U.S. Department of the Interior
Bureau of Land Management

Human Health Risk Assessment for Mercury Releases to the Kuskokwim River from the BLM Red Devil Mine

Doug Cox, Ph.D., BLM Nat'l Operations Center

Presentation Organization

- PART 1: Site setting and the Kuskokwim River
  - History of mercury mining activities
  - Summary of relevant site investigations
- PART 2: Fish telemetry and tissue study
  - ***(Presented by Dr. Angela Matz)***
- PART 3: Human health Risk Assessment Issues
  - RI results and Supplemental RI findings
  - Multiple lines of evidence
  - Supplemental RI risk assessment approaches
  - Overview of preliminary findings

Strategy and Disclaimers

- BLM is the lead agency managing the RI/FS program at the Red Devil Mine (**RDM**) site, with support from the US EPA and the Alaska Dept. of Environmental Conservation (ADEC)
- This presentation summarizes BLM's approach to evaluating human health risk from site contaminants in the Kuskokwim River, primarily mercury (**Hg**) and methylmercury (**MeHg**)
- The multiple lines of evidence approach discussed herein represent BLM's viewpoint and not necessarily those of the other agencies
- Every effort has been made to develop a multi-endpoint data driven approach that more accurately represents site risk than any individual parameter

Human Health Risk Issues for Red Devil Mine and Kuskokwim River

- Is mercury from RDM being methylated and getting into the Kuskokwim River food chain?
  - To what extent is mercury site-specific vs regional?
- Why is mercury the primary concern?
  - ***Cinnabar ore → Hg → MeHg → food chain bioaccumulation → human exposure → potential toxicity***
  - Other COCs – arsenic (As), antimony (Sb)
    - Toxic but not bioaccumulative
- Are local subsistence populations at risk from consumption of Kuskokwim River fish?

Human Health Risk Assessment Challenges

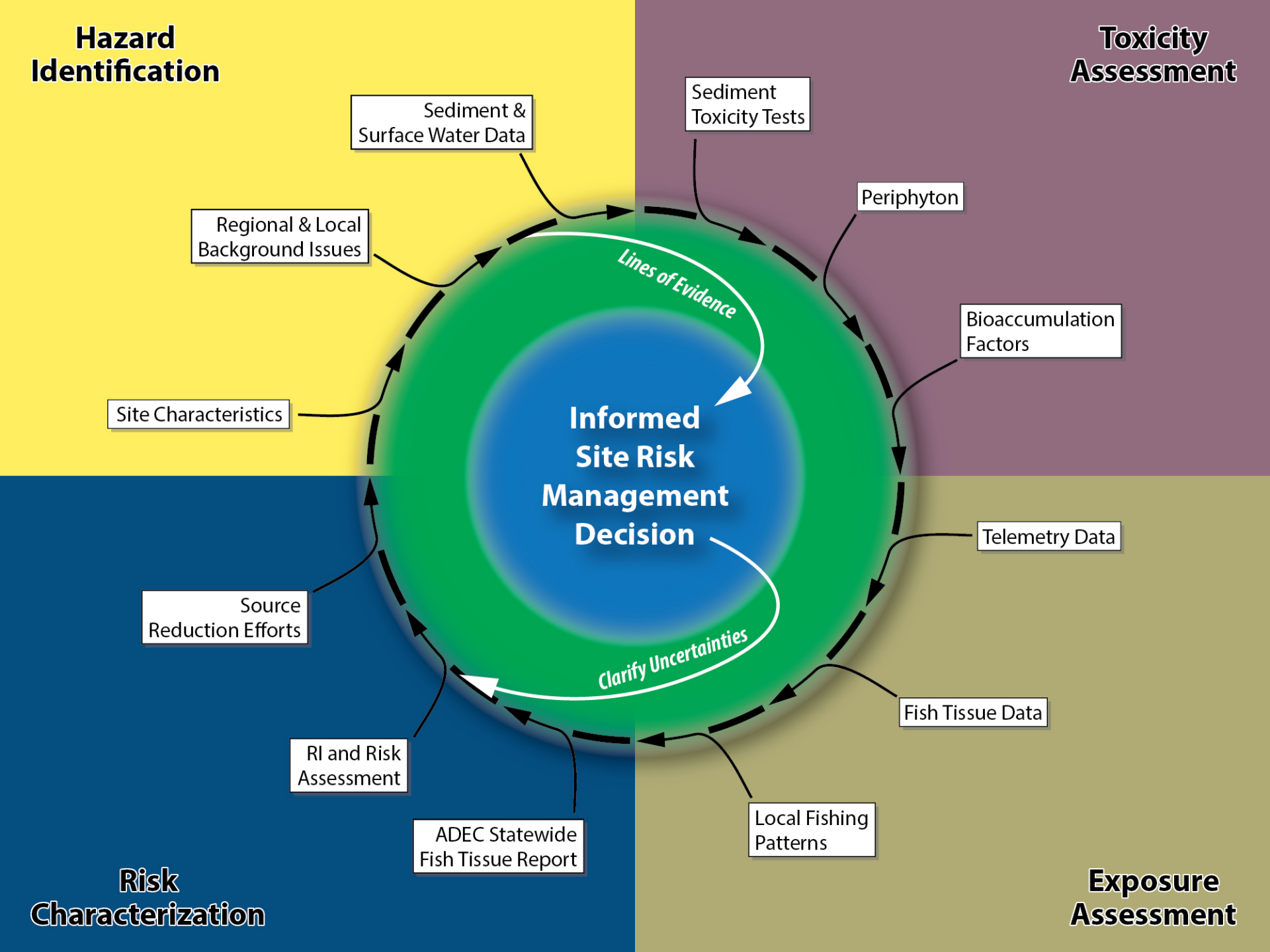
- Red Devil Mine site is located in the Alaska mercury belt with elevated background levels of Hg
  - ➢ Naturally occurring Hg sources drain into the river
  - ➢ Other Hg mines located up- and down-gradient of Red Devil
- Some fish consumed by subsistence populations are mobile and move around within the river systems
  - Pike prefer habitat not found in river reach near Red Devil
  - Burbot travel widely in the Kuskokwim and tributaries
- *BLM Objective: develop risk assessment strategy that incorporates all relevant data*
  - *Distinguish between site and regional risk*

Multiple Lines of Evidence (MLOE)

