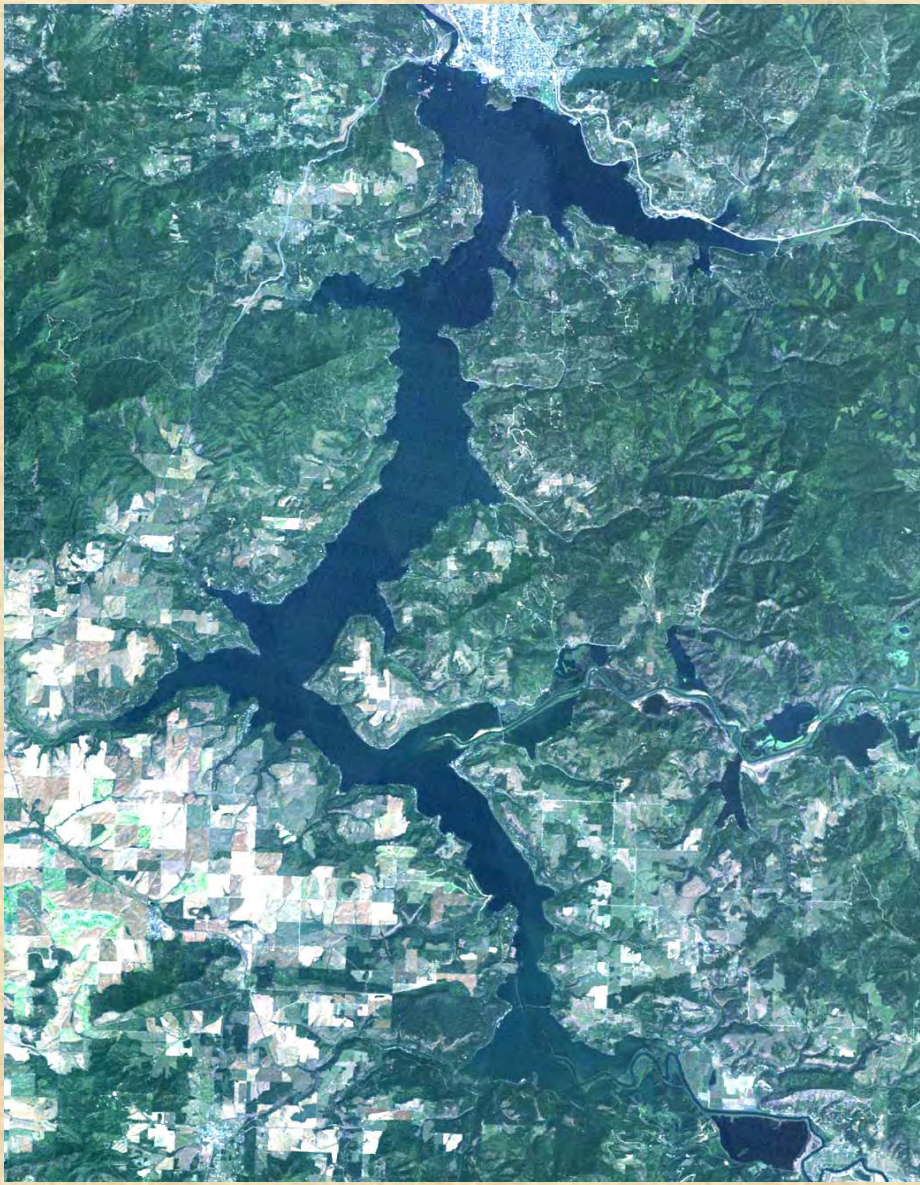
Coeur d'Alene Lake Management Plan

Prepared by:

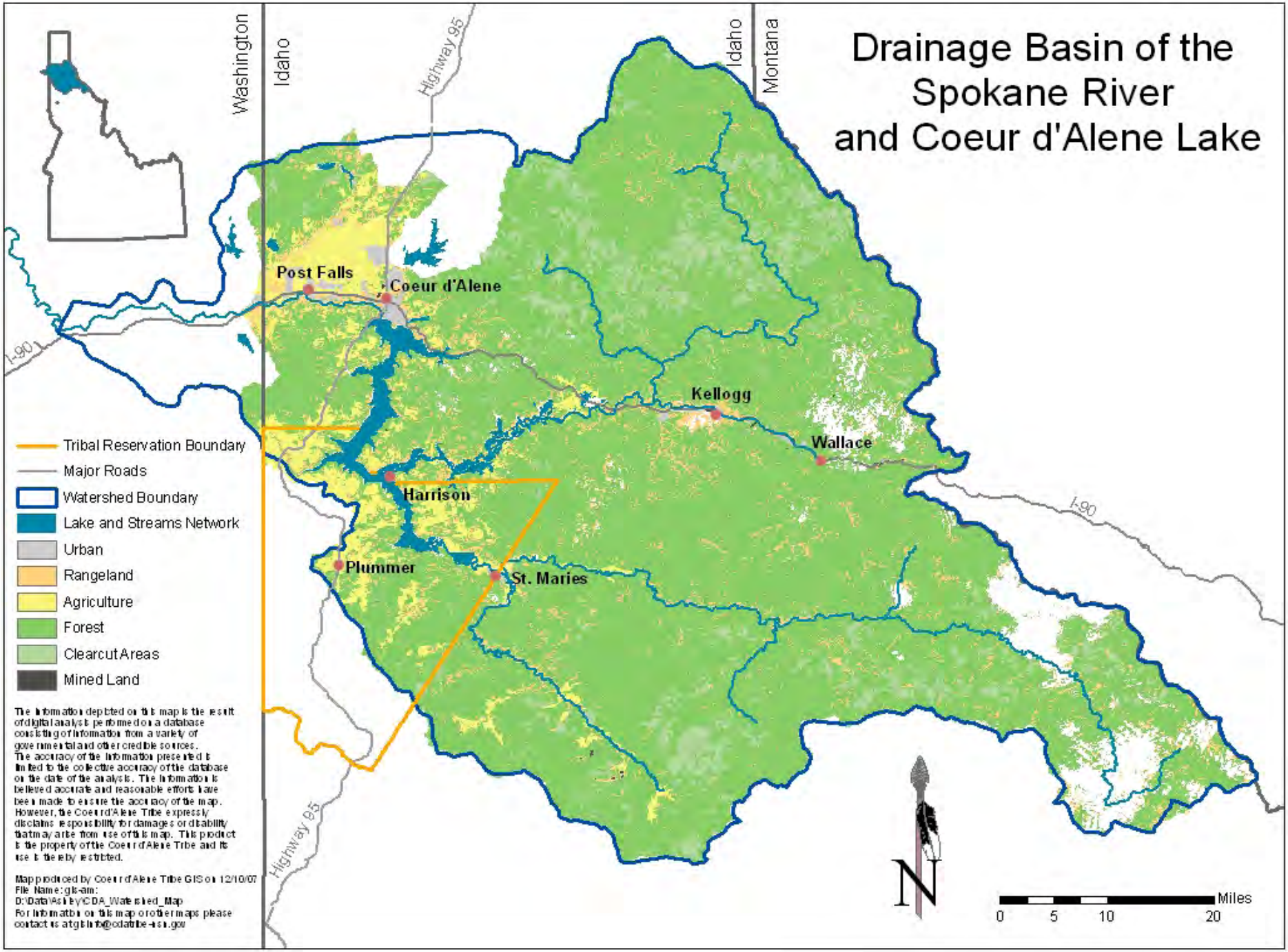
State of Idaho
Department of Environmental Quality
and the
Coeur d'Alene Tribe



Coeur d'Alene Lake Management Plan
Idaho DEQ and Coeur d'Alene Tribe
Finalized March 2009

Stated Goal:

"To protect and improve lake water quality by limiting basin-wide nutrient inputs that impair lake water quality conditions, which in turn influence the solubility of mining-related metals contamination contained in lake sediments."

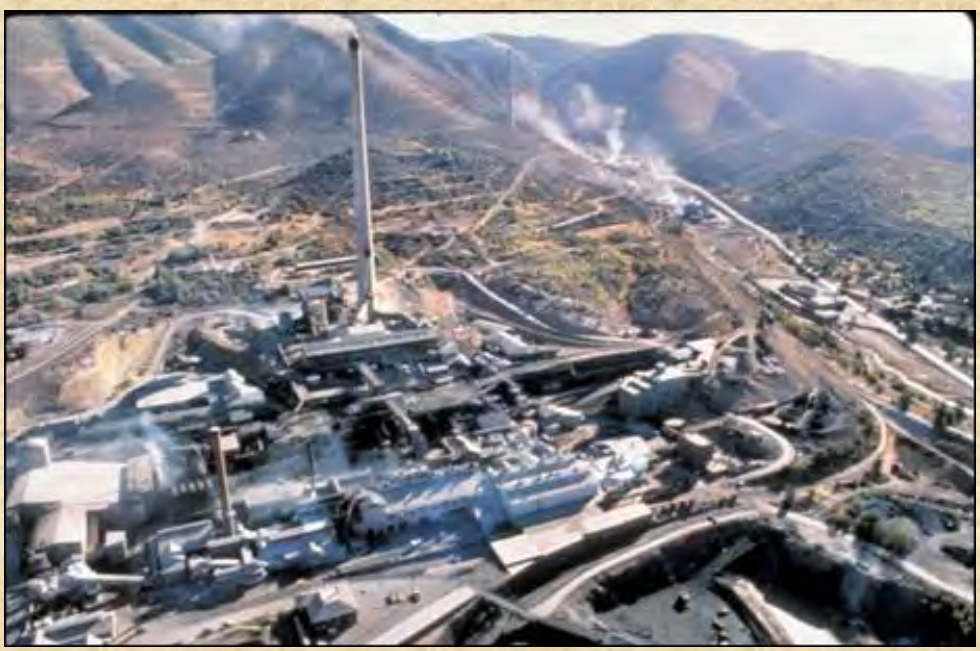

Drainage Basin of the
Spokane River
and Coeur d'Alene Lake
Washington
Idaho
Idaho
Montana
Highway 95
Highway 95
I-90
I-90
Post Falls
Coeur d'Alene
Kellogg
Wallace
Harrison
Plummer
St. Maries
Tribal Reservation Boundary
Major Roads
Watershed Boundary
Lake and Streams Network
Urban
Rangeland
Agriculture
Forest
Clearcut Areas
Mined Land
The information depicted on this map is the result of digital analysis performed on a database consisting of information from a variety of governmental and other credible sources. The accuracy of the information presented is limited to the collective accuracy of the database on the date of the analysis. The information is believed accurate and reasonable efforts have been made to ensure the accuracy of the map. However, the Coeur d'Alene Tribe expressly disclaims responsibility for damages or liability that may arise from use of this map. This product is the property of the Coeur d'Alene Tribe and its use is tightly restricted.
Map produced by Coeur d'Alene Tribe GIS on 12/10/07
File Name: gis-am:
D:\Data\Ashley\CDA_Watershed_Map
For information on this map or other maps please contact us at gis.info@cdatribe-nsn.gov
N
Miles
0
5
10
20

Coeur d'Alene Lake

Surface area =	31,875 acres
Lake volume =	2.3 million ac-ft
Max depth =	64 m
Mean depth =	22 m
Mean retention time =	0.5 years
Watershed area =	2.4 million acres
Shoreline length =	150 miles

Silver Valley/Bunker Hill Mining District & Complex – a Superfund Site since 1983

A century of millions of tons of mine tailings, slurries, and sediments enriched with metals transported down the Coeur d'Alene River and settling in the bottom of Coeur d'Alene Lake



Coeur d'Alene Lake Management Plan

Background

- Bottom sediments of Coeur d'Alene Lake have high concentrations of trace metals (e.g. lead, zinc, cadmium).
- In 2001 the U.S. Supreme Court affirmed that the United States, as trustee, and Cd'A Tribe as beneficiary, hold title to the bed and banks of most of the lower one-third of the lake and lower St. Joe River.
- The EPA 2002 Record of Decision (ROD) deferred a CERCLA clean-up remedy for the lake, and instead advised a LMP to be developed by DEQ, Tribe, and stakeholders.

