Runoff of Mercury from UCD/DOE LEHR Superfund Site – Putah Creek Mercury Issues

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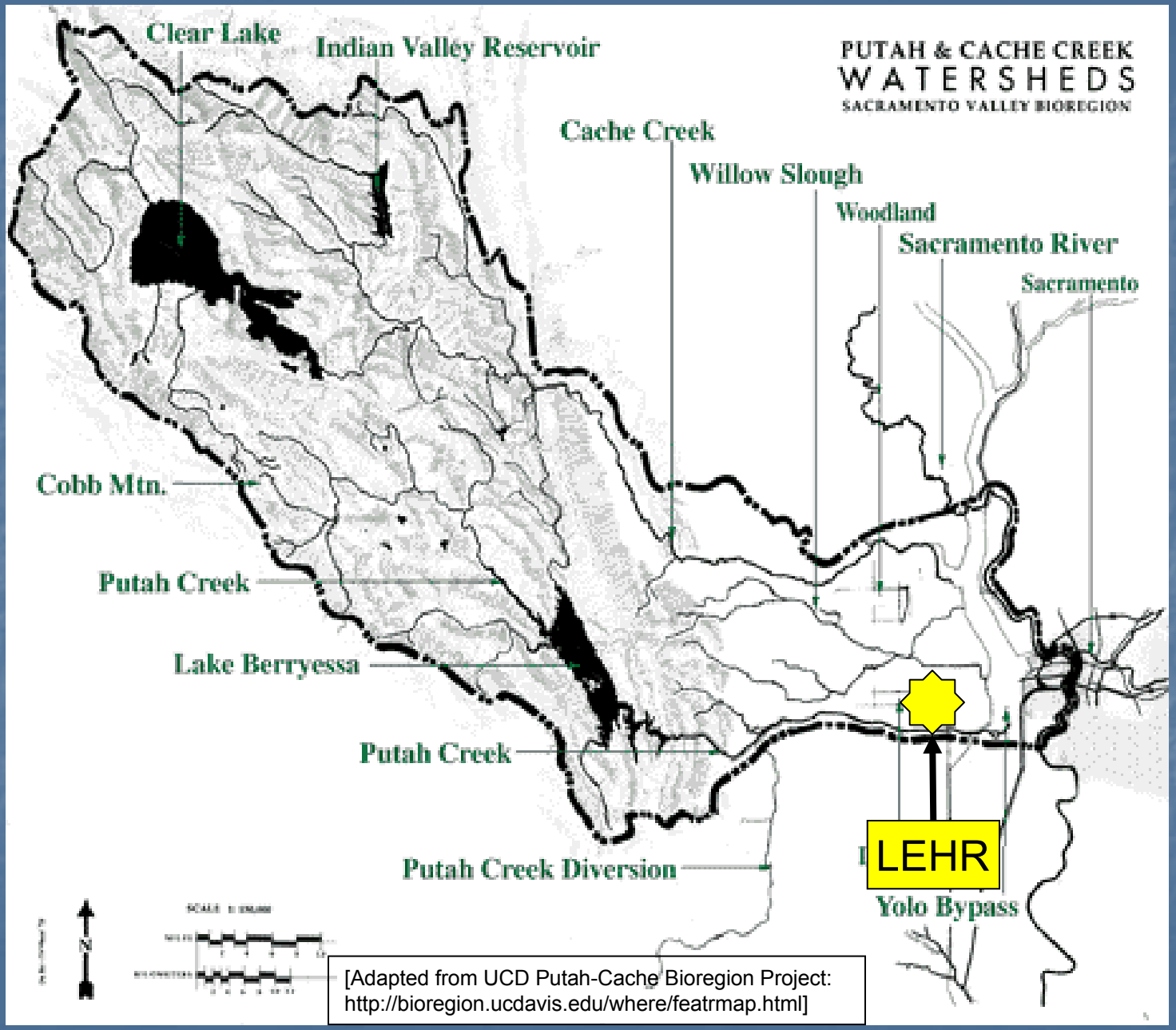
- Putah Creek Fish Contain Excessive Hg Compared to Human Health Guidelines
- Monitoring at UCD/DOE LEHR Superfund Site Revealed More Than 500 ng/L Hg in Some Stormwater Runoff
- Presentation Will Review These Findings as Well as Sources & Control of Hg in Putah Creek as Well at LEHR

