Australian Government
Department of the Environment and Energy
Supervising Scientist

How specific is site-specific?

Guidance for selecting and evaluating approaches for deriving site-specific water quality guideline values

Rick van Dam[1], Andrew Harford[1], Chris Humphrey[1] & Alicia Hogan[2]

[1] Environmental Research Institute of the Supervising Scientist (ERISS), Darwin, NT, Australia

[2] NRA Environmental Consultants, Cairns, Qld, Australia

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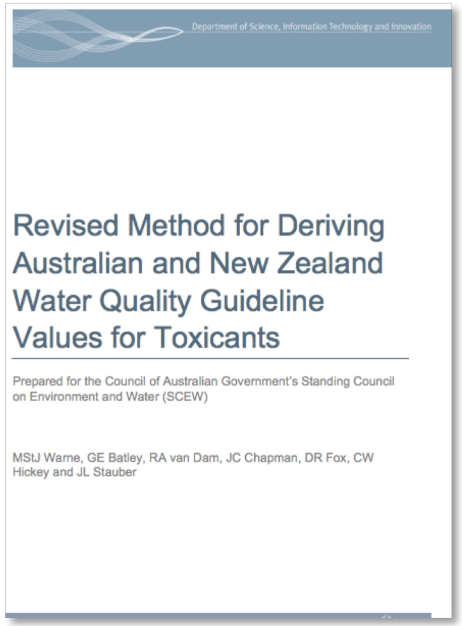
Outline

- *The need*
- **Context for site-specific GVs**
  - What they are
  - Why we need them
  - Decisions, complexity and gaps in guidance
  - Guiding principles
- **Types of site-specific GVs**
- **How can we assist end users?**
- **Key messages**

The need

- Still a general lack of understanding of site-specific GVs
  - What they are
  - How they can be derived
  - Relative strengths and limitations
  - How they can be appropriately applied (i.e. what is fit for purpose?)

- Little new guidance on *site-specific* GVs provided as part of the revision of the Aust/NZ Water Quality Guidelines
  - Except guidance on *how* to derive GVs

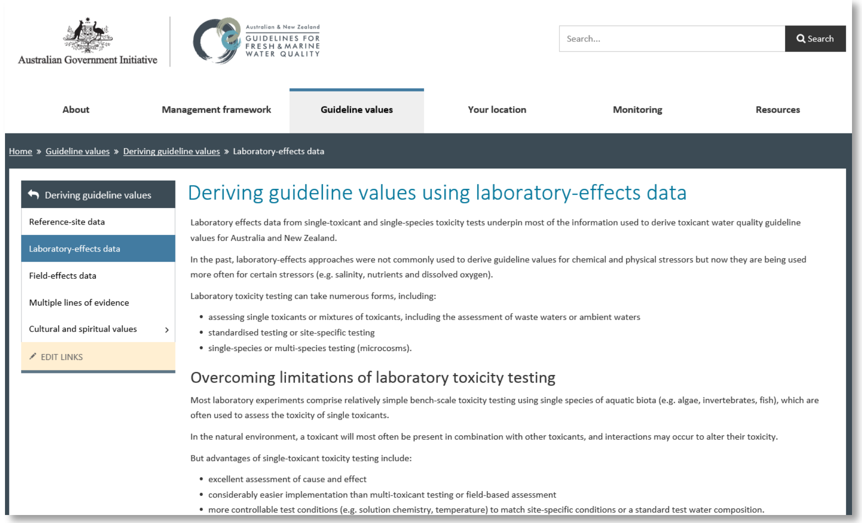


Department of Science, Information Technology and Innovation

Revised Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants

Prepared for the Council of Australian Government's Standing Council on Environment and Water (SCEW)

MStJ Warne, GE Batley, RA van Dam, JC Chapman, DR Fox, CW Hickey and JL Stauber



Australian Government Initiative

Australian & New Zealand GUIDELINES FOR FRESH & MARINE WATER QUALITY

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Deriving guideline values
- Reference-site data
- Laboratory-effects data
- Field-effects data
- Multiple lines of evidence
- Cultural and spiritual values

EDIT LINKS

Deriving guideline values using laboratory-effects data

Laboratory effects data from single-toxicant and single-species toxicity tests underpin most of the information used to derive toxicant water quality guideline values for Australia and New Zealand.

In the past, laboratory-effects approaches were not commonly used to derive guideline values for chemical and physical stressors but now they are being used more often for certain stressors (e.g. salinity, nutrients and dissolved oxygen).

