# Canadian Water Quality Guidelines for the Protection of Aquatic Life

## Introduction and Overview

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Presented at:

Webinar,
Canadian Society of Environmental Biologists
Wednesday, 9. November 2016

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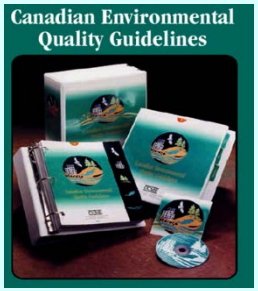
| Newfdlnd ST: | 13:30-14:30 |
| Atlantic ST: | 13:00-14:00 |
| Eastern ST: | 12:00-13:00 |
| Central ST: | 11:00-12:00 |
| Mountain ST: | 10:00-11:00 |
| Pacific ST: | 9:00-10:00 |


- 1992-2011: Environment Canada
  - assessing substances for their toxicity
  - developing water quality and tissue residue quality guidelines
  - Same group – different names

- 1999 Canadian Environmental Quality Guidelines Compendium
- 2007 Canadian Water Quality Guidelines Derivation Protocol
- Course conductor for Water Quality Guidelines training courses

- 2011-current: independent environmental consultant
  - specializing in water quality issues and training courses
  - Providing advice on use of guidelines to regulators, consultants and industry

**Ambient Water Quality for the 21st Century**

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# Outline – points to cover

- What are environmental quality guidelines
  - In general
  - “Use Protection” purpose
- What are CWQG-PAL
  - More specific
  - How they are used
  - Who is developing them
  - Where to find / get them
  - What do they look like
  - Some of their advantages and limitations
  - Derivation methods
- Lead-in to more in-depth courses

# What are EQB? (general)

**"Environmental Quality Benchmarks"**

- Have many names:
  - guidelines, criteria, objectives, standards, limits, …
- Origins:
  - provincial, federal, national, international, ..
- Different legal standing:
  - from voluntary guidance to mandatory limit
- Common purposes:
  - Protect a "Use" of the environment
    - examples - next slide

# "Use Protection" Purpose

**"Human" and "Environment", e.g.:**

- Canadian National Ambient Air Quality Objectives - H&E
- Indoor Air Quality Standards - H
- Guidelines for Canadian Drinking Water Quality - H
- Recreational Water Quality Guidelines - H
- **Canadian Water Quality Guidelines for the Protection of Aquatic Life** - E
- CWQGs for the Protection of Agricultural Water Uses - Irrigation & Livestock Watering
- Canadian Sediment Quality Guidelines for the Protection of Aquatic Life - E
- Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health - H&E
- Canadian Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota - E

**…. Provincial, Other Countries, …..**

- WHO – World Health Organization-Guidelines for Drinking Water Quality - H

# Who issues EQ-Benchmarks?

- Regulatory Bodies
  - Governments
    - e.g., EC/HC, Ont., Que., Alb., B.C.;
    - International:  US EPA, EU, Australia, China, ….
- Advisory Bodies
  - e.g., WHO, CCME, …
- Others
  - Consultants, academics, , …

# Why?

CWQG / CWQG-PAL

Why develop Canadian Water Quality Guidelines for the protection of aquatic life?

Why protect aquatic life and not just human health?

- Environment needs / deserves protection
- Everything is connected
- human health depends on a healthy ecosystem !!

"Guidelines are one Tool"

# What are Canadian Water Quality Guidelines?

## Great Tools,
### but with Imperfections & Limitations!!!

**Goal:**

- "… to protect aquatic organisms from undue harm caused by exposure to harmful substances (or conditions) in water."

- "… aim to protect most sensitive life stage of most sensitive species in aquatic ecosystems."

**By:**

- Providing a threshold level for a toxic substance

- … aims to approximate the level where there are no observable negative effects (or only accepted effects) on aquatic organisms.
  - **if exceeded …. have increasing chance of effects occurring.**

# What is a CWQG-PAL? (cont.)

**Threshold value is:**

- Based on aquatic toxicity tests
  - As many as possible/available
  - Mainly lab, but also mesocosm, field studies
- Considers only water-exposure
- Apply to ambient water bodies, and groundwater !!

# What is a CWQG-PAL? (cont.)

**Threshold value is:**

- National in scope !!
  - not necessarily site specific
- Science-based, not accounting for socio-economic factors, technology, or implementation issues
  - E.g., detection limits, mitigation measures or costs, clean-up capacity, filtering capability, etc.
- Not relying on assimilative capacity of Nature
- **Note:** WQGs are **not** "pollute-up-to permits"

**CCME Non-degradation Policy:**

**"For waters of superior quality or that support valuable biological resources, … the degradation of the existing water quality should always be avoided."** **(CEQG Binder; Intro to CWQG-PAL chapter)**

# What is a CWQG-PAL? (cont.)

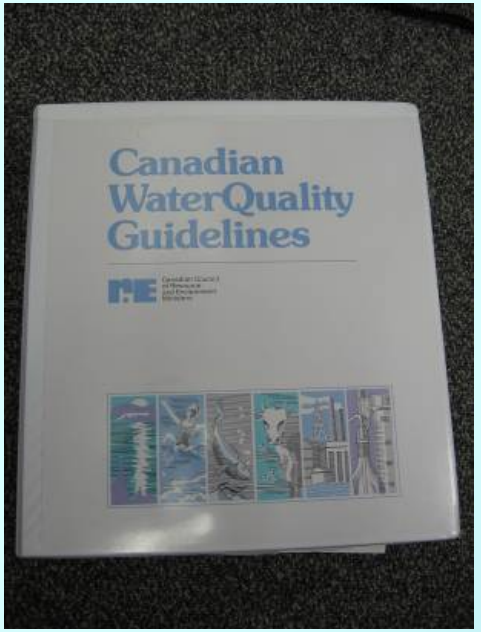
"… technical tools to increase jurisdictions' capacity to manage the impacts of land and water use activities …" (from CCME website)

- Can be: simple -> complex
  - single value
  - range
  - equation / table
  - narrative statement
- Factsheet and Guidance Document
- CWQG-PAL are Recommendations / Guidance Values
  - Adherence is voluntary !!
  - Why not mandatory / legal limit?
    - Issuing Body is CCME (explain later) [no authority]
    - Ease of development
  - But Impact …. Prudent to adhere to CWQG
    - Can be made into legal limits !

