SECTION B.16

ENVIRONMENTAL RISK ASSESSMENT FOR METALS IN SEDIMENTS

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Environmental Risk Assessment for Metals in Sediments

by

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noranda

5th annual BC Metal Leaching and ARD Workshop

Outline

- Background on metals in sediments
- Sediment Quality Guidelines
- Environmental Risk Assessment
- Case Studies
- Overview of sediment quality near other Noranda Sites
- Conclusions

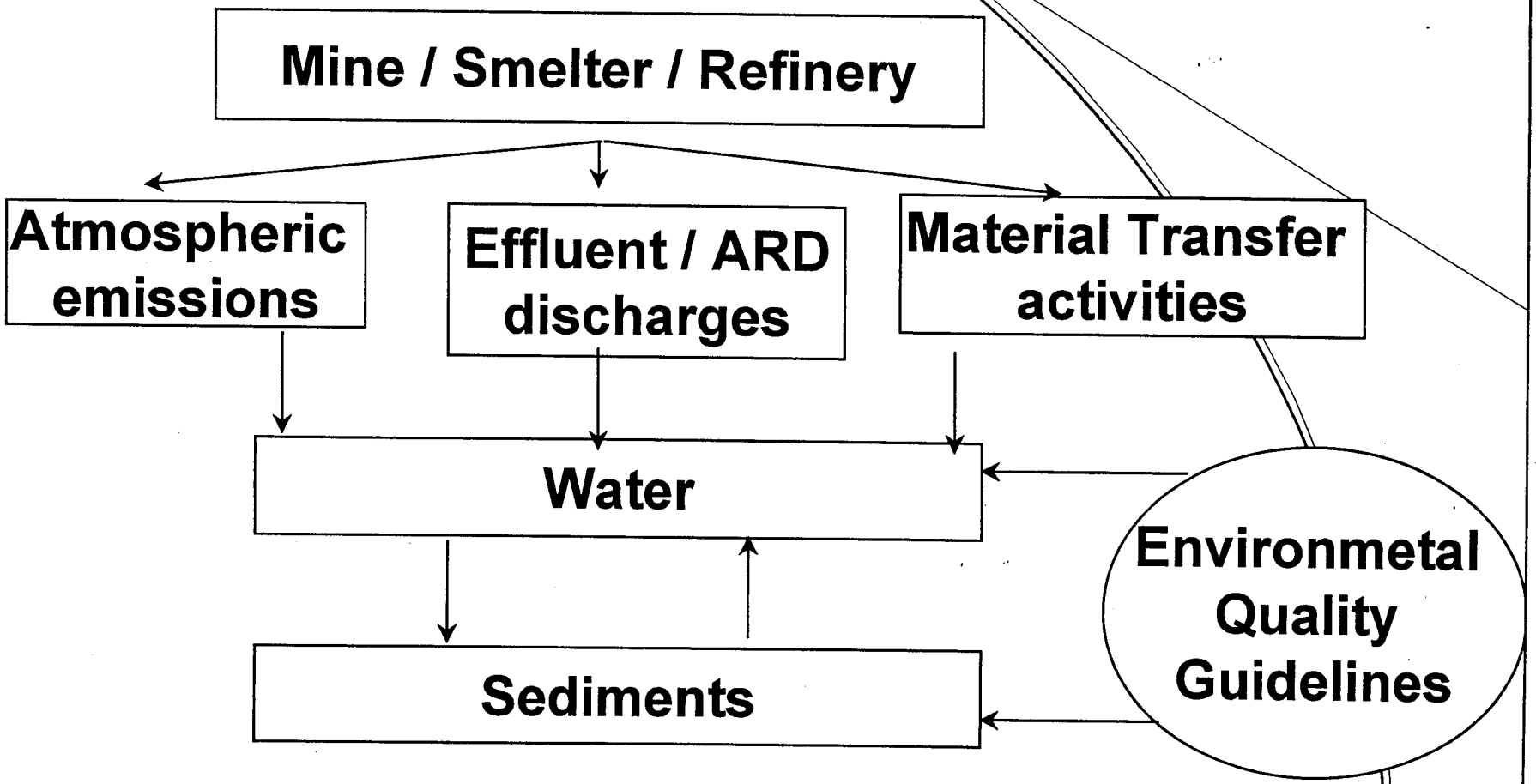
Background

- Metals are naturally present in sediments from pristine and mineralized areas
- Metal concentrations are higher near our sites
  - naturally (geological anomalies at mine sites)
  - due to activities (mining, milling, smelting, refining)
- Some metals are essential elements (eg. Zn, Fe, Se)

Background (cont'd)

- Everything is toxic, the important is the dose!
- Some of the main factors driving metal toxicity in sediments
  - intrinsic toxicity of the metal
  - biological species used to determine toxicity
  - metal speciation
  - grain size and TOC of sediment

Pathways of metals from our operations to aquatic sediments



Sediment Quality Guidelines

- Numerical values to assess sediment quality.
- Statistically derived using data mainly from North America
- Do not account for site-specificity and bio-availibility of metals.
- If used for remediation decision, it can be very costly for industry

Sediment Quality Guidelines Development Methods

- Background Approach
- Equilibrium Partitioning Approach
- Screening Level Concentrations Approach (ON,CSL)
- Spiked Sediment Toxicity Approach (EC)
- National Status and Trends Program Approach (Modified) (EC)