- Designed to support decision making by ***integrating multiple datasets*** into an ***evidence-based conclusion***
- Commonly used approach in ecological risk assessment, where there are large amounts of data available for multiple endpoints
- At Red Devil, MLOE will help distinguish between *regional* and *site-specific* issues
  - Naturally elevated mercury levels in region
  - Widespread fish movement in the River environs
  - Human use patterns based on resource availability

Lines of Evidence Considered in the HH Risk Assessment

- Hazard Identification
  - Site characteristics, regional and local background, sediment data
- Exposure Assessment
  - Telemetry data, fish tissue, ADFG consumption survey
- Toxicity Assessment
  - Sediment toxicity tests, periphyton, site-specific bioaccumulation factors
- Risk Characterization
  - RI and Supplemental RI, ADEC statewide fish monitoring report, source control efforts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Source Reduction Efforts
Lines of Evidence
Clarify Uncertainties
Informed Site Risk Management Decision

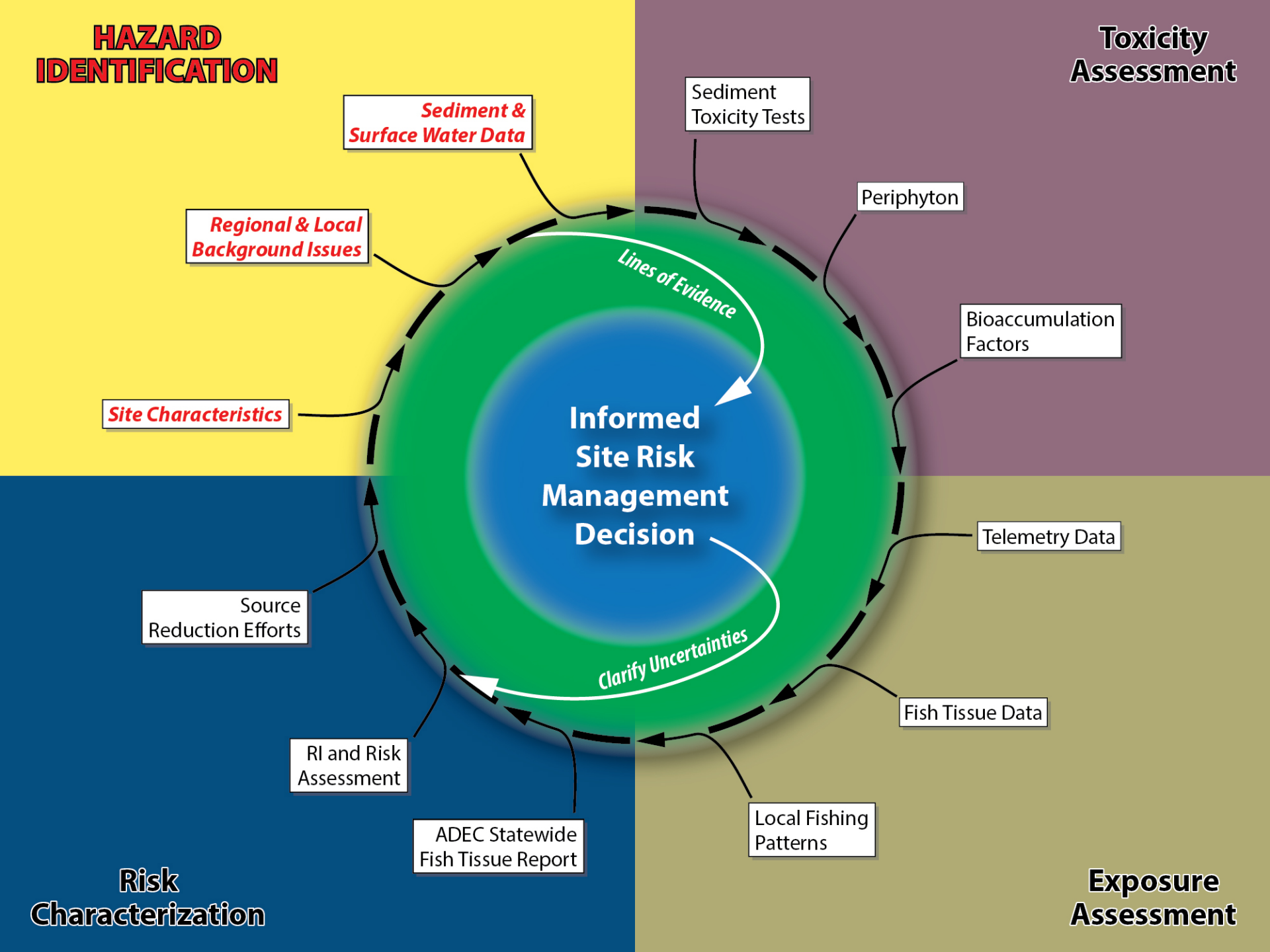
Remedial Investigation Findings

RI conducted between 2009 – 2014, and concluded

- The RDM is a source of heavy metals contamination to site soils, groundwater, surface water, and sediments
- Contaminants are migrating offsite through groundwater and surface water transport (Red Devil Creek)
- Transport of contaminated tailings by Red Devil Creek has contaminated sediments in the Kuskokwim River
- Potential risks to human and ecological receptors were calculated for the mine site *but not the Kuskokwim River*
  - Primary COCs are arsenic, antimony, and mercury