# How Guidelines are Used

- compare environmental concentration levels to identify/assess ambient conditions being monitored
- Trigger for env. management action
- Set discharge limits and remediation targets
- Evaluate the toxicity risk potential of a substance
- Source of scientific information on substance, guidance for toxic impacts

# Who is developing (C)WQG? - brief history ....




- CCREM / CCME (Canadian Council of Ministers of the Environment)
  - 1987: CWQG binder
    - With periodic Updates (Appendices) of new guidelines
    - Distributed nationally and internationally
  - 1991: First Development Protocol
  - Additional guidelines (air, soil, sediment, tissue residue)
  - 1999: release of CEQG Binder
  - 2007: New / Second Development Protocol

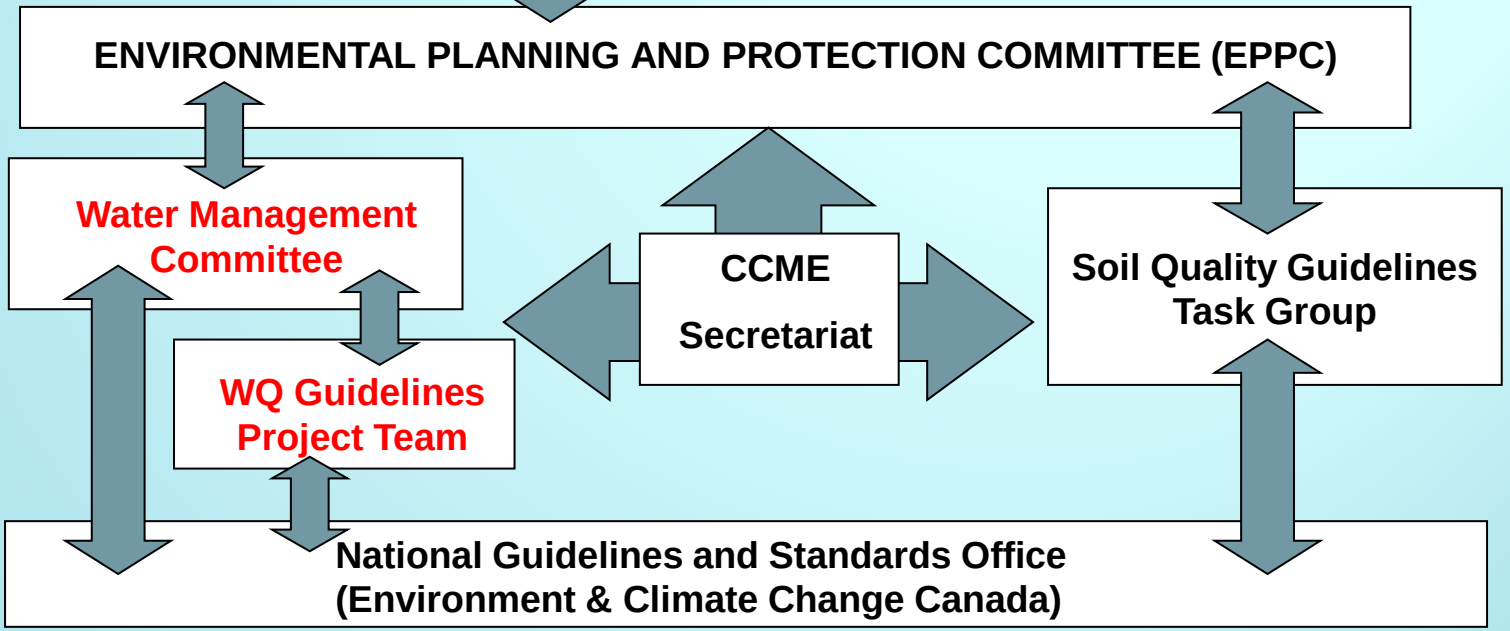
Continuous guideline development / publication process

***Provincial Territorial Federal representation on all committees***

CCME
Canadian Council of Ministers of the Environment
Le Conseil canadien des ministres de l'environnement

***The major intergovernmental environment minister's forum, for discussion and joint action on environmental issues of national and international concern***

**WMC manages intergovernmental approaches to water issues in Canada. Its work includes recommending priorities for cooperative action on existing and emerging water issues and coordinating the delivery of activities under CCME's strategic vision for water**

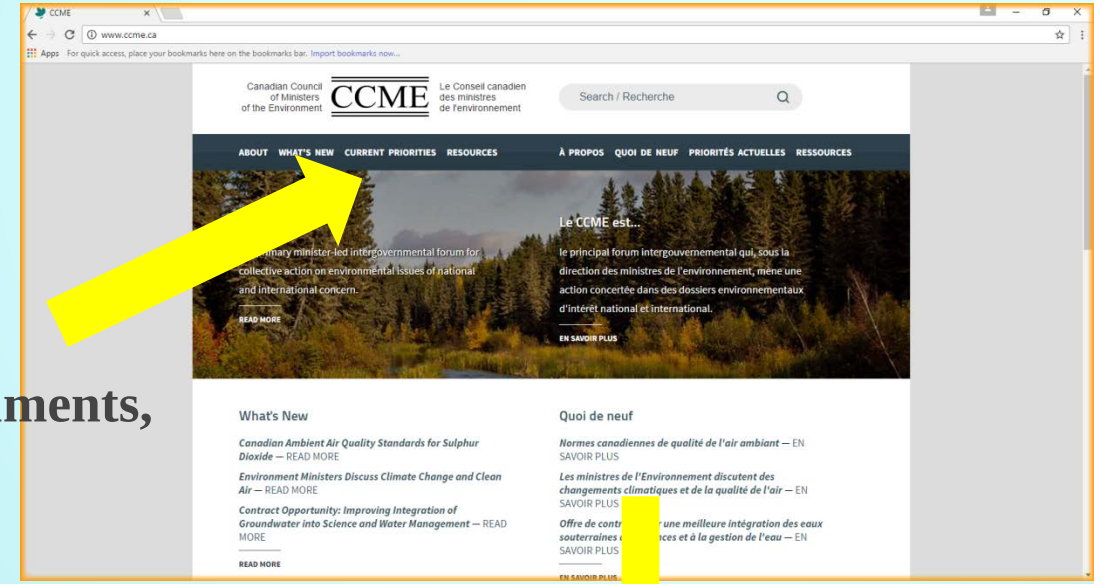


# Where to find these CWQG?

Not at ECCC website !!