Sediment Quality Guidelines

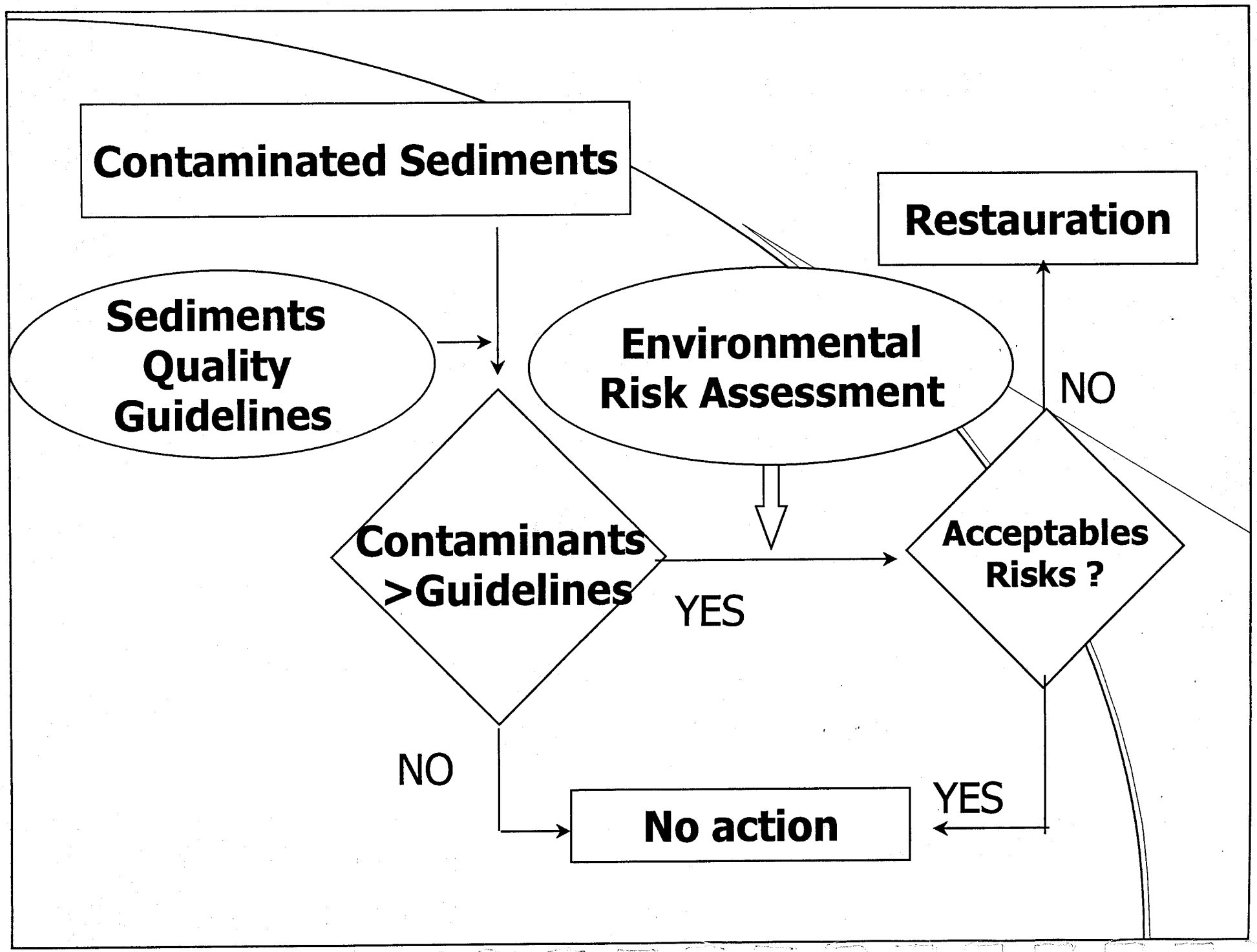
Probable Effect Level (Env. Can. 98)	**197**	**315**	**3.5**	**91.3**
Severe Effects Level (Ontario 93)	**110**	**820**	**10**	**250**
Toxic Effect Level (CSL 92)	**86**	**540**	**3**	**170**

Sediment Quality Guidelines vs Noranda Sites

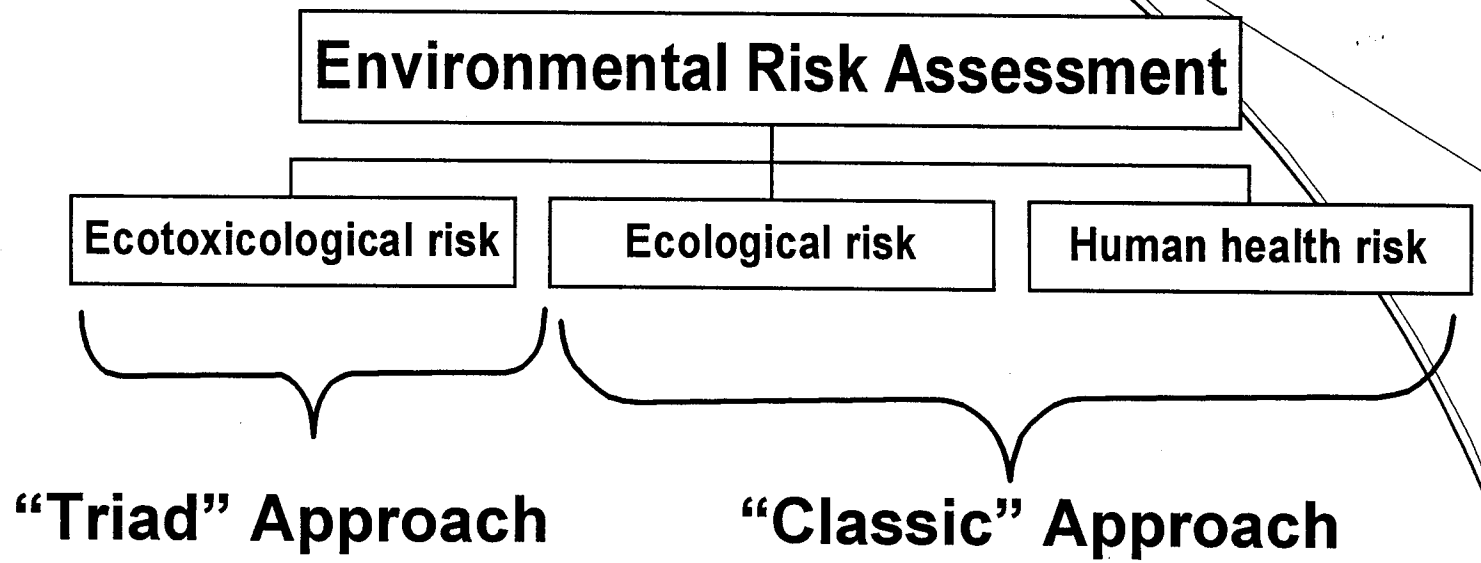
(Maximum Metal Concentrations)

Criteria / Sites	Cu (µg/g)	Zn (µg/g)	Cd (µg/g)	Pb (µg/g)
Env. Can. 98 - PEL	**197**	**315**	**3.5**	**197**
Mattabi (max.) FW	**3400**	**46000**	**108**	**1780**
Dalhousie (max.) M	**-**	**3500**	**6.8**	**490**
Quai 103 (max.) FW	**3570**	**653**	**5**	**113**
Mont-Louis (max.) M	**15000**	**710**	**7.1**	**57**
Sandy Beach (max) M	**5800**	**3200**	**3.1**	**300**

