.16	Black Crappie	0.33
Bluegill	0.14	Crappie	0.29
Green Sunfish	0.17	Hitch	0.09
Redear Sunfish	0.15	Sacramento Pikeminnow	0.50
Hybrid Sunfish	0.19	Crayfish	0.21
Sunfish	0.14	<b>BOLD:</b> Samples with Sufficient	ent Numbers

#### Summary Mean Hg Concentrations for Legal &/or Edible-Size Fish & from Lake Berryessa (OEHHA, 2006)

Species	Hg (ppm)		
Channel Catfish	0.52		
White Catfish	0.77		
Catfish	0.56		
Largemouth Bass	0.75		
Smallmouth Bass	0.93		
Black Bass	0.76		
Rainbow Trout	0.17		
Chinook (King) Salmon	0.48		
Bluegill	0.39		
Carp	0.54		
<b>BOLD:</b> Samples with Sufficient Numbers			

#### Safe Eating Guidelines Fish Consumption from Putah Creek



Women of childbearing age, pregnant or breastfeeding women, and children 17 years and under

#### BEST CHOICES UP TO 3 MEALS A WEEK

Trout or Sacramento blackfish

#### EAT IN MODERATION NO MORE THAN 1 MEAL A WEEK

Largemouth, smallmouth, or spotted bass, bluegill or other sunfish, carp or goldfish, catfish (including bullheads), crappie, sucker, hitch, or crayfish



Women beyond childbearing age and men

#### BEST CHOICES

UP TO 3 MEALS A WEEK

Trout\*, Sacramento blackfish\*, bluegill or other sunfish, catfish (including bullheads), sucker, carp or goldfish, or crayfish

EAT IN MODERATION

NO MORE THAN 1 MEAL A WEEK

Largemouth, smallmouth, or spotted bass, crappie, or hitch

\* May be eaten daily by women beyond childbearing age and men

Source: OEHHA, "Fact Sheet – Health Advisory: Safe Eating Guidelines for Fish and Shellfish from Lake Berryessa and Putah Creek, including Lake Solano (Napa, Yolo, and Solano Counties)," Office of Environmental Health Hazard Assessment, CA EPA, Sacramento, CA, June (2006).

#### Safe Eating Guidelines Fish Consumption from Lake Berryessa

Women of childbearing age, pregnant or breastfeeding women, and children 17 years and under

#### BEST CHOICES UP TO 3 MEALS A WEEK

There are no best choices for this population at Lake Berryessa

EAT IN MODERATION NO MORE THAN 1 MEAL A WEEK

Bluegill or other sunfish; trout; or kokanee

AVOID NO MORE THAN 1 MEAL A MONTH

Largemouth, smallmouth, or spotted bass; catfish; and chinook (king) salmon



Women beyond childbearing age and men

BEST CHOICES UP TO 3 MEALS A WEEK

Trout or kokanee

EAT IN MODERATION NO MORE THAN 1 MEAL A WEEK

Largemouth, smallmouth, or spotted bass; catfish; chinook (king) salmon; bluegill or other sunfish

Source: OEHHA, "Fact Sheet – Health Advisory: Safe Eating Guidelines for Fish and Shellfish from Lake Berryessa and Putah Creek, including Lake Solano (Napa, Yolo, and Solano Counties)," Office of Environmental Health Hazard Assessment, CA EPA, Sacramento, CA, June (2006).

# **CALFED Mercury Project** Concentrations of Hg in Water (Based on data from Stephenson *et al.* (2008)

Location	Concentration or Mean ± SD (ng Hg/L)		
Putah Creek at Mace Blvd (63 samples 2003 – 2006)	23.82 ± 16.64		
Creek during Some High Creek Flows	100		
MeHg in Putah Creek	0.15 ± 0.03		
MeHg in Cache Creek	0.26 ± 0.09		



### **Current Fate of Hg in Putah Creek**

- Putah Creek Waters Contain High Concentrations of Hg
   Some of Total Annual Loads of Hg & Sediment in Putah Creek Water Diverted for Agriculture Use
  - Some Putah Creek Hg Deposited in Creek Sediment
     & Agriculture Soils
  - Tailwater from Irrigated Agriculture Discharge to Yolo Bypass
  - Need for Settling Basin for Creek Hg near Yolo Bypass
    - Who Will Remove Sediments from Basin?
    - Cache Creek Settling Basin Situation

# Summary of Issues Hg in LEHR Stormwater Runoff

April 2004 UCD Oatman Letter to CVRWQCB Regarding 2000 – 2004 Data:

- There is significant mercury (Hg) present in rainwater at concentrations (30 ng/L) near the California Toxics Rule (CTR) standard (50 ng/L) for Hg.
- Almost every on-site sample (except rainwater or blanks) and nearly half of the off-site samples not part of LEHR/SCDS have results that exceed 50 ng/L for Hg.
- Off-site samples from the sampling location nearest to LEHR/SCDS (collected from drainage ditch ½ mile south of Putah Creek near Old Davis Road) had Hg levels (74-421 ng/L) comparable to samples collected on site at LF-1 (58-300 ng/L) and LS-1 (48-540 ng/L).