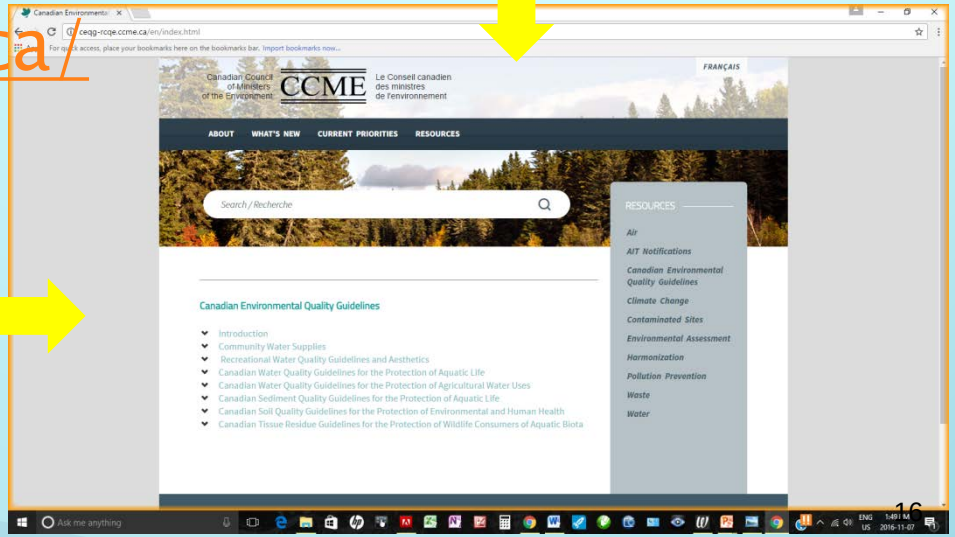
- www.ccme.ca
  - Click on “Resources”
  - Click on “CEQGs”

**Also provides Supporting Documents, *“Scientific Criteria Documents”***



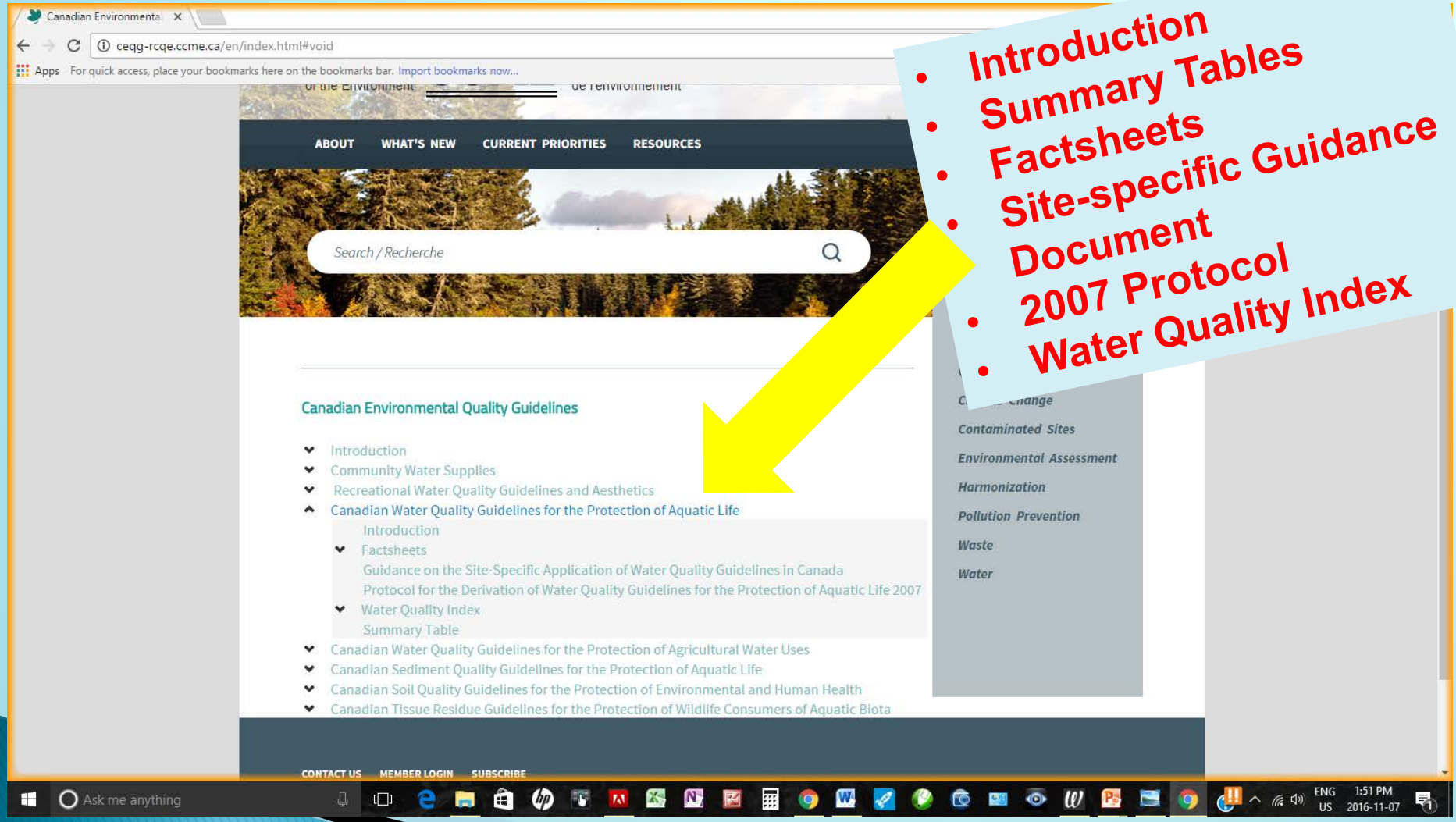

- http://ceqg-rcqe.ccme.ca/
  - Select “CEQG Online”

**Provides Factsheets, Summary Tables, Protocols, etc.**



# CEQG Online

**www.ceqg-rcqe.ccme.ca**




- Introduction
- Summary Tables
- Factsheets
- Site-specific Guidance Document
- 2007 Protocol
- Water Quality Index

# What does a Factsheet look like?

- **It provides:**
  - **Background info on substance**
  - **Methodology used** (i.e., protocol) **for guideline derivation**
  - **Toxicity information**
  - **Authoring jurisdiction and creation date of guideline** (and source of supporting documentation)
  - **Publication date by CCME, and revision date** (i.e. Update)

**Canadian Water Quality Guidelines for the Protection of Aquatic Life**

**ARSENIC**

Arsenic (elemental) is a silver-grey crystalline metallic material that melts at 817°C, sublimes at 613°C, and has a density of 5.72 g·cm$^{-3}$ at room temperature (Eisler 1988; Hazardous Substances Data Bank 1989). Arsenic has an atomic number of 33 and an atomic weight of 74.92 atomic mass units (amu). Although arsenic is odourless, tasteless, and insoluble in water, its inorganic salts and organic compounds vary in their physical and chemical properties (Hazardous Substances Data Bank 1989). The solubility of the arsenic ion depends on the nature of the counter ions (Slooff et al. 1990).

