Mercury contamination in the Columbia Basin—Sources and Pathways

October 30, 2007

Columbia Toxics Workgroup

USGS, Tacoma Washington

Sources subgroup– very diverse in terms of expertise as well as organizational representation

- Lorraine Edmond, US EPA, subgroup lead

Subgroup members (alphabetical):

- Linda Bingler, Battelle Pacific Northwest Laboratory
- Brent Foster, Columbia Riverkeeper
- Andrew Kolosseus, Washington Department of Ecology
- Joanne LaBaw, US EPA
- Agnes Lut, Oregon Department of Environmental Quality
- Kevin Masterson, Oregon Department of Environmental Quality
- Jennifer Morace, US Geological Survey
- Sondra Miller, Boise State University
- Elena Nilsen, US Geological Survey
- Helen Rueda, US EPA
- John Sands, US Department of Energy

Objective:

to “inventory and characterize” the potential sources and pathways

- Quantify where possible, but data seldom available to do with any certainty
- Mercury sources as initial focus of investigation
- Look at both “the usual suspects” (originating sources) and the transport pathways

Purpose:

At least two-fold:

- Contribute information on potential contamination sources to the State of the River Report and its supporting appendices

  (This is the most immediate)

- Help focus future toxic reduction efforts

  (this one is ultimately the most important-- if we don't know where it's coming from, we won't know what to do about it)

Specifically, we focused on:

- Point sources (as permitted by NPDES)
- Tributaries (analogous to point sources at mouth)
- Urban / industrial stormwater / non-point source runoff
- Air deposition
- Sediments
- Mining / mineral processing
- “In-place” (hazardous waste) sources

What you won’t get:

What you will get:

Puzzle pieces

- Maps
- Tables
- Graphs
- Summary “bullets”
- Annotated bibliography of information sources

Point sources– “major”

- **There are 26 “major” NPDES point sources that discharge directly to the Columbia**
- **15 industrial**
- **11 municipal**
- **These are thought of as “sources” but are actually also transport pathways**
- **(Keep this in mind when linking to potential toxics reduction activities)**

Point sources, cont'd

- major dischargers in basin = 132
- majors on mainstem = 26
- 70 of the 132 are wastewater treatment plants

The U.S. Environmental Protection Agency (EPA) has compiled this computer representation from data or information sources that may not have been verified by the EPA. This data is offered here as a general representation only, and is not to be re-used without verification by an independent professional qualified to certify such data or information. The EPA does not guarantee the accuracy, completeness, or timeliness of the information shown, and shall not be liable for any loss or injury resulting from reliance upon the information shown.

Columbia River Basin NPDES Dischargers

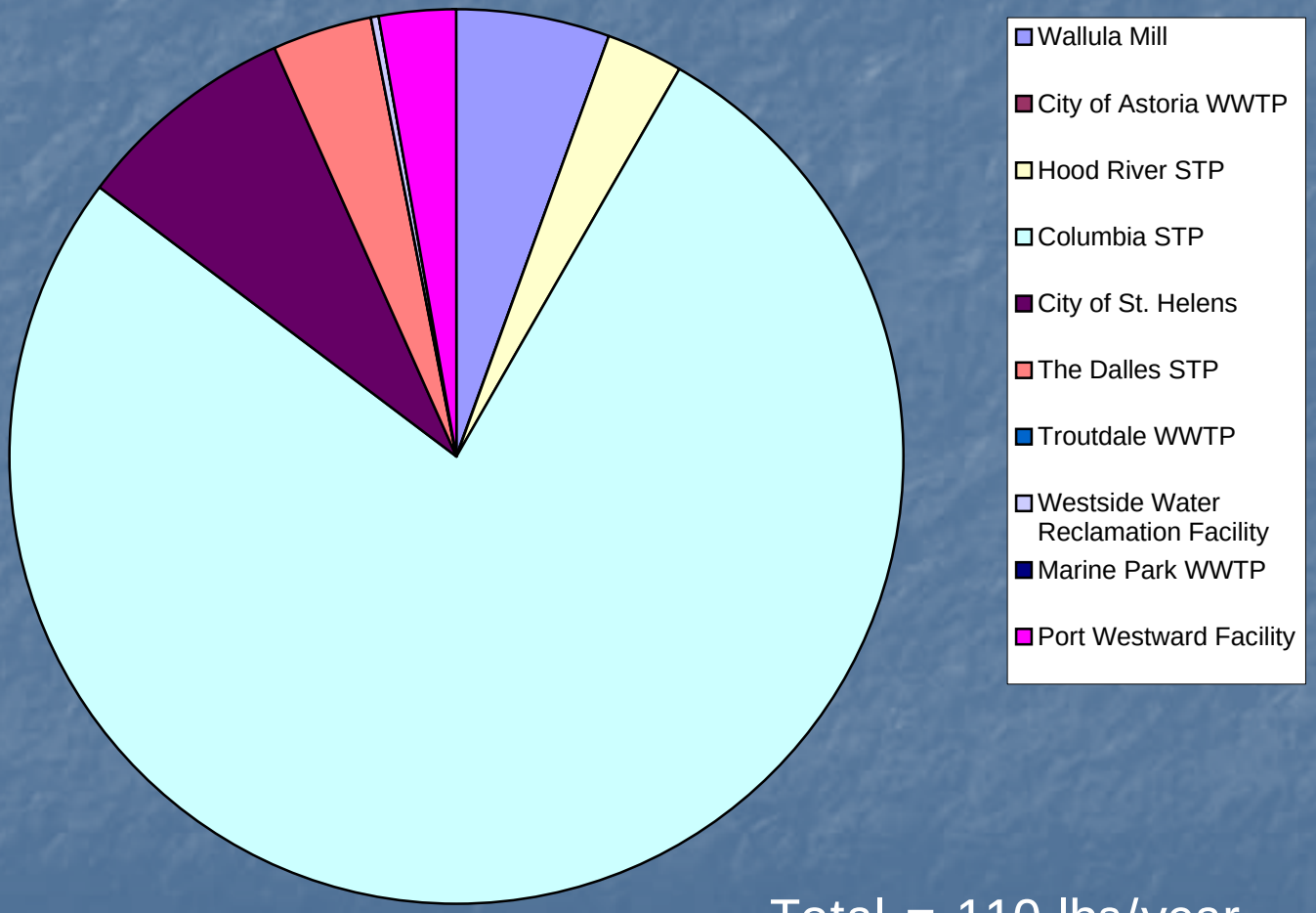
Major Dischargers Along the Columbia River