FW: Freshwater M: Marine


Contaminated Sediments
Restauration
Sediments Quality Guidelines
Environmental Risk Assessment
NO
Contaminants >Guidelines
YES
Acceptables Risks ?
NO
No action
YES

Assessment of Environmental Risks related to the presence of contaminated sediments



"Triad" Approach

"Classic" Approach

Ecological and Human Health Risk Assessment

Risk

=

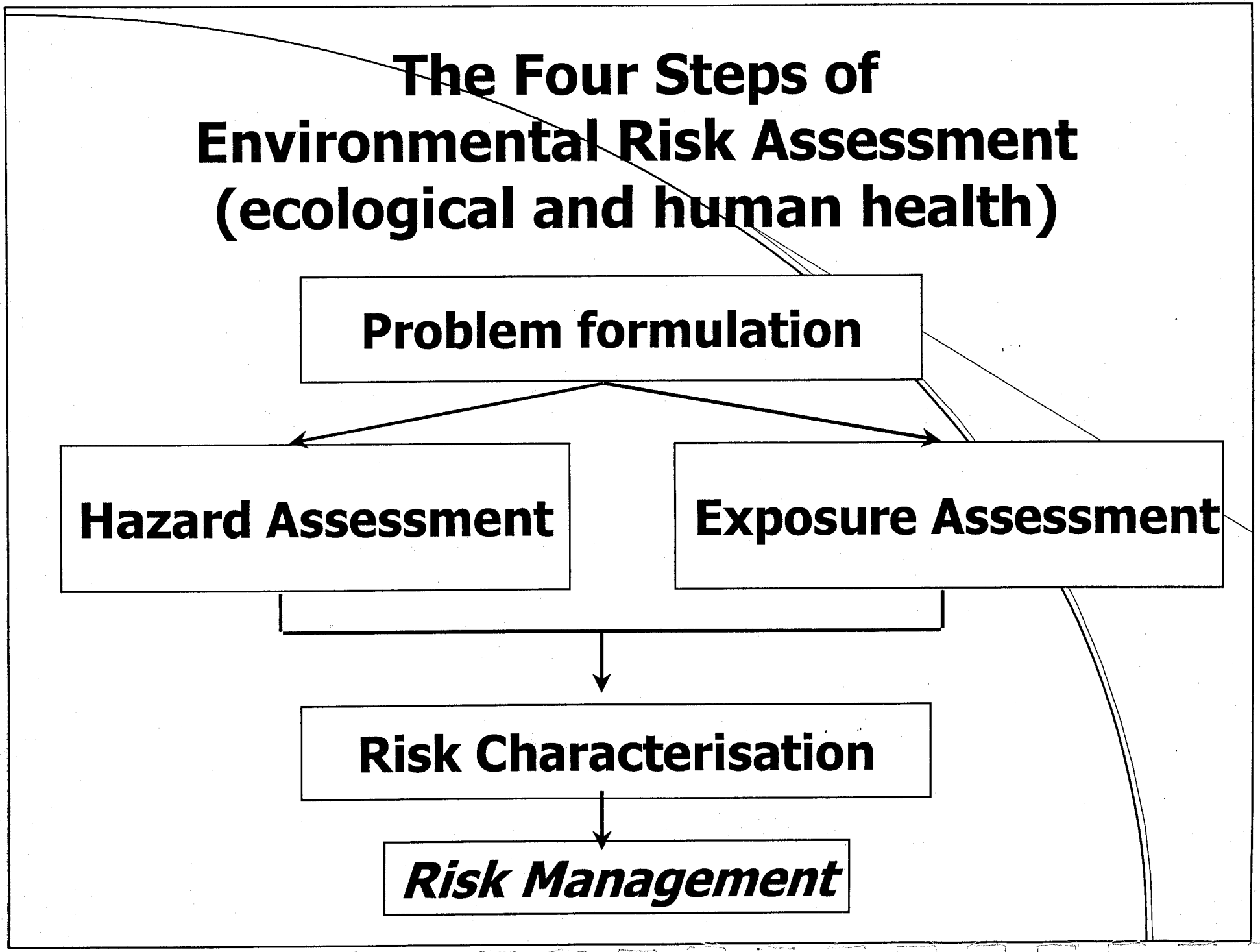
Hazard (Toxic Effect) X Exposure

Various Levels of Environmental Risk Assessment

Screening Assessment

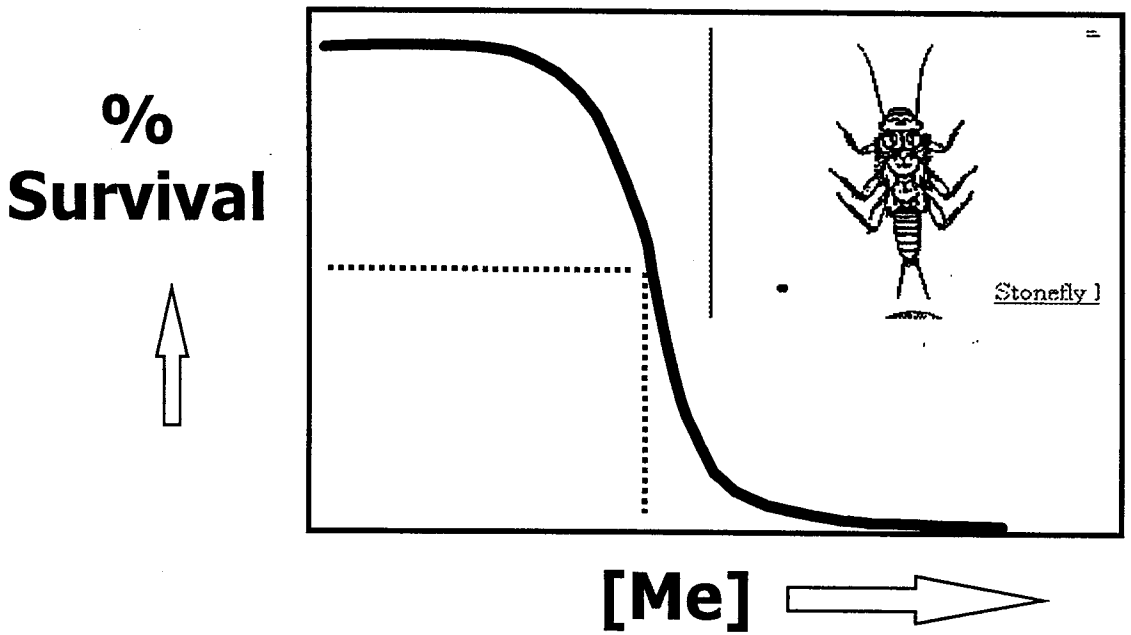
Preliminary Quantitative Assessment

Detailed Quantitative Assessment


The Four Steps of
Environmental Risk Assessment
(ecological and human health)
Problem formulation
Hazard Assessment
Exposure Assessment
Risk Characterisation
Risk Management