Additional Background:

- **Idaho DEQ and the Cd'A Tribe have water quality authorities and jurisdictions under the federal CWA.**

- **Land-use management is done by the basin stakeholders.**

- **Since 2002, DEQ and the Tribe, along with an array of governmental agencies and community stakeholders, have been trying to finalize an updated LMP. A final LMP published March 2009; signed by Coeur d'Alene Tribal Chairman Chief Allan and Governor Otter, and forwarded to EPA.**

Coeur d'Alene Lake Management Plan

Beginning Objectives

1. Improve Scientific Understanding of Lake Conditions.

2. Establish and Strengthen Partnerships.

3. Develop and Implement a 3-Year Nutrient Source Inventory.

4. Increase Public Awareness of Lake Conditions.

5. Establish Funding Mechanisms to Support the LMP Goal, Objectives, and Strategies.

Table A1. Monitoring and research studies conducted in Coeur d'Alene Lake since 1975 (this is not a complete list). See References for full citations.

1975:
EPA National Eutrophication Survey – 3 sampling visits, April, July, & September
(U.S. EPA, 1977)

1987:
USGS sampling trips
(Woods, 1989)

1989:
USGS extensive sampling of metal concentrations in lakebed sediments
(Horowitz *et al*. 1993, 1995)

1991 and 1992:
USGS baseline study of limnological conditions
(Woods and Beckwith, 1997)

1994:
USGS bioassays of dissolved zinc inhibition of phytoplankton
(Woods and Beckwith, 1997)

1998 - 2001:
USGS study of benthic flux of metals and nutrients from sediments
(Kuwabara *et al*., 2000 and Kuwabara *et al*. 2003)

August 2001, June 2004, June 2005:
USGS – research of zinc effects on phytoplankton productivity
(Kuwabara, *et al*. 2006)

2002 – 2005:
Studies & reports produced for Avista FERC Relicensing - Spokane River Hydrologic Project

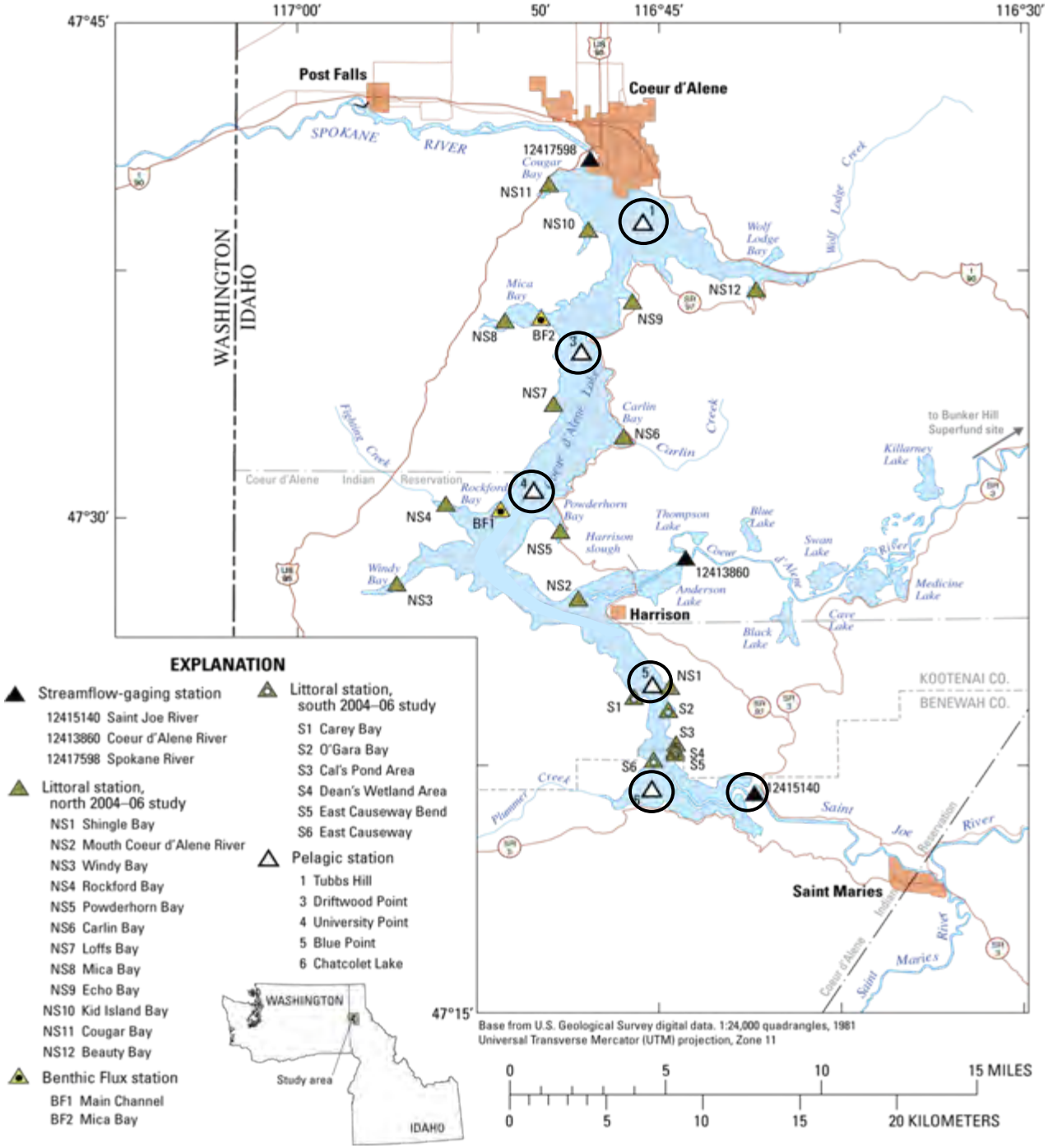
October 2003 – August 2006:
USGS & Coeur d'Alene Tribe – further baseline studies of limnological conditions
(Wood and Beckwith, 2008)

2004 – 2006:
USGS, University of Western Australia – Centre for Water Research, and Coeur d'Alene Tribe – development of ELCOM-CAEDYM computer model specific for Cd'A Lake
(Dallimore *et al*., 2007 and Hipsey *et al.* 2007)

March 2003 – ongoing:
EPA - Basin Environmental Monitoring Program including two inflow river stations and one lake outflow station

