RIETVLEI MAC

WATER QUALITY REPORT

29 May 2013

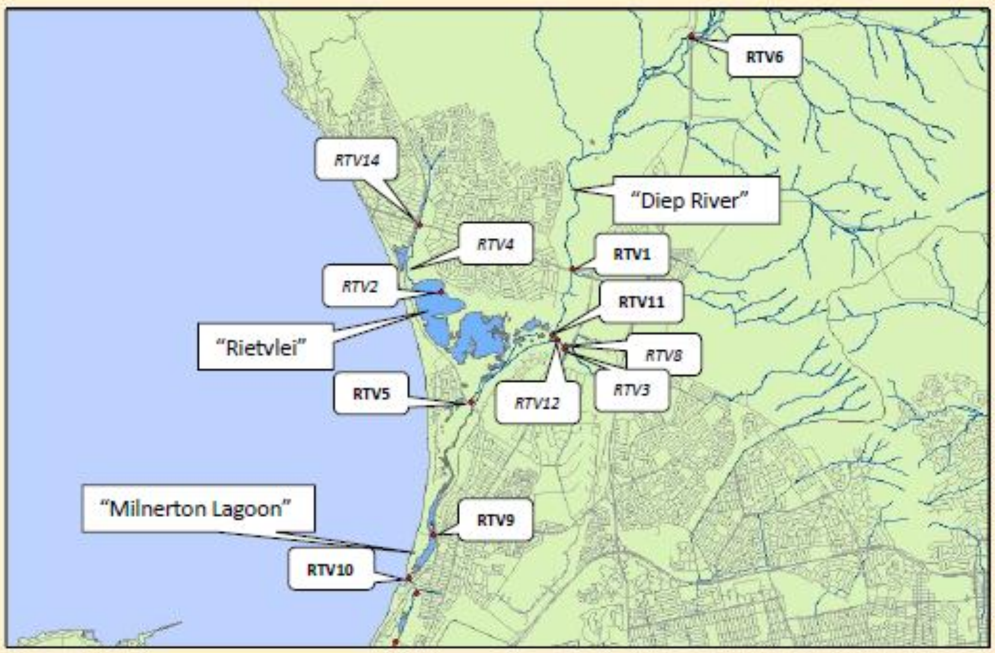
Prepared by C Haskins (Catchment, Stormwater and River Management)

RIETVLEI

Monthly monitoring is undertaken at the locations indicated in the map and table below. These samples are analysed by the City's Scientific Services laboratories and include a range of biological (bacterial and algal), physical and chemical measurements.

Bacterial analyses provide an indication of whether there is any contamination from sewage or animal faecal material. Chemical analyses are used variously to further clarify the nature of pollution issues and also provide an indication of the condition of the ecosystem.

Algal analyses (chlorophyll, microcystin toxins and algal enumeration) are also undertaken, but only in the deep water lake (RTV02).



Location of water quality monitoring stations in the lower Diep / Rietvlei catchment area

Description	Code
Diep River at N7 road bridge	RTV06
Diep River at Blaauwberg Road bridge	RTV01
Diep River downstream of Potsdam WWTW discharge	RTV11
Diep River at Otto du Plessis Drive bridge	RTV05
Milnerton Lagoon at Woodbridge Island	RTV09

Description	Code
Milnerton Lagoon at estuary mouth	RTV10
Bayside stormwater canal at Blaauwberg Rd	RTV14
Bayside stormwater canal near pumpstation	RTV04
Deep water lake - sample collected from pier in watersport area	RTV02
Duikersvlei Stream u/s of confluence with Theo Marais Park stormwater canal	RTV08
Stormwater outfall from Theo Marais Park (Montagu Gardens)	RTV03
Theo Marais downstream of Duikersvlei confluence	RTV12

Bacterial Monitoring

Faecal coliforms and *Escherichia coli* (*E.coli*) are measured in the City's Microbiology laboratory and results are compared to the recreational target guideline for full (≤130 colony-forming units per 100ml) and intermediate contact (≤1000 colony-forming units per 100ml). The full and intermediate contact guidelines can be applied to the formal recreational areas where sailing, water-skiing and canoing take place such as in the deep water lake (RTV02) and Milnerton Lagoon (RTV09 & 10), while the intermediate contact guideline is used to assess the condition of the rivers and canals. Note that the full contact guideline assumes significant and lengthy full body immersion associated with swimming and diving, while the intermediate contact guideline assumes partial contact that would take place during paddling, splashing and brief immersion such as when a vessel capsizes. Swimming and diving in urban water bodies are <u>not</u> recommended.

Extracts from: South African Water Quality Guidelines. Volume 2: Recreational Use. Department of Water Affairs 1996.

E. coli is the preferred indicator of faecal pollution by warm-blooded animals. It is primarily used to indicate the potential presence of bacterial pathogens such as *Salmonella spp*., *Shigella spp*., *Vibrio cholerae*, *Campylobacter jejuni*, *Campylobacter coli*, *Yersinia enterocolitica* and pathogenic *E. coli*. These bacteria can cause gastrointestinal diseases such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever after ingestion of contaminated water.

- **Full-contact recreation (swimming): effects of E. coli on human health**

E. coli range (counts/100m•)	Effects
Target Water Quality Range 0 - 130	*A low risk of gastrointestinal illness is indicated for contact recreational water use. This is not expected to exceed a risk of typically < 8 illnesses/1 000 swimmers*
130 - 200	A slight risk of gastrointestinal effects among swimmers and bathers may be expected. Negligible effects are expected if these levels occur in isolated instances only
200 - 400	Some risk of gastrointestinal effects exists if geometric mean or median *E. coli* levels are in this range, particularly if this occurs frequently. The risk is minimal if only isolated samples fall in this range. Resampling should be conducted if individual results > 400/100 m• are recorded
> 400	Risks of health effects associated with contact recreational water use increase as *E. coli* levels increase. The volume of water which needs to be ingested in order to cause ill effects decreases as the *E. coli* density increases. Gastrointestinal illness can be expected to increase approximately in accordance with the following relationship, based on US EPA epidemiological studies: $y = -150.5 + 423.5(\log x)$ where y = illness rate/100 000 persons, x = number of *E. coli*/100 m• (x• 3)

- **Intermediate contact recreation**

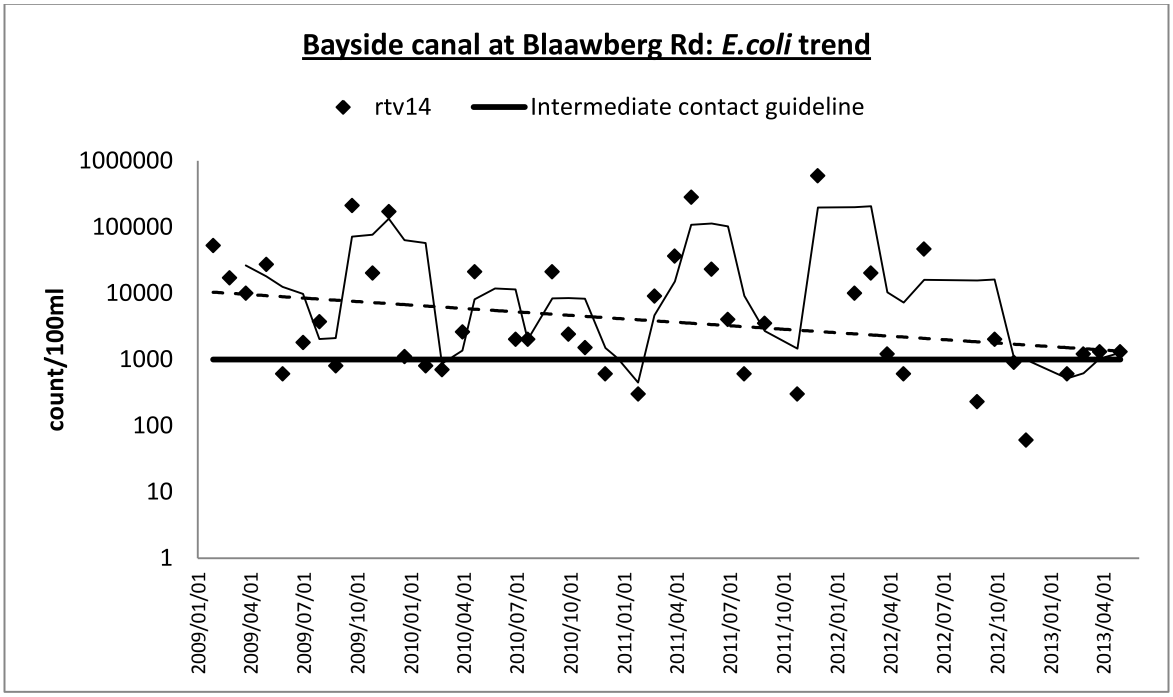
Faecal coliform range (counts/ 100 m•)	Effects
Target Water Quality Range 0 - 1 000	*Health effects are indicated for intermediate contact with recreational water. If water contact is extensive, such as may occur for novice waterskiing or novice windsurfing and if full-body immersion is likely to occur, the more stringent criteria proposed for full-contact recreation may be more appropriate*
1 000 - 4 000	It may be expected that limited contact with water of this quality is associated with a risk of gastrointestinal illness. The upper limit of this range corresponds to the limit recommended by the Australian guidelines for at least four out of five samples collected over 30 days
> 4 000	Intermediate recreational contact with water can be expected to carry an increasing risk of gastrointestinal illness as faecal coliform levels increase

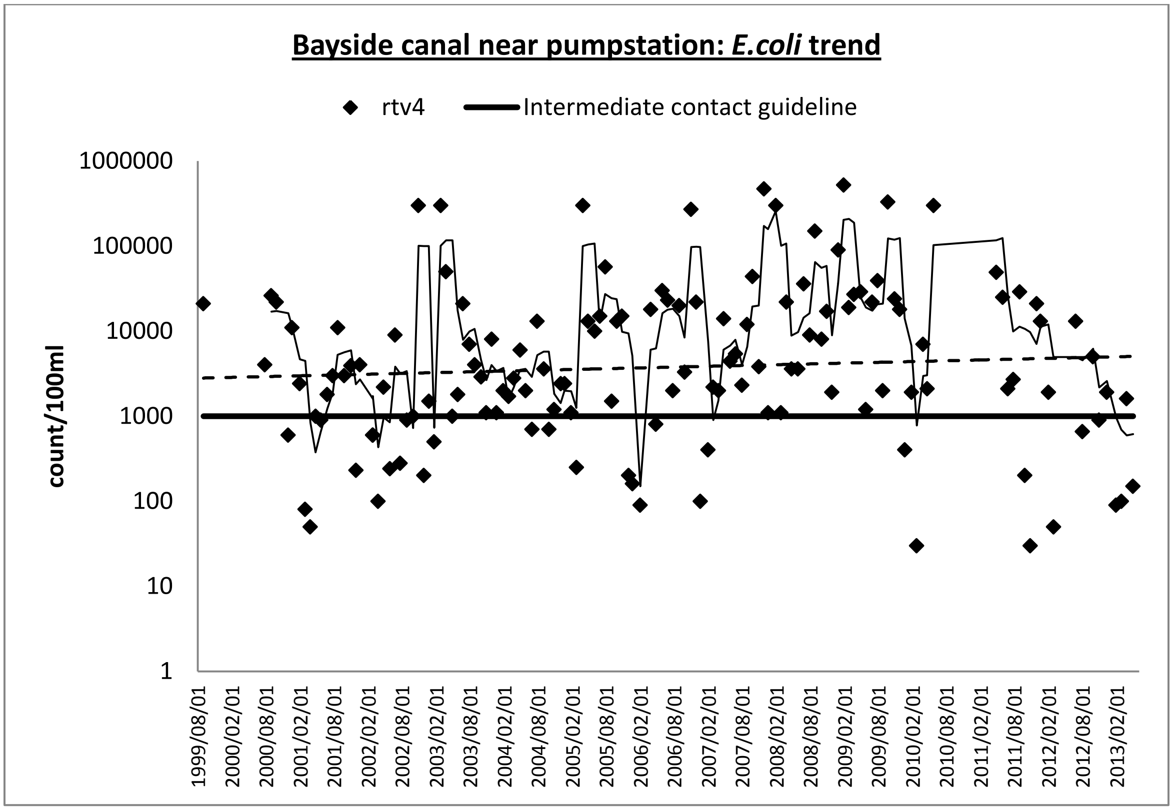
Interpretation of the intermediate contact guideline:

Grade	Faecal coliform count (including *E. coli*)
Target	≤ 1 000 CFU/100 ml
Acceptable	1 001-2 000 CFU/100 ml
Risk	2 001-4000 CFU/100 ml
Unacceptable	>4000 CFU/100 ml

The graphs below illustrate the relative quantities and trends in *E.coli* at 12 sample locations over a period of several years. The graphs have been grouped as follows: 3 samples in Bayside canal and the deep water lake, 6 samples on the Diep River itself from the N7 to the sea, 3 samples in the Duikersvlei and Theo Marais canals.

Bayside canal and watersports area




Bayside canal near pumpstation: E.coli trend
rtv4
Intermediate contact guideline
count/100ml
1000000
100000
10000
1000
100
10
1
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
2006/02/01
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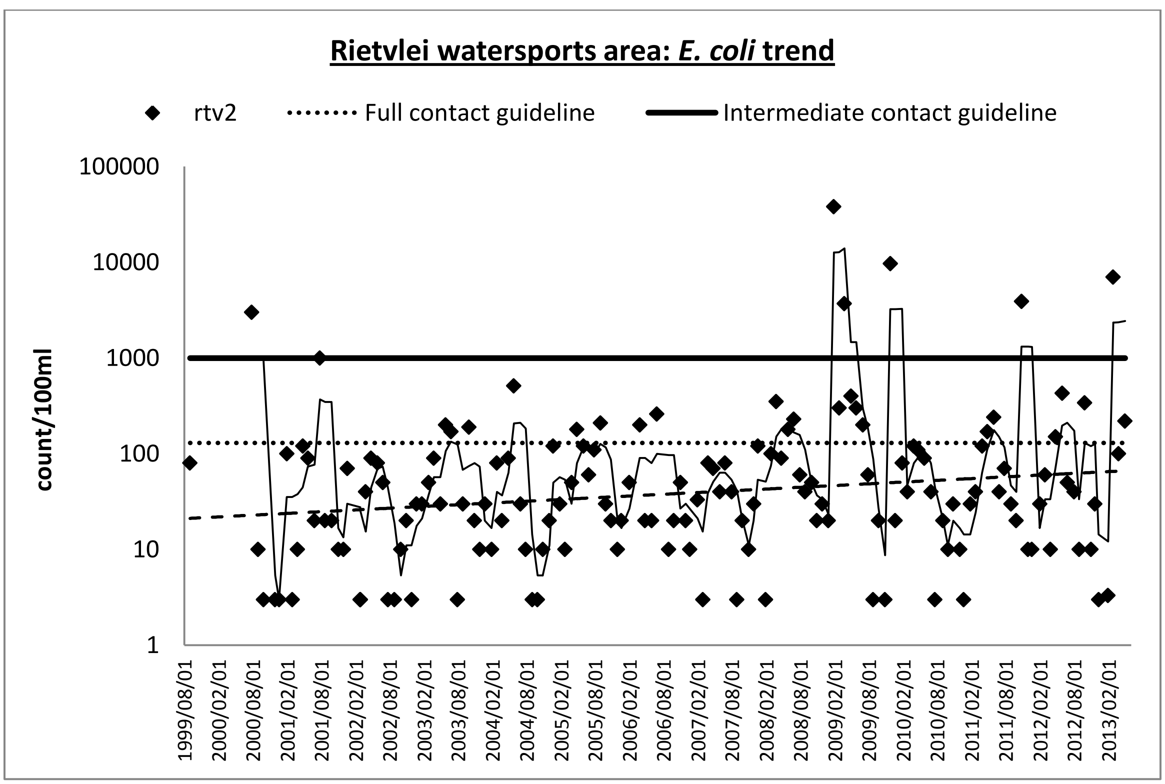
2012/08/01
2013/02/01


