# SOUTH AFRICAN WATER QUALITY GUIDELINES FOR FRESHWATER ECOSYSTEMS – VERSION 2 Volume 2: Implementation Manual

ON Odume, NJ Griffin, PK Mensah, D Forsyth, L Ncube and HJ van Niekerk



TT 936/2/23



# South African Water Quality Guidelines for Freshwater Ecosystems – Version 2

# **Volume 2: Implementation Manual**



# Report to the Water Research Commission

by

## ON Odume<sup>1</sup>, NJ Griffin<sup>1</sup>, PK Mensah<sup>1,3</sup>, D Forsyth<sup>1</sup>, L Ncube<sup>2</sup> and HJ van Niekerk<sup>2</sup>

<sup>1</sup>Institute for Water Research, Rhodes University <sup>2</sup>Department of Environmental Sciences, University of South Africa <sup>3</sup>Department of Fisheries and Aquatic Sciences, University of Cape Coast, Ghana

WRC Report No. TT 936/2/23 ISBN 978-0-6392-0596-0

#### **Obtainable from**

Water Research Commission Bloukrans Building, Lynnwood Bridge Office Park 4 Daventry Street Lynnwood Manor PRETORIA

orders@wrc.org.za or download from www.wrc.org.za

This report forms part of a set of two reports. the other report is *South African Water Quality Guidelines for Freshwater Ecosystems – Version 2. Volume 1: Technical Report.* (WRC Report No. TT 936/1/23)

#### DISCLAIMER

This report has been reviewed by the Water Research Commission (WRC) and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the WRC, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

# ACKNOWLEDGEMENTS

The project team wishes to thank the following people for their contributions to the project.

Reference Group	Affiliation		
Bonani Madikizela	Water Research Commission (Chairperson)		
Akhona Mkonde	University of South Africa		
Indrani Govender	Durban University of Technology		
Patsy Scherman	Scherman Environmental cc.		
Janine Adams	Nelson Mandela University		
Pieter Viljoen	Department of Water and Sanitation		
Jackie Jay	Department of Water and Sanitation		
Ntuthuko Masikane	University of Zululand		
Helen Dallas	Freshwater Research Centre		
Christa Thirion	Department of Water and Sanitation		
Nyamande Tovhowani	Department of Water and Sanitation		
Jurgo van Wyk	Department of Water and Sanitation		
Gerda Kruger	Water Research Commission		

This page was intentionally left blank

# CONTENTS

ACK	NOWLEDGEMENTS	i
CONT LIST LIST ACRO	TENTS	iii iv vi vii
CHAF	PTER 1: INTRODUCTION	.1
1.1	NOTES TO USERS	.1
1.2	1996 GUIDELINE	.1
1.3	CRITICISM	.2
1.4	REVISION	.2
CHAF	PTER 2: TIER 1	.4
2.1	INTRODUCTION	.4
2.2	METHODS	.4
2.3	TOXICOLOGICAL RESPONSE DATA	.4
2.4	TOXICOLOGICAL DATA TO GUIDELINES	.5
	2.4.1 Overview	.5
	2.4.2 Endpoints	.6
	2.4.3 Ecological categories	.6
2.5	USE OF TIER 1 GUIDELINES	.7
CHAF	PTER 3: TIER 2	15
3.1	INTRODUCTION	15
3.2	METHODS	15
3.3	USE OF TIER 2 GUIDELINES	16
3.4	INTERPRETATION OF THE CONCENTRATION DURATION CURVE	20
3.5	MACROINVERTEBRATES	21
CHAP	PTER 4: TIER 3	25
4.1	INTRODUCTION	25
4.2	METHODS	25
4.3	USE OF TIER 3 FOR SITE-SPECIFIC WATER QUALITY RISK ASSESSMENT	26
СНА	PTER 5: REFERENCES	37

# LIST OF FIGURES

Figure 2-1 Example of a Species Sensitivity Distribution (SSD) plot, produced using 722 records of $LC_{50}$ data from 86 different taxa exposed to copper chloride (CuCl <sub>2</sub> )
Figure 2-2 Water quality guidelines DSS opening page7
Figure 2-3 Water quality guidelines DSS Tier 1 data entry page
Figure 2-4 Water quality guideline DSS at Tier 1 level, showing the selection process of compounds for which a guideline can be generated
Figure 2-5 Water quality guidelines DSS Tier 1 interface for user file upload
Figure 2-6 Example of a concentration duration curve as produced by the Tier 1 guideline DSS. These data were entered in a similar format to the data in Table 2-2
Figure 2-7 Example of a simple guideline report produced when no data are supplied at Tier 1 level of the water quality guideline DSS. See text for full explanation
Figure 2-8 Example of a simple guideline report produced when no data are supplied at Tier 1 level of the water quality guideline DSS. See text for full explanation
Figure 3-1 DSS screen showing the interface for Tiers 1-3
Figure 3-2 DSS screen showing names of chemical constituents for which guidelines exist for ecoregion level 2 (ecoregion 1.02)
Figure 3-3 DSS screenshot showing Get Timeseries button for importing own data for comparison with guidelines
Figure 3-4 DSS screenshot showing the selection of All for all the ecological categories including the RQO and the selection of Site A12A. An hypothetical RQOs value of 0.07 mg/l for aluminium
Figure 3-5 A typical DSS output table showing the guidelines for AI for ecoregion level 1.02 and the associated confidence rating
Figure 3-6 A typical DSS concentration duration curve. (Note that this example is not produced based on the data in Figure 3-5 above)
Figure 3-7 DSS screenshot showing display temperature information near the bottom of the screen
Figure 3-8 DSS screenshot showing predicted macroinvertebrate taxa for ecoregion level 2 (level 2 ecoregion 1.03)
Figure 3-9 DSS screenshot showing addition and/or removal of taxa based on the difference between predicted and observed communities, as well as the entering of the number of samples, no. of seasons and no. of hydrological cycles
Figure 3-10 DSS output for Tier 2 using macroinvertebrate data for guidelines
Figure 3-11 DSS output showing the confidence rating for the macroinvertebrate guideline
Figure 4-1 Screenshot of the DSS interface for Tier 3
Figure 4-2 Screenshot of the physico-chemical severity rating for the risk-triggering event
Figure 4-3 Screenshot of the DSS showing the macroinvertebrate risk rating
Figure 4-4 Screenshot showing the likelihood rating for frequency of occurrence, frequency of impact and detection for the risk triggering event (an agricultural farmland)

Figure 4-5 Screenshot of the DSS showing the sub-component for which assessment is needed regarding the uncertainty sub-model
Figure 4-6 Screenshot of the DSS showing the uncertainty rating about the reliability and reasonability of the assumptions regarding the risk-triggering events
Figure 4-7 Screenshot of the DSS showing the uncertainty rating about the physico-chemical severity rating.
Figure 4-8 Screenshot of the DSS showing the uncertainty rating about the physico-chemical severity rating.
Figure 4-9 Screenshot of the DSS showing the uncertainty rating about the expert agreement/disagreement and literature support
Figure 4-10 Screenshot of the DSS showing the uncertainty rating the knowledge of site-specific risk modifying factors
Figure 4-11 DSS screenshot showing the final output of the site-specific water quality risk assessment rating for the risk triggering event
Figure 4-12 DSS screenshot showing the final output of the accompanying uncertainty/confidence rating for the site-specific water quality risk assessment rating

# LIST OF TABLES

Table 2-1 Guideline derivation for application to SSD consensus model fits. Corresponding to generic ecological categories of Kleynhans and Louw (2007).       7
Table 2-2 File format for upload of own data in csv format for analysis under the guideline DSS. The examplehere is for aluminium data collected at two different sites.10
Table 3-1 Guideline derivation for Ecoregion level 2 and geozone macroinvertebrate risk estimates,corresponding to generic ecological categories of Kleynhans and Louw (2007).16
Table 3-2 File format for upload of own data in csv format for analysis in the DSS. The example here is foraluminium data collected at two different sites (A12A and B12B)
Table 4-1 Overall site-specific risk rating based on the consequence and likelihood sub-models
Table 4-2 Overall uncertainty rating associated with the site-specific water quality risk assessment
Table 4-3 Rating for the duration aspect of the consequence sub-model
Table 4-4 Rating for the spatial scale dimension of the consequence sub-model.       29
Table 4-5 Macroinvertebrates severity rating as a function of the extent of deviation between the expected andobserved taxa returned by the macroinvertebrate risk model in Tier 2.29
Table 4-6 Rating for frequency of occurrence of the risk-triggering event.         30
Table 4-7 Rating for frequency of impact of the risk-triggering event.       30
Table 4-8 Rating for the detection of the risk-triggering event or its impact on the water quality component of the resource.         31

# **ACRONYMS & ABBREVIATIONS**

ACWUA	Assessment of Consideration for Water Use Application		
AEV	Acute Effect Value		
AQUIRE	Aquatic toxicity information retrieval database		
CAS	Chemical Abstracts Service		
CCME	Canadian Council of Ministers of the Environment		
CEV	Chronic Effect Value		
CSV	Comma Separated Values file format		
DSS	Decision Support System		
DWA	Department of Water Affairs		
DWAF	Department of Water Affairs and Forestry		
DWS	Department of Water and Sanitation		
ECx	Effect concentrations where x% effect was observed		
EPA	Environmental Protection Agency		
HTML	Hypertext Mark-up Language		
IUA	Integrated Units of Analysis		
LCx	Lethal concentrations where x% mortality was observed		
LOEC	Lowest Observed Effect Concentration		
MIRAI	Macroinvertebrate Rapid Assessment Index		
NOEC	No Observed Effect Concentration		
NWA	National Water Act		
NWRS	National Water Resource Strategy		
QSAR	Quantitative Structure Activity Relationships		
RDM	Resource-Directed Measures		
RQO	Resource Quality Objective		
RU	Resource Units		
SACNASP	South African Council for Natural Scientific Professions		
SASS	South African Scoring System		
SAWQG	South African Water Quality Guidelines		
SDC	Source-Directed Controls		
SSD	Species Sensitivity Distribution		
TPC	Threshold of Potential Concern		
TWQR	Target Water Quality Range		
USEPA	United States Environmental Protection Agency		
WMS	Water Management System		
WQG	Water Quality Guideline		
WRC	Water Research Commission		

This page was intentionally left blank

# **CHAPTER 1: INTRODUCTION**

## 1.1 NOTE TO USERS

This implementation manual must be read with the technical report: South African Water Quality Guidelines for Freshwater Ecosystems – Version 2; Volume 1: Technical Report. Download the DSS from here: <u>https://www.ru.ac.za/iwr/resources/software/wqgdss/</u>

### 1.2 1996 GUIDELINES

In 1995 and 1996, the Department of Water Affairs and Forestry (DWAF) published a series of water quality guidelines. The guidelines covered water quality in marine and fresh waters, and produced different guidelines for different end users depending on their priorities and/or needs. One user for which a water quality guideline was compiled was freshwater ecosystems (DWAF 1996).

The 1996 freshwater ecosystem guidelines contained guideline values for water quality parameters understood to be of importance to freshwater ecosystems. In general, two boundary values were used to derive three potential classes that water might be in with respect to the concentration of one particular water quality parameter. The classes were defined in terms of acute and chronic toxicological response, which are defined as follows:

- The Chronic Effect Value (CEV), is defined as that concentration or level of a constituent at which there is expected to be a significant probability of measurable chronic effects to up to 5% of the species in the aquatic community.
- The Acute Effect Value (AEV) is defined as that concentration or level of a constituent above which there is expected to be a significant probability of acute toxic effects to up to 5% of the species in the aquatic community. Acute effects here would be mortality.

Knowledge of these criteria allows the definition of a management objective, the Target Water Quality Range (TWQR), which is the range of concentrations of a particular compound that are ideal for aquatic ecosystems, and that will not lead to measurable adverse effects given life-long exposure (DWAF 1996). As both the AEV and CEV are adverse effects, the TWQR is lower than these. As the concentration of the water quality parameter increases, one can anticipate that chronic effects would occur, followed by acute impacts.

Guidelines were produced for 16 toxic inorganic compounds, 3 toxic organic compounds, 4 system variables, 1 non-toxic inorganic constituents, and 2 nutrients (25 compounds in total). The majority of toxic inorganic compounds were metals, making these compounds well represented in the final guidelines.

CEV and AEV were calculated following methods derived from EPA (Environmental Protection Agency) methods, and gave guidelines that were methodologically aligned with those of the United States, Netherlands, and Canada (Roux et al., 1996, DWAF 1996). Basically, deriving an aquatic ecosystem water quality guideline for the 1996 guidelines involved toxicity data from the EPA AQUIRE database (more recently absorbed into the Ecotox database which we used for the current project), or a toxicity estimate using EPA's implementation of Quantitative Structure Activity Relationships, or QSAR (DWAF 1996, EPA 2023a, 2023b). Thereafter, a series of calculations followed, the structure of which depended on data availability (Roux et al., 1996, DWAF 1996). The 1996 aquatic ecosystem water quality guidelines relied more on data from particular animal taxa.

Plant or algal toxicity only contributed to the CEV, but not the AEV (DWAF 1996). Owing to the limited set of toxicity data available, boundary values produced were then adjusted using a safety factor depending on specific data factors. Finally, again depending on certain criteria, one might to adjust the final values to account for site-specific factors (DWAF 1996).

The 1996 aquatic ecosystem guidelines therefore reflect the response of taxa to a toxin, or possibly the predicted response to a toxin. The response is a simple physiological one to a single stressor. This is unlike what might be found in nature, where other stressors and other factors mediate the success of a taxon in a particular location. This makes these guidelines widely appropriate across a range of environments and locations, but with little consideration of how natural variation between sites may occur.

## 1.3 CRITICISM

The criticism of the 1996 Guidelines are fully described in Volume 1 of this series. Briefly, the guidelines have been criticise for four fundamental reasons. First, they have been criticised for not being risk-based. Second, they have been criticized for not aligning with important strategies and approach for managing freshwater resources as envisaged in the National Water Act. The reason for this is that the guidelines were developed prior to the promulgation of the National Water Act in 1998. The third reason is that with the exception of a few system variables, the guidelines are not site-specific, and thus prescribe a single target water quality range (TWQR) for the entire country, implying that spatial contexts have not been taken into account. Fourth, the guidelines have also been criticised for being limited in the number of compounds for which guidelines exist, implying that recent research in the field of contaminants of emerging concerns such as pharmaceutical compounds are not reflected in the guidelines. In addition to these criticisms, the guidelines are hard-copy paper based, and have thus been criticize for not being easily updatable and not facilitating rapid decision making process. In this regard, a software-based decision support system (DSS) was recommended in revising the guidelines.

## 1.4 REVISION

Since the 1996 guidelines were published, much research has been undertaken locally and internationally in terms of derivation approaches, use of technologies in guideline application, effects of critical pollutants such as pesticides, persistent organic pollutants, endocrine disruptive compounds, pharmaceuticals, acid mine drainage, and emerging toxicants of concern. The majority of these pollutants are not in the current SAWQGs for freshwater ecosystem. Thus, a revision is imperative to reflect new knowledge and research in the field of guideline development. Risk-based guideline implies that there must be a shift from the effects of pollutants on single species to the effect on ecosystems as a whole.

This project largely adopted the Boyd et al. (2015) proposed framework for the revision of risk-based water quality guidelines in South Africa. Thus, the revised South African Water Quality Guideline (SAWQG) for aquatic ecosystems is a three-tiered approach packaged into a Decision Support System (DSS), which is ultimately used to derive the risk-based water quality guidelines.

Tier 1, which represents the scientific domain, is generic and the most conservative guideline, with minimum user input requirement and a simple output provided by a Decision Support System (DSS). This level of guidelines is largely what the 1996 SAWQG details, but has been updated by adding new variables that have become imperatives, as well as updating to current science. The Tier 1 guideline is conservative and precautionary in nature as it gives protection to the most sensitive receptor in the aquatic ecosystem. It is also generic due to its applicability to all water resources.

Tier 2 is at ecoregional levels, which largely relies on predefined water use scenarios and limited site characterisation choices. However, it requires some user skill as it is precedent on common field observation as well as measurement input for scenarios manipulation. In this sense, the in-stream water quality due to site location and the actual water quality profile are used to rate possible occurrence of risk. The water quality guideline (WQG) at this level may also be derived using the DSS.

