ECO-SOCIAL ASSESSMENTS OF AQUATIC ECOSYSTEMS
VOLUME 2 OF 2: NOTES FOR USING GENERIC RELATIONSHIPS IN DRIFT

H Bukhari, A Joubert, C Brown, L van Niekerk, S Taljaard

WATER RESEARCH COMMISSION

TT 934/2/23

AFRICA'S LIVING RIVERS PROGRAMME

ECO-SOCIAL ASSESSMENTS OF AQUATIC ECOSYSTEMS

VOLUME 2 OF 2: NOTES FOR USING GENERIC RELATIONSHIPS IN DRIFT

Report to the

WATER RESEARCH COMMISSION

By **H Bukhari, A Joubert, C Brown, L van Niekerk, S Taljaard**

WRC Report No. TT 934/2/23

March 2024

WATER
RESEARCH
COMMISSION

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 is the final report of Water Research Commission project no. C2020-00437
Project Leader: CA Brown

The outcomes of this report are published in two volumes, namely
Volume 1: Library of Generic Relationships for SADC Rivers and Estuaries (WRC Report No. TT 934/1/23)
Volume 2: Notes for Using Generic Relationships in Drift (this report)

ISBN 978-0-6392-0592-2

Suggested citation

Bukhari H, Joubert A, Brown C, van Niekerk L and Taljaard S (2024) Eco-Social Assessments of Aquatic Ecosystems, Volume 2: Notes for using Generic Relationships in DRIFT. Africa's Living Rivers Programme (WRC Report No. TT 934/2/23). Water Research Commission, Pretoria.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

This pagw was intentionally left blnak

1 INTRODUCTION

Africa's Living Rivers Programme Module 2: Knowledge Capture Project was funded by the South African Water Research Commission (Contract #: C2020-00437). The project started in April 2021 and ended in February 2024.

The main aim of Contract #: C2020-00437 was to develop a set of indicators, links and generic response curves that depict the relationships between physical-chemical-biological drivers and ecological-social responses in southern African rivers and estuaries. The idea being that the indicators, links and generic curves can be used to set up a coarse-level DRIFT (Downstream Response to Imposed Flow Transformations) Eco-social Model for most major river basins in the Southern African Development Community (SADC) for which daily hydrological time series are available at a fraction of the time and expense of set up the model from scratch. Once set up, the DRIFT Eco-social Model can be used to provide first-level predictions of the ecological and social implications of changes in the flow of water and sediment for the rivers and estuary in the basin.

1.1. Report outline

This report is the Eco-Social Assessments of Aquatic Ecosystems (Volume 2): Notes for using Generic Relationships in DRIFT. It is one of three products from this project:

- Eco-Social Assessments of Aquatic Ecosystems (Volume 1): Library of Generic Relationships for SADC Rivers and Estuaries.
- Eco-Social Assessments of Aquatic Ecosystems (Volume 2): Notes for using Generic Relationships in DRIFT.
- A DRIFT database setup using the generic indicators, links and response curves for rivers presented in Volume 1 of the report. It is called DRIFT-Generic-SADC.

This report is arranged along the following sections:

Section 1	Introduction
Section 2	Getting started
Section 3	Adding hydrology
Section 4	Adjustments and balancing
Section 5	Estuary specific adjustments
Section 6	Exporting and analysing results

This report should be read in conjunction with the DRIFT Manual (www.drift-eflows.com).

2 GETTING STARTED

These notes offer guidance on the use of the generic library of indicators, links and response curves provided in Volume 1. They are designed as a supplement to the DRIFT User Manual. The manual, along with other helpful resources, including tutorial videos and related publications, are available on the DRIFT website (www.drift-eflows.com). The latest version of DRIFT as of February 2024 is 4.16 and is included with the Final Report of Contract #: C2020-00437.

2.1. Setting up a new DRIFT database

Setting up a DRIFT database (DB) for project would involve:

- creating a new DRIFT DB
- selecting a sub-set of the generic indicators for each of geomorphology, algae, riverine vegetation, macroinvertebrates and fish based on characteristics of each reach/ site
- generating baseline daily time series for hydrology, either measured or simulated, for each site and importing these into DRIFT
- generating scenario daily time series for hydrology and importing these into DRIFT
- adjusting of response curves, modifiers, and connectivity percentages if needed
- Adding baseline ecological status for each discipline and site
- running the model and exporting results
- processing outputs and analysing results

Each of these steps are described in further detail in this report.

2.2. Navigating, editing and saving in DRIFT

Navigating, editing, and saving in the DRIFT software are covered thoroughly in the DRIFT software manual. However, to remind users, where a screenshot of the DRIFT DSS is shown, very brief instructions on how to navigate to, and edit on that screen are provided below it, and not in the main text.

As a general reminder, most of the DRIFT software windows have an edit button in the top left corner. To edit, click this button to turn on the edit session. When editing is complete make sure to turn of the edit session by clicking the edit button again. All screens also have a save button. Remember to press save to save your edits, if you do not save these edits may be lost. Remember there is no undo button in DRIFT 4.16. Backups should be created periodically by zipping the DB folder and saving it with the current date and time.

2.3. Creating a new DRIFT DB

The DRIFT-Generic-SADC database has three sites (Table 2.1; Figure 2.1) and the database is pre-loaded with all the SADC generic indicators, links and response curves for rivers. Limited technical background in DRIFT is required to use this preset database, which can be used to conduct a rapid EFlows assessment.

To start your study, make a copy of the “DRIFT-Generic-SADC” database and rename it to “DRIFT-Generic-*RiverUnderStudy*”. The three sites in the generic DB must be assigned to the corresponding river reaches under study. The geographic coordinates of the selected sites and reaches can also be entered into DRIFT (see Section 5.2 of the main DRIFT User Manual).

For more experienced DRIFT users, this database provides a starting point to develop a full river network as required. However, that process (such as adding nodes, sites, etc.) is left to the more advanced user and is not covered in this report.

Table 2.1 Layout of three site DRIFT-Generic-SADC database

Site Code	Site name	Description
EF0	UpstreamDam	An EFlows site upstream of the proposed dam, weir or abstraction point. Likely to have connectivity related impacts but not affected by changes in flow.
EF1	Dewatered	An EFlows site downstream of a proposed dam, weir or abstraction point. Likely to be dewatered.
EF2	FurtherDownstream	An EFlows site further downstream of the proposed dam. Can be located downstream of a tailrace, irrigation return flows, or where a tributary joins the river.

Note: Any section of the river inundated by a reservoir is not modelled by the generic library. This habitat is considered completely transformed from river to lake/reservoir.

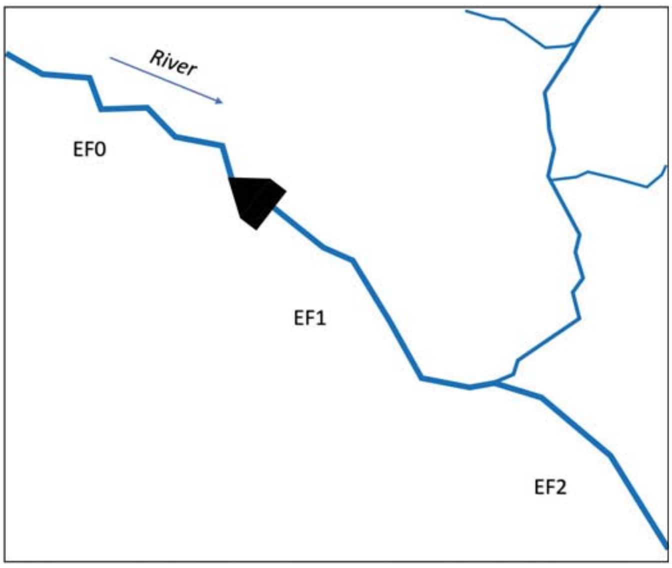
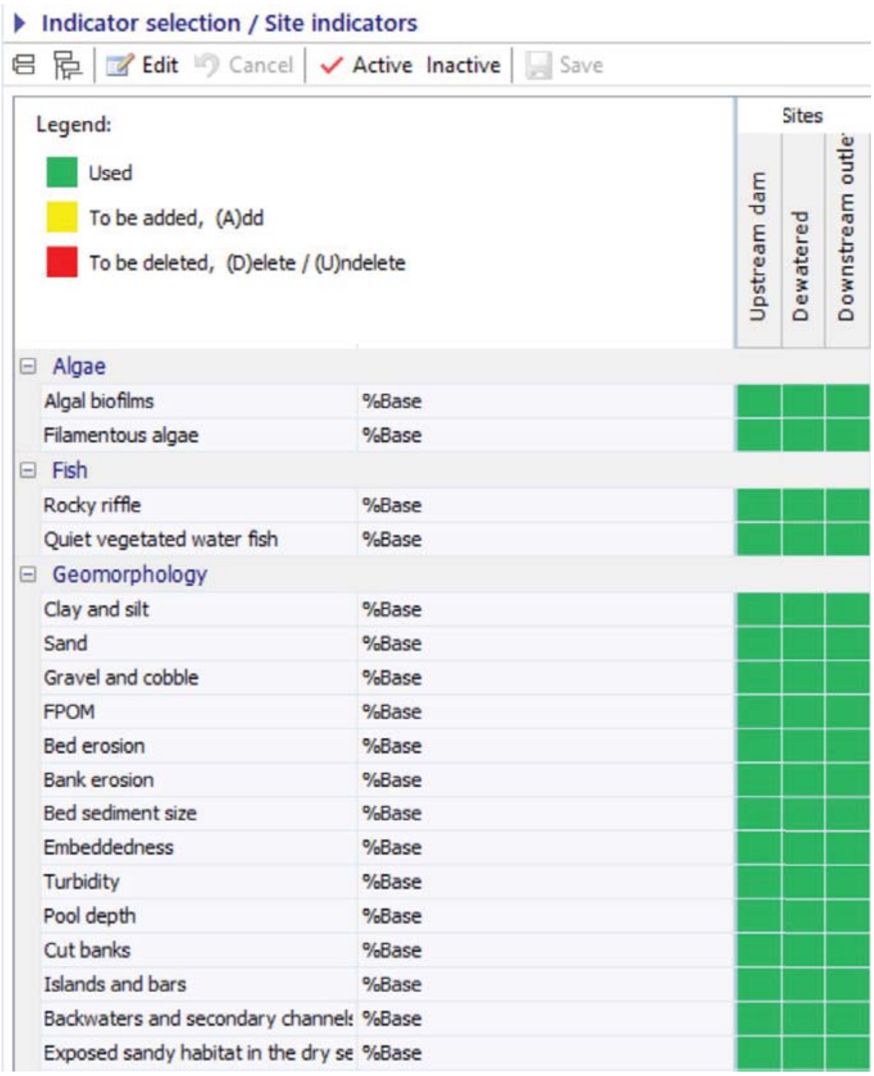


Figure 2.1 Layout of sites and instream weir in the DRIFT-Generic-SADC database.