Major Steps in Risk Assessment

- **Hazard Assessment (Dose-response)**
  - **characterizes relationships between doses and incidences of effects in exposed populations.**



Exposure Pathways

Human Health

Ecological

Contaminated Soil

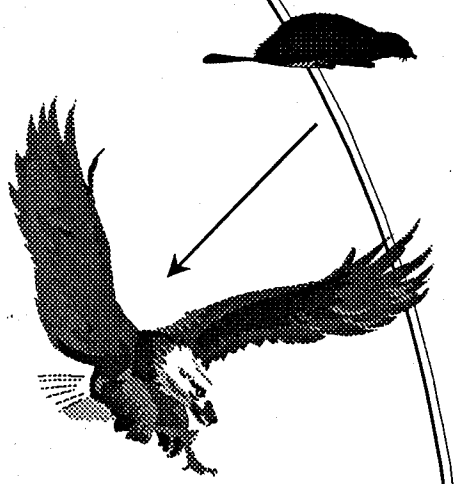
Groundwater

Soil Insects

Drinking water

Adult

Child



Exposure Assessment measures the intensity, frequency, and duration of exposures to contaminants.

Human Health vs Ecological Risk Assessment

Human Health

- One species.
- Effects assessment can target different types of human activities, and different organs.
- Protect individuals
- Has been around for many decades.

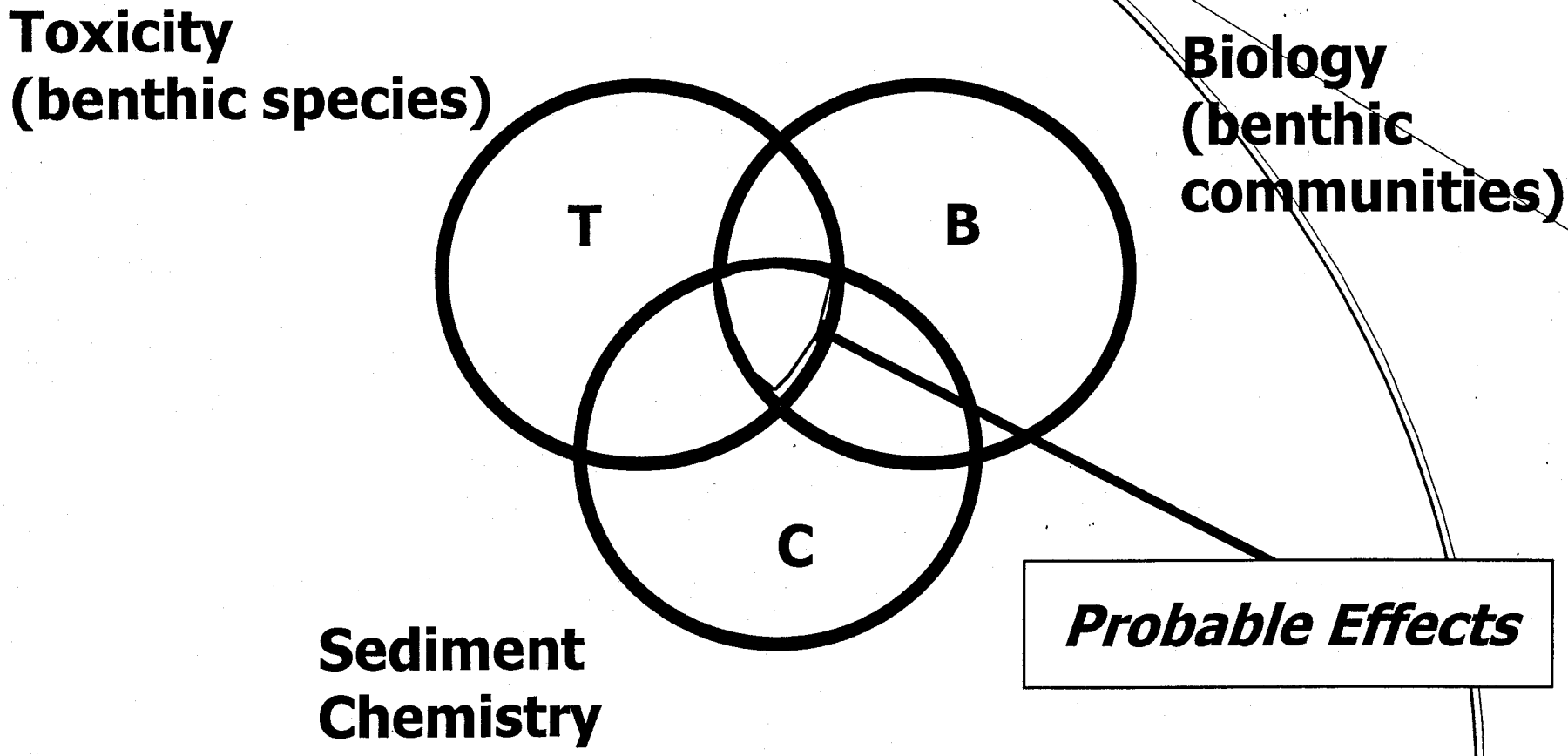
Ecological

- Many species within 3-4 levels of foodchain. *(main technical challenge)*
- Mainly toxicity and bio-accumulation information for key species.
- Protect populations.
- Developped in last 10 yrs and used for < 5 yrs.

Both equally important to regulators

Ecotoxicological Risk Assessment

Triad Approach
(weight of evidence)



Case Studies

Montreal Harbour (Sector 103) Sediments

Sediments near 2 wharfs used
by Mines Gaspe

Contaminated Sediments in St-Lawrence River, QC

- Contaminated sediments in bays around Dock 103 of Montreal harbour.
- 5 partners involved (2 gov.+ 3 industries).
- COC: Hydrocarbons and metals (Cu, Se, etc..).
- Using the Centre St-Laurent interim sediment quality criteria, the degree and extent of contamination (hazard) was relatively high.
- Agreement reached to assess environmental risks (ecotox, ecological and human health) before implementation of remediation plan.
- First time this type of study done in Québec: level of ERA for contaminated sediments and partnership.