Laboratory toxicity testing can take numerous forms, including:

- assessing single toxicants or mixtures of toxicants, including the assessment of waste waters or ambient waters
- standardised testing or site-specific testing
- single-species or multi-species testing (microcosms).

Overcoming limitations of laboratory toxicity testing

Most laboratory experiments comprise relatively simple bench-scale toxicity testing using single species of aquatic biota (e.g. algae, invertebrates, fish), which are often used to assess the toxicity of single toxicants.

In the natural environment, a toxicant will most often be present in combination with other toxicants, and interactions may occur to alter their toxicity.

But advantages of single-toxicant toxicity testing include:

- excellent assessment of cause and effect
- considerably easier implementation than multi-toxicant testing or field-based assessment
- more controllable test conditions (e.g. solution chemistry, temperature) to match site-specific conditions or a standard test water composition.

Context for site-specific GVs

What are they? *Spatial and temporal scales*

Default GV (DGV)

- *A generic guideline value recommended for application in the absence of a more specific guideline value (e.g. site-specific)*

Regional GVs

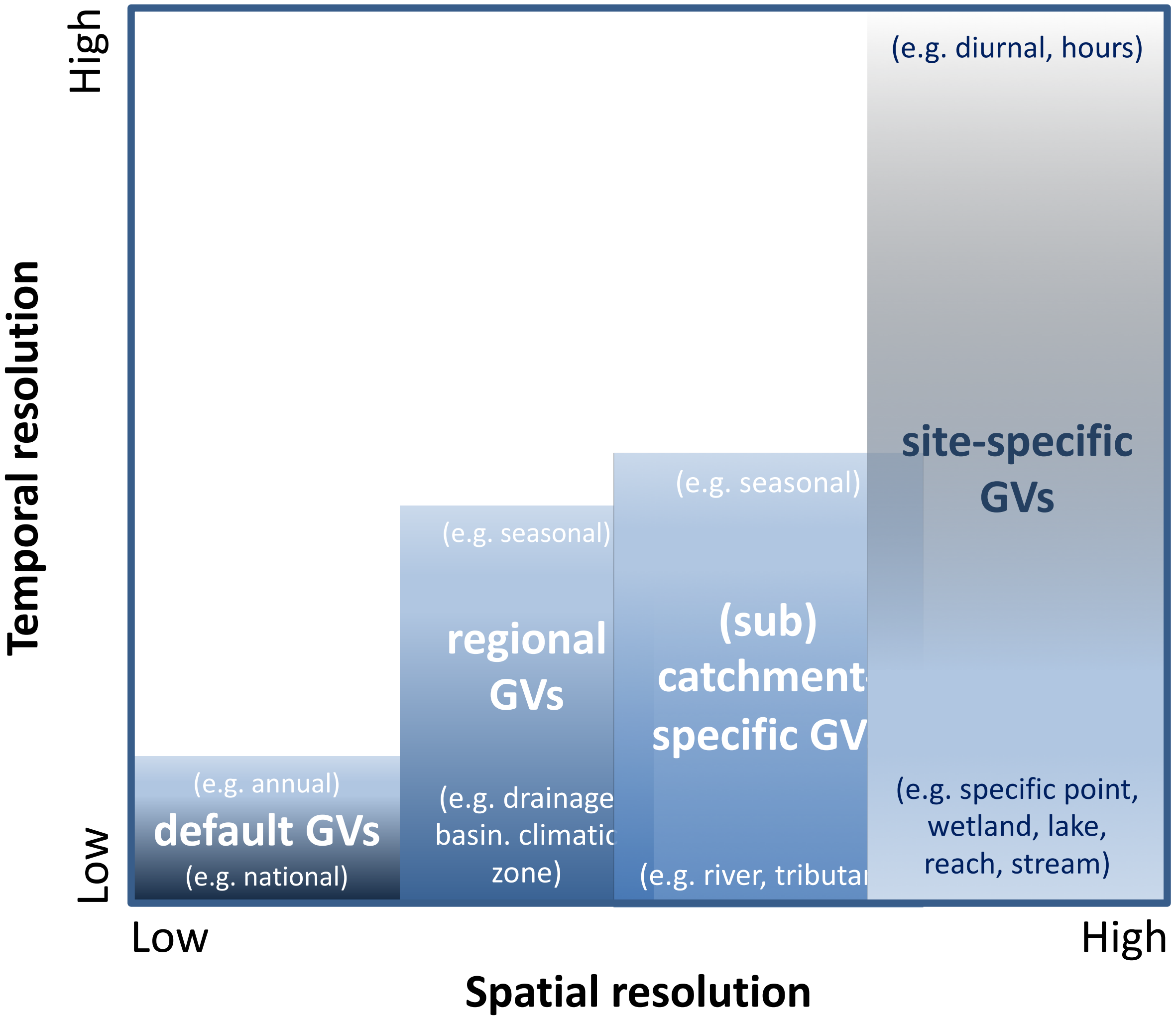
(Sub)catchment GVs

Site-specific GV

- *A guideline value that is relevant to the specific location or conditions that are the focus of a given assessment or issue*

Context for site-specific GVs

What are they? *Spatial and temporal scales*



- Much complexity at the scale at which site-specific GVs are used

Context for site-specific GVs

Why/when are they needed?