2.4. Selecting Eco-Social indicators

Ecosystem indicators should be selected to best describe the local environment of the river sites under study (Figure 2.2). Information on the presence of habitats, vegetation and guilds of invertebrates and fish can be collected based on literature reviews, interviews with locals and local specialists, and from field surveys. Brief guidelines for selecting indicators are provided (Table 2.2) whereas, detailed descriptions of each indicator are provided in Volume 1.



Setup → Indicator selection → Site indicators

All indicators are preloaded in the database. To remove an indicator, click edit, select the indicator and site where it must be removed and then type D to delete; and type U to undelete mistakenly deleted indicators. Please note that once deleted all links and response curves for that indicator will be removed from that site. Once done, click save and close the editing session.

Figure 2.2 Selecting and unselecting ecosystem indicators.

Table 2.2 Suggested selection criteria for ecosystem indicators.

Selection criteria	*Indicator*
Geomorphology	
Sediment supply indicators that may be selected depending on the types of sediments expected to be carried by the river.	Clay and silt
	Sand
	Gravel and cobble
Core geomorphology indicators that may be selected for most if not all river sites.	Bed erosion
	Bank erosion
	Bed sediment size
Additional core indicators that can be selected if of concern in the study, such as to invertebrates or fish	Embeddedness
	Turbidity
	FPOM (Fine Particulate Organic matter)
Situational geomorphology indicators that are relevant based on the presence of specific habitats. Select based on presence of habitat in the river reach under study. The selection can vary between sites.	Pool depth
	Backwaters and secondary channels
	Cut banks
	Islands and bars
	Exposed sandy habitat in the dry season
	Exposed cobble habitat in the dry season
	Exposed bedrock habitat in the dry season
	Inundated sandy habitat
	Inundated cobble habitat
	Inundated bedrock habitat
	Riffle habitat
Algae	
Both algae indicators can be selected for most river sites. Keep in mind that even if the algal indicators are not present in the baseline, conditions may arise that cause them to become more abundant.	Algal biofilms
	Filamentous algae
Riverine vegetation	
These five indicators represent three lateral vegetation zones: 1) *aquatic* zone plants that are in the water 2) *emergent* zone plants that are on the water's edge; and 3) *wetbank* zone plants that are inundated at least once a year. While all five indicators may be relevant at most river sites, at least one indicator can be selected for each zone (and considering the presence of the indicator at the site). For example, in case the riverbed is completely bedrock, the aquatic plants on sand can be unselected. Do note that reeds (see below) may also be counted towards any of these zones depending on where they are growing.	Aquatic plants on rock
	Aquatic plants in sand
	Emergent graminoids
	Wetbank grasses
	Wetbank shrubs/trees
Papyrus (*Cyperus papyrus*), dry dormant reeds (*Phragmites australis*) and evergreen reeds (*Phragmites mauritianus)* are common across SADC and are included directly in the library as species. These indicators should be selected if the specific species are present at the site	Papyrus (*Cyperus papyrus)*
	Reeds dry dormant *(Phragmites australis)*
	Reeds evergreen (*Phragmites mauritianus)*
These are composite indicators that make it easier for other disciplines to link to riverine vegetation indicators.	Agg: Aquatic veg
	Agg: Marginal and riparian veg
Select if floating exotics are present in the system and if they are similar in nature to water hyacinth which is captured by this indicator.	Floating exotics
Macroinvertebrates	
	Caenidae

Selection criteria	*Indicator*
In the absence of additional information, at least one Ephemeroptera indicator can be selected. Note that Caenidae prefer fine sediment beds and Oligoneuriidae are generally present in the tropics.	Heptageniidae
	Oligoneuriidae
In the absence of additional information, at least one Diptera indicator can be selected. Simuliidae can be selected if Black Fly related concerns are present in the river under study.	Ceratopogonidae
	Chironomidae
	Simuliidae
Can select if riffle habitat is present.	Elmidae
Between dragonflies (Gomphidae) and damselflies (Coenagrionidae) dragonflies are more commonly occurring.	Coenagrionidae
	Gomphidae
Sometimes used as indicator of pollutants in the water so may not be present at polluted sites.	Hydropsychidae
	Perlidae
Select if Schistosomiasis (Bilharzia) is a potential concern for the area under study.	Freshwater snails
Species from these shrimp families may be an important part of commercial fishing (e.g. Macrobrachium).	Atyidae
	Palaemonidae
This composite indicator combines the abundance of Ceratopogonidae, Chironomidae and Hydropsychidae. Therefore, at least one of the constituents must be selected.	Agg: Invert food for inverts
These are composite indicators that make it easier for fish to link to macroinvertebrate indicators. Should not be modified.	Agg: EPT food for fish
	Agg: Invert food for fish
Fish	
Select fish indicators based on the species present in the river. If that information is not available, select indicators based on the presence of habitats (e.g. if riffles are present select riffle dependent fish).	Riffle dependent fish (small)
	Quiet vegetated waters dependent fish
	Floodplain dependent fish
	Migratory fish (large)
	Tolerant fish
Social	
Select if sand and gravel mining occurs in the river reach	Sand and gravel resources
Select if reed harvesting occurs in the river reach	Reed harvesting potential
Select if river is used for subsistence or commercial fishing.	Fishing resources
Can be selected for most sites.	Aesthetic value

3 ADDING HYDROLOGY

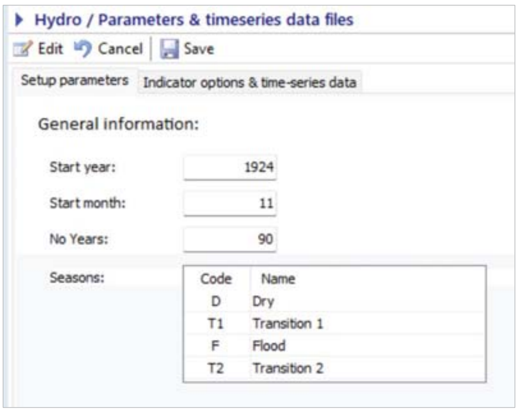
A basic requirement for the DRIFT DSS is a continuous daily hydrological flow sequences for a minimum of 20 years (but preferably longer) for each site for each scenario. Hydrologists undertake the relevant hydrological modelling outside the DRIFT DSS, and the data provided by them is imported into the DSS.

All projections are made against a baseline hydrology regime. This is usually set to current day water resource development, infrastructure, and abstraction levels, from gauge or modelled data. However, the baseline may also be set to naturalised flows, or an expected future flows after the completion of currently under approved and construction projects.

The start month of the hydrology timeseries must be in the middle of the dry season and must follow a specific format (Figure 3.1). Date format is 'YYYYMMDD' for daily timestep files and the files should be saved as *'SiteCode'-'ScenarioCode'.day* for daily timestep files. The hydrology files should be kept in the DRIFT\DRIFT-Generic-RiverUnderStudy\Data\Hydrology\ folder. Once the baseline hydrology is acquired, its details including start date, length in years and start month must be entered (Figure 3.2).

```
Daily,m3/s
Date,EF2-Base
19241101,109.1401292
19241102,111.1589158
19241103,111.1589158
19241104,113.2010718
19241105,115.2667082
19241106,115.2667082
19241107,115.2667082
19241108,115.2667082
19241109,115.2667082
19241110,115.2667082
19241111,115.2667082
19241112,117.3559356
19241113,119.4688647
19241114,121.6056056
```

Figure 3.1 Required format for hydrology data, daily timestep left and sub-daily timestep right.



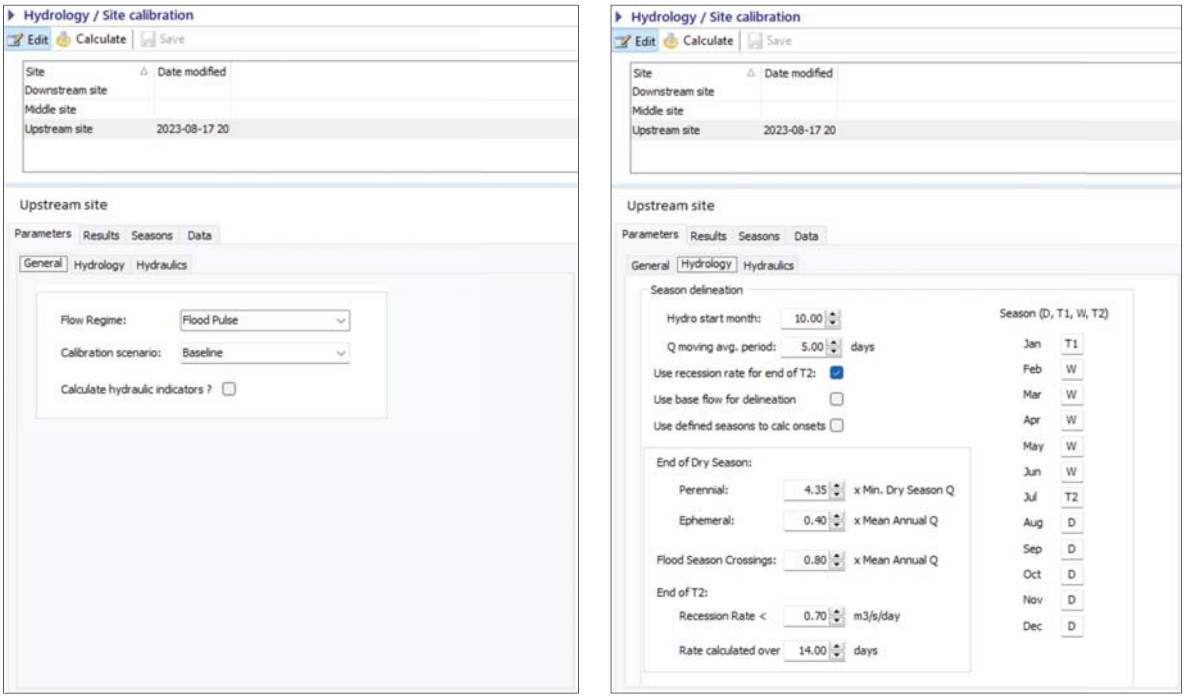
Knowledge Capture → Hydrology & Hydraulics → Parameters & timeseries data

Figure 3.2 Hydrology parameter setup.