Legend

- Major Dischargers within 1 Mile of the Columbia River
- Columbia Basin

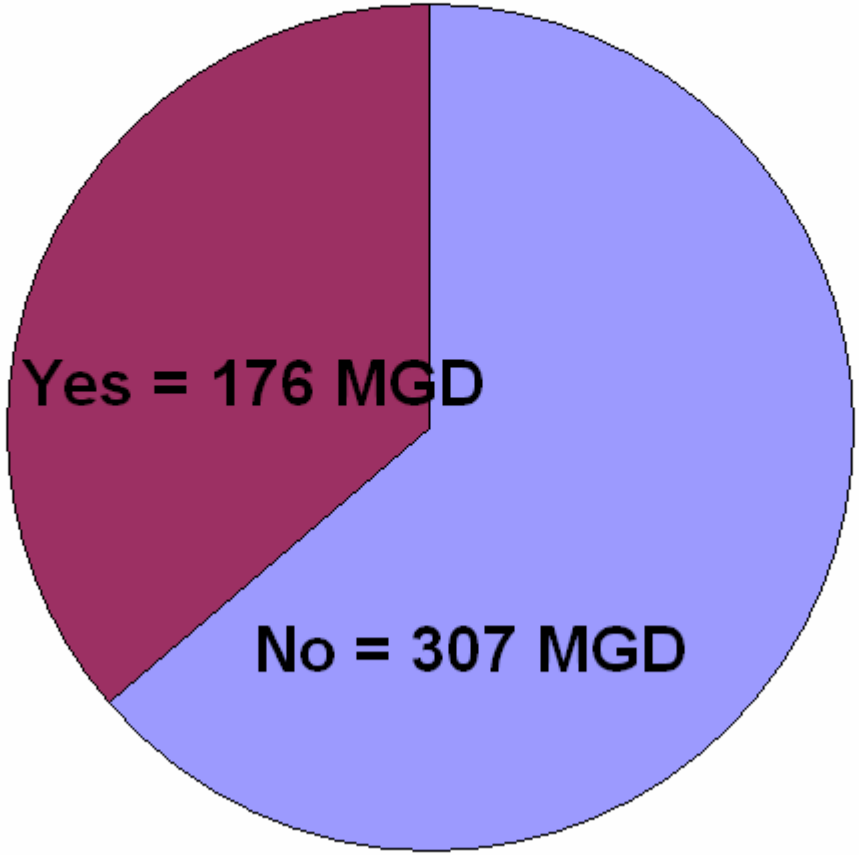
August 2007

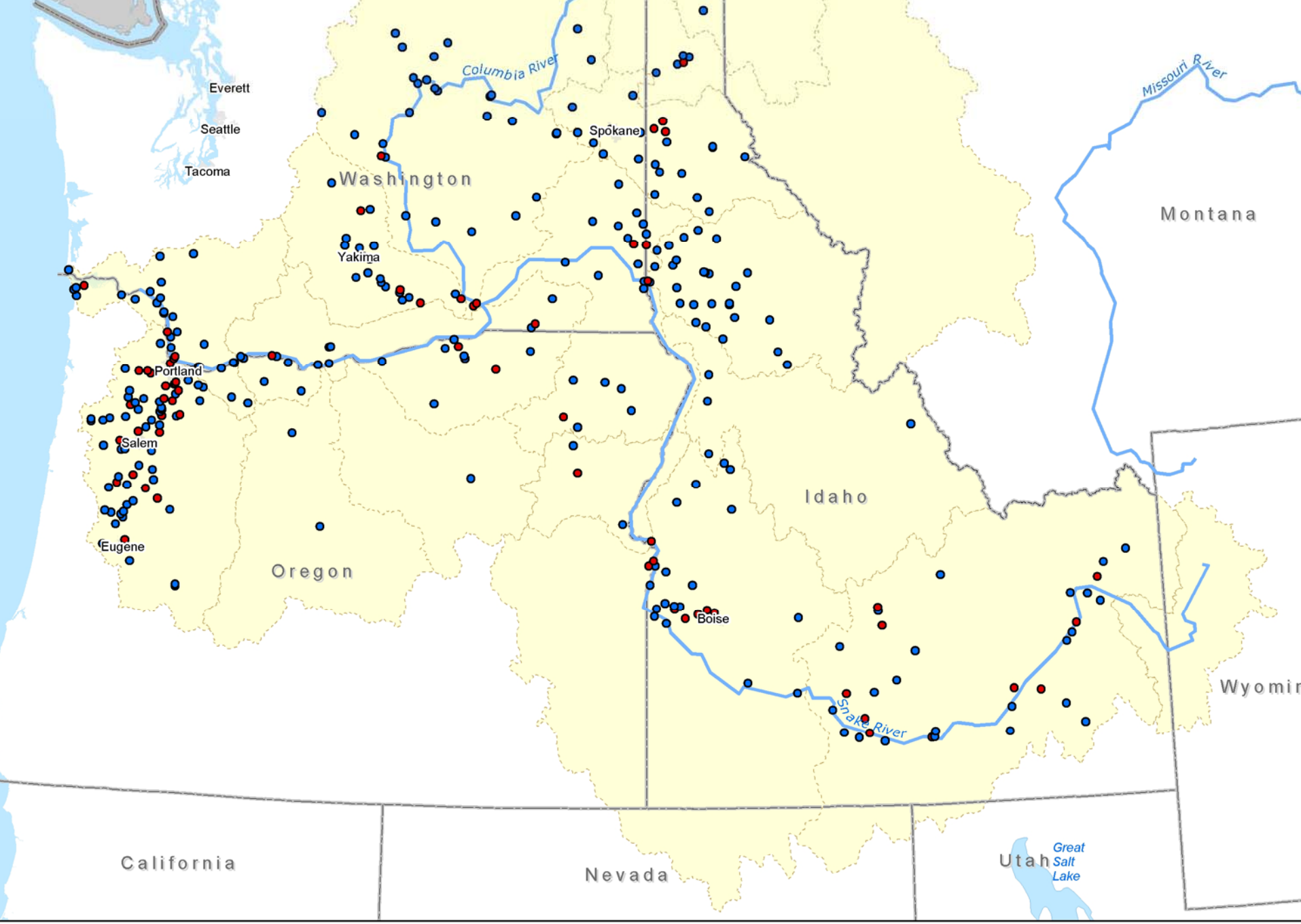
Mercury load from major NPDES dischargers (lbs/year)



Total = 110 lbs/year

Discharge volumes with and without mercury data, millions of gallons/day





Environmental Protection Agency (EPA) has compiled
nter representation from data or information sources that
ave been verified by the EPA. This data is offered here
al representation only, and is not to be re-used without
by an independent professional qualified to verify such

Columbia River

Legend

Wastewater Treatment Plants

Point sources– “minor”

- Minor dischargers in basin = 1797
- “short list” minors in entire basin = 583
  (after eliminating categories that seemed to have low potential to discharge toxic contaminants)
- short list minors within one mile of main stem = 103
- 258 of the 1797 are wastewater treatment

Environmental Protection Agency (EPA) has compiled
nter representation from data or information sources that
ave been verified by the EPA. This data is offered here
al representation only, and is not to be re-used without
by an independent professional qualified to verify such