Sediment Concentrations

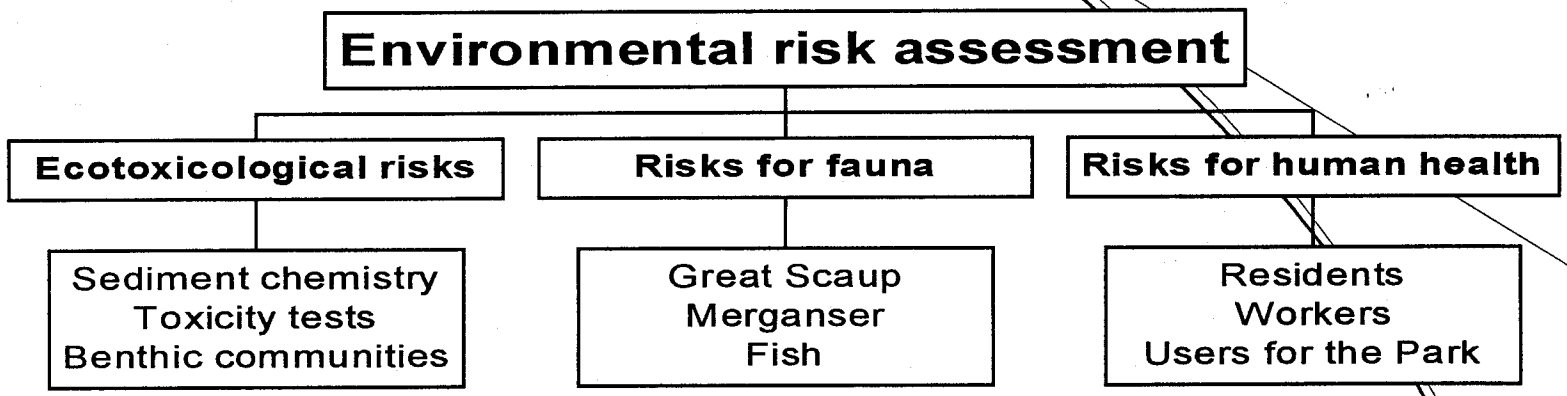
Mean Concentration in each bay (mg/kg), 1994

	North Bay	South Bay	SQG (SEL)
Arsenic	*110*	6,18	17
Cadmium	*3,19*	2,20	3
Chromium	*971*	*101*	100
Copper	*5194*	*150*	86
Mercury	*1,51*	*1,04*	1
Nickel	*670*	39,6	61
Lead	*170*	133	170
Selenium	*220*	4,3	10
Zinc	*755*	389	540
O&G min.	*24390*	*8045*	5000
Total PCB	0,48	0,14	1,0
PAH high MW	32,9	24,4	>
PAH low MW	*60,1*	*24,9*	>

92 samples
89 metal analyses
83 organic analyses

Total estimated volume:
40,000m^3

Conclusions of the evaluation of risks related to the sediment of Sector 103



***Low to high* risk**
(according to the cell)

Low risk
(for fishermen with an important consumption of local fish)

Background on Wharfs used by Mines Gaspé

Mont-Louis Wharf

- 1957-1994 : Bunker C Oil transfer
- 1987-1989 : Transfer of copper concentrate
- Since 1995 : infrastructures no longer needed by Mines Gaspé

Sandy Beach Wharf

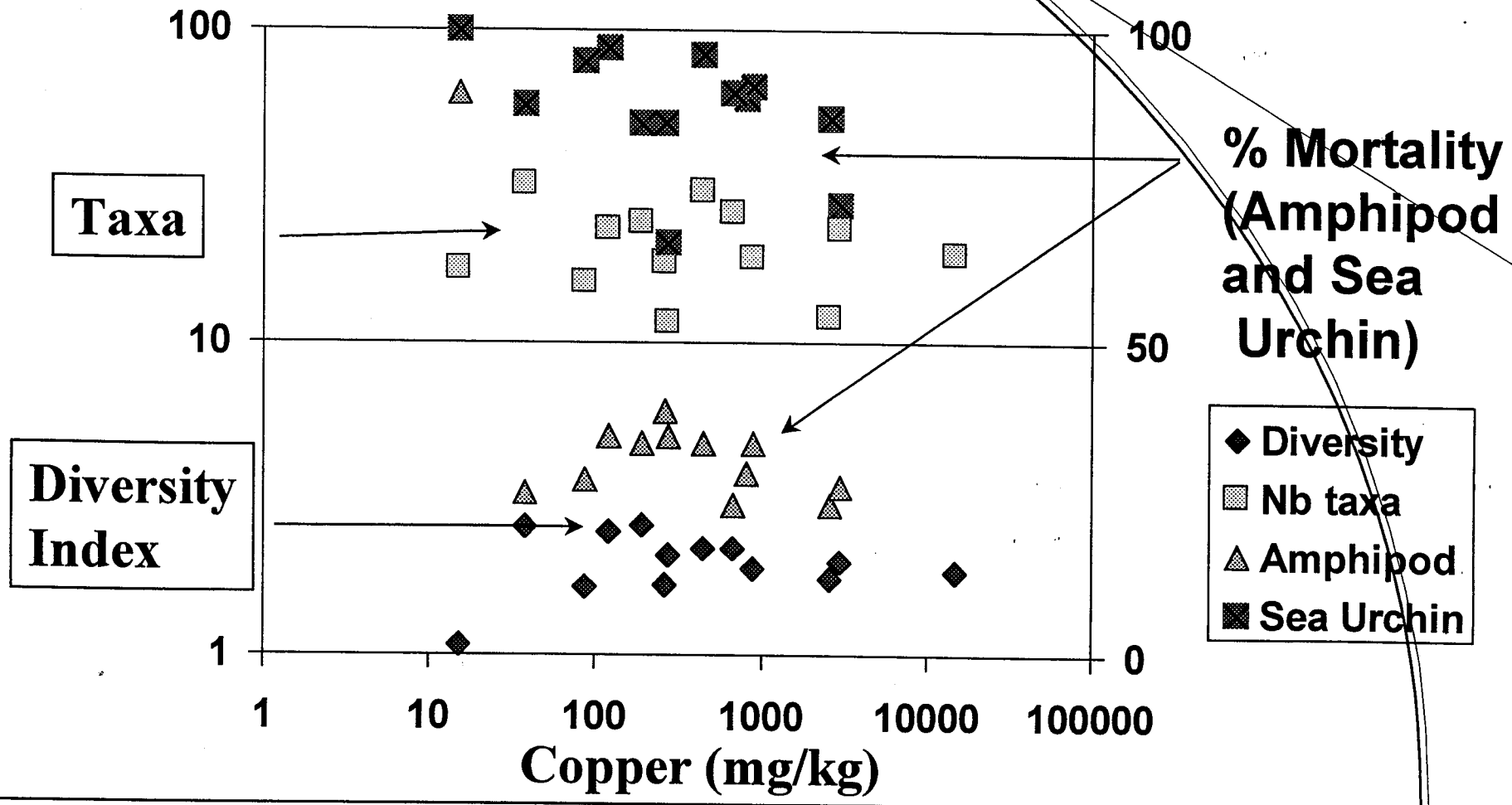
- Transfer of copper concentrate and sulfuric acid