Coeur d'Alene Lake

Water Quality Sampling Sites

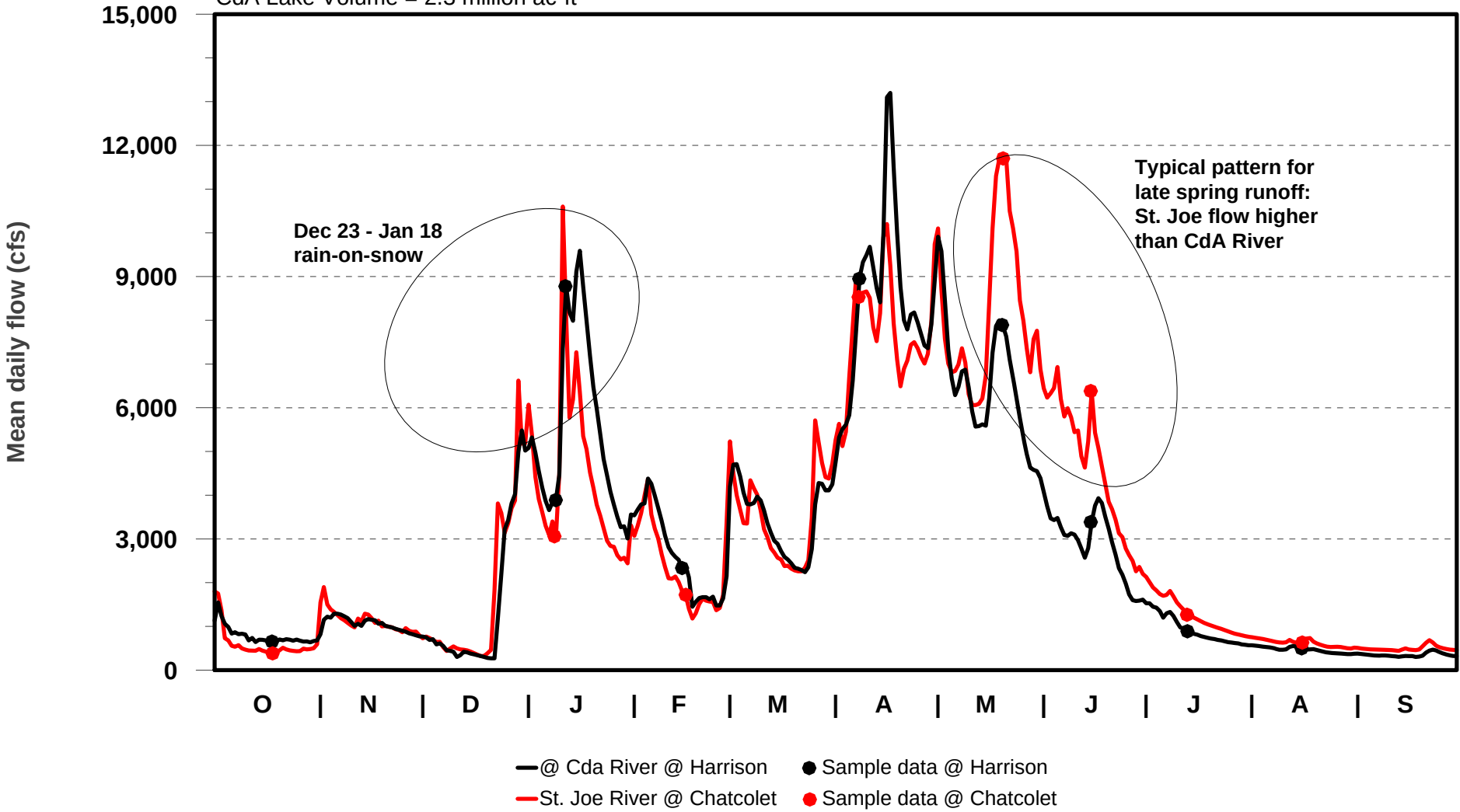


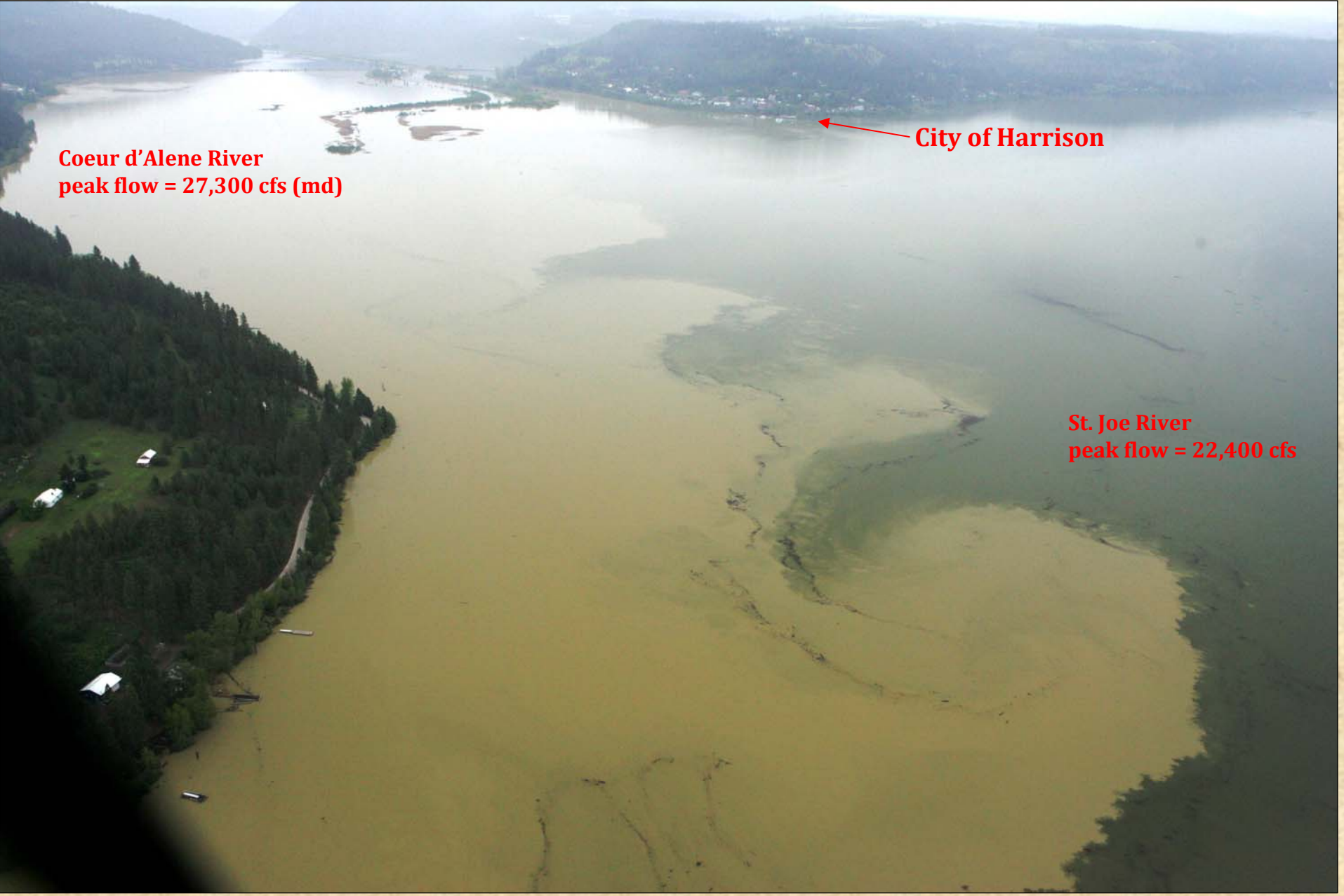
USGS Riverine Monitoring (BEMP)
Mean Daily Flow of CdA River @ Harrison & St. Joe River @ Chatcolet
WY 2006: October 2005 - September 2006

For Power Point

WY 2006
CdA River = 2,069,000 ac-ft
St. Joe River = 2,201,000 ac-ft
4,270,000 ac-ft

CdA Lake Volume = 2.3 million ac-ft





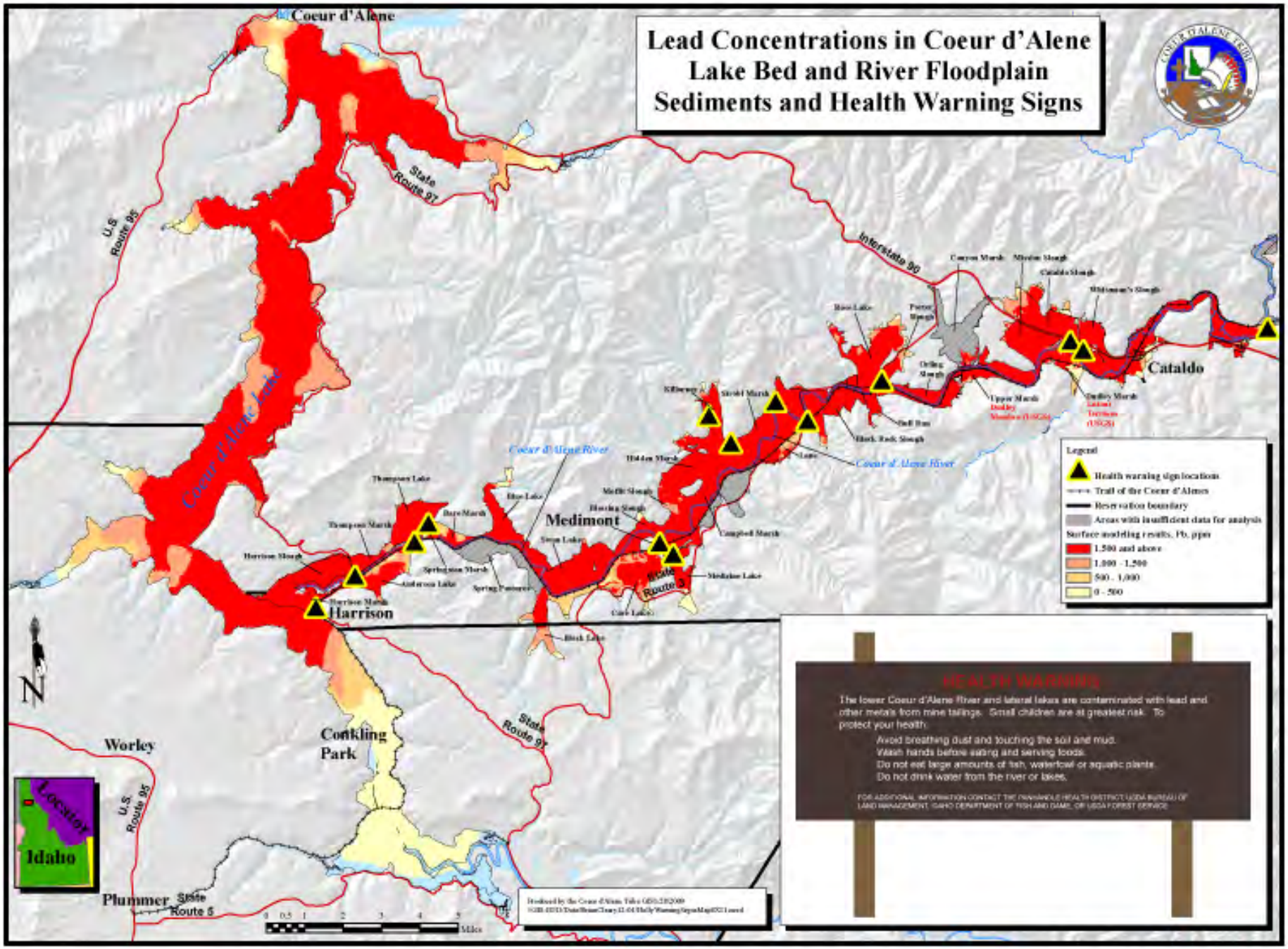
Flood induced plume, Coeur d'Alene River, May 2008

Table 25. Statistical summary of selected trace elements in surficial and subsurface lakebed sediments in enriched and unenriched areas, Coeur d'Alene Lake (Horowitz *et al*. 1993, 1995 and Woods and Beckwith, 1997).

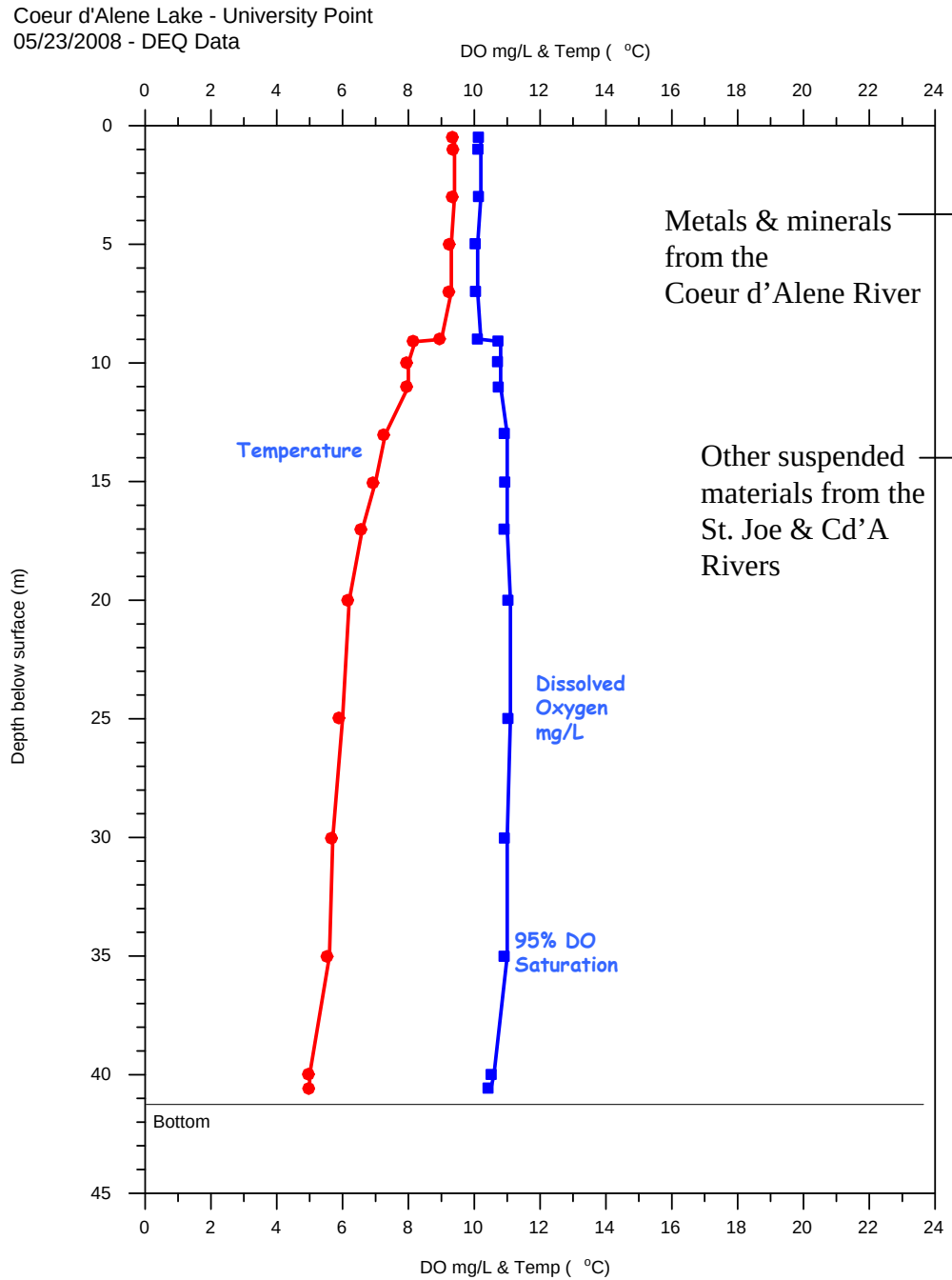
[mg/kg, milligrams per kilogram; S, surfical sample; C, subsurface core sample]

Trace Element	Sample Type	Concentration for enriched area (mg/kg) Minimum	Maximum	Mean	Median	Median for unenriched areas[1]
Arsenic	S	2.4	660	151	120	4.7
	C	3.5	845	103	30	12
Cadmium	S	<0.5	157	62	56	2.8
	C	<0.1	137	25	26	0.3
Copper	S	9	215	72	70	25
	C	20	650	91	60	30
Lead	S	14	7,700	1,900	**1,800**	**24**
	C	12	27,500	3,200	**1,250**	**33**
Mercury	S	0.02	4.9	1.8	1.6	0.05
	C	<0.01	9.9	1.9	0.95	0.06
Zinc	S	63	9,100	3,600	**3,500**	**110**
	C	59	14,000	2,400	**2,100**	**118**

[1]Unenriched area median concentration for sample type S based on 17 samples from southern area of Coeur d'Alene Lake and lower reach of St. Joe River. Unenrinched area median concentration type C based on 189 sample aliquots from cores beneath enriched area.