Supplemental Remedial Investigation for Red Devil Mine

- Supplemental RI and Risk Assessment underway
  - BLM, EPA Region 10 and ADEC
- Filling data gaps for the Kuskokwim River near to and downriver of Red Devil Creek
- Additional river data collected in 2015-16:
  - Cross-river and downriver extent of sediment impacts
  - 28 day sediment toxicity test (*Hyalella azteca*)
  - Periphyton tissue samples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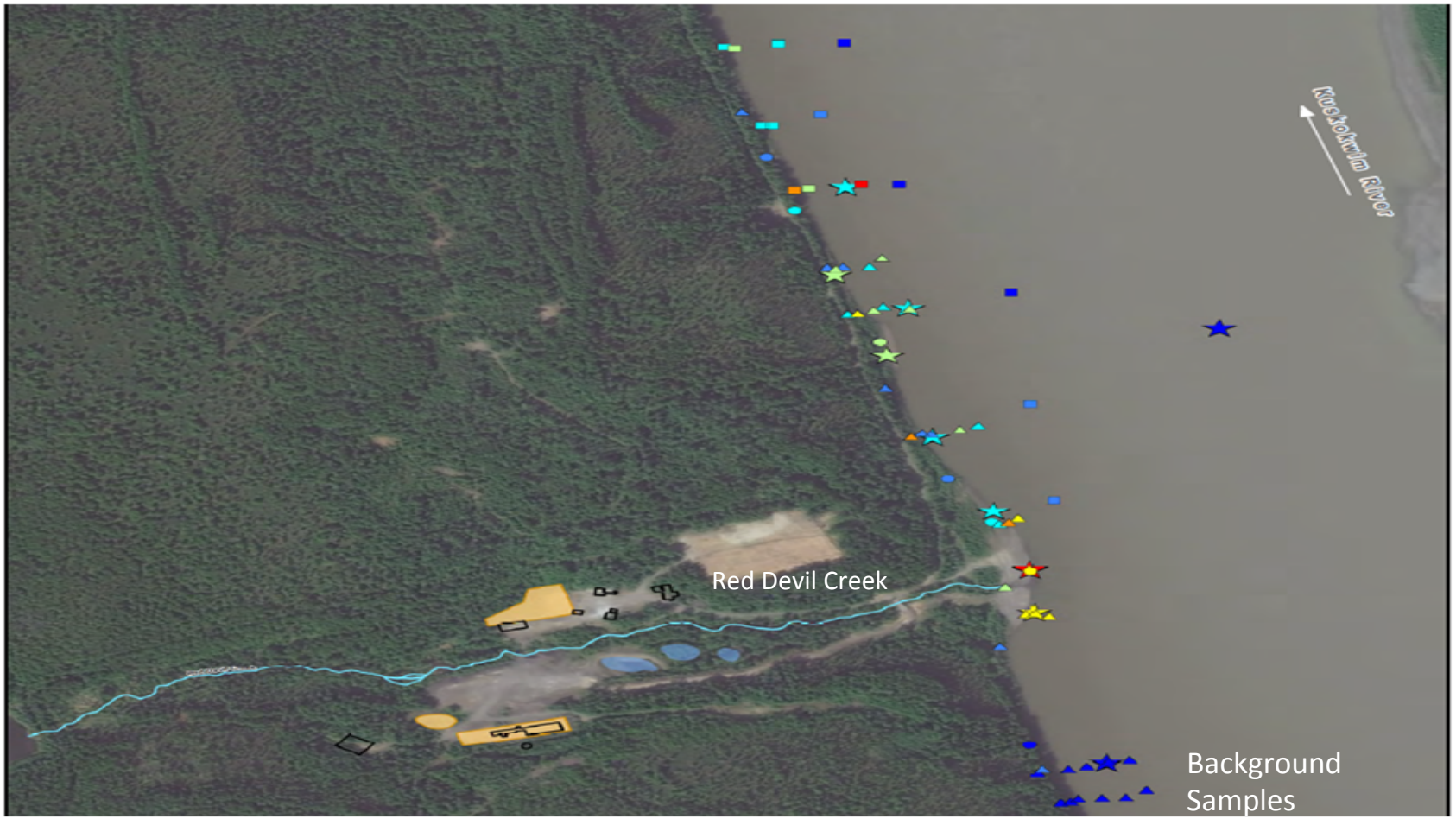
Hazard Identification: Site and Kuskokwim River Characteristics

- Red Devil Mine is located in a highly mineralized zone in interior Alaska
  - Other abandoned mines located in the region
  - Naturally occurring background levels important to project
  - Mercury, arsenic and antimony are the primary COCs
- The Kuskokwim River near Red Devil is characterized by linear shorelines, strong current, high turbidity, and low density of shoreline wetlands
  - Poor breeding and foraging habitat for pike
- Site constituents transported to Kuskokwim River in tailings waste via Red Devil Creek, creating a semi-stable delta
  - Further input reduced due to early actions on-site