Arsenic is produced as arsenic trioxide ($As_2O_3$) through the roasting of arsenical gold ores. Demand for arsenic has fallen since the 1980s because of its ecotoxicity (Government of Canada 1993).

Arsenic is used in metallurgical applications and in manufacturing wood preservatives. Arsenic compounds are also used in herbicide, pharmaceutical, and glass manufacturing (Government of Canada 1993).

The largest natural source of arsenic entering surface waters is that from weathered rocks and soils (Nriagu 1989). Smelting and refining industries are anthropogenic sources (MacLatchy 1992).

Levels of total arsenic in uncontaminated surface waters are generally less than 2 µg·L$^{-1}$ (Government of Canada 1993). All lake and estuary samples (683 samples) showed arsenic concentrations below 50 µg·L$^{-1}$ (Leger 1991).

Arsenic undergoes chemical and microbiological oxidation, reduction, and methylation (Eisler 1988). In rivers, approximately two thirds of the total arsenic is soluble and one third is adsorbed to suspended solids (Reuther 1986). Arsenic is sorbed by colloidal humic material under conditions of high organic content, low pH, low phosphorus, and low mineral content (Thanabalasingam and Pickering 1986). Arsenic is affected by biotic uptake, sorption to iron or clay particles, or, less frequently, by precipitation or co-precipitation (Government of Canada 1993).

There is no indication that arsenic biomagnifies in freshwater food chains (National Academy of Sciences 1977; National Research Council of Canada 1978; Jenkins 1980; Phillips 1980, 1990; Eisler 1988). The degree and rate of uptake depends on phosphorus, which interacts with arsenic and competes for sorption sites, thus reducing the surfaces available for arsenic (Reuther 1992).

### Water Quality Guideline Derivation

The Canadian water quality guidelines for arsenic for the protection of aquatic life were developed based on the CCME protocol (CCME 1991). For more information, see the supporting documents (CCME 1997; Fletcher et al. 1998).

### Freshwater Life

Data on the toxicity of arsenic to freshwater biota were available for 21 species of fish, 14 species of invertebrates, and 14 species of plants. Rainbow trout *(Oncorhynchus mykiss)* and climbing perch *(Anabas testudineus)*, the most sensitive fish, seem to be equally as sensitive as invertebrates such as copepods *(Cyclops vernalis)* and daphnids *(Daphnia magna)*. Some aquatic plants, however, are an order of magnitude more sensitive (CCME 1997).

The lowest estimates of toxicity for fish ranged from a 28-d $LC_{50}$ of 550 µg·L$^{-1}$ for rainbow trout *(O. mykiss)* (Birge et al. 1979), a 7-d LOEC of 500 µg·L$^{-1}$ and a 72-h LOEC (survival) of 970 µg·L$^{-1}$ for climbing perch *(A. testudineus)* (Jana and Sahana 1989), to a 7-d LOEC of 970 µg·L$^{-1}$ for catfish *(Clarias batrachus)* (Jana and Sahana 1989).

The lowest estimates of toxicity for invertebrates ranged from a 14-d $EC_{20}$ (sublethal concentration causing 20%

**Table 1. Water quality guidelines for arsenic* for the protection of aquatic life (CCME 1997).**

| Aquatic life | Guideline value (µg·L$^{-1}$) |
|---|---|
| Freshwater | 5.0 |
| Marine | 12.5† |

*For total arsenic.
†Interim guideline.

# What does a CWQG Factsheet look like?

- **It provides:**
  - **Guideline derivation process** (critical study, safety factor, guideline value)
  - **Toxicity Figure**
  - **Now also a Graph**
    - SSD Curve
- **For freshwater and marine, respectively**



reduction in growth) of 320 µg·L$^{-1}$ for the copepod *C. vernalis* (Borgmann et al. 1980), a 21-d $EC_{16}$ (reproduction) of 520 µg·L$^{-1}$ for *D. magna* (Biesinger and Christensen 1972), a 96-h $EC_{50}$ (immobility) of 850 µg·L$^{-1}$ for *Bosmina longirostris* (Passino and Novak 1984), and a 7-d $LC_{80}$ of 960 µg·L$^{-1}$ for *Gammarus pseudolimnaeus* (Spehar et al. 1980), to a 7-d LOEC (immobilization) of 1000 µg·L$^{-1}$ for *Ceriodaphnia dubia* (Spehar and Fiant 1986).

The lowest estimates of toxicity for plants ranged from a 14-d $EC_{50}$ (growth) of 50 µg·L$^{-1}$ for *Scenedesmus obliquus* (Vocke et al. 1980), two $EC_{50}$s (growth) of 75 µg·L$^{-1}$ for *Melosira granulata* and *Ochromonas vallesiaca* (Planas and Healey 1978), to a 20-d VSUE (very severe unfavourable effect) of 960 µg·L$^{-1}$ for *S. quadricus* (Fargasova 1993).

The water quality guideline for arsenic for the protection of freshwater life is 5.0. It was derived by multiplying the 14-d $EC_{50}$ (growth) of 50 µg·L$^{-1}$ (Vocke et al. 1980) for the most sensitive organism to arsenic, the alga *S. obliquus,* by a safety factor of 0.1 (CCME 1991).

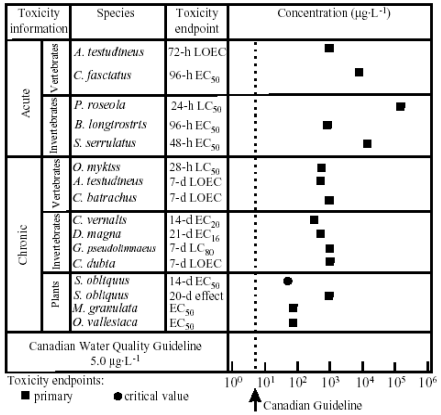



**Figure 1. Select freshwater toxicity data for arsenic.**

## Marine Life

Data on toxicity of arsenic to marine biota were available for 8 species of fish, 21 species of invertebrates, and 4 species of plants. Fish seem to be more tolerant than either invertebrates or aquatic plants. The most sensitive fish studied, pink salmon *(O. gorbuscha)* and striped bass *(Morone saxatilis),* were over an order of magnitude less sensitive than the most sensitive invertebrates studied, Dungeness crabs *(Cancer magister)*, zooplankters *(Eurythemora affinis)*, Pacific oysters *(Crassostrea edulis),* and sea urchins *(Paracentrotus lividus)*. Aquatic plants, especially the red alga *Champia parvula* and *Skeletonema costatum,* seem to be four to eight times more sensitive than invertebrates (CCME 1997).