Lead Concentrations in Coeur d'Alene Lake Bed and River Floodplain Sediments and Health Warning Signs
Coeur d'Alene
Cataldo
Medimont
Harrison
Conkling Park
Worley
Plummer
Coeur d'Alene Lake
Coeur d'Alene River
Interstate 90
State Route 97
U.S. Route 95
State Route 5
Legend
Health warning sign location
Trail of the Coeur d'Alenes
Reservation boundary
Areas with insufficient data for analysis
Surface modeling results, Pb, ppm
1,500 and above
1,000 - 1,500
500 - 1,000
0 - 500
HEALTH WARNING
The lower Coeur d'Alene River and lateral lakes are contaminated with lead and other metals from mine tailings. Small children are at greatest risk. To protect your health:
Avoid breathing dust and touching the soil and mud.
Wash hands before eating and serving foods.
Do not eat large amounts of fish, waterfowl or aquatic plants.
Do not drink water from the river or lakes.
Locator
Idaho
N
Miles

What flows into the Lake?



Metals & minerals from the Coeur d'Alene River

Other suspended materials from the St. Joe & Cd'A Rivers

Dissolved metals –
Arsenic, Cadmium, Copper, Lead, Zinc

Suspended particulates some w/metals:
Fe^{+3} & Mn^{+4} oxides w/sorbed metals
Organic material w/sorbed metals
Galena – PbS
Sphalerite - ZnS
Pyrite - FeS
Other iron sulfides (FeS) w/metals
Siderite – $FeCO_3$
Sulfates

Inorganic phosphorus & nitrogen
(PO_4^{---}, NO_3^-, NH_4^+ – i.e. nutrients)

Complex poly-phosphates

Suspended sediment with -
sorbed phosphates on positively charged clay edges, & $FePO_4$, $AlPO_4$.

Particulate and dissolved organic matter (carbon based) w/ P & N

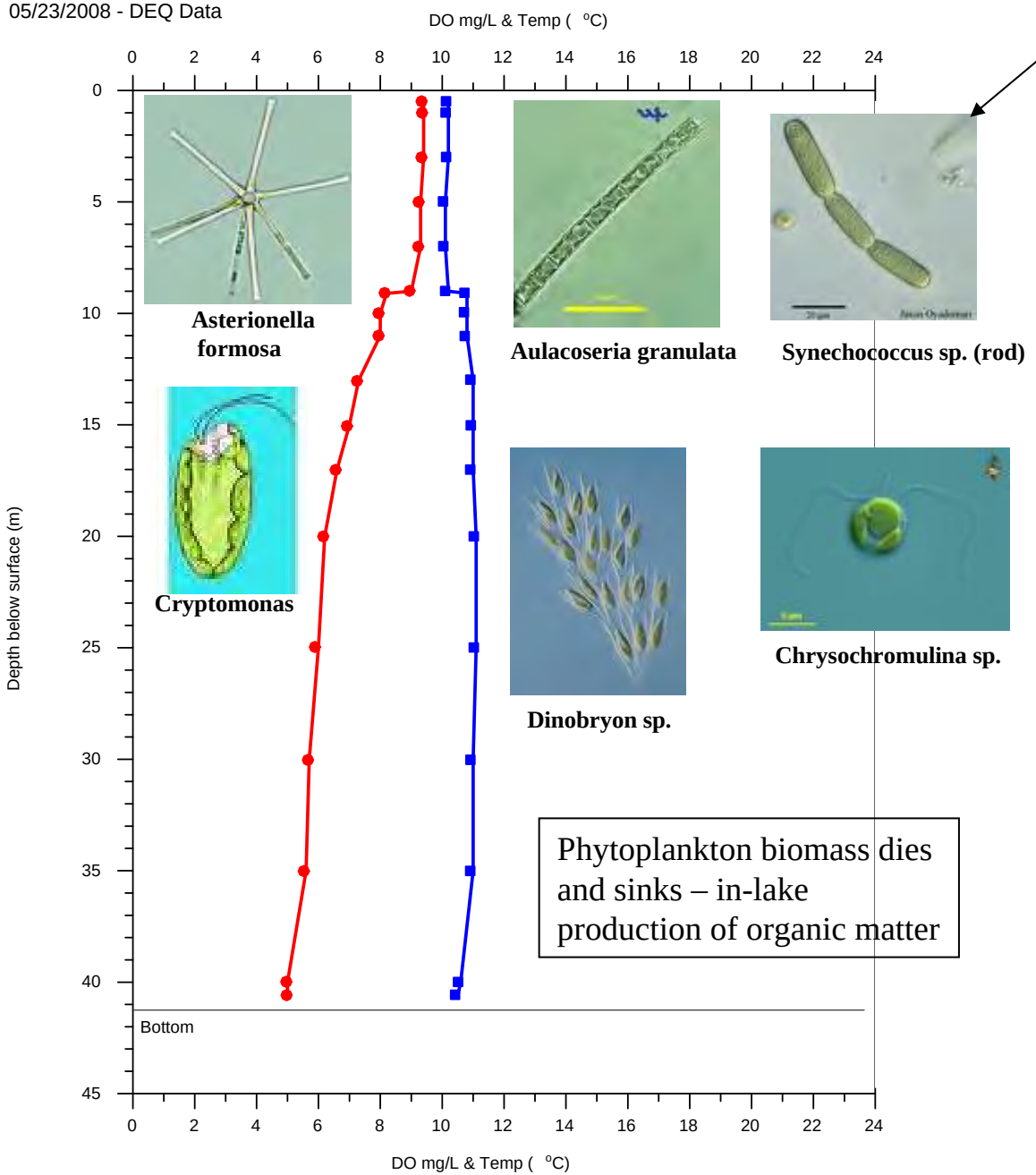
Suspended materials sink to the lake bottom

Microbially mediated reactions on organic material (BOD):

$$CH_3COO^- + 2O_2 \rightarrow 2CO_3^{2-} + 3H^+$$

if present, O_2 most favorable terminal electron acceptor for oxidation of organic compounds.

Coeur d'Alene Lake - University Point
05/23/2008 - DEQ Data



Phytoplankton biomass dies and sinks – in-lake production of organic matter

Free – floating algae, or Phytoplankton

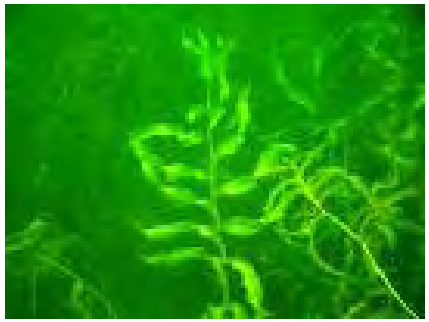
In lakes, phosphorus is most often the limiting nutrient to phytoplankton growth. In lakes world-wide, the general measured trend is that the higher the P concentration, the more phytoplankton growth and biomass. Biomass of phytoplankton is often measured by the amount of chlorophyll *a* trapped on a filter of a known amount of water filtered.

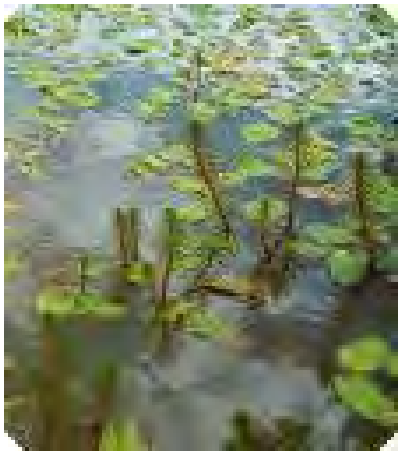
Excess P from human activities, such as wastewater, fertilizes a lake.

In Cd'A Lake, dissolved zinc actually inhibits phytoplankton growth.

Rooted Aquatic Plants or Macrophytes

Another source of organic material that eventually ends up on the bottom of Coeur d'Alene Lake is rooted aquatic plants in shallow waters that die-back each year. Rooted aquatic plants can also be promoted to greater growth with excess nutrients coming into a lake.