Sediment Sampling for Mercury (partial view) RI and RI Supplement

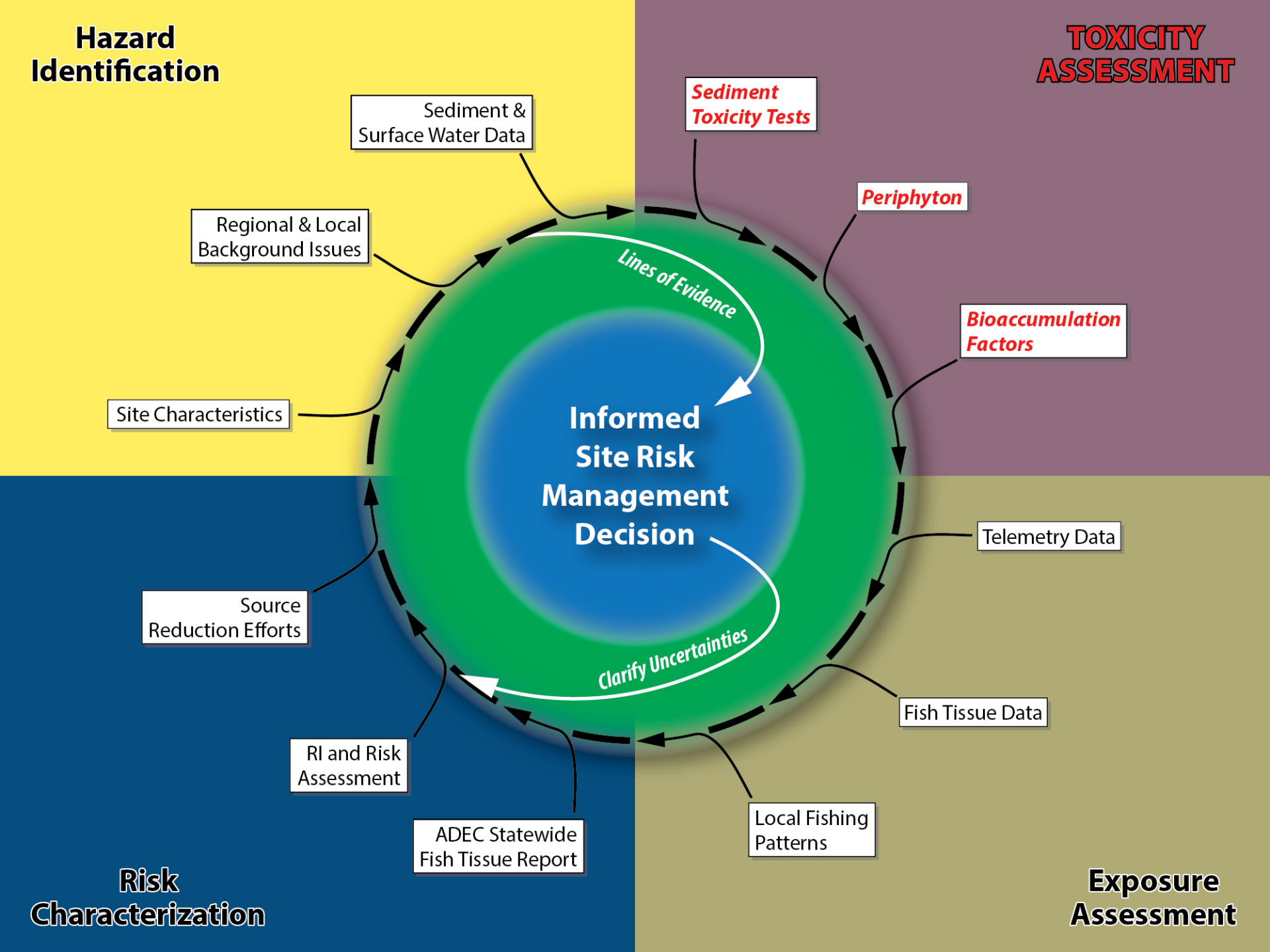


Environmental Mercury at the Aquatic Environment

- Multi-year sampling of sediment (17+ locations) were collected from the Kuskokwim River shoreline during the RI
- Supplemental RI
  - Twelve sediment samples were collected from the area upriver of, in the vicinity of, and downriver of Red Devil Creek delta
  - Twelve sediment samples were collected from locations cross-river and downriver from the site
- All samples analyzed for Hg, subset for methylmercury
- Concentrations generally decreased in down river and cross river samples

Environmental Mercury at the Aquatic Environment

- RI Conclusions:
  - While there is a measurable and biologically significant elevation of mercury and arsenic in fish and insects in Red Devil Creek, similar levels are found near other abandoned mines in the middle Kuskokwim River watershed
  - Percentage of readily bioavailable mercury in sediment samples is low, typically less than 1% of total mercury
    - However, the historic amount of Hg historically released into the river from Red Devil provides ample Hg for methylation even if overall rates are low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Risk Characterization
Exposure Assessment

Human Health Toxicity Concerns for Methylmercury ; EPA Summary

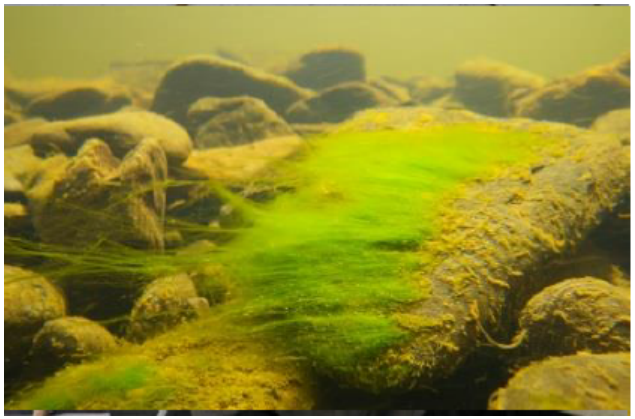
- Exposure to methylmercury most commonly occurs when people eat fish and shellfish with high levels of methylmercury
- Almost all people have some methylmercury in their bodies
- Mercury is a neurotoxin, and possible symptoms of methylmercury poisoning may include:
  - loss of peripheral vision
  - "pins and needles" feelings, usually in the hands, feet, and around the mouth
  - lack of coordination of movements
  - impairment of speech, hearing, walking, muscle weakness
- Children exposed to methylmercury *in utero* can have impacts to their:
  - cognitive thinking,
  - memory, attention, and language
  - fine motor and visual spatial skills

Sediment Toxicity Results (conducted primarily for ERA)

- Amphipod (*Hyalella azteca)* sediment toxicity tests
  - 28 day laboratory study
  - no effect in 6 of 9 samples between RD delta area (downriver) and control samples
    - 3 samples from test area showed reduced survival rates
  - Possibly due to differences in sediment texture and/or TOC content between the site and reference samples
  - Minimal impact on growth rates of organism
- RD sediments appear to be minimally toxic to sensitive aquatic organisms
  - No direct link to human health, indicative only

Periphyton Mercury Tissue Data

- Methylmercury was not detected in tissue samples collected from periphyton communities near Red Devil Mine (0.5 ng/g wet wt)