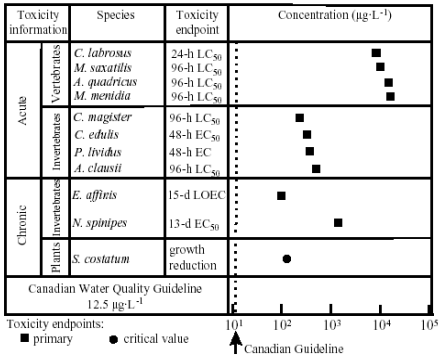



**Figure 2. Select marine toxicity data for arsenic.**

The lowest estimates of toxicity for marine fish ranged from a 10-d $LC_{54}$ of 3790 µg·L$^{-1}$ for pink salmon *(O. gorbuscha)* (Holland et al. 1964), a 96-h $LC_{50}$ of 10 300 µg·L$^{-1}$ for striped bass *(M. saxatilis)* (Dwyer et al. 1992), to a 96-h $LC_{50}$ of 14 900 µg·L$^{-1}$ for the fourspine stickleback *(Apeltes quadracus)* (USEPA 1980).

The lowest estimates of toxicity for invertebrates ranged from a 96-h $LC_{50}$ of 230 µg·L$^{-1}$ for Dungeness crabs *(C. magister)* (Martin et al. 1981), a 15-d LOEC (survival) of 100 µg·L$^{-1}$ for the zooplankter *E. affinis* (Sanders 1986), a 48-h $EC_{50}$ (development) of 326 µg·L$^{-1}$ for Pacific oysters *(Crassostrea edulis)* (Martin et al. 1981), developmental effects at 370 µg·L$^{-1}$ for sea urchins *(P. lividus)* ([48-h exposure] Pegano et al. 1982), to a 96-h $LC_{50}$ of 510 µg·L$^{-1}$ for *Acartia clausii* (USEPA 1980).

The lowest estimates of toxicity for plants ranged from the 14-d decrease in reproductive success of 60 µg·L$^{-1}$ for the red alga *C. parvula* (Thursby and Steel 1984), to growth reductions in *S. costatum* after exposure to 125 µg·L$^{-1}$ (Sanders 1979).

The interim water quality guideline for arsenic for the protection of marine and estuarine life is 12.5 µg·L$^{-1}$. It

# What does a CWQG Factsheet look like?

- **Factsheet provides:**
  - **References**
  - **How to cite the guideline**
  - **Whom to contact for further information**
    - **Science-related**
    - **Publication-related**



was derived by multiplying the LOEC of 125 $\mu g \cdot L^{-1}$ (Sanders 1979) for the most sensitive organism to arsenic, the diatom *S. costatum*, by a safety factor of 0.1 (CCME 1991).

## References

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Phillips, D.J.H. 1980. Quantitative aquatic biological indicators. Applied Science Publishers Ltd., London.

Reference listing:

Canadian Council of Ministers of the Environment. 2001. Canadian water quality guidelines for the protection of aquatic life: Arsenic. Updated. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

For further scientific information, contact:

Environment Canada
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For additional copies, contact:

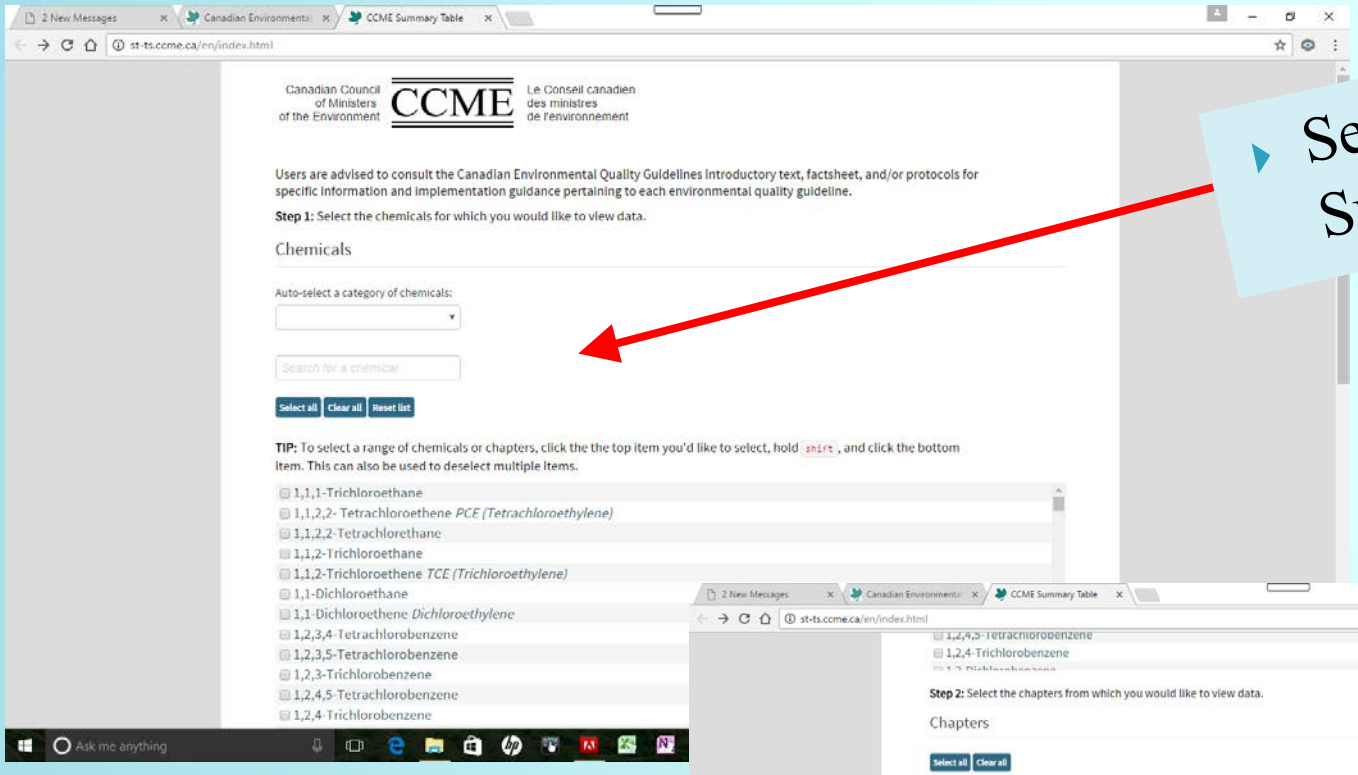
CCME Documents
c/o Manitoba Statutory Publications
0 Vaughan St.
nipeg, MB R3C 1T5
(204) 945-4664
le: (204) 945-7172
spccme@chc.gov.mb.ca