3.1. Site calibration

Site calibration is the process of setting flow thresholds at each site that will determine the starts and ends of the flow seasons. Once baseline hydrology is placed in the required format in the \Data\Hydrology\ folder each site must be calibrated (Figure 3.3)

The parameters (Table 3.1) are set/adjusted through trial and error so that season demarcations “look reasonable” (the threshold does not appear too high or too low); and as few seasons are ‘missing’ as possible, preferably none (Figure 3.4).



Knowledge Capture → Hydrology & Hydraulics → Site Calibration

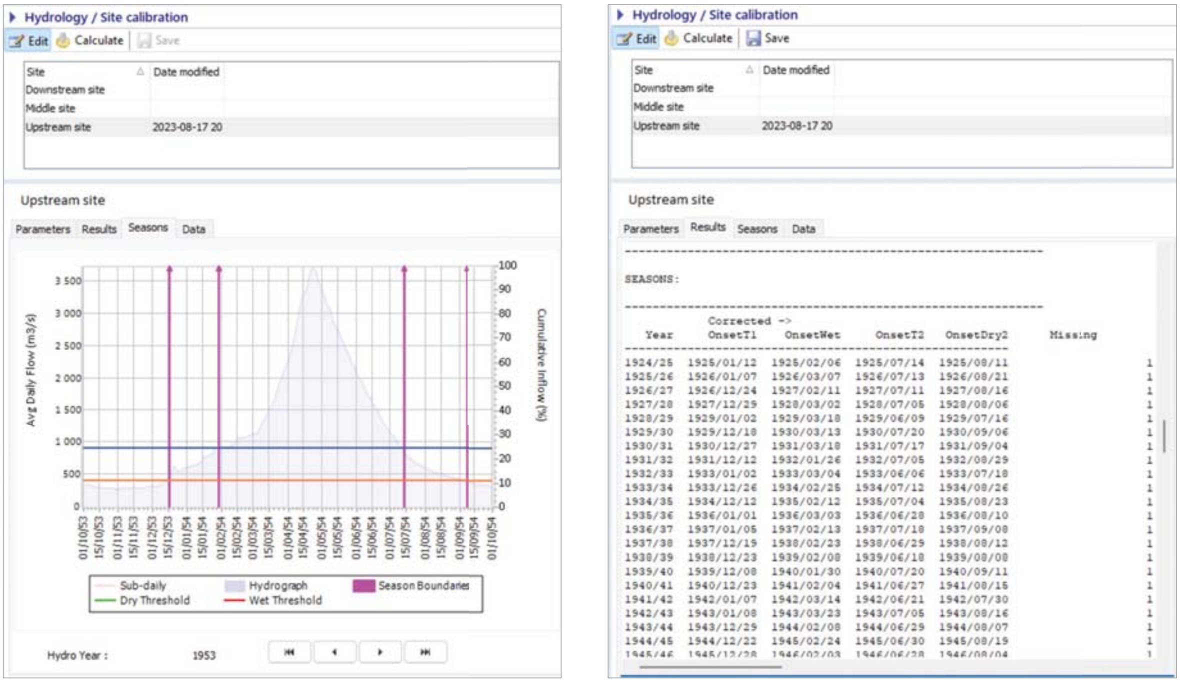
Select the site to be calibrated and click Edit. First, in the Parameters\General tab (left) select flood pulse as the flow regime and the name of the scenario that will be used for the baseline calibration. Next in the Parameters\Hydrology tab add the calibration parameters (right) and click Calculate when done.

Figure 3.3 Site calibration tab in DRIFT.

Table 3.1 Explanation of site calibration parameters

Parameter	Description
Hydro start month	The start month (1 to 12; where 1 is January) must be in the middle of the dry season and the same month which the hydrology files start at.
Q moving avg period	The number of days over which key parameters are calculated 5 days is set as the default.
End of dry season	Dry to T1 season threshold
Perennial rivers	Set using a multiple of the minimum dry season discharge. Although it may vary, setting this to 5 to 10 times minimum dry season discharge suggested as a starting point.

Parameter	Description
Ephemeral rivers	Set using a multiple of the mean annual discharge as the minimum dry season discharge may be zero or very low. A starting point may be between 0.3 to 0.7
Start and end of Wet season	T1 to Wet and Wet to T2 threshold
Flood Season Crossings	Set using a multiple of the mean annual discharge and is often near the mean annual discharge (e.g. 1.0 to 1.2 times mean Annual Q).
End of T2 season	**T2 to Dry threshold**
Use recession rate for end of T2	If unchecked T2 will end when the flows cross the Dry/T1 threshold. If checked T2 will end when the recession rate is less than the specified value in $m^3/s/day$ calculated over a defined set of days.
Use base flow for delineation	Used for flashy hydrology beyond the scope of this manual. Keep unchecked.
Use defined seasons to calculate onsets	Estimated seasons must be entered in the seasons tab to the right. Keep unchecked, however, these estimated seasons are used by the software in certain cases and so must be filled



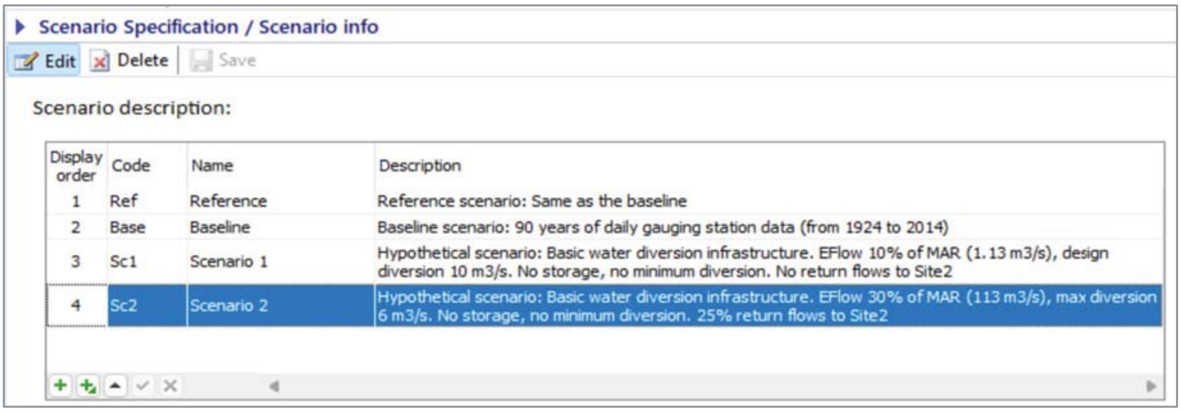
Knowledge Capture → Hydrology & Hydraulics → Site Calibration

Once site calibration calculations are concluded, click on Seasons (left) to view how season demarcations look like for each year of the record. The hydro-year can be navigated using the buttons at the bottom. Next click on Results (right) and scroll down to the Seasons section of the panel to check how many seasons were missed.

Figure 3.4 Reviewing results of site calibration.

3.2. Assessment scenarios

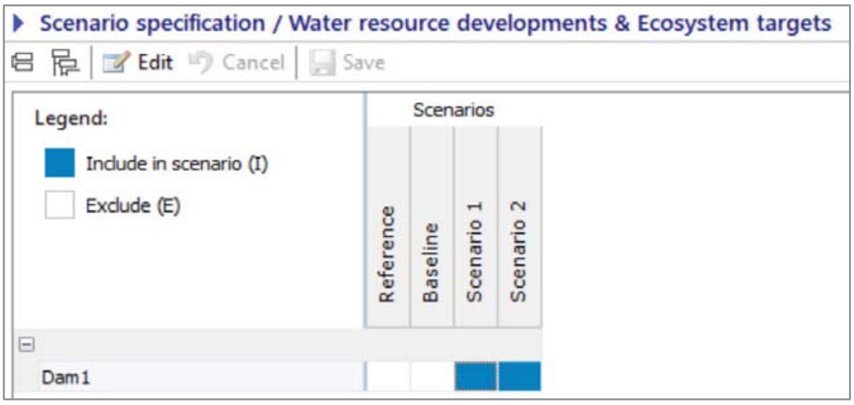
DRIFT is a scenario based EFlows assessment approach. This provides decision makers with information to weigh options and trade-offs under various future development and operational scenarios. A baseline and two dummy scenarios are added to the DRIFT-Generic-SADC database. If a scenario is not used it can be deleted or additional scenarios added as required (Figure 3.5). The reference scenario is just a copy of the baseline scenario and is required for DRIFTs inner working (and subsequently ignored). For the rapid assessment a single in-channel dam or weir is defined which blocks movement between EFlows Site 0 (EF0, UpstreamDam) and EFlows Site 1 (EF1; Dewatered). It can be added to any assessment scenario (Figure 3.6). Refer to the main DRIFT manual to change the location of the weir or to add additional in-channel barriers.



Setup → Scenarios specification → General description

To add a scenario click edit followed by the green plus sign. To delete a scenario click edit, select the scenario to delete and then click delete. Save afterwards and close the edit session.

Figure 3.5 Adding and deleting scenarios.

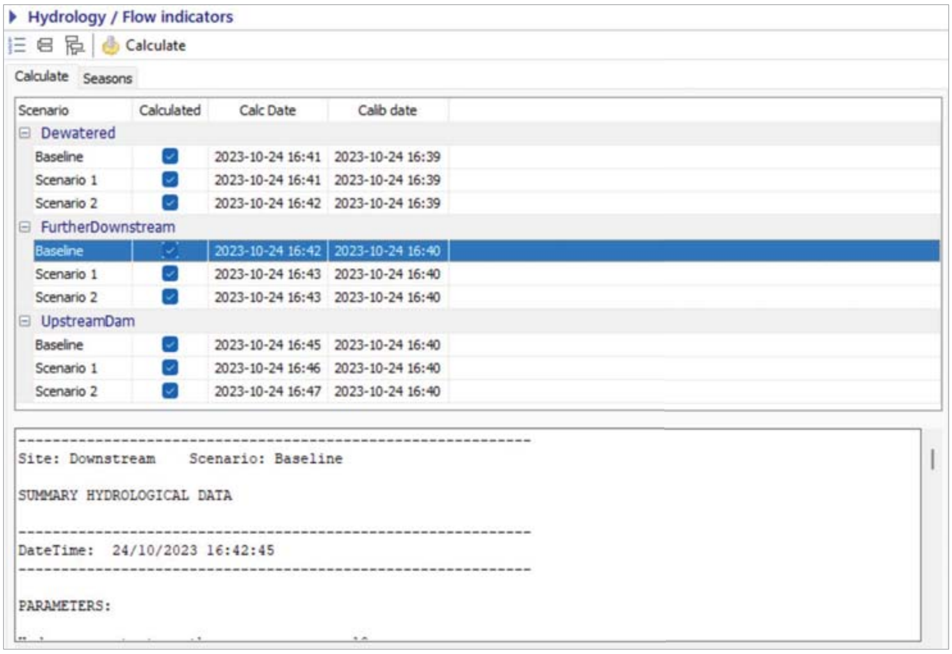


Setup → Scenarios specification → Specifications

To include the dam in the scenario click edit followed by typing I to include and E to exclude the dam from the scenario.

Figure 3.6 Adding in channel weirs to scenarios.

Once each site has been calibrated with the baseline hydrology and all the scenario hydrology is placed in the \Data\Hydrology\ folder, DRIFT is used to calculate the flow indicators for each site and scenario (Figure 3.7). The results are also automatically saved and can be viewed in a text file in the \Data\FlowIndicators\ folder. These files have the naming convention "SiteCode"-"ScenarioCode".hst, e.g. EF0-Base.hst and can be opened in Notepad to view.



Knowledge Capture → Hydrology & Hydraulics → Calculate flow indicators

Calculate flow indicators by clicking each site and scenario and clicking calculate. Note the flow indicators for a site must be calculated after the site is calibrated. Therefore, if a site is re-calibrated the flow indicators must also be recalculated. These date of calibration and calculation can be checked on this screen. Often if unforeseen errors are arising in the software, re-running the calibration and calculation might resolve the issue.

Figure 3.7 Flow indicator calculation tab.

4 ADJUSTMENTS AND BALANCING

To use this library, the absolute minimum requirement is a hydrological timeseries for the baseline, and preferably also for other scenarios. Starting from this bare minimum requirement, the generic database can be further refined by adjusting response curves and modifiers, reviewing connectivity related links, and updating the baseline ecological status.

4.1. Adjustments to response curves

In the case where the response curves have hydrology driving indicators, the x axis will be automatically populated by DRIFT with physical units such as m^3/s for discharge, Mm^3 for daily volume, days for season duration, etc. These values on the x-axes depends on the input baseline hydrology which will vary from site to site. Because the x-axes may change in range or shape, in some cases, the generic response curves may need to be adjusted. This can occur for many reasons, for example, if there is low natural variation, very extreme variation, or very skewed distribution (Table 4.1) in the baseline flows. The key is to ensure that the response curves should carry the purpose described in the supporting explanations. In general, in these circumstances, the response (y axis) will be adjusted, but it may be useful to adjust certain points on the x-axes as well (but never the median), to better correspond to known thresholds.

Response curves can also be fine-tuned if additional information is available. For example, if gravel and cobble beds are located at the centre of the bed and their inundation is not very sensitive to flows the scores that relate inundated cobble habitat to reduced flows can be made less severe (Table 4.2). The degree of positive and negative scoring also depends on the median baseline abundance, such as in the case of fish and prey/food. If fish are at carrying capacity due to habitat availability, an increase in prey abundance will not allow for a very large increase in fish abundance.

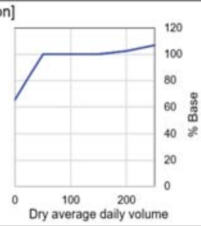
> If major changes are made, supported by new studies or literature, it will be appreciated that such changes are communicated to the study team (admin@southernwaters.co.za) so that such edits may be added to the generic library to benefit its users.

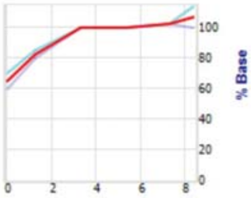
Table 4.1 Examples of response curves where adjustments must be made.

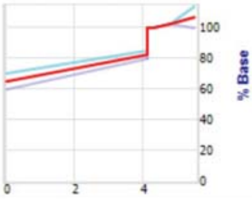
Generic response curve

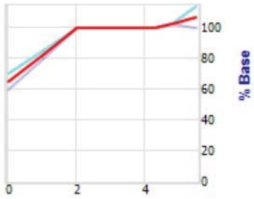
Dry average daily volume [D season]

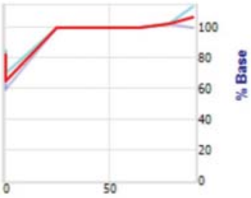
	%Base	Y1
Min	0	-2
Min Base	25	-1
	50	0
Median	100	0
	150	0
Max Base	200	0.1
Max	250	0.4

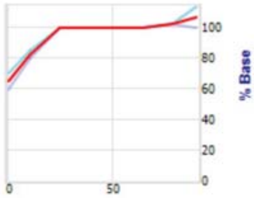


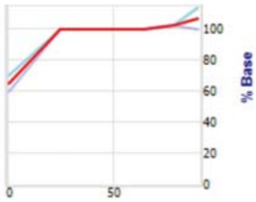
<table>
<tr><th>RC examples after site hydrology is added</th><th>Possible adjustments</th></tr>
<tr><td>Follows the general shape and concept of the generic response curve.
Dry ave daily vol [D season]
<table>
<tr><th>Desc</th><th>Mm3/d</th><th>Y1</th><th>Y2</th></tr>
<tr><td>Min</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td>Min Base</td><td>1.268</td><td>-1.000</td><td></td></tr>
<tr><td></td><td>3.259</td><td>0.000</td><td></td></tr>
<tr><td>Median</td><td>4.108</td><td>0.000</td><td></td></tr>
<tr><td></td><td>5.268</td><td>0.000</td><td></td></tr>
<tr><td>Max Base</td><td>7.265</td><td>0.100</td><td></td></tr>
<tr><td>Max</td><td>8.354</td><td>0.400</td><td></td></tr>
</table>


</td><td>No adjustment is required.</td></tr>
<tr><td>Impacts begin very early as Min base value is very close to Median, e.g. Min Base is 99.5% of Median value.
Dry ave daily vol [D season]
<table>
<tr><th>Desc</th><th>Mm3/d</th><th>Y1</th><th>Y2</th></tr>
<tr><td>Min</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td>Min Base</td><td>4.102</td><td>-1.000</td><td></td></tr>
<tr><td></td><td>4.104</td><td>0.000</td><td></td></tr>
<tr><td>Median</td><td>4.108</td><td>0.000</td><td></td></tr>
<tr><td></td><td>4.250</td><td>0.000</td><td></td></tr>
<tr><td>Max Base</td><td>4.758</td><td>0.100</td><td></td></tr>
<tr><td>Max</td><td>5.472</td><td>0.400</td><td></td></tr>
</table>


</td><td>Possible remedy: Min base and next x axis value changed to 1 and 2 Mm3/d
Dry ave daily vol [D season]
<table>
<tr><th>Desc</th><th>Mm3/d</th><th>Y1</th><th>Y2</th></tr>
<tr><td>Min</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td>Min Base</td><td>1.000</td><td>-1.000</td><td></td></tr>
<tr><td></td><td>2.000</td><td>0.000</td><td></td></tr>
<tr><td>Median</td><td>4.108</td><td>0.000</td><td></td></tr>
<tr><td></td><td>4.250</td><td>0.000</td><td></td></tr>
<tr><td>Max Base</td><td>4.758</td><td>0.100</td><td></td></tr>
<tr><td>Max</td><td>5.472</td><td>0.400</td><td></td></tr>
</table>


</td></tr>
<tr><td>Two x axis values are the same (e.g. Min and Min base are both 0) therefore issues arise on which value to use
Dry ave daily vol [D season]
<table>
<tr><th>Desc</th><th>Mm3/d</th><th>Y1</th><th>Y2</th></tr>
<tr><td>Min</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td>Min Base</td><td>0.000</td><td>-1.000</td><td></td></tr>
<tr><td></td><td>24.174</td><td>0.000</td><td></td></tr>
<tr><td>Median</td><td>48.349</td><td>0.000</td><td></td></tr>
<tr><td></td><td>63.117</td><td>0.000</td><td></td></tr>
<tr><td>Max Base</td><td>77.886</td><td>0.100</td><td></td></tr>
<tr><td>Max</td><td>89.569</td><td>0.400</td><td></td></tr>
</table>


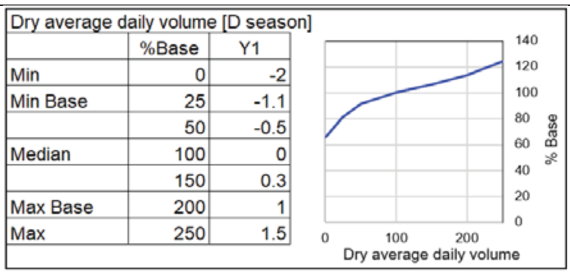
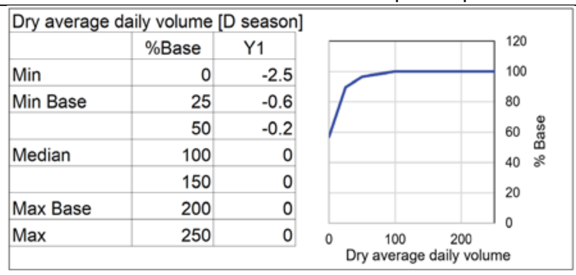
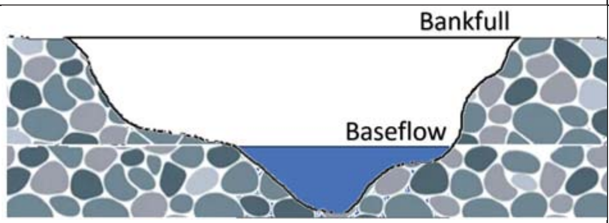
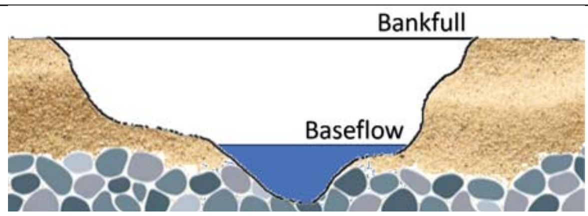
</td><td>Possible remedy 1: Min base x axis changed to 10 Mm³/d
Dry ave daily vol [D season]
<table>
<tr><th>Desc</th><th>Mm3/d</th><th>Y1</th><th>Y2</th></tr>
<tr><td>Min</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td>Min Base</td><td>10.000</td><td>-1.000</td><td></td></tr>
<tr><td></td><td>24.174</td><td>0.000</td><td></td></tr>
<tr><td>Median</td><td>48.349</td><td>0.000</td><td></td></tr>
<tr><td></td><td>63.117</td><td>0.000</td><td></td></tr>
<tr><td>Max Base</td><td>77.886</td><td>0.100</td><td></td></tr>
<tr><td>Max</td><td>89.569</td><td>0.400</td><td></td></tr>
</table>


Possible remedy 2: Y1 severity score change to -2 (or -1) for both Min and Min base
Dry ave daily vol [D season]
<table>
<tr><th>Desc</th><th>Mm3/d</th><th>Y1</th><th>Y2</th></tr>
<tr><td>Min</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td>Min Base</td><td>0.000</td><td>-2.000</td><td></td></tr>
<tr><td></td><td>24.174</td><td>0.000</td><td></td></tr>
<tr><td>Median</td><td>48.349</td><td>0.000</td><td></td></tr>
<tr><td></td><td>63.117</td><td>0.000</td><td></td></tr>
<tr><td>Max Base</td><td>77.886</td><td>0.100</td><td></td></tr>
<tr><td>Max</td><td>89.569</td><td>0.400</td><td></td></tr>
</table>


</td></tr>
</table>

The DRIFT-Generic-SADC response curves can be further adjusted based on available site-specific information (Table 4.2).

Table 4.2 Examples of site-specific adjustments that can be made to response curves

DRIFT-Generic-SADC response curve links Dry average daily volume to inundated cobble habitat in almost a proportional manner and does not make assumptions on the locations of the cobbles in the river bed.	If the cobble beds are restricted to the centre of the riverbed, increasing flows will not inundate more cobbles and the abundance of inundated cobbles will be less sensitive to flow reductions up to a point.
	
	

4.2. Review and adjustment of modifiers

Reasonable modifiers according to Volume 1 of the report are entered into DRIFT-Generic-SADC. However, if the user has additional site- or species-specific information, they are welcome to make adjustments to the generic modifiers. For example, the suggested dependence on the previous year for Quiet vegetated dependant water fish is 55%. However, if it is known that the species present in the reach under study has a much lower fecundity or a longer time to sexual maturity, this would imply a higher dependence on the previous year. This modifier could therefore be changed accordingly. Modifiers make substantial change to the results, and it is worthwhile to review these.

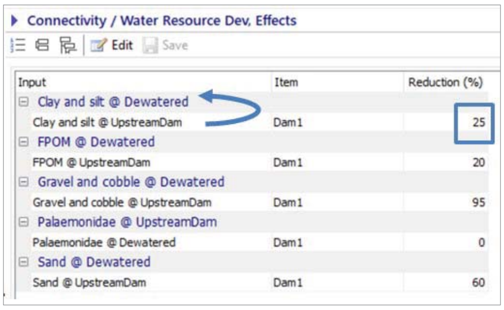
4.3. Adjustments to connectivity

The pre-defined barrier between EFlows Site 0 and EFlows Site 1 presents a barrier to connectivity as follows:

- The dam and reservoir restrict the flow of sediment downstream.
    - Silt and clay (25% reduction): Fine sediments remain in suspension and flow through the reservoir; unless the reservoir is very long then they will be deposited.
    - FPOM (20% reduction): These fine sediments remain in suspension and flow through the reservoir.
    - Sand (60% reduction). Sand will be deposited at the start of the reservoir due to the slowdown in velocities.
    - Gravel and cobbles (95% reduction): These heavy bedload sediments will be deposited and not make it downstream of the weir.
- The weir and reservoir restrict the movement of animals both upstream and downstream
    - Migratory fish Upstream movement (70% blocked) and Downstream movement (50% blocked): the dam wall and reservoir are difficult to breach by fish. Some may enter the turbine which can be fatal.

- Palaemonidae Upstream movement (70% blocked) and downstream movement (50% blocked): the dam wall and reservoir are difficult to breach by shrimps.

If additional information is available, then these impacts to connectivity can be fine-tuned (Figure 4.1). For example, if the weir under study has a well-designed fish passage, then it may have a lower impact on the movement of fish.



Knowledge Capture → Connectivity → Water Resource Dev Effects

Dam1 reduces Clay and silt from Upstream to Dewatered by 25%.

Figure 4.1 Connectivity tab in the DRIFT DSS.

4.4. Balancing

The time series of the indicator will show variability over time, responding to climate changes and water resource developments in the scenarios. However, for the baseline scenario, the mean value across this time series, must be between 98% and 102% for all indicators (Figure 4.2). As the flow patterns will vary from river to river and from site to site, the generic response curves may need slight adjustments to account for this. The modifiers that directly limit the indicator percentage (Minimum % of Base and Maximum % of Base) should preferably not be used during the balancing process. These types of adjustments are called “balancing”.

When balancing, remember to balance in the order of operations. In other words, start at the most upstream site and the first discipline (geomorphology) and then move to the next discipline and then the next site. Running the DRIFT software will update changes across sites and disciplines. If the DB includes up- and down-stream migrations, it is particularly important to “Run All” scenarios frequently when balancing. If there are migration related response curves, it is a good strategy, to turn off migration links and balance all the other response curves to give the overall 98% to 102% result, and then, once these are balancing, switch the migration back on and balance the migration.

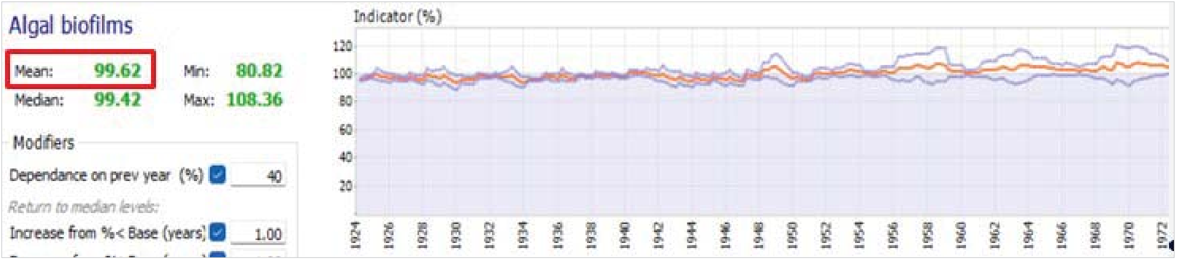


Figure 4.2 Although variations occur in the baseline, the Mean should be near 100%

4.5. Ecological Categories

The ecological status (health or condition) of a river ecosystem is defined as its ability to support and maintain a balanced, integrated composition of physio-chemical and habitat characteristics, as well as biotic components on a temporal and spatial scale that are comparable to the natural characteristics of ecosystems of the region (Kleynhans 1996; Table 4.3). Converting scenario results to Ecological Categories provides an understandable scoring criterion to compare different sites and scenarios assessed and may be an administrative requirement in some cases.

Table 4.3 Definitions of Ecological Status categories (after Kleynhans 1996 and 1999).

A	Unmodified, natural	As close as possible to natural conditions.
B	Largely natural	Modified from the original natural condition but not sufficiently to have produced measurable change in the nature and functioning of the ecosystem.
C	Moderately modified	Changed from the original condition sufficiently to have measurably altered the nature and functioning of the ecosystem, although the difference may not be obvious to a casual observer.
D	Largely modified	Sufficiently altered from the original natural condition for obvious impacts on the nature and functioning of the ecosystem to have occurred.
E **F**	Completely modified	Important aspects of the original nature and functioning of the ecosystem are no longer present. The area is heavily negatively impacted by human interventions.

As, in DRIFT, all change is evaluated against the baseline, the Baseline Ecological status (BES) of each river reach must be entered into the DRIFT DSS (Figure 4.3). Secondly, the user must review whether an increase in abundance of the indicators selected is a move towards natural or away from natural conditions for the river under study (Figure 4.4). For instance, in some cases a certain plant of fish species may be native (an increase would be towards natural) whereas in other areas it may be invasive (an increase would be away from natural).

Integrity / Present Ecological Status

Edit Save

Discipline	Upstream dam	Dewatered	Downstream outlet
Geomorphology	B/C	B/C	B/C
Vegetation	B/C	B/C	B/C
Algae	B/C	B/C	B/C
Macro-invertebrates	B/C	B/C	B/C
Fish	B/C	B/C	B/C
Social	B/C	B/C	B/C

Knowledge Capture → Integrity → Present Ecological Status

To update the Baseline Ecological Status (BES), click Edit, select the cell to update, and enter the BES (A, A/B, B, B/C, C, C/D, D, D/E, or E) for that site and discipline.

Figure 4.3 Present Ecological Status tab in the DRIFT software.

Integrity / Abundance/Integrity relationship

Edit Save

Indicator	1_Lephalala	2_NoName	3_Olifantspruit	4_Mogalakwena1	5_Mogalakwena2
Fish					
Rocky riffle fish	Towards		Towards	Towards	Towards
Quiet vegetated water fish	Towards		Towards	Towards	Towards
Floodplain dependent fish	Towards				
Migratory	Towards		Towards	Towards	Towards
Tolerant species	Towards	Towards	Towards	Towards	Towards
Fish health	Towards	Towards	Towards	Towards	Towards
Species diversity	Towards		Towards	Towards	Towards
Comp: Fish abundance	Towards	Towards	Towards	Towards	Towards
Geomorphology					
Clay silt FPOM supply	Away	Away	Away	Away	Away
Sand Gravel supply	Away	Towards	Towards	Towards	Towards
Bed erosion	Away	Away	Away	Away	Away
Bank erosion	Away	Away	Away	Away	Away
Bed Sediment size	Towards		Towards	Towards	Away
Embeddedness	Away		Away	Away	Away
Pool depth	Towards	Towards	Towards	Towards	Towards
Backwaters and secondary channels	Towards		Towards	Towards	Towards
Inset bench and sand bars	Away	Towards	Towards	Towards	Away
Inundated sandy habitat	Away	Towards	Away	Away	Away
Inundated cobble habitat	Towards		Towards	Towards	Towards
Riffles	Towards	Towards	Towards	Towards	Towards
Flood bench	Towards		Towards	Towards	Towards
Macro-invertebrates					

Knowledge Capture → Integrity → Abundance Integrity relationship

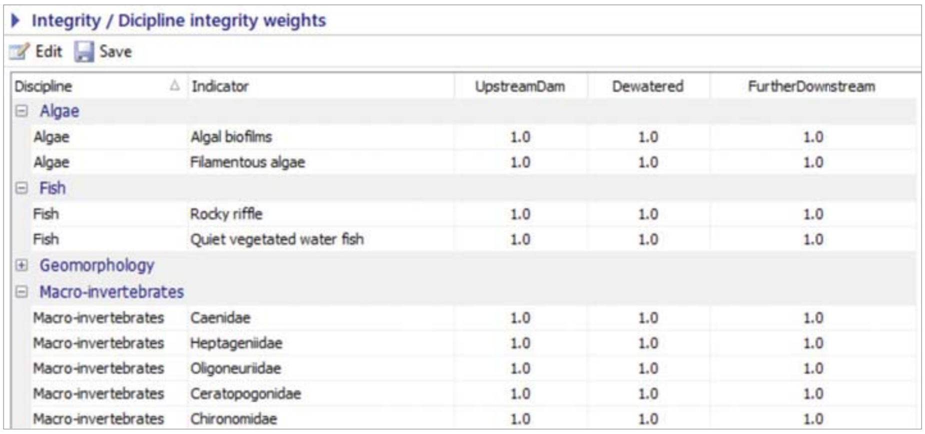
'Towards' means an increase in abundance is a move toward the natural condition for the ecosystem (e.g. an increase in indigenous fish) and 'Away' means an increase is a move away from the natural condition for the ecosystem (e.g. increase in alien invasive vegetation). To update, enter Towards or Away by typing or selecting it from the dropdown.

Figure 4.4 Abundance/Integrity relationships.

The contribution of each discipline to a site's overall ecosystem integrity is determined by "site integrity weights". Within a discipline, the contribution of each indicator to the discipline's integrity is determined by "discipline integrity weights". By default, each indicator in each discipline is given the same weight when calculating the discipline's integrity score; and each discipline is given the same weight when calculating the site integrity. In the case of DRIFT-Generic-SADC minor adjustments have been made to weights, for example:

- For geomorphological integrity: sediment loads, bed erosion and bank erosion were excluded as they are driving factors and processes rather than outcomes in geomorphological indicators such as bed sediment size, etc.
- For overall site integrity:
    - Algal indicators are excluded as it is difficult to assign a consistent score for these that indicate whether a change in abundance is a move toward or away from natural. While small variations in the abundance are natural, both a large increase and a large decrease in their abundance may represent a move away from natural for the system.
    - Fish indicators were more heavily weighted because fish integrate many of the other aspects of the river.
    - Social indicators are excluded – they are not part of ecological integrity.

The weights can be adjusted if additional information is available (Figure 4.5 and Figure 4.6).



Integrity / Dicipline integrity weights

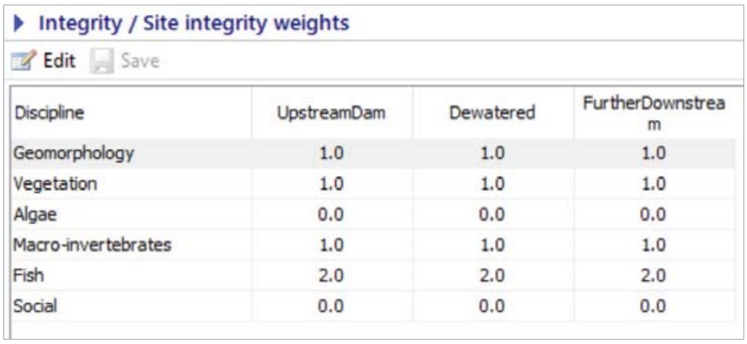
Edit Save

Discipline	Indicator	UpstreamDam	Dewatered	FurtherDownstream
Algae				
Algae	Algal biofilms	1.0	1.0	1.0
Algae	Filamentous algae	1.0	1.0	1.0
Fish				
Fish	Rocky riffle	1.0	1.0	1.0
Fish	Quiet vegetated water fish	1.0	1.0	1.0
Geomorphology				
Macro-invertebrates				
Macro-invertebrates	Caenidae	1.0	1.0	1.0
Macro-invertebrates	Heptageniidae	1.0	1.0	1.0
Macro-invertebrates	Oligoneuriidae	1.0	1.0	1.0
Macro-invertebrates	Ceratopogonidae	1.0	1.0	1.0
Macro-invertebrates	Chironomidae	1.0	1.0	1.0

Knowledge Capture → Integrity → Discipline integrity weights

Discipline integrity weights are used to weigh how much each indicator contributes towards the discipline's overall integrity. To update the weights, click Edit, select the cell to update, and enter a new weight between 0 and 1 for example 0.5.

Figure 4.5 Discipline integrity weights tab in the DRIFT software.



Integrity / Site integrity weights

Edit Save

Discipline	UpstreamDam	Dewatered	FurtherDownstream
Geomorphology	1.0	1.0	1.0
Vegetation	1.0	1.0	1.0
Algae	0.0	0.0	0.0
Macro-invertebrates	1.0	1.0	1.0
Fish	2.0	2.0	2.0
Social	0.0	0.0	0.0

Knowledge Capture → Integrity → Site integrity weights

Site integrity weights are used to weigh how much each discipline integrity contributes to the sites overall integrity.

Figure 4.6 Site integrity weights tab in the DRIFT software.

5 ESTUARY SPECIFIC GUIDELINES

Although the generic relationships for estuaries provide a wealth of information, they are not directly usable in the DRIFT software due to the various limitations described in Volume 1 of this study. Some initial concepts for the steps required for this translation are described:

Step 1. Select ecosystem indicators relevant to the estuary being modelled from the list of possible estuary indicators

Step 2. Access the generic estuary response curves for that indicator

Step 3. For each of these response curves evaluate which season(s) it is applicable in. Relationships related to floods are likely only applicable in the wet season whereas others such as salinity may be applicable to both dry and wet seasons. Remember that DRIFT has four seasons and response curves across the four seasons in a single year are additive.

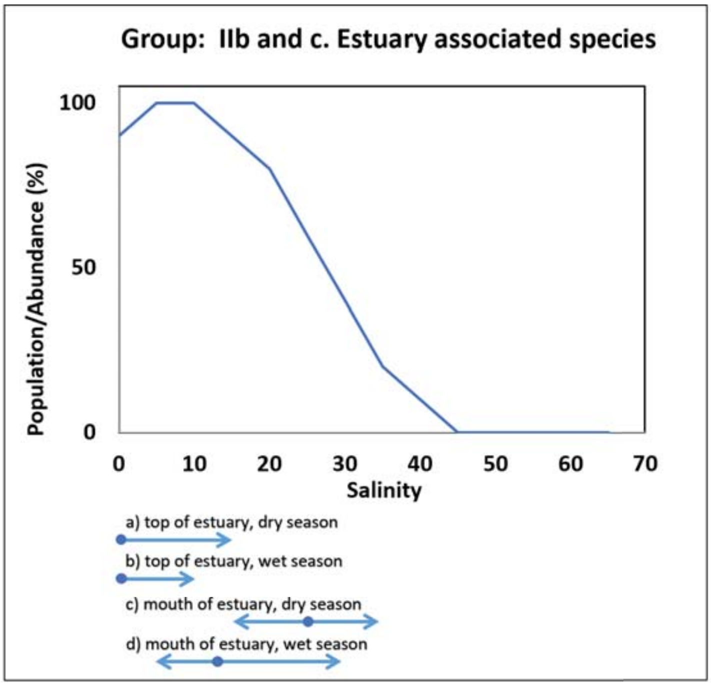
Step 4. Based on this selection enter the links into DRIFT. The x-axis of these response curves will be auto-populated by DRIFT by the values that occur in the baseline. These can be adjusted if required to extend the range and generally the median value is not changed.

Step 5. For each value on the x-axis of the DRIFT response curve, use the generic estuary relationships for guidance to estimate the corresponding change from the baseline in the responding indicator under those conditions.

Step 6. Convert the generic response to DRIFT severity scores (see the DRIFT software manual) and enter into the DRIFT response curves.

These steps should be conducted with care and caution and by a specialist versed in both the DRIFT method and the understanding of estuary ecosystems. This may be a complex and iterative process and has only been completed for one estuary in SADC.

As a worked example the single generic relationship between IIB and C Estuary associated species and salinity (Figure 5.1) may translate into four DRIFT response curves (Table 5.1). Note that in this example, the DRIFT response to the median value of the salinity at each site and season is zero and the rest of the responses are scaled accordingly.



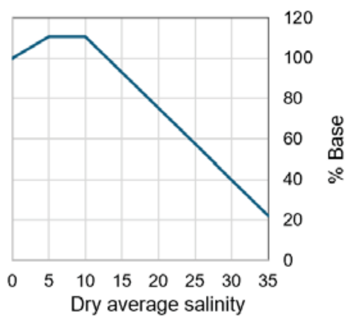
Note: Arrows indicate the baseline seasonal range of salinities from two sites in the Pungwe Estuary, circles indicate median salinity in the baseline.

Figure 5.1 Generic relationship between salinity and estuary associated species.

Table 5.1 Possible translation of relationship between salinity and estuary associated species.

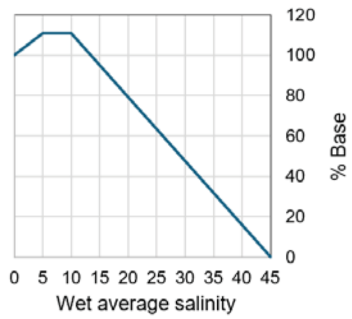
Top of estuary, dry season

Dry average salinity	ppt	Y1
Min	0	-0.018
Min base	0	-0.018
	0.069	-0.009
Median	**0.139**	**0.000**
	5.000	0.956
Max base	10	0.956
Max	35	-4.622



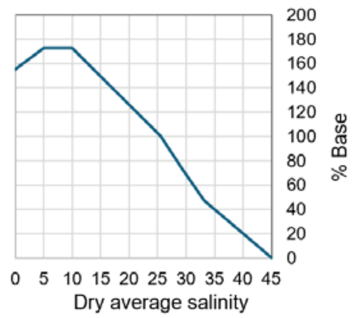
Top of estuary, wet season

Wet average salinity	ppt	Y1
Min	0	0.000
Min base	0	0.000
	0	0.000
Median	**0.000**	0.000
	5	0.978
Max base	10	0.978
Max	45	-5.938



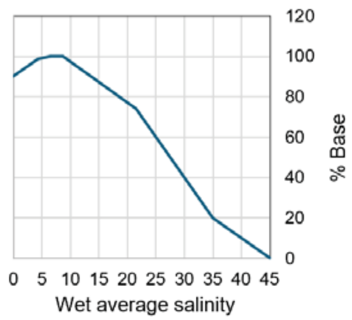
Mouth of estuary, dry season

Dry average salinity	ppt	Y1
Min	0	2.234
Min base	5	2.467
	10	2.467
Median	25.516	0.000
	29.326	-1.562
Max base	33.137	-3.124
Max	45	-5.938



Mouth of estuary, wet season

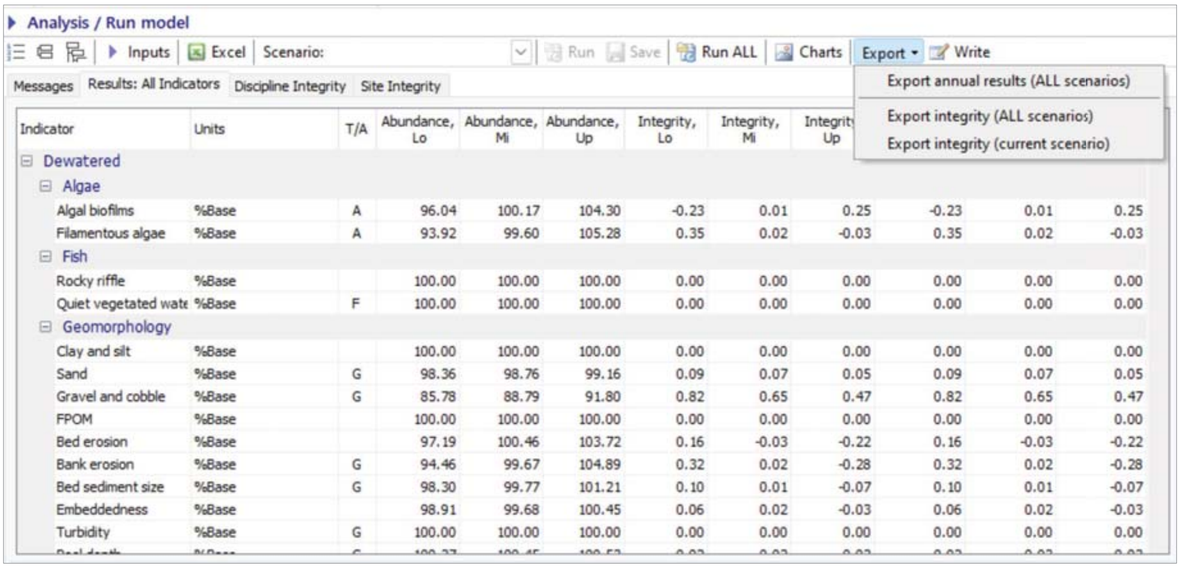
Wet average salinity	ppt	Y1
Min	0	-0.594
Min base	4.261	-0.088
	6.512	0.000
Median	8.626	0.000
	21.477	-1.538
Max base	35	-4.750
Max	45	-5.938



For flood related relationships, further exploration into the indicator being modelled and the baseline hydrology of the target estuary are required. At the generic level, the flood related responses are based on two thresholds: (1) flood volumes below which lowering flood volume makes no further negative impact as, for example, small flood volumes may not influence sediment processes in large estuaries; and (2) flood volume above which increasing flood volume makes no further positive impact as response are transferred to the nearshore marine (note that very large floods may also have a short-term negative influence flushing out biota and uprooting and damaging flora). The DRIFT response will relate to where the median flood volume is located. For instance, if the median is below the lower threshold (for example in a very regulated river), further lowering the floods will not have any negative impact, if it is beyond the upper threshold (for example, an estuary with regular floods) further increases may not markedly benefit the responding indicator. The most likely possibility is that the median lies between the lower and upper thresholds, in which case the difference between the lower threshold, median and upper threshold and the preference of the species represented by the indicator in the estuary should be evaluated when developing the DRIFT response curve. Lastly, although the generic relationships present a linear relationship this should be fine-tuned based on available information.

6 EXPORTING AND ANALYSING RESULTS

Once all the previous steps have been completed the model can be run and results exported (Figure 6.1). If results have been exported previously the new export will overwrite previous results. Results are exported to the \Data\Export\ folder. The model can also be run at any intermediate stage to update the internal links and displays.



Analysis → Scenario outcomes → Run model

Click Run ALL to run the model for all sites and all scenarios. Once the run is complete, click Export annual results to export results as timeseries of percentage of baseline abundance for each indicator at each site; and click Export integrity to export the integrity results.

Figure 6.1 Running the model and exporting results.

Annual results are exported in the form of annual (end of year) values of the abundance of each indicator at each site (Table 6.1). The Excel sheets are exported to the folder \Export\FullResults\ and also contain timeseries labelled as Upper and Lower which represent the error bounds of the abundance. Average abundances over the timeseries for each indicator are exported into the “Results (Indicators)” sheet (Table 6.2).

Discipline integrity and site integrity outputs (Table 6.3 and Table 6.4) include a base integrity score which is a change from zero and an adjusted integrity which is a change from the baseline ecological category as it has been entered in DRIFT. Integrity scores are also provided with a Lower and Upper integrity which corresponds to the Lower and Upper error bars for the indicator abundance. Integrity number scores can be converted to Ecological Categories (Table 4.3) using the scale in Table 6.5.

Table 6.1 Example of annual timeseries DRIFT output.

	A	B	C	D
1	Site	FurtherDownstream		
2	Discipline	Vegetation		
3		Middle		
4	Scenarios	Reference		
5	Years	Aquatic plants on rock	Aquatic plants in sand	Emergent graminoids
6	1924	94.14	96.06	98.81
7	1925	91.82	88.91	96.49
8	1926	92.41	92.12	100.05
9	1927	92.33	94.04	105.89
10	1928	92.20	92.72	108.72
11	1929	87.68	86.03	107.56
12	1930	89.04	87.31	103.22
13	1931	92.42	94.64	100.00
14	1932	93.58	96.19	106.32
15	1933	89.43	81.81	94.83
16	1934	90.94	90.00	100.28
17	1935	93.33	93.49	104.65
18	1936	93.49	90.19	99.32
19	1937	95.34	95.59	101.93

Table 6.2 Example of Indicator results outputs from DRIFT.

Indicator	Units	T/A	Abundance, Lo	Abundance, Mi	Abundance, Up	Integrity, Lo	Integrity, Mi	Integrity, Up	Adjusted Integrity, Lo	Adjusted Integrity, Mi	Adjusted Integrity, Up
- Site : Dewatered											
- Discipline : Algae											
Algal biofilms	%Base	A	75.910	99.086	122.261	-1.395	-0.053	1.368	-1.395	-0.053	1.368
Filamentous algae	%Base	A	33.497	62.460	91.423	3.851	2.174	0.497	3.851	2.174	0.497

The output includes Abundance of the indictor and error bounds.

Table 6.3 Example of Discipline Integrity outputs from DRIFT.

	A	B	C	D	E	F	G	H
1	Site		Integrity, Lo	Integrity, Mi	Integrity, Up	Adjusted Integrity, Lo	Adjusted Integrity, Mi	Adjusted Integrity, Up
2	-	Discipline : Algae						
3		Dewatered	-0.449	1.060	2.609	-1.216	0.294	1.843
4		FurtherDownstream	-0.411	0.914	2.305	-1.179	0.145	1.537
5		UpstreamDam	-0.153	0.012	0.296	-0.916	-0.750	-0.466
6	-	Discipline : Geomorphology						
7		Dewatered	-1.962	-1.295	-0.704	-2.679	-2.012	-1.422
8		FurtherDownstream	-1.910	-1.213	-0.633	-2.621	-1.924	-1.344
9		UpstreamDam	-0.364	-0.048	0.312	-1.066	-0.750	-0.390
10	-	Discipline : Macro-invertebrates						
11		Dewatered	-1.761	-1.022	-0.326	-2.512	-1.773	-1.078
12		FurtherDownstream	-1.645	-0.940	-0.278	-2.394	-1.690	-1.028
13		UpstreamDam	-0.206	0.026	0.293	-0.961	-0.728	-0.461

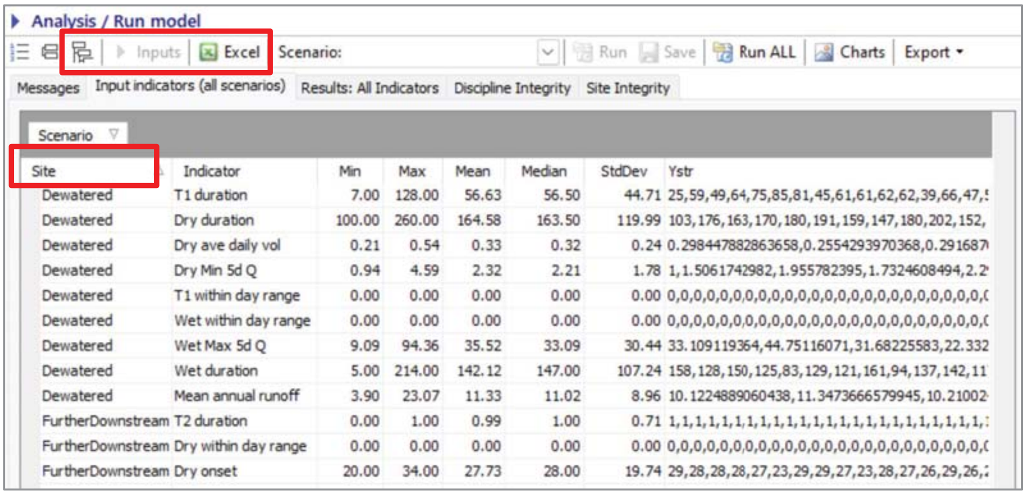
Table 6.4 Example of Overall Site Integrity outputs from DRIFT.

Site	Integrity, Lo	Integrity, Mi	Integrity, Up	Adjusted Integrity, Lo	Adjusted Integrity, Mi	Adjusted Integrity, Up
Dewatered	-1.02777	-0.45682	0.09941	-1.77271	-1.20176	-0.64553
FurtherDownstream	-0.95437	-0.42141	0.09331	-1.69768	-1.16472	-0.65000
UpstreamDam	-0.16482	-0.00273	0.19150	-0.90845	-0.74636	-0.55213

Table 6.5 Integrity scores that correspond to Ecological Status categories and sub-categories.

Ecological sub-category	Integrity value	Suggested colour coding	
		Hex Code	Colour
A	-0.075 < EC	#0000FF	
A/B	-0.25 < EC ≤ -0.075	#0F87FF	
B	-0.55 < EC ≤ -0.25	#47CFFF	
B/C	-0.9 < EC ≤ -0.55	#66FFFF	
C	-1.25 < EC ≤ -0.9	#00FF00	
C/D	-1.65 < EC ≤ -1.25	#42BE36	
D	-2.175 < EC ≤ -1.65	#FFBE32	
D/E	-2.7 < EC ≤ -2.175	#EB652D	
E	-3.25 < EC ≤ -2.7	#FF0000	
E/F	-3.7 < EC ≤ -3.25	#C84150	
F	EC ≤ -3.7	#C80A5A	

A summary of the inputs can be exported from DRIFT (Figure 6.2); these are useful in explaining the resultant changes under various scenarios.



Analysis → Scenario outcomes → Run model

Click Inputs to load inputs; then click the expand all button; then click on Site to sort by site, and finally click the Excel button to export a summary of the input data.

Figure 6.2 Exporting the summary of drivers from DRIFT.

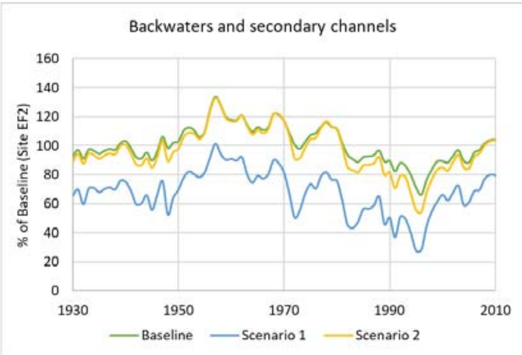
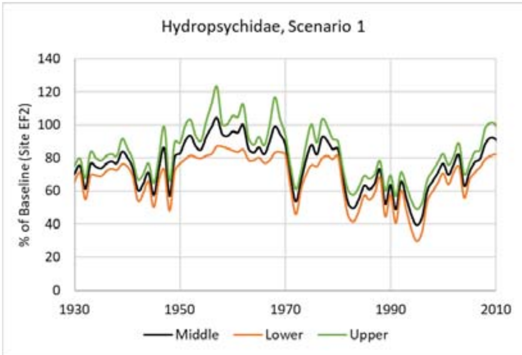
6.1. Analysing results

Various analysis can be undertaken using the outputs of the DRIFT software. Tables, charts, and graphs should be organized and explained in a way that answers the questions posed by decision makers (Table 6.6).

These can be generated using the accompanying excel sheet "Summary_DRIFT-Generic-SADC" placed in the \Export\ folder. Using and editing of the excel sheet "Summary_DRIFT-Generic-SADC" requires knowledge of MS Excel may require knowledge of VBA Excel Macros for troubleshooting if needed.

Table 6.6 Examples on how outputs from DRIFT can be communicated to decision makers.

1. **Timeseries of indicator abundance:** Abundance of each indicator at each site for every year of the timeseries.

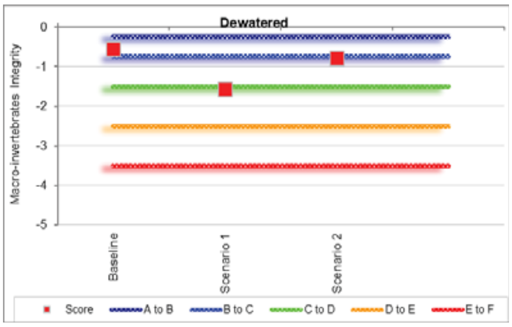
Multiple scenarios, single indicator	*Single scenario with error bounds*
	

2. **Percentage change in indicators from baseline:** Average abundance of each indicator compared to the baseline for scenarios under study, at each site averaged over the entire period.

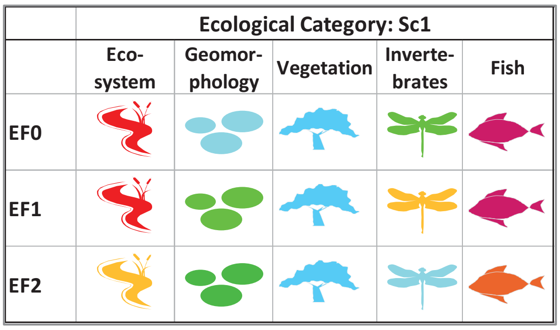
Site EF 1, Vegetation	**Scenario 1**	**Scenario 2**
Aquatic plants on rock	-65.3	-29.2
Aquatic plants in sand	-84.9	-31.3
Emergent graminoids	-21.3	-12.6
Wetbank grasses	-15.9	-11.5
Wetbank shrubs and trees	-7.7	-4.3
Papyrus	-18.2	-9.4
Reeds evergreen	-8.3	-2.9
Reeds dry dormant	-17.0	-12.0
Water hyacinth	-10.4	-5.1
Agg: Aquatic vegetation	-75.1	-30.3
Agg: Marginal and riparian vegetation	-15.0	-9.5

3.	**Discipline integrity:** Average abundance of all indicators in a disipline combined with whether an increase/decrease is a move towards natural

One site and discipline, multiple scenarios

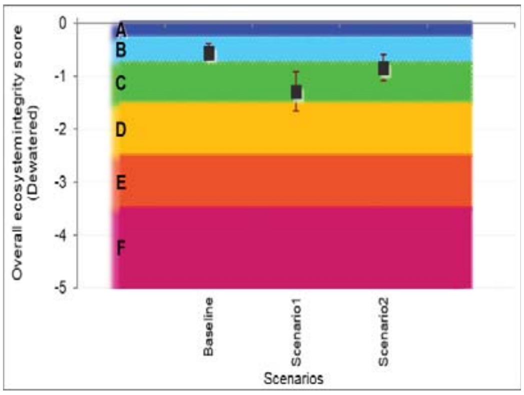


One scenario, multiple sites and disciplines presented as colour coded icons.

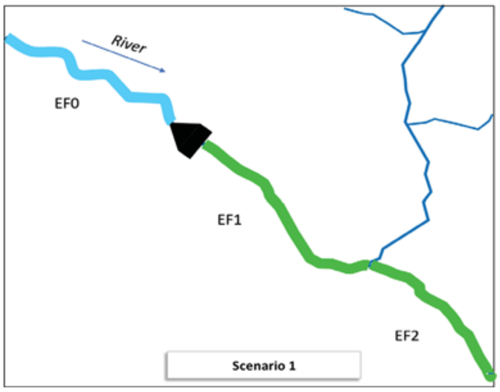


4	**Site integrity:** Combination of all disciplines at a site for an overall site wise comparison

One site, multiple scenarios, with error bounds



Multiple sites, one scenario presented as colored reaches on a map



5.	**Overall ecosystem intergiry for the study area:** Site integrities weighted by the length of the reach they each represent