MEASUREMENT AND MONITORING OF PHYSICAL, CHEMICAL AND BIOLOGICAL EFFECTS OF MINING, PARTICULARLY PLACER MINING

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Objective of Presentation

- To review the potential effects of mining on the aquatic environment (with emphasis on placer mining).
- To make available information on some of the Canadian experience and regulatory approaches.
- To facilitate discussion on approaches that may be appropriate in Guyana.

Guidelines and Regulations

- Water and sediment quality guidelines are non-enforceable statements of a desirable range, or limits to the range, of measurable parameters (such as pH or contaminant concentrations).
- Regulations may set legally enforceable limits on the concentration of substances in effluents or the receiving environment.

Example

	Canadian Water Quality Guideline	Fisheries Act (Metal Mining Liquid Effluent Regulation)		
		Monthly	**Composite**	**Grab**
pH	6.5 - 9.0	6.0	5.5	5.0
TSS	5 mg/L **:** 25 mg/L **:** 10%	25	37.5	50
Zinc	0.03 mg/L	0.5	0.75	1.0
(only examples are provided … many other substances could also be listed)				

Generic Concerns with Mining Effluents

- Mining effluents in general have the potential to cause adverse effects in the natural environment via a number of mechanisms (physical habitat alteration, mobilization of metals and other chemicals, acidity, turbidity, toxicity, etc.)
- Placer mining is in many respects a special case.

Why Monitor?

- Monitoring may be performed for several reasons, including:
  - monitoring for compliance with regulations (Compliance Monitoring);
  - monitoring to provide assurance that an operation or process is functioning as intended (Operational Monitoring); and
  - Environmental Effects Monitoring (EEM) to show that the actual environmental effects do not exceed their expected magnitude or spatial extent (as may be outlined in an EIA).

What to Monitor?

- Monitoring should address clearly defined objectives.
- For compliance monitoring, there may be regulations that specify the location(s) that must be monitored, parameters, and sampling frequency.
- For EEM, there may be general guidelines for the design of a program that can be customized to suit local conditions.

Physical Parameters

- Temperature
- Conductivity
- Total Suspended Solids
- Total Settleable Solids
- Turbidity

Chemical Parameters

- Mining in General
  - Heavy Metals (Fe, Mn, Cd, Cu, Hg, Pb, Zn)
  - Metalloids (As)
  - Process Chemicals (cyanide)
  - Radionuclides (Ra, U)
  - acidity (pH)

- Placer Mining
  - Mercury

Biological Parameters

- Acute Toxicity
  - Rainbow Trout toxicity test is widely used; what is an appropriate fish species in Guyana?
  - Water flea (*Daphnia magna*) also widely used; again must consider relevance to Guyana.
- Benthic Invertebrate Community Structure
  - Widely used and directly relevant to the magnitude and spatial extent of biological effects.
  - Rapid bio-assessment techniques are cost effective and highly transferable.