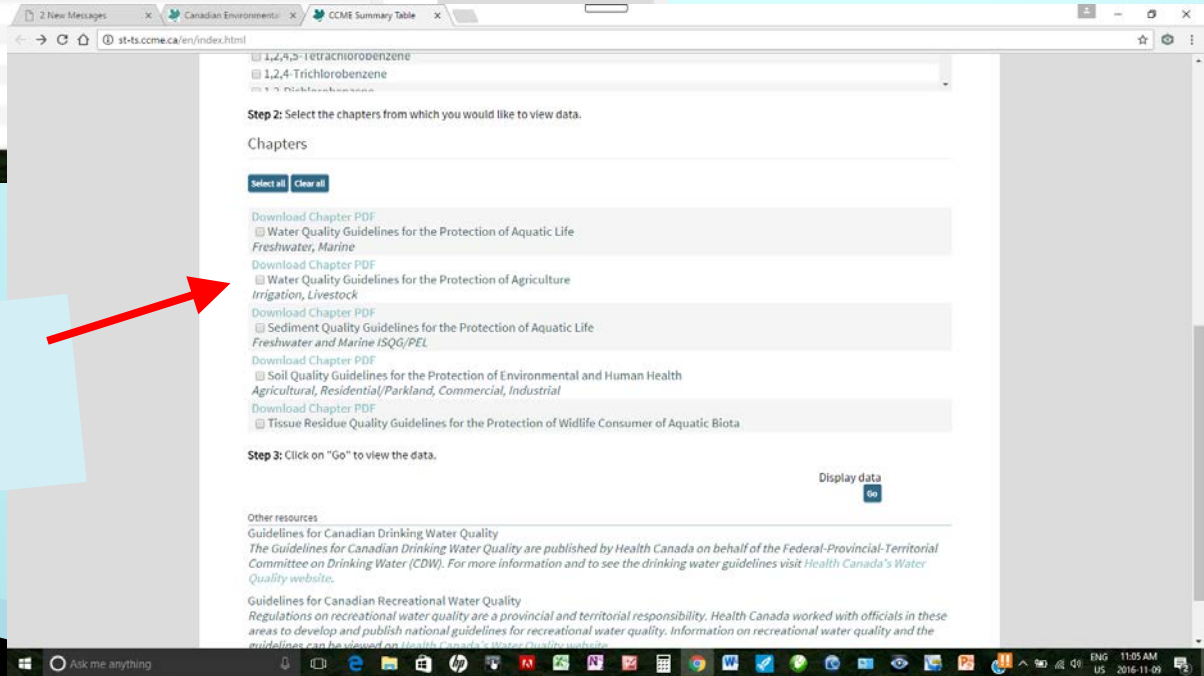
ible en français.

**Both Contacts are now outdated in older Factsheets!**

# Summary Tables - Online



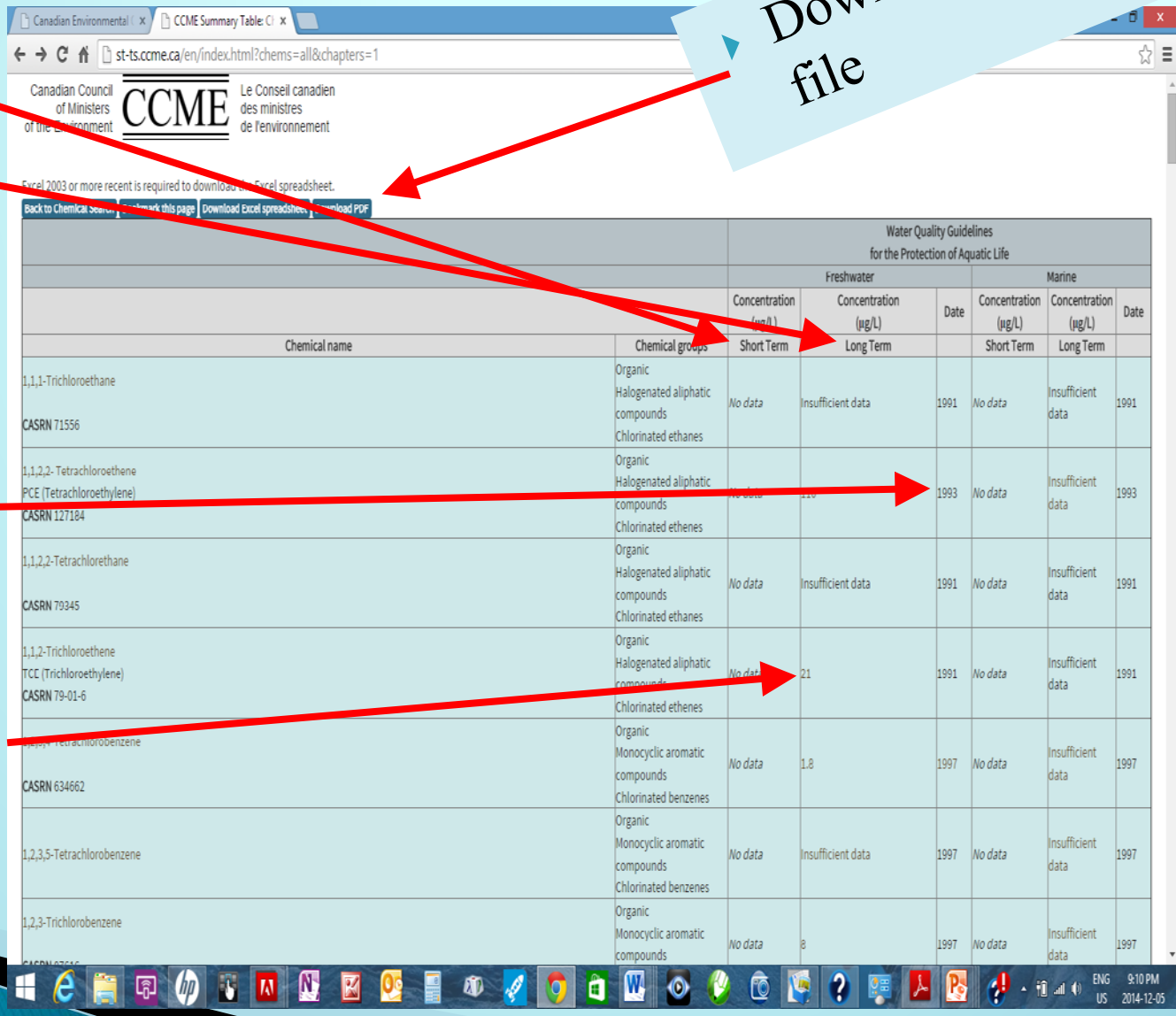

Select the Substance(s)