Presented to UCD/DOE LEHR Superfund Site Group November 18, 2008

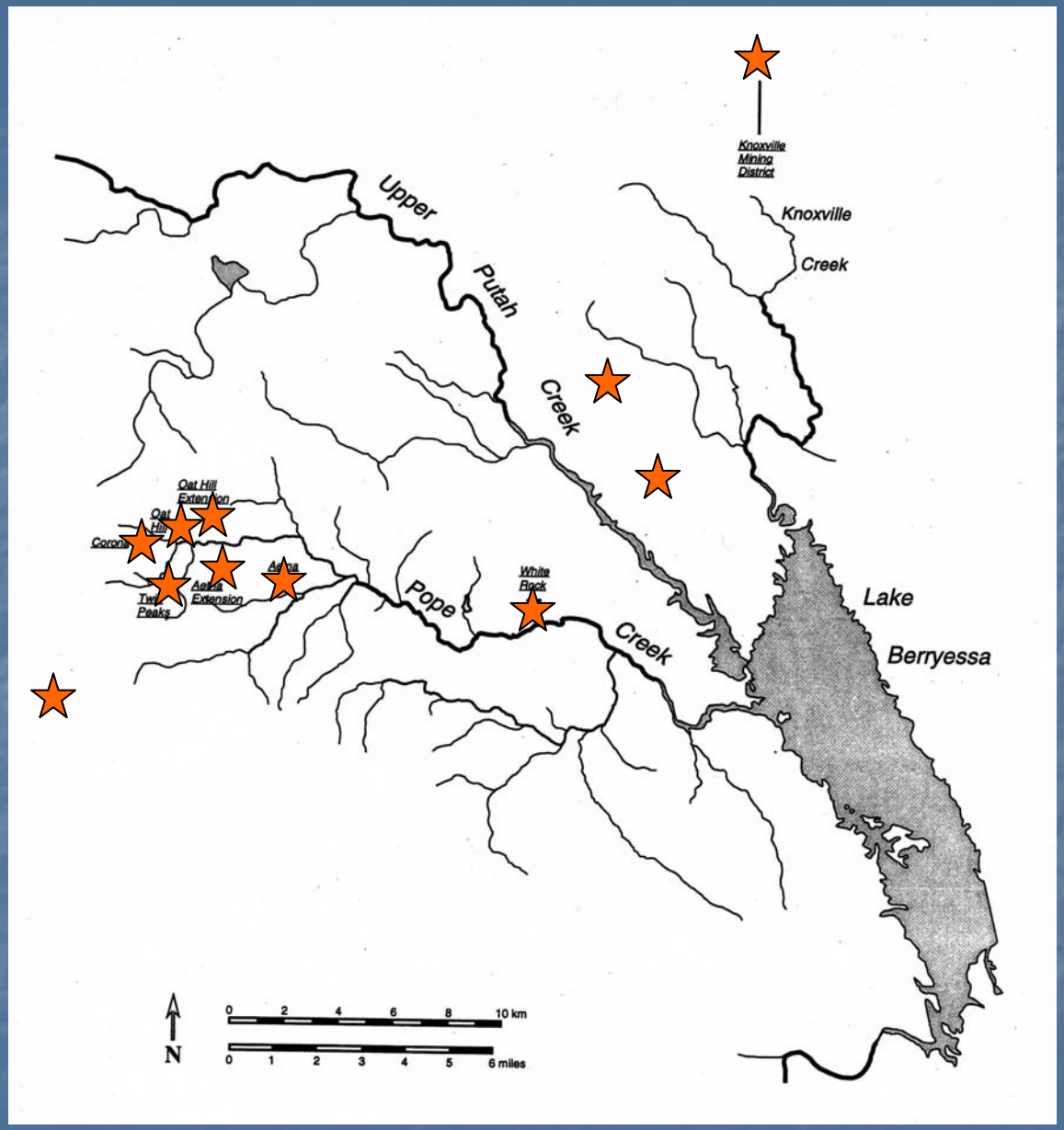

PUTAH & CACHE CREEK
WATERSHEDS
SACRAMENTO VALLEY BIOREGION
Clear Lake
Indian Valley Reservoir
Cache Creek
Willow Slough
Woodland
Sacramento River
Sacramento
Cobb Mtn.
Putah Creek
Lake Berryessa
Putah Creek
Putah Creek Diversion
LEHR
Yolo Bypass
[Adapted from UCD Putah-Cache Bioregion Project:
http://bioregion.ucdavis.edu/where/featrmap.html]

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

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

Hg in Putah Creek Fish

- 1994 LEHR UCD/DOE Becomes NPL Superfund Site
- 1995 DSCSOC Developed to Assist Public in LEHR Site Investigation and Remediation
- 1995: DSCSOC 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 OCl Pesticides & Hg

Hg in Putah Creek Fish

- 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?

Hg in Putah Creek Fish

- 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