The Tier 3 guideline is site-specific guidance and may be employed as a risk assessment protocol. As such, it requires highly skilled input and output interpretation. The Tier 3 risk category is based on site-specific risk assessments and objectives setting. The DSS allows for derivation of Tier 3 water quality guidelines.

These water quality guidelines are for freshwater ecosystems, and as such it is appropriate to align the classes derived to correspond with ecological categories derived as part of the ecoclassification process as described by Kleynhans and Louw (2007). Although methodologies differ between various Tier levels, all produce guidelines correspond to ecological categories A to F, or from natural water quality to critically impacted.

# CHAPTER 2: TIER 1

### 2.1 INTRODUCTION

Tier 1 guidelines are conceptually linked to the previous 1996 guidelines in that there is no spatial component and that Tier 1 guidelines are conservative and are derived from toxicological response data (DWAF 1996, Roux et al., 1996). The guidelines are therefore based on taxa responses to the toxin in question, unmediated by local ecologies and other factors that might alter the toxicological response.

The use of toxicological results in setting of guidelines has wide application worldwide (Posthuma et al., 2019). Conceptually, knowing the response of a taxon to a compound allows one to make recommendations about acceptable levels of that compound for protection of that taxon. Knowing the response of a range of taxa to a compound allows one to make rough estimations of how a community or an ecosystem might respond. This is the concept that underlies the use of multiple toxicological results in a species sensitivity distribution (SSD) to produce sensible ecosystem water quality guidelines. These methods underlie the derivation of ecologically-based guidelines around the globe, including Australia/New Zealand (Warne et al., 2015, 2018), the European Union (EU), United States (US) (USEPA 1992, 1998, 2023) and Canada (CCME 2007, Posthuma et al., 2019).

The Tier1 methods that were finally selected broadly follow those described in Posthuma et al. (2019). Toxicological data from a number of sources were compiled into a database, where they were standardized, and identified flawed records were filtered out These data were queried to produce an SSD, from which an appropriate protective concentration suitable for guideline production were extracted.

### 2.2 METHODS

### 2.3 TOXICOLOGICAL RESPONSE DATA

Toxicological data was downloaded from the USEPA Ecotox database (Olker et al., 2022) in May 2021. Text files with received data were uploaded to a PostgreSQL database, and compiled to a single data table. Data were simplified as required, and filtered such that only valid freshwater ecotoxicological records were used, giving a final data set of 165 320 valid freshwater toxicology records on 907 compounds.

The other primary source of data was MistraPharma's WikiPharma database (Molander et al., 2009), downloaded in January 2022. This data source contains the results of toxicological testing for environmental effects of pharmaceuticals in fresh water. WikiPharma contains 7 999 toxicological endpoint records of 341 compounds.

Guidelines are generated for 24 inorganic compounds, 45 organic compounds and 26 pharmaceuticals. Where compounds are present in an ionized state in freshwater, toxicological results from their salts are used to generate SSDs and extract guidelines. Where the compound existed in water as a cation, the chloride, sulphate, hydroxide and carbonate salt results were used. Where it was an anion, the hydrogen, sodium, potassium, and magnesium salts were used. All hydration states of the salt were used, and a conversion factor was used to get the mass fraction of the test compound in the salt.

All data were coded using a CAS number to provide an unambiguous unique reference for each compound. The CAS Registry Number provides a unique identification number from the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature (CAS 2023). All data were filtered to ensure that only freshwater toxicological data from records with suitable numeric results and adequate controls were loaded to the DSS. Within the DSS the units of the endpoints were converted to the units used with the DSS where possible. Where this was not possible, toxicological records were not used in guideline derivation.

## 2.4 TOXICOLOGICAL DATA TO GUIDELINES

### 2.4.1 Overview

For any given compound, data can be queried from underlying freshwater toxicology database to conform to a number of criteria (see below for details), and used to create an SSD analysis, from which a protective guideline can be generated such that one can define what proportion of taxa are protected from exceeding the selected endpoint (e.g. see Figure 2-1) (Posthuma et al., 2002 and references therein). This point defines the guideline value, and, depending on one's requirements, can be highly protective, or less. It will be affected by the toxicological endpoint selected for SSD analysis, and by underlying data availability. Clearly, if a suitable guideline for water quality for aquatic ecosystems is desired, it will best be achieved by basing the guideline of an SSD based on toxicological data from an adequately large and diverse dataset. When this is the case, confidence in a derived guideline can be high, and it can be taken as representative of an ecosystem with all its diversity. Where the dataset is limited, and/or skewed in favour of particular taxa, risk is higher that the derived guideline is inappropriate. In the case of some potential toxins, large datasets of results are available (e.g. see Figure 2-1). However, some toxins have received less attention, and as a result, guideline boundary values are less reliable.



Figure 2-1 Example of a Species Sensitivity Distribution (SSD) plot, produced using 722 records of LC<sub>50</sub> data from 86 different taxa exposed to copper chloride (CuCl<sub>2</sub>).

### 2.4.2 Endpoints

Generally, toxicity can either be classified as acute or chronic. Here, these follow general conventions (e.g. Batley et al., 2018; EPA 2023) and in the context of this guideline are defined as:

- Acute: Acute tests are short-term exposure tests to a potential toxicant. They commonly have lethality
  as an endpoint. For this guideline, data selected are those from tests that assess mortality and that
  return valid numeric endpoints that assess impacts on 40-60% of the population (the great majority of
  these data were labelled as EC<sub>50</sub> or LC<sub>50</sub>).
- Chronic: Chronic tests are longer term exposures to potential toxicants. They generally use a sublethal endpoint that assesses a criterion relevant to the test population. Here, data selected are those from tests that affect growth, development, reproduction, physiology, genetics, and behaviour and feeding of the test taxa and that returned valid numeric data for NOEC, LOEC and other endpoints returning data for effects that impact 10% or less of a population.

Given that enough data are available for each compound, a chronic and an acute SSD analysis is undertaken for each compound. The chronic endpoint data are used to derive the natural or A class, while acute data are used to define the remainder of the classes.

For most organic compounds and pharmaceuticals, using toxicological data to derive a guideline is fairly straightforward, as toxicological tests are run on the dissolved compounds directly. Inorganic compounds, which are usually tested in the form of one or another salt, are more complex, as the toxicological results reflect the combined impact of ions on the test organism(s). However, management systems utilize measures of the active compound, and not its salt, and so guidelines for individual compounds or elements are required.

In order that guidelines on inorganic ions could be included, salts were identified where the compound being tested was assessed using several of its salts. These were selected in order that the toxicological impact of the associated ion would not be high and therefore that the toxicological response would indicate to a great extent the compounds or elements being tested. What this in effect meant was that, for any given cation, the chloride, sulphate, hydroxide and carbonate salt results were used together to determine the SSD. For anions, the hydrogen, sodium, potassium, and magnesium salts would be considered. Different hydration states of the salts were also combined.

#### 2.4.3 Ecological categories

The boundary values that define ecological categories A to F are presented in Table 2-1 below. The guidelines produce a means of classifying water into 6 classes that correspond to the ecological categories from the Ecoclassification process as described in Kleynhans and Louw (2007).

The result of using chronic results for class A is that the Natural or A class is very conservative, and, for the toxins is assessed at Tier 1, many but not all of which are not found naturally, class A should represent the natural state. The other taxa allow for an increasing level of mortality, until, at class F, half the individuals of 30% or more of the taxa present or expected to die in the relatively short term.

generic ecological categories of Kleynhans and Louw (2007).			
Category	Title	Description	
А	Natural	Chronic impacts in 1% or fewer of test taxa.	
В	Largely natural	Acute impacts in 5% or fewer of test taxa.	
С	Moderate impact	Acute impacts in 10% or fewer of test taxa.	
D	Large impact	Acute impacts in 20% or fewer of test taxa.	
E	Serious impact	Acute impacts in 30% or fewer of test taxa.	
F	Critical impact	Acute impacts in more than 30% of test taxa.	

Table 2-1 Guideline derivation for application to SSD consensus model fits. Corresponding to generic ecological categories of Kleynhans and Louw (2007).

## 2.5 USE OF TIER 1 GUIDELINES

When a user starts the DSS, they are offered the choice of undertaking a Tier 1, 2, or 3 analysis (see Figure 2-2). Pressing the Tier 1 button takes one to the page for Tier 1 analysis (see Figure 2-3).

WQG-DSS main todo list V1 File Setup	.0.0.44		
Risk-Based Water Quality Guideline for Aquatic Ecosystems			
Tier	1 Do Tier 1 process		
Tier	2 Do Tier 2 process		
Tier	Do Tier 3 process		

Figure 2-2 Water quality guidelines DSS opening page.

Once on that page, the first thing that a user should do is select a variable for which guidelines are sought. Pressing this option presents a list of variables in a drop-down list (see Figure 2-4). These consist of elements or ions, organic compounds (including a number of biocides) and selected pharmaceuticals, here shown by name and CAS number. The CAS number is a unique identification number assigned by the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature. Then the user has a choice as to whether to simply produce a guideline, or to supply one's own data for comparison against the generated guideline.



Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 2-3 Water quality guidelines DSS Tier 1 data entry page.



Figure 2-4 Water quality guideline DSS at Tier 1 level, showing the selection process of compounds for which a guideline can be generated.

If a simple guideline is required, one can click on the button to generate a guideline. On clicking this button, the DSS undertakes an acute and a chronic SSD analysis, and outputs ecological category boundaries (with error estimates). For Ecological Categories A-E, the boundary conditions are the upper boundary of the particular class in concentrations of the compound. Ecological category F consists of all concentrations greater

than that given for Ecological Category E (see Table 2-1 for details, and Figure 2-7 and Figure 2-8 for examples). Output of this process is an HTML file that is transmitted to the user's default browser for visualization (see Figure 2-7). Within the output is a table, with information on Ecological Category names (A-F), a brief description of the Category, the class upper (or, for F, lower) boundary value, and description of the risk posed, based on the SSD analysis. This thus provides a simple tabulation of the guideline values and the implication of guideline levels for the environment.

Another option that is open at Tier 1 is to upload one's own data for comparison with the guidelines. When multiple values are uploaded, the DSS generates a concentration duration plot, that can give an estimate of risk at any particular site. Here, one can import a simple .csv file, with data on the compound requested (in mg/ $\ell$ ), and a column with site of sample identifiers (sitename). An example of data file structure is presented in Table 2-2. The interface for file upload is shown in Figure 2-5. Pressing on "Get timeseries" opens a file browser window that allows a user to select a file with their own data.



Figure 2-5 Water quality guidelines DSS Tier 1 interface for user file upload.

The data input format is a standard CSV text file containing columns as follows: sitename, ecoregion, data1[,data2,data3]. Column sitename is required, and column data1 is required. Column ecoregion is optional, as are further data columns. The data column names can be any single word, like: Al or Aluminium, or Ca or Calcium. Each row begins with the sitename, and where there are multiple sitenames, they must be grouped together. The number of sites is limited to 10.

sitename	AI
A12A	0.01
A12A	0.2
A12A	0.001
B12B	0.07
B12B	0.09
B12B	0.1
B12B	0.11

Table 2-2 File format for upload of own data in csv format for analysis under the guideline DSS	. The
example here is for aluminium data collected at two different sites.	

Now, when a guideline is generated, the DSS generates an html file that contains the same guideline boundary value table as is generated when a guideline without sample input data is produced from SSD analysis of toxicological data (see Figure 2-8). It also produces summary statistics on the submitted data (5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentiles, as well as sample mean) for each of the samples defined under column "sitename" in the input file. The output also contains a concentration duration curve that shows the percentage of uploaded samples that are likely to equal or exceed a particular concentration of the compound for which a guideline is required, again grouped by site or sample identifier (for an example, see Figure 2-6). If the input samples were collected regularly, they would represent a time series, and, if they were collected over a long enough time frame, might be valuable as a tool for predictions of future water quality at the site samples were collected at. Plotting these data against concentration allows the user to easily identify concentrations that are either always, or never, exceeded. By plotting the guideline ecological category values on the y-axis, the plot allows the user to directly read what proportion of submitted samples are in which ecological category.



Figure 2-6 Example of a concentration duration curve as produced by the Tier 1 guideline DSS. These data were entered in a similar format to the data in Table 2-2.

In the example presented in Figure 2-66, aluminium data from two hypothetical sites (A12A and B12B) are used to generate a pair of concentration duration curves. The guideline boundaries are also shown, and these allow the water quality implications of the concentration duration plot to be read from the figure. In this example, inspection of the two sets of data shows two different sets of behaviour. Site A12A, which shows varying water quality with approximately 20% of samples in ecological category A, 38% in category B, about 10% in category C, 14% in category D, and the remaining 18% in category E. Site B12B varies far less, with about 48% of samples in category B, and the remaining 52% of samples in category C.

Unless the number of individual samples in each user-defined group is large, the percentages as reported above from graphical inspection may be somewhat ambiguous, as they are based on intersections between concentration duration curves and guideline category boundaries. When few samples are present, these intersections will be at interpolations of the flow duration curve. When few data are available may be wiser to rely on a simple count of data points in each category.

# **Output: Tier 1**

Generated: 2023/11/02 15:47:00

This is Tier 1 output from the Water Quality Guidelines Decision Support System (WQGDSS).

Selected chemical Aluminium

#### **Timeseries info**

Sitenames None Imported

Chemicals None Imported

#### Filename:

None Imported

Sitename	Chemical	5 <sup>th</sup>	50 <sup>th</sup>	95th	Mean
No chemicals imported					

### Info for selected chemical

Ecological Category	Description of Category	Water quality guideline value	Risk Description
A	Natural	<= 0.0070 mg/L (0.0054-0.0086 95% CI)	<=1% chronic guideline Concentration of a water quality constituent most likely suitable for 99% or more of species. The risk of more than 1% of species being affected is low. Extremely sensitive species may still be affected.
В	Largely Natural	<= 0.119 mg/L (0.0754-0.162 95% CI)	<=5% acute guideline Concentration of a water quality constituent most likely non-lethal for 95% or more of species. The risk of more than 5% of species being affected is low. Highly sensitive species may still be affected.
С	Moderate impact	<= 0.218 mg/L (0.150-0.286 95% CI)	<=10% acute guideline Concentration of a water quality constituent may cause mortality in a number of species. The risk of 10% or fewer of the species dying is high, with moderate impact on biodiversity and ecosystem functionality.
D	Large impact	<= 0.475 mg/L (0.303-0.647 95% CI)	<=20% acute guideline Concentration of a water quality constituent may cause mortality in a large number of species. The risk of 20% or less of the species

Ecological Category	Description of Category	Water quality guideline value	Risk Description
			dying is high, with large impact on biodiversity and ecosystem functionality.
E	Serious impact	<= 0.880 mg/L (0.517-1.2 95% CI)	<=30% acute guideline Concentration of a water quality constituent may cause mortality in a very large number of species. The risk of 30% or less of the species dying is high, with serious impact on biodiversity and ecosystem functionality. Water quality is unacceptable.
F	Critical impact	>0.880 mg/L	>30% acute guideline Concentration of a water quality constituent may cause mortality in a very large number of species. The risk of 30% or more of the species dying is high. Water quality is unacceptable.

To see a distribution curve graph you must import a timeseries.

# Figure 2-7 Example of a simple guideline report produced when no data are supplied at Tier 1 level of the water quality guideline DSS. See text for full explanation.

For each of the ecological categories A-E, the generated guideline report gives the upper boundary value, and the 95% confidence interval (CI) around the derived boundary value (Figure 2-7). The confidence interval indicates the level of statistical support for the boundary estimation based on the available toxicological data. Category F is defined as having a greater concentration of the compound for which guidelines are requested than the other combined ecological categories.

In contrast to the simple guideline report shown in Figure 2-7, when a user uploads their own data, analysis of these data in light of the generated guideline is also presented in the output report (Figure 2-8). When the "Generate Guideline" button is pressed after loading user data, the basic guidelines from Figure 2-7 are produced together with summary statistics from user data, and a concentration duration curve with overlaid guidelines (Figure 2-8). The summary statistics include the 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentiles, as well as sample mean. The concentration duration plot is the same as Figure 2-6 above, and is interpreted in the same way.