Select the Chapter(s)

# Summary Tables - Online

- Note Short Term and Long Term Exposure guidelines
- Note creation date of guideline
  - (1987 to current)
- Click on value for more info




| Chemical name | Chemical groups | Water Quality Guidelines for the Protection of Aquatic Life – Freshwater Concentration (µg/L) Short Term | Freshwater Concentration (µg/L) Long Term | Freshwater Date | Marine Concentration (µg/L) Short Term | Marine Concentration (µg/L) Long Term | Marine Date |
|---|---|---|---|---|---|---|---|
| 1,1,1-Trichloroethane CASRN 71556 | Organic Halogenated aliphatic compounds Chlorinated ethanes | *No data* | Insufficient data | 1991 | *No data* | Insufficient data | 1991 |
| 1,1,2,2- Tetrachloroethene PCE (Tetrachloroethylene) CASRN 127184 | Organic Halogenated aliphatic compounds Chlorinated ethenes | | | 1993 | *No data* | Insufficient data | 1993 |
| 1,1,2,2-Tetrachlorethane CASRN 79345 | Organic Halogenated aliphatic compounds Chlorinated ethanes | *No data* | Insufficient data | 1991 | *No data* | Insufficient data | 1991 |
| 1,1,2-Trichloroethene TCE (Trichloroethylene) CASRN 79-01-6 | Organic Halogenated aliphatic compounds Chlorinated ethenes | | 21 | 1991 | *No data* | Insufficient data | 1991 |
| CASRN 634662 | Organic Monocyclic aromatic compounds Chlorinated benzenes | *No data* | 1.8 | 1997 | *No data* | Insufficient data | 1997 |
| 1,2,3,5-Tetrachlorobenzene | Organic Monocyclic aromatic compounds Chlorinated benzenes | *No data* | Insufficient data | 1997 | *No data* | Insufficient data | 1997 |
| 1,2,3-Trichlorobenzene | Organic Monocyclic aromatic compounds | *No data* | 8 | 1997 | *No data* | Insufficient data | 1997 |

# Advantages of the Guidelines

- Thorough, extensive development process (for post-1987 values)
- Using best-available science
- Scientifically very defensible
- Peer-reviewed
- Nationally approved
- Respected, internationally recognized
- PROTECTIVE - with limitations !!!

# Limitations of the CWQG-PAL - National Guidelines

- "Broad ecosystem coverage" in approach
  - but ecosystems and environments vary across Canada
    - e.g., some national guidelines not applicable / underprotective to Northern conditions (colder, soft water, nutrient poor, often higher natural background levels)
    - But also, when Natural Background is high, a national guideline can be overprotective
  - **Solution: development of Site-Specific WQG**

- Some guidelines are dated;
  - Some are 20-30 yrs old, new info available, better derivation method

# Limitations of the CWQG-PAL - National Guidelines

- Science-based limitations:
  - generally apply to single substances or components;
    - But **"Chemical Soup"** in the environment
  - apply to water-exposure only; i.e., do not incorporate food web effects (bioaccumulation or biomagnification)
  - Limited incorporation of toxicity modifying factors

➔ **a (national) water quality guideline can be underprotective**

# Derivation Methods for a Guideline value

- **Safety Factor Method**
  - Lowest Value x Safety Factor
  - Used from 1987 to 2007
- **Species Sensitivity Distribution Method**
  - SSD
  - Preferred Method since 2007 (new Protocol)
    - If not possible to apply, fall back to SF method

# (A) Safety Factor Method

- Very simple, straight-forward method:
  - Collect as much toxicity data as possible
    - Evaluate, assess, select. … for as many species as possible
  - Select the lowest acceptable appropriate toxicity value from all species
    - (i.e., key study / key value)
  - Apply safety factor
- guideline is a single number

# (A) Safety Factor Method (cont.)

- **Key Study / Key Value**
  - lowest acceptable toxicity value
    - Acceptable according to Derivation Protocol
    - Can be of any acceptable toxicity endpoint
      - Growth, reproduction, lethality, immobilization, survival of young, behavioural changes, fitness, etc.
    - **But** must be ecologically relevant
    - Can be of any acceptable impact level
      - 10%, 20%, 50% - $EC_{10}$ growth, $LC_{50}$
    - Can be of any acceptable exposure time span
      - 96 hours, 21 days, etc.

# (A) Safety Factor Method (cont.)

**Safety Factor**

- Also called:
  - uncertainty factor,
  - assessment factor,
  - extrapolation factor,
  - … (fudge factor)
- Size arbitrary, with weak scientific defense
- 
- Normally depends on type of key study
  - CWQG Protocol: 10, 20, 100
  - (other jurisdictions: as above, and 1000, …)

- **Arbitrary Extrapolation from One Known** (measured toxic impact) **to the Unknown** (the protective threshold value)

**CAUTION !! Extrapolation is unreliable**

# (B) Species Sensitivity Distribution Method (SSD)

A more complicated, statistical method:

- Collect as much toxicity data as possible
- Evaluate, assess, select. … for as many species as possible
- Select the lowest acceptable appropriate toxicity value for each species
  - (i.e., species key study / species key value), focus on no-/low-effects
- Create table of "species key values" for all available species
- Analyse this table statistically
  - Create a "toxicity impact graph" ( the SSD curve)
  - The species are distributed along the curve based on their sensitivity to the toxic substance - (sigmoidal curve, cf. dose-response curve)
  - Determine a level on the curve as the guideline value
    - Usually use the 5$^{th}$ centile