Columbia River Basin

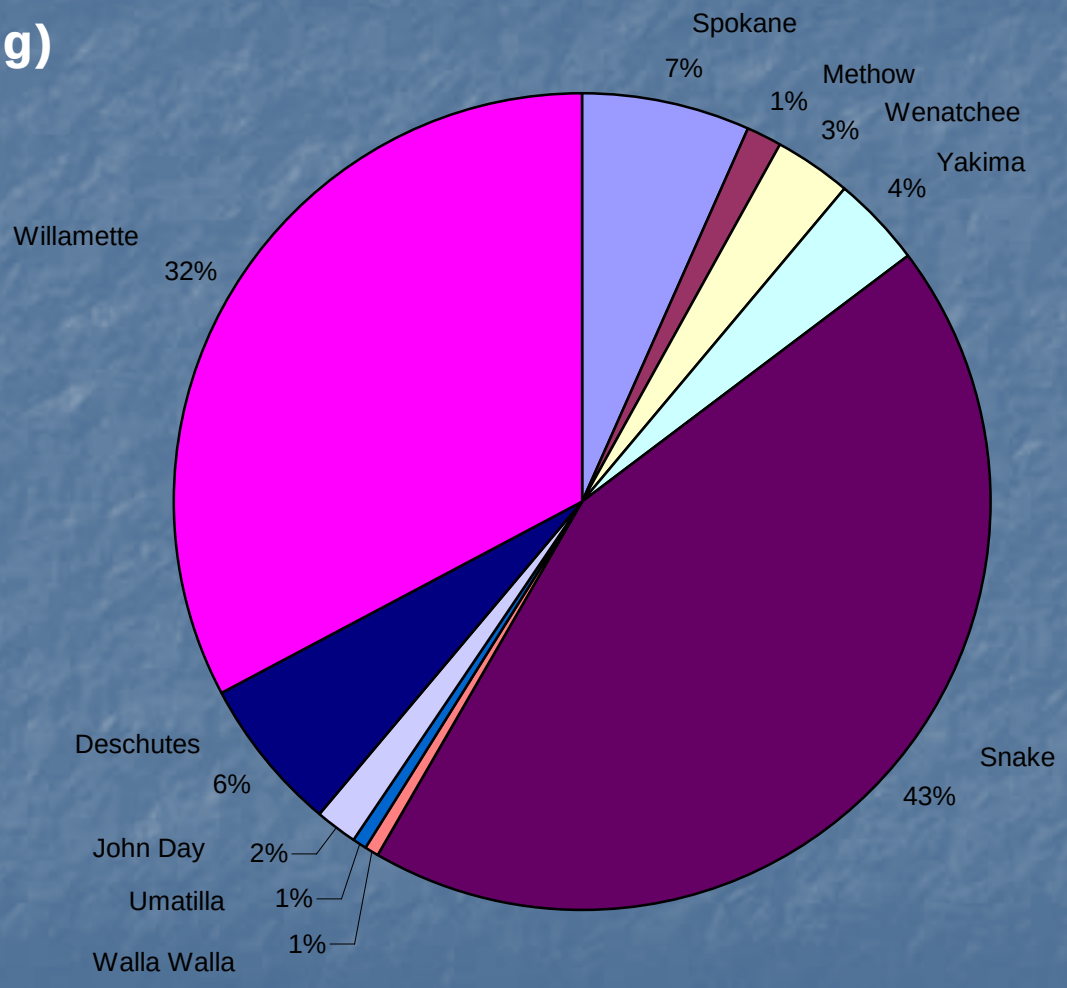
Legend

Minor Dischargers within 1

N
W E

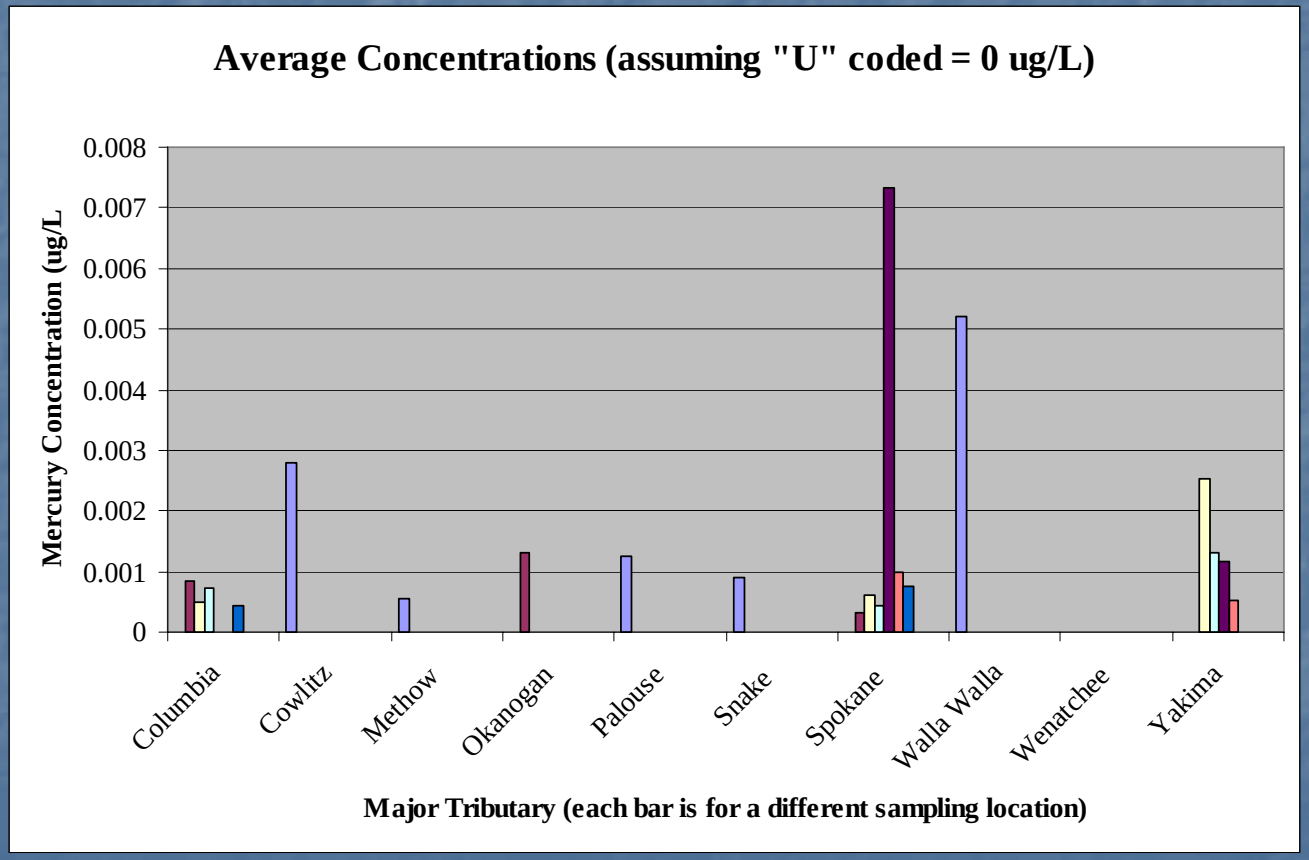
Tributary contribution to Columbia (USGS data, 2000) Spokane to Willamette

(Flow, not Hg)



Data from Dan Wise, USGS, 2007

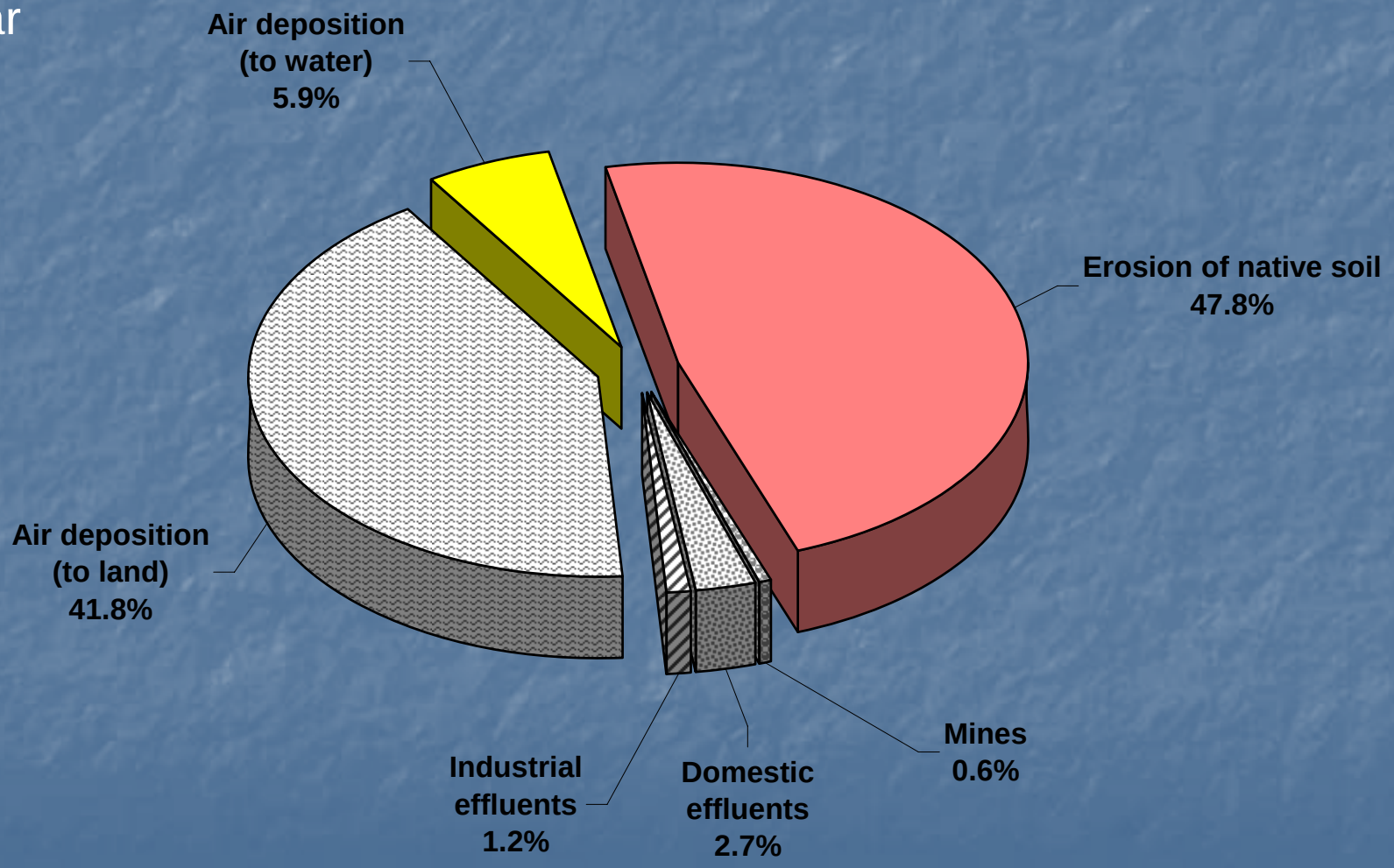
Mercury in Washington tributaries



Washington tributaries, Conclusions:

- The biggest problems with analyzing data are the lack of data and high MDLs.
- Average mercury concentrations ranged from 0.5-7 ng/L in the 9 largest tributaries with data (water quality standard is 12 ng/L; n=330 but only 100 without U-codes)
- The Spokane River had some of the highest concentrations, but also had some of the lowest.
- Depending on how you treat U-coded data, the Columbia River itself has less Hg (if U=0), about the same Hg (if U-coded data deleted), or more Hg (if U=MDL) than the tributaries.

From Willamette TMDL: An average of 126.8 kg (279 lbs) of total mercury is estimated to be discharged by the Willamette into the Columbia River each year



Surface runoff

- Urban stormwater (point and nonpoint discharge)

  Some is regulated, some isn't. Even where there are permits, there is not a general requirement for toxics monitoring. They may monitor for some metals, but probably not at very low detection limits.

  We can inventory the number of permitted stormwater discharges in the basin. Most are general technology-based permits. May have to do the inventory by county, depending on how the state databases are organized.

Surface runoff, cont'd

Stormwater runoff from non-urban lands (non-point discharge)

Recent (and regional) sources of information

- Puget Sound toxics loading analysis
- Willamette River mercury TMDL

Surface runoff, Puget Sound example

- Concentrations of mercury in stormwater by land use (ug/l)

  0.3 (commercial/industrial),
  0.03 (residential), and
  0.005 (open)

  Multiplied by discharge to yield loads (metric tons per year)

  0.35 (commercial/industrial)
  0.083 (residential), and
  0.25 (open) totaling 0.68 metric tons/year

  or 1500 pounds/year

Surface runoff, Puget Sound example, cont'd

- Conclusion: Mercury runoff loadings are relatively evenly distributed between developed and undeveloped areas, and are much more significant contributors to the total load than point source discharges, including CSOs.