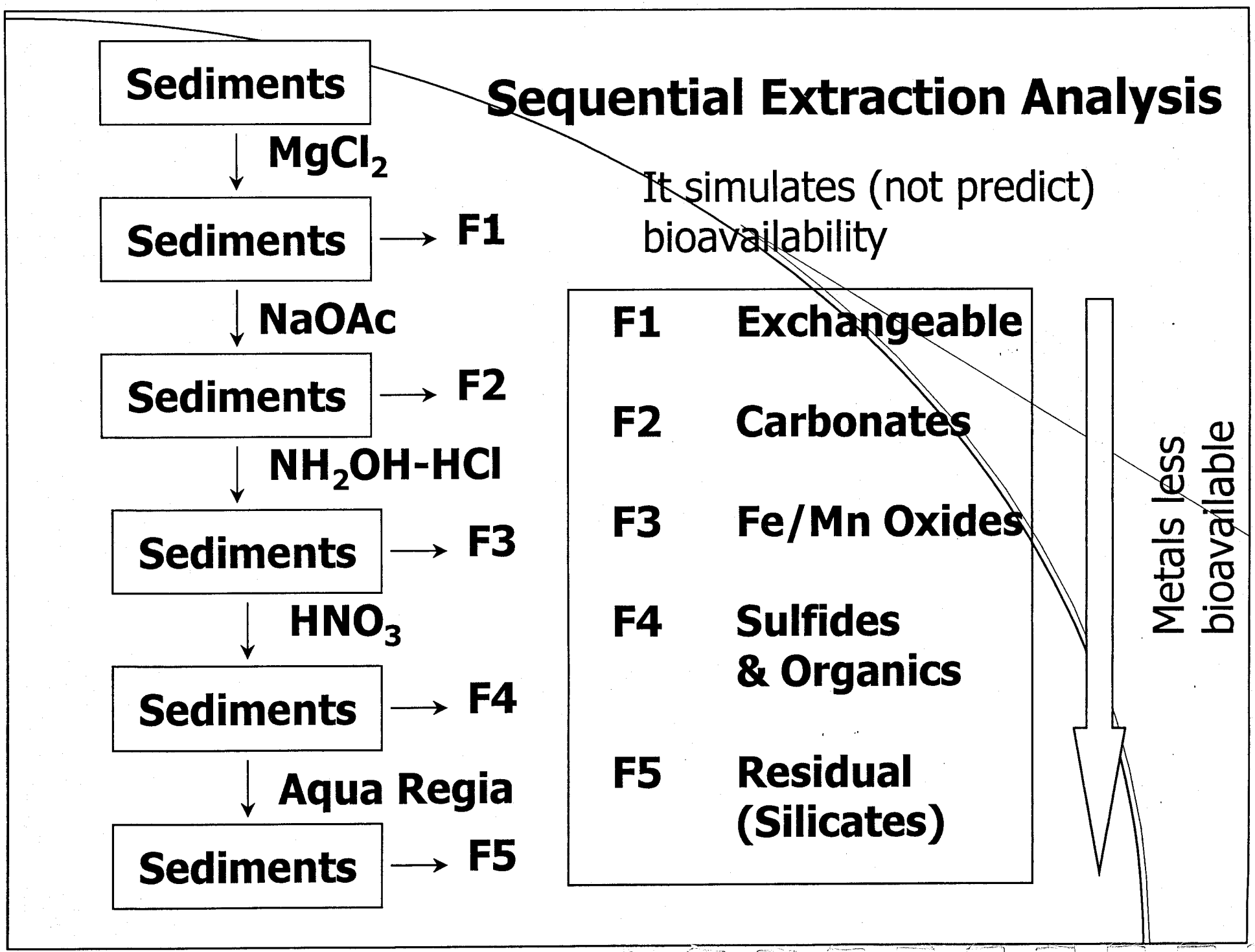
Ecotoxicological Evaluation of sediments near Mont-Louis and Sandy Beach Wharfs