# Output: Tier 1

Generated: 2023/11/01 12:05:25

This is Tier 1 output from the Water Quality Guidelines Decision Support System (WQGDSS).

Selected chemical Aluminium

#### Timeseries info

Sitenames

- A12A
- B12B

#### Chemicals

• AL

#### Filename:

H:\WQGDSS\data\timeSereisAL.csv

Sitename	Chemical	5 <sup>th</sup>	50 <sup>th</sup>	95th	Mean
A12A	AL	0.010	0.050	0.710	0.213
B12B	AL	0.090	0.120	0.200	0.124
	·	·		-	-

# Info for selected chemical

Ecological Category	Description of Category	Water quality guideline value	Risk Description
A	Natural	<= 0.0070 mg/L (0.0054-0.0086 95% CI)	<=1% chronic guideline Concentration of a water quality constituent most likely suitable for 99% or more of species. The risk of more than 1% of species being affected is low. Extremely sensitive species may still be affected.
В	Largely Natural	<= 0.119 mg/L (0.0754-0.162 95% CI)	<=5% acute guideline Concentration of a water quality constituent most likely non-lethal for 95% or more of species. The risk of more than 5% of species being affected is low. Highly sensitive species may still be affected.
С	Moderate impact	<= 0.218 mg/L (0.150-0.286 95% CI)	<=10% acute guideline Concentration of a water quality constituent may cause mortality in a number of species. The risk of 10% or fewer of the species dying is high, with moderate impact on biodiversity and ecosystem functionality.
D	Large impact	<= 0.475 mg/L (0.303-0.647 95% CI)	<=20% acute guideline Concentration of a water quality constituent may cause mortality in a large number of species. The risk of 20% or less of the species dying is high, with large impact on biodiversity and ecosystem functionality.
E	Serious impact	<= 0.880 mg/L (0.517-1.2 95% CI)	<=30% acute guideline Concentration of a water quality constituent may cause mortality in a very large number of species. The risk of 30% or less of the species dying is high, with serious impact on biodiversity and ecosystem functionality. Water quality is unacceptable.

Ecological Category	Description of Category	Water quality guideline value	Risk Description
F	Critical impact	>0.880 mg/L	>30% acute guideline Concentration of a water quality constituent may cause mortality in a very large number of species. The risk of 30% or more of the species dying is high. Water quality is unacceptable.

Figure 2-8 Example of a simple guideline report produced when no data are supplied at Tier 1 level of the water quality guideline DSS. See text for full explanation.

# CHAPTER 3: TIER 2

### 3.1 INTRODUCTION

South Africa rivers are spatially variable and heterogenous. This spatial variability is driven by several factors such as climate, physiography, geology and soils as well as attitude. As a result, rivers in South Africa have been typed hierarchically into ecoregion levels I and II. The underlying assumption is that rivers within the same ecoregion are ecologically more similar than rivers in distinct ecoregions. One of the criticisms of the 1996 Guidelines is that they were prescriptive without taking spatial variability into account in the sense that the same guideline values were applied throughout the country. A key short-coming of this approach is that in some parts of the country, certain water quality variables are naturally elevated due to underlying natural factors, e.g. some coastal rivers in the Eastern Cape such as Swartkops River that has elevated salt levels due to the underlying geology. The revised guidelines accounted for spatial variability within the country by deriving guidelines at ecoregion level II.

#### 3.2 METHODS

Tier 2 Guidelines were derived using the DWS data in the WMS database. WMS maintains a good set of data on major salts and other commonly measured physico-chemical variables such as nutrients, pH and dissolved oxygen, but has very little data on organic contaminants including herbicide and pesticide levels (guidelines for organic chemicals were derived at Tier 1 using toxicological data). WMS contains data from 333 routinely monitored points, which were relied upon as the primary source of data for the derivation of Tier 2 Guidelines. These data cover the period 1970s-2020 but this varies by ecoregion. The DWS data covers all seasons in South Africa, and by using these spatially and seasonally variable dataset, the revised guidelines thus account for both spatial and seasonal variability. Given the general rarity of data on metals in WMS, and the near absence of data on organic toxins, guidelines for these variables were derived only at Tier 1 based on ecotoxicological data, and may be regarded as conservatives.

Tier 2 physico-chemical guidelines were derived at ecoregion level 2. The DWS data were processed and regionalised. The derivation of the guidelines follows mainly the water quality methods for the Reserve (DWAF 2008), with some modifications. The Reserve method places emphasis on the use of data from over earliest three-year period, but an exploration of the data per ecoregion level II suggest data paucity in many of the ecoregions. Therefore, the guidelines were developed based on all data reported for an ecoregion. For nutrients and common inorganic salts, the guidelines were developed as per using DWS data.

In addition to physico-chemical constituents, Tier 2 guidelines also uses macroinvertebrate biomonitoring data. The expected assemblage per ecoregion level 2 were derived from the Macroinvertebrate Response Assessment Index (MIRAI) model version 2 (Thirion, 2007). The rationale is that under reference conditions, the expected assemblage should be similar to those observed. To derive macroinvertebrate-based guidelines at Tier 2, a macroinvertebrate risk model was developed and implemented. The macroinvertebrate risk model relies on three metrics: ecoregion level 2 presence and associated confidence, geozone presence and associated confidence and water quality sensitivity for each macroinvertebrate taxon.

An estimate of the amount of risk associated with changes in the macroinvertebrate community in any particular ecoregion level 2 and geozone location can be generated using the macroinvertebrate risk model. If the macroinvertebrate reference community perfectly matches those observed at a site, the site risk score would be zero, and the site would be classified an ecological category A. As the community accumulates differences from the reference community, either through omission of taxa or insertion of new taxa, the risk score would accumulate. The boundary levels outlining the different categories is presented below in Table

3-1. Different methods were used to derive guidelines for dissolved oxygen (DO), and pH as described in Volume 1. Temperature guidelines method default to Dallas and Rivers-Moore (2019a, 2019b, 2022). A summary of this is also described in Volume 1.

Table 3-1 Guideline derivation for Ecoregion level 2 and geozone macroinvertebrate risk estimates,
corresponding to generic ecological categories of Kleynhans and Louw (2007).

Ecological		Upper boundary	
category	Name	for rescaled risk	Description
A	Unmodified, natural	0.05	Unmodified and natural, expected and observed taxa are the same or extremely similar. Risk is very low.
В	Largely natural	0.2	A small change between the expected and observed taxa have taken place. Risk is low.
С	Moderately impacted	0.4	Moderate change has taken place between expected and observed taxa. Risk is moderate.
D	Largely impacted	0.6	Large change has taken place between expected and observed taxa. Risk is high
E	Seriously impacted	0.8	Serious change has taken place between expected and observed taxa, resulting in the loss of many taxa. The risk is very high and unacceptable.
F	Critically impacted	1	The macroinvertebrate assemblage has been critically modified, many taxa have been lost; the risk is extreme and unacceptable.

## 3.3 USE OF TIER 2 GUIDELINES

Upon starting the DSS, the user should click on the Tier 2 button to open the Tier 2 screen of the DSS as shown in Figure 3-1 below. Within Tier 2, the user is able to generate guidelines for both macroinvertebrates and physico-chemistry at ecoregion level 2. The user may decide to use both, i.e. macroinvertebrate data and physico-chemistry or either, depending on the availability of data and the user interest. To proceed, the user must enter the ecoregion level 2 either be selecting the number corresponding to the ecoregion (on the top left side of the DSS screen), or by entering the longitude and latitude information for the site and then clicking on the "Find" button. If the longitude and latitude information is entered and the Find button is pressed, the DSS immediately recover the corresponding ecoregion level 2. Upon entering the Ecoregion level 2 information, the DSS return a screen with the list of chemicals for which guidelines exist at that particular ecoregion level 2 (Figure 3-2).



Figure 3-1 DSS screen showing the interface for Tiers 1-3

trm_Tier2 Step 1 Step 2				- 0 ×
Using Ecoregion to generate referen	ce taxa		Compound	Select Category   Select Sta
EcoRegion Select •		Find Ecoregion	Import Timeseries	
Albitude Enter Alt Generative Reference Taxa		Lat -33 Find	Enter ROD value 0.00	<u>c</u> :
Select Tava that are present, deselect those not present       Important       Conferenza       Turbellovia       Objechets       Hydrografia       Pattermonidae       Partidae       Banidae 2 top       Banidae 2 top       Banidae 2 top       Carlinge       Hydrografiae       Perklae       Banidae 2 top       Banidae 2 top       Banidae 2 top       Banidae 3 top       Canidae       Popymäanzylidae       Prospitalmidae       Prospitalmidae       No. of Seasons       1       No. of Seasons       1	egion Map in Google Earth		select for comparison. Amminia Ammonia Ammonia Ammonia Ammonia Berofilum Berofilum Berofilum Coloride Cooper Bechical, conductivity Pouride Iron Lead Magnacianti Lead Magnacianti Lead Magnacianti Magnace Motydenum Nickel Notate, nictogen Phosphate, phosphorus Phosphate, phosphorus Sodium Supende, solids Tendum Supende, solids Tendum Supende, solids Tendum Total, all shinity Tenduk	
		Display	/ Results	
D Search		ef 🖪 🕱		^ 💘 0 ♥ <sup>ENG</sup> 🗇 🕫 🐿 11.11 🔮

Figure 3-2 DSS screen showing names of chemical constituents for which guidelines exist for ecoregion level 2 (ecoregion 1.02).

Once the screen with the names of chemicals have been returned, the user has the option to generate the guidelines for a particular chemical for that ecoregion level 2 by simply clicking on the chemical and displaying results, or by importing own data, and comparing these data with the guidelines. To import own data, click on the Timeseries button, and then the Get timeseries button, and then click on the Accept button (Figure 3-3).

den Franzische Annen bereiten den so	Compound	Select Category Select Site
sing Ecoregion to generate reference taxa	Compound	(≆ ALL (≆ ALL
Region 1.02	Find Ecoregion Import Timeseries	C A
ation Select •	Lon 26	C B
ude Enter Alt	Lat [-33	
Enter Au		C 6
Generate Reference Texa	Find Enter 800 value	CE
	mg/L	
ct Taxa that are present, deselect those not present	🖉 Import Timeseries — 🗖 X	
Porifera		
Coelenterata	Get Timeseries	1
Oliopchaeta	Settion 2 headers	
Heudinea	Filename is C/\WQGDSS\data\timeSereisAL.csv	
Amphipoda	Reading data	
Potamonautidae	Added chemical A12A,Al Added chemical B12B Al	
Atyidae	Add 16 data items	
Palaemonidae Hadrocades		
Notonemouidae		
Periidae		
Beetidae 1 sp		
Baetidae 2 spp		
Baetidae >2 spp		
Caeriidae Eithemeriidae	Accept Lancel	
Heptageniidae	Nickel Nickel	
Leptophlebiidae	Nitrate ndrogen	
Oligoneuridae	Phosphate_phosphorus	
Polymitarcyidae	Potassium	
Prosopistomatidae	Sodium	
of Samples	Strontium	
	Sulphate	
a of Seasons	Suspended_solids	
al Materialia	Titanium	
s er nyarocycles	Total_alkalinity	

Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 3-3 DSS screenshot showing Get Timeseries button for importing own data for comparison with guidelines.

The data input format is a standard CSV text file containing columns as follows: sitename, ecoregion, data1[,data2,data3] (Table 3-2). Column sitename is required, and column data1 is required. Column ecoregion is optional, as are further data columns. The data column names can be any single word, like: Al or Aluminium, or Ca or Calcium. Each row begins with the sitename, and where there are multiple sitenames, they must be grouped together. The number of sites is limited to 10.

•		
	sitename	AI
	A12A	0.01
	A12A	0.2
	A12A	0.001
	A12A	0.5
	A12A	0.71
	A12A	0.02
	A12A	0.05
	B12B	0.07
	B12B	0.09
	B12B	0.1
	B12B	0.11
	B12B	0.12
	B12B	0.13
	B12B	0.15
	B12B	0.15
	B12B	0.2

Table 3-2 File format for upload of own data in csv format for analysis in the DSS.	The example here
is for aluminium data collected at two different sites (A12A and B12	2B).

Once the data has been imported, the user has the option of returning guidelines for all the ecological categories by selecting the ALL button at the top right conner under "Select Category or selecting only the ecological category of interest, from category A to F. The User can also compare guidelines for all the sites by selecting the All button under "Select Site" or by selecting only the site of interest. Still the user also has the

option of comparing the water quality data with an RQO (Resource quality objective) value in case where an RQO exist. In such a situation, the user can just enter the RQO number, under "Enter RQO value" on the right side of the screen (Figure 3-4).

	Compound	Select Category Select Site
ng Ecoregion to generate reference taxa	compound	G All C All
gion 1.02 •	- Find Ecceseries	C A C A12A
ion Select	Lon 26	C B C BICD
te Estada	Let L33	CD
Enter At	[-u	CE
Annual Relevant Test	Find	C F
uniting minimize and	mg/L	C RQO
Taxa that are present, deselect those not present	that we shall be a set of the set	
orifera	Aluminium	
oelenterata	Ammonia	1
ligochaeta	Ammonium_nitrogen Arsenic	
irutinea	Beryllium	
mphipoda	Cadmium	
tvidae	Calcium	
alaemonidae	Chloride	
lydracarina	Electrical_conductivity	
lotonemouridae	Flouride	
eritoze setidae 1 sp	Lead	
aetidae 2 spp	Magnesium	
aetidae >2 spp	Major_dissolved_salts Manganese	
aenulae nhemeridae	Molybdenum	
leptageniidae	Nickel Nitrate/nitrite nitrogen	
eptophlebiidae	Nitrate_nitrogen	
ligoneuridae	Phosphate_phosphorus Retarsium	
otymitarcyidae iosopistomatidae	Silicon	
	Sodium	
ampies 0	Sulphate	
of Seasons	Suspended_solids	
d bh desceder .	Titanium	
n nyarocycles 11 💼	Total_alkalinity	

Figure 3-4 DSS screenshot showing the selection of All for all the ecological categories including the RQO and the selection of Site A12A. An hypothetical RQOs value of 0.07 mg/l for aluminium.

Now, the user can then click on the display results button to output the results. In the case of the example of the output displayed in Figure 3.4 above, the water quality data for aluminium are from site A12A and are compared with guidelines for ecological categories A-F, and for an RQO value of 0.07 mg/l. The DSS generates an html file that contains the guideline boundary value (Figure 3.5). It also produces summary statistics on the submitted data (5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentiles, as well as sample mean) for each of the samples defined under column "sitename" in the input file. The output also contains a concentration duration curve that shows the percentage of uploaded samples that are likely to equal or exceed a particular concentration of the compound for which a guideline is required, again grouped by site or sample identifier (Figure 3.6). If the input samples were collected regularly, they would represent a time series, and, if they were collected over a long enough time frame, might be valuable as a tool for predictions of future water quality at the site samples were collected at.

Plotting these data against concentration allows the user to easily identify concentrations that are either always, or never, exceeded. By plotting the guideline ecological category values on the y-axis, the time equal or exceedance on the x-axis, the plot allows the user to directly read what proportion of submitted samples are in which ecological category, or proportion that are equal or exceeding that particular ecological category or the RQO. The DSS also produces a table that provides a confidence measure for the Tier 2 guideline values for that particular ecoregion. The measure of confidence simply reflect the number of samples used to generate the guideline value for that particular ecoregion. Care should thus be taken when interpreting guidelines with low confidence level (Figure 3-5).

Ecological Category	Title	Water Quality Guideline Value	Description
A	Unmodified, natural	<=0.0020	Unmodified, natural
B	Largely Natural	<=0.0050	Largely natural with very minmal or negligible effect
С	Moderately impacted	<=0.0080	Moderately impacted, some noticeable effect have occured but do not translate into significant effect on basic ecosystem function and processes
D	Largely impacted	<=0.0140	Effect is significant and has impacted considerably on basic ecosystem function and processes
E	Seriously impacted	<=0.0230	Effect is serious and unacceptable, management action must be taken to remedy the situation
F	Critically impacted	> 0.0320	Effect is critical and unacceptable, management action must be taken to remedy the situation
	×.		
Confide	nce rating		Description

Figure 3-5 A typical DSS output table showing the guidelines for AI for ecoregion level 1.02 and the associated confidence rating.