- Note: in this analysis, they look at runoff as a pathway, regardless of its initial source so quantity includes atmospheric mercury, mercury naturally present in soils, and any other mercury that finds its way into runoff

Surface runoff, Puget Sound example, cont'd

- Important caveat:
- "Our understanding of the relationships between land use and toxic chemical loadings from runoff may be inadequate to provide sufficiently credible guidance for developing control actions..."
- The conclusions also point to the need for more data—on mass loading from specific locations, as well as on "the relative importance of atmospheric deposition on concentrations in runoff from undeveloped land uses."

Runoff-- Willamette TMDL example

- Non-point source runoff was the dominant source of Hg to the watershed
- TMDL broke that down into two sources:

  Hg whose source was air deposition

  Hg whose source was native soils

Willamette TMDL example, cont'd

- To estimate the amount of Hg-containing soil moving into the watershed, had to assume a delivery ratio
- Used 20% for the Willamette, (literature values range from 5% tp 40%)
- Important to note: not a lot of this work has been done in high desert basins, most comes from studies in Florida or northern temperate climates
- Soil loss rates were used from extensive data from NRCS in Willamette, were not desert soils
- Had a single estimate of average native soil Hg from a MS thesis

How can these projects compare/contribute to our understanding of the Hg sources to the Columbia River?

- For urban areas, could use runoff concentrations from the projects west of the Cascades (Puget Sound, Willamette, new data from Portland Harbor)
- We have land cover areas and urban land use proportions from GIS for the basin and can compare those to Puget Sound and Willamette basins

However... we don’t have:

Discharge volumes suitable for the Columbia

(climates on west side is too different to extrapolate)

Delivery coefficients for how much soil is delivered to streams

factors include :

soil erodibility,

vegetation cover,

slope,

rainfall patterns

So what can we do to estimate the relative importance of the runoff sources?

- Take a closer look at the puzzle pieces we have, look at similarities and differences, make comparisons to Puget Sound and Willamette approaches and conclude something about how different or similar the Columbia should be.

Air deposition

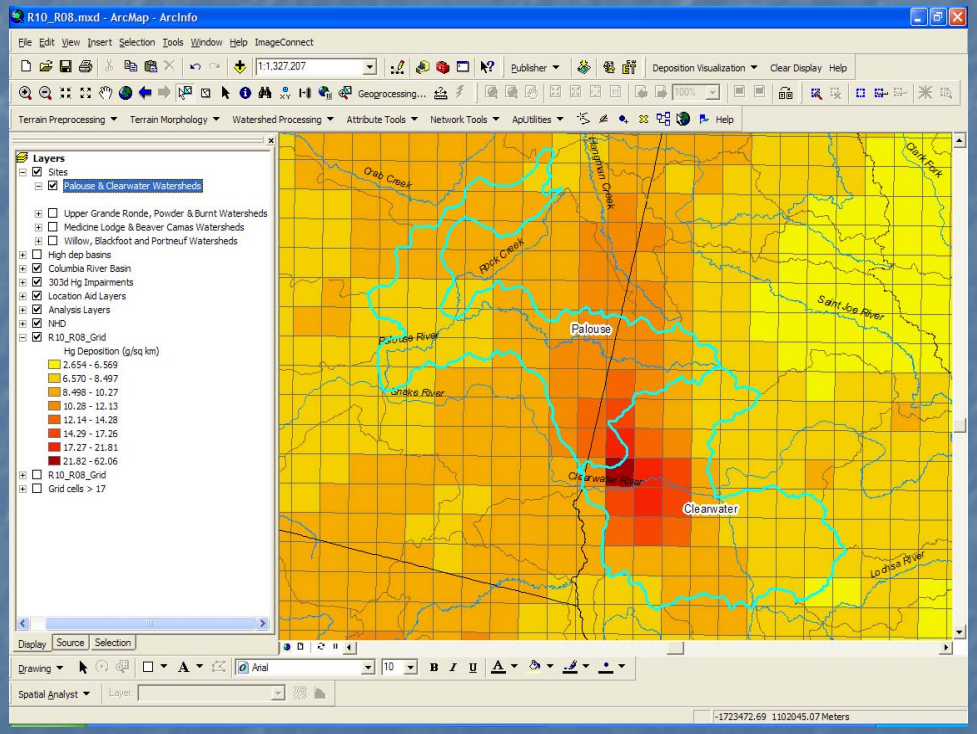
- Primary data source is Regional Modeling System for Aerosols and Deposition (REMSAD) data developed by EPA Office of Water
  - REMSAD model can provide estimate of total Hg air deposition in the Columbia Basin and estimates of the top 3 sources within defined geographic units within the Basin
  - The model uses monitoring and emissions inventory data for numerous point sources inside and outside of the Basin, as well as estimates for deposition from global background sources
  - Using current data, the estimate of total Hg deposition in the Columbia Basin = 29,568 pounds per year

Air deposition, cont'd

- New data showing higher Hg emissions from Ash Grove Cement (Durkee, OR) and the Nevada gold mines is now being added to the model, which will result in an upward revision of Columbia air deposition estimates

- Useful to focus model on smaller geographic units within the Basin (e.g., watersheds and sub-watersheds) to gain a better understanding of localized impacts of mercury deposition

Example of REMSAD output from one watershed that shows contributions from two regional sources

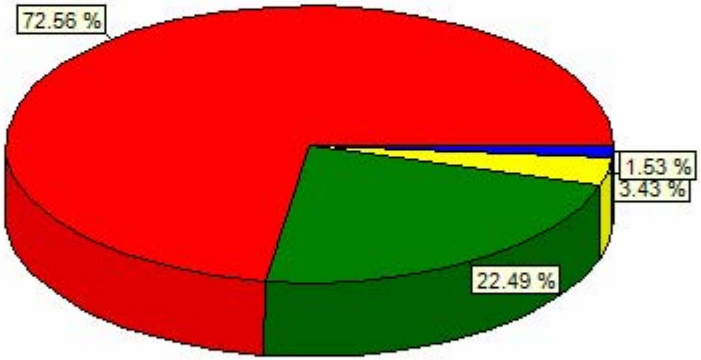


Deposition Chart

Mercury deposition from selected sources (grams)

Total mercury = 470,897.6 g
Total Area = 22,955.53 Sq km

BG_Avg_of_CTM-GRAHM-GEOSCHEM_Boundary	341,674.671
ID_Potlatch_Corp_ID_Division-Pulp_and_Paperboard	105,892.788
Other sources	16,129.78
OR_Ash_Grove_Cement_Company	7,200.373



Other data sources on mercury air deposition include:

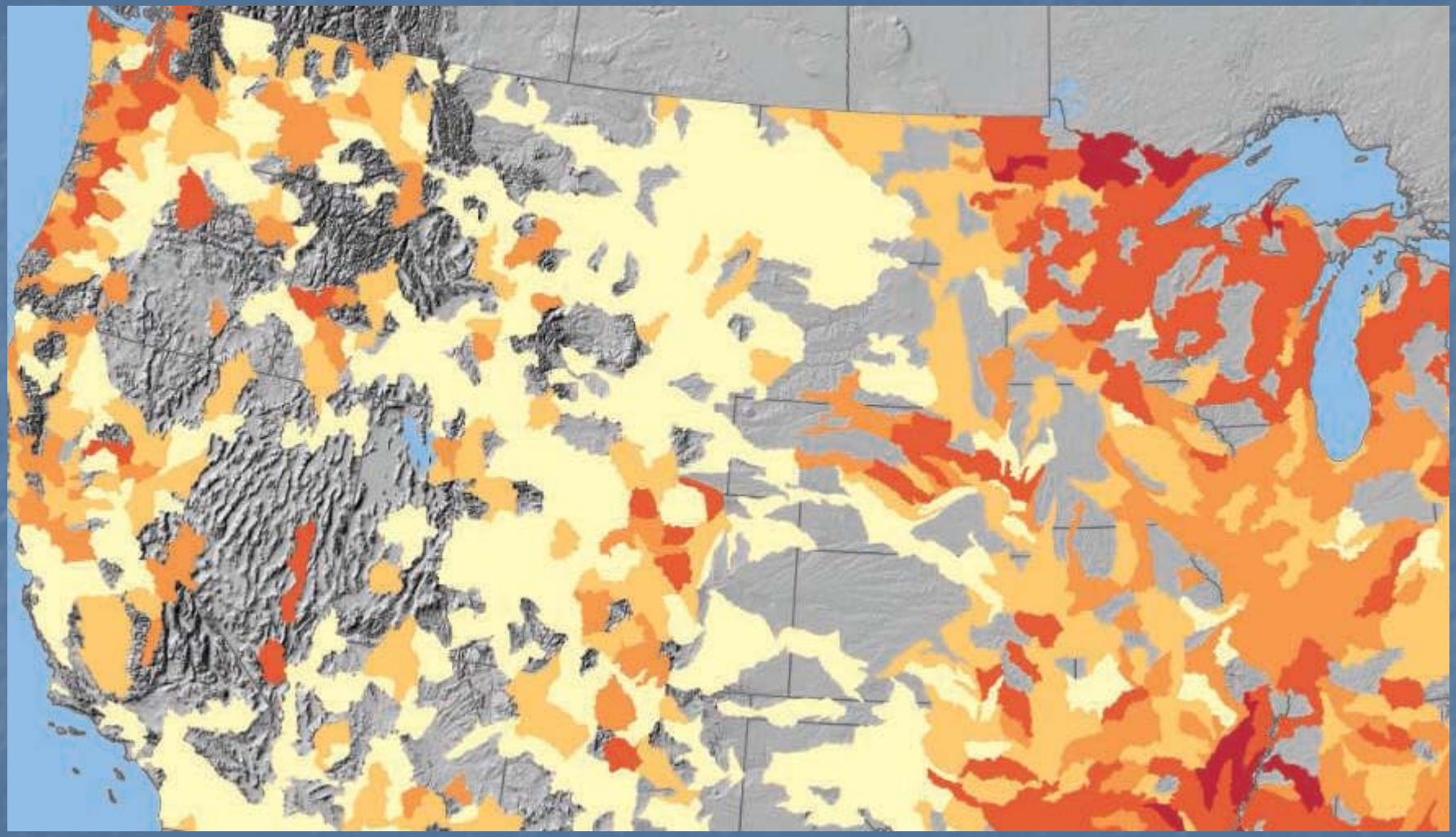
- TRI data
  - Provides estimated mercury emissions from a limited number of industrial sources in Region 10
- Willamette Basin (OR) Mercury TMDL estimates
  - Approximately 48% Hg loading into the Willamette River comes from air deposition (12.5% of which is direct deposition to water), while most of the remaining load comes from erosion of native soils
- Recent study of on mercury emissions from wildfires *(National Center for Atmospheric Research)*
  - 30% of all human-caused Hg deposition in the US estimated to be from wildfires → re-emitting Hg after it falls from other sources

Some remaining questions about Hg air deposition in the Columbia Basin:

- How much of the mercury deposited in the Basin falls directly into tributaries and the mainstem?
- Besides direct deposition, what are the loading pathways to tributaries and mainstem from mercury air deposition sources?
- How much of the mercury deposited to land in the Basin makes it to the tributaries and the mainstem over a 10, 20, 50-year time frame?
- What is the magnitude of mercury air deposition from regional sources within specific areas of the Basin or segments of the river?

Methylation potential

- Ongoing USGS project to evaluation methylation potential for the US
- Map derived from >55,000 water quality sites and 2500 watersheds
- The map presents a Hg sensitivity score at the HUC-8 scale based on both ambient water chemistry and soils/wetlands density. The water chemistry constituents considered are pH, sulfate and organic carbon.
- Darker color represents an ecosystem more sensitive to methylation
- Data source: Nate Booth, USGS Mercury Study Team



Sediments as a source of mercury

- Literature – Little data available directly related to main stem Columbia River sediments.
  - 2003 Washington State Department of Ecology Study above four lower Columbia River Dams examining contribution from Hanford – downriver pools higher median mercury concentrations; no direct correlation of metals to Hanford as source.
  - 2006 EPA Region 10 study upper Columbia River site – sampling in 2005, Marcus Flats; surficial and cores; 68 to 84% detection in whole sediment samples.
  - 2002 USGS study of Lake Roosevelt – six sediment cores within lake; vertical distributions increase with depth.
  - 2007 EPA Region 10 study mid-Columbia (in prep) – surface grabs collected 2004

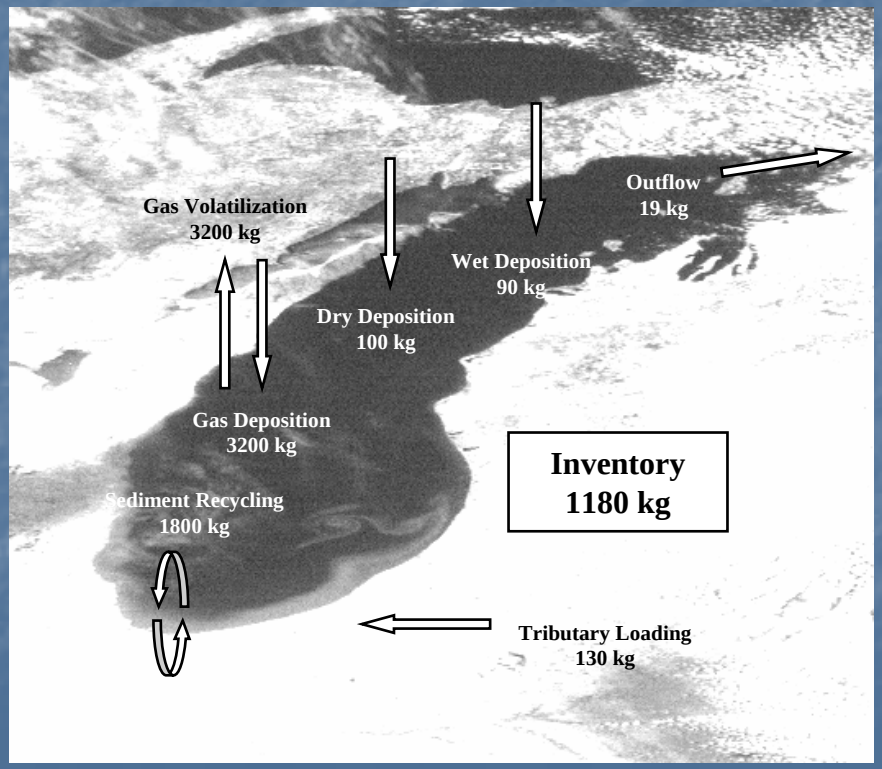
Sediments, cont'd

- Mercury in sediments most directly related to historic discharges (i.e. seasonal runoff, waste water treatment plant discharge)
- Mercury in sediments likely to be buried beneath "cleaner" sediments
- Potential for reintroduction of mercury from sediments due to re-suspension caused by flow changes.

Relative Contributions--- (PCB example)

As a reference, this figure shows an accounting of the major sources and sinks of PCBs in Lake Michigan, highlighting the relative importance of each environmental compartment

(values reported are independent of each other– not a mass balance)