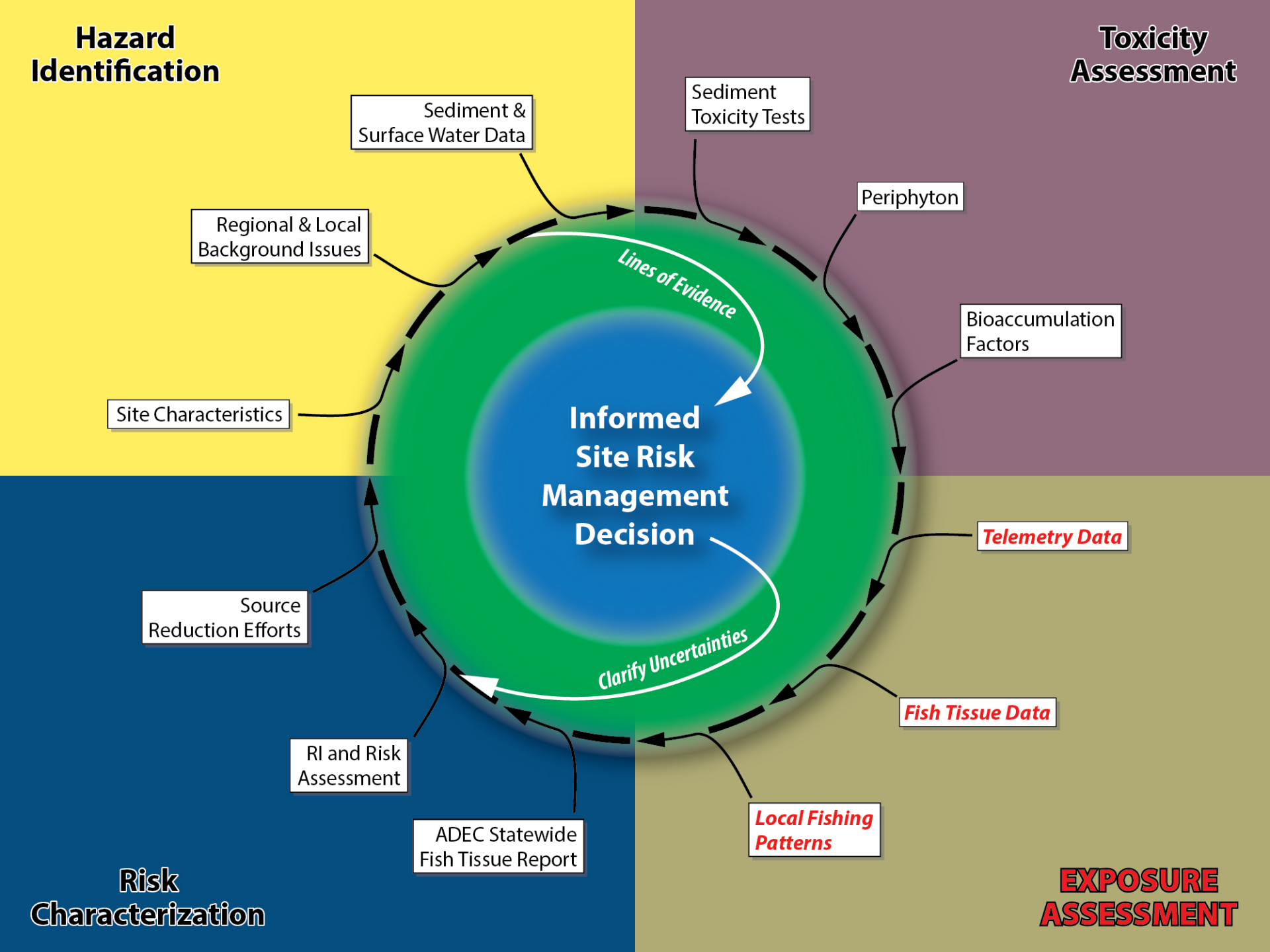


Periphyton growing on large cobble substrate in Kuskokwim River near Red Devil Creek

- Periphyton data suggest that mercury released from Red Devil Mine has not resulted in elevated methylmercury levels in the base of the aquatic food web in the Kuskokwim River

Bioaccumulation Findings and Assumptions from Telemetry and Tissue Study

- Mercury concentrations in pike and burbot were assumed to be 100% MeHg
  - This is a conservative assumption, since EPA noted that only 80-90% of Hg may be methylated in upper trophic level fish
- The MeHg:Total Hg ratios for Kuskokwim River fish were near 1.0, but those for tributary fish were lower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Exposure Assessment: Populations, Pathways, and Assumptions

Supplemental Risk Assessment will consider:

- Residents (adult and child)
- **Recreational or Subsistence User** (adult and child)
- Industrial/mine worker

- Dermal contact with sediments
- Incidental ingestion of sediments
- **Fish ingestion** *(pathway of primary interest)*

Based on approaches from 2014 RI report

- Combination of default and site-specific assumptions

Fish harvesting done during regulated seasons

Exposure Assessment: Populations, Pathways, and Assumptions

Primary focus of presentation:

- Risks from exposure to methylmercury in the tissue of upper trophic level fish consumed by local subsistence populations
  - Supplemental risk assessment will consider other populations and exposure pathways

Exposure Assessment Challenges

- Consideration of regional Hg impacts vs site-specific impacts
- Evaluating fish movement in the Kuskokwim and tributaries
  - Species of interest do not live exclusively near Red Devil
- Understanding dietary habits and consumption rates

Subsistence Fish Consumption Issues

- Alaska Dept of Fish and Game (ADFG) did a survey of consumption rates and types of wild food used by central Kuskokwim area residents
- Fish of interest for human consumption:
  - Salmon, sheefish, Arctic grayling, other whitefish
  - Pike, burbot (important but lesser resource overall)
- Traditional knowledge from locals indicates they are more successful fishing for pike in the tributaries than in the Kuskokwim River

Subsistence Harvest Study

"THE SUBSISTENCE HARVEST IN 8 COMMUNITIES IN THE CENTRAL KUSKOKWIM RIVER DRAINAGE, 2009"

Alaska Dept. of Fish and Game, Division of Subsistence: Juneau, v. Technical paper no. 365.

- 11 of 13 Red Devil households were surveyed in 2010, community total of 27 residents
- Four species of fish (primarily salmon) made up 67% of subsistence harvest (by weight)
- Mean value of 26.7 lbs of pike harvested per capita