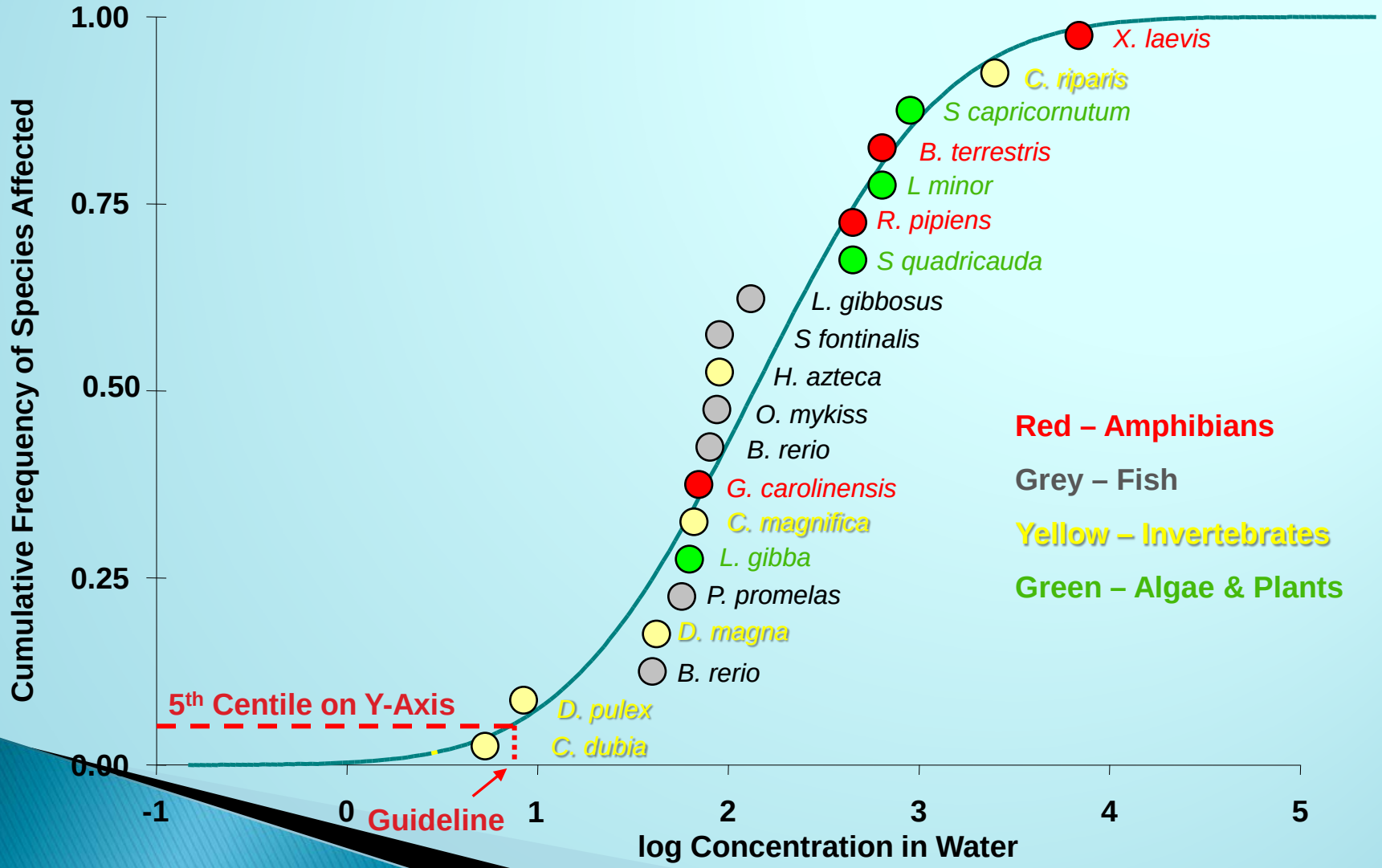
**Statistical Extrapolation from Many Known** (measured toxic impacts) **to the Unknown** (the protective threshold value)

Improvement:

extrapolate with Stats !!

extrapolate from many individual species' toxicity tests

# Species Sensitivity Distribution



# (B) Species Sensitivity Distribution Method (SSD)

- Several curves are fitted using:
  - the most appropriate distribution
  - several models (e.g., normal, logistic, Gompertz, Weibull, Fisher-Tippet, ML, etc.)
  - Statistical requirement: Model curve must pass "goodness of fit" tests and/or visual inspection
  - If either toxicological or statistical requirement is not met, the next tier derivation method (Safety Factor Method) will be used
- Best-fitting model curve is selected for guideline determination:
  - CWQG = concentration corresponding to the 5$^{th}$ Centile of Y-axis (HC5)
- NGSO created "SSD Master" to assist guideline developers

# Species Sensitivity Distribution (SSD)(cont.)

- **Pro:**
  - Graphic / nice picture – **Probabilistic Approach**
  - Uses information from many species
    - Attempt in ecosystem simulation
    - but still far from realistic !
  - Uses Statistical Extrapolation (rather than arbitrary SF)
    - Elegant concept, currently “in”,
    - considered much better than “lowest x SF”
- **Con:**
  - Data intensive
  - Complex, complicated
    - Devil lies in the Details
    - Many different ways to do it
  - Requires operator expertise in toxicology and statistics
  - Easy to manipulate, hard to spot manipulation

# In Summary – CWQG-PAL

**Key points to remember**

- Interpretation: .. level below which adverse effects are not expected. If exceeded .. …increased probability of an adverse effect.
- National, toxicity-derived value, not site-specific, not accounting for socio-economic factors or implementation issues
- derived from a consistent approach using no-/ low-effects aquatic toxicity data
- Not legally binding, but …
  - basis for regulations, permits, effluent discharge limits

# In Summary – CWQG-PAL

**Key points to remember**

- Developed jointly by F/P/T, published by CCME
- Implementation:
  - All Canadian provinces use the CWQGs, sometimes together with their own WQG or objectives
- Used as:
  - Indicators for state-of-the-environment reporting
  - Water Quality Index
  - Basis for management objectives and strategies for toxic substances
  - To developing licences and/or effluent permits

# …. This was a brief Intro to CWQG-PAL …

- Generally, what are EQBs
- Specifically, what are CWQG-PAL
  - Purpose and Use
  - Some History, & Who develops them
  - Where to find them
  - What they look like - Factsheets
  - Some of their advantages and limitations
  - How are they derived - methods
    - "lowest x SF"
    - "SSD"

But there is more ….

# … more in-depth aspects ….

- How to develop a CWQG-PAL
  - whole process
  - Details on the derivation methods
    - Esp. on the SSD method
- How to actually apply a national CWQG
  - in detail
  - What to do if a monitoring value exceeds the value
- How to apply it to a specific site
- How to develop a Site-Specific WQG
- How to incorporate toxicity modifying factors
- Comparison to WQG from other jurisdictions
  - Provincial
  - International
- Process & problems of using/adopting values from other jurisdictions
- How to assess & evaluate an aquatic toxicity test for suitability and acceptability in guideline derivation
- How to assess and evaluate a CWQG / SS-WQG
  - E.g., a proponent-submitted site-specific WQG for a mine site
- How to properly create a SSD-curve for a WQG
- … and a lot more ….

# My Courses

- I teach:
  - short courses (like this one),
  - Half-day & full-day courses,
  - Multiple-day courses
- On all aspects of water quality guidelines
- I offer them in Ottawa / travel to other locales
- If you are interested in a course, please contact me.

Thank You !!!

# Questions ???