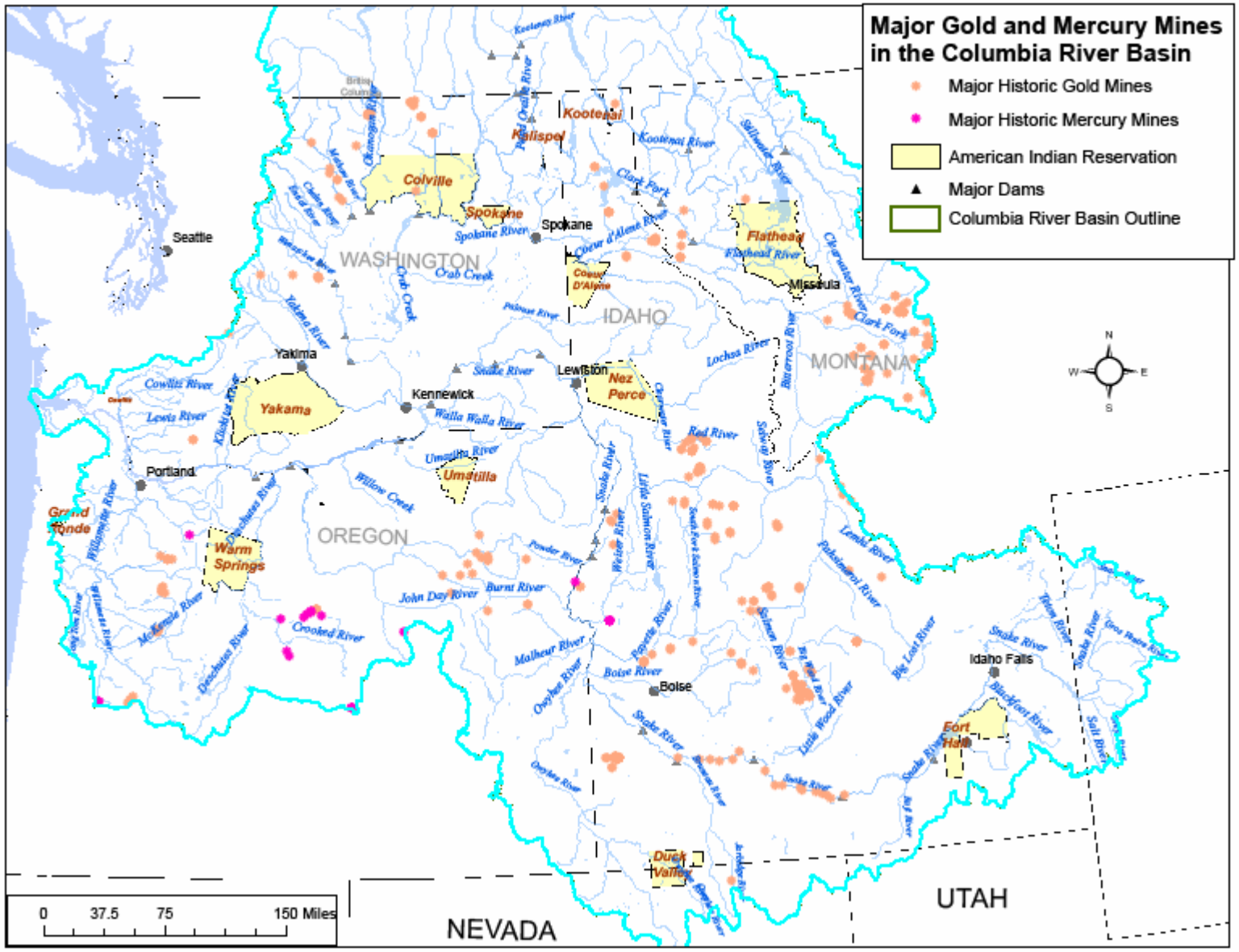


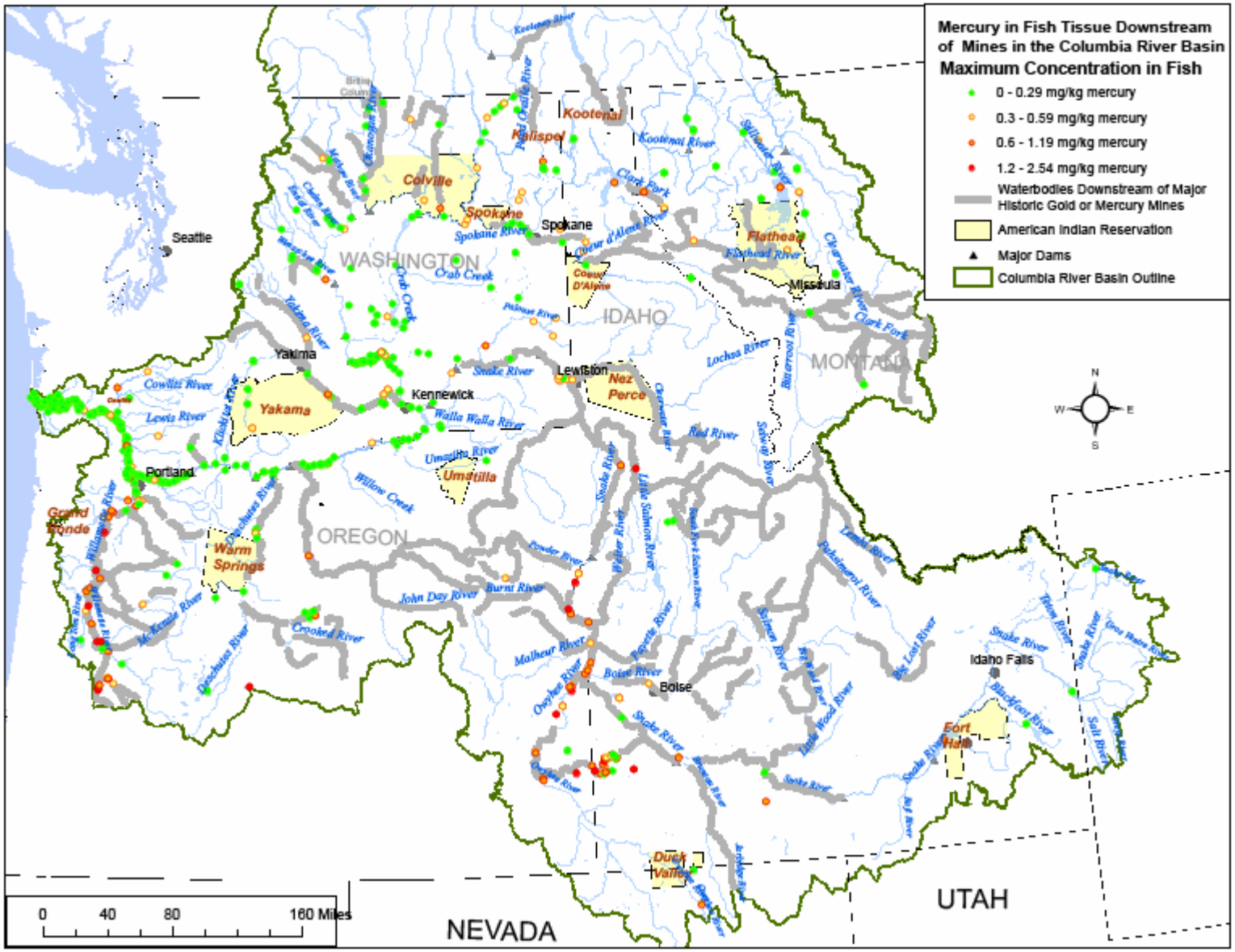
Mining / mineral processing

Inventory of mining projects:

- USGS database (MRDS) is one source of inventory information:
- 222 major gold mines
- 14 major mercury mines

- Some sources are well-studied while others are not much more than locations and some production information.


Major Gold and Mercury Mines in the Columbia River Basin
Major Historic Gold Mines
Major Historic Mercury Mines
American Indian Reservation
Major Dams
Columbia River Basin Outline
WASHINGTON
IDAHO
MONTANA
OREGON
NEVADA
UTAH
Seattle
Spokane
Kootenai
Kalispel
Colville
Spokane
Coeur D'Alene
Flathead
Missoula
Yakima
Yakama
Kennewick
Lewiston
Nez Perce
Portland
Grand Ronde
Warm Springs
Umatilla
Boise
Idaho Falls
Fort Hall
Duck Valley
0 37.5 75 150 Miles
N
S
E
W


Mercury in Fish Tissue Downstream of Mines in the Columbia River Basin
Maximum Concentration in Fish
0 - 0.29 mg/kg mercury
0.3 - 0.59 mg/kg mercury
0.6 - 1.19 mg/kg mercury
1.2 - 2.54 mg/kg mercury
Waterbodies Downstream of Major Historic Gold or Mercury Mines
American Indian Reservation
Major Dams
Columbia River Basin Outline
WASHINGTON
IDAHO
MONTANA
OREGON
NEVADA
UTAH
Seattle
Spokane
Missoula
Yakima
Kennewick
Lewiston
Portland
Boise
Idaho Falls
Kootenai
Kalispel
Colville
Spokane
Flathead
Coeur D'Alene
Yakama
Nez Perce
Umatilla
Warm Springs
Grand Ronde
Fort Hall
Duck Valley
0
40
80
160 Miles
N
S
E
W

Mining, cont'd

- Idaho Geological Survey has provided information on some specific mines with potential to release mercury
  - Idaho Almaden mine, near Weiser, largest Hg producer in Idaho
  - Mines near Silver City, Owyhee Mountains, released Hg from amalgamation process

Mining/mineral processing sources overlap with many of the other sources/pathways

- Some historic mines (gold mines or mercury mines) known to release mercury may be captured under Superfund projects

Upper Columbia project (not "NPL-listed" but a large Superfund project)

Primary source is the Cominco smelter at Trail BC, known to release mercury, releases have been quantified

Black Butte Mine, Oregon (an Emergency Response cleanup has been completed, but further work will be required)

300,000 cubic yards of tailings, some in creek

Mining, cont'd

- Other mines with mercury releases have been studied as the result of investigations related to TMDLs

- Jordan Creek, Oregon
- Bohemia District, Oregon

Mining, cont'd

- Current mining / air sources

  Nevada gold mines emit mercury to the air as a result of their ore roasting process and are some of the important sources being quantified for the air deposition modeling.

