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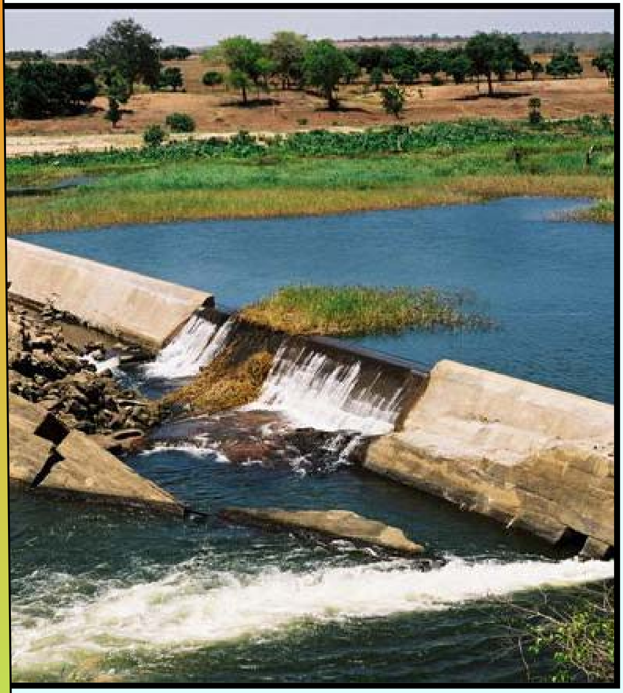

KOMATI CATCHMENT ECOLOGICAL WATER REQUIREMENTS STUDY

EWR REPORT: QUALITY

February 2006

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KOMATI CATCHMENT ECOLOGICAL WATER REQUIREMENTS STUDY

QUALITY REPORT

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Inception Report
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EXECUTIVE SUMMARY

BACKGROUND

The Komati River Catchment was identified by DWAF as a priority catchment for a comprehensive Reserve determination, due to the stressed nature of the catchment, requires the completion of a Comprehensive Reserve assessment before licensing and effective water resource planning can take place for the catchment. The major stresses in the catchment are the high water demands for ESKOM, irrigation, afforestation and industry and rapidly increasing domestic water demands. The water shortages experienced in the area have led to intense competition for the available water resources among user sectors. Planned extensions to irrigation have been put on hold and a substantial portion of the population in the catchment does not have access to basic level of services. Furthermore the large number of dams in the study area not only changes the flow regime but also impacts the water quality.

The Resource Directed Measures Directorate (D: RDM) of DWAF identified that the Komati River catchment requires the completion of a Comprehensive Reserve and the terms of reference for the water quality component of the Ecological Reserve therefore prescribed that water quality be assessed at a Comprehensive level using best available methods. This report forms part of a comprehensive assessment of the Ecological Water Requirements of the Komati River Catchment

AIMS

The terms of reference for the water quality component of the Ecological Reserve prescribed that water quality be assessed at a Comprehensive level using best available methods.

Assumptions and Limitations

Long-term water quality data for the Komati River Catchment were patchy and the relationships with flow were unreliable, so the confidence in the flow-concentration modelling was very low. Furthermore, dilution as a management option is not considered to address water quality problems as part of the Reserve flow requirements.

STUDY AREA

The study area for this project was initially defined by the D: RDM as the Komati River Catchment (X1) within South Africa. This area comprises two distinct sections: Komati West, comprising the area upstream of Swaziland, and Komati North, comprising the area downstream of Swaziland. The study focussed on the Komati River and main tributaries, namely: Lomati, Teespruit, Gladdespuit and Seekoeispruit. In January 2005 the study area was expanded to include Swaziland.

METHODS

Comprehensive methods for the present state assessment of water quality were the updated methods of September 2003 (based on the DWAF methods manual of 2002) for the water quality Reserve, while the technical determination of the benchmarks followed the Stressor-Response method described by Jooste and Rossouw (2002). Water quality consequences of operational flow scenarios were assessed using flow-concentration modelling as a tool for assessing impacts, as well as the physico-chemical approach for assessing water quality impacts as outlined in the EcoClassification manual of Kleynhans et al. (2005). The EcoClassification (or ecological classification) process refers to the determination and categorisation of the Present Ecological State (PES) of various biophysical attributes of rivers compared to the natural/close to natural, reference condition (Kleynhans et al. 2005). This method has been developed to determine a river's EcoStatus, using a systematic and quantitative approach.

Although the updated water quality manual (methods outlined in Palmer et al. 2004) was used to determine present state, the Physico-Chemical Driver Assessment Index (PAI) driver tables in the physico-chemical chapter of Kleynhans et al. (2005) were used to evaluate the water quality consequences of flow scenarios.

Identification of the key water quality issues was based on an assessment of DWAFs existing water quality data, supplemented by additional data collected during the study. Flow concentration modelling was used to assess the water quality consequences of selected operational scenarios at selected sites only (i.e., where there were sufficient hydrological and water quality records). Plotting monthly median concentrations against monthly mean flow data generated flow-concentration relationships. The derived regression relationships were used to convert the flow time-series to a time series of expected concentrations for different flow scenarios.

RESULTS

Limitations in water quality data

All DWAFs long-term monitoring sites include monitoring of the major ions (Mg^+, Na^+, Ca^+, SO_4^-, Cl^-), pH and nutrients (PO_4-P, NO_2, NO_3 & NH_3) and these include sites K1, K2, K3, G1 and L1.

The following were limitations on the available DWAF water quality data per site.

EWR Site	***Available water quality***
K1	*Data available from 1977 to 2005 at X1H018Q01*
K2	*Data available from 1992 to 2004 at Weir X1H001Q01*
K3	*Data available from 1977 to 2004 X1H003Q01*
K5	*Data available from 1993 to 2005 X1H042Q01*
G1	*Data available from 1977 to 2005 X1H029Q01*
S1	*No data except collected for this study*
T1	*No data except collected for this study*
M1	*No data except collected for this study*
L1	*Data available from 2000 to 2004 X1HO49Q1*

None of the sites had the following set of water quality variables that are required for the water quality data to be statistically analyzed per Resource Unit:

- *Chlorophyll-a (some limited data)*
- *Dissolved oxygen*
- *Turbidity*
- *Inorganic salts (DWAF data was converted using Jooste salt balance model)*
- *Temperature*
- *Toxic substances*
    - *Al*
    - *As*
    - *Atrazine*
    - *Cd*
    - *Cr (III)*
    - *Cr (IV)*
    - *Cu*
    - *Cyanide*
    - *Endosulphan*
    - *Pb*
    - *Hg*
    - *Phenol*

The consequences of these limitations were that the flow concentration model could not be run for sites T1, S1, L1 and M1. The flow concentration model was run at the remaining sites, but the modelling method indicated that there was not a correlation between flow and water quality at these sites (either due to for chemical constituents showing an increase in concentration with increasing flow or the available data being too patchy for an appropriate analysis). This is because these pollutants often arise from diffuse sources in the surrounding catchment. It cannot automatically be assumed that if the flow in a river is *decreased, the in-stream concentration of the pollutant will also decrease. This will depend on site-specific factors that require further investigation.*

Water quality trends

The available water quality data was analysed statistical to determine water quality trends per site and between sites. The following table indicates the major water quality trends per EWR site. This approach was used to generate the PAI as well as ecological consequences per flow scenario.

EWR site	***Water quality driver and trend***
K1	*There are two main dams in the upper Komati River (Nooitgedacht and Vygeboom) that have operating rules that are designed to maximise yield The volume of water that is abstracted depends on the available water through inter-basin transfers from the incremental catchment of the east-Vaal Subsystem, which includes the upper Vaal, upper Usutu and upper Vaal Rivers.* *The upper Komati River Catchment is generally in a good ecological condition, with the main impacts relating to dry land farming and forestry. Nooitgedacht Dam does not make any compensatory releases, so low-flows have decreased. Water temperatures are likely to have increased due to reduced low-flows, and nutrients have increased due to trout dams and tourist developments. There is large potential for opencast coal mining in this area, and this may compromise the good quality water that currently characterises the area.*
K2	*Although there is no cessation of flow at K2, the hydrology has changed significantly: Vygeboom Dam releases minimal water and has had moderate impacts on the floods. The middle Komati River Catchment is generally in a moderate ecological condition, with the notable exception of the Gladdespruit River (Resource Unit G), which is in a largely modified condition (Category D). The main impacts in the Gladdespruit relate to trout farms, gold mines, forestry, and excessive encroachment of alien vegetation. The main water quality issues are bacterial problems (cattle grazing, sewage effluent waste water treatment works in the Seekoeispruit and lower Teespruit, runoff from poor sanitation in the area), nutrient enrichment, and some contamination from domestic washing powders.*
K3	*There are two main dams in the Lower Komati River System: Maguga Dam (in Swaziland) and Driekoppies Dam, situated on the Lomati River. The main purposes of these dams are to stabilise river flows, provide for the increase in primary water demand, allow for moderate increase in irrigation development, and assure water supplies to existing irrigation and urban development in the lower Komati Basin. Until such a time as Maguga Dam has sufficient water to supply the lower Komati River, Driekoppies Dam is being used to supply demands as far as Komatipoort. This means that*

EWR site	***Water quality driver and trend***
	baseflows in the lower Lomati River are higher than usual. A large number of weirs were built in the lower Komati River, mainly between 1984 and 1992 with inadequate outlet discharge capacities. As a result, the weirs pose significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations. *The lower Komati River Catchment is in a poor ecological condition. The large number of weirs and associated irrigation in the lower reaches of the river has resulted in a deterioration of the water quality to such an extent that it has become enriched with nutrients and the dissolved oxygen levels become limiting to the ecology.. Ecological conditions at K3 are highly impacted by frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir. Clearing of bank vegetation and sand mining has reduced bank stabilisation and led to alien vegetation encroachment. The main water quality issues are nutrients (with associated benthic algal blooms) and bacterial contamination and increased water temperatures and slight salinisation when the river stops flowing.*
M1	*Maguga Dam has had a significant impact on this site, and instream habitat availability is impacted by dense growth of benthic diatoms possibly associated with the release of cold water.*
G1	*The main impacts in the Gladdespruit are related to a reduction in low-flow due to forestry, water quality problems due to acid mine drainage from old gold mines, sulphates and raw sewerage, erosion and sedimentation, alien invasives and trout dams.*
T1	*The hydrology and geomorphology of the Teespruit have been slightly impacted due to small-scale abstractions. The water quality is in good condition except for the lower section where there is a sewerage works with associated organic pollution*
S1	*The Seekoeispruit is unregulated and so the hydrology is close to natural, with small impacts related to abstraction of low-flows. The riparian is invaded by alien vegetation (mostly wattle), and poor landuse practices have led to erosion and embeddedness of the streambed. The main water quality issues are associated with a number of poorly functioning sewage works and general low level of sanitation throughout the catchment, particularly in the vicinity of Badplaas.*
L1	*The ecosystem at L1 is fairly healthy, although there has been a major change due to the impacts of Driekoppies Dam. The vegetation is greatly modified from natural from a fairly sparsely vegetated channel to a channel with a significant woody vegetation component. Generally the water quality is good and the only potential impacts are due to dissolved oxygen and temperature from upstream regulation.*

Water quality issues are mainly related to nutrient status and fluctuating temperature and oxygen levels due to flow regulation in the catchment. The Present Ecological State assessments for water quality are shown below in table below, as well as the water quality category used to design quality EcoSpecs.

EWR Site	***PES***	***REC***
K1	*B*	*B*
K2	*B/C*	*B/C*
K3	*D*	*D*
G1	*C*	*C*
T1	*C*	*C*
M1	*B/C*	*B/C*
L1	*B/C*	*B/C*

Although flow scenarios do impact on water quality, impacts are generally not significant enough to change water quality status to another category.

The current water quality status is shown in the table below, as well as the water quality category used to design quality EcoSpecs.

Water Quality Unit and EWR site	**PES: water quality(methods manual)**	**PES: water quality (EcoClassification approach)**	**Recommended water quality category of the overall REC (quality EcoSpecs)**
WQU 1	**B**	**B**	**B**
WQU 2: K1 Gevonden	**B**	**B/C**	**B**
WQU 3: K2-Kromdraai	**B/C**	**C**	**B/C**
WQU 4: G1 – Vaalkop	**B/C**	**C**	**B/C**
WQU 5: S1 – Seekoeispruit	**B/C**	*****	**B/C**
WQU 6: T1-Teespruit	**C**	**C**	**C**
WQU 7: K3-Tonga	**C/D**	*****	**C/D**
WQU 8: K5	**D**	*****	**D**
WQU 9:	**B**		**B**
WQU 10: L1-Kleindoringkop	**B/C**	**B/C**	**B/C**
WQU 11 Mtsoli	**A/B**	*****	**A/B**
M1: Silingani	**B/C**	**B**	**B/C**

CONCLUSIONS AND RECOMMENDATIONS

This report has provided an assessment of water quality conditions for the Komati Ecological Water Resource study. The river is generally in a Good - Fair condition in terms of water quality, with a hot spot occurring at the lower Komati, down to the confluence with the Crocodile River.

Water quality is generally not the driver of the overall EcoStatus of rivers in the study area, as parameters such as flow and the status of the riparian vegetation are more instrumental in determining the health of the river.

The water quality data available for the EWR sites in the Komati River did not enable the flow concentration modelling to be undertaken. This was due to either there not being sufficiently long a data set available for the PES and reference condition; or that there was not a strong enough correlation between concentration and flow present for selected variables for time-series modelling to be carried out.

The flow scenarios that would improve water quality in the lower reaches are those scenarios that include improved (from present) baseflows (Scenario 6). The scenarios that would improve the water quality are 3, 6.1 and 6.2.

The recommended flows for the lower Komati, which is in a bad ecological condition, are designed to restore perenniality through improved baseflows. However, these actions alone will be inadequate. There is a need to reduce irrigation return flows and inundation from weirs. The Inkomati Catchment Management Agency could play a vital role in co-ordinating efforts to improve the riparian zone as a buffer, control deforestation, control cultivation and grazing in riparian zone, and reduce fragmentation caused by weirs.

The options for improving the water quality are related to realities in the catchment, which include:

- *ESKOM: The strategic demands by ESKOM in the upper catchment provide limited scope for improved flows.*
- *Dams: The ecological conditions downstream of large dams have changed irreversibly from historical reference conditions and it was considered unrealistic to recommend an improvement in current conditions.*
- *Weirs: The ecology of the lower Komati River has been severely impacted by a large number of weirs and associated irrigation development. These have had a major impact on habitat availability and low flow conditions in particular.*
- *Non-flow related impacts: Many of the reasons for ecological degradation in the Komati River are unrelated to flow, so improved flows alone are not going to solve the problems (for example high social and cultural value) and improved landuse practices due to the conversion of land from agriculture to conservation.*

The water quality assessment methods used for the Reserve needs to be refined and a consolidate method produced. For example the assessment of water quality was conducted carrying out methods updated from DWAF (2002), as well as the EcoClassification approach as outlined in Kleynhans et al. (2005). Although the methods should be used together, i.e. the PES assessment using DWAF methods is used to populate the ratings tables in the EcoClassification manual, there are no instructions in either manual as to how this procedure should take place. The EcoClassification approach will also be using a model developed by Jooste of RQS, DWAF. A water quality manual should therefore be developed which includes instructions on how all these tools must be used to conduct a water quality assessment in an EWR study.

Further development is also required around the integration of water quality and quantity. Although flow-concentration modelling was used for this study, it was of little value as the available data did not lend itself to modelling.

Jooste's inorganic salt assessment method, as well as the other variables that are being planned for incorporation into this model, need to be made readily available for Reserve practitioners. The current inorganic salt model requires a manipulation to occur as the DWAF monitoring only measures salts such sodium, magnesium etc and this need then to be converted to inorganic salts. This method needs further refinement to include variables other than salts.

The water quality linkage that is currently being finalized in SPATSIM needs also to be to be made readily available for Reserve practitioners.

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ACRONYMS

D: RDM	Directorate: Resource Directed Measures
DSS	Decision Support System
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category / Electrical Conductivity (context-dependent)
EWR	Ecological Water Requirements
ISP	Internal Strategic Perspective
KNP	Kruger National Park
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MSL	Mean Sea Level
MV	Marginal vegetation
nMAR	Naturalised Mean Annual Runoff
NWA	National Water Act
PAI	Physico-Chemical Driver Assessment Index
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
RU	Resource Unit
SPATSIM	Spatial and Time Series Information Modelling (software)
SRP	Soluble Reactive Phosphorous
TIN	Total Inorganic Nitrogen
TP	Total Phosphorous
TSOFT	Time Series Display and Analysis Software
WMA	Water Management Area
WMS	Water Management System
WQU	Water Quality Unit
WR90	Surface Water Resources of South Africa, 1990
WWTW	Waste Water Treatment Works
WQ	Water Quality

GLOSSARY

DROUGHT FLOW	The minimum flow required facilitating the survival of the riverine ecosystem in a particular condition and over short, infrequent periods, when users are subject to water restrictions. In the Komati River System, Drought flows were defined as low-flows that occur less than 10% of the time under natural conditions for each month.
ECOLOGICAL CATEGORY	A category indicating the potential management target for a river. Values range from Category A (unmodified, natural) to Category D (largely modified). This term replaces former terms used, namely: Ecological Reserve Category (ERC), Desired Future State (DFS) and Ecological Management Class (EMC). The reasons for these changes are explained in the proceedings of a workshop to clarify the terminology used in Reserve determinations (DWAF 2003). It should be noted that a distinction is made between Management Classes, which form part of the National Classification System, and Ecological Categories, which forms part of the Ecological Water Requirement assessment.
ECOSPECS	Clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity) that defines the Ecological Category. The purpose of EcoSpecs is to establish clear goals relating to resource quality (Kleynhans *et al.* 2005).
ECOSTATUS	An overall assessment of the Ecological Category (A-F), based on rule-based integration of specialist indices (water quality, fish, etc). Ecostatus refers to the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services" (Iversen *et al.* 2000, *In* IWR Environmental 2003).
ECOLOGICAL WATER REQUIREMENTS (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.

INSTREAM FLOW REQUIREMENTS (IFR)	The flow patterns (magnitude, timing and duration) needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to the quantity component only of Ecological Water Requirements.
MAINTENANCE FLOW	The flow required to meet the requirements of the riverine ecosystem at a particular site and maintain the resource base in a particular condition during "normal" climatic years. The distinction between "normal" and "drought" was based on an examination of monthly flow duration curves. For the Komati River System, "normal" low-flows were defined as those that occur at or more than 30% of the time under natural conditions for each month.
PRESENT ECOLOGICAL STATE (PES)	The degree to which ecological conditions of an area have been modified from natural (reference) conditions. The measure is based on water quality variables, biotic indicators and habitat information collected 1 to 3 years prior to the assessment. Results are classified on a 6-poin scale, from Category A (*Largely Natural*) to Category F (*Critically Modified*).
REFERENCE CONDITION	Natural ecological conditions, prior to human development.
RESERVE	The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems under the National Water Act, 1998 (Act No. 36 of 1998) in order to secure ecologically sustainable development and use of the relevant water resource. The Reserve refers to the modified Ecological Water Requirement, where operational limitations, and stakeholder consultation are taken into account.
RESOURCE QUALITY OBJECTIVE	Quantitative and auditable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection. This term takes into account the management *classes* and the requirements

	of other users. These components are not addressed in this project
RESOURCE UNIT	Stretches of river that are sufficiently ecologically distinct to warrant their own specification of Ecological Water Requirements, and that can be practically managed as a single unit.

1 INTRODUCTION

1.1 BACKGROUND

The National Water Act (NWA, Act No. 36 of 1998, Section 3) requires that the Reserve be determined for rivers, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. It is therefore imperative that the Reserve is determined and its requirements are met before the needs of other economic activities can be satisfied. As the Department of Water Affairs and Forestry (DWAF) is the custodian of the nation's water resources, it is their responsibility to ensure the adequate protection and effective management of these resources

The Directorate: Resource Directed Measures (D:RDM) is tasked with the responsibility of ensuring that the Reserve requirements, which have priority over other uses in terms of the Act, are determined before license applications are to be processed. Water resources in the Komati River Catchment (Water Management Area 5) are fully allocated, and the full implementation of the Reserve will almost certainly result in curtailment of water allocations once the compulsory licensing process is implemented. A comprehensive determination of the Reserve is therefore needed for the Komati River Catchment. Because the Komati is a shared watercourse, international obligations have to be taken into consideration as well as the operating rules in Swaziland that will impact on the downstream ecological water requirements.

The D: RDM identified that the Komati River Catchment requires a comprehensive Reserve assessment before licensing can take place due to the stressed nature of this catchment. The available water resources cannot meet all the water requirements of the users in these catchments, without trade-off among water user sectors. The Reserve determination process for the Komati Catchment was initiated in 2003 and is made up of a number of studies. This report describes the process and results of the assessment conducted for the water quality component of the Ecological Reserve. The tasks addressed during this report are therefore those related to water quality only. The objective of this assessment is therefore to provide quantified and descriptive information regarding flows and associated concentrations of water quality constituents, which describe both the present state of the system and conditions for the selected Ecological Categories (EC).

1.2 WATER QUALITY IN THE ECOLOGICAL RESERVE

One of the underlying principles of the National Water Act (Act 36 of 1998) and DWAF's water resource strategy is that of water resource protection to ensure long-term sustainable use for people. Water resource protection and long-term use is therefore linked to the goods and services provided by the river. The Ecological Reserve determination for water quality encompasses a description of the current water quality status and therefore the river's capacity to provide services such as waste assimilation, how much it has changed from its reference state, and what water quality status is needed to sustain a particular level of ecosystem health or Ecological Category (EC).

Although the Ecological Reserve approach assesses frequency, magnitude and duration for flow, the same is not true for water quality. Water quality assessments still focus on magnitude (primarily the concentration of chemical constituents), with water quality modelling incorporating some degree of duration, where applicable. The water quality approach is therefore still primarily a hazard, and not risk-based, approach (DWAF 2002). Hazard can be described as a state that may result in an undesired event, whereas risk includes the *probability* of that event. Risk therefore results from the existence of a hazard and uncertainty about its expression or effect.

The terms of reference for the water quality component of the Ecological Reserve for the Komati catchment study area prescribed that water quality be assessed at a comprehensive level using best available methods. Comprehensive methods are the updated methods of September 2003 for the water quality Reserve found on the Ninham Shand web-site *http://projects.shands.co.za/Hydro/hydro/WQReserve/main.htm* and outlined in Palmer *et al*. (2004). These methods are based on a manual produced for DWAF in 2002, entitled *Assessing water quality in ecological reserve determinations for rivers: Version 2, Draft 15.0, March 2002*, and discussions held at a workshop in Grahamstown in July 2003 regarding the water quality Reserve.

One of the objectives of current research around EWR assessments was to incorporate all the methods necessary to undertake an EWR assessment in SPATSIM (Spatial and Time Series Information Modelling software), an integrated information storage and modelling system developed by Prof Denis Hughes of the Institute for Water Research, Rhodes University. Water quantity methods have already been incorporated and used via this storage system, and water quality methods are currently being incorporated as part of a Water Research Commission-funded DSS project. Although the text of the methods has been included in SPATSIM, methods cannot yet be used through this storage system, as calculations cannot be undertaken as yet (Hughes, IWR, *pers. comm.).* Some of the methods have not been included, e.g. Jooste's inorganic salt assessment method, as the latest version of this method is not yet available from Dr Jooste. Although methods are currently being finalized in SPATSIM, this operating system was not available for use by the Komati water quality team.

The generic 8-step Ecological Reserve procedure is shown in Figure 1.1. The detailed steps of the water quality Reserve are shown in Figure 1.2 (which also shows the links between water quality and quantity), and Table 1.1. The information was taken from the water quality manual on the Ninham Shand web site, and modified at a March 2005 water quality EcoClassification workshop that has been included in Kleynhans *et al*. (2005).

1.2.1 EcoClassification

The EcoClassification (or ecological classification) process refers to the determination and categorisation of the Present Ecological State (PES) of various biophysical attributes of rivers compared to the natural/close to natural, reference condition (Kleynhans *et al*. 2005). This method has been developed to determine a river's Ecostatus using a systematic and quantitative approach. The state of the river is therefore expressed in terms of its following biophysical components.

- Drivers (physico-chemical (as describes the chemical component of water quality only), geomorphology, hydrology) which provide a particular habitat template, and
- biological responses (fish, riparian vegetation and aquatic invertebrates).

Although the updated water quality manual (methods outlined in Palmer *et al*. 2004) was used to determine present state, the Physico-Chemical Driver Assessment Index (PAI) driver tables in the physico-chemical chapter of the EcoClassification training manual were used to evaluate the water quality consequences of flow scenarios (Kleynhans *et al*. 2005).

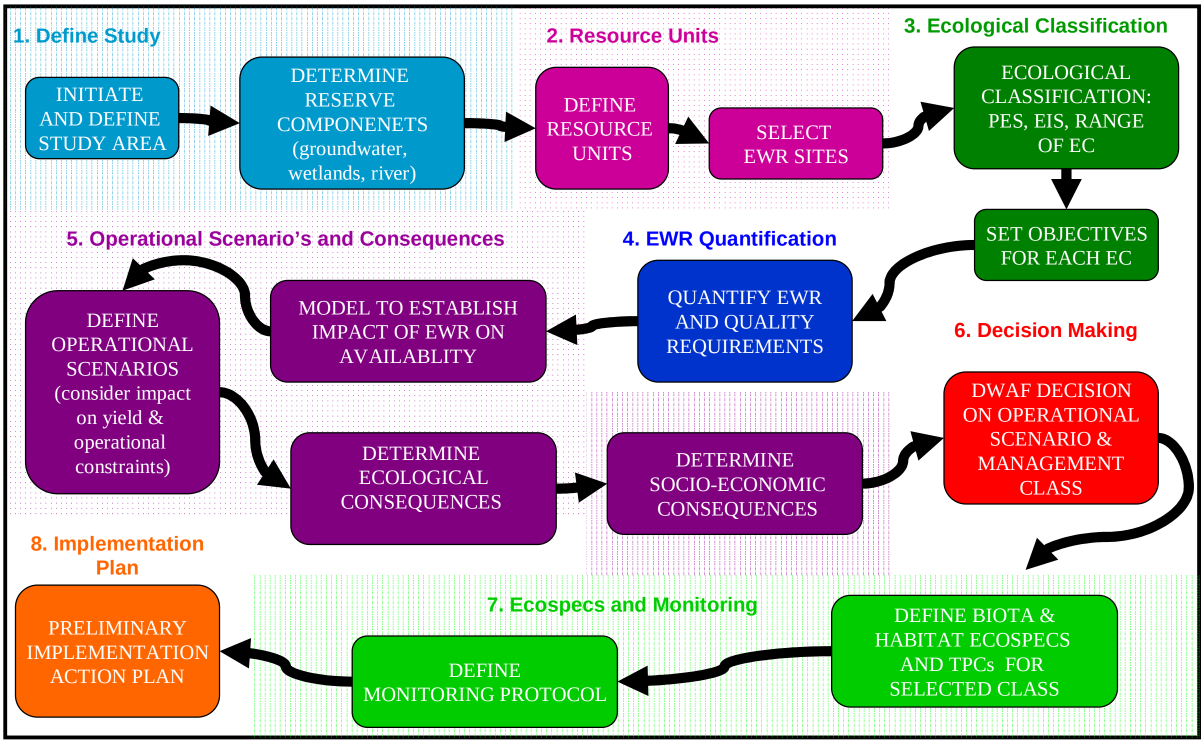

Figure 1.1: The 8-step Ecological Reserve procedure (DWAF 2003).

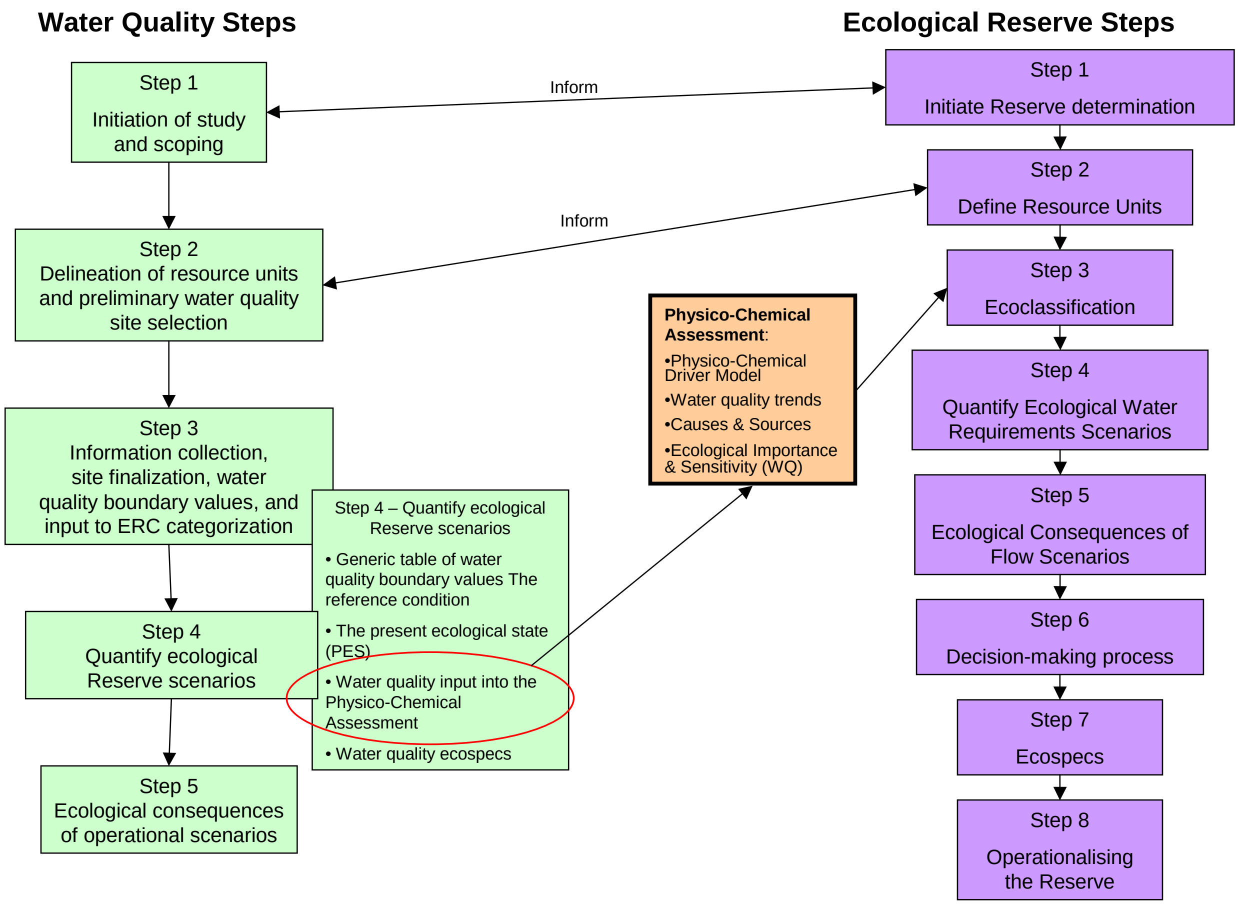

Figure 1.2: Flow diagram indicating the general approach for the water quality component of the Ecological Reserve determination study, as well as links between water quality and quantity.

Table 1.1: Summary of the 5 steps taken for the water quality component of the Ecological Water Requirement Assessment study.

Steps in the Reserve process	Quality component of the Ecological Reserve determination
1. Initiate Reserve determination • **Study area** • **Level, method and components** • **Study team**	<u>Step 1: Initiate study and scoping</u> 1) Study domain: Geographic scope • Length of river, tributaries, note point sources and refugia, level of confidence 2) Finalisation of water quality variables • 1. Obligatory, 2. Standard list, 3. Optional additions that may need method development. For 3 take account of local geology, discharges and impacts, add variables on a site-specific basis
2. Define Resource Units	<u>Step 2: Delineation of Resource Units (RU) and preliminary water quality units (WQU) selection</u> 1) Delineation of Resource Units • Ecoregions, dams, tributaries = resource unit • Towns and pollution point-sources may define additional water quality units 2) Preliminary site selection • Map physico-chemical and biomonitoring sites, screen data availability e.g.

	length of dataset
3. Define Ecological Categories and recommend	Step 3: Information collection, site finalisation, water quality boundary values and input to EC categorization or EcoClassification 1) Data preparation • Take account of inadequate data, and potential for modelling/extrapolation 2) Site finalisation • RU may need to be spilt into WQU. If there are data gaps data can be extrapolated within RU (note changes in confidence), but not between RU. Data gaps signal need for data collection. 3) Water quality boundary values • Generic boundary-value tables • Reference condition • Present ecological state (PES) 4) Input to EC categorization or EcoClassification • Water quality variable categories to be represented by an overall water quality category • Trends of change • Input into Ecological Importance and Sensitivity
4. Quantify ecological scenarios	Step 4: Quantify Ecological Reserve scenarios 1) Take water quality boundary values + insights from EC workshop 2) EcoSpecs • Per WQU, boundary values for each variable, level of confidence • Clarifying comments, narrative descriptions linking values to site-specific information, including refugia and impact sources 3) Flow-concentration modelling • Apply flow-related information to ecological flow recommendations • Note where flow recommendation would mean WQ boundary conditions violated
5. Ecological consequences of operational scenarios (quantity and quality). Yield consequences of EWRs	Step 5: Ecological consequences of operational scenarios 1) Input into yield scenarios (use flow concentration modelling) 2) Input in water quality operational scenarios

Note that categories are described as Natural (Category A) to Poor (Category D) in the methods manual, but as the Reserve process requires categories A – F, all benchmark tables had to be recalibrated accordingly.

According to the updated method above the following water quality data needs to be statistically analyzed per Resource Unit:

pH Chlorophyll-*a* SASS Dissolved oxygen Soluble reactive phosphates (SRP) – median Total inorganic nitrogen (TIN) median (NO_2 + NO_3 + NH_3) Salts • $MgSO_4$

- Na_2SO_4
- $CaCl_2$
- NaCl
- $CaSO_4$

Temperature

Toxic substances

- Al
- Ammonia
- As
- Atrazine
- Cd
- Cr (III)
- Cr (IV)
- Cu
- Cyanide
- Endosulphan
- Flouride
- Pb
- Hg
- Phenol

Turbidity

1.3 PURPOSE OF THIS REPORT

The purpose of this report is:

- To provide a present state assessment for water quality per Water Quality Units (WQUs) that was delineated in the Resource Units Report (AfiDev 2005a).
- To provide a description of how flow-concentration modelling can be used to integrate water quality and water quantity during the EWR process.
- To provide the water quality consequences of a range of predicted flow scenarios.
- To provide ecological specifications for water quality for each selected EWR site.

2. STUDY AREA

2.1 INTRODUCTION

The study area for this project was defined by the D: RDM as the Komati River Catchment (X1) within South Africa. This area comprises three distinct sections: Komati West, comprising the area upstream of Swaziland, Swaziland and Komati North, comprising the area downstream of Swaziland. The study focussed on the Komati River and main tributaries, namely: Lomati, Teespruit, Gladdespruit and Seekoeispruit (see Figure 2.1). The Study Area was subsequently extended to include Swaziland. Seven sites were selected for EWR assessment (Table 2-1).

Table 2.1: Details of EWR Sites selected, arranged in order downstream.

Site Name	River	Resource Unit	Locality
Komati River			
K1-Gevonden	Upper Komati	B	25^o 51' 15.6"S; 30^o 22' 35.9"E
K2-Kromdraai	Upper Komati	C	26^o 02' 19.7"S; 31^o 00' 11.3"E
M1-Silingani	Middle Komati	Maguga	26^o 38’ 12.8”S; 31^o 23’ 53.5”E
K3-Tonga	Lower Komati	D	25^o 40' 01.1"S; 31^o 48' 04.8"E
Tributaries			
G1-Vaalkop	Gladdespruit	G	25^o 46' 18.2"S; 30^o 37' 37.8"E
T1-Teespruit	Teespruit	T	26^o 01' 09.5"S; 30^o 51' 07.3"E
L1-Kleindoringkop	Lomati	M	25^o 38' 58.0"S; 31^o 37' 23.5"E

There are several dams in the study area that impact the flows in the systems and also the water quality at various sites. The Hydrology and System Operation Report (AfriDev 2005b) and the capacity of the dams to release water was taken into account when running certain scenarios, and the following maximum outlet capacities were applied at each regulated EWR site:

- **K1** = 13 m^3/s (max release capacity of Nooitgedacht Dam);
- **K2** = 20 m^3/s (max release capacity for Vygeboom Dam);
- **K3** = 60 m^3/s (max release capacity for Maguga Dam);
- **M1** = 60 m^3/s (max release capacity for Maguga Dam), and;
- **L1 = 34 m^3/s** (max release capacity for Driekoppies Dam).

2.2 RESOURCE UNITS

The Study Area was delineated into ten Resource Units (RU) prior to the selection of EWR sites (Figure 2-2). These are stretches of river that are sufficiently unique to warrant their own EWR and that can be managed as separate entities. In January 2005 the Study Area was extended to include Swaziland adding an additional RU, between Maguga Dam and Bhalekane Bridge (Table 2-2). The following RUs were delineated:

Komati River

- RU A: Upstream of Nooitgedacht Dam
- RU B: Nooitgedacht Dam to Vygeboom Dam
- RU C: Vygeboom Dam to Maguga Dam
- RU Maguga: Maguga Dam to Balekane Bridge
- RU D: Balekane Bridge to Lomati River Confluence
- RU E: Lomati River confluence to Komatipoort

Tributaries

- RU L: Lomati River upstream of Driekoppies Dam
- RU M: Lomati River downstream of Driekoppies Dam
- RU T: Teespruit
- RU S: Seekoeispruit
- RU G: Gladdespruit

Seven sites were originally selected for assessment. Two sites became inundated during the course of the study due to the upgrading of weirs, while an additional site in Swaziland was included in January 2005. The process of selecting sites was based on an examination of river video footage taken during a helicopter survey in July 1997 and June 2003 and subsequent ground-truthing by a full team of specialists. A detailed description of the process of delineating resource units and selecting sites is presented in the Resource Unit Report (AfriDev 2005a).

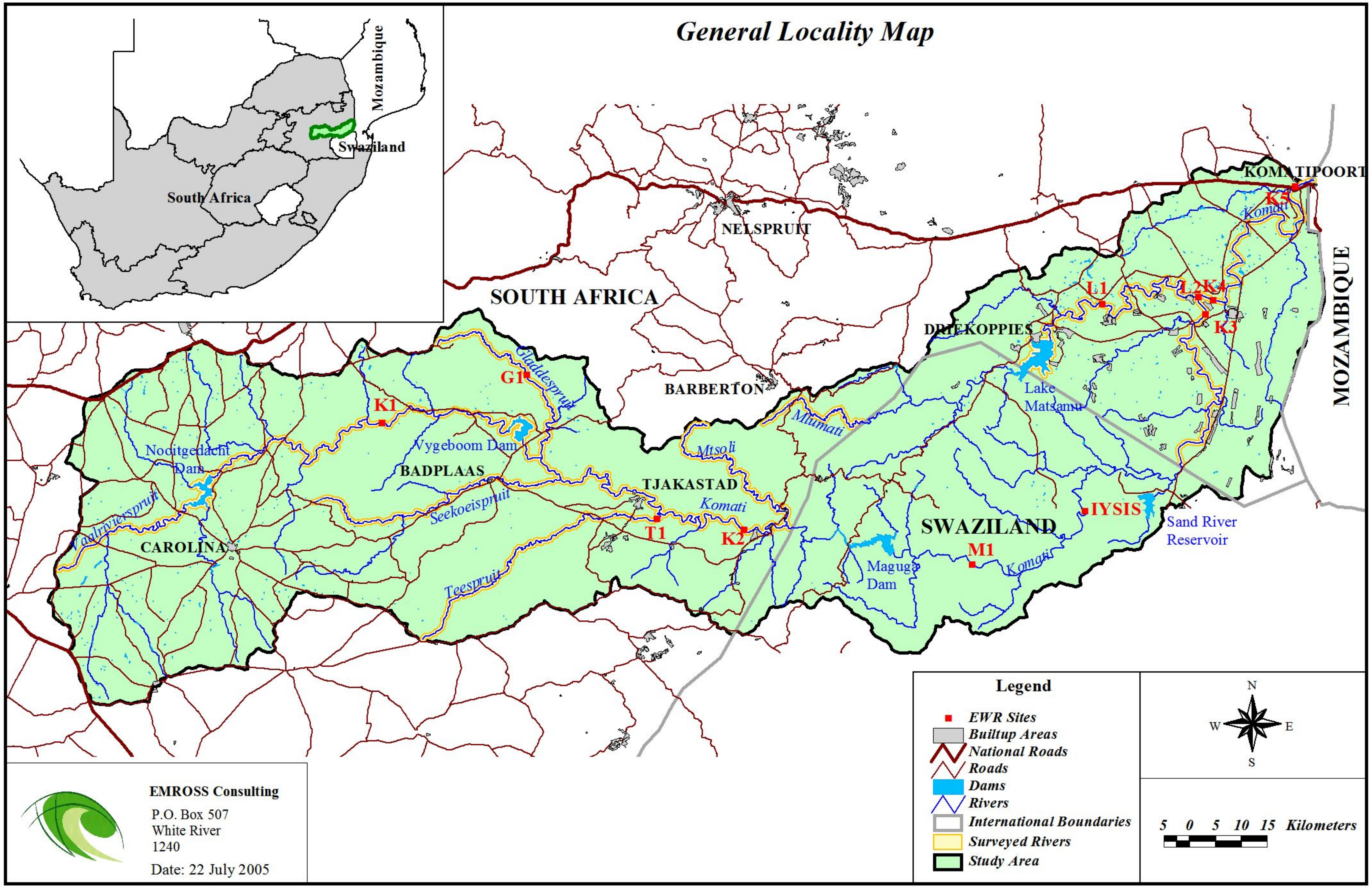

Figure 2.1: General locality map of the Komati River Basin, showing main rivers, tributaries, towns, dams and EWR sites.

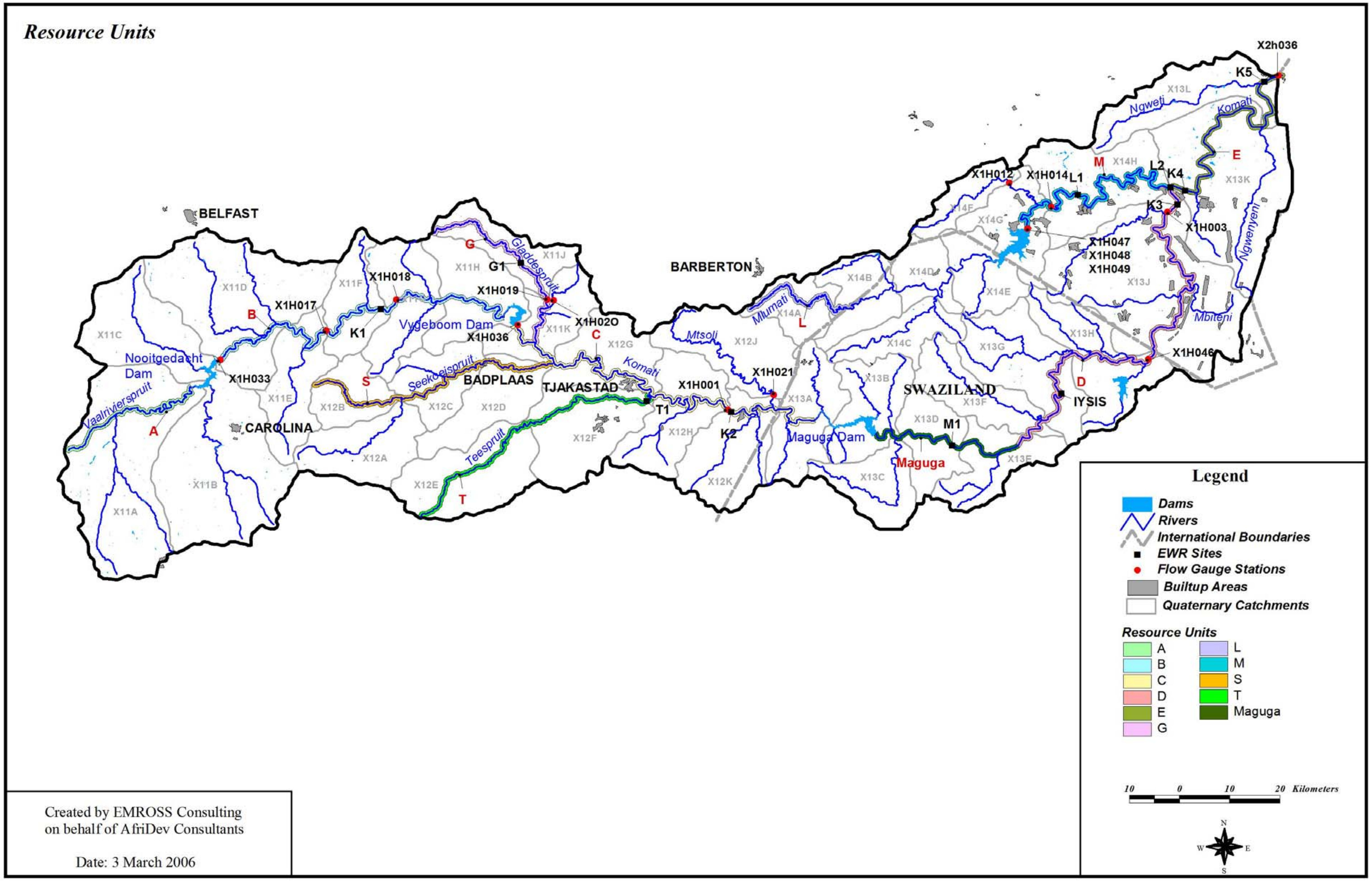

Figure 2.2: General locality map of the Komati River Basin, showing Resource Units.

3 WATER QUALITY DATA AVAILABLE AND SUMMARY OF WATER QUALITY UNITS

3.1 AVAILABLE WATER QUALITY INFORMATION

The following information was used to conduct the present state assessments listed in this document.

- Literature regarding water quality issues in the catchments.
- Information supplied by Dr Rob Palmer from previous studies on the Komati River.
- Information supplied by DWAF Regional Office in Nelspruit.
- Specific National water quality data received from DWAF's head office for the Komati catchment (see Table 3.1)
- Results of water quality samples collected by members of the project team and analyzed by Resource Quality Services (RQS) of DWAF (see Table 3.2).
- Benthic community composition (macroinvertebrates, ASPT and SASS5 scores) was sourced from the invertebrate specialist of the Komati Reserve study for the EWR sites (intensive invertebrate monitoring conducted); other data such as the invertebrate class data was accessed from Dr Rob Palmer.
- Chlorophyll-*a* analyses were undertaken at selected impoundments in the catchment as an indicator of algal abundance, during the field surveys in 2003 and 2004. Samples were also sent to RQS for phytoplankton results but these samples were lost at RQS.
- No instream toxicity tests were undertaken
- Toxics are listed and assessed when data are available.
- As a method does not exist for assessing the present state of turbidity, results are compared to the domestic use Target Water Quality Range (TWQR), as aquatic ecosystem guidelines do not exist.

TWQR for domestic use – turbidity: 0 – 1 NTU (DWAF 1996).

Information sources for water quality include the DWAF National monitoring programme, and published reports (e.g., King and Tharme 1994, Ninham Shand 1994).

3.1.1 DWAF water quality data

The Department of Water Affairs and Forestry conducts an ongoing water quality monitoring programme on the Komati River. Historical and current water quality-monitoring sites shown in Table 3.3 and their localities in Figure 3.1. Not all monitoring sites are currently being monitored (as indicated), but there are long-term monitoring sites for most of the preliminary Resource Units identified. Most of the available data are short in duration, with some data starting during the mid 1960's, but most records start in the late 1970's and 1980's (JIBS 2000).

All DWAFs long-term monitoring sites include monitoring of the major ions (Mg^+, Na^+, Ca^+, SO_4^-, Cl^-), pH and nutrients (PO_4-P, NO_2, NO_3 & NH_3). Additional sampling will be required for dissolved oxygen.

The sites provided in Table 3.1 generally have medium to high confidence, with moderate-term data sets, and some of the parameters monitored required for this study. The exceptions are chlorophyll *a*, dissolved oxygen and biocides, which would require special investigation.

Table 3.1: DWAF water quality monitoring points availably, data duration and EWR site represented in Komati River Catchment within South Africa.

DWAF Code	Site name and EWR represented	No.	Start date	End date
X1H001Q01	Komati River At Hooggenoeg **K2**	262	31/10/1977	29/03/2005
X1H003Q01	Komati River At Tonga **K3**	936	01/03/1977	22/03/2005
X1H012Q01	Mhlambanyati River At Rusoord	86	15/11/1977	25/12/1991
X1H014Q01	Mlumati River At Lomati	602	27/03/1972	15/03/2005
X1H016Q01	Buffel Spruit At Doornpoort	450	10/04/1977	14/03/2005
X1H017Q01	Komati River At Waterval **K1**	20	11/12/1979	11/04/2002
X1H018Q01	Komati River At Gemsbokhoek **K1**	297	12/04/1977	15/03/2005
X1H019Q01	At Vriesland On Gladdespruit **G1**	146	13/04/1977	20/11/1996
X1H020Q01	Poponyane River At Vriesland **G1**	267	13/04/1977	20/11/1996
X1H021Q01	Mtsoli River At Diepgezet	256	31/10/1977	29/03/2005
X1H027Q01	Canal From Gladdespruit At Vriesland **G1**	6	18/06/1992	22/05/2002
X1H029Q01	Canal From Popenyane River At Vriesland **G1**	7	18/06/1992	08/07/2004
X1H033Q01	Nooitgedacht Dam On Komati River: Down Stream Weir **K1**	95	19/04/1983	07/07/2004
X1H036Q01	Vygeboom Dam On Komati River: Down Stream Weir **K1**	117	29/03/1982	30/03/2005
X1H042Q01	Komati River At Komatiepoort/Old Road Bridge **K5 ****	116	12/01/1993	15/03/2005
X1HO49Q1	**L1:** Kleindoringkop	93	2000	2004
X1R001Q01	Nooitgedacht Dam On Komati River: Near Dam Wall **K1**	185	23/01/1970	15/02/2005
X1R003Q01	Vygeboom Dam On Komati River:	111	17/03/1975	15/03/2005

DWAF Code	Site name and EWR represented	No.	Start date	End date
	Near Dam Wall **K1**			

**Selected for monitoring purposes only.

3.1.2 Water quality data collected during the study

From the existing DWAF data in Table 3.1, it can be seen that there was no water quality data available for the Seekoeispruit or the Teespruit and hence an initial field survey was undertaken on the Komati River study area, in August 2003. This survey enabled water quality samples to be collected at selected points as well as land use information to be recorded. Follow up surveys undertaken by members of the project team enabled more water quality samples to be collected (See Table 3.2). The water quality samples collected were analysed by Resource Quality Services (RQS), DWAF. These points were registered on DWAF's Water Management System (WMS), the repository for national water quality data.

Table 3.2: Sites and dates of water quality data collected during study.

Site	Aug 03	Sep 03	Oct 03	Nov 03	Dec 03	Jan 04	April 04	May 04
G1 - Vaalkop	X					X	X	
K1 Gevonden	X		X	X		X	X	
K2-Kromdraai			X	X		X	X	
K3-Tonga			X	X			X	
Tonga Upstream								X
K4-Elsane						X		
K5-X1H042Q1		X	X	X	X	X		X
T1-Teespruit			X	X		X	X	
L1-Kleindoringkop				X		X	X	X
Driekoppies Dam				X				X
Vygeboom Dam							X	
Nooitgedacht							X	
S1 - Seekoeispruit								
M1-Silingani						X		X

3.2 SUMMARY OF WQU IN THE KOMATI RIVER

Delineation of Water Quality Units (WQU's) was based on the methods for assessing water quality in ecological Reserve determinations for Rivers (DWAF 2002). The WQU's for the Komati River are indicated in Figure 3.1 and details of these units can be found in Komati Resource Unit Report (AfriDev 2005a).

Eleven water quality units were recognised within the Study Area as follows (Figure 3.1):

1. Upper Komati: Headwaters of Komati upstream and down to Nooitgedacht Dam
2. Upper Komati: Nooitgedacht Dam to Vygeboom Dam
3. Upper Komati: Vygeboom Dam to Swaziland
4. Gladdespruit
5. Seekoeispruit
6. Teespruit
7. Lower Komati: From Swaziland to the confluence with the Lomati River (Mananga to Tonga)
8. Lower Komati: From the confluence of the Lomati River to the confluence with the Crocodile River (Tonga to Crocodile Bridge)
9. Lomati: Upper Lomati to Swaziland
10. Lomati: Lower Lomati from Driekoppies Dam to the confluence with the Komati River
11. Mtsoli River from headwaters to confluence with Komati River

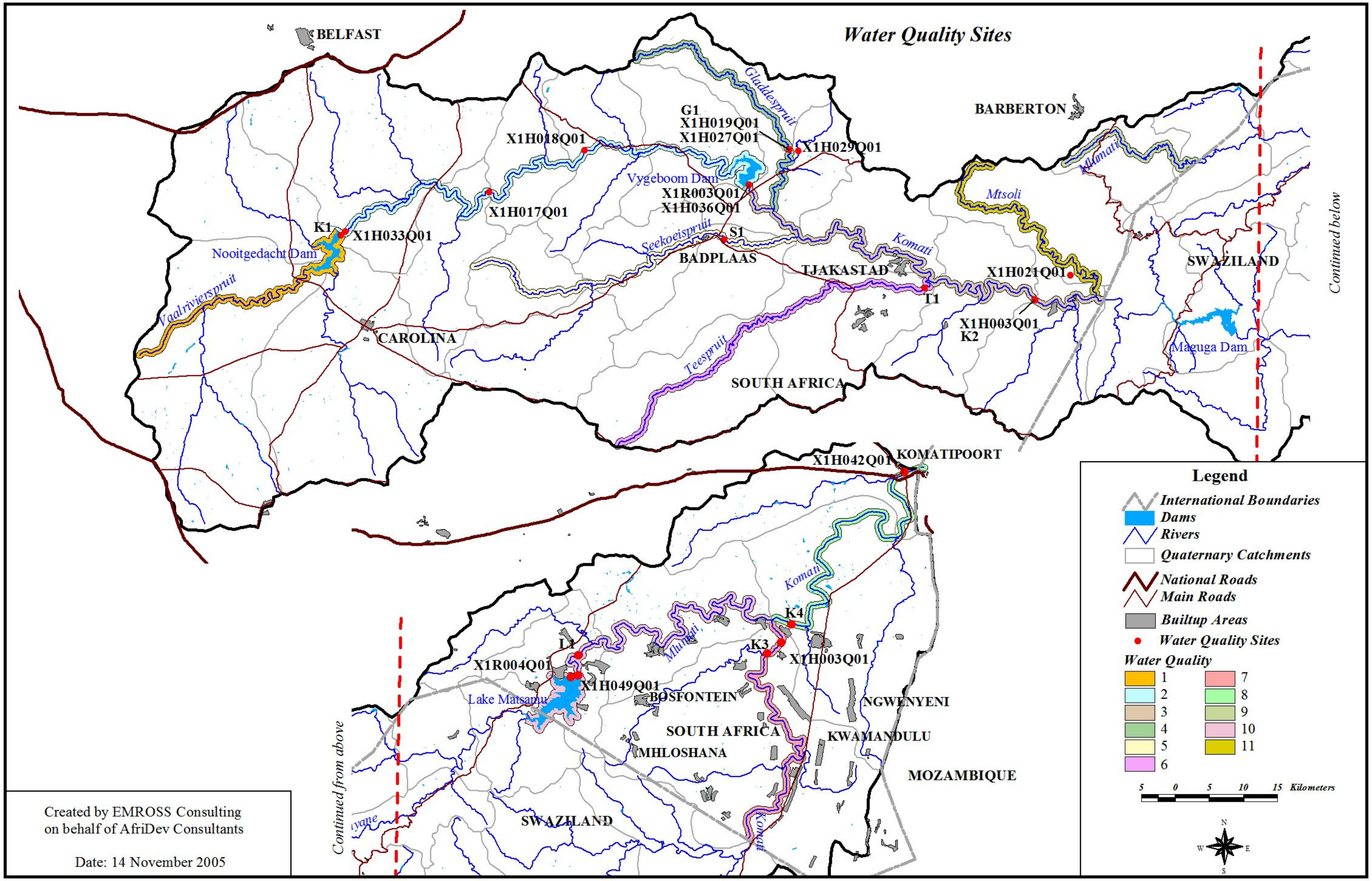

Figure 3.1: Water Quality Units and DWAF monitoring points for the Komati River.

3.3 WATER QUALITY SUMMARY IN THE KOMATI RIVER

A preliminary statistical water quality assessment was undertaken on the existing data (Appendix A). This statistical analysis divided the data into three sets namely (depending on the available data):

- Full data set
- Latest five years (Present status)
- Earliest five years (reference condition)

3.3.1 Water quality per WQU

Table 3.3 is a brief assessment of the water quality issues per WQU.

Table 3.3: Water Quality Units (WQUs) and descriptive information on the water quality issues.

WQU no.	Description	Land use activities and implications for water quality
1	**UPPER KOMATI** Headwaters of Komati upstream and down to Nooitgedacht Dam	Land use mainly commercial farming. There are four opencast coal mines in the upper catchment. There is large potential for opencast coal mining in this area, and this may compromise the good quality water that currently characterises the area. There are small nutrient inputs from farming along the steep banks of the river. No major water quality problems.
2	**UPPER KOMATI** Nooitgedacht Dam to Vygeboom Dam	Land use mainly cultivated lands and extensive grazing. There are two main dams in the upper Komati River (Nooitgedacht and Vygeboom) that have operating rules that are designed to maximise yield The volume of water that is abstracted depends on the available water through inter-basin transfers from the incremental catchment of the east-Vaal Subsystem, which includes the upper Vaal, upper Usutu and upper Vaal Rivers. The upper Komati River Catchment is generally in a good ecological condition, with the main impacts relating to dry land farming and forestry. The Nooitgedacht Dam does not make any compensatory releases, so low-flows have decreased. Water temperatures are likely to have increased due to reduced low-flows, and nutrients have increased due to trout dams and tourist developments. Water quality problems relating to changes in river discharges caused by the transfers from the Nooitgedacht Dam by Eskom. Only surface warm water spills from Nooitgedacht Dam. Despite this there are no difference in water quality between the Nooitgedacht Dam and Vygeboom Dam
3	**UPPER KOMATI**	Land use mainly extensive grazing, limited cultivated lands and villages. Although there is no cessation of flow at K2,

WQU no.	Description	Land use activities and implications for water quality
	Vygeboom Dam to Swaziland	the hydrology has changed significantly: Vygeboom Dam releases minimal water and has had moderate impacts on the floods. The middle Komati River Catchment is generally in a moderate ecological condition, with the notable exception of the Gladdespruit River (Resource Unit G), which is in a largely modified condition (Category D). The main impacts in the Gladdespruit relate to trout farms, gold mines, forestry, and excessive encroachment of alien vegetation. Water quality problems relating to relating to changes in river discharges caused by the transfers from the Vygeboom Dam. The main water quality issues are bacterial problems (cattle grazing, sewage effluent waste water treatment works in the Seeikoespruit and lower Teespruit, runoff from poor sanitation in the area), nutrient enrichment, and some contamination from domestic washing powders.
4	**TRIBUTARY** Gladdespruit	Land use mountain grassland, sour lowveld bushveld, patches of Afromontane forest and intensive afforestation of exotic pine plantations. Water quality problems in the Gladdespruit relate to a current gold mine and mining residues (sulphates, low pH, metals). Due to improved mining methods and rehabilitation these impacts are not measured at present. Furthermore afforestation (high turbidity runoff), excessive encroachment of alien vegetation and many sand roads on the slopes above the rivers (sedimentation). Water is abstracted for gold mining from the river. It is important to note that the flow is further altered by a diversion weir at Vriesland that transfers water to the Vygeboom Dam.
5	**TRIBUTARY** Seeikoeispruit	The Seekoeispruit is unregulated and so the hydrology is close to natural, with small impacts related to abstraction of low-flows. The riparian is invaded by alien vegetation (mostly wattle), and poor landuse practices have led to erosion and embeddedness of the stream bed. The main water quality issues are associated with a number of poorly functioning sewage works and general low level of sanitation throughout the catchment, particularly in the vicinity of Badplaas (two waste water treatment works). Informal villages along the banks of the river, erosion from the removal of vegetation for firewood and grazing of animals. Typical water quality variables of concern are microbiological, nutrient enrichment and high turbidity.
6	**TRIBUTARY** Teespruit	The hydrology and geomorphology of the Teespruit have been slightly impacted due to small-scale abstractions. There is a greenstone mine near the Teespruit River, but its impacts on the river are negligible. The water quality is

WQU no.	Description	Land use activities and implications for water quality
		in good condition except for the lower section where there is a sewerage works with associated organic pollution. Water quality problems relating nutrient inputs upstream of the site due to a waste water treatment works inflow upstream of the site, catchment slopes being highly degraded due to over grazing, the removal of vegetation for firewood and many villages on the slopes of the river. Typical water quality variables of concern are microbiological, nutrients and turbidity.
7	**LOWER KOMATI** From Swaziland to the confluence with the Lomati River (Mananga to Tonga)	There are two main dams associated with this site in the Lower Komati River System: Maguga Dam (in Swaziland) and Sand River. The Maguga and Sand River Reservoir regulate stream flow, which has resulted in a changed flow regime and periods in winter when the flow stops. The Magugu–IYSIS canal further removes up to 9 m^3/s for irrigation. Furthermore a large number of weirs were built in the lower Komati between 1984 and 1992 with inadequate outlet discharge capacities. As a result, the weirs pose significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations. Land use is mainly crop farming, sugar cane and banana plantations. Water quality problems associated with coal mining on the banks of the river upstream of Tonga, runoff from burgeoning urban population, intensive irrigated sugar cane, many diversion weirs. The lower Komati River Catchment is in a poor ecological condition. Ecological conditions is further highly impacted by frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir. Clearing of bank vegetation and sand mining has reduced bank stabilisation and led to alien vegetation encroachment. The main water quality issues are nutrients (with associated benthic algal blooms), bacterial contamination and increased water temperatures, slight salinisation when the river stops flowing and microbiological contamination.
8	**LOWER KOMATI** From the confluence of the Lomati River to the confluence with the Crocodile River (Tonga to Crocodile Bridge)	There are two main dams in the Lower Komati River System: Maguga Dam (in Swaziland) and Driekoppies Dam. Driekoppies Dam is situated on the Lomati River, and its main purpose is to stabilise river flows, provide for the increase in primary water demand, to allow for moderate increase in irrigation development, and assure water supplies to existing irrigation and urban development in the lower Komati Basin. Until such a time

WQU no.	Description	Land use activities and implications for water quality
		as Maguga Dam has sufficient water to supply the lower Komati River, Driekoppies Dam is being used to supply demands as far as Komatipoort. This means that baseflows in the lower Lomati River are higher than usual. A large number of weirs were built in the lower Komati and Lomati Rivers, mainly between 1984 and 1992 with inadequate outlet discharge capacities. As a result, the weirs pose significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations. The lower Komati River Catchment is in a poor ecological condition. The large number of weirs and associated irrigation in the lower reaches of the river has resulted in a deterioration of the water quality to such an extent that it has become enriched with nutrients and the dissolved oxygen levels become limiting to the ecology. The overall picture is one of a system that deteriorates in the lower reaches. Frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir. The main water quality issues are nutrients (with associated benthic algal blooms), decrease dissolved oxygen, bacterial contamination, increased water temperatures, slight salinisation when the river stops flowing and possible toxicity (due to pesticide usage).
9	**LOMATI** Upper Lomati to Swaziland	Land use dominated by Sour Lowveld Bushveld, North Eastern Mountain Grassland and mountain slopes are covered by pine plantations. Minimal water quality variables of concern except for possible influence of afforestation (turbidity).
10	**LOMATI** Lower Lomati from Driekoppies Dam to the confluence with the Komati River	The ecosystem is fairly healthy, although there has been a major change due to the impacts of Driekoppies Dam. The vegetation is greatly modified from natural from a fairly sparsely vegetated channel to a channel with a significant woody vegetation component. Land use is mainly sugar cane, orchards and intensive crop farming. Water quality will be affected by environmental flows from the Driekoppies Dam. Typical water quality problems are nutrient enrichment (phosphates, nitrates, nitrites, ammonia), aquatic algae, higher salinity values (electrical conductivity) and microbiological contamination.
11	**MTSOLI** Mtsoli River to confluence with Komati River	Generally the water quality is good and the only potential impacts are due to afforestation.

3.3.2 General water quality trends in study area

Possible sources of pollution may be divided into two categories:

Diffuse source

- Agricultural fertilizers
- Agricultural insecticides, pesticides and fungicides (i.e. biocides)
- Atmospheric deposition
- Rural domestic and sewage effluent runoff

Point sources

- Industrial effluent, and micro organic pollutants
- Domestic and treated sewage effluent
- Mining effluent

In the Komati study area the majority of the pollution sources are as a result of diffuse sources of agricultural origin (fertilizers and biocides) and mining. Point sources are limited to treated sewage effluent and mining effluents.

The statistical analysis of the water quality data available for the study area (Appendix A) is presented in graphical form in Figures 3.2 to 3.7. In these figures site K5 is the water quality monitoring site at the Komatipoort Bridge (X1H042Q01) which is the lowest site in the Komati catchment and upstream of the Crocodile River confluence. The following general trend can be seen per water quality variables:

Ortho-phosphates (Figures 3.2 and 3.3)

There is a general increase in ortho-phosphates in the Komati River from K1 (mean of 0.016 mg/l) to K5 (mean of 0.27 mg/l). This is due largely to the intensive sugar cane irrigation in the middle and lower Komati River. The Gladdespruit has low ortho-phosphates (mean of 0.014 mg/l) and the lower Lomati shows the impact of intensive irrigation with a mean of 0.022 mg/l. The range in ortho-phosphates values in Figure 3.3 indicate seasonal variability.

Nitrate and nitrite (Figures 3.4 and 3.5)

There is a general increase in nitrate and nitrite in the Komati River with more than five times the values at K5 (mean of 0.474 mg/l) compared to K1 (mean of 0.093 mg/l). This is due mainly to the intensive sugar cane irrigation in the middle and lower Komati River. The Gladdespruit has low nitrate and nitrite (mean of 0.079 mg/l) and the lower Lomati shows the impact of intensive irrigation with a mean of 0.225 mg/l. The ranges in nitrate and nitrite values in Figure 3.5 indicate seasonal variability.

Electrical Conductivity (Figures 3.6 and 3.7)

There is a general increase in electrical conductivity with distance downstream, with more than doubling of the values from K1 (mean of 20.3 mS/m) to K5 (mean of 53.9 mS/m). This is due largely to return flows from the intensive sugar cane irrigation in the middle and lower Komati River. The Gladdespruit has low electrical conductivity (mean of 11.4 mS/m). The range in electrical conductivity values in Figure 3.7 indicate seasonal variability at sites L1, K3 and K5 only.

3.3.3 Biological monitoring trends in catchment area

Figure 3.8 is a comparison of the invertebrate monitoring undertaken per RU in the study area. The graph shows the total SASS score as a function of the ASPT (Average Score Per Taxon). The results indicate highest scores in the upper reaches, and lowest scores in the lower reaches. The comparison indicates that there is a high variability in the results due to seasonal flow variability (natural and due to the high degree of regulation), habitat degradation and consequent water quality changes. This comparison concurs with the water quality trends indicating a decrease in biological integrity down the length of the Komati River. The only exception, when comparing water quality to the macroinvertebrate results is the Gladdespruit, where the SASS and ASPT scores are low (category D/E). This could be due to historic surveys being focussed on impacts from gold mining.

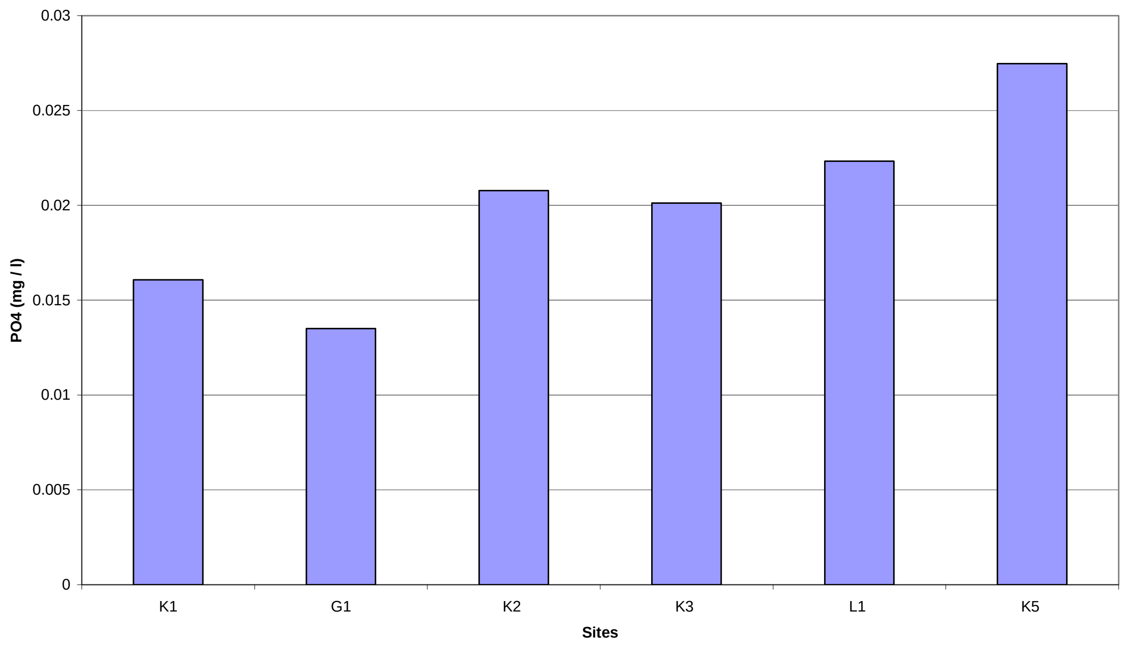

Figure 3.2: Mean Ortho-phosphate water quality trends per EWR site.

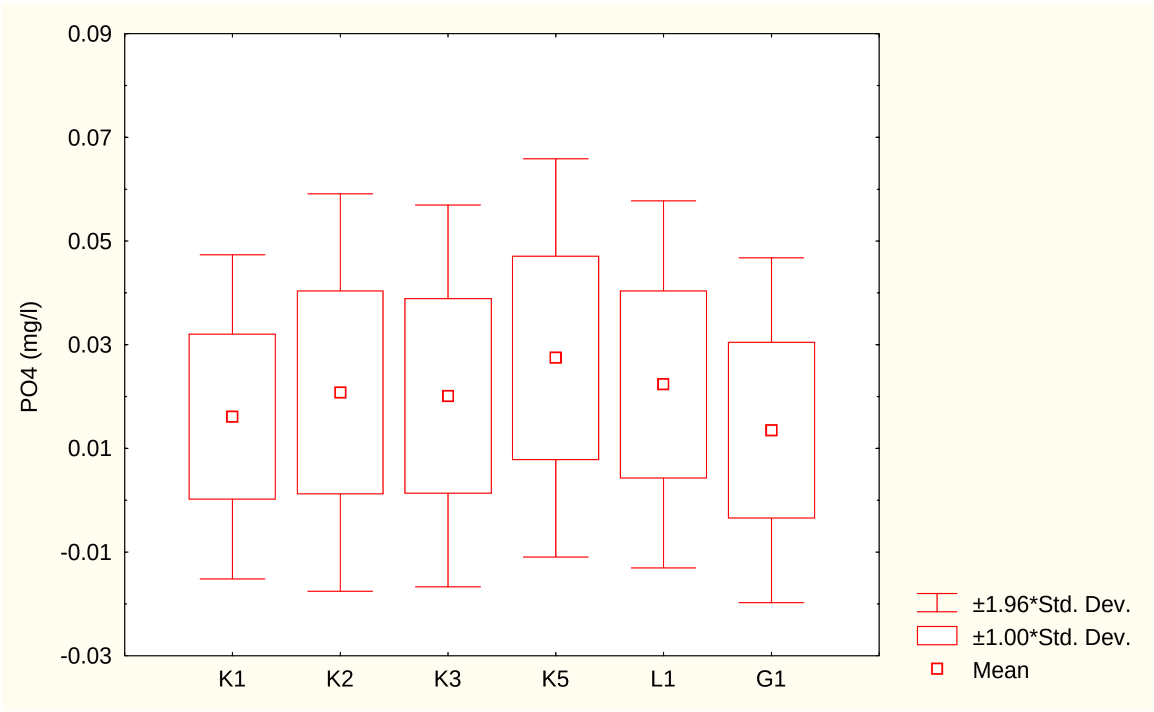

Figure: 3.3: Box and whisker ortho-phosphate water quality trends per EWR site

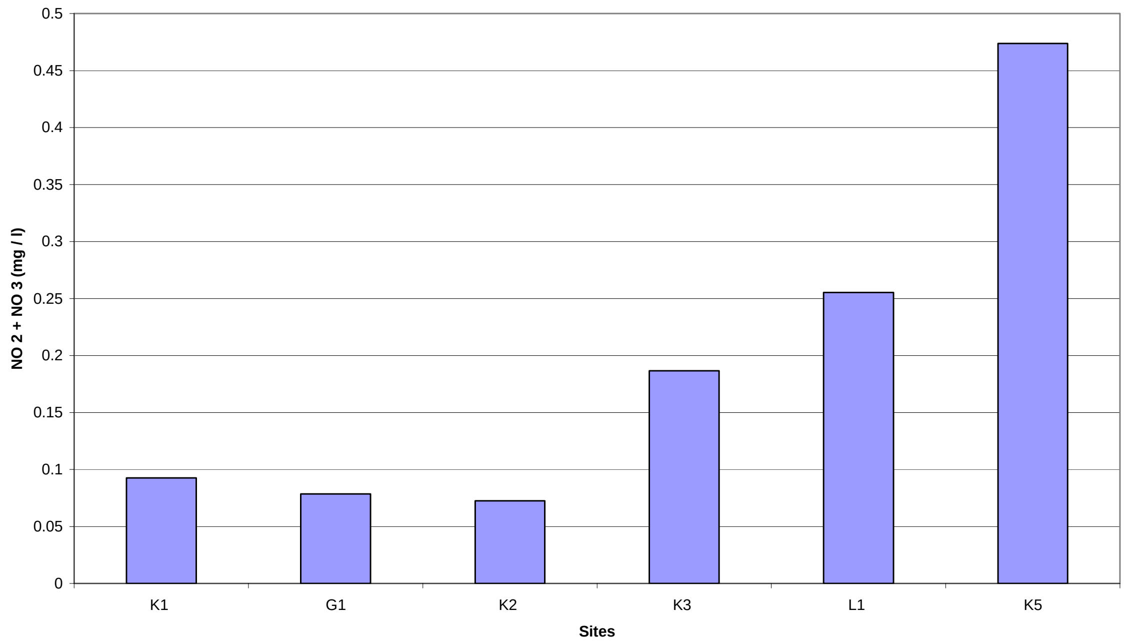

Figure 3.4: Mean nitrate + nitrite water quality per EWR site in the Komati River.

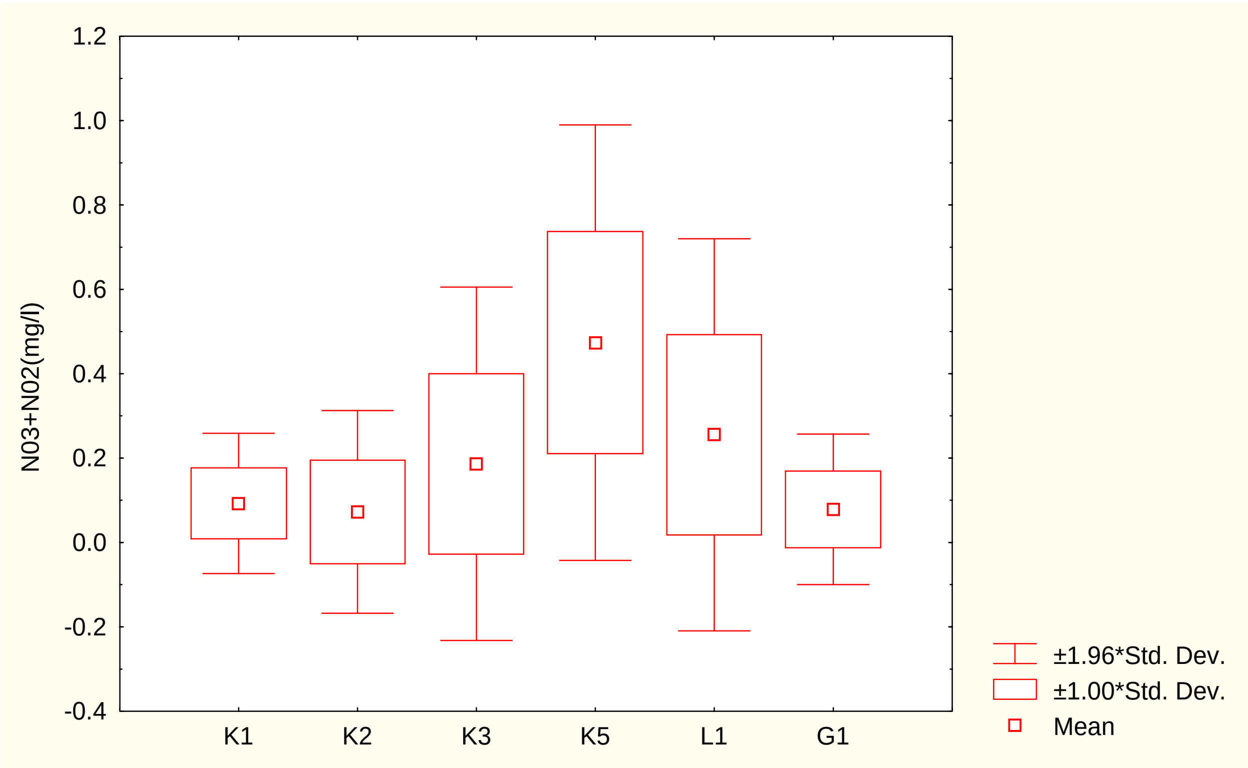

Figure 3.5: Box and whisker nitrate + nitrite water quality trends per EWR site

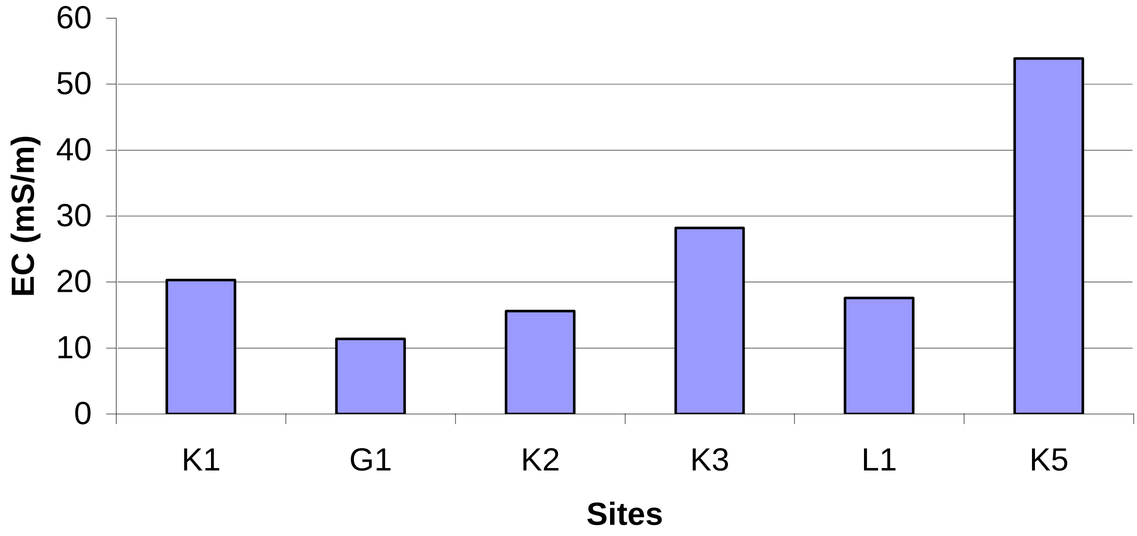

Figure 3.6: **Mean electrical conductivity values per EWR site in the Komati River.**

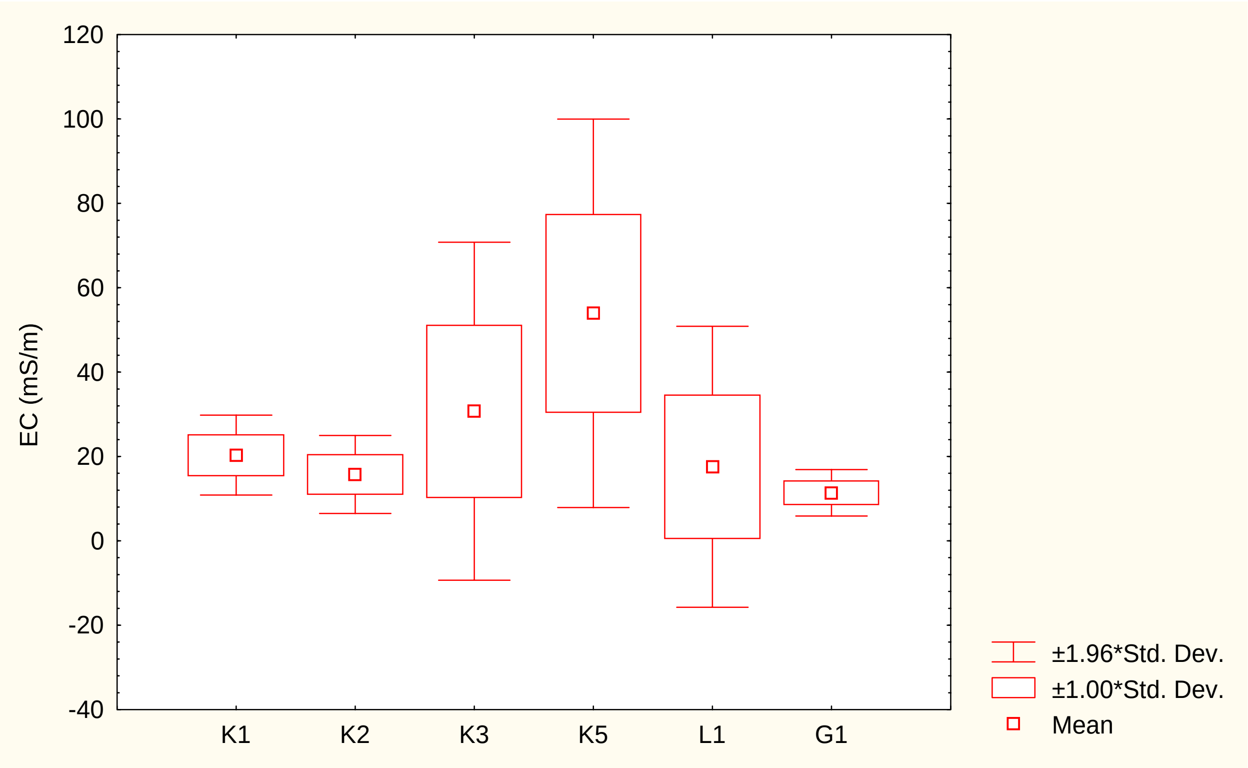

Figure 3.7: Box and whisker electrical conductivity water quality trends per EWR site.

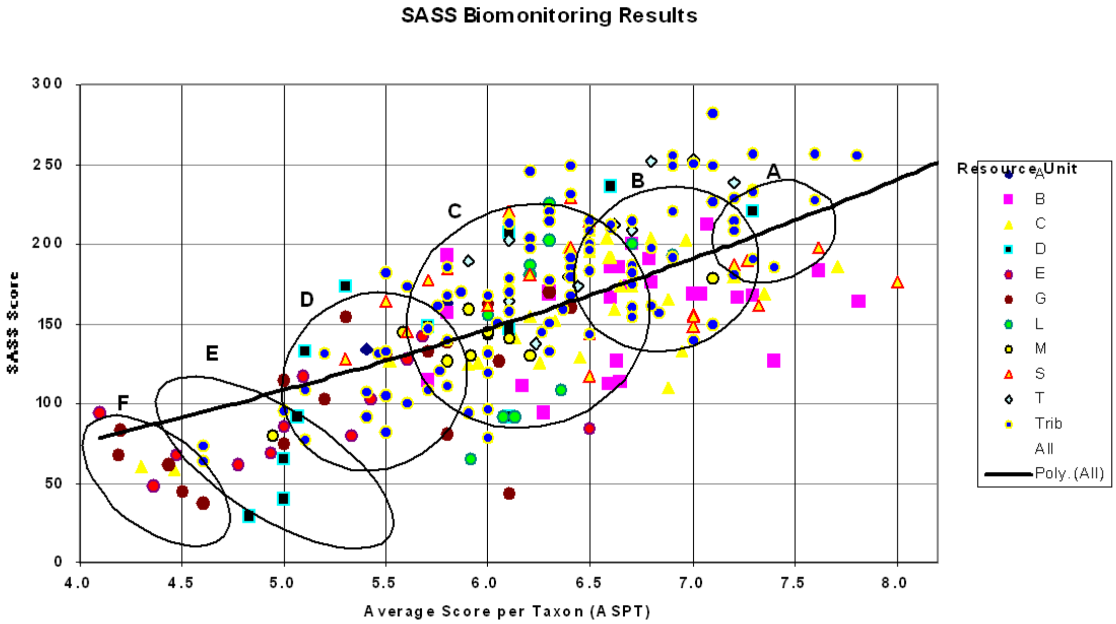

Figure 3.8: Comparison of SASS and ASPT scores in the Resource Units in the Komati study.

4 WATER QUALITY PRESENT STATE ASSESSMENT

4.1 INTRODUCTION

Although an EWR or Ecological Reserve study can aim to be conducted at a Comprehensive level, the results of the assessment can have differing levels of confidence, depending on the quality and extent of the available data (better data provide higher confidence results), the ability to collect additional data and/or to undertake field or laboratory studies, and/or the availability of appropriate modelling tools. Some of the factors that affect data quality have time and budget implications. Depending on the constraints of the budget, available time and the quality of existing data, ecological Reserve assessments can be undertaken so as to produce high, medium or low confidence results. The objective is therefore to provide the highest level of confidence within the resources available.

This section lists the results of the water quality assessment conducted for the Komati Comprehensive Reserve Determination Study, and details the Present Ecological State (PES) assessment for each WQU evaluated during the study. The confidence in the present state classification was verified using the power statistic, G-Power (Faul and Redfelder 1992).

4.2 APPROACH

4.2.1 Recalibration of benchmarks

Each WQU was assigned a Reference Condition (RC) and a Present Ecological State (PES), where possible, using available methods. The RC reflects the unimpacted state (typically the earliest 5 years of water quality data), whilst the PES reflects the current state (typically the latest 5 years of available water quality data) in terms of water quality. This allows the specialist to recalibrate benchmarks for the various variables in relation to the RC, if the variables assessed do not correspond to the benchmark table categories provided in the methods manual (DWAF 2002).

Note that categories are described as Natural to Poor in the methods manual, but as the EWR process requires categories A – F, all benchmark tables were recalibrated accordingly (Table 4.1). The methods manual also does not differentiate categories such as Upper and Lower Good (i.e. A/B and B/C). The recalibration process also identified these categories.

Table 4.1: Recalibrated benchmarks for Total Inorganic Nitrogen (TIN), Soluble Reactive Phosphorous (SRP), periphyton, pH, and biological indicators (i.e. macroinvertebrates and ASPT) using the A-F classification system.

Descriptive classification + allocated range from methods manual	Numerical classification	Value per category
TIN		
Natural: ≤ 0.25 mg/L	A	≤ 0.25 mg/L
Upper Good	A/B	0.5 mg/L
Good: 0.251 - 1.0 mg/L	B	0.75 mg/L
Lower Good	B/C	1.0 mg/L
Upper Fair	C	2.0 mg/L
Fair: 1.01 – 4.0 mg/L	C/D	3.0 mg/L
Lower Fair	D	4.0 mg/L
Poor: > 4.0 mg/L	E/F	> 4.0 mg/L
SRP or PO_4		
Natural: ≤ 0.005 mg/L	A	≤ 0.005 mg/L
Upper Good	A/B	0.012 mg/L
Good: 0.0051 – 0.025 mg/L	B	0.02 mg/L
Lower Good	B/C	0.025 mg/L
Upper Fair	C	0.058 mg/L
Fair: 0.0251 – 0.125 mg/L	C/D	0.091 mg/L
Lower Fair	D	0.125 mg/L
Poor: > 0.125 mg/L	E/F	> 0.125 mg/L
PH		
Natural: 6.5 – 8.00	A	6.5 – 8.00
Upper Good	A/B	5^{th} Percentile: 5.75 – 6.00 95^{th} Percentile:8.05 – 8.37
Good: 5.75 – 8.05 and 6.46 – 9.00	B	5^{th} Percentile: 6.00 – 6.24 95^{th} Percentile:8.37 – 8.69
Lower Good	B/C	5^{th} Percentile: 6.24 – 6.46 95^{th} Percentile:8.69 – 9.00
Upper Fair	C	5^{th} Percentile: 5.00 – 5.23 95^{th} Percentile:9.05 – 9.36
Fair: 5.00 -5.7 and 9.05 – 10.00	C/D	5^{th} Percentile: 5.23 – 5.46 95^{th} Percentile: 9.36 – 9.67
Lower Fair	D	5^{th} Percentile: 5.46 – 5.7 95^{th} Percentile: 8.56 – 10.00
Poor: < 5.00 or > 10.0	E/F	< 5.00
PERIPHYTON		
Natural: < 1.7 mg/m^2	A	< 1.7 mg/m^2
Upper Good	A/B	1.7 – 8.13 mg/m^2
Good: 1.7 – 21 mg/m^2	B	8.13 – 14.56 mg/m^2
Lower Good	B/C	14.56 – 21 mg/m^2
Upper Fair	C	21 – 42 mg/m^2
Fair: 21 – 84 mg/m^2	C/D	42 – 63 mg/m^2
Lower Fair	D	63 – 84 mg/m^2
Poor: > 84 mg/m^2	E/F	> 84 mg/m^2

BIOLOGICAL INDICATOR (ASPT)		
Natural: 7	A	7
Upper Good	A/B	6.67
Good: 6	B	6.34
Lower Good	B/C	6
Upper Fair	C	5.67
Fair: 5	C/D	5.34
Lower Fair	D	5
Poor: < 5	E/F	< 5

4.2.2 Data collation

The following information was used to conduct the present state assessments listed in this document.

- Literature regarding water quality conditions in the catchment (King and Tharme 1994, Ninham Shand 1994), a field survey undertaken in August 2003 to verify the delineation of WQUs, as well as discussions with Dr Rob Palmer.
- Water quality data from selected DWAF monitoring points in the catchment (Table 4.2), as well as spot samples taken during field surveys during this study (Table 3.2). Samples were analysed at Resource Quality Services (RQS), DWAF and entered in the water Management System (WMS).
- Biotic integrity data (macroinvertebrates) were sourced from Dr Rob Palmer, the invertebrate specialist of the Komati Reserve study for the EWR sites (intensive invertebrate monitoring conducted); other data were accessed from SASS (i.e. rapid monitoring using the South African Scoring System)
- Fish categories are included for the EWR sites from the relevant specialists of the Komati Reserve study.
- Chlorophyll-*a* analyses were undertaken at selected points in the catchment as an indicator of algal abundance, during the field surveys as well as there was some data in the DWAF database on the impoundments.
- No in-stream toxicity testing was undertaken.
- The following version of the salt model of Jooste (RQS, DWAF) was used to generate PES categories for inorganic salts: SALTBA21.Note that the model provides categories, but not values.
- Available data were screened for toxics, e.g. metals. Toxics are listed and assessed where data were available.
- As a method does not exist for assessing the present state of turbidity, results were compared to the domestic use Target Water Quality Range (TWQR), as aquatic ecosystem guidelines do not exist.

  TWQR for domestic use – turbidity: 0 – 1 NTU (DWAF 1996).

- The systems operational procedures document on the Komati River systems was used for dam and weir operations (AfriDev 2005b).

- The Resource Units Report for the Komati catchment ecological reserve (AfriDev 2005a).

Table 4.2: DWAF monitoring points that were utilized for the PES assessment.

WQU	EWR site	DWAF monitoring point	Description of location
2	K1	X1H033Q01	Nooitgedacht Dam on Komati River: down stream weir
3	K2	X1H001Q01	Komati River at Hooggenoeg
8	K3	X1H003Q01	Komati River at Tonga
8	K5	X1H042Q01	Komati River at Komatiepoort/old road bridge
4	G1	X1H019Q01	At Vriesland on Gladdespruit
1		X1R001Q01	Nooitgedacht Dam on Komati River: near dam wall
2		X1R003Q01	Vygeboom Dam on Komati River: near dam wall
6	T1	None	Teespruit
9/10	L1	X1HO49Q1	Kleindoringkop
9/10	S1	None	Seeikoespruit
11	M	X1H021Q01	Mtsoli River At Diepgezet

4.3 DATA MANIPULATION

Once the WQUs had been delineated, data suitable for determining both the RC and PES were selected based on data frequency, the position of the DWAF monitoring point within the WQU, and the length of the data record. DWAF water quality data were manipulated according to the following procedure:

- Generate files per DWAF monitoring point, and per RC or PES.
- In Excel, replace all "<" signs with half the value, e.g. replace <0.04 with 0.02, as a statistically approved method of manipulating water quality data below quantification levels.
- As Total Inorganic Nitrogen is required by the water quality method, produce TIN by adding (NO_2+NO_3) and NH_4.
- Generate scatter plots, box-and-whisker plots and summary statistics (e.g. means, 95th percentiles, 50th percentiles) per water quality variable.

Table 4.3 briefly shows the calculations needed for both RC and PES assessments (for Comprehensive Reserve studies).

Table 4.3: Calculations required for the PES assessment for water quality (Comprehensive Reserve).

Variable	Methodology
Inorganic salts	Individual salts put into computer salt model. <u>RC – unimpacted site</u> 60 samples over 3-year period. 95th percentile (at this percentile 95% of the variable are situated below this point).

Variable	Methodology
	PES 95th percentile with formulae
Nutrients (PO_4 and TIN)	RC – unimpacted site 60 samples over 3-year period. Median concentrations PES Assemble TIN & SRP from most recent 5 years. Calculate 50th percentile or median
Dissolved oxygen	RC – unimpacted site 5th percentile Check what values calculated and if benchmark values need to be changed PES 5th percentile
pH	RC – unimpacted site 5th and 95th percentiles Default benchmark boundary values if no data PES Comparing 5th & 95th percentile to table or calibrated table. NOTE: changes in DWAF pH determination method.
Turbidity	Optional variable. Should be incorporated if the land use practices indicate overgrazing, contour ploughing, removal of riparian vegetation and forestry. No assessment methodology available
Temperature	RC – unimpacted site 10th and 90th percentiles for each month No data – locally calibrated empirical relationship between air temp and water temp OR modelling – done by month and then calibrate 10th and 90th percentiles for each month PES As above or if no data then monitor for at least one seasonal cycle
Toxic substances e.g. metals, pesticides	RC – unimpacted site Toxic substances do not usually occur naturally, therefore value detected = RC PES 95th percentiles Additional information for Ammonia
Biological indicator of water quality	RC – unimpacted site RC for Level 2 Ecoregion used. If no data – then need SASS Values compared against the ASPT Scores in benchmark table. PES 3 or more sites per resource unit, and calculate median value
Chlorophyll-a	RC – unimpacted site 60 samples over 1-3 year period. Median concentrations PES If available – assemble data from last 5 years, calculate average of phytoplankton or median of periphyton

Variable	Methodology
	If no data – expert judgment used (visual)
Toxicity	Not yet fully understood For the Komati study water no toxicity tests were undertaken as historical SASS data indicated that none were required. Pesticide use is expected in the lower Komati due to the intense irrigation of pesticides.

To assess the status of the inorganic salts, salt ions need to be aggregated and assessed against the benchmark tables in the methods manual. The SaltBA21 model of Jooste (RQS, DWAF) was used to generate these data. The model can be found at http://www.dwaf.gov.za/iwqs/gis_data/SaltBA21.exe

Once the RC and PES values have been calculated and categories A – F assigned for each of the variables assessed, an integrated water quality category is produced per WQU for present state.

Assessing data confidence: In a water quality Reserve determination, the water quality specialist has to assess confidence in the data set used to assess the present ecological state. This assessment is conducted using a package called **G*Power** (Version 2.0) is a freeware software package that can be used to provide an objective measure of the confidence in the data set used, and is available from http://www.psycho.uni-duesseldorf.de/aap/projects/gpower/.

Due to the impacts of the dam operations it expected that water temperature and oxygen levels could be impacted. Expert knowledge of the impact of dams as well as the knowledge of the operational procedures of these dams in the Komati catchment was used to determine possible impacts on water quality.

4.4 PRESENT ECOLOGICAL STATE (PES) RESULTS

PES assessments for water quality are shown per WQU. WQUs are presented per Resource Unit.

RESOURCE UNIT A: Upper Komati

Water quality unit 1: Source of Komati to Nooitgedacht Dam.

Land use mainly commercial farming. There are four opencast coalmines in the upper catchment. There is large potential for opencast coal mining in this area, and this may compromise the good quality water that currently characterises the area. There are small nutrient inputs from farming along the steep banks of the river. No major water quality problems. The only water quality sampling point in this WQU is in the Nooitgedacht Dam close to the dam wall.

Data confidence:

The following confidences were generated using G-Power.

pH	Low
TIN	Low
SRP	Low
EC	Low
F	Low

No temperature, dissolved oxygen and turbidity data were available

Trends:

It is expected that the water quality will remain the same over the short term period (5 years) if the open cast coal mines are not increased or mismanaged so as to cause typical acid mine drainage. The long-term water quality trend (20 years) should remain the same as the present state.

River	**Upper Komati**	**DWAF Water Quality Monitoring points**	
WQU 1	Nooitgedacht dam on Komati river: near dam wall	**RC**	X1R001Q01 (1970 – 1980) n = 19
EWR site		**PES**	X1R001Q01 (1995 – 2005) n = 50

Water Quality Constituents		**Value (mean)**	**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$		**C**
	Na_2SO_4		**A**
	$MgCl_2$		**A**
	$CaCl_2$		**A**
	NaCl		**B**
	$CaSO_4$		**A**
Nutrients (mg/L)	SRP	0.018	**B**
	TIN	0.146	**A**
Physical variables	pH (pH units)	6.01 – 8.28	**B**
	Temperature (^{o} C)	No data	Bedrock could warm up water during low flows
	Dissolved oxygen (mg/l)	No data	
	Turbidity (NTU)		High sediment potential due to erosive soils
	Chl-a: periphyton (mg/m^2)	Not sampled	

Response variable	Biotic community composition - macroinvertebrate (ASPT) score	Not applicable	
	In-stream toxicity	No data	
Toxics	Fluoride (μg/l)	170	**A**
Overall site classification		*B*	

RESOURCE UNIT B: Upper Komati

Water quality unit 2: Nooitgedacht Dam to Vygeboom Dam

This resource unit is in the northern escarpment mountain ecoregion with the main land cover being Piet Retief sour-veld, poplars and dry land grazing. Land use mainly commercial farming with cultivated lands and extensive grazing. There are two main dams in the upper Komati River (Nooitgedacht and Vygeboom) that have operating rules that are designed to maximise yield. Eskom water requirements impact the flow in this reach of the river. There are small nutrient inputs from farming along the steep banks of the river. There was no difference in water quality between the Nooitgedacht Dam and Vygeboom Dam

The upper Komati River Catchment is generally in a good ecological condition, with the main impacts relating to dry land farming and forestry. The Nooitgedacht Dam does not make any compensatory releases, so low-flows have decreased. Water temperatures are likely to have increased due to reduced low-flows, and nutrients have increased due to trout dams and tourist developments. Water quality problems relating to changes in river discharges caused by the transfers from the Nooitgedacht Dam by Eskom. Only surface warm water spills from Nooitgedacht Dam. There are no difference in water quality between the Nooitgedacht Dam and Vygeboom Dam

Confidence:

The following confidences were generated using G-Power.

pH	Low
TIN	Low
SRP	Low
EC	Low
F	Low

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality will remain the same over the short-term period (5 years) as it is not expected that Eskom will increase their water usage. The long-term water quality trend (20 years) should remain the same as the present state.

River	Upper Komati		**DWAF Water Quality Monitoring points**	
WQU	2		**RC**	X1H033Q01 (1988 – 1988) n =15
EWR site	K1		**PES**	X1H033Q01 (1998 – 2004) n =35
Water Quality Constituents			**Value (mean)**	**Category / Comment**
Inorganic salts (mg/l)	$MgSO_4$			B
	Na_2SO_4			A
	$MgCl_2$			A
	$CaCl_2$			A
	NaCl			A
	$CaSO_4$			A
Nutrients (mg/L)	SRP		0.025	B/C
	TIN		0.09	A
Physical variables	pH (pH units)		6.3 – 8.58	B
	Temperature (º C)		Expected to increase due to dams and surface runoff	Potential impacts associated with the operational procedure and releases from the Nooitgedacht Dam as there are only surface warm water spills.
	Dissolved oxygen (mg/l)		No data	
	Turbidity (NTU)		No data	The river banks are eroded due to steep slopes as well as animal trampling. Dam will settle any turbidity
Response variable	Algae Chl-a: and phaeophyte (ug/l)		Chlorophyll-a (2.9 ug/l) and phaeophyte (2.5 ug/l).	**A** Chlorophyll-a and phaeophyte) values low in Nooitgedacht Dam. Diatoms on rocks in river.
	Biotic community composition - macroinvertebrate (ASPT) score		Fish B/C ASPT – 5.4 – 5.8 SASS 5 134 - 163	B
	In-stream toxicity		Not sampled	
Toxics	Fluoride (μg/l)		200	A

River	Upper Komati	DWAF Water Quality Monitoring points
Overall site classification		**B**

RESOURCE UNIT C: Upper Komati Vygeboom Dam to Swaziland border

Water quality unit 3: Vygeboom Dam to Swaziland border

The main vegetation cover is Mountain grassland, sour lowveld bushveld and patches of Afromontane forest. Land use is mainly extensive grazing mainly by communal livestock, limited cultivated lands and villages. A large area of the lower section of this RU is within a conservation area (Nkomazi Wilderness Area and Songimvelo Nature Reserve).

Water quality problems relating to changes in river discharges caused by the transfers from the Vygeboom Dam and the stream being regulated by the Vygeboom Dam. The Teeuspruit and Seekoeispruit flow into the Komati below the Vygeboom Dam. Both of these rivers have wastewater treatment works that discharge into the rivers resulting in nutrient enrichment and microbial contamination.

Confidence:

The following confidences were generated using G-Power.

pH	Medium
TIN	Medium
SRP	Medium
EC	Medium
F	Medium

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality will remain the same over the short-term period (5 years) as it is not expected that Eskom will increase their water usage. The long-term water quality trend (20 years) could deteriorate due to the continued degradation of the marginal vegetation.

River	Upper Komati	**DWAF Water Quality Monitoring points**	
WQU	3	**RC**	XH001Q01 (1977-1987) n = 96
EWR site	K2	**PES**	XH001Q01 (1995-2005) n = 71

Water Quality Constituents		**Value**	**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$		B
	Na_2SO_4		A
	$MgCl_2$		B
	$CaCl_2$		A
	NaCl		A
	$CaSO_4$		A
Nutrients (mg/L)	SRP	0.20	D/E
	TIN	0.157	B
Physical variables	pH (pH units)	7.25 – 8.41	B
	Temperature (º C)	No data	Impacts expected as a resulted of warming in the Vygeboom and operational procedure
	Dissolved oxygen (mg/l)	No data	
	Turbidity (NTU)		High sediment inputs especially from Seeikoespruit
Response variable	Chl-a:	Chlorophyll-a values in Vygeboom Dam low (1.0 – 1.25 ug/l)	A
	Biotic community composition - macroinvertebrate (ASPT) score	ASPT – 6 – 8 SASS5 ca. 200	C
	In-stream toxicity		Not sampled
Toxics	Fluoride (μg/l)	252	A
Overall site classification		**B/C**	

RESOURCE UNIT G: Upper Komati Gladdespruit (G1)

Water quality unit 4: Gladdespruit

Land use mountain grassland, sour lowveld bushveld, patches of Afromontane forest and intensive afforestation of exotic pine plantations.

There is one gold mine in the upper Gladdespruit, near the village of Mamre. This area is also impacted by an abandoned gold mine.

Water quality problems in the Gladdespruit relate to a current gold mine and mining residues (sulphates, low pH, metals). Due to improved mining methods and rehabilitation these impacts are not measured at present. Furthermore afforestation (high turbidity runoff), excessive encroachment of alien vegetation and many sand roads on the slopes above the rivers (sedimentation). Water is abstracted for gold mining from the river.

It is important to note that the flow is further altered by a diversion weir at Vriesland (a water transfer system to the Vygeboom Dam).

Confidence:

The following confidences were generated using G-Power.

pH	Medium
TIN	Medium
SRP	Medium
EC	Medium
F	Medium

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality will remain the same over the short-term period (5 years) as it is not expected that Eskom will increase their water usage (transfer to Vygeboom Dam). The long-term water quality trend (20 years) could deteriorate due to the continued degradation of the marginal vegetation and upstream land use.

<table>
<tr><td>River</td><td colspan="2">Gladdespruit</td><td colspan="3">DWAF Water Quality Monitoring points</td></tr>
<tr><td>WQU</td><td colspan="2">4</td><td>RC</td><td colspan="2">X1H019Q01 (1977-1987) n= 105</td></tr>
<tr><td>EWR site</td><td colspan="2">G1 Vaalkop</td><td>PES</td><td colspan="2">X1H019Q01 (1986-1996) n= 44</td></tr>
<tr><td colspan="3">Water Quality Constituents</td><td colspan="2">Value</td><td>Category / Comment</td></tr>
<tr><td colspan="2" rowspan="6">Inorganic salts (mg/L)</td><td>$MgSO_4$</td><td colspan="2"></td><td>B</td></tr>
<tr><td>Na_2SO_4</td><td colspan="2"></td><td>A</td></tr>
<tr><td>$MgCl_2$</td><td colspan="2"></td><td>A</td></tr>
<tr><td>$CaCl_2$</td><td colspan="2"></td><td>A</td></tr>
<tr><td>NaCl</td><td colspan="2"></td><td>A</td></tr>
<tr><td>$CaSO_4$</td><td colspan="2"></td><td>A</td></tr>
<tr><td colspan="2" rowspan="2">Nutrients (mg/l)</td><td>SRP</td><td colspan="2">0.014</td><td>B/C</td></tr>
<tr><td>TIN</td><td colspan="2">0.235</td><td>B/C</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>PH (pH units)</td><td colspan="2">7.25 – 8.44</td><td>B/C</td></tr>
<tr><td>Temperature (º C)</td><td colspan="2">No data</td><td></td></tr>
</table>

Physical variables	Dissolved oxygen (mg/l)	No data	
	Turbidity (NTU)		High TDS values recorded (range 7 to 155)
Response variable	Chl-a: periphyton (mg/m^2)	None recorded	
	Biotic community composition - macroinvertebrate (ASPT) score	ASPT 4.21 – 6.3 (5.2) SASS - 37- 132 (77)	D
	In-stream toxicity	Not sampled	
Toxics	Fluoride (μg/l	167	A
Overall site classification		**B/C** (potential residual mining impacts)	

RESOURCE UNIT: S Seekoeispruit

Water quality unit 5: Seekoeispruit

Most of the river is located in the Northern Escarpment Mountain ecoregion.

The Seekoeispruit is unregulated and so the hydrology is close to natural, with small impacts related to abstraction of low-flows. The riparian is invaded by alien vegetation (mostly wattle), and poor landuse practices have led to erosion and embeddedness of the stream bed. The land use is mainly dryland agriculture and irrigation. The main water quality issues are associated with a number of poorly functioning sewage works and general low level of sanitation throughout the catchment, particularly in the vicinity of Badplaas (two waste water treatment works – Aventura and Badplaas that have settling ponds that discharge effluent into the river). Informal villages along the banks of the river, erosion from the removal of vegetation for firewood and grazing of animals. Typical water quality variables of concern are microbiological, nutrient enrichment and high turbidity.

Confidence:

The confidence for this site was very low as only one sample was available. No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality will remain the same over the short-term period (5 years) as it is not expected that Eskom will increase their water usage (transfer to Vygeboom Dam). The long-term water quality trend (20 years) could deteriorate due to the continued degradation of the marginal vegetation and upstream land use.

River	**Seekoespruit**	**DWAF Water Quality Monitoring points**	
WQU	5	**RC**	

EWR site	S1		PES	
Water Quality Constituents		**Value**	**Category / Comment**	
Inorganic salts (mg/L)	$MgSO_4$		***B***	
	Na_2SO_4		**C**	
	$MgCl_2$		**C**	
	$CaCl_2$		**B**	
	NaCl		**C**	
	$CaSO_4$		**C**	
Nutrients (mg/L)	SRP	0.028	**C/D**	
	TIN	0.04	**A**	
Physical variables	pH (pH units)	7.75	**A**	
	Temperature (º C)	No data	Bedrock could warm up water during low flows	
	Dissolved oxygen (mg/l)	No data		
	Turbidity (NTU)		High sediment potential due to erosive soils	
Response variable	Chl-a: periphyton (mg/m^2)	Not sampled		
	Biotic community composition - macroinvertebrate (ASPT) score	SASS5 – 117 – 128 ASPT – 5.3 – 6.5	*C*	
	In-stream toxicity	Not sampled		
Toxics	Fluoride (μg/l)	0.5	**A**	
Overall site classification		*B/C*		

RESOURCE UNIT: T Teespruit

Water quality unit 6: Teespruit

The main vegetation cover is Mountain grassland sour lowveld bushveld and patches of Afromontane forest. The river is unregulated. The hydrology and geomorphology of the Teespruit have been slightly impacted due to small-scale abstractions.

There is a greenstone mine near the Teespruit River, but its impacts on the river are negligible. The water quality is in good condition except for the lower section where there is a sewerage works with associated organic pollution. Water quality problems relating nutrient inputs upstream of the site due to a wastewater treatment works inflow upstream of the site, catchment slopes being highly degraded due to over grazing by livestock, the removal of vegetation for firewood and many villages on the slopes of the river. Typical water quality variables of concern are microbiological, nutrients and turbidity.

There is a greenstone mine near the Teespruit River, but its impacts on the river are likely to be minimal.

Confidence:

Only four water quality samples were collected at this site (winter 2003 and summer 2004)

The following confidences were allocated to the data.

pH	Low
TIN	Low
SRP	Low
EC	Low
F	Low

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality will remain the same over the short-term period (5 years) The long-term water quality trend (20 years) could deteriorate due to the continued degradation of the marginal vegetation and continued overgrazing.

River	**Teespruit**		**DWAF Water Quality Monitoring points**	
WQU	6		**RC**	
EWR site	T1		**PES**	N=4
Water Quality Constituents			**Value**	**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$			B
	Na_2SO_4			A
	$MgCl_2$			A
	$CaCl_2$			A
	NaCl			B
	$CaSO_4$			B
Nutrients (mg/L)	SRP		0.04	C/D
	TIN		0.186	A
Physical variables	pH (pH units)		7.48 – 7.74	A
	Temperature (º C)		No data	No impacts expected.
	Dissolved oxygen (mg/l)		No data	

	Turbidity (NTU)		Expect high turbidity after rains due to removal of riparian vegetation and the natural steep topography
Response variable	Chl-a: periphyton (mg/m^2)	Not sampled	
	Biotic community composition - macroinvertebrate (ASPT) score	ASPT: 5 .9 to 7.2 SASS: 163 to 239	C
	In-stream toxicity	Not sampled	
Toxics	Fluoride (μg/L)	363	A
Overall site classification		*C*	

RESOURCE UNIT D: Mananga to Lomati River

Water quality unit 7: From Swaziland to the confluence with the Lomati River (Mananga to Tonga):

Lebombo Arid Mountain Bushveld dominates the vegetation cover.

There are two main dams associated with this site in the Lower Komati River System: Maguga Dam (in Swaziland) and Sand River Reservoir. The Maguga and Sand River Reservoir regulate stream flow, which has resulted in a changed flow regime and periods in winter when the flow stops. The Magugu–IYSIS canal further removes up to 9 m^3/s for irrigation. Furthermore a large number of weirs were built in the lower Komati between 1984 and 1992 with inadequate outlet discharge capacities. As a result, the weirs pose significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations.

The land use is mainly crop farming, sugar cane and banana plantations.

Water quality problems associated with coal mining on the banks of the river upstream of Tonga, runoff from burgeoning urban population, intensive irrigated sugar cane, many diversion weirs. Ecological conditions is further highly impacted by frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir. Clearing of bank vegetation and sand mining has reduced bank stabilisation and led to alien vegetation encroachment. The main water quality issues are nutrients (with associated benthic algal blooms), bacterial contamination and increased water temperatures, slight salinisation when the river stops flowing and microbiological contamination.

Confidence:

The following confidences were generated using G-Power.

pH	High
TIN	High
SRP	High
EC	High
F	High

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality could improve over the short-term period (5 years) with possible releases from Maguga Dam. The long-term water quality trend (20 years) could deteriorate as a result, the many weirs posing significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations

River	Lower Komati	**DWAF Water Quality Monitoring points**		
WQU	7	**RC**	X1H003Q01 (1977 – 1987) n = 201	
EWR site	K3	**PES**	X1H003Q01 (1995 – 2005) n = 345	
Water Quality Constituents		**Value**		**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$			B
	Na_2SO_4			B
	$MgCl_2$			B
	$CaCl_2$			A
	NaCl			B
	$CaSO_4$			A
Nutrients (mg/L)	SRP	0.025		C
	TIN	0.32		C
Physical variables	pH (pH units)	5.01 – 7.22		C/D
	Temperature (º C)	No data		River stops flowing in winter – high temperatures in pools
	Dissolved oxygen (mg/l)	No data		
	Turbidity (NTU)			Expect high turbidity after rains due to removal of riparian vegetation and the natural steep topography
	Chl-a: periphyton (mg/m^2)	Not sampled		Rocks clogged with filamentous algae

Response variable	Biotic community composition - macroinvertebrate (ASPT) score	ASPT – 4.5 to 6.1 SASS < 50	D/E
	In-stream toxicity	Not sampled	Potential
Toxics	Fluoride (μg/l)	225	A
Overall site classification		*C/D*	

RESOURCE UNIT E: Lower Komati (Lomati River to Komatipoort)

Water quality unit: 8 Confluence of the Lomati River to the confluence with the Crocodile River (Tonga to Crocodile Bridge)

The river is characterised by a wide low gradient almost completely inundated by weirs leaving no flowing water habitats.

There are two main dams in the Lower Komati River System: Maguga Dam (in Swaziland) and Driekoppies Dam. Driekoppies Dam is situated on the Lomati River, and its main purpose is to stabilise river flows, provide for the increase in primary water demand, to allow for moderate increase in irrigation development, and assure water supplies to existing irrigation and urban development in the lower Komati Basin. Until such a time as Maguga Dam has sufficient water to supply the lower Komati River, Driekoppies Dam is being used to supply demands as far as Komatipoort. This means that baseflows in the lower Lomati River are higher than usual. A large number of weirs were built in the lower Komati and Lomati Rivers, mainly between 1984 and 1992 with inadequate outlet discharge capacities. As a result, the weirs pose significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations.

The lower Komati River Catchment is in a poor ecological condition. The large number of weirs and associated irrigation in the lower reaches of the river has resulted in a deterioration of the water quality to such an extent that it has become enriched with nutrients and the dissolved oxygen levels become limiting to the ecology. The overall picture is one of a system that deteriorates in the lower reaches. There are frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir.

Confidence:

The following confidences were generated using G-Power.

pH	High
TIN	High
SRP	High
EC	High
F	High

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality will continue to deteriorate over a short-term period (5 years) and unless the EWR and international obligations are applied, the water quality will further deteriorate in the long term (20 years). This declining trend is due to flow regulation weirs and upstream dams as well as diffuse agriculture return flows (salts, fertilizers, nutrients, lack of dissolved oxygen).

River	Lower Komati (Komati Bridge)	**DWAF Water Quality Monitoring points**	
WQU	8	**RC**	X1H042Q01 (1993 – 1999) n = 11
EWR site	K5	**PES**	X1H042Q01 (1999 – 2005) n = 116

Water Quality Constituents		**Value**	**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$		**B**
	Na_2SO_4		**B**
	$MgCl_2$		**B**
	$CaCl_2$		**A**
	NaCl		**B**
	$CaSO_4$		**A**
Nutrients (mg/L)	SRP	0.03	**C/D**
	TIN	0.498	**C/D**
Physical variables	pH (pH units)	7.28 – 9.26	**C/D**
	Temperature (º C)	No data	Many weirs will result in temperature increases in the lower reaches
	Dissolved oxygen (mg/l)	No data	Dissolved oxygen would be expected to have a wide diurnal variation due to the algal proliferation
	Turbidity (NTU)	Not sampled	Trapped and settled by weirs
Response variable	Chl-a: periphyton (mg/m^2)	Not sampled	Expect to be high - euthrophication indicated by the proliferation of green algae

	Biotic community composition - macroinvertebrate (ASPT) score	SASS – 50 – 180 ASPT – 4 – 7.2	*D* Declining trend due to isolation and inundation of habitats by weirs
	In-stream toxicity	Not sampled	Due to the extensive use if pesticides would expect Instream toxicity
Toxics	Fluoride (μg/l)	290	*D*
Overall site classification		*D*	

RESOURCE UNIT H: Upper Lomati to Swaziland

Water quality units 9. Upper Lomati to Swaziland

Sour Lowveld Bushveld dominates the land use. North Eastern Mountain Grassland and mountain slopes are covered by pine plantations.

No water quality data available for this WQU. There are minimal water quality variables of concern except for possible influence of afforestation (turbidity).

It is estimated that the water quality PES for this WQU will be a category B.

RESOURCE UNIT M: Upper Lomati to Swaziland

Water quality units 10. Upper Lomati to Swaziland

The land use is mainly sugar cane, orchards and intensive crop farming and this WQU is in the lowveld ecoregion.

The ecosystem is fairly healthy, although there has been a major change due to the impacts of Driekoppies Dam. The vegetation is greatly modified from natural from a fairly sparsely vegetated channel to a channel with a significant woody vegetation component.

Water quality will be affected by environmental flows from the Driekoppies Dam, Schoemans and diversion weirs. Driekoppies Dam releases according to farmers needs but also has a constant base flow. Schoeman's weir is used for generating hydroelectricity. Furthermore when Maguga Dam is full the Schoeman's weir will be used for releases to the Lomati River.

Water quality will be affected by environmental flows from the Driekoppies Dam. Typical water quality problems are nutrient enrichment (phosphates, nitrates, nitrites, ammonia), aquatic algae, higher salinity values (electrical conductivity) and microbiological contamination.

Confidence:

Data available from 2000 only.

The following confidences were generated using G-Power.

pH	Medium
TIN	Medium
SRP	Medium
EC	Medium
F	Medium

No temperature, dissolved oxygen and turbidity data were available.

Trends:

Water quality will be affected by environmental flows from the Driekoppies Dam, Schoemans and diversion weirs.

It is expected that the water quality will probably improve over the short-term period (5 years) if the EWR and international obligations flow requirements are applied. The water quality will could deteriorate in the long term (20 years). This declining trend is due to flow regulation, from the Driekoppies Dam, Schoemans and diversion weirs, as well as diffuse agriculture return flows (salts, fertilizers, nutrients, lack of dissolved oxygen).

River	Lower Lomati	**DWAF Water Quality Monitoring points**	
WQU	10	**RC**	
EWR site	L1	**PES**	X1HO49Q1 (2000-2004) N = 93
Water Quality Constituents		**Value**	**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$		B
	Na_2SO_4		A
	$MgCl_2$		A
	$CaCl_2$		A
	NaCl		B
	$CaSO_4$		A
Nutrients (mg/L)	SRP	0.022	C
	TIN	0.277	B/C
Physical variables	pH (pH units)	6.9 – 8.6	B
	Temperature (º C)	No data	Driekoppies Dam operational procedures will impact temperatures due to releases from deeper colder water
	Dissolved oxygen (mg/l)	No data	

	Turbidity (NTU)		Sediments settled out in dams
Response variable	Chl-a: periphyton (mg/m^2)	Not sampled	
	Biotic community composition - macroinvertebrate (ASPT) score	ASPT – 5.5 – 7 SASS 60 - 250	*C*
	In-stream toxicity	Not sampled	
Toxics	Fluoride (μg/l)	154	A
Overall site classification		*B/C*	

RESOURCE UNIT: MTSOLI

Water quality units 11. Mtsoli River to confluence with Komati River

The upper reaches of the Mtsoli River has commercial forestry and at the lowest reaches at Diepgezet there is an abandoned asbestos mine and a golf course.

Generally the water quality is good and the only potential impacts are due to afforestation.

Confidence:

The following confidences were generated using G-Power.

pH	Medium
TIN	Medium
SRP	Medium
EC	Medium
F	Medium

No temperature, dissolved oxygen and turbidity data were available.

Trends:

It is expected that the water quality should remain stable over the short-term period (5 years) with no land use changes expected. The long-term water quality trend (20 years) is expected to remain stable.

River	Mtsoli River	**DWAF Water Quality Monitoring points**		
WQU	11	**RC**	X1HO21Q1 (1977-1987) N = 132	
EWR site	M1	**PES**	X1HO21Q1 (2002-2005) N = 80	
Water Quality Constituents		**Value**		**Category / Comment**

Inorganic salts (mg/L)	$MgSO_4$		A
	Na_2SO_4		A
	$MgCl_2$		A
	$CaCl_2$		A
	NaCl		A
	$CaSO_4$		A
Nutrients (mg/L)	SRP	0.012	B
	TIN	0.06	A
Physical variables	pH (pH units)	6.12 – 8.61	C
	Temperature (º C)	No data	No impacts expected.
	Dissolved oxygen (mg/l)	No data	
	Turbidity (NTU)		
Response variable	Chl-a: periphyton (mg/m^2)	Not sampled	
	Biotic community composition - macroinvertebrate (ASPT) score	ASPT 6 to 7.6 (6.9) SASS 96 to 234 (183)	B
	In-stream toxicity	Not sampled	
Toxics	Fluoride (μg/l)	50	A
Overall site classification		*A/B*	

RESOURCE UNIT M1: - Silingani

This site is situated 20 km downstream from Maguga Dam that was completed in 2002. The dam controls 90 % of both the catchment and MAR. The main changes in water quality as a result of the dam are temperature and turbidity. There is no alien vegetation present. Mesophytic grasses and sedges dominate the annual flood bench. The banks of the main channel are dominated by clumps of reeds (*Phramites mauritianus*) trees (*Breonadia salicina, Olea woodiana, Nuxia oppositifolia*) and sedges (*Cyperus marginatus*).

The area of the dam is considered to be culturally important by the Swazi people. Rural communities are dependant on the river for irrigation, spiritual activities, drinking, washing and using resources such as edible, medicinal plants, building materials, carving and firewood.

The major water quality issues are as a result of microbiology contamination from animals and people. The dam will responsible for the storage and trapping of sediments that will result in lower turbidity. Reduced flood flows due to the dam will result in encroachment of the secondary channel by vegetation.

Confidence:

Only two samples available.

Trends:

It is expected that the water quality will improved over the next 5 years due to the Maguga Dam trapping of sediments and lower the turbidity. Depending on the operational procedure for the dam the main changes in water quality as a result of the dam are temperature and turbidity. The long-term water quality trend (20 years) is expected to remain stable.

River	**Maguga Dam**	**DWAF Water Quality Monitoring points**	
WQU		**RC**	
EWR site	**M1 Silingani**	**PES**	
Water Quality Constituents		**Value**	**Category / Comment**
Inorganic salts (mg/L)	$MgSO_4$		A
	Na_2SO_4		A
	$MgCl_2$		A
	$CaCl_2$		A
	NaCl		A
	$CaSO_4$		A
Nutrients (mg/L)	SRP	0.012	C
	TIN	0.186 - 0.218	A
Physical variables	pH (pH units)	7.45 - 7.94	A
	Temperature (º C)	No data	Impacts expected.
	Dissolved oxygen (mg/l)	No data	
	Turbidity (NTU)	30.9	Impacts of erosion releases from Maguga Dam
Response variable	Chl-a: periphyton (mg/m^2)	Not sampled	
	Biotic community composition - macroinvertebrate (ASPT) score	ASPT 6.3 – 6.4 SASS 185 - 190	B
	In-stream toxicity	Not sampled	
Toxics	Fluoride (μg/l)	100	A
Overall site classification		*B/C*	

5 FLOW-CONCENTRATION MODELLING

5.1 INTRODUCTION

Flow-concentration modelling is undertaken once all the relevant water quality data have been selected, manipulated and the PES assessment compiled. The results of the flow-concentration modelling provide input into determining both the water quality and overall ecological categories for the various flow scenarios as selected for evaluation by the hydrological and project management team.

In order for the flow-concentration modelling to be undertaken, the following must be provided by the water quality team:

- Monthly median values for each variable calculated over the same time period used for the PES and RC assessment (usually 3 or 5 years) at each EWR site.
- Sample size (n) and time period (e.g. 2000 – 2004)
- Variables required include:
    - TDS / Conductivity
    - salt ions (Na, SO_4, Cl, Mg etc.)
    - pH
    - nutrient variables
    - any constituents considered a potential water quality problem, e.g. fluoride

The objective of this activity is to set up the tools required during the fifth step of the Ecological water resource process, i.e. to assess the ecological consequences of various flow scenarios. The assessment of water quality conditions can be as simple as a qualitative statement based on expert judgement of the expected water quality behaviour under different flow regimes, or as complex as the application of a hydrodynamic river water quality model to simulate water quality changes under different flows. Malan and Day (2002a) reviewed a number of approaches for linking discharge, water quality and biotic responses in rivers. Their report described, in detail, two fairly simple approaches that could be used, namely a discharge-concentration modelling method and a time-series modelling method which is compatible with the flow-stressor response approach used in water quantity ecological water resource determinations. The selection of an assessment appropriate tool is a function of the confidence required and the budget made available (DWAF 2002).

Flow-concentration modelling was adopted for this study, and was used to provide information toward assessing water quality consequences of various flow scenarios. As limited flow-concentration modelling could be undertaken due to data constraints, additional sources of information were used to make predictions. These data and approaches are discussed in Section 6 of this report.

5.1.1 The need for water quality modelling

This section of the report describes the methods used and results obtained from water quality modelling carried out as part of the determination of the Ecological Reserve for the Komati River system. The term *water quality modelling* is used to describe techniques employed to obtain quantitative predictions of what the concentration of chemical constituents in a given river reach would be under given conditions of flow (e.g. a proposed flow regime). The concentration of in-stream chemical constituents, as well as the values of physical variables, may vary significantly with changes in flow. In addition, aquatic biota respond not only to the hydraulic habitat and amount of water supplied, but also to the quality of that water. Thus it is important that the water quality conditions likely to occur under a proposed flow regime also be predicted and reported in a quantitative manner. This will ensure that in meeting the ecological Reserve with regard to *quantity* the water *quality* component of the Reserve is also attained.

5.1.2 Outline of the approach used

Water quality data for the Reference Condition (RC) and Present Ecological State (PES) at each EWR site were used to obtain flow-concentration relationships by plotting monthly median concentrations against monthly mean flow data and deriving the regression equation. These flow-concentration (Q-C) relationships were used to predict, for a given flow, what the expected in-stream concentration would be, and were used to set up a matrix of flows and associated predicted concentrations for identified water quality variables. The appropriate matrix was used to convert the flow time-series to a time-series of expected concentrations for different flow scenarios. From these time-series, concentration-exceedence curves were generated and the flow scenarios could then be compared with regard to the likely resultant changes in the concentrations of key water quality constituents.

5.2 METHODS AND DATA SOURCES USED

Water quality modelling was carried out in the following manner.

5.2.1 Flow-concentration modelling

Flow-concentration (Q-C) modelling was used to estimate the concentration of a particular chemical constituent that would be expected to occur in a river reach at a given flow. This technique is described in detail in Malan and Day (2002a, b) and Malan *et al*. (2003).

For each EWR site, present day (PES) water quality data were obtained from the nearest DWAF monitoring site. Reference Condition (RC) water quality was inferred from either historical data or from an un-impacted tributary using the procedure described in the Resource Directed Measures manual (DWAF 1999). In order to satisfy the requirements for modelling the data need to be representative of the water quality at the EWR site under consideration, and consist of at least 60 data points collected during both the dry and wet seasons. Water quality data collected from a pipeline or from a dam are not suitable for use in modelling (Malan and Day 2002a). Where possible, the data used for Q-C modelling were the same as those used in the water quality assessment (Section 4). Simulated flow data used in the water quantity determinations of the EWR as supplied by the hydrologist for the project, were also used. Monthly mean flows were calculated using data from the entire data-set.

Monthly mean flow values were correlated with median monthly concentration values for each water quality variable for which there were suitable data. Median water quality values were used since concentrations can range widely and a single extreme event can alter the mean significantly. It is therefore statistically correct to use median values. However, mean discharge values were used as is the convention in the field of hydrology. Correlation of concentration and flow values was carried out separately for the Reference Condition (i.e. least impacted state) as well as for the Present Ecological State. The water quality constituents examined included EC (Electrical Conductivity), TP (Total Phosphorus), SRP (Soluble Reactive Phosphorus), and TIN (Total Inorganic Nitrogen). The selection of chemical constituents modelled depended on the availability of data at each site.

Graphs of concentration versus flow were plotted and a regression line drawn through the data points. The "best fit" was chosen by using the relationship (in Microsoft Excel) that yielded the highest value of the coefficient r^2. An r^2 value greater than or equal to 0.65 was used as the criterion for assessing the significance of the Q-C relationship. This value of 0.65 was chosen after consideration of the literature. Sites and variables for which the r^2 value was greater than 0.65 (and where concentration was inversely related to flow – Section 5.2.4) were used to make predictions of concentration under different flow regime. For each EWR site and for each recommended monthly flow, the median concentration and 95% confidence intervals of each chemical constituent could be predicted using the appropriate regression relationship.

The concentration of each water quality variable was predicted (where possible) for key months under the prescribed EWR base-flow regime. Predictions were made for base-flows, rather than total flow (which would include floods and any excess flow in the system). Therefore, in the case of EC and other chemical constituents that decrease in concentration with increased flow (Section 5.3.1), the predictions from Q-C modelling represent the *worst case scenario*.

5.2.2 Information that can be obtained using flow-concentration modelling

The following information can be obtained using flow-concentration (Q-C) modelling, depending on the availability and reliability of data at each EWR site:

- Flow-concentration relationships for the key water quality variables.
- Estimates of how many months of the year, under the proposed EWR base flow, the water quality Reserve would be attained with regard to the various water quality constituents (TDS, nutrients) as well as the likely assessment category (A, B, C etc.).

- In what month the worst water quality would be likely to occur and what concentrations could be expected.
- What flows, in the absence of pollution control, would be required to dilute pollutants in order to attain the water quality Reserve.

5.2.3 Production of concentration-exceedence curves

The software package TSOFT (Time Series Display and Analysis Software) (Hughes *et al*. 2000) was used to transform time-series of flow to time-series of concentration. This was carried out for each EWR site, and for each water quality variable where there was a good correlation between flow and concentration ($r^2 \geq 0.65$). The regression equation that had been derived at each site using Q-C modelling was used to convert time-series of flow to time-series of predicted concentration.

5.2.4 Production of summary statistics

The terms of reference for the Komati Comprehensive Reserve study requires that median concentrations (where data permits) be predicted that will occur under each flow scenario. Summary statistics were therefore prepared by transforming flow values to concentration values (using the appropriate regression equation). Various statistics (e.g. the median, standard deviation etc) were calculated for each scenario in a spreadsheet package (EXCEL). Summary statistics were calculated for the entire time-series (under each scenario) as well as for the months of February and August, which represented wet and dry months respectively (Appendix A).

5.2.5 Assumptions and approximations in the approach

There are some important assumptions in the modelling method that need to be taken into account when interpreting the results.

- A low confidence is expressed in the quantitative predictions obtained using flow-concentration and time-series water quality modelling, as in-stream concentrations of chemical constituents are inherently variable and are affected by factors other than flow. The modelling method used is a very simple approach and is aimed at providing an *estimate* of predicted water quality.
- Use is made of monthly median values of concentrations and monthly average flow through which a trend-line is fitted. Unless there is measured water quality data for very low flows and very high flows, extrapolation to these conditions (as occurs when converting to concentration time-series) is likely to be inaccurate.
- It is important to note that all predictions of water quality made in this report are made under the assumption that the present loading of pollution will remain the same.
- Concentration exceedence (duration) curves can be used to compare and rank some of the water quality consequences that will arise from different flow scenarios. The

results however are not sufficiently accurate to make exact quantitative predictions. Values given in this report are estimates.

- The water quality experienced by aquatic biota at a given site is composed of many different variables. The effect of altered flow on many of these variables (e.g. dissolved oxygen, temperature) cannot be predicted using the simple modelling methods used in this project, and a way of combining the overall impact of the variables that can be predicted has not yet been developed.
- The modelling method is not suitable for chemical constituents that show an increase in concentration with increasing flow. This is because these pollutants often arise from diffuse sources in the surrounding catchment. It cannot automatically be assumed that if the flow in a river is decreased, the in-stream concentration of the pollutant will also decrease. This will depend on site-specific factors that require further investigation.

5.2.6 Water quality assessment categories

Modelling of individual salts was not carried out in this study because elevated salinity was generally not considered an issue. In the case of nutrients, the assessment method for the PES makes use of annual means (which may need to be benchmarked) whereas the modelling method uses monthly median values. This makes it difficult to compare the predicted category for TIN or SRP with the PES category.

The information provided in this section of the report (Section 5) was utilized by the water quality team at the scenario workshop to assess the consequences of manipulating flows (i.e. various flow scenarios) on water quality. These assessments are outlined in Section 6 of the report.

5.3 RESULTS

The water quality flow concentration modelling results for the Komati Comprehensive Reserve Determination Study are presented below and indicated in Table 5.1. Table 5.1 shows a summary of the DWAF monitoring stations that were used to provide water quality data used for modelling. Also shown is the time-period of data used and the extent of the water quality modelling that could be undertaken.

As can be seen from table 5.1 the results there was no suitable monitoring station / adequate data for any of the EWR sites.

Table 5.1: Sources of water quality data used for Q-C modelling in the Komati system and the extent of modelling carried out at each site (Appendix C).

EWR Site	Water quality data		Comments
	RC	PES	Comments – regression relationship
K1 X1H033Q01	1977 - 1982	2000 - 2005	Poor data set with less than the required number of data points for modelling. r^2 values for all variables <0.53. No time-series modelling done because for the available data set the flow was not inversely related to concentration.
K2 X1H001Q01	1977 – 1982	2002 - 2005	Available data for modelling. r^2 values for all variables. With the exception of Electrical conductivity, (r^2 values for PES of 0.79), all other r^2 values <0.25. No time-series modelling done because for the available data set the flow was not inversely related to concentration.
K3 X1H003Q01	1977 - 1982	2000 - 2005	Available data for modelling. r^2 values for all variables. With the exception of Electrical conductivity, (r^2 values for RC of 0.765), all other r^2 values <0.40. No time-series modelling done because for the available data set the flow was not inversely related to concentration
K5 X1H042Q01	1993 - 1999	2000 - 2005	Poor data set for RC with less than the required number of data points for modelling. No time-series modelling done.
G1 X01H019Q01	1977 - 1982	1991 - 1996	Poor data set with less than the required number of data points for modelling. r^2 values for all variables <0.47. No time-series modelling done because for the available data set the flow was not inversely related to concentration.
T1	X	X	Not sufficient water quality data. Time-series modelling not done.
L1 X01H049Q01	X	2000 - 2004	Only PES data available. Time-series modelling not done.
S1	X	X	Not sufficient water quality data. Time-series modelling not done.
Mtsoli	1977-1987	1995-2005	Not sufficient water quality data. Time-series modelling not done.

EWR Site	Water quality data		Comments
	RC	PES	Comments – regression relationship
M1 Silingane			Not sufficient water quality data. Time-series modelling not done.

The reasons for the water quality modelling results in the Komati River are as follows:

- Poor data records at most sites (data patchy and not all required variable analysed)
- Short duration of available data
- No r^2 value was greater than 0.65 (where concentration was inversely related to flow) were found

No transformation matrices were set up for the Komati River as there was not sufficient data and the r^2 values were less than 0.65 (see Table 5.1).

5.4 CONCLUSIONS

In order to undertake flow concentration modelling it is imperative that a good long-term water quality data set exists. The requirements for the flow concentration modelling are that at least 60 data points (3 or 5 years) are required for both the PES and RC.

The water quality data set available for the Komati River for the chosen EWR sites did not enable the use of the TSOFT package to transform the time-series of flow to time series of concentration. It is recommended that for any future water quality and flow concentration modelling to be undertaken on the Komati River that DWAF monitors the EWR sites at least monthly for the following variables:

- TDS / Conductivity
- salt ions (Na, SO_4, Cl, Mg etc.)
- pH
- nutrient variables (ortho-phosphates, ammonia, nitrate+ nitrite)
- any constituents considered a potential water quality problem, e.g. fluoride

The EcoSpecs and monitoring programme should address the above requirements.

6 WATER QUALITY CONSEQUENCES OF OPERATIONAL FLOW SCENARIOS

6.1 INTRODUCTION

Sections 5 and 6 of this report, i.e. flow-concentration modelling and the assessment of water quality consequences of operational flow scenarios, represent the steps of the EWR or Ecological Reserve process where the integration of water quality and quantity takes place. Flow-concentration modelling provides quantitative information to make predictions of water quality consequences. If lacking or minimal data can be modelled (such as in this study), qualitative predictions are made from available data and linking flow-duration curves (Appendix E) to knowledge of water quality conditions. An assessment is therefore made of how water quality conditions may change under selected flow scenarios.

As the EcoClassification approach was in use by the time of the Komati scenario workshop in May 2005, the ratings tables in the Physico-Chemical Driver Assessment Index (PAI) section of the Kleynhans *et al.* (2005) report were used extensively. These tables are a further development of the benchmark tables presented in the water quality methods manual and provide a direct link between the A-F water quality categories, boundary values or qualitative descriptions (e.g. for turbidity) per water quality variable, a description of deviation from RC and a PES rating of 0-5.

The integration between quality and quantity that occurs at this stage therefore provides the decision-maker with information on in-stream water quality conditions under a variety of operational flow scenarios. These operational scenarios account for operational constraints in the catchment, and normally include the recommended EWR. The decision-maker will then be in a position to determine whether quality source controls and/or dilution are required as part of water quality management to achieve the resource quality objectives.

6.2 APPROACH

The following approach was adopted by the water quality team during this phase:

- Limited flow-concentration modelling (Q-C) was available due to the lack of appropriate data and relationships between water quality variables and flow (Section 5 of this report).
- Flow-duration curves were provided to the water quality team. An example is shown in Figure 6.1 below. Further examples are shown in Appendix E. An explanation for the key to the figures is shown in Table 6.1.
- The water quality assessment conducted for the EWR sites (see PES tables in Section 4 of this report) was related to the 'Present (Day)' scenario (see Figure 6.1 and Table 6.1). This scenario was therefore used as the water quality baseline and conditions under all other scenarios compared to this assessment.
- Monthly flow-duration curves and ratings tables in Kleynhans *et al.* (2005) were used to provide qualitative water quality assessments under various flow scenarios at EWR

sites where Q-C modelling could not be conducted. The rating tables shown in the text below therefore present an updated PES assessment of water quality conditions per EWR site using the EcoClassification approach.

Note rank and %wt values on the ratings tables per variable and per EWR site. The importance and rating of these variables are dependent on river and river reach as different reaches of a river have different characteristics.

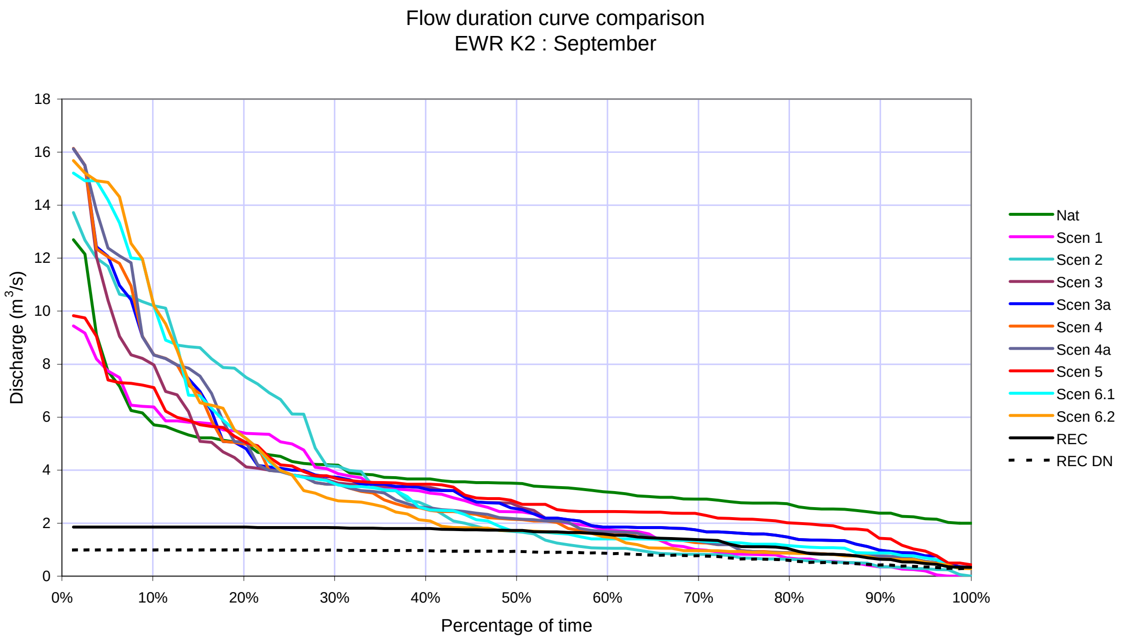

Figure 6.1: An example of a flow-duration curve provided to the water quality team by the project hydrologist.

Table 6.1: Descriptions of scenarios listed on flow-duration curves. The left column refers to the key on the graph, while the column on the right lists the interpretation of the description for purposes of evaluating flows and water quality implications.

Key on flow-duration curves	Description
Scenario 1:	No EWR with present use only and with Driekoppies Dam supplying the lower Komati River. Although this is an unlikely future scenario, the baseline data collected during this study was collected under these conditions, so this scenario serves as an important baseline.
Scenario 2	No EWR with full Treaty demands and Driekoppies and Maguga Dams supplying lower Komati River.
Scenario 3:	Recommended Ecological Category, including full flood requirements
Scenario 3A:	Recommended Ecological Category, but excluding floods that cannot be supplied because of outlet constraints. Exclude K3 as a driver because if its requirements cannot be

Key on flow-duration curves	Description
	supplied and there is no point in releasing water. This scenario will include checking flows at M1 and L1.But excluding floods that cannot be released
Scenario 4:	Down Alternative, including full flood requirements
Scenario 4A:	Down Alternative with the same changes as for 3A.
Scenario 5:	Up alternative, including full flood requirements.
Scenario 6:	Low flow requirements only (ie excluding all flood requirements)
Scenario 6.1:	Recommended Ecological Category
Scenario 6.2:	Below Recommended Ecological Category
Scenario 6.2a:	Below Recommended Ecological Category including Mozambique releases

At a meeting of 8 April 2005 it was agreed to exclude the following scenarios from further analysis:

- **Scenario 0:** Natural Conditions.
- **Scenario 5:** Up alternative, including full flood requirements.

6.3 RESULTS

The results are presented per EWR site.

6.3.1 EWR 1 (K1) Gevonden

A present state water quality assessment was conducted for the upper stretch of the Komati River (WQU) using data from X1H033Q01. Flow-concentration modelling was not conducted for this site. High and low, flow duration curves were used to assess the various scenarios.

SCORING GUIDELINES **EWR1** Scenario: Present

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	5	40	0.00	0.07	0.00	Yes	High
SALTS	2	95	0.00	0.17	0.00	Yes	High
NUTRIENTS	2	95	2.00	0.17	0.35	Yes	High
TEMPERATURE	3	85	1.00	0.15	0.15	Yes	Low
TURBIDITY	4	50	1.00	0.09	0.09	Yes	Medium
OXYGEN	3	85	1.00	0.15	0.15	Yes	Low
TOXICS	1	100	0.00	0.18	0.00	Yes	Low
TOTALS		550			0.75		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**85.09**		
PHYSICO-CHEMICAL CATEGORY					**B**		
BOUNDARY CATEGORY							

The Reference Condition water quality of K1 would be an improvement on the current water quality status due to there being no commercial farming, no Eskom water requirements, nor any open-cast coal mines.

The Nooitgedacht Dam which is upstream of K1 which has operating rules that are designed to maximise yield. The volume of water that is abstracted depends on the available water through inter-basin transfers from the incremental catchment of the east-Vaal Subsystem, which includes the upper Vaal, upper Usutu and upper Vaal Rivers.

Eskom water requirements impact the flow in this reach of the river. There are four open-cast coal mines in the upper catchment, upstream of Nooitgedacht Dam. There are small nutrient inputs from farming along the steep banks of the river. No difference in water quality between the Nooitgedacht Dam and Vygeboom Dam.

The Present Day upper Komati River Catchment is generally in a good ecological condition, with the main impacts relating to dry land farming and forestry. The Nooitgedacht Dam does not make any compensatory releases, so low-flows have decreased. Water temperatures are likely to have increased due to reduced low-flows, and nutrients have increased due to trout dams and tourist developments. There is large potential for opencast coal mining in this area, and this may compromise the good quality water that currently characterises the area.

It is anticipated that water quality conditions will stay stable (i.e. as at present state) under all flow scenarios evaluated for the PD scenario**.**

SCENARIO 6.2

SCORING GUIDELINES **K1** Scenario: PES down floods down Sc 6.2

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	5	20	0.50	0.04	0.02	5.00	5.00
SALTS	4	40	1.00	0.08	0.08	5.00	5.00
NUTRIENTS	1	100	2.00	0.20	0.41	3.00	5.00
TEMPERATURE	2	80	0.50	0.16	0.08	5.00	5.00
TURBIDITY	3	70	1.50	0.14	0.21	5.00	3.00
OXYGEN	2	80	1.00	0.16	0.16	5.00	3.00
TOXICS	1	100	0.00	0.20	0.00	5.00	3.00
TOTALS		490			0.97		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**80.61**	83.00	
PHYSICO-CHEMICAL CATEGORY					**B/C**		
BOUNDARY CATEGORY							

The summer (February) flows same as Present Day (Sc 1) and no water quality changes expected for Sc 6.2.

The low flow (September) month will have higher flows available for 40% of the time at high flows. The low flows will be the same as Present Day (Sc 1). The water quality will improve due to higher flows (dilution and improved dissolved oxygen and more natural temperatures).

6.3.2 EWR 2 (K2) Kromdraai

The reference condition water quality of K2 would have been better improved due to the impacts of regulated flow from Vygeboom Dam being negated. The water quality improvements, compared to PES, would include no temperature changes in the impoundment and an improved water quality upstream in the Komati, Seeikoespruit and Teespruit Rivers.

Present Day: Scenario 1

Impacts expected as a resulted of warming in the Vygeboom Dam and operational procedure. Constant compensation releases of between 0.46 and 0.65 m^3/s. the water quality would still be impacted by the unregulated Seeikoespruit and Teespruit releasing high sediments and nutrients. PD water quality PAI percentage score is 78.5 (B/C).

SCORING GUIDELINES **K2** Scenario: Sc 1 = PD

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	20	0.50	0.04	0.02	5.00	5.00
SALTS	3	50	0.75	0.10	0.07	5.00	5.00
NUTRIENTS	2	80	1.75	0.16	0.27	3.00	5.00
TEMPERATURE	2	80	1.00	0.16	0.16	5.00	5.00
TURBIDITY	1	100	2.00	0.20	0.39	5.00	3.00
OXYGEN	2	80	1.00	0.16	0.16	5.00	3.00
TOXICS	1	100	0.00	0.20	0.00	5.00	3.00
TOTALS		510			1.07		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**78.53**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		
BOUNDARY CATEGORY							

Scenario 3a: REC and floods that cannot be supplied.

For 15% of the time there will be higher flows as a result of scenario 3a when compared to the PD. SC 3a water quality PAI percentage score is 79.31 (B/C). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD.

SCORING GUIDELINES **K2** Scenario: Sc 3a

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	20	0.50	0.04	0.02	5.00	5.00
SALTS	3	50	0.75	0.10	0.07	5.00	5.00
NUTRIENTS	2	80	1.50	0.16	0.24	3.00	5.00
TEMPERATURE	2	80	1.00	0.16	0.16	5.00	5.00
TURBIDITY	1	100	2.00	0.20	0.39	5.00	3.00
OXYGEN	2	80	1.00	0.16	0.16	5.00	3.00
TOXICS	1	100	0.00	0.20	0.00	5.00	3.00
TOTALS		510			1.03		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**79.31**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		
BOUNDARY CATEGORY							

Scenario 4a: Below PES with floods that cannot be met.

The flows will be above PD for 20% of the time in high flows. SC 4a water quality PAI percentage score is 81.08 (B/C). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to dilution by greater flow.

SCORING GUIDELINES **K2** Scenario: Sc 4a

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	20	0.50	0.04	0.02	5.00	5.00
SALTS	3	50	0.75	0.10	0.07	5.00	5.00
NUTRIENTS	2	80	1.25	0.16	0.20	3.00	5.00
TEMPERATURE	2	80	1.00	0.16	0.16	5.00	5.00
TURBIDITY	1	100	1.75	0.20	0.34	5.00	3.00
OXYGEN	2	80	1.00	0.16	0.16	5.00	3.00
TOXICS	1	100	0.00	0.20	0.00	5.00	3.00
TOTALS		510			0.95		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**81.08**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		
BOUNDARY CATEGORY							

Scenario 6.1: REC with no floods

The flows will be above PD for 35% of the time in high flows. SC 6.2 water quality PAI percentage score is 82.06 (B/C). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to dilution by greater flow.

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	Rank	%wt	Rating	Weight	Weighted score	Flow related?	Confidence
pH	3	20	0.50	0.04	0.02	5.00	5.00
SALTS	3	50	0.75	0.10	0.07	5.00	5.00
NUTRIENTS	2	80	1.25	0.16	0.20	3.00	5.00
TEMPERATURE	2	80	1.00	0.16	0.16	5.00	5.00
TURBIDITY	1	100	1.50	0.20	0.29	5.00	3.00
OXYGEN	2	80	1.00	0.16	0.16	5.00	3.00
TOXICS	1	100	0.00	0.20	0.00	5.00	3.00
TOTALS		510			0.90		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**82.06**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		
BOUNDARY CATEGORY							

Scenario 6.2: Category lower than PES with no floods (C)

The flows will be above PD for 20% of the time in high flows. SC 6.2 water quality PAI percentage score is 81.08 (B/C). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to dilution by greater flow.

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	Rank	%wt	Rating	Weight	Weighted score	Flow related?	Confidence
pH	4	20	0.50	0.04	0.02	5.00	5.00
SALTS	3	50	0.75	0.10	0.07	5.00	5.00
NUTRIENTS	2	80	1.25	0.16	0.20	3.00	5.00
TEMPERATURE	2	80	1.00	0.16	0.16	5.00	5.00
TURBIDITY	1	100	1.75	0.20	0.34	5.00	3.00
OXYGEN	2	80	1.00	0.16	0.16	5.00	3.00
TOXICS	1	100	0.00	0.20	0.00	5.00	3.00
TOTALS		510			0.95		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**81.08**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		
BOUNDARY CATEGORY							

6.3.3 EWR 3 (K3) Tonga

There are two main dams in the Lower Komati River System are the Maguga Dam (in Swaziland) and Driekoppies Dam. Driekoppies Dam is situated on the Lomati River, and its main purpose is to stabilise river flows, provide for the increase in primary water demand, to allow for moderate increase in irrigation development, and assure water supplies to existing irrigation and urban development in the lower Komati Basin.Until such a time as Maguga Dam has sufficient water to supply the lower Komati River, Driekoppies Dam is being used to supply demands as far as Komatipoort. This means that baseflows in the lower Lomati River are higher than usual. A large number of weirs were built in the lower Komati and Lomati Rivers, mainly between 1984 and 1992 with inadequate outlet discharge capacities. As a result, the weirs pose significant problems to the management of these rivers, particularly during low-flows, when it becomes increasingly difficult to meet downstream requirements and international obligations.

The lower Komati River Catchment is in a poor ecological condition. The large number of weirs and associated irrigation in the lower reaches of the river has resulted in a deterioration of the water quality to such an extent that it has become enriched with nutrients and the dissolved oxygen levels become limiting to the ecology. The overall picture is one of a system that deteriorates in the lower reaches. Ecological conditions at K3 are highly impacted by frequent and extended periods of flow cessation, caused primarily by diversion of water at Tonga Weir. Clearing of bank vegetation and sand mining has reduced bank stabilisation and led to alien vegetation encroachment. The main water quality issues are nutrients (with associated benthic algal blooms) and bacterial contamination and increased water temperatures and slight salinisation when the river stops flowing.

The RC water quality at K3 would have been improved due to no impacts of flow regulation by the dams. The RC water quality would have been seasonal water temperatures, high dissolved oxygen values and a lower nutrient status.

Present Day Scenario 1

The summer (Feb) flows in this scenario will have no flow for 50% of the time. Sc PD.2 water quality PAI percentage score is 39.19 (Category D/E). Water quality problems such as nutrient enrichment (phosphates, nitrates, nitrites, ammonia), algae, salinity and microbiological contamination will worsen due to lower flows.

The winter (Sep) flows in this scenario will have no flow for 90% of the time. Sc PD.2 water quality PAI percentage score is 39.19 (D/E). Water quality problems such as nutrient enrichment (phosphates, nitrates, nitrites, ammonia), algae, salinity and microbiological contamination will worsen due to lower flows.

SCORING GUIDELINES **K3** Scenario: PD = Sc 1

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	40	1.50	0.06	0.10	5.00	5.00
SALTS	1	100	3.50	0.16	0.56	5.00	5.00
NUTRIENTS	1	100	3.50	0.16	0.56	3.00	5.00
TEMPERATURE	2	90	4.50	0.15	0.65	5.00	5.00
TURBIDITY	2	90	3.00	0.15	0.44	5.00	3.00
OXYGEN	1	100	4.50	0.16	0.73	5.00	3.00
TOXICS	1	100	0.00	0.16	0.00	5.00	3.00
TOTALS		620			3.04		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**39.19**		
PHYSICO-CHEMICAL CATEGORY					**D/E**		

Scenario 3a

There will be no periods of no flow in the winter for Sc 3a. Conversely, 70 % of the time when flows less than 12m^3/s discharge were higher flows than PD.

In the summer (Feb) there will be no periods of no flow but less high flows for 30% of the time when compared to the PD.

SC 3a's water quality PAI percentage score is 50.82 % (D). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to dilution by greater flow. Water quality issues will remain the same as the PD with nutrient enrichment (phosphates, nitrates, nitrites, ammonia), filamentous algae on rocks, higher salinity values (electrical conductivity) and microbiological contamination

SCORING GUIDELINES K3 Scenario: 3a

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	3	40	1.00	0.07	0.07	5.00	5.00
SALTS	2	90	3.00	0.15	0.44	5.00	5.00
NUTRIENTS	2	90	3.00	0.15	0.44	3.00	5.00
TEMPERATURE	1	100	3.00	0.16	0.49	5.00	5.00
TURBIDITY	2	90	3.00	0.15	0.44	5.00	3.00
OXYGEN	1	100	3.00	0.16	0.49	5.00	3.00
TOXICS	1	100	0.50	0.16	0.08	5.00	3.00
TOTALS		610			2.46		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**50.82**		
PHYSICO-CHEMICAL CATEGORY					**D**		

Scenario 2

There will be 10% of no flow in the winter and summer for Sc 2.

Sc 3a's water quality PAI percentage score is 49.34 % (D). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to dilution by greater flow. Water quality problems such as nutrient enrichment (phosphates, nitrates, nitrites, ammonia), algae, salinity and microbiological contamination will worsen due to no flows.

SCORING GUIDELINES **K3** Scenario: Sc 2

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	3	40	1.00	0.07	0.07	5.00	5.00
SALTS	2	90	3.00	0.15	0.44	5.00	5.00
NUTRIENTS	2	90	3.50	0.15	0.52	3.00	5.00
TEMPERATURE	1	100	3.00	0.16	0.49	5.00	5.00
TURBIDITY	2	90	3.00	0.15	0.44	5.00	3.00
OXYGEN	1	100	3.00	0.16	0.49	5.00	3.00
TOXICS	1	100	0.50	0.16	0.08	5.00	3.00
TOTALS		610			2.53		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**49.34**		
PHYSICO-CHEMICAL CATEGORY					**D**		

Scenario 6.1

There will be 30% of no flow in winter for Sc 2. In the summer there will be no periods on no flow.

Sc 6.1 water quality PAI percentage score is 50.82 % (D). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to dilution by greater flow. Water quality problems such as nutrient enrichment (phosphates, nitrates, nitrites, ammonia), algae, salinity and microbiological contamination will remain the same as for PD.

SCORING GUIDELINES **K4** Scenario: Sc 6.2

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	60	0.50	0.11	0.05	5.00	5.00
SALTS	3	70	2.00	0.12	0.25	5.00	5.00
NUTRIENTS	2	80	1.50	0.14	0.21	3.00	5.00
TEMPERATURE	1	100	1.00	0.18	0.18	5.00	5.00
TURBIDITY	4	60	0.50	0.11	0.05	5.00	3.00
OXYGEN	1	100	1.50	0.18	0.26	5.00	3.00
TOXICS	1	100	0.00	0.18	0.00	5.00	3.00
TOTALS		570			1.00		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**80.00**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		

6.3.4 K4

There are no flow measurements at K4 and consequently no flow duration curves. The PAI model was used with expert judgement for potential flows for Sc 4 and 6. Under these scenarios it would be expected that the PAI score would be 69.95 (C) which would improve the water quality at this site due to improved winter and summer flows.

SCORING GUIDELINES **EWR4** Scenarios Sc4, Sc6

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	40	0.50	0.07	0.04	5.00	5.00
SALTS	2	95	0.50	0.17	0.08	5.00	5.00
NUTRIENTS	2	95	1.50	0.17	0.25	5.00	5.00
TEMPERATURE	2	95	2.50	0.17	0.42	5.00	5.00
TURBIDITY	3	50	2.00	0.09	0.18	5.00	3.00
OXYGEN	2	95	2.50	0.17	0.42	5.00	3.00
TOXICS	1	100	1.00	0.18	0.18	5.00	3.00
TOTALS		570			1.55		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**68.95**		
PHYSICO-CHEMICAL CATEGORY					**C**		

6.3.5 M1: Silingani

The reference water quality would be better than the PD dues to no upstream flow regulation by Maguga Dam. The water quality impacts of natural flows would be greater dissolved oxygen in the river as well as lower temperatures.

Present Day

The PD water quality PAI percentage score is 84.41 % (B). The water quality status is impacted by the flow regulation from Maguga Dam. The water quality will improve due to dilution by greater flow

SCORING GUIDELINES **M1** Scenario: PD

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	3	70	0.00	0.12	0.00	0.00	5.00
SALTS	3	70	1.00	0.12	0.12	2.00	5.00
NUTRIENTS	3	70	1.00	0.12	0.12	1.00	5.00
TEMPERATURE	1	100	2.00	0.17	0.34	1.00	5.00
TURBIDITY	2	80	1.50	0.14	0.20		3.00
OXYGEN	1	100	0.00	0.17	0.00	1.00	3.00
TOXICS	1	100	0.00	0.17	0.00	5.00	3.00
TOTALS		590			0.78		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**84.41**		
PHYSICO-CHEMICAL CATEGORY					**B**		

Scenario 3a

There will be flow changes for summer for Sc 3a. In winter there will be greater high flows when compared to PD (Scenario 1). The low flows (less than 5 m^3/s) are similar to PD the summer there will be no periods on no flow. There will be no periods of no flow for both summer and winter and flows for scenario 3a are all above the PD all year.

Sc 3a water quality PAI percentage score is 84.56 % (B). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to slightly improved flows.

SCORING GUIDELINES **M1** Scenario: 3a

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	3	70	0.00	0.12	0.00	0.00	5.00
SALTS	3	70	1.00	0.12	0.12	2.00	5.00
NUTRIENTS	4	50	1.00	0.09	0.09	1.00	5.00
TEMPERATURE	1	100	2.00	0.18	0.35	1.00	5.00
TURBIDITY	2	80	1.50	0.14	0.21		3.00
OXYGEN	1	100	0.00	0.18	0.00	1.00	3.00
TOXICS	1	100	0.00	0.18	0.00	5.00	3.00
TOTALS		570			0.77		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**84.56**		
PHYSICO-CHEMICAL CATEGORY					**B**		

6.3.6 EWR T1 - Teespruit

The reference condition water quality would be better than the current water quality status due to no land degradation (less sediments) and no nutrient inputs (wastes from humans and animals).

There are no flow stations in the Teespruit and no way of regulating flow (no dams). Consequently the PAI model could not be run for this site. None of the scenarios would improve water quality at this site due to no possibilities of upstream releases (do dams, weirs or interbasin transfers).

6.3.7 EWR G1 - Gladdespruit

The reference condition water quality in the Gladdespruit would be better than the current water quality status due to no afforestation, gold mining and trout farming. The water quality variable that would be improved is turbidity, salts, electrical conductivity, a reduction in sulphates, an increase in pH and decrease in metal concentrations.

Water quality problems relating to gold mining residues (sulphates, low pH, metals) have been recorded in the past but due to improved mining methods and rehabilitation these impacts are not measured at present. Further land use such as pine forests (high turbidity runoff), many sand roads on the slopes above the rivers (sedimentation) occur in this resource unit. Water is abstracted for gold mining from the river.

Due to the lack of regulation ability at this site the PAI model was not run.

6.3.8 EWR L1-Kleindoringkop

The ecosystem at L1 is fairly healthy, although there has been a major change due to the impacts of Driekoppies Dam. The vegetation is greatly modified from natural from a fairly sparsely vegetated channel to a channel with a significant woody vegetation component. Generally the water quality is good and the only potential impacts are due to dissolved oxygen and temperature from upstream regulation.

The Driekoppies Dam is situated on the Lomati River, and its main purpose is to stabilise river flows, provide for the increase in primary water demand, to allow for moderate increase in irrigation development, and assure water supplies to existing irrigation and urban development in the lower Komati Basin.

Driekoppies Dam would not have impacted the reference condition water quality at L1 and the flows in the river would have been natural. Water quality problems such as nutrient enrichment (phosphates, nitrates, nitrites, ammonia), higher salinity values (electrical conductivity) and microbiological contamination would not have occurred.

Present Day or Scenario 1.

There will be flow changes for summer for Sc 1 and these flows will be less than the natural flows. The flows will be greater than PD flows for 80 % of the time in winter. More higher flows than natural flows due to releases from the Driekoppies Dam.

Sc 1 (PD) water quality PAI percentage score is 80.00 % (B/C). The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to slightly improved flows.

SCORING GUIDELINES L1 Scenario: PD

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	Rank	%wt	Rating	Weight	Weighted score	Flow related?	Confidence
pH	4	60	0.50	0.11	0.05	5.00	5.00
SALTS	3	70	2.00	0.12	0.25	5.00	5.00
NUTRIENTS	2	80	1.50	0.14	0.21	3.00	5.00
TEMPERATURE	1	100	1.00	0.18	0.18	5.00	5.00
TURBIDITY	4	60	0.50	0.11	0.05	5.00	3.00
OXYGEN	1	100	1.50	0.18	0.26	5.00	3.00
TOXICS	1	100	0.00	0.18	0.00	5.00	3.00
TOTALS		570			1.00		
PHYSICO-CHEMICAL PERCENTAGE SCORE					80.00		
PHYSICO-CHEMICAL CATEGORY					B/C		

Scenario 6.2

Scenario 6.2 has higher flows than Present Day flows for 75 % of the time in summer (only lower in low flows). Summer flows are regulated and less than the natural flows.The flows will be greater than PD flows for 70 % of the time in winter. More higher flows than natural flows due to releases from the Driekoppies Dam. Only low flows less than natural for 10% of the time.

Sc 6.2 water quality PAI percentage score is 80.00 % (B/C) that is the same as the PD scenario. The water quality status under this scenario is slightly improve due to dilution by greater flow when compared PD. The water quality will improve due to slightly improved flows.

SCORING GUIDELINES **L1** Scenario: Sc 6.2

PHYSICO-CHEMICAL CHANGES							
Physico-chemical Metrics	**Rank**	**%wt**	**Rating**	**Weight**	**Weighted score**	**Flow related?**	**Confidence**
pH	4	60	0.50	0.11	0.05	5.00	5.00
SALTS	3	70	2.00	0.12	0.25	5.00	5.00
NUTRIENTS	2	80	1.50	0.14	0.21	3.00	5.00
TEMPERATURE	1	100	1.00	0.18	0.18	5.00	5.00
TURBIDITY	4	60	0.50	0.11	0.05	5.00	3.00
OXYGEN	1	100	1.50	0.18	0.26	5.00	3.00
TOXICS	1	100	0.00	0.18	0.00	5.00	3.00
TOTALS		570			1.00		
PHYSICO-CHEMICAL PERCENTAGE SCORE					**80.00**		
PHYSICO-CHEMICAL CATEGORY					**B/C**		

6.3.9 S1 - Seekoespruit

There are no flow measurements at this site and consequently the PAI model could not be used.

7 ECOLOGICAL SPECIFICATIONS (ECOSPECS) FOR WATER QUALITY PER EWR SITE

7.1 INTRODUCTION

This section of the report will list, per EWR site, the water quality objectives or ecological specifications (EcoSpecs) required in order to meet the water quality component of the Recommended Ecological Category (REC) for the constituents used in the assessment. Quality EcoSpecs will therefore be listed per EWR site based on the REC.

Quality EcoSpecs are related to attaining the recommended water quality category of the overall REC, and are presented as 95th percentiles, i.e. values not to be exceeded more than 5% of the time, for inorganic salts, physical variables and toxics; and 50th percentiles for nutrients, i.e. TIN and SRP. Biotic community composition (invertebrates) should not drop below the indicated values. Percentiles should be calculated within the framework of the current assessment method, i.e. using the PES monitoring point as shown on the table for the relevant EWR site, and the most recent 3 to 5 years of data, equivalent to a minimum of 60 data points. This approach is consistent with that to be used for the design of a monitoring programme for water quality. Present state categories per water quality constituent are shown as additional information.

Table 7.1 summarises the output of the EcoClassification process, and shows the recommended and alternative future management category of the system. Relevant to this section of the report is the PES and REC per EWR site. As can be seen from Table 7.1, the recommendation is that the PES be maintained at all EWR sites except Site K3, where an improvement was recommended.

Table 7-1. Summary of the Present Ecological State, Ecological Importance and Sensitivity (EIS), Social Importance (SI) and Recommended Ecological Categories (REC) and alternatives for each Resource Unit..

			EIS			*Ecological Category*		
RU	***Site***	***PES***	***Nat***	***Pre***	***SI***	***REC***	***Alternatives***	
B	*K1*	***B/C***	*V.H*	*H*	*M*	***B/C***	***B***	***C/D***
C	*K2*	***C***	*H*	*H*	*H*	***C***	***B***	***D***
D	*K3*	***E***	*V.H*	*M*	*V.H*	***D***	*N/A*	*N/A*
G	*G1*	***D***	*H*	*L*	*L*	***D***	***C***	*N/A*
T	*T1*	***C***	*H*	*H*	*M*	***C***	***B***	***D***
M	*L1*	***C/D***	*V.H*	*H*	*H*	***C/D***	*N/A*	*N/A*
A	-	***B***	*M*	*M*	*L*	***B***	*N/A*	*N/A*
E	-	***E***	*V.H*	*M*	*V.H*	***D***	*N/A*	*N/A*
L	-	***B***	*V.H*	*V.H*	*H*	***B***	*N/A*	*N/A*
S	-	***C***	*M*	*M*	*M*	***C***	*N/A*	*N/A*
Maguga	*M1*	***C***	*H*	*H*	*V.H*	***C***	***B***	***D***

Note the discrepancy in assessment results depending on the approach used for determining water quality category. Results of Section 4 follow the approach of the DWAF (2002) methods manual, while the ratings tables shown in Section 6 following the approach of Kleynhans *et al*. (2005). Although the latter approach is focused on a physical-chemical only, and does not include scores for response variables (i.e. Chlorophyll-a levels, fish or invertebrate scores) explicitly in the tables, tables do include qualitative assessments for variables such as turbidity. The EcoClassification approach is therefore considered a more quantitative approach to assessing the physico-chemical state of water bodies. The results section displays both sets of assessment results.

7.2 RESULTS

Results are expressed per EWR site. EcoSpecs presented as narrative descriptions are taken from the EcoClassification manual of Kleynhans *et al*. (2005).

7.2.1 EWR 1 (Upper Komati River)

<table>
<tr><th>River</th><td>Upper Komati</td><th colspan="3">DWAF Water Quality Monitoring points</th></tr>
<tr><th>WQU</th><td>1</td><th colspan="2">RC</th><td>X1H033Q01 (1983-1988) n = 15</td></tr>
<tr><th>EWR Site</th><td>K1</td><th colspan="2">PES</th><td>X1H033Q01 (1998-2002) n = 19</td></tr>
<tr><th colspan="2">Water quality constituents</th><th colspan="2">Present state</th><th>Quality EcoSpecs
(Benchmark classification)</th></tr>
<tr><td rowspan="6">Inorganic salts</td><td>$MgSO_4$</td><td colspan="2">B</td><td>16 mg/l</td></tr>
<tr><td>Na_2SO_4</td><td colspan="2">A</td><td>20 mg/l</td></tr>
<tr><td>$MgCl_2$</td><td colspan="2">A</td><td>15 mg/l</td></tr>
<tr><td>$CaCl_2$</td><td colspan="2">A</td><td>21 mg/l</td></tr>
<tr><td>NaCl</td><td colspan="2">A</td><td>45 mg/l</td></tr>
<tr><td>$CaSO_4$</td><td colspan="2">A</td><td>351 mg/l</td></tr>
<tr><td rowspan="2">Nutrients</td><td>SRP</td><td colspan="2">B/C (0.025)</td><td>0.017 mg/l</td></tr>
<tr><td>TIN</td><td colspan="2">A (0.09)</td><td>0.129 mg/l</td></tr>
<tr><td rowspan="4">Physical variables</td><td>pH (pH units)</td><td colspan="2">B (6.3 – 8.58)</td><td>5th Percentile:6.00-6.25
95thPercentile:8.37-8.69</td></tr>
<tr><td>Temperature</td><td>Expected to increase due to dams and surface runoff</td><td rowspan="2">Potential impacts associated with the operational procedure and releases from the Nooitgedacht Dam as there are only surface warm water spills.</td><td>Vary not more than 2º C when compared to natural mean monthly</td></tr>
<tr><td>Dissolved oxygen</td><td>No data</td><td>7 – 8 mg/L</td></tr>
<tr><td>Turbidity (NTU)</td><td colspan="2">No data - The river banks are eroded due to steep slopes as well as animal trampling. Dam will settle any turbidity</td><td>Small change allowed – largely natural and related to natural catchment processes such as rainfall runoff</td></tr>
</table>

Response variables	Chl-a: periphyton	(A) Chlorophyll-a values low (2.9 ug/l) and phaeophyte (2.5 ug/l) in Nooitgedacht Dam. Diatoms on rocks in river.	< 1.7 mg/m^2
	Chl-a: phytoplankton		5 µg/l
	Biotic community composition - macroinvertebrate	(B) Fish B/C ASPT– 5.4–5.8 SASS5 134-163	ASPT 6
	In-stream toxicity	Not sampled	
Toxics	Fluoride	200 A	1500 µg/l (A category)
	Al		20 µg/l (A category)
	Ammonia		15 µg/l (A category)
	As		20 µg/l (A category)
	Atrazine		19 µg/l (A category)
	Cd soft*		0.2 µg/l (A category)
	Cd mod**		0.2 µg/l (A category)
	Cd hard***		0.3 µg/l (A category)
	Chorine (free)		0.4 µg/l (A category)
	Cr(III)		24 µg/l (A category)
	Cr(VI)		14 µg/l (A category)
	Cu soft*		0.5 µg/l (A category)
	Cu mod**		1.5 µg/l (A category)
	Cu hard***		2.4 µg/l (A category)
	Cyanide		4 µg/l (A category)

- PES for water quality (Methods Manual, Section 4): B category
- PES for water quality (EcoClassification approach, Section 6): B category
- Overall PES: B/C category
- Recommended water quality component of the REC: **B/C category**

7.2.2 EWR 2 (Upper Komati River)

River	Upper Komati	**DWAF Water Quality Monitoring points**		
WQU	2	**RC**	X1H001Q01 (1977-1982) n = 96	
EWR Site	K2	**PES**	X1H001Q01 (2001-2005) n = 71	
Water quality constituents		**Present state**	**Quality EcoSpecs (Benchmark classification)**	**Improve ments required**
Inorganic salts	$MgSO_4$	B	16 mg/l	
	Na_2SO_4	A	20 mg/l	
	$MgCl_2$	B	15 mg/l	
	$CaCl_2$	A	21 mg/l	
	NaCl	A	45 mg/l	
	$CaSO_4$	A	351 mg/l	
Nutrients	SRP	B (0.018)	0.017 mg/l	
	TIN	B (0.146)	0.129 mg/l	

Physical variables	pH (pH units)	B/C (6.2-9.19)		5^{th} Percentile:6.24-6.46 95^{th}Percentile:8.69-9.00
	Temperature	No data	Impacts expected as a resulted of warming in the Vygeboom and operational procedure.	Vary not more than 2º C when compared to natural mean monthly
	Dissolved oxygen	No data		7 – 8 mg/L
	Turbidity (NTU)	High sediment inputs especially from Seeikoespruit		Small change allowed – largely natural and related to natural catchment processes such as rainfall runoff
Response variables	Chl-a: periphyton	Chlorophyll-a values in Vygeboom Dam low (1.0 – 1.25 ug/l)		21 mg/m²
	Chl-a: phytoplankton			< 5 ug/l
	Biotic community composition - macroinvertebrate	ASPT – 6 – 8 SASS5 ca. 200		ASPT > 6
	In-stream toxicity	Not sampled		
Toxics	Fluoride	150 (A)		1500 µg/l (A category)
	Al			20 µg/l (A category)
	Ammonia			15 µg/l (A category)
	As			20 µg/l (A category)
	Atrazine			19 µg/l (A category)
	Cd soft*			0.2 µg/l (A category)
	Cd mod**			0.2 µg/l (A category)
	Cd hard***			0.3 µg/l (A category)
	Chorine (free)			0.4 µg/l (A category)
	Cr(III)			24 µg/l (A category)
	Cr(VI)			14 µg/l (A category)
	Cu soft*			0.5 µg/l (A category)
	Cu mod**			1.5 µg/l (A category)
	Cu hard***			2.4 µg/l (A category)
	Cyanide			4 µg/l (A category)

- PES for water quality: B category
- PES for water quality (EcoClassification approach, Section 6): B/C category
- Overall PES: C category
- Recommended water quality component of the REC: C category

7.2.3 EWR 3 (Lower Komati River)

River	Lower Komati	**DWAF Water Quality Monitoring points**	
WQU	8	**RC**	X1H003Q01 (1977-1982) n = 102
EWR Site	K3	**PES**	X1H003Q01 (2000-2005) n = 158
Water quality constituents		**Present state**	**Quality EcoSpecs (Benchmark classification)**
	$MgSO_4$	B	16 mg/l
	Na_2SO_4	B	20 mg/l

Inorganic salts	$MgCl_2$	B	15 mg/l
	$CaCl_2$	A	21 mg/l
	NaCl	B	45 mg/l
	$CaSO_4$	A	351 mg/l
Nutrients	SRP	C 0.02	0.017 mg/l
	TIN	C0.32	0.129 mg/l
Physical variables	pH (pH units)	B 6.01 –8.77	6.5 to 8.0
	Temperature	No data	Vary not more than 2º C when compared to natural mean monthly
	Dissolved oxygen		7 – 8 mg/L
	Turbidity (NTU)	Expect high turbidity after rains due to removal of riparian vegetation and the natural steep topography	
Response variables	Chl-a: periphyton	Not sampled, Rocks clogged with filamentous algae	
	Chl-a: phytoplankton		< 5ug/l
	Biotic community composition - macroinvertebrate	(E) ASPT – 5 SASS5 < 50	ASPT 5
	In-stream toxicity	Not sampled	
Toxics	Fluoride	A	1500 µg/l (A category)
	Al		20 µg/l (A category)
	Ammonia		15 µg/l (A category)
	As		20 µg/l (A category)
	Atrazine		19 µg/l (A category)
	Cd soft*		0.2 µg/l (A category)
	Cd mod**		0.2 µg/l (A category)
	Cd hard***		0.3 µg/l (A category)
	Chorine (free)		0.4 µg/l (A category)
	Cr(III)		24 µg/l (A category)
	Cr(VI)		14 µg/l (A category)
	Cu soft*		0.5 µg/l (A category)
	Cu mod**		1.5 µg/l (A category)
	Cu hard***		2.4 µg/l (A category)
	Cyanide		4 µg/l (A category)

- PES for water quality B/C
- PES for water quality (EcoClassification approach): C
- Overall PES: E category
- Recommended water quality component of the REC: B/C category

7.2.4 Upper Komati G1

River	Upper Komati	**DWAF Water Quality Monitoring points**	
WQU	4	**RC**	X1H019Q01 (1977-1982) n = 81
EWR Site	G1	**PES**	X1H019Q01 (1991-1996) n = 12
Water quality constituents		**Present state**	**Quality EcoSpecs (Benchmark classification)**
Inorganic salts	$MgSO_4$	B	16mg/l
	Na_2SO_4	A	20 mg/l
	$MgCl_2$	A	15 mg/l
	$CaCl_2$	A	21 mg/l
	NaCl	A	45 mg/l
	$CaSO_4$	A	351 mg/l
Nutrients	SRP	0.014	>0.125 mg/l
	TIN	0.235	0.75 mg/l
Physical variables	pH (pH units)	7.25 – 8.44	5^{th} Percentile:6.00-6.25 95^{th}Percentile:8.37-8.69
	Temperature	No data	
	Dissolved oxygen	No data	
	Turbidity (NTU)	High TDS values recorded (range 7 to 155)	
Response variables	Chl-a: periphyton	None recorded	
	Chl-a: phytoplankton		
	Biotic community composition - macroinvertebrate	(D) ASPT 4.21 – 6.3 SASS5 - 30- 160	ASPT > 5
	In-stream toxicity	Not sampled	
Toxics	Fluoride	167	1500 µg/l (A category)
	Al		20 µg/l (A category)
	Ammonia		15 µg/l (A category)
	As		20 µg/l (A category)
	Atrazine		19 µg/l (A category)
	Cd soft*		0.2 µg/l (A category)
	Cd mod**		0.2 µg/l (A category)
	Cd hard***		0.3 µg/l (A category)
	Chorine (free)		0.4 µg/l (A category)
	Cr(III)		24 µg/l (A category)
	Cr(VI)		14 µg/l (A category)
	Cu soft*		0.5 µg/l (A category)
	Cu mod**		1.5 µg/l (A category)
	Cu hard***		2.4 µg/l (A category)
	Cyanide		4 µg/l (A category)

- PES for water quality (Methods manual): B/C
- PES for water quality (EcoClassification approach): C
- Overall PES: D
- Overall REC: D
- Recommended water quality component of the REC: B/C category

7.2.5 Upper Komati T1

<table>
<tr><td>River</td><td>Upper Komati</td><td colspan="3">DWAF Water Quality Monitoring points</td></tr>
<tr><td>WQU</td><td>6</td><td colspan="2">RC</td><td></td></tr>
<tr><td>EWR Site</td><td>T1</td><td colspan="2">PES</td><td>N = 4</td></tr>
<tr><td colspan="2">Water quality constituents</td><td colspan="2">Present state</td><td>Quality EcoSpecs (Benchmark classification)</td></tr>
<tr><td rowspan="6">Inorganic salts</td><td>$MgSO_4$</td><td colspan="2">B</td><td>16 mg/L</td></tr>
<tr><td>Na_2SO_4</td><td colspan="2">A</td><td>20 mg/L</td></tr>
<tr><td>$MgCl_2$</td><td colspan="2">A</td><td>15 mg/L</td></tr>
<tr><td>$CaCl_2$</td><td colspan="2">A</td><td>21 mg/L</td></tr>
<tr><td>NaCl</td><td colspan="2">B</td><td>45 mg/L</td></tr>
<tr><td>$CaSO_4$</td><td colspan="2">B</td><td>351 mg/L</td></tr>
<tr><td rowspan="2">Nutrients</td><td>SRP</td><td colspan="2">0.04</td><td>0.125 mg/L</td></tr>
<tr><td>TIN</td><td colspan="2">0.186</td><td><0.75 mg/L</td></tr>
<tr><td rowspan="4">Physical variables</td><td>pH (pH units)</td><td colspan="2">7.48 – 7.74</td><td>5th Percentile:600-6.25
95thPercentile:8.37-8.69</td></tr>
<tr><td>Temperature</td><td>No data</td><td rowspan="2">No impacts expected</td><td></td></tr>
<tr><td>Dissolved oxygen</td><td>No data</td><td></td></tr>
<tr><td>Turbidity (NTU)</td><td colspan="2">Expect high turbidity after rains due to removal of riparian vegetation and the natural steep topography</td><td></td></tr>
<tr><td rowspan="4">Response variables</td><td>Chl-a: periphyton</td><td colspan="2">Not sampled</td><td></td></tr>
<tr><td>Chl-a: phytoplankton</td><td colspan="2"></td><td></td></tr>
<tr><td>Biotic community composition - macroinvertebrate</td><td colspan="2">ASPT 5.7 – 7.2</td><td>ASPT > 6</td></tr>
<tr><td>In-stream toxicity</td><td colspan="2">Not sampled</td><td></td></tr>
<tr><td rowspan="15">Toxics</td><td>Fluoride</td><td colspan="2">363</td><td>1500 µg/l (A category)</td></tr>
<tr><td>Al</td><td colspan="2"></td><td>20 µg/l (A category)</td></tr>
<tr><td>Ammonia</td><td colspan="2"></td><td>15 µg/l (A category)</td></tr>
<tr><td>As</td><td colspan="2"></td><td>20 µg/l (A category)</td></tr>
<tr><td>Atrazine</td><td colspan="2"></td><td>19 µg/l (A category)</td></tr>
<tr><td>Cd soft*</td><td colspan="2"></td><td>0.2 µg/l (A category)</td></tr>
<tr><td>Cd mod**</td><td colspan="2"></td><td>0.2 µg/l (A category)</td></tr>
<tr><td>Cd hard***</td><td colspan="2"></td><td>0.3 µg/l (A category)</td></tr>
<tr><td>Chorine (free)</td><td colspan="2"></td><td>0.4 µg/l (A category)</td></tr>
<tr><td>Cr(III)</td><td colspan="2"></td><td>24 µg/l (A category)</td></tr>
<tr><td>Cr(VI)</td><td colspan="2"></td><td>14 µg/l (A category)</td></tr>
<tr><td>Cu soft*</td><td colspan="2"></td><td>0.5 µg/l (A category)</td></tr>
<tr><td>Cu mod**</td><td colspan="2"></td><td>1.5 µg/l (A category)</td></tr>
<tr><td>Cu hard***</td><td colspan="2"></td><td>2.4 µg/l (A category)</td></tr>
<tr><td>Cyanide</td><td colspan="2"></td><td>4 µg/l (A category)</td></tr>
</table>

- PES for water quality (Methods manual): C
- PES for water quality (EcoClassification approach): C
- Overall PES: C
- Overall REC: C

- Recommended water quality component of the REC: C category

7.2.6 Lomati L1

River	Lomati	**DWAF Water Quality Monitoring points**		
WQU	10	**RC**		
EWR Site	L1	**PES**		X1HO49Q1 (2000-2004) N = 93
Water quality constituents		**Present state**		**Quality EcoSpecs (Benchmark classification)**
Inorganic salts	$MgSO_4$	B		16 mg/L
	Na_2SO_4	A		20 mg/L
	$MgCl_2$	A		15 mg/L
	$CaCl_2$	A		21 mg/L
	NaCl	B		45 mg/L
	$CaSO_4$	A		351 mg/L
Nutrients	SRP	0.022		0.0.058 mg/L
	TIN	0.277		<0.25 mg/L
Physical variables	pH (pH units)	6.9 – 8.6		5^{th} Percentile:5.75-6.00 95^{th}Percentile:8.05-8.37
	Temperature	No data	Driekoppies Dam operational procedures will impact temperatures due to releases from deeper colder water	
	Dissolved oxygen	No data		
	Turbidity (NTU)	Sediments settled out in dams		
Response variables	Chl-a: periphyton	Not sampled		21 mg/m²
	Chl-a: phytoplankton			5 µg/l in Driekoppies Dam
	Biotic community composition - macroinvertebrate	(C) ASPT – 5.5 – 7 SASS5 60 - 250		ASPT > 6
	In-stream toxicity	Not sampled		
Toxics	Fluoride	0.1 A		1500 µg/l (A category)
	Al			20 µg/l (A category)
	Ammonia			15 µg/l (A category)
	As			20 µg/l (A category)
	Atrazine			19 µg/l (A category)
	Cd soft*			0.2 µg/l (A category)
	Cd mod**			0.2 µg/l (A category)
	Cd hard***			0.3 µg/l (A category)
	Chorine (free)			0.4 µg/l (A category)
	Cr(III)			24 µg/l (A category)
	Cr(VI)			14 µg/l (A category)
	Cu soft*			0.5 µg/l (A category)
	Cu mod**			1.5 µg/l (A category)
	Cu hard***			2.4 µg/l (A category)
	Cyanide			4 µg/l (A category)

- PES for water quality (Methods manual): B/C
- PES for water quality (EcoClassification approach): B/C
- Overall PES: C/D
- Recommended water quality component of the REC: B/C

7.2.7 Seekoeispruit

River	**Seekoeispruit**	**DWAF Water Quality Monitoring points**	
WQU	5	**RC**	
EWR Site	S1	**PES**	
Water quality constituents		**Present state**	**Quality EcoSpecs (Benchmark classification)**
Inorganic salts	$MgSO_4$	B	
	Na_2SO_4	C	
	$MgCl_2$	C	
	$CaCl_2$	B	
	NaCl	C	
	$CaSO_4$	C	
Nutrients	SRP	0.028	0.058 mg/l
	TIN	0.04	<0.25 mg/l
Physical variables	pH (pH units)	7.75	6.5-8.00
	Temperature	No data Bedrock could warm up water during low flows	
	Dissolved oxygen	No data	
	Turbidity (NTU)	High sediment potential due to erosive soils	
Response variables	Chl-a: periphyton	Not sampled.	
	Chl-a: phytoplankton		
	Biotic community composition - macroinvertebrate	(C) SASS5 – 120 – 230 ASPT – 5.3 - 8	ASPT > 5.5
	In-stream toxicity	Not sampled	
Toxics	Fluoride	50 (A)	1500 µg/l (A category)
	Al		20 µg/l (A category)
	Ammonia		15 µg/l (A category)
	As		20 µg/l (A category)
	Atrazine		19 µg/l (A category)
	Cd soft*		0.2 µg/l (A category)
	Cd mod**		0.2 µg/l (A category)
	Cd hard***		0.3 µg/l (A category)
	Chorine (free)		0.4 µg/l (A category)
	Cr(III)		24 µg/l (A category)
	Cr(VI)		14 µg/l (A category)
	Cu soft*		0.5 µg/l (A category)
	Cu mod**		1.5 µg/l (A category)
	Cu hard***		2.4 µg/l (A category)
	Cyanide		4 µg/l (A category)

- PES for water quality (Methods manual): B/C
- PES for water quality (EcoClassification approach):
- Overall PES: C
- Recommended water quality component of the REC: B/C

7.2.8 Mtsoli River

WQU	Mtsoli River			
EWR Site		**PES**		X1HO21Q1 (1977-1987) N = 132
		RC		X1HO21Q1 (2002-2005) N = 80
Water quality constituents		**Present state**		**Quality EcoSpecs (Benchmark classification)**
Inorganic salts	$MgSO_4$	A		16 mg/L
	Na_2SO_4	A		20 mg/L
	$MgCl_2$	A		15 mg/L
	$CaCl_2$	A		21 mg/L
	NaCl	A		45 mg/L
	$CaSO_4$	A		351 mg/L
Nutrients	SRP	0.012		0.125 mg/L
	TIN	0.06		<0.75 mg/L
Physical variables	pH (pH units)	6.12 – 8.61		5^{th} Percentile:6,00-6.25 95^{th}Percentile:8.37-8.69
	Temperature	No data	No impacts expected	
	Dissolved oxygen	No data		
	Turbidity (NTU)			
Response variables	Chl-a: periphyton			
	Chl-a: phytoplankton			
	Biotic community composition - macroinvertebrate			
	In-stream toxicity	Not sampled		
Toxics	Fluoride	50		1500 µg/l (A category)
	Al			20 µg/l (A category)
	Ammonia			15 µg/l (A category)
	As			20 µg/l (A category)
	Atrazine			19 µg/l (A category)
	Cd soft*			0.2 µg/l (A category)
	Cd mod**			0.2 µg/l (A category)
	Cd hard***			0.3 µg/l (A category)
	Chorine (free)			0.4 µg/l (A category)
	Cr(III)			24 µg/l (A category)
	Cr(VI)			14 µg/l (A category)
	Cu soft*			0.5 µg/l (A category)
	Cu mod**			1.5 µg/l (A category)
	Cu hard***			2.4 µg/l (A category)
	Cyanide			4 µg/l (A category)

- PES for water quality (Methods manual): B/C
- PES for water quality (EcoClassification approach):

- Overall PES: C
- Recommended water quality component of the REC: B/C

7.2.9: M1: Silingani

WQU	Lomati River			
EWR Site	M1: Silingani	**PES**		
		RC		
Water quality constituents		**Present state**		**Quality EcoSpecs (Benchmark classification)**
Inorganic salts	$MgSO_4$	A		16 mg/l
	Na_2SO_4	A		20 mg/l
	$MgCl_2$	A		15 mg/l
	$CaCl_2$	A		21 mg/l
	NaCl	A		45 mg/l
	$CaSO_4$	A		351 mg/l
Nutrients	SRP	0.012		0.125 mg/l
	TIN	0.06		<0.75 mg/l
Physical variables	pH (pH units)	6.12 – 8.61		5^{th} Percentile:6.00-6.25 95^{th}Percentile:8.37-8.69
	Temperature	No data	No impacts expected	
	Dissolved oxygen	No data		
	Turbidity (NTU)			
Response variables	Chl-a: periphyton			
	Chl-a: phytoplankton			
	Biotic community composition - macroinvertebrate			ASPY > 6
	In-stream toxicity	Not sampled		
Toxics	Fluoride	50		1500 µg/l (A category)
	Al			20 µg/l (A category)
	Ammonia			15 µg/l (A category)
	As			20 µg/l (A category)
	Atrazine			19 µg/l (A category)
	Cd soft*			0.2 µg/l (A category)
	Cd mod**			0.2 µg/l (A category)
	Cd hard***			0.3 µg/l (A category)
	Chorine (free)			0.4 µg/l (A category)
	Cr(III)			24 µg/l (A category)
	Cr(VI)			14 µg/l (A category)
	Cu soft*			0.5 µg/l (A category)
	Cu mod**			1.5 µg/l (A category)
	Cu hard***			2.4 µg/l (A category)
	Cyanide			4 µg/l (A category)

- PES for water quality (Methods manual): B/C
- PES for water quality (EcoClassification approach):
- Overall PES: C
- Recommended water quality component of the REC: B/C

8 CONCLUSIONS

This report has provided an assessment of water quality conditions for the Komati Ecological Water Resource study. Water quality is generally not the driver of the overall Ecostatus of rivers in the study area, as parameters such as flow and the status of the riparian vegetation are more instrumental in determining the health of the river. The river is generally in a Good - Fair condition in terms of water quality, with a hot spot occurring at the lower Komati EWR 4 and down to the confluence with the Crocodile River. Current status is shown in Table 8.1, as well as the water quality category used to design quality EcoSpecs.

Table 8.1: Summary of water quality status in Komati River study area.

Water Quality Unit and EWR site	PES: water quality (methods manual)	PES: water quality (EcoClassification approach)	Recommended water quality category of the overall REC (quality EcoSpecs)
WQU 1	**B**	**B**	**B**
WQU 2: K1 Gevonden	**B**	**B/C**	**B**
WQU 3: K2-Kromdraai	**B/C**	**C**	**B/C**
WQU 4: G1 – Vaalkop	**B/C**	**C**	**B/C**
WQU 5: S1 – Seekoeispruit	**B/C**	*****	**B/C**
WQU 6: T1-Teespruit	**C**	**C**	**C**
WQU 7: K3-Tonga	**C/D**	*****	**C/D**
WQU 8: K5	**D**	*****	**D**
WQU 9:	**B**		**B**
WQU 10: L1-Kleindoringkop	**B/C**	**B/C**	**B/C**
WQU 11 Mtsoli	**A/B**	*****	**A/B**
M1: Silingani	**B/C**	**B**	**B/C**

* no flow measurements

Water quality issues are mainly related to nutrient status and fluctuating temperature and oxygen levels due to flow regulation in the catchment. In addition the flow regulated, especially in the lower Komati, has a major impact on the water quality.

The flow scenarios that would improve water quality in the lower reaches are those scenarios that include improved (from present) baseflows (Scenario 6). The scenarios that would improve the water quality are 3, 6.1 and 6.2a. It is recommended that Scenario 6.2a be accepted because of its least impact on the socio-economy of the Komati catchment, and because it also meets South Africa and Swaziland's international obligations on sharing water with its downstream neighbour Mozambique.

9 RECOMMENDATIONS

An important principle that needs to be remembered when considering water quality and the Ecological Water Requirements process is that the environmental flows that are recommended should be those that satisfy the requirements of the aquatic biota with regard to hydraulic habitat. Flows should not be recommended because they are required to dilute pollutants to a level acceptable to the biota. If they are, it should be stated clearly that this is a management decision and that the “extra” water required for dilution is not part of the Ecological Reserve.

This report has provided an assessment of water quality conditions for the Komati Ecological Water Resource study. Water quality is generally not the driver of the overall EcoStatus of rivers in the study area, as parameters such as flow and the status of the riparian vegetation are more instrumental in determining the health of the river. The river is generally in a Good - Fair condition in terms of water quality, with a hot spot occurring at the lower Komati EWR 4 and down to the confluence with the Crocodile River.

The assessment of water quality was conducted carrying out methods updated from the DWAF methods manual of 2002, as well as the EcoClassification approach as outlined in Kleynhans *et al.* (2005). Although the methods should be used together, i.e. the PES assessment using DWAF methods is used to populate the ratings tables in the EcoClassification manual, there are no instructions in either manual as to how this procedure should take place. The EcoClassification approach also used a model developed by Jooste of RQS, DWAF. A water quality manual should therefore be developed which includes instructions on how all these tools must be used to conduct a water quality assessment in an EWR study.

The water quality data available for the EWR sites in the Komati River did not enable the flow concentration modelling to be undertaken. This was due to either there not being sufficiently long a data set available for the PES and reference condition; or that there was not a strong enough correlation between concentration and flow present for selected variables for time-series modelling to be carried out.

The recommended flows for the lower Komati, which is in a bad ecological condition, are designed to restore perenniality through improved baseflows. However, these actions alone will be inadequate. There is a need to reduce irrigation return flows and inundation from weirs. The Nkomati Catchment Management Agency could play a vital role in co-ordinating efforts to improve the riparian zone as a buffer, control deforestation, control cultivation and grazing in riparian zone, and reduce fragmentation caused by weirs.

It is recommended that Scenario 6.2a be accepted because of its least impact on the socio-economy of the Komati catchment, and because it also meets South Africa and Swaziland’s international obligations on sharing water with its downstream neighbour Mozambique.

The options for improving the water quality are related to realities in the catchment, which include:

- ESKOM: The strategic demands by ESKOM in the upper catchment provide limited scope for improved flows.
- Dams: The ecological conditions downstream of large dams have changed irreversibly from historical reference conditions and it was considered unrealistic to recommend an improvement in current conditions.
- Weirs: The ecology of the lower Komati River has been severely impacted by a large number of weirs and associated irrigation development. These have had a major impact on habitat availability and low flow conditions in particular.
- Non-flow related impacts: Many of the reasons for ecological degradation in the Komati River are unrelated to flow, so improved flows alone are not going to solve the problems (for example high social and cultural value) and improved landuse practices due to the conversion of land from agriculture to conservation.

The water quality assessment methods used for the Reserve needs to be refined and a consolidate method produced. For example the assessment of water quality was conducted carrying out methods updated from DWAF (2002), as well as the EcoClassification approach as outlined in Kleynhans *et al.* (2005). Although the methods should be used together, i.e. the PES assessment using DWAF methods is used to populate the ratings tables in the EcoClassification manual, there are no instructions in either manual as to how this procedure should take place. The EcoClassification approach will also be using a model developed by Jooste of RQS, DWAF. A water quality manual should therefore be developed which includes instructions on how all these tools must be used to conduct a water quality assessment in an EWR study.

Jooste's inorganic salt assessment method as well as the other variables that are being planned for incorporation into this model, needs to be made readily available for Reserve practitioners. The SaltBA21 model of Jooste (RQS, DWAF) used to generate the status of the inorganic salts, salt ions need to be aggregated. Currently a manipulation is required as the DWAF monitoring programme only measures salts ions such sodium, magnesium etc and these need then to be converted to inorganic salts. This method needs further refinement to also include variables other than salts.

The water quality linkage that is currently being finalized in SPATSIM needs also to be to be made readily available for Reserve practitioners. Jooste's inorganic salt assessment method as well as the other variables that are being planned for incorporation into this model, needs to be made readily available for Reserve practitioners.

Details of the proposed monitoring programme are given AfriDev (2006), but below are some suggestions of monitoring variables that should be included in this monitoring programme:

- Microbiological variables (total bacteria and *E. coli* in particular) to be included because of the general low levels of sanitation and dependence of some communities on run of the river for drinking water.

- Toxicity testing is seldom applied for state of the river type monitoring, and is more relevant for point source problems, however, in the Komati and Lomati, toxicity trials may be useful for monitoring impacts of pesticides and herbicides used in the irrigation areas. It may be worth considering doing this from time to time - especially when herbicides and pesticides are applied to sugarcane - using water collected from selected irrigation return flows as well as run of the river water from upstream control (upstream of irrigation areas) and downstream impacted sites.

- Sodium, calcium and magnesium is important for working out the SAR, which is of interest to irrigators, as is iron and manganese

- Periphyton (Chlorophyll-a) sampling should also be conducted regularly at EWR sites 3 and 4, and monitoring of turbidity should be instituted.

10 REFERENCES

AfriDev (2005a). Resource Unit Report. Komati Catchment Ecological Water Requirements Study. Department of Water Affairs and Forestry, Pretoria. Report No. RDM X100-01-CON-COMPR2-0403.

AfriDev (2005b). Hydrology and System Operations Report. Komati Catchment Ecological Water Requirements Study. Department of Water Affairs and Forestry, Pretoria. Report No. RDM X100-01-CON-COMPR2-0504.

AfriDev (2006). Monitoring and Ecospecs Report. Komati Catchment Ecological Water Requirements Study. Department of Water Affairs and Forestry, Pretoria. Report No. RDM X100-01-CON-COMPR2-0905.

Department of Water Affairs and Forestry (1996). South African water quality guidelines (second edition). Volume 1: Domestic use. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (1999). Resource directed measures for protection of water resources. Institute for Water Quality studies, Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (2002). Assessing water quality in ecological reserve determinations for rivers: Version 2, Draft 15.0, March 2002. Department of Water Affairs and Forestry, Pretoria.

Department Of Water Affairs And Forestry, South Africa (2003). Proceedings of Ecological Reserve (Quantity) Workshop. 8&9th April, Delectus Manor, Pretoria.

Faul, F and Redfelder, E (1992). GPOWER: A Priori, Post-hoc and compromise Power analysis for MS-DOS (Computer Programme). Bonn University, Dept of Psychology. Bonn Germany.

Hughes, D A, Forsyth, D and Watkins, D A (2000). An integrated software package for the analysis and display of hydrological or water resource time series data. WRC Report No. 867/2/00, Water Research Commission, Pretoria.

IWR Environmental 2003. Mhlatuze Catchment: Ecological Reserve and Monitoring Programme. Mhlatuze monitoring Report. DWAF January 2003. Prepared for the Department of Water Affairs and Forestry.

JIBS (Joint Inkomati Basin Study). (2000). Phase 2. Report prepared by Consultec and BKS Acres Consulting Engineers for the Tripartite Permanent Technical Committee comprising the Kingdom of Swaziland, Republic of Moçambique and the Republic of South Africa. Main Draft Report and Annexures – September 2000.

Jooste, S. and Rossouw, J. N. (2002). Hazard-based water quality EcoSpecs for the Ecological Reserve in Fresh Surface Water Resources. Report No. N/0000/REQ0000. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

King J. M. and Louw, D. (1998). Instream flow assessments for regulated rivers in South Africa using the Building Block Methodology. Aquatic Ecosystem Health and Management 1: 109-124.

King, J. M and Tharme, R. E. 1994. Assessment of the Instream Flow Incremental Methodology and initial development of alternative instream flow methodologies for South Africa. Water Research Commission Report 295/1/94. 590 pp

Kleynhans, C. J, Louw, M. D, Thirion, C, Rossouw, N. and Rowntree, K. (2005). River EcoClassification: Manual for Ecostatus Determination. First draft for training purposes.

Kleynhans, C.J and Louw, M.D. (2006). Ecological Reserve Monitoring: Preliminary Generic guidelines . With contributions from C Thirion, P Scherman, N Muller, D Hughes, L du Preez and K Rowntree. Draft report DWAF RQS.

Kleynhans, CJ, Louw, MD, Thirion, C, Rossouw, NJ, and Rowntree, K. (2005). River EcoClassification: Manual for EcoStatus determination (Version 1). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. KV 168/05.

Malan, H L and Day, J A (2002a). Development of numerical methods for predicting relationships between stream flow, water quality and biotic responses in rivers. WRC Report no. 956/1/02. Water Research Commission, Pretoria.

Malan, H L and Day, J A (2002b). Linking discharge, water quality and biotic responses in rivers: A Literature Review. WRC Report No. 956/2/02. Water Research Commission, Pretoria.

Malan, H, Bath, A, Day, J and Joubert, A (2003). A simple flow-concentration modelling method for integrating water quality and water quantity in rivers. Water SA 29 (3) 305-312.

Ninham Shand web-site: http://projects.shands.co.za/Hydro/hydro/WQReserve/main.htm.

Ninham Shand, 1994. Driekoppies Dam EWR worksession. Proceedings of the worksession that took place 13-14 September 1994. Driekoppies Environmental Task Group IEM Consultants to the Komati Basin Water Authority.

Palmer, C G, Muller, W J and Hughes, D A (2004). Chapter 6: Water quality in the ecological Reserve. IN: *SPATSIM, an integrating framework for ecological Reserve and implementation: incorporating water quality and quantity components for rivers.* Hughes DA (Ed.) WRC Report No. 1160/1/04, Water Research Commission, Pretoria.

Appendix A1

Site Statistics

Table of Contents

EWR Site K1

K1

X1H033Q1 1983-2002 All	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	95	9.01	8.6	1.50	20.1	3.38
Ca-Diss-Water (mg/L)	95	12.8	11.7	5.80	20.9	3.78
DMS-Tot-Water (mg/L)	95	145	135	77	227	43.04
pH-Diss-Water (pH units)	95	7.73	7.84	4.54	8.58	0.568
TAL-Diss-Water (mg/L)	95	70.03	60.9	19.6	129	30.6
Si-Diss-Water (mg/L)	95	4.5	4.5	0.2	11.1	2.52
SO4-Diss-Water (mg/L)	95	15.5	14.7	2	32	5.69
SAR-Diss-Water (null)	95	0.418	0.41	0.290	1.19	0.098
NO3+NO2-N-Diss-Water (mg/L)	95	0.093	0.067	0.02	0.493	0.085
NH4-N-Diss-Water (mg/L)	95	0.046	0.04	0.02	0.38	0.044
F-Diss-Water (mg/L)	95	0.232	0.2	0.05	1.67	0.16
Na-Diss-Water (mg/L)	95	8.17	8.3	4.4	18.6	1.61
Mg-Diss-Water (mg/L)	95	10.96	9.5	4.2	21.7	4.44
PO4-P-Diss-Water (mg/L)	95	0.016	0.013	0.003	0.121	0.016
K-Diss-Water (mg/L)	95	2.36	2.34	1.16	4.22	0.644
EC-Phys-Water (mS/m)	95	20.3	19.3	11.4	31.2	4.83

X1H033Q1 1983-1988 RC	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	15	8.03	8.8	1.5	11.5	3.13
Ca-Diss-Water (mg/L)	15	10.9	10.7	7.7	20.9	3.37
DMS-Tot-Water (mg/L)	15	118	112	77	227	38.3
pH-Diss-Water (pH units)	15	7.11	7.17	6.32	8	0.433
TAL-Diss-Water (mg/L)	15	53.2	43.2	19.6	129	28.3
Si-Diss-Water (mg/L)	15	4.67	4.5	1.19	11.1	2.56
SO4-Diss-Water (mg/L)	15	13.6	13	2	26.3	5.72
SAR-Diss-Water (null)	15	0.481	0.45	0.34	1.19	0.206
NO3+NO2-N-Diss-Water (mg/L)	15	0.111	0.1	0.02	0.25	0.083
NH4-N-Diss-Water (mg/L)	15	0.077	0.06	0.02	0.38	0.086
F-Diss-Water (mg/L)	15	0.288	0.19	0.05	1.67	0.388
Na-Diss-Water (mg/L)	15	8.42	7.7	5.9	18.6	3.09
Mg-Diss-Water (mg/L)	15	8.46	6.9	4.2	21.7	4.13
PO4-P-Diss-Water (mg/L)	15	0.012	0.01	0.003	0.025	0.006
K-Diss-Water (mg/L)	15	2.5	2.47	1.4	3.59	0.694
EC-Phys-Water (mS/m)	15	17.3	16.6	13.9	30	4.04

X1H033Q1 1998-2002 PES	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	19	7.28	7.3	4.2	12	2.17
Ca-Diss-Water (mg/L)	19	15.1	15.6	10.9	18.6	2.31
DMS-Tot-Water (mg/L)	19	170	181	108	197	26.9
pH-Diss-Water (pH units)	19	8.06	8.07	7.66	8.43	0.21
TAL-Diss-Water (mg/L)	19	86.2	96.9	36.1	108	22.2
Si-Diss-Water (mg/L)	19	5.35	5.56	0.57	9	1.98
SO4-Diss-Water (mg/L)	19	18.2	16.3	10.2	32	5.31
SAR-Diss-Water (null)	19	0.4	0.387	0.312	0.5	0.055
NO3+NO2-N-Diss-Water (mg/L)	19	0.06	0.02	0.02	0.493	0.107
NH4-N-Diss-Water (mg/L)	19	0.023	0.02	0.02	0.061	0.01
F-Diss-Water (mg/L)	19	0.207	0.2	0.137	0.252	0.029
Na-Diss-Water (mg/L)	19	8.66	8.9	5.2	10.3	1.1
Mg-Diss-Water (mg/L)	19	12.8	14.4	5.65	15.7	3.08
PO4-P-Diss-Water (mg/L)	19	0.024	0.016	0.005	0.121	0.027
K-Diss-Water (mg/L)	19	1.9	1.78	1.16	2.83	0.391
EC-Phys-Water (mS/m)	19	23.3	24.3	14.9	26.8	3.18

EWR Site K2

K2

X1H001Q01 1977-2005 All	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	262	5.01	5	1.5	22.7	3.05
Ca-Diss-Water (mg/L)	262	10.1	9.59	3.6	31.4	3.60
DMS-Tot-Water (mg/L)	262	116	110	43	295	32.8
pH-Diss-Water (pH units)	262	7.55	7.57	5.25	9.19	0.513
TAL-Diss-Water (mg/L)	262	63.2	59.1	21.1	175	20.0
Si-Diss-Water (mg/L)	262	8.68	8.89	5.16	15.7	1.22
SO4-Diss-Water (mg/L)	262	5.75	5.8	2.00	24.0	3.88
SAR-Diss-Water (null)	261	0.489	0.49	0.110	0.960	0.110
NO3+NO2-N-Diss-Water (mg/L)	262	0.076	0.04	0.020	0.961	0.108
NH4-N-Diss-Water (mg/L)	262	0.049	0.037	0.015	0.350	0.048
F-Diss-Water (mg/L)	262	0.211	0.211	0.050	1.03	0.112
Na-Diss-Water (mg/L)	262	8.38	8.27	1.000	16.7	2.36
Mg-Diss-Water (mg/L)	262	7.61	7.20	3.30	21.9	2.39
PO4-P-Diss-Water (mg/L)	262	0.017	0.013	0.003	0.133	0.017
K-Diss-Water (mg/L)	262	0.883	0.78	0.150	3.29	0.462
EC-Phys-Water (mS/m)	262	15.6	14.8	6.80	35.1	4.39

X1H001Q01 1977-1982 RC	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	96	3.71	3.15	1.50	22.7	3.63
Ca-Diss-Water (mg/L)	96	9.62	8.80	4.00	31.4	4.47
DMS-Tot-Water (mg/L)	96	99.9	97.5	50.0	200	21.9
pH-Diss-Water (pH units)	96	7.24	7.28	5.25	9.19	0.438
TAL-Diss-Water (mg/L)	96	55.9	54.6	23.6	118	13.9
Si-Diss-Water (mg/L)	96	9.13	9.24	6.47	10.5	0.721
SO4-Diss-Water (mg/L)	96	3.44	2.00	2.00	24.0	3.14
SAR-Diss-Water (null)	96	0.459	0.450	0.110	0.960	0.116
NO3+NO2-N-Diss-Water (mg/L)	96	0.039	0.020	0.020	0.610	0.075
NH4-N-Diss-Water (mg/L)	96	0.071	0.050	0.020	0.350	0.066
F-Diss-Water (mg/L)	96	0.183	0.165	0.050	1.03	0.144
Na-Diss-Water (mg/L)	96	7.39	7.30	1.000	16.7	1.97
Mg-Diss-Water (mg/L)	96	6.49	6.60	3.30	8.50	1.08
PO4-P-Diss-Water (mg/L)	96	0.022	0.013	0.003	0.133	0.024
K-Diss-Water (mg/L)	96	0.661	0.615	0.150	2.16	0.308
EC-Phys-Water (mS/m)	96	12.9	12.3	6.80	27.5	2.87

X1H001Q01 2002-2005 PES	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	71	5.63	5.00	2.50	10.8	1.60
Ca-Diss-Water (mg/L)	71	11.9	11.7	5.82	19.6	2.70
DMS-Tot-Water (mg/L)	71	141	136	83.2	207	30.9
pH-Diss-Water (pH units)	71	7.90	7.90	7.25	8.41	0.266
TAL-Diss-Water (mg/L)	71	77.0	77.5	27.2	120	20.4
Si-Diss-Water (mg/L)	71	7.81	7.71	5.16	10.2	1.16
SO4-Diss-Water (mg/L)	71	8.68	7.99	2.00	17.9	3.22
SAR-Diss-Water (null)	71	0.531	0.517	0.319	0.731	0.090
NO3+NO2-N-Diss-Water (mg/L)	71	0.118	0.055	0.020	0.961	0.157
NH4-N-Diss-Water (mg/L)	71	0.039	0.020	0.015	0.157	0.035
F-Diss-Water (mg/L)	71	0.252	0.251	0.100	0.370	0.060
Na-Diss-Water (mg/L)	71	9.86	9.55	5.93	15.4	1.99
Mg-Diss-Water (mg/L)	71	9.10	8.77	3.60	16.2	2.89
PO4-P-Diss-Water (mg/L)	71	0.020	0.017	0.005	0.056	0.010
K-Diss-Water (mg/L)	71	1.11	0.975	0.519	3.29	0.495
EC-Phys-Water (mS/m)	71	19.5	18.9	10.8	27.4	4.10

EWR Site K3

K3

X1H003Q01 1977-2005 All	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	936	32.6	20.8	2.50	214	29.9
Ca-Diss-Water (mg/L)	936	11.4	9.80	2.90	63.6	5.73
DMS-Tot-Water (mg/L)	935	190	153	32.0	738	111
pH-Diss-Water (pH units)	928	7.80	7.97	5.10	8.77	0.557
TAL-Diss-Water (mg/L)	927	78.8	69.6	9.80	291	37.9
Si-Diss-Water (mg/L)	926	8.06	8.15	1.16	17.0	1.44
SO4-Diss-Water (mg/L)	925	8.19	7.30	2.00	65.8	5.93
SAR-Diss-Water (null)	919	1.32	1.09	0.150	4.14	0.724
NO3+NO2-N-Diss-Water (mg/L)	935	0.158	0.115	0.020	2.03	0.179
NH4-N-Diss-Water (mg/L)	935	0.043	0.040	0.015	0.420	0.033
F-Diss-Water (mg/L)	936	0.211	0.200	0.050	1.23	0.095
Na-Diss-Water (mg/L)	936	27.8	19.8	2.10	135	22.3
Mg-Diss-Water (mg/L)	936	10.3	8.67	1.000	50.9	5.43
PO4-P-Diss-Water (mg/L)	936	0.018	0.015	0.003	0.308	0.017
K-Diss-Water (mg/L)	936	1.44	1.25	0.150	4.60	0.661
EC-Phys-Water (mS/m)	936	28.2	22.5	6.40	107	16.7

X1H003Q01 1977-1982 RC	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	102	15.7	12.2	4.00	59.1	11.6
Ca-Diss-Water (mg/L)	102	8.15	7.35	2.90	33.5	4.61
DMS-Tot-Water (mg/L)	102	120	109	32.0	258	46.9
pH-Diss-Water (pH units)	102	8.48	8.45	8.37	8.77	0.097
TAL-Diss-Water (mg/L)	102	56.3	53.3	9.80	125	20.1
Si-Diss-Water (mg/L)	102	8.46	8.51	5.57	17.0	1.44
SO4-Diss-Water (mg/L)	102	4.01	2.00	2.00	23.0	3.71
SAR-Diss-Water (null)	102	0.960	0.860	0.340	2.04	0.391
NO3+NO2-N-Diss-Water (mg/L)	102	0.046	0.020	0.020	0.310	0.054
NH4-N-Diss-Water (mg/L)	102	0.048	0.020	0.020	0.230	0.048
F-Diss-Water (mg/L)	102	0.168	0.150	0.050	0.540	0.105
Na-Diss-Water (mg/L)	102	15.7	13.3	5.70	42.0	8.82
Mg-Diss-Water (mg/L)	102	6.68	6.45	1.000	13.0	2.22
PO4-P-Diss-Water (mg/L)	102	0.013	0.010	0.003	0.065	0.011
K-Diss-Water (mg/L)	102	0.985	0.955	0.150	2.19	0.390
EC-Phys-Water (mS/m)	102	17.6	15.4	6.40	42.9	7.19

X1H003Q01 2000-2005 PES	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	158	47.9	37.7	2.50	168	41.1
Ca-Diss-Water (mg/L)	158	16.1	13.4	5.24	63.6	8.14
DMS-Tot-Water (mg/L)	158	265	232	62.7	738	146
pH-Diss-Water (pH units)	150	6.82	6.88	5.10	7.22	0.361
TAL-Diss-Water (mg/L)	149	105	98.0	31.4	291	47.8
Si-Diss-Water (mg/L)	149	9.20	9.14	1.16	16.1	1.80
SO4-Diss-Water (mg/L)	149	11.7	9.82	2.00	65.8	7.40
SAR-Diss-Water (null)	152	1.51	1.35	0.211	3.77	0.806
NO3+NO2-N-Diss-Water (mg/L)	158	0.279	0.225	0.020	1.38	0.231
NH4-N-Diss-Water (mg/L)	158	0.036	0.020	0.015	0.185	0.025
F-Diss-Water (mg/L)	158	0.225	0.217	0.100	0.439	0.068
Na-Diss-Water (mg/L)	158	38.3	30.5	3.58	125	29.2
Mg-Diss-Water (mg/L)	158	14.5	12.9	3.34	50.9	7.93
PO4-P-Diss-Water (mg/L)	158	0.025	0.017	0.005	0.134	0.021
K-Diss-Water (mg/L)	158	1.47	1.31	0.378	3.62	0.542
EC-Phys-Water (mS/m)	158	39.5	35.1	9.20	107	21.8

EWR Site K4

K4	
K4	**Count = 1**
Date	**10/11/2003**
pH-Diss-Water (pH units)	8.07
KJEL N-Tot-Water (mg/L)	0.601
NO3+NO2-N-Diss-Water (mg/L)	0.06
NH4-N-Diss-Water (mg/L)	0.015
F-Diss-Water (mg/L)	0.259
TAL-Diss-Water (mg/L)	121
Na-Diss-Water (mg/L)	33.8
Mg-Diss-Water (mg/L)	15.3
Si-Diss-Water (mg/L)	7.88
P-Tot-Water (mg/L)	0.015
PO4-P-Diss-Water (mg/L)	0.01
SO4-Diss-Water (mg/L)	8.32
Cl-Diss-Water (mg/L)	42.7
K-Diss-Water (mg/L)	1.14
Ca-Diss-Water (mg/L)	15.7
EC-Phys-Water (mS/m)	37.7
DMS-Tot-Water (mg/L)	266
SAR-Diss-Water (null)	1.46
HARD-Tot-Water (mg/L)	102
LANGL-Index-Water (null)	0.075
RYZNAR-Index-Water (null)	8.22
CORR-Diss-Water (null)	0.568

EWR Site K5

K5

X1H042Q01 1993-2005 All	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	116	60.3	43.6	9.00	171	40.7
Ca-Diss-Water (mg/L)	116	28.3	25.8	5.78	61.1	13.4
DMS-Tot-Water (mg/L)	116	377	356	76.3	744	168
pH-Diss-Water (pH units)	116	8.29	8.27	7.28	9.26	0.256
TAL-Diss-Water (mg/L)	116	161	160	30.1	302	66.3
Si-Diss-Water (mg/L)	116	12.5	11.9	5.49	19.9	2.57
SO4-Diss-Water (mg/L)	116	20.4	19.8	4.11	48.2	9.12
SAR-Diss-Water (null)	116	1.47	1.41	0.584	2.41	0.424
NO3+NO2-N-Diss-Water (mg/L)	116	0.474	0.519	0.020	1.23	0.263
NH4-N-Diss-Water (mg/L)	116	0.045	0.043	0.015	0.130	0.029
F-Diss-Water (mg/L)	116	0.291	0.283	0.100	0.466	0.090
Na-Diss-Water (mg/L)	116	44.9	38.3	9.93	93.7	22.2
Mg-Diss-Water (mg/L)	116	23.2	21.5	3.58	50.8	11.3
PO4-P-Diss-Water (mg/L)	116	0.027	0.022	0.005	0.141	0.020
K-Diss-Water (mg/L)	116	1.56	1.32	0.499	4.82	0.717
EC-Phys-Water (mS/m)	116	53.9	50.0	11.7	106	23.5

X1H042Q01 1993-1999 RC	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	11	70.7	84.3	9.00	149	46.7
Ca-Diss-Water (mg/L)	11	32.6	37.2	6.90	53.4	16.9
DMS-Tot-Water (mg/L)	11	434	443	92.0	704	219
pH-Diss-Water (pH units)	11	8.32	8.42	7.69	8.83	0.357
TAL-Diss-Water (mg/L)	11	183	185	37.9	302	91.5
Si-Diss-Water (mg/L)	11	11.9	12.7	5.49	16.1	3.39
SO4-Diss-Water (mg/L)	11	22.5	26.7	8.10	32.3	9.19
SAR-Diss-Water (null)	11	1.63	1.55	0.810	2.38	0.518
NO3+NO2-N-Diss-Water (mg/L)	11	0.639	0.605	0.207	1.10	0.257
NH4-N-Diss-Water (mg/L)	11	0.049	0.047	0.020	0.099	0.031
F-Diss-Water (mg/L)	11	0.296	0.280	0.150	0.450	0.081
Na-Diss-Water (mg/L)	11	53.7	50.3	11.4	93.7	28.9
Mg-Diss-Water (mg/L)	11	26.5	27.0	4.50	44.1	14.1
PO4-P-Diss-Water (mg/L)	11	0.020	0.017	0.009	0.045	0.010
K-Diss-Water (mg/L)	11	1.62	1.28	1.05	3.83	0.800
EC-Phys-Water (mS/m)	11	61.0	64.2	14.6	97.2	29.3

X1H042Q01 2000-2005 PES	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	104	58.9	43.0	11.0	171	40.1
Ca-Diss-Water (mg/L)	104	27.8	25.5	5.78	61.1	13.0
DMS-Tot-Water (mg/L)	104	370	336	76.3	744	162
pH-Diss-Water (pH units)	104	8.29	8.27	7.28	9.26	0.245
TAL-Diss-Water (mg/L)	104	158	149	30.1	299	63.3
Si-Diss-Water (mg/L)	104	12.6	11.8	7.77	19.9	2.49
SO4-Diss-Water (mg/L)	104	20.0	19.5	4.11	48.2	8.90
SAR-Diss-Water (null)	104	1.45	1.37	0.584	2.41	0.405
NO3+NO2-N-Diss-Water (mg/L)	104	0.453	0.474	0.020	1.23	0.258
NH4-N-Diss-Water (mg/L)	104	0.045	0.043	0.015	0.130	0.029
F-Diss-Water (mg/L)	104	0.290	0.286	0.100	0.466	0.091
Na-Diss-Water (mg/L)	104	43.7	37.5	9.93	90.7	21.20
Mg-Diss-Water (mg/L)	104	22.9	20.9	3.58	50.8	11.0
PO4-P-Diss-Water (mg/L)	104	0.028	0.022	0.005	0.141	0.020
K-Diss-Water (mg/L)	104	1.52	1.32	0.499	3.70	0.637
EC-Phys-Water (mS/m)	104	53.0	49.0	11.7	106	22.8

EWR Site G1

G1

X1H019Q01 1977-1996 All	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	146	2.94	1.50	1.50	8.30	1.78
Ca-Diss-Water (mg/L)	146	8.50	7.95	2.30	32.6	3.73
DMS-Tot-Water (mg/L)	146	78.3	75.5	34.0	170	25.8
pH-Diss-Water (pH units)	146	7.15	7.13	6.04	8.62	0.491
TAL-Diss-Water (mg/L)	146	37.3	35.7	13.0	102	16.0
Si-Diss-Water (mg/L)	146	9.21	8.86	3.52	19.8	2.13
SO4-Diss-Water (mg/L)	146	10.5	10.6	2.00	24.6	3.98
SAR-Diss-Water (null)	145	0.316	0.300	0.110	0.750	0.107
NO3+NO2-N-Diss-Water (mg/L)	146	0.079	0.040	0.020	0.500	0.091
NH4-N-Diss-Water (mg/L)	146	0.045	0.020	0.020	0.312	0.045
F-Diss-Water (mg/L)	146	0.095	0.050	0.050	0.470	0.071
Na-Diss-Water (mg/L)	146	4.70	4.35	1.000	14.0	2.17
Mg-Diss-Water (mg/L)	146	5.07	5.00	1.50	10.1	1.47
PO4-P-Diss-Water (mg/L)	146	0.014	0.007	0.003	0.133	0.017
K-Diss-Water (mg/L)	146	0.479	0.420	0.150	2.420	0.347
EC-Phys-Water (mS/m)	146	11.4	11.2	5.10	22.4	2.81

X1H019Q01 1977-1982 RC	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	81	2.30	1.50	1.50	6.60	1.39
Ca-Diss-Water (mg/L)	81	8.92	8.10	2.30	32.6	4.55
DMS-Tot-Water (mg/L)	81	80.9	80.0	34.0	160	27.8
pH-Diss-Water (pH units)	81	7.01	7.07	6.04	8.00	0.384
TAL-Diss-Water (mg/L)	81	40.1	38.5	13.7	91.4	16.4
Si-Diss-Water (mg/L)	81	9.58	9.48	3.52	19.8	2.54
SO4-Diss-Water (mg/L)	81	10.0	10.5	2.00	17.0	3.52
SAR-Diss-Water (null)	81	0.323	0.300	0.110	0.750	0.123
NO3+NO2-N-Diss-Water (mg/L)	81	0.041	0.020	0.020	0.460	0.055
NH4-N-Diss-Water (mg/L)	81	0.044	0.020	0.020	0.230	0.041
F-Diss-Water (mg/L)	81	0.080	0.050	0.050	0.470	0.063
Na-Diss-Water (mg/L)	81	4.82	4.40	1	14.0	2.46
Mg-Diss-Water (mg/L)	81	4.96	5.00	1.50	8.60	1.53
PO4-P-Diss-Water (mg/L)	81	0.017	0.007	0.003	0.133	0.021
K-Diss-Water (mg/L)	81	0.473	0.420	0.150	2.42	0.392
EC-Phys-Water (mS/m)	81	11.4	11.2	5.10	21.1	2.89

X1H019Q01 1991-1996 PES	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	12	3.60	3.55	3.00	4.60	0.441
Ca-Diss-Water (mg/L)	12	9.25	8.80	6.50	14.2	2.20
DMS-Tot-Water (mg/L)	12	89.3	85.5	59.0	170	30.1
pH-Diss-Water (pH units)	12	7.79	7.80	7.25	8.44	0.361
TAL-Diss-Water (mg/L)	12	39.4	35.9	17.4	102	22.1
Si-Diss-Water (mg/L)	12	9.05	8.99	7.19	14.0	1.79
SO4-Diss-Water (mg/L)	12	15.5	16.3	4.20	24.6	5.92
SAR-Diss-Water (null)	11	0.312	0.280	0.210	0.580	0.102
NO3+NO2-N-Diss-Water (mg/L)	12	0.209	0.207	0.067	0.484	0.132
NH4-N-Diss-Water (mg/L)	12	0.068	0.020	0.020	0.312	0.106
F-Diss-Water (mg/L)	12	0.167	0.160	0.100	0.310	0.061
Na-Diss-Water (mg/L)	12	5.02	4.40	3.10	11.7	2.33
Mg-Diss-Water (mg/L)	12	6.09	5.90	3.30	10.1	1.73
PO4-P-Diss-Water (mg/L)	12	0.014	0.013	0.006	0.030	0.008
K-Diss-Water (mg/L)	12	0.624	0.465	0.150	1.61	0.436
EC-Phys-Water (mS/m)	12	13.2	12.4	9.40	22.4	3.40

R001

R001

X1R001Q01 1970-2005 All	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	185	8.19	6.80	1.50	128	11.9
Ca-Diss-Water (mg/L)	185	10.5	10.0	2.10	36.2	3.65
DMS-Tot-Water (mg/L)	171	120	113	76.0	510	47.1
pH-Diss-Water (pH units)	185	7.64	7.77	5.32	8.28	0.442
TAL-Diss-Water (mg/L)	185	49.3	47.1	14.8	147	17.8
Si-Diss-Water (mg/L)	172	3.00	2.97	0.200	9.95	1.86
SO4-Diss-Water (mg/L)	185	19.4	20.1	2.00	91.2	9.93
SAR-Diss-Water (null)	180	0.466	0.460	0.030	2.67	0.240
NO3+NO2-N-Diss-Water (mg/L)	185	0.142	0.105	0.020	2.10	0.189
NH4-N-Diss-Water (mg/L)	171	0.040	0.020	0.015	0.327	0.037
F-Diss-Water (mg/L)	181	0.182	0.180	0.050	0.490	0.064
Na-Diss-Water (mg/L)	185	8.29	7.70	1.000	84.8	7.69
Mg-Diss-Water (mg/L)	185	7.52	7.20	1.50	24.3	2.91
PO4-P-Diss-Water (mg/L)	178	0.021	0.015	0.003	0.388	0.032
K-Diss-Water (mg/L)	178	2.82	2.75	0.790	8.72	0.966
EC-Phys-Water (mS/m)	185	17.3	16.5	4.10	75.1	6.59

X1R001Q01 1970-1972 RC	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	7	8.76	7.00	3.70	22.0	6.88
Ca-Diss-Water (mg/L)	7	10.8	11.0	2.10	16.0	5.07
pH-Diss-Water (pH units)	7	7.61	7.60	7.30	7.90	0.254
TAL-Diss-Water (mg/L)	7	48.6	45.1	28.4	80.4	22.8
SO4-Diss-Water (mg/L)	7	12.6	9.00	2.00	22.9	9.76
SAR-Diss-Water (null)	6	0.357	0.325	0.030	0.730	0.343
NO3+NO2-N-Diss-Water (mg/L)	7	0.020	0.020	0.020	0.020	0.00
F-Diss-Water (mg/L)	3	0.050	0.050	0.050	0.050	0.00
Na-Diss-Water (mg/L)	7	5.86	1.000	1.000	14.0	6.28
Mg-Diss-Water (mg/L)	7	6.36	5.50	4.00	10.0	1.91
EC-Phys-Water (mS/m)	7	14.9	14.4	11.1	20.0	3.46

X1R001Q01 2000-2005 PES	Count	Mean	Median	Minimum	Maximum	Std dev
Cl-Diss-Water (mg/L)	50	6.29	5.00	2.50	12.4	2.66
Ca-Diss-Water (mg/L)	50	11.4	10.7	7.15	20.9	3.12
DMS-Tot-Water (mg/L)	49	122	110	81.7	249	36.6
pH-Diss-Water (pH units)	50	7.80	7.86	6.71	8.24	0.283
TAL-Diss-Water (mg/L)	50	57.7	52.5	32.5	147	24.1
Si-Diss-Water (mg/L)	50	3.63	3.21	0.200	8.09	2.27
SO4-Diss-Water (mg/L)	50	16.0	18.2	3.00	26.4	6.30
SAR-Diss-Water (null)	50	0.401	0.422	0.265	0.535	0.073
NO3+NO2-N-Diss-Water (mg/L)	50	0.096	0.056	0.020	1.10	0.152
NH4-N-Diss-Water (mg/L)	49	0.050	0.020	0.015	0.327	0.061
F-Diss-Water (mg/L)	50	0.170	0.178	0.100	0.287	0.053
Na-Diss-Water (mg/L)	50	7.10	7.16	4.51	10.4	1.26
Mg-Diss-Water (mg/L)	50	8.24	7.10	3.89	20.8	3.73
PO4-P-Diss-Water (mg/L)	50	0.018	0.014	0.005	0.072	0.012
K-Diss-Water (mg/L)	50	2.31	2.56	0.790	3.17	0.731
EC-Phys-Water (mS/m)	50	18.0	16.6	12.1	32.4	4.47

R003

R003						
X1R003Q1 1975-2005 All	**Count**	**Mean**	**Median**	**Minimum**	**Maximum**	**Std dev**
Cl-Diss-Water (mg/L)	111	3.44	3.00	1.50	9.40	1.88
Ca-Diss-Water (mg/L)	111	8.06	8.20	3.30	17.2	1.69
DMS-Tot-Water (mg/L)	105	82.5	83.6	54.0	164	16.1
pH-Diss-Water (pH units)	111	7.38	7.40	6.07	10.1	0.558
TAL-Diss-Water (mg/L)	111	42.4	41.8	17.2	92.4	9.56
Si-Diss-Water (mg/L)	105	7.07	7.29	0.450	15.1	1.52
SO4-Diss-Water (mg/L)	111	6.64	6.32	2.00	30.4	4.47
SAR-Diss-Water (null)	111	0.295	0.291	0.066	0.600	0.071
NO3+NO2-N-Diss-Water (mg/L)	111	0.075	0.055	0.020	0.308	0.065
NH4-N-Diss-Water (mg/L)	105	0.044	0.020	0.015	0.307	0.045
F-Diss-Water (mg/L)	111	0.112	0.100	0.050	0.380	0.069
Na-Diss-Water (mg/L)	111	4.52	4.30	1.000	12.0	1.36
Mg-Diss-Water (mg/L)	111	5.88	5.80	4.00	10.4	0.959
PO4-P-Diss-Water (mg/L)	111	0.012	0.008	0.003	0.061	0.012
K-Diss-Water (mg/L)	111	0.901	0.780	0.150	2.85	0.455
EC-Phys-Water (mS/m)	111	11.6	11.4	6.00	21.1	2.21
X1R003Q1 1975-1980 RC	**Count**	**Mean**	**Median**	**Minimum**	**Maximum**	**Std dev**
Cl-Diss-Water (mg/L)	12	1.98	1.50	1.50	7.20	1.65
Ca-Diss-Water (mg/L)	12	6.94	7.30	3.30	9.70	1.87
DMS-Tot-Water (mg/L)	6	78.3	81.5	64.0	86.0	8.73
pH-Diss-Water (pH units)	12	7.61	7.28	6.61	10.1	0.940
TAL-Diss-Water (mg/L)	12	40.3	40.6	17.2	49.0	8.70
Si-Diss-Water (mg/L)	6	8.14	8.06	7.59	9.05	0.511
SO4-Diss-Water (mg/L)	12	4.74	2.00	2.00	30.4	8.18
SAR-Diss-Water (null)	12	0.305	0.310	0.250	0.350	0.038
NO3+NO2-N-Diss-Water (mg/L)	12	0.023	0.020	0.020	0.060	0.012
NH4-N-Diss-Water (mg/L)	6	0.028	0.020	0.020	0.050	0.013
F-Diss-Water (mg/L)	12	0.080	0.050	0.050	0.180	0.049
Na-Diss-Water (mg/L)	12	4.44	4.35	3.60	5.30	0.530
Mg-Diss-Water (mg/L)	12	5.66	5.60	4.90	6.50	0.576
PO4-P-Diss-Water (mg/L)	12	0.021	0.007	0.003	0.061	0.024
K-Diss-Water (mg/L)	12	1.02	0.835	0.520	1.62	0.383
EC-Phys-Water (mS/m)	12	9.63	9.90	6.00	11.9	1.83
X1R003Q1 2002-2005 PES	**Count**	**Mean**	**Median**	**Minimum**	**Maximum**	**Std dev**
Cl-Diss-Water (mg/L)	34	4.04	5.00	2.50	5.58	1.24
Ca-Diss-Water (mg/L)	34	9.10	8.90	8.18	10.6	0.713
DMS-Tot-Water (mg/L)	34	91.2	92.1	72.0	108	7.19
pH-Diss-Water (pH units)	34	7.72	7.78	6.85	8.05	0.245
TAL-Diss-Water (mg/L)	34	47.6	47.7	30.0	56.1	5.35
Si-Diss-Water (mg/L)	34	6.28	6.18	4.13	9.06	1.01
SO4-Diss-Water (mg/L)	34	8.00	8.06	3.00	15.5	3.38
SAR-Diss-Water (null)	34	0.277	0.289	0.066	0.399	0.067
NO3+NO2-N-Diss-Water (mg/L)	34	0.091	0.070	0.020	0.282	0.062
NH4-N-Diss-Water (mg/L)	34	0.048	0.020	0.015	0.307	0.066
F-Diss-Water (mg/L)	34	0.120	0.100	0.050	0.193	0.030
Na-Diss-Water (mg/L)	34	4.43	4.58	1.000	6.36	1.13
Mg-Diss-Water (mg/L)	34	6.18	6.17	4.76	7.94	0.598
PO4-P-Diss-Water (mg/L)	34	0.016	0.013	0.005	0.047	0.010
K-Diss-Water (mg/L)	34	0.854	0.910	0.342	1.12	0.181
EC-Phys-Water (mS/m)	34	13.0	13.1	10.9	14.9	1.01

EWR Site T1

T1

T1 2003-2004 All	Count	Average	Minimum	Maximum
pH-Diss-Water (pH units)	4	7.60	7.48	7.74
KJEL N-Tot-Water (mg/L)	4	1.78	0.355	4.55
NO3+NO2-N-Diss-Water (mg/L)	4	0.171	0.055	0.520
NH4-N-Diss-Water (mg/L)	4	0.015	0.015	0.015
F-Diss-Water (mg/L)	4	0.363	0.235	0.605
TAL-Diss-Water (mg/L)	4	61.3	39.8	98.2
Na-Diss-Water (mg/L)	4	14.6	11.8	19.9
Mg-Diss-Water (mg/L)	4	6.25	4.12	9.34
Si-Diss-Water (mg/L)	4	8.82	6.97	10.2
P-Tot-Water (mg/L)	4	0.114	0.042	0.199
PO4-P-Diss-Water (mg/L)	4	0.036	0.012	0.083
SO4-Diss-Water (mg/L)	4	11.9	6.79	17.7
Cl-Diss-Water (mg/L)	4	8.44	2.50	13.4
K-Diss-Water (mg/L)	4	1.61	0.689	2.68
Ca-Diss-Water (mg/L)	4	8.77	6.53	11.8
EC-Phys-Water (mS/m)	4	17.0	12.2	23.9
DMS-Tot-Water (mg/L)	4	128	90.9	186
HARD-Tot-Water (mg/L)	4	47.6	33.3	68.0

EWR Site L1

L1

X1H049Q1 2000-2002 All	Count	Mean	Median	Minimum	Maximum	Std dev
ASAR-Diss-Water Result	13	0.370	0.293	0.146	1.63	0.384
CORR-Diss-Water Result	82	0.499	0.468	0.227	1.16	0.172
Ca-Diss-Water Result	82	10.3	6.42	2.02	52.1	9.59
Cl-Diss-Water Result	83	15.1	5.00	5.00	107.62	21.6
DMS-Tot-Water Result	82	126	73.9	30.0	648	123
EC-Phys-Water Result	93	17.6	10.6	3.39	89.4	17.0
F-Diss-Water Result	83	0.154	0.133	0.050	0.409	0.064
HARD-Tot-Water Result	82	55.8	32.5	7.10	311	55.1
K-Diss-Water Result	83	1.03	0.914	0.583	3.42	0.398
KJEL N-Tot-Water Result	17	0.275	0.296	0.095	0.451	0.109
Mg-Diss-Water Result	82	7.29	3.99	0.500	43.9	7.73
NH4-N-Diss-Water Result	93	0.052	0.043	0.015	0.237	0.042
NO3+NO2-N-Diss-Water Result	93	0.255	0.194	0.020	1.31	0.237
Na-Diss-Water Result	83	12.9	6.45	3.46	68.9	15.2
P-Tot-Water Result	17	0.027	0.025	0.005	0.062	0.015
PO4-P-Diss-Water Result	93	0.022	0.017	0.006	0.119	0.018
SAR-Diss-Water Result	82	0.670	0.505	0.341	2.49	0.435
SO4-Diss-Water Result	83	8.59	6.70	2.00	31.0	6.89
Si-Diss-Water Result	93	7.57	6.94	4.87	15.6	2.06
TAL-Diss-Water Result	82	56.7	34.7	12.4	284	53.2
pH-Diss-Water Result	93	7.83	7.79	6.96	8.58	0.294

Site S1

S1	
SEEKOEISPRUIT S1	**Count = 1**
Date	08/03/2003
pH-Diss-Water (pH units)	7.75
NO3+NO2-N-Diss-Water (mg/L)	0.020
NH4-N-Diss-Water (mg/L)	0.020
F-Diss-Water (mg/L)	0.446
TAL-Diss-Water (mg/L)	56.7
Na-Diss-Water (mg/L)	11.4
Mg-Diss-Water (mg/L)	6.67
Si-Diss-Water (mg/L)	9.28
PO4-P-Diss-Water (mg/L)	0.028
SO4-Diss-Water (mg/L)	4.79
Cl-Diss-Water (mg/L)	5.00
K-Diss-Water (mg/L)	0.662
Ca-Diss-Water (mg/L)	9.45
EC-Phys-Water (mS/m)	15.3
DMS-Tot-Water (mg/L)	108

EWR Site M1

M1		
M1 @ SILINGANE ON KOMATI	**Count = 2**	
Date	2004-05-02	2004-01-26
pH-Diss-Water (pH units)	7.45	7.94
KJEL N-Tot-Water (mg/L)	0.429	2.62
NO3+NO2-N-Diss-Water (mg/L)	0.198	0.171
NH4-N-Diss-Water (mg/L)	0.02	0.015
F-Diss-Water (mg/L)	0.100	0.10
TAL-Diss-Water (mg/L)	29.3	52.1
Na-Diss-Water (mg/L)	8.45	8.11
Mg-Diss-Water (mg/L)	4.39	6.11
Si-Diss-Water (mg/L)	7.29	6.26
P-Tot-Water (mg/L)	0.015	0.058
PO4-P-Diss-Water (mg/L)	0.012	0.012
SO4-Diss-Water (mg/L)	3	3.00
Cl-Diss-Water (mg/L)	2.5	6.94
K-Diss-Water (mg/L)	1.06	1.73
Ca-Diss-Water (mg/L)	5.65	7.09
EC-Phys-Water (mS/m)	10.1	13.5
DMS-Tot-Water (mg/L)	61.8	97.5
HARD-Tot-Water (mg/L)	32.2	42.8
LANGL-Index-Water (null)	1.69	0.873
CORR-Diss-Water (null)	0.227	0.248

Mtsoli

Mtsoli						
X1H021Q01 MTSOLI 1977-2005	**Count**	**Mean**	**Median**	**Minimum**	**Maximum**	**Std dev**
CORR-Diss-Water Result	59	0.244	0.220	0.054	0.506	0.093
Ca-Diss-Water Result	202	6.01	5.40	1.20	31.1	3.29
Cl-Diss-Water Result	202	3.28	2.50	1.50	10.6	1.95
Cl-Diss-Water Detection Limit	202	3.99	3.00	3.00	10.0	2.06
DMS-Tot-Water Result	202	67.6	62.1	34.0	356	30.2
EC-Phys-Water Result	266	9.51	8.92	4.10	42.6	3.71
EC-Phys-Water Detection Limit	266	0.972	1.000	0.100	2.00	0.518
F-Diss-Water Result	203	0.090	0.050	0.050	0.374	0.067
F-Diss-Water Detection Limit	203	0.113	0.100	0.100	0.200	0.034
HARD-Tot-Water Result	59	43.5	36.8	29.1	187	23.7
HARD-Mg-Calc-Water Result	3	18.3	18.5	17.8	18.7	0.434
K-Diss-Water Result	203	0.355	0.301	0.150	2.47	0.338
K-Diss-Water Detection Limit	203	0.300	0.300	0.300	0.300	0.00
KJEL N-Tot-Water Result	2	0.348	0.348	0.325	0.371	0.033
KJEL N-Tot-Water Detection Lim	2	0.190	0.190	0.190	0.190	0.00
LANGL-Index-Water Result	59	1.29	1.39	0.002	2.48	0.490
Mg-Diss-Water Result	203	5.44	5.22	2.50	26.5	1.93
NH4-N-Diss-Water Result	223	0.046	0.020	0.015	1.45	0.100
NH4-N-Diss-Water Detection Lim	223	0.039	0.040	0.030	0.040	0.004
NO3+NO2-N-Diss-Water Result	223	0.040	0.020	0.020	0.396	0.044
NO3+NO2-N-Diss-Water Detectio	223	0.053	0.040	0.040	0.110	0.025
Na-Diss-Water Result	203	2.95	2.60	1.000	17.6	2.45
P-Tot-Water Result	2	0.023	0.023	0.019	0.026	0.005
PO4-P-Diss-Water Result	223	0.013	0.012	0.003	0.061	0.010
PO4-P-Diss-Water Detection Lim	223	0.009	0.005	0.005	0.023	0.006
RYZNAR-Index-Water Result	59.0	10.2	10.4	6.92	11.6	0.858
SAR-Diss-Water Result	202	0.209	0.190	0.050	0.800	0.120
SO4-Diss-Water Result	202	3.67	2.00	2.00	15.8	2.87
SO4-Diss-Water Detection Limit	202	4.26	4.00	4.00	6.00	0.671
Si-Diss-Water Result	223	5.72	5.53	3.58	15.6	1.10
Si-Diss-Water Detection Limit	223	0.454	0.400	0.400	0.800	0.114
TAL-Diss-Water Result	203	37.3	34.6	14.8	220	18.3
TAL-Diss-Water Detection Limit	203	4.79	4.00	4.00	8.00	1.59
TEMP-Phys-Water Result	3	17.7	17.0	14.0	22.0	4.04
pH-Diss-Water Result	223	7.46	7.49	6.12	8.61	0.459
pHs-Calc-Water Result	3	9.07	9.07	9.06	9.09	0.014

X1H021Q01 MTSOLI 1995-2005 F	Count	Mean	Median	Minimum	Maximum	Std dev
CORR-Diss-Water Result	59	0.244	0.220	0.054	0.506	0.093
Ca-Diss-Water Result	71	6.94	5.80	4.40	31.1	3.99
Cl-Diss-Water Result	71	3.83	3.90	1.50	9.30	1.59
Cl-Diss-Water Detection Limit	71	5.80	5.00	3.00	10.0	2.65
DMS-Tot-Water Result	71	79.1	66.0	49.2	356	45.2
EC-Phys-Water Result	92	10.9	9.10	7.22	42.6	5.62
EC-Phys-Water Detection Limit	92	0.920	0.550	0.100	2.00	0.881
F-Diss-Water Result	72	0.113	0.100	0.050	0.374	0.077
F-Diss-Water Detection Limit	72	0.136	0.100	0.100	0.200	0.048
HARD-Tot-Water Result	59	43.5	36.8	29.1	187	23.7
HARD-Mg-Calc-Water Result	3	18.3	18.5	17.8	18.7	0.434
K-Diss-Water Result	72	0.465	0.334	0.150	2.47	0.473
K-Diss-Water Detection Limit	72	0.300	0.300	0.300	0.300	0.00
KJEL N-Tot-Water Result	2	0.348	0.348	0.325	0.371	0.033
KJEL N-Tot-Water Detection Lim	2	0.190	0.190	0.190	0.190	0.00
LANGL-Index-Water Result	59	1.29	1.39	0.002	2.48	0.490
Mg-Diss-Water Result	72	6.03	5.28	3.87	26.5	2.94
NH4-N-Diss-Water Result	92	0.024	0.020	0.015	0.083	0.014
NH4-N-Diss-Water Detection Lim	92	0.037	0.040	0.030	0.040	0.005
NO3+NO2-N-Diss-Water Result	92	0.056	0.055	0.020	0.396	0.052
NO3+NO2-N-Diss-Water Detectio	92	0.070	0.060	0.040	0.110	0.032
Na-Diss-Water Result	72	3.96	2.71	1.000	17.6	3.62
P-Tot-Water Result	2	0.023	0.023	0.019	0.026	0.005
PO4-P-Diss-Water Result	92	0.015	0.012	0.006	0.061	0.009
PO4-P-Diss-Water Detection Lim	92	0.014	0.011	0.005	0.023	0.007
RYZNAR-Index-Water Result	59	10.2	10.4	6.92	11.6	0.858
SAR-Diss-Water Result	71	0.247	0.199	0.050	0.777	0.157
SO4-Diss-Water Result	71	4.16	3.00	2.00	11.7	2.57
SO4-Diss-Water Detection Limit	71	4.73	4.00	4.00	6.00	0.970
Si-Diss-Water Result	92	5.65	5.30	3.58	15.6	1.53
Si-Diss-Water Detection Limit	92	0.530	0.500	0.400	0.800	0.147
TAL-Diss-Water Result	72	43.6	36.3	23.1	220	27.0
TAL-Diss-Water Detection Limit	72	6.22	8.00	4.00	8.00	2.00
pH-Diss-Water Result	92	7.76	7.76	6.65	8.32	0.270
pHs-Calc-Water Result	3	9.07	9.07	9.06	9.09	0.014

X1H021Q01 MTSOLI 1977-1987 F	Count	Mean	Median	Minimum	Maximum	Std dev
Ca-Diss-Water Result	92	5.64	5.20	1.20	26.7	3.21
Cl-Diss-Water Result	92	2.13	1.50	1.50	6.70	1.29
Cl-Diss-Water Detection Limit	92	3.00	3.00	3.00	3.00	0.00
DMS-Tot-Water Result	92	60.3	58.0	34.0	144	15.4
EC-Phys-Water Result	131	8.67	8.70	4.10	17.3	1.77
EC-Phys-Water Detection Limit	131	1.000	1.000	1.000	1.000	0.00
F-Diss-Water Result	92	0.065	0.050	0.050	0.330	0.050
F-Diss-Water Detection Limit	92	0.100	0.100	0.100	0.100	0.00
K-Diss-Water Result	92	0.273	0.150	0.150	1.000	0.191
K-Diss-Water Detection Limit	92	0.300	0.300	0.300	0.300	0.00
Mg-Diss-Water Result	92	5.02	5.20	2.50	7.10	0.907
NH4-N-Diss-Water Result	92	0.058	0.050	0.020	0.160	0.039
NH4-N-Diss-Water Detection Lim	92	0.040	0.040	0.040	0.040	0.00
NO3+NO2-N-Diss-Water Result	92	0.023	0.020	0.020	0.080	0.012
NO3+NO2-N-Diss-Water Detectio	92	0.040	0.040	0.040	0.040	0.00
Na-Diss-Water Result	92	2.41	2.50	1.000	7.20	0.999
PO4-P-Diss-Water Result	92	0.013	0.009	0.003	0.050	0.011
PO4-P-Diss-Water Detection Lim	92	0.005	0.005	0.005	0.005	0.00
SAR-Diss-Water Result	92	0.189	0.190	0.050	0.800	0.087
SO4-Diss-Water Result	92	3.16	2.00	2.00	15.8	3.02
SO4-Diss-Water Detection Limit	92	4.00	4.00	4.00	4.00	0.00
Si-Diss-Water Result	92	5.83	5.74	4.82	9.26	0.594
Si-Diss-Water Detection Limit	92	0.400	0.400	0.400	0.400	0.00
TAL-Diss-Water Result	92	34.2	33.5	14.8	87.1	10.3
TAL-Diss-Water Detection Limit	92	4.00	4.00	4.00	4.00	0.00
TEMP-Phys-Water Result	3	17.7	17.0	14.0	22.0	4.04
pH-Diss-Water Result	92	7.12	7.11	6.12	8.13	0.310

Appendix A2

Monthly Statistics

X1R003Q01 (Very limited data)															
			pH-Diss-Water (pH units)	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
Jan	**1970-1976**	**Count**	6	6	3	6	6	3	6	6	6	3	6	6	6
		Mean	1.95	6.65	75.33333	7.015	40.4	8.073333	3.666667	0.303333	0.02	0.053333	0.08	4.333333	5.516667
		Median	1.5	7	79	7.145	38.25	7.59	2	0.305	0.02	0.04	0.075	4.35	5.5
		Min	1.5	3.3	64	6.18	35.8	7.58	2	0.26	0.02	0.02	0.05	4.1	4.9
		Max	4.2	8.5	83	7.41	48.5	9.05	12	0.34	0.02	0.1	0.12	4.6	6.2
		Std dev	1.10227	1.918072	10.01665	0.430198	5.218812	0.845833	4.082483	0.030111	0	0.041633	0.033466	0.206559	0.563619
	2000-2005	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.190667	9.111333	91.54767	7.721333	47.406	5.471333	8.209667	0.27	0.069	0.035	0.117333	4.348333	6.378333
		Median	5	9.402	92.971	7.829	46.52	5.717	9.3	0.255	0.055	0.02	0.1	4.156	6.388
		Min	2.5	8.463	88.566	7.488	42.41	4.858	3	0.236	0.02	0.015	0.1	3.712	6.217
		Max	5.072	9.469	93.106	7.847	53.288	5.839	12.329	0.319	0.132	0.07	0.152	5.177	6.53
		Std dev	1.464603	0.562472	2.583081	0.202273	5.492856	0.534653	4.759115	0.043486	0.057297	0.030414	0.030022	0.751199	0.156724
Feb	**1980-1987**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	3.125	9.175	90.25	7.1525	49.35	7.4725	6.45	0.275	0.02	0.025	0.125	4.325	5.7
		Median	3	9.1	94.5	7.42	50.7	7.355	5.05	0.27	0.02	0.02	0.08	4.35	5.4
		Min	1.5	6.5	65	6.07	33.9	6.76	4.5	0.23	0.02	0.02	0.05	3	4
		Max	5	12	107	7.7	62.1	8.42	11.2	0.33	0.02	0.04	0.29	5.6	8
		Std dev	1.887459	2.248518	20.15564	0.740152	12.60833	0.691152	3.177525	0.052599	0	0.01	0.113578	1.268529	1.669331
	2000-2005	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.04	9.125667	91.156	7.828333	46.042	5.332	10.64333	0.254	0.038333	0.018333	0.106333	4.013	5.95
		Median	4.62	8.522	92.709	7.888	48.178	5.908	10.405	0.251	0.04	0.02	0.1	4.184	5.817
		Min	2.5	8.22	85.19	7.636	39.584	4.132	9.18	0.224	0.02	0.015	0.05	3.433	5.743
		Max	5	10.635	95.569	7.961	50.364	5.956	12.345	0.287	0.055	0.02	0.169	4.422	6.29
		Std dev	1.347145	1.315814	5.360948	0.170518	5.698594	1.039508	1.595904	0.031607	0.017559	0.002887	0.059752	0.516199	0.296764
Mar	**1975-1982**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	3.4	9.633333	101	7.17	56.8	10.07333	3.866667	0.366667	0.04	0.05	0.133333	6.433333	6.633333

X1R003Q01 (Very limited data)															
			pH-Diss-Water (pH units)	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Median	1.5	7.2	72	7.14	39.8	7.77	2	0.27	0.02	0.04	0.17	3.7	5.3
		Min	1.5	4.5	67	6.61	38.2	7.38	2	0.27	0.02	0.02	0.05	3.6	4.2
		Max	7.2	17.2	164	7.76	92.4	15.07	7.6	0.56	0.08	0.09	0.18	12	10.4
		Std dev	3.290897	6.690541	54.61685	0.575587	30.84088	4.331632	3.233162	0.167432	0.034641	0.036056	0.072342	4.821134	3.308071
	2000-2005	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	3.6035	8.69275	81.72075	7.6635	40.8275	6.26425	7.56925	0.299	0.09925	0.0905	0.1215	4.6655	5.8345
		Median	3.457	8.662	82.839	7.687	41.85	6.4785	7.252	0.3175	0.0475	0.02	0.118	4.925	5.7655
		Min	2.5	8.589	72.016	7.421	30.018	5.402	3	0.162	0.02	0.015	0.1	2.448	4.759
		Max	5	8.858	89.189	7.859	49.592	6.698	12.773	0.399	0.282	0.307	0.15	6.364	7.048
		Std dev	1.296476	0.115558	7.156579	0.186957	8.250727	0.584387	4.018463	0.099227	0.122674	0.144353	0.025475	1.631583	1.081463
Apr	**1977-1986**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	2.625	6.075	68.5	7.0725	35.75	7.61	6.1	0.2525	0.025	0.03	0.145	3.5	5.2
		Median	1.5	6.15	69	7.01	34.35	7.635	6.1	0.25	0.02	0.02	0.145	3.5	5.2
		Min	1.5	5.4	66	6.73	32.6	7.43	2	0.24	0.02	0.02	0.05	3.3	5
		Max	6	6.6	70	7.54	41.7	7.74	10.2	0.27	0.04	0.06	0.24	3.7	5.4
		Std dev	2.25	0.499166	1.732051	0.372324	4.198809	0.129872	3.466026	0.015	0.01	0.02	0.082664	0.182574	0.163299
	2000-2005	**Count**	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	3.75	9.0795	90.0535	7.698	50.671	6.4975	5.281	0.1715	0.0375	0.148	0.1235	2.7975	6.0485
		Median	3.75	9.0795	90.0535	7.698	50.671	6.4975	5.281	0.1715	0.0375	0.148	0.1235	2.7975	6.0485
		Min	2.5	8.933	84.939	7.617	46.313	6.476	3	0.066	0.02	0.02	0.1	1	5.008
		Max	5	9.226	95.168	7.779	55.029	6.519	7.562	0.277	0.055	0.276	0.147	4.595	7.089
		Std dev	1.767767	0.207182	7.232995	0.114551	6.163143	0.030406	3.225821	0.1492	0.024749	0.181019	0.033234	2.542049	1.471489
May	**1992-1996**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	3.166667	8.7	78	6.896667	41.23333	7.903333	4.166667	0.25	0.09	0.033333	0.176667	3.833333	5.666667
		Median	3.5	9.7	76	7.1	38.8	8.14	4.9	0.25	0.06	0.04	0.18	4.1	5.3
		Min	1.5	6.2	74	6.24	38.5	7.28	2	0.2	0.05	0.02	0.05	3.2	5.2

X1R003Q01 (Very limited data)															
			pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Max	4.5	10.2	84	7.35	46.4	8.29	5.6	0.3	0.16	0.04	0.3	4.2	6.5
		Std dev	1.527525	2.179449	5.291503	0.582266	4.476978	0.545008	1.908752	0.05	0.060828	0.011547	0.125033	0.550757	0.723418
	2000-2005	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.166667	9.321	92.83967	7.604667	51.04533	6.144333	5.107333	0.267667	0.031667	0.079333	0.128667	4.317333	6.338333
		Median	5	9.212	95.215	7.48	49.877	6.16	4.476	0.272	0.02	0.079	0.131	4.364	6.328
		Min	2.5	9.072	84.192	7.396	47.171	5.697	3	0.236	0.02	0.074	0.1	3.895	6.034
		Max	5	9.679	99.112	7.938	56.088	6.576	7.846	0.295	0.055	0.085	0.155	4.693	6.653
		Std dev	1.443376	0.317841	7.738427	0.291714	4.571868	0.439709	2.483921	0.029738	0.020207	0.005508	0.027574	0.401042	0.309629
Jun	1995-1996	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	2.1	8.1	83.66667	7.083333	42.83333	7.663333	8.633333	0.353333	0.083333	0.026667	0.083333	5.366667	5.833333
		Median	1.5	8.4	86	7.18	41.4	7.51	11.5	0.33	0.11	0.02	0.1	5.4	5.6
		Min	1.5	6.8	79	6.77	38	7.46	2	0.32	0.02	0.02	0.05	4.5	5
		Max	3.3	9.1	86	7.3	49.1	8.02	12.4	0.41	0.12	0.04	0.1	6.2	6.9
		Std dev	1.03923	1.178983	4.041452	0.277909	5.68712	0.309892	5.762233	0.049329	0.055076	0.011547	0.028868	0.85049	0.971253
	2000-2005	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	5.192667	9.537667	95.41133	7.593	47.872	6.967	9.994	0.298333	0.137	0.045	0.157333	4.756	5.887
		Median	5	9.536	93.922	7.586	48.054	6.197	8.182	0.293	0.119	0.047	0.179	4.69	5.89
		Min	5	8.729	89.432	7.478	46.834	6.035	6.315	0.276	0.116	0.041	0.1	4.281	5.788
		Max	5.578	10.348	102.88	7.715	48.728	8.669	15.485	0.326	0.176	0.047	0.193	5.297	5.983
		Std dev	0.333708	0.809501	6.846588	0.118655	0.960027	1.476199	4.846105	0.025423	0.033808	0.003464	0.050143	0.511205	0.097535
Jul	1993-1996	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	5.466667	7.666667	78.33333	6.906667	37.43333	6.606667	5.366667	0.346667	0.11	0.026667	0.15	5.333333	5.866667
		Median	5.5	7.6	79	6.8	36.1	7.5	4	0.33	0.11	0.02	0.11	4.9	5.3
		Min	1.5	5.6	63	6.62	34.4	4.37	2	0.28	0.07	0.02	0.05	3.8	4.9
		Max	9.4	9.8	93	7.3	41.8	7.95	10.1	0.43	0.15	0.04	0.29	7.3	7.4
		Std dev	3.950105	2.100794	15.01111	0.352326	3.875994	1.950034	4.2194	0.076376	0.04	0.011547	0.1249	1.789786	1.342882

X1R003Q01 (Very limited data)															
			pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	2000-2005	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.166667	8.817	86.55333	7.522	44.84	6.552333	7.601667	0.248	0.113333	0.029333	0.119	3.880333	5.891333
		Median	5	8.584	89.566	7.794	45.306	6.604	6.86	0.213	0.132	0.02	0.12	3.328	6.014
		Min	2.5	8.56	77.217	6.845	38.768	6.427	6.429	0.21	0.055	0.015	0.1	3.28	5.562
		Max	5	9.307	92.877	7.927	50.446	6.626	9.516	0.321	0.153	0.053	0.137	5.033	6.098
		Std dev	1.443376	0.424522	8.253243	0.590058	5.85293	0.109098	1.671809	0.063238	0.051598	0.020648	0.01852	0.998527	0.288287
Aug	1994-1996	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	2.5	8.033333	76	7.053333	43.2	7.72	2	0.303333	0.11	0.02	0.08	4.6	5.566667
		Median	1.5	8	70	7.35	41.1	7.86	2	0.28	0.1	0.02	0.05	4	5.6
		Min	1.5	7.1	70	6.41	39.4	7.32	2	0.27	0.09	0.02	0.05	4	4.8
		Max	4.5	9	88	7.4	49.1	7.98	2	0.36	0.14	0.02	0.14	5.8	6.3
		Std dev	1.732051	0.950438	10.3923	0.557704	5.179768	0.351568	0	0.049329	0.026458	3.29E-10	0.051962	1.03923	0.750555
	2000-2005	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.166667	9.29	94.02033	7.951667	46.91333	6.804	10.68367	0.305	0.123333	0.024667	0.121667	4.919333	6.247
		Median	5	8.742	96.745	7.981	46.181	6.374	11.302	0.291	0.115	0.02	0.122	4.636	6.211
		Min	2.5	8.498	87.186	7.829	43.877	5.312	8.408	0.24	0.1	0.02	0.1	3.793	6.024
		Max	5	10.63	98.13	8.045	50.682	8.726	12.341	0.384	0.155	0.034	0.143	6.329	6.506
		Std dev	1.443376	1.166869	5.95908	0.110947	3.461104	1.747147	2.038106	0.073014	0.028431	0.008083	0.021502	1.291523	0.243008
Sep	1981-1987	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	2.6	7.233333	75	6.966667	39.8	7.88	6.1	0.306667	0.076667	0.036667	0.083333	4.466667	5.366667
		Median	3	7.1	75	7.02	39.8	7.9	7.1	0.28	0.07	0.04	0.05	4	5.2
		Min	1.5	6.8	68	6.45	39.4	7.69	2	0.22	0.02	0.02	0.05	3.2	5.1
		Max	3.3	7.8	82	7.43	40.2	8.05	9.2	0.42	0.14	0.05	0.15	6.2	5.8
		Std dev	0.964365	0.51316	7	0.492172	0.4	0.180831	3.702702	0.102632	0.060277	0.015275	0.057735	1.553491	0.378594
	2000-2005	Count	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	3.75	9.4415	92.6555	7.8905	49.1415	5.8825	7.4605	0.257	0.119	0.0175	0.1155	4.183	6.416

X1R003Q01 (Very limited data)															
			pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Median	3.75	9.4415	92.6555	7.8905	49.1415	5.8825	7.4605	0.257	0.119	0.0175	0.1155	4.183	6.416
		Min	2.5	9.326	91.969	7.775	47.266	5.777	5.675	0.217	0.11	0.015	0.1	3.496	6.241
		Max	5	9.557	93.342	8.006	51.017	5.988	9.246	0.297	0.128	0.02	0.131	4.87	6.591
		Std dev	1.767767	0.163342	0.970858	0.163342	2.652358	0.1492	2.525078	0.056569	0.012728	0.003536	0.02192	0.971565	0.247487
Oct	**1993-1996**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	1.875	7.75	80.25	6.9625	41.5	8.135	7.35	0.31	0.045	0.02	0.065	4.85	6.3
		Median	1.5	8	77.5	6.995	39.9	8.025	7.45	0.295	0.04	0.02	0.05	4.5	5.95
		Min	1.5	5.6	60	6.36	29.6	7.58	5.1	0.24	0.02	0.02	0.05	3.3	5.4
		Max	3	9.4	106	7.5	56.6	8.91	9.4	0.41	0.08	0.02	0.11	7.1	7.9
		Std dev	0.75	1.586401	19.2592	0.617542	11.28362	0.652508	1.815673	0.074386	0.03	0	0.03	1.621727	1.134313
	2000-2005	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.167	8.763	92.93167	7.81	49.48833	6.006667	7.117	0.305	0.086	0.034	0.103667	4.846667	6.291667
		Median	5	8.569	92.328	7.778	50.766	5.477	8.887	0.314	0.084	0.015	0.1	5.18	6.108
		Min	2.5	8.327	90.828	7.704	45.671	5.381	3	0.217	0.055	0.015	0.1	3.376	5.937
		Max	5.001	9.393	95.639	7.948	52.028	7.162	9.464	0.384	0.119	0.072	0.111	5.984	6.83
		Std dev	1.443664	0.558852	2.461654	0.125108	3.365589	1.001699	3.57708	0.083863	0.032047	0.032909	0.006351	1.335571	0.473986
Nov	**1993-1996**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	2.9	7.45	74.25	6.9225	38.375	7.5525	4.95	0.305	0.0375	0.0275	0.0625	4.525	5.55
		Median	2.25	7.55	73	6.975	37.25	7.59	3.9	0.31	0.035	0.02	0.05	4.5	5.6
		Min	1.5	6.4	67	6.34	32.7	7.08	2	0.29	0.02	0.02	0.05	4.4	5.2
		Max	5.6	8.3	84	7.4	46.3	7.95	10	0.31	0.06	0.05	0.1	4.7	5.8
		Std dev	1.933908	0.793725	7.088723	0.552954	5.85911	0.424608	3.813572	0.01	0.020616	0.015	0.025	0.125831	0.264575
	2000-2005	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	4.184667	9.029333	96.61333	7.676667	50.64467	6.989333	9.095333	0.295667	0.109667	0.038	0.115	4.759667	6.331
		Median	5	8.403	91.431	7.74	50.699	6.211	8.474	0.298	0.103	0.031	0.1	4.679	6.266
		Min	2.5	8.384	90.669	7.473	45.856	5.693	5.301	0.216	0.055	0.015	0.1	3.369	6.126

X1R003Q01 (Very limited data)															
			pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Max	5.054	10.301	107.74	7.817	55.379	9.064	13.511	0.373	0.171	0.068	0.145	6.231	6.601
		Std dev	1.459214	1.101337	9.643505	0.180533	4.761732	1.815286	4.140117	0.078526	0.058287	0.027185	0.025981	1.432704	0.24408
Dec	1991-1996	Count	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	1.5	8.066667	83.66667	7.33	46.2	8.003333	5.2	0.306667	0.043333	0.036667	0.05	4.733333	6.2
		Median	1.5	8.4	85	7.3	47.3	8.03	6.5	0.32	0.02	0.04	0.05	5	6.2
		Min	1.5	7	80	7.08	42.3	7.9	2	0.25	0.02	0.02	0.05	3.9	6.2
		Max	1.5	8.8	86	7.61	49	8.08	7.1	0.35	0.09	0.05	0.05	5.3	6.2
		Std dev	0	0.945163	3.21455	0.266271	3.482815	0.092916	2.787472	0.051316	0.040415	0.015275	0	0.737111	8.43E-08
	2000-2005	Count	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	2.5	9.299	93.3315	7.7365	50.947	6.403	5.4665	0.3155	0.127	0.015	0.1	5.2225	6.941
		Median	2.5	9.299	93.3315	7.7365	50.947	6.403	5.4665	0.3155	0.127	0.015	0.1	5.2225	6.941
		Min	2.5	8.176	83.682	7.445	47.044	5.582	3	0.297	0.055	0.015	0.1	4.571	5.938
		Max	2.5	10.422	102.981	8.028	54.85	7.224	7.933	0.334	0.199	0.015	0.1	5.874	7.944
		Std dev	0	1.588162	13.64645	0.412243	5.519676	1.161069	3.488158	0.026163	0.101823	0	0	0.92136	1.418456

X1R001Q01 (Very limited data)																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+ NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Jan	1970-1976	Count	10	10	10	10	10	0	10	9	10		6	10	10	3	3	10
		Mean	72.6	6.58	8.23	7.373	38.94	#DIV/0!	9.39	0.35	0.079		0.05	4.93	4.95	0.0025	1.213333	11.73
		Median	72	3.8	8.15	7.4	30.5	#NUM!	4.5	0.34	0.02		0.05	2.7	5.5	0.0025	1.23	12.75
		Min	70	1.5	2.1	6.65	14.8	0	2	0.03	0.02		0.05	1	1.5	0.0025	1.18	4.1
		Max	76	22	16	7.9	80.4	0	22.9	0.73	0.61		0.05	14	10	0.0025	1.23	20
		Std dev	2.458545	6.619466	5.819708	0.446991	24.28087	#DIV/0!	9.459087	0.271201	0.186574		8.33E-10	5.343126	2.750858	4.12E-11	0.028868	5.835152
	2000-2005	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	2.6	6.328	10.9882	7.8046	49.9476	2.9292	16.7074	0.4072	0.0668	0.0352	0.1602	7.0206	7.0252	0.01482	2.3552	16.96
		Median	3	5	10.91	7.849	49.733	2.966	19.471	0.425	0.055	0.02	0.163	7.109	6.767	0.014	2.434	16.3
		Min	0	2.5	10.069	7.39	39.624	1.319	3	0.298	0.02	0.02	0.1	5.026	5.77	0.0051	1.139	13.9
		Max	5	10.802	12.407	8.034	59.155	4.77	26.406	0.465	0.107	0.064	0.247	8.215	9.376	0.026	3.038	21.7
		Std dev	2.073644	3.24952	0.99387	0.254398	7.335788	1.244409	9.437473	0.063633	0.035344	0.021241	0.062727	1.223578	1.376525	0.007497	0.743307	2.873674
Feb	1980-1987	Count	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	82	5.933333	8.633333	6.8925	43.875	3.595	16.2	0.4375	0.1	0.0325	0.1775	7.35	7.375	0.008875	2.93	15.6
		Median	80	6	9	7.14	43.5	3.575	15.65	0.435	0.085	0.02	0.17	7.35	7.35	0.0085	2.965	15.3
		Min	80	5.5	7.3	6.01	34.3	1.54	11.4	0.42	0.05	0.02	0.14	6.9	6.4	0.0025	2.73	12.7
		Max	86	6.3	9.6	7.28	54.2	5.69	22.1	0.46	0.18	0.07	0.23	7.8	8.4	0.016	3.06	19.1
		Std dev	3.464102	0.404145	1.193035	0.594047	8.496421	2.032576	4.846304	0.020616	0.059442	0.025	0.04113	0.420317	0.865544	0.005662	0.156844	2.736177
	2000-2005	Count	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	3	5.03575	10.59275	7.87175	45.4555	2.9855	17.37725	0.4065	0.0595	0.0305	0.21175	6.6465	6.41375	0.01255	2.2525	16.25
		Median	3.5	5	10.753	7.851	46.016	3.1945	18.074	0.412	0.0505	0.02	0.237	7.0935	6.176	0.00905	2.5585	14.85
		Min	0	2.5	8.138	7.741	32.527	1.42	9.024	0.29	0.04	0.015	0.1	5.063	4.291	0.0051	0.931	14.3
		Max	5	7.643	12.727	8.044	57.263	4.133	24.337	0.512	0.097	0.067	0.273	7.336	9.012	0.027	2.962	21
		Std dev	2.160247	2.100027	2.419285	0.142682	11.79664	1.133597	7.203837	0.09349	0.025749	0.024447	0.078881	1.070197	1.949597	0.010328	0.9413	3.190089

X1R001Q01 (Very limited data)																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Mar	1975-1982	Count	6	6	6	6	6	3	6	6	6	3	6	6	6	6	6	6
		Mean	78	6.35	7.7	6.68	37.76667	4.9	9.533333	0.438333	0.14	0.033333	0.176667	6.55	5.683333	0.014583	2.515	11.65
		Median	77.5	4.95	7	6.945	36.4	4.81	8.05	0.435	0.175	0.04	0.155	6.5	5.55	0.0145	2.365	11.15
		Min	75	3.4	6.5	5.32	33.5	4.03	5.7	0.41	0.02	0.02	0.15	5.7	4.7	0.0025	2.18	9.4
		Max	82	11.2	11	7.31	46.9	5.86	14.9	0.47	0.19	0.04	0.27	7.5	7.4	0.029	3.16	14.8
		Std dev	3.34664	3.382159	1.723949	0.727929	4.858669	0.918314	3.550023	0.023166	0.067231	0.011547	0.047188	0.612372	1.030372	0.009394	0.370176	2.286263
	2000-2005	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	2.4	5.4814	9.6656	7.833	49.4328	4.4116	13.7242	0.3906	0.0602	0.0804	0.1538	6.4002	6.8202	0.0144	1.819	15.216
		Median	3	5	9.226	7.879	52.399	3.859	16.457	0.386	0.055	0.02	0.164	6.297	7.242	0.013	1.989	13.7
		Min	0	2.5	7.154	7.592	33.172	1.942	3	0.283	0.02	0.015	0.1	4.81	4.064	0.012	0.919	12.08
		Max	4	12.407	12.753	8.049	58.287	6.895	23.207	0.466	0.14	0.327	0.212	7.876	8.116	0.021	2.983	19.9
		Std dev	1.81659	4.06832	2.143207	0.180706	9.710863	2.020482	8.527918	0.074798	0.049145	0.137871	0.052002	1.099556	1.664392	0.003715	0.830717	3.105363
Apr	1977-1986	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	79.8	5.46	9.04	7.098	47.48	2.824	12.6	0.522	0.5	0.034	0.142	8.3	6.22	0.0819	3.308	15.76
		Median	77	5.2	9.5	6.96	48.7	2.64	14	0.53	0.08	0.02	0.14	8	6	0.0025	2.43	15.6
		Min	77	4	7	6.84	38.4	2.36	6.4	0.5	0.05	0.02	0.05	7.7	5.1	0.0025	2.34	14.4
		Max	86	8.4	10.2	7.48	55.8	3.83	16.5	0.54	2.1	0.06	0.24	9	7.9	0.388	6.27	18.7
		Std dev	4.086563	1.745852	1.289574	0.277345	6.326689	0.57804	3.815102	0.016432	0.89719	0.019494	0.068702	0.565685	1.12116	0.171188	1.6824	1.758693
	2000-2005	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	2	5.7878	11.7858	7.7898	63.1818	5.5068	12.176	0.3746	0.064	0.081	0.179	6.7374	8.4668	0.01602	2.0696	18.16
		Median	2	5	10.247	7.742	54.826	5.356	9.278	0.344	0.056	0.044	0.206	6.464	7.403	0.013	2.255	17.4
		Min	0	2.5	8.465	7.589	40.847	2.079	3	0.273	0.02	0.02	0.1	4.618	5.126	0.0051	0.977	13.2
		Max	4	11.439	16.975	8.07	112.845	8.091	21.811	0.482	0.096	0.276	0.217	8.16	14.903	0.031	3.012	25.3
		Std dev	1.581139	3.339445	3.492232	0.18816	28.60902	2.533024	7.546026	0.082664	0.031409	0.109695	0.0502	1.435731	3.749983	0.009563	0.782594	4.990291
May	1992-	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

X1R001Q01 (Very limited data)																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Ddss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
	1996	**Mean**	95.2	7.72	9.84	7.82	41.28	3.274	18.8	0.36	0.149	0.0304	0.228	5.86	6.06	0.024	3.48	15.42
		Median	96	8.4	9.9	7.86	40.7	3.84	18.3	0.35	0.156	0.02	0.22	5.8	5.8	0.025	3.61	14.9
		Min	92	5.2	7.7	7.64	35.4	0.98	14.8	0.33	0.114	0.02	0.19	4.9	5.3	0.011	2.81	13.5
		Max	96	10.8	13.2	8.02	47.5	3.98	23.9	0.43	0.175	0.049	0.29	7.3	7.3	0.033	3.73	17.7
		Std dev	1.788854	2.389979	2.301738	0.154758	5.604641	1.287898	3.260368	0.04	0.028293	0.014398	0.039623	0.884873	0.808084	0.008185	0.380395	1.848513
	2000-2005	**Count**	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
		Mean	1.857143	5.396714	12.66657	7.662571	70.80057	4.028571	16.30086	0.415	0.076429	0.04	0.187429	7.900714	10.61229	0.019	2.469429	20.65714
		Median	2	5	11.2	7.798	51.67	3.506	18.455	0.419	0.055	0.047	0.183	7.31	8.028	0.018	2.536	18.1
		Min	0	5	7.558	6.71	36.82	0.408	9.988	0.302	0.02	0.015	0.1	7.125	5.051	0.013	1.928	15
		Max	4	7.777	20.334	8.237	147.12	7.926	22.395	0.501	0.161	0.065	0.287	10.417	20.828	0.031	2.954	32.4
		Std dev	1.345185	1.049607	4.509844	0.51181	40.8636	2.885883	5.15346	0.070791	0.058853	0.020992	0.05608	1.211821	5.84469	0.007095	0.413085	6.268136
Jun	**1995-1996**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	95.66667	6.733333	11.26667	7.776667	49.06667	3.21	21.26667	0.33	0.161	0.046333	0.186667	5.566667	6.5	0.041333	3.616667	16.23333
		Median	96	6.3	9.7	7.72	51.1	3.73	20.6	0.29	0.159	0.045	0.19	4.7	6.5	0.042	3.66	16.2
		Min	95	5.7	9.7	7.59	42.6	2.12	19	0.26	0.114	0.02	0.17	4.7	6.3	0.021	3.49	14.7
		Max	96	8.2	14.4	8.02	53.5	3.78	24.2	0.44	0.21	0.074	0.2	7.3	6.7	0.061	3.7	17.8
		Std dev	0.57735	1.305118	2.713546	0.22053	5.727419	0.944299	2.663331	0.096437	0.048031	0.027025	0.015275	1.501111	0.2	0.020008	0.111505	1.550269
	2000-2005	**Count**	2	2	2	4	4	4	4	4	3	3	3	3	3	3	3	3
		Mean	3.5	6.2235	9.163	7.7525	67.642	4.86375	15.212	0.394	0.409333	0.083	0.154667	7.168667	10.765	0.020667	1.968667	19.29333
		Median	3.5	6.2235	9.163	7.7155	49.3225	5.039	16.8095	0.407	0.069	0.052	0.131	6.944	6.346	0.015	2.074	15.2
		Min	3	5	8.922	7.442	44.6	2.24	7.004	0.282	0.055	0.02	0.1	4.505	5.919	0.013	0.852	12.68
		Max	4	7.447	9.404	8.137	127.323	7.137	20.225	0.48	1.104	0.177	0.233	10.057	20.03	0.034	2.98	30
		Std dev	0.707107	1.73029	0.340825	0.336585	39.98089	2.319095	5.7243	0.085787	0.60164	0.082964	0.069587	2.78281	8.026565	0.01159	1.067903	9.357464
Jul	**1993-1996**	**Count**	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
		Mean	95.28571	6.557143	8.4	7.701429	40.25714	3.485714	19.62857	0.401429	0.232571	0.036714	0.214286	6.371429	6.357143	0.037571	3.581429	15.44286

X1R001Q01 (Very limited data)																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Median	96	6.4	8.2	7.7	38.9	3.77	19.3	0.37	0.232	0.02	0.2	6	6.2	0.025	3.77	15.2
		Min	93	4.4	7.4	7.49	36.5	2.7	15.4	0.28	0.162	0.02	0.15	4.1	5.3	0.019	2.38	14.8
		Max	96	9.2	9.5	7.94	46.2	3.86	26.5	0.65	0.301	0.064	0.28	10.2	7.5	0.089	4.05	16.8
		Std dev	1.253566	1.747243	0.711805	0.138254	3.818751	0.446089	4.04628	0.127727	0.044534	0.021438	0.049281	2.152297	0.799702	0.025159	0.5488	0.713809
	2000-2005	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	2	5.9015	12.9555	7.82575	65.18525	3.6265	18.74625	0.38625	0.0695	0.05475	0.1715	7.13275	9.90725	0.01525	2.7105	20.55
		Median	2	5	11.453	7.8445	52.2515	3.726	18.529	0.3995	0.066	0.048	0.171	7.0725	7.487	0.0155	2.8385	18.25
		Min	0	5	8.94	7.47	34.585	0.417	16.688	0.275	0.02	0.032	0.1	6.893	5.885	0.013	2.057	15.8
		Max	4	8.606	19.976	8.144	121.653	6.637	21.239	0.471	0.126	0.091	0.244	7.493	18.77	0.017	3.108	29.9
		Std dev	1.632993	1.803	5.08728	0.330882	39.19948	2.542918	2.29727	0.085936	0.044381	0.025526	0.059248	0.260026	6.044757	0.001708	0.458665	6.577994
Aug	**1994-1996**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	95.5	5.45	9.725	7.84	42.875	3.305	22.25	0.435	0.2265	0.027	0.1825	7.175	6.45	0.0535	4.345	16.5
		Median	96	6.45	9.55	7.885	43.25	3.475	22.45	0.415	0.2495	0.02	0.18	6.85	6.4	0.031	3.88	16.3
		Min	94	1.5	8.3	7.55	37.2	2.62	21.2	0.37	0.145	0.02	0.17	5.7	6	0.016	3.55	15.7
		Max	96	7.4	11.5	8.04	47.8	3.65	22.9	0.54	0.262	0.048	0.2	9.3	7	0.136	6.07	17.7
		Std dev	1	2.740438	1.424488	0.20672	5.137688	0.46422	0.74162	0.074162	0.054666	0.014	0.012583	1.560716	0.420317	0.055669	1.160503	0.909212
	2000-2005	**Count**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	2	7.8952	10.4368	7.8404	52.2246	2.7438	16.7888	0.4126	0.0742	0.0432	0.1936	6.9466	7.2288	0.028	2.3188	17.42
		Median	2	8.256	11.194	7.896	53.006	3.111	19.584	0.422	0.078	0.02	0.184	7.305	8.135	0.023	2.6	16.9
		Min	0	5	8.655	7.378	40.093	0.2	5.992	0.265	0.02	0.015	0.171	4.78	3.893	0.013	0.977	15.3
		Max	4	10.812	11.667	8.062	61.973	6.373	20.389	0.535	0.109	0.107	0.229	8.304	9.544	0.052	2.975	21.1
		Std dev	1.581139	2.815867	1.409853	0.274241	10.02591	2.453598	6.100361	0.099556	0.037891	0.038919	0.024037	1.326009	2.178661	0.017117	0.779866	2.385791
Sep	**1981-1987**	**Count**	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	2	7.8952	10.4368	6.8075	39.775	3.415	16.075	0.48	0.2075	0.0425	0.175	8.125	7.5	0.01725	3.17	16.1
		Median	2	8.256	11.194	6.895	37.4	3.81	15.75	0.475	0.235	0.04	0.145	7.95	7.35	0.0195	3.245	16.8

X1R001Q01 (Very limited data)

			Cl-Diss-Water (mg/L)	Ca-Diss-Water mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Min	0	5	8.655	6.5	37	1.19	14.4	0.46	0.02	0.02	0.14	7.4	6.8	0.006	2.58	13.6
		Max	4	10.812	11.667	6.94	47.3	4.85	18.4	0.51	0.34	0.07	0.27	9.2	8.5	0.024	3.61	17.2
		Std dev	1.581139	2.815867	1.409853	0.206458	5.026181	1.562594	2.005617	0.021602	0.141745	0.0263	0.063509	0.771902	0.725718	0.008617	0.433667	1.68523
	2000-2005	**Count**	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	85.25	8.225	9.275	7.803	51.643	2.006333	20.55733	0.415667	0.088667	0.037333	0.143	7.331333	7.505333	0.017333	2.809333	18.4
		Median	86.5	8.15	9.1	7.707	49.802	2.613	19.712	0.431	0.055	0.046	0.147	7.305	6.676	0.016	2.892	18
		Min	81	6.3	8.3	7.623	40.002	0.652	18.317	0.367	0.049	0.015	0.1	7.156	6.65	0.013	2.582	15.8
		Max	87	10.3	10.6	8.079	65.125	2.754	23.643	0.449	0.162	0.051	0.182	7.533	9.19	0.023	2.954	21.4
		Std dev	2.872281	1.972097	0.960469	0.242685	12.66228	1.175004	2.761795	0.043097	0.063579	0.019502	0.041146	0.189875	1.459022	0.005132	0.199302	2.821347
Oct	**1993-1996**	**Count**	6	6	6	6	6	6	6	5	6	6	6	6	6	6	6	6
		Mean	95.5	7.2	8.466667	7.795	39.73333	2.903333	25.41667	0.472	0.253833	0.0425	0.186667	7.45	6.516667	0.026	2.825	15.55
		Median	96	7.15	8.5	7.825	39.7	2.93	25.9	0.47	0.2705	0.043	0.17	7.4	6.55	0.021	2.885	15.65
		Min	93	6.2	7.7	7.65	38.4	1.71	22.4	0.45	0.202	0.02	0.16	7.2	6.1	0.015	2.62	14.9
		Max	96	8.3	9	7.88	41.2	3.81	27.8	0.49	0.28	0.066	0.28	7.7	6.8	0.041	2.97	16
		Std dev	1.224745	0.69857	0.51251	0.082644	1.143095	0.685468	1.911457	0.017889	0.034354	0.019967	0.045898	0.216795	0.248328	0.010412	0.152676	0.459347
	2000-2005	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	2.25	5.262	10.45525	7.931	48.12875	3.12425	17.01725	0.409	0.10425	0.03025	0.13525	7.00325	7.278	0.014	2.26475	16.15
		Median	2.5	5	10.0995	7.934	49.225	2.7075	17.4	0.4135	0.098	0.0175	0.1345	7.454	6.7545	0.013	2.5515	16.2
		Min	0	2.5	8.786	7.739	41.505	1.652	7.554	0.327	0.055	0.015	0.1	5.208	6.344	0.012	0.79	13.5
		Max	4	8.548	12.836	8.117	52.56	5.43	25.715	0.482	0.166	0.071	0.172	7.897	9.259	0.018	3.166	18.7
		Std dev	1.707825	2.487551	1.763856	0.154532	5.256996	1.66657	7.736562	0.074829	0.048183	0.027269	0.040722	1.26554	1.34352	0.002708	1.103418	2.148643
Nov	**1993-1996**	**Count**	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
		Mean	94.85714	7.885714	9.528571	7.725714	41.25714	2.25	24.94286	0.47	0.225	0.031143	0.248571	7.828571	6.942857	0.022143	2.987143	16.52857
		Median	96	7.9	9.3	7.76	40.1	2.56	24	0.48	0.231	0.02	0.18	7.9	6.9	0.025	2.91	16.7
		Min	93	6	8.9	7.46	37.7	0.83	18.9	0.43	0.136	0.02	0.13	7.4	6.6	0.014	2.59	15.4

X1R001Q01 (Very limited data)																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Ddss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Max	96	9.8	10.7	7.98	49.6	2.99	30.2	0.49	0.29	0.049	0.49	8.4	7.4	0.03	3.53	17.3
		Std dev	1.46385	1.41236	0.694537	0.185998	4.166076	0.883535	4.216577	0.02	0.046662	0.013981	0.146222	0.325137	0.263674	0.006362	0.291074	0.722759
	2000-2005	**Count**	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
		Mean	2	10.031	11.215	7.733667	54.82433	1.611667	18.207	0.454	0.077667	0.054	0.190333	8.145667	8.148333	0.018	2.784	18.73333
		Median	2	10.248	12.298	7.964	55.308	1.674	19.167	0.428	0.068	0.054	0.184	8.439	7.04	0.019	2.735	18.5
		Min	0	7.77	9.044	7.211	41.688	0.2	14.655	0.422	0.04	0.02	0.18	6.901	6.487	0.014	2.713	15.6
		Max	4	12.075	12.303	8.026	67.477	2.961	20.799	0.512	0.125	0.088	0.207	9.097	10.918	0.021	2.904	22.1
		Std dev	2	2.160688	1.880143	0.453703	12.9013	1.381555	3.182512	0.050319	0.043317	0.048083	0.014572	1.127004	2.414486	0.003606	0.104504	3.256276
Dec	**1991-1996**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	93.33333	8.166667	10.2	7.88	43.33333	1.613333	23.2	0.463333	0.162667	0.049333	0.233333	7.8	6.766667	0.012	2.83	16.9
		Median	93	7.9	9.4	7.9	42.3	1.21	24.3	0.47	0.195	0.058	0.16	7.8	6.9	0.014	2.81	16.9
		Min	91	7.6	9.1	7.72	42.2	0.79	17.2	0.41	0.07	0.02	0.15	6.8	6.5	0.008	2.68	16.5
		Max	96	9	12.1	8.02	45.5	2.84	28.1	0.51	0.223	0.07	0.39	8.8	6.9	0.014	3	17.3
		Std dev	2.516611	0.737111	1.652271	0.150997	1.877054	1.082882	5.53263	0.050332	0.081464	0.026102	0.135769	1.00	0.23094	0.003464	0.160935	0.4
	2000-2005	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	2.666667	6.302	11.00633	7.739333	58.64933	3.583	12.99167	0.381	0.096333	0.025333	0.134	6.628333	7.382333	0.030033	2.106	17.46667
		Median	3	5.426	11.479	7.754	59.662	2.52	12.675	0.413	0.055	0.02	0.1	7.159	7.225	0.013	2.454	16.5
		Min	1	5	9.361	7.55	49.545	0.867	7.01	0.284	0.055	0.015	0.1	4.995	6.174	0.0051	1.042	15.9
		Max	4	8.48	12.179	7.914	66.741	7.362	19.29	0.446	0.179	0.041	0.202	7.731	8.748	0.072	2.822	20
		Std dev	1.527525	1.898192	1.467256	0.182443	8.642611	3.37546	6.146121	0.08561	0.071591	0.013796	0.05889	1.443132	1.294193	0.036558	0.939642	2.214347

X1H033Q01 (Very limited data available)																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
Jan	**1983-1990**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	11	8.85	101.75	7.1225	41.875	3.8025	13.45	0.4275	0.086	0.05475	0.1975	7.125	7.425	0.007625	2.315	16.15
		Median	10.25	8.5	96.5	7.21	42.75	3.87	16	0.44	0.087	0.0595	0.23	7.7	6.55	0.006	2.64	15.95
		Min	8.5	6.4	77	6.32	23.6	1.19	4.7	0.3	0.04	0.04	0.05	4.4	6.1	0.0025	1.17	14.1
		Max	15	12	137	7.75	58.4	6.28	17.1	0.53	0.13	0.06	0.28	8.7	10.5	0.016	2.81	18.6
		Std dev	2.920046	2.411777	27.21978	0.73368	14.24766	2.096829	5.892651	0.09639	0.038262	0.009845	0.104043	1.939716	2.08066	0.005879	0.767702	1.862794
	1995-2004	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	7.5	11.03333	134	8.00667	57.73333	2.736667	25	0.45667	0.1	0.02	0.2	8.2	8.06667	0.013	2.86	18.36667
		Median	8	11.5	125	7.93	47.8	2.78	26.8	0.45	0.055	0.02	0.2	8.8	8.3	0.012	2.38	19
		Min	6.2	9.5	121	7.93	46.8	2.38	20	0.43	0.02	0.02	0.19	6.8	5.8	0.007	2.26	15.1
		Max	8.3	12.1	156	8.16	78.6	3.05	28.2	0.49	0.225	0.02	0.21	9	10.1	0.02	3.94	21
		Std dev	1.135782	1.361372	19.15724	0.13279	18.07798	0.337095	4.386342	0.03055	0.109659	3.29E-10	0.01	1.216553	2.15948	0.006557	0.93723	3.000556
Feb	**1983-1990**	**Count**	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	11.5	10.16667	108.6667	7.385	49.65	3.295	14.45	0.42	0.075	0.05	0.18	7.55	8.1	0.00875	2.565	16.85
		Median	12	9	107	7.385	49.65	3.295	14.45	0.42	0.075	0.05	0.18	7.55	8.1	0.00875	2.565	16.85
		Min	9.9	8.9	94	7.3	41.8	1.24	11.5	0.4	0.02	0.04	0.17	6.6	6.8	0.0025	2.47	14.7
		Max	12.6	12.6	125	7.47	57.5	5.35	17.4	0.44	0.13	0.06	0.19	8.5	9.4	0.015	2.66	19
		Std dev	1.417745	2.107922	15.56706	0.12021	11.10158	2.906209	4.17193	0.02828	0.077782	0.014142	0.014142	1.343503	1.83848	0.008839	0.13435	3.040559
	1995-2004	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	9	10.43333	129.3333	7.70667	54.2	3.533333	24.26667	0.46667	0.054333	0.02	0.203333	8.033333	8.2	0.019667	2.63	17.33333
		Median	10.5	10.9	126	7.84	49.3	3.05	25	0.49	0.053	0.02	0.19	8.7	7.3	0.021	2.39	18.4
		Min	5.9	5.8	89	7.31	24.5	2.65	20	0.41	0.02	0.02	0.19	6.5	4.5	0.007	1.92	11.4
		Max	10.6	14.6	173	7.97	88.8	4.9	27.8	0.5	0.09	0.02	0.23	8.9	12.8	0.031	3.58	22.2
		Std dev	2.685144	4.418522	42.09909	0.34962	32.42885	1.200347	3.951371	0.04933	0.035019	3.29E-10	0.023094	1.331666	4.22256	0.012055	0.855628	5.478443
Mar	**1983-**	**Count**	3	3	3	4	4	3	3	3	3	3	3	3	3	3	3	3

X1H033Q01 (Very limited data available)																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	1990	Mean	9.466667	9.033333	93.33333	7.37	46.825	2.413333	12.7	0.40667	0.091	0.061333	0.18	6.6	6.43333	0.008333	2.453333	15.1
		Median	10	8.3	83	7.28	41.7	2.12	13	0.38	0.093	0.06	0.17	5.9	6.4	0.008	2.38	14.3
		Min	8.4	8.1	83	7.11	30.1	1.92	11.1	0.37	0.08	0.054	0.16	5.9	6.3	0.007	2.22	13.9
		Max	10	10.7	114	7.81	73.8	3.2	14	0.47	0.1	0.07	0.21	8	6.6	0.01	2.76	17.1
		Std dev	0.92376	1.446836	17.89786	0.31284	20.09384	0.688573	1.473092	0.05508	0.010149	0.008083	0.026458	1.212436	0.15275	0.001528	0.277369	1.74356
	1995-2004	Count	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	7.5	14.35	160	7.9	80.15	4.88	17.8	0.4	0.05	0.02	0.19	8.5	11.65	0.014	2.12	23.05
		Median	7.5	14.35	160	7.9	80.15	4.88	17.8	0.4	0.05	0.02	0.19	8.5	11.65	0.014	2.12	23.05
		Min	5.6	14.1	159	7.87	78.5	4.2	15.7	0.37	0.02	0.02	0.19	7.8	11.5	0.012	2.05	23
		Max	9.4	14.6	161	7.93	81.8	5.56	19.9	0.43	0.08	0.02	0.19	9.2	11.8	0.016	2.19	23.1
		Std dev	2.687006	0.353553	1.414214	0.04243	2.333452	0.961665	2.969848	0.04243	0.042426	0	0	0.989949	0.21213	0.002828	0.098995	0.070711
Apr	1983-1990	Count	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	7.2	13.25	161.5	7.47	83.6	7.01	14.95	0.47	0.05	0.02	0.19	8.5	11.65	0.014	2.12	23.05
		Median	7.2	13.25	161.5	7.47	83.6	7.01	14.95	0.47	0.05	0.02	0.19	8.5	11.65	0.014	2.12	23.05
		Min	5.4	12.3	146	7.3	73.5	6.48	12.5	0.45	0.02	0.02	0.19	7.8	11.5	0.012	2.05	23
		Max	9	14.2	177	7.64	93.7	7.54	17.4	0.49	0.08	0.02	0.19	9.2	11.8	0.016	2.19	23.1
		Std dev	2.545584	1.343503	21.92031	0.24042	14.28356	0.749533	3.464823	0.02828	0.042426	0	0	0.989949	0.21213	0.002828	0.098995	0.070711
	1995-2004	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	8.0048	13.6672	151.4038	7.943	72.518	6.3676	20.0956	0.3726	0.1518	0.035	0.2224	7.506	10.5942	0.03702	1.9806	20.16
		Median	8.7	14.3	173	7.83	87.7	5.5	17.6	0.37	0.05	0.02	0.25	7.901	13.1	0.019	1.583	24
		Min	5	7.7	98	7.66	33.5	3.79	10.185	0.312	0.02	0.02	0.137	5.203	5	0.0051	1.163	11.9
		Max	12.024	18.577	197.495	8.374	108.403	9.498	31.951	0.46	0.493	0.061	0.27	10.1	14.703	0.121	3.7	25.1
		Std dev	3.015479	4.166164	45.4071	0.3233	35.20939	2.255038	8.330905	0.05704	0.201314	0.020688	0.053789	2.158721	4.85535	0.047706	0.994473	6.275189
May	1983-1990	Count	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	10.63333	10.13333	120	7.27667	54.66667	4.316667	12.6	0.41333	0.149	0.070667	0.223333	7.5	9.2	0.012	2.496667	17.33333
		Median	11.4	10.7	112	7.17	43.1	3.09	10.4	0.39	0.16	0.052	0.16	8.3	7.2	0.013	2.31	17.3

X1H033Q01 (Very limited data available)																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Min	8.8	8.4	86	6.9	35	1.95	9.9	0.37	0.047	0.05	0.15	5.9	6.4	0.009	1.85	15
		Max	11.7	11.3	162	7.76	85.9	7.91	17.5	0.48	0.24	0.11	0.36	8.3	14	0.014	3.33	19.7
		Std dev	1.594783	1.530795	38.62642	0.43981	27.35038	3.16369	4.250882	0.05859	0.096969	0.034078	0.118462	1.385641	4.17612	0.002646	0.757452	2.350177
	1995-2004	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	6.35	16.6	187.75	8.0525	101.375	6.39	16.225	0.36	0.03975	0.025	0.1875	8.325	14.45	0.02	1.7775	24.15
		Median	6.55	16.8	191	8	101.8	6.345	15.95	0.365	0.043	0.02	0.195	8.4	14.5	0.018	1.755	24.4
		Min	4.2	14.3	174	7.89	95.5	5.77	14.5	0.33	0.02	0.02	0.16	7.5	14.1	0.01	1.71	22.2
		Max	8.1	18.5	195	8.32	106.4	7.1	18.5	0.38	0.053	0.04	0.2	9	14.7	0.034	1.89	25.6
		Std dev	1.823001	1.798147	9.912114	0.19432	5.183548	0.578216	2.041854	0.0216	0.014198	0.01	0.01893	0.623832	0.26458	0.010198	0.080571	1.438749
Jun	**1983-1990**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	11.05	11.4	132.75	7.5625	61.775	4.7975	12.65	0.4425	0.1585	0.0515	0.2625	8.325	10.45	0.02075	2.355	19.675
		Median	11.15	10.55	119	7.475	54.4	4.765	13.2	0.46	0.195	0.053	0.26	8.05	8.45	0.019	2.54	17.05
		Min	6.4	8.3	91	7.22	31.4	1.59	10.2	0.35	0.02	0.04	0.18	7.2	6.4	0.007	1.76	14.7
		Max	15.5	16.2	202	8.08	106.9	8.07	14	0.5	0.224	0.06	0.35	10	18.5	0.038	2.58	29.9
		Std dev	4.012065	3.800877	52.5	0.37044	35.05808	2.903554	1.694107	0.06449	0.09414	0.008386	0.06994	1.335103	5.68067	0.012842	0.397869	7.125716
	1995-2004	**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
Jul	**1983-1990**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	11.76667	15.73333	175.3333	7.56	91.33333	9.12	7.233333	0.67333	0.156667	0.176333	0.71	13	12.5	0.010333	2.573333	24.53333
		Median	11.5	16.7	189	7.78	102.4	8.77	9.5	0.43	0.08	0.099	0.27	10.3	15.7	0.011	2.67	26.1
		Min	8.4	11.7	120	7.1	55.1	7.46	2	0.4	0.02	0.05	0.19	10.1	4.2	0.008	1.91	19.7
		Max	15.4	18.8	217	7.8	116.5	11.13	10.2	1.19	0.37	0.38	1.67	18.6	17.6	0.012	3.14	27.8

X1H033Q01 (Very limited data available)																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Std dev	3.507611	3.647373	49.92327	0.3985	32.16121	1.859866	4.545694	0.4477	0.187172	0.178074	0.832346	4.850773	7.25052	0.002082	0.620672	4.271222
	1995-2004	**Count**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	6.592	16.3902	186.6878	8.107	100.2764	6.2552	15.7444	0.3772	0.0696	0.02	0.1994	8.7072	14.5672	0.022	1.8092	25.02
		Median	6.7	16.1	183	8.145	98.1	6.04	15.3	0.39	0.02	0.02	0.2	8.6	14.8	0.013	1.77	25
		Min	5.7	15.6	175	7.82	94.4	5.4	12.222	0.336	0.02	0.02	0.18	8.136	13	0.008	1.61	23.5
		Max	7.46	17.951	198.439	8.43	109.382	8.19	20.6	0.39	0.221	0.02	0.217	9.2	16.036	0.063	1.996	26.4
		Std dev	0.867364	0.919935	9.425542	0.22565	5.803877	1.132477	3.053548	0.02344	0.087048	0	0.013107	0.440975	1.29197	0.023195	0.148907	1.112205
Aug	**1983-1990**	**Count**	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Mean	10.25	12.325	142	6.61	69.75	3.2725	12.975	0.395	0.1025	0.0525	0.1725	7.65	11.225	0.013375	2.1375	19.4
		Median	9.7	9.95	122.5	6.95	56.75	3.215	11.05	0.4	0.12	0.055	0.18	7.2	8.15	0.0145	2.195	16.1
		Min	1.5	8.5	96	4.54	36.8	0.2	10.7	0.34	0.02	0.02	0.11	6.8	6.9	0.0025	1.5	15.4
		Max	20.1	20.9	227	8	128.7	6.46	19.1	0.44	0.15	0.08	0.22	9.4	21.7	0.022	2.66	30
		Std dev	8.459511	5.877854	58.78208	1.51142	43.53868	3.294494	4.0885	0.0526	0.05909	0.027538	0.046458	1.181807	7.05095	0.008864	0.581399	7.086137
	1995-2004	**Count**	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	6.533333	17.2	197.3333	8.16	98.45	5.205	18.15	0.38	0.0425	0.02	0.21	8.85	15.4	0.012	1.76	25.8
		Median	7	16.4	188	8.16	98.45	5.205	18.15	0.38	0.0425	0.02	0.21	8.85	15.4	0.012	1.76	25.8
		Min	5.3	16.2	188	8.07	97.3	4.67	15.6	0.37	0.02	0.02	0.2	8.5	15.1	0.006	1.74	25
		Max	7.3	19	216	8.25	99.6	5.74	20.7	0.39	0.065	0.02	0.22	9.2	15.7	0.018	1.78	26.6
		Std dev	1.078579	1.56205	16.16581	0.12728	1.626346	0.756604	3.606245	0.01414	0.03182	0	0.014142	0.494975	0.42426	0.008485	0.028284	1.131371
Sep	**1983-1990**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	8.233333	15.3	173.3333	7.69667	93.96667	6.126667	8.833333	0.37333	0.026667	0.04	0.186667	8.533333	15.1333	0.007667	2.06	23.26667
		Median	7	14.3	165	7.5	87.3	6.15	9	0.36	0.02	0.05	0.19	9.2	14.7	0.0025	2.21	25.6
		Min	3.4	12.6	130	7.17	71.6	5.49	7.5	0.35	0.02	0.02	0.05	7.1	10.1	0.0025	1.4	17.5
		Max	14.3	19	225	8.42	123	6.74	10	0.41	0.04	0.05	0.32	9.3	20.6	0.018	2.57	26.7
		Std dev	5.553677	3.315117	48.04512	0.64779	26.34053	0.625327	1.258306	0.03215	0.011547	0.017321	0.135031	1.24231	5.2634	0.008949	0.59925	5.024274
	1995-	**Count**	3	3	3	5	5	5	5	5	3	3	3	3	3	3	3	3

X1H033Q01 (Very limited data available)																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	2004	Mean	5.533333	16.60433	189.7153	7.8918	88.9058	4.835	13.2432	0.3746	0.038667	0.02	0.229667	9.217	15.7083	0.012667	2.502333	25.7
		Median	5.6	16	185	7.96	98	4.655	14.416	0.38	0.02	0.02	0.239	8.8	15.225	0.013	2.437	25.7
		Min	5	15.413	178.146	7.33	36.7	0.86	9.4	0.29	0.02	0.02	0.2	8.6	14.6	0.011	1.91	23.4
		Max	6	18.4	206	8.219	116.6	7.99	17.4	0.443	0.076	0.02	0.25	10.251	17.3	0.014	3.16	28
		Std dev	0.503322	1.582547	14.51334	0.36236	30.43195	2.978636	3.428896	0.05857	0.032332	3.29E-10	0.026274	0.901037	1.4134	0.001528	0.627556	2.3
Oct	1983-1990	Count	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Mean	14.14	11.5	125.8	8.096	54.18	2.104	13.78	0.428	0.1344	0.0598	0.246	7.74	9.3	0.0192	2.494	18.76
		Median	13.9	9.5	107	8.09	38.5	1.06	13.7	0.4	0.088	0.064	0.23	8.4	7.5	0.018	2.6	17.7
		Min	12.3	8.9	93	7.78	32.7	0.68	8.6	0.35	0.02	0.04	0.2	6.3	6.6	0.015	1.89	15.1
		Max	17.1	20.2	224	8.46	125.3	6.7	16.9	0.51	0.25	0.084	0.29	8.9	18.1	0.025	2.82	27.4
		Std dev	1.862257	4.880061	55.38682	0.29314	39.84855	2.586026	3.259908	0.0687	0.104167	0.019447	0.041593	1.281796	4.94014	0.003701	0.391254	5.033687
	1995-2004	Count																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
Nov	1983-1990	Count	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	10.73333	13.66667	155	7.61667	76.13333	5.466667	14.13333	0.41667	0.093333	0.066	0.24	8.366667	12.1	0.019667	2.503333	21.2
		Median	11.3	12.2	148	8.09	76	4.68	8.6	0.44	0.06	0.053	0.23	8.4	12.3	0.018	2.21	21.8
		Min	6.8	8.6	103	6.4	35	4.5	7.5	0.33	0.02	0.05	0.22	7.6	6.2	0.016	1.71	15
		Max	14.1	20.2	214	8.36	117.4	7.22	26.3	0.48	0.2	0.095	0.27	9.1	17.8	0.025	3.59	26.8
		Std dev	3.682843	5.937452	55.8301	1.06228	41.20016	1.521096	10.55099	0.07767	0.094516	0.025159	0.026458	0.750555	5.80259	0.004726	0.973721	5.922837
	1995-2004	Count	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	5.733333	16.21167	181.944	8.08167	98.24033	5.329667	15.20967	0.382	0.032333	0.027333	0.22	8.787333	14.2067	0.019	1.667667	24.33333
		Median	5.1	16.3	184.832	8.03	98.221	5.19	14.6	0.37	0.02	0.02	0.22	8.7	14.62	0.019	1.65	24.3

X1H033Q01 (Very limited data available)																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Min	5	15.5	173	8	94.4	4.779	14.3	0.36	0.02	0.02	0.2	8	13.1	0.017	1.53	21.9
		Max	7.1	16.835	188	8.215	102.1	6.02	16.729	0.416	0.057	0.042	0.24	9.662	14.9	0.021	1.823	26.8
		Std dev	1.184624	0.671869	7.906036	0.11644	3.850036	0.632179	1.324304	0.02987	0.021362	0.012702	0.02	0.834435	0.96857	0.002	0.147297	2.45017
Dec	**1983-1990**	**Count**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Mean	12.4	11.9	124	7.29	52.56667	4.016667	13.53333	0.43333	0.153333	0.043333	0.216667	7.966667	10.3667	0.009833	2.603333	18.53333
		Median	11.4	9.6	97	6.9	36.1	4.19	13.5	0.46	0.19	0.04	0.21	7.7	6.7	0.005	3.02	16.6
		Min	11.3	8.1	83	6.83	19.6	0.83	6.6	0.34	0.02	0.02	0.16	7.6	6.1	0.0025	1.22	14
		Max	14.5	18	192	8.14	102	7.03	20.5	0.5	0.25	0.07	0.28	8.6	18.3	0.022	3.57	25
		Std dev	1.819341	5.335729	59.3043	0.73695	43.5982	3.103632	6.95006	0.08327	0.119304	0.025166	0.060277	0.550757	6.87701	0.010611	1.22916	5.749203
	1995-2004	**Count**	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		Mean	7.85	10.65	127.5	7.99	50.25	1.095	28.4	0.48	0.087	0.0355	0.175	8.35	7.65	0.0145	2.68	18.2
		Median	7.85	10.65	127.5	7.99	50.25	1.095	28.4	0.48	0.087	0.0355	0.175	8.35	7.65	0.0145	2.68	18.2
		Min	5.8	9.9	120	7.91	44.4	0.57	24.8	0.47	0.079	0.02	0.15	7.8	6.8	0.011	2.53	17.1
		Max	9.9	11.4	135	8.07	56.1	1.62	32	0.49	0.095	0.051	0.2	8.9	8.5	0.018	2.83	19.3
		Std dev	2.899138	1.06066	10.6066	0.11314	8.273149	0.742462	5.091169	0.01414	0.011314	0.02192	0.035355	0.777817	1.20208	0.00495	0.212132	1.555635

X1H042Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Jan		Count																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	Count	8	8	8	11	9	11	9	9	11	11	9	9	9	11	9	11
		Mean	34.92963	22.377	290.7081	8.333182	125.521	12.55673	21.03011	1.106889	0.308545	0.055091	0.266444	28.94689	16.81867	0.027727	1.709	42.05455
		Median	33.8855	20.3085	260.5115	8.289	121.81	11.947	13.728	0.953	0.266	0.047	0.276	23.652	16.605	0.027	1.419	37.9
		Min	20.473	14.054	188.81	8.019	85.099	9.647	8.682	0.792	0.055	0.015	0.164	17.227	11.965	0.013	1.048	25.7
		Max	54.778	31.876	432.004	8.814	184.243	17.116	42.23	1.873	0.564	0.1	0.401	56.52	26.639	0.042	3.226	61.8
		Std dev	12.98444	6.766822	94.30191	0.206409	37.39732	2.483957	13.22534	0.359127	0.181837	0.032157	0.070782	13.8629	5.426584	0.010422	0.726241	13.83563
Feb		Count																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	Count	9	9	9	11	9	11	9	9	12	12	9	9	9	12	9	12
		Mean	45.83844	24.01944	316.6176	8.254	133.1598	12.72555	23.62633	1.411333	0.39575	0.058917	0.285111	38.24189	18.15778	0.029167	2.233778	48.1
		Median	37.127	22.259	313.814	8.246	137.9	12.47	25.842	1.298	0.316	0.0575	0.286	36.31	20.691	0.0325	1.936	48.15
		Min	24.463	14.645	205.44	7.996	84.594	9.884	6.999	1.115	0.081	0.015	0.216	22.901	10.526	0.014	0.93	30.3
		Max	90.868	41.209	541.299	8.588	212.243	16.965	42.755	2.348	0.937	0.119	0.358	75.859	25.281	0.041	4.821	77.4
		Std dev	21.58623	8.527152	104.7763	0.162001	39.24477	1.997207	12.891	0.375983	0.264622	0.033695	0.05153	16.05206	5.362347	0.008851	1.223965	13.73655
Mar		Count																
		Mean																

X1H042Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	11	11	11	12	9	12	9	9	12	12	9	9	9	12	9	12
		Mean	35.82627	19.65109	258.7679	8.145167	124.5908	12.17367	19.74933	1.331222	0.44325	0.033167	0.255	34.82178	16.51922	0.042333	1.775778	43.025
		Median	31.871	19.312	240.051	8.198	109.725	11.73	17.993	1.264	0.417	0.02	0.233	33.497	16.421	0.035	1.623	38.05
		Min	9	6.9	92	7.15	85.45	8.498	7.191	0.845	0.055	0.015	0.177	17.782	9.764	0.013	0.603	25.8
		Max	77.311	34.952	483.128	8.92	190.368	18.817	36.596	2.41	1.225	0.084	0.373	72.784	23.119	0.088	2.893	70.1
		Std dev	21.94679	8.187455	112.5694	0.417176	36.41491	2.897581	8.303275	0.472882	0.295664	0.023836	0.066916	16.97948	4.689383	0.022777	0.77966	15.27893
Apr		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	8	8	8	11	8	11	8	8	11	11	8	8	8	11	8	11
		Mean	47.41463	21.9475	309.4933	8.239727	132.739	13.40382	17.78038	1.416125	0.487273	0.043182	0.28	38.36888	18.40613	0.025182	1.42	47.71818
		Median	33.575	17.9155	252.7325	8.256	112.121	11.715	17.87	1.2705	0.524	0.043	0.2715	29.4525	14.6375	0.026	1.2905	42.8
		Min	12.539	11.453	147.086	7.621	69.831	9.911	11.788	0.771	0.02	0.015	0.176	13.889	7.997	0.013	0.804	21.5
		Max	108.121	36.703	503.559	8.615	233.443	23.014	25.648	2.115	0.912	0.102	0.44	67.643	33.53	0.041	2.785	89.7
		Std dev	34.41757	10.17991	148.475	0.309099	62.45443	4.292827	4.644412	0.441511	0.269836	0.025123	0.09919	20.48907	10.03142	0.00846	0.597438	21.67721
May		**Count**																
		Mean																
		Median																
		Min																
		Max																

X1H042Q01																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water (pH units)**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Std dev																
	2000-2005	**Count**	9	9	9	11	9	11	9	9	11	11	9	9	9	11	9	11
		Mean	53.29756	27.63767	352.5437	8.356545	145.3303	12.45955	18.63111	1.349	0.460545	0.029818	0.272111	40.41111	21.61356	0.045182	1.409222	51.31818
		Median	38.664	26.957	366.43	8.261	164.804	12.554	19.476	1.246	0.539	0.02	0.268	36.734	23.999	0.031	1.269	50.6
		Min	16.334	14.156	181.986	8.112	80.304	10.128	5.844	0.869	0.02	0.015	0.159	17.567	8.988	0.018	0.934	26.8
		Max	142.156	49.748	619.973	8.805	194.597	14.235	32.908	1.951	0.895	0.062	0.381	78.262	39.637	0.141	2.275	86.4
		Std dev	42.44685	12.43153	148.2554	0.215623	43.40348	1.487044	8.21362	0.376358	0.319557	0.016061	0.068548	20.57251	9.797032	0.034922	0.455803	18.94512
Jun		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	9	9	9	10	9	10	9	9	10	10	9	9	9	10	9	10
		Mean	67.11478	31.26611	401.7801	8.3095	170.1822	13.1951	19.05089	1.499778	0.5133	0.048	0.282889	47.94889	24.88878	0.0328	1.203	56.638
		Median	49.406	29.947	399.158	8.3325	185.506	12.354	21.749	1.321	0.617	0.049	0.288	40.505	27.414	0.0185	1.241	55.25
		Min	11.74	5.778	76.256	7.774	30.058	9.695	4.108	0.8	0.11	0.02	0.151	9.927	3.576	0.01	0.915	11.68
		Max	132.644	55.797	653.249	8.522	256.984	18.575	27.489	2.019	0.72	0.077	0.418	80.389	39.922	0.113	1.544	93.5
		Std dev	45.01787	17.77955	204.0697	0.208962	81.16238	2.895787	8.029813	0.455051	0.211452	0.017353	0.096763	25.96148	12.99996	0.032352	0.21997	27.40296
Jul		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	10	10	10	12	10	12	10	10	11	11	9	9	9	11	9	11
		Mean	64.0558	30.2876	394.0537	8.2655	168.2042	11.79717	19.1582	1.4862	0.522727	0.043909	0.254667	45.96256	24.50056	0.021636	1.286111	59.68182

X1H042Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Median	52.206	26.444	357.7295	8.259	160.635	10.9815	15.6125	1.3725	0.356	0.033	0.229	37.839	20.799	0.02	1.109	50.5
		Min	27.898	13.518	199.145	8.192	90.191	8.632	6.247	1.143	0.213	0.02	0.1	23.63	10.909	0.013	0.924	31.5
		Max	145.047	55.527	677.843	8.382	259.699	17.791	48.186	2.112	0.904	0.094	0.434	87.578	45.399	0.034	2.344	100.7
		Std dev	37.3697	13.28723	158.1174	0.054604	60.09333	2.63998	12.50061	0.352212	0.26588	0.028763	0.113209	22.24566	11.32519	0.006423	0.452103	22.79447
Aug		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	10	10	10	13	10	13	10	10	13	13	10	10	10	13	10	13
		Mean	83.5831	37.5578	482.4385	8.36	205.037	12.75292	20.5052	1.5927	0.552385	0.060615	0.3297	55.6096	31.0449	0.041162	1.3088	69.86923
		Median	68.211	32.1625	488.5075	8.342	222.284	13.132	22.933	1.6665	0.608	0.047	0.3605	56.7735	31.395	0.013	1.291	75.1
		Min	31.684	17.098	225.985	8.182	103.498	9.994	7.904	1.056	0.063	0.015	0.161	24.554	11.907	0.0051	1.028	33.4
		Max	158.731	61.135	737.989	8.659	298.675	17.22	39.012	2.019	1.224	0.206	0.466	84.15	50.816	0.304	1.687	105.9
		Std dev	52.02047	18.29947	211.1832	0.1453	79.04079	2.342992	11.36784	0.382749	0.318375	0.053691	0.118251	24.91859	14.86694	0.080078	0.233538	26.72004
Sep		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	8	8	8	10	8	10	8	8	10	10	8	8	8	10	8	10
		Mean	91.33263	38.04625	514.1491	8.4547	216.5731	13.2939	24.05375	1.70275	0.3814	0.0487	0.360125	60.02138	32.83538	0.0276	1.25075	73.18
		Median	86.046	36.5365	503.275	8.4005	216.5645	13.354	24.5005	1.6075	0.334	0.035	0.377	57.104	31.057	0.019	1.2415	72.95
		Min	40.549	25.034	341.266	8.228	156.723	11.135	15.817	1.278	0.055	0.015	0.23	35.848	21.002	0.013	0.862	49.4
		Max	170.641	58.156	744.085	8.945	279.07	16.483	33.615	2.155	0.77	0.115	0.46	90.704	46.18	0.07	1.695	103.6

X1H042Q01																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water (pH units)**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Std dev	52.65771	12.70634	143.8783	0.199372	41.1257	1.764091	6.265448	0.333251	0.323234	0.039175	0.07585	19.7232	9.06449	0.022167	0.251286	17.80136
Oct		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	9	9	9	12	9	12	9	9	12	12	9	9	9	12	9	12
		Mean	93.60422	36.04456	497.503	8.373583	206.6191	14.0765	19.00589	1.764667	0.395833	0.0475	0.353556	61.00444	32.10089	0.02075	1.175	68.46667
		Median	86.174	34.294	516.786	8.3785	225.362	14.5825	19.094	1.947	0.4885	0.0495	0.399	65.622	32.944	0.0165	1.185	70.75
		Min	45.675	22.086	284.111	8.069	126.89	11.28	10.46	1.138	0.02	0.015	0.192	29.498	17.527	0.013	0.633	42.1
		Max	161.271	49.881	662.946	8.573	254.582	15.813	27.195	2.153	0.863	0.078	0.442	85.786	45.118	0.055	1.457	95.6
		Std dev	44.02671	10.66805	134.0272	0.137201	46.61463	1.72136	5.28733	0.377011	0.289854	0.022113	0.088417	19.34917	9.496937	0.01191	0.247398	17.52548
Nov		**Count**																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	8	8	8	10	8	10	8	8	10	10	8	8	8	10	8	10
		Mean	54.69938	23.7355	336.4258	8.1917	142.6385	13.5265	18.67825	1.520125	0.2351	0.027	0.279375	41.9035	20.26013	0.0259	1.751625	52.12
		Median	48.6335	24.9085	348.1715	8.3555	160.586	14.402	19.5615	1.3935	0.155	0.02	0.286	37.395	23.1185	0.0225	1.685	56.35
		Min	32.591	11.009	161.784	7.279	56.151	7.773	10.272	1.185	0.02	0.015	0.169	23.846	7.645	0.013	0.922	26.5
		Max	96.887	36.738	494.983	8.628	216.275	19.887	29.967	2.147	0.59	0.079	0.45	70.775	31.177	0.062	3.078	69.1
		Std dev	23.52543	9.358671	132.2813	0.413354	63.46581	3.839125	7.520062	0.325916	0.218426	0.021218	0.096965	17.18764	9.417633	0.014715	0.768171	16.89193
Dec		**Count**																
		Mean																

X1H042Q01																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water (pH units)**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Median																
		Min																
		Max																
		Std dev																
	2000-2005	**Count**	8	8	8	10	8	10	8	8	8	8	8	8	8	8	8	8
		Mean	34.57913	19.63775	272.1114	8.1917	142.6385	13.5265	18.67825	1.520125	0.32975	0.033125	0.258625	32.67813	15.78513	0.02625	2.145875	38.9625
		Median	34.5975	20.415	269.9045	8.3555	160.586	14.402	19.5615	1.3935	0.326	0.02	0.248	32.212	14.9205	0.0275	2.2765	38.7
		Min	10.956	9.505	121.544	7.279	56.151	7.773	10.272	1.185	0.02	0.015	0.147	10.119	8.056	0.013	0.499	18.4
		Max	53.107	33.275	445.554	8.628	216.275	19.887	29.967	2.147	0.629	0.066	0.386	56.222	25.333	0.041	3.696	60.9
		Std dev	14.42669	7.118081	106.6435	0.413354	63.46581	3.839125	7.520062	0.325916	0.223182	0.021649	0.086807	15.40898	6.465789	0.010361	1.010436	14.29305

X1H003Q01																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
Jan	**1978-1982**	**Count**	7.00	7.00	7.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	8.34	5.27	78.29	6.86	37.96	8.78	3.06	0.61	0.11	0.06	0.10	7.99	4.75	0.01	0.98	10.96
		Median	8.40	5.70	76.00	6.93	39.80	8.64	2.00	0.56	0.02	0.03	0.11	6.90	4.90	0.01	0.89	10.65
		Min	5.70	3.70	64.00	6.17	24.90	7.54	2.00	0.45	0.02	0.02	0.05	5.70	2.60	0.00	0.15	9.30
		Max	12.90	6.40	101.00	7.23	46.80	10.67	8.10	0.85	0.31	0.19	0.16	11.00	6.80	0.04	2.19	13.90
		Std dev	2.71	1.00	12.57	0.33	7.07	1.06	2.20	0.16	0.12	0.06	0.05	2.11	1.18	0.01	0.68	1.41
	2000-2005	**Count**	5.00	5.00	5.00	20.00	18.00	20.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
		Mean	7.19	7.76	98.42	8.00	76.57	8.47	11.13	1.24	0.20	0.03	0.21	25.51	10.62	0.02	1.65	28.91
		Median	5.00	8.24	107.05	7.96	63.67	8.56	10.19	0.88	0.18	0.02	0.21	20.05	8.89	0.02	1.36	24.40
		Min	5.00	6.10	69.00	7.68	42.22	6.05	6.03	0.56	0.04	0.02	0.14	9.46	5.23	0.01	0.80	15.20
		Max	12.25	8.63	114.49	8.31	156.87	12.04	32.07	3.47	0.48	0.11	0.28	98.76	24.51	0.06	3.62	78.30
		Std dev	3.25	1.06	18.67	0.19	34.19	1.65	5.82	0.80	0.13	0.03	0.04	21.66	5.36	0.01	0.85	15.25
Feb	**1978-1982**	**Count**	6.00	6.00	6.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	14.49	13.66	171.40	6.80	46.30	8.39	4.44	0.63	0.06	0.08	0.10	8.54	4.28	0.01	0.89	14.39
		Median	12.52	10.57	139.07	6.84	39.45	8.40	2.00	0.62	0.04	0.06	0.05	7.60	4.15	0.01	0.85	10.95
		Min	10.87	9.73	120.84	6.27	9.80	7.24	2.00	0.34	0.02	0.02	0.05	6.00	1.00	0.00	0.15	8.90
		Max	19.93	24.50	308.05	7.31	101.50	9.59	11.80	0.97	0.14	0.19	0.29	16.90	7.80	0.02	1.64	30.80
		Std dev	4.24	5.88	71.85	0.38	26.72	0.81	3.71	0.22	0.05	0.06	0.09	3.45	2.00	0.01	0.46	7.35
	2000-2005	**Count**	5.00	5.00	5.00	11.00	10.00	11.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	69.48	14.54	271.90	8.08	92.16	9.92	9.95	1.41	0.28	0.03	0.21	30.68	12.13	0.02	1.75	33.63
		Median	62.13	12.41	212.33	8.02	81.63	9.50	9.35	1.41	0.25	0.03	0.21	26.46	10.24	0.02	1.50	30.75
		Min	42.02	11.40	197.22	7.77	50.09	7.61	5.81	0.78	0.11	0.02	0.14	11.54	5.10	0.01	0.85	16.70
		Max	136.79	23.93	490.62	8.48	170.92	13.42	14.62	2.29	0.65	0.05	0.33	59.40	21.14	0.05	3.39	54.40
		Std dev	39.02	5.29	124.01	0.21	36.32	1.59	2.84	0.46	0.19	0.01	0.05	14.80	4.97	0.01	0.75	12.47

X1H003Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Mar	1978-1982	Count	7.00	7.00	7.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
		Mean	18.73	12.97	136.35	6.85	41.03	8.22	2.43	0.74	0.02	0.03	0.19	10.15	5.25	0.01	0.90	12.28
		Median	6.00	11.55	130.00	7.05	41.10	8.30	2.00	0.68	0.02	0.02	0.17	9.30	5.00	0.01	0.90	11.70
		Min	4.00	3.00	32.00	6.01	16.40	7.41	2.00	0.57	0.02	0.02	0.05	6.00	2.80	0.00	0.63	6.40
		Max	57.19	31.70	266.90	7.35	73.60	9.03	4.70	1.34	0.05	0.14	0.47	24.20	9.40	0.04	1.14	24.30
		Std dev	20.11	9.38	77.17	0.44	14.43	0.51	0.96	0.24	0.01	0.04	0.11	4.98	1.63	0.01	0.16	4.52
	2000-2005	Count	8.00	8.00	8.00	17.00	12.00	17.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
		Mean	21.48	10.35	152.29	7.89	75.37	9.63	9.92	1.18	0.23	0.03	0.20	22.93	9.38	0.04	1.35	26.08
		Median	17.10	9.18	119.66	7.89	74.26	9.84	10.21	1.03	0.25	0.02	0.19	19.41	9.39	0.02	1.27	23.90
		Min	6.00	3.90	68.00	7.46	32.67	6.38	2.00	0.70	0.06	0.02	0.13	10.50	3.67	0.01	0.89	12.64
		Max	57.46	26.52	385.01	8.28	125.97	11.98	17.32	1.97	0.54	0.12	0.29	45.12	14.97	0.10	1.82	43.90
		Std dev	17.04	7.26	104.18	0.24	27.56	1.15	3.85	0.46	0.14	0.03	0.05	12.54	3.72	0.03	0.32	10.58
Apr	1978-1982	Count	10.00	10.00	10.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
		Mean	33.17	10.23	172.31	6.97	45.55	9.18	2.33	0.72	0.03	0.07	0.15	9.95	5.60	0.02	0.83	12.64
		Median	31.48	10.72	166.54	6.91	45.40	8.53	2.00	0.70	0.02	0.02	0.12	9.90	5.30	0.01	0.76	12.80
		Min	8.50	3.00	81.00	6.30	41.30	6.63	2.00	0.55	0.02	0.02	0.05	7.20	4.90	0.00	0.58	11.10
		Max	83.34	20.04	362.93	8.34	52.50	12.84	5.60	0.85	0.06	0.23	0.54	13.40	6.90	0.07	1.26	15.00
		Std dev	25.31	6.35	93.21	0.51	3.44	1.85	1.09	0.09	0.02	0.08	0.13	1.50	0.57	0.02	0.19	1.06
	2000-2005	Count	5.00	5.00	5.00	15.00	13.00	15.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
		Mean	6.44	5.28	67.40	7.97	81.24	9.41	11.97	1.26	0.41	0.04	0.18	27.60	10.62	0.03	1.30	29.79
		Median	6.70	4.80	63.00	8.03	70.27	9.00	10.27	0.98	0.46	0.03	0.17	22.42	9.18	0.02	1.15	31.40
		Min	4.00	2.90	38.00	7.48	31.37	6.39	2.00	0.36	0.02	0.02	0.10	4.30	3.34	0.01	0.80	9.20
		Max	9.10	7.90	99.00	8.41	157.60	12.03	23.23	3.19	0.84	0.09	0.26	89.92	22.99	0.08	2.24	72.00
		Std dev	2.14	1.86	22.35	0.22	37.74	1.74	6.21	0.83	0.23	0.03	0.05	24.88	5.96	0.02	0.51	18.27
May	1978-	Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

X1H003Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	1982	Mean	20.21	9.91	152.49	6.94	58.22	7.73	3.26	0.96	0.02	0.04	0.15	15.68	6.57	0.01	0.96	18.07
		Median	14.57	8.30	122.88	6.74	54.00	8.50	2.00	0.86	0.02	0.02	0.15	12.90	6.20	0.01	0.92	15.40
		Min	5.00	5.60	81.00	6.36	40.10	5.59	2.00	0.64	0.02	0.02	0.11	11.10	4.40	0.00	0.68	13.80
		Max	40.62	18.53	286.57	8.00	88.50	9.37	7.50	1.87	0.05	0.12	0.24	37.10	10.70	0.03	1.32	33.60
		Std dev	12.42	3.88	63.49	0.60	17.40	1.41	2.08	0.36	0.01	0.04	0.04	8.31	1.79	0.01	0.25	6.35
	2000-2005	Count	6.00	6.00	6.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
		Mean	32.02	10.26	177.43	8.11	109.61	9.98	9.58	1.57	0.31	0.03	0.21	39.74	13.65	0.02	1.42	39.04
		Median	30.29	11.10	185.20	8.08	81.68	9.23	8.72	1.07	0.29	0.02	0.18	19.45	10.01	0.02	1.25	23.65
		Min	6.90	5.60	85.00	7.90	60.27	8.87	5.08	0.79	0.08	0.02	0.15	13.09	5.62	0.01	0.99	19.10
		Max	62.78	15.24	286.20	8.42	223.92	13.41	16.92	3.51	0.64	0.07	0.33	109.07	29.58	0.06	2.40	88.20
		Std dev	22.15	3.88	82.51	0.14	58.44	1.53	3.21	1.05	0.15	0.02	0.07	38.95	9.56	0.02	0.50	28.67
Jun	1978-1982	Count	10.00	10.00	10.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	7.84	5.22	87.20	7.40	61.45	8.05	2.68	1.13	0.05	0.06	0.11	19.94	8.09	0.02	0.82	21.44
		Median	7.60	4.80	86.50	7.36	56.25	7.97	2.00	0.92	0.02	0.03	0.11	14.40	7.30	0.01	0.77	18.65
		Min	4.00	3.00	74.00	7.08	46.50	6.29	2.00	0.69	0.02	0.02	0.05	12.20	6.40	0.00	0.50	14.90
		Max	12.80	7.40	97.00	7.90	84.20	9.33	7.40	2.04	0.14	0.23	0.29	42.00	11.80	0.05	1.52	34.40
		Std dev	2.82	1.39	7.00	0.26	13.20	0.90	1.91	0.48	0.05	0.07	0.08	11.33	2.00	0.01	0.33	7.15
	2000-2005	Count	4.00	4.00	4.00	19.00	14.00	19.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
		Mean	16.09	10.00	140.80	8.19	136.53	9.43	11.01	2.04	0.24	0.03	0.25	57.86	18.67	0.02	1.37	52.34
		Median	10.83	8.43	112.42	8.17	113.50	9.42	11.67	1.61	0.25	0.02	0.24	36.49	14.92	0.01	1.43	40.80
		Min	10.41	7.08	104.85	8.03	66.46	7.63	6.30	0.84	0.02	0.02	0.14	13.93	6.86	0.01	0.38	20.20
		Max	32.30	16.06	233.51	8.40	217.53	11.72	15.73	3.60	0.50	0.07	0.36	119.95	31.99	0.05	2.53	94.80
		Std dev	10.80	4.09	61.95	0.11	59.99	1.11	3.50	1.16	0.11	0.02	0.08	44.48	10.04	0.01	0.49	30.91
Jul	1978-1982	Count	9.00	9.00	9.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		Mean	42.65	14.12	226.28	7.49	67.10	8.03	3.16	1.19	0.08	0.04	0.26	20.97	8.19	0.01	1.03	21.81

X1H003Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Median	28.41	16.90	224.33	7.50	64.10	8.47	2.00	1.05	0.06	0.02	0.29	17.70	7.90	0.00	1.00	20.70
		Min	5.00	5.24	62.66	7.30	52.40	5.57	2.00	0.86	0.02	0.02	0.05	13.40	6.60	0.00	0.40	15.40
		Max	123.70	22.41	470.52	7.84	94.40	9.60	7.50	2.01	0.19	0.10	0.49	40.80	12.10	0.02	1.86	33.90
		Std dev	41.31	5.67	129.07	0.19	14.83	1.30	2.15	0.39	0.08	0.03	0.17	9.10	1.84	0.01	0.48	6.06
	2000-2005	Count	7.00	7.00	7.00	18.00	16.00	18.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
		Mean	10.96	8.64	109.14	8.21	129.18	9.04	11.06	1.95	0.31	0.04	0.24	52.27	17.12	0.02	1.28	48.24
		Median	10.30	7.10	104.00	8.20	108.55	8.28	11.29	1.47	0.23	0.02	0.22	35.38	13.76	0.01	1.24	36.40
		Min	7.10	4.70	88.00	8.04	64.08	6.17	2.00	0.46	0.05	0.02	0.17	8.79	7.68	0.01	0.96	21.40
		Max	17.70	20.10	160.00	8.39	226.74	16.62	16.22	3.77	0.87	0.19	0.36	124.53	33.10	0.08	1.63	96.40
		Std dev	3.64	5.38	24.82	0.10	53.33	2.39	3.80	1.13	0.22	0.04	0.07	40.60	8.28	0.02	0.21	26.80
Aug	1978-1982	Count	6.00	6.00	6.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		Mean	19.34	9.69	145.05	7.29	71.91	7.81	4.80	1.44	0.03	0.05	0.22	26.29	9.13	0.01	1.03	25.51
		Median	13.39	9.59	134.74	7.39	68.90	7.80	2.00	1.68	0.02	0.06	0.19	30.40	8.50	0.01	1.03	28.10
		Min	11.70	7.20	106.00	6.70	54.30	6.16	2.00	0.85	0.02	0.02	0.16	13.60	7.00	0.00	0.69	15.00
		Max	49.60	12.20	224.00	7.86	92.80	8.97	15.00	1.94	0.05	0.08	0.39	39.10	11.80	0.02	1.27	35.00
		Std dev	14.89	1.69	40.74	0.42	14.50	1.05	4.81	0.44	0.01	0.03	0.08	9.94	1.77	0.01	0.20	7.99
	2000-2005	Count	6.00	6.00	6.00	22.00	15.00	22.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
		Mean	42.18	15.23	255.55	8.27	133.98	9.76	16.18	1.58	0.36	0.03	0.24	42.78	18.63	0.03	1.28	46.38
		Median	25.35	11.60	197.21	8.24	120.56	8.99	9.99	1.41	0.22	0.02	0.23	30.63	15.90	0.02	1.26	39.80
		Min	13.83	9.42	139.62	7.83	34.79	5.03	2.00	0.34	0.06	0.02	0.10	4.24	3.79	0.01	0.75	9.51
		Max	135.95	29.32	591.84	8.60	290.82	18.52	65.83	3.14	1.21	0.10	0.42	85.02	50.87	0.13	1.68	106.70
		Std dev	46.66	7.78	170.67	0.20	70.84	3.32	15.95	0.82	0.31	0.02	0.09	27.57	12.21	0.03	0.26	25.24
Sep	1978-1982	Count	7.00	7.00	7.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	56.67	14.23	254.00	7.07	68.49	8.26	4.20	1.29	0.04	0.04	0.19	21.89	7.90	0.01	1.27	21.60
		Median	15.90	11.30	125.00	7.12	71.60	8.48	2.00	1.33	0.02	0.03	0.18	22.25	8.45	0.01	1.20	22.15

X1H003Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Min	10.50	6.40	108.00	6.65	38.20	6.25	2.00	0.92	0.02	0.02	0.13	11.10	3.80	0.00	0.59	11.50
		Max	155.40	30.55	572.29	7.60	89.30	9.03	11.20	1.66	0.11	0.06	0.30	31.40	9.80	0.03	1.84	28.80
		Std dev	65.35	9.75	211.47	0.33	15.05	0.89	3.43	0.24	0.04	0.02	0.06	6.22	1.96	0.01	0.43	5.32
	2000-2005	Count	6.00	6.00	6.00	19.00	15.00	19.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
		Mean	21.94	10.14	149.08	8.20	119.10	8.91	13.67	1.56	0.19	0.04	0.23	38.36	15.59	0.02	1.39	40.75
		Median	14.95	9.81	138.03	8.23	112.34	8.24	10.94	1.43	0.16	0.04	0.22	40.75	14.83	0.02	1.29	40.10
		Min	13.87	7.10	108.00	7.81	42.78	6.56	4.27	0.28	0.06	0.02	0.14	4.10	4.66	0.01	0.82	10.81
		Max	49.40	13.75	215.00	8.50	213.72	14.12	39.64	2.70	0.65	0.08	0.40	73.35	31.83	0.08	2.87	68.10
		Std dev	14.06	2.61	42.41	0.19	46.81	2.18	9.78	0.71	0.16	0.02	0.07	20.46	6.46	0.02	0.47	16.42
Oct	1978-1982	Count	8.00	8.00	8.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	66.94	18.67	331.72	7.15	73.57	8.38	5.07	1.28	0.05	0.05	0.17	23.17	8.43	0.01	1.22	24.22
		Median	43.94	15.25	258.65	7.16	69.55	8.41	3.20	1.20	0.02	0.04	0.19	20.35	7.70	0.01	1.21	21.30
		Min	17.73	10.95	166.33	6.60	59.00	6.65	2.00	0.71	0.02	0.02	0.11	11.20	6.00	0.00	1.00	15.20
		Max	156.39	31.84	621.56	8.00	103.40	9.70	10.50	1.89	0.15	0.12	0.24	40.80	13.00	0.03	1.52	42.90
		Std dev	57.49	8.33	179.78	0.49	15.41	1.26	3.95	0.43	0.06	0.03	0.05	10.74	2.76	0.01	0.18	10.10
	2000-2005	Count	6.00	6.00	6.00	14.00	12.00	14.00	12.00	12.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
		Mean	84.12	20.05	369.92	8.23	127.04	9.35	11.97	1.80	0.25	0.05	0.24	45.07	17.54	0.02	1.54	46.40
		Median	83.73	22.41	371.11	8.21	112.56	8.70	9.58	1.77	0.15	0.05	0.26	37.96	15.86	0.02	1.37	42.35
		Min	14.10	7.20	134.00	7.96	55.87	6.45	7.51	0.21	0.06	0.02	0.10	3.58	7.72	0.01	1.00	13.50
		Max	159.24	30.45	620.53	8.44	224.34	20.26	27.81	3.66	0.73	0.09	0.34	111.51	33.55	0.04	2.80	91.40
		Std dev	73.19	11.04	249.78	0.14	45.39	3.44	5.59	0.90	0.25	0.03	0.06	28.43	6.68	0.01	0.48	21.07
Nov	1978-1982	Count	9.00	9.00	9.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	26.31	11.42	177.48	7.06	67.96	9.34	6.28	1.10	0.02	0.03	0.21	19.29	7.81	0.01	1.27	20.33
		Median	27.54	11.72	192.56	7.23	67.05	8.93	4.70	1.03	0.02	0.02	0.18	17.95	7.70	0.01	1.26	19.15
		Min	9.10	6.90	103.00	5.10	34.70	5.93	2.00	0.78	0.02	0.02	0.12	13.40	6.00	0.00	0.94	15.20

X1H003Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Max	48.10	18.64	230.00	8.49	125.30	16.97	19.70	1.60	0.04	0.06	0.51	30.70	10.40	0.04	1.81	28.80
		Std dev	11.32	3.51	46.40	0.89	26.19	2.85	5.63	0.25	0.01	0.01	0.11	5.32	1.27	0.01	0.26	4.56
	2000-2005	**Count**	5.00	5.00	5.00	19.00	15.00	19.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
		Mean	45.62	15.94	277.49	8.09	102.70	9.62	12.34	1.58	0.25	0.03	0.25	35.55	13.55	0.03	1.77	38.75
		Median	51.77	16.51	310.40	8.10	98.87	8.61	9.10	1.58	0.06	0.02	0.24	33.41	13.11	0.02	1.66	37.90
		Min	15.85	11.52	142.22	7.51	51.09	6.83	3.00	0.91	0.02	0.02	0.15	14.06	6.20	0.01	0.78	17.10
		Max	66.31	20.08	353.09	8.57	230.04	20.66	32.97	2.57	1.38	0.07	0.44	62.77	30.70	0.12	3.15	67.30
		Std dev	19.31	3.71	83.28	0.28	43.72	3.00	8.00	0.42	0.40	0.01	0.07	13.97	5.98	0.03	0.63	14.00
Dec	**1978-1982**	**Count**	10.00	10.00	10.00	10.00	10.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
		Mean	74.59	16.35	332.82	6.79	55.45	8.82	7.07	0.77	0.06	0.04	0.15	12.01	5.93	0.01	0.75	14.76
		Median	38.30	10.30	198.00	6.89	50.40	8.77	5.40	0.82	0.02	0.04	0.12	12.20	5.60	0.01	0.86	14.80
		Min	9.30	7.30	112.00	5.20	30.10	7.33	2.00	0.48	0.02	0.02	0.05	6.10	3.40	0.00	0.15	8.10
		Max	168.23	30.09	649.39	7.63	91.30	10.84	23.00	1.08	0.17	0.07	0.36	21.80	8.70	0.02	1.45	25.10
		Std dev	65.87	9.76	230.33	0.69	23.51	1.06	6.39	0.23	0.06	0.02	0.12	5.37	1.79	0.00	0.50	4.95
	2000-2005	**Count**	6.00	6.00	6.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	27.89	13.60	203.09	8.01	86.64	8.35	12.40	1.26	0.28	0.02	0.20	26.85	10.93	0.03	1.74	31.06
		Median	26.32	11.39	195.34	8.00	83.31	8.89	10.59	1.25	0.28	0.02	0.20	25.26	10.74	0.02	1.44	29.20
		Min	15.74	10.15	152.80	7.78	46.17	1.16	7.56	0.50	0.02	0.02	0.14	7.70	6.10	0.01	1.00	15.00
		Max	43.70	19.44	262.16	8.29	156.01	12.64	21.31	2.07	0.70	0.04	0.29	57.43	18.80	0.06	3.00	58.20
		Std dev	12.40	4.39	51.55	0.16	32.54	2.94	4.91	0.56	0.21	0.01	0.05	15.84	3.81	0.01	0.78	13.32

X1H001Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Jan	1978-1982	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	3.93	10.08	94.00	7.25	50.90	8.34	5.67	0.37	0.04	0.04	0.15	5.45	5.08	0.01	0.72	11.87
		Median	4.70	6.55	83.50	7.36	41.35	8.26	2.00	0.40	0.02	0.03	0.14	5.40	5.25	0.00	0.73	10.25
		Min	1.50	4.00	62.00	6.99	33.70	7.63	2.00	0.22	0.02	0.02	0.05	5.00	4.00	0.00	0.57	9.90
		Max	6.10	30.30	168.00	7.40	99.10	9.77	24.00	0.43	0.12	0.09	0.30	5.90	5.70	0.04	0.88	20.50
		Std dev	1.95	9.97	38.33	0.20	24.20	0.78	8.98	0.08	0.04	0.03	0.09	0.40	0.61	0.01	0.12	4.23
	2002-2004	Count	5.00	5.00	5.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	3.59	9.17	106.62	7.75	59.30	7.75	10.59	0.49	0.11	0.03	0.24	7.98	6.48	0.02	1.13	15.44
		Median	2.50	9.06	107.98	7.78	58.22	8.05	10.37	0.47	0.07	0.02	0.25	8.21	6.35	0.02	1.03	16.10
		Min	2.50	6.90	83.18	7.40	37.46	5.47	6.72	0.44	0.02	0.02	0.21	6.54	4.67	0.01	0.79	10.84
		Max	5.43	12.36	125.35	7.93	82.96	8.91	14.87	0.56	0.29	0.05	0.27	8.97	9.06	0.03	1.62	20.20
		Std dev	1.49	2.06	15.52	0.19	14.75	1.32	2.73	0.05	0.10	0.02	0.03	0.88	1.57	0.01	0.33	3.31
Feb	1978-1982	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	1.50	7.72	85.50	6.97	47.90	8.64	3.35	0.35	0.03	0.06	0.08	5.52	6.98	0.00	0.36	10.78
		Median	1.50	7.85	86.50	7.03	48.30	8.85	2.00	0.34	0.02	0.05	0.05	5.35	7.05	0.00	0.34	11.00
		Min	1.50	6.70	71.00	6.21	37.90	7.93	2.00	0.32	0.02	0.04	0.05	5.10	5.30	0.00	0.15	9.80
		Max	1.50	8.60	96.00	7.50	57.70	9.18	10.10	0.39	0.08	0.09	0.25	6.10	8.20	0.01	0.62	11.40
		Std dev	0.00	0.86	9.05	0.43	8.01	0.50	3.31	0.03	0.02	0.02	0.08	0.49	1.02	0.00	0.23	0.61
	2002-2004	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	5.09	9.58	111.17	7.65	57.83	8.21	9.26	0.52	0.10	0.03	0.26	8.23	6.43	0.03	1.24	15.30
		Median	5.01	10.33	110.82	7.56	58.25	8.21	8.74	0.51	0.08	0.02	0.26	8.48	6.60	0.02	1.16	15.80
		Min	2.50	5.82	84.80	7.25	37.83	6.78	4.17	0.38	0.02	0.02	0.23	6.36	3.60	0.01	0.78	10.80
		Max	7.46	11.74	135.05	8.22	74.30	9.76	15.36	0.73	0.21	0.08	0.30	9.03	9.00	0.06	1.72	17.80
		Std dev	1.58	2.12	16.28	0.39	12.12	1.25	4.52	0.12	0.07	0.03	0.03	0.97	1.77	0.02	0.40	2.42

X1H001Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Mar	1978-1982	Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		Mean	2.44	9.86	89.14	7.07	51.50	8.41	2.44	0.34	0.05	0.07	0.12	5.01	5.81	0.01	0.58	12.77
		Median	1.50	6.60	76.00	7.15	43.90	8.56	2.00	0.34	0.02	0.08	0.05	5.00	6.20	0.00	0.34	10.40
		Min	1.50	4.20	50.00	6.38	23.60	6.47	2.00	0.22	0.02	0.02	0.05	4.30	3.30	0.00	0.15	6.80
		Max	4.40	24.50	170.00	7.69	105.00	9.21	5.10	0.56	0.15	0.09	0.31	6.30	8.50	0.04	2.16	27.50
		Std dev	1.24	7.24	38.81	0.40	25.92	1.01	1.17	0.11	0.05	0.03	0.10	0.63	1.61	0.02	0.72	6.77
	2002-2004	Count	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	5.58	9.83	113.85	7.82	60.13	9.27	7.90	0.54	0.16	0.04	0.22	8.77	6.53	0.02	0.89	15.83
		Median	5.59	9.38	111.62	7.77	57.52	9.49	7.97	0.52	0.17	0.04	0.22	8.11	6.56	0.02	0.84	15.55
		Min	5.00	8.63	99.91	7.55	49.69	7.74	6.12	0.32	0.05	0.02	0.10	5.93	4.64	0.01	0.74	14.20
		Max	6.59	12.68	133.53	8.14	76.99	10.16	9.68	0.71	0.24	0.09	0.29	11.64	8.42	0.03	1.22	18.90
		Std dev	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Apr	1978-1982	Count	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	2.63	8.75	93.20	7.26	53.34	9.36	2.50	0.46	0.06	0.10	0.16	7.35	6.61	0.04	0.70	12.06
		Median	3.15	8.55	91.00	7.25	52.40	9.17	2.00	0.48	0.02	0.02	0.21	7.25	6.60	0.03	0.69	12.25
		Min	1.50	7.40	86.00	6.96	47.50	8.19	2.00	0.37	0.02	0.02	0.05	5.90	5.90	0.01	0.15	10.40
		Max	3.60	10.20	105.00	7.57	60.80	10.53	7.00	0.57	0.35	0.35	0.25	9.20	7.50	0.08	1.32	14.40
		Std dev	0.99	0.81	7.64	0.17	3.79	0.69	1.58	0.07	0.11	0.12	0.09	1.25	0.51	0.03	0.38	1.51
	2002-2004	Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
		Mean	4.73	10.66	122.71	7.90	67.23	7.94	7.42	0.48	0.12	0.03	0.19	8.38	7.77	0.02	0.95	16.80
		Median	5.00	10.33	122.63	7.92	64.48	7.41	7.16	0.47	0.12	0.02	0.21	7.84	7.19	0.02	0.98	16.40
		Min	2.50	9.57	110.99	7.46	59.38	6.79	5.84	0.38	0.02	0.02	0.10	7.20	6.33	0.01	0.57	15.80
		Max	6.17	11.70	135.11	8.17	77.49	9.53	9.60	0.58	0.23	0.04	0.23	9.59	9.81	0.03	1.26	18.50
		Std dev	1.35	0.90	9.66	0.27	7.81	1.15	1.51	0.08	0.09	0.01	0.05	1.08	1.46	0.01	0.31	1.08
May	1978-	Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

X1H001Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	1982	Mean	3.62	12.73	117.89	7.47	66.18	9.49	4.64	0.49	0.02	0.10	0.14	8.59	6.97	0.03	0.54	14.82
		Median	3.30	10.80	117.00	7.49	65.60	9.47	4.30	0.46	0.02	0.13	0.10	7.20	7.10	0.02	0.56	15.10
		Min	1.50	8.80	89.00	7.12	50.90	8.43	2.00	0.30	0.02	0.02	0.05	6.20	5.70	0.00	0.41	11.80
		Max	7.20	24.70	162.00	7.88	94.20	10.33	10.90	0.96	0.02	0.19	0.33	16.70	8.30	0.07	0.63	20.40
		Std dev	1.52	5.92	23.72	0.22	13.79	0.52	3.05	0.20	0.00	0.08	0.10	3.31	0.99	0.02	0.06	2.79
	2002-2004	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	4.66	12.10	139.63	7.87	79.56	7.62	6.08	0.46	0.05	0.05	0.23	8.87	9.65	0.02	0.68	19.25
		Median	5.00	11.36	133.00	7.89	77.37	7.74	6.89	0.45	0.06	0.03	0.23	8.81	8.80	0.02	0.65	18.70
		Min	2.50	10.25	128.15	7.45	72.41	6.53	3.00	0.40	0.02	0.02	0.17	8.02	8.51	0.01	0.52	17.60
		Max	5.48	14.91	163.63	8.18	93.05	8.57	9.01	0.55	0.09	0.16	0.28	9.91	11.93	0.02	0.80	21.50
		Std dev	1.08	1.75	14.15	0.24	7.92	0.89	2.53	0.05	0.02	0.05	0.04	0.78	1.48	0.01	0.11	1.45
Jun	1978-1982	Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	4.32	9.94	104.67	7.28	59.66	9.56	2.00	0.48	0.02	0.06	0.23	8.35	7.44	0.02	0.46	14.49
		Median	3.40	10.20	112.00	7.58	63.70	9.63	2.00	0.51	0.02	0.02	0.26	9.20	7.65	0.01	0.47	14.70
		Min	1.50	8.10	87.00	5.25	47.10	8.62	2.00	0.39	0.02	0.02	0.05	5.90	5.20	0.00	0.15	12.00
		Max	16.10	12.60	121.00	7.88	70.10	10.24	2.00	0.58	0.05	0.19	0.36	10.30	9.82	0.04	1.12	20.60
		Std dev	4.55	1.45	13.20	0.79	8.85	0.52	0.00	0.08	0.01	0.06	0.10	1.68	1.26	0.01	0.27	2.68
	2002-2004	Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
		Mean	5.06	12.25	148.68	7.85	84.29	7.33	8.27	0.48	0.06	0.05	0.27	9.07	9.72	0.01	0.72	19.95
		Median	5.00	12.23	149.53	7.83	84.49	7.74	7.88	0.47	0.05	0.03	0.27	9.24	9.65	0.01	0.70	19.95
		Min	5.00	10.56	136.46	7.65	77.56	5.64	4.03	0.42	0.05	0.02	0.25	7.96	8.35	0.01	0.69	18.20
		Max	5.28	13.48	165.15	8.17	91.61	9.28	12.66	0.55	0.08	0.11	0.28	9.85	11.22	0.03	0.78	21.70
		Std dev	0.13	1.13	11.13	0.20	6.53	1.53	3.47	0.05	0.02	0.04	0.01	0.83	1.31	0.01	0.04	1.63
Jul	1978-1982	Count	9.00	9.00	9.00	8.00	8.00	8.00	8.00	8.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
		Mean	8.14	9.09	98.78	7.18	49.50	9.44	3.69	0.45	0.03	0.14	0.23	7.64	6.87	0.01	0.77	12.63

X1H001Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water (pH units)	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Diss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Median	5.40	8.60	98.00	7.31	50.35	9.55	2.00	0.43	0.02	0.17	0.11	7.30	7.10	0.01	0.75	12.20
		Min	1.50	7.80	84.00	6.62	42.40	9.01	2.00	0.38	0.02	0.02	0.05	6.40	5.50	0.00	0.61	12.00
		Max	22.70	11.50	120.00	7.45	55.80	9.58	11.50	0.61	0.08	0.19	1.03	11.20	8.00	0.05	1.13	15.50
		Std dev	8.48	1.29	9.52	0.32	5.48	0.20	3.45	0.08	0.02	0.07	0.32	1.68	0.86	0.02	0.19	1.13
	2002-2004	**Count**	7.00	7.00	7.00	8.00	8.00	8.00	8.00	8.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		Mean	5.53	14.13	166.66	7.88	90.81	8.14	8.04	0.51	0.06	0.05	0.26	10.16	11.59	0.02	0.91	22.49
		Median	5.00	13.60	164.07	7.97	93.05	8.07	7.01	0.52	0.06	0.05	0.25	10.55	11.26	0.02	0.85	22.10
		Min	5.00	11.03	138.91	7.40	67.40	6.61	2.00	0.32	0.02	0.02	0.22	7.93	8.77	0.01	0.60	19.90
		Max	7.73	19.59	207.21	8.33	119.74	10.13	14.05	0.62	0.08	0.13	0.34	11.44	16.23	0.03	1.65	27.30
		Std dev	1.04	2.66	21.40	0.30	15.65	1.01	3.60	0.09	0.02	0.04	0.04	1.19	2.34	0.01	0.34	2.47
Aug	**1978-1982**	**Count**	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	3.62	10.32	109.67	7.50	62.88	9.51	2.97	0.49	0.03	0.11	0.15	8.33	7.10	0.01	0.66	13.47
		Median	3.20	9.55	107.50	7.35	60.70	9.59	2.00	0.44	0.02	0.07	0.13	7.40	7.05	0.01	0.72	13.30
		Min	1.50	8.40	97.00	6.39	56.30	8.95	2.00	0.38	0.02	0.02	0.05	7.30	6.60	0.00	0.53	12.00
		Max	7.30	15.70	125.00	9.19	72.70	9.86	7.80	0.67	0.04	0.22	0.37	11.00	7.60	0.02	0.75	15.00
		Std dev	2.23	2.68	13.14	0.92	7.00	0.35	2.37	0.11	0.01	0.09	0.12	1.59	0.33	0.01	0.10	1.05
	2002-2004	**Count**	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	5.90	14.03	164.57	8.09	91.85	7.03	7.53	0.55	0.07	0.04	0.28	11.62	11.87	0.03	0.93	22.75
		Median	5.00	13.94	164.31	8.04	94.27	7.53	7.83	0.57	0.06	0.02	0.27	11.75	11.83	0.02	0.89	23.40
		Min	5.00	11.73	143.91	7.90	75.85	5.79	2.00	0.48	0.04	0.02	0.22	10.05	9.50	0.01	0.76	19.30
		Max	7.80	15.73	183.90	8.41	102.39	7.71	10.06	0.63	0.12	0.10	0.37	13.18	16.17	0.06	1.15	24.60
		Std dev	1.39	1.47	13.48	0.20	10.09	0.90	2.93	0.06	0.03	0.03	0.06	1.31	2.40	0.02	0.19	1.93
Sep	**1978-1982**	**Count**	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		Mean	2.80	9.76	103.86	7.17	58.47	9.09	3.84	0.47	0.02	0.05	0.20	7.91	7.07	0.03	0.69	13.67
		Median	3.00	9.90	103.00	7.28	59.10	9.26	2.00	0.50	0.02	0.05	0.24	8.30	7.30	0.02	0.59	13.80

X1H001Q01																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water (pH units)**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Min	1.50	8.90	85.00	6.70	46.40	7.47	2.00	0.36	0.02	0.02	0.05	5.70	6.30	0.00	0.47	12.00
		Max	4.50	10.60	114.00	7.40	67.90	10.22	8.50	0.51	0.02	0.09	0.29	8.60	7.50	0.08	1.14	14.90
		Std dev	1.35	0.53	9.49	0.29	6.39	0.84	3.15	0.05	0.00	0.03	0.11	1.02	0.43	0.03	0.23	1.01
	2002-2004	**Count**	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	7.76	14.37	177.75	8.10	97.92	7.16	9.75	0.61	0.07	0.04	0.30	12.74	11.67	0.02	1.39	24.43
		Median	8.21	14.29	179.01	8.15	98.54	7.17	7.98	0.61	0.06	0.02	0.31	12.89	11.68	0.01	1.02	24.50
		Min	5.00	13.29	169.70	7.80	91.42	6.50	7.03	0.52	0.06	0.02	0.23	10.94	10.89	0.01	0.97	23.30
		Max	10.82	15.66	184.79	8.33	101.15	7.63	16.74	0.73	0.10	0.11	0.37	15.36	12.30	0.02	2.21	25.40
		Std dev	2.36	0.95	6.38	0.21	3.54	0.41	3.80	0.08	0.02	0.04	0.06	1.62	0.54	0.00	0.60	0.73
Oct	**1978-1982**	**Count**	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	3.61	9.36	101.63	7.33	57.59	8.73	3.05	0.50	0.03	0.05	0.23	8.13	6.29	0.01	0.86	13.09
		Median	3.20	9.20	102.50	7.20	58.30	9.06	2.00	0.50	0.02	0.05	0.23	8.25	6.40	0.01	0.80	13.00
		Min	3.00	8.80	87.00	6.70	46.60	7.30	2.00	0.41	0.02	0.02	0.16	6.70	5.60	0.00	0.63	12.30
		Max	5.50	10.30	113.00	7.81	67.80	9.35	6.80	0.59	0.10	0.06	0.31	9.30	7.30	0.01	1.26	14.50
		Std dev	0.95	0.53	7.33	0.42	5.77	0.77	1.97	0.05	0.03	0.01	0.05	0.84	0.57	0.00	0.25	0.65
	2002-2004	**Count**	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	7.06	15.38	186.33	8.14	105.77	7.31	8.05	0.56	0.04	0.05	0.29	12.28	12.88	0.01	1.13	25.50
		Median	7.61	15.45	186.91	8.21	107.55	7.23	7.90	0.60	0.06	0.02	0.31	12.76	13.12	0.01	1.13	25.70
		Min	5.00	13.86	157.58	7.79	85.90	6.55	6.82	0.46	0.02	0.02	0.10	10.29	10.29	0.01	0.93	21.30
		Max	8.59	16.80	202.36	8.27	115.51	8.52	9.38	0.61	0.06	0.12	0.37	13.67	14.62	0.02	1.35	27.40
		Std dev	1.65	1.08	15.85	0.18	10.49	0.69	1.06	0.07	0.02	0.05	0.10	1.46	1.44	0.00	0.16	2.24
Nov	**1978-1982**	**Count**	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
		Mean	2.99	10.64	107.22	7.31	59.44	9.36	4.46	0.54	0.05	0.04	0.22	8.49	5.78	0.02	0.85	13.67
		Median	3.20	8.10	90.00	7.35	49.10	9.48	4.30	0.54	0.02	0.04	0.20	8.40	5.60	0.02	0.85	11.90
		Min	1.50	6.10	83.00	6.50	45.10	8.32	2.00	0.41	0.02	0.02	0.16	6.20	4.20	0.00	0.50	10.60

X1H001Q01																		
			Cl-Diss-Water (mg/L)	**Ca-Diss-Water (mg/L)**	**DMS-Tot-Water (mg/L)**	**pH-Diss-Water (pH units)**	**TAL-Diss-Water (mg/L)**	**Si-Diss-Water (mg/L)**	**SO4-Diss-Water (mg/L)**	**SAR-Diss-Water (null)**	**NO3+NO2-N-Diss-Water (mg/L)**	**NH4-N-Diss-Water (mg/L)**	**F-Diss-Water (mg/L)**	**Na-Diss-Water (mg/L)**	**Mg-Diss-Water (mg/L)**	**PO4-P-Diss-Water (mg/L)**	**K-Diss-Water (mg/L)**	**EC-Phys-Water (mS/m)**
		Max	7.20	31.40	200.00	7.70	118.30	10.14	7.10	0.68	0.25	0.05	0.31	10.80	7.50	0.04	1.24	25.10
		Std dev	1.86	7.88	36.78	0.40	23.48	0.56	2.09	0.08	0.08	0.01	0.06	1.53	1.25	0.01	0.25	4.57
	2002-2004	**Count**	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
		Mean	6.06	10.08	124.41	7.74	60.50	7.26	12.95	0.57	0.47	0.04	0.22	9.58	7.37	0.02	2.19	18.10
		Median	6.19	10.91	133.27	7.80	67.70	7.38	14.85	0.55	0.30	0.02	0.23	9.27	7.63	0.02	2.16	18.80
		Min	5.00	6.99	83.30	7.45	27.25	5.16	7.46	0.48	0.05	0.02	0.10	8.57	4.54	0.01	1.09	12.68
		Max	7.11	12.50	155.27	7.99	88.95	8.84	17.94	0.65	0.96	0.09	0.30	11.61	10.59	0.05	3.29	21.70
		Std dev	1.03	2.34	27.61	0.21	23.15	1.42	4.62	0.08	0.43	0.04	0.08	1.19	2.27	0.01	0.79	3.36
Dec	**1978-1982**	**Count**	10.00	10.00	10.00	11.00	11.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	3.79	7.37	90.60	7.07	50.68	9.15	3.36	0.47	0.08	0.04	0.22	6.85	6.05	0.05	0.74	11.97
		Median	1.50	7.80	88.00	7.10	49.90	9.07	2.00	0.46	0.02	0.02	0.16	7.10	6.15	0.04	0.77	11.70
		Min	1.50	4.10	78.00	6.73	40.90	8.51	2.00	0.11	0.02	0.02	0.05	1.00	3.90	0.01	0.50	10.00
		Max	12.80	10.80	117.00	7.40	64.40	10.45	7.60	0.74	0.61	0.08	0.66	8.90	7.70	0.13	0.94	14.50
		Std dev	3.98	2.28	11.90	0.20	7.26	0.56	2.34	0.16	0.19	0.02	0.21	2.30	1.11	0.04	0.16	1.36
	2002-2004	**Count**	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	6.11	10.23	123.74	7.88	65.51	8.27	7.77	0.60	0.15	0.02	0.27	10.17	7.27	0.02	1.29	17.78
		Median	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	0.14	0.02	0.29	10.36	6.61	0.02	1.36	16.80
		Min	5.00	8.03	95.85	7.60	46.21	7.09	3.00	0.49	0.04	0.02	0.19	7.34	5.42	0.01	0.93	14.90
		Max	7.21	13.88	159.06	8.35	91.42	8.78	10.65	0.68	0.30	0.02	0.33	12.12	10.93	0.04	1.76	23.60
		Std dev	0.92	2.47	24.80	0.28	17.13	0.64	2.96	0.08	0.11	0.00	0.06	1.78	2.18	0.01	0.32	3.42

X1019Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
Jan	1977-1982	Count	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	1.00	79.10	1.68	6.74	24.04	7.97	7.97	0.29	0.05	0.06	0.05	3.26	3.38	0.01	0.30	8.03
		Median	1.00	78.50	1.50	6.61	19.80	7.09	7.70	0.28	0.03	0.02	0.05	3.15	3.00	0.00	0.23	6.95
		Min	1.00	78.00	1.50	6.33	13.70	6.41	5.10	0.18	0.02	0.02	0.05	1.00	1.50	0.00	0.15	5.10
		Max	1.00	82.00	3.30	7.20	56.80	14.10	13.40	0.55	0.11	0.18	0.05	8.90	6.80	0.01	0.62	13.10
		Std dev	0.00	1.37	0.57	0.36	13.06	2.30	2.45	0.10	0.04	0.07	0.00	2.34	1.75	0.00	0.18	2.79
	1989-1996	Count	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
		Mean	1.00	91.25	4.13	7.27	29.43	8.50	10.35	0.26	0.10	0.04	0.08	3.78	5.00	0.01	0.30	10.75
		Median	1.00	91.00	3.95	7.09	28.90	8.44	7.90	0.27	0.11	0.04	0.08	3.75	5.00	0.01	0.34	10.65
		Min	1.00	89.00	3.20	6.74	22.50	7.96	5.60	0.21	0.05	0.02	0.05	3.10	4.00	0.01	0.15	9.20
		Max	1.00	94.00	5.40	8.18	37.40	9.16	20.00	0.30	0.14	0.07	0.10	4.50	6.00	0.02	0.38	12.50
		Std dev	0.00	2.22	1.11	0.65	7.26	0.52	6.73	0.04	0.04	0.02	0.03	0.73	0.82	0.00	0.10	1.45
Feb	1977-1982	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	2.00	79.83	2.43	6.77	25.15	8.01	6.45	0.31	0.05	0.03	0.12	3.55	3.30	0.01	0.31	8.85
		Median	2.00	79.50	1.50	6.75	26.95	7.88	7.15	0.33	0.03	0.03	0.05	3.80	3.40	0.01	0.37	8.80
		Min	2.00	78.00	1.50	6.04	14.80	7.08	2.00	0.16	0.02	0.02	0.05	1.00	2.10	0.00	0.15	6.90
		Max	2.00	82.00	5.00	7.40	32.70	9.59	8.90	0.41	0.11	0.05	0.47	5.00	4.50	0.01	0.44	11.10
		Std dev	0.00	2.04	1.51	0.49	7.67	0.86	2.74	0.10	0.04	0.02	0.17	1.40	0.92	0.00	0.13	1.52
	1989-1996	Count																
		Mean																
		Median																
		Min																
		Max																
		Std dev																
Mar	1977-	Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

X1019Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	1982	Mean	3.00	79.20	2.00	6.99	39.52	8.25	5.66	0.26	0.03	0.04	0.08	3.56	3.90	0.01	0.38	12.04
		Median	3.00	78.00	1.50	6.80	25.00	8.04	4.70	0.27	0.02	0.04	0.05	3.30	3.50	0.00	0.38	10.20
		Min	3.00	78.00	1.50	6.17	22.40	7.66	2.00	0.14	0.02	0.02	0.05	2.60	2.80	0.00	0.15	8.20
		Max	3.00	82.00	4.00	7.90	91.40	9.48	8.90	0.35	0.06	0.06	0.12	5.20	5.20	0.02	0.58	21.10
		Std dev	0.00	1.79	1.12	0.64	29.49	0.71	2.92	0.08	0.02	0.02	0.04	0.99	1.22	0.01	0.15	5.17
	1989-1996	Count	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	3.00	90.67	4.57	7.70	33.17	8.85	6.33	0.27	0.11	0.04	0.10	3.83	4.93	0.01	0.23	11.57
		Median	3.00	91.00	4.40	7.81	34.30	9.19	5.80	0.23	0.11	0.04	0.11	3.40	4.90	0.01	0.15	12.10
		Min	3.00	89.00	3.70	7.26	24.40	7.80	5.20	0.22	0.06	0.02	0.05	2.90	3.90	0.01	0.15	9.30
		Max	3.00	92.00	5.60	8.02	40.80	9.55	8.00	0.36	0.17	0.06	0.15	5.20	6.00	0.02	0.40	13.30
		Std dev	0.00	1.53	0.96	0.39	8.26	0.92	1.47	0.08	0.05	0.02	0.05	1.21	1.05	0.00	0.14	2.05
Apr	1977-1982	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	4.00	78.17	1.93	7.29	47.30	9.46	8.83	0.38	0.06	0.06	0.09	6.08	5.53	0.01	0.39	11.77
		Median	4.00	77.50	1.50	7.19	41.10	8.37	9.85	0.32	0.07	0.05	0.08	4.60	5.35	0.00	0.43	10.40
		Min	4.00	77.00	1.50	6.89	32.30	7.30	4.00	0.18	0.02	0.02	0.05	2.90	3.20	0.00	0.15	9.80
		Max	4.00	82.00	4.10	8.00	79.40	15.11	12.30	0.75	0.09	0.12	0.16	14.00	8.60	0.01	0.65	16.90
		Std dev	0.00	1.94	1.06	0.39	16.67	2.94	3.46	0.20	0.04	0.03	0.05	4.02	1.74	0.00	0.20	2.77
	1989-1996	Count	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	4.00	91.00	5.33	7.80	47.80	9.59	8.13	0.33	0.19	0.12	0.16	5.37	6.13	0.01	0.46	12.73
		Median	4.00	91.00	5.80	7.62	25.20	7.97	8.20	0.26	0.23	0.07	0.15	3.40	4.30	0.01	0.49	8.40
		Min	4.00	90.00	3.90	7.33	16.00	6.76	4.20	0.14	0.08	0.02	0.13	1.00	4.00	0.01	0.31	7.40
		Max	4.00	92.00	6.30	8.44	102.20	14.03	12.00	0.58	0.27	0.27	0.19	11.70	10.10	0.01	0.57	22.40
		Std dev	0.00	1.00	1.27	0.58	47.34	3.90	3.90	0.23	0.10	0.14	0.03	5.61	3.44	0.00	0.13	8.39
May	1977-1982	Count	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	5.00	78.50	2.56	6.88	35.81	8.69	10.36	0.28	0.04	0.05	0.06	4.04	4.95	0.01	0.85	11.01
		Median	5.00	77.50	1.50	7.00	35.40	8.67	10.30	0.26	0.03	0.02	0.05	3.80	5.00	0.01	0.54	10.95

X1019Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Min	5.00	77.00	1.50	6.30	29.10	7.41	7.30	0.22	0.02	0.02	0.05	3.30	4.20	0.00	0.15	9.90
		Max	5.00	82.00	6.60	7.30	45.50	10.45	13.80	0.41	0.09	0.23	0.13	5.60	5.60	0.03	2.17	12.20
		Std dev	0.00	2.00	1.81	0.36	5.76	1.24	2.22	0.06	0.03	0.07	0.03	0.70	0.45	0.01	0.76	0.84
	1989-1996	**Count**	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		Mean	5.00	90.00	6.05	8.09	35.70	9.01	10.65	0.28	0.16	0.02	0.05	4.05	4.90	0.01	0.40	10.95
		Median	5.00	90.00	6.05	8.09	35.70	9.01	10.65	0.28	0.16	0.02	0.05	4.05	4.90	0.01	0.40	10.95
		Min	5.00	89.00	4.90	8.06	31.60	8.82	10.20	0.23	0.14	0.02	0.05	3.30	4.80	0.01	0.38	10.70
		Max	5.00	91.00	7.20	8.12	39.80	9.19	11.10	0.33	0.18	0.02	0.05	4.80	5.00	0.02	0.42	11.20
		Std dev	0.00	1.41	1.63	0.04	5.80	0.26	0.64	0.07	0.03	0.00	0.00	1.06	0.14	0.01	0.03	0.35
Jun	**1977-1982**	**Count**	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Mean	6.00	78.30	1.93	7.15	40.53	9.27	9.65	0.32	0.08	0.05	0.06	4.90	5.31	0.03	0.51	11.85
		Median	6.00	77.50	1.50	7.15	36.10	8.64	9.30	0.29	0.02	0.02	0.05	4.15	4.90	0.04	0.32	11.25
		Min	6.00	77.00	1.50	6.92	33.20	7.84	7.40	0.24	0.02	0.02	0.05	3.50	4.60	0.00	0.15	10.40
		Max	6.00	82.00	4.20	7.34	71.30	12.31	13.00	0.69	0.46	0.12	0.10	12.50	7.80	0.05	2.42	16.50
		Std dev	0.00	1.83	0.94	0.14	11.28	1.39	1.74	0.13	0.14	0.04	0.02	2.69	0.99	0.02	0.68	1.72
	1989-1996	**Count**	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	6.00	91.67	3.90	7.79	29.13	8.98	14.27	0.29	0.28	0.03	0.08	3.80	4.17	0.01	0.32	10.30
		Median	6.00	90.00	4.00	7.66	27.50	9.21	14.40	0.29	0.29	0.02	0.05	3.50	3.90	0.01	0.39	10.00
		Min	6.00	89.00	3.40	7.60	27.40	8.45	10.60	0.27	0.12	0.02	0.05	3.40	3.30	0.01	0.15	10.00
		Max	6.00	96.00	4.30	8.11	32.50	9.28	17.80	0.30	0.43	0.04	0.13	4.50	5.30	0.01	0.42	10.90
		Std dev	0.00	3.79	0.46	0.28	2.92	0.46	3.60	0.02	0.15	0.01	0.05	0.61	1.03	0.00	0.15	0.52
Jul	**1977-1982**	**Count**	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	7.00	78.67	3.52	7.15	46.12	9.45	12.62	0.29	0.03	0.06	0.11	4.90	6.38	0.00	0.61	12.73
		Median	7.00	77.50	3.30	7.15	42.50	10.28	12.00	0.28	0.02	0.05	0.05	4.50	6.25	0.00	0.43	11.85
		Min	7.00	77.00	1.50	7.00	38.40	3.52	9.80	0.11	0.02	0.02	0.05	2.00	5.70	0.00	0.15	11.40
		Max	7.00	82.00	5.80	7.32	66.40	12.52	15.90	0.63	0.07	0.12	0.32	11.10	7.40	0.01	1.44	16.30

X1019Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Std dev	0.00	2.25	2.22	0.11	10.69	3.07	2.68	0.19	0.02	0.04	0.11	3.32	0.60	0.00	0.47	1.89
	1989-1996	Count	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		Mean	7.00	92.00	5.20	7.47	34.20	7.84	13.40	0.27	0.17	0.02	0.22	4.10	5.40	0.01	0.42	11.95
		Median	7.00	92.00	5.20	7.47	34.20	7.84	13.40	0.27	0.17	0.02	0.22	4.10	5.40	0.01	0.42	11.95
		Min	7.00	90.00	3.30	7.40	30.50	7.24	9.60	0.25	0.14	0.02	0.12	4.00	5.10	0.01	0.36	11.00
		Max	7.00	94.00	7.10	7.54	37.90	8.43	17.20	0.29	0.21	0.02	0.31	4.20	5.70	0.01	0.47	12.90
		Std dev	0.00	2.83	2.69	0.10	5.23	0.84	5.37	0.03	0.05	0.00	0.13	0.14	0.42	0.00	0.08	1.34
Aug	1977-1982	Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
		Mean	8.00	78.78	3.14	7.18	41.42	10.44	11.53	0.34	0.03	0.04	0.13	5.30	5.71	0.02	0.52	12.08
		Median	8.00	78.00	3.60	7.30	42.60	10.72	12.10	0.37	0.02	0.02	0.12	5.80	5.70	0.02	0.63	12.00
		Min	8.00	77.00	1.50	6.33	34.70	9.29	8.90	0.20	0.02	0.02	0.05	3.20	4.80	0.00	0.15	11.00
		Max	8.00	82.00	4.90	7.41	45.60	11.04	12.70	0.42	0.10	0.12	0.39	6.10	7.10	0.03	0.73	13.30
		Std dev	0.00	2.22	1.36	0.34	3.58	0.56	1.28	0.07	0.03	0.04	0.11	0.98	0.71	0.01	0.23	0.68
	1989-1996	Count	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	8.00	91.33	5.10	8.11	37.57	8.48	15.43	0.32	0.15	0.03	0.18	5.20	6.50	0.01	0.87	14.43
		Median	8.00	91.00	5.70	7.91	40.10	9.05	10.90	0.29	0.13	0.02	0.18	4.80	5.70	0.01	0.64	14.30
		Min	8.00	89.00	3.40	7.79	32.30	7.19	10.80	0.27	0.10	0.02	0.14	4.50	5.70	0.01	0.36	13.80
		Max	8.00	94.00	6.20	8.62	40.30	9.19	24.60	0.40	0.22	0.05	0.22	6.30	8.10	0.01	1.61	15.20
		Std dev	0.00	2.52	1.49	0.45	4.56	1.12	7.94	0.07	0.06	0.02	0.04	0.96	1.39	0.00	0.66	0.71
Sep	1977-1982	Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	9.00	78.17	2.20	6.95	46.37	10.83	11.67	0.40	0.03	0.05	0.07	6.50	6.07	0.03	0.44	12.88
		Median	9.00	78.00	1.50	6.99	42.20	10.61	11.30	0.33	0.02	0.05	0.05	5.20	6.15	0.03	0.44	12.00
		Min	9.00	77.00	1.50	6.74	30.80	9.94	9.80	0.31	0.02	0.02	0.05	5.20	4.20	0.01	0.33	10.80
		Max	9.00	81.00	5.70	7.18	65.20	12.43	15.30	0.71	0.06	0.09	0.12	12.60	7.80	0.04	0.55	17.00
		Std dev	0.00	1.47	1.71	0.16	12.33	0.86	1.92	0.16	0.02	0.03	0.04	2.99	1.15	0.01	0.07	2.19
	1989-	Count	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

X1019Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
	1996	Mean	9.00	93.00	4.57	7.82	44.17	9.43	14.70	0.32	0.14	0.03	0.19	5.33	6.37	0.02	0.59	14.07
		Median	9.00	93.00	3.90	7.82	46.20	9.43	14.60	0.34	0.09	0.02	0.22	5.60	6.10	0.02	0.53	14.10
		Min	9.00	90.00	3.00	7.45	34.80	9.27	14.20	0.26	0.07	0.02	0.11	4.20	6.10	0.02	0.50	13.20
		Max	9.00	96.00	6.80	8.20	51.50	9.59	15.30	0.36	0.27	0.05	0.24	6.20	6.90	0.03	0.73	14.90
		Std dev	0.00	3.00	1.99	0.38	8.53	0.16	0.56	0.05	0.11	0.02	0.07	1.03	0.46	0.01	0.13	0.85
Oct	1977-1982	Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
		Mean	10.00	78.43	1.87	7.21	60.36	13.97	9.47	0.40	0.03	0.03	0.08	7.01	6.39	0.04	0.41	14.67
		Median	10.00	77.00	1.50	7.11	49.50	11.06	10.50	0.35	0.02	0.02	0.05	6.10	6.10	0.01	0.36	13.00
		Min	10.00	77.00	1.50	6.90	39.20	10.23	4.20	0.29	0.02	0.02	0.05	5.70	5.00	0.00	0.15	11.90
		Max	10.00	82.00	4.10	7.68	87.30	19.80	15.00	0.65	0.07	0.10	0.15	12.20	8.40	0.13	0.63	18.30
		Std dev	0.00	2.15	0.98	0.33	20.67	4.24	4.14	0.12	0.02	0.03	0.04	2.32	1.10	0.05	0.17	2.81
	1989-1996	Count	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
		Mean	10.00	90.75	4.38	7.58	42.43	8.05	12.78	0.34	0.15	0.11	0.17	5.85	6.68	0.02	0.60	13.90
		Median	10.00	90.50	4.90	7.66	36.65	7.91	12.40	0.30	0.04	0.05	0.18	4.60	6.00	0.01	0.44	11.75
		Min	10.00	89.00	1.50	7.25	17.40	7.13	5.10	0.25	0.02	0.02	0.11	3.90	5.30	0.01	0.15	11.40
		Max	10.00	93.00	6.20	7.77	79.00	9.26	21.20	0.51	0.48	0.31	0.20	10.30	9.40	0.03	1.36	20.70
		Std dev	0.00	1.71	2.24	0.23	26.29	0.93	6.59	0.12	0.23	0.14	0.04	2.99	1.86	0.01	0.53	4.54
Nov	1977-1982	Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
		Mean	11.00	77.40	1.50	7.11	46.88	10.10	12.40	0.31	0.10	0.02	0.08	4.95	4.85	0.02	0.68	12.02
		Median	11.00	77.00	1.50	7.04	45.20	9.68	14.40	0.31	0.02	0.02	0.05	5.30	4.55	0.02	0.55	11.40
		Min	11.00	77.00	1.50	6.93	36.60	8.20	2.00	0.25	0.02	0.02	0.05	3.70	3.50	0.00	0.44	10.20
		Max	11.00	79.00	1.50	7.48	68.90	12.84	17.00	0.39	0.50	0.02	0.14	5.80	6.30	0.03	1.09	16.20
		Std dev	0.00	0.89	0.00	0.22	13.06	1.71	5.94	0.06	0.20	0.00	0.04	0.96	1.14	0.01	0.26	2.19
	1989-1996	Count	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	11.00	92.00	4.23	7.94	25.30	8.83	13.10	0.31	0.18	0.04	0.12	4.37	4.63	0.01	0.47	10.20
		Median	11.00	91.00	4.20	7.92	22.60	8.78	13.60	0.31	0.21	0.04	0.15	3.90	4.50	0.01	0.37	9.40

X1019Q01																		
			Cl-Diss-Water (mg/L)	Ca-Diss-Water (mg/L)	DMS-Tot-Water (mg/L)	pH-Diss-Water	TAL-Diss-Water (mg/L)	Si-Diss-Water (mg/L)	SO4-Diss-Water (mg/L)	SAR-Diss-Water (null)	NO3+NO2-N-Ddss-Water (mg/L)	NH4-N-Diss-Water (mg/L)	F-Diss-Water (mg/L)	Na-Diss-Water (mg/L)	Mg-Diss-Water (mg/L)	PO4-P-Diss-Water (mg/L)	K-Diss-Water (mg/L)	EC-Phys-Water (mS/m)
		Min	11.00	89.00	3.90	7.54	22.10	8.28	5.60	0.27	0.12	0.02	0.05	3.60	3.60	0.01	0.35	9.00
		Max	11.00	96.00	4.60	8.37	31.20	9.44	20.10	0.36	0.22	0.05	0.17	5.60	5.80	0.01	0.69	12.20
		Std dev	0.00	3.61	0.35	0.42	5.12	0.58	7.26	0.05	0.05	0.01	0.06	1.08	1.11	0.00	0.19	1.74
Dec	**1977-1982**	**Count**	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
		Mean	12.00	78.25	2.44	6.89	35.11	8.84	12.49	0.31	0.03	0.04	0.09	4.36	4.34	0.02	0.50	10.10
		Median	12.00	77.50	1.50	6.86	35.70	8.79	12.45	0.30	0.02	0.04	0.08	4.20	4.40	0.01	0.49	10.15
		Min	12.00	77.00	1.50	6.30	19.30	7.47	9.00	0.17	0.02	0.02	0.05	2.20	3.00	0.00	0.15	7.10
		Max	12.00	81.00	5.60	7.52	47.20	10.35	16.20	0.50	0.05	0.07	0.20	7.80	5.70	0.05	0.94	12.40
		Std dev	0.00	1.58	1.49	0.41	8.40	0.97	2.65	0.11	0.01	0.02	0.05	1.78	0.97	0.02	0.28	1.52
	1989-1996	**Count**	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	12.00	90.00	7.00	7.57	16.90	7.87	11.60	0.22	0.22	0.10	0.16	2.90	4.80	0.01	0.45	9.20
		Median	12.00	90.00	7.00	7.57	16.90	7.87	11.60	0.22	0.22	0.10	0.16	2.90	4.80	0.01	0.45	9.20
		Min	12.00	90.00	7.00	7.57	16.90	7.87	11.60	0.22	0.22	0.10	0.16	2.90	4.80	0.01	0.45	9.20
		Max	12.00	90.00	7.00	7.57	16.90	7.87	11.60	0.22	0.22	0.10	0.16	2.90	4.80	0.01	0.45	9.20
		Std dev	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix B

Salt Water Quality Assessments using Jooste's Inorganic Salt Assessment Method

Where:
All = All available data
RC = Reference Condition
PES = Present Ecological Status

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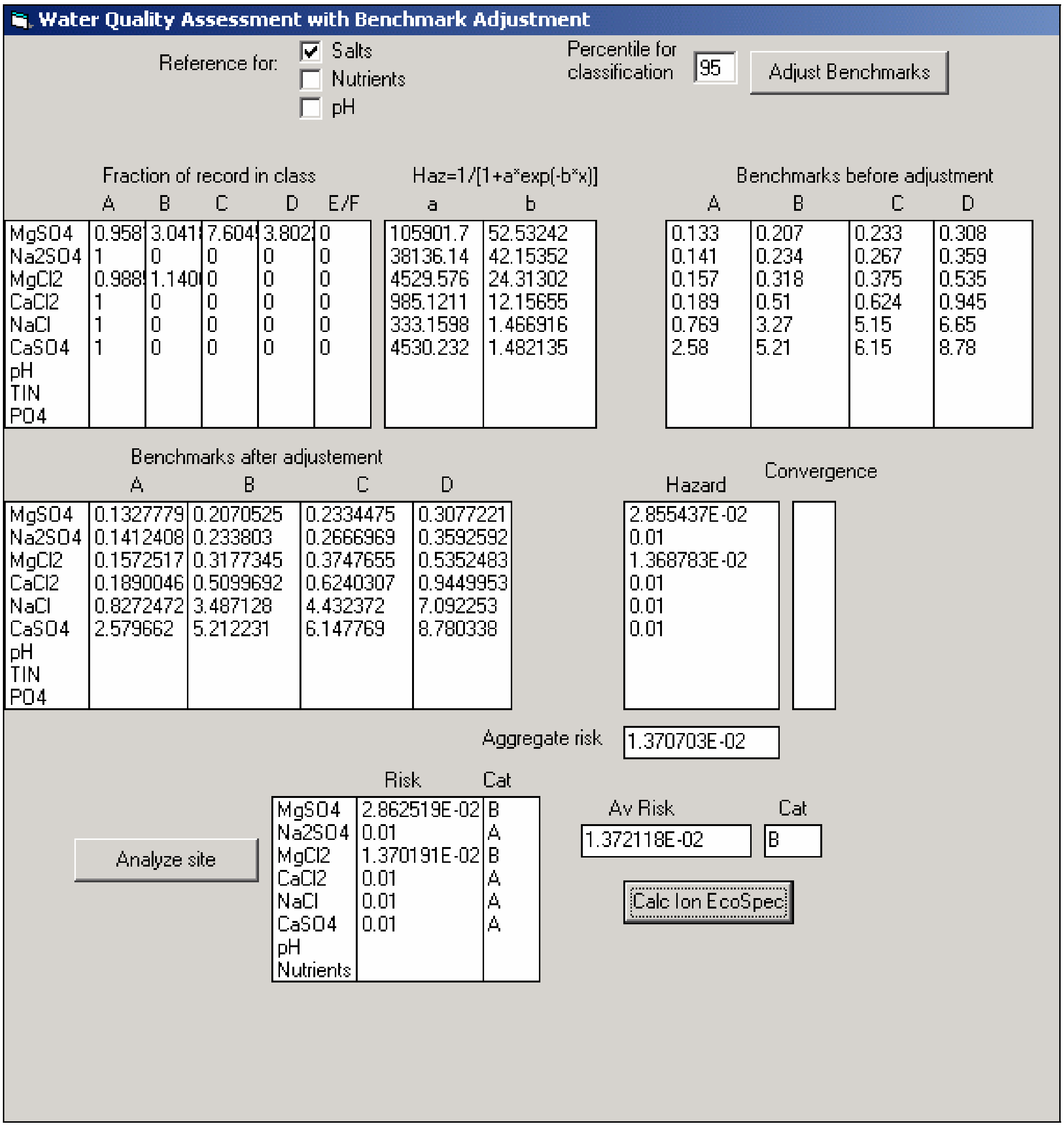
X1H001Q01

All data



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95

Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.958	3.041	7.604	3.802	0	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	0.988	1.140	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	2.855437E-02	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	1.368783E-02	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 1.370703E-02

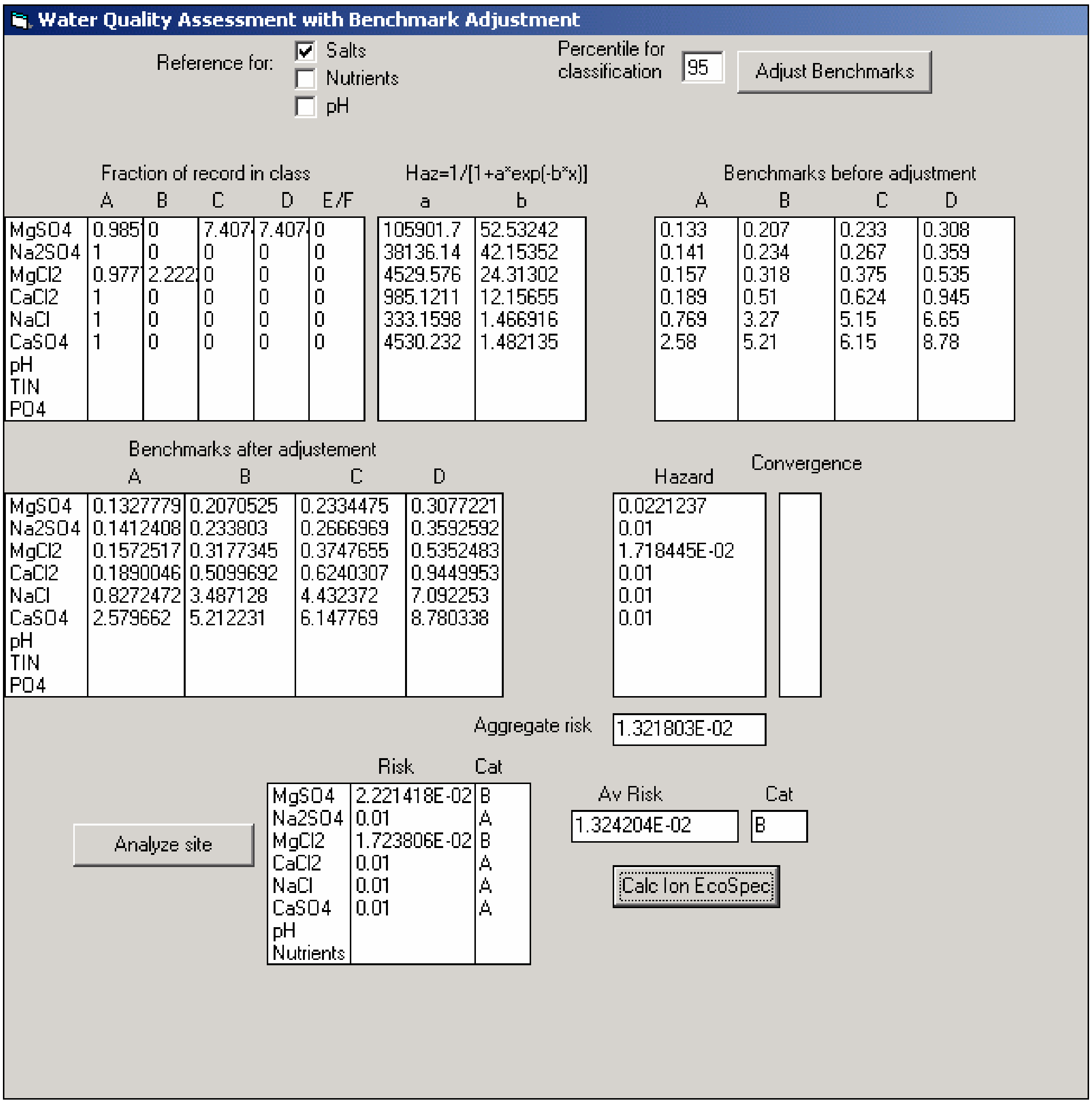
Analyze site

	Risk	Cat
MgSO4	2.862519E-02	B
Na2SO4	0.01	A
MgCl2	1.370191E-02	B
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

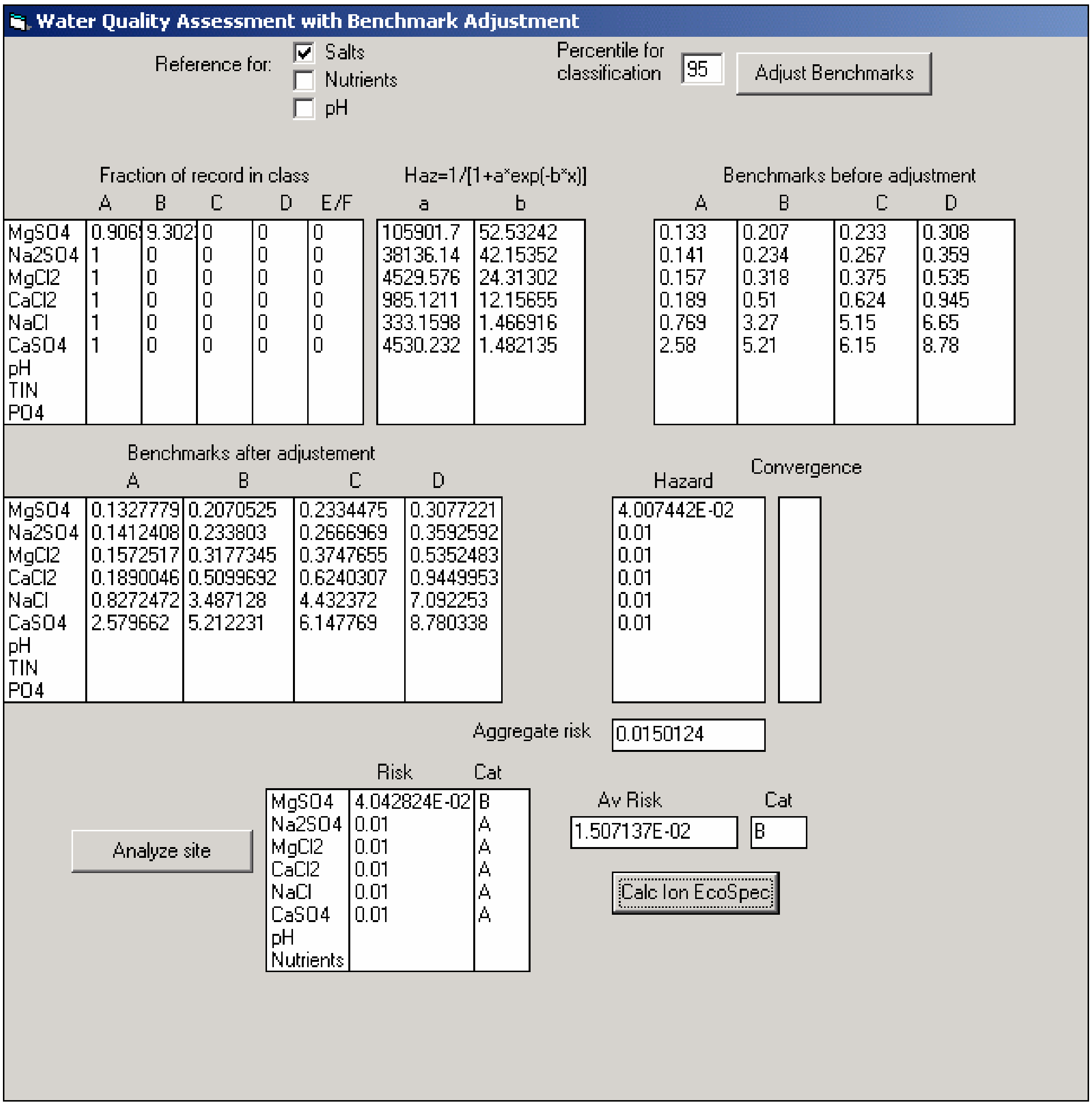
Av Risk	Cat
1.372118E-02	B

Calc Ion EcoSpec

RC


Water Quality Assessment with Benchmark Adjustment
Reference for:
Salts
Nutrients
pH
Percentile for classification
95
Adjust Benchmarks
Fraction of record in class
A B C D E/F
Haz=1/[1+a*exp(-b*x)]
a b
Benchmarks before adjustment
A B C D
MgSO4 0.985 0 7.407 7.407 0 105901.7 52.53242 0.133 0.207 0.233 0.308
Na2SO4 1 0 0 0 0 38136.14 42.15352 0.141 0.234 0.267 0.359
MgCl2 0.977 2.222 0 0 0 4529.576 24.31302 0.157 0.318 0.375 0.535
CaCl2 1 0 0 0 0 985.1211 12.15655 0.189 0.51 0.624 0.945
NaCl 1 0 0 0 0 333.1598 1.466916 0.769 3.27 5.15 6.65
CaSO4 1 0 0 0 0 4530.232 1.482135 2.58 5.21 6.15 8.78
pH
TIN
PO4
Benchmarks after adjustement
A B C D
Hazard
Convergence
MgSO4 0.1327779 0.2070525 0.2334475 0.3077221 0.0221237
Na2SO4 0.1412408 0.233803 0.2666969 0.3592592 0.01
MgCl2 0.1572517 0.3177345 0.3747655 0.5352483 1.718445E-02
CaCl2 0.1890046 0.5099692 0.6240307 0.9449953 0.01
NaCl 0.8272472 3.487128 4.432372 7.092253 0.01
CaSO4 2.579662 5.212231 6.147769 8.780338 0.01
pH
TIN
PO4
Aggregate risk
1.321803E-02
Risk Cat
MgSO4 2.221418E-02 B
Na2SO4 0.01 A
MgCl2 1.723806E-02 B
CaCl2 0.01 A
NaCl 0.01 A
CaSO4 0.01 A
pH
Nutrients
Analyze site
Av Risk
Cat
1.324204E-02
B
Calc Ion EcoSpec

PES



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.906	9.302	0	0	0	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	4.007442E-02	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 0.0150124

Analyze site

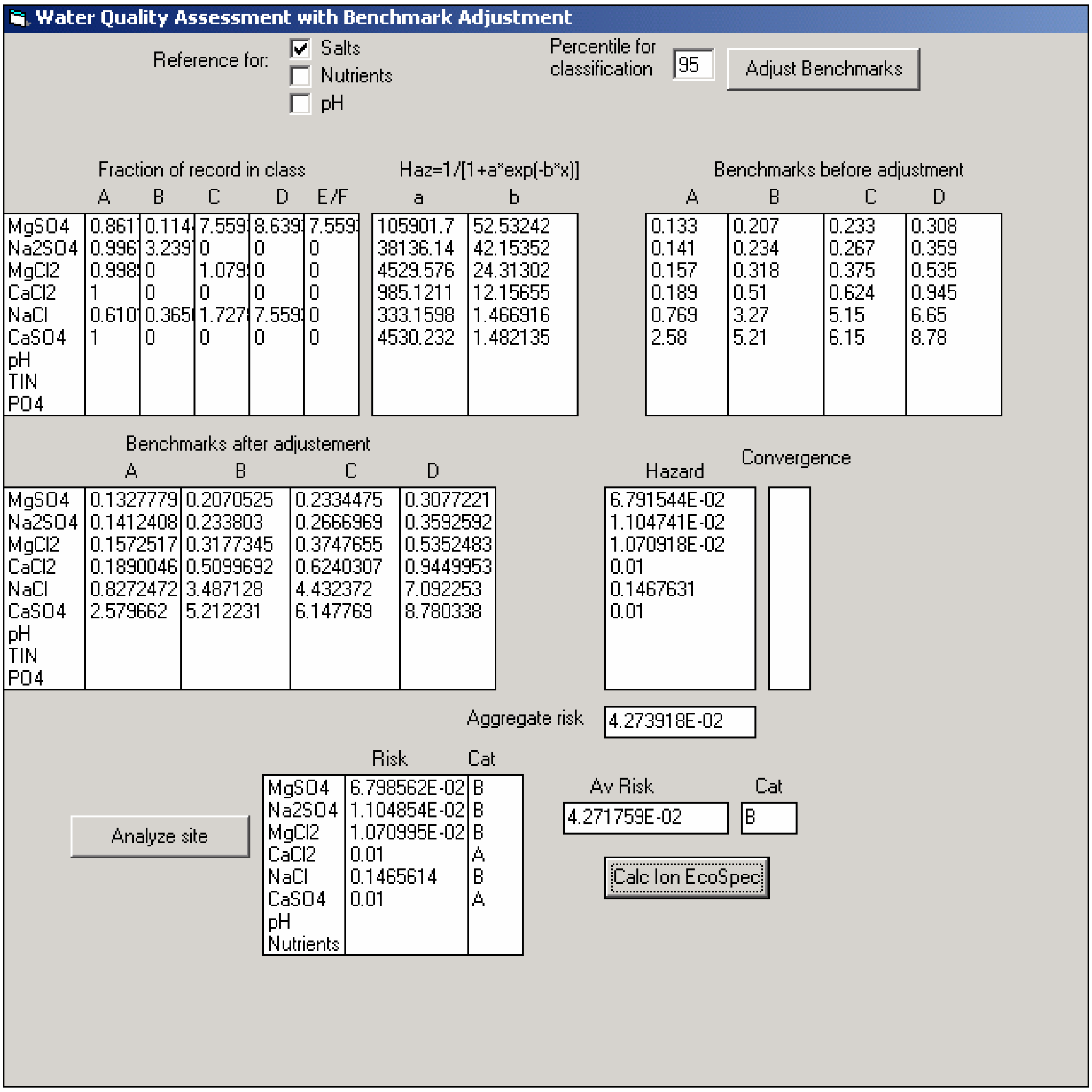
	Risk	Cat
MgSO4	4.042824E-02	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 1.507137E-02 — Cat: B

Calc Ion EcoSpec

X1H003Q01

All data



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class

	A	B	C	D	E/F
MgSO4	0.861	0.114	7.559	8.639	7.559
Na2SO4	0.996	3.239	0	0	0
MgCl2	0.998	0	1.079	0	0
CaCl2	1	0	0	0	0
NaCl	0.610	0.365	1.727	7.559	0
CaSO4	1	0	0	0	0
pH					
TIN					
PO4					

Haz=1/[1+a*exp(-b*x)]

a	b
105901.7	52.53242
38136.14	42.15352
4529.576	24.31302
985.1211	12.15655
333.1598	1.466916
4530.232	1.482135

Benchmarks before adjustment

A	B	C	D
0.133	0.207	0.233	0.308
0.141	0.234	0.267	0.359
0.157	0.318	0.375	0.535
0.189	0.51	0.624	0.945
0.769	3.27	5.15	6.65
2.58	5.21	6.15	8.78

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	6.791544E-02	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	1.104741E-02	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	1.070918E-02	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.1467631	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 4.273918E-02

Analyze site

	Risk	Cat
MgSO4	6.798562E-02	B
Na2SO4	1.104854E-02	B
MgCl2	1.070995E-02	B
CaCl2	0.01	A
NaCl	0.1465614	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 4.271759E-02 — Cat: B

Calc Ion EcoSpec

RC

Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.991	7.856	0	1.122	0	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	0.943	5.611	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	1.363984E-02	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	2.814254E-02	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 0.0136304

Analyze site

	Risk	Cat
MgSO4	1.364393E-02	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	2.816292E-02	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk	Cat
1.363447E-02	B

Calc Ion EcoSpec

PES

Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class; Haz=1/[1+a*exp(-b*x)]; Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.808	0.149	1.197	1.796	1.197	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	0.997	0	2.994	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	0.583	0.353	4.191	2.095	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement; Hazard; Convergence

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	9.571198E-02	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	1.196617E-02	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.172285	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 5.166053E-02

Analyze site

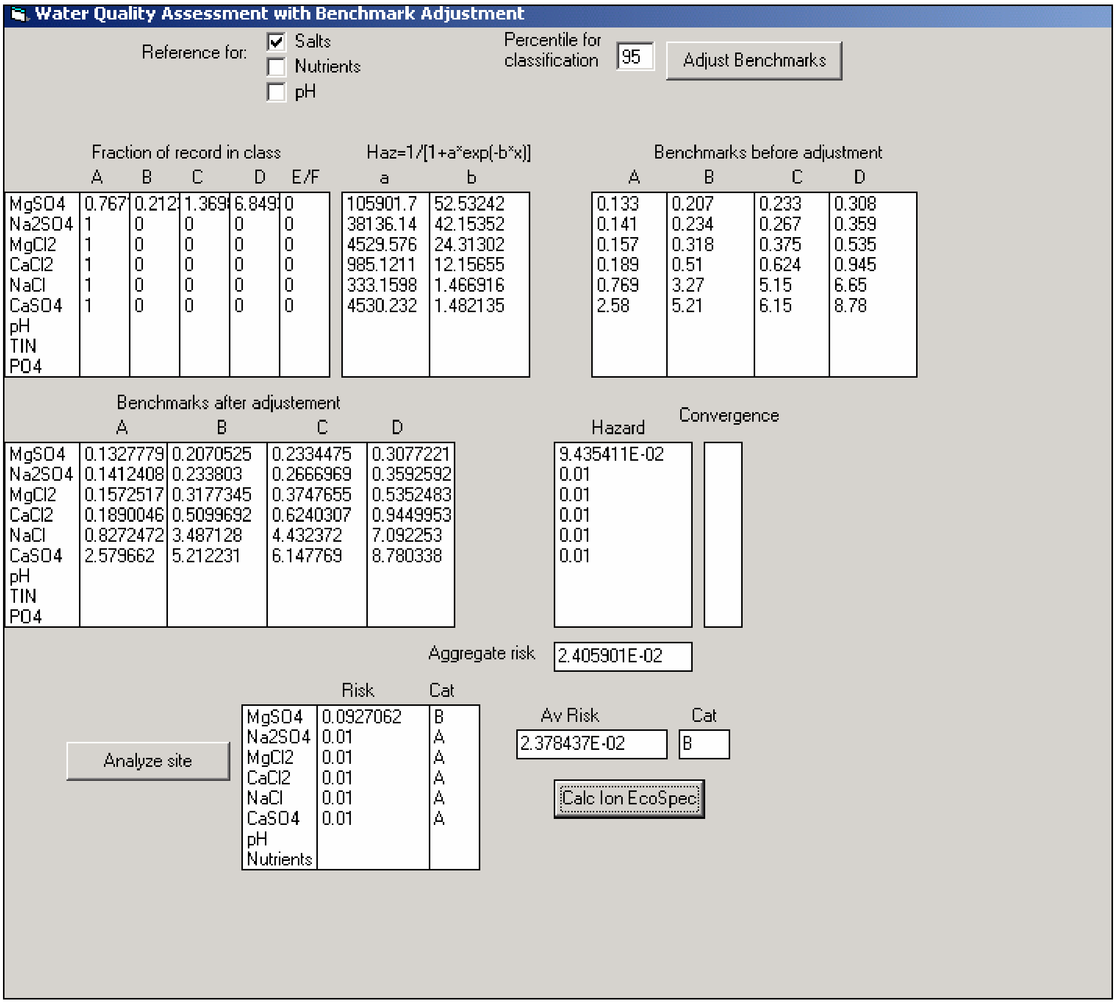
	Risk	Cat
MgSO4	9.598138E-02	B
Na2SO4	0.01	A
MgCl2	1.197207E-02	B
CaCl2	0.01	A
NaCl	0.1718015	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk	Cat
5.162583E-02	B

Calc Ion EcoSpec

X1H019Q01

All data



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.767	0.212	1.369	6.849	0	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	9.435411E-02	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 2.405901E-02

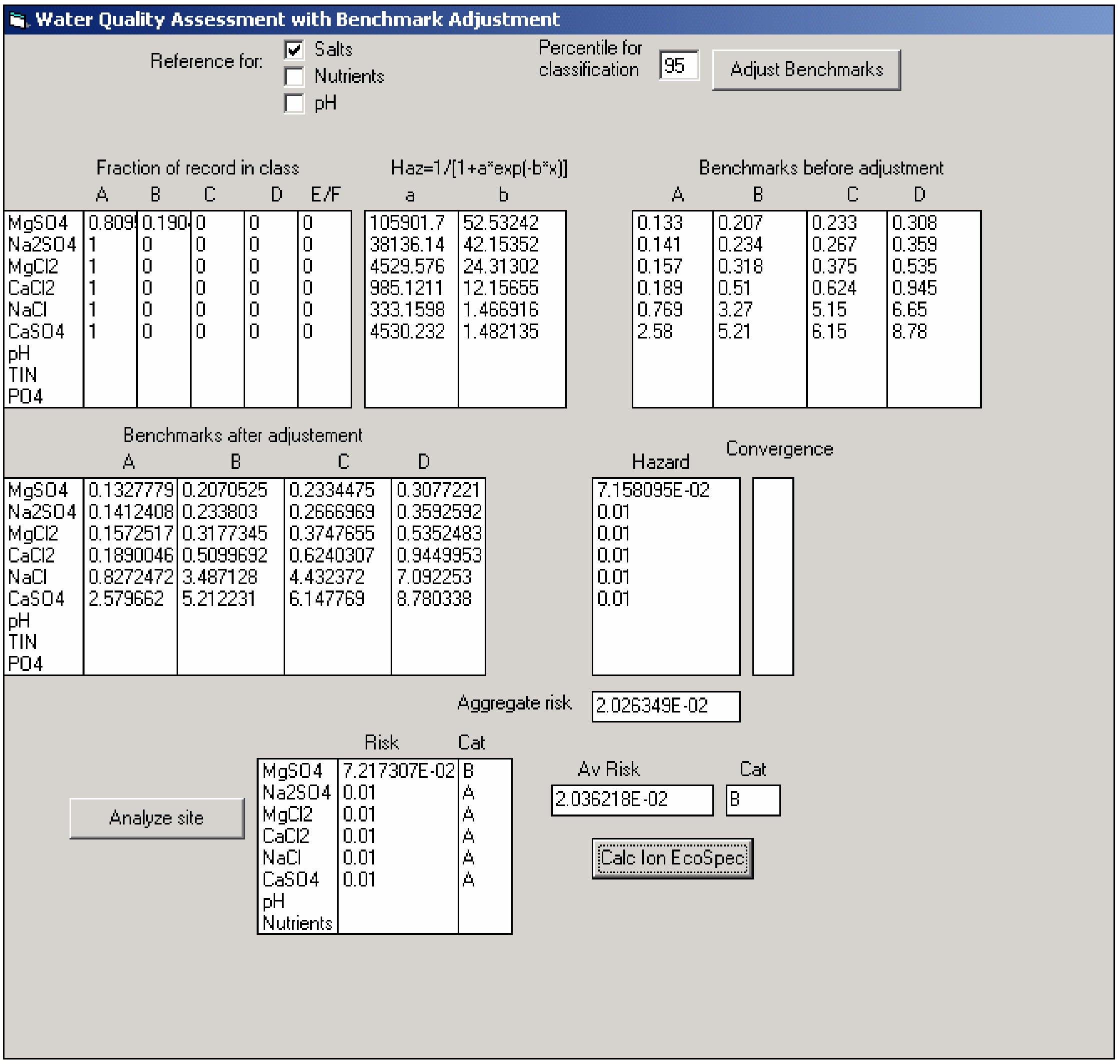
	Risk	Cat
MgSO4	0.0927062	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Analyze site

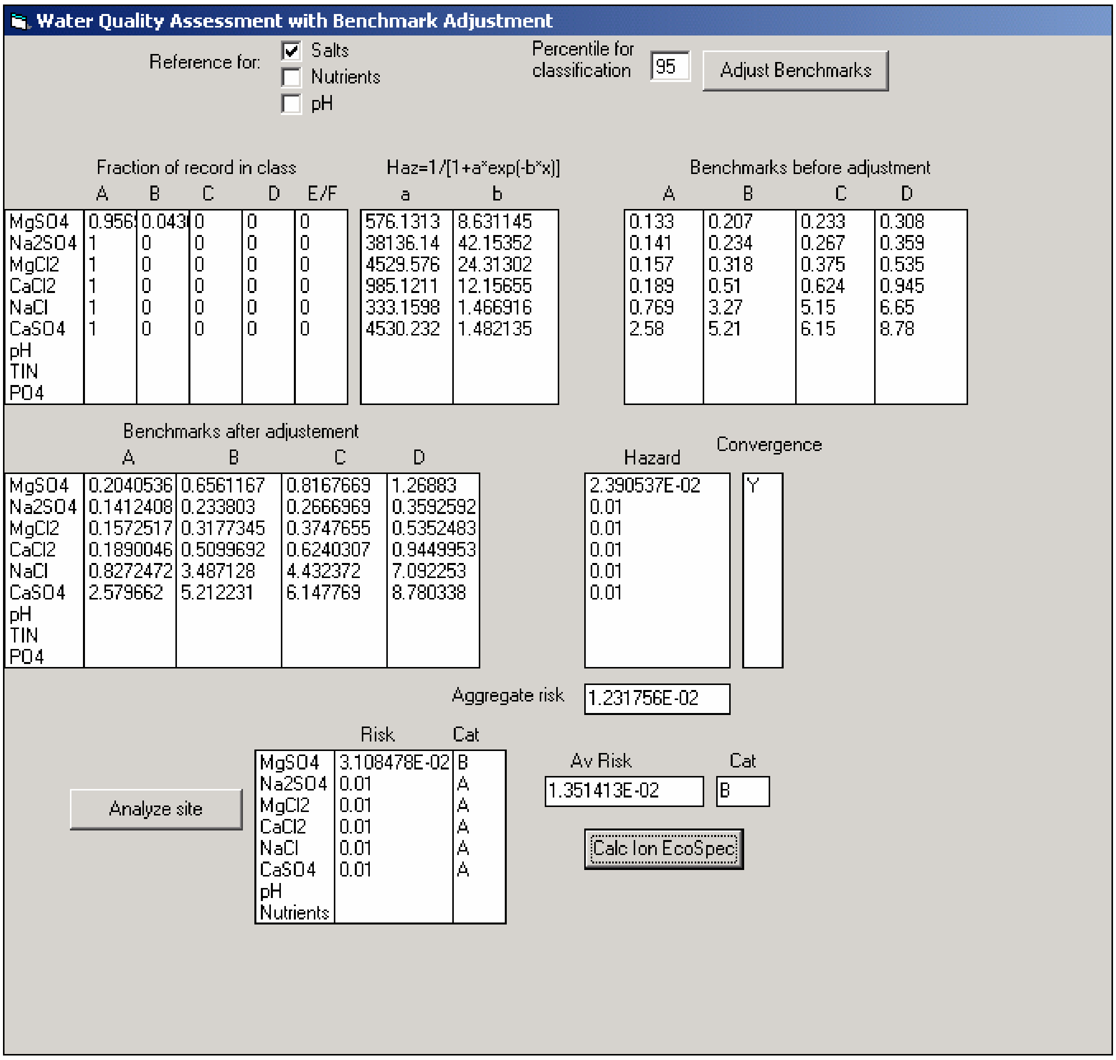
Av Risk: 2.378437E-02 — Cat: B

Calc Ion EcoSpec

RC


Water Quality Assessment with Benchmark Adjustment
Reference for:
Salts
Nutrients
pH
Percentile for classification
95
Adjust Benchmarks
Fraction of record in class
A B C D E/F
MgSO4 0.809 0.190 0 0 0
Na2SO4 1 0 0 0 0
MgCl2 1 0 0 0 0
CaCl2 1 0 0 0 0
NaCl 1 0 0 0 0
CaSO4 1 0 0 0 0
pH
TIN
PO4
Haz=1/[1+a*exp(-b*x)]
a b
105901.7 52.53242
38136.14 42.15352
4529.576 24.31302
985.1211 12.15655
333.1598 1.466916
4530.232 1.482135
Benchmarks before adjustment
A B C D
0.133 0.207 0.233 0.308
0.141 0.234 0.267 0.359
0.157 0.318 0.375 0.535
0.189 0.51 0.624 0.945
0.769 3.27 5.15 6.65
2.58 5.21 6.15 8.78
Benchmarks after adjustement
A B C D
MgSO4 0.1327779 0.2070525 0.2334475 0.3077221
Na2SO4 0.1412408 0.233803 0.2666969 0.3592592
MgCl2 0.1572517 0.3177345 0.3747655 0.5352483
CaCl2 0.1890046 0.5099692 0.6240307 0.9449953
NaCl 0.8272472 3.487128 4.432372 7.092253
CaSO4 2.579662 5.212231 6.147769 8.780338
pH
TIN
PO4
Hazard
7.158095E-02
0.01
0.01
0.01
0.01
0.01
Convergence
Aggregate risk 2.026349E-02
Risk Cat
MgSO4 7.217307E-02 B
Na2SO4 0.01 A
MgCl2 0.01 A
CaCl2 0.01 A
NaCl 0.01 A
CaSO4 0.01 A
pH
Nutrients
Analyze site
Av Risk 2.036218E-02
Cat B
Calc Ion EcoSpec

PES



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95

Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)]

	A	B	C	D	E/F	a	b
MgSO4	0.956	0.043	0	0	0	576.1313	8.631145
Na2SO4	1	0	0	0	0	38136.14	42.15352
MgCl2	1	0	0	0	0	4529.576	24.31302
CaCl2	1	0	0	0	0	985.1211	12.15655
NaCl	1	0	0	0	0	333.1598	1.466916
CaSO4	1	0	0	0	0	4530.232	1.482135
pH							
TIN							
PO4							

Benchmarks before adjustment

A	B	C	D
0.133	0.207	0.233	0.308
0.141	0.234	0.267	0.359
0.157	0.318	0.375	0.535
0.189	0.51	0.624	0.945
0.769	3.27	5.15	6.65
2.58	5.21	6.15	8.78

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.2040536	0.6561167	0.8167669	1.26883	2.390537E-02	Y
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 1.231756E-02

Analyze site

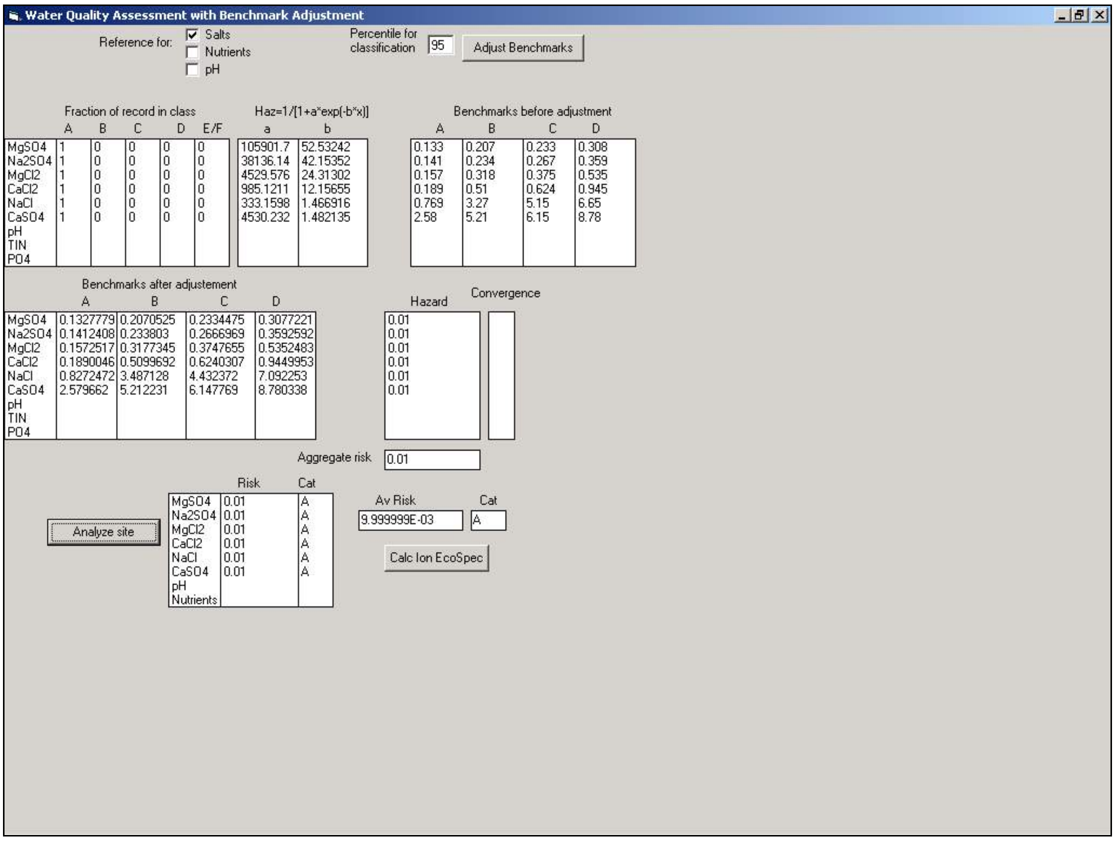
	Risk	Cat
MgSO4	3.108478E-02	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 1.351413E-02 Cat: B

Calc Ion EcoSpec

X1H021Q01

First 10 Years


Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	1	0	0	0	0	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.01	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 0.01

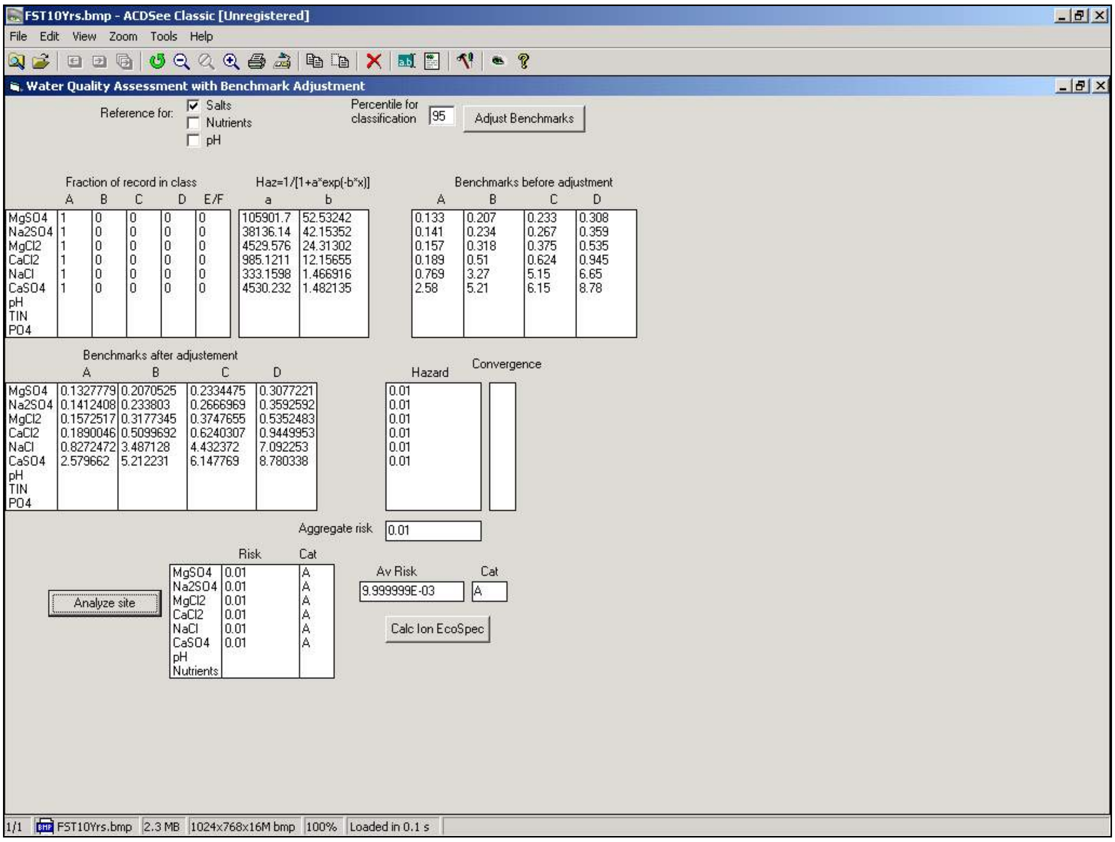
Analyze site

	Risk	Cat
MgSO4	0.01	A
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 9.999999E-03 — Cat: A

Calc Ion EcoSpec

Last 5 Years


FST10Yrs.bmp - ACDSee Classic [Unregistered]
File Edit View Zoom Tools Help
Water Quality Assessment with Benchmark Adjustment
Reference for:
Salts
Nutrients
pH
Percentile for classification
95
Adjust Benchmarks
Fraction of record in class
A B C D E/F
Haz=1/[1+a*exp(-b*x)]
a b
Benchmarks before adjustment
A B C D
MgSO4 1 0 0 0 0 105901.7 52.53242 0.133 0.207 0.233 0.308
Na2SO4 1 0 0 0 0 38136.14 42.15352 0.141 0.234 0.267 0.359
MgCl2 1 0 0 0 0 4529.576 24.31302 0.157 0.318 0.375 0.535
CaCl2 1 0 0 0 0 985.1211 12.15655 0.189 0.51 0.624 0.945
NaCl 1 0 0 0 0 333.1598 1.466916 0.769 3.27 5.15 6.65
CaSO4 1 0 0 0 0 4530.232 1.482135 2.58 5.21 6.15 8.78
pH
TIN
PO4
Benchmarks after adjustement
A B C D
Hazard
Convergence
MgSO4 0.1327779 0.2070525 0.2334475 0.3077221 0.01
Na2SO4 0.1412408 0.233803 0.2666969 0.3592592 0.01
MgCl2 0.1572517 0.3177345 0.3747655 0.5352483 0.01
CaCl2 0.1890046 0.5099692 0.6240307 0.9449953 0.01
NaCl 0.8272472 3.487128 4.432372 7.092253 0.01
CaSO4 2.579662 5.212231 6.147769 8.780338 0.01
pH
TIN
PO4
Aggregate risk 0.01
Risk Cat
Analyze site
MgSO4 0.01 A
Na2SO4 0.01 A
MgCl2 0.01 A
CaCl2 0.01 A
NaCl 0.01 A
CaSO4 0.01 A
pH
Nutrients
Av Risk Cat
9.999999E-03 A
Calc Ion EcoSpec
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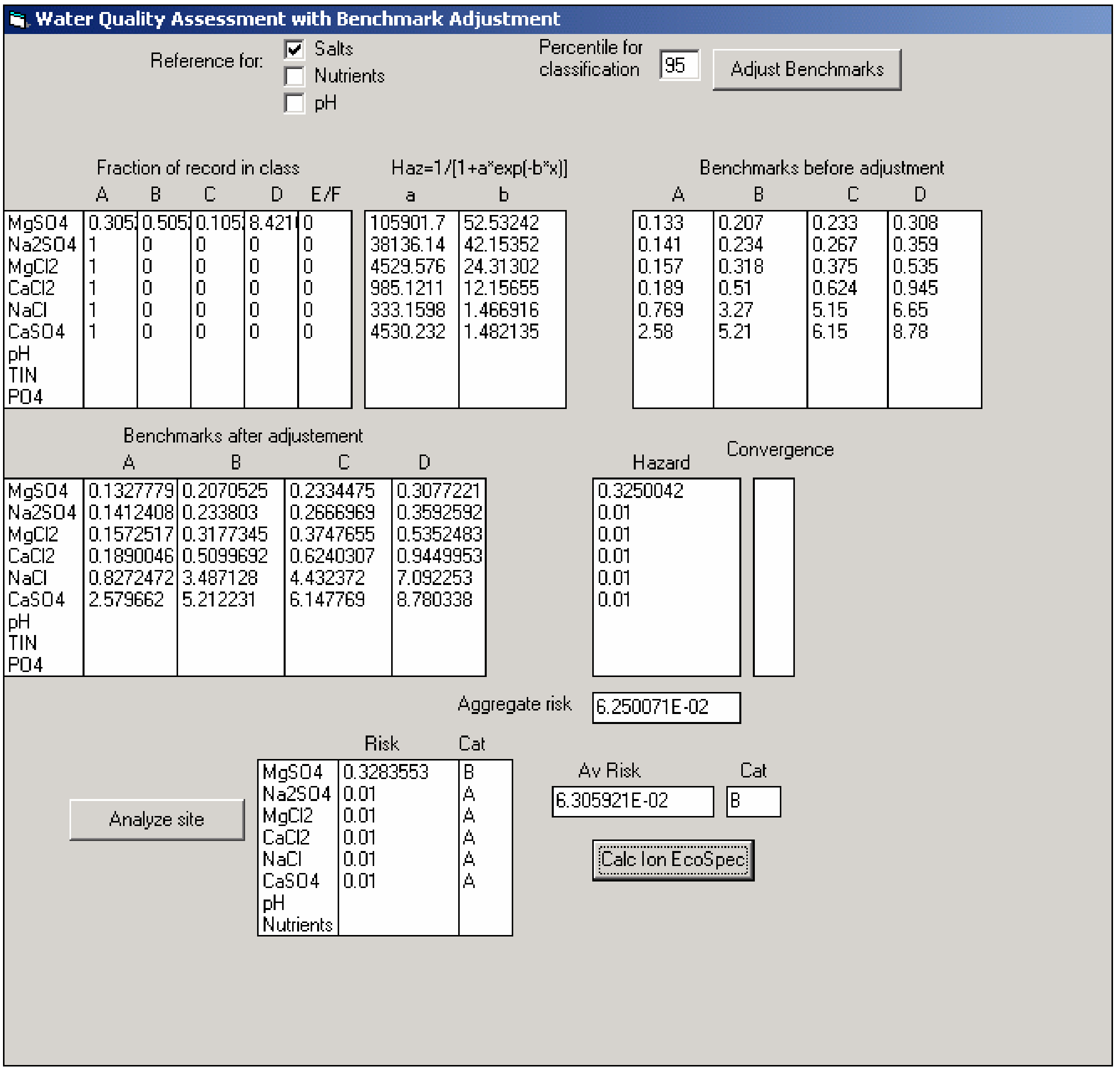
X1H033Q01

All data



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

	Fraction of record in class A	B	C	D	E/F	Haz=1/[1+a*exp(-b*x)] a	b	Benchmarks before adjustment A	B	C	D
MgSO4	0.305	0.505	0.105	8.421	0	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

	Benchmarks after adjustement A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.3250042	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 6.250071E-02

Analyze site

	Risk	Cat
MgSO4	0.3283553	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 6.305921E-02 — Cat: B

Calc Ion EcoSpec

RC

Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

	Fraction of record in class A	B	C	D	E/F	Haz=1/[1+a*exp(-b*x)] a	b	Benchmarks before adjustment A	B	C	D
MgSO4	0.962	3.738	0	0	0	644.6602	9.082439	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

	Benchmarks after adjustement A	B	C	D	Hazard	Convergence
MgSO4	0.2062886	0.6358893	0.7885569	1.218158	2.208598E-02	Y
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 1.201433E-02

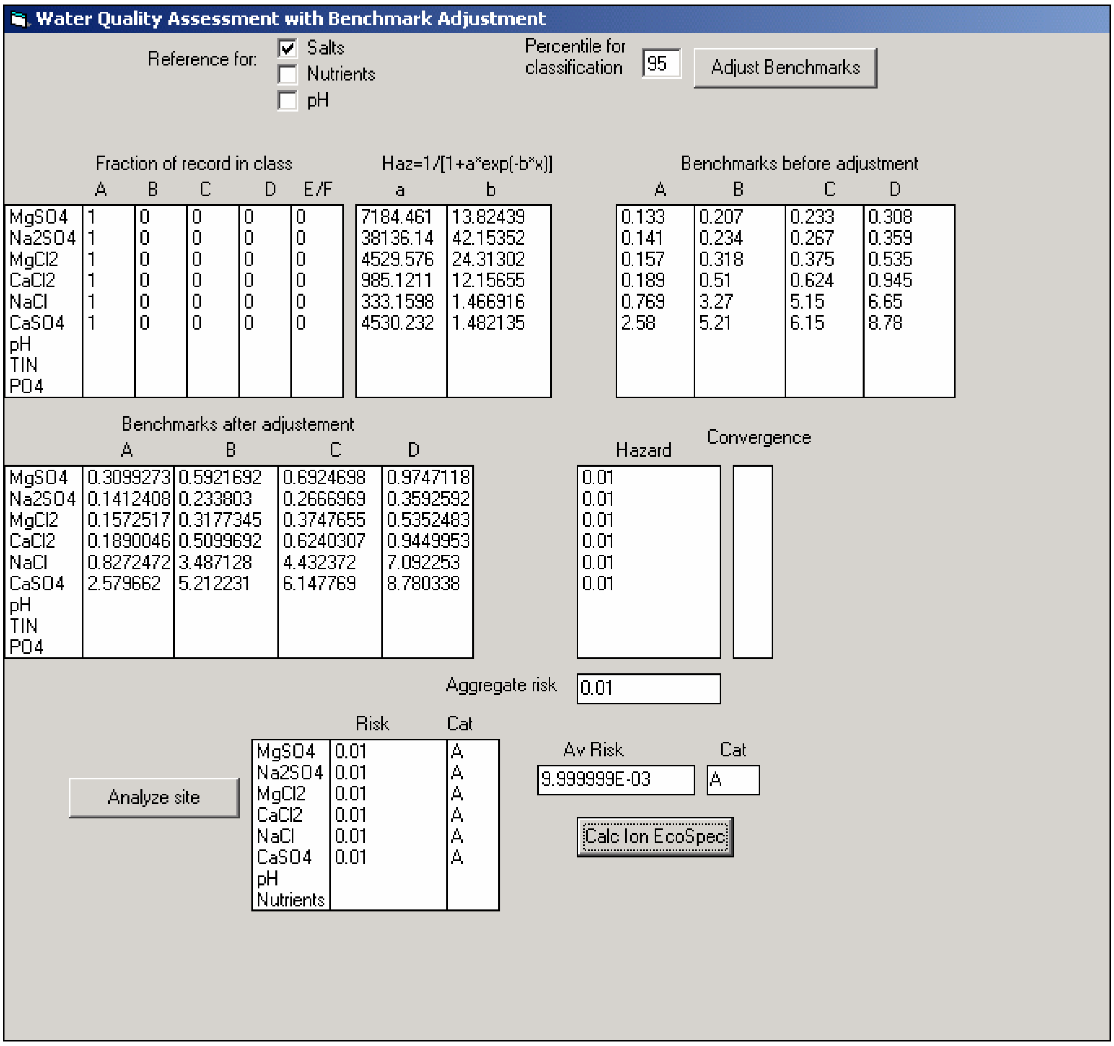
Analyze site

	Risk	Cat
MgSO4	0.0222	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk	Cat
1.203333E-02	B

Calc Ion EcoSpec

PES


Water Quality Assessment with Benchmark Adjustment
Reference for:
Salts
Nutrients
pH
Percentile for classification
95
Adjust Benchmarks
Fraction of record in class
A B C D E/F
Haz=1/[1+a*exp(-b*x)]
a b
Benchmarks before adjustment
A B C D
MgSO4 1 0 0 0 0 7184.461 13.82439 0.133 0.207 0.233 0.308
Na2SO4 1 0 0 0 0 38136.14 42.15352 0.141 0.234 0.267 0.359
MgCl2 1 0 0 0 0 4529.576 24.31302 0.157 0.318 0.375 0.535
CaCl2 1 0 0 0 0 985.1211 12.15655 0.189 0.51 0.624 0.945
NaCl 1 0 0 0 0 333.1598 1.466916 0.769 3.27 5.15 6.65
CaSO4 1 0 0 0 0 4530.232 1.482135 2.58 5.21 6.15 8.78
pH
TIN
PO4
Benchmarks after adjustement
A B C D
Hazard
Convergence
MgSO4 0.3099273 0.5921692 0.6924698 0.9747118 0.01
Na2SO4 0.1412408 0.233803 0.2666969 0.3592592 0.01
MgCl2 0.1572517 0.3177345 0.3747655 0.5352483 0.01
CaCl2 0.1890046 0.5099692 0.6240307 0.9449953 0.01
NaCl 0.8272472 3.487128 4.432372 7.092253 0.01
CaSO4 2.579662 5.212231 6.147769 8.780338 0.01
pH
TIN
PO4
Aggregate risk 0.01
Risk Cat
MgSO4 0.01 A
Na2SO4 0.01 A
MgCl2 0.01 A
CaCl2 0.01 A
NaCl 0.01 A
CaSO4 0.01 A
pH
Nutrients
Analyze site
Av Risk
9.999999E-03
Cat
A
Calc Ion EcoSpec

X1H042Q01

All data

Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)]

	A	B	C	D	E/F	a	b
MgSO4	0.25	0.258	8.620	0.25	0.155	105901.7	52.53242
Na2SO4	1	0	0	0	0	38136.14	42.15352
MgCl2	0.905	5.172	8.620	3.448	0	4529.576	24.31302
CaCl2	1	0	0	0	0	985.1211	12.15655
NaCl	0.189	0.724	8.620	0	0	333.1598	1.466916
CaSO4	1	0	0	0	0	4530.232	1.482135
pH							
TIN							
PO4							

Benchmarks before adjustment

A	B	C	D
0.133	0.207	0.233	0.308
0.141	0.234	0.267	0.359
0.157	0.318	0.375	0.535
0.189	0.51	0.624	0.945
0.769	3.27	5.15	6.65
2.58	5.21	6.15	8.78

Benchmarks after adjustement

	A	B	C	D	Hazard
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.5486897
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	6.617672E-02
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01
NaCl	0.8272472	3.487128	4.432372	7.092253	0.3007259
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01
pH					
TIN					
PO4					

Convergence

Aggregate risk: 0.1575987

Analyze site

	Risk	Cat
MgSO4	0.5449218	C
Na2SO4	0.01	A
MgCl2	6.666522E-02	B
CaCl2	0.01	A
NaCl	0.3004426	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 0.1570049 — Cat: B

Calc Ion EcoSpec

RC

Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95

Adjust Benchmarks

	Fraction of record in class A	B	C	D	E/F	Haz=1/[1+a*exp(-b*x)] a	b	Benchmarks before adjustment A	B	C	D
MgSO4	0.383	0.260	6.849	0.191	9.589	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	0.986	1.369	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	0.273	0.712	1.369	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

	Benchmarks after adjustement A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.4219069	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	1.442877E-02	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.2492918	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 0.1192712

Analyze site

	Risk	Cat
MgSO4	0.4141139	C
Na2SO4	0.01	A
MgCl2	1.449028E-02	B
CaCl2	0.01	A
NaCl	0.248125	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk	Cat
0.1177882	B

Calc Ion EcoSpec

PES

Water Quality Assessment with Benchmark Adjustment

Reference for: ☑ Salts ☐ Nutrients ☐ pH

Percentile for classification: 95

Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)]

	A	B	C	D	E/F	a	b
MgSO4	0.238	0.265	8.849	0.247	0.159	105901.7	52.53242
Na2SO4	1	0	0	0	0	38136.14	42.15352
MgCl2	0.902	5.309	8.849	3.539	0	4529.576	24.31302
CaCl2	1	0	0	0	0	985.1211	12.15655
NaCl	0.168	0.743	8.849	0	0	333.1598	1.466916
CaSO4	1	0	0	0	0	4530.232	1.482135
pH							
TIN							
PO4							

Benchmarks before adjustment

A	B	C	D
0.133	0.207	0.233	0.308
0.141	0.234	0.267	0.359
0.157	0.318	0.375	0.535
0.189	0.51	0.624	0.945
0.769	3.27	5.15	6.65
2.58	5.21	6.15	8.78

Benchmarks after adjustement

	A	B	C	D
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953
NaCl	0.8272472	3.487128	4.432372	7.092253
CaSO4	2.579662	5.212231	6.147769	8.780338
pH				
TIN				
PO4				

Hazard	Convergence
0.5543186	
0.01	
6.766814E-02	
0.01	
0.3084442	
0.01	

Aggregate risk: 0.1600718

Analyze site

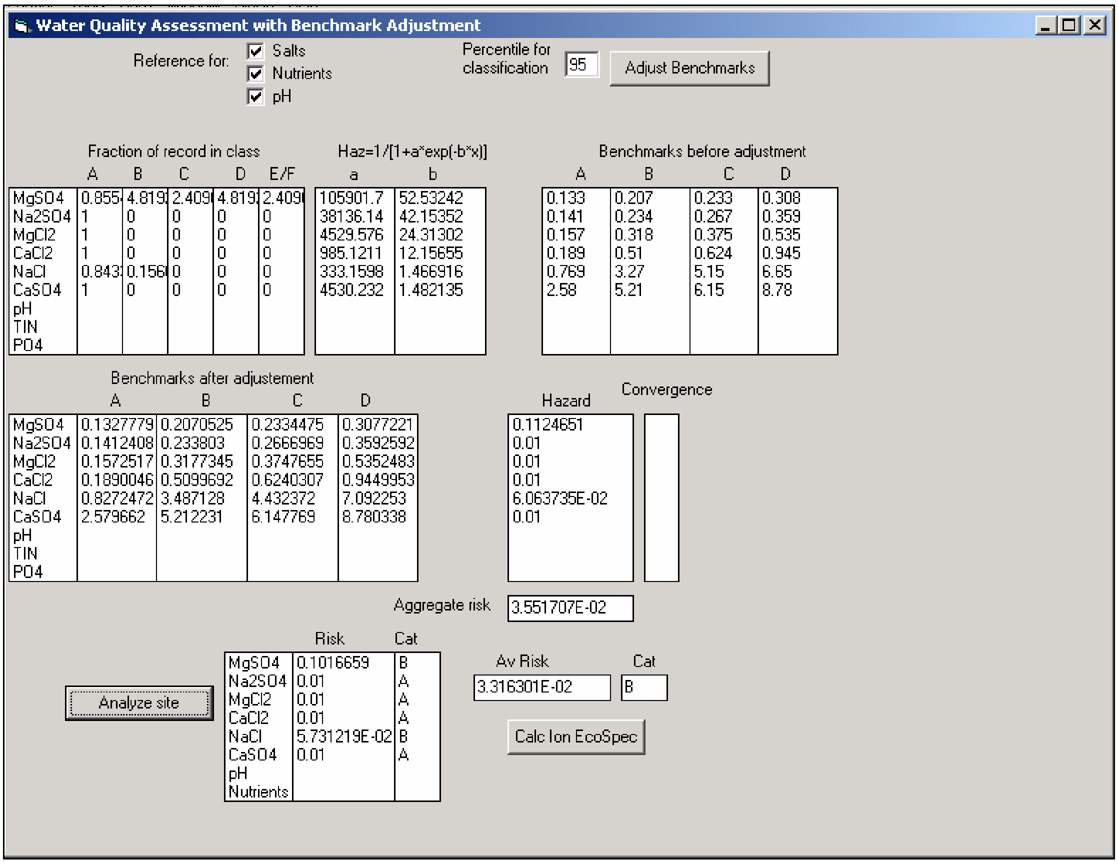
	Risk	Cat
MgSO4	0.5505	C
Na2SO4	0.01	A
MgCl2	6.818303E-02	B
CaCl2	0.01	A
NaCl	0.3082223	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk	Cat
0.1594842	B

Calc Ion EcoSpec

X1H049Q01

All data



Fraction of record in class; Haz=1/[1+a*exp(-b*x)]; Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.855	4.819	2.409	4.819	2.409	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	0.843	0.156	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement; Hazard; Convergence

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.1124651	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	6.063735E-02	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

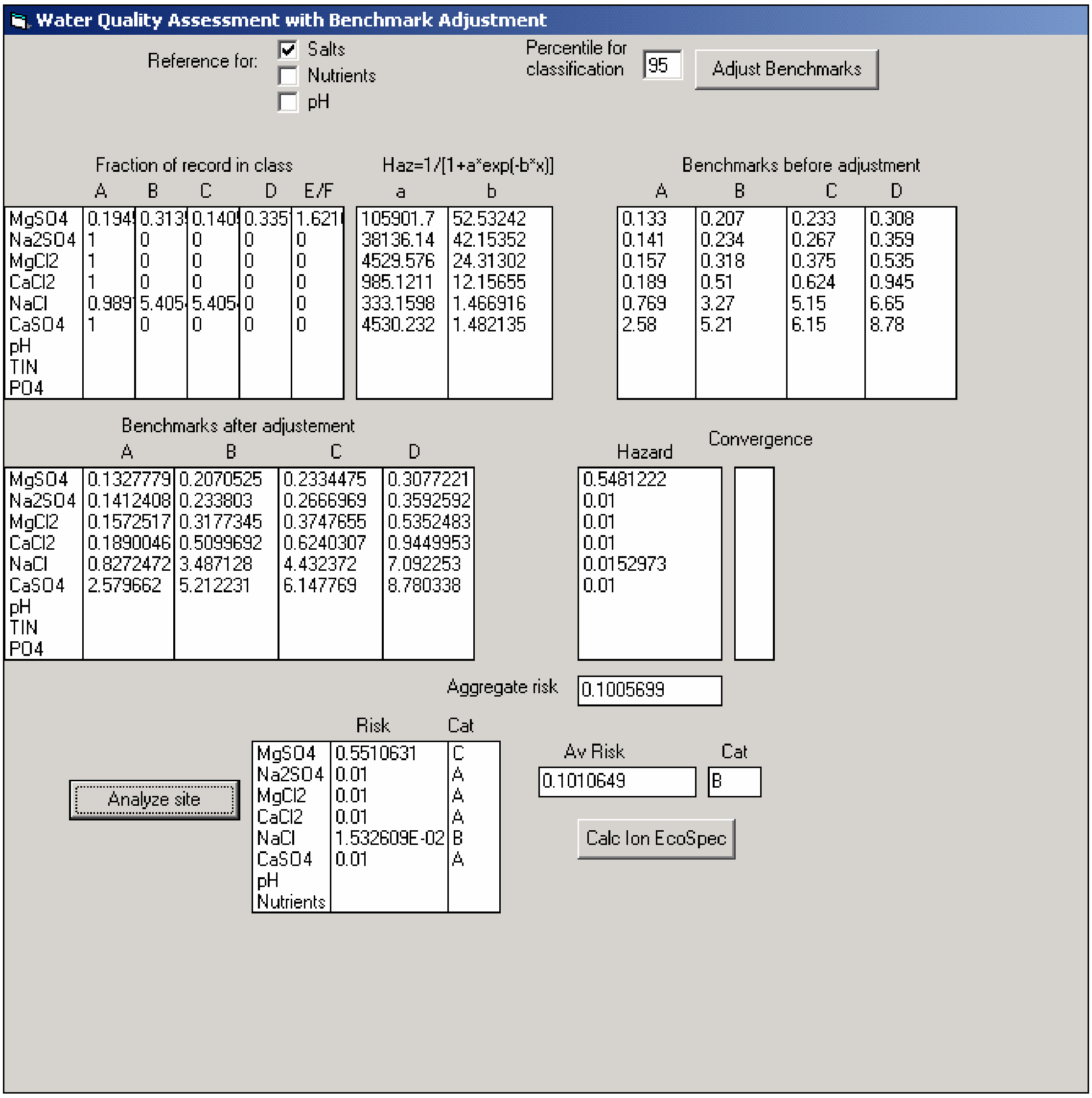
Aggregate risk: 3.551707E-02

	Risk	Cat
MgSO4	0.1016659	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	5.731219E-02	B
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 3.316301E-02 Cat: B

X1R001Q01

All data



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.194	0.313	0.140	0.335	1.621	105901.7	52.53242	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	0.989	5.405	5.405	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustment / Hazard / Convergence

	A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.5481222	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.0152973	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 0.1005699

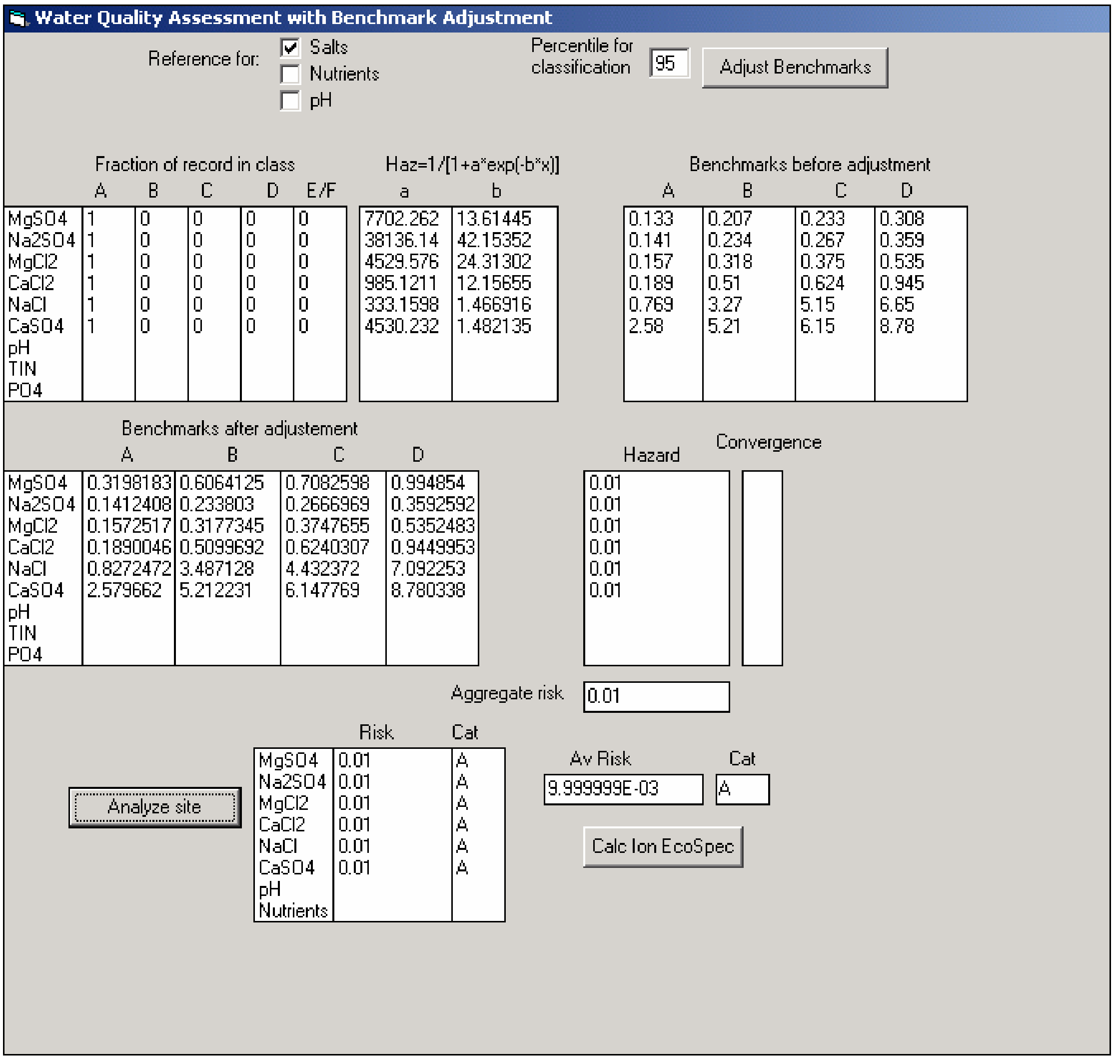
Analyze site

	Risk	Cat
MgSO4	0.5510631	C
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	1.532609E-02	B
CaSO4	0.01	A
pH		
Nutrients		

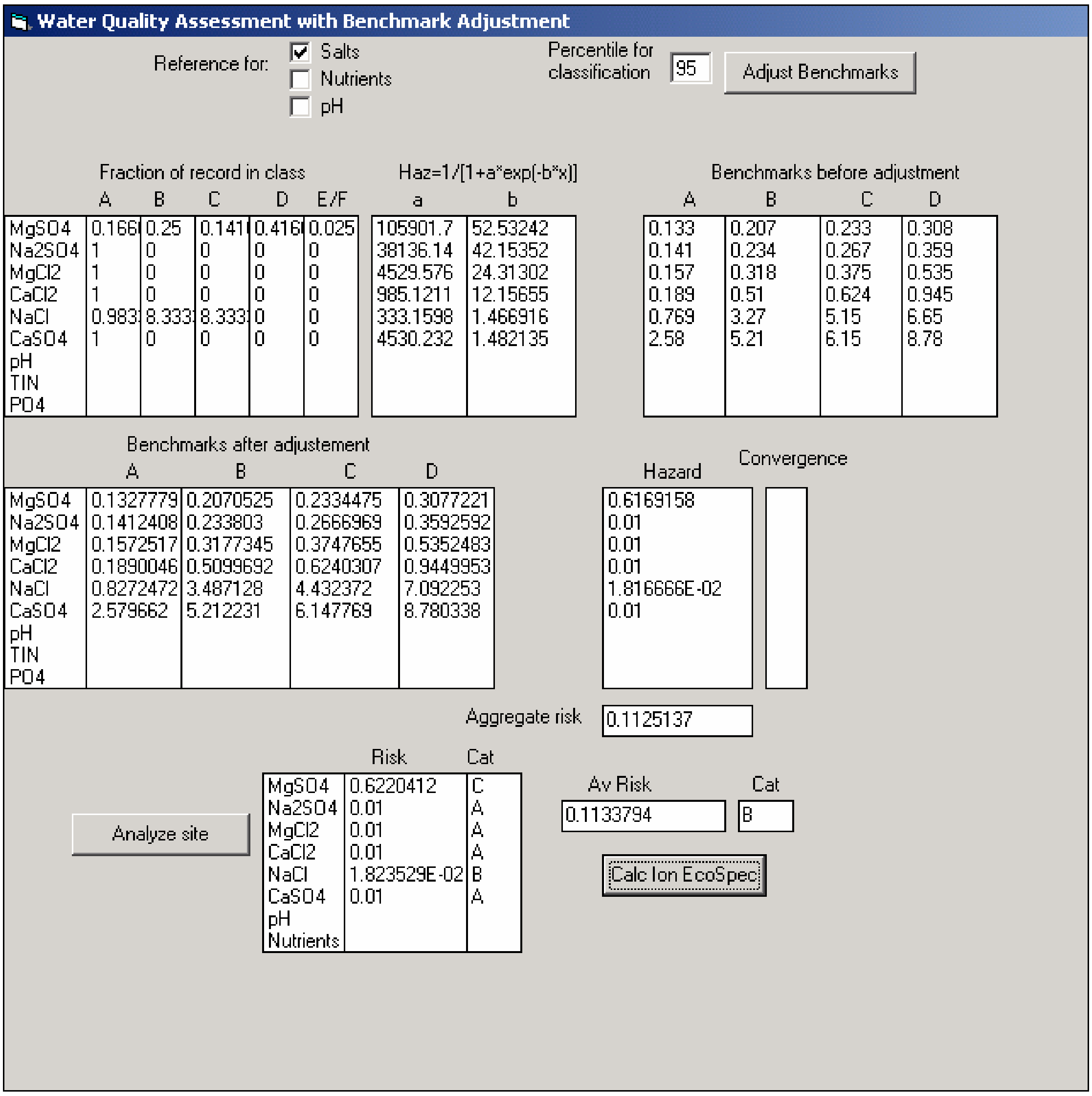
Av Risk: 0.1010649 — Cat: B

Calc Ion EcoSpec

RC

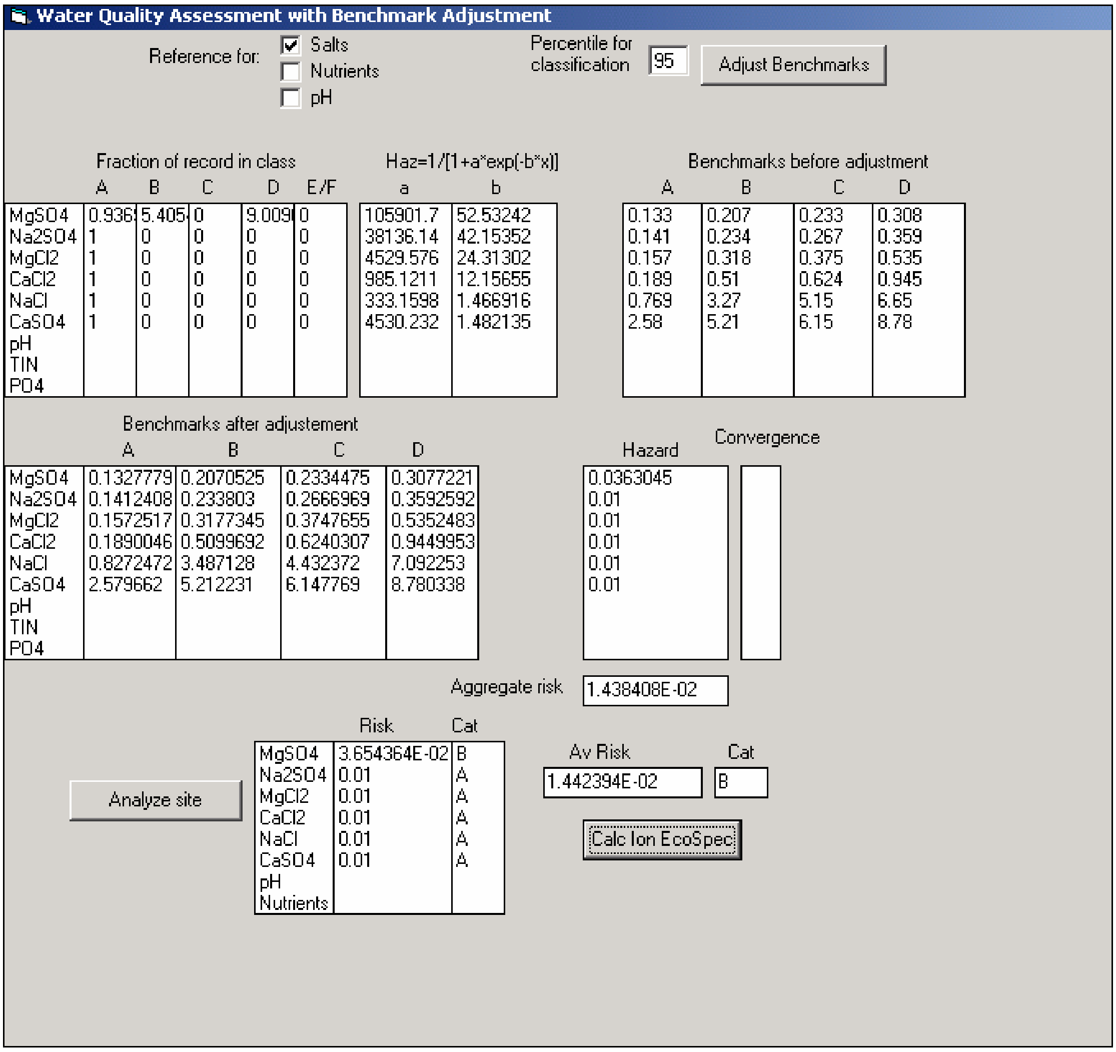

Water Quality Assessment with Benchmark Adjustment
Reference for:
Salts
Nutrients
pH
Percentile for classification
95
Adjust Benchmarks
Fraction of record in class
A B C D E/F
Haz=1/[1+a*exp(-b*x)]
a b
Benchmarks before adjustment
A B C D
MgSO4 1 0 0 0 0 7702.262 13.61445 0.133 0.207 0.233 0.308
Na2SO4 1 0 0 0 0 38136.14 42.15352 0.141 0.234 0.267 0.359
MgCl2 1 0 0 0 0 4529.576 24.31302 0.157 0.318 0.375 0.535
CaCl2 1 0 0 0 0 985.1211 12.15655 0.189 0.51 0.624 0.945
NaCl 1 0 0 0 0 333.1598 1.466916 0.769 3.27 5.15 6.65
CaSO4 1 0 0 0 0 4530.232 1.482135 2.58 5.21 6.15 8.78
pH
TIN
PO4
Benchmarks after adjustment
A B C D
Hazard
Convergence
MgSO4 0.3198183 0.6064125 0.7082598 0.994854 0.01
Na2SO4 0.1412408 0.233803 0.2666969 0.3592592 0.01
MgCl2 0.1572517 0.3177345 0.3747655 0.5352483 0.01
CaCl2 0.1890046 0.5099692 0.6240307 0.9449953 0.01
NaCl 0.8272472 3.487128 4.432372 7.092253 0.01
CaSO4 2.579662 5.212231 6.147769 8.780338 0.01
pH
TIN
PO4
Aggregate risk
0.01
Risk Cat
MgSO4 0.01 A
Na2SO4 0.01 A
MgCl2 0.01 A
CaCl2 0.01 A
NaCl 0.01 A
CaSO4 0.01 A
pH
Nutrients
Analyze site
Av Risk
9.999999E-03
Cat
A
Calc Ion EcoSpec

PES


Water Quality Assessment with Benchmark Adjustment
Reference for:
Salts
Nutrients
pH
Percentile for classification
95
Adjust Benchmarks
Fraction of record in class
A B C D E/F
Haz=1/[1+a*exp(-b*x)]
a b
Benchmarks before adjustment
A B C D
MgSO4 0.166 0.25 0.141 0.416 0.025 105901.7 52.53242 0.133 0.207 0.233 0.308
Na2SO4 1 0 0 0 0 38136.14 42.15352 0.141 0.234 0.267 0.359
MgCl2 1 0 0 0 0 4529.576 24.31302 0.157 0.318 0.375 0.535
CaCl2 1 0 0 0 0 985.1211 12.15655 0.189 0.51 0.624 0.945
NaCl 0.983 8.333 8.333 0 0 333.1598 1.466916 0.769 3.27 5.15 6.65
CaSO4 1 0 0 0 0 4530.232 1.482135 2.58 5.21 6.15 8.78
pH
TIN
PO4
Benchmarks after adjustement
A B C D
Hazard
Convergence
MgSO4 0.1327779 0.2070525 0.2334475 0.3077221 0.6169158
Na2SO4 0.1412408 0.233803 0.2666969 0.3592592 0.01
MgCl2 0.1572517 0.3177345 0.3747655 0.5352483 0.01
CaCl2 0.1890046 0.5099692 0.6240307 0.9449953 0.01
NaCl 0.8272472 3.487128 4.432372 7.092253 1.816666E-02
CaSO4 2.579662 5.212231 6.147769 8.780338 0.01
pH
TIN
PO4
Aggregate risk 0.1125137
Risk Cat
MgSO4 0.6220412 C
Na2SO4 0.01 A
MgCl2 0.01 A
CaCl2 0.01 A
NaCl 1.823529E-02 B
CaSO4 0.01 A
pH
Nutrients
Analyze site
Av Risk 0.1133794
Cat B
Calc Ion EcoSpec

X1R003Q01

All data



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

	Fraction of record in class A	B	C	D	E/F	Haz=1/[1+a*exp(-b*x)] a	b
MgSO4	0.936	5.405	0	9.009	0	105901.7	52.53242
Na2SO4	1	0	0	0	0	38136.14	42.15352
MgCl2	1	0	0	0	0	4529.576	24.31302
CaCl2	1	0	0	0	0	985.1211	12.15655
NaCl	1	0	0	0	0	333.1598	1.466916
CaSO4	1	0	0	0	0	4530.232	1.482135
pH							
TIN							
PO4							

Benchmarks before adjustment A	B	C	D
0.133	0.207	0.233	0.308
0.141	0.234	0.267	0.359
0.157	0.318	0.375	0.535
0.189	0.51	0.624	0.945
0.769	3.27	5.15	6.65
2.58	5.21	6.15	8.78

	Benchmarks after adjustement A	B	C	D	Hazard	Convergence
MgSO4	0.1327779	0.2070525	0.2334475	0.3077221	0.0363045	
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 1.438408E-02

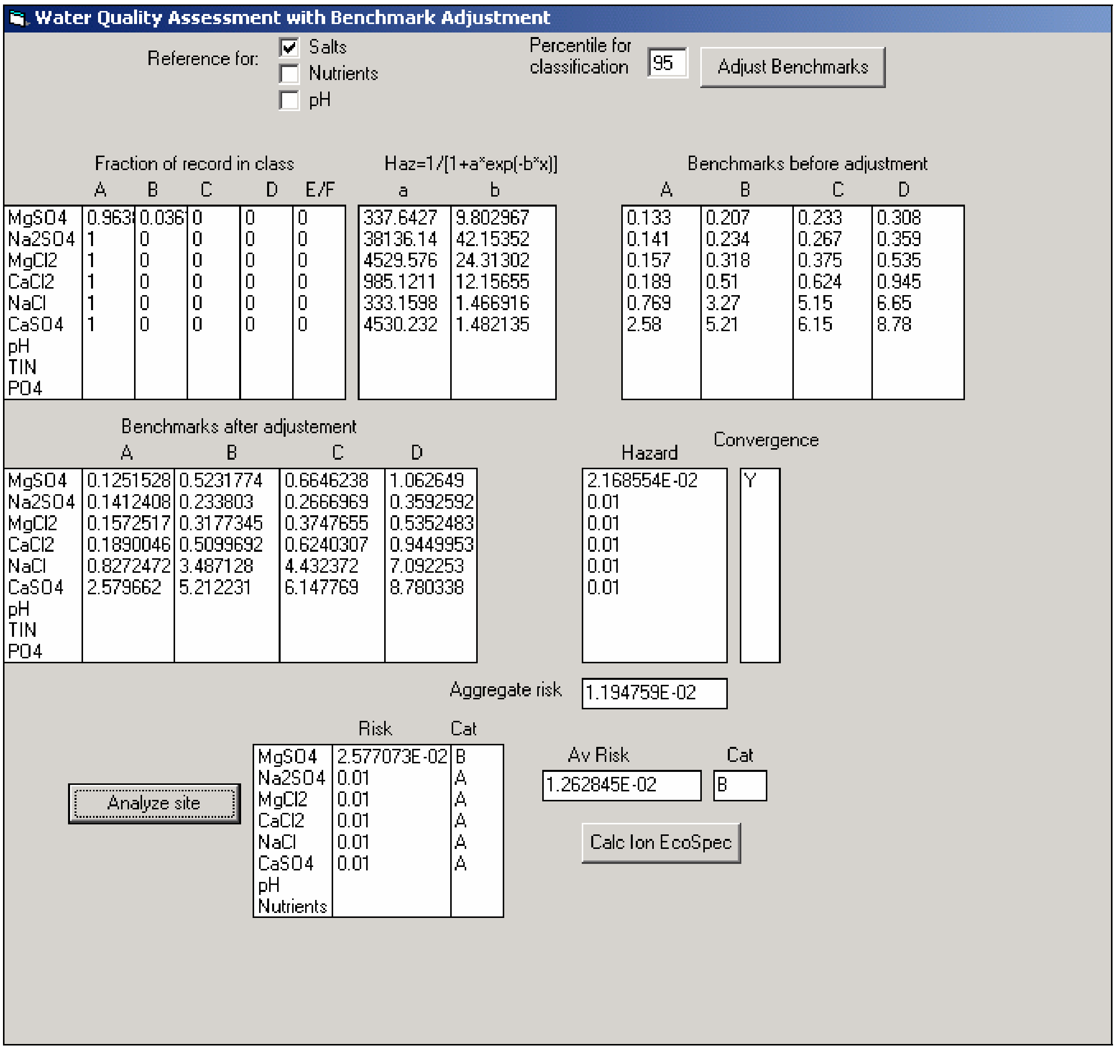
Analyze site

	Risk	Cat
MgSO4	3.654364E-02	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 1.442394E-02 — Cat: B

Calc Ion EcoSpec

RC



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)] / Benchmarks before adjustment

	A	B	C	D	E/F	a	b	A	B	C	D
MgSO4	0.963	0.036	0	0	0	337.6427	9.802967	0.133	0.207	0.233	0.308
Na2SO4	1	0	0	0	0	38136.14	42.15352	0.141	0.234	0.267	0.359
MgCl2	1	0	0	0	0	4529.576	24.31302	0.157	0.318	0.375	0.535
CaCl2	1	0	0	0	0	985.1211	12.15655	0.189	0.51	0.624	0.945
NaCl	1	0	0	0	0	333.1598	1.466916	0.769	3.27	5.15	6.65
CaSO4	1	0	0	0	0	4530.232	1.482135	2.58	5.21	6.15	8.78
pH											
TIN											
PO4											

Benchmarks after adjustement / Hazard / Convergence

	A	B	C	D	Hazard	Convergence
MgSO4	0.1251528	0.5231774	0.6646238	1.062649	2.168554E-02	Y
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 1.194759E-02

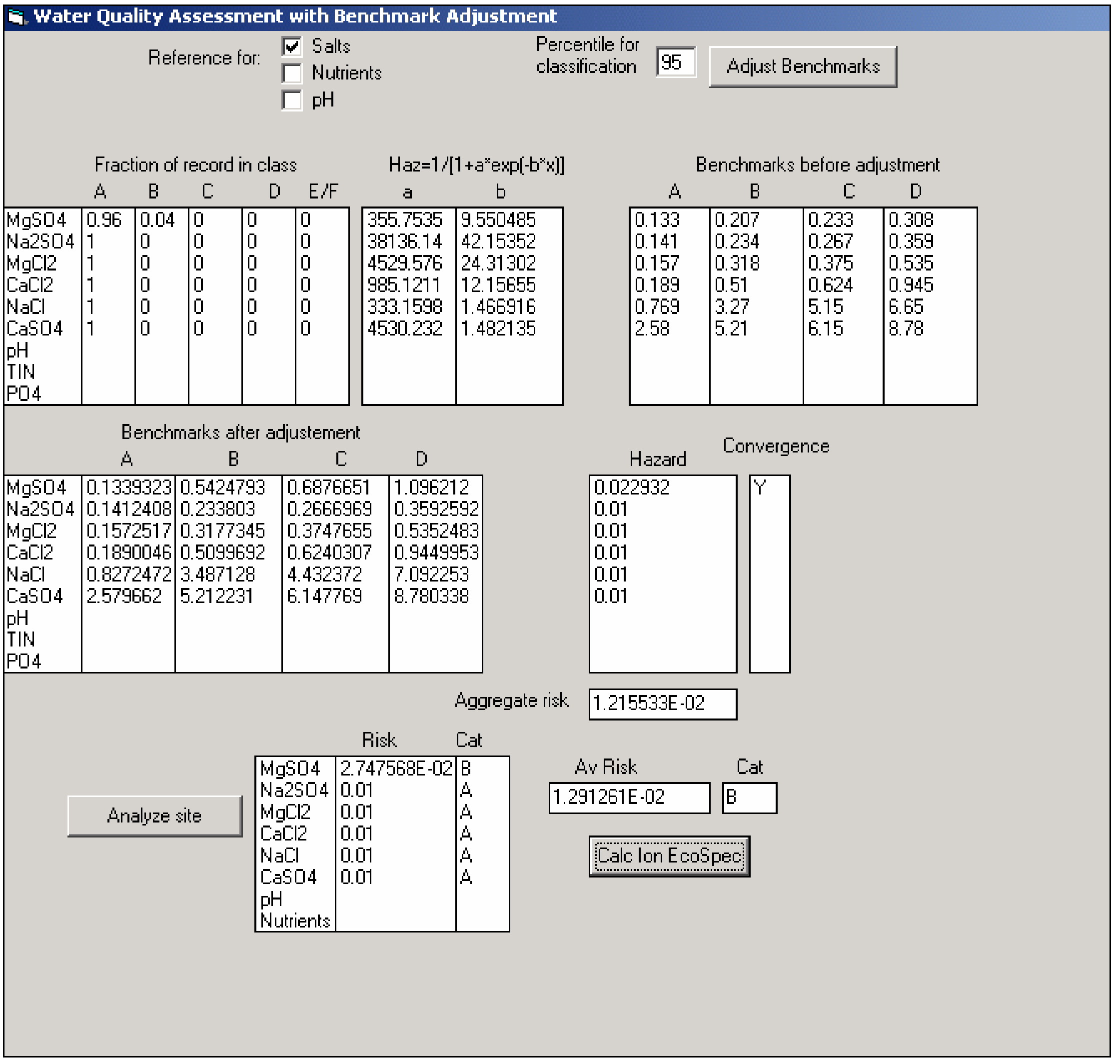
Analyze site

	Risk	Cat
MgSO4	2.577073E-02	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk: 1.262845E-02 — Cat: B

Calc Ion EcoSpec

PES



Water Quality Assessment with Benchmark Adjustment

Reference for: [x] Salts [ ] Nutrients [ ] pH

Percentile for classification: 95 — Adjust Benchmarks

Fraction of record in class / Haz=1/[1+a*exp(-b*x)]

	A	B	C	D	E/F	a	b
MgSO4	0.96	0.04	0	0	0	355.7535	9.550485
Na2SO4	1	0	0	0	0	38136.14	42.15352
MgCl2	1	0	0	0	0	4529.576	24.31302
CaCl2	1	0	0	0	0	985.1211	12.15655
NaCl	1	0	0	0	0	333.1598	1.466916
CaSO4	1	0	0	0	0	4530.232	1.482135
pH							
TIN							
PO4							

Benchmarks before adjustment

A	B	C	D
0.133	0.207	0.233	0.308
0.141	0.234	0.267	0.359
0.157	0.318	0.375	0.535
0.189	0.51	0.624	0.945
0.769	3.27	5.15	6.65
2.58	5.21	6.15	8.78

Benchmarks after adjustment

	A	B	C	D	Hazard	Convergence
MgSO4	0.1339323	0.5424793	0.6876651	1.096212	0.022932	Y
Na2SO4	0.1412408	0.233803	0.2666969	0.3592592	0.01	
MgCl2	0.1572517	0.3177345	0.3747655	0.5352483	0.01	
CaCl2	0.1890046	0.5099692	0.6240307	0.9449953	0.01	
NaCl	0.8272472	3.487128	4.432372	7.092253	0.01	
CaSO4	2.579662	5.212231	6.147769	8.780338	0.01	
pH						
TIN						
PO4						

Aggregate risk: 1.215533E-02

	Risk	Cat
MgSO4	2.747568E-02	B
Na2SO4	0.01	A
MgCl2	0.01	A
CaCl2	0.01	A
NaCl	0.01	A
CaSO4	0.01	A
pH		
Nutrients		

Av Risk	Cat
1.291261E-02	B

Analyze site — Calc Ion EcoSpec

Appendix C

Regression Equations and Coefficients

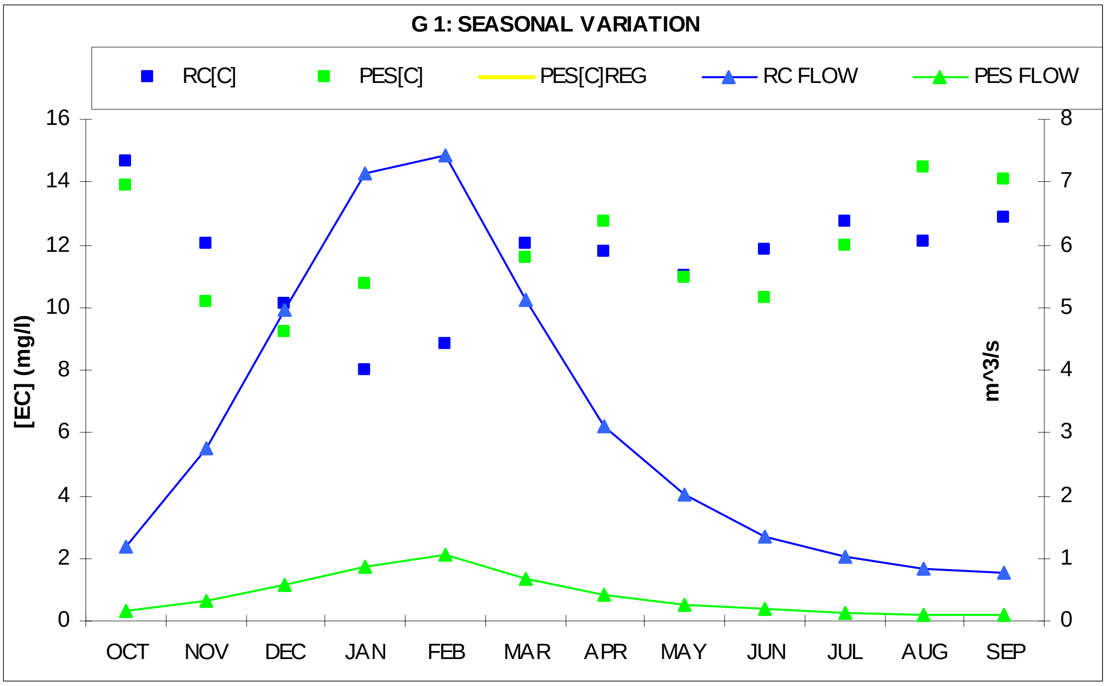
X1H033Q01 – K 1	**Constituent**	**Equations**	**Regression coefficient(r2)**
Reference Condition	EC TIN SRP	y = 0.1053x2 - 1.008x + 20.335 y = 0.1819x-0.0989 y = -0.0025Ln(x) + 0.0168	R^2 = 0.3386 R^2 = 0.0267 R^2 = 0.1516
Present Ecological State	EC TIN SRP	y = 0.0726x2 - 0.3411x+20.396 y =-0.0017x2+0.0206x +0.0455 y =-0.0004x2+0.0052x+ 0.0045	R^2 = 0.5295 R^2 = 0.207 R^2 = 0.2281
XH001Q01 – K 2	**Constituent**	**Equations**	**Regression coefficient(r2)**
Reference Condition	EC TIN SRP	y = 0.0287x2-0.2551x + 13.044 y = -0.0013x2+0.0193x + 0.051 y = 0.0125e0.0332x	R^2 = 0.2071 R^2 = 0.2498 R^2 = 0.0242
Present Ecological State	EC TIN SRP	y = 0.2653x2 - 3.1049x+25.278 y = 0.2135e-0.0653x y = -0.0001x2+0.0014x+0.0168	R^2 = 0.7926 R^2 = 0.2495 R^2 = 0.0694
X1H019Q01 – G 1	**Constituent**	**Equations**	**Regression coefficient(r2)**
Reference Condition	EC TIN SRP	y = 0.0983x2-1.1915x + 13.924 y = -0.0007x2 + 0.0092x+0.066 y = -0.0049Ln(x) + 0.0236	R^2 = 0.3893 R^2 = 0.1153 R^2 = 0.1087
Present Ecological State	EC TIN SRP	y = 0.0855x2 - 0.9046x+12.967 y = -0.0006x2+0.0027x+0.2343 y = 0.0002x2 - 0.0024x+0.0156	R^2 = 0.4697 R^2 = 0.0732 R^2 = 0.3252
X1H003Q01 – K 3	**Constituent**	**Equations**	**Regression coefficient(r2)**
Reference Condition	EC TIN SRP	y = 0.3343x2 - 3.8875x+25.328 y = -0.0007x2+0.0075x+0.0846 y = -0.0002x2 + 0.002x+0.0205	R^2 = 0.6537 R^2 = 0.0636 R^2 = 0.0797
Present Ecological State	EC TIN SRP	y = 0.3888x2 - 4.1312x+44.243 y = -0.0014x2 + 0.022x+0.2446 y = -0.0002x2 + 0.002x+0.0205	R^2 = 0.3956 R^2 = 0.0961 R^2 = 0.0797

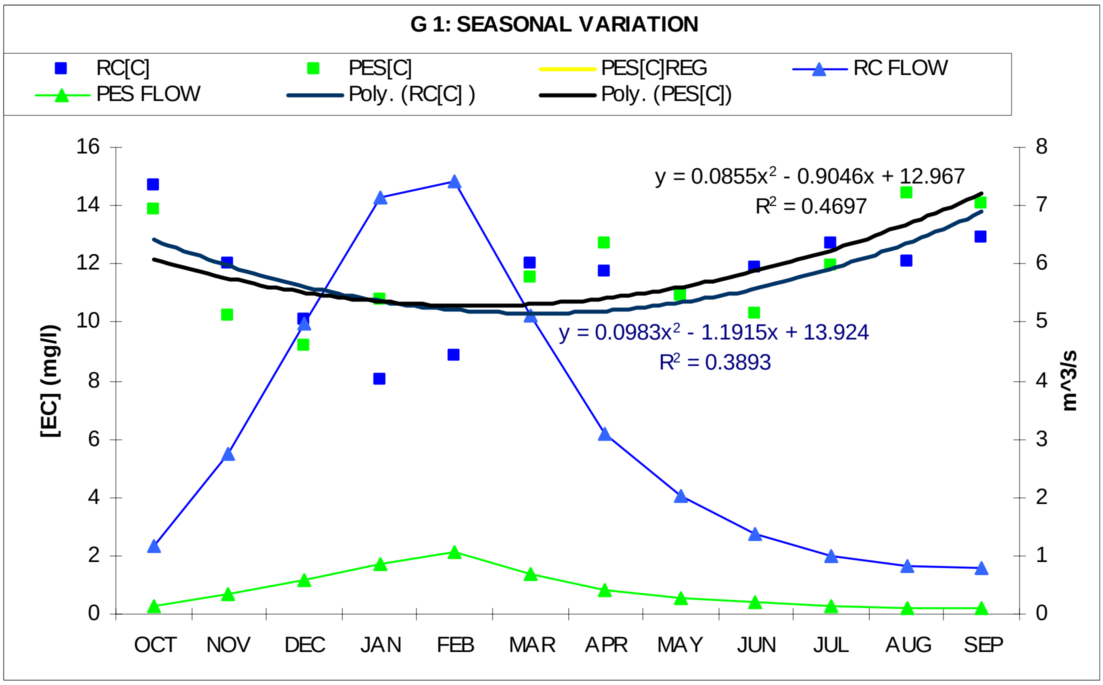
Appendix D

Flow Concentration Matrices

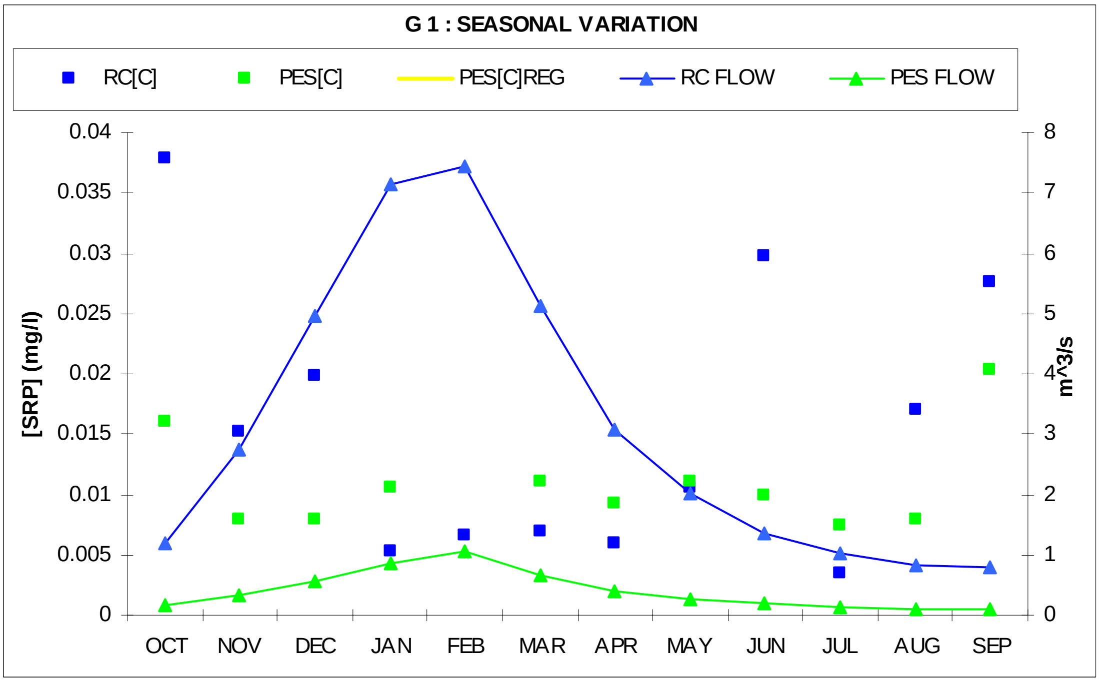
Table of Contents

G 1 – EC

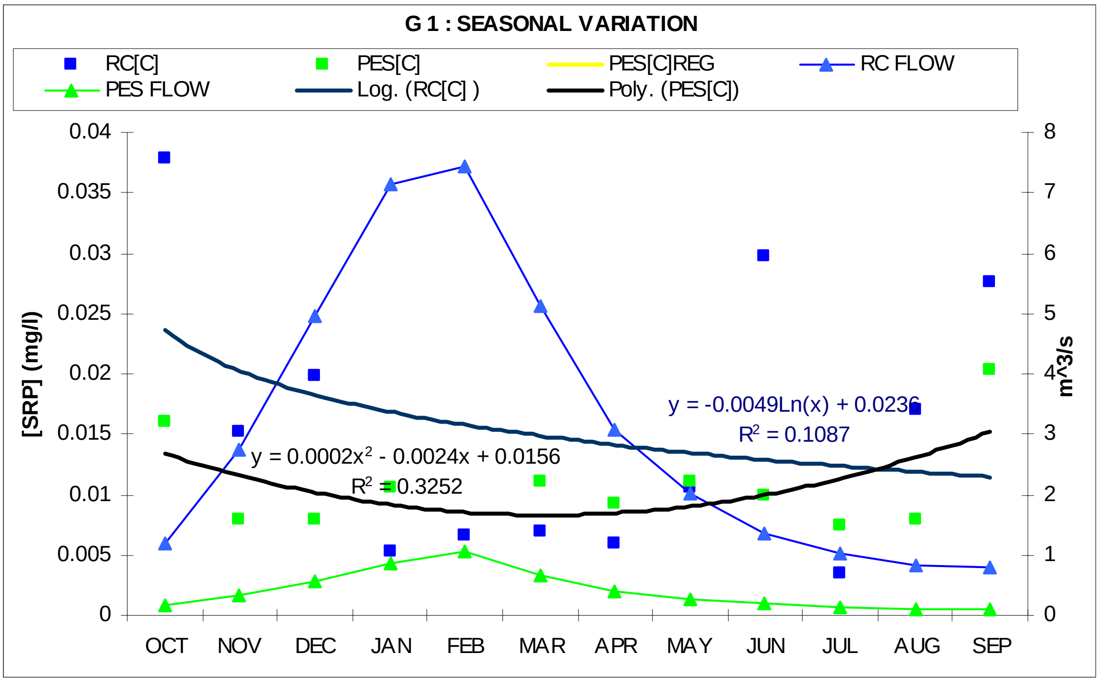

G 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[EC] (mg/l)
m^3/s
16
14
12
10
8
6
4
2
0
8
7
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


G 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Poly. (PES[C])
y = 0.0855x² - 0.9046x + 12.967
R² = 0.4697
y = 0.0983x² - 1.1915x + 13.924
R² = 0.3893
[EC] (mg/l)
m^3/s
16
14
12
10
8
6
4
2
0
8
7
6
5
4
3
2
1
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

G 1 – SRP

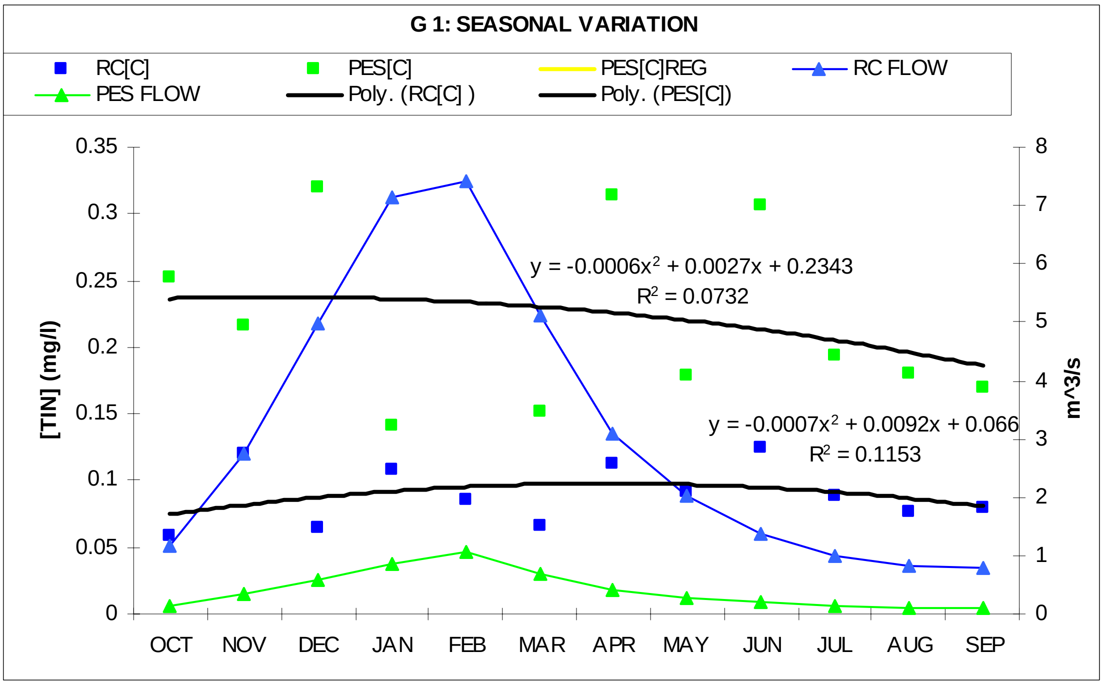


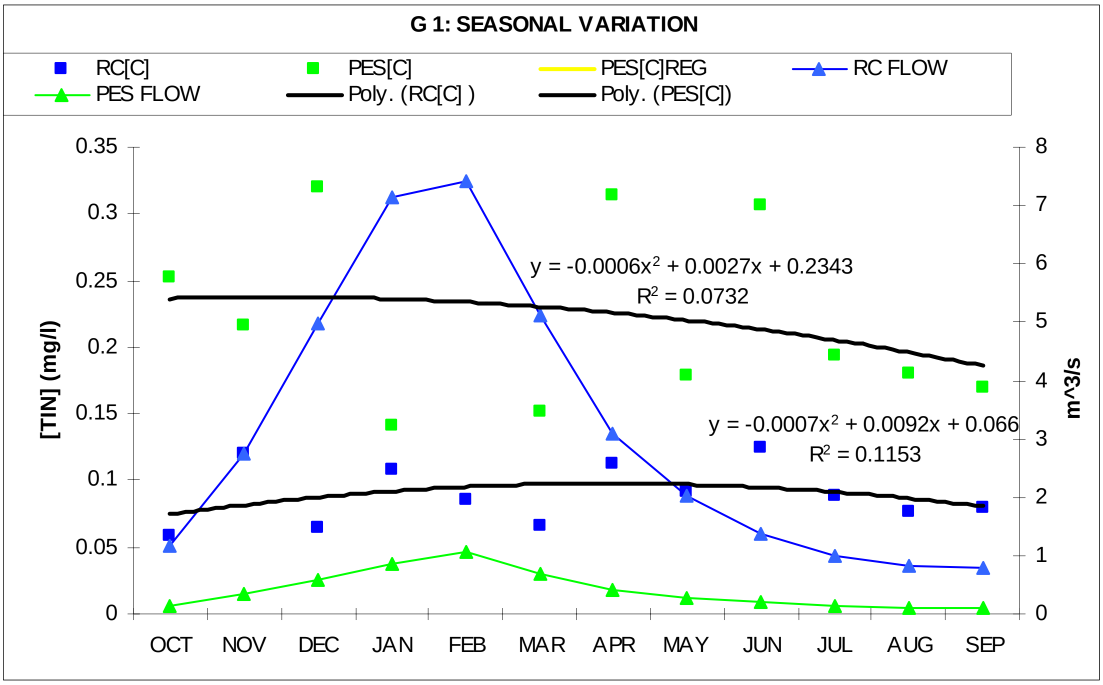
G 1 : SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[SRP] (mg/l)
m^3/s
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
8
7
6
5
4
3
2
1
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP



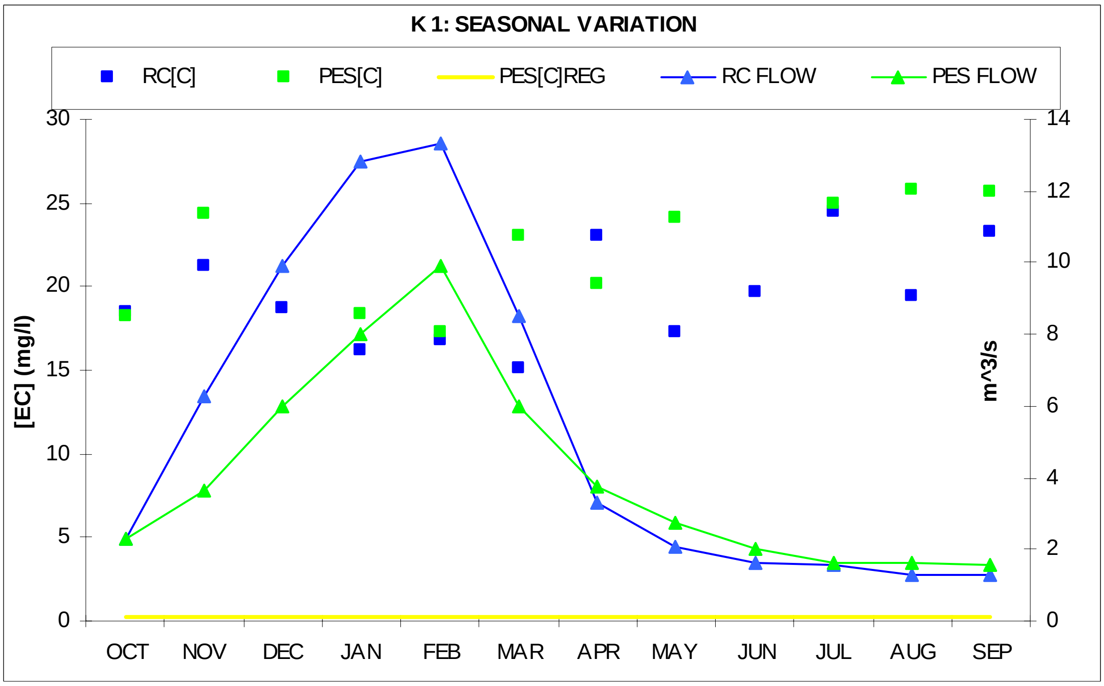
G 1 : SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Log. (RC[C])
Poly. (PES[C])
[SRP] (mg/l)
m^3/s
y = -0.0049Ln(x) + 0.0236
R² = 0.1087
y = 0.0002x² - 0.0024x + 0.0156
R² = 0.3252
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
8
7
6
5
4
3
2
1
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

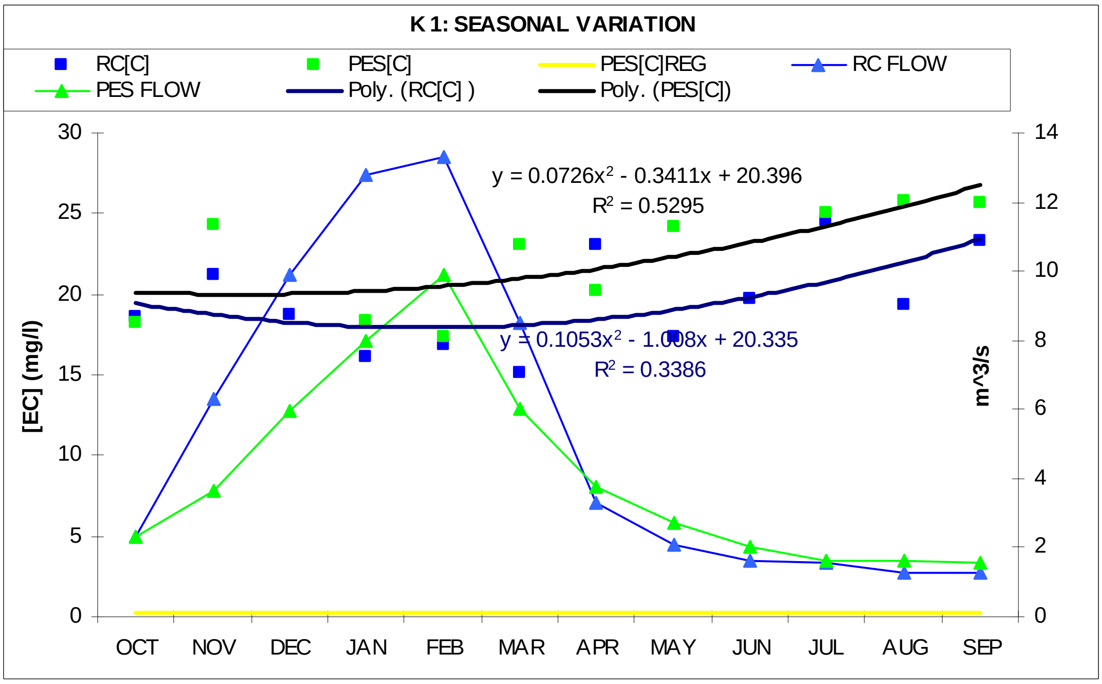
G 1 - TIN


G 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Poly. (PES[C])
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
[TIN] (mg/l)
8
7
6
5
4
3
2
1
0
m^3/s
y = -0.0006x2 + 0.0027x + 0.2343
R2 = 0.0732
y = -0.0007x2 + 0.0092x + 0.066
R2 = 0.1153
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

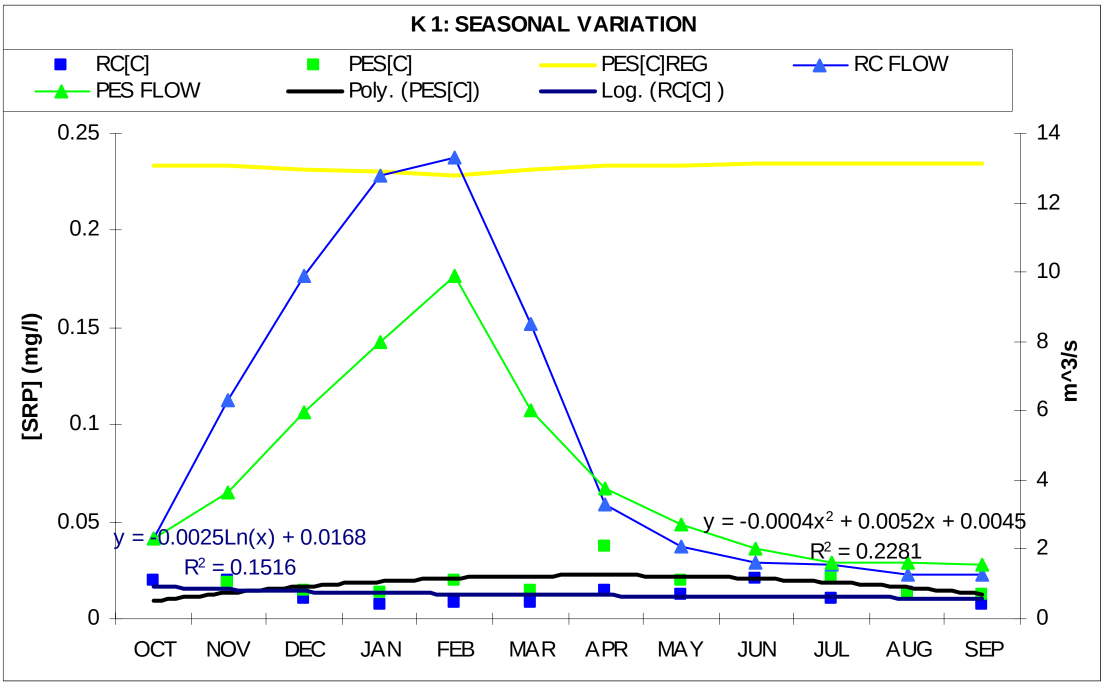

G 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Poly. (PES[C])
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
[TIN] (mg/l)
8
7
6
5
4
3
2
1
0
m^3/s
y = -0.0006x2 + 0.0027x + 0.2343
R2 = 0.0732
y = -0.0007x2 + 0.0092x + 0.066
R2 = 0.1153
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

K 1 - EC


K 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[EC] (mg/l)
m^3/s
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


K 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Poly. (PES[C])
y = 0.0726x² - 0.3411x + 20.396
R² = 0.5295
y = 0.1053x² - 1.008x + 20.335
R² = 0.3386
[EC] (mg/l)
m^3/s
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

K 1- SRP


K 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (PES[C])
Log. (RC[C])
[SRP] (mg/l)
m^3/s
y = -0.0025Ln(x) + 0.0168
R² = 0.1516
y = -0.0004x² + 0.0052x + 0.0045
R² = 0.2281
0.25
0.2
0.15
0.1
0.05
0
14
12
10
8
6
4
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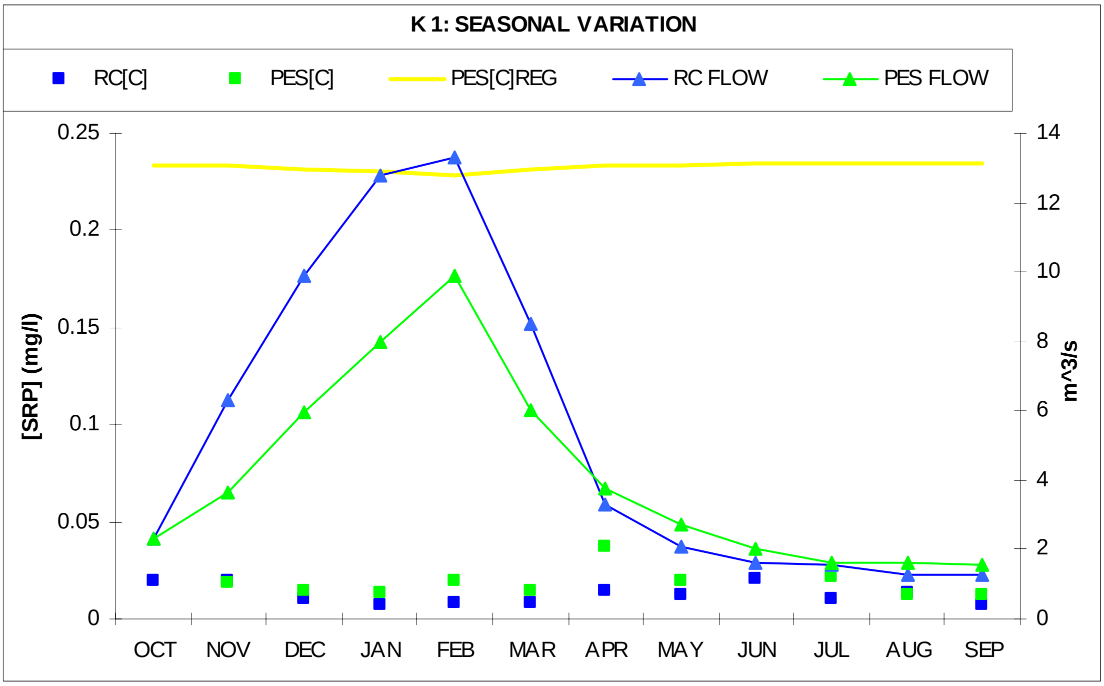
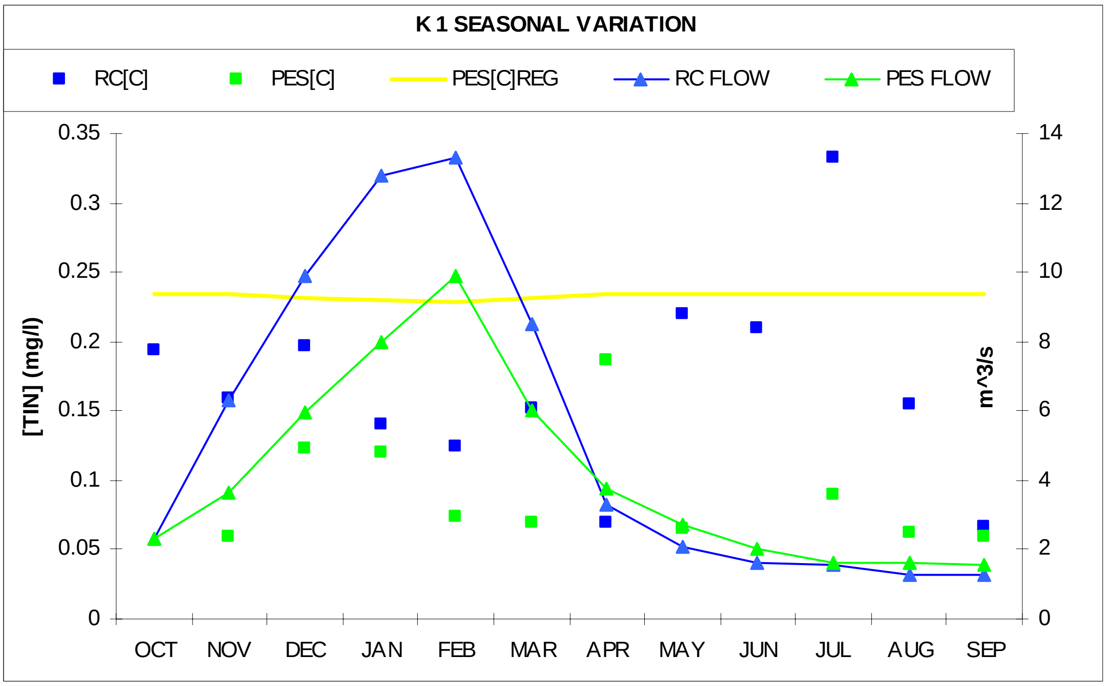
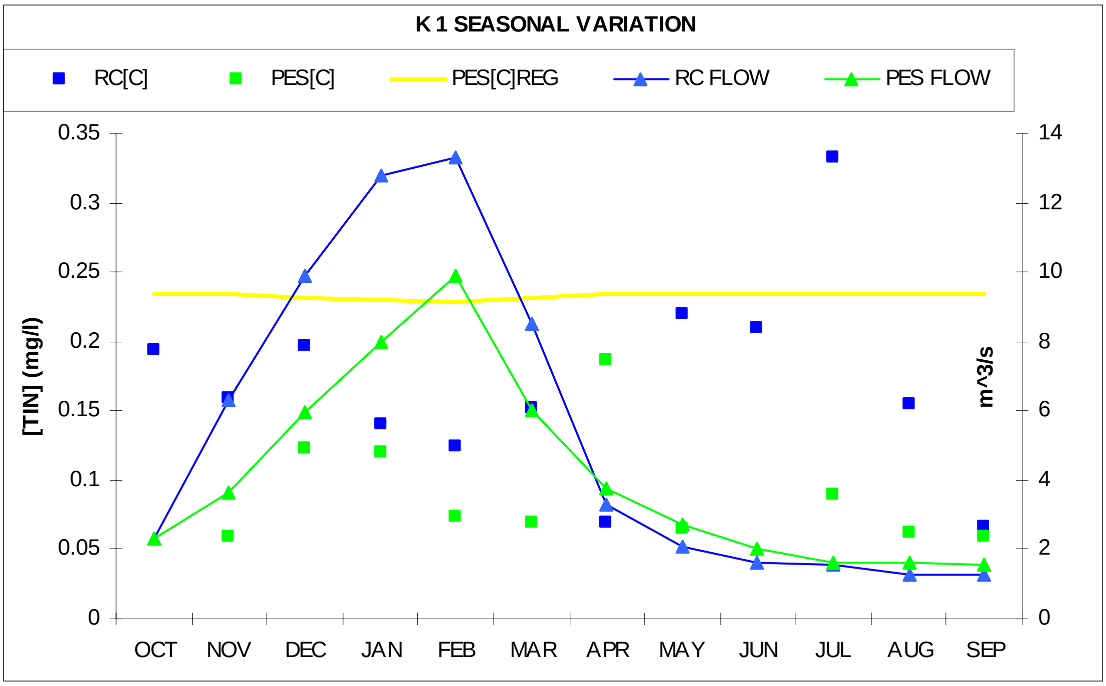
JUN
JUL
AUG
SEP

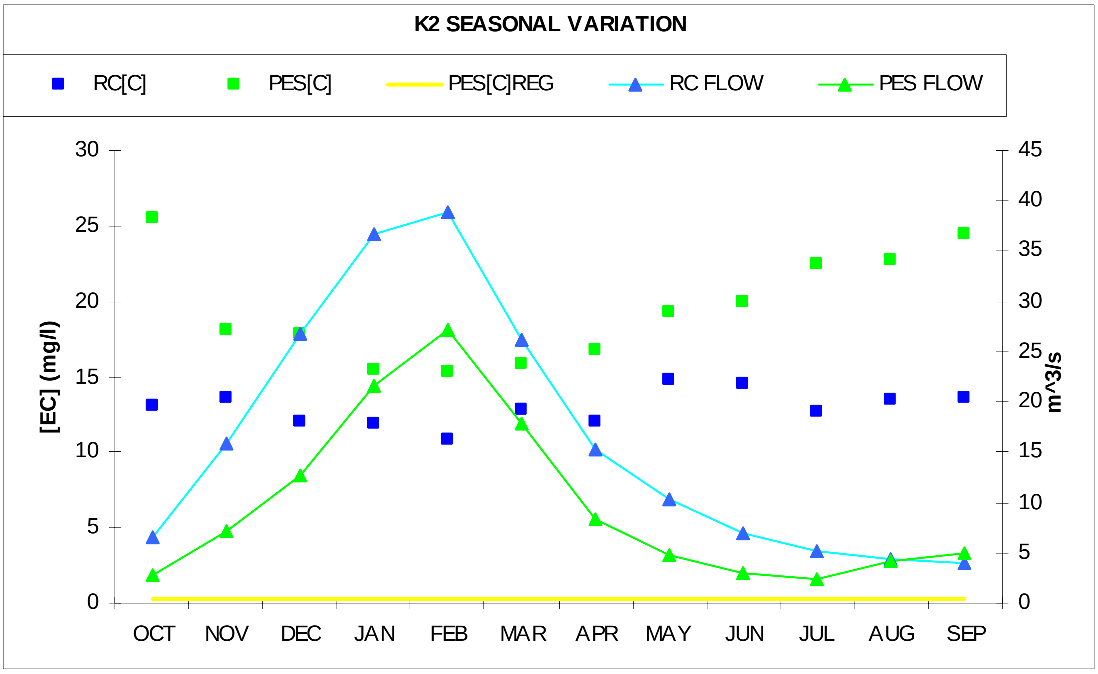

K 1: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[SRP] (mg/l)
m^3/s
0.25
0.2
0.15
0.1
0.05
0
14
12
10
8
6
4
2
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

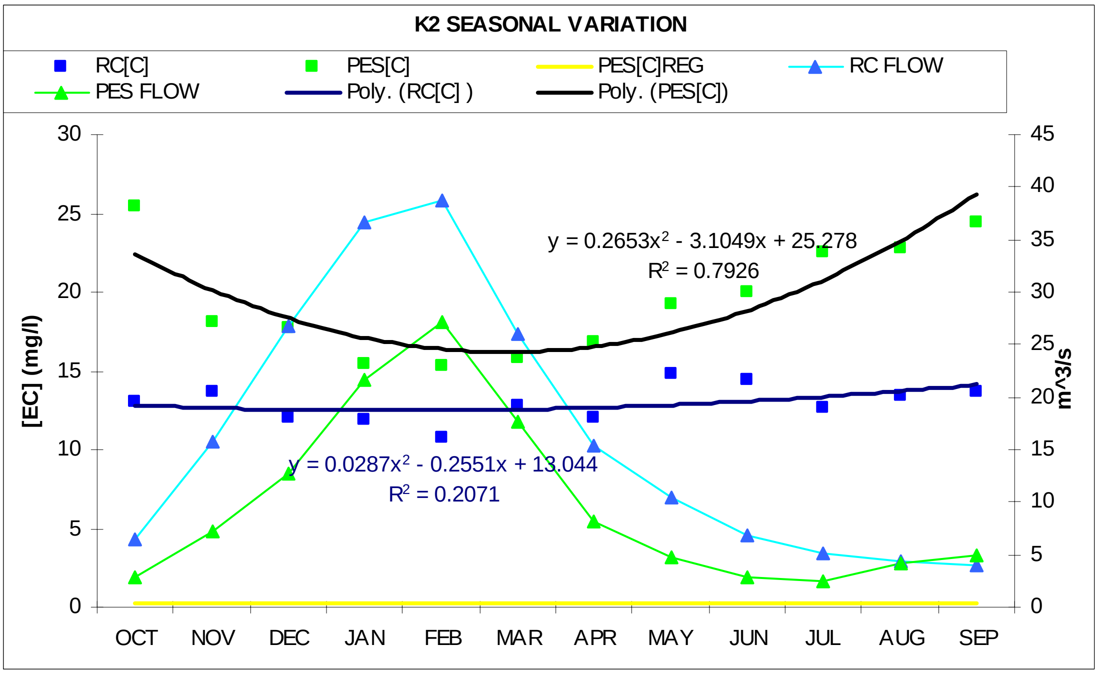
K 1 – TIN


K 1 SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[TIN] (mg/l)
m^3/s
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
14
12
10
8
6
4
2
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

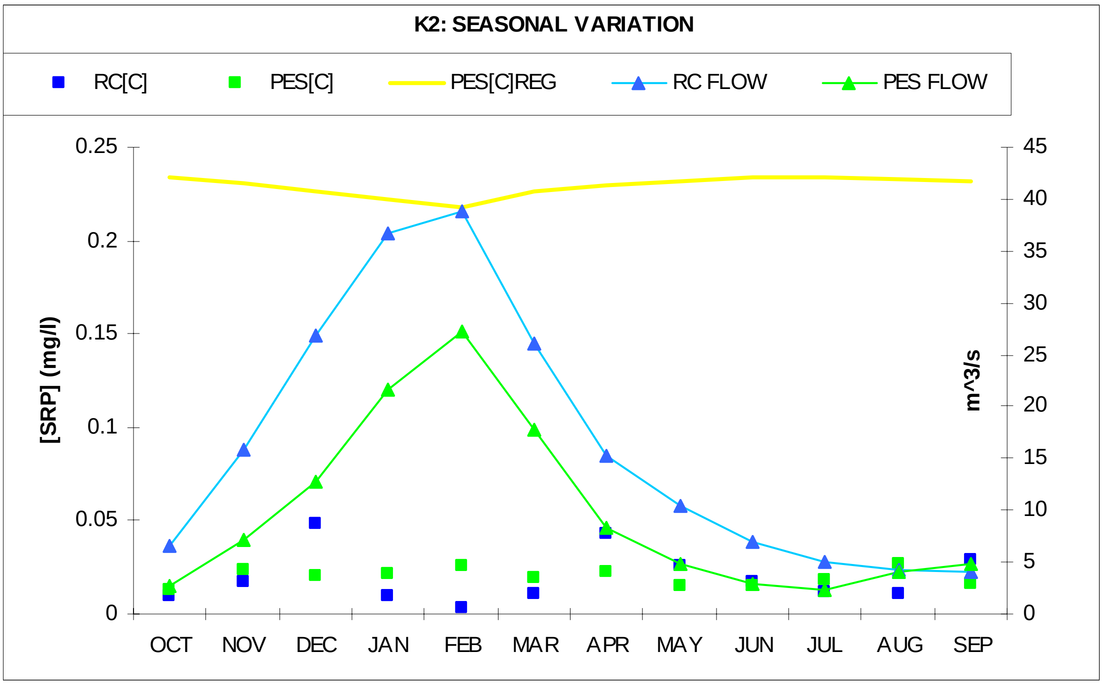

K 1 SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[TIN] (mg/l)
m^3/s
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
14
12
10
8
6
4
2
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

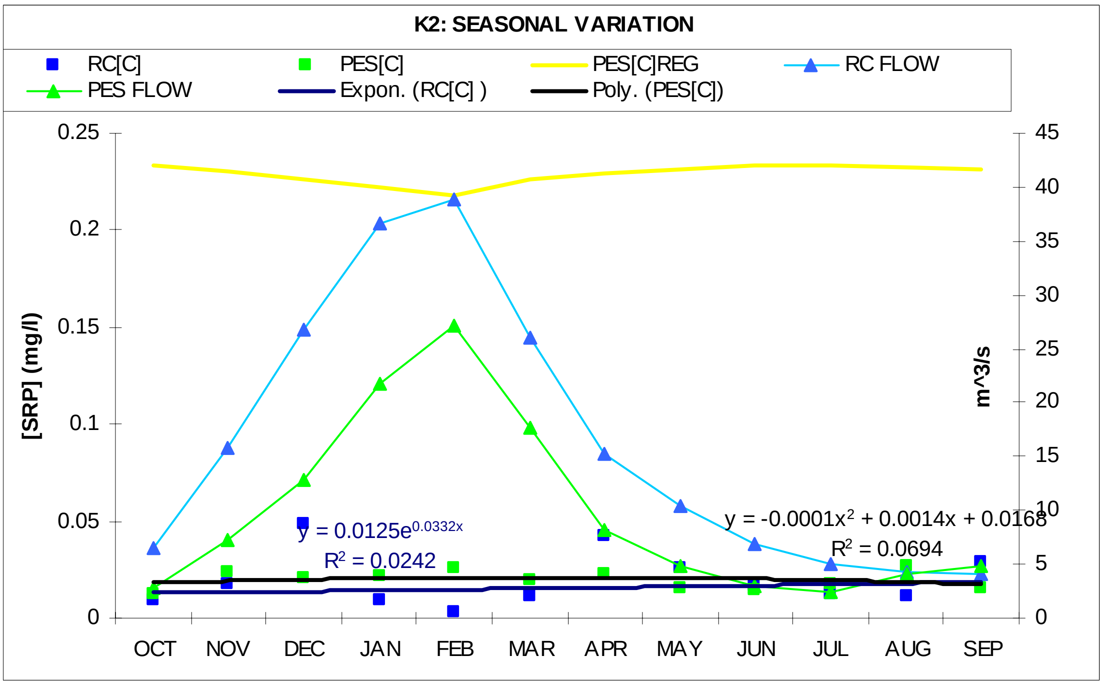
K 2 - EC


K2 SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[EC] (mg/l)
m^3/s
30
25
20
15
10
5
0
45
40
35
30
25
20
15
10
5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

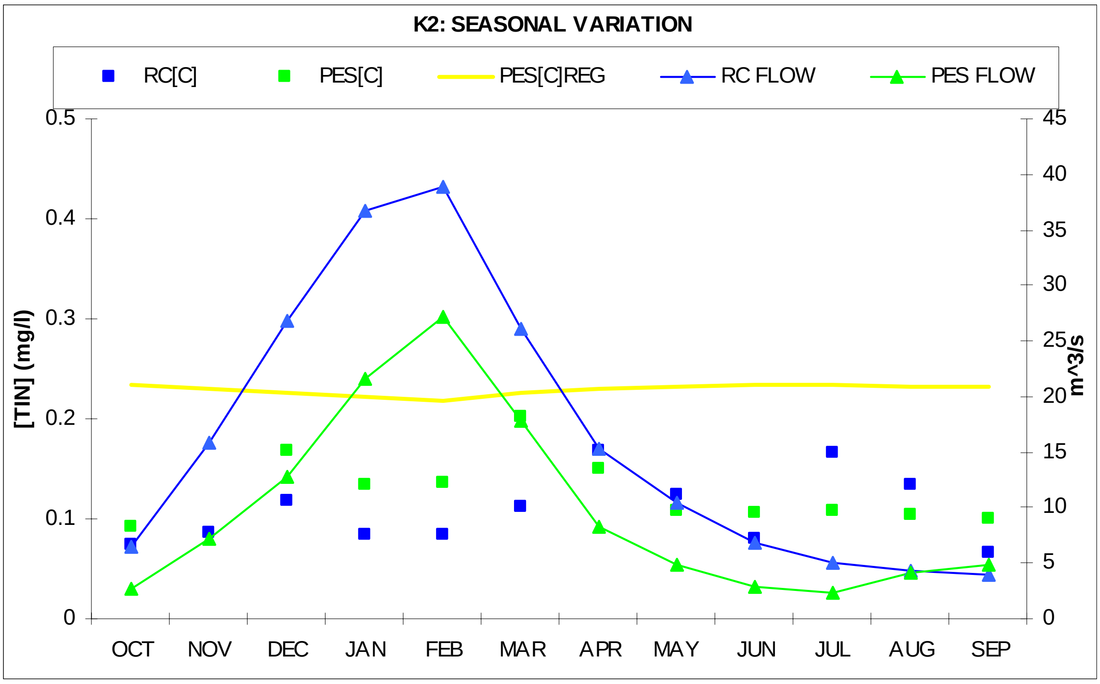

K2 SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Poly. (PES[C])
y = 0.2653x² - 3.1049x + 25.278
R² = 0.7926
y = 0.0287x² - 0.2551x + 13.044
R² = 0.2071
[EC] (mg/l)
m^3/s
30
25
20
15
10
5
0
45
40
35
30
25
20
15
10
5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

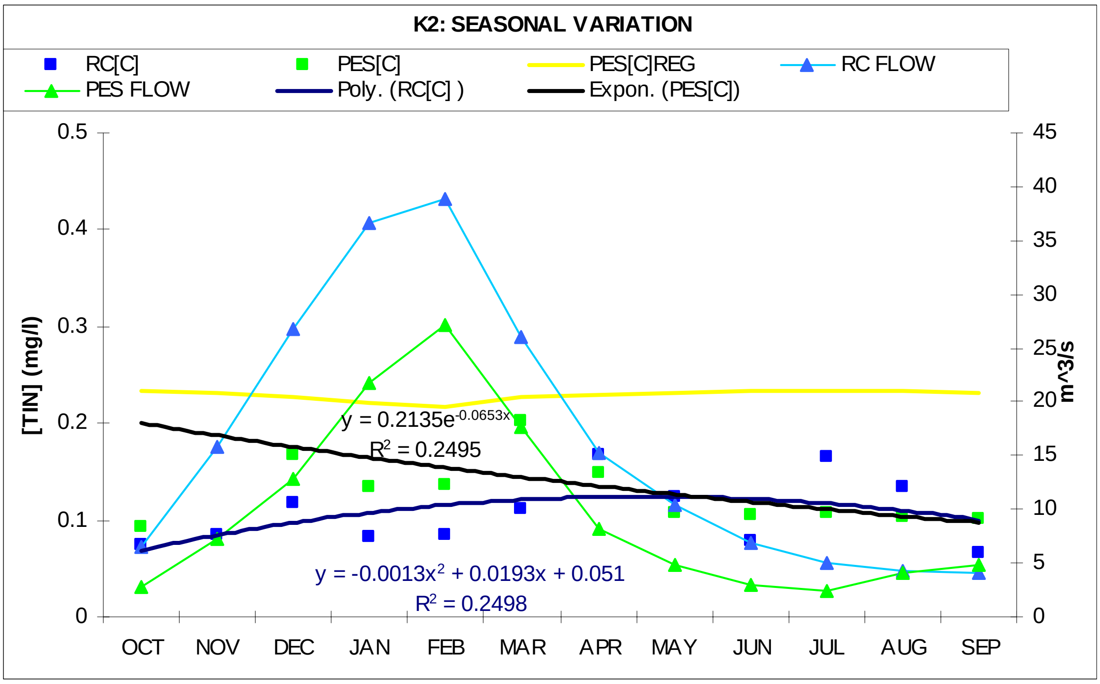
K 2 - SRP


K2: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[SRP] (mg/l)
m^3/s
0.25
0.2
0.15
0.1
0.05
0
45
40
35
30
25
20
15
10
5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

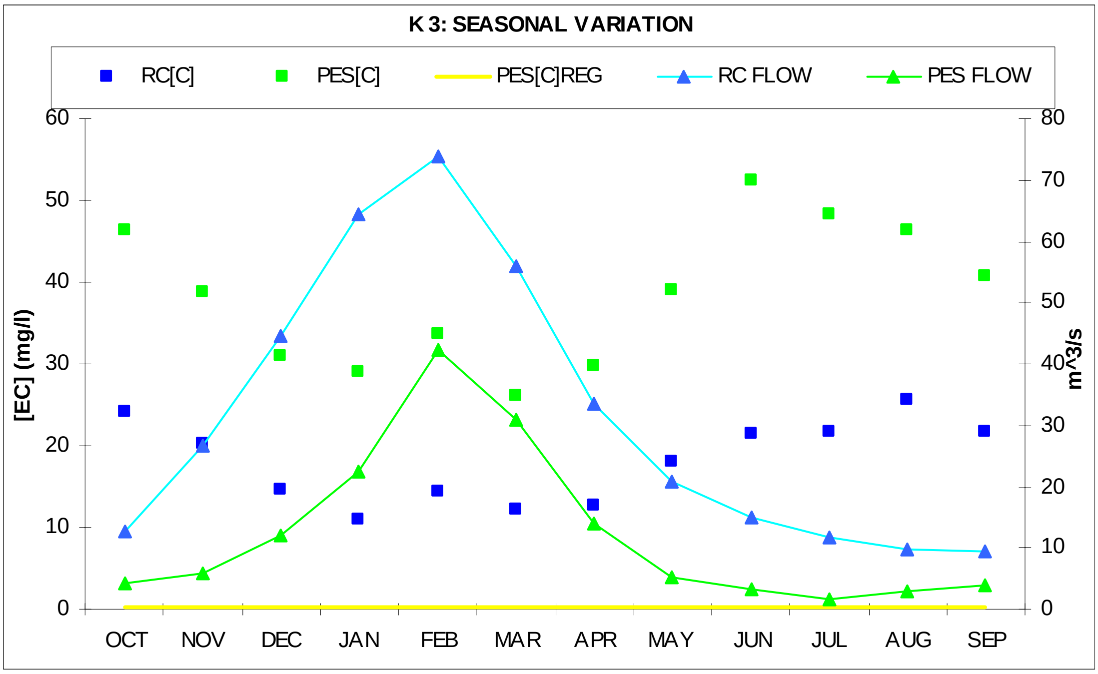

K2: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Expon. (RC[C])
Poly. (PES[C])
[SRP] (mg/l)
m^3/s
y = 0.0125e^0.0332x
R² = 0.0242
y = -0.0001x² + 0.0014x + 0.0168
R² = 0.0694
0.25
0.2
0.15
0.1
0.05
0
45
40
35
30
25
20
15
10
5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

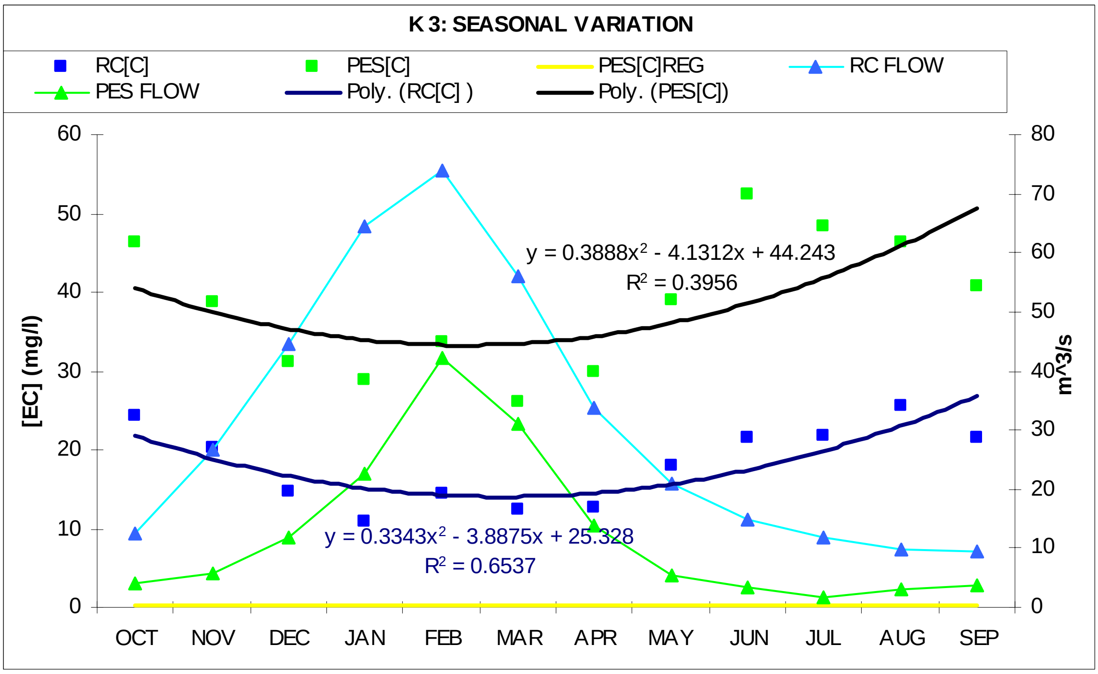
K 2 - TIN


K2: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[TIN] (mg/l)
m^3/s
0.5
0.4
0.3
0.2
0.1
0
45
40
35
30
25
20
15
10
5
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

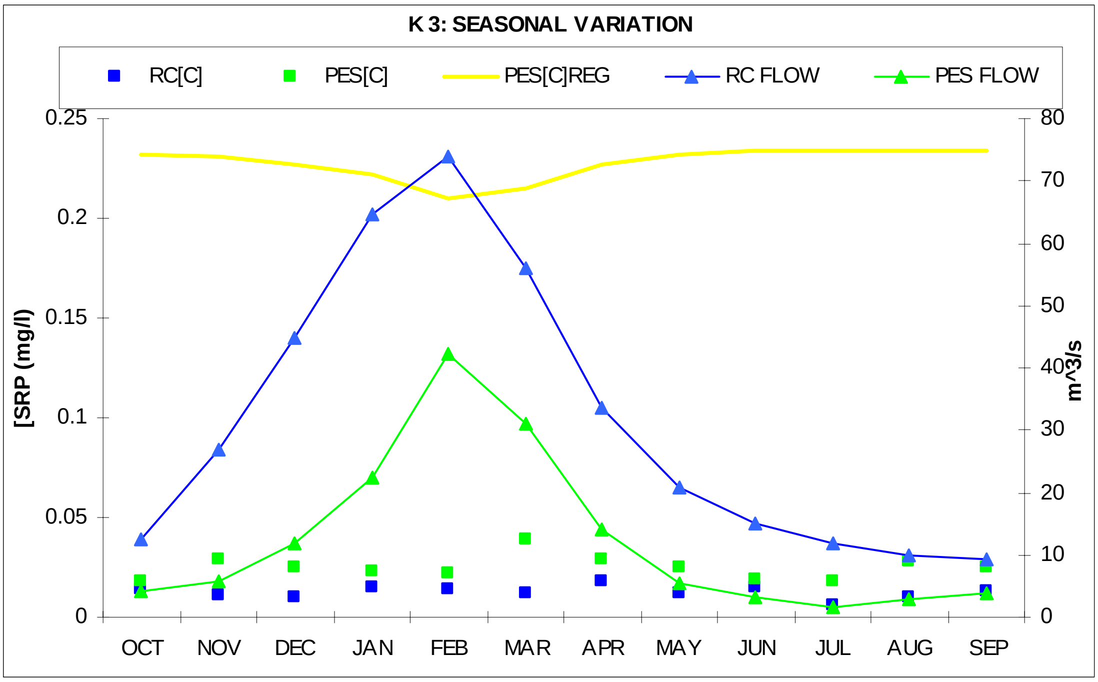

K2: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Expon. (PES[C])
y = 0.2135e^-0.0653x
R^2 = 0.2495
y = -0.0013x^2 + 0.0193x + 0.051
R^2 = 0.2498
[TIN] (mg/l)
m^3/s
0.5
0.4
0.3
0.2
0.1
0
45
40
35
30
25
20
15
10
5
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

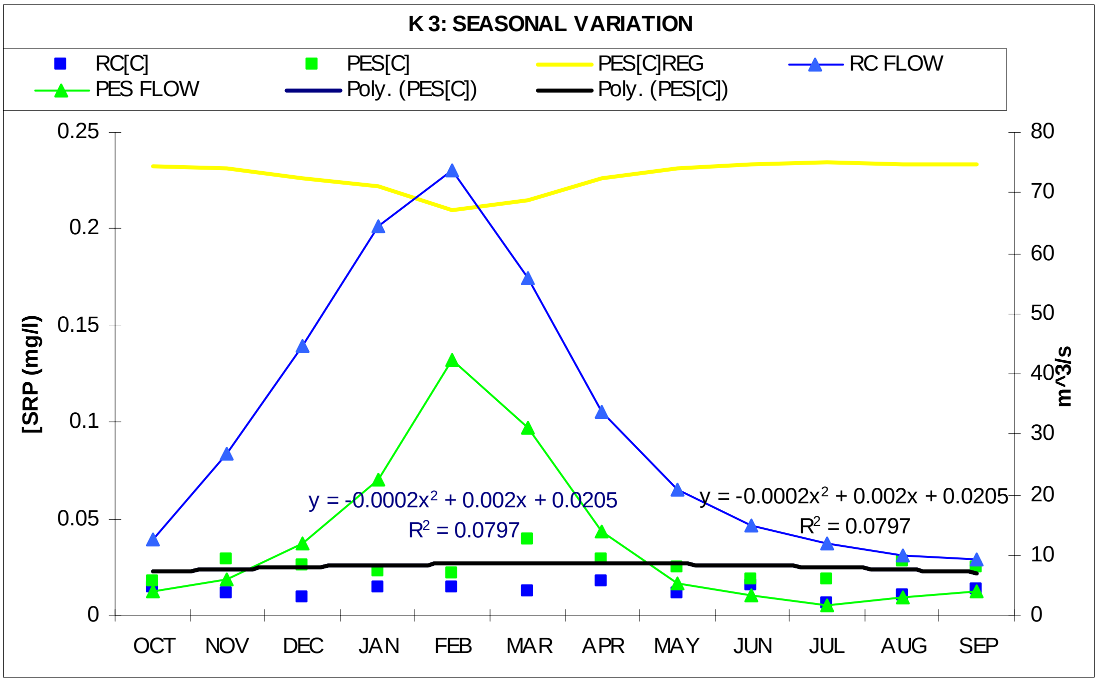
K 3 - EC


K 3: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[EC] (mg/l)
m^3/s
60 50 40 30 20 10 0
80 70 60 50 40 30 20 10 0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

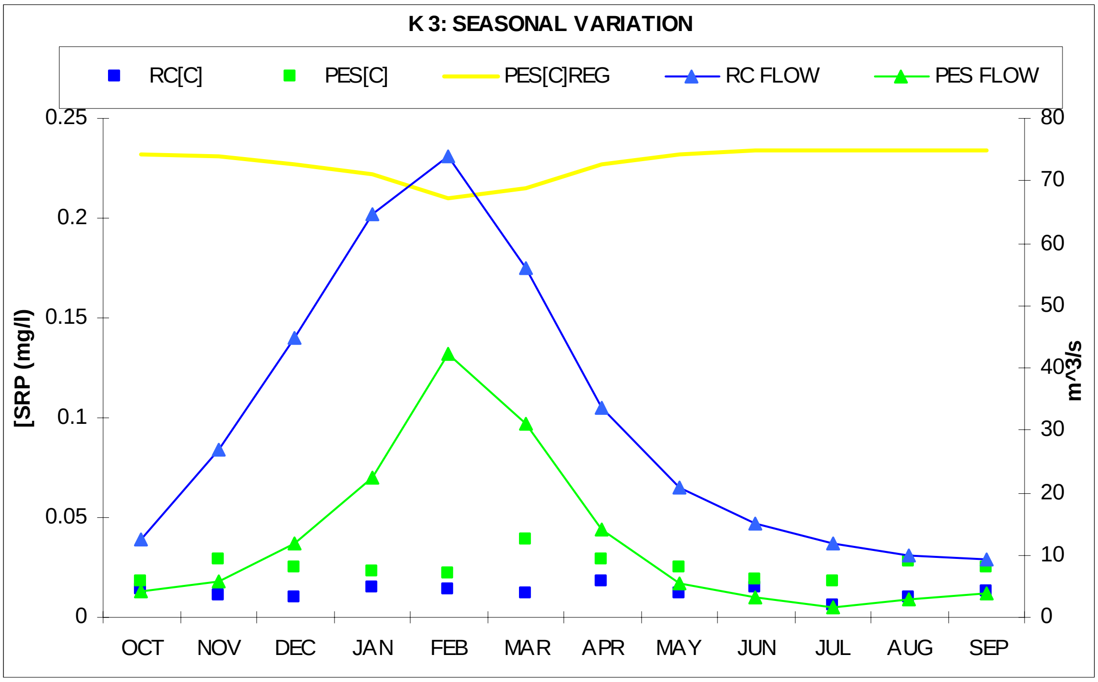

K 3: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (RC[C])
Poly. (PES[C])
y = 0.3888x² - 4.1312x + 44.243
R² = 0.3956
y = 0.3343x² - 3.8875x + 25.328
R² = 0.6537
[EC] (mg/l)
m^3/s
60 50 40 30 20 10 0
80 70 60 50 40 30 20 10 0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

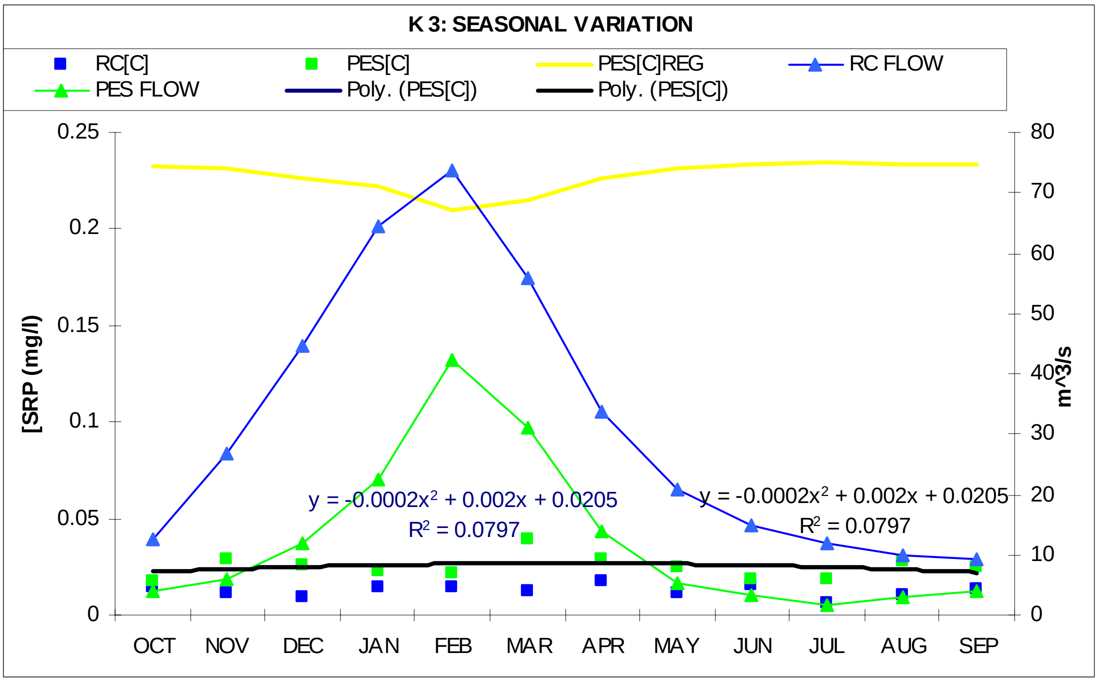
K 3 - SRP


K 3: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[SRP (mg/l)]
m^3/s
0.25
0.2
0.15
0.1
0.05
0
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


K 3: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (PES[C])
Poly. (PES[C])
[SRP (mg/l)]
m^3/s
y = -0.0002x² + 0.002x + 0.0205
R² = 0.0797
y = -0.0002x² + 0.002x + 0.0205
R² = 0.0797
0.25
0.2
0.15
0.1
0.05
0
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

K 3 - TIN


K 3: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
[SRP (mg/l)]
m^3/s
0.25
0.2
0.15
0.1
0.05
0
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


K 3: SEASONAL VARIATION
RC[C]
PES[C]
PES[C]REG
RC FLOW
PES FLOW
Poly. (PES[C])
Poly. (PES[C])
[SRP (mg/l)]
m^3/s
y = -0.0002x² + 0.002x + 0.0205
R² = 0.0797
y = -0.0002x² + 0.002x + 0.0205
R² = 0.0797
0.25
0.2
0.15
0.1
0.05
0
80
70
60
50
40
30
20
10
0
OCT
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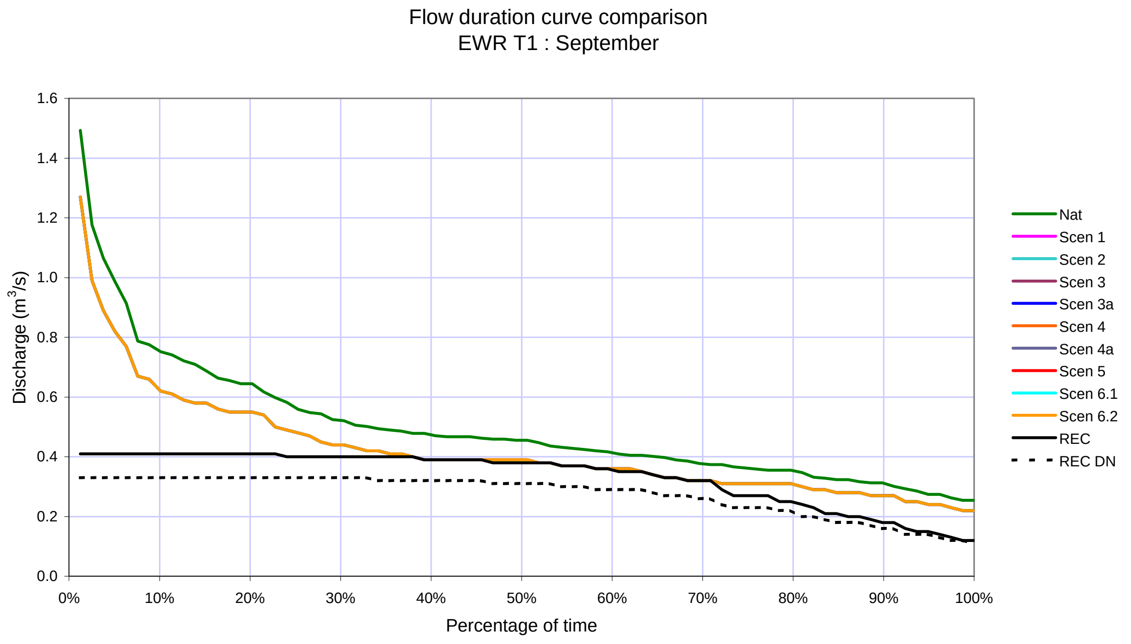
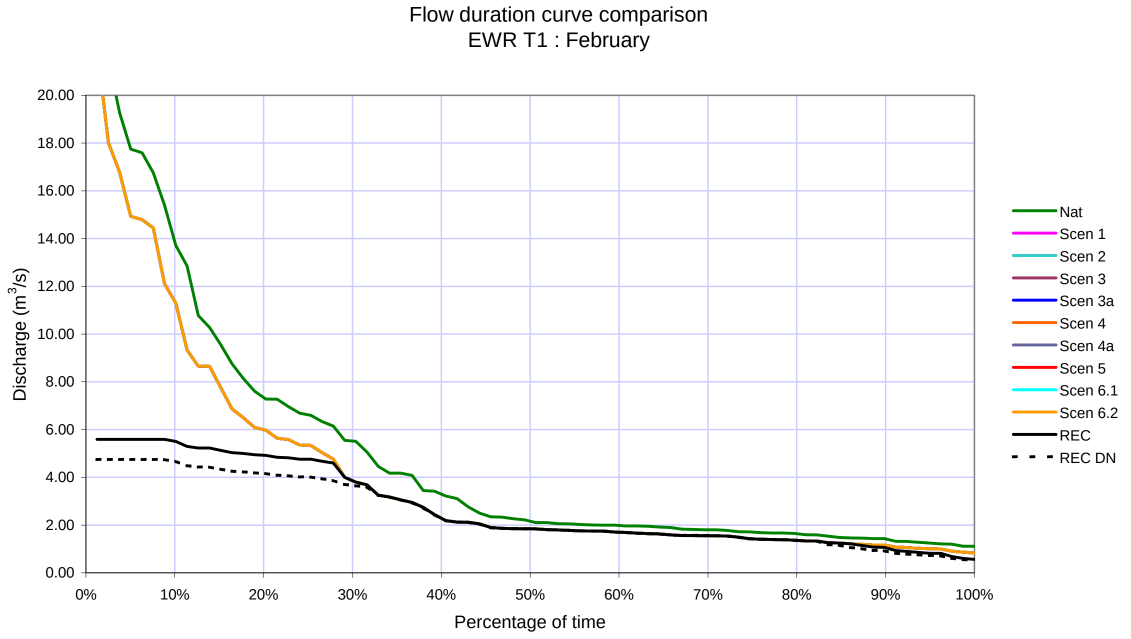
Appendix E

Flow Duration Curves

Table of Contents

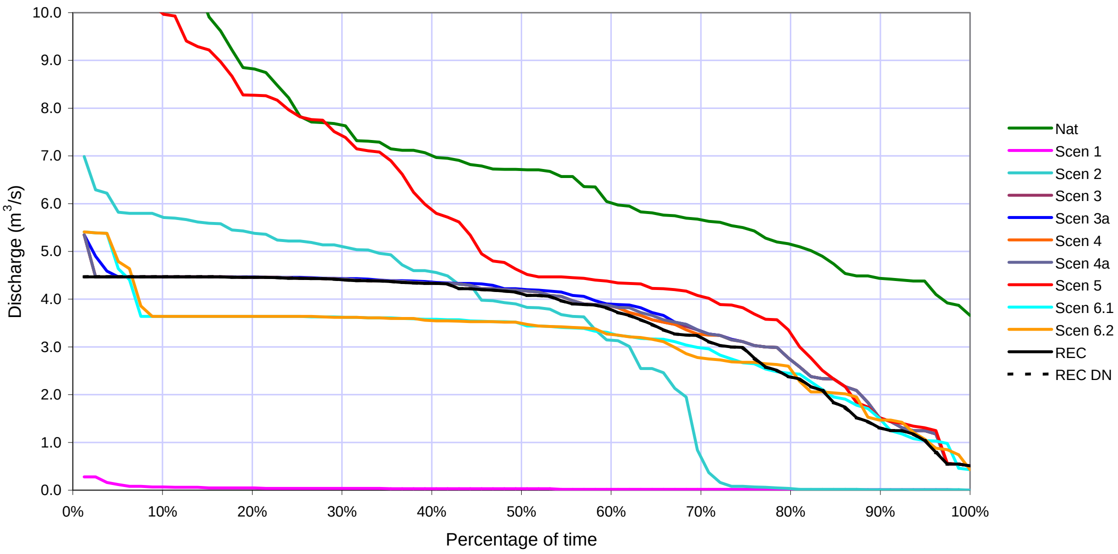
EWR Site T1


Flow duration curve comparison
EWR T1 : September
Discharge (m³/s)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
REC
REC DN

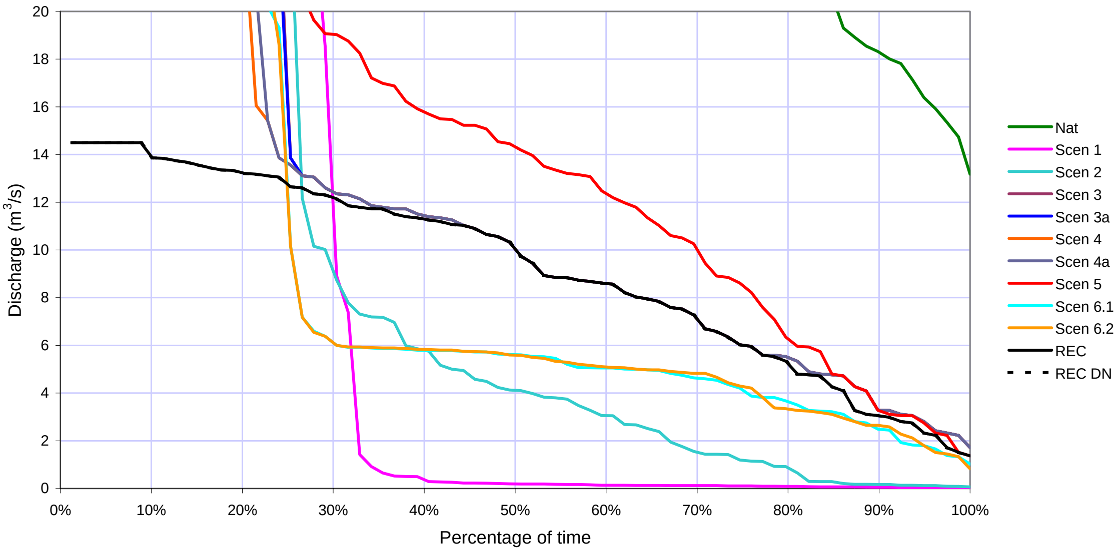

Flow duration curve comparison
EWR T1 : February
Discharge (m³/s)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
REC
REC DN

EWR Site K3

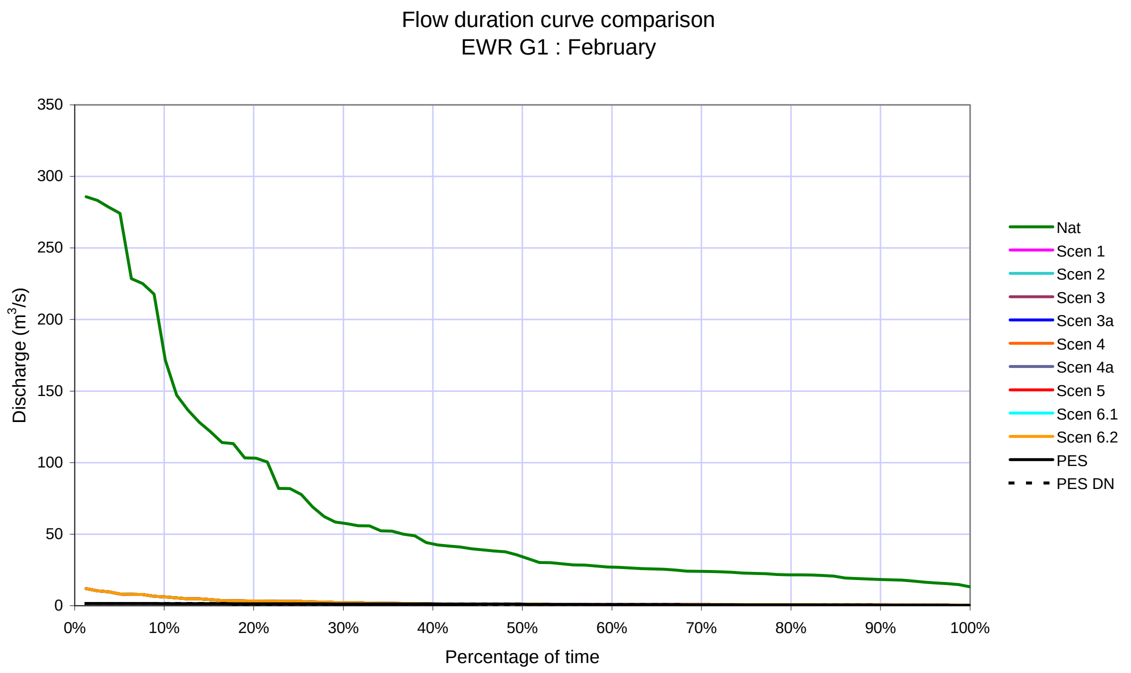
Flow duration curve comparison
EWR K3 : September

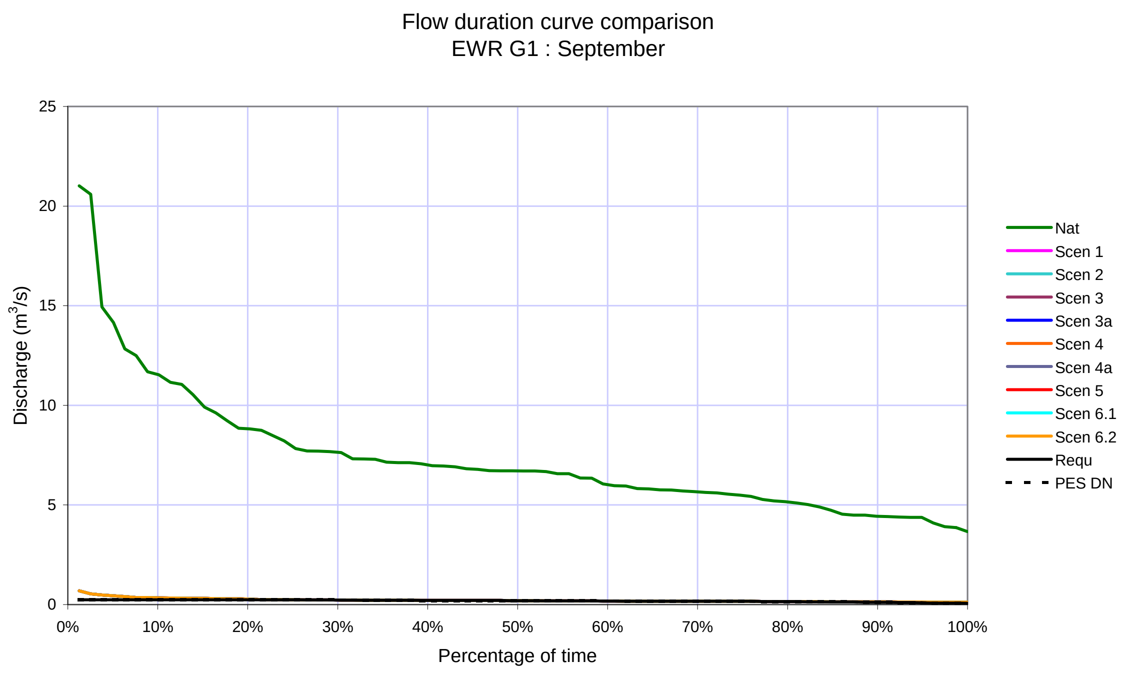


Flow duration curve comparison
EWR K3 : February



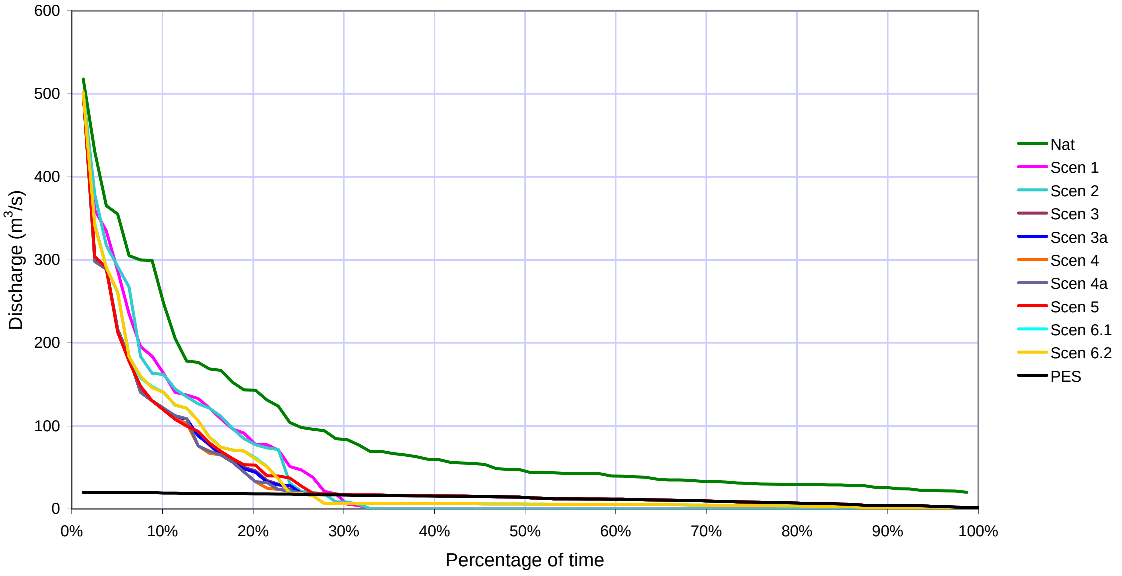
EWR Site G1


Flow duration curve comparison
EWR G1 : February
350
300
250
200
150
100
50
0
Discharge (m3/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES
PES DN

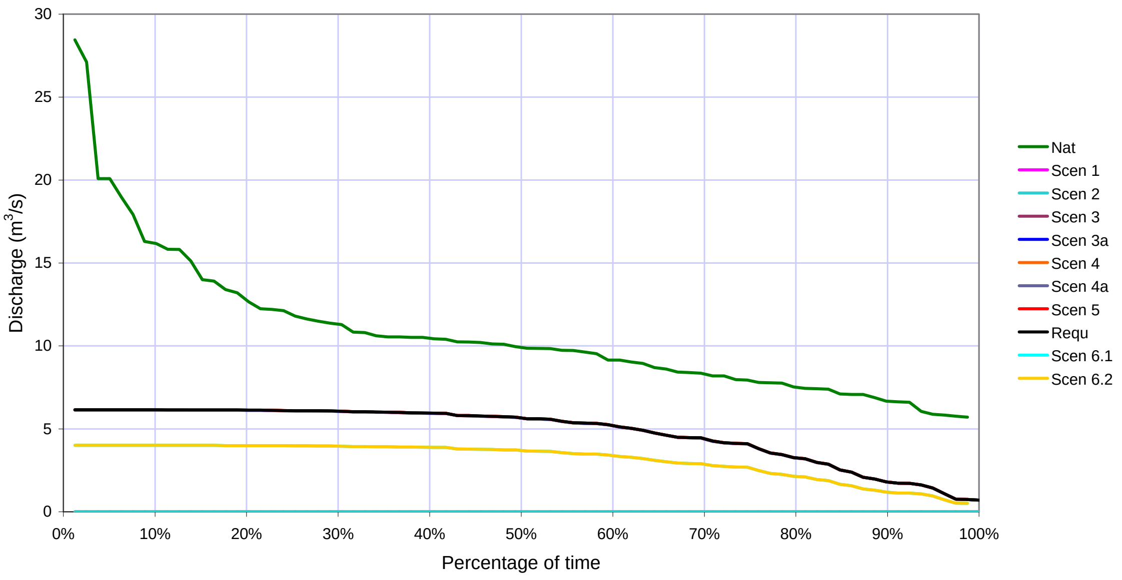

Flow duration curve comparison
EWR G1 : September
25
20
15
10
5
0
Discharge (m3/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
Requ
PES DN

EWR Komati Border

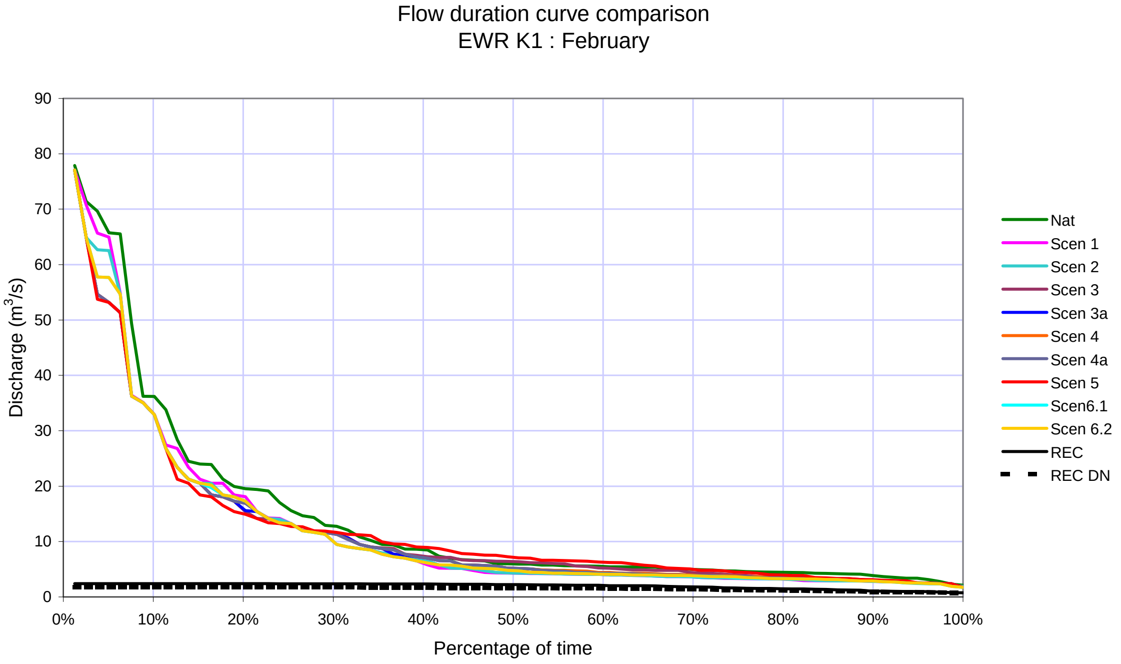
Flow duration curve comparison
EWR K border : February

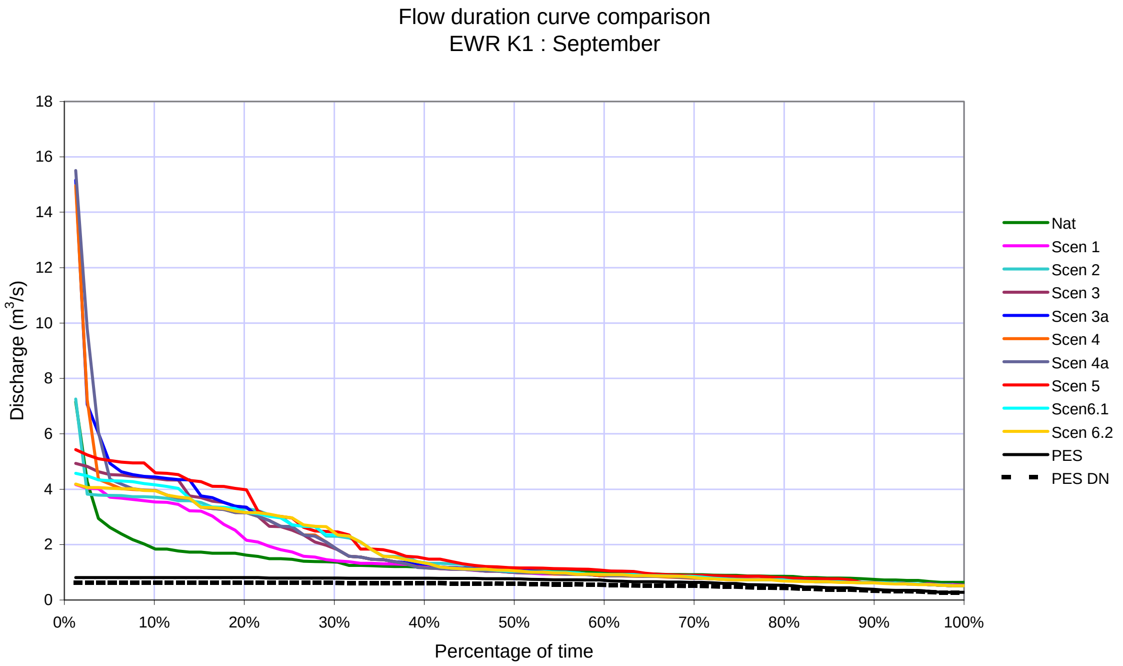


Flow duration curve comparison
EWR K border : September

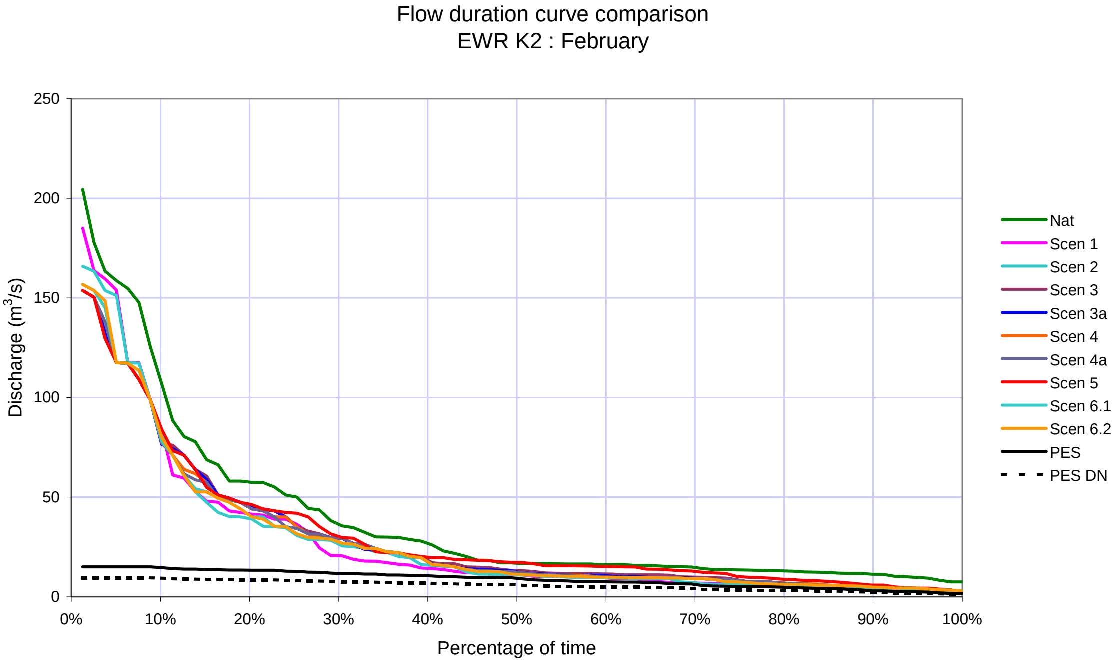


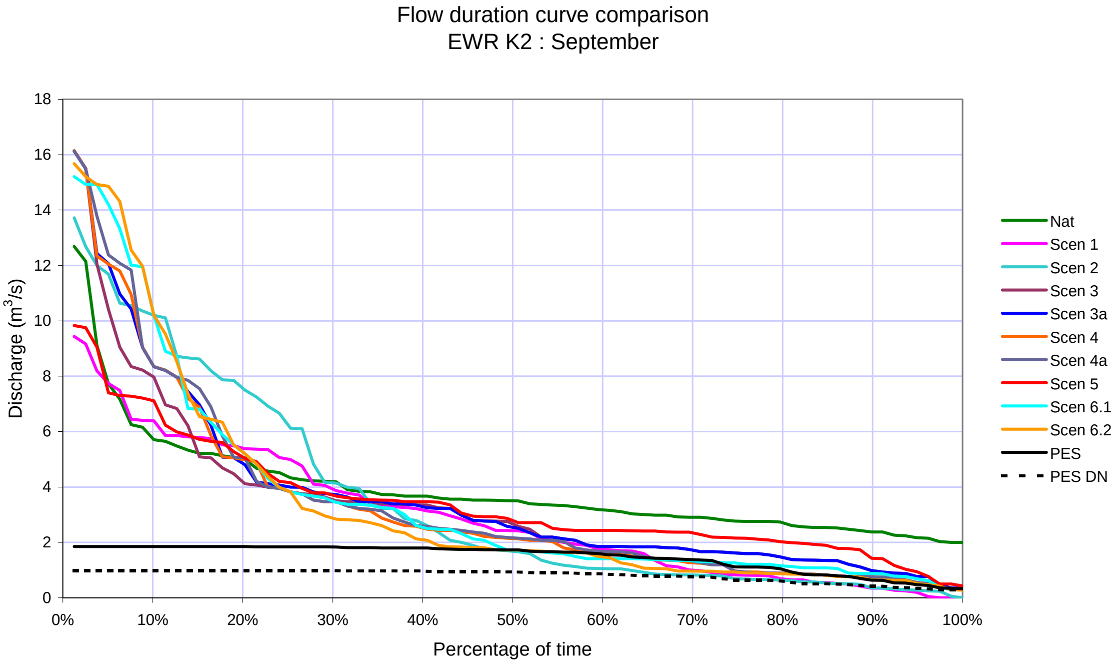
EWR Site K1


Flow duration curve comparison
EWR K1 : February
Discharge (m³/s)
Percentage of time
0
10
20
30
40
50
60
70
80
90
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen6.1
Scen 6.2
REC
REC DN

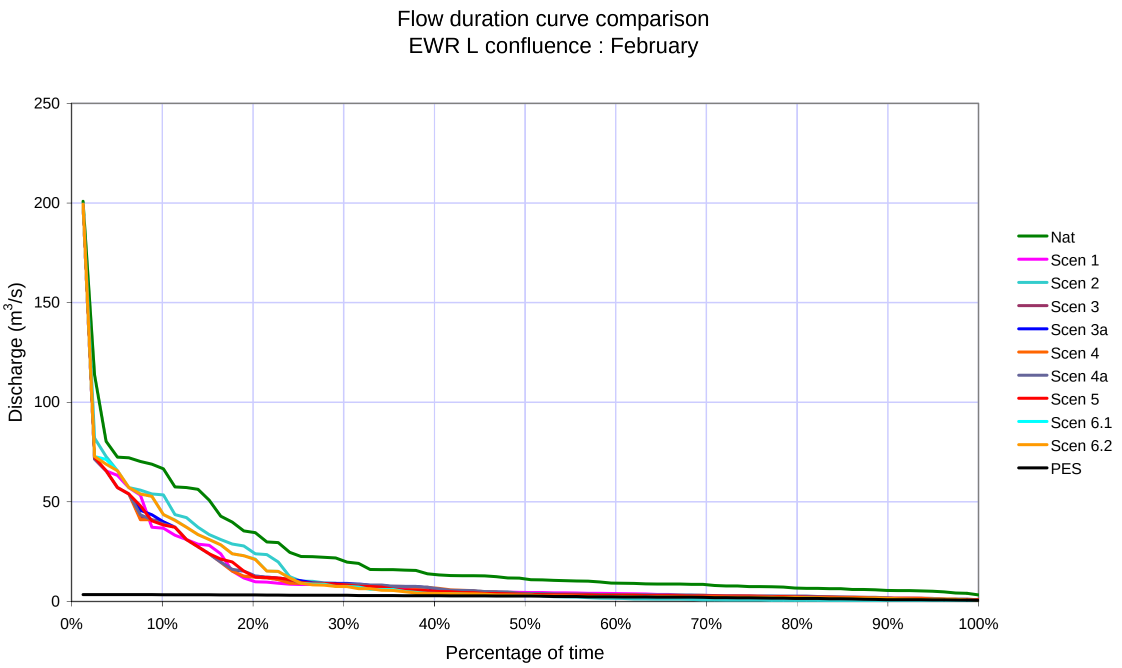

Flow duration curve comparison
EWR K1 : September
Discharge (m³/s)
Percentage of time
0
2
4
6
8
10
12
14
16
18
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen6.1
Scen 6.2
PES
PES DN

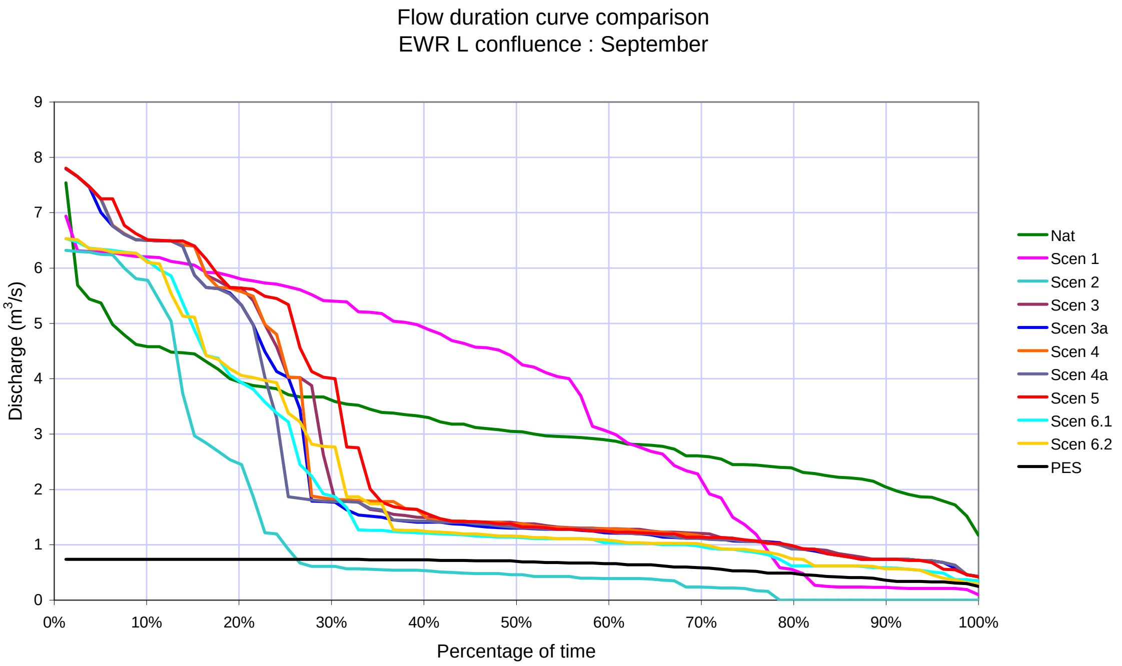
EWR Site K2


Flow duration curve comparison
EWR K2 : February
250
200
150
100
50
0
Discharge (m3/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES
PES DN

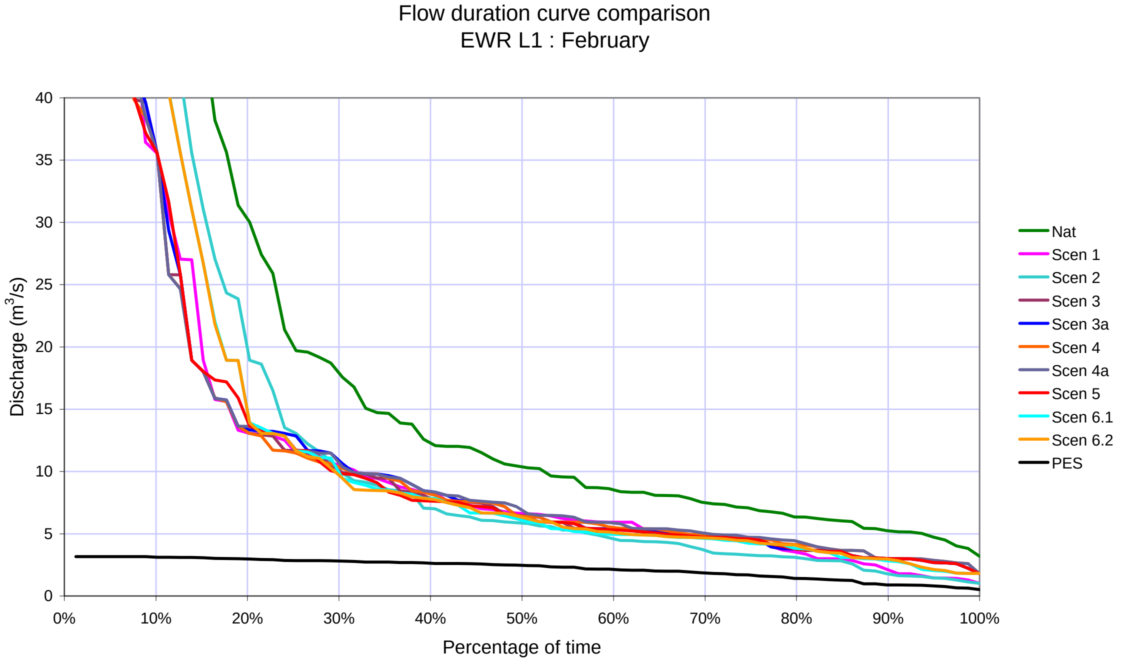

Flow duration curve comparison
EWR K2 : September
18
16
14
12
10
8
6
4
2
0
Discharge (m3/s)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES
PES DN

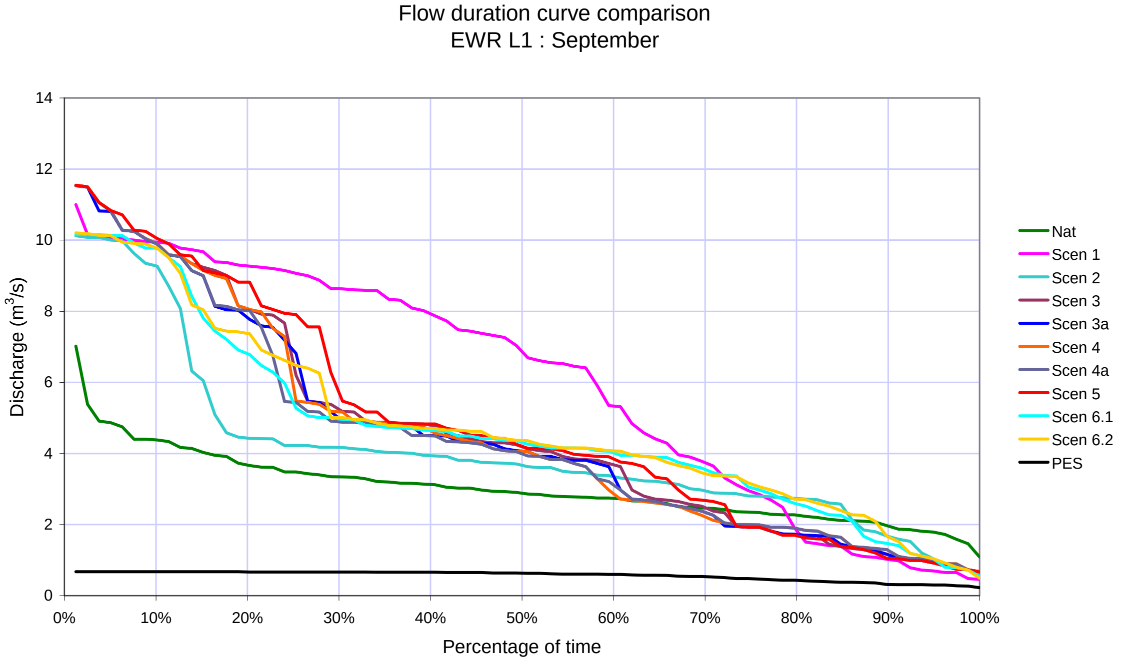
EWR Lomati confluence



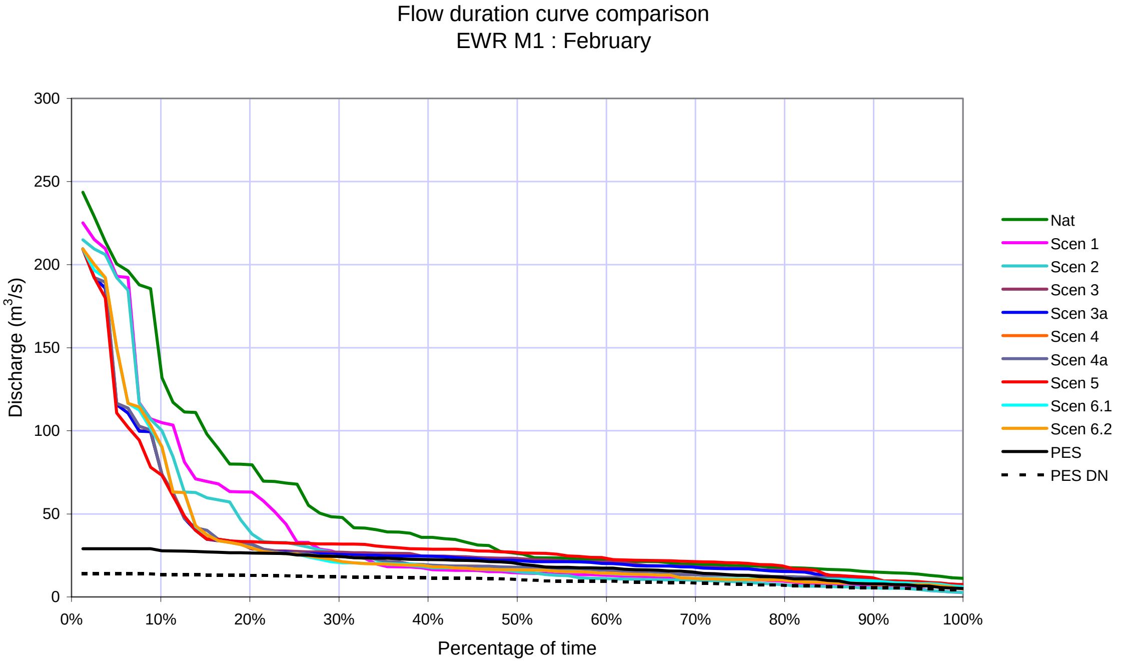


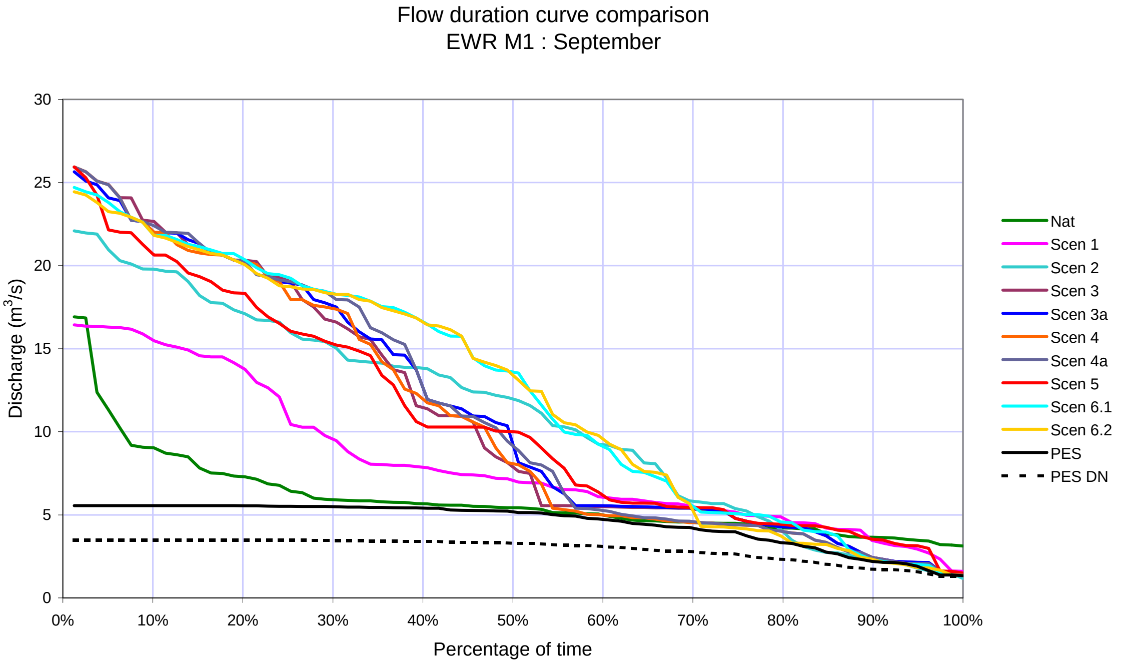
EWR Site L1


Flow duration curve comparison
EWR L1 : February
Discharge (m3/s)
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES


Flow duration curve comparison
EWR L1 : September
Discharge (m3/s)
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES

EWR Site M1


Flow duration curve comparison
EWR M1 : February
Discharge (m³/s)
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES
PES DN


Flow duration curve comparison
EWR M1 : September
Discharge (m³/s)
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of time
Nat
Scen 1
Scen 2
Scen 3
Scen 3a
Scen 4
Scen 4a
Scen 5
Scen 6.1
Scen 6.2
PES
PES DN