Photograph by James Van Lanen

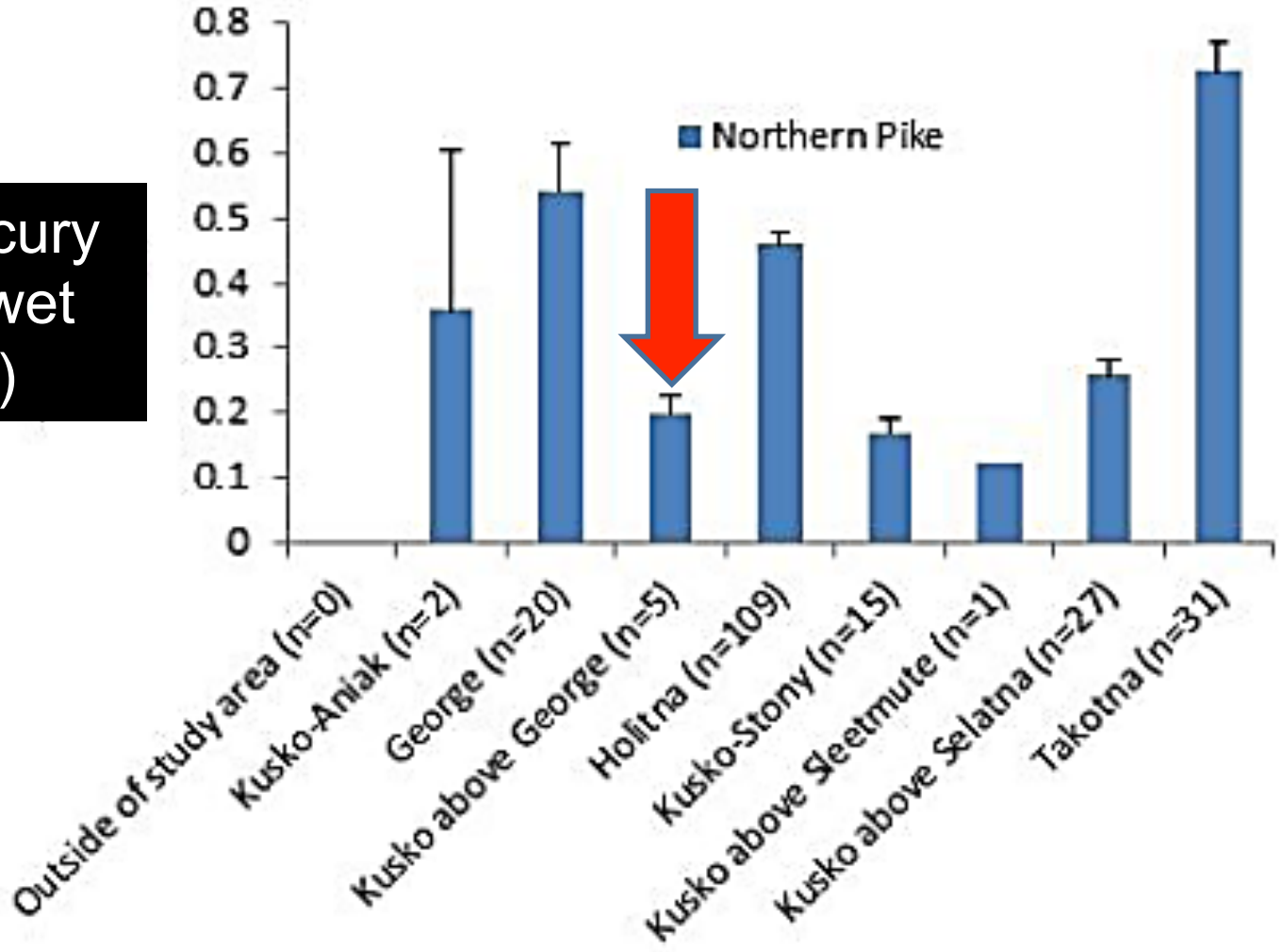
Figure 8-8.–A Sleetmute resident deploys a driftnet in the Kuskokwim River.

Kuskokwim Fishing Patterns - Pike

- Pike frequent tributaries with low energy habitat
- Ambush predators, prefer slower moving waters with vegetation
- Kuskokwim habitat poor for pike

Mercury Concentrations in Pike

Total Mercury (mg/kg, wet weight)