- *Where* 1. a toxicant identified as a significant hazard to the site of interest,
- *And* 2. aquatic ecosystems are the key (& most sensitive) community value,
- *And* 3. a default GV doesn't exist* *or* the existing default GV is not appropriate/applicable

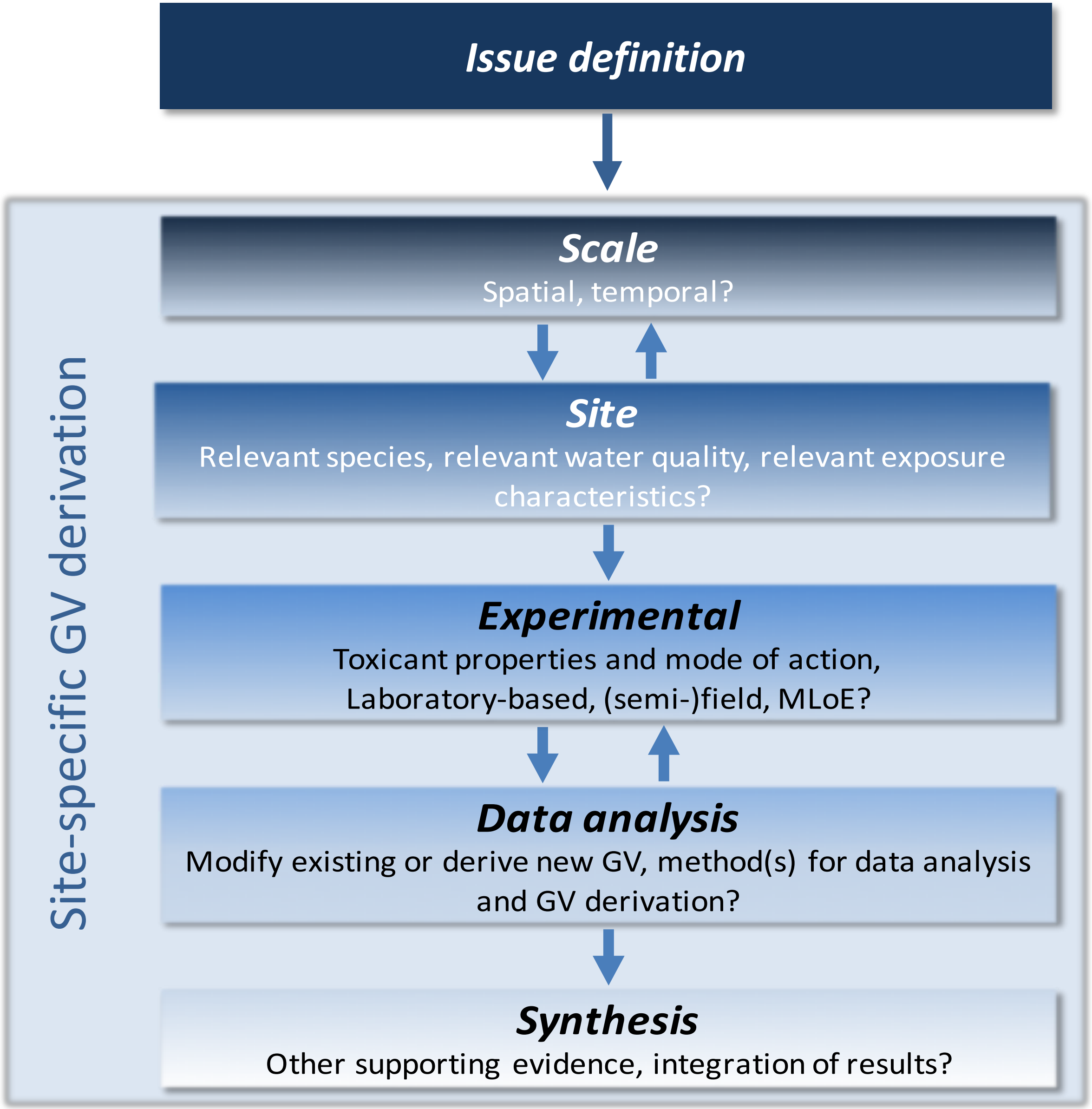
e.g.
- Existing default GV considered too under- or over-protective
- High conservation area
- Local species/ecosystems of particular importance
- Specific water quality that has potential to affect bioavailability/ toxicity of contaminant of concern
- Nature of exposure is substantially different
- Natural background concentrations exceed the default GV