Rietvlei watersports area: E. coli trend
rtv2
Full contact guideline
Intermediate contact guideline
count/100ml
100000
10000
1000
100
10
1
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
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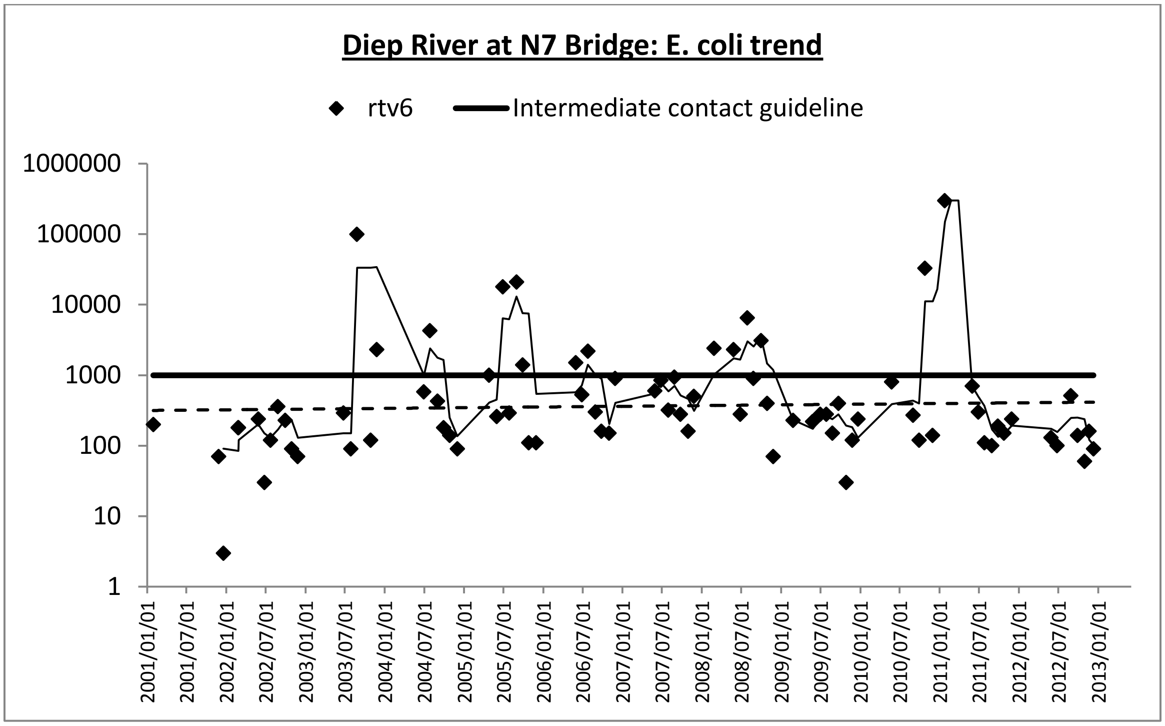
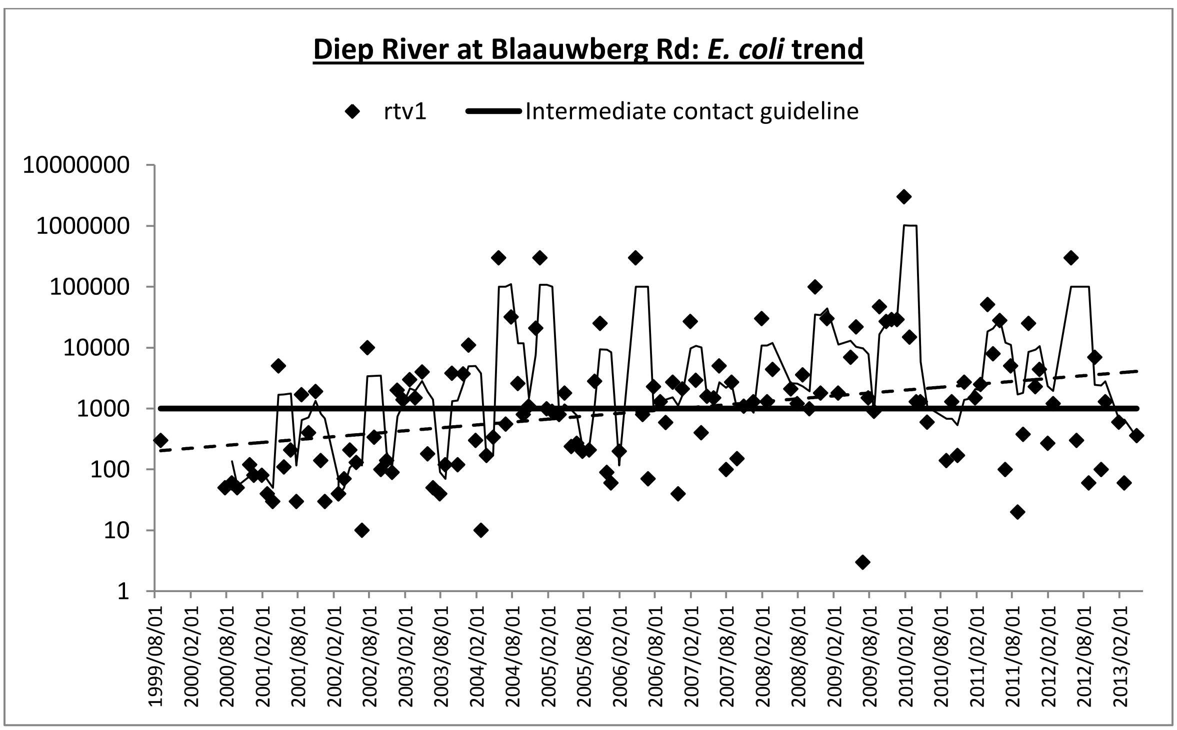
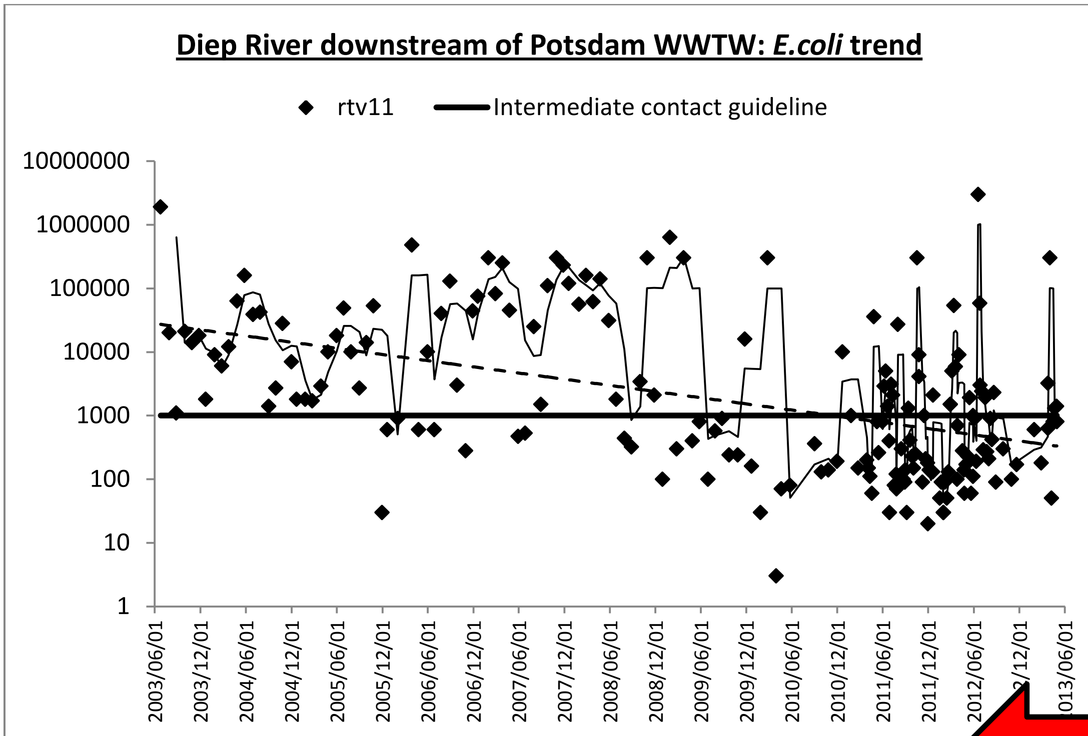
2012/02/01
2012/08/01
2013/02/01

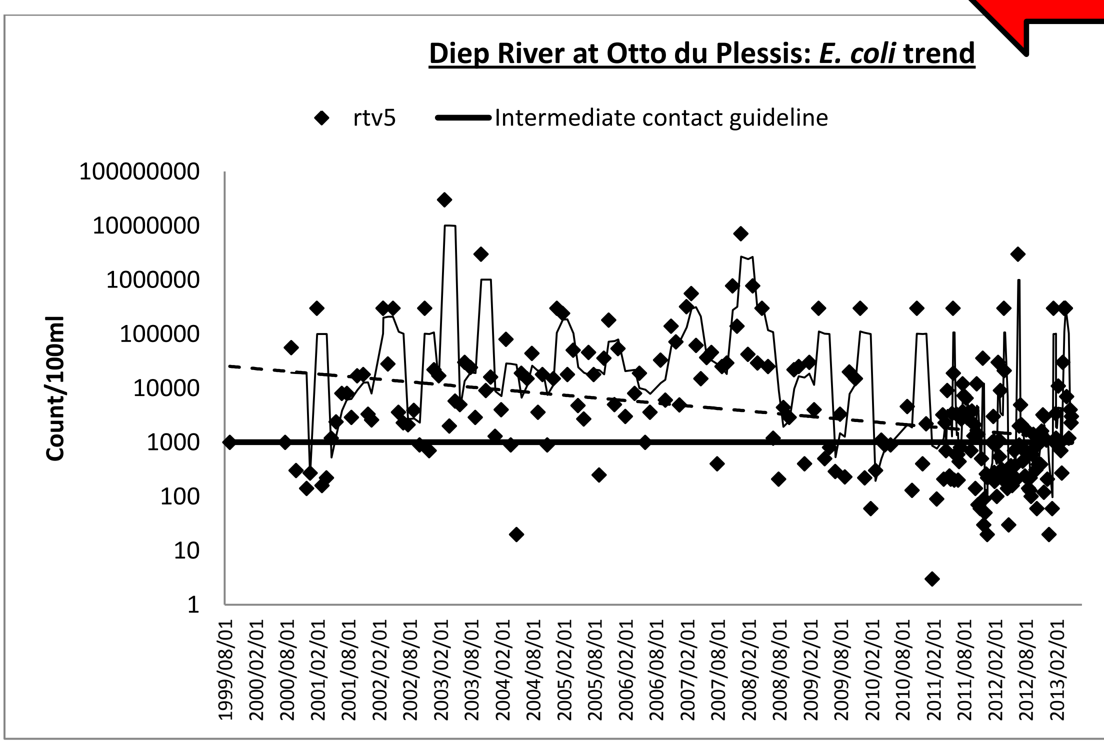
Diep River from N7 to sea






Diep River downstream of Potsdam WWTW: *E.coli* trend
rtv11
Intermediate contact guideline
10000000
1000000
100000
10000
1000
100
10
1
2003/06/01
2003/12/01
2004/06/01
2004/12/01
2005/06/01
2005/12/01
2006/06/01
2006/12/01
2007/06/01
2007/12/01
2008/06/01
2008/12/01
2009/06/01
2009/12/01
2010/06/01
2010/12/01
2011/06/01
2011/12/01
2012/06/01
2013/06/01


Theo Marais enters


Diep River at Otto du Plessis: *E. coli* trend
rtv5
Intermediate contact guideline
Count/100ml
100000000
10000000
1000000
100000
10000
1000
100
10
1
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
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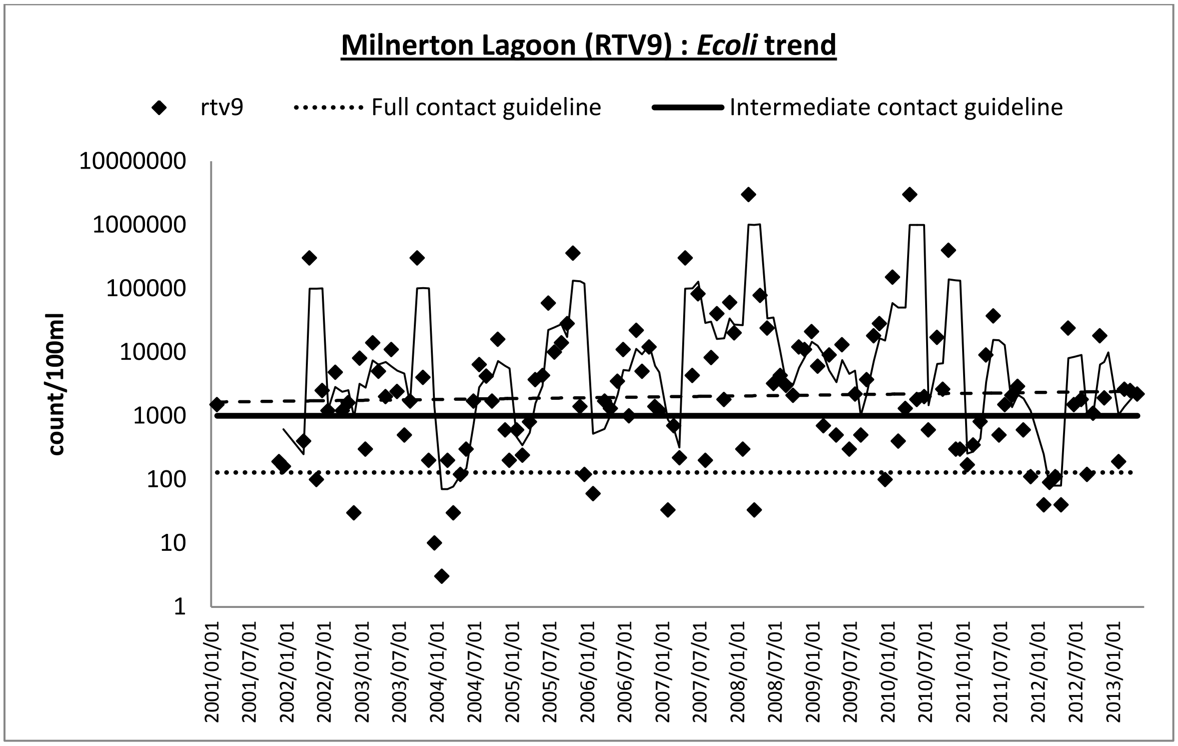
2013/02/01


Milnerton Lagoon (RTV9) : Ecoli trend
rtv9
Full contact guideline
Intermediate contact guideline
count/100ml
10000000
1000000
100000
10000
1000
100
10
1
2001/01/01
2001/07/01
2002/01/01
2002/07/01
2003/01/01
2003/07/01
2004/01/01
2004/07/01
2005/01/01
2005/07/01
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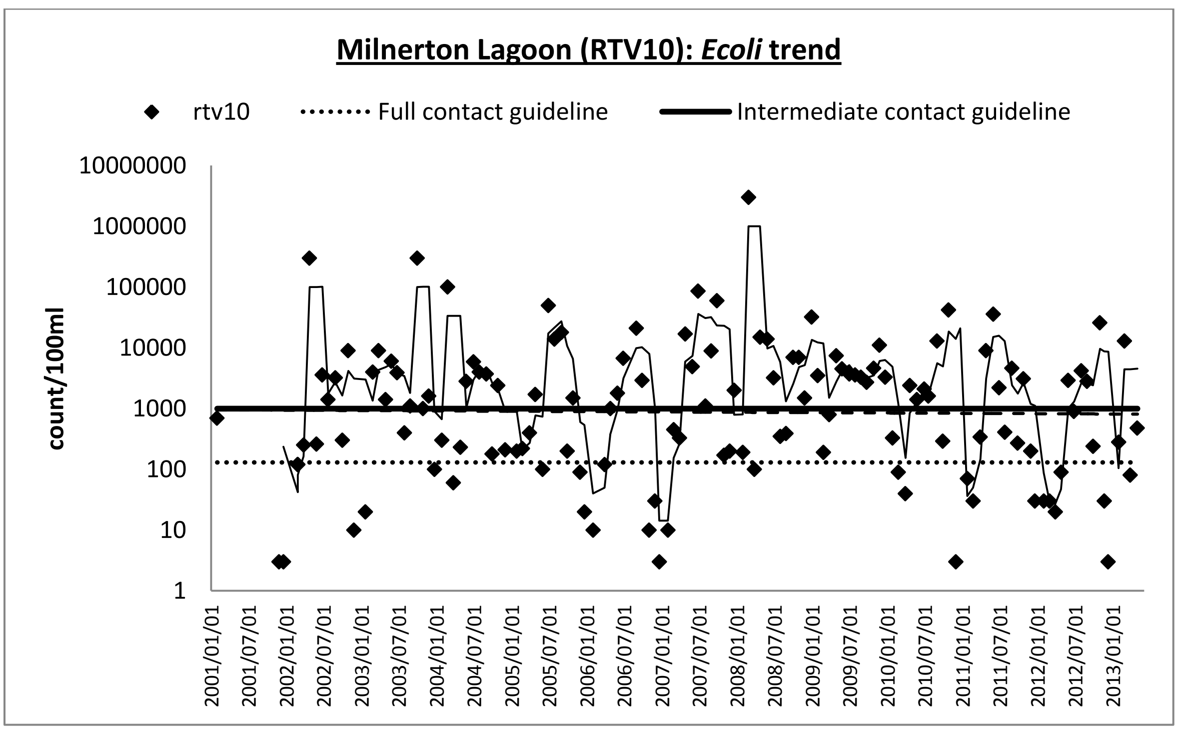
2012/07/01
2013/01/01