Hg in Putah Creek Fish

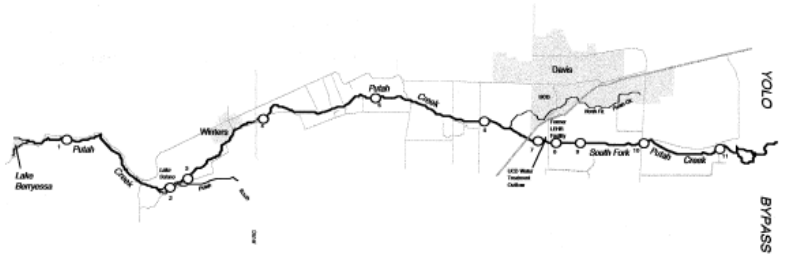
- 1998/1999: UCD Had D. Slotton Survey Fish throughout Putah Creek below Lake Berryessa
- Found Fish with Excessive Hg throughout Creek

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:

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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 2008)

- “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)
Channel Catfish	**0.15**
White Catfish	**0.14**
Catfish	**0.14**
Largemouth Bass	**0.46**
Sacramento Blackfish	**0.09**
Sacramento Sucker	**0.16**
Bluegill	**0.14**
Green Sunfish	0.17
Redear Sunfish	0.15
Hybrid Sunfish	0.19
Sunfish	**0.14**

Species	Hg (ppm)
Carp	**0.18**
Rainbow Trout	0.08
Brown Trout	0.06
Trout	**0.07**
White Crappie	0.28
Black Crappie	0.33
Crappie	0.29
Hitch	0.09
Sacramento Pikeminnow	0.50
Crayfish	0.21
BOLD: Samples with Sufficient 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
BOLD: Samples with Sufficient Numbers	