### Hg in LEHR Stormwater Runoff

- Hg Concentration in LEHR Stormwater Runoff: ~ 500 ng/L
   Maximum Allowed Hg Concentration: 50 ng/L
  - CTR Criterion Putah Creek Is Listed as "Impaired" for Hg
- CVRWQCB Has Ordered UCD to Manage Stormwater Runoff to Keep Hg in Runoff < 50 ng/L</li>
- UCD/DOE Needs to
  - Determine Source(s) of Hg in Stormwater Runoff from LEHR
  - Control LEHR Source(s) of Hg in Stormwater Runoff
- Achieving CTR Hg Criterion (50 ng/L)
  - Does Not Ensure Prevention of Hg Accumulation in Some Fish in Some Situations
  - Protective Concentration for Hg Currently Believed ~ 5 ng/L

## CALFED Mercury Project Hg Loads

Yolo Bypass to Delta: Total 423 kg Hg/yr
Putah Creek to Yolo Bypass: Total 6.4 kg Hg/yr
< ~ 4% of Total Hg to Yolo Bypass</li>
Actually Less Owing to Agricultural & Wetland Diversions
LEHR Stormwater Runoff to Putah Creek:
~ 3×10<sup>-5</sup> kg Hg/yr
Hg Concentrations in Runoff > 50 ng/L (CTR Criterion) Violates CWA for Discharge to Water-Quality-Limited Waterbody

 Implementation of Delta Hg TMDL Could Significantly Reduce Allowable Hg Discharge



Source: Weiss Associates, Emeryville, CA

## Hg Concentrations in Near LEHR Area Soils

(Source: Weiss Assoc., 2008)

Sample Depth	Mean ± SD (mg/kg Hg)		
Surface	1.3 ± 1.1		
2 ft	1.9 ± 1.3		
3 – 4 ft	0.25 ± 1.7		
8 – 22 ft	0.16 ± 0.16		
30 – 40 ft	0.19 ± 0.09		

## **PRG Values for Hg in Soil**

- US EPA Region 9 PRGs (Preliminary Remediation Goals)
  - Claimed to be "Risk-Based" Concentrations
  - Intended to Assist Risk-Assessors & Others in Initial Screening Evaluation of Environmental Measurements

US EPA Region 9 PRGs for Hg:
 Residential Areas: 23 mg/kg
 Industrial Areas: 310 mg/kg

#### Average Concentrations of Hg in Soil at Selected Locations at LEHR Site (Source: Weiss Assoc., 2008)

The and the Product of the	Soil Depth: ≤ 2 ft			Soil Depth: >2 - 4 ft		
Area	No. Samples	(mg/kg Hg)		No.	(mg/kg Hg)	
		Mean	SD	Samples	Mean	SD
Eastern Dog Pens	25	1.7	3.1	19	1.7	2.5
Western Dog Pens	163	1.1	0.92	28	1.1	1.1
Landfill No. 1	11	1.4	0.81	2	0.6	0.57
Landfill No. 2	11	0.5	0.29	5	0.93	0.69
Landfill No. 3	9*	1.1	8.0	1	0.75	n/a
Non OU Area	71	0.89	0.77	18	1.2	0.72
Old Davis Road Stormwater Runoff Ditch	5	0.8	0.59	0		

\* One anomalous sample (49.5 mg/kg) excluded

#### **LEHR Site Mercury**

Soil Sampling for Hg Focused on Waste Management Units Some Near–Surface Samples Contain > 0.5-5 mg/kg Hg Deeper Samples Typically Contain < 0.2-1 mg/kg Hg</p> Current LEHR Stormwater Runoff Monitoring Program Grossly Inadequate for Assessing LEHR Sources of Hg to Stormwater Runoff Contributions of Hg from Sources Need Comprehensive Assessment of Site as Current Source of Hg in Stormwater Runoff Need to Measure Hg in Surface Soils Across Site Need to Assess Contribution of Areas of Site to Hg in Stormwater Runoff

## Hg at LEHR Site

Hg Present in Top 2 ft of Soil near LEHR Site
Sources of Hg:

Not Likely UCD Waste Disposal Activities

 More Likely: Hg Mining Activities Upstream of Lake Berryessa

During Flood Flows before Monticello Dam

Mining–Derived Hg Was Carried Downstream &

Spread over Soils near Putah Creek

Likely That Soils near Putah Creek Outside Current Channel/Levees Contain Excessive Hg

## Hg at LEHR Site

 Need to Investigate Surface Soil & Waters near Putah Creek Channel below Lake Berryessa to Determine Extent of Soil Pollution by Hg

- Putah Creek Sediments near LEHR: 0.1 5 mg/kg Hg
- City Of Davis Stormwater Detention Pond Sediments:
   <0.06 0.16 mg/kg Hg</li>

Control of Excessive Hg in Putah Creek Fish Likely Difficult

- Key Source: Likely General Contamination of Creek Sediments
   & Banks
- CVRWQCB Hg TMDL for Putah Creek Scheduled by 2015
  - May be accelerated Under Delta Vision Strategy Implementation Requirements

#### **Need for Studies**

- Surface Soils in Former Putah Creek Flood Areas Need to Be Evaluated to Determine If Soil Mercury Is Threat to Public Health & Environment
- Need to Determine If There Are Areas of Putah Creek Channel That Are the Major Sources of Hg That Control
  - Low-Flow Putah Creek Background Hg
  - High Flow Hg
  - Groundwater Recharge Issues
- Need to Develop Approach to Control Hg in Putah Creek That Is Discharged to Agricultural Lands & Yolo Bypass

#### **Implications for UCD & City of Davis**

 Surface Soils in non-LEHR Areas of UCD & City of Davis Areas That Putah Creek Used to Flood:

- Likely Contain Sufficient Mercury to Cause Stormwater Runoff from Those Areas to Contain Sufficient Mercury to Violate CTR Criterion
- Stormwater Runoff from Those Areas Should Be Monitored for Hg
  - Not Currently Required
- Future: UCD & City Will Have to Meet the CVRWQCB 2015 TMDL Requirements for Hg in Stormwater Runoff
  - Will Likely Have to Implement Stormwater Runoff Control Programs for Hg If Runoff Violates Water Quality Standards/Objectives for Discharges to Putah Creek

## Regulation of Mercury in Agricultural Runoff

 Water Quality Impacts of Runoff/Discharge from Irrigated Agricultural Lands Regulated in Central Valley by CVRWQCB's Irrigated Lands "Ag Waiver" Program
 Program Requires Limited Monitoring

 To Try to Detect Violations of Water Quality Objectives

- If Violations Found, BMPs Required to Try to Control Violations
- No Requirement for Monitoring Hg in Ag Runoff / Discharges
  - Hg in Runoff from Agricultural Lands Is Not Being Regulated

Even Though High-Hg Waters Are Used by Some for Crop Irrigation & Ag Lands Flooded during High Stream Flows

 Implementation of Putah Creek 2015 Hg TMDL May Necessitate Control of Hg from Agricultural Lands

#### Reports

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 Lee, G. F. and Jones-Lee, A., "Stormwater Runoff Water Quality Evaluation and Management Program for Hazardous Chemical Sites: Development Issues," <u>Superfund Risk</u> <u>Assessment in Soil Contamination Studies: Third Volume</u>, ASTM STP 1338, American Society for Testing and Materials, pp. 84-98 (1998).
 http://www.gfredlee.com/stmhzpap.htm

### Acknowledgements

Dr. Chris Foe & Stephen Louis, CVRWQCB Provided Background Data on Putah Creek **Mercury Studies** Bob Devany, Weiss Associates, Emeryville, CA Provided Mercury Data on LEHR Site Sue Fields & Christine Judal, UCD Provided Additional Information Dave Feliz, DFG Yolo Wildlife Area Provided Information on Flow of Putah Creek into Yolo Bypass

### **Further Information Web Sites**



Drs. G. Fred Lee and Anne Jones-Lee: http://www.gfredlee.com

DSCSOC: http://www.gfredlee.com/DSCSOC/DSCSOC.htm

# Downstream Putah Creek at the LEHR Site November 30, 2008



# Upstream Putah Creek at Old Davis Road November 30, 2008



# Putah Creek During High Flow January 6, 2007



# Downstream Putah Creek at Mace Blvd November 30, 2008



# Upstream Putah Creek at Mace Blvd November 30, 2008



# Los Rios Check Dam at the End of Putah Creek in the Yolo Bypass



# Putah Creek Downstream of Los Rios Check Dam November 30, 2008



# Putah Creek Upstream of Los Rios Check Dam November 30, 2008



# Lehr Site During Stormwater Runoff Event