- Site-specific GVs being increasingly applied in regulatory settings
  - Importance of doing it well, and for end users on all sides of the fence being informed

* Could first consider cost-benefit of deriving *site-specific* GV versus *default* GV.

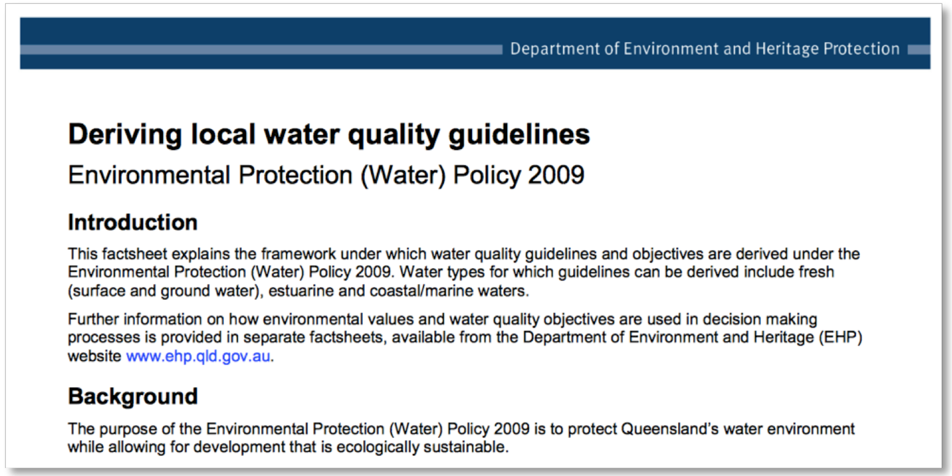
Context for site-specific GVs

Decisions, complexity and gaps in guidance



How are regulators and industry meant to know

- what is good versus what is bad?
- what is fit-for-purpose?
- what to use where?


Department of Environment and Heritage Protection

Deriving local water quality guidelines

Environmental Protection (Water) Policy 2009

Introduction

This factsheet explains the framework under which water quality guidelines and objectives are derived under the Environmental Protection (Water) Policy 2009. Water types for which guidelines can be derived include fresh (surface and ground water), estuarine and coastal/marine waters.

Further information on how environmental values and water quality objectives are used in decision making processes is provided in separate factsheets, available from the Department of Environment and Heritage (EHP) website www.ehp.qld.gov.au.

Background

The purpose of the Environmental Protection (Water) Policy 2009 is to protect Queensland's water environment while allowing for development that is ecologically sustainable.

Qld EHP (2009)

Guiding principles*

- Importance of understanding the issue
- Ensuring the outcome addresses the issue and is fit-for-purpose
- Need for robust derivation methods
- Appropriate balance between prescription and flexibility
- Strengths of using multiple lines of evidence
- Importance of transparency and quality
- Importance of independent peer review

→ New guidance adds a layer beneath these principles

* From van Dam et al (2014) *ESPR* 21, 118-130.

Types of site-specific GVs

1. Modifying default GVs
2. Deriving new site-specific GVs

Types of site-specific GVs

1. Modify default GV to suit local conditions ('site-adapted')

- Added risk approach
- Non-local species removal ('recalculation procedure')
- Local species addition
- Water effect ratio (WER) approach
- Adjusting default GV based on a generic toxicity correction
- Biotic ligand model

EPA United States Environmental Protection Agency

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Copper Biotic Ligand Model

About the Biotic Ligand Model (BLM) | BLM Demonstration | References

About the Biotic Ligand Model (BLM)

EPA's 2007 aquatic life freshwater quality criteria for copper is based on the Biotic Ligand Model (BLM). The BLM is a metal bioavailability model that uses receiving water body characteristics and monitoring data to develop site-specific water quality criteria. Input data for the BLM include: temperature, pH, dissolved organic carbon (DOC), major cations (Ca, Mg, Na, & K), major anions (SO_4 & Cl), alkalinity, and sulfide.