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

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

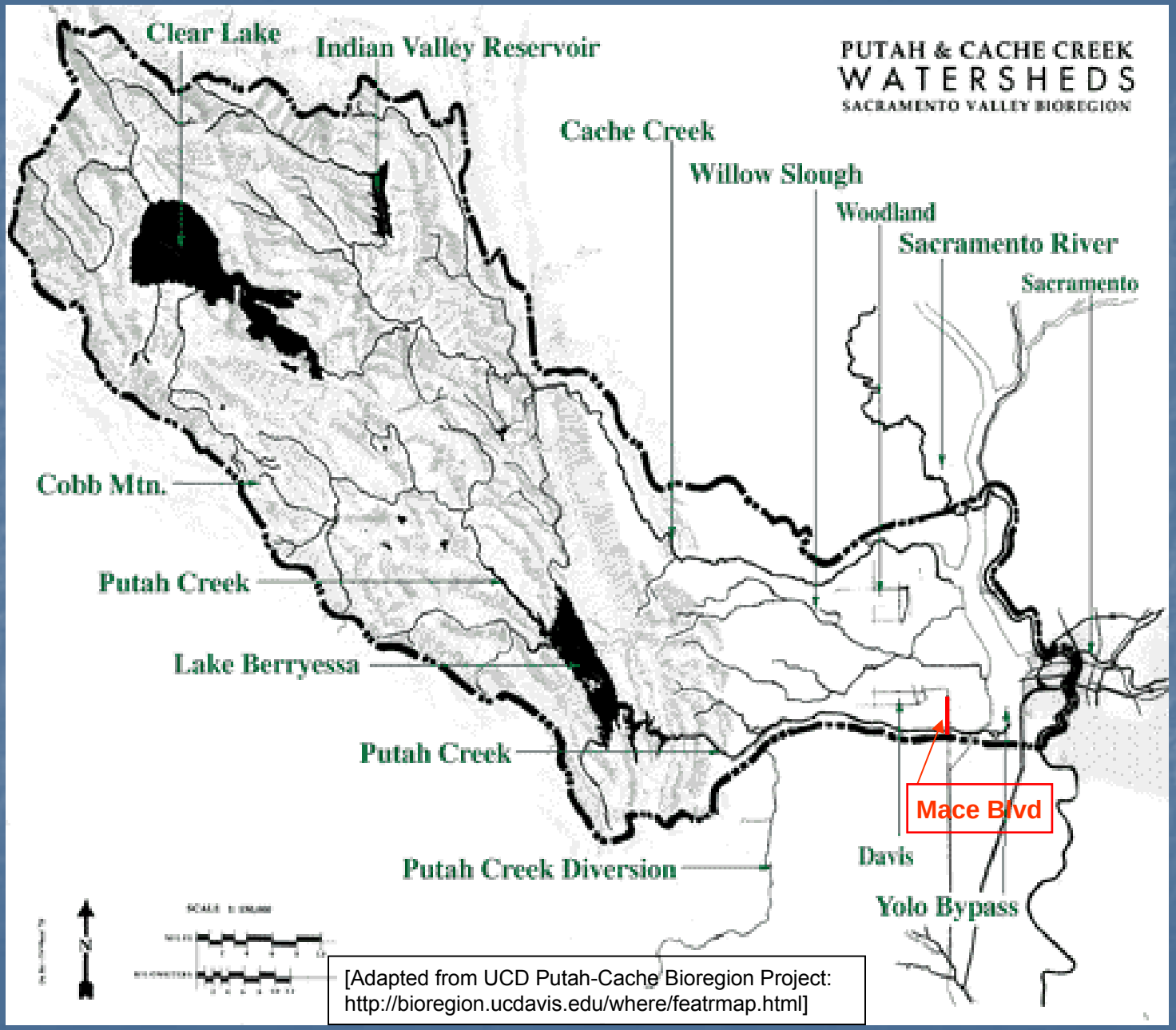
Women of childbearing age, pregnant or breastfeeding women, and children 17 years and under

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).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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:

1) 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.

2) 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.