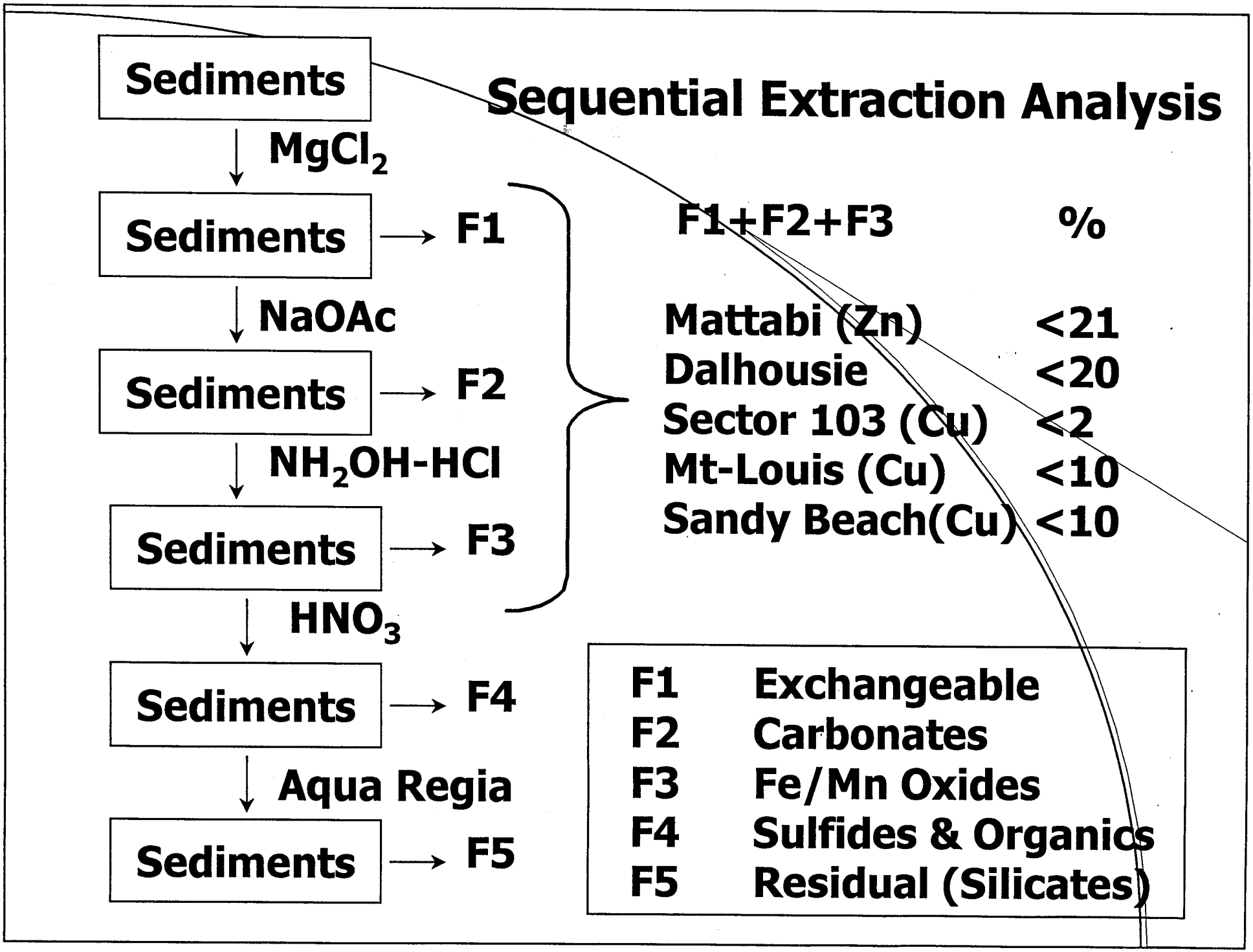
- **Objectives:** to determine the degree and extent of contamination and effects on benthos

- **Partners** : Transport Canada, Public Works, Mines Gaspé, CTN, Environment Canada, Fisheries and Oceans, MEF.

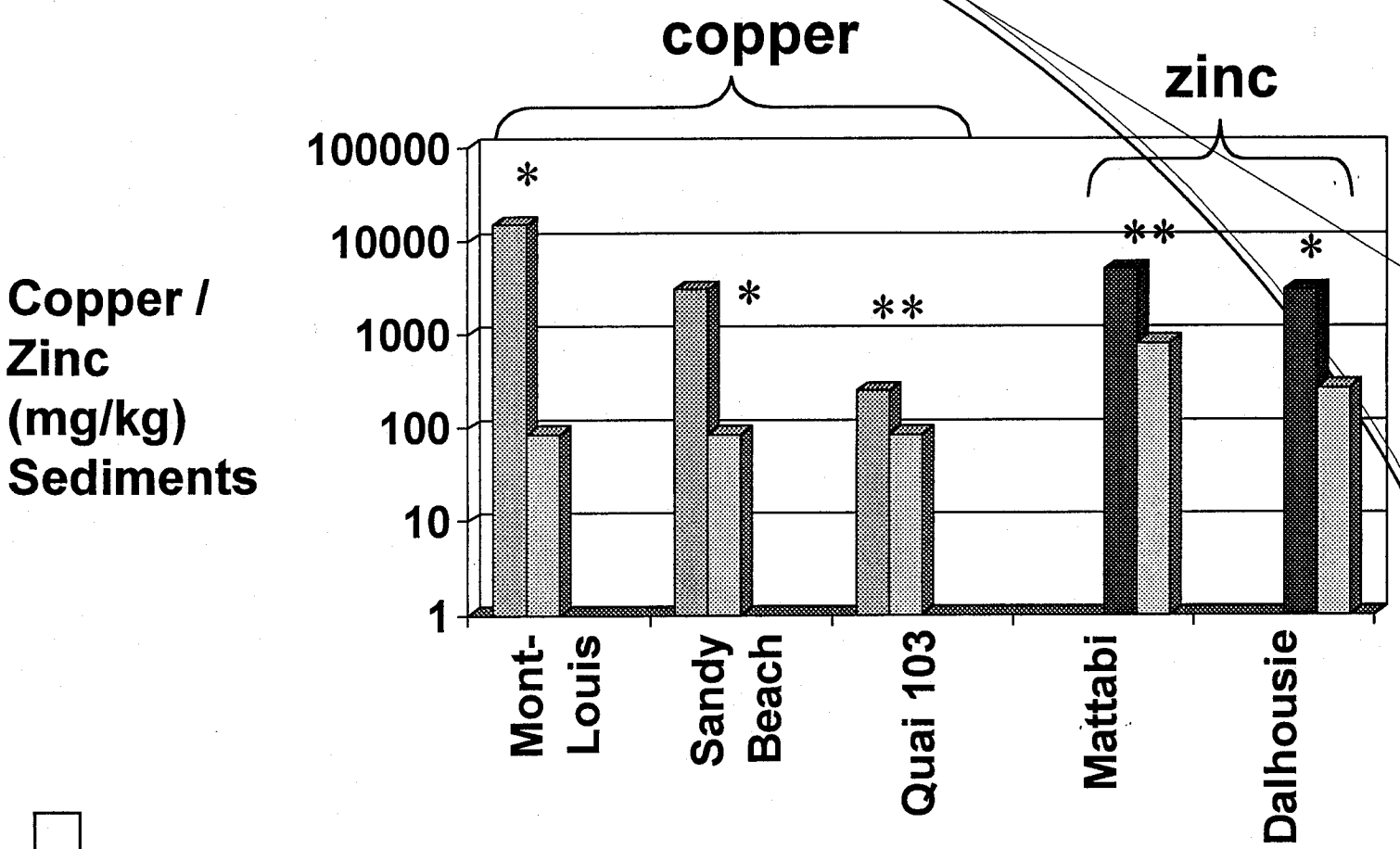
Biological Responses
Mont- Louis & Sandy Beach