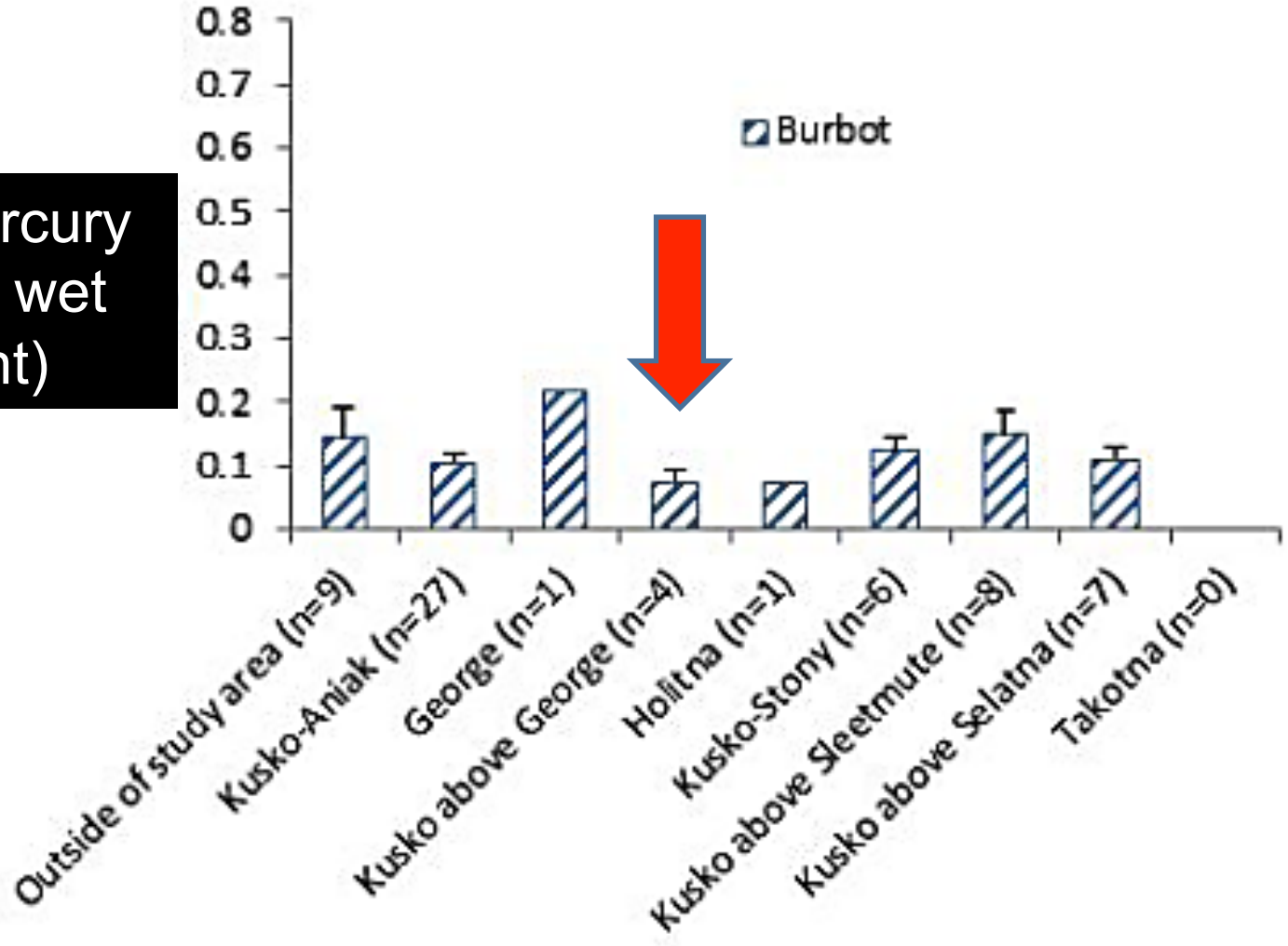


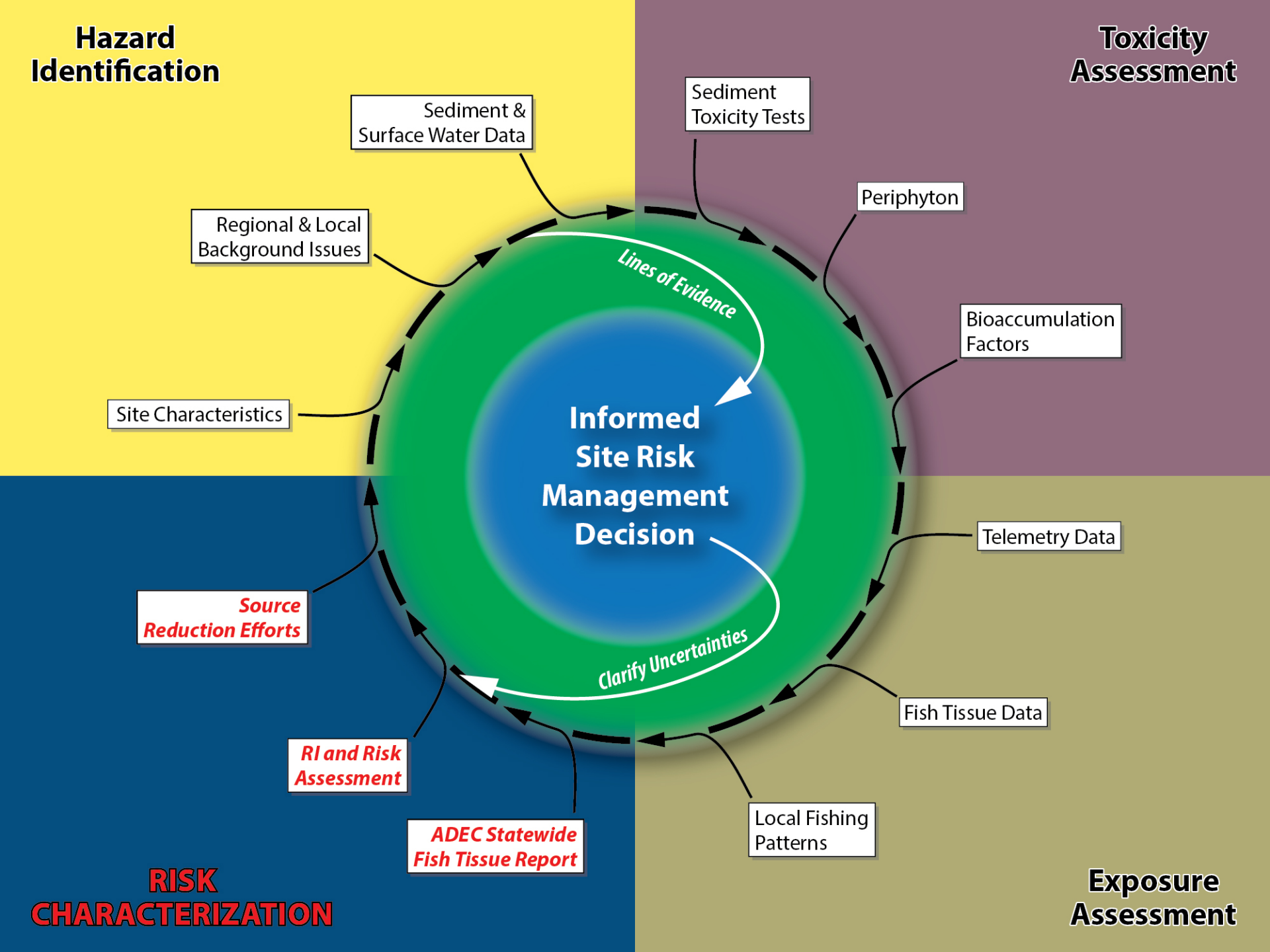
Kuskokwim Fishing Patterns - Burbot

- Burbot migrate hundreds of miles each year
- Local fishermen catch burbot in Kuskokwim in winter

Mercury Concentrations in Burbot

Total Mercury (mg/kg, wet weight)

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Risk Characterization: Lines of Evidence Strategy for the Kuskokwim River

- *"In this step, the toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of risk."* (EPA, RAGS A, 1989)
- This presentation attempts to summarize various findings, observations and data sets, and to see if the results collectively lead to an overall conclusion about risk
- Objective is to evaluate whether mercury releases from Red Devil Mine is entering upper trophic level fish in the Kuskokwim River and posing a potential risk to subsistence villagers consuming the fish

Risk Characterization: Combining Lines of Evidence

For purposes of this evaluation, the LOE have been condensed into the four pillars of risk assessment

- Hazard identification
  - Including site characterization
- Toxicity assessment
- Exposure Assessment
- Risk Characterization
  - Uncertainty analysis

Risk Characterization: Hazard Identification Summary

- Mercury releases (and other COCs) from the RDM site have impacted sediment and biota in RD Creek and in the Kuskokwim River near the site
- RD mine site is located in a mineralized area
  - Naturally occurring Hg, other abandoned mines site also contribute to Hg levels in the Kuskokwim River
- Habitat in Kuskokwim River near RDM site is low quality for pike and burbot
  - Fast water, straight banks, minimal aquatic vegetation, heavily cobbled, lack of benthic invertebrates

Risk Characterization: Toxicity Assessment Summary

- Methylmercury not detected in periphyton collected in the Kuskokwim River offshore from RD mine site
- Sediment toxicity tests showed minimal/modest toxicity to sensitive aquatic organisms
- Mercury chemistry
  - Much of the total mercury in sediment is sparingly soluble, limiting the amount available for methylation
  - Readily bioavailable mercury in sediment samples is low (1% or less)
  - The total amount of Hg historically released into the river system from RD mine provides material for methylation even if overall rates are low