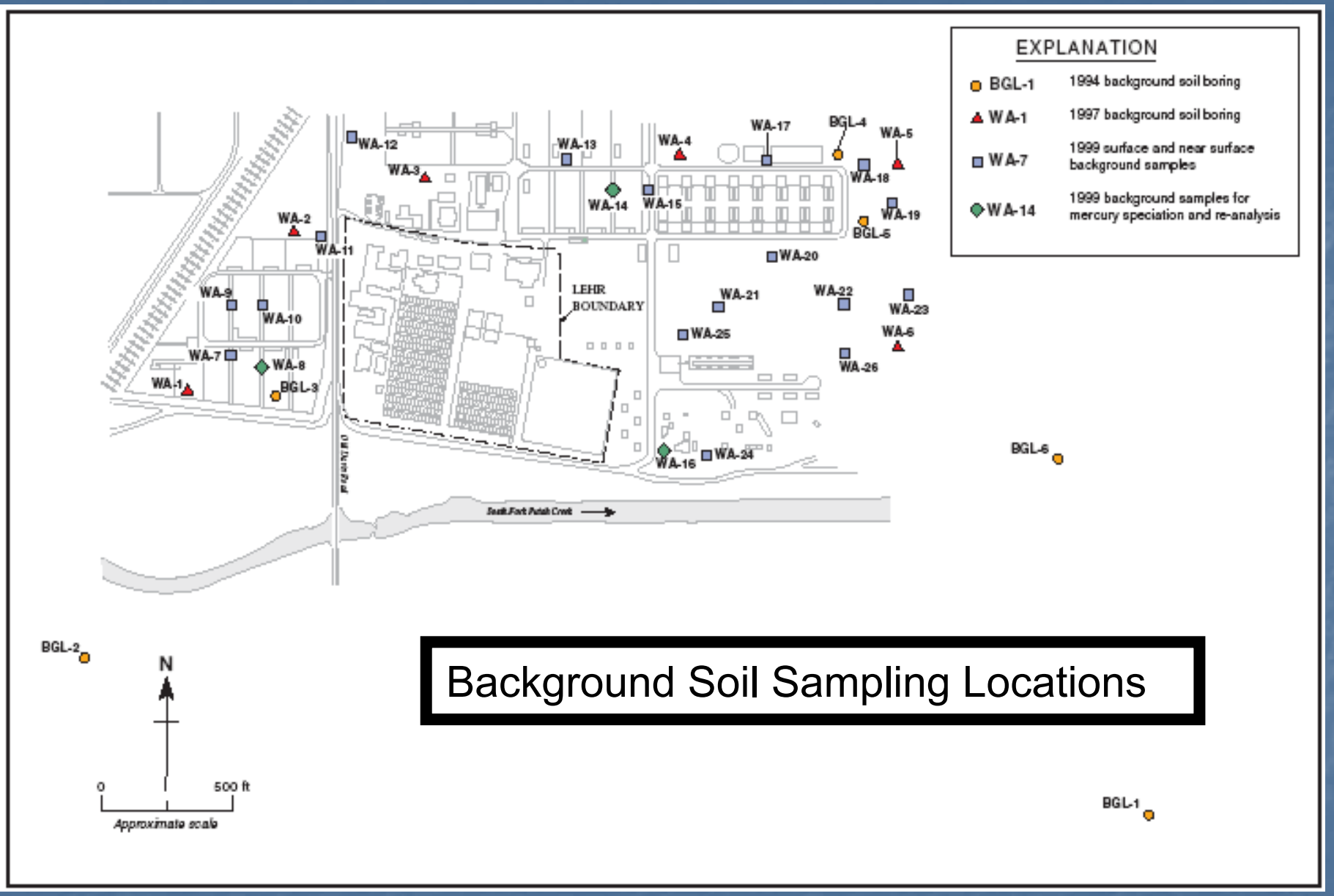
3) Off-site samples from the sampling location nearest to LEHR/SCDS (collected from drainage ditch ½ mile south of Putah Creek near Old Davis Road) had Hg levels (74-421 ng/L) comparable to samples collected on site at LF-1 (58-300 ng/L) and LS-1 (48-540 ng/L).

Hg in LEHR Stormwater Runoff

- CVRWQCB Has Ordered UCD to Manage Stormwater Runoff to Keep Hg in Runoff < 50 ng/L
- 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
    - Actually Less Owing to Agricultural & Wetland Diversions and Flooding During High Flows
- LEHR Stormwater Runoff to Putah Creek:
  ~ 3×10^{-5} 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



Background Soil Sampling Locations

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)

(

Area	Soil Depth: ≤ 2 ft			Soil Depth: >2 - 4 ft		
	No. Samples	(mg/kg Hg)		No. Samples	(mg/kg Hg)	
		Mean	SD		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	0.8	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 Soil 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 < 0.1-1 mg/kg Hg
- 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

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LEHR Site Mercury

- Soil Sampling for Hg Focused on Waste Management Units
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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
- 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

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 Used by Some Agriculture for Crop Irrigation and Ag Lands Flooded During High Stream Flows

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- 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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- 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