Figure 3-6 A typical DSS concentration duration curve. (Note that this example is not produced based on the data in Figure 3-5 above).

#### 3.4 INTERPRETATION OF THE CONCENTRATION DURATION CURVE

The concentration duration curve is interpreted in terms of the proportion of samples that are within or exceed a particular water quality guideline value for the specified ecological category. In the case of the plot shown in Figure 3-6, 38% of the samples exceeds guideline values for ecological category E, meaning that 62% of the samples are within this ecological category. For ecological category D, 45% of the samples exceed the guideline value for this ecological category, implying that 55% of the samples were within this ecological category C, 58% of the samples exceed its guideline value, and only 42% were within the guideline value. 70% of the samples exceed guideline value for ecological category B, and 85% of

the samples exceed guideline values for ecological category A. Regarding the RQO, 47% of the samples exceed the RQO value and only 53% of the samples were within the example RQO value.

As already stated in Tier 1, unless the number of individual samples in each user-defined group is large, the percentages as reported above from graphical inspection may be somewhat ambiguous, as they are based on intersections between concentration duration curves and guideline category boundaries. When few samples are present, these intersections will be at interpolations of the flow duration curve. When few data are available it may be wiser to rely on a simple count of data points in each category.

#### Temperature guidelines

As the DSS defers to Dallas and Rivers-Moore (2019b) for temperature guidelines, to return methods for setting targets for temperature, the user should click on the button "Display Temperature information" at the bottom of the DSS as shown below (Figure 3-7).



Figure 3-7 DSS interface showing display temperature information near the bottom of the screen.

#### 3.5 MACROINVERTEBRATES

As stated earlier, at Tier 2, the DSS allows one to either work with macroinvertebrate or chemical data, or a combination of both. The principle underpinning the use of macroinvertebrate for guideline is different from that for chemistry, and users are refer to the technical report. Once the user has open the Tier 2 DSS screen as per earlier instruction, to generate macroinvertebrate guidelines, the user must click on the Ecoregion button to select the appropriate ecoregion level 2. The user must also click on the Zonation button to select the appropriate zone (A-F; S). And then enter the appropriate value for the site altitude (Figure 3-8). Once these have been completed, the user then clicks on the Generate Reference taxa button for the DSS to predict the macroinvertebrate taxa likely to occur in that region, within the specified longitudinal zone. The predicted macroinvertebrate taxa are selected automatically by the DSS as shown in the Figure 3-8 below.

	4		
Jsing Ecoregion to generate reference taxa		Compound	CALL CALL
oRegion 103  meterion D Generate Reference Taxa  Cenerate Reference Taxa  Codenterate Code	Find Ecoregion Lon 26 Lot 733 Find	Import Timeseries	
ic. of Hydrocycles			
		1	

Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 3-8 DSS screenshot showing predicted macroinvertebrate taxa for ecoregion level 2 (level 2 ecoregion 1.03).

The macroinvertebrates guidelines are generated only by comparing the predicted taxa versus the observed data. To compare the predicted and observed data, the user can either deselect taxa that are not observed, by clicking the appropriate taxa, or adding taxa that were observed but not predicted by clicking the appropriate taxa as shown below (Figure 3-9). The number of macroinvertebrate samples, the number of sampling seasons and the number of hydrological cycles the samples cover should also be entered at the left bottom of the screen. In this particular example (see DSS screen below), there were three samples, covering two seasons and one hydrological cycle (Figure 3-9). These allow an estimation of confidence of the results. Once these have been entered, the user should then click on the Display Results button for an output.

Using Ecoregion to generate reference taxa	Find Ecoregion	Compound Import Timeseries	$\left  \begin{array}{c} \operatorname{Select} Select Sele$
Ionation D • Nitrude 360 Generate Reference Taxa	Lon 26 Lat -33 Find	Inter 1000 Junior Data	C =
elect Text totat are present, deselect those not present		Select for comparison Ammonia Ammonia Calcum Calcum Bentrial, conductivity Rounde Magnesiam Magnesiam Magnesiam Magnesiam Phraphate, phospheria Phraphate, phospheria Phraphate, phospheria Phraphate, phospheria Discon Soliphate Total, Jakaniny Total, Jakaniny Total, Jakaniny Fil	
No. of Seasons 2 4 No. of Hydrocycles 1 4			
	Display	Results	

Figure 3-9 DSS screenshot showing addition and/or removal of taxa based on the difference between predicted and observed communities, as well as the entering of the number of samples, no. of seasons and no. of hydrological cycles.

The DSS output an HTML file format (Figure 3-10). The output contains an ecological category and management class (if already known and selected) as well as the ecoregion, zonation and altitude. The number of expected taxa and those observed are also returned by the DSS output. The DSS also return a list of taxa with their indicative risk profile relative to their absence from the resource. Therefore, the risk profile does not indicate the degree of risk of the particular taxon, instead it indicates the risk to the resource should that taxon be absent when it was predicted to be present and vice versa. For example, the risk to the resource is higher for highly tolerant taxa compare to very sensitive taxa. That is, when a highly tolerant taxa is absent when it has been predicted to be present, then the risk to the resource is higher compare to when a very sensitive taxon was expected but not observed. The DSS also return the ecological category based on the difference between the observed and expected taxa. In the case of the example shown below, the DSS has returned an ecological category B. The final output is the confidence rating. The DSS takes the information entered regarding the number of samples, seasons and hydro cycle to return a confidence rating table (Figure ). This allows for the interpretation of the results within context.

I	Taxa at risk:			
	Porifera	3.1	D: Largely impacted	
	Coelenterata	3.7	E: Seriously impacted	
	Turbellaria	3.4	E: Seriously impacted	
	Oligochaeta	3.9	E: Seriously impacted	
	Hirudinea	4.5	F: Critically impacted	
	Potamonautidae	3.9	E: Seriously impacted	
	Atyidae	3.8	E: Seriously impacted	
	Hydracarina	3.8	E: Seriously impacted	
	Baetidae 1 sp	4.1	E: Seriously impacted	
	Baetidae 2 spp	4.1	E: Seriously impacted	
	Baetidae >2 spp	3.5	E: Seriously impacted	
	Caenidae	4.1	E: Seriously impacted	
	Heptageniidae	2.9	D: Largely impacted	
	Leptophlebiidae	4.3	F: Critically impacted	
	Prosopistomatidae	3.4	E: Seriously impacted	
	Calopterygidae	3.4	E: Seriously impacted	
	Protoneuridae	3.4	E: Seriously impacted	
	Gomphidae	4.1	E: Seriously impacted	
	Dipseudopsidae	3.0	D: Largely impacted	
	Ecnomidae	3.3	D: Largely impacted	
	Hydropsychidae 1 sp	4.1	E: Seriously impacted	
	Hydropsychidae 2 spp	4.1	E: Seriously impacted	
	Hydropsychidae >2 spp	3.5	E: Seriously impacted	
	Philopotamidae	3.3	D: Largely impacted	
	Risk average	0.164		
	Risk %	16.36	4	
	Risk scaled 1-5	1.655		
	Risk category risk category B: moderate			

Figure 3-10 DSS output for Tier 2 using macroinvertebrate data for guidelines.

,	g
Number of Samples :	3
Number of Seasons :	2
Number of Hydrocycles :	1
Confidence Rating	Description
Low	Less than 6 samples collected may not have covered an entire hydrological cycle and all the seasons.

Figure 3-11 DSS output showing the confidence rating for the macroinvertebrate guideline.

# CHAPTER 4: TIER 3

### 4.1 INTRODUCTION

Tier 3 assessment is triggered when risk is suspected based on the results of Tiers 1 and/or 2. Tier 3 provides a means for a site-specific water quality risk assessment and the associated confidence level. A key feature of Tier 3 assessments is that they are event/scenario-based. The reasoning behind this approach is that improving water quality implies a focus on the event/scenario driving water quality change rather than on the symptoms. The guidelines at Tier 3 are based on site-specific risk assessment and should be performed only by experts or a trained practitioner.

### 4.2 METHODS

The risk assessment model has three sub-models: 1) the consequence sub-model, 2) the likelihood sub-model and 3) the uncertainty sub-model. In the consequence sub-model, consequence is conceptualized as the sum of severity, duration and spatial scale (magnitude). Severity is determined as the effect on the water physico-chemistry and macroinvertebrate response. The physico-chemical severity is extrapolated from the percent Time Equal or Exceeded curve relative to the water quality guideline value for a predetermined ecological category A-F (read from either Tier 1 or Tier 2 Guidelines). Based on the percent Time Equal or Exceeded curve, the water physico-chemical severity is rated. The sub-model uses the average of the ratings for all physio-chemical variable to determine the overall severity rating for physico-chemistry.

Macroinvertebrate response data are used in the consequence sub-model to determine the biological dimension of the severity. The deviation of the observed data from the expected calculated based on the macroinvertebrate risk model (Tier 2) provides the basis for the rating of macroinvertebrate severity. Where the macroinvertebrate risk model returns a deviation, corresponding to ecological category F, then the severity rating of 5 is awarded, whereas a deviation between the expected and observed assemblage corresponding to an ecological category B, corresponds to a severity rating of 1. An ecological category A has no severity rating, implying that the expected and observed assemblages are either the same or extremely similar. The overall severity in the consequence sub-model is calculated as the average of the physico-chemical severity rating and that for the macroinvertebrate response.

The second dimension of the consequence sub-model is the duration. The duration relates to the temporality of the event/scenario or compound that trigger the risk. The duration is rated. Event that occurs within a short period say one day to one month with no discernible impact on the water quality are rated lower compared to those occurring over a prolong period say one year with noticeable impact on the water quality status.

The third dimension of the consequence sub-model is the spatial scale, which quantify the spatial magnitude of the risk-triggering event. The spatial scale is rated in the consequence sub-model as well. Events that occur within a confined/localized area are rated lower compared to those occurring over and affecting several catchments or resource units.

The likelihood sub-model calculates the probability of the event occurrence, its impact and its detection. In the sub-model, likelihood is calculated as the sum of the frequency of occurrence of the risk-triggering event, frequency of the impact of the event and its detection, following DWS (2023).

The frequency of the risk triggering event refers to how often the event occurs. Events that occur rarely are rated lower compared to those that occur frequently or daily.

The frequency of impact relates to how often the occurrence of the event impact on the receiving water resource. This aspect is critical as the mere occurrence of an event does not necessarily translate to an impact. The frequency of impact is also rated in the likelihood sub-model.

The early detection of a water quality risk-triggering event is critical for water resource protection. Events that are detected early enough may trigger the necessary management action or mitigation measures unlike those that are difficult to detect yet may have serious impact on water quality. The detection aspect of the likelihood-sub model allows for the rating of the ease with which the event or its impact may be detected.

The site-specific water quality risk assessment model returns an overall risk rating for a site by integrating the consequence and likelihood sub-models as per Table 4-1 below.

Rating	Risk category	Description
1-20	Very low	Risk is acceptable.
21-40	Low	Risk is acceptable, water quality impact is minimal and easily managed/mitigated.
41-120	Moderate	Water quality risk are notable and require mitigation measures.
121-180	High	Water quality risk are very notable, may be long term and may require specialist mitigation measures.
181-225	Very High	Water quality risk is unacceptable and mitigation measures must be implemented to lower the risk.

The levels of uncertainty/or confidence associated the risk rating is assessed and rated. The rating is done based on i) the reliability and reasonability of the assumptions made about the various metrics or component of the risk; ii) the adequacy of the relevant, reliable data and information upon which the risk judgement is based; iii) the degree of agreement among experts and/or literature support for the various components of the risk being described; iv) the degree to which the phenomenon in question is well-understood and whether it can accurately be modelled; v) knowledge or otherwise of the site-specific risk modifying factors. These are integrated to produce an uncertainty/confidence rating as shown in Table 4-2 below.

Rating	Confidence level	Description
1-5	Very high	The uncertainty associated with the risk assessment is acceptable.
6-10	High	The uncertainty associated with the risk assessment is minimal and acceptable.
11-15	Moderate	The uncertainty associated with the risk assessment is notable.
16-20	Low	The uncertainty associated with the risk assessment is high. Steps should be taken to reduce the uncertainty and improve the confidence level.
21-25	Very low	The uncertainty associated with the risk assessment is very high. Steps should be taken to reduce the uncertainty and improve the confidence level.

### Table 4-2 Overall uncertainty rating associated with the site-specific water quality risk assessment.

### 4.3 USE OF TIER 3 FOR SITE-SPECIFIC WATER QUALITY RISK ASSESSMENT

Upon starting the DSS, the user should click on the Tier 3 button to open the Tier 3 screen of the DSS as shown in Figures 4.1 below. In Tier 3, there are three sub-models the user must complete. These are the consequence, likelihood and uncertainty sub-models. The user starts by clicking on the consequence sub-model. On the consequence sub-model, the user enters the water quality issue(s) for which risk assessment is sought. Please note that this should ideally be the risk triggering event/or scenario rather than the water

quality stressor or symptoms. In the case of the example shown in Figure 4-1 below, the risk-triggering event is an agricultural farmland. Within the consequence sub-model, the DSS allows the user to undertake the severity rating for both or either physico-chemistry and macroinvertebrates.

😨 Tier3 - restart	- o x
Consequence Likelyhood Uncertainty	
Severity Rating	
Water Quality Issue Enter your water quality issue	
Physice-Chemistry Macroinvertebrate Rating	
Select macroinvertebrate rating	
Select	
8 Langely related 1	
C Moderately impacted 2	
D Largely impacted 3	
E Seriously impacted 4	
F Critically impacted 5	
Average PhysicsChemical     0     Duration     Spatial Scile       MacrolinvertBiotek Rating     0     1     -very localized       /2     - one work to system     2 - entire site       /2     0     1 - one year to system     3 - quaternary catchment       Coverall sevently Rating     0     - 0     - 0       0     - 0     - 0     years     - 0       - 0     - 5     - more than 20 years     - 5 - primary catchment	
Consequence rating 0 Next	
📰 🔎 Search 🔛 🕒 📮 🜑 🗰 💿 💗 👊 🏟 💆 📮	∧ 👯 🟮 ♥ ENG 🗇 d≬ 🐲 12:50 INTL 🗇 d≬ 🐲 2023/12/08

Figure 4-1 Screenshot of the DSS interface for Tier 3.

To undertake the severity rating for the physico-chemistry, click on the physico-chemistry button to return a DSS screen shown in Figure 4-2. Click on the Add Row button to enter the name of the chemical variables and undertake the rating for each variable. Once the Add Row button is activated, type in the name of the chemical variable(s), and enter the % time equal or exceedance, read from the Tier 1 or Tier 2 duration curve for that variable. The time equal or exceedance refers to the percentage of samples that are outside the range of the water quality guideline values for the particular ecological category (please refers to the interpretation of Tier 1 or Tier 2 frequency duration curve). For example, in the DSS screen below (Figure 4.2), the time equal or exceedance for nitrite-nitrogen is 50% (meaning 50% of the samples fall outside of the water quality guideline value for the particular ecological category of interest, e.g. A-D). That for Nitrate-nitrogen is 70% meaning only 30% of the samples fall within the water quality guideline value for the particular ecological category of interest. Once these values have been entered the DSS automatically calculates the average physico-chemical rating by integrating the rating for all the physico-chemical variables. Variables can be removed by clicking on the Remove last button, or added by Clicking on the Add Row button.

The duration of the risk triggering event/scenario is rated by clicking on the appropriate duration rating. This function allows the user to assess the temporal dimension of the risk triggering event as shown in Table 4-3. In the particular example displayed on the DSS screen (Figure 4-2) the duration is rated 4, meaning the risk triggering event has been occurring between 5-20 years, and is considered a long event in which the water quality status may be permanently degraded, and improvement is almost impossible.

Duration of		
event/scenario	Rating	Description
One day to one month	1	An event occurring over a very short period, and has no noticeable effect on the water quality status.
One month to one year	2	An event occurring over a short period, the water quality status may be impacted but the status remains the same. The impact is not enough to change the water quality status.
One year to 5 years	3	An event occurring over a relatively long period, the water quality status may be impacted, there is a degradation of the water quality status. Mitigation/management action may improve the status.
5 years to 20 years	4	A long event in which the water quality status may be permanently degraded, and improvement is almost impossible.
More than 20 years	5	A very long event resulting in an extremely impacted water quality status, resulting in an F category, and no management action may result in any noticeable improvement.