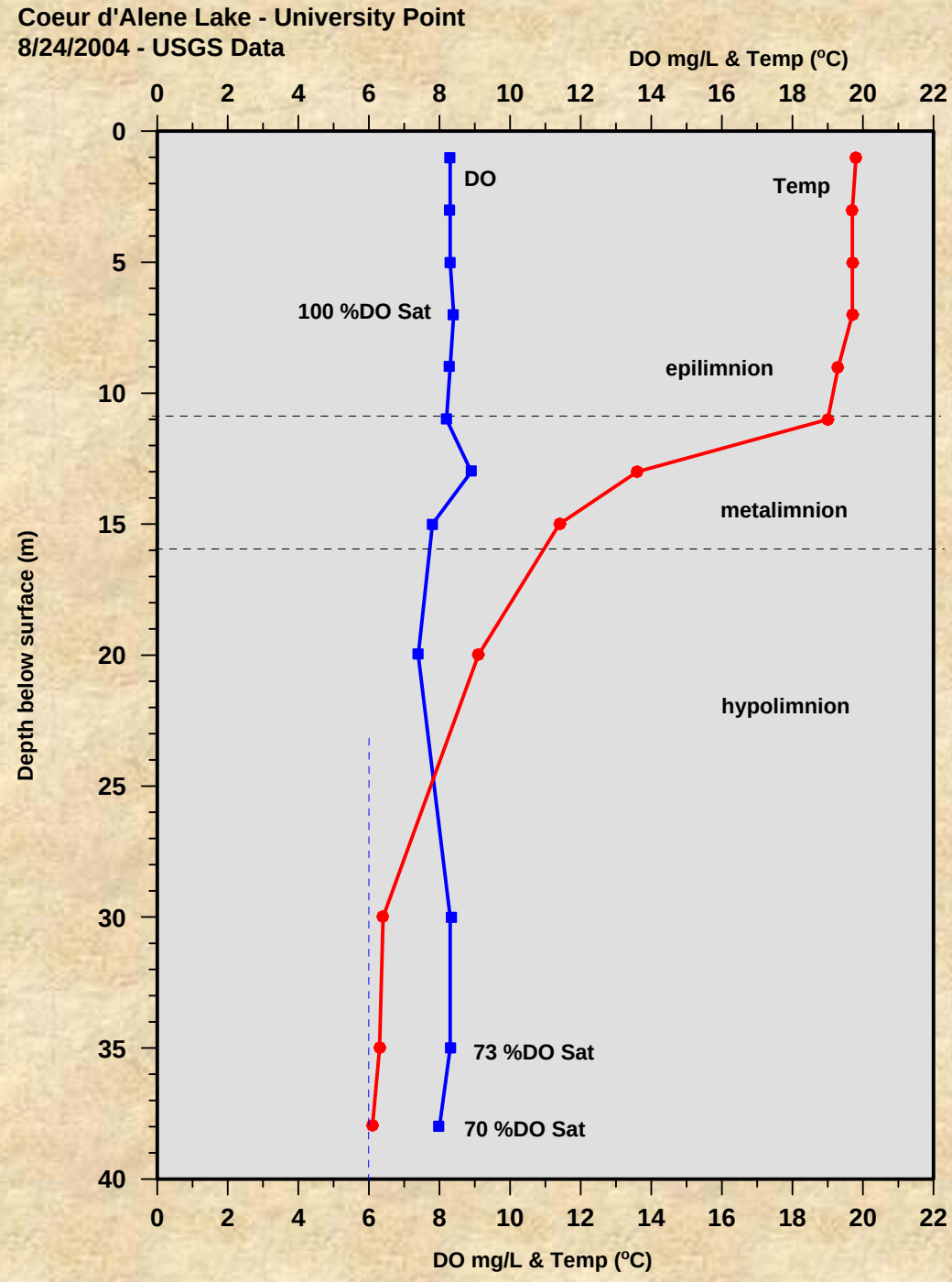


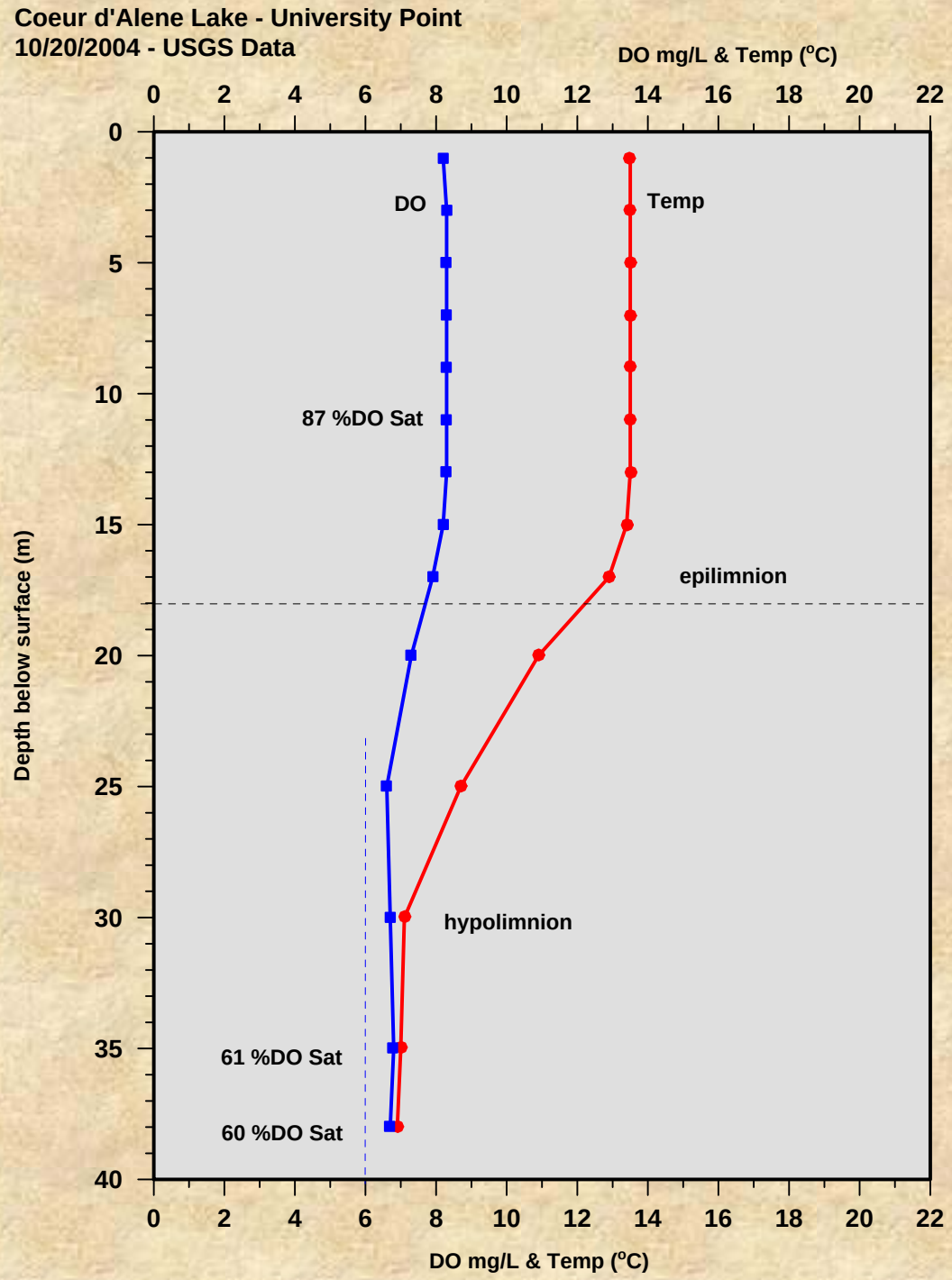


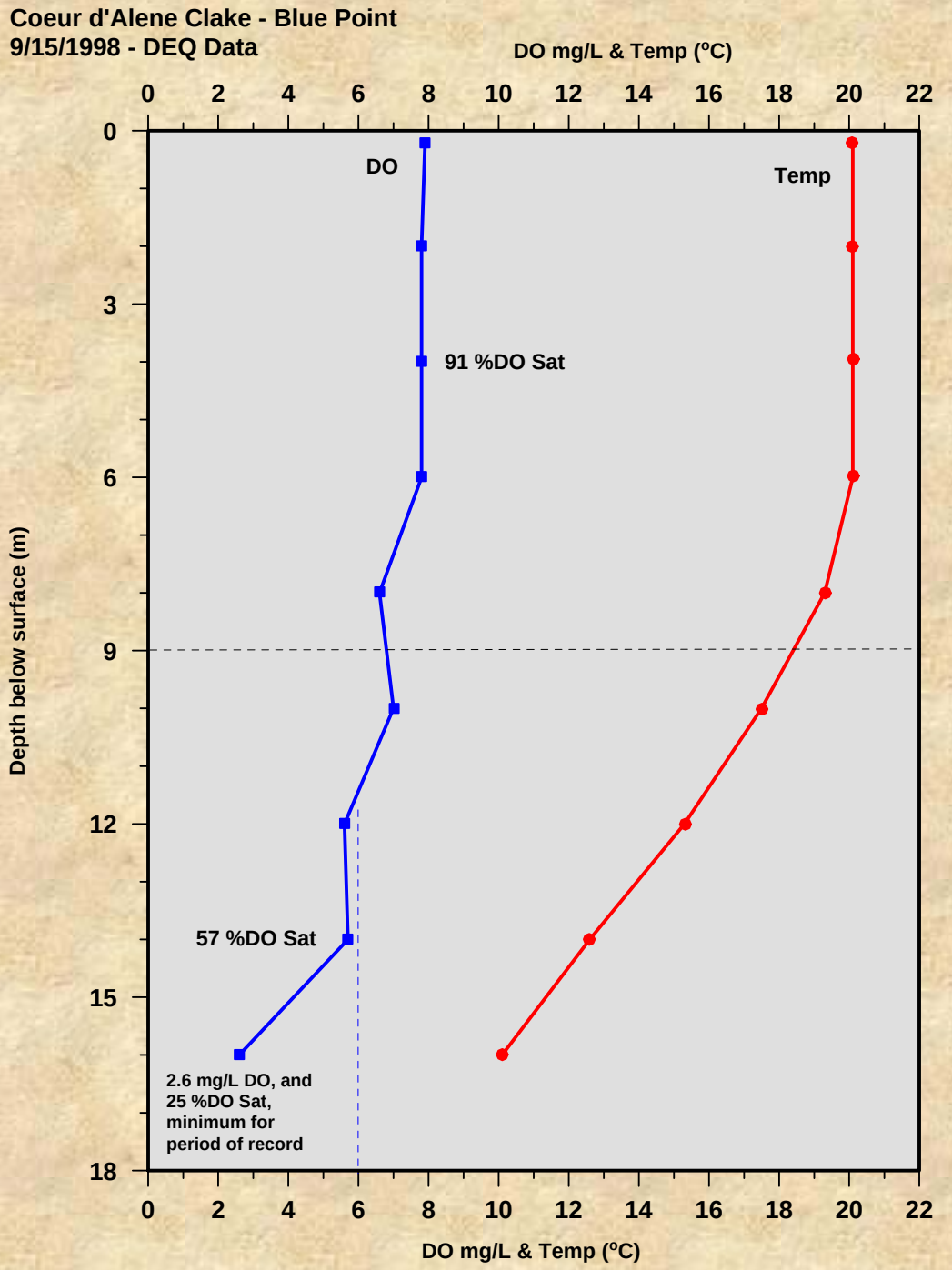
Some Key Scientific Questions for Cd'A Lake

1. Is there a nutrient load into the lake above current levels that could lead to anoxia in the lower-most portion of northern waters, and increase the level of anoxia in southern waters? Would this result in the release of heavy metals within the sediments into the water column (i.e. would the geochemistry change from current conditions)?

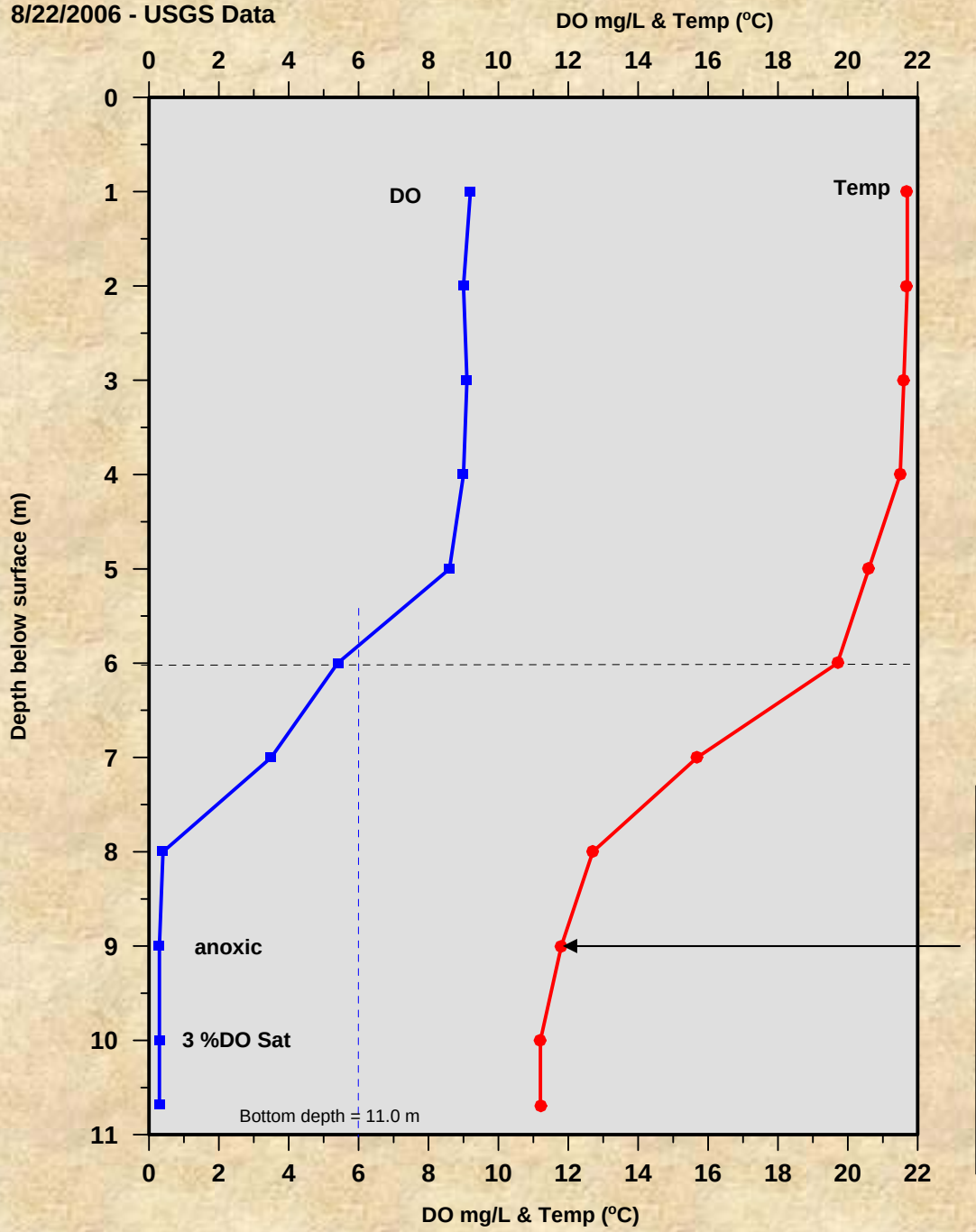
2. What happens if dissolved zinc becomes reduced below the level of toxicity?