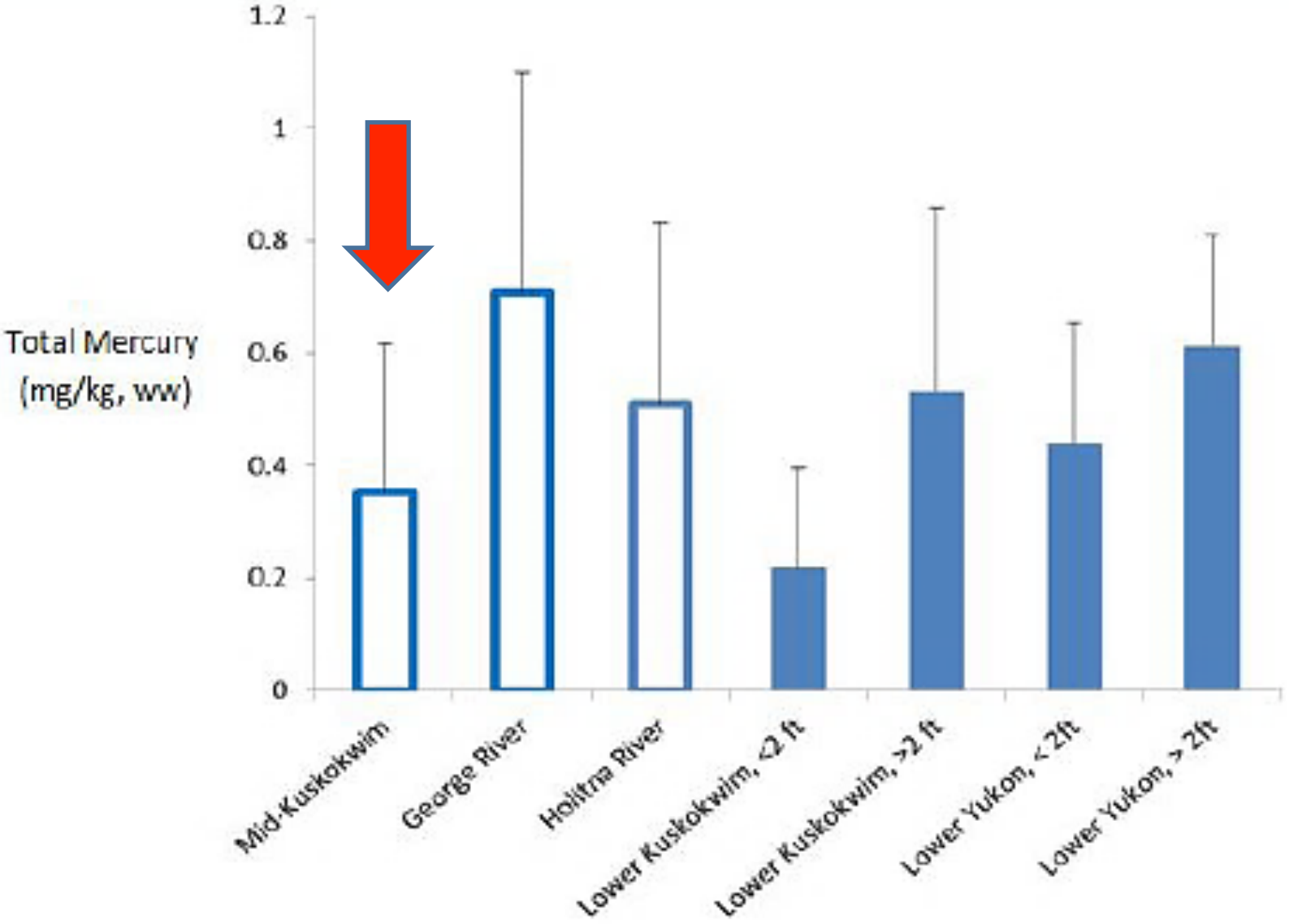
Risk Characterization: Exposure Assessment Summary

- Subsistence villagers consume pike and burbot but they are not major components of their diet
- Pike are generally not found in the Kuskokwim River near RD mine site, rather they are typically caught in tributary waterways
- Tissue and telemetry study showed that pike and burbot move within the Kuskokwim watershed but each prefers specific habitats

Risk Characterization: Regional vs Site-Specific Risk

- Mercury levels in fish are more representative of ***regional*** (burbot) or **home waterway** (pike) exposure rather than the Kuskokwim River at RDM
- Site-specific human health risks for fish consumption are difficult to quantify:
  - Impact area from site is small in relation to home range of species of interest
  - Habitat in Kuskokwim near RDM unattractive to pike; villagers tend to fish elsewhere
  - COCs (esp Hg) are widespread in the watershed
  - BLM doing sediment – food chain modeling as part of site-specific uncertainty analysis

Regional Mercury Concentrations in Pike



Risk Characterization Summary

The risk characterization in the Supplemental Risk Assessment will consider:

- Site-specific sediment exposure risk estimates
- Multiple lines of evidence for exposure and risk
- Regional fish consumption risk estimates
  - Importance of regional background mercury levels
  - Kuskokwim River and state-wide mercury fish tissue levels
  - Subsistence harvest consumption rates
- Traditional knowledge about fishing practices

Current Project Status

- The ***Supplemental RI Human Health and Ecological Risk Assessment for the Kuskokwim River*** is being developed by BLM with input from EPA and ADEC
- Based on:
  - Updated sediment and biota data
  - Telemetry and tissue concentration data
  - RI risk assessment approaches and updated information
  - ADFG fish consumption information
  - Fish contaminant uptake modeling

ADEC Statewide Pike and Burbot Data and State Fish Consumption Advisories

- Total Hg tissue levels measured in pike and burbot from the middle Kuskokwim are consistent with the median 2001-2016 statewide Hg tissue levels (http://dec.alaska.gov/eh/docs/vet/Fish/MetalsResults/TotalMercuryInAlaskanFish.pdf)

- State of Alaska Epidemiology Department has issued fish consumption advisories for Hg across the state
  - For women of childbearing age and children in the Middle Kuskokwim area, it is recommended to eat more fish < 2 feet in length and less of longer fish
  - Advisories more restrictive in other river systems

Next Steps for Red Devil Mine Site

- Finalize Supplemental Risk Assessment and RI
  - Review and discussion with EPA and ADEC
- Evaluate RI and Supplemental RI conclusions
- Integrate results into Feasibility Study for both upland (site) and aquatic (Red Devil Creek, Kuskokwim River) settings
  - Remediate RD Creek and Kuskokwim tailings delta
- Develop Proposed Plan outlining BLM project goals

Questions?