#### Table 4-3 Rating for the duration aspect of the consequence sub-model.

😰 Tier3 - restart	-	0	×
Consequence Likelyhood Uncertainty			
Sevenity Rating			
Water Quality Issue Enter your water quality issue			
Physico-Chemistry Macroinvertebrate Rating			
Add Row         Feter Physico-Chemical Visable         Soverity Rating           Add Row         Notate - nitrogen         90.00         3           Remove last         Add Row         90.00         4           3         3         5			
Average PhysicoChemical     L0     Duration     Spatial Scale       Macroinvertebrate Rating     0			
Vert			
	10		0914
■ P Search ■ ■ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □	n ⊗ d≬ ¶	2023	3/12/08

Figure 4-2 Screenshot of the physico-chemical severity rating for the risk-triggering event.

Once the duration is rated, the spatial scale should also be rated. The spatial relates to the extent of geographical coverage of the risk triggering event, and is rated as per Table 4-4 below: In the case of the example provided (Figure 4-2) on the DSS screen, the spatial scale is rated 2 meaning the risk-triggering event, i.e. the agricultural farmland affects an entire site.

Duration of	Severity	
event/scenario	rating	Description
Very localized	1	A confined and highly localized event.
Entire site	2	An event affecting an entire site.
Quaternary	3	An event affecting and entire sites, extending down streams and affecting
catchment		downstream resource, potentially more than one resource units.
Secondary	4	A large event affecting an entire secondary catchment. Resources within
catchment		the secondary catchment are affected. May affect multiple provinces.
Primary	5	An event with large spatial scale, affecting the entire country and
catchment and		potentially beyond.
beyond		

#### Table 4-4 Rating for the spatial scale dimension of the consequence sub-model.

If macroinvertebrate data exist, then severity rating can also be undertaken for the macroinvertebrate component. Click on the macroinvertebrate rating to return the DSS screen shown in Figure 4-3 below. Then select the macroinvertebrate rating, from A to F. These rating are based on the macroinvertebrate risk model results for macroinvertebrate-based ecological categories returned at Tier 2 assessment (refers to the interpretation of the macroinvertebrate risk model results in Tier 2). These rating are as described in Table 4-5Table 4-5 Macroinvertebrates severity rating as a function of the extent of deviation between the expected and observed taxa returned by the macroinvertebrate risk model in Tier 2. below: In the case of the DSS screen shown below, the severity rating for the macroinvertebrate is a "C" meaning that a moderate change has taken place between expected and observed taxa.

Upon completion of the consequence model either by rating the severity for physico-chemistry and/or macroinvertebrates, the DSS automatically calculates the overall consequence rating. In the case of the example on the DSS screen, the overall consequence rating is 9.0.

		Upper boundary		
Ecological		for rescaled		Severity
category	Title	risk	Description	rating
А	Unmodified, natural	0.05	Unmodified and natural, expected and observed taxa are perfectly the same.	No rating
В	Largely natural	0.2	A small change between the expected and observed taxa have taken place. Risk is low.	1
С	Moderately impacted	0.4	Moderate change has taken place between expected and observed taxa. Risk is moderate.	2
D	Largely impacted	0.6	Large change has taken place between expected and observed taxa. Risk is high.	3
E	Seriously impacted	0.8	Serious change has taken place between expected and observed taxa, resulting in the loss of many biotas. The risk is very high and unacceptable.	4
F	Critically impacted	1	The macroinvertebrate assemblage has been critically modified, many biota have been lost; the risk is extreme and unacceptable.	5

# Table 4-5 Macroinvertebrates severity rating as a function of the extent of deviation between the expected and observed taxa returned by the macroinvertebrate risk model in Tier 2.

Average PhysicoChemical Acceleration (20)  Average PhysicoChemical  Acceleration  Acce	s Severity Ra nodified, Natural No Rating tely natural 1 Seatedy impacted 2 outly impacted 3 outly impacted 4 ically impacted 5 Septial Scale rooth 1 very localized rooth 2 - entire site	leveity Flating Vo Rating
eventry Hading     Enter your water quility issue       Hysico-Chemistry     Microinvertebrate Rating       Select macroinvertebrate Rating     Enterply and C       Microinvertebrate Rating     Category       Title     A       Unmodifie     Largety and C       Select macroinvertebrate rating     Category       Title     A       Unmodifie     Largety and C       D     Largety and C       E     Seriously in F       Cettory in Acceloivertebrate Rating     C       Verage PhysicoChemical Acceloivertebrate Rating     C       Verage Residence     C       Verage Residence     C       Image: Series and the series of the series	r Severity Ra nodified, Matural No Rating ply natural 1 Sentely impacted 2 outly impacted 3 outly impacted 4 ically impacted 5 Spatial Scale roomth P 2 - entire site	Security Rating to Fating 1
ter Quality issue     ter Quality issue     ter Quality issue     ter Quality issue     Select macroinventebrate Rating     Select macroinventebrate Rating     Select macroinventebrate Rating     Category Tate     A Demodelin     Largety nat     C Moderately     D Largety in     E Serioudy in     F Critically in     rearge PhysicoChemical     Lo     rearge PhysicoChemical     Lo     T - one day to one month     C - one month to one year     /2     Gone year to System     Seriel sevenity Rating     LO	nordfiel, Hetural No Reting tely natural 1 Sentally impacted 2 poly impacted 3 outly impacted 4 cally impacted 5 Spatial Scale r 1 - very localed no year P 2 - entire site	Security Rating to Rating
ysics-Chemistry Metroinvertebrate rating Select macroinvertebrate rating  Category Title A Unmodifie Largely ma C Modernel D Largely ma C Modernel D Largely ma C Modernel D Largely ma C Coloration F Contractly in Contract A2 Contract	Severity Ra modified, Natural No Rating gly natural 1 Severity impacted 2 acatly impacted 3 uouly impacted 4 icably impacted 5 Spetial Scale O 1 - very localized O 1 - very localized	Severity Plating Vo Rating 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Select macroinvertebiste rating	s Seventy Ra nodfind, Natural No Rating tely natural 1 Solatily impacted 2 exhi impacted 3 outry impacted 4 kcally impacted 5 Spatial Scale r 1 - very localized no year r 2 - entire site	Receitly Rating
Category Teta     A Utmodifie     B Largely nat     C Mobiented     D Largely in     C Mobiented     D Largely in     E Seriously in     F Critically in     E Critically in     C Cr	Severity for a Severity for Severity for a Severity for Severity for a Severity for a Severity for a Severity for a Sever	Aventy Hating Vo Rating 2 1
renge PhysicoChemical     acroinvertebrate Rating     C     C     Croinvertebrate Rating     C	roomin, roomin	so rang
C Moderately D Largely im E Serioudy im F Critically in F Critically in rolewarebrate Rating C C) C C C C C C C C C C C C C C C C C	Spatial Scale month Spatial Scale Spatial Scale month Spatial Scale r - 1 + very localized r - 2 - entire site	
D Largely im E Seriously in F Critically in rage PhysicoChemical (a) PhysicoChemical (a) C (2) C (2) C (2) C (2) C (2) C (3) C	ely impacted 3 outy impacted 4 ically impacted 5 Spatial Scale (* 1 - very localized ne year / 2 - entire site	
E         Seriously in           F         Critically in           repr PhysicoChemical         4.0           C         1- one day to one month to one year           /2         - one month to one year           /2         - one month to one year           /2         - one year to 5 years	outly repacted 4 ically impacted 5 Spatial Scale	
F Cretically in     rage PhysicoChemical     A0     Duration     Tolowerebrate Rating     C (2)     C (2)     C (3)     C (3)     C (3)     C (4)     C	solly impacted 5 Spatial Scale For 1 - sery localized ne year Gr 2 - entire site	
age PhysicoChemical 4.0 Duration Collivertebrate Rating C (2) C - one day to one month to low evently Rating 1.0 C - one year to 5 years	Spatial Scale month □ 1 - very localized ne year □ 2 - entire site	
<ul> <li>4 - 5 to 20 years</li> <li>5 - more than 20 years</li> </ul>	C 4 - secondary catchment	r catchment atchment
Consequence rating		Next

Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 4-3 Screenshot of the DSS showing the macroinvertebrate risk rating.

To proceed to the likelihood sub model, click on the Next button at the bottom of the screen. This takes you to the likelihood sub-model. Within the Likelihood sub-model, rating is done for the risk triggering event/scenario based on 1) the frequency of occurrence, 2) frequency of impact and 3) detection. These ratings are done as per Table 4-6 to Table 4-8 below: In the case of the example shown in Figure 4-4 below on the DSS screen, the frequency of occurrence has been rated as monthly, the impact as > 40% meaning that it is an event that very seldom impacts the water quality or it is highly unlikely that it impacts on the water quality. The detection is rated as difficult to detect.

Frequency of occurrence	Rating	Description
Annually or more	1	An event that rarely occurs, mainly annually or more
Biannual	2	An event that occurs occasionally, mainly six monthly or more, but less than annually.
Monthly	3	An event that occurs monthly but less than six monthly.
Weekly	4	An event that occurs frequently, mainly weekly.
Daily or less	5	A highly frequent event, occurring daily or even hourly, creating a condition of persistence.

Table 4-6 Rating	for frequency of	occurrence of the	risk-triggering event
			00 0

#### Table 4-7 Rating for frequency of impact of the risk-triggering event.

Frequency of impact (how often does the event impact on		
the receiving water resource?)	Rating	Description
>20%	1	An event/concern/scenario whose frequency of impact on
		the water quality is negligible.
>40%	2	An event that very seldom impacts the water quality or it is
		highly unlikely that it impacts on the water quality.
>60%	3	An event that occasionally impacts on the water quality
>80%	4	An event that often/regularly impacts on the water quality
>100%	5	An event that definitely impacts on the water quality

Table 4-8 Rating for the detection of the risk-triggering event or its impact on the water quality
component of the resource.

Detection	Rating	Description
Immediately	1	The effect on the water quality is immediate and can be detected easily
Without much effort	2	The effect on water quality may not be immediate but can be detected easily.
Require some effort to detect	3	The effect on water quality may not be easily observable and some effort is required to detect it.
Difficult to detect	4	The effect on water quality is difficult to observe and detect
Unnoticed	5	The effect on water quality may go unnoticed and is very difficult to detect.



Figure 4-4 Screenshot showing the likelihood rating for frequency of occurrence, frequency of impact and detection for the risk triggering event (an agricultural farmland).

Upon completion of the likelihood sub-model, click on Next button to commence the uncertainty assessment. The uncertainty sub-model has five components (Figure 4-5)

Category Robelly of assumption 0 Physics - Chemical seventy dimension 0 Reconverteburs seventy dimension 0 Eget agreement/ Recature support 0 Reck assessor's knowledge of the site-specific modifying factors 0

Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 4-5 Screenshot of the DSS showing the sub-component for which assessment is needed regarding the uncertainty sub-model.

To start, click on the first component: the reliability and reasonability of assumption, and the click on the Edit button to open the DSS screen as shown in Figure 4-5. From the options provided, select the most appropriate regarding the assumption and reasonability of the risk-triggering event. In this particular example (Figure 4-6), option 1 has been selected, indicating very low uncertainty/very high confidence, suggesting that the risk is definitely attributable to the risk-triggering event being assessed. Once done, click the Save button and continue.

Crease and the second s
tagory Provide Second S
kor-themical severity demension       0         properturbative severity demension       0         assessor's browledge of the site-specific modifying factors       0         concretainty scoring regarding the reliability and reasonability of the assumption of the risk-triggering events       Score         Description of the risk-triggering event       Score       Description of uncertainty         ner risk is argely attributable to the risk-triggering event       1       Very low uncertainty wight confidence         ner risk is argely attributable to the risk-triggering event.       1       Very low uncertainty wight confidence         ner risk is argely attributable to the risk-triggering event.       2       Low uncertainty / moderate confidence         ner risk is argely attributable to the risk-triggering event.       3       Moderate uncertainty / moderate confidence         age size studies attributable to the risk triggering event scores with other events/scenarios. The contribution(s) of other attribute to the risk triggering event scores with other events/scenarios. The contribution(s) of cother 4       High uncertainty / low confidence         he risk triggering event scores with other events/scenarios. The contribution(s) of cother 4       High uncertainty / low confidence         he risk triggering event scores with other events/scenarios. The contribution(s) of other events is a scores attribute to the risk existing event event scenarios. The contribution(s) of cother events is a scores attrisk event (scenarios. The is possible to attribute scen
Incertainty scoring regarding the reliability and reasonability of the assumption of the risk-triggering events       Score       Description of uncertainty         The risk is definitely attributable to the risk-triggering event.       I       Very low uncertainty/very high confidence         The risk is definitely attributable to the risk-triggering event.       I       Very low uncertainty/very high confidence         The risk is definitely attributable to the risk-triggering event. Although other events may       2       Low uncertainty/high confidence         The risk is largering event.       Store       Moderate uncertainty/high confidence         The risk is largering event.       Moderate uncertainty/high confidence         The risk inggering event occurs with other events/scenarios. The contribution(s) of other       4         High uncertainty/low confidence       5         Very high uncertainty/very low confidence         The risk triggering event(s) occurs with other events/scenarios. It is impossible to attribute       5         Very high uncertainty/very low confidence       5
Description of the risk-triggering event.     Score     Description of the risk-triggering event.       The risk is definely attributable to the risk-triggering event.     If     Wry low uncertainty/ wry logh collidence       The risk is largely attributable to the risk-triggering event.     Score     Low uncertainty/ high collidence       The risk is largely attributable to the risk-triggering event.     Mough the risk-triggering event.     Score     Low uncertainty/ high collidence       The risk is largely attributable to the risk-triggering event.     Mough the risk-triggering event.     Moderate uncertainty / moderate confidence       The risk inggering event cours with other events/scenarios. The contribution(s) of other events, triggering event.     High uncertainty/ low confidence       The risk triggering event cours with other events/scenarios. The contribution(s) of other     4     High uncertainty/ low confidence       The risk triggering event cours with other events/scenarios. The is impossible to attribute     5     Very ligh uncertainty/ very low confidence
The risk is largely attributable to the risk-triggering event. Abhough other events may contribute to the risk such contribution(s) is/are largely negligible. The risk is largely attributable to the risk-triggering event. Abhough the risk-triggering event 3 may exist which er events, they may only moderately contribute to the risk being assessed. Line risk triggering event occurs with other events/scenarios. The contribution(s) of other events is impossible to attribute to the risk being assessed. Line risk triggering event occurs with other events/scenarios. It is impossible to attribute 5 Very high uncertainty/ very low confidence 6 Very hig
ter risk is targely attributable to the risk-triggering event. Athrough the risk-triggering event 3 Moderate uncertainty /moderate confidence sessed. If the risk being assessed may be significant. The contribution(s) of other 4 High uncertainty / low confidence exclosers in the risk bring assessed may be significant. If is impossible to attribute 5 Very high uncertainty / very low confidence er risk triggering event(s) being assessed.
the risk triggering event accurs with other events/scenarios. The contribution(s) of other exerts/scenarios the risk being assessed may be significant. the risk triggering event(s) being assessed. S Very high uncertainty/ very low confidence e risk only to the event(s) being assessed.
te risk triggering event(s) occurs with other events/scenarios. It is impossible to attribute 5 Very high uncertainty/ very low confidence e risk only to the event(s) being assessed.
Seve

Figure 4-6 Screenshot of the DSS showing the uncertainty rating about the reliability and reasonability of the assumptions regarding the risk-triggering events.

The uncertainty regarding the physico-chemical severity rating is also assessed. Click on the physico-chemical severity dimension and then click on the Edit Button to take you to the screen display in Figure 4-7. Select the appropriate option from those provided in the DSS. As shown in the figure, a rating of 3 has been activated/awarded, meaning the uncertainty is moderate. Once done, click on the Save button and continue.