Milnerton Lagoon (RTV10): Ecoli trend
rtv10
Full contact guideline
Intermediate contact guideline
count/100ml
10000000
1000000
100000
10000
1000
100
10
1
2001/01/01
2001/07/01
2002/01/01
2002/07/01
2003/01/01
2003/07/01
2004/01/01
2004/07/01
2005/01/01
2005/07/01
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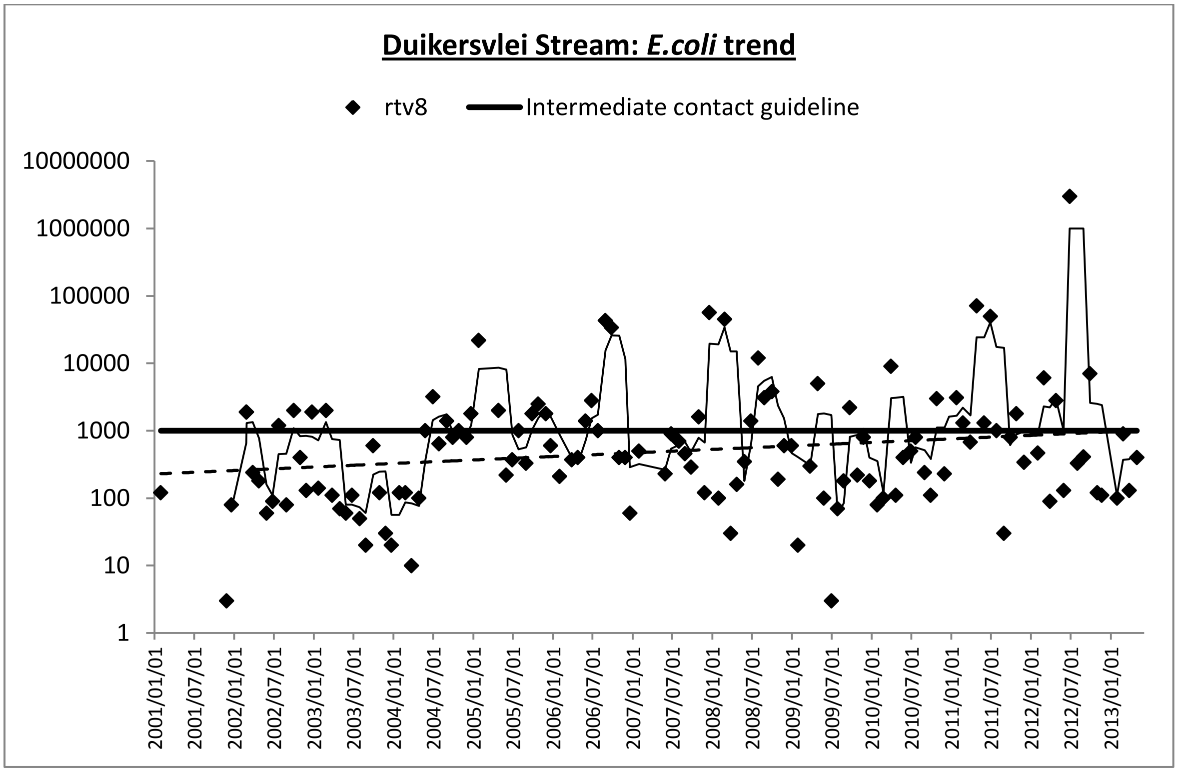
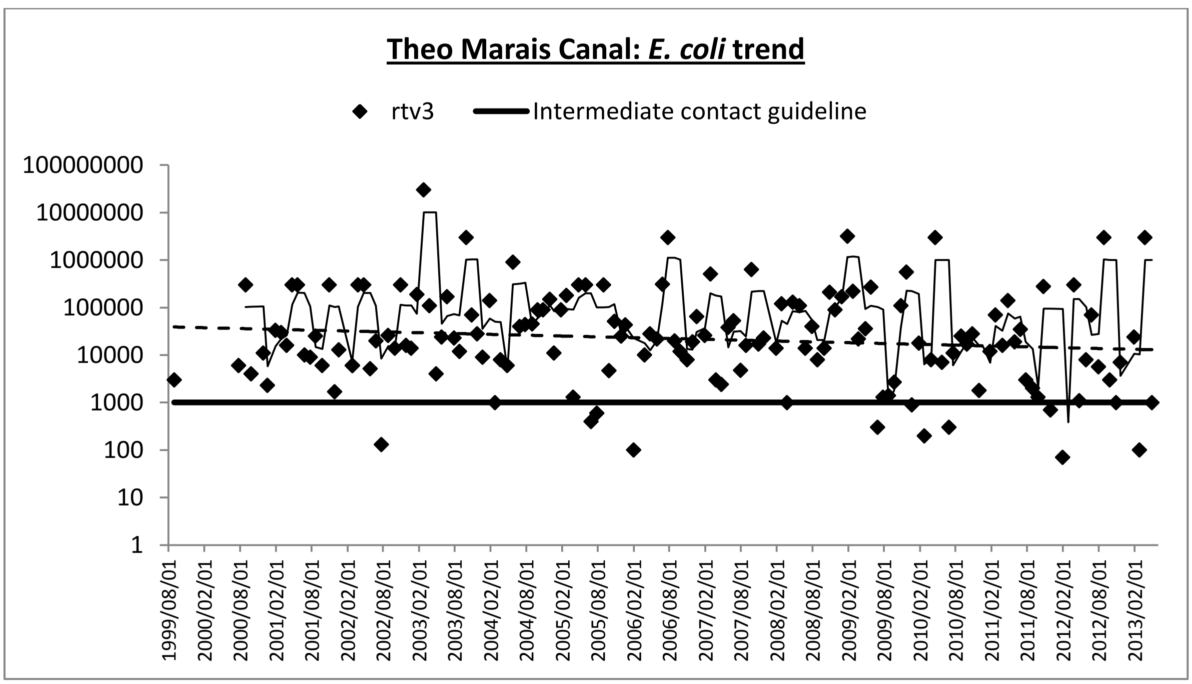
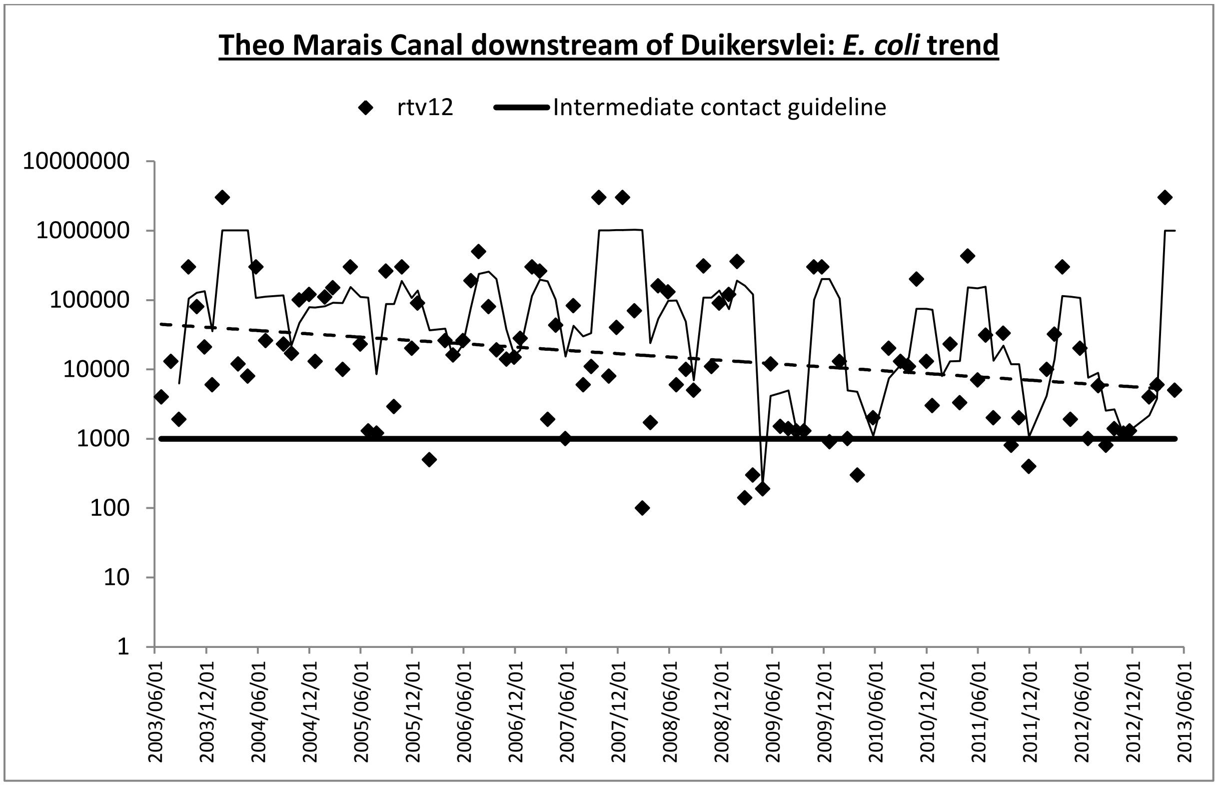
2012/07/01
2013/01/01

Theo Marais Canal and Duikersvlei Stream







Nutrients

Nutrients are essential requirements for all living organisms, and plants in particular respond with rapid growth and productivity when nitrogen and phosphorus are abundant. However anthropogenic sources of these nutrients can mean that there is an excessive availability with prolific growth of aquatic plants such as reeds and hyacinth, and algae being a consequence of this.

It is interesting to note that reeds may assist to an extent with water quality improvement through the uptake of nutrients and filtering which results in sediments settling out of the water column. However the increased growth and sediment trapping ability of reedbeds also creates an environment conducive for the further spread of reeds into areas that may have previously been too deep for them to colonise. This creates a significant management challenge. The rivers, canals and water bodies in this catchment support healthy stands of both *Phragmites* and *Typha* reeds. The extreme depth of the recreational water body precludes the establishment of reeds with only large sedges and some pond weed generally occurring on the shallow fringes of the water body.

Inorganic nitrogen

Nitrogen is present in many forms within the aquatic environment and undergoes breakdown through processing in the nitrogen cycle, ultimately being volatilized to nitrogen in gaseous form. "Inorganic nitrogen" comprising soluble ammonia and nitrite+nitrate is used by plants and algae for growth. The series of graphs below illustrates the inorganic nitrogen trends in different areas of the catchment.

Inorganic nitrogen guideline levels (thresholds) applicable to both rivers and vleis are also depicted on the graphs (see also table below), and these facilitate interpretation of the results. Note that the Categories A to F in the table below are comparable to the management classes specified within various aquatic ecosystem assessment procedures used widely around South Africa. Categories A to D are regarded by the Department of Water Affairs as permissible management classes. Systems in a class E or F must be managed to at least a class D or better.

Total Inorganic Nitrogen Threshold Levels[1]	Category	Interpretation
< 0.25	A	No change from natural
0.7	B	Small change from natural
1	C	Moderate change from natural
4	D	Large change from natural
10	E	Serious change from natural
> 10	F	Extreme change from natural

The series of graphs below illustrates the inorganic nitrogen trends in different areas of Rietvlei and the various rivers or canals. A trend line (light dotted line) has also been included on each graph in order to provide a rough indication of whether nutrient levels are increasing, decreasing or stable. Note that the interim guideline inorganic N level in the Rietvlei EMP stipulated between 0.5 and 2 mg/l N (Category B > C/D) for the estuarine area.

Total phosphorus

Phosphorus is also an essential nutrient for plant growth although it is generally present in lower concentrations than nitrogen, and plants need proportionately less P than N. It tends to be the nutrient that ultimately limits / controls rate of growth and productivity in plants and therefore is often targeted as a nutrient of concern in catchment scale initiatives to address urban sources of phosphate pollution. Phosphorus is a conservative nutrient that does not breakdown – in systems (e.g. RTV02) which have continuous inputs via the catchment inflows and a long hydraulic residence time; phosphorus levels will inevitably increase and be recycled internally between organic and inorganic forms.

Both "total phosphorus" and "orthophosphate" are measured, however it is the orthophosphate (also sometimes called soluble reactive phosphorus) that is immediately available for uptake by plants and algae. Conservative nutrients such as phosphorus will tend to remain locked in the vlei and recycled

[1] Threshold levels are as determined in the development of a Water Quality Index for Cape Town's rivers, wetlands and estuaries (Day and Clark 2012)

through natural processes of biotic growth, senescence and decomposition. Total phosphorus (TP) is a measure of all the chemical species of phosphorus present in the water column. It includes dissolved forms, insoluble particulate forms and phosphorus already incorporated into phytoplankton cells. For this reason data reflecting total phosphorus and chlorophyll levels are often strongly correlated (refer to RTV2 trend graphs for Total phosphorus and chlorophyll-a which have remarkably similar 'signatures'!). Total phosphorus is considered useful for determining trophic status, because it represents all the phosphorus *potentially* available for incorporation into active biomass.

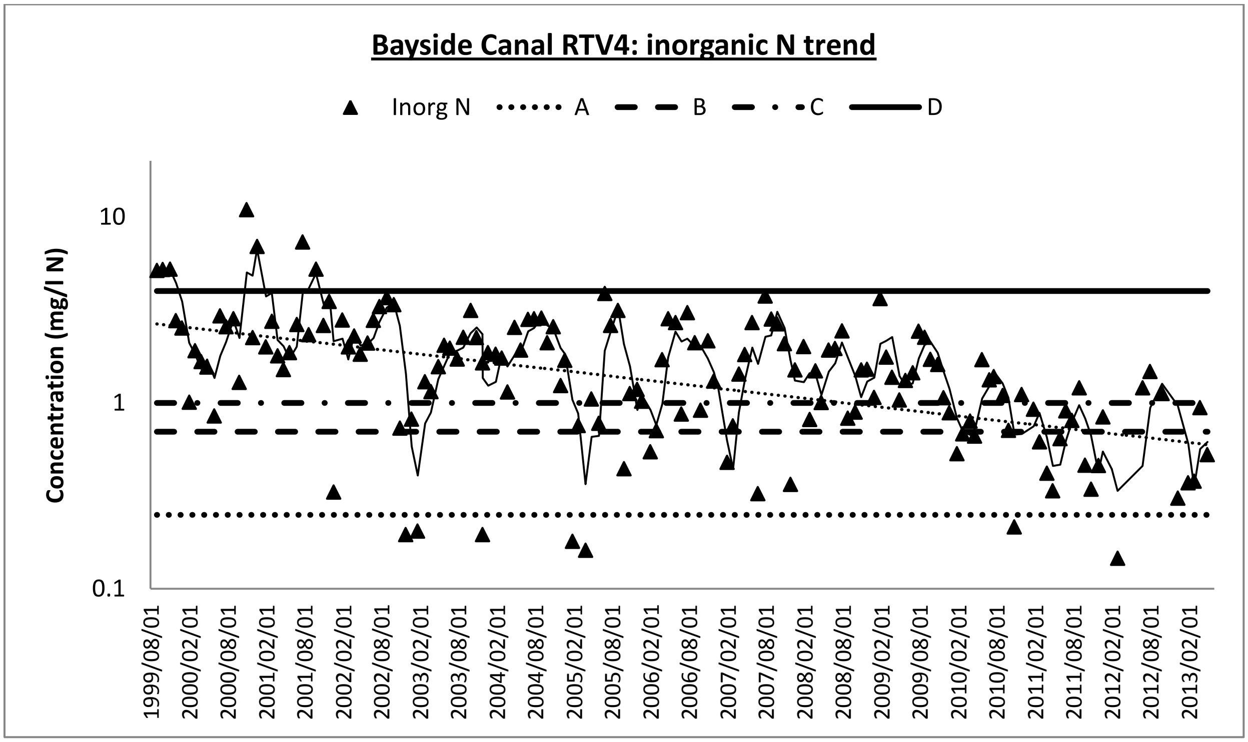
Under natural conditions, phosphorus may be growth-limiting in aquatic ecosystems. High concentrations of phosphorus increase potential productivity i.e. promote plant growth. Rooted submerged and emergent macrophytes obtain the bulk of their phosphorus nutrients from the sediment. By contrast, free floating macrophytes and phytoplankton obtain their phosphorus from the water column. Manipulation (increases or decreases) in phosphorus concentration is likely to lead to a more rapid response from floating macrophytes or algae, than from rooted macrophytes.

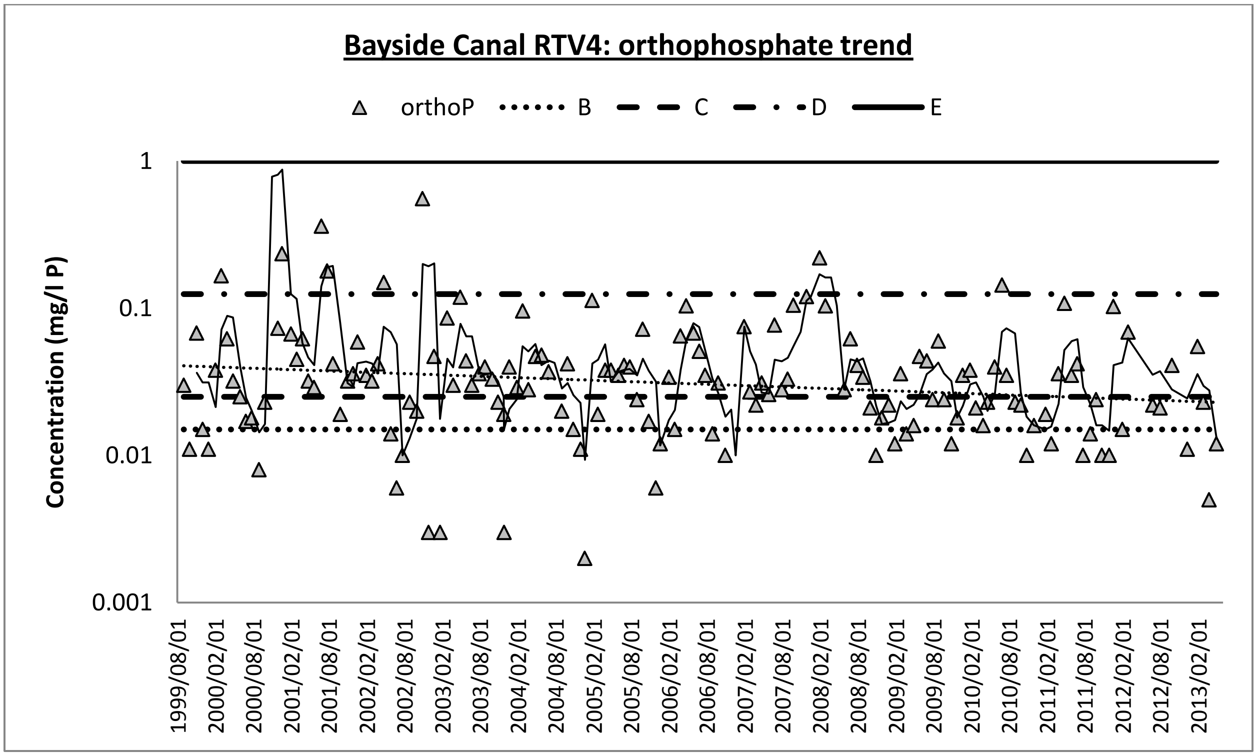
Rapid turn-over of plant material, particularly phytoplankton, associated with high concentrations of dissolved phosphorus can contribute to the formation of anoxic conditions as a result of rapid decomposition of plant cells. These conditions can in turn promote release of phosphorus from sediments, fuelling additional productivity.

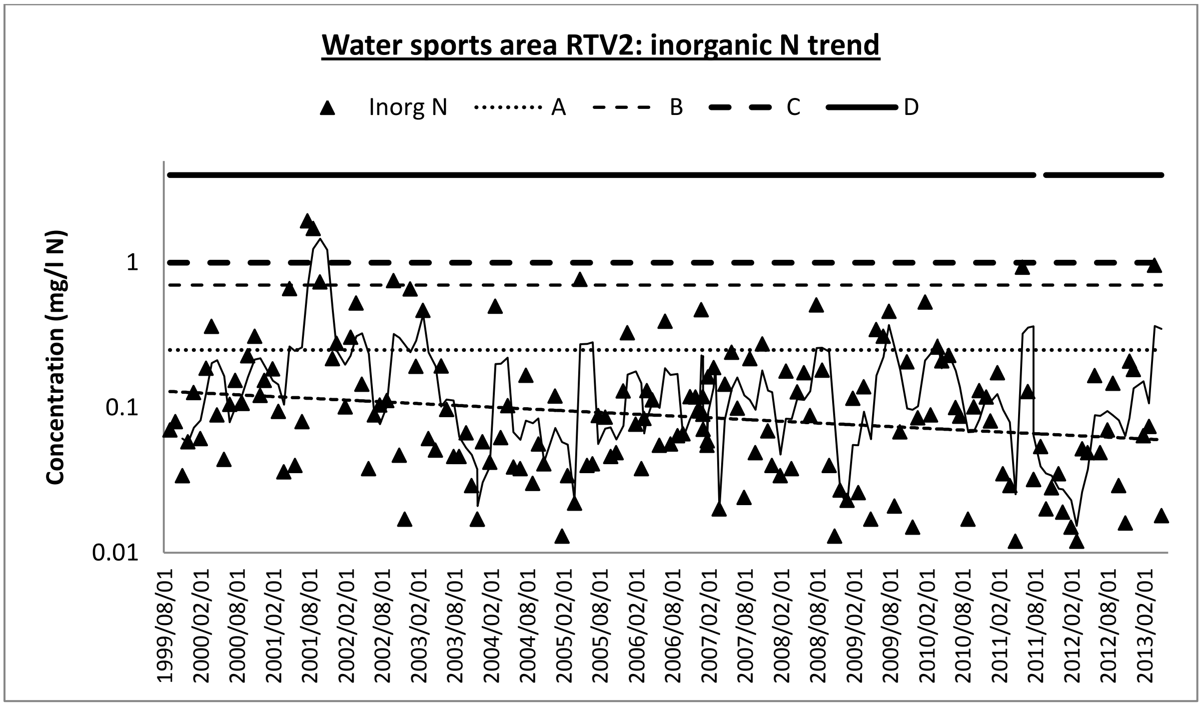
Total phosphorus and orthophosphate guideline levels (thresholds) applicable to vleis and rivers, respectively are depicted on the trend graphs (see also table below), and these facilitate interpretation of the results. A trend line (light dotted line) has also been included on each graph in order to provide a rough indication of whether nutrient levels are increasing, decreasing or stable. Note that the Rietvlei EMP recommended the interim target orthophosphate level at 0.1 mg/l P (Category C/D).