Sediments
MgCl2
Sediments
F1
NaOAc
Sediments
F2
NH2OH-HCl
Sediments
F3
HNO3
Sediments
F4
Aqua Regia
Sediments
F5
Sequential Extraction Analysis
It simulates (not predict) bioavailability
F1 Exchangeable
F2 Carbonates
F3 Fe/Mn Oxides
F4 Sulfides & Organics
F5 Residual (Silicates)
Metals less bioavailable


Sediments
MgCl2
Sediments
F1
NaOAc
Sediments
F2
NH2OH-HCl
Sediments
F3
HNO3
Sediments
F4
Aqua Regia
Sediments
F5
Sequential Extraction Analysis
F1+F2+F3 %
Mattabi (Zn) <21
Dalhousie <20
Sector 103 (Cu) <2
Mt-Louis (Cu) <10
Sandy Beach(Cu) <10
F1 Exchangeable
F2 Carbonates
F3 Fe/Mn Oxides
F4 Sulfides & Organics
F5 Residual (Silicates)

Site-specific data vs generic guidelines



: Sediment quality criteria

* : No severe effects observed

** : severe effects observed

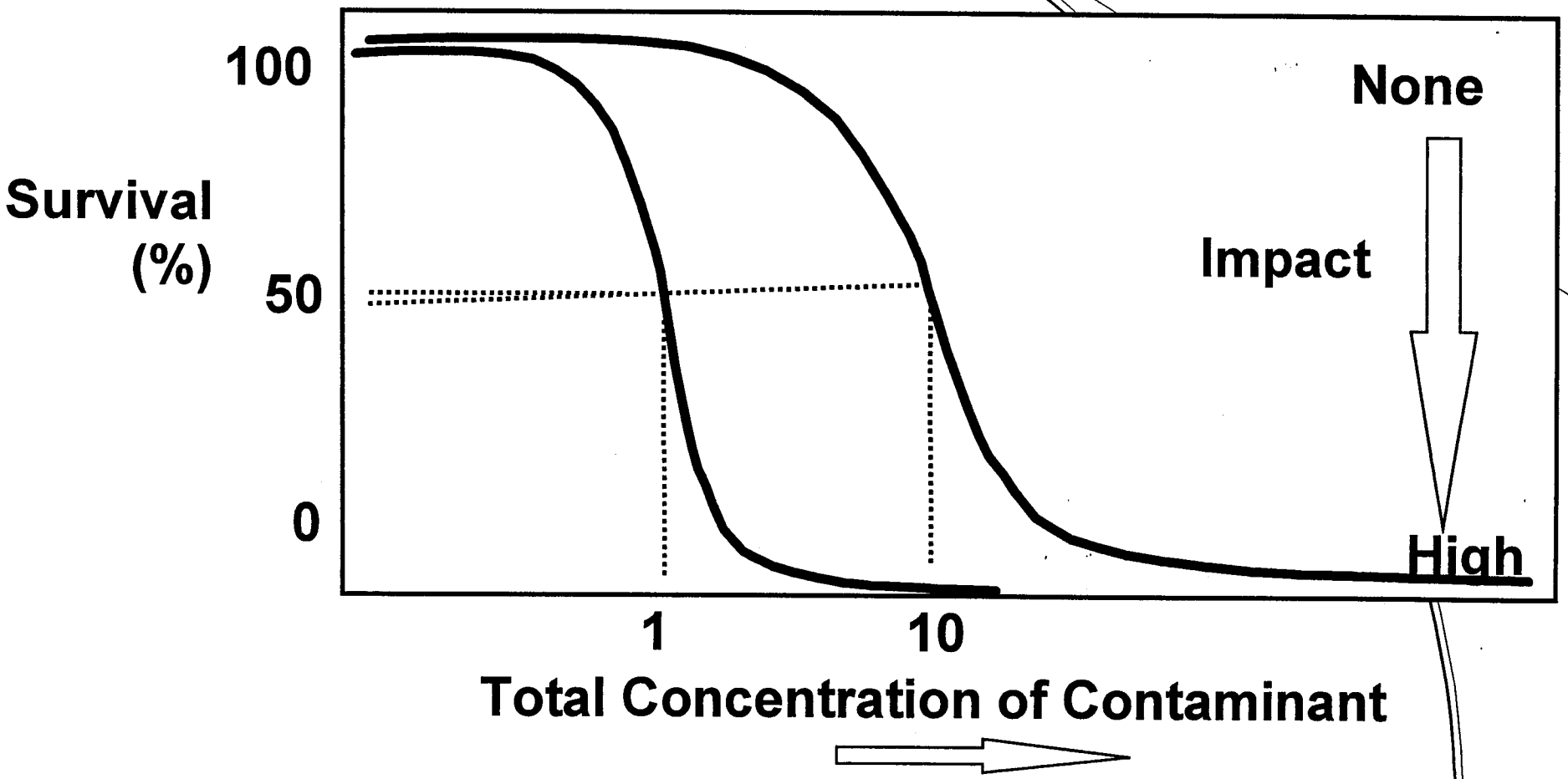
Overview of sediment quality near some Noranda Sites

- In the vicinity of many of our sites, Sediment Quality Guidelines (SQG) are often exceeded (by far!)
- Measured effects are often not as severe as predicted by SQG; however, SQG are useful to screen data.
- Effects of metals in sediments are dependant on speciation and bioavailibility.

Are metals in sediments always an environmental problem when exceeding SQG?

- The answer is no!
- Only site-specific study can help in quantifying risks ! It is up to the proponent to determine if impacts are less than predicted by guidelines!
- If the metal is found to be in an non-bioavailable form, the long term stability need to be adressed.
- Potential impacts from sediment clean-up can be worst than observed effects.

Potential Toxic Effects



RISK ASSESSMENT

Actual *Engineering* Risk = Consequence X Probability

Actual *Ecological* Risk = Toxicity $_{effect}$ X Exposure

Public Perception:

Perceived Risk = Actual Risk + Outrage

Linking ARD prediction to ERA

- Adding uncertainties : Ecological and human health risk assessment have also uncertainties related to each of the parameters used (eg. partition coefficient, etc..)
- Predicting metal bioavailability in downstream sediments from ARD prediction data would have at best a high level of uncertainty.