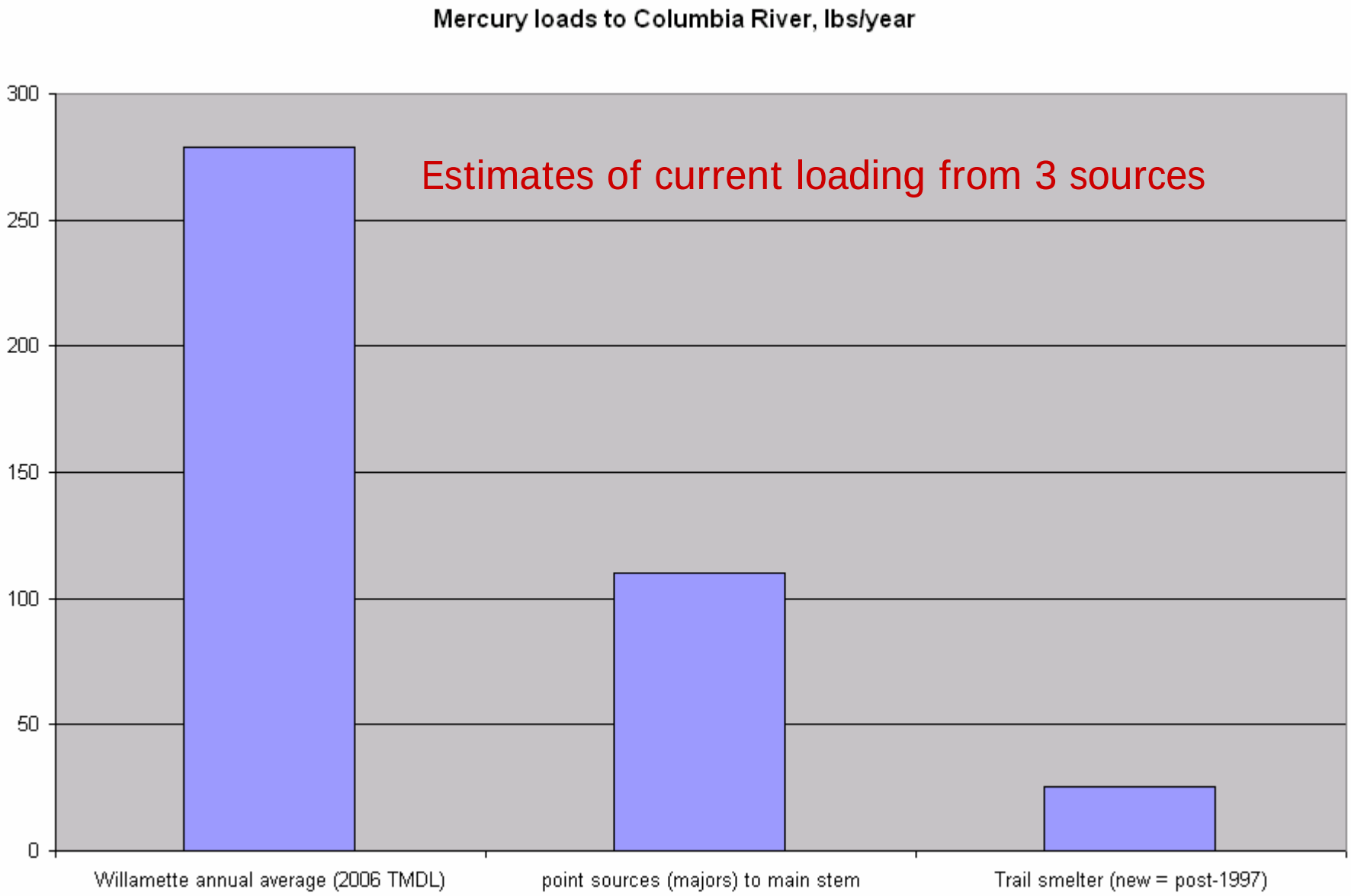
  These have been implicated as sources for mercury showing up in fish tissue in Idaho reservoirs

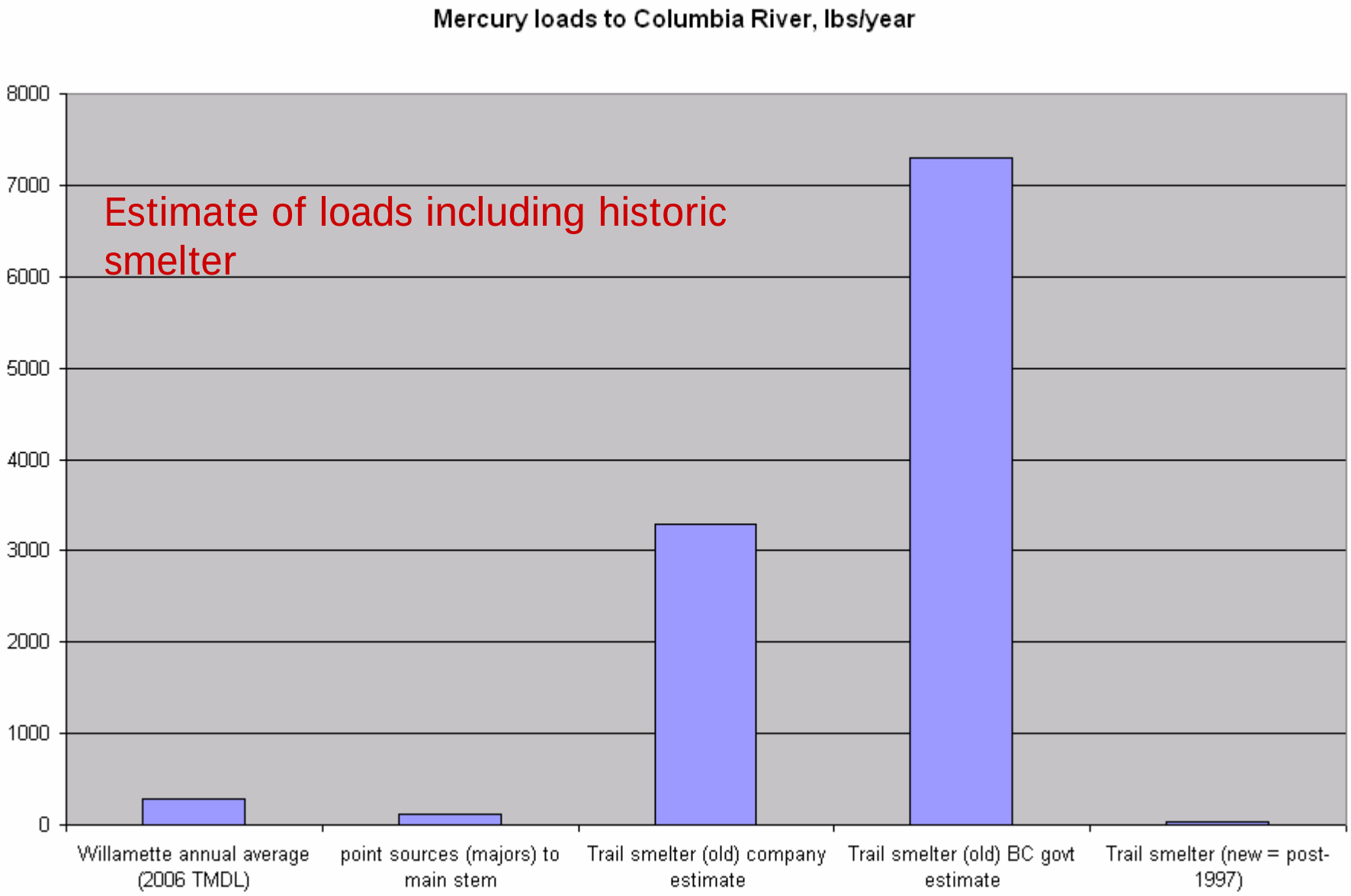
Potential "In-place" sources of Hazardous Wastes:

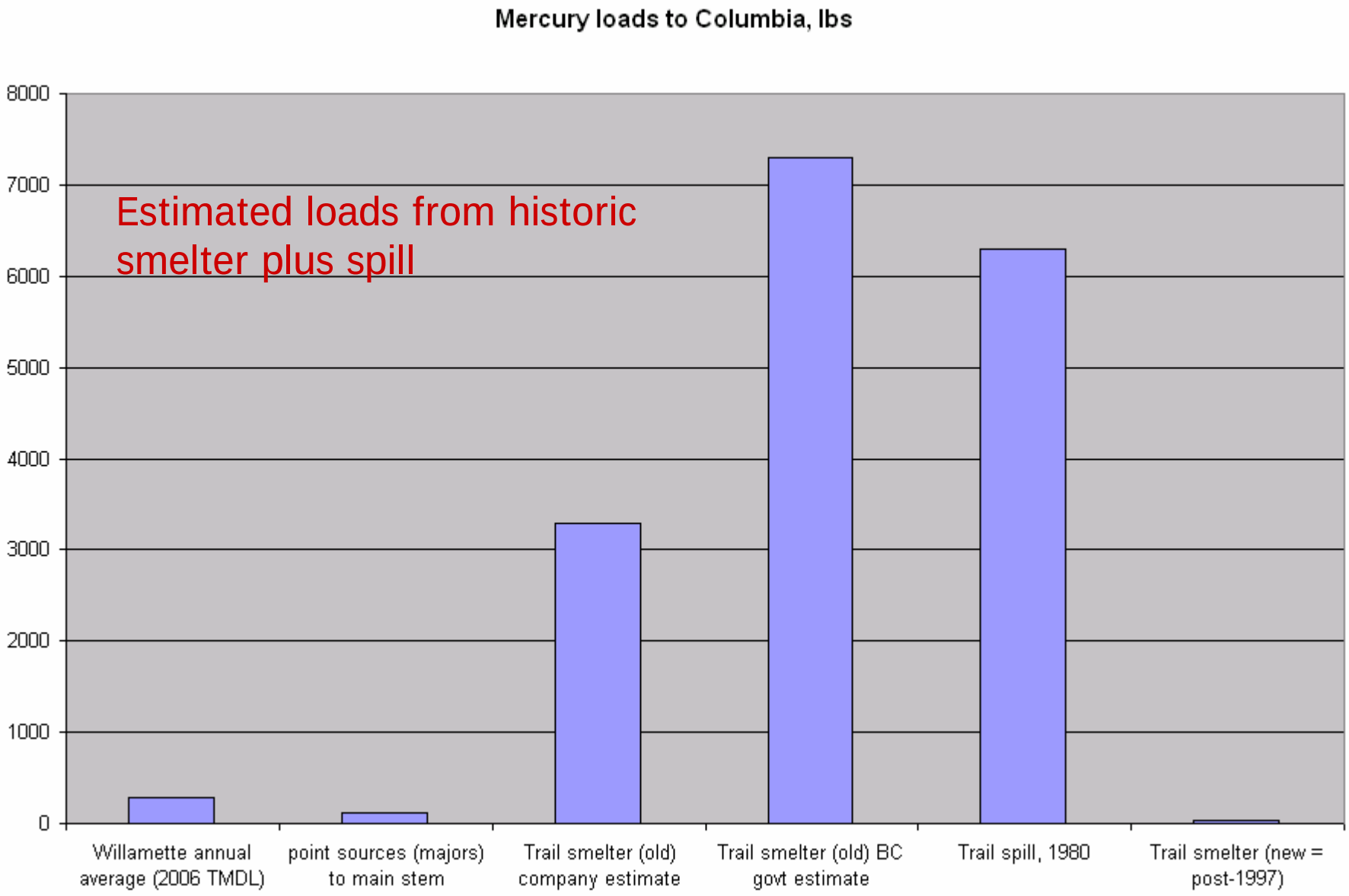
- **EPA/CERCLIS sites**
  - **Active Superfund sites (40)**
  - **Sites that are currently undergoing investigation/cleanup**
- **Sites that still require assessment**
- **RCRA Sites**
  - **Approximately 56 large quantity generators that have mercury waste (2005)**
- **State-lead Clean up sites in Washington & Oregon**

  (approx 650 in OR + WA state databases)

There are some things we can quantify for the sake of comparison:


Mercury loads to Columbia River, lbs/year
Estimates of current loading from 3 sources
300
250
200
150
100
50
0
Willamette annual average (2006 TMDL)
point sources (majors) to main stem
Trail smelter (new = post-1997)


Mercury loads to Columbia River, lbs/year
8000
7000
6000
5000
4000
3000
2000
1000
0
Estimate of loads including historic smelter
Willamette annual average (2006 TMDL)
point sources (majors) to main stem
Trail smelter (old) company estimate
Trail smelter (old) BC govt estimate
Trail smelter (new = post-1997)


Mercury loads to Columbia, lbs
Estimated loads from historic smelter plus spill
8000
7000
6000
5000
4000
3000
2000
1000
0
Willamette annual average (2006 TMDL)
point sources (majors) to main stem
Trail smelter (old) company estimate
Trail smelter (old) BC govt estimate
Trail spill, 1980
Trail smelter (new = post-1997)

Summary of significant data gaps

- Point sources
  - Many with no toxics data, most with inadequate reporting limits, minor point sources not characterized at all
- Tributaries
  - Many with no toxics data, most with inadequate reporting limits
- Runoff
  - Lacking spatially-explicit information on delivery rates, soil concentrations
- Atmospheric deposition
  - Emissions sources not well quantified, need links to erosion, methylation

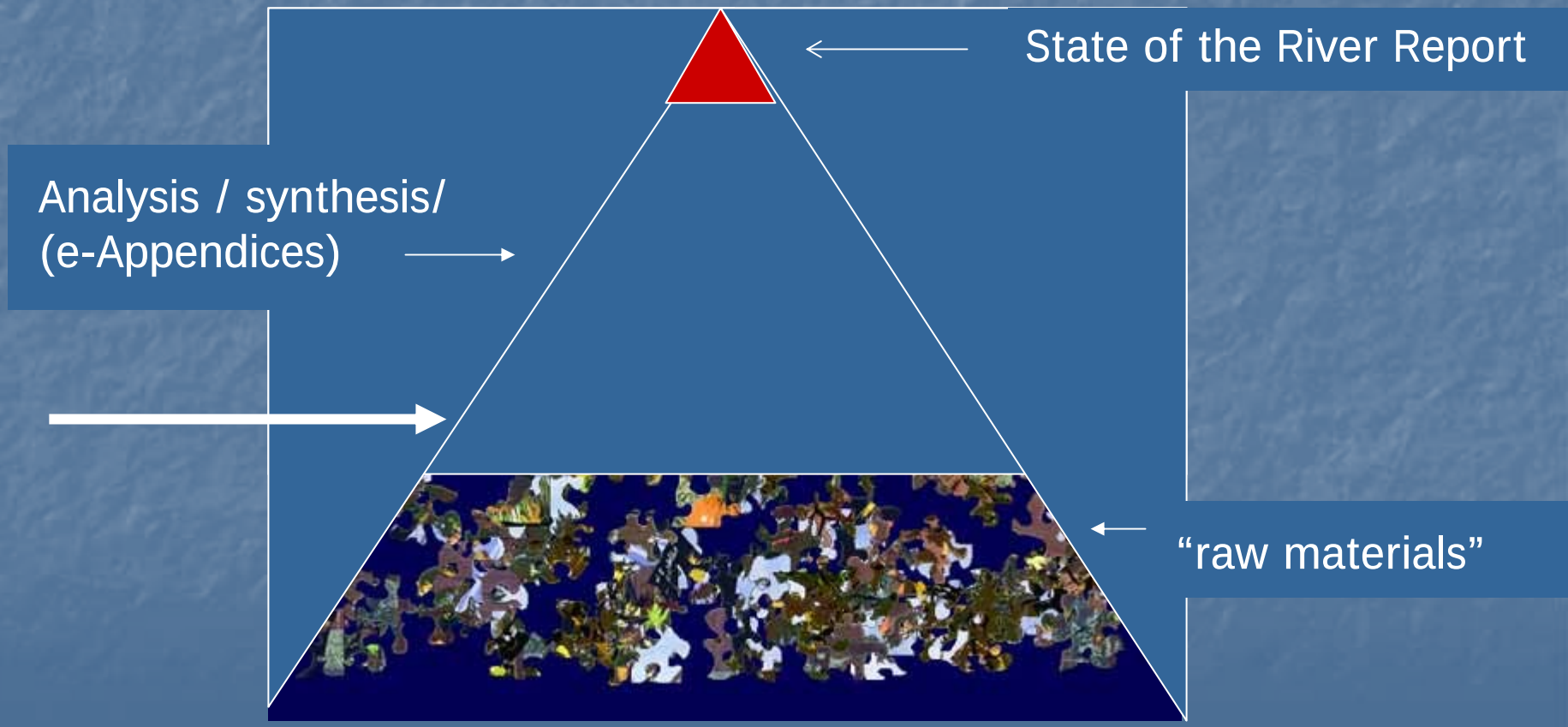
Data gaps, cont'd

- Sediments
  - Spatial and temporal gaps in ambient data
- Mining
  - Data scattered, not consistent between states, potential for release not well characterized
- In place sources
  - Toxics data lacking. Inventory hampered by databases varying between governmental (state and federal) agencies. Many data bases can not be searched according to specific toxic contaminants, making contaminant-specific searches difficult if not impossible.

Implications for reduction activities:

- Certain pollutants require cross-program reduction and monitoring efforts.
- Mercury is a particularly obvious example -- water and air need to work together. If we only focus on water and only talk among water quality people, our analyses and our reduction efforts will be incomplete and ineffective.

Where we are today with our Sources inventory and characterization:



What next?

- Additional gathering and assembly of puzzle pieces for Hg
- Begin work on the other Tier One contaminants
  - PBDEs
  - PCBs
  - DDTs