Total Phosphorus Threshold Levels VLEIS and ESTUARIES	Orthophosphate Threshold Levels RIVERS	Category	Interpretation
< 0.005	**<0.005**	**A**	**No change from natural**
0.015	**0.015**	**B**	**Small change from natural**
0.047	**0.025**	**C**	**Moderate change from natural**
0.13	**0.125**	**D**	**Large change from natural**
1	**1**	**E**	**Serious change from natural**
> 1	**>1**	**F**	**Extreme change from natural**

Bayside canal and watersports area







Water sports area RTV2: inorganic N trend
Inorg N
A
B
C
D
Concentration (mg/l N)
1
0.1
0.01
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
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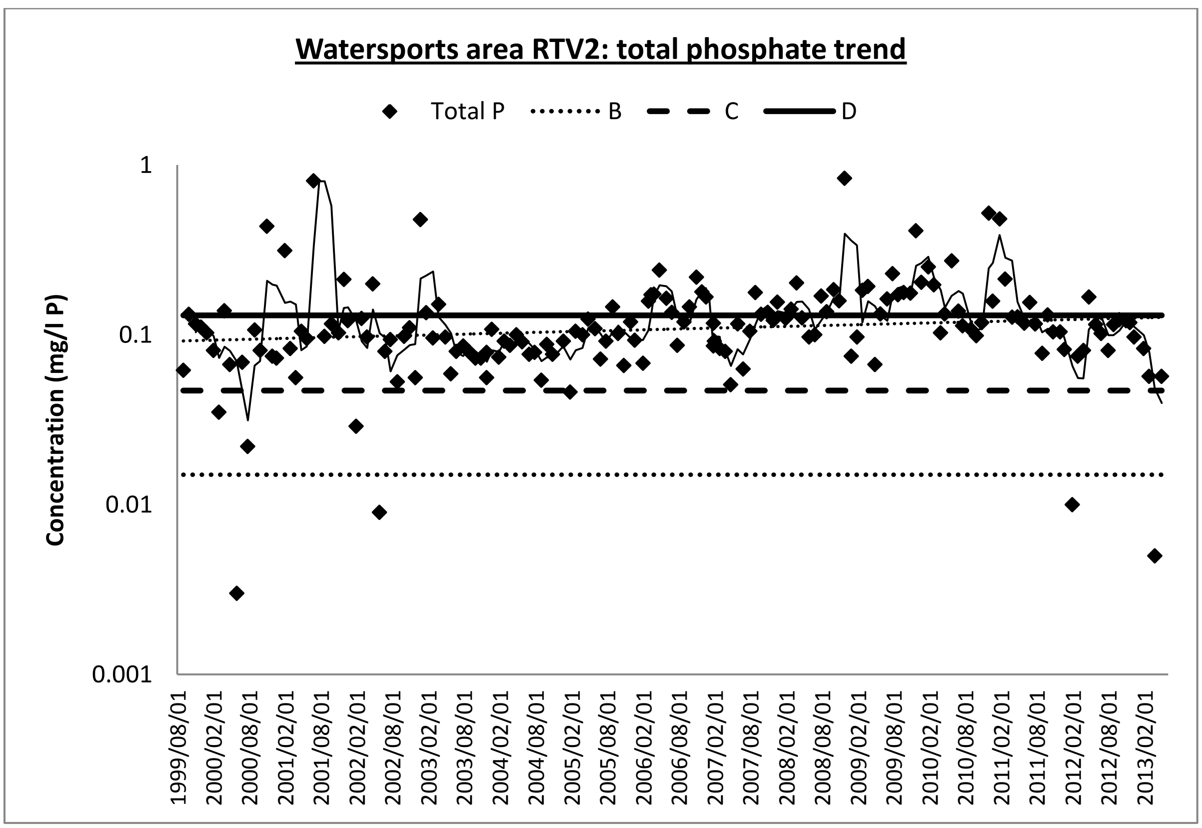
2012/08/01
2013/02/01



Watersports area RTV2: total phosphate trend
Total P
B
C
D
Concentration (mg/l P)
1
0.1
0.01
0.001
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
2006/02/01
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2009/08/01
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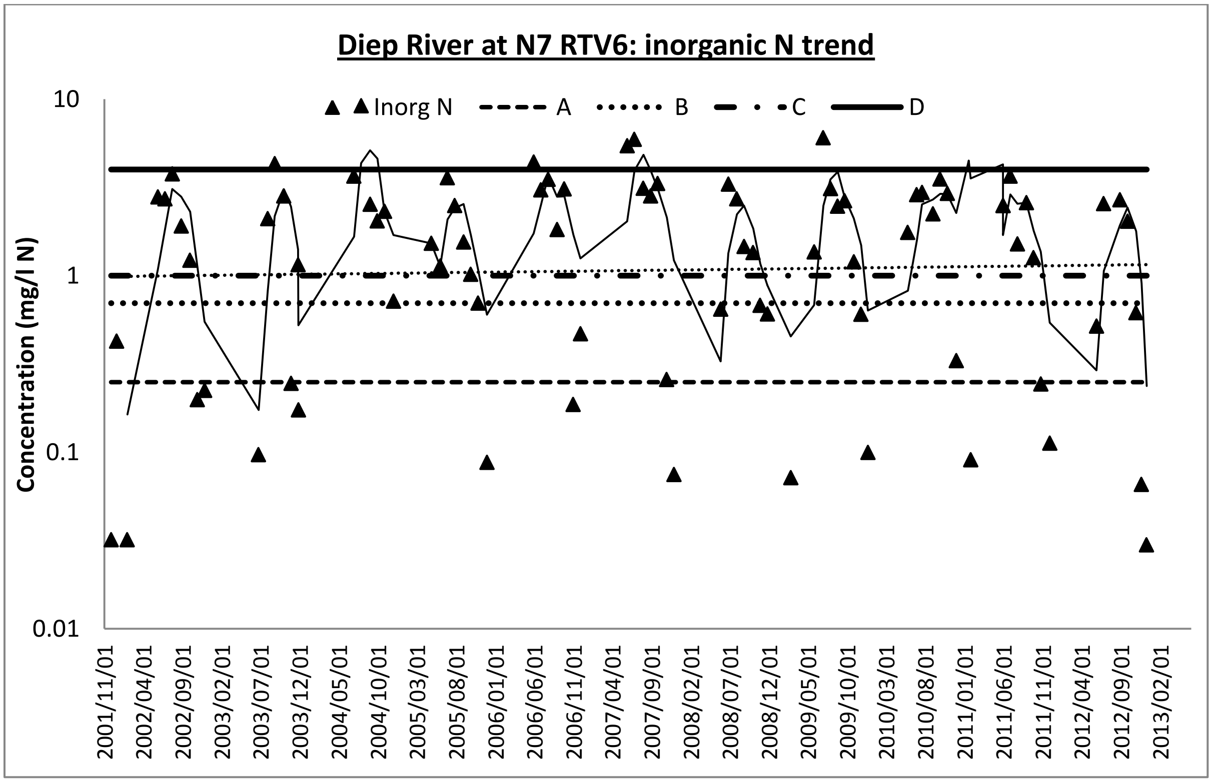
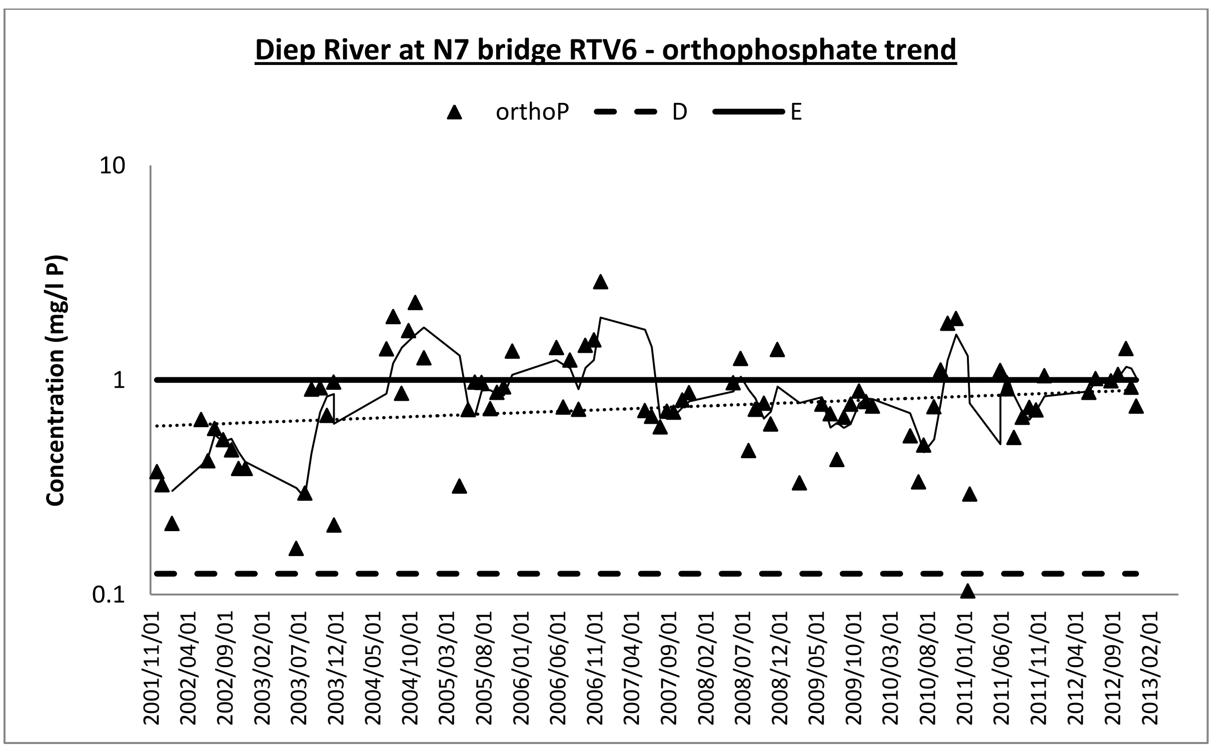
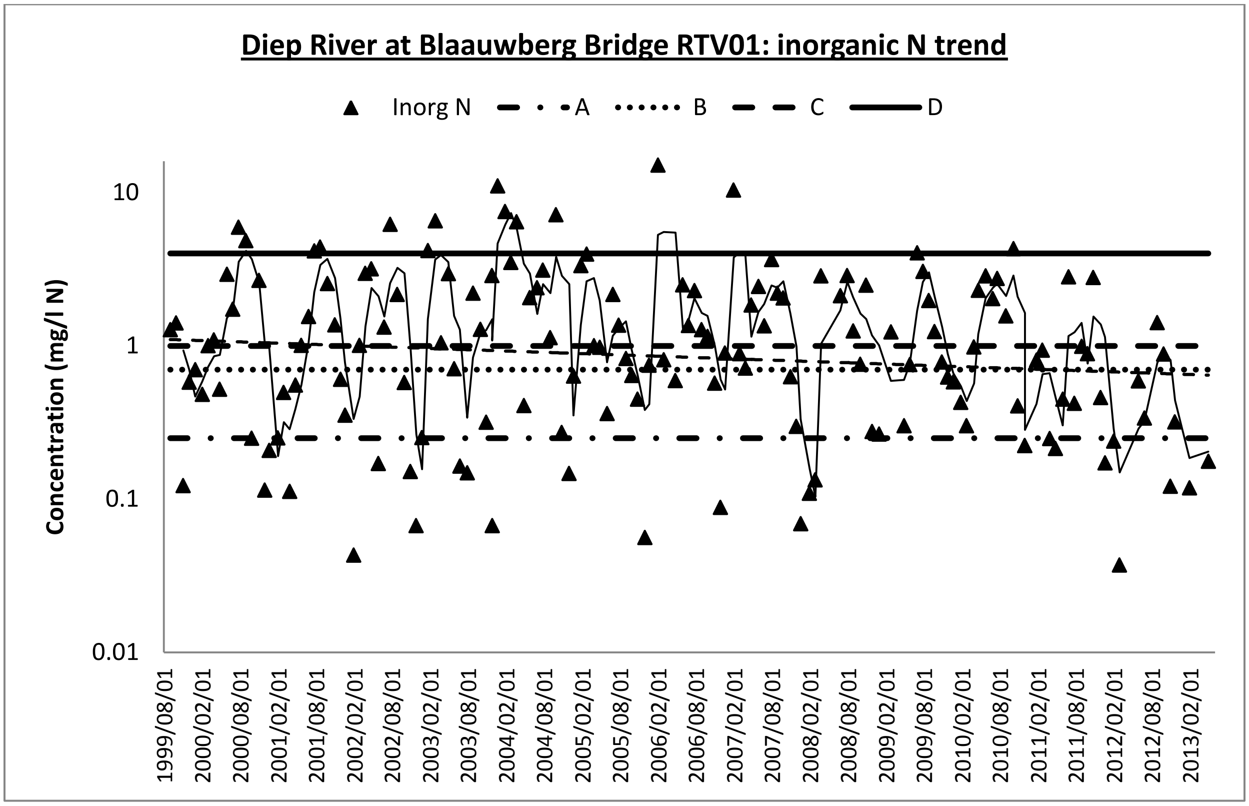
2012/08/01
2013/02/01

Diep River from N7 to sea






Diep River at Blaauwberg Bridge RTV01: inorganic N trend
Inorg N
A
B
C
D
Concentration (mg/l N)
10
1
0.1
0.01
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
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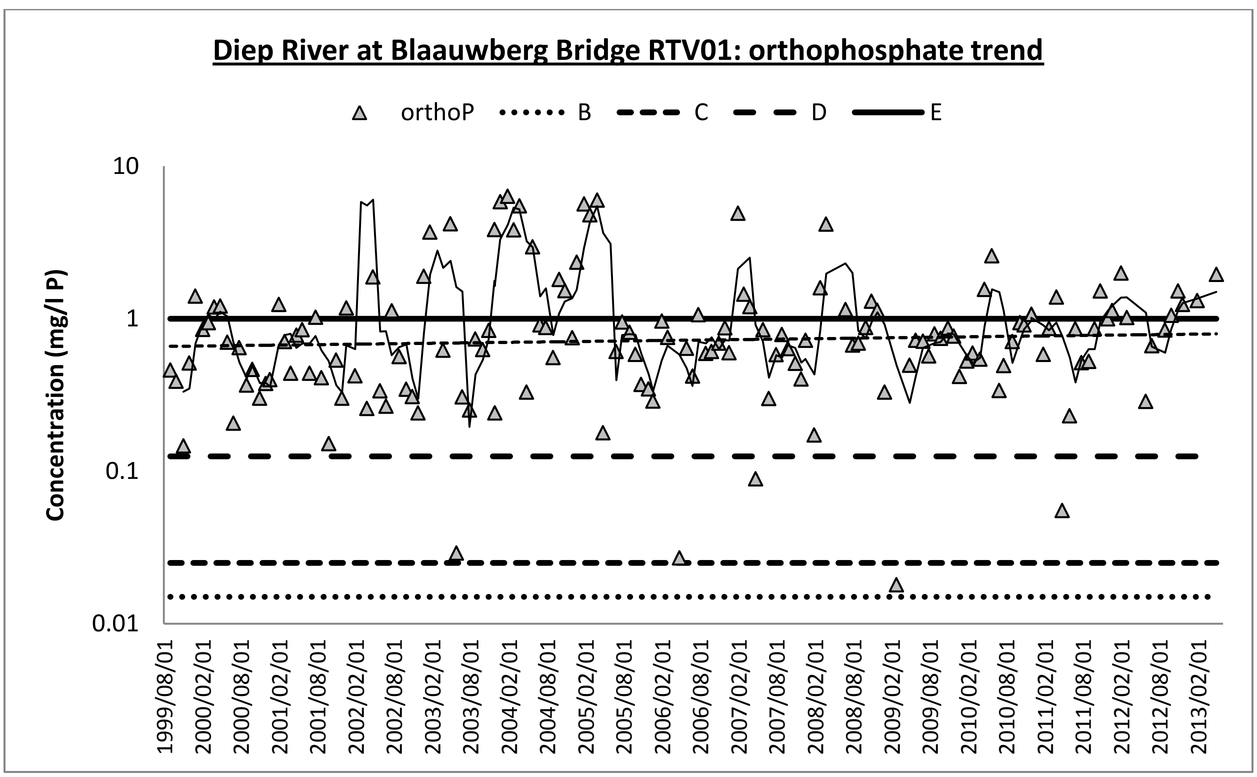
2012/08/01
2013/02/01


Diep River at Blaauwberg Bridge RTV01: orthophosphate trend
orthoP
B
C
D
E
Concentration (mg/l P)
10
1
0.1
0.01
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
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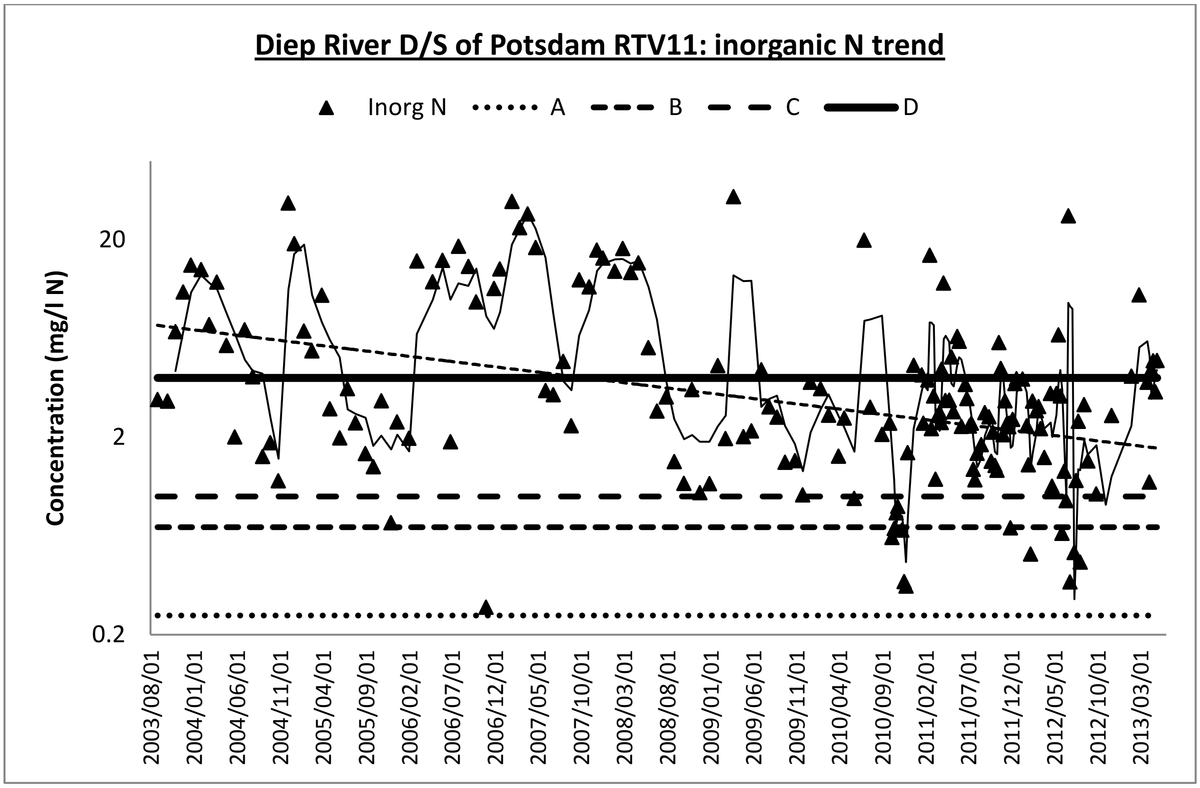
2012/08/01
2013/02/01