Coeur d'Alene Lake - University Point
8/24/2004 - USGS Data
DO mg/L & Temp (°C)
0
2
4
6
8
10
12
14
16
18
20
22
Depth below surface (m)
0
5
10
15
20
25
30
35
40
DO
Temp
100 %DO Sat
epilimnion
metalimnion
hypolimnion
73 %DO Sat
70 %DO Sat
DO mg/L & Temp (°C)


Coeur d'Alene Lake - University Point
10/20/2004 - USGS Data
DO mg/L & Temp (°C)
0 2 4 6 8 10 12 14 16 18 20 22
Depth below surface (m)
0 5 10 15 20 25 30 35 40
DO
Temp
87 %DO Sat
epilimnion
hypolimnion
61 %DO Sat
60 %DO Sat
DO mg/L & Temp (°C)


Coeur d'Alene Clake - Blue Point
9/15/1998 - DEQ Data
DO mg/L & Temp (ºC)
0
2
4
6
8
10
12
14
16
18
20
22
DO
Temp
91 %DO Sat
57 %DO Sat
2.6 mg/L DO, and
25 %DO Sat,
minimum for
period of record
Depth below surface (m)
0
3
6
9
12
15
18
DO mg/L & Temp (ºC)

Coeur d'Alene Lake - Chatcolet Lake
8/22/2006 - USGS Data



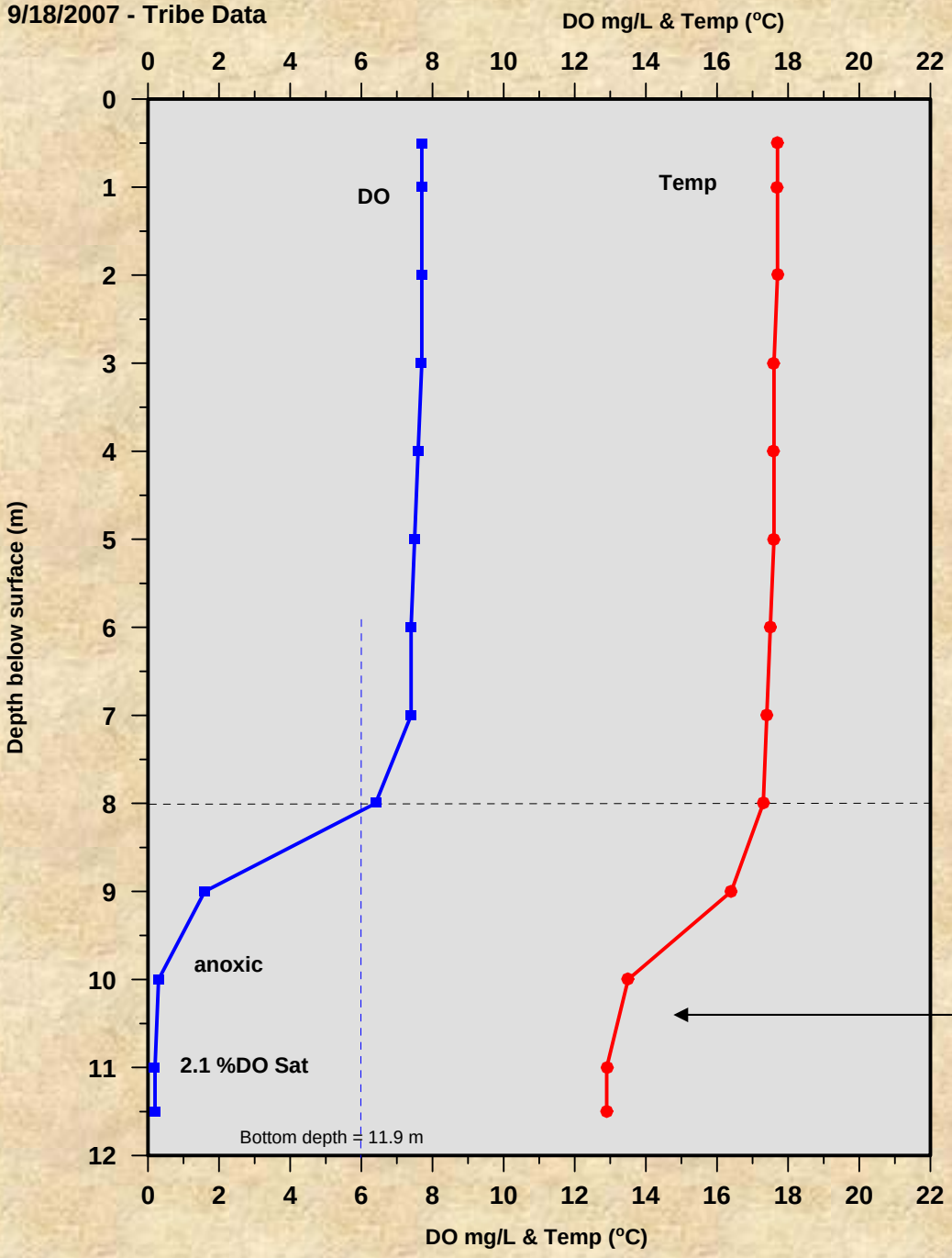
Composite photic zone sample 0.5 - 8m, in (ug/L)

TP =	14
DOP =	5
D. NH_4 =	9
D. Iron =	28
D. Mn =	52
D. Zinc =	8
D. Lead =	<0.08

Discrete grap sample at 9 m, in (ug/L)

TP =	180
DOP =	162
D. NH_4 =	162
D. Iron =	2,720
D. Mn =	910
D. Zinc =	31
D. Lead =	0.50