Potential Effects of Placer Mining

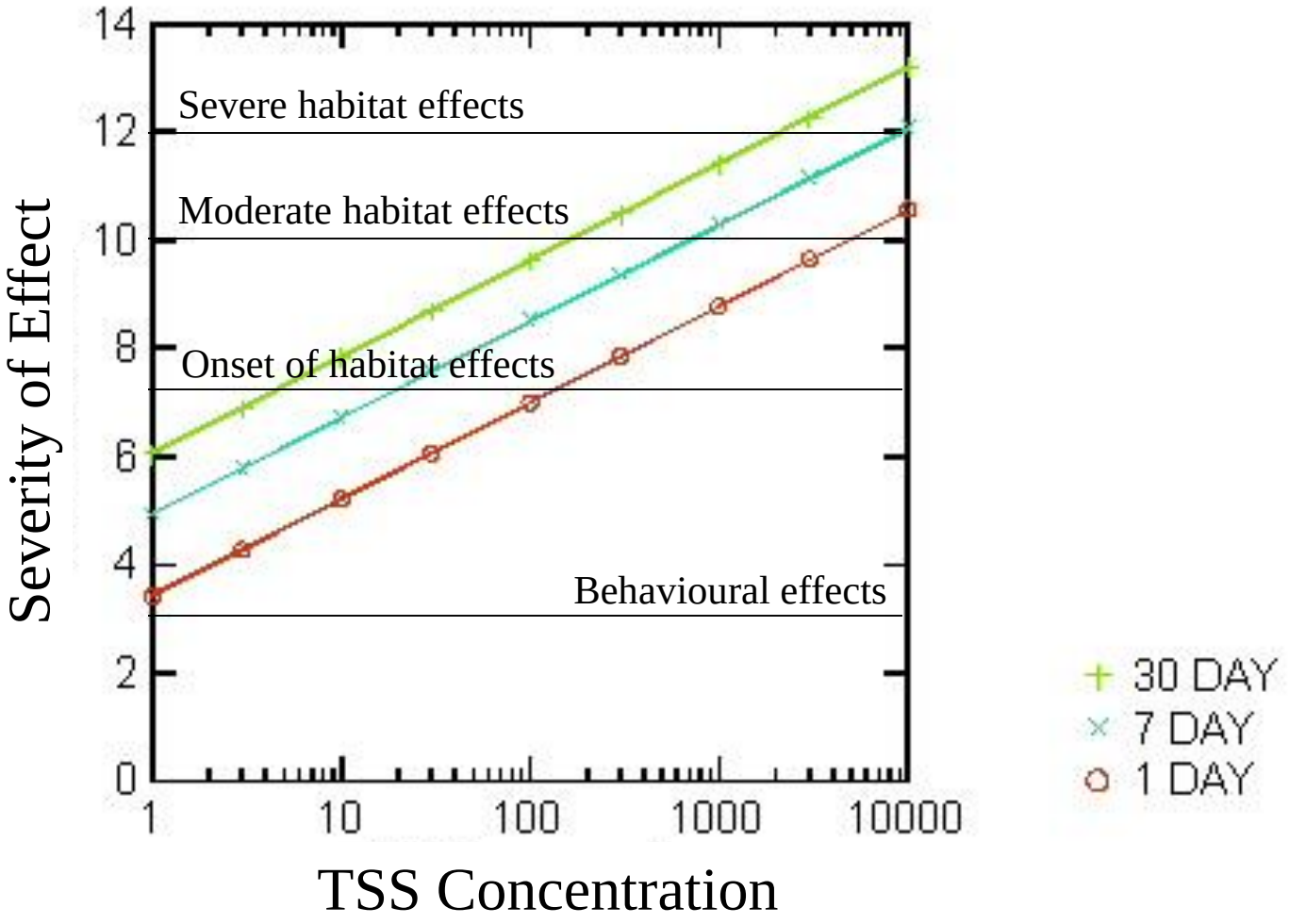
Placer mining can cause:

- shoreline and aquatic habitat disruption causing harm to fish populations and fisheries;
- release of suspended solids causing harm to fish and damaging fish spawning or rearing habitat;
- release of heavy metals including mercury, leading to bioaccumulation and potential harm to humans.

Effects of TSS on Aquatic Life

- Direct injury to fish
- Habitat exclusion and habitat alteration
- Changes in stream bed porosity
- Changes in stream morphology
- Damage to fish spawning habitats
- Damage to fish rearing habitat
- Reduced primary productivity
- Reduced secondary productivity

Severity of Effects of TSS



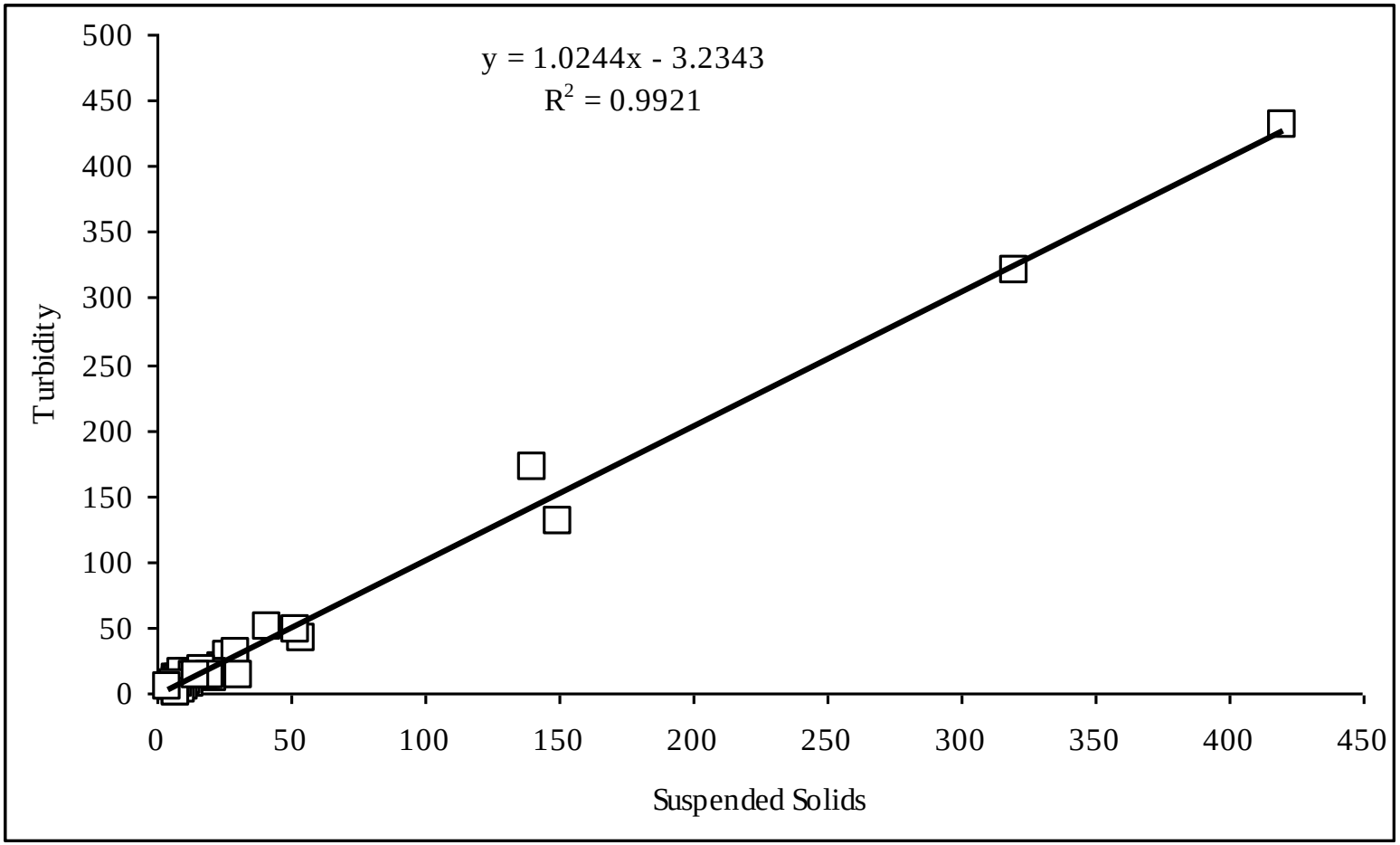
Feasibility and Practicality of Various Test Methods