Diep River D/S of Potsdam RTV11: inorganic N trend
Inorg N
A
B
C
D
Concentration (mg/l N)
20
2
0.2
2003/08/01
2004/01/01
2004/06/01
2004/11/01
2005/04/01
2005/09/01
2006/02/01
2006/07/01
2006/12/01
2007/05/01
2007/10/01
2008/03/01
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2009/06/01
2009/11/01
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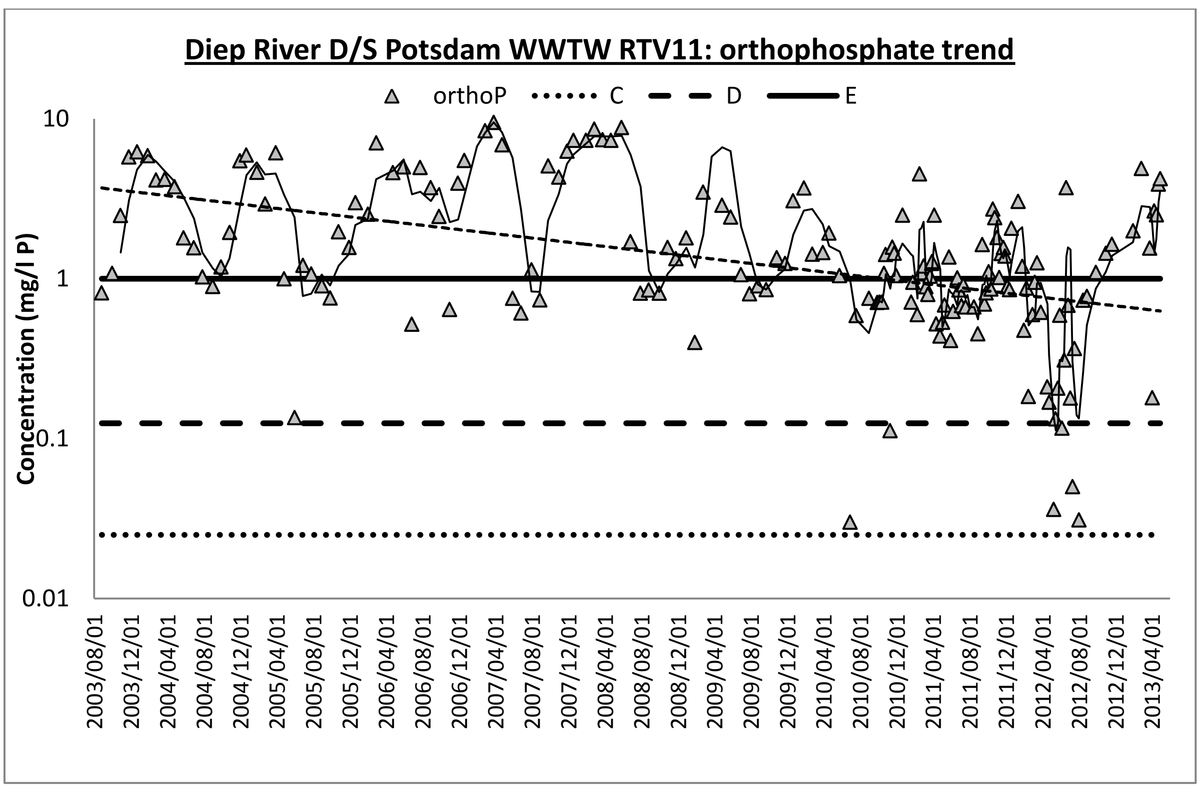
2010/09/01
2011/02/01
2011/07/01
2011/12/01
2012/05/01
2012/10/01
2013/03/01


Diep River D/S Potsdam WWTW RTV11: orthophosphate trend
orthoP
C
D
E
Concentration (mg/l P)
10
1
0.1
0.01
2003/08/01
2003/12/01
2004/04/01
2004/08/01
2004/12/01
2005/04/01
2005/08/01
2005/12/01
2006/04/01
2006/08/01
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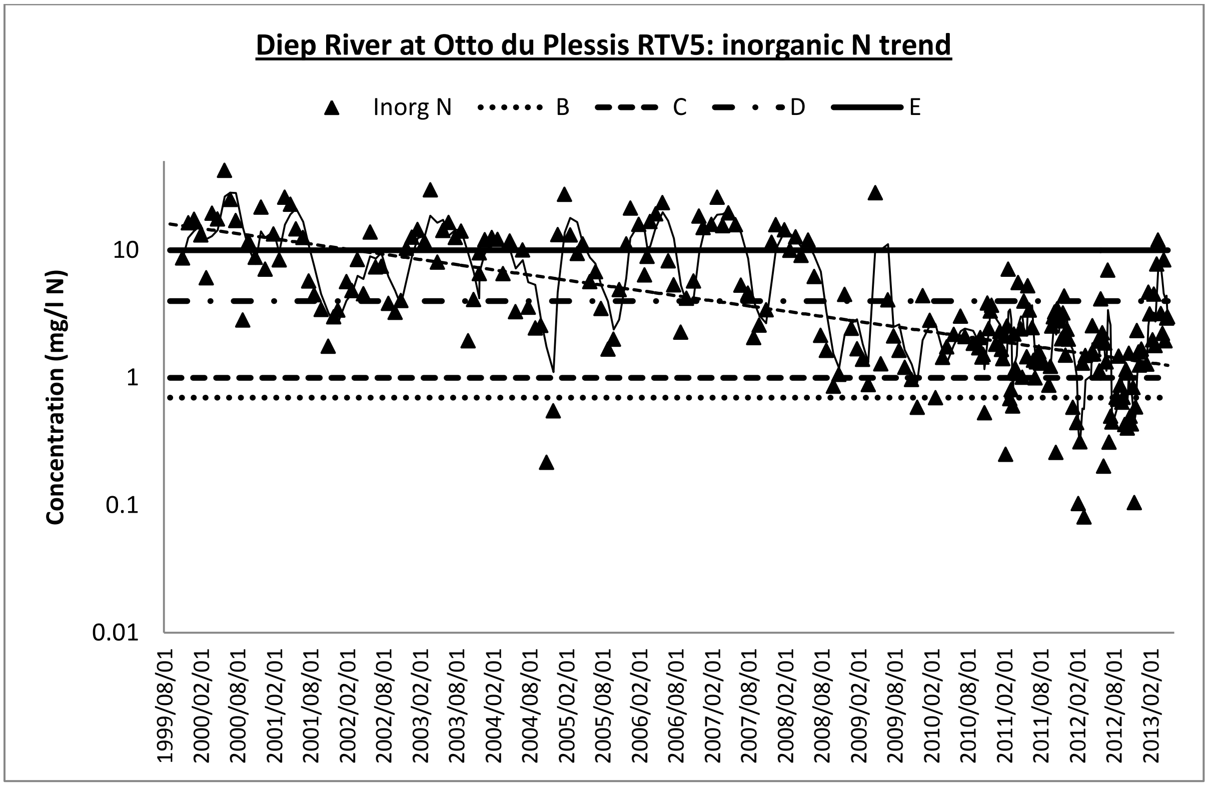
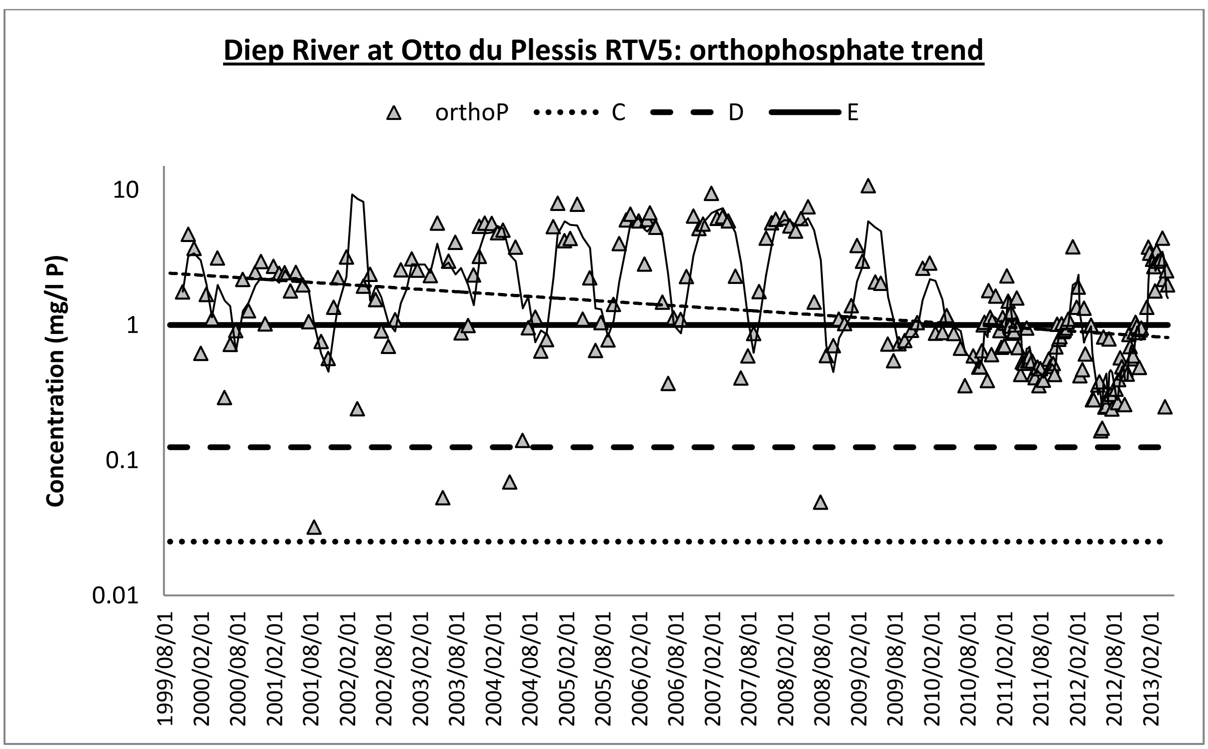
2012/12/01
2013/04/01


Diep River at Otto du Plessis RTV5: inorganic N trend
Inorg N
B
C
D
E
Concentration (mg/l N)
10
1
0.1
0.01
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
2006/02/01
2006/08/01
2007/02/01
2007/08/01
2008/02/01
2008/08/01
2009/02/01
2009/08/01
2010/02/01
2010/08/01
2011/02/01
2011/08/01
2012/02/01
2012/08/01
2013/02/01


Diep River at Otto du Plessis RTV5: orthophosphate trend
orthoP
C
D
E
Concentration (mg/l P)
10
1
0.1
0.01
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
2006/02/01
2006/08/01
2007/02/01
2007/08/01
2008/02/01
2008/08/01
2009/02/01
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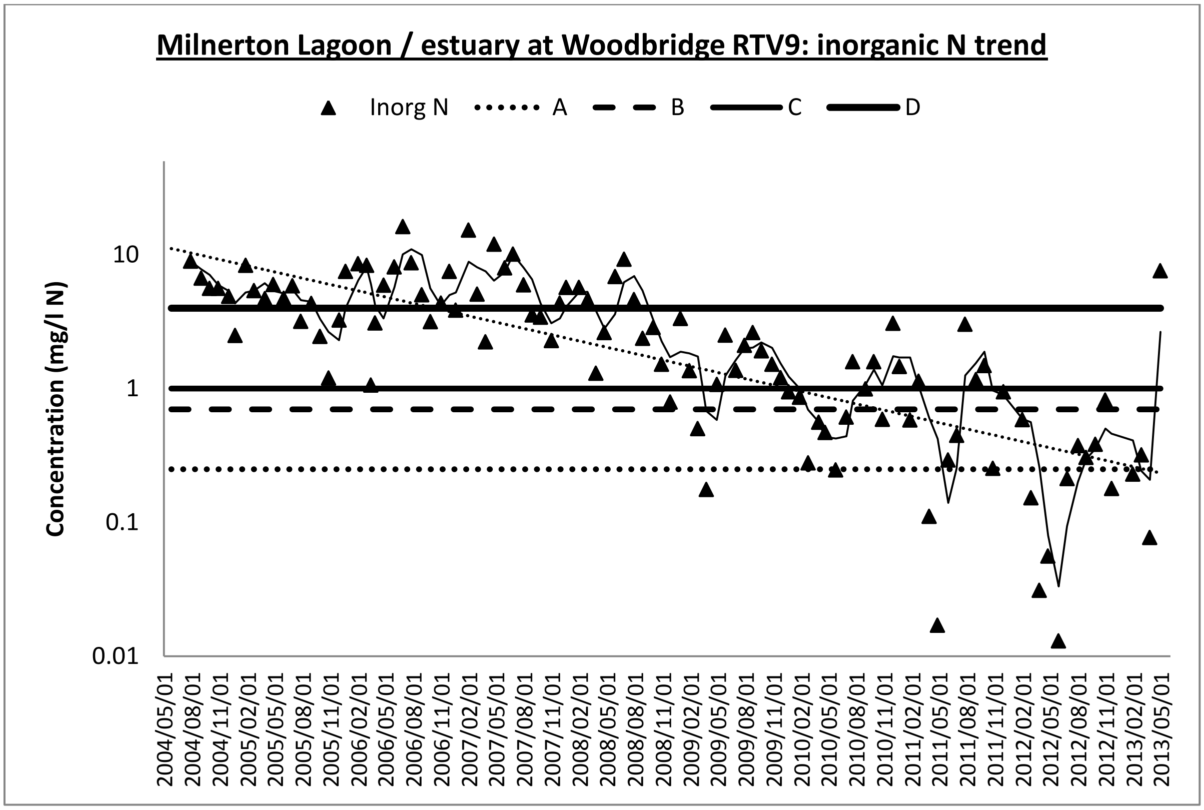
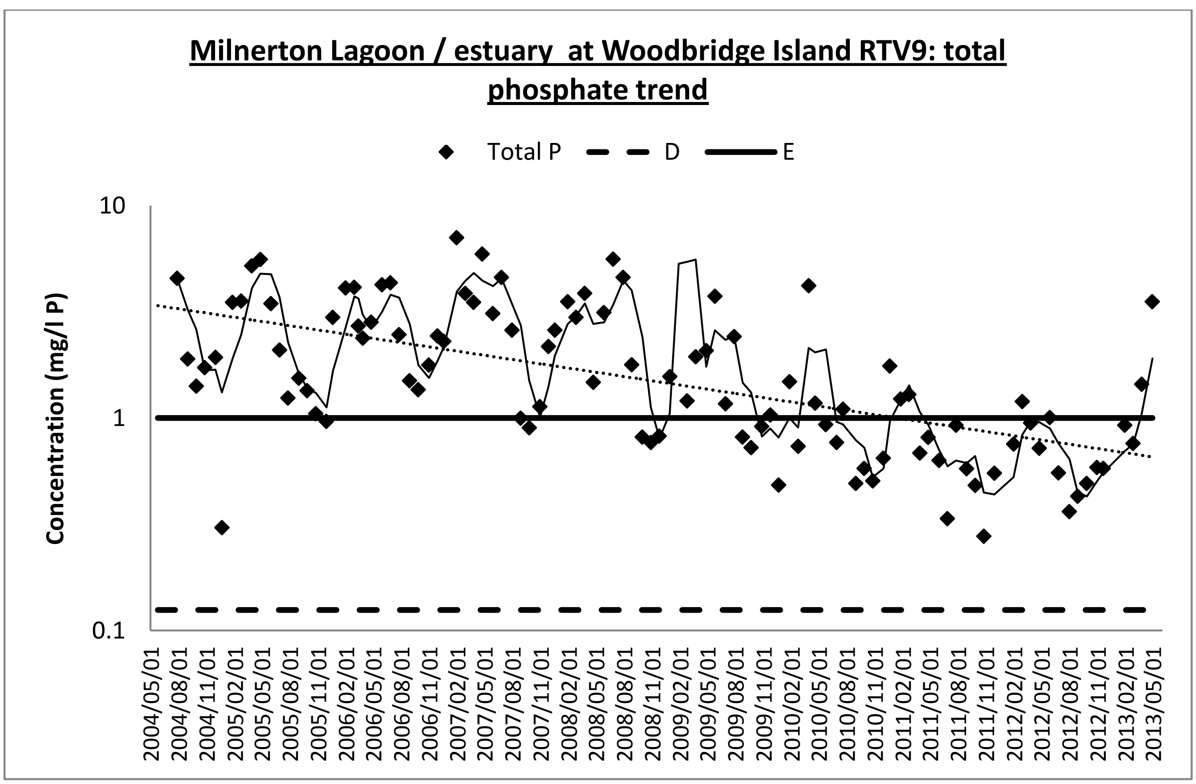
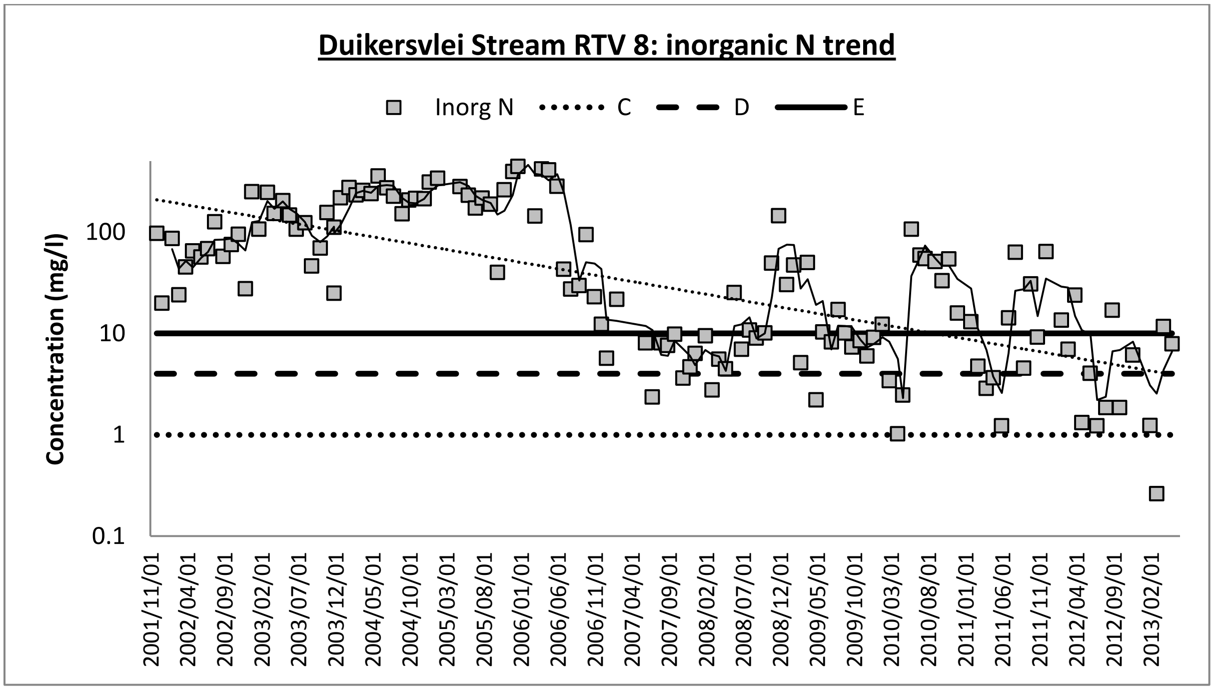
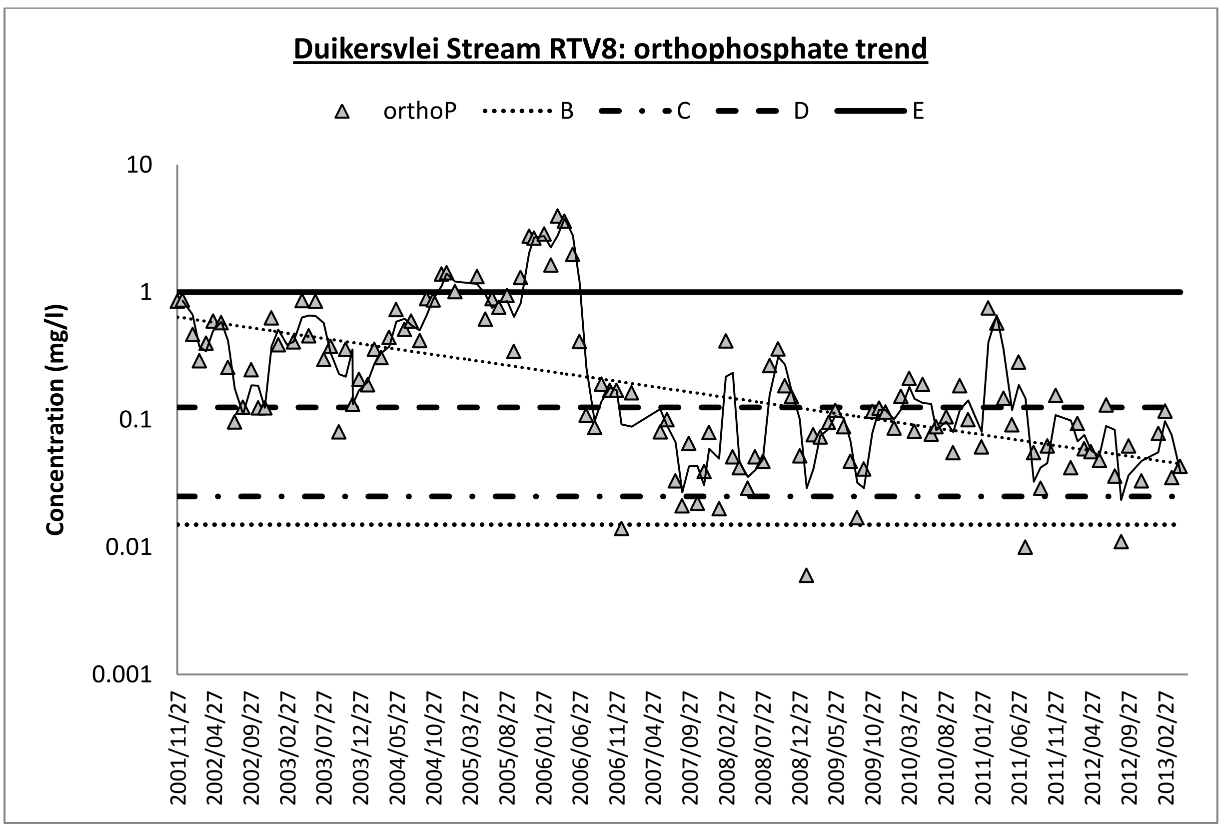
2011/02/01
2011/08/01
2012/02/01
2012/08/01
2013/02/01

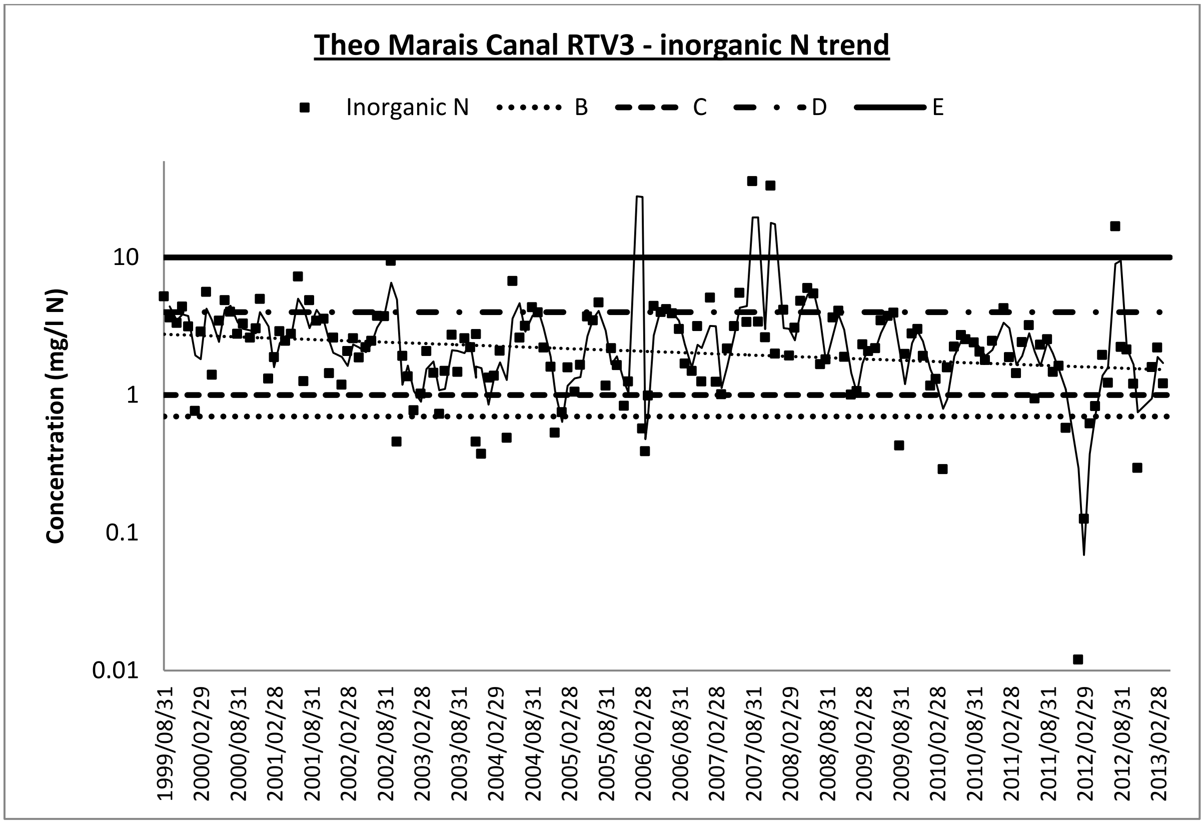

Milnerton Lagoon / estuary at Woodbridge RTV9: inorganic N trend
Inorg N
A
B
C
D
Concentration (mg/l N)
10
1
0.1
0.01

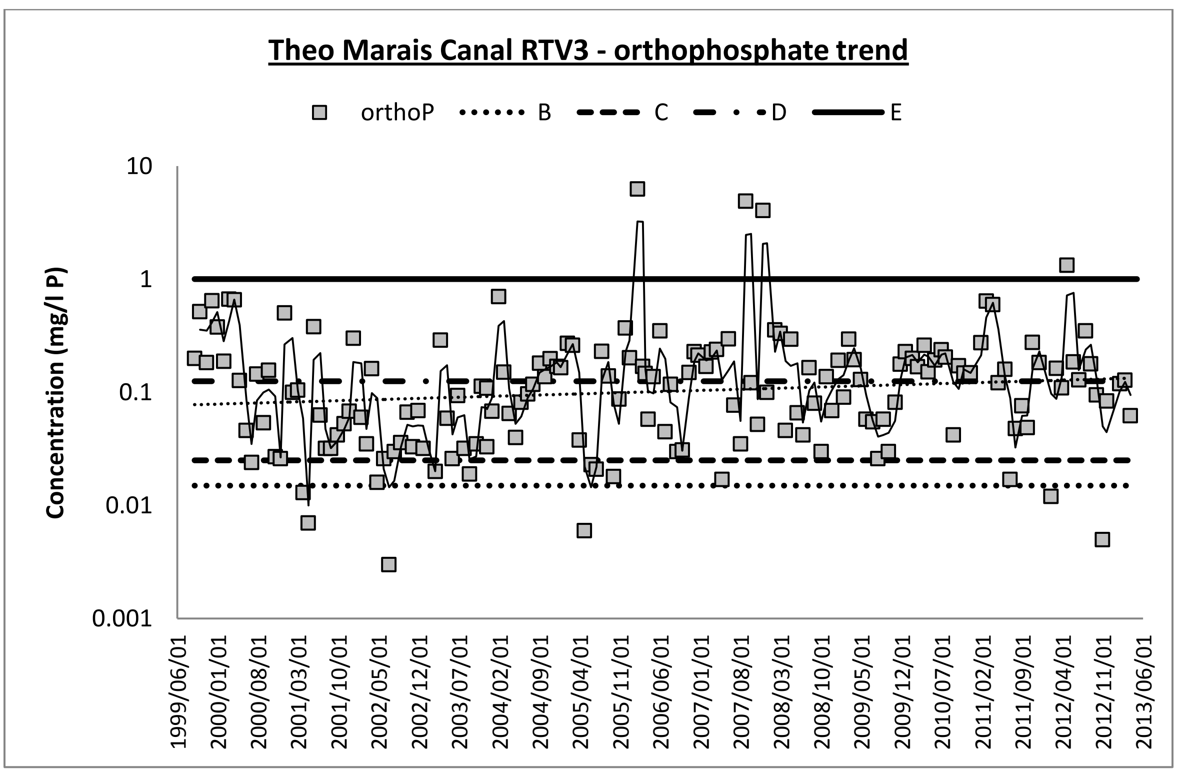

Milnerton Lagoon / estuary at Woodbridge Island RTV9: total phosphate trend
Total P
D
E
Concentration (mg/l P)
10
1
0.1

Theo Marais Canal and Duikersvlei Stream






Theo Marais Canal RTV3 - inorganic N trend
Inorganic N
B
C
D
E
Concentration (mg/l N)
10
1
0.1
0.01
1999/08/31
2000/02/29
2000/08/31
2001/02/28
2001/08/31
2002/02/28
2002/08/31
2003/02/28
2003/08/31
2004/02/29
2004/08/31
2005/02/28
2005/08/31
2006/02/28
2006/08/31
2007/02/28
2007/08/31
2008/02/29
2008/08/31
2009/02/28
2009/08/31
2010/02/28
2010/08/31
2011/02/28
2011/08/31
2012/02/29
2012/08/31
2013/02/28


Theo Marais Canal RTV3 - orthophosphate trend
orthoP
B
C
D
E
Concentration (mg/l P)
10
1
0.1
0.01
0.001
1999/06/01
2000/01/01
2000/08/01
2001/03/01
2001/10/01
2002/05/01
2002/12/01
2003/07/01
2004/02/01
2004/09/01
2005/04/01
2005/11/01
2006/06/01
2007/01/01
2007/08/01
2008/03/01
2008/10/01
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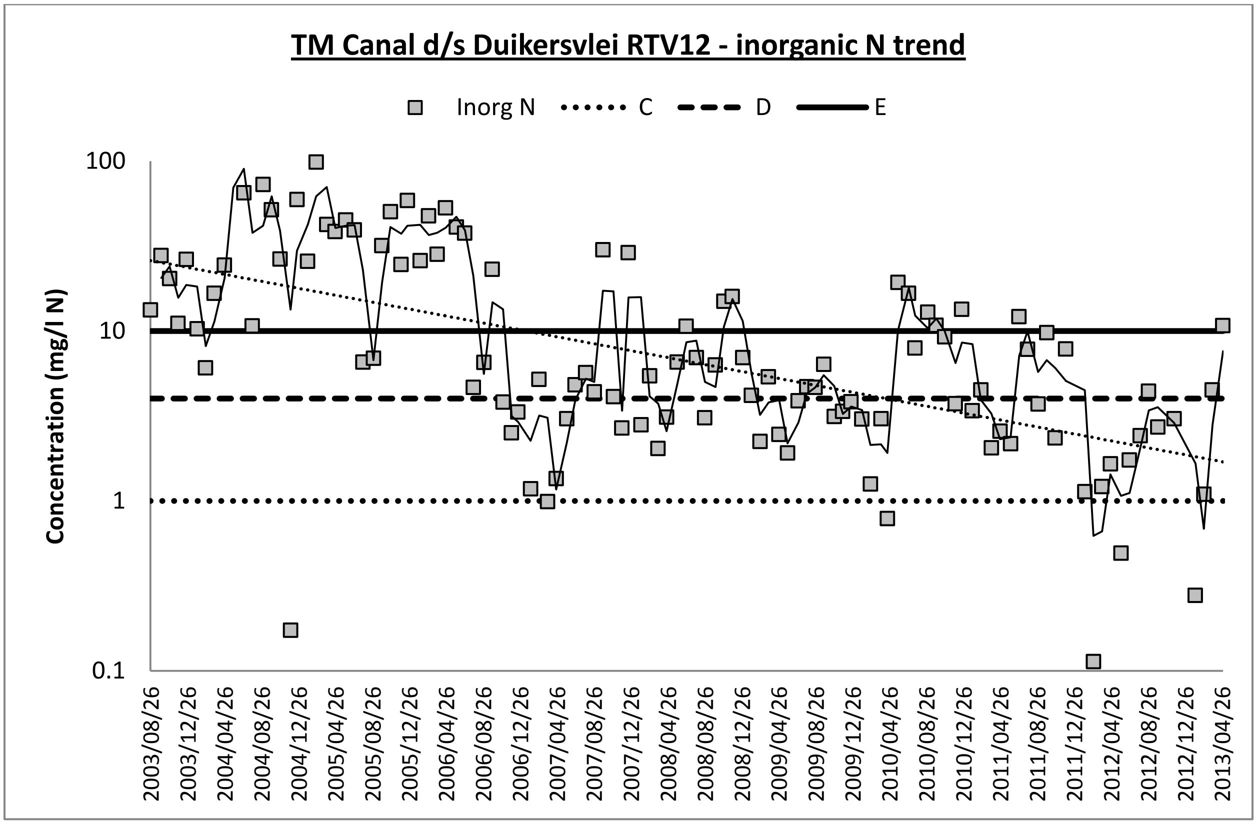
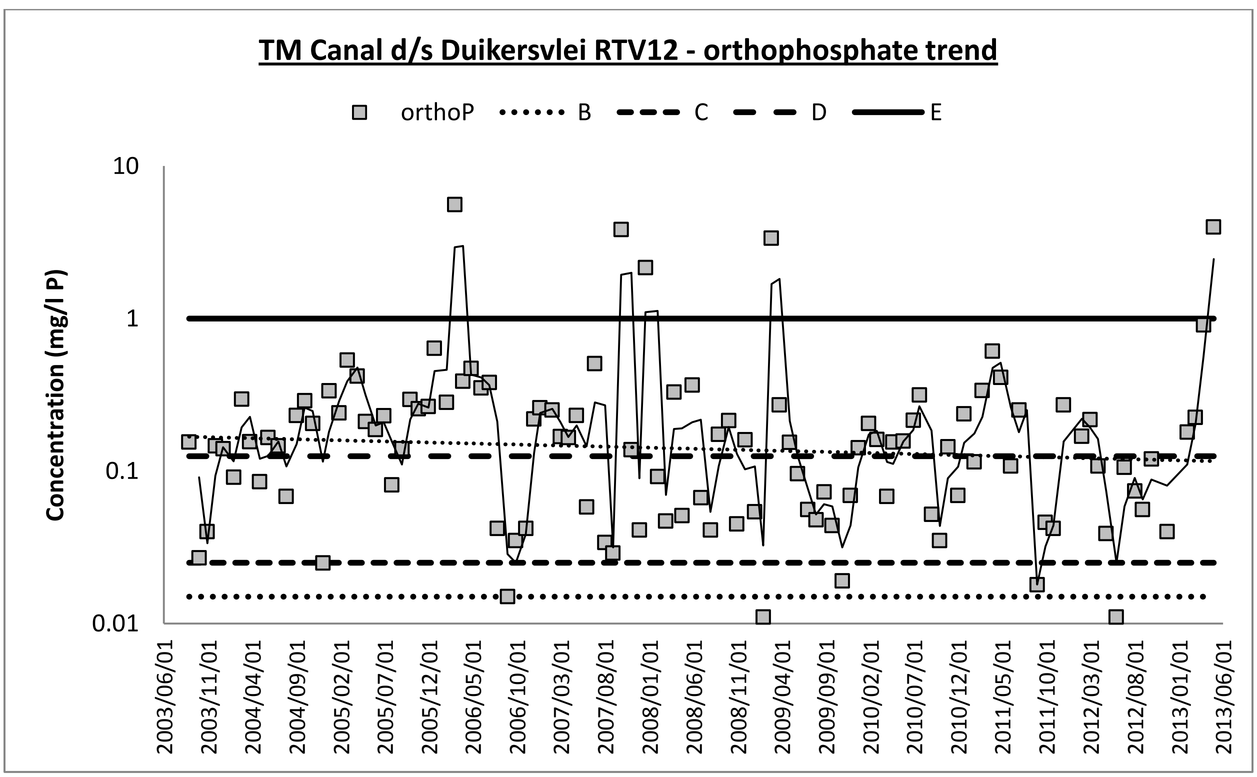
2012/04/01
2012/11/01
2013/06/01


TM Canal d/s Duikersvlei RTV12 - inorganic N trend
Inorg N
C
D
E
Concentration (mg/l N)
100
10
1
0.1
2003/08/26
2003/12/26
2004/04/26
2004/08/26
2004/12/26
2005/04/26
2005/08/26
2005/12/26
2006/04/26
2006/08/26
2006/12/26
2007/04/26
2007/08/26
2007/12/26
2008/04/26
2008/08/26
2008/12/26
2009/04/26
2009/08/26
2009/12/26
2010/04/26
2010/08/26
2010/12/26
2011/04/26
2011/08/26
2011/12/26
2012/04/26
2012/08/26
2012/12/26
2013/04/26


TM Canal d/s Duikersvlei RTV12 - orthophosphate trend
orthoP
B
C
D
E
Concentration (mg/l P)
10
1
0.1
0.01
2003/06/01
2003/11/01
2004/04/01
2004/09/01
2005/02/01
2005/07/01
2005/12/01
2006/05/01
2006/10/01
2007/03/01
2007/08/01
2008/01/01
2008/06/01
2008/11/01
2009/04/01
2009/09/01
2010/02/01
2010/07/01
2010/12/01
2011/05/01
2011/10/01
2012/03/01
2012/08/01
2013/01/01
2013/06/01

Conductivity / Salinity

Electrical conductivity (EC) is a measure of the amount of dissolved inorganic ions (salts) in water (usually measured in mS/m), and thus also provides a measure of water salinity. EC levels below 450 mS/m are usually indicative of brackish conditions, although the following habitats can be broadly defined:

- freshwater systems: EC < 450 mS/m
- brackish systems: EC 450 mS/m – 2000 mS/m
- saline systems: EC 2000 mS/m to 6 000 mS/m
- seawater: EC is in the order of around 5 400 mS/m
- hypersaline systems: > 6 000 mS/m

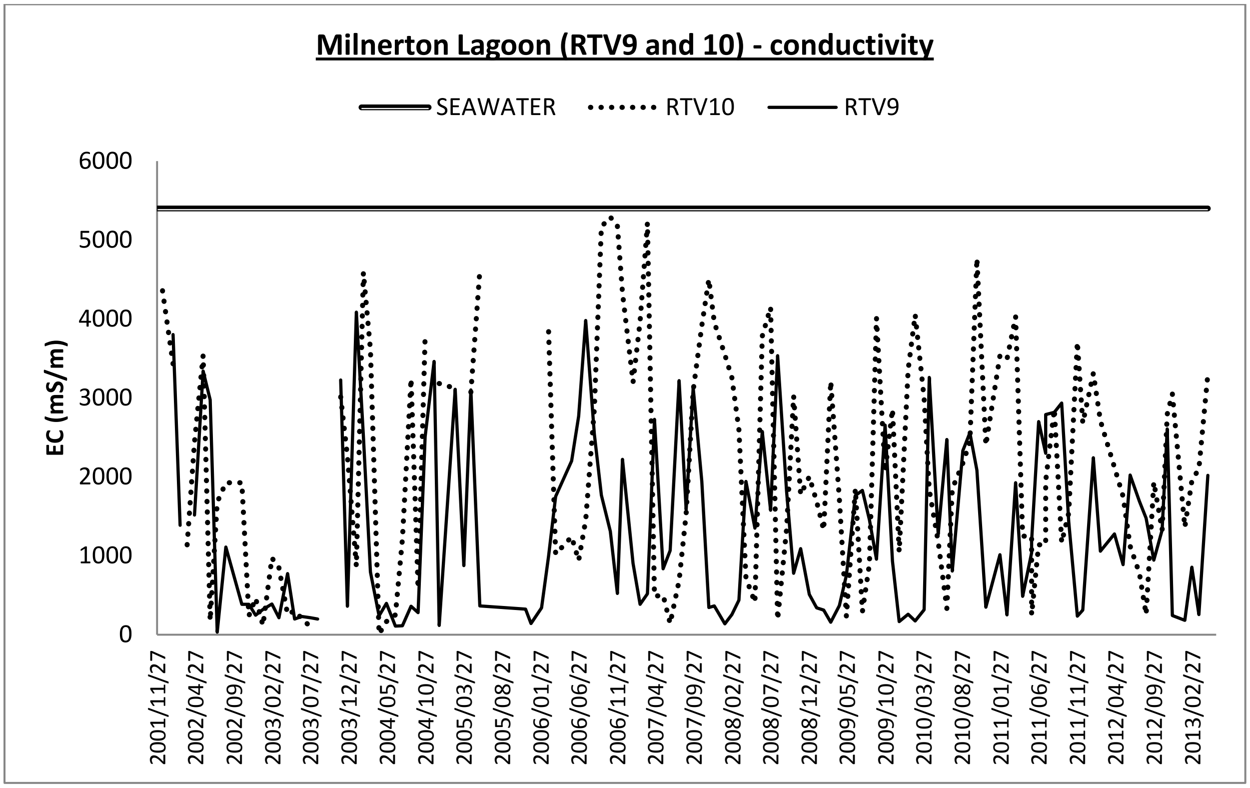
In shallow, freshwater wetland systems of the Western Cape, the dominant, often invasive rooted emergent macrophyte species is usually *Typha capensis*, with species such as *Schoenoplectus littoralis* potentially dominating slightly deeper waters and, depending on water clarity, indigenous submerged aquatic vegetation usually dominated by *Potamogeton pectinatus*. *Typha capensis* is a cosmopolitan species, often associated (in large stands) with the production of nuisance seeds and with a tendency, in certain situations, to invade large areas of wetland, at the exclusion of other species. It provides a densely vegetated habitat, with individual stands senescing after two or three year's growth.

At higher salinities (usually > 1000 mS/m), shoreline dominance by *Typha capensis* appears to give way to *Phragmites australis* – a cosmopolitan reed, which is not associated with many of the nuisance properties of *Typha capensis* and forms less dense stands along lake shores. *Schoenoplectus littoralis* appears tolerant of slightly brackish conditions too, and occurs in the upper reaches of various estuarine systems. *Juncus kraussii* and *Bolboschoenus maritimus* are both sedge species that appear to thrive in slightly elevated salinities – possibly because of exclusion / lower dominance by *Typha capensis*.

Phytoplankton occurs at all salinity levels, although species composition varies. Certain species of Blue-green algae may also occur even under hypersaline conditions.

Salinity (as measured by "conductivity") is greatest close to the sea where the incoming tides regularly bring in plugs of salt water to Milnerton Lagoon. However, due to the dominance and diluting effect of large volumes of the lower conductivity effluent entering the river from Potsdam WWTW, the extent of saline intrusion up the river gradually declines with distance from the sea.

The graphs also depict seasonal cycles due to the influence of winter rains which significantly reduce conductivity. This seasonal pattern is however not so clear in the deep water lake (RTV2) where conductivity appears to be more stable. Interestingly the average conductivity at RTV2 (386 mS/m) which is assumed to reflect "natural" background levels is higher than that at either RTV1 (242 mS/m) or RTV5 (162 mS/m)



Milnerton Lagoon (RTV9 and 10) - conductivity
SEAWATER
RTV10
RTV9
EC (mS/m)
6000
5000
4000
3000
2000
1000
0
2001/11/27
2002/04/27
2002/09/27
2003/02/27
2003/07/27
2003/12/27
2004/05/27
2004/10/27
2005/03/27
2005/08/27
2006/01/27
2006/06/27
2006/11/27
2007/04/27
2007/09/27
2008/02/27
2008/07/27
2008/12/27
2009/05/27
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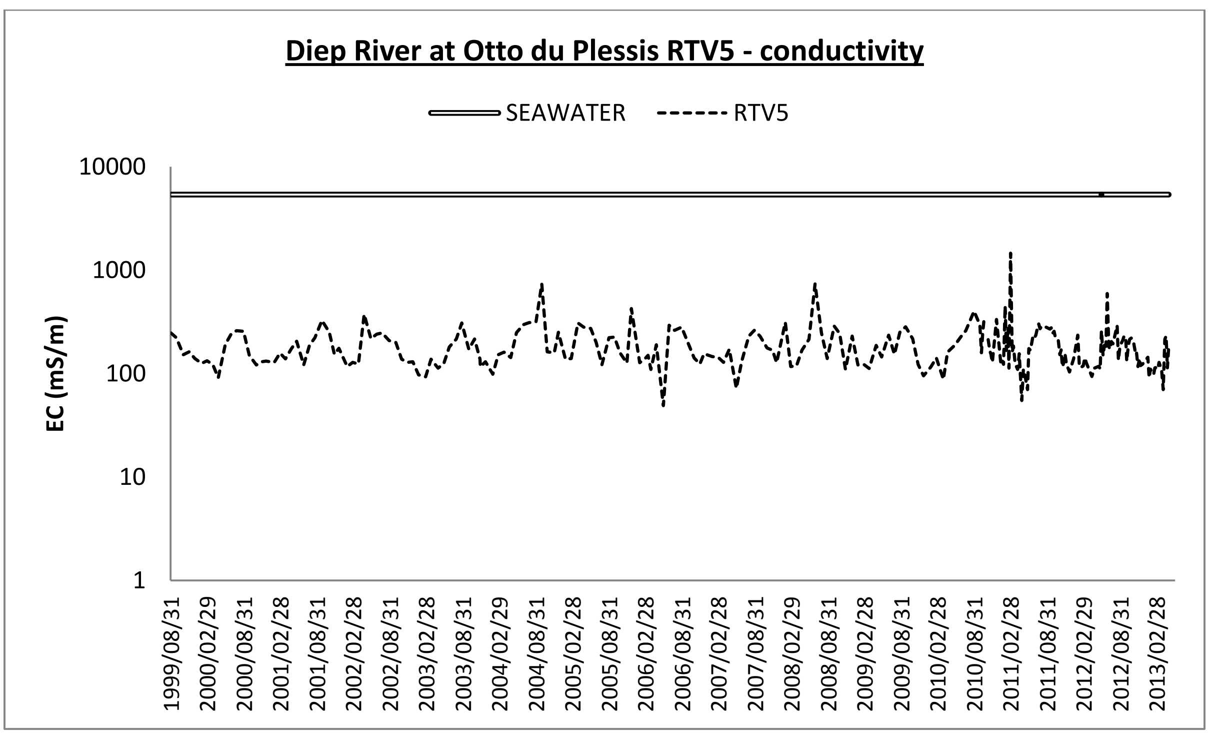
2012/04/27
2012/09/27
2013/02/27



Diep River at Otto du Plessis RTV5 - conductivity
SEAWATER
RTV5
EC (mS/m)
10000
1000
100
10
1
1999/08/31
2000/02/29
2000/08/31
2001/02/28
2001/08/31
2002/02/28
2002/08/31
2003/02/28
2003/08/31
2004/02/29
2004/08/31
2005/02/28
2005/08/31
2006/02/28
2006/08/31
2007/02/28
2007/08/31
2008/02/29
2008/08/31
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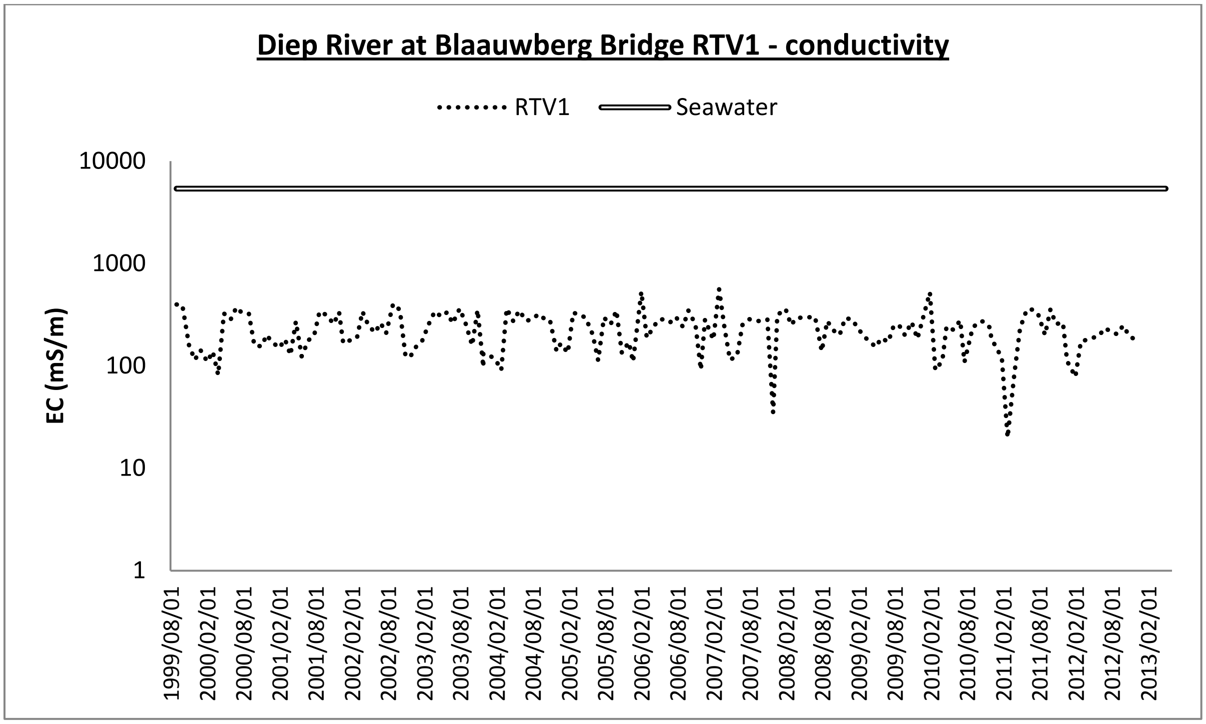
2012/02/29
2012/08/31
2013/02/28


Diep River at Blaauwberg Bridge RTV1 - conductivity
RTV1
Seawater
EC (mS/m)
10000
1000
100
10
1
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
2006/02/01
2006/08/01
2007/02/01
2007/08/01
2008/02/01
2008/08/01
2009/02/01
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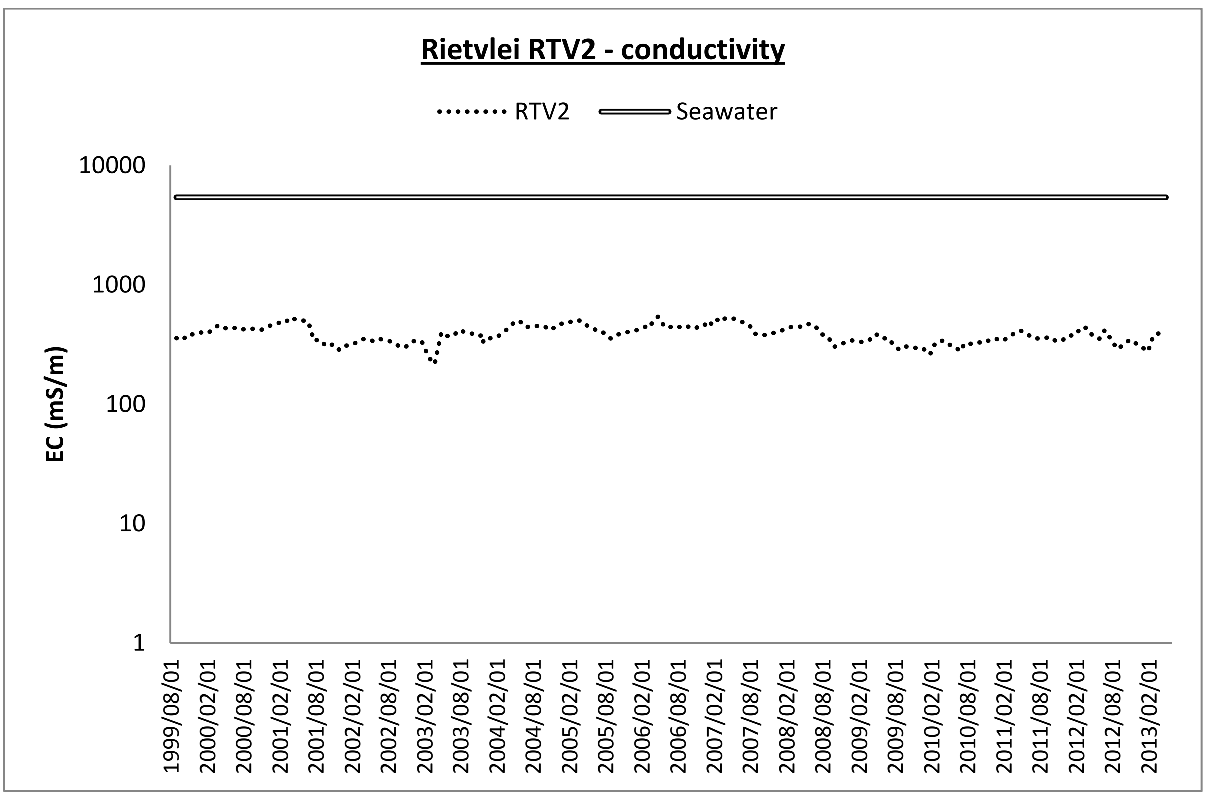
2011/02/01
2011/08/01
2012/02/01
2012/08/01
2013/02/01

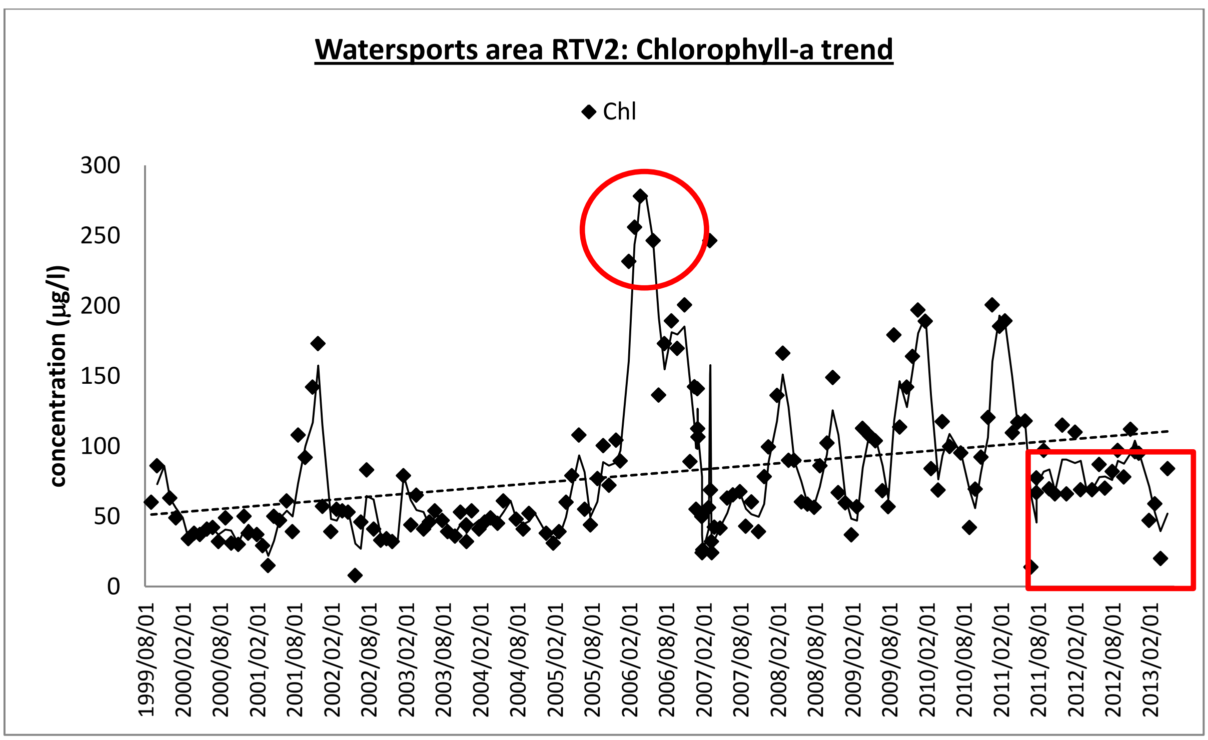

Rietvlei RTV2 - conductivity
RTV2
Seawater
EC (mS/m)
10000
1000
100
10
1
1999/08/01
2000/02/01
2000/08/01
2001/02/01
2001/08/01
2002/02/01
2002/08/01
2003/02/01
2003/08/01
2004/02/01
2004/08/01
2005/02/01
2005/08/01
2006/02/01
2006/08/01
2007/02/01
2007/08/01
2008/02/01
2008/08/01
2009/02/01
2009/08/01
2010/02/01
2010/08/01
2011/02/01
2011/08/01
2012/02/01
2012/08/01
2013/02/01

Algae

The sudden growth and subsequent die-back or simple turnover of phytoplankton (algae) blooms can have significant negative ecological impacts when they are associated with the creation of anoxic conditions as a result of decomposition. Anoxia can result in fish deaths and promote release of phosphorus from sediments. Blooms of blue-green algae (cyanobacteria) are usually associated with very high nutrient concentrations. In large concentrations, they form thick, unsightly scums, which may be odorous and at times can produce toxins that cause skin irritations on contact with water or vomiting, acute gastroenteritis and impaired liver function if ingested.

The quantity of algae (as determined through the measurement of chlorophyll-a) in the deep water lake (RTV2) appears to be increasing. There have however been no harmful algal blooms due to Cyanonphyceae since 2006 when toxic *Microcystis* blooms followed an extensive fish kill. The peak in chlorophyll level during this bloom is clearly evident on the graph below (see red circle). Although the long term trend line (dotted) suggests that the quantity of algae is increasing, the most recent results over the last 18 months indicates an improvement (see lower chlorophyll results enclosed within the red square).

Filamentous algae (*Cladophora* / *Entermorpha*) has been observed in the Milnerton Lagoon and the ponds adjacent to the Dolphin Beach Hotel periodically and is common in wetlands and vlei during summer / autumn. This algae is harmless but when it senesces, dies and decomposes it sometimes forms unsightly yellowish clumps resembling cotton wool.



Dissolved oxygen

Oxygen levels have been graphically depicted at just 3 sites within the catchment. These sites were chosen as they are generally representative of many of the other sample locations. The table below assists with interpretation of these graphs.

The deep water lakes (RTV2) have excellent levels i.e. generally > 6 mg/ l and often > 8mg/l indicating that, in terms of oxygen content, the water body is un-impacted. It is interesting to note that during late 2006 / early 2007, recorded oxygen levels were relatively low for a short period (see red circle on graph). At the same time, there was an extensive fish kill which was thought to be due to a low oxygen event due to lake turnover which would have brought anoxic nutrient enriched waters to the surface. Shortly after the fish kill, the vlei experienced a toxic bloom of Blue-green algae (Cyanophyceae) – this bloom was probably fuelled by the surge of nutrients which was brought up to the surface during the turnover.

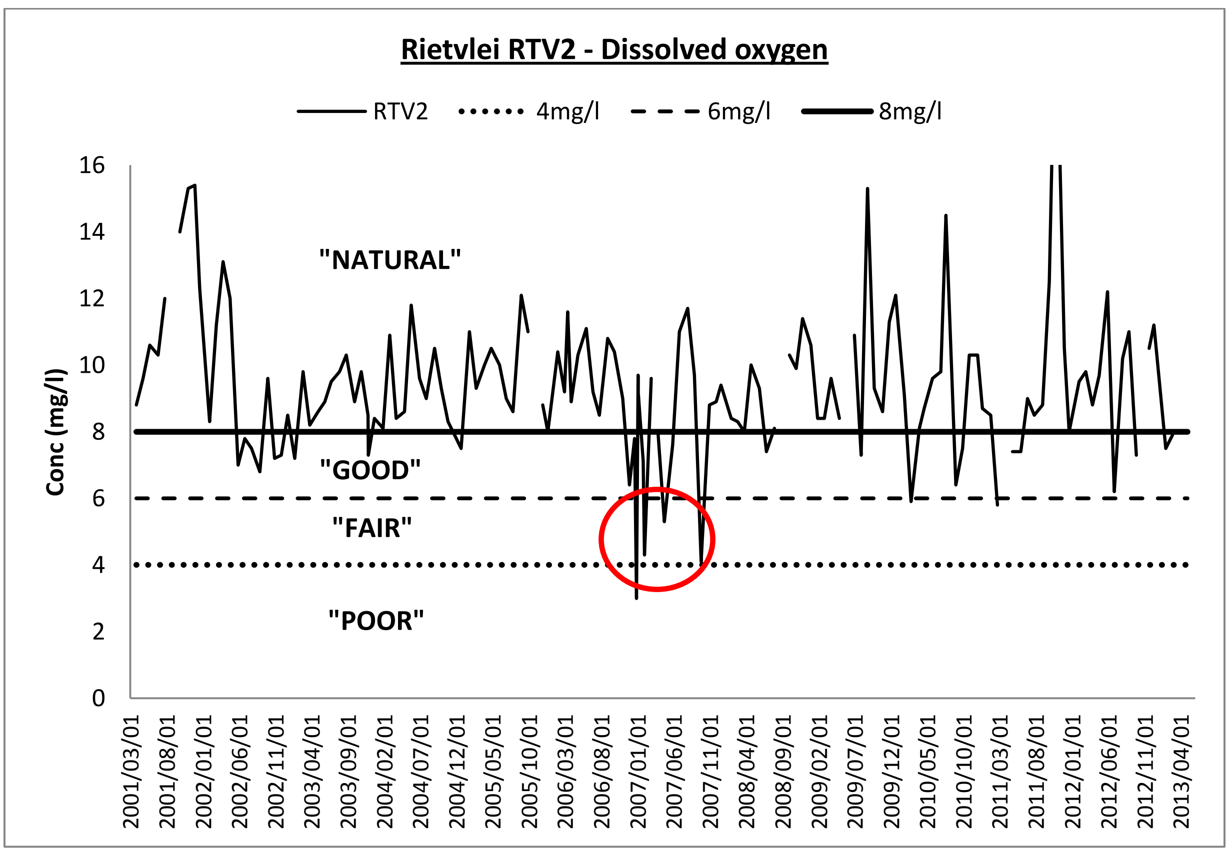
Oxygen levels will tend to be lower in situations where the water is stagnant, warm and contains high organic loads – the latter results in significant oxygen demand during break down / decomposition. An example of this can be seen at the Otto du Plessis Drive sample site (RTV5) (and indeed other sites along this stretch of the river from Potsdam downstream) and in polluted canals such as Theo Marais canal. At RTV5 dissolved oxygen levels are generally "poor" (<4 mg/l) to occasionally "fair" due to the organic loads from various sources such as Potsdam and the urbanized upstream catchment. A seasonal pattern is evident since during winter there is more flow and water movement which helps to oxygenate the water column. During summer, high water temperatures result in less oxygen being available.

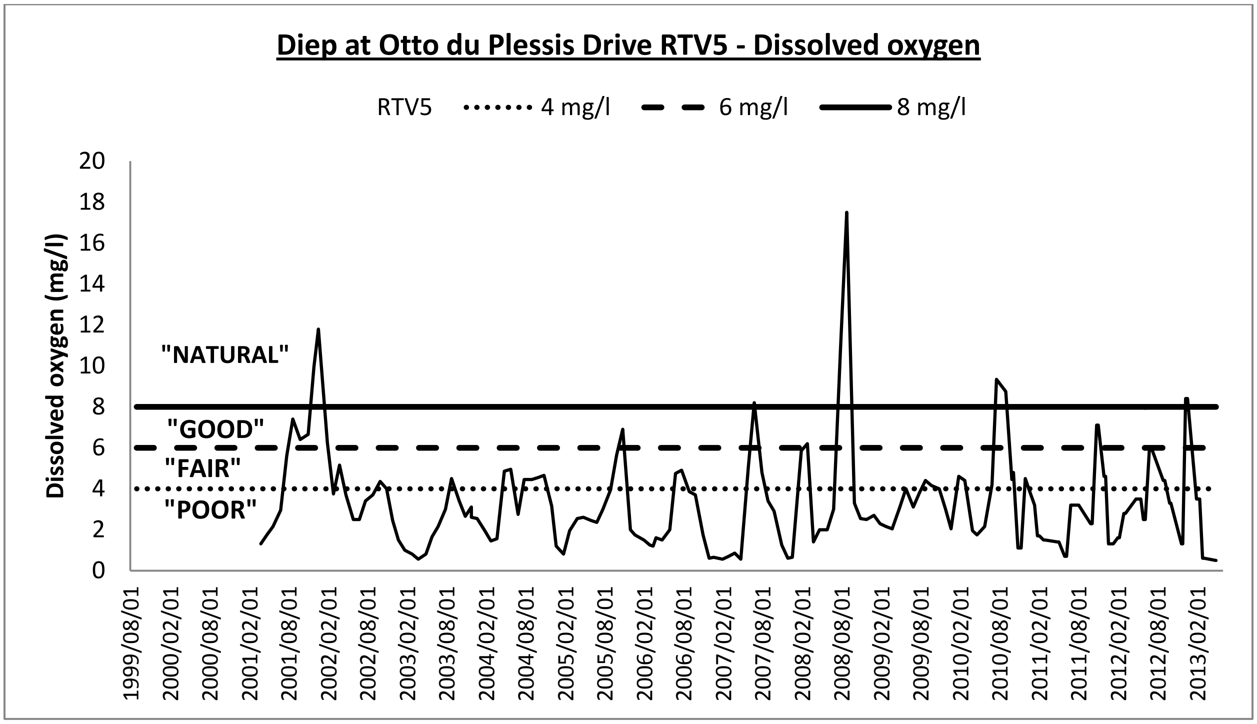
Within the Milnerton Lagoon, oxygen levels fluctuate across the "fair" to "natural" spectrum - the low levels again reflecting the influence of catchment derived pollutants. During high/Spring tides when there is a lot of water movement into and out of the lagoon, dissolved oxygen levels are significantly improved.

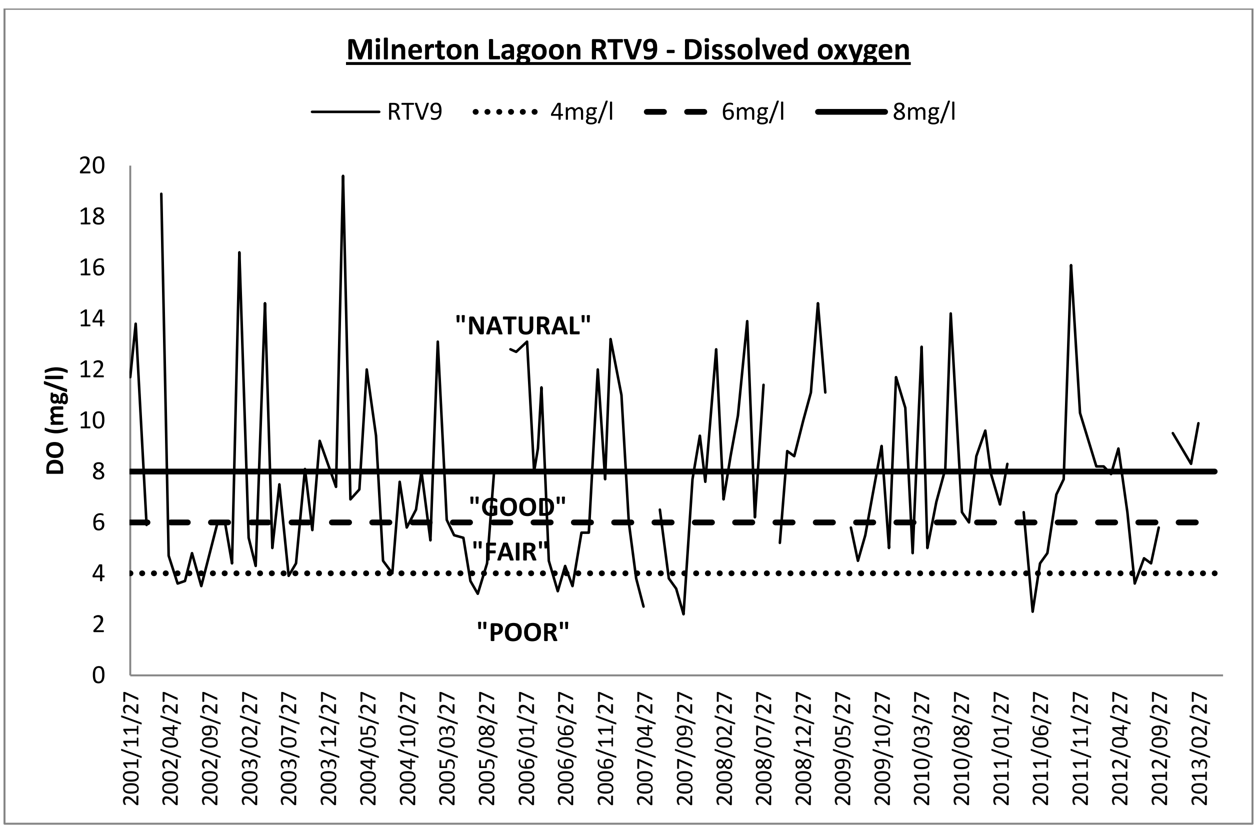
Present Ecological State (PES) rating values for dissolved oxygen

Deviation from reference condition	Environmental clues	Oxygen conc. (mg/L)	Category
No change	Known to be a pristine river, no known problems or concerns about dissolved oxygen; all oxygen sensitive species are present.	> 8	A
Small change	Some manmade modifications in the catchment but no known problems or concerns about DO, most oxygen sensitive species are present.	7 to 8	B

Moderate change	Some concerns about dissolved oxygen, some oxygen sensitive species are present but mostly oxygen tolerant species.	6 to 7	C
Large change	Known problems with reduced dissolve oxygen, mostly low DO tolerant species are present.	4 to 6	D
Serious change	Major known problems with low dissolved oxygen, anoxic odours sometimes present, only very low DO tolerant species present.	2 to 4	E
Extreme change	Major known problems with low dissolved oxygen, anoxic odours generally present, only very low DO tolerant species present.	< 2	F




Diep at Otto du Plessis Drive RTV5 - Dissolved oxygen
RTV5 4 mg/l 6 mg/l 8 mg/l
Dissolved oxygen (mg/l)
"NATURAL"
"GOOD"
"FAIR"
"POOR"
0 2 4 6 8 10 12 14 16 18 20
1999/08/01 2000/02/01 2000/08/01 2001/02/01 2001/08/01 2002/02/01 2002/08/01 2003/02/01 2003/08/01 2004/02/01 2004/08/01 2005/02/01 2005/08/01 2006/02/01 2006/08/01 2007/02/01 2007/08/01 2008/02/01 2008/08/01 2009/02/01 2009/08/01 2010/02/01 2010/08/01 2011/02/01 2011/08/01 2012/02/01 2012/08/01 2013/02/01


Milnerton Lagoon RTV9 - Dissolved oxygen
RTV9 4mg/l 6mg/l 8mg/l
DO (mg/l)
"NATURAL"
"GOOD"
"FAIR"
"POOR"
0 2 4 6 8 10 12 14 16 18 20
2001/11/27 2002/04/27 2002/09/27 2003/02/27 2003/07/27 2003/12/27 2004/05/27 2004/10/27 2005/03/27 2005/08/27 2006/01/27 2006/06/27 2006/11/27 2007/04/27 2007/09/27 2008/02/27 2008/07/27 2008/12/27 2009/05/27 2009/10/27 2010/03/27 2010/08/27 2011/01/27 2011/06/27 2011/11/27 2012/04/27 2012/09/27 2013/02/27

Fish kill – Feb/March 2013

The fish kill which occurred earlier this year is believed to have been due to an extreme low oxygen event which was most likely brought about by decomposition of organic sediments and filamentous algae. The measured low dissolved oxygen content was further exacerbated by significantly raised ambient air and water temperatures due to heat wave conditions. No toxic algae were detected. It was postulated in certain media accounts that there was possibly a link between the fish deaths and the blasting of the Seli 1. As there were no further fish deaths after a second round of blasting of the wreck (28 May 2013), it can be said with certainty that blasting did not result in the fishkill.

Most of the fish that succumbed were estuarine species (“freshwater” species such as carp and tilapia being generally unaffected). Juvenile estuarine fish were also not affected. Most of the dead fish were located in the lower lagoon area on the seaward side of the floating oil containment boom/curtain that had been erected during the Seli 1 salvage operations that were taking place during that week.

The event took place during the spring tides when large numbers of fish are known to move into and out of estuaries. It is possible that a significant number of fish became trapped in the lower lagoon area during the spring low tide. The sheer number of individuals breathing in this relatively small contained area would have also greatly reduced the dissolved oxygen content of the water, thus contributing to stress and mortality rates of these fish.