Coeur d'Alene Lake - Chatcolet Lake
9/18/2007 - Tribe Data

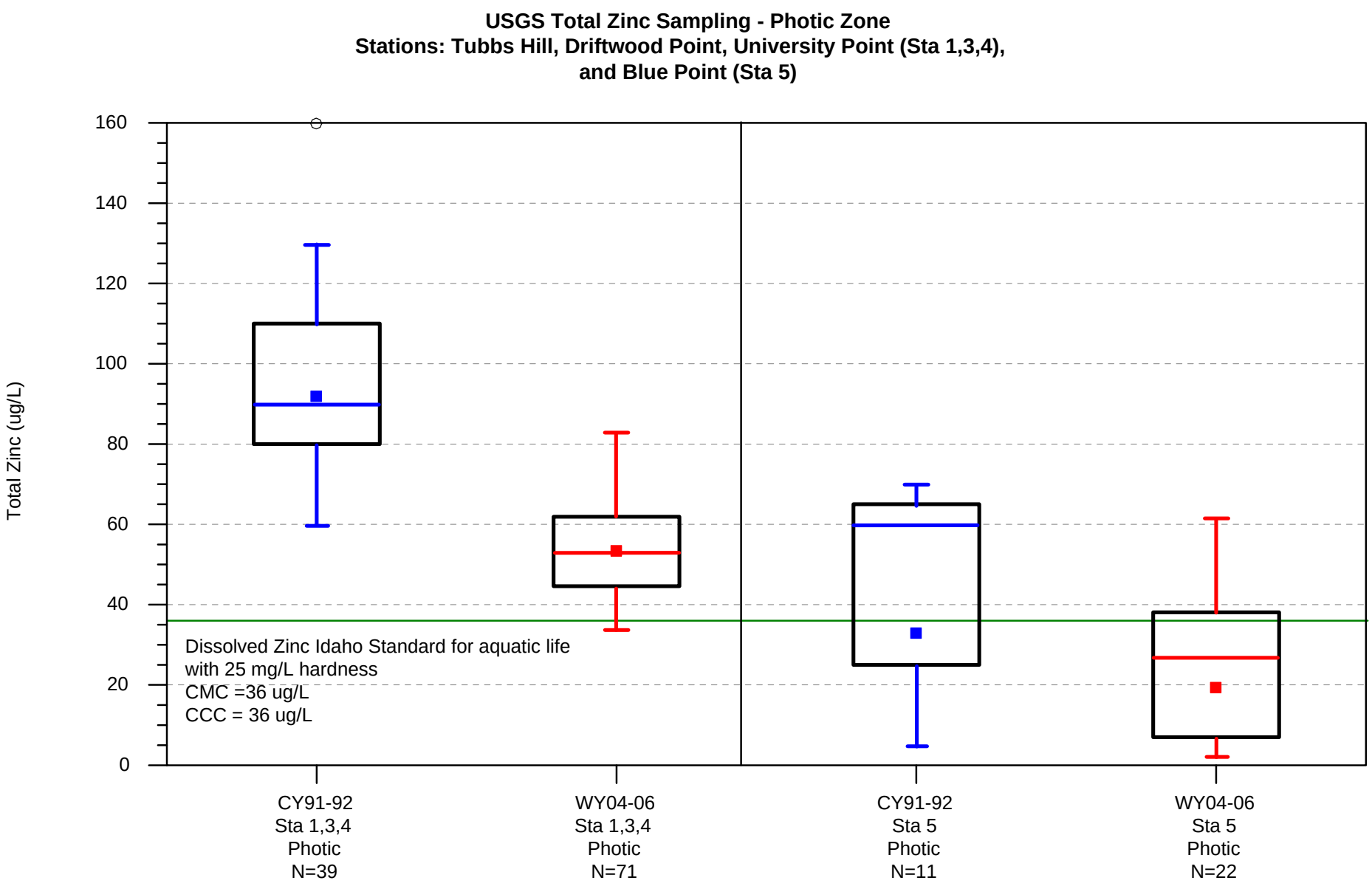


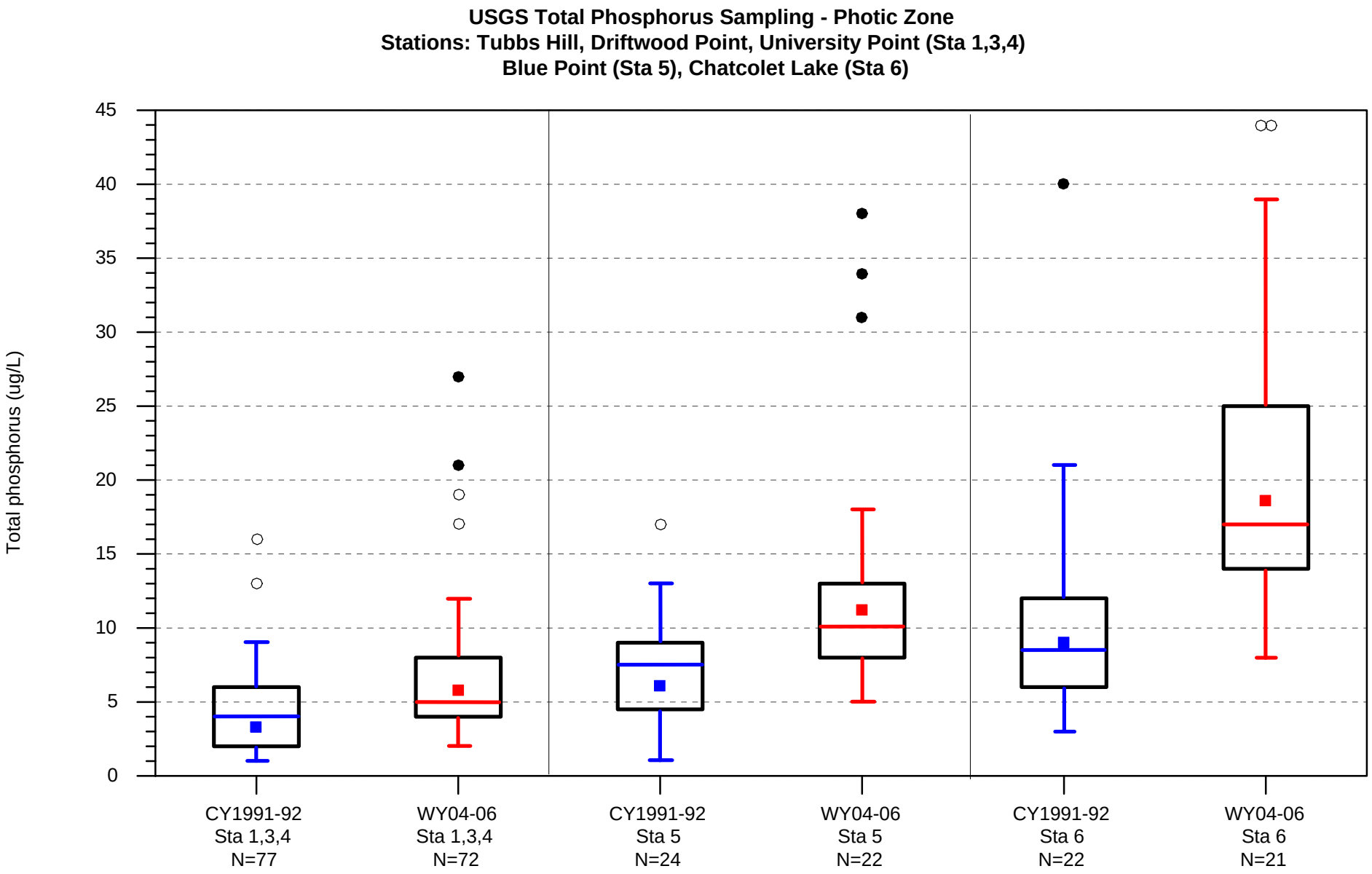
Composite photic zone sample
1.0 - 7 m, in (ug/L)

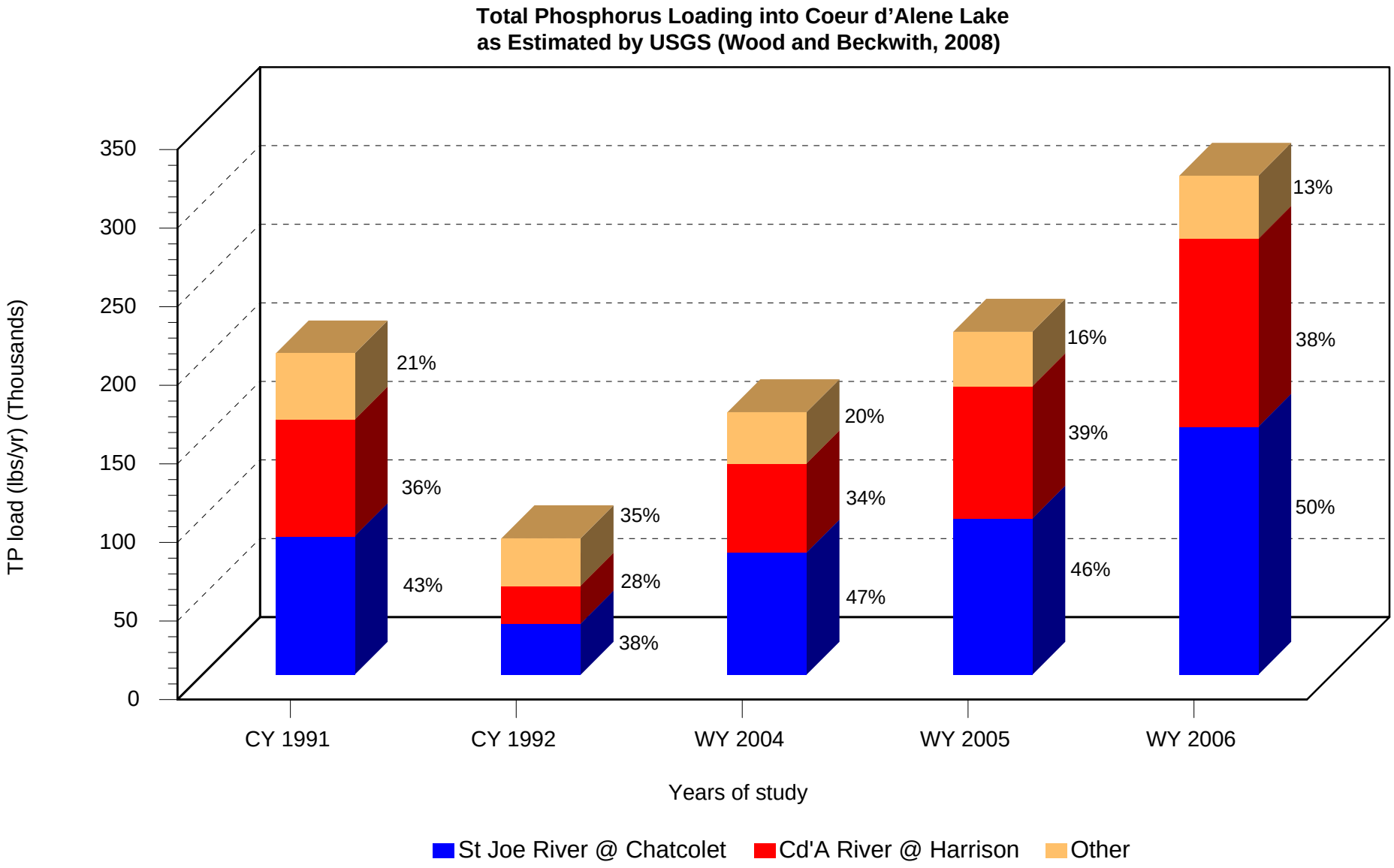
TP =	32
DOP =	7
D. NH_4 =	<10
D. Iron =	35
D. Mn =	10
D. Lead =	< 0.1
D. Arsenic =	0.8

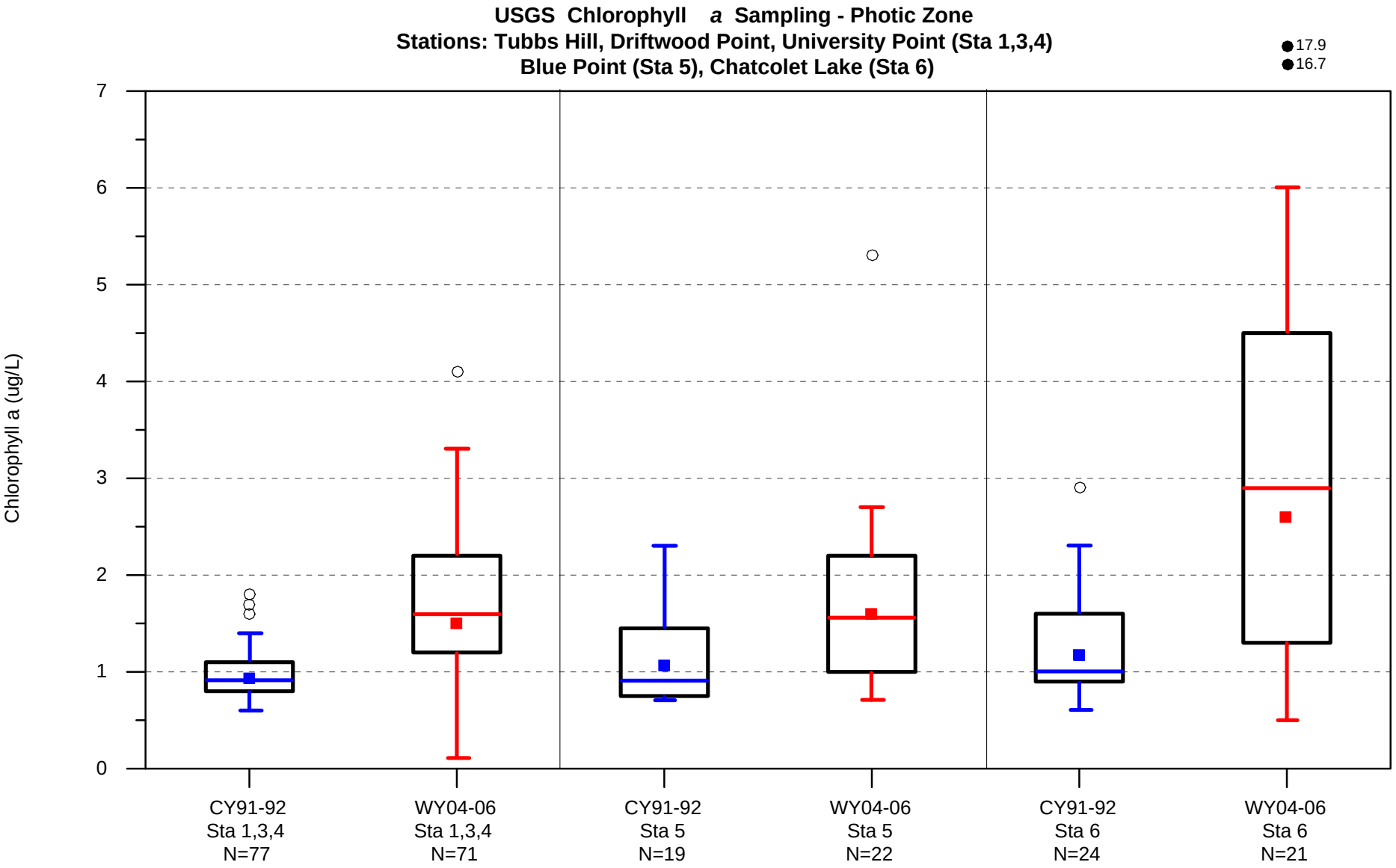
Discrete grap sample
at 10.5 m, in (ug/L)

TP =	490
DOP =	325
D. NH_4 =	7 30
D. Iron =	9,210
D. Mn =	1,790
D. Lead =	<0.1
D. Arsenic =	10.3