Ammonia

Table 8.3.7 Freshwater trigger values as total ammonia-N in µg/L at different pH (Temperature is not taken into consideration)

pH	Freshwater Trigger value (µg/L as total ammonia-N)	Marine Trigger value (µg/L as total ammonia-N)
6.0	2570	5960
6.1	2555	5870
6.2	2540	5760
6.3	2520	5630
6.4	2490	5470
6.5	2460	5290
6.6	2430	5070
6.7	2380	4830
6.8	2330	4550
6.9	2260	4240
7.0	2180	3910
7.1	2090	3560
7.2	1990	3200
7.3	1880	2840
7.4	1750	2490
7.5	1610	2150
7.6	1470	1850
7.7	1320	1560

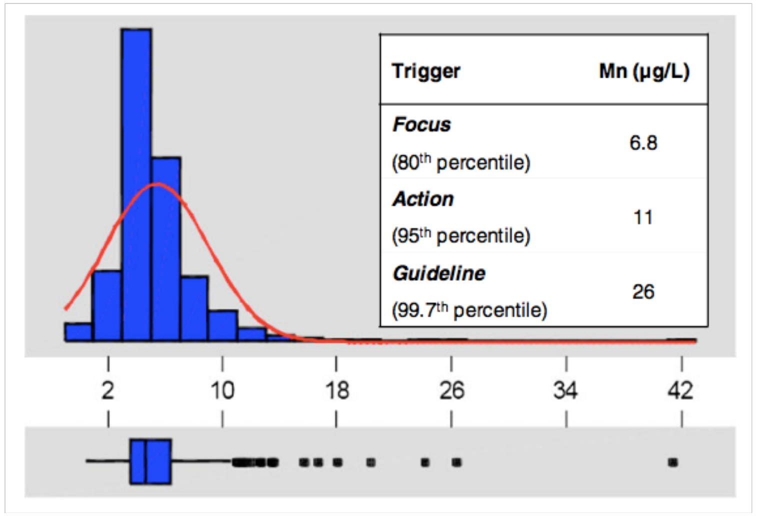
ANZECC & ARMCANZ (2000)

Types of site-specific GVs

2. Derive new site-specific GV

- Background / reference water quality approach
- Non-local species in local water quality
- Local species in local water quality
  - supplemented with other relevant data (e.g. non-local species in ‘relevant’ water quality)
  - adjusted based on local data for modifiers of toxicity
- Field or semi-field (mesocosm) data
- Multiple lines of evidence

Referential GV for Mn



Iles (2004)

Types of site-specific GVs

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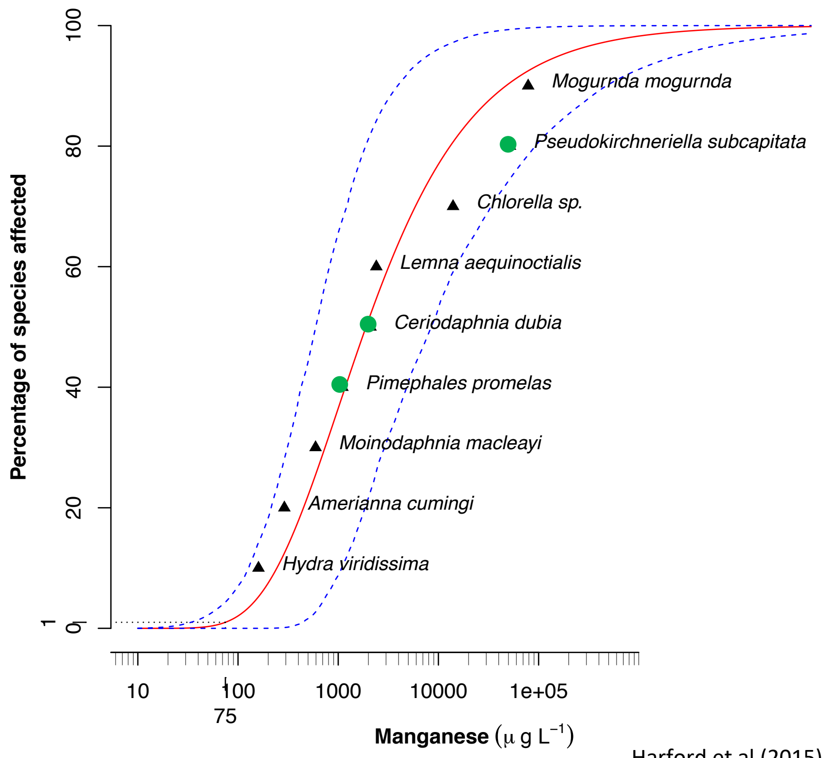
GV for Mn