METHODS FOR MEASURING SUSPENDED SOLIDS			
RANGE	**METHOD**	**COST/DIFFICULTY**	
>1,000 mg/L	Settleable Solids using Imhoff Cone (volumetric)	low	low
	Settleable Solids using centrifuge	moderate	low
	Suspended Solids using hydrometer	low	moderate
<1,000 mg/L	Suspended Solids by filtration and weighing (gravimetric)	high	high
	Turbidity, using turbidity meter	high	moderate
	Clarity, using "wedge"	low	low

Regulation of TSS

- TSS could be regulated using simple methods such as the Imhoff Cone, centrifuge, hydrometer, clarity “wedge”, or turbidity meter.
- Work may be required to develop regional calibrations between these methods and “true” TSS values, in order to set consistent standards.

Relationship Between TSS and Turbidity



Mercury Analysis

Mercury may be lost in two forms:

- spills or releases of liquid mercury (likely to be retained in settling ponds, or to reach river sediments); or
- releases of volatile mercury during amalgamation and losses from retorts (much of which may be dispersed).

Mercury Analysis

- Mercury concentrations in water samples are likely to be very low at all times, and prone to significant contamination in working areas.
- Mercury concentrations in sediment are likely to be very patchy, especially if liquid mercury is the most likely source.
- Mercury concentrations in fish tissues will concentrate and integrate from multiple sources, and provide information directly relevant to protecting human health.

Mercury in Fish Tissues

- Analysis of mercury in fish tissues requires specialized laboratory services.
- Consider monitoring total mercury in predatory fish.
- Assume all mercury in fish flesh is methyl mercury.
- In Canada, the fish consumption guideline is set at 0.5 mg/kg in flesh.

Biological Monitoring

- Monitoring of fish habitat quality, fish population status and growth rates are feasible but expensive.
- Monitoring of benthic invertebrate communities using rapid bio-assessment techniques is possible and cost effective.
- Artificial substrates or rapid bio-assessment techniques could be developed for use by regulatory staff in Guyana.

Summary

- The major environmental effects of placer mining in Guyana are likely related to physical habitat disturbance and release of TSS.
- Mercury contamination is probably a relatively minor issue, although human health concerns may raise its profile.

Summary

- It is probably most important to monitor TSS, at the level of the mining operation, using simplified techniques.
- Regulatory or research teams could develop regional databases linking the simplified techniques to quantitative measurements.

Summary

- Effluent quality guidelines or regulations may be required. If so, these should be “effects based”, reflecting the size and sensitivity of the receiving water, as well as the size and nature of the mining operation.
- The EIA process can be used to assess potential effects and these will indicate the required scope of monitoring programs.

Summary

- The EIA process should be linked with EEM, such that monitoring programs reflect the anticipated potential environmental effects, and mitigation measures employed.