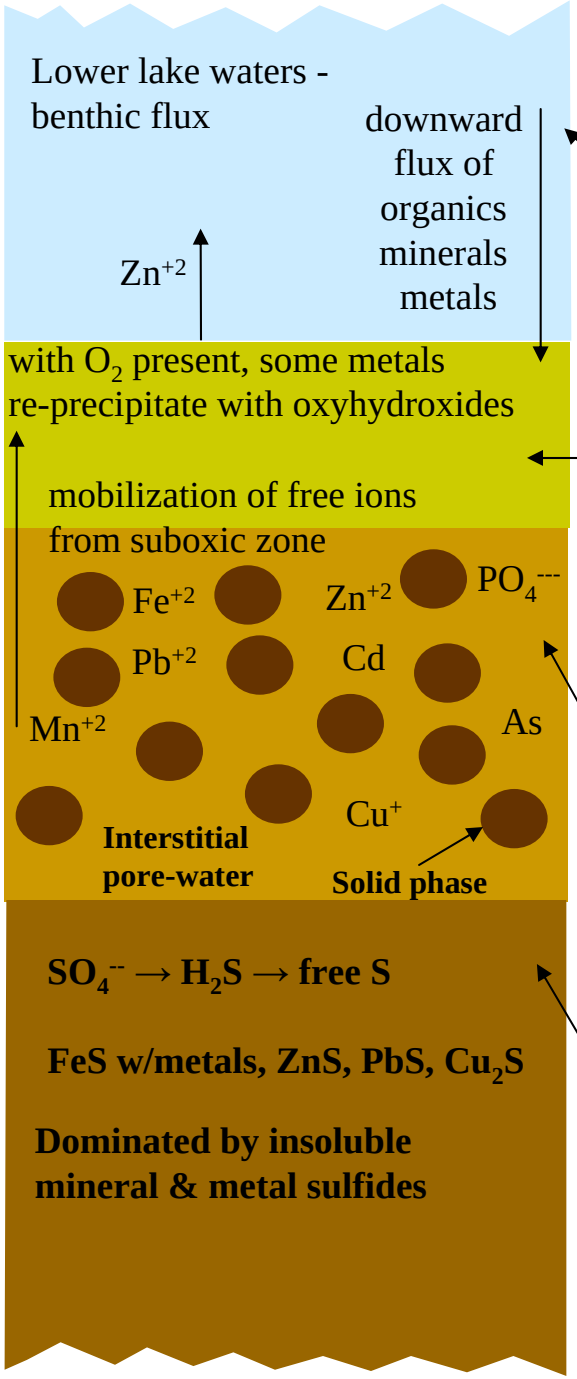

USGS Total Zinc Sampling - Photic Zone
Stations: Tubbs Hill, Driftwood Point, University Point (Sta 1,3,4),
and Blue Point (Sta 5)
Total Zinc (ug/L)
160
140
120
100
80
60
40
20
0
Dissolved Zinc Idaho Standard for aquatic life
with 25 mg/L hardness
CMC =36 ug/L
CCC = 36 ug/L
CY91-92
Sta 1,3,4
Photic
N=39
WY04-06
Sta 1,3,4
Photic
N=71
CY91-92
Sta 5
Photic
N=11
WY04-06
Sta 5
Photic
N=22


USGS Total Phosphorus Sampling - Photic Zone
Stations: Tubbs Hill, Driftwood Point, University Point (Sta 1,3,4)
Blue Point (Sta 5), Chatcolet Lake (Sta 6)
Total phosphorus (ug/L)
45
40
35
30
25
20
15
10
5
0
CY1991-92
Sta 1,3,4
N=77
WY04-06
Sta 1,3,4
N=72
CY1991-92
Sta 5
N=24
WY04-06
Sta 5
N=22
CY1991-92
Sta 6
N=22
WY04-06
Sta 6
N=21


Total Phosphorus Loading into Coeur d'Alene Lake
as Estimated by USGS (Wood and Beckwith, 2008)
TP load (lbs/yr) (Thousands)
350
300
250
200
150
100
50
0
21%
36%
43%
35%
28%
38%
20%
34%
47%
16%
39%
46%
13%
38%
50%
CY 1991
CY 1992
WY 2004
WY 2005
WY 2006
Years of study
St Joe River @ Chatcolet
Cd'A River @ Harrison
Other


USGS Chlorophyll a Sampling - Photic Zone
Stations: Tubbs Hill, Driftwood Point, University Point (Sta 1,3,4)
Blue Point (Sta 5), Chatcolet Lake (Sta 6)
17.9
16.7
Chlorophyll a (ug/L)
0
1
2
3
4
5
6
7
CY91-92
Sta 1,3,4
N=77
WY04-06
Sta 1,3,4
N=71
CY91-92
Sta 5
N=19
WY04-06
Sta 5
N=22
CY91-92
Sta 6
N=24
WY04-06
Sta 6
N=21

Complex Geochemistry of Lake Sediments



Lower lake waters **- in northern pool of Cd'A Lake (hypolimnion) Dissolved Oxygen (DO) > 6.0 mg/L down to the sediments.**

Sediment-water interface **≈ 2 – 5 cm thick – DO present, organic matter present. Inorganic particulates (with associated metals) such as ferric and manganese oxyhydroxides, siderite, sulfides, have low solubility within this zone.**

Microbial degradation of organic matter that settles into lower waters and onto interface is the primary consumptive process of oxygen. The rate of DO depletion is governed by the rates of organic loading to the hypolimnion.

Each year 0.5 – 2 cm of new particulate matter settles on the top of the lakebed, with burial of existing materials.

Suboxic zone **≈ 10 cm thick. Low DO.**
Oxidation of organic materials by bacteria with a sequence of terminal electron acceptors: $O_2 \rightarrow NO_3^- \rightarrow$ Mn oxyhydroxides $\rightarrow$ Fe oxyhydroxides
$Fe^{+3} \rightarrow Fe^{+2}$ & $Mn^{+4} \rightarrow Mn^{+2}$ mediated by metal reducing bacteria
$Fe^{+3} \rightarrow Fe^{+2}$ & $Mn^{+4} \rightarrow Mn^{+2}$ also caused by low redox potentials
Produces dissolution of solids and free ions in pore-water.

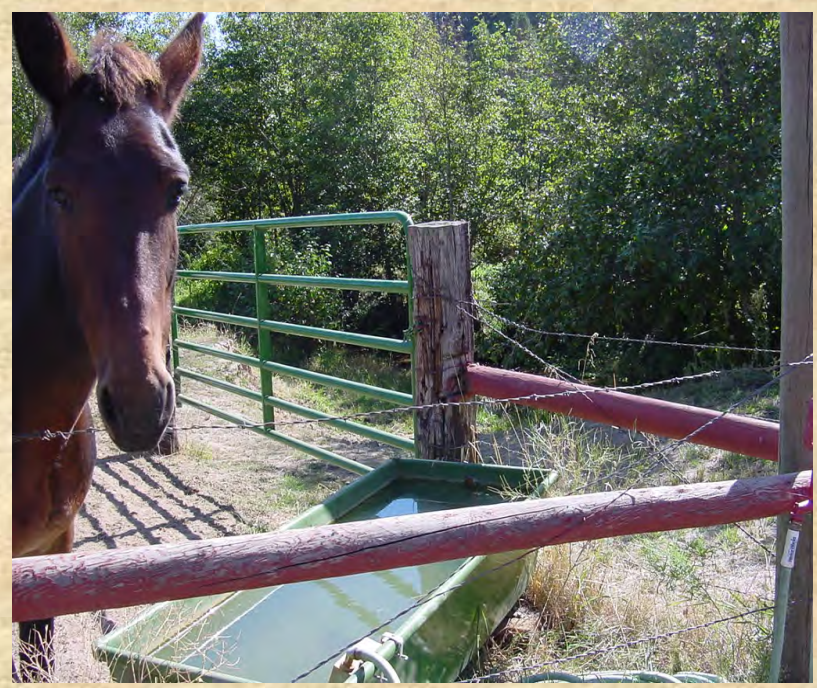
Deep anoxic zone **– no DO – estimated maximum 100 cm thick with metals contaminated sediment.**
$Fe^{+3} \rightarrow Fe^{+2}$ & $Mn^{+4} \rightarrow Mn^{+2}$ and
$SO_4^{--} \rightarrow H_2S \rightarrow$ free S - mediated by sulfate-reducing bacteria
formation of very insoluble FeS w/metals (ferrous), ZnS, PbS, Cu_2S

What can *you* do to help ensure
the quality of the lake?

Leave native vegetation along shorelines

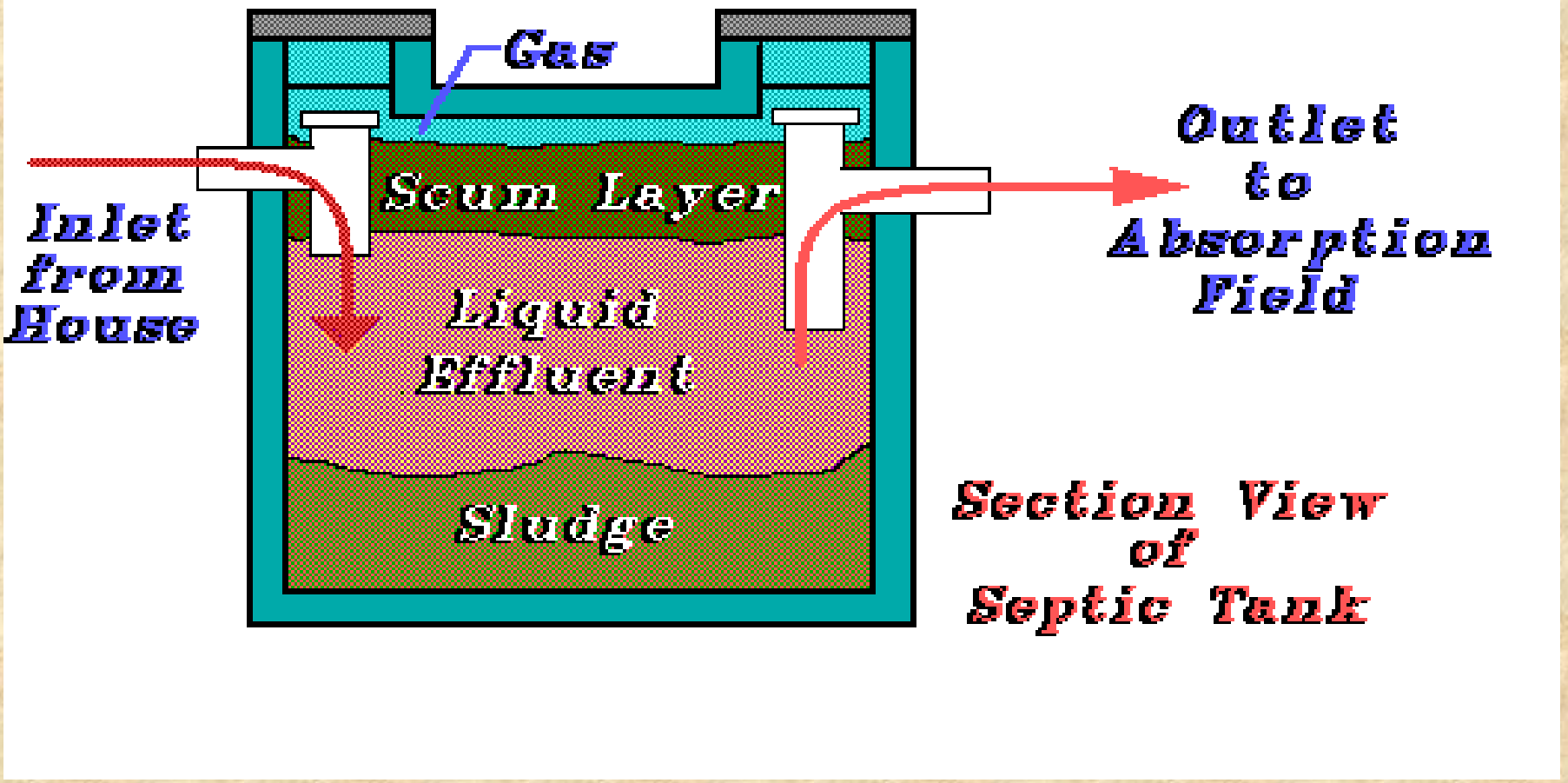
Maintain buffers during construction

Maintain exclusionary fencing



Apply fertilizers and pesticides responsibly

Maintain septic systems & drain fields



Remove vegetation from props