Harford et al (2015)

2. Derive new site-specific GV

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  - supplemented with other relevant data (e.g. non-local species in 'relevant' water quality)
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$$\text{DOC modified U GV} = GV_2 / (1 + 2 \times 0.09) \times (1 + DOC_{Ck} \times 0.09)$$

Uranium GV DOC correction

DOC in creek water (mg/L)	DOC modified U guideline value (µg/L)
2	2.8
3	3.0
4	3.2
5	3.4
6	3.7
7	3.9
8	4.1
9	4.3
10	4.5
15	5.6
20	6.6

van Dam et al (2017)

Types of site-specific GVs

2. Derive new site-specific GV

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    - supplemented with other relevant data (e.g. non-local species in 'relevant' water quality)
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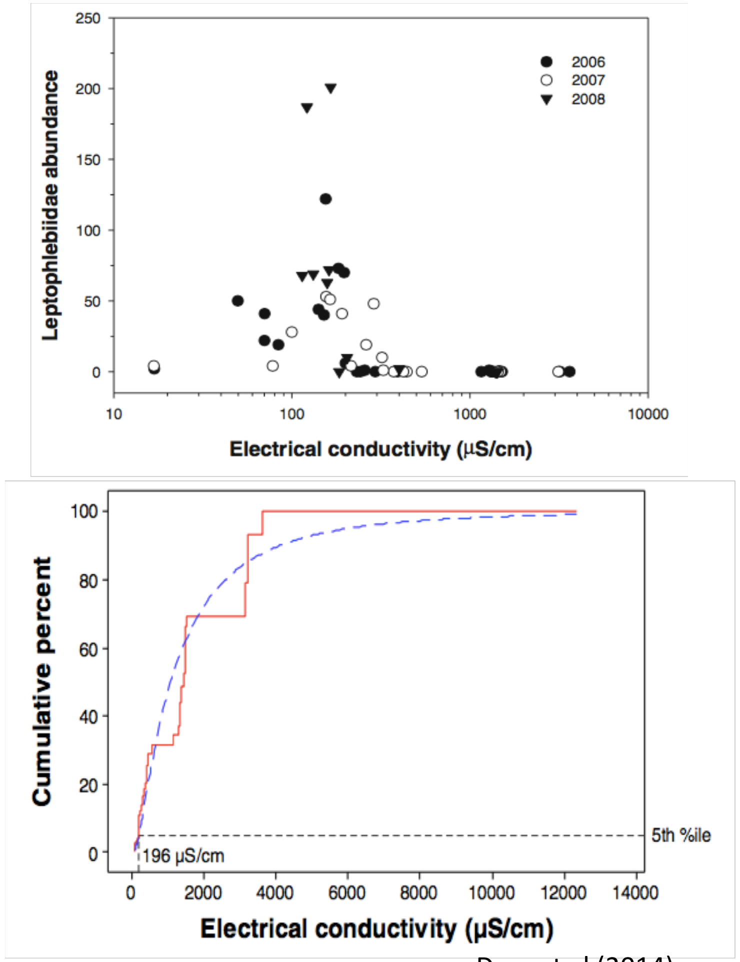
Field-based GV for EC



van Dam et al (2014)

2. Derive new site-specific GV

- Background / reference water quality approach
- Non-local species in local water quality
- Local species in local water quality
  - supplemented with other relevant data (e.g. non-local species in 'relevant' water quality)
  - adjusted based on local data for modifiers of toxicity
- Field or semi-field (mesocosm) data
- Multiple lines of evidence

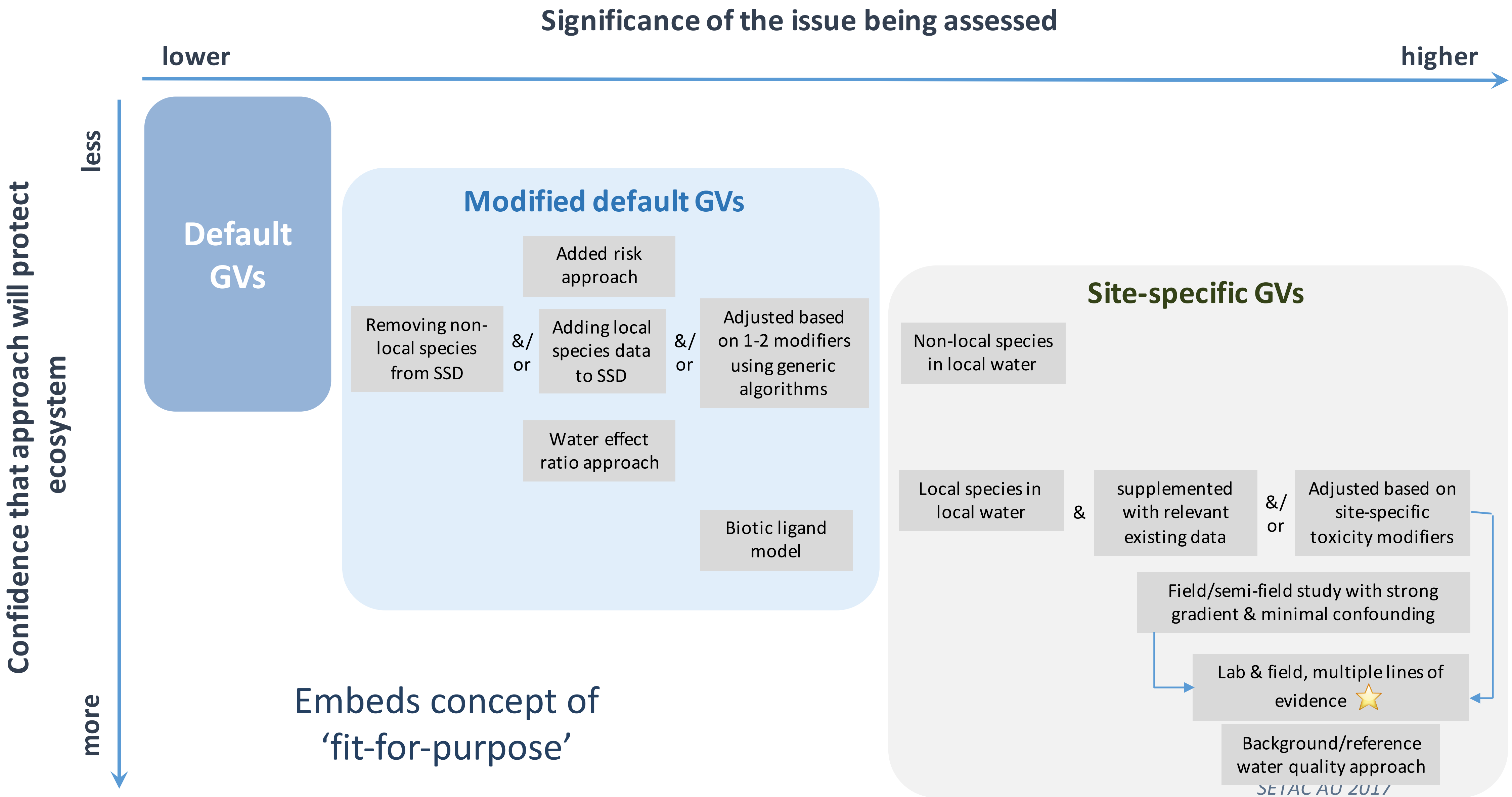
Line of evidence and response	Conditions	Candidate GVs (mg/L)
Laboratory		
Sub-lethal toxicity, 6 local species	Short-term: chronic 72-144 h exposures; Mg:Ca <9:1	**2.5**
Mesocosms	Mid-term and sustained: chronic 4-8 week exposures; Mg:Ca <20:1	
Zooplankton: 4 weeks: Similarity		2.4
Zooplankton: 4 weeks: Taxa number		**2.3**
Chlorophyll a concentration: 4 weeks		1.5
Chlorophyll a concentration: 8 weeks		2.7
Billabong macroinvertebrates	Long-term and sustained: average of antecedent wet and dry seasons median contaminant values; Mg:Ca ~3.5:1	
GTB similarity		5.6
GTB taxa number		**3.9**
SSD: All sites		4.7
SSD: GTB		5.0
TITAN: All minesites, filtered		1.3
TITAN: All minesites, unfiltered		2.4

Humphrey et al (2017)

How can we help end users?

How to help end users?

Conceptual hierarchy of approaches



How to help end users?

Document relative strengths and limitations

Table 2 Attributes of methods that can be used to derive water quality benchmarks for specific sites.

	Scientific defensibility			Applicability				Practicality			Cost-effectiveness	
Approach	Based on biological effects data?	Considers potential for bioaccumulation	Considers site-specific conditions?	Applicable to all classes of chemicals?	Degree of site-specificity	Uncertainty in the applicability	Acceptability to stakeholders	Supports the development of numerical benchmarks	Level of complexity	Timeliness	Relative expense of implementation	Requires generation of new biological data?
Modification of existing generic benchmark (modified default, site-adapted)												
Added risk approach	No		No	No	Low	High		Yes	Low	Fast	Low	No
Recalculation procedure (species removal)	No		No	Yes	Low	High		Yes	Low	Fast	Low	No
Water effect ratio (WER) approach	Yes		Yes	Yes	Moderate	Moderate		Yes	High	Moderate	Moderate	Yes
Species addition	Yes		Yes/No	Yes	Low	Low - Moderate		Yes	Moderate	Moderate	Moderate	Yes
Adjustment based on 1-2 modifiers of toxicity	Yes		Yes	No	Moderate	Moderate		Yes	Moderate	Fast	Low	No
Biotic ligand model	Yes		Yes	No	High	Moderate		Yes	Moderate	Fast	Low	No
Derivation of new site-specific benchmark												
Background/reference water quality approach	No		No	No	Low	Low		Yes	Low	Fast	Low	No
All local species but not in local water quality	Yes		No	Yes	Low	High		Yes	Moderate	Moderate	Moderate	Yes
All local species in local water quality	Yes		Yes	Yes	High	Low		Yes	Moderate	Moderate	Moderate	Yes
Non-local species in local water quality	Yes		Yes	Yes	Moderate	Moderate		Yes	Moderate	Moderate	Moderate	Yes
All local species in local water quality supplemented with other relevant data (e.g. non-local species in similar water quality)	Yes		Yes	Yes	Moderate	Moderate		Yes	Moderate	Moderate	Moderate	Yes
All local species in local water quality with adjustment based on data for local toxicity modifying factors	Yes		Yes	Yes	High	Low		Yes	Moderate - High	Moderate - Slow	Moderate - High	Yes
Use of field or semi-field data	Yes		Yes	Yes	High	Moderate		Yes	High	Slow	High	Yes
Weight of evidence approach	Yes		Yes	Yes	High	Low		Yes	High	Slow	High	Yes

How to help end users?

Develop a site-specific GV ‘applicability’ classification?

Table 3 Potential scoring system to determine the robustness of approaches used to derive biological effects-based site-specific water quality benchmarks.

Element of a modified generic/site-specific benchmark	Points
Laboratory (single species data)	
Modified generic benchmarks	
Modified a generic benchmark by removing non-local/relevant species	1
Incorporated corrections to the benchmark based on generic quantitative relationships for toxicity modifiers (i.e. not locally-validated)	1 per correction
Modified a generic benchmark based on the water effect ratio (WER) approach	1 per species
Site-specific benchmarks	
Assessed toxicity to local/locally-relevant species in local water quality, having demonstrated adequate representativeness of the assessment	2 per species
Incorporated corrections to the benchmark based on locally-derived or -validated quantitative relationships for relevant toxicity modifiers or other relevant conditions	2 per correction
Retained data for non-local species tested in similar water quality	1

Table 4 Scoring system to determine the applicability of approaches used to derive biological effects-based site-specific water quality benchmarks.

Category	Example of application	Points	GV Type*
A	Slightly/moderately disturbed ecosystems	<6	M-D
B	Slightly/moderately disturbed ecosystems where contaminant represents a moderate or higher risk	>6	M-D or S-S
C	High ecological / conservation value ecosystems	>12	S-S
D	High ecological / conservation value ecosystems where contaminant represents a moderate or higher risk	>20	S-S

* M-D: Modified default GV; S-S: Site-specific GV

Site-specific GV examples from ERISS

NH_3	U	Mn	Mg
-	-	-	-
1	-	-	-
-	-	-	-
16	14	12	12
2	2	-	4
-	-	1	-
-	-	-	6
-	-	-	2
-	-	-	2
-	-	-	3
-	-	-	2
-	1	1	3
19	**17**	**14**	**34**

NH_3 – Mooney et al (in prep); U – van Dam et al (2017); Mn – Harford et al (2015); Mg – Humphrey et al (2017)

Key messages

Key messages

- There is no 'one size fits all' approach for site-specific GVs
  → flexibility is essential

- More guidance is needed for the selection, use and assessment of site-specific GVs
  - Available approaches
  - Strengths and limitations
  - Applicability
  - Importance of independent peer review

- Must be done under an overarching framework/set of principles that
  - Emphasises issue definition
  - Allows adequate balance between prescription and flexibility
  - Maximises quality and rigour by appropriately using best available science
  - Recognises and ensures 'fit-for-purpose'

- Final guidance will represent a useful support tool for those deriving and assessing site-specific GVs (and hopefully will be incorporated into the new WQGs website)

Thank you

Acknowledgments
Tom Mooney, Lisa Chandler, Andrew Butler