Intergence   Likelyhood - Uncertainty   Category Macroinverteleaste severity dimension Spert agreement/disagreement/likessure support Dat assessor's knowledge of the site-specific modifying factors	Prok         Un           1         Ede           0         -	certainty/confide Save Final Repo	ice rating: Unknown	1		
tgary ability and reasonability of assumption croinvertebrate severity dimension est agreement/disagreement/likerature support assessor's knowledge of the site-specific modifying factors	Pisk         Un           1         Ede           0         0           0         0	certainty/confide Save Final Repo	oce rating: Unknown			
liability and reasonability of assumption scroinvertelevate severity dimension pet agreement/disagreement/literature support & assessor's knowledge of the site-specific modifying factors	1 0 0	Save Final Rigits	nce rating: Unknown			
ctoinvertebrate severity dimension et agreement/disagreement/likesature support assessor's knowledge of the site-specific modifying factors	0 0	Save Final Repo				
croinvertebrate severity dimension left agreement/disagreement/literature support k assessor's knowledge of the site-specific modifying factors	0	Save Final Report				
eet agreement/disagreement/literature support k assessor's knowledge of the site-specific modifying factors	0		<u>.                                    </u>			
k assessor's knowledge of the site-specific modifying factors						
	0					
Incertainty scoring associated with the physico	o-chemical severity dimension of sit	e-specific risk	assessment.			
Physico-chemical se	overity	Score E	escription of uncertainty			
Appropriate and relevant physico-chemical variables are sele- variables areanalysed. The sampling covers all seasons and m collector(s) is/are highly competent. There is a very high con	ected, a minimum of 20 samples per selected nore than 2 hydrologicalcycles. The data fidence in the data.	1 Very low u	scertainty/ very high confidence			
Appropriate and relevant physico-chemical variables are sele- variables areanalysed. The sampling covers all seasons and m collector(s) has/have received adequate training. There is a h	ected, a minimum of 15 samples per selected sore than 2 hydrologicalcycles. The data iigh confidence in the data.	2 Low uncer	ainty/ high confidence			
Appropriate and relevant physico-chemical variables are sele- variables areanalysed. The sampling covers all seasons and at collector(s) has/have received some training. The confidence	icted, a minimum of 10 samples per selected t least a hydrological cycle.The data t in the data is moderate.	3 Moderate	incertainty /moderate confidence			
Some relevant physico-chemical variables are selected, a min analysed. The sampling covers some seasons. The data collec the data is low.	nimum of 5 samples per selected variables are ctor(s) received some training. Confidence in	4 High unce	tainty/ low confidence			
Some relevant physico-chemical variables are selected, a min are analysed. The sampling cover at least a season. The data of Confidence in the data is very low.	nimum of one sample per selected variables collector(s) received some training.	5 Very high I	incertainty/ very low confidence			
	Save					

Figure 4-7 Screenshot of the DSS showing the uncertainty rating about the physico-chemical severity rating.

The uncertainty regarding the macroinvertebrate severity rating is also assessed. Click on the macroinvertebrate severity dimension, and then click on the Edit Button. This takes you to the DSS screen shown in Figure 4-8. Click on the option most relevant for the macroinvertebrate data used in undertaking the severity rating. In the particular example shown in Figure 4-8 below on the DSS screen, the uncertainty is rated as 4 meaning there is a low confidence or high uncertainty regarding the macroinvertebrate data used in undertaking the macroinvertebrate severity rating, read from Tier 2. Once done, click on the save button and continue.

sevents Likelyhood Uncertainty gary Pick addy and reasonability of essumption at agreement/likes/user support a sussar's knowledge of the site-specific modifying testers assessir's knowledge of the site-specific modifying testers montainty sceing associated with the macroinvertibutes seventy dimension of site-specific risk assessment. Macroinvertibutes seventy dimension of site-specific risk assessment. Imminum of eight samples were collected, covering all sessons. The data collector is 5ASS-5 a coredited. 2 I Low uncertainty/high confidence A minimum of four samples were collected, may or may not have everent all as collector is 3ASS-5 a coredited. 2 I Low uncertainty/high confidence A minimum of risk samples were collected. The data collector is 5ASS-5 a coredited or may have exceeded armay have recented to the high-uncertainty/wer low confidence Same taking. Binimum of one sample collected. The data collector is 5ASS-5 a coredited or may have received all as collector is 5ASS-5 a coredited or may have received to the samples were collected. The data collector is 5ASS-5 a coredited or may have received as mont have a vereent at the high-uncertainty/wer low confidence Binning. Binning.	specific       Uncertainty         ignory       inc.         index and reasonable of essumption       1         inco-chemical seventy dimension       1         incommuno of signt semples were collected, covering all season. The data collector is 5455-5       1         inminum of signt semples were collected, covering all season. The data collector is 5455-5       1       Very low uncentainty/ wory high confidence         5555-5       1       Very low uncentainty/ wory high confidence       1       1         inminum of signt semples were collected, covering all season. The data collector is 5455-5       1       Very low uncentainty/ wory high confidence         5555-5       1       Very low uncentainty/ wory high confidence       1       1         5555-5       1       Very low uncentainty/ wory high confidence       1       1       1         5555-5       1       Very low uncentainty/ wor solind confidence       1       1	tequerers [Linkybood Workthint]  tepport assemption  tequerers  tequerers	sequence Likelyhood Uncertainty			
egory       Rok       Implement         abdity of escondality of assumption       Implement       Implement         et agreement/lites/genent/Resulture support       Implement       Implement         et agreement/lites/genent/Resulture support       Implement       Implement         et agreement/lites/genent/Resulture support       Implement       Implement         et agreement/Resulture support       Implement       Implement         matcrianty scening associated with the matcriantwethetate severity       Scening       Description of uncertainty         A minimum of eight samples were collected, covering all seasons. The data collector is SAS5-5       Implement       Very high confidence         A minimum of the samples were collected, covering all seasons. The data collector is SAS5-5       Implement       Moderate uncertainty/were high confidence         s SAS5-5 accredited       Implement       Matcrianty have received       Implement         s SAS5-5 accredited       Implement       Moderate uncertainty/were low confidence         is SAS5-5 accredited or may have received as matcrianty.       Moderate uncertainty/were low confidence         is start       Implement       Implement       Implement         is start       Save       Implement       Implement         is start       Implement       Implement       Implement	gay:       Rok         Bably and reasonability of assumption.       1         isco-channel second       1         isco-channel second </th <th>eggeneration       1         ability and reasonability of assumption       1         is checkerial assemption       1         is aggeneration       0         is aggeneration       0</th> <th></th> <th></th> <th></th> <th></th>	eggeneration       1         ability and reasonability of assumption       1         is checkerial assemption       1         is aggeneration       0				
ability of reasonability of summation       1         tice-chemical secretly dimension       3         et agreement/likesure support       0         iscasses's knowledge of the site-specific modylying factors       0         certainty scoring associated with the macroin-wite/state sevenity dimension of site-specific risk assessment.         Macroin-wete/state sevenity       Scoring         become of float       1         te minimum of site samples were collected, covering al seasons. The data collector is 5ASS-5       1         Very low uncertainty/ wery high confidence         Amonimum of float samples were collected, covering al seasons. The data collector is 5ASS-5       1         SSSS 24 accoded or may have te collected, covering al seasons. The data collector is 5ASS-5       1         SSSS 24 accoded or may have te collected, covering al seasons. The data collector is 5ASS-5 accredited       2         Low uncertainty/moderate confidence       Moderate uncertainty/moderate confidence         SSSS 24 accoded or may have received al may have received al may have received as seme to may confidence       1         Innovanue       1       1         Innovanue       1       1         SSSS 24 accoded or may have received as seme to may not set secretized armay have received as seme to may not set secretized armay have received as seme to may not set secretized armay have received aseme       1 <td< th=""><th>belay and reasonability of assumption.</th><th>Uncertainty contradence taking: United and Uncertainty Contradence taking: Uncertainty Co</th><th>egony'</th><th>Risk</th><th></th><th></th></td<>	belay and reasonability of assumption.	Uncertainty contradence taking: United and Uncertainty Contradence taking: Uncertainty Co	egony'	Risk		
Acco-chemical severity dimension       1         assessit's knowledge of the site-specific modifying factors       0         containity scoring associated with the macroinvertebrate severity dimension of site-specific mit assessment.         minimum of eight samples were collected, covering all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received all seasons. The data collector is 5455-5 accredited or may have received allow and to the seasocial data collector is 5455-5 accredited or may hav	Acce-temical severity dimension  a generant/disagreement/likeature support  a generant/disagreement/likeature support  cetatinity scoring associated with the macroinventebrate severity dimension of site-specific risk assessment.  Cetatinity scoring associated with the macroinventebrate severity dimension of site-specific risk assessment.  Macroinventebrate severity dimension  Macroinventebrate severity  Macroinventebrate  Macroinventebrat	Accordence (a secretly demonsion       1         at agreement (deagreement)	bility and reasonability of assumption	1	Uncertainty/contridence rating: Unknown	
et agreement/Messature support     0       assessor's knowledge of the site-specific middlying factors     0       one training status of the site-specific middlying factors     0       one training of going associated with the macroinvertebrate severity dimension of site-specific risk assessment.     Image: Society of the site-specific middlying factors       A minimum of eight samples were collected, covering all sessons. The data collector is 5555 5     1     Very low uncertainty/very high confidence       Junimum of the samples were collected, covering all sessons. The data collector is 5555 5     1     Very low uncertainty/index confidence       2     Low uncertainty/index confidence     3     Moderate uncertainty/index confidence       5:5555 Saccredited or may have received and training.     Moderate uncertainty/low confidence       Innimum of one sample collected. The data collector is 5555 accredited for may have received some     3       Save     Save     1	expressment/lifesarguresmentextended lifesarguresment/lifesarguresment/lifesarguresment/lifesa	Start agreement/idearguetme	sico-chemical severity dimension	3 Edit:		
et agreement/Sagreemen	et agreement/Gaugeemen	per agreement/disa			Save Final Report	
a unsector's knowledge of the site-specific mod/ping factors       0         Incentainty scoring associated with the macroinvertebrate severity demonsion of site-specific risk assessment.       Social Second	antenser's knowledge of the site-specific mod/ying factors 0  containing associated with the macroinvertebrate severity dimension of site-specific risk assessment.           Macroinvertebrate severity dimension of site-specific risk assessment.         Immuno of splan serples were collected, covering all sessons. The data collector is 5555-5       1       Very low uncetainty/very high confidence         imminum of four samples were collected, covering all sessons. The data collector is 5555-5       1       Very low uncetainty/high confidence         imminum of four samples were collected, covering all sessons. The data collector is 5555-5       1       Very low uncetainty/high confidence         imminum of four samples were collected, covering all sessons. The data collector is 5555-5       1       Very low uncetainty/high confidence         isS55-4       2       Low uncetainty/high confidence       2         isseminum of four samples were collected, may or may not have covered all sessons. The data collector is 55555 accredited or may have received       4       High uncertainty/low confidence         isseminum of four sample collected. The data collector is 55555 accredited ormay have received some       5       Very high uncertainty/very low confidence         isseminum       Save       Save       Save       Save       Save	A same stars is brownledge of the ster-specific roudships (actor)       0         Increasing second activity with the macroinvertificate security dimension of site specific risk assessments.       Social Description of uncertainty         Increasing second activity of the ster-specific roudships (actor)       Social Description of uncertainty/ were high confidence         Annimum of four samples were collected, covering all seasons. The data collector is 5ASS-5       Lew uncertainty/high confidence         Annimum of four samples were collected, may or may not have covered all seasons. The data collector is 5ASS-5       Lew uncertainty/indecate confidence         Sass-5       Lew uncertainty/indecate confidence       Moderate uncertainty/indecate confidence         Annimum of four samples were collected, may or may not have covered all seasons. The data collector is 5ASS-5 accordited or may have received some tainty invertainty/invery low confidence         Annimum of cos sample collected. The data collector is 5ASS-5 accredited or may have received some tainty/invery low confidence         Save	pert agreement/disagreement/literature suppo	et 0		
Increating second with the macroinvertebrate severity dimension of site-specific risk assessment.           Macroinvertebrate severity         Scoring         Description of uncertainty           Imminue of eight samples were collected, covering all seasons. The data collector is 5455-5         1         Very low uncertainty/ very high confidence           A minimum of our samples were collected, covering all seasons. The data collector is 5455-5         1         Very low uncertainty/ very high confidence           Saminum of the samples were collected, covering all seasons. The data collector is 5455-5         1         Non-contract the sample severe collected, may or may on have received as a collector is 5455-5           Sate SacedRed or may have received some training.         Low uncertainty/indexeats confidence           Infinitum of one sample collected. The data collector is 5455-5         High uncertainty/low confidence           Minimum of one sample seve collected. The data collector is 5455-5         Very high uncertainty/low confidence           minimum of one sample collected. The data collector is 5455-5         Very high uncertainty/very low confidence	Service service of the service of th	Increatinty scoring associated with the macroinvertifyints severity dimension of site-specific risk assessment.           Macroinvertifyints exercised         Scoring         Description of uncertainty           A minimum of sight samples were collected, covering all seasons. The data collector is 5455-5         1         Very low uncertainty/very high confidence           A minimum of sourges were collected, covering all seasons. The data collector is 5455-5         1         Very low uncertainty/very high confidence           A minimum of sourges were collected, covering all seasons. The data collector is 5455-5         2         Low uncertainty/index confidence           A minimum of sourges were collected, may or may not have exerced as accelectors         3         Molecular uncertainty/index confidence           A minimum of sourges were collected. The data collector is 5455-5 accredited or may have received some         4         High uncertainty/very low confidence           Annihumum of one sample collected. The data collector is 5455 accredited ormay have received some         5         Very high uncertainty/very low confidence	k assessor's knowledge of the site-specific mo	difying factors 0		
Macroinvertebrate severity     Scering     Description of uncertainty/ Description of uncertainty/ Very low uncertainty/very high confidence       A minimum of is samples were collected, covering all seasons. The data collector is SASS-5     1     Very low uncertainty/hole confidence       A minimum of is unaples were collected, covering all seasons. The data collector is SASS-5     1     Very low uncertainty/hole confidence       A minimum of is unaples were collected, may or may not have covered all seasons. The data collector is SASS-5 accredited or may have received some training.     Moderate uncertainty/moderate confidence       Is SASS-5 accredited or may have received some training.     I bely uncertainty/low confidence       Imminum of one sample collected. The data collector is SASS accredited or may have received some training.     Very high uncertainty/low confidence	Macroinventebrate sevenity     Serving     Description of uncertainty       Imminum of sight samples were collected, covering all seasons. The data collector is SASS-5     1     Very low uncertainty/ very high confidence       Imminum of sight samples were collected, covering all seasons. The data collector is SASS-5     2     Low uncertainty/ index collector is collector.       SASS-5     Sacrofited     3     Moderate uncertainty/ uncertainty/ very high confidence       Imminum of signt samples were collected, may or may not have received     4     High uncertainty/ uncertainty/ uncertainty/ very low confidence       SASS-5     Sacrofited or may have received some training.     5     Very high uncertainty/ very low confidence       Imminum of or sample collected. The data collector is SASS-5 accredited ormay have received some     5     Very high uncertainty/very low confidence	Macroinvertebrate severity     Scering     Description of uncertainty       A minimum of eight samples were collected, covering all seasons. The data collector is SASS-5     1     Very low uncertainty/wery high confidence       A minimum of four samples were collected, covering all seasons. The data collector is SASS-5 accredited     2     Low uncertainty/high confidence       A minimum of four samples were collected, may or may on these covered all seasons. The data collector is SASS-5 accredited or may have received some training.     3     Molecular uncertainty/moderate confidence       A minimum of one sample collected. The data collector is SASS-5 accredited or may have received some training.     4     High uncertainty/very low confidence       Sammum of a sample sever collected. The data collector is SASS-5 accredited or may have received some training.     5     Very high uncertainty/very low confidence	ncertainty scoring associated with the macro	nvertebrate severity dimension of site-specific risk	assessment.	
International of eight samples were collected, covering all seasons. The data collector is SASS-5 1 Very low uncertainty/very high confidence international of our samples were collected, covering all seasons. The data collector is SASS-5 exceeded. 2 Low uncertainty/indexte confidence SASS-5 seconded or may have resolved same training. International of our sample were collected. The data collector is SASS-3 exceeded or may have received same training. Save Save	Imminum of eight samples were collected, covering all seasons. The data collector is SASS-3          imminum of six samples were collected, covering all seasons. The data collector is SASS-3 excredited.       2       Low uncertainty/very high confidence         imminum of six samples were collected, covering all seasons. The data collector is SASS-3 excredited.       2       Low uncertainty/index officience         SASS-3 excredited or may have received same taxing.       3       Moderate uncertainty/inex confidence         minimum of six samples were collected. The data collector is SASS-3 excredited ormay have received same taxing.       4       High uncertainty/inex confidence         minimum of on sample were collected. The data collector is SASS-3 excredited ormay have received same       5       Very high uncertainty/ivery low confidence	Imminum of eight samples were collected, covering all seasons. The data collector is SASS-3       1     Very low uncertainty/very high confidence       Imminum of sus maples were collected, covering all seasons. The data collector is SASS-3 exceeded.     2       2     Low uncertainty/high confidence       SASS-3     Saccedded or may have received some taining.     4       High uncertainty/lew confidence     4       High uncertainty/lew confidence     4       Imminum of on sample aver collected. The data collector is SASS-3 accredited or may have received some taining.     4       Imminum of on sample aver collected. The data collector is SASS-3 accredited or may have received some taining.     5       Very high uncertainty/very low confidence     5	Macro	nvertebrate severity	Scoring Description of uncertainty	
A minimum of sin samples were collected, overring all seasons. The data collector is 5A55-3 secredized Solution of four samples were collected, may or may not have covered all seasons. The data collector is 5A55-3 secredized come banking, Solution of one sample collected. The data collector is 5A553 secredized or may have received some summum of one sample collected. The data collector is 5A553 secredized or may have received some Sove	A minimum of sin samples were collected, nav or may not have covered all seasons. The data collector is 5A55-5 accredited or may have received all seasons. The data collector is 5A55-5 accredited or may have received all seasons. The data collector is 5A55-5 accredited or may have received all seasons. The data collector is 5A55-5 accredited or may have received search and the search accelerator is 5A55-5 accredited or may have received search and the search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited or may have received search accelerator is 5A55-5 accredited accelerator is 5A55-5 accre	A minimum of sins samples were collected, overing all seasons. The data collector is 5X55-3 exceeded:       2     Low uncertainty/high confidence       3     Moderate uncertainty/high confidence       3     Moderate uncertainty/high confidence       3     Moderate uncertainty/high confidence       ammount of one sample collected. The data collector is 5X553 accredited or may have received same taining.     4     High uncertainty/high confidence	minimum of eight samples were collected,	overing all seasons. The data collector is SASS-5	1 Very low uncertainty/ very high confidence	
a minimum of four samples were collected, may or may not have reverted all seasons. The data collector is 3 Moderate uncertainty/moderate confidence 5 Servet Samples were collected. The data collector is 5ASSS accredited ormay have received at High uncertainty/lew confidence minimum of one sample collected. The data collector is 5ASSS accredited ormay have received some is in sining. Servet	minimum of our samples were collected, may or may not have exceeded all seasons. The data collector   3   Moderate uncertainty/imoderate confidence     seasons are collected. The data collector is \$4555 accredited ormay have received   4   High uncertainty/ime confidence     iminimum of one sample collected. The data collector is \$4555 accredited ormay have received some   3   Very high uncertainty/ivery low confidence     iminimg.      Save	a minimum of four samples were collected, may or may not have exceeded a samon. The data collector a Moderate uncertainty/imoderate coefidence SSSS accredited some taning. SSSS accredited commy have received as the sample collected. The data collector is SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some and the sample collected. The data collector is SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some and the sample collected. The data collector is SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS accredited commy have received some a SSS very low coefidence SSSS very low coefidence	A minimum of six samples were collected, co	rering all seasons. The data collector is SASS-5 accr	edited. 2 Low uncertainty/high confidence	
a minimum of 2 samples were collected. The data collector is SASSS accredited ormay have received some binning.  Seve  Seve	Imminum of 2 tampins were collected. The data collector is 54553 accredited ormay have received Imminum of one sample collected. The data collector is 54555 accredited ormay have received some I Very high uncertainty/very low confidence I Seve	A monetary of 2 samples were collected. The data collector is 5553 accredited ormay have received some 5 Very high uncertainty/wery low confidence and the sample collected. The data collector is 5555 accredited ormay have received some 5 Very high uncertainty/wery low confidence 5 Seve	A minimum of four samples were collected, n is SASS-5 accredited or may have received sor	ay or may not have covered all seasons. The data one training.	ollector 3 Moderate uncertainty/moderate confidence	
Imminium of one sample collected. The data collector is SASSS accredited ormay have received some S Very high uncertainty/very low confidence	Iminimum of one sample collected. The data collector is SASSS accredited ormay have received some 3 Very high uncertainty/very low confidence	Imminum of one sample collected. The data collector is \$4553 accredited ormay have received some 3 Very high uncertainty/very low confidence spinog.	A minimum of 2 samples were collected. The come training.	lata collector is SASSS accredited or may have rece	weil 4 High uncertainty/low confidence	
Seve		See	eminimum of one sample collected. The data	collector is SASS5 accredited ormay have received	some 5 Very high uncertainty/very low confidence	
				Save		

Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 4-8 Screenshot of the DSS showing the uncertainty rating about the physico-chemical severity rating.

The uncertainty regarding the experts agreement/disagreement/literature support as well as that for the risk assessor's knowledge of the site-specific modifying factors are assessed following the same procedures already described. In the case of the example provided in Figure 4-9, expert agreement is rated as 1 meaning the agreement between experts or literature support for the rating of the likelihood metrics and the duration of the risk triggering event is very high. The site-specifying modifying factors is rated 2 (Figure 4-10), meaning that the knowledge of site-specific risk modifying factors is high, and thus the confidence level is high.

tespone       Likelyhood Uncertainty         tespone       Plack         tespone       1         tessons       tespone         tespone       tespone	requere Likelyheed Uncertainty tergory	er3 - restart					-	0	×
teppoy       Eds.         Bablity and reasonability of assumption       1         galaci-chemical sevetty differention       3         A reasonary browledge of the ske-specific modifying factors       0         Assessing the level of expert agreement/literature support at Tier 3 site-specific risk assessment.         Expert agreement between experts or literature support for the rating of the likelihood metrics and the duatod in the skipgend for the rating of the likelihood metrics and the duatod in the skipgend for the rating of the likelihood metrics and the duatod in the skipgend or experts or literature support for the rating of the likelihood metrics and the duatod in the skipgend or experts or literature support for the rating of the likelihood metrics and the duatod in the skipgend or explicit literature support for the rating of the likelihood metrics and the duatod metric in the singer of the rating of the likelihood metrics and the singer of the structure support for the rating of the likelihood metrics and the duatod metric is and the duatod metrics and the duatod metric is and the duatod metrics and the duatod	teggy       Edst       Uncertaintly/confidence rating:       Uncertaintly/confidence rating:         tide:       identity and reasonability of summing       identity         tide:       identity       identity       identity         tide:       identity       identity       identity       identity         tide:       identity       identity       identity       identity         tide:       identity       identity       identity       identity	sequence Likelyhood Uncertainty							
biblity and reasonability of ensumption       1         splace-thermical sevently dimension       3         convertined sevently dimension       4         a assessor's browledge of the site-specific modifying factors       0         sevently dimension       1         sevently dimension       0         sevently dimension       1         wey now uncertainty / wey nodifi	Bablety and reasonability of ensumption       1         a reasonability of ensumption       3         contentical sectify dimension       4         a sensor's knowledge of the site-specific moddying fasters       0         usessessing the level of expert agreement/disagreement/literature support at Tier 3 site-specific risk assessment.       Expert agreement/disagreement/literature support at Tier 3 site-specific risk assessment.         The agreement between spectra of levenus support for the stang of the lakelhood metrics and the 1       1       We pleas uncertainty / we	tegory Risk							
yalco-themical teventy dimension 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	yada-ahamiaal sevening dimension 3 1 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	Gability and reasonability of assumption	Incertai	nty/confidence rating: Unknown					
sensor's troubledge of the ster-specific modifying factors     0       sensor's troubledge of the ster-specific modifying factors     0       sensor's troubledge of the ster-specific modifying factors     0   Sensor the construct starture support for the rating of the likelihood metrics and the 1 Vay law uncertainty/ very high confidence dividence of the starture support for the rating of the likelihood metrics and 1 Moderate uncertainty/ index stee confidence dividence of the starture support for the rating of the likelihood metrics and 1 Moderate uncertainty/ low confidence dividence to very latic literature support for the rating of the likelihood metrics and 1 Moderate uncertainty/ low confidence dividence to very latic literature support for the rating of the likelihood metrics and 1 Moderate uncertainty/ low confidence dividence dividence dividence dividence dividence divide sterior to very latic literature support for the rating of the likelihood metrics and 1 Moderate uncertainty/ low confidence dividence dividence dividence dividence divide sterior to very latic literature support for the rating of the likelihood metrics and 1 Moderate uncertainty/ low confidence dividence support for the rating of the likelihood metrics and 4 High uncertainty/ low confidence	acconventedrate severity domention       4       Sour Find Report         acconventedrate severity domention       4       Sour Find Report         Assessing the level of expert agreement/disagreement/literature support at Ter 3 site-specific risk assessment.       Expendent bases may be a find Report         The agreement bases may be report or the strature support for the strature of the likelihood metrics and the       1       Not workershift/ very high confidence         The agreement bases may be report to the strature support for the strature of the likelihood metrics and the       2       Low uncertainty/ inpode at confidence         The agreement bases may be to the strature support for the strature of the likelihood metrics and the       3       Modente uncertainty/ moderate confidence         There is strature support for the strature of the taking of the likelihood metrics and the       4       High uncertainty/ low confidence         There is strature support for the strature of the taking of the likelihood metrics and the duration of the risk-tiggering.       4       High uncertainty/ very low confidence         Based       Save       5       Very high uncertainty/ very low confidence       1         Based       Save       5       Very high uncertainty/ very low confidence       1         Based       Save       5       Very high uncertainty/ very low confidence       1         Based       Save       5       Very high uncer	sysico-chemical severity dimension 3 Ede							
A measor's knowledge of the ske-specific modifying factors       0         Sessessing the level of expert agreement/disagreement/disagreement/literature support at Tier 3 site-specific risk assessment.         Expert agreement between experts or learning of the likelhood metrics and the       1       Very low uncertainty/ very high confidence         The agreement between experts or learning of the likelhood metrics and the       2       Low uncertainty/ high confidence         The agreement between experts or learning of the likelhood metrics and the       2       Low uncertainty/ high confidence         There is the agreement between experts or learning of the likelhood metrics and       4       High uncertainty/ low confidence         There is the agreement between experts or learning of the likelhood metrics and       4       High uncertainty/ low confidence         There is the agreement between experts or learning of the likelhood metrics and       4       High uncertainty/ low confidence         There is the agreement between experts or learning of the likelhood metrics and       4       High uncertainty/ very low confidence         Back       5       Very high uncertainty/ very low confidence       5         Back       5       Very high uncertainty/ very low confidence         Back       5       Very high uncertainty/ very low confidence         Back       5       Very high uncertainty/ very low confidence         Back	At assessor's knowledge of the site-specific modifying factor.          Assessing the level of expert agreement/disagreement/literature support at Tier 3 site-specific risk assessment.         The agreement between experts of levelue support for the straing of the likelihood metrics and the 1 work highering event in key. Jugate of the site support for the straing of the likelihood metrics and the 2 low uncertainty/ high confidence         There is some agreement between experts of levelue support for the straing of the likelihood metrics and the 2 low uncertainty/ high confidence         There is some agreement between experts of levelue support for the straing of the likelihood metrics and 4 High uncertainty/ low confidence         There is some agreement between experts of levelue support for the rating of the likelihood metrics and 4 High uncertainty/ low confidence         Base some agreement between experts of levelue support for the rating of the likelihood metrics and 4 High uncertainty/ low confidence         Base some agreement between experts of levelue support for the rating of the likelihood metrics and 4 High uncertainty/ low confidence         Base some agreement between experts or levelue support for the rating of the some agreement between experts or levelue support for the rating of the some agreement between experts or level likelihood metrics and 4 High uncertainty/ low confidence         Base some agreement between experts or levelue support for the rating of the some agreement between experts or levelue support for the rating of the some agreement between experts or levelue support for the rating of the some agreement between experts or levelue some agreement between experts or levelue some agreement between experts or levelue some agreement between experts or leve	acroinvertebrate severity dimension 4	Sev	Final Report					
As assessor's become degree of the set-specific modifying factors       0         Assessing the level of expert agreement/literature support at Tier 3 site-specific risk assessment.         Expert agreement/literature support       Score         Description of uncertainty/ transment between experts of learning support for the siteng of the likelihood metrics and the duation of the risk-triggering.       Very low uncertainty/ rev high confidence duation of the risk-triggering.         The agreement between experts of learning support for the siteng of the likelihood metrics and the duation of the risk-triggering.       Moderate uncertainty / moderate confidence duation of the risk-triggering.         There is string advectore to reveal to a learning of the likelihood metrics and the duation of the risk-triggering.       He likelihood metrics and duation of the risk-triggering.       He likelihood metrics and duation of the risk-triggering.         Save       Save       Save       Save	Assessing the level of expert agreement/disagreement/literature support at Tier 3 site-specific risk assessment.           Expert agreement between pays to all the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the target support for the stange of the likelhood metrics and the duation of the mak-tiggering.         Yery leve confidence           Save         Save         Save         Save         Save								
Assessing the level of expert agreement/disagreement/literature support at Tier 3 site-specific risk assessment.           Expert agreement/literature support         Score         Description of uncertainty           The agreement between experts or literature support for the rating of the likelihood metrics and the 1 Very low uncertainty/ very high coordidance discovery high ancertainty / how confidence discovery high coordidance highering.           There is service discovery high literature support for the rating of the likelihood metrics and the dustor of the maximigering.         5         Very high uncertainty/ very low coerdidance           Save         Save         Save         Very high uncertainty/ very low coerdidance	Assessing the level of expert agreement/disagreement/literature support at Tier 3 site-specific risk assessment.           Expensive between experts or literature support for the rating of the likelihood metrics and the         1         Very low uncertainty/very high confidence           duation of the risk toggering occurs in the identification of the risk of the likelihood metrics and the         2         Low uncertainty/very high confidence           The agreement between experts or literature support for the rating of the likelihood metrics and         2         Low uncertainty/indentification           The agreement between experts or literature support for the rating of the likelihood metrics and         3         Moderate uncertainty/indentificate           There is string dispersioned between experts or literature support for the rating of the likelihood metrics and         4         High uncertainty/indentificate           There is string dispersioned between experts or very high literature support for the rating of the likelihood metrics and         4         High uncertainty/ very low confidence           Basel	sk assessor's knowledge of the site-specific modifying factors 0							
Saves       Save	Assessment, believel of expert agreement/disagreement/disagreement/disagreement/ Expert agreement between experts of tendnus support for the taking of the likelihood metrics and the the agreement between experts of latentum support for the taking of the likelihood metrics and the the agreement between experts of latentum support for the taking of the likelihood metrics and the duration of the rule support and the rule support for the taking of the likelihood metrics and the the agreement between experts of latentum support for the taking of the likelihood metrics and the duration of the rule support of the rule support for the taking of the likelihood metrics and the agreement between experts of latentum support for the taking of the likelihood metrics and the support of latentum support for the taking of the likelihood metrics and the support of latentum support for the taking of the likelihood metrics and the support of latentum support for the taking of the likelihood metrics and the support support of latentum support for the taking of the likelihood metrics and the support of latentum support for the taking of the likelihood metrics and Support support of latentum support for the taking of the likelihood metrics and Support support support for the taking of the likelihood metrics and Support support support for the taking of the likelihood metrics and Support support support support for the taking of the likelihood metrics and Support support support support for the taking of the likelihood metrics and Support support support support for the taking of the taking of the taking of the likelihood metrics and Support support support support for the taking of the taking of the taking of the support support for the taking of the support for the taking of the taking of the taking of the support for the taking of the support support for the taking of the support for the taking of the support for the taking of the support support support for the taking of the support for the taking of the support	e santa ter de la sua de secondo	192	1					
Light agreement between experts of the straing of the lakelhood metrics and the solution of the risk-triggering event is very high.         Description of the solution of the risk-triggering.           The agreement between experts of levels usupport for the straing of the lakelhood metrics and the solution of the risk-triggering between experts of levels usupport for the straing of the lakelhood metrics and the solution of the risk-triggering between experts of levels usupport for the straing of the lakelhood metrics and the solution of the risk-triggering.         2         Low uncertainty/ high confidence           The systemment between experts of levels usupport for the rating of the lakelhood metrics and the solution of the risk-triggering.         3         Moderate uncertainty / moderate confidence           There is this agreement between experts of levels usupport for the rating of the lakelhood metrics and the solution of the risk-triggering.         5         Very high uncertainty / very low confidence           Save         Save         5         Very high uncertainty / very low confidence         5	Light agreement between experts of lexature support     Sofe     Description of undertainty/ to advance on the risk-triggering event is very high.       The systematic between experts of lexature support for the string of the likelihood metrics and the duration of the risk-triggering.     1     Very low uncertainty/ high confidence       There is some agreement between experts of lexature support for the string of the likelihood metrics and the duration of the risk-triggering.     3     Moderate uncertainty/ moderate confidence       There is some agreement between experts of lexature support for the rating of the likelihood metrics and the duration of the risk-triggering.     4     High uncertainty/ low confidence       There is some agreement between experts of lexature support for the rating of the likelihood metrics and the duration of the risk-triggering.     5     Very high uncertainty/ low confidence       There is some agreement between experts or lexature support for the rating of the likelihood metrics and the duration of the risk-triggering.     5     Very high uncertainty/ very low confidence       Save     Save     5     Very high uncertainty/ very low confidence	Assessing the level of expert agreement/disagreement/literature support at Tier 3	site-s	pecific risk assessment.					
The agreement between experts of the rank-triggering.  Sere	In any properties that have a spart or like the two is spart for the straing of the likelihood metrics and the 2 Low uncertainty/ high confidence that duration of the risk-triggering. There is strain a greaternet between experts or likerature support for the rating of the likelihood metrics and 4 High uncertainty/ low confidence the duration of the risk-triggering. There is strain a greaternet between experts or likerature support for the rating of the likelihood metrics and 4 High uncertainty/ very low confidence likelihood metrics and the duration of the risk-triggering. There is strain a greaternet between experts or likerature support for the rating of the likelihood metrics and 4 High uncertainty/ very low confidence likelihood metrics and the duration of the risk-triggering. Shore	Expert agreement/ interature support	Score	Description of uncertainty					
The agreement between experts or literature support for the rating of the likelihood metrics and the duration of the risk-triggering event in high. There is some agreement between experts or literature support for the rating of the likelihood metrics and the duration of the risk-triggering. There is uniou disagreement between operts or iterature support for the rating of the likelihood metrics and kikelihood metrics and the duration of the mak-triggering. Save	The agreement between experts or iterature support for the rating of the likelihood metrics and the duration of the risk-triggering-energy in high. There is non-agreement between experts or iterature support for the rating of the likelihood metrics and the duration of the risk-triggering. If the superimetric between experts or iterature support for the rating of the likelihood metrics and the duration of the risk-triggering. If the superimetric between experts or iterature support for the rating of the likelihood metrics and the duration of the risk-triggering. If the superimetric between experts or very little iterature support for the rating of the likelihood metrics and the duration of the risk-triggering. If the rating of the likelihood metrics and the duration of the risk-triggering. If the risk-triggering is the rating of th	the agreement between experts or itterature support for the rating of the takelihood methos and the duration of the risk-triggering event is very high.		very low uncertainty/ very high contidence					
There is sure agreement between experts or literature support for the rating of the likelihood metrics and 1 Moderate uncertainty / moderate confidence the duation of the risk-triggering. High uncertainty / low confidence the duation of the risk-triggering.	There is non-agreement between experts or learnane support for the rating of the likelihood metrics and 3 Moderate uncertainty / moderate confidence the duation of the risk triggering. High uncertainty / low confidence between experts or very little learnane support for the rating of the likelihood metrics and 4 High uncertainty / very low confidence likelihood metrics and the duation of the risk-triggering.	The agreement between experts or literature support for the rating of the likelihood metrics and the duration of the risk-triggering event is high.	2	Low uncertainty/ high confidence					
There is life agreement between experts or literature support for the rating of the likelihood metrics and 4 High uncertainty/ low confidence the duration of the risk-triggering.  Save	There is lift agreement between experts or learning of the taking of the likelihood metrics and       4       High uncertainty/ low confidence         There is tarious disagreement between experts or very lattle literature support for the rating of the likelihood metrics and the duration of the risk-triggering.       5       Very high uncertainty/ very low confidence	There is some agreement between experts or literature support for the rating of the likelihood metrics and the durationof the risk-triggering.	3	Moderate uncertainty /moderate confidence					
There is strious disagreement between experts or very little literature support for the rating of the likelihood metrics and the duration of the risk-triggering.	There is show diagreement between experts or very lattle iterature support for the rating of the     5     Very high uncertainty/ very low confidence       Bitelihood metrics and the duration of the risk-triggering.     Sere	There is little agreement between experts or literature support for the rating of the likelihood metrics and the duration of the risk-triggering.	4	High uncertainty/ low confidence					
Sex	Sex	There is serious disagreement between experts or very little literature support for the rating of the likelihood metrics and the duration of the risk-triggering.	5	Very high uncertainty/ very low confidence					
		See							
			4	-			NG		12:00
		P Search		🖷 🧶 💥 🛂		∧ 🗞 0 ਵ ¦	VTL @ 40 1	2023/	12/08
P Search ▲ 🍠 D 🍹 😒 🗃 💿 🥶 🦉 🧐 🖉 🦉 💆	O Search     O ▼ MTL ♥ 00 ♥ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ▼ MTL ♥ 00 ₩ 2023/026     A ♥ 0 ♥ 0 ♥ 0 ♥ 0 ♥ 0 ♥ 0 ♥ 0 ♥ 0 ♥		-		 				

Figure 4-9 Screenshot of the DSS showing the uncertainty rating about the expert agreement/disagreement and literature support.

geory Lotyteou billy and reasonability of essumption ico-themical security dimension invertetistat security dimension et agreement/disagreement/iterature support	Rok         I         I           3         I         I           4         I         I	Uncertainty/confidence rating: Unknown	
ncertainty assessment regarding the ris	k assessor's knowledge of the site-s	ecific risk modifying factors.	
thomesge of site-specific risk modifyingfactors sils, climate, vegetation, hydrology, social-economic pabered.	is very high. Comprehensive data such as geolo c context, etc have been collected/ orare availal	e and Very low uncertainty/ very high confidence	
e knowledge of site-specific risk modifyingfactors getation, hydrology, social-economic context, etc.)	is high. Adequate data such as geology, soils, c save been collected/ or are availableand analys	ante 2 Low uncertainty/ high confidence	
knowledge of site-specific risk modifyingfactors nate, vegetation, hydrology, social-economic cont haved	is moderate. Some data such as geology, soils, jext, etc have been collected/ or are availablean	3 Moderate uncertainty /moderate confidence	
le is known about the site-specific riskmodifying f ardingfactors that may modify the risk.	factors. Very little data is available on the site	4 High uncertainty/ low confidence	
	See		

Tiers 1, 2 and 3 water quality aquatic ecosystem guidelines: Manual

Figure 4-10 Screenshot of the DSS showing the uncertainty rating the knowledge of site-specific risk modifying factors.

Once the risk rating and associated confidence level/uncertainty has been done, click on the Save Final Report button. This should generate the final report as shown in Figure 4-11 and Figure 4-12 below. As can be seen, the report is broken into two main sections. The risk rating for the site based on the consequence and likelihood sub-models as well as the uncertainty accompanying the risk.

0	Consequenc	e		Generated: 2023/12/	J8 12:1/:42	
	Severity Rating					
	Water Quality Issu	e : An agricultural farmland				
	F	hysico-chemistry	Macroinverteb	rate Rating		
	Average : 4.0 of 3	items entered.	MacroInvertebrate : C (2) MacroInvertebrate Rating : C			
	Average Physicov + Macroinvertebrat / 2 = Overall Severity	Chemical : 4.0 e Rating : C (2) / Rating : 3.0	Duration : 4 - 5 to 20 years	Spatial : 2 - entire site		
	Consequence Rating : 9.0					
	Likelyhood • Rating of frequ • Rating for freq • Rating for the Calculated likelyho Risk : Overall site-spe	uency of occurrance of the risk tr uency of impact of the risk-trigge detection of the risk-triggering ev ood : 9 (sum of the above values 81.0 (Consequence Rating cific risk rating based on 1	iggering event : 3 Monthly ring event : 2 : >40% vent or its impact on the water qualit -) * Likelyhood) the Consequence and Likelih	y component of the resource : 4 :	Difficult to detect	
	Rating	Risk Category	Descrip	tion		
	41-120	Moderate	Water quality risk are potable	and require mitigation		

Figure 4-11 DSS screenshot showing the final output of the site-specific water quality risk assessment rating for the risk triggering event.

Uncertainty	Uncertainty					
Reliability and reasona	Reliability and reasonability of assumption					
(1) : The risk is d	(1) : The risk is definitely attributable to the risk-triggering event. Very low uncertainty/ very high confidence					
Physico-chemical seve	Physico-chemical severity dimension					
(3) : Appropriate	(3): Appropriate and relevant physico-chemical variables are selected, a minimum of 10 samples per selected variables areanalysed. The					
sampling covers	sampling covers all seasons and at least a hydrological cycle. The data collector(s) has/have received some training. The confidence in					
the data is mode	the data is moderate. Moderate uncertainty /moderate confidence					
Macroinvertebrate sev	Macroinvertebrate severity dimension					
(4) : A minimum	(4): A minimum of 2 samples were collected. The data collector is SASS5 accredited or may have received some training. <i>High</i>					
uncertainty/low c	uncertainty/ow confidence					
Expert agreement/disa	Expert agreement/disagreement/literature support					
(1) : The agreem	(1): The agreement between experts or literature support for the rating of the likelihood metrics and the duration of the risk-triggering					
event is very hig	event is very high. Very low uncertainty/ very high confidence					
Risk assessor's knowle	Risk assessor's knowledge of the site-specific modifying factors					
(2) : The knowled	(2) : The knowledge of site-specific risk modifyingfactors is high. Adequate data such as geology, soils, climate, vegetation,hydrology,					
social-economic	social-economic context, etc have been collected' or are availableand analysed. Low uncertainty/ high confidence					
Rating	Confidence Level	Description				
11	Moderate	The uncertainty associated with the risk assessment is notable.				

Figure 4-12 DSS screenshot showing the final output of the accompanying uncertainty/confidence rating for the site-specific water quality risk assessment rating.

# **CHAPTER 5: References**

Batley GE, van Dam RA, Warne MStJ, Chapman JC, Fox DR, Hickey CW and Stauber JL (2018) *Technical rationale for changes to the Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants*. Prepared for the revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra.

Boyd L, Moodley P and Jooste S (2015) *WRC/DWA framework document for the revision of Water Quality Guidelines: Facilitation of Workshops for the Risk-Based Water Quality Guidelines Update.* Department of Water Affairs, Pretoria.

Canadian Council of Ministers of the Environment (CCME) (2007) *Canadian environmental quality guidelines: Canadian water quality guidelines for the protection of aquatic life*. Canadian Council of Ministers of the Environment, Winnipeg.

Chemical Abstracts Service (CAS) (2023) CAS History. [https://www.cas.org/about/cas-history] Accessed: 4 July 2023.

Dallas HF and Rivers-Moore NA (2019a) Environmental water temperature guidelines for perennial rivers in South Africa. Volume 1: Technical Report. Water Research Commission, Pretoria, South Africa. WRC Report No. TT 799/1/19.

Dallas HF and Rivers-Moore NA (2019b) Environmental water temperature guidelines for perennial rivers in South Africa. Volume 2: A technical manual for setting water temperature targets. Water Research Commission, Pretoria, South Africa. WRC Report No. TT 799/2/19.

Dallas HF and Rivers-Moore NA. (2022). A protocol and tools for setting environmental water temperature guidelines for perennial rivers in South Africa. African Journal of Aquatic Science 47(3): 275-290. DOI: 10.2989/16085914.2021.1982673.

Department of Water Affairs (DWA) (2011) *Planning Level Review of Water Quality in South Africa.* Directorate Water Resource Planning Systems: Water Quality Planning. Resource Directed Management of Water Quality. Sub-series No. WQP 2.0. Department of Water Affairs, Pretoria.

Department of Water Affairs and Forestry (DWAF) (1996) *South African Water Quality Guidelines. Volume 7: Aquatic Ecosystems.* Department of Water Affairs, Pretoria.

Department of Water Affairs and Forestry (DWAF) (2008). *Methods for determining the water quality component of the ecological reserve for rivers*. Department of Water Affairs and Forestry, Pretoria.

Department of Water and Sanitation (DWS) (2023) Revision of the general authorisation in terms of section 39 of the National Water Act, 1998 (Act No. 34 of 1998) for water uses as defined in section 21(c) or section 21(i). *Environmental Toxicology and Chemistry* 38(4): 905-917.

Environmental Protection Agency (EPA) (2023a) *Aquatic toxicity information retrieval (AQUIRE) database*. [https://cfpub.epa.gov/si/si\_public\_record\_Report.cfm?Lab=NHEERL&dirEntryID=10912]. Accessed 6 September 2023. Environmental Protection Agency (EPA) (2023b) *Assessment Tools for the Evaluation of Risk.* [https://cfpub.epa.gov/si/si\_public\_record\_report.cfm?Lab=NHEERL&dirEntryId=74887]. Accessed 6 September 2023.

Kleynhans CJ and Louw MD (2007) *Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2).* Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08. Water Research Commission, Gezina.

Molander L, Ågerstrand M and Rudén C (2009) WikiPharma – A freely available, easily accessible, interactive and comprehensive database for environmental effect data for pharmaceuticals. *Regulatory Toxicology and Pharmacology* 55: 367-371.

Olker JH, Elonen CM, Pilli A, Anderson A, Kinziger B, Erickson S, Skopinski M, Pomplun A, LaLone CA, Russom CL and Hoff D (2022). The ECOTOXicology Knowledgebase: A Curated Database of Ecologically Relevant Toxicity Tests to Support Environmental Research and Risk Assessment. *Environmental Toxicology and Chemistry* 41(6):1520-1539.

Posthuma L, Suter GW II and Traas TP (2002) Species Sensitivity Distributions in *Ecotoxicology*. Lewis Publishers, Boca Raton.

Posthuma L, van Gils J, Zijp MC, van de Meent D and de Zwardt D (2019) Species Sensitivity Distributions for Use in Environmental Protection, Assessment, and Management of Aquatic Ecosystems for 12 386 *Chemicals. Environmental Toxicology and Chemistry* 38(4): 905-917.

Roux DJ, Jooste SHJ and MacKay HM (1996) Substance-specific water quality criteria for the protection of South African freshwater ecosystems: methods for derivation and initial results for some inorganic toxic substances. *South African Journal of Science* 92: 198-206.

Thirion C (2007) *Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2).* Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 332/08. Water Research Commission, Gezina.

United States Environmental Protection Agency (USEPA) (1992) *Framework for ecological risk assessment. Risk Assessment Forum,* USEPA. EPA/600/R-92-001. Washington, DC.

United States Environmental Protection Agency (USEPA) (1998) *Guidelines for Ecological risk Assessment*. Risk Assessment Forum, USEPA. EPA/630/R095//002F. Washington DC.

United States Environmental Protection Agency (USEPA) (2023) *Clean Water Act Analytical Methods: Whole Effluent Toxicity Methods.* [https://www.epa.gov/cwa-methods/whole-effluent-toxicity-methods] Accessed 17 July 2023.

Vellemu E, Mensah PK, Odume ON and Griffin N (2018) Using a risk-based approach for derivation of water quality guidelines for sulphate. *Mine Water and the Environment* 37: 166-173.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL. (2015) *Revised Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants – update of 2014 version*. Prepared for the revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Department of Science, Information Technology and Innovation, Brisbane, Queensland. The State of Queensland, Brisbane.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL (2018) *Revised Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants – update of 2015 version.* Prepared for the revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra.