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(Registration No. 94/05593/07)
t/a

GHT CONSULTING SCIENTISTS

SURFACE-, GROUNDWATER & ENVIRONMENTAL SCIENTISTS

Camden Power Station

ROUTINE MONITORING PHASE 57
APRIL 2014

PROJECT TEAM
L.J. van Niekerk
M. Smit

Project no.:	220-22-mon.697	Start Date:	January 2014
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PO Box 32998 Fichardt Park 9317 • http://www.ghtglobal.com • E-Mail: ghtfs@ghtglobal.com
Tel: +27 (0) 51 444 0002 • Fax: +27 (0) 51 444 0088 • Cell: +27 (0) 82 652 2992 +27 (0) 82 656 6996

28 May 2014 Our ref.: RVN 697.2/1471

The Environmental Coordinator
The Environmental Department
Camden Power Station
Private Bag X1002
Nucam
2355
FOR ATTENTION: Me Malekgoa Sejake

Dear Madam,

Final Report - Routine Monitoring Phase 57

It is our pleasure to enclose one electronic copy of the report: RVN 697.2/1471 "CAMDEN POWER STATION – ROUTINE MONITORING PHASE 57 Final Report". We trust that the report will fulfil the expectations of Camden Power Station and we will supply any additional information if required.

Please feel free to contact me should you have any queries or suggestions.

Yours sincerely,

L.J. van Niekerk. (Pr.Sci.Nat)

Copies: One (1) electronic copy e-mail to Camden Power Station.
Three (3) hard copies to Me Malekgoa Sejake.

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APPENDICES

1 INTRODUCTION

1.1 General

GHT Consulting was appointed by Camden Power Station to conduct a Routine Monitoring on the surface and groundwater environments in the vicinity of the power station. The scope of work includes the following:

1.2 Date and number of the monitoring event

It was deducted from a count of the historical groundwater sampling events that this sampling phase is approximately the 57th major sampling event. The groundwater sampling events were however not conducted as frequently as the surface water sampling phases. The major sampling events would however be sufficient for establishing a phase number to be used in the numbering convention for this and future ground- and surface water monitoring phases.

In the numbering convention, both the date and the number of the monitoring events are used and this report is therefore numbered as follows: April 2013, Phase 57, as a site inspection and evaluation of the water and waste management system at Camden Power Station, as well as sampling of the existing and newly identified monitoring sites took place on the 10th of April 2014.

1.3 Identification, consolidation and numbering of monitoring areas and sites

The monitoring sites at Camden Power Station have been classified according to their location relative to the infrastructure and natural streams or drainage systems in the environment. All the activities at Camden Power Station drains along three small streams towards one major stream, the Witpint Spruit, east of the power station. The Witpunt Spruit drains into the Vaal River approximately 5 kilometres downstream from the power station. These three effected sub drainage and one major drainage systems or streams are described as follow:

- Sub Drainage System 1: Witpunt Spruit Northern Tributary
  - Ash Dam Complex Eastern Drainage System
  - Power Station Area North-western Drainage System
  - SANDF Village Area South-eastern Drainage System
- Sub Drainage System 2: Witpunt Spruit Central Tributary
  - Power Station Area North-eastern Drainage System
- Sub Drainage System 3: Witpunt Spruit Southern Tributary
  - Power Station Area - Eastern Drainage System
  - Coal Stock Yard Area – Southern and Eastern Drainage Systems
- Major Drainage System 1: Witpunt Spruit
  - Witpunt Spruit East of Power Station
  - Vaal River approximately 5 km downstream from Power Station

These three monitoring areas, as well as the surface- and groundwater monitoring sites identified during the site assessment, are shown in the site maps of Camden Power Station attached in **Appendix A**.

From the data gathered during the field visits and site inspections, nine different types of monitoring sites were identified. These different types of monitoring sites are:

- Groundwater sites (labelled B),
- River or natural stream sites (labelled R),
- Canal or trench sites (labelled C),
- Sewage effluent or discharge sites (labelled K),
- Pan or dam sites (labelled P),
- Seepage sites (labelled S),
- Sump sites (labelled T),
- Auger holes and Dugged trenches (labelled D) and
- Other sites (labelled Z).

All the sampling sites identified at Camden Power Station are listed in **Appendix B.**

1.4 Approach to study

This report investigates the current state of the monitoring system and various monitoring sites at Camden Power Station in order to identify any problems that may require attention. The work done during the phases of this contract is as follows:

- Project; - Routine Monitoring Phase 57; April 2014
  - Perform a site assessment and audit of the water and waste management and monitoring system at the power station in order to identify potential environmental risks,
  - Sample surface- and groundwater sites that form part of the power station's monitoring network,
  - Submit the surface- and groundwater samples for chemical analyses as well as selected samples for hydrocarbon and bacteriological analyses at a recognised laboratories,
  - Write a report containing findings on the current condition of the monitoring network and the water and waste management system as well as a detailed discussion regarding the chemical analyses. The report will include a risk assessment based on the site assessment of the water and waste management and monitoring system as well as on the results of the chemical analyses performed on the surface- and groundwater samples. Recommendations for remedial actions were deemed necessary will also be provided.

2 SITE ASSESSMENT AND AUDIT

2.1 Field inspection

A very important part of a routine monitoring investigation is the field visit to the possible pollution sources and their associated individual monitoring sites. This enables the investigators to make first-hand observations regarding the management and condition the possible pollution sources as well as the physical condition of each monitoring site. By noting the conditions of the different pollution sources and monitoring sites during a specific monitoring phase in table format, problematic areas may be readily identified and reported on. During the subsequent monitoring phases, these problematic areas are then revisited to determine whether the problematic situation has been addressed. This process allows one to measure the performance of the responsible persons involved in rectifying possible detrimental environmental issues at the Power Station.

During the fieldwork a total number of fifty-seven surface water sites, twelve boreholes and six auger monitoring sites were visited and inspected. Forty-nine water samples were collected from the various monitoring sites and submitted for chemical analyses at Aquatico Scientific (Pty) Ltd Laboratories. Three selected samples (sites K01 – sewage effluent from the power station, C20 – clean water canal south east of Coal Stock Yard discharge into veldt, and P08 – reclamation dam east of Power Station) were also submitted for bacteriological analyses, while four samples (P08 – Reclamation dam east of power station, B06 – borehole east of Reclamation dam, B08 – borehole east of Power Station & Coal Stock Yard and C16 – clean water canal east of Reclamation dam) were submitted for hydrocarbon as well as oil and grease analyses at the Organic Analysis Laboratory.

2.2 Mitigation and maintenance recommended during the Detailed Site Assessment – December 2013

The tables containing the response from the Site Assessment done in December 2013 by GHT Consulting Scientists, was completed with information received from Camden Power Station. The sites were also inspected by GHT during the site assessment. All this information of the various monitoring sites are summarised in a site-specific fashion in **Table 1** and **Table 4**.

Table 1. Witpunt Spruit Northern Tributary Drainage System response from Phase 56.

Site Information						Response From Previous Phase					Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	First Reported	Problem Identified During Previous Phases	Mitigation/Maintenance Proposed During Previous Phase	Actions Taken Since Previous Phase	Rectified Since Previous Phase	Responsible Person	Completion Date	Remarks
Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	P09	Large pan west of Ash Dam used as ash water return dam - De Jager Pan.	26.62000	30.07420		Ph37	Water level dangerously high. The integrity of the ash dam may be at risk due to the fact that the high water level in the De Jager Pan is saturating the base of the ash dam.	Urgent attention must be given to the dangerously high water level of the De Jager Pan. The Water level must be controlled and monitored regularly.		Partial.	M. Ueckermann / P Mkhize		
	C17	AWR canal next to ash dam. Inspect and monitoring water quality if required.	26.60570	30.07560		Ph53	The pump system that has been introduced to the canals reduced the water level significantly.	Keep monitoring water level. Inspect pumps regularly and clean any spills.	Water levels are being managed.	On-going	S Shabangu/ Roshcon		
	C18		26.62000	30.07910		Ph53				On-going			
	B02	Monitoring groundwater contamination from Ash dam and Domestic Waste Site.	26.62014	30.07672	5	Ph29	The area is being levelled. The standing water that covered the opening of the borehole has cause it to silt up and is now blocked at 4.5m. Most severe contaminated ground water sample. Water quality is above recommended standard. Mn - 2.750mg/l,	The borehole will be sealed according to DWAF standardsas part of new contract.	The borehole will be sealed according to DWAF standardsas part of new contract.	Partial.	T Mpongo		
	*C01	Seepage north of road. Road filling act as clean-dirty water separation. Inspect and monitoring water quality.	26.60570	30.07560		Ph30	Water level still extremely high. Water quality is above recommended standard. SO4 -1034mg/l, EC - 197mS/m.	Water from C01 must be prevented to dam in the area or flow into the surrounding area. Water levels in the AWR canals must be monitored regularly.	Water levels in the AWR Canals are being managed.	Partial.	I Hogdskin		
	D02	Monitoring shallow groundwater contamination of ash dam.	-26.60509	30.07425		Ph47	Water quality is above recommended standard. Due to seepage from the ash dam complex. Mn - 1.2mg/l	Monitor regularly.	Water levels in the AWR Canals are being managed.	Ongoing.	V Pandaram/ S Shabangu		
	D03	Monitoring shallow groundwater contamination of ash dam.	-26.60685	30.07813		Ph47	The auger hole is damaged due to construction work taking place and was not sampled.	The auger hole will be replaced as part of the new contract.	Auger hole will be replaced as part of new contract.	Partial.	V Pandaram/ S Shabangu		

Table 1. Continues.

Ash Facility and Associated Drainage Systems.	D04	Monitoring shallow groundwater contamination of ash dam.	-26.60882	30.08072		Ph47	Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 1282mg/l, EC - 266mS/m, Na - 234mg/l, Mn - 2.1mg/l, Mg - 105mg/l	Water levels in the AWR canals must be monitored regularly.	Water levels in the AWR Canals are being managed.	Ongoing	V Pandaram/ S Shabangu		
	B20	Monitoring groundwater contamination east of ash dam and north of power station.	26.61012	30.08427	14	Ph46	Salt precipitation around borehole due to artesian nature of borehole. Water quality is above recommended standard. Seepage investigation in progress. pH - 10.5	Complete seepage investigation.	Seepage Investigation in progress.	Partial.	V Pandaram / T Mpongo		
	B21	Monitoring groundwater contamination east of ash dam and north of power station.	26.61099	30.08472	18	Ph55	Excavation work around borehole in progress.	Care must be taken not to compromise the integrity of the borehole.		Ongoing	T Mpongo / A Simelane		
	*C03	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61070	30.08430		Ph29	The seepage from the AWR canals has reduce significantly. Canals C03 and C06 still has an above recommended water quality. C03: SO4 - 1195mg/l, EC - 250mS/m, Na - 312mg/l C06: SO4 - 818mg/l, EC - 196mS/m C07: SO4 - 758mg/l, EC - 181mS/m	Water levels in the AWR canals must be monitored regularly.	Water levels in the AWR Canals are being managed.	Ongoing	M Ueckermann / S Shabangu		
	*C06	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.60930	30.08790		Ph29					M Ueckermann / S Shabangu		
	*C07	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.60490	30.09350		Ph29					M Ueckermann / S Shabangu		
	B03	Monitoring groundwater contamination east of ash dam and north of power station.	26.60911	30.08775	6		Satisfactory condition. Artesian nature of borehole likely due to recent heavy rains and seepage from the shallow aquifer into the borehole.	Keep monitoring borehole.		Ongoing	V Pandaram		
Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	D07	Monitoring shallow groundwater contamination of ash dam.	-26.61927	30.08052		Ph47	Wrong number on number plate. .	Water levels in the AWR canals must be monitored regularly. Replace number plate.	Water levels in the AWR Canals are being managed.	On-going	V Pandaram/ S Shabangu		
	B22	Monitoring groundwater contamination South east from Ash dam and Domestic Waste Site.	26.62143	30.07977	18	Ph46	Wrong number on number plate. Water quality is above recommended standard due to elevated Fe. Fe - 0.291mg/l	Rectify number and monitor Fe closely.	None	No	T Mpongo		
	*S04	Clean water run-off canal next to road passing raw water dams. Monitoring water quality.	26.62059	30.08369			Satisfactory condition. SO4 - 279mg/l	A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	A seepage investigation will be done as part of the new contract.	Partial.	V Pandaram/T Mpongo		
	D06	Monitoring shallow groundwater contamination of ash dam.	-26.61594	30.08230		Ph47	Wrong number on number plate. Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 2312mg/l, pH - 4.54, EC - 319mS/m, Al - 9.41mg/l, Mn - 13.3mg/l, Mg - 226mg/l, Ca - 514mg/l	Water levels in the AWR canals must be monitored regularly. Replace number plate.	Water levels in the AWR Canals are being managed.	On-going	V Pandaram/ S Shabangu		
	*S01	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61480	30.08410		Ph29	Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 1553mg/l, EC - 261mS/m, Na - 201mg/l, Mg - 164mg/l	Water levels in the AWR canals must be monitored regularly.	Water levels in the AWR Canals are being managed.	On-going	M Ueckermann/ H. Jairaj		

Table 1. Continues.

Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	*C27	Clean water run-off canal NW of PS between Road and old Railway line. Monitoring water quality.	26.61406	30.08433			Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 1553mg/l	Water levels in the AWR canals must be monitored regularly.			V Pandaram/I Hodgskin		
	*C04	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61250	30.08450		Ph29	Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 672mg/l	Water levels in the AWR canals must be monitored regularly.	Water levels in the AWR Canals are being managed.	On-going	M Ueckermann/ H. Jairaj		
	*S03	Run-off from area north of PS released into natural environment. Monitor water quality.	26.61690	30.08810		Ph29	S03 and C25 is historically the most severe contaminated surface site. S03 SO4 -732 mg/l, Mn - 3.190mg/l C25 SO4 - 602 mg/l	The source of the pollution must be establish and removed. A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	A seepage investigation will be done as part of the new contract.	Partial.	V Pandaram / T Mpongo		
	*C25	Run-off from area north of PS released into natural environment. Monitor water quality.	26.61710	30.08714		Ph29					V Pandaram / T Mpongo		
	D24	Dugged Pit west of clean water canal C25.	26.61704	30.08679			A pit dugged by Power Station to determine source of seepage and pollution at S03. D24 has an above recommended standard water quality. pH - 4.02, SO4 - 2036mg/l, EC - 265mS/l, Ca - 416mg/l, Mn - 9.78mg/l, Mg - 161mg/l, Al - 25.2mg/l, Fe - 0.32mg/l	The source of the pollution must be establish and removed. A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	A seepage investigation will be done as part of the new contract.	Partial.			

Table 2. Witpunt Spruit Central Tributary response from Phase 56.

Site Information						Response From Previous Phase					Response		
Area With Possible Env. Hazards	**Sites**	**Description / Objective**	**Latitude (°S)**	**Longitude (°E)**	**Sample Depth**	**First Reported**	**Problem Identified During Previous Phases**	**Mitigation/Maintenance Proposed During Previous Phase**	**Actions Taken Since Previous Phase**	**Rectified Since Previous Phase**	**Responsible Person**	**Completion Date**	**Remarks**
Witpunt Spruit Central Tributary - Area East of Power Station.	*C08	Run-off from area north-east of PS released into natural environment. Monitor water quality.	26.61590	30.09510			Satisfactory condition. SO4 - 92.6mg/l			Yes	V Pandaram / T Mpongo		
	*Z03	Leaking Pipes east of C08 at security fence. Inspect and monitoring water quality.	26.61561	30.09520		Ph45	Standing water visible between the two fences.	The leaking pipe must be fixed.	None	No	A Sebothoma		
	*S02	Surface run-off and seepage from PS. Possibly a fountain. Monitor water quality.	26.61300	30.09270		Ph29	Satisfactory condition.	The area must be monitored regularly.	~	On-going	V Pandaram / T Mpongo		
	*C09	Clean water run-off canal. Monitoring water quality.	26.61470	30.09690			Satisfactory condition. SO4 - 119mg/l		~	~			
	B05	Monitoring groundwater quality north-east of PS.	26.61372	30.09761	8		Satisfactory condition.		~	~			

Table 3. Witpunt Spruit Southern Tributary response from Phase 56.

Site Information						Response From Previous Phase					Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	First Reported	Problem Identified During Previous Phases	Mitigation/Maintenance Proposed During Previous Phase	Actions Taken Since Previous Phase	Rectified Since Previous Phase	Responsible Person	Completion Date	Remarks
Witpunt Spruit Central Tributary - Clean water bypass system.	*C10	Clean water run-off canal from DWA&F reservoirs & south-western PS area. Monitoring water quality.	26.62330	30.08930			Satisfactory condition. SO4 - 177mg/l				M Dubazana		
	*C24	Run-off from area west of CSY released into natural environment. Monitor water quality.	26.62548	30.09223			Satisfactory condition. SO4 - 98.9mg/l	The area must be monitored closely.			D. Khumalo		
	*C20	Clean water run-off canal south-east of CSY downstream from C19 released into natural environment. Monitoring water quality.	26.62310	30.09670		Ph38 Ph50	Water flowing into canal from old pipe upstream near old power box. The pipe seem to come from outside the Power Station fence. A sample of the water was taken from the ouflow of the pipe and marked X100. The water has a dangerous water quality (Class 4) due to high bacteriological count. C20 SO4 - 118mg/l, E.Coli - 261cfu/100ml, Heterotrophic plate count - Innumerable Total Coliforms -Innumerable	Pipe must be removed from canal. Operations at the sewage plant must be improved and no effluent must be discharged into C20.	Area cleaned .	Partial.	I Hogdskin		
Witpunt Spruit Central Tributary - Dirty water interception system.	K01	Standard of operations of sewage plant and quality of water released into the reclamation dam.	26.62310	30.09670		Ph40	Water has a dangerous water quality (Class 4) due to high bacteriological count and elevated NO3-N. NO3-N - 15.2mg/l, NH4 - 8.44mg/l E.Coli - 0cfu/100ml, Heterotrophic plate count - Innumerable Total Coliforms -0/100ml	The treatment of the effluent must be monitored regularly to ensure that is up to standard as set by the water use license.		On-going	I Hogdskin		
	P04	Coal settling pond & Splitter box. Inspect operations.	26.62190	30.09800			Coal settling pond satisfactory. Some debris in splitter box and canals surrounding the coal stock yard	Regular inspections in this area must be conducted and problems rectified..		On-going	S Shabangu		
	C11	Dirty water run-off canal downstream from CSY. Inspect all dirty water canals.	26.62120	30.09840		Ph41	Slow water flow. Area between the fences are blocked with silt and debris. Cleaning of the canal in progress.	The area between the fences must be cleaned regularly.	None	No	M Dubazana		
	P05	CSY dam receiving dirty water run-off. Inspect regularly & monitor water quality.	26.62130	30.10130			Some silt visible, yet satisfactory condition.	Dam must be inspected regularly.		On-going	M Dubazana		

Table 3. Continues.

Witpunt Spruit Central Tributary - Area East of Power Station.	P11	Station drain dams collection sump. Inspect operations.	26.61880	30.09810		Ph41	Lots of oil and silt in sump.	Operations at the sump must be inspected regularly and cleaned to prevent oil spills into the environment.	None	On-going	M Dubazana / T Mpongo		
	C13	Canal discharge contaminated water from northern station dams into reclamation dam. Monitoring water quality.	26.61880	30.09810		Ph39	Lots of ash visible in canal.	Canal must be cleaned.	None	No	M Dubazana		
	P08	Reclamation dam. Inspect and monitoring water quality.	26.62000	30.09980		Ph39	Oil visible in dam. Water has a dangerous water quality (Class 4) due to high bacteriological count. E.Coli - 1120, Heterotrophic plate count - Innumerable Total Coliforms - Innumerable	Operations at the oil skimmers must be improved to prevent oil spills into the environment. Work to be completed.		Ongoing.	M Ueckermann/ M Dubazana		
	*Z04	Leaking pipes south of B06. Inspect and monitoring water quality.	26.61993	30.10101		Ph45	Satisfactory condition.		~	~	A.Sebothoma		
Witpunt Spruit Central Tributary.	*C15	Clean run-off from area east of PS released into natural environment. Monitor water quality.	26.62070	30.09920			Water has a dangerous water quality due to elevated SO4. SO4 - 551mg/l	Monitor water quality closely. If high levels of contamination persist a seepage investigation must be done to determine the source of pollution.	~	~	T Mpongo		
	*C16	Clean run-off from area east of PS downstream of C15 released into natural environment. Monitor water quality.	26.62000	30.10220		Ph41	Lots of coal visible in canal. SO4 - 145mg/l	Coal must be removed from canal.	None	No	S Shabangu		
	*C26	Dugged canal west of SANDF sewage plant. Inspect regularly & monitoring discharge water quality.	26.61748	30.10806			Satisfactory condition. SO4 - 24.4mg/l	Water responsibility of SANDF, Keep monitoring water quality. Relevant authorities needs to be notified.		On-going	V.Pandaram		

* Surface water sites supposed to contain clean water:

Table 4. Witpunt Spruit Tributary response from Phase 56.

Site Information						Response From Previous Phase					Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	First Reported	Problem Identified During Previous Phases	Mitigation/Maintenance Proposed During Previous Phase	Actions Taken Since Previous Phase	Rectified Since Previous Phase	Responsible Person	Completion Date	Remarks
Witpunt Spruit Water Course	*R01	Witpunt Spruit background water quality entering the system.	26.59330	30.09620			Satisfactory condition. SO4 -85.6mg/l		~	~	I Hogdskin		
	*P01	Dam receiving run-off from PS and SANDF contributing to Witpunt Spruit. Monitoring water quality.	26.61200	30.10650			Satisfactory condition. SO4 -394mg/l		~	~	I Hogdskin / Pierre		
	*P02	Dam receiving run-off from PS and SANDF contributing to Witpunt Spruit. Monitoring water quality.	26.61120	30.10740			Satisfactory condition. SO4 -328mg/l		~	~	I Hogdskin / Pierre		
	*R02	Witpunt Spruit final water quality released from the system.	26.62290	30.11430			Satisfactory condition. SO4 -174mg/l		~	~	I Hogdskin		

* Surface water sites supposed to contain clean water

2.3 Current state of possible pollution sources and associated monitoring sites.

The current states, as observed and noted during Phase 57, of the possible pollution sources and associated monitoring sites at Camden Power Station are summarised in a site-specific fashion in **Table 5** to **Table 8**. These tables contain columns in which the mitigation to problems identified during the current monitoring phase is listed. Also included are photographs taken during the latest monitoring phase of aspects relevant to the monitoring system. In the tables, these photographs are referred to by number at the monitoring site location where the photographs were taken. This should assist the Camden Power Station Environmental Department in managing the identified pollution sources and other problems related to the environment.

Response tables attached in **Appendix B** must be completed by the relevant personnel of Camden Power Station and send to GHT Consulting before the next Site Assessment and Audit that will take place in July 2014. These tables serve as a control to evaluate the actions taken in addressing the identified problems and upon completion included in future monitoring reports.

Table 5. Witpunt Spruit Northern Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled	Type Analyses	Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	P09	Large pan west of Ash Dam used as ash water return dam - De Jager Pan.	26.62000	30.07420		2014/04/03	11:13	Dangerously High	Yes	N,M	1	Water level dangerously high. The integrity of the ash dam may be at risk due to the fact that the high water level in the De Jager Pan is saturating the base of the ash dam. Field ph 10.6	Urgent attention must be given to the dangerously high water level of the De Jager Pan. The Water level must be controlled and monitored regularly.	M. Ueckermann / P Mkhize		
	C17	AWR canal next to ash dam. Inspect and monitoring water quality if required.	26.60570	30.07560		2014/04/03	12:51	Low	No	V	2, 3, 4, 5	The pump system that has been introduced to the canals reduced the water level significantly. A pan containing oil on ground at NW corner of ash dam	Keep monitoring water level. Inspect pumps regularly and clean any spills. Pan with oil must be removed.	S Shabangu/ Roshcon		
	C18		26.62000	30.07910		2014/04/03	11:20	Low	No	V						
	Domestic Waste Site	Historic Waste Site. Inspect and monitoring standing water quality if required.	26.62014	30.07672		2014/04/03	12:10	~	No	~		Lots of standing water.	This area must be levelled and monitored regularly.	T Mpongo		
	*C01	Seepage north of road. Road filling act as clean-dirty water separation. Inspect and monitoring water quality.	26.60570	30.07560		2014/04/03	12:58	Low / Stagnant	Yes	N	6	Water level still extremely high. Water quality is above recommended standard. SO4 -624mg/l, EC - 173mS/m.	Water from C01 must be prevented to dam in the area or flow into the surrounding area. Water levels in the AWR canals must be monitored regularly.	I Hogdskin		
	D02	Monitoring shallow groundwater contamination of ash dam.	-26.60509	30.07425		2014/04/03	12:50	0.76	Yes	N,M		Water quality is above recommended standard. Due to seepage from the ash dam complex. Mn - 2.4mg/l	Monitor regularly.	V Pandaram/ S Shabangu		

Table 5. Continues.

Ash Facility and Associated Drainage Systems.	D04	Monitoring shallow groundwater contamination of ash dam.	-26.60882	30.08072		2014/04/03	12:44	1.24	Yes	N,M		Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 865mg/l, EC - 228mS/m, Na - 214mg/l, Mn - 6.02mg/l	Water levels in the AWR canals must be monitored regularly.	V Pandaram/ S Shabangu		
	D05	Monitoring shallow groundwater contamination of ash dam.	-26.61192	30.08167		2014/04/03	12:28	1.54	Yes	N,M		Water quality is above recommended standard. Due to seepage from the ash dam complex. Na - 222mg/l,	Water levels in the AWR canals must be monitored regularly.	V Pandaram/ S Shabangu		
	B20	Monitoring groundwater contamination east of ash dam and north of power station.	26.61012	30.08427	14	2014/04/03	11:15	Artesian	Yes	N,M	7	Salt precipitation around borehole due to artesian nature of borehole. Water quality is above recommended standard. Seepage investigation in progress. pH - 10.3	Complete seepage investigation.	V Pandaram / T Mpongo		
	B21	Monitoring groundwater contamination east of ash dam and north of power station.	26.61099	30.08472	18	2014/04/03	11:24	4.95	Yes	N,M		Excavation work around borehole in progress.	Care must be taken not to compromise the integrity of the borehole.	T Mpongo / A Simelane		
	*C03	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61070	30.08430		2014/04/03	11:22	Low / Slow	Yes	N	8	The seepage from the AWR canals has reduce significantly. Canals C03 and C06 still has an above recommended water quality. C03: SO4 - 1159mg/l, EC - 302mS/m, Na - 390mg/l, Ca - 314mg/l C06: SO4 - 1058mg/l, EC - 270mS/m, Na - 305mg/l, Ca - 312mg/l C07: SO4 - 960mg/l, EC - 252mS/m, Na - 286mg/l	Water levels in the AWR canals must be monitored regularly.	M Ueckermann / S Shabangu		
	*C06	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.60930	30.08790		2014/04/03	11:06	Low / Mod	Yes	N	9			M Ueckermann / S Shabangu		
	*C07	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.60490	30.09350		2014/04/03	11:19	Low / Mod	Yes	N,M				M Ueckermann / S Shabangu		
	B03	Monitoring groundwater contamination east of ash dam and north of power station.	26.60911	30.08775	6	2014/04/03	11:05	Artesian	Yes	N,M	10	Satisfactory condition. Artesian nature of borehole likely due to recent heavy rains and seepage from the shallow aquifer into the borehole.	Keep monitoring borehole.	V Pandaram		
Wipunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	D07	Monitoring shallow groundwater contamination of ash dam.	-26.61927	30.08052		2014/04/03	12:08	0.95	Yes	N,M		Wrong number on number plate. .	Water levels in the AWR canals must be monitored regularly. Replace number plate.	V Pandaram/ S Shabangu		
	B22	Monitoring groundwater contamination South east from Ash dam and Domestic Waste Site.	26.62143	30.07977	18	2014/04/03	11:51	1.05	Yes	N,M	11	Wrong number on number plate. Water quality is above recommended standard due to elevated Fe. Fe - 0.558mg/l	Rectify number and monitor Fe closely.	T Mpongo		
	*P13	Dugged pit west of PS between PS and DWS. Monitor water quality.	26.62036	30.08171		2014/04/03	11:48	Damp	No	N,M		Satisfactory condition.	~	Maintenance??		
	*S04	Clean water run-off canal next to road passing raw water dams. Monitoring water quality.	26.62059	30.08369		2014/04/03	11:47	High / Stagnant	Yes	N,M		Satisfactory condition. SO4 - 350mg/l	A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	V Pandaram/T Mpongo		
	*Z02	Leaking Pipes. Standing contaminated water spilled in the area. Inspect and monitoring water quality.	26.62098	30.08416		2014/04/03	11:39	Dry	No	V		Satisfactory condition.	~	A.Sebothoma / M Dubazana		
	D06	Monitoring shallow groundwater contamination of ash dam.	-26.61594	30.08230		2014/04/03	12:30	1.52	No	N,M		Wrong number on number plate. Water level to low to sample. Water quality historically above recommended standard due to seepage from the ash dam complex.	Water levels in the AWR canals must be monitored regularly. Replace number plate.	V Pandaram/ S Shabangu		

Table 5. Continues.

Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	*C04	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61250	30.08450		2014/04/03	11:51	Low / Slow	Yes	N	12	Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 907mg/l, EC - 194mS/m	Water levels in the AWR canals must be monitored regularly.	M Ueckermann/ H. Jairaj		
	*S03	Run-off from area north of PS released into natural environment. Monitor water quality.	26.61690	30.08810		2014/04/03	09:14	Mod / Stagnant	Yes	N,M	13	S03 and C25 is historically the most severe contaminated surface site. S03 pH - 3.27 , SO4 -2632 mg/l, EC 346mS/m Ca - 494 mg/l Fe - 59mg/l C25 SO4 - 519 mg/l Fe - 0.389 mg/l Fe - Mn 5.08mg/l	The source of the pollution must be establish and removed. A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	V Pandaram / T Mpongo		
	*C25	Run-off from area north of PS released into natural environment. Monitor water quality.	26.61710	30.08714		2014/04/03	09:13	Low / Stagnant	Yes	N	14			V Pandaram / T Mpongo		
	D24	Dugged Pit west of clean water canal C25.	26.61704	30.08679		2014/04/03	09:14	Full	Yes	N	15	A pit dugged by Power Station to determine source of seepage and pollution at S03. D24 has an above recommended standard water quality. pH - 3.96, SO4 - 1996mg/l, EC - 254mS/l, Ca - 497mg/l, Mn - 6.86mg/l, Mg - 120mg/l, Al - 26.70	The source of the pollution must be establish and removed. A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.			
	*C05	Clean water run-off canal downstream from C25. Monitoring water quality.	26.61290	30.08630		2014/04/03	13:06	Low	Yes	N		Water quality is above recommended standard. SO4 - 563mg/l	The area must be monitored closely.	V Pandaram / T Mpongo		

* Surface water sites supposed to contain clean water

Table 6. Witpunt Spruit Central Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled		Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Central Tributary - Area East of Power Station.	*C08	Run-off from area north-east of PS released into natural environment. Monitor water quality.	26.61590	30.09510		2014/04/03	09:12	Low / Slow	Yes	N	16	Satisfactory condition. SO4 - 73.5mg/l	~	V Pandaram / T Mpongo		
	*Z03	Leaking Pipes east of C08 at security fence. Inspect and monitoring water quality.	26.61561	30.09520		2014/04/03	13:18	Low / Stagnant	No	V		Standing water visible between the two fences.	The leaking pipe must be fixed.	A Sebothoma		
	*S02	Surface run-off and seepage from PS. Possibly a fountain. Monitor water quality.	26.61300	30.09270		2014/04/03	13:12	Dry	No	N,M		Satisfactory condition.	The area must be monitored regularly.	V Pandaram / T Mpongo		
	*C09	Clean water run-off canal. Monitoring water quality.	26.61470	30.09690		2014/04/03	10:59	Low / Slow	Yes	N		Satisfactory condition. SO4 - 429mg/l	~			
	B05	Monitoring groundwater quality north-east of PS.	26.61372	30.09761	8	2014/04/03	11:15	1.05	Yes	N		Satisfactory condition.	~			

* Surface water sites supposed to contain clean water

Table 7. Witpunt Spruit Southern Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled		Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Central Tributary - Clean water bypass system.	*C20	Clean water run-off canal south-east of CSY downstream from C19 released into natural environment. Monitoring water quality.	26.62310	30.09670		2014/04/03	08:38	Low / Slow	Yes	N,B	17	Water flowing into canal from old pipe upstream near old power box. The pipe seem to come from outside the Power Station fence. The water has a dangerous water quality (Class 4) due to high bacteriological count. C20 SO4 - 453mg/l, E.Coli - 74cfu/100ml, Total Coliforms - 76/100ml	Pipe must be removed from canal. Operations at the sewage plant must be improved and no effluent must be discharged into C20.	I Hogdskin		
Witpunt Spruit Central Tributary - Dirty water interception system.	K01	Standard of operations of sewage plant and quality of water released into the reclamation dam.	26.62310	30.09670		2014/04/03	08:45	Low /Slow	Yes	N,B		Water has a dangerous water quality (Class 4) due to high bacteriological count and elevated NO3-N. pH - 3.60 NO3-N - 22.3mg/l, NH4 -4.79mg/l	The treatment of the effluent must be monitored regularly to ensure that is up to standard as set by the water use license.	I Hogdskin		
	P04	Coal settling pond & Splitter box. Inspect operations.	26.62190	30.09800		2014/04/03	08:39	Full	No	V	18, 19, 20	Some coal and dibrisin coal settling pond. Some debris in splitter box and canals surrounding the coal stock yard	Regular inspections in this area must be conducted and problems rectified..	S Shabangu		
	C11	Dirty water run-off canal downstream from CSY. Inspect all dirty water canals.	26.62120	30.09840		2014/04/03	09:52	Low / Mod	No	V	21, 22	Slow water flow. Area between the fences are blocked with silt and debris. Oil visible in water.	The area between the fences must be cleaned regularly and oil removed .	M Dubazana		
	P05	CSY dam receiving dirty water run-off. Inspect regularly & monitor water quality.	26.62130	30.10130		2014/04/03	09:50	Low	No	N	23	Construction in progress. Satisfactory condition.	Dam must be inspected regularly.	M Dubazana		

Table 7. Continues.

Witpunt Spruit Central Tributary - Area East of Power Station.	P11	Station drain dams collection sump. Inspect operations.	26.61880	30.09810		2014/04/03	08:52	Full	No	V	24	Lots of oil and silt in sump.	Operations at the sump must be inspected regularly and cleaned to prevent oil spills into the environment.	M Dubazana / T Mpongo		
	C13	Canal discharge contaminated water from northern station dams into reclamation dam. Monitoring water quality.	26.61880	30.09810		2014/04/03	08:55	Low / Mod	No	V		Lots of ash visible in canal.	Canal must be cleaned.	M Dubazana		
	P08	Reclamation dam. Inspect and monitoring water quality.	26.62000	30.09980		2014/04/03	10:54	Low	Yes	N,M ,H,B	25	Oil visible in dam. Water has a dangerous water quality (Class 4) due to high No2, N and NH4 and also bacteriological count. NO2 - 1.53mg/l, N- 13.5mg/l NH4 - 5.25mg/l E.Coli - 74/100ml, Total Coliforms - 76/100ml	Operations at the oil skimmers must be improved to prevent oil spills into the environment. Work to be completed.	M Ueckermann/ M Dubazana		
	*Z04	Leaking pipes south of B06. Inspect and monitoring water quality.	26.61993	30.10101		2014/04/03	09:13	Low / Slow	No	V		Satisfactory condition.	~	A.Sebothoma		
Witpunt Spruit Central Tributary.	*C15	Clean run-off from area east of PS released into natural environment. Monitor water quality.	26.62070	30.09920		2014/04/03	10:54	Damp	No	N		Satisfactory condition.	Monitor water quality closely. If high levels of contamination persist a seepage investigation must be done to determine the source of pollution.	T Mpongo		
	*C16	Clean run-off from area east of PS downstream of C15 released into natural environment. Monitor water quality.	26.62000	30.10220		2014/04/03	09:38	Low / Slow	Yes	N,H		Lots of coal visible in canal. SO4 - 494mg/l	Coal must be removed from canal.	S Shabangu		
	*C26	Dugged canal west of SANDF sewage plant. Inspect regularly & monitoring discharge water quality.	26.61748	30.10806		2014/04/03	10:11	Low / Slow	Yes	N	26	Satisfactory condition. SO4 - 116mg/l, Fe 0.915mg/l, Mn - 0.908	Water responsibility of SANDF, Keep monitoring water quality. Relevant authorities needs to be notified.	V.Pandaram		
	*K02	Sewage plant at SANDF. Inspect regularly & monitoring discharge water quality.	26.61750	30.10880		2014/04/03	10:12	Dry	No	V		Satisfactory condition.	~	D. Khumalo/ H. Jairaj		

Table 8. Witpunt Spruit Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled		Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Water Course	*R01	Witpunt Spruit background water quality entering the system.	26.59330	30.09620		2014/04/03	13:25	High / Fast	Yes	N,M		Water has a dangerous water quality, mostlikely due to minning operations upstream. pH - 4.86 SO4 -241mg/l, Mn 0.878mg/l	The area must be monitored regularly.	I Hogdskin		
	*P01	Dam receiving run-off from PS and SANDF contributing to Witpunt Spruit. Monitoring water quality.	26.61200	30.10650		2014/04/03	10:20	Mod	Yes	N	28	Satisfactory condition. SO4 -316mg/l	~	I Hogdskin / Pierre		
	*P02	Dam receiving run-off from PS and SANDF contributing to Witpunt Spruit. Monitoring water quality.	26.61120	30.10740		2014/04/03	10:21	Mod	Yes	N	29	Satisfactory condition. SO4 -199mg/l	~	I Hogdskin / Pierre		
	*R02	Witpunt Spruit final water quality released from the system.	26.62290	30.11430		2014/04/03	10:29	High / Fast	Yes	N,M	30	Satisfactory condition. SO4 -228mg/l	~	I Hogdskin		
Vaal River Water Course	*R03	Vaal River background water quality entering the system.	26.64870	30.15170		2014/04/03	13:31	High / Fast	Yes	N,M		Satisfactory condition. SO4 -22.6mg/l	~	I Hogdskin		
	*R04	Vaal River final water quality released from the system.	26.67880	30.12390		2014/04/03	13:45	High / Fast	Yes	N,M		Satisfactory condition. SO4 -44.1mg/l	~	I Hogdskin		

* Surface water sites supposed to contain clean water

Photo 1. – Extremely high water level in the De Jager Pan P09.

Photo 2. – Water level of C17.

Photo 3. – Pan with oil north west of Ash dam at C17.

Photo 4. – Water level in Canal C17.

Photo 5. – Water level in Canal C18 next to contractors area.

Photo 6. – Water level at C01.

Photo 7. – Artesian borehole B20

Photo 8. – Canal C03.

Photo 9. – Canal C06.

Photo 10. – Artesian borehole B03.

Photo 11. – Borehole B22 with wrong number plate.

Photo 12. – Canal C04.

Photo 13. – Seepage at S03.

Photo 14. – Canal C25.

Photo 15. – Pit D24 next to Canal C25.

Photo 16. – Canal C08.

Photo 17. – Canal C20.

Photo 18. – Coal settling dam P04.

Photo 19. – Canal at coal stock yard.

Photo 20. – Splitter box near P04.

Photo 21. – Debris between the fences at canal C11.

Photo 22. – Oil in canal C11.

Photo 23. – Construction at coal stock yard dam P05.

Photo 24. – Oil and silt in sump P11.

Photo 25. – Reclamation dam P08.

Photo 26. – Seepage at canal C26.

Photo 27. – River R05.

Photo 28. – Farm dam P01.

Photo 29. – Farm dam P02.

Photo 30. – Witpunt Lower sample point R02.

3 SURFACE- AND GROUNDWATER QUALITY

Surface- and groundwater samples taken during the current monitoring phase were submitted to Aquatico Scientific (Pty) Ltd. and Organic Analysis Laboratory for analyses of the different parameter concentrations. The results of the analyses are presented in this section by various graphical means and observations regarding the contamination status of the surface- and groundwater are made.

Although the concentrations of more than 20 inorganic chemical parameters in the water samples were determined during some previous sampling phases, only six parameters are used as indicators of contamination in the monitoring of the pollution potential in this system. These six parameters are: the electrical conductivity (**EC**), the major ions **Ca**, **Cl,** and **SO_4** as well as the minor ion **Fe** and **Mn**. The suitability of these parameters to act as *indicator elements* in the evaluation of water contamination was determined by GHT during a previous investigation. The additional information on the concentrations of the other elements is required to evaluate the accuracy and reliability of the chemical analyses.

3.1 Chemical Analysis Reliability

The most common way to evaluate the reliability of an analysis is to perform an Ion Balance Calculation. For any water analysis, the total cation and anion concentrations should balance. The difference between these concentrations is referred to as the Ion Balance Error. A negative value indicates that anions predominate in the analysis, whereas a positive value shows that cations are more abundant. For the analysis to be considered reliable, the ion balance error should not be greater than 5% of the total ion concentration. A value greater than this figure indicates that some major constituents have not been analysed for or that there is an analytical error. Some trace elements are not included in the ion balance calculation. However, these may still be important as pollution indicators and may be used to identify point sources of pollution.

3.2 Chemical Data Presentation Formats

The results of the inorganic chemical analyses are presented in various formats in this report. These formats include

- Water Quality Tables classified according to different South Africa Water Quality Guidelines,
- Pollution Index Tables comparing chemical concentrations with background concentrations for the specific area,
- Time Graphs of the chemical concentrations variations over time of the groundwater sites.
- Bar Chart Plots of the surface water sites along the drainage systems, and

The formats used are not exhaustive and any special requirements could be incorporated if suggested by the client or if shown necessary as the monitoring program progresses. The formats of data presentation used in this report are discussed below.

3.2.1 Data Tables and Water Quality Tables

Data Tables

The results of all the inorganic chemical, hydrocarbon and bacteriological analyses that have been performed on water samples from Camden Power Station during the current and previous phases of the monitoring program are available in an electronic database for review.

Water Quality Tables

In these tables the water samples from each monitoring site are classified according to the "South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993" and the "South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, Second Edition 1996", as well as according to the publication "Quality of Domestic Water Supplies, DWA&F, Second Edition 1998". The South African National Standard (SANS 241: 2006 Edition 6.1 and SANS 241-1:2011 Edition 1) are use as primary standard. A description of the various Classes is given in **Table 9** to **Table 13**.

Table 9. Classification system used to evaluate water quality Classes.

Quality of Domestic Water Supplies, DWA&F, Second Edition 1998

Class 0	**- Ideal water quality** - Suitable for lifetime use.
Class 1	**- Good water quality** - Suitable for use, rare instances of negative effects.
Class 2	**- Marginal water quality** - Conditionally acceptable. Negative effects may occur in some sensitive groups
Class 3	**- Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.
Class 4	**- Dangerous water quality** - Totally unsuitable for use. Acute effects may occur.

South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993 & Second Edition 1996

NR	**- Target water quality range** - No risk.
IR	**- Good water quality** - Insignificant risk. Suitable for use, rare instances of negative effects.
LR	**- Marginal water quality** - Allowable low risk. Negative effects may occur in some sensitive groups
HR	**- Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.

Table 10. DWA&F drinking water standards.

PARAMETER	CLASS 0	CLASS 1	CLASS 2	CLASS 3	CLASS 4
~ Microbiological Quality ~					
Faecal Coliforms	**0.00**	**0 - 1**	1 - 10	10 - 100	> 100
Total Coliforms	**0**	**0 - 10**	10 - 100	100 - 1 000	> 1 000
E. Coli	**0**	**0 - 1**	1 - 10	10 - 100	> 100
~ Physical Quality ~					
Electrical Conductivity (mS/m)	**< 70**	70 - 150	150 - 370	370 - 520	> 520
pH	**5 - 9.5**	4.5 - 5 & 9.5 - 10	4 - 4.5 & 10 - 10.5	3 - 4 & 10.5 - 11	< 3 & >11
Total Dissolved Solids [TDS] mg/L	**< 450**	450 - 1 000	1 000 - 2 400	2 400 - 3 400	> 3 400
Turbidity	**< 0.1**	0.1 - 1	1 - 20	20 - 50	> 50
~ Chemical Quality ~					
Arsenic [As] (mg/L)	**< 0.010**	0.01 - 0.05	0.05 - 0.2	0.2 - 2.0	> 2
Cadmium [Cd] (mg/L)	**< 0.003**	0.003 - 0.005	0.005 - 0.020	0.020 - 0.050	> 0.050
Aluminium [Al] (mg/l)	**0 - 0.15**	0.15 - 0.5	0.50 - 1	> 1	~
Boron [B] (mg/L)	**0 - 0.5**	0.5 - 2	2 - 4	> 4	~
Calcium [Ca] (mg/L)	**0 - 80**	80 - 150	150 - 300	> 300	~
Chloride [Cl] (mg/L)	**< 100**	100 - 200	200 - 600	600 - 1 200	> 1 200
Chrome [Cr] (mg/l)	**0 - 0.10**	0.10 - 0.20	0.20 - 1	1 - > 5	
Copper [Cu] (mg/L)	**0 - 1**	1 - 1.3	1.3 - 2.0	2.0 - 15	> 15
Fluoride [F] (mg/L)	**< 0.7**	0.7 - 1.0	1 - 1.5	1.5 - 3.5	> 3.5
Iron [Fe] (mg/L)	**< 0.5**	0.5 - 1	1 - 5	5 - 10	> 10
Total Hardness	**0 - 200**	200 - 300	300 - 600	> 600	~
Magnesium [Mg] (mg/L)	**< 70**	70 - 100	100 - 200	200 - 400	> 400
Manganese [Mn] (mg/L)	**0 - 0.1**	0.1 - 0.4	0.4 - 4	4 - 10	> 10
Nitrate [N] (mg/L)	**< 6**	6 - 10	10 - 20	20 - 40	> 40
Nitrite [N] (mg/L)	**< 6**	6 - 10	10 - 20	20 - 40	> 40
Potassium [K] (mg/L)	**< 25**	25 - 50	50 - 100	100 - 500	> 500
Sodium [Na] (mg/L)	**< 100**	100 - 200	200 - 400	400 - 1 000	> 1 000
Sulphate [SO_4] (mg/L)	**< 200**	200 - 400	400 - 600	600 - 1 000	> 1 000

Table 11. SANS 2006 drinking water standards.

Determinand	Unit	Class I (recommended operational limit)	Class II (max. allowable for limited duration)	Class II water consumption period,[a] max.
Physical and organoleptic requirements				
Colour (aesthetic)	mg/L pt	< 20	20-50	No limit[b]
Conductivity at 25 °C (aesthetic)	mS/m	< 150	150-370	7 years
Dissolved solids (aesthetic)	mg/L	< 1 000	1 000-2 400	7 years
Odour (aesthetic)	TON	<5	5-10	No limit[b]
pH value at 25 °C (aesthetic/operational)	pH units	5,0 - 9,5	4,0 - 10,0	No limit[c]
Taste (aesthetic)	FTN	< 5	5-10	No limit
Turbidity (aesthetic/operational/indirect health)	NTU	< 1	1-5	No limit[d]
Chemical requirements — macro-determinand				
Ammonia as N (operational)	mg/L	< 1,0	1,0-2,0	No limit[d]
Calcium as Ca (aesthetic/operational)	mg/L	< 150	150-300	7 years
Chloride as Cl^- (aesthetic)	mg/L	< 200	200-600	7 years
Fluoride as F^- (health)	mg/L	< 1,0	1,0-1,5	1 year
Magnesium as Mg (aesthetic/health)	mg/L	< 70	70- 100	7 years
(Nitrate and nitrite) as N (health)	mg/L	< 10	10-20	7 years
Potassium as K (operational/health)	mg/L	< 50	50- 100	7 years
Sodium as Na (aesthetic/health)	mg/L	< 200	200-400	7 years
Sulfate as $SO_4^=$ (health)	mg/L	< 400	400-600	7 years
Zinc as Zn (aesthetic/health)	mg/L	< 5,0	5,0- 10	1 year

Determinand	Unit	Class I (recommended operational limit)	Class II (max. allowable for limited duration)	Class II water consumption period," max.
Chemical requirements — mlcro-determlnand				
Aluminium as AI (health)	mg/L	< 300	300-500	1 year
Antimony as Sb (health)	mg/L	< 10	10-50	1 year
Arsenic as As (health)	mg/L	< 10	10-50	1 year
Cadmium as Cd (health)	mg/L	<5	5- 10	6 months
Total Chromium as Cr (health)	mg/L	< 100	100-500	3 months
Cobalt as Co (health)	mg/L	< 500	500-1 000	1 year
Copper as Cu (health)	mg/L	< 1 000	1 000-2 000	1 year
Cyanide (recoverable) as CW (health)	mg/L	<50	50-70	1 week
Iron as Fe (aesthetic/ operational)	mg/L	< 200	200-2 000	7 years[b]
Lead as Pb (health)	mg/L	< 20	20-50	3 months
Manganese as Mn (aesthetic)	mg/L	< 100	100-1000	7 years
Mercury as Hg (health)	mg/L	< 1	1-5	3 months
Nickel as Ni (health)	mg/L	< 150	150- 350	1 year
Selenium as Se (health)	mg/L	< 20	20-50	1 year
Vanadium as V (health)	mg/L	< 200	200- 500	1 year
Chemical requirements — organic determinand				
Dissolved organic carbon as C (aesthetic/health)	mg/L	< 10	10-20	3 months[e]
Total trihalomethanes (health)	mg/L	< 200	200-300	10 years[f]
Phenols (aesthetic/health)	mg/L	< 10	10-70	No limi[b]

[a] The limits for the consumption of class II water are based on the consumption of 2 L water per day by a person of mass 70 kg

[b] The limits given are based on aesthetic aspects.

[c] No primary health effect- low pH values can result in structural problems in the distribution system.

[d] These values can indicate process efficiency and risks associated with pathogens.

[e] When dissolved organic carbon is deemed of natural origin, the consumption period can be extended.

[f] This is a suggested value because trihalomethanes have not been proven to have any effect on human health.

Table 12. SANS 2011 drinking water standards.

Determinand	Risk	Unit	Standard limits [a] (Class I)
Physical and aesthetic determinands			
Free chlorine	Chronic health	mg/L	≤ 5
Monochloramine	Chronic health	mg/L	≤ 3
Colour	Aesthetic	mg/L Pt-Co	≤ 15
Conductivity at 25 ° C	Aesthetic	mS/m	≤ 170
Odour or taste	Aesthetic	-	Inoffensive
Total dissolved solids	Aesthetic	mg/L	≤ 1 200
Turbidity [b]	Operational	NTU	≤ 1
	Aesthetic	NTU	≤ 5
pH at 25 ° C [c]	Operational	pH units	≥ 5 to ≤ 9,7
Chemical determinands — macro-determinands			
Nitrate as N [d]	Acute health - 1	mg/L	≤ 11
Nitrite as N [d]	Acute health - 1	mg/L	≤ 0,9
Sulfate as SO_4^{2-}	Acute health - 1	mg/L	≤ 500
	Aesthetic	mg/L	≤ 250
Fluoride as F^-	Chronic health	mg/L	≤ 1,5
Ammonia as N	Aesthetic	mg/L	≤ 1,5
Chloride as Cl^-	Aesthetic	mg/L	≤ 300
Sodium as Na	Aesthetic	mg/L	≤ 200
Zinc as Zn	Aesthetic	mg/L	≤ 5
Chemical determinands — micro-determinands			
Antimony as Sb	Chronic health	µg/L	≤ 20
Arsenic as As	Chronic health	µg/L	≤ 10
Cadmium as Cd	Chronic health	µg/L	≤ 3
Total chromium as Cr	Chronic health	µg/L	≤ 50
Cobalt as Co	Chronic health	µg/L	≤ 500
Copper as Cu	Chronic health	µg/L	≤ 2 000
Cyanide (recoverable) as CN^-	Acute health - 1	µg/L	≤ 70
Iron as Fe	Chronic health	µg/L	≤ 2 000
	Aesthetic	µg/L	≤ 300
Lead as Pb	Chronic health	µg/L	≤ 10
Manganese as Mn	Chronic health	µg/L	≤ 500
	Aesthetic	µg/L	≤ 100
Mercury as Hg	Chronic health	µg/L	≤ 6
Nickel as Ni	Chronic health	µg/L	≤ 70
Selenium as Se	Chronic health	µg/L	≤ 10
Uranium as U	Chronic health	µg/L	≤ 15
Vanadium as V	Chronic health	µg/L	≤ 200
Aluminium as Al	Operational	µg/L	≤ 300

Determinand	Risk	Unit	Standard limits [a] (Class I)
Chemical determinands-organic determinands			
Total organic carbon as C	Chronic health	mg/L	≤10
Trihalomethanes			
Chloroform	Chronic health	mg/L	≤ 0,3
Bromoform	Chronic health	mg/L	≤ 0,1
Dibromochloromethane	Chronic health	mg/L	≤ 0,1
Bromodichloromethane	Chronic health	mg/L	≤ 0,06
Microcystin as LR [e]	Chronic health	µg/L	≤1
Phenols	Aesthetic	µg/L	≤10

[a] The health-related standards are based on the consumption of 2 L of water per day by a person of a mass of 60 kg over a period of 70 years.

[b] Values in excess of those given in column 4 may negatively impact disinfection.

[c] Low pH values can result in structural problems in the distribution system.

[d] This is equivalent to nitrate at 50 mg $N0_3^-$/Land nitrite as 3 mg $N0_2^-$/L.

[e] Microcystin only needs to be measured where an algal bloom (> 20 000 cyanobacteria cells per millilitre) is present in a raw water source. In the absence of algal monitoring, an algal bloom is deemed to occur where the surface water is visibly green in the vicinity of the abstraction, or samples taken have a strong musty odour.

Table 13. DWA&F Standards for bacterial activity in water.

A -Total Coliform
A range of between 5 and 100 is indicative of inadequate treatment, post-treatment contamination or growth in the distribution system. Risk of infectious disease transmission with continuous exposure and slight risk with occasional exposure.
A range greater than 100 is indicative of poor treatment, post-treatment contamination or definite growth in the water distribution system. Significant and increasing risk of infectious disease transmission.
B -Faecal Coliform
A range between 0 and 10 has a slight risk of microbial infection with continuous exposure.
A range between 10 and 20 has a risk of infectious disease transmission with continuous exposure
A range greater than 20 has a significant and increasing risk of infectious disease transmission. As faecal coliform levels increase, the required amount of water ingested to cause infection decreases.

Pollution Index Tables

In this report Pollution Index Tables are used to obtain a first estimate of the probability that contaminants are impacting on the groundwater at Camden Power Station. For groundwater sites the Pollution Index (PI) for a specific indicator element is calculated by relating the current concentration to the concentrations recorded at a number of background sites, and by assuming that the indicator element concentrations of the background samples follow a normal distribution. The background sites all occur upstream from the power station activities and were sampled during April 2009 **(see GHT report RVN 552.1/958, Hydrocensus Report, May 2009)**. With the data gathered during the Hydrocensus investigation pollution index references were calculated for different indicator elements for future use. The Pollution Index References are given in **Table 14**.

Table 14. Pollution Index References.

Site No.	Date	EC	Cl	Ca	SO4	Na	F	Mn
FBB09	20090420	23	10.1	13.9	0.2	23.5	0.01	0.03
FBB10	20090430	26	21.1	15.5	20	13.9	0.04	0.00
FBB13	20090430	60	20.6	44.2	162	39.3	0.16	0.06
FBB14	20090431	22	17.8	9.9	2	16.9	0.2	0.10
FBB15	20090431	27	19	19	3	8.6	0.02	0.00
FBB17	20090431	26	22.4	16.7	12	11.8	0.02	0.00
FBB18	20090431	14	21.7	5.1	9	6.8	0.14	0.00
FBF01	20090430	30	6.7	27.9	38	12.3	0.09	0.00
FBF02	20090430	32	21	22.7	28	17.1	0.08	0.01
FBF03	20090430	27	21.3	17.5	18	9.1	0.05	0.00
Average		28.70	18.17	19.24	29.22	15.93	0.08	0.02
StDev		12.05	5.38	10.80	48.18	9.57	0.07	0.03
Ave + (½ × StDev)		34.72	20.86	24.64	53.31	20.71	0.11	0.04
Ave + StDev		40.75	23.55	30.04	77.40	25.50	0.15	0.05
Ave + (2 × StDev)		52.79	28.92	40.83	125.59	35.07	0.21	0.09

The PI for each indicator element under consideration is calculated by taking the difference between the current concentration and the average concentration obtained for the background samples. This difference is then divided by the standard deviation of the background samples, as explained in the Eq.1:

$$(PI)_{indicator\ element\ A} = \frac{(Current\ conc. - Ave\ \ background\ \ conc.)_{indicator\ element\ A}}{(St.\ dev.\ \ of\ \ background\ \ conc)_{indicator\ element\ A}} \qquad \text{(Eq.1)}$$

To interpret the PI's, the following should be noted:

- Negative PI's imply that the current indicator element concentration is lower than the average background concentration and that contaminant impacts are therefore not visible.
- PI's greater than 0.5 imply that the current sample concentration is more than half a standard deviation larger than the average concentration measured at the background sampling sites. The likelihood of obtaining a concentration of this magnitude in an uncontaminated sample is <30.9%. The sample could possibly be contaminated.
- PI's greater than unity imply that the current sample concentration is more than one standard deviation larger than the average concentration measured at the background sampling sites. The likelihood of obtaining a concentration of this magnitude in an uncontaminated sample is <15.9%. There is therefore a high probability that the sample is contaminated.
- PI's greater than two imply that the current sample concentration is more than two standard deviations larger than the average concentration measured at the background sampling sites. The likelihood of obtaining a concentration of this magnitude in an uncontaminated sample is <2.3%. There is therefore a very high probability that the sample is contaminated.

Table 15. Groundwater classification system used to evaluate the pollution indices of the current chemical results.

PI < 0.5 -	**No contaminant impacts**
0.5 < PI < 1.0 -	**Low probability that the sample is contaminated**
1.0 < PI < 2.0 -	**High probability that the sample is contaminated**
PI > 2.0	**Very high probability that the sample is contaminated**

For stream sites the PI's are calculated by comparing the concentrations at sites that could be under the influence of contaminant impacts with the concentration recorded at a position upstream from the power station activities. It should be understood that the upstream sample may already be contaminated due to the activities of other polluters situated upstream from the power station. The PI's calculated for the stream sites therefore only reflect the impacts of power station activities on the stream. The PI for a specific indicator element at a specific stream site is calculated by simply dividing the indicator element concentration by the indicator element concentration recorded at the upstream site, as explained in Eq.2:

Stream sites: $$(PI)_{indicator\ element\ A} = \frac{(Current\ \ conc.)_{indicator\ element\ A}}{(Upstream conc.)_{indicator\ element\ A}} \qquad \text{(Eq.2)}$$

To interpret the PI's of the stream sites, the following should be noted:

- PI's smaller than 1.0 imply that the current indicator element concentration is lower or equal than the background concentration at the upstream site and that contaminant impacts are therefore not visible.

- PI's between 1.0 and 1.5 imply that the current indicator element concentration is between 0% and 50% higher than the background concentration at the upstream site. The site could possibly be affected by contaminant impacts from the power station.
- PI's between 1.5 and 2.0 imply that the current indicator element concentration is between 50% and 100% higher than the background concentration at the upstream site. The site is probably affected by contaminant impacts from the power station.
- PI's greater than 2.0 imply that the current indicator element concentration is more than 100% higher than the background concentration at the upstream site. There is a very high probability that the site is affected by contaminant impacts from the power station.

Table 16. Surface water classification system used to evaluate the pollution indices of the current chemical results.

PI < 1.0 -	**No contaminant impacts**
1.0 < PI < 1.5 -	**Low probability that the sample is contaminated**
1.5 < PI < 2.0 -	**High probability that the sample is contaminated**
PI > 2.0	**Very high probability that the sample is contaminated**

3.2.2 MMAC Plots and Time Graphs

Monitoring is undertaken so that changes in water quality over time can be identified. Such changes may be particularly evident in areas affected by surface activities, which could enhance water degradation. For this investigation the evaluation of previous and the current monitoring period has again been condensed and plotted in a format referred to as the Maximum, Minimum, Average and Current plot (MMAC). The results from a number of sample sites can be plotted in a single diagram for comparison.

A diagram of an MMAC plot is shown in the Figure 1 and serves to explain the meaning of each element in the presentation. Instead of only an average value, twice the standard deviation, given as one value above and one value below the average is supplied. The standard deviation allows an idea of the usual range of values measured for the particular constituent at the particular site. A small standard deviation indicates a stable sample, while a large value represents a high variation in values. The maximum and minimum values ever recorded at the site are indicated in these plots by horizontal lines.

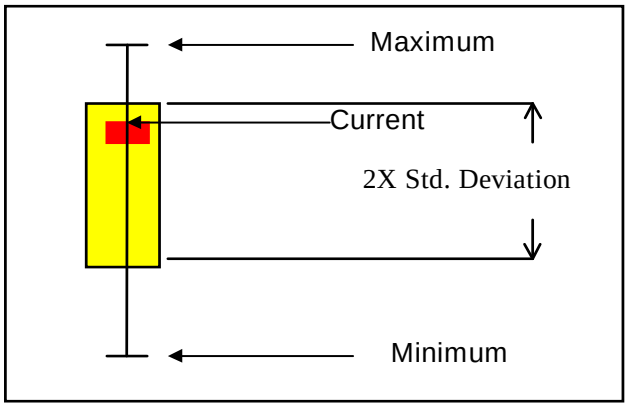


Figure 1. Maximum, Minimum, Average and Current Plot (MMAC)

In this way, a visual comparison may be made between the different sampling points for each monitoring period. At the same time, the history of each sampling point can be assessed. For

example, if the red rectangle in the diagram were an actual data point, the current value would be higher than the average. If this is the case for other indicator parameters, and the condition persists through a number of monitoring events, then progressive degradation is indicated.

The geohydrological software package 'WISH' *(Institute of Groundwater Studies, UOVS, 1999)* was used to evaluate the data. On each of the plots the Department of Water Affairs and Forestry drinking water standard for human consumption is indicated and can be described as follows:

- The Target Water Quality Range (TR) for a particular constituent is indicated by the lower horizontal line on the figures. Concentrations below this value correspond to levels at which the presence of the particular constituent would have no known adverse or anticipated effects on the fitness of the water assuming long-term continuous use. If the quality is within the TR one can immediately concluded that water quality in that particular case is not an issue to the water use concerned. However, if the water quality falls outside the TR it does not mean that the water is unsuitable for a particular use, but rather that the particular situation must be more thoroughly assessed by referencing the comprehensive guidelines.
- The upper horizontal line of the standard indicates the Maximum Allowable Limit (AL). This is the limit above which remedial action should be implemented. It does not mean that the water is unsuitable for a particular use, but rather that the particular situation must be more thoroughly assessed by referencing the comprehensive guidelines.

3.2.3 Bar Chart Plots

Bar charts of the indicator element concentrations are constructed to evaluate the spatial changes in the groundwater quality along surface streams or drainage systems. The indicator element concentrations are used as an indication of the contamination status of these streams at the sampling positions so that the impact that activities at the power station have on the natural surface water in the area may be investigated.

To study the changes in the water quality of the streams over distance, bar charts are used in conjunction with MMAC plots. This enables the investigator to detect whether any external influence along the stream causes the water quality of the stream to change. The bar charts display the water quality as measured at sampling positions along the Witpunt Spruit Northern Tributary, Witpunt Spruit Central Tributary, Witpunt Spruit Southern Tributary and the Witpunt Spruit that had water and were sampled during the latest sampling event. All the sampling sites of the tributaries and surface water pollution sources are also plotted on these graphs at the localities where the possible impacts could occur.

General observations

The MMAC plots indicate that there is considerable variability in the content of indicator elements within surface water of Camden Power Station. Standard deviations in the indicator element concentrations are generally much higher at surface water sampling sites as compared to groundwater sampling sites. This response is to be expected when site drainage characteristics are considered. It must also be kept in mind that water is re-circulated between different sites at the power station. Surface water quality in the drainage system has the potential, therefore, to be affected by several factors including:

- Dilution effects from sudden rain storms;
- Concentration effects due to evaporation;
- Solution/dissolution effects as a result of water moving along the drain bed;

- Changes in mineral speciation over time with water movement through the system.

The MMAC plots also confirm that water quality has degraded at several sampling sites on the Power Station property. Plots also suggest that there is some attenuation in indicator contents as polluted water migrates from surface water bodies, through the unsaturated zone, and into underlying aquifers.

The general trends in the indicator element concentrations as observed during previous monitoring phases are still identifiable when considering the time graphs constructed for this report. Changes in the chemical characteristics of the water over time are evident.

3.3 Evaluation of Surface- and Groundwater Quality

In this section the results of the chemical analyses of the water samples taken during the current monitoring phase is discussed and related to the results of previous monitoring phases. At the time of the latest sampling event, most of the streams at Camden Power Station were characterized by slow flowing water. It is therefore fair to assume that the dilution effect of continuous stream flow was negligibly small to moderate during the months preceding the sampling event.

3.3.1 Effected Sub Drainage System 1 – Witpunt Spruit Northern Tributary

Table 17. *Current water quality classification table for surface water chemical results for the Witpunt Spruit Northern Tributary Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
P09	10.30	159.00	1165	171.00	0.497	187.00	40.60	80.30	635.00	1.480		1.430		0.003	0.001	1.750	1.290	0.001	0.002	0.001	0.001			54.600	16.76	17.75	2.860
*C01	8.03	173.00		215.00	41.300	142.00	28.80	96.20	624.00	0.242		0.309		0.003	0.001	2.490	0.003							218.000	20.10	21.04	2.280
*C03	7.99	302.00		314.00	29.600	390.00	66.70	245.00	1159.00	0.112		0.312		0.003	0.001	4.580	0.003							240.000	35.87	36.77	1.240
*S04	7.88	96.80	725	95.70	56.800	45.90	3.53	17.80	350.00	0.405		0.299		0.003	0.001	0.186	0.003	0.001	0.002	0.001	0.001			237.000	12.57	11.53	-4.300
*C04	7.57	194.00		247.00	67.100	152.00	12.10	90.50	907.00	0.157		0.315		0.003	0.001	1.020	0.003							141.000	24.29	24.77	0.980
*S03	3.27	346.00		494.00	272.000	56.60	8.85	16.10	2632.00	0.097		0.303		59.000	15.400	0.634	0.536							2.480	55.33	51.05	-4.020
*D24	3.96	254.00		497.00	120.000	38.70	9.85	9.08	1996.00	0.055		0.361		0.085	6.860	0.477	26.700							2.480	41.89	36.73	-6.560
*C25	6.65	95.50	767	113.00	48.600	16.60	11.70	11.20	519.00	0.468		0.312		0.389	5.080	0.177	0.003							32.500	11.82	10.76	-4.700
*C05	7.87	130.00		148.00	59.300	75.30	10.90	44.70	563.00	0.300		0.302		0.003	0.001	0.383	0.003							176.000	16.54	15.82	-2.230
*C06	7.66	270.00		312.00	56.700	305.00	43.00	181.00	1058.00	0.142		0.300		0.003	0.001	2.730	0.003							215.000	31.46	34.60	4.750
*C07	8.22	252.00	1911	271.00	52.800	286.00	39.30	165.00	960.00	0.147		0.313		0.003	0.163	2.450	0.003	0.001	0.002	0.001	0.001			193.000	28.53	31.32	4.650

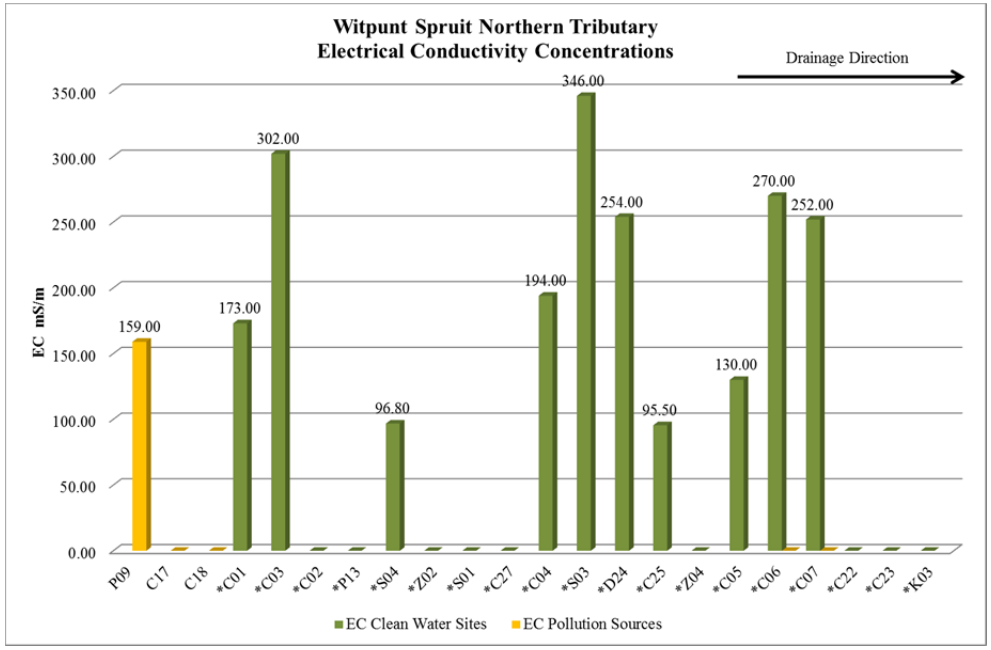
* Surface water sites supposed to contain clean water.

Table 18. *Current pollution index table for surface water chemical results for the Witpunt Spruit Northern Tributary Drainage System.*

Background Site	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*R01	2014/04/10	52.90	38.600	25.300	18.000	5.790	15.70	241.00	0.308

Site No.	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
P09	2014/04/10	3.0	4.4	0.0	10.4	7.0	5.1	2.6	4.805
*C01	2014/04/10	3.3	5.6	1.6	7.9	5.0	6.1	2.6	0.786
*C03	2014/04/10	5.7	8.1	1.2	21.7	11.5	15.6	4.8	0.364
*S04	2014/04/10	1.8	2.5	2.2	2.6	0.6	1.1	1.5	1.315
*S01	2014/04/10	3.7	6.4	2.7	8.4	2.1	5.8	3.8	0.510
*C27	2014/04/10	6.5	12.8	10.8	3.1	1.5	1.0	10.9	0.315
*C04	2014/04/10	4.8	12.9	4.7	2.2	1.7	0.6	8.3	0.179
*S03	2014/04/10	1.8	2.9	1.9	0.9	2.0	0.7	2.2	1.519
*D24	2014/04/10	2.5	3.8	2.3	4.2	1.9	2.8	2.3	0.974
*C25	2014/04/10	5.1	8.1	2.2	16.9	7.4	11.5	4.4	0.461
*S03	2014/04/10	4.8	7.0	2.1	15.9	6.8	10.5	4.0	0.477

* Surface water sites supposed to contain clean water



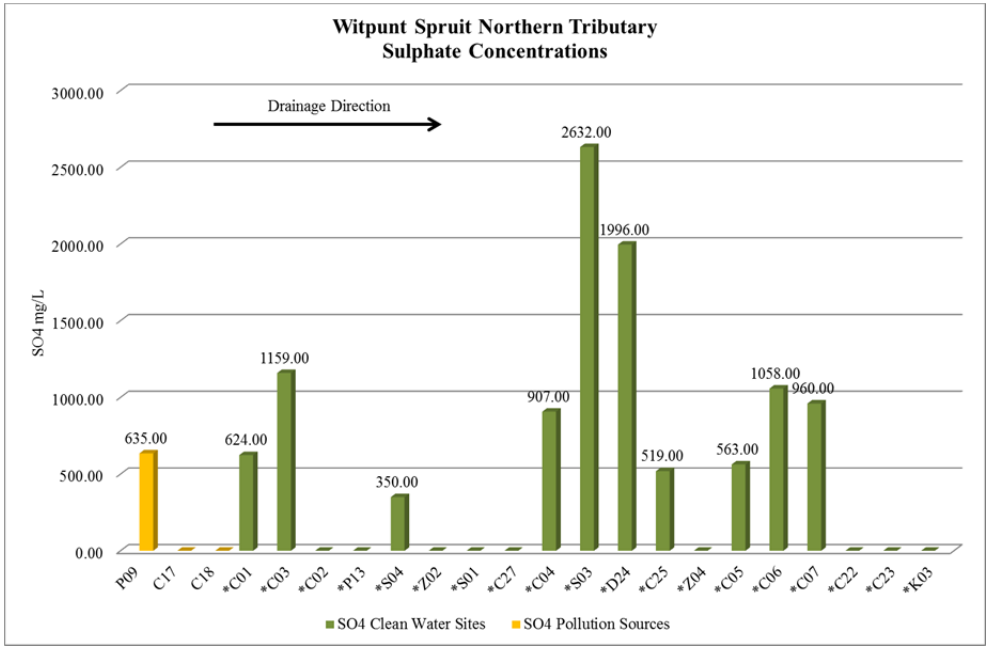


Figure 2. *Bar charts of the sulphate and electrical conductivity concentrations at sampling sites along the Witpunt Spruit Northern Tributary Drainage System.*

Table 19. *Current water quality classification table for groundwater chemical results for the Witpunt Spruit Northern Tributary Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
SHALLOW PURGED AQUIFER																											
D07	6.99	47.80	287	40.30	13.400	23.60	8.970	15.20	126.00	0.008		0.454		0.003	0.393	0.326	0.003	0.001	0.008	0.001	0.001			54.600	4.18	4.38	2.330
D02	6.23	26.60	159	18.70	5.040	19.70	3.850	16.80	68.40	0.104		0.316		0.003	2.400	0.120	0.003	0.001	0.002	0.001	0.001			24.200	2.41	2.35	-1.330
D04	8.27	228.00	1717	274.00	57.100	214.00	20.300	112.00	865.00	0.295		0.726		0.003	6.020	3.010	0.003	0.001	0.002	0.001	0.001			249.000	26.22	28.31	3.840
D05	7.57	150.00	1098	107.00	12.100	222.00	51.500	95.90	493.00	0.168		0.754		0.003	0.001	1.740	0.003	0.001	0.002	0.001	0.001			154.000	16.11	17.31	3.580
B19	8.50	39.10	180	15.00	3.390	50.20	3.490	102.00	0.04	0.099		0.370		0.003	0.001	0.034	0.003	0.001	0.002	0.001	0.001			7.240	3.05	3.30	3.870
B21	8.98	94.70	645	32.70	17.500	146.00	13.400	75.70	335.00	0.137		0.364		0.003	0.001	1.190	0.003	0.001	0.002	0.001	0.001			31.800	9.78	9.76	-0.070
B03	7.20	42.10	310	47.20	17.600	13.00	3.130	13.70	99.10	0.093		0.922		0.003	0.001	0.005	0.003	0.001	0.002	0.001	0.001			93.700	4.39	4.45	0.610
B04	7.49	35.00	197	16.50	6.100	49.80	2.830	28.40	0.04	0.261		0.353		0.003	0.380	0.068	0.003	0.001	0.002	0.001	0.001			141.000	3.66	3.57	-1.250
DEEP UTILIZABLE AQUIFER																											
B20	10.30	38.40	354	1.65	0.009	84.50	1.510	24.20	8.43	0.055		0.328		0.003	0.001	0.429	0.003	0.001	0.002	0.001	0.001			147.000	3.82	3.80	-0.360
B22	7.71	19.70	165	9.55	5.470	20.90	2.640	14.10	0.20	0.283		0.345		0.558	0.032	0.025	0.003	0.001	0.002	0.001	0.001			82.700	2.10	1.91	-4.550

Table 20. *Current pollution index table for groundwater chemical results for the Witpunt Spruit Northern Tributary Drainage System.*

Site No.	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
SHALLOW PURGED AQUIFER									
D07	2012/12/04	1.6	2.5	-0.5	3.3	-0.9	0.4	2.0	-1.1
D02	2012/12/04	-0.2	0.3	-1.3	2.5	-2.0	0.7	0.8	0.3
D04	2012/12/04	16.5	27.0	3.5	45.1	1.4	20.2	17.3	3.2
D05	2012/12/04	10.1	9.5	-0.7	46.8	7.8	16.9	9.6	1.3
B19	2012/12/04	0.9	-0.1	-1.5	9.1	-2.1	18.2	-0.6	0.3
B21	2012/12/04	5.5	1.8	-0.2	30.2	0.0	12.8	6.3	0.8
B03	2012/12/04	1.1	3.3	-0.2	1.0	-2.1	0.0	1.5	0.2
B04	2012/12/04	0.5	0.1	-1.2	9.1	-2.2	3.1	-0.6	2.7
DEEP UTILIZABLE AQUIFER									
B20	2014/04/10	0.8	-1.5	-1.8	16.7	-2.5	2.2	-0.4	-0.4
B22	2014/04/10	-0.7	-0.7	-1.3	2.7	-2.2	0.1	-0.6	3.1

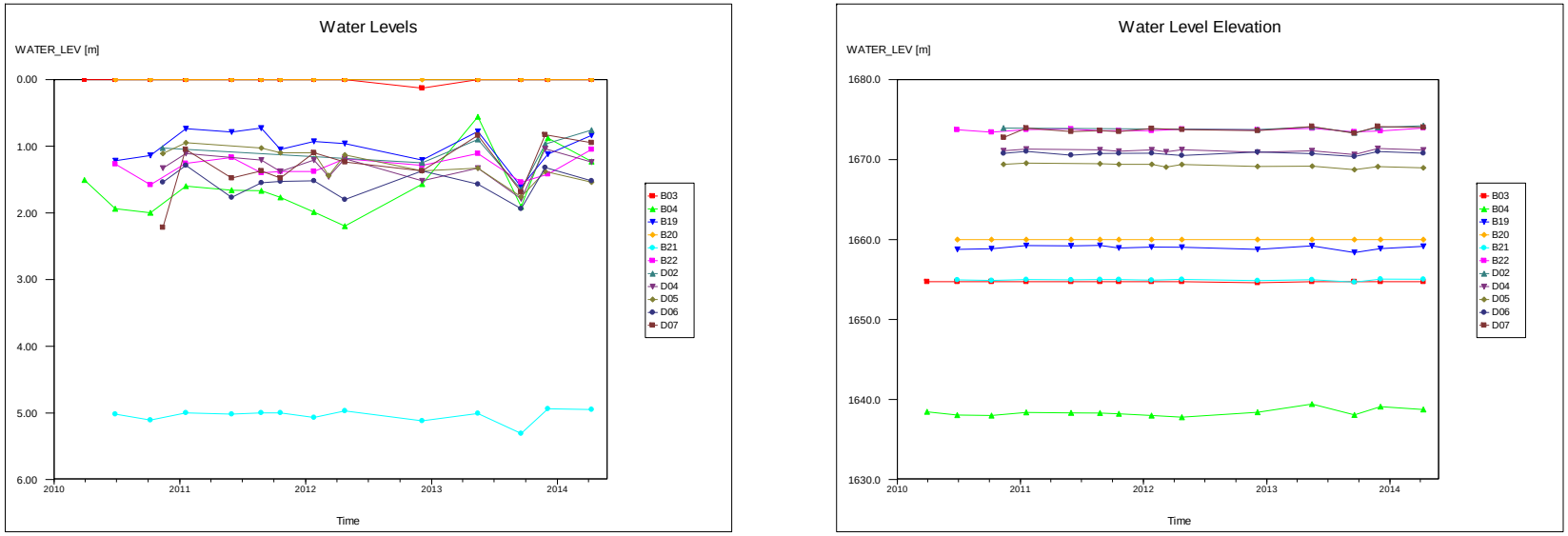
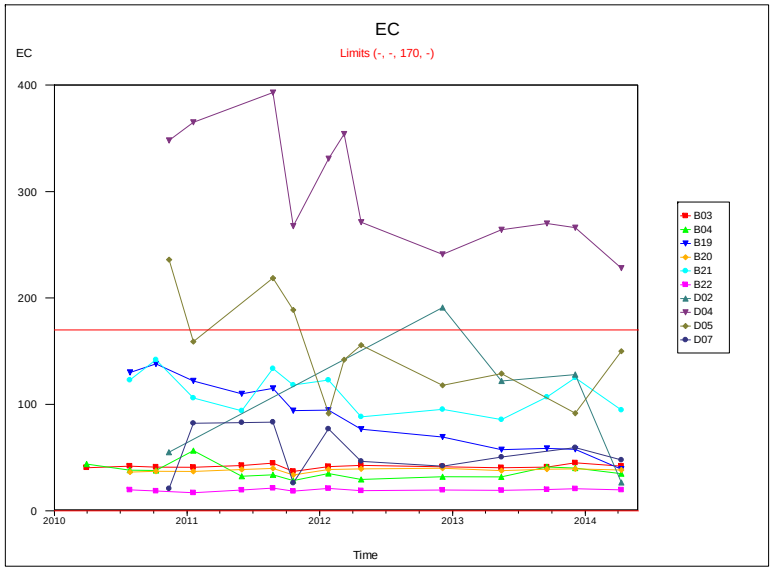


Figure 3. Groundwater depths in mbgl and groundwater elevations in mamsl observed Witpunt Spruit Northern Tributary Drainage System.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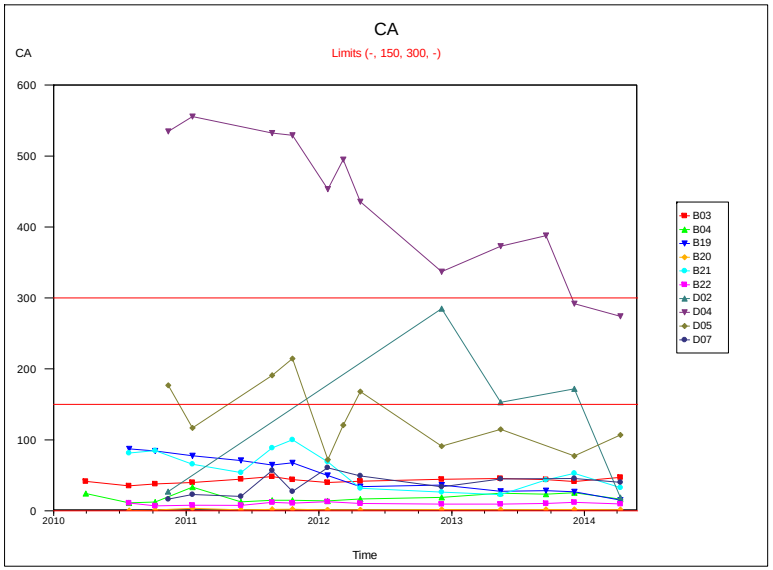
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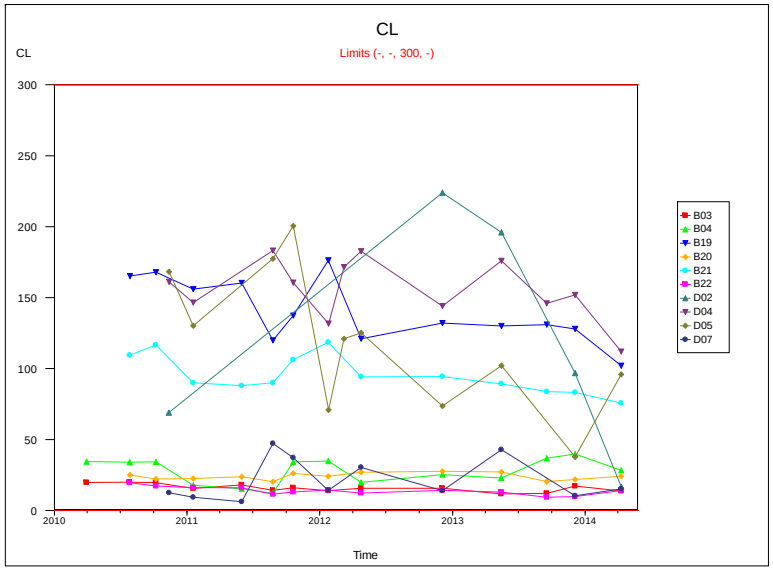
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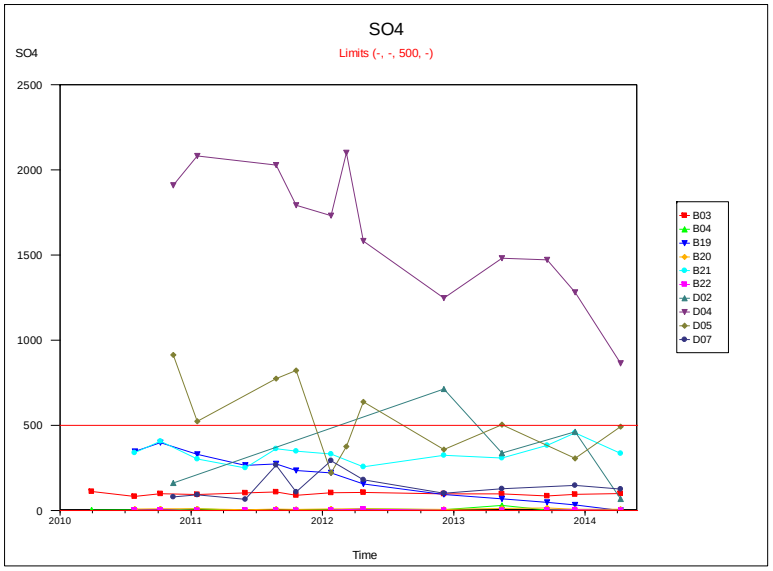
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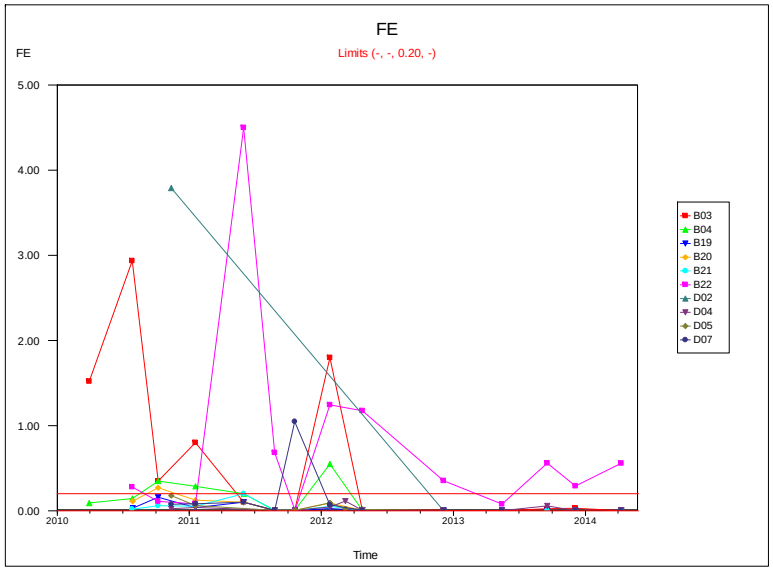


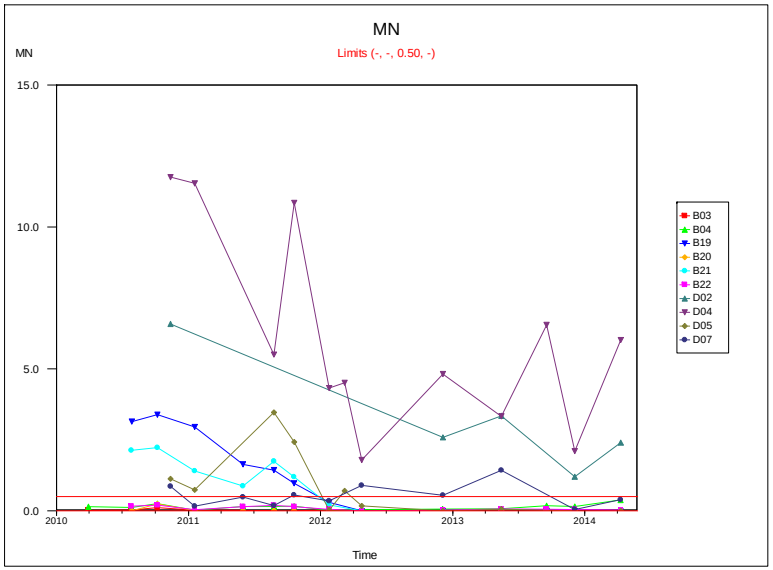


Figure 4. *Time graphs of the electrical conductivity, sulphate, chloride, calcium, iron and manganese concentrations at groundwater sampling sites in the Witpunt Spruit Northern Tributary Drainage System.*

3.3.2 Effected Sub Drainage System 2 – Witpunt Spruit Central Tributary

Table 21. *Current water quality classification table for surface water chemical results for the Witpunt Spruit Central Tributary Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
*C08	7.52	29.00		29.70	8.050	12.30	2.3100	7.64	73.50	0.235		2.660		0.003	0.001	0.135	0.003							36.900	2.69	2.74	0.960
*C09	7.63	96.50		96.90	30.500	69.80	5.3900	33.10	429.00	0.366		0.931		0.003	0.001	0.328	0.003							45.300	10.86	10.52	-1.590

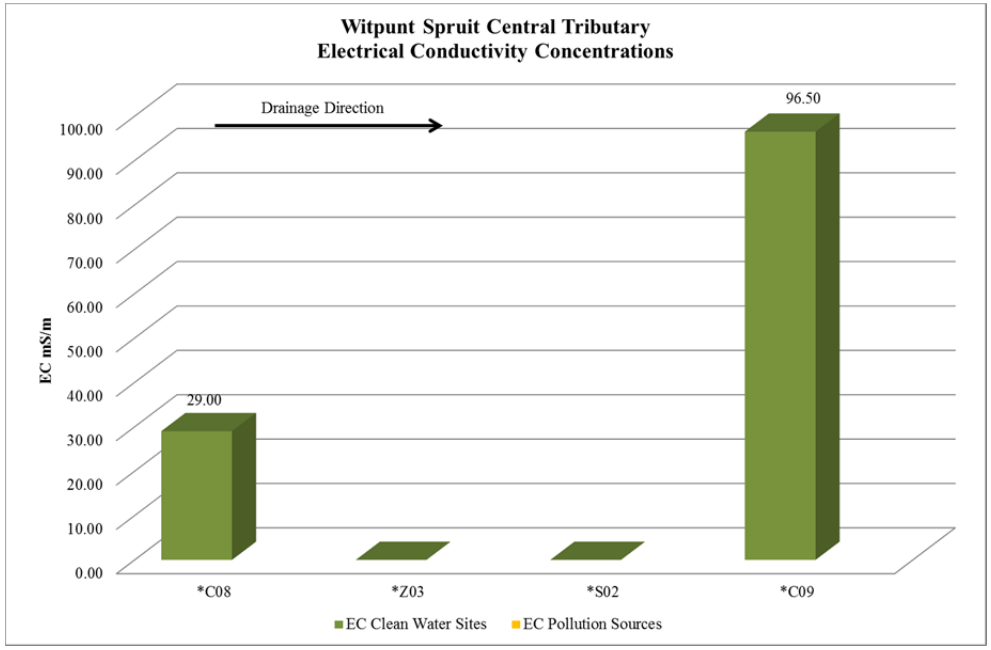
* Surface water sites supposed to contain clean water.

Table 22. *Current pollution index table for surface water chemical results for the Witpunt Spruit Southern Tributary Drainage System.*

Background Site	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*R01	2014/04/10	52.90	38.600	25.300	18.000	5.790	15.70	241.00	0.308

Site No.	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*C08	2014/04/10	0.5	0.8	0.3	0.7	0.4	0.5	0.3	0.8
*C09	2014/04/10	1.8	2.5	1.2	3.9	0.9	2.1	1.8	1.2

* Surface water sites supposed to contain clean water



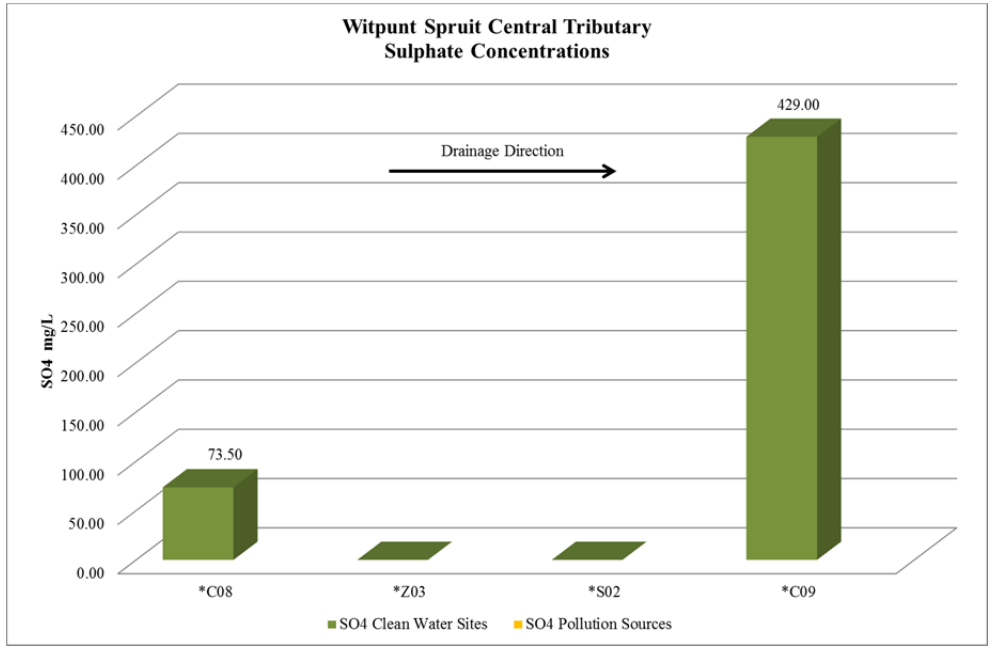


Figure 5. Bar charts of the sulphate and electrical conductivity concentrations at sampling sites along the Witpunt Spruit Central Tributary Drainage System.

Table 23. *Current water quality classification table for groundwater chemical results for the Witpunt Spruit Central Tributary Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
SHALLOW PURGED AQUIFER																											
B05	7.88	32.10		22.00	11.700	29.50	3.550	7.36	6.66	0.153		0.312		0.003	0.001	0.007	0.003							168.000	3.74	3.43	-4.220

Table 24. *Current pollution index table for groundwater chemical results for the Witpunt Spruit Central Tributary Drainage System.*

Site No	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
SHALLOW PURGED AQUIFER									
B05	2014/04/10	0.3	0.6	-0.7	4.6	-2.0	-1.3	-0.5	1.1

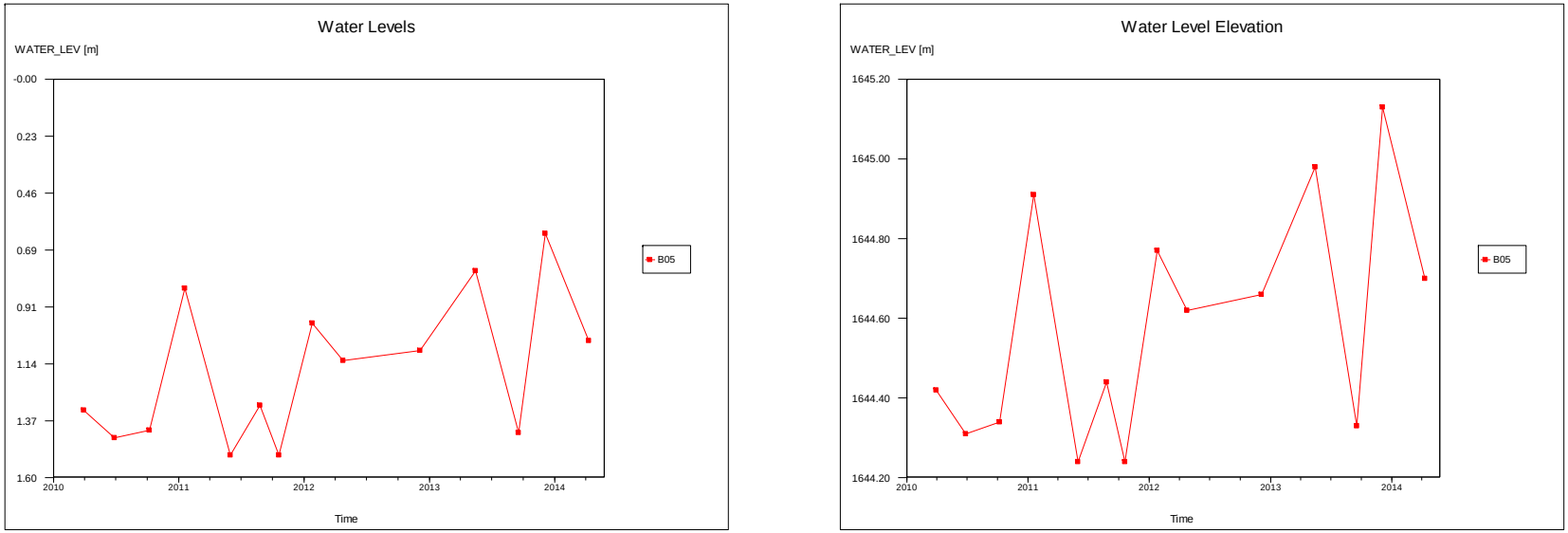
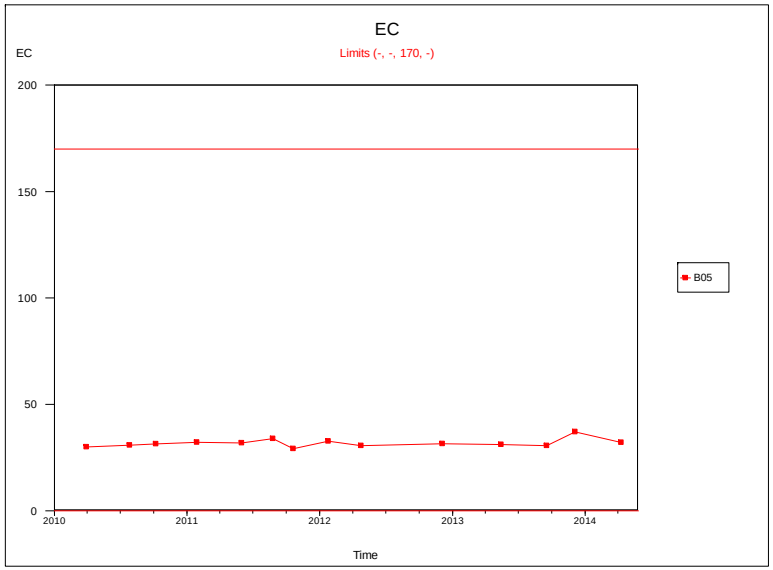


Figure 6. Groundwater depths in mbgl and groundwater elevations in mamsl observed Witpunt Spruit Central Tributary Drainage System.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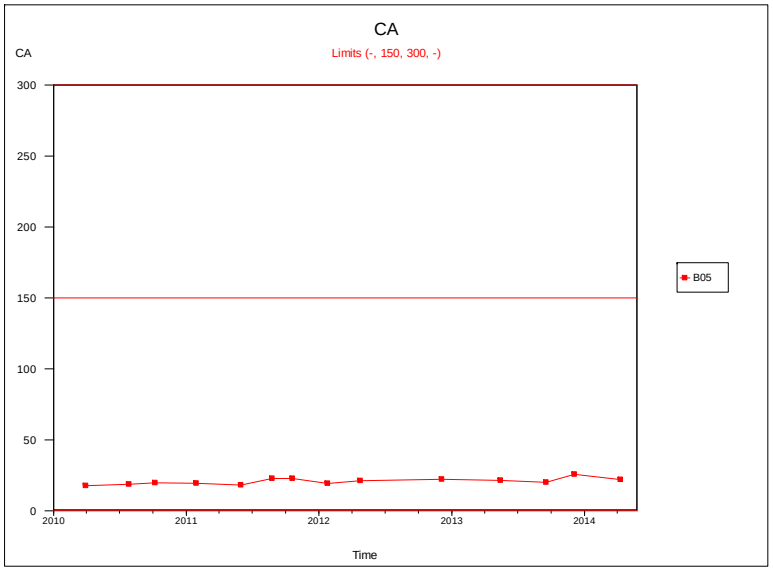
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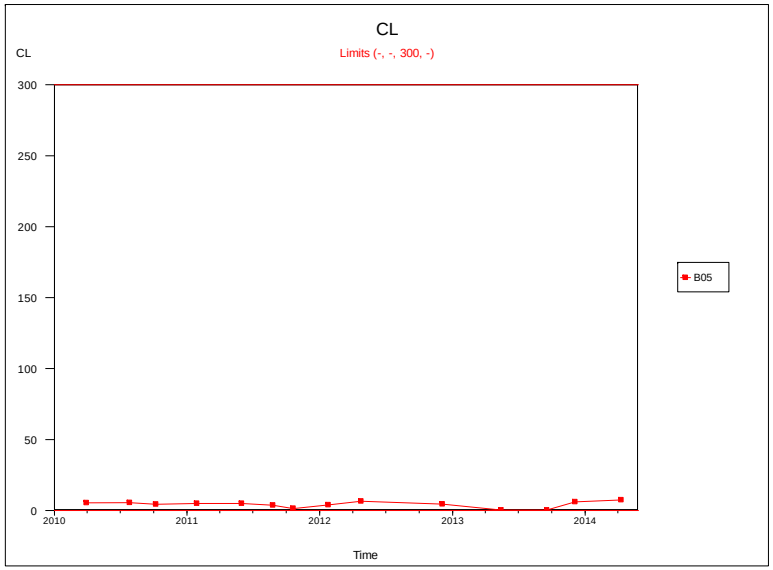
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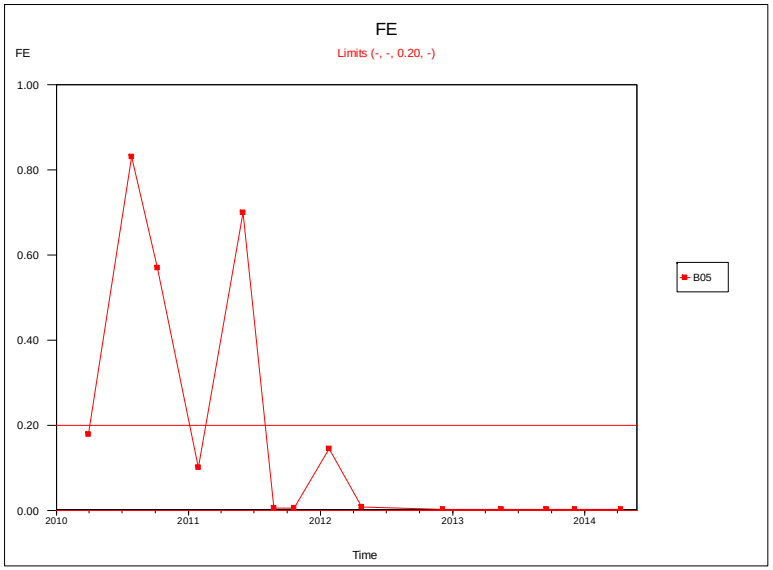
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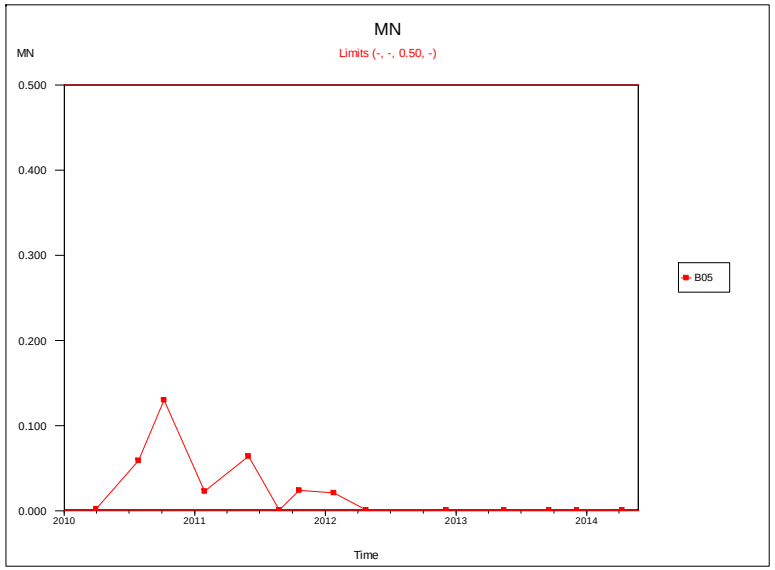


Figure 7. Time graphs of the electrical conductivity, sulphate, chloride, calcium, iron and manganese concentrations at groundwater sampling sites in the Witpunt Spruit Central Tributary Drainage System.

3.3.3 Effected Sub Drainage System 3 – Witpunt Spruit Southern Tributary

Table 25. *Current water quality classification table for surface water chemical results for the Witpunt Spruit Southern Tributary Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
*C10	7.90	37.30		32.90	20.700	13.90	1.740	8.85	71.10	0.137		0.345		0.003	0.001	0.080	0.003							120.000	4.16	3.99	-2.060
*C24	7.30	48.10	304	41.00	21.900	25.00	5.170	13.30	105.00	0.426		0.378		0.018	0.001	0.058	0.003	0.001	0.002	0.001	0.001			114.000	4.89	5.07	1.770
*C20	8.14	99.00		109.00	57.300	37.00	4.190	13.50	453.00	0.129	0.062	0.307	0.043	0.003	0.001	0.117	0.003					0.010	25.200	159.000	13.02	11.87	-4.630
K01	3.60	57.30		30.50	9.700	29.50	9.180	59.80	52.00	0.204	0.060	22.300	4.790	0.003	0.135	0.058	0.003					2.460	11.100	2.480	4.42	3.84	-7.040
P08	7.37	78.70		58.30	19.500	56.60	13.600	44.50	180.00	0.465	1.530	13.500	5.250	0.003	0.126	0.214	0.003	0.001	0.002	0.001	0.001	1.160	498.000	84.700	7.69	7.33	-2.400
*C16	7.56	118.00		109.00	35.200	88.40	23.000	64.40	494.00	0.910		3.980		0.003	0.001	0.503	0.003						141.000	79.300	14.02	12.77	-4.670
*C26	6.65	48.50		34.20	8.720	25.80	8.790	33.10	116.00	0.291		0.317		0.915	0.908	0.043	0.003							28.100	3.95	3.80	-1.870
*C21	7.84	98.60		107.00	55.000	37.00	4.080	13.40	416.00	0.133		0.332		0.003	0.001	0.115	0.003							157.000	12.21	11.58	-2.660
*C12	7.27	41.30		30.80	17.200	20.30	4.400	16.20	105.00	0.102		0.462		0.003	0.001	0.063	0.003							46.600	3.61	3.95	4.420
*R05	7.55	90.60	648	81.40	27.700	63.60	16.000	47.60	346.00	0.636		2.050		0.003	0.001	0.360	0.003	0.001	0.002	0.001	0.001			67.500	10.08	9.52	-2.860

* Surface water sites supposed to contain clean water.

Table 26. *Current pollution index table for surface water chemical results for the Witpunt Spruit Southern Tributary Drainage System.*

Background Site	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*R01	2014/04/10	52.90	38.600	25.300	18.000	5.790	15.70	241.00	0.308

Site No.	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*C10	2014/04/10	0.7	0.9	0.8	0.8	0.3	0.6	0.3	0.4
*C24	2014/04/10	0.9	1.1	0.9	1.4	0.9	0.8	0.4	1.4
*C20	2014/04/10	1.9	2.8	2.3	2.1	0.7	0.9	1.9	0.4
K01	2014/04/10	1.1	0.8	0.4	1.6	1.6	3.8	0.2	0.7
P08	2014/04/10	1.5	1.5	0.8	3.1	2.3	2.8	0.7	1.5
*C16	2014/04/10	2.2	2.8	1.4	4.9	4.0	4.1	2.0	3.0
*C26	2014/04/10	0.9	0.9	0.3	1.4	1.5	2.1	0.5	0.9
*C21	2014/04/10	1.9	2.8	2.2	2.1	0.7	0.9	1.7	0.4
*C12	2014/04/10	0.8	0.8	0.7	1.1	0.8	1.0	0.4	0.3
*R05	2014/04/10	1.7	2.1	1.1	3.5	2.8	3.0	1.4	2.1

* Surface water sites supposed to contain clean water

Table 27. *Current petroleum hydrocarbon analyses results Witpunt Spruit Southern Tributary Drainage System.*

Site	Total Hydrocarbons mg/L	Ethanol mg/L	Benzene mg/L	TAME mg/L	Toluene mg/L	Ethylbenzene mg/L	o-Xylene mg/L	m+p-Xylene mg/L	Naphtalene mg/L
B06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 28. *Current oil and grease analyses results Witpunt Spruit Southern Tributary Drainage System.*

Site	P08 mg/L	B06 mg/L	C16 mg/L	B08 mg/L
Soap Oil & Grease	31.30	5.0	0.2	0.5

Table 29. *Current water quality classification table for bacteriological analyses results Witpunt Spruit Southern Tributary Drainage System.*

No.	Quality Class	E. Coli count/100ml	Heterotrophic plate count count/ml	Total Coliforms count/100ml
P08	Class 4	2	~	3
*C20	Class 4	74	~	76
K01	Class 4	0.0	~	0.0

* Surface water sites supposed to contain clean water.

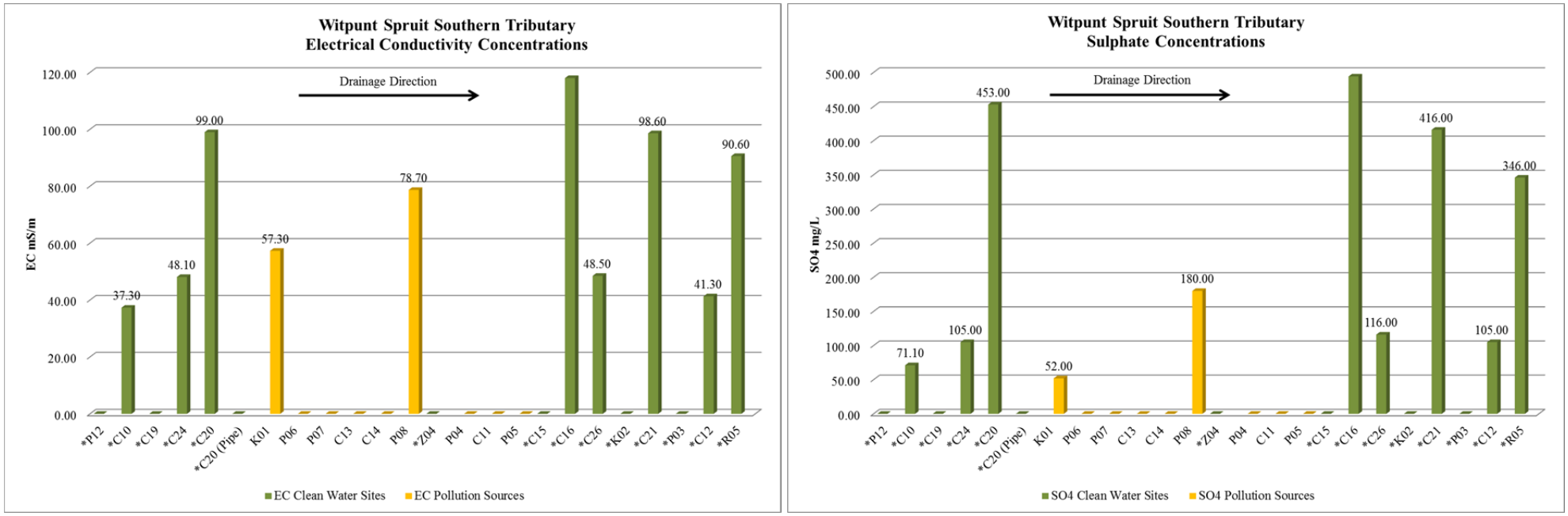


Figure 8. Bar charts of the sulphate and electrical conductivity concentrations at sampling sites along the Witpunt Spruit Southern Tributary Drainage System.

Table 30. *Current water quality classification table for groundwater chemical results for the Witpunt Spruit Southern Tributary Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO2-N mg/L	NO3-N mg/L	NH4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
SHALLOW PURGED AQUIFER																											
B01	7.43	113.00		108.00	74.700	54.50	1.220	24.90	280.00	0.189		0.325		0.003	0.200	0.023	0.003							339.000	13.35	13.94	2.180
B08S	7.91	95.00		62.10	62.400	58.10	5.890	23.60	394.00	0.080		0.314		0.003	0.232	0.196	0.003						0.080	154.000	11.98	10.91	-4.640
B06	7.30	110.00		93.80	40.900	87.30	14.000	63.90	442.00	0.393		0.315		0.003	0.315	0.319	0.003						69.700	96.000	12.97	12.21	-3.030
B07	6.85	27.00		9.76	7.150	25.10	3.580	11.00	75.60	0.063		0.350		0.003	0.180	0.029	0.003							26.300	2.44	2.26	-3.760
DEEP UTILIZABLE AQUIFER																											
B08D	7.95	92.20		52.70	61.400	57.800	5.460	23.30	377.00	0.055		0.318		0.003	0.233	0.191	0.003							140.000	11.33	10.34	-4.580

Table 31. *Current pollution index table for groundwater chemical results for the Witpunt Spruit Southern Tributary Drainage System.*

Site No	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
SHALLOW PURGED AQUIFER									
B01	2014/04/10	7.0	9.6	5.1	10.1	-2.5	2.3	5.2	1.6
B08S	2014/04/10	5.5	4.8	4.0	10.9	-1.6	2.1	7.6	0.0
B06	2014/04/10	6.7	8.1	2.0	17.3	0.1	10.3	8.6	4.7
B07	2014/04/10	-0.1	-0.6	-1.1	3.6	-2.0	-0.5	1.0	-0.3
DEEP UTILIZABLE AQUIFER									
B08D	2014/04/10	5.3	3.8	3.9	10.8	-1.6	2.0	7.2	-0.4

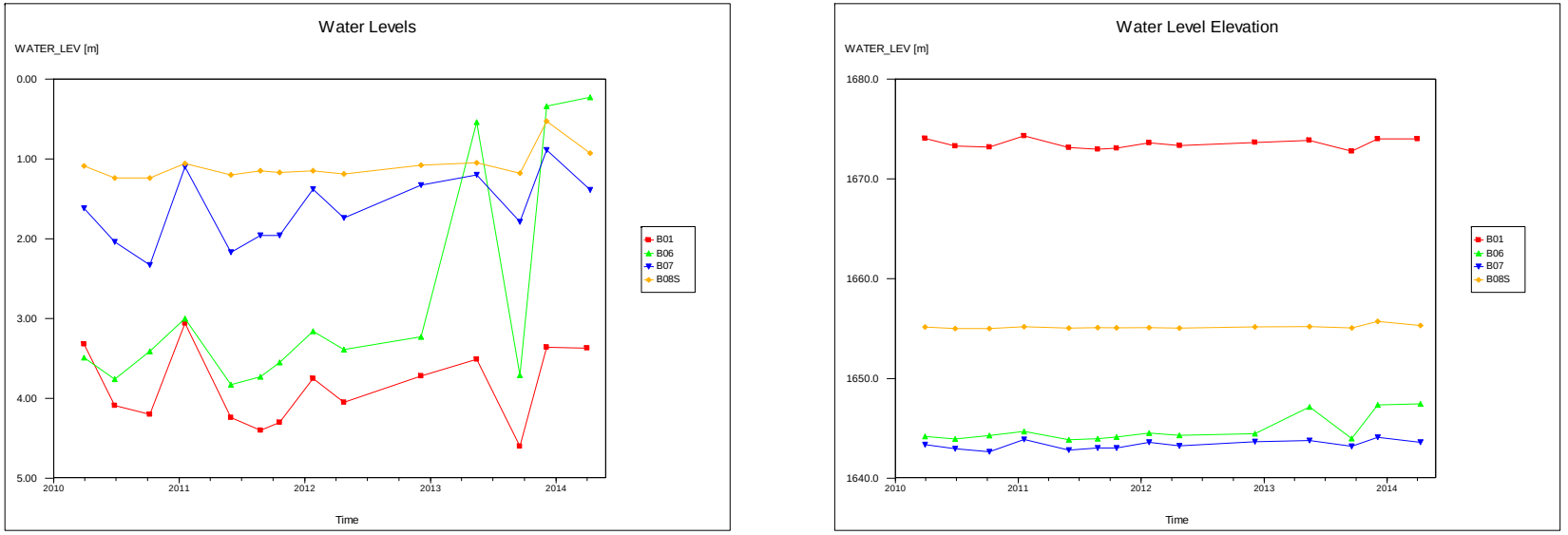
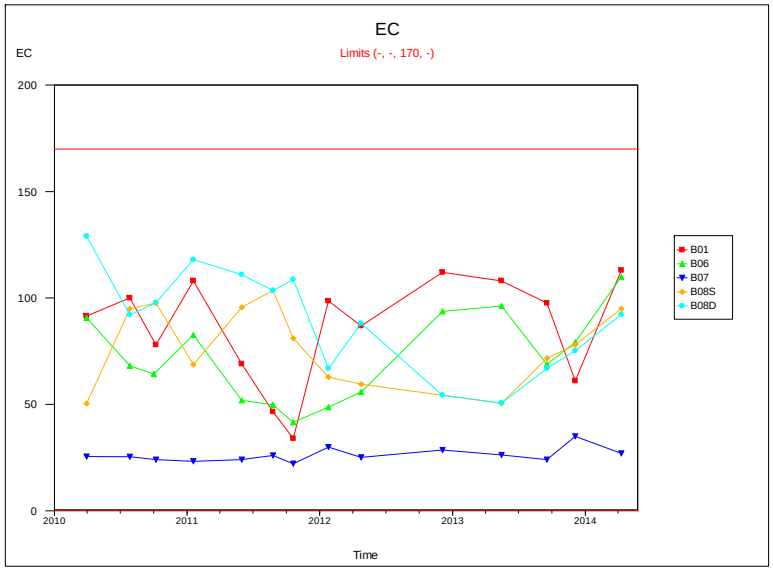


Figure 9. Groundwater depths in mbgl and groundwater elevations in mamsl observed Witpunt Spruit Southern Tributary Drainage System.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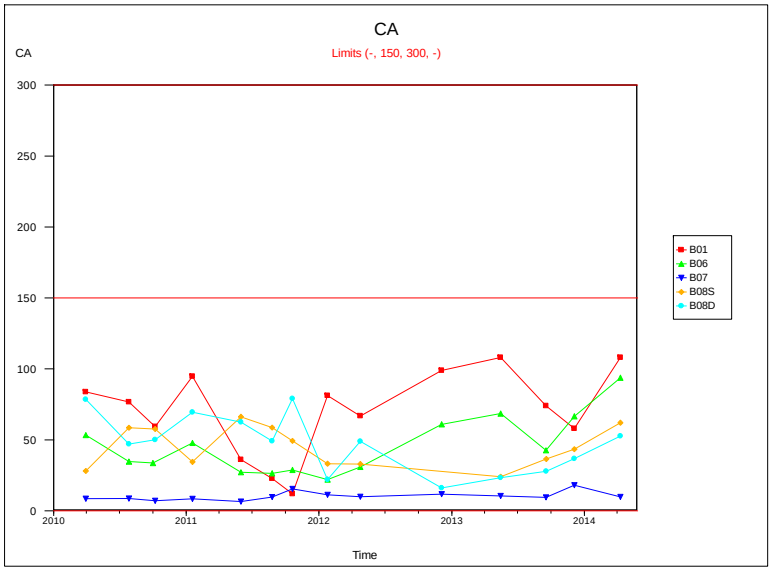
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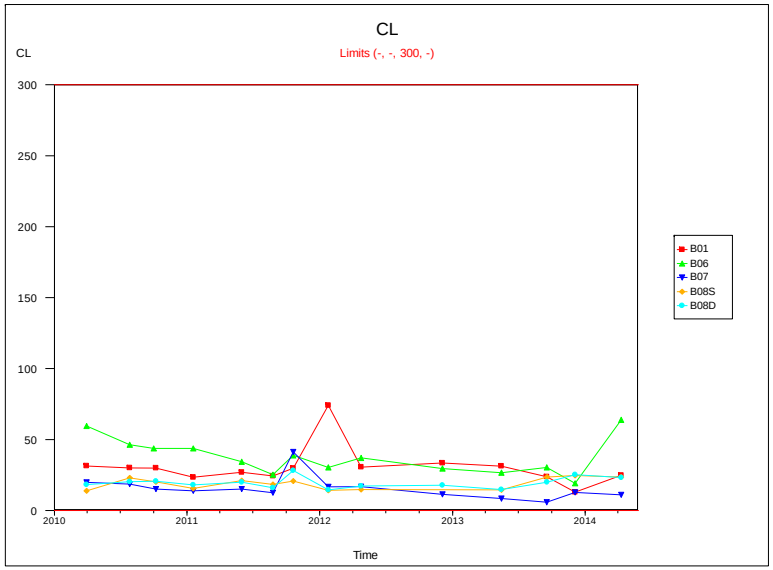
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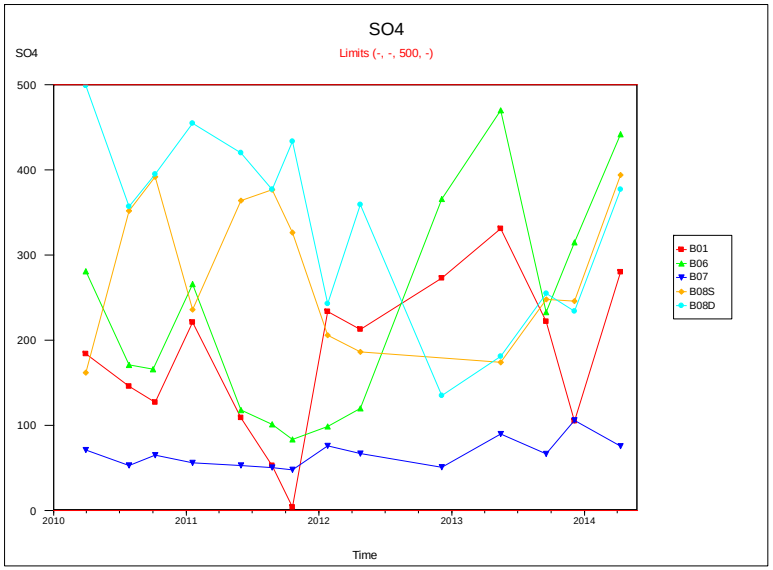
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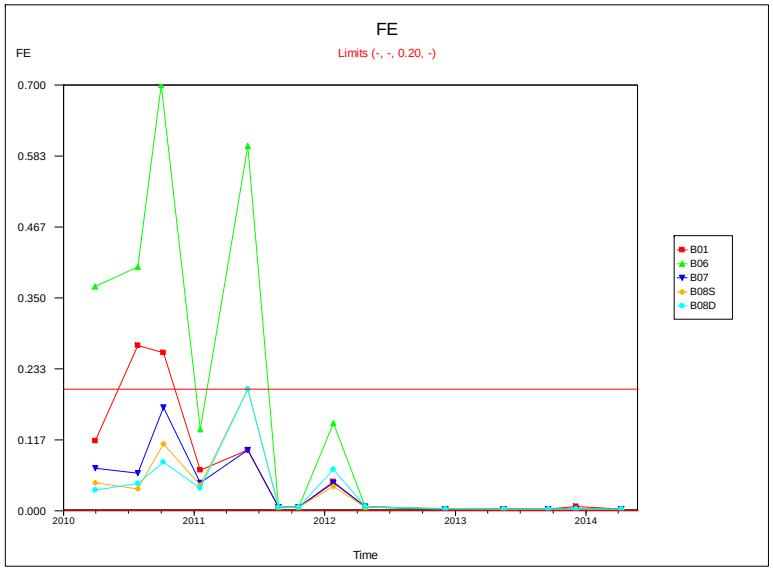


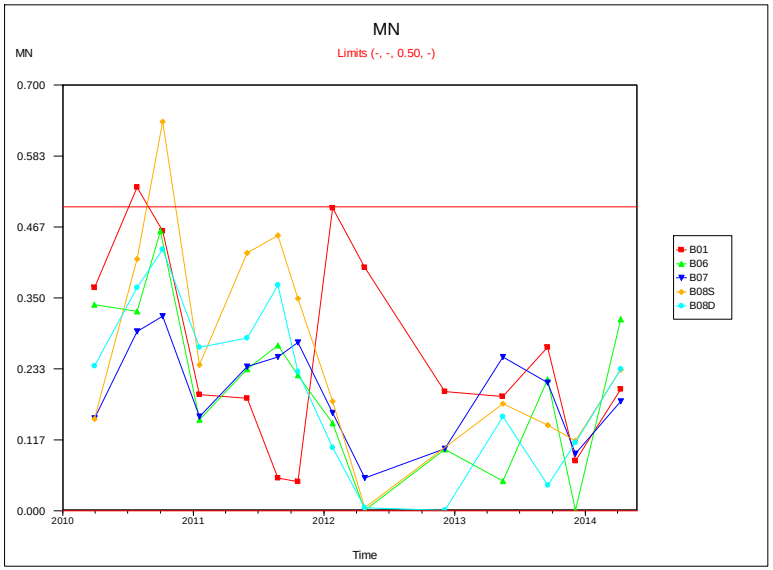


Figure 10. Time graphs of the electrical conductivity, sulphate, chloride, calcium, iron and manganese concentrations at groundwater sampling sites in the Witpunt Spruit Southern Tributary Drainage System.

3.3.4 Effected Major Drainage System 1 – Witpunt Spruit Drainage System

Table 32. *Current water quality classification table for surface water chemical results for the Witpunt Spruit Drainage System.*

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
*R01	4.86	52.90	362	38.60	25.300	18.00	5.790	15.70	241.00	0.308		0.458		0.003	0.878	0.400	0.699	0.001	0.006	0.001	0.001			2.480	5.56	4.95	-5.750
*P01	7.38	81.40		60.40	33.200	56.60	11.600	38.80	316.00	0.263		0.334		0.003	0.001	0.368	0.003							43.600	8.58	11.17	-0.470
*P02	6.36	52.40		41.10	23.900	19.50	6.920	16.80	199.00	0.275		0.329		0.003	0.114	0.063	0.003							8.580	4.83	5.04	2.200
*R02	5.51	50.90	343	39.90	23.200	17.20	6.210	13.60	228.00	0.225		0.364		0.003	0.379	0.046	0.255	0.001	0.002	0.001	0.001			2.480	5.22	4.81	-4.030
*R03	6.89	13.20	70	6.58	4.220	6.06	3.970	10.70	22.60	0.115		0.236		0.094	0.001	0.018	0.035	0.001	0.002	0.001	0.001			7.950	0.95	1.04	4.330
*R04	6.70	16.00	94	9.12	5.680	6.77	4.080	10.60	44.10	0.117		0.354		0.014	0.001	0.020	0.003	0.001	0.002	0.001	0.001			4.460	1.34	1.32	-0.630

* Surface water sites supposed to contain clean water.

Table 33. *Current pollution index table for surface water chemical results for the Witpunt Spruit Drainage System.*

Background Site	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*R01	2014/04/10	52.90	38.600	25.300	18.000	5.790	15.70	241.00	0.308

Site No.	Date	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L
*P01	2014/04/10	1.5	1.6	1.3	3.1	2.0	2.5	1.3	0.9
*P02	2014/04/10	1.0	1.1	0.9	1.1	1.2	1.1	0.8	0.9
*R02	2014/04/10	1.0	1.0	0.9	1.0	1.1	0.9	0.9	0.7
*R03	2014/04/10	0.2	0.2	0.2	0.3	0.7	0.7	0.1	0.4
*R04	2014/04/10	0.3	0.2	0.2	0.4	0.7	0.7	0.2	0.4

* Surface water sites supposed to contain clean water

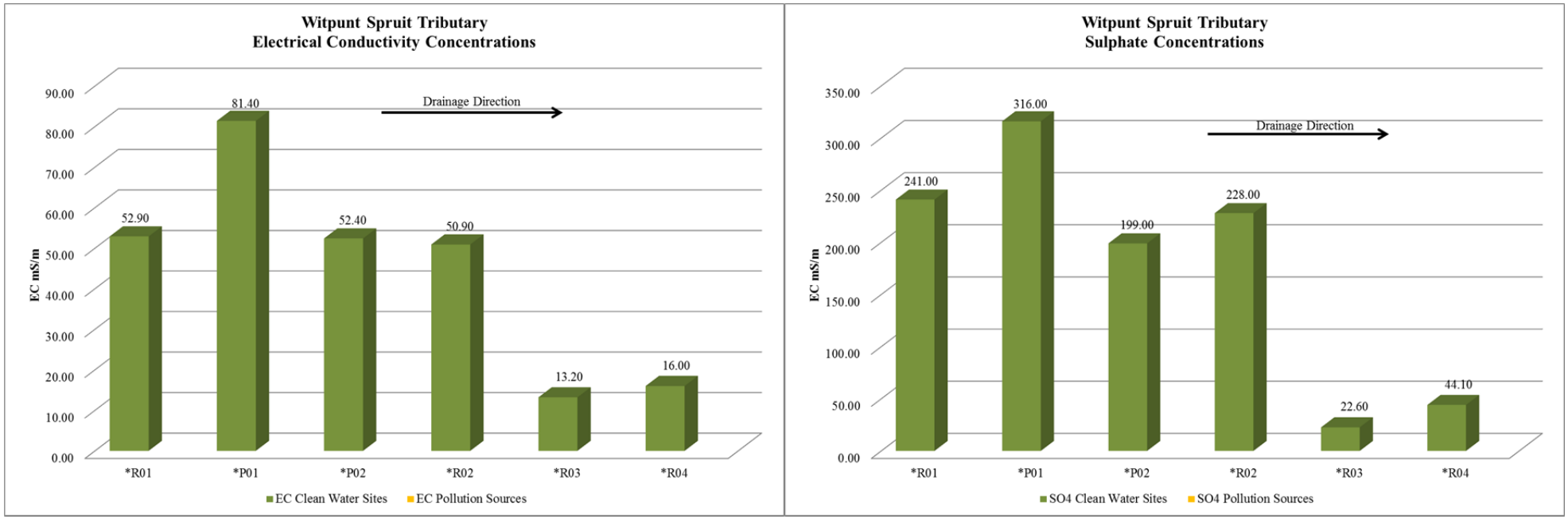


Figure 11. Bar charts of the sulphate and electrical conductivity concentrations at sampling sites along the Witpunt Spruit Drainage System.

4 CONCLUSIONS AND RECOMMENDATIONS

This report discusses findings made during routine water quality monitoring Phase 57 undertaken at Eskom Camden Power Station by GHT Consulting Scientists in April 2014.

Response tables attached in **Appendix B** must be completed by the relevant personnel of Camden Power Station and send to GHT Consulting before the next Site Assessment and Audit that will take place in June 2014. These tables serve as a control to evaluate the actions taken in addressing the identified problems and upon completion included in future monitoring reports.

The following conclusions and recommendations have been made on the basis of site observations, monitoring measurements, and analyses of laboratory test results:

4.1 Problems identified at Effected Sub Drainage Area 1 - Witpunt Spruit Northern Tributary

4.1.1 Current state of the pollution sources and their associated water monitoring systems

- Although the water in the Ash Dam Complex is being managed the water levels at some of the ground- and surface sites have increased due to recent rains that occurred at Camden Power Station.

- A major concern is the dangerously high water level of the De Jager Pan (P09). The high water level has a serious negative impact on the whole of the ash dam complex.

- The pump system installed in the Ash Water Return canals seemed to have the desired effect on the canals. The water levels of the ash water return canals (C17 and C18) have been reduced significantly by the temporary pumps installed on the northern and southern corners of the Ash Dam Complex. The reduction of the water levels also has a positive impact on the seepage in the areas adjacent to the Ash Dam Complex. The slope of the canals is however still inadequate and the some seepage will occur.

- Even though the water levels and the flow in the Ash Water Return canals have improved, evidence of the seepage that occurred can still be seen in the chemical analysis of Canals C01, C03 and auger holes D02, D04 and D05. All the water must be channelled into De Jager Pan P09.

- The areas at the temporary pumps at ash water return canals (C17 and C18) must be inspected regularly and any oil and diesel spills must be cleaned-up. Operations of the pumps must be according to regulation and the oil spills must be cleaned and oil drums stored according to regulation. All leaks must be fixed and the ash water must be prevented from flowing into the surrounding area.

- Borehole B02 will be plugged and replaced, according to DWAF standards, June 2014 as part of the new contract. The waste site area must be filled up to prevent damming of water in the area.

- The seepage with precipitated salts from canal C17 was detected at the northern side of the ash dam at C01 and needs to be monitored investigated and intercepted.

- The auger D03 drilled for the seepage investigation was damaged and will be replaced in the in 2014 as part of the new contract.

- A seepage investigation will be done, in 2014 as part of the new contract, to determine the artesian nature of borehole B20 and the impact and extend of the seepage.

- A seepage investigation will be done, in 2014 as part of the new contract, to seepage at S01 and S04 west of the western cooling towers to determine the impact and extend of the seepage.

- Ash spills in the Sub Drainage Area 1 must be monitored regularly, the area cleaned and ash moved to the appropriate area when necessary.

- Excavation work around borehole B21 are currently in progress. Care must be taken not to compromise the integrity of the borehole.

- The following sites are numbered incorrectly. Auger hole D06 is marked B22, Auger hole D07 is marked B09 and borehole B22 is marked B10.

4.1.2 Groundwater levels

- Although the water in the Ash Dam Complex is being managed the water levels at all groundwater sites has increased due to recent rains that occurred at Camden Power Station. Although the seepage from the Ash Dam Complex has been reduced more work still has to be done when studying the chemical analysis.

4.1.3 Chemical analyses results

- From the tables and charts in **Paragraph 1.1.1** of this document it can be concluded that the Power Station activities have a definite impact on the surface water qualities of the Witpunt Spruit Northern Tributary. Several of the chemical elements concentrations measured at some of the sites are above the South Africa National Standard: Drinking Water.
  - A matter of concern is that 90% of the clean water surface sites has an above recommended standard water quality. Only one of the 10 clean water sites sampled is not within the recommended standard (Sites S04).
  - Another indication of the extent of the seepage from the ash dam complex is the presence of the indicator element SO_4 at nearly all the clean water sites.
  - The above recommended standards of canals C03, C04, C06 and C07 is most likely due historical contaminant build-up over time and these contaminants was released due the recent heavy rains.
  - The seepage at S03, C25 and the dug pit at D24 in the north western corner of the power station area is the most severe contaminated surface sites at Camden Power Station. A seepage investigation will be done in 2014 to determine the impact and extent of the seepage. It is imperative that no water from canal C25 flows into the environment. The culvert must be sealed to prevent polluted water from flowing into the environment.
  - The water from canal C01 must be intercepted as it has a water quality above the recommended standard.

- From the tables and charts in **Paragraph 1.1.1** of this document it can be concluded that the Power Station activities have a definite impact on the groundwater qualities of the Witpunt Spruit Northern Tributary
  - Borehole B02 is historically the most severely contaminated monitoring site on the Power Station with a low pH and very high Sulphate, Iron, Aluminium and Manganese

concentrations classifying water from this site as dangerous. Due to the fact that the borehole is blocked at 4.5m the remaining part of the borehole will be plugged and replaced, according to DWAF standards, in June 2014 as part of the new contract.

- Auger holes D02, D04 and D05 has a water quality above the recommended standard limit. This indicates that the movement of the pollution is in the shallow aquifer. Upgrading of the ash water return canals is essential to prevent future contamination.
- Borehole B20 has an elevated pH. This must be monitored closely.
- Borehole B22 has a slightly elevated Fe. This must be monitored closely.
- All other boreholes are in a satisfactory condition with water qualities below the recommended standard.

4.2 Problems identified at Effected Sub Drainage Area 2 - Witpunt Spruit Central Tributary

4.2.1 Current state of the pollution sources and their associated water monitoring systems

- All surface sites were satisfactory during the monitoring phase.

4.2.2 Groundwater levels

- The groundwater levels, measured from surface of the boreholes have decreased since the previous monitoring phase even though the sampling phase took at the end of the wet season.

4.2.3 Chemical analyses results

- From the tables and charts in **Paragraph 3.3.2** of this document it can be concluded that the Power Station activities have a no impact on the groundwater qualities of the Witpunt Spruit Central Tributary.
  - The water quality of borehole B05 is below the recommended standard and in a satisfactory condition.

4.3 Problems identified at Effected Sub Drainage Area 3 - Witpunt Spruit Southern Tributary

4.3.1 Current state of the pollution sources and their associated water monitoring systems

- Water is flowing into canal C20 through an emergency overflow pipe from the raw water system. The outflow of this overflow pipe is located close to the old power box. Water from the pipe has an elevated bacteriological count. The source of high bacteriological count must be determined or the pipe removed from the canal.

- The cement canals intercepting runoff and sludge from the Coal Stockpile has a low water level. Some coal and silt visible in canal yet it is still in a satisfactory condition. These canals must be inspected and maintained regularly.

- The coal settling pond P04 has some debris build-up, this must be removed and the area inspected regularly

- The area at canal C11 is being cleaned regularly but however the areas between the security fences are still blocked with silt and debris. Oil was also visible in the canal. This area must be cleaned.

- The Coal Stock Yard Dam is in the process of being relined and is in a satisfactory condition.

- The northern oil skimmer (P07) is in a satisfactory condition. Large spillages of contaminated water occur from time to time at the station drains collection sump (P11). This water also contains oily substances and is a huge threat to the environment. It is recommended that the area at the collection sump must be redesign and upgraded according to industry standards. The collection bay at the northern oil skimmer is in a satisfactory condition. These areas must be visited and inspected regularly to monitor the operations and water levels in these dams and sumps.

- Although the water from canals C13 and C14 flows into the Reclamation dam P08, the ash must be removed from the canals.

- The Reclamation Dam P08 contains large quantities of oil in the water as well as on the dam walls. Operations at the oil skimmers must be improved to prevent oil spills into the environment.

- The coal in canal C16 must be cleaned and moved to the appropriate area.

- All the dirty water canals in this area must be inspected regularly and maintenance done as required preventing spillages of contaminant material into the natural environment.

4.3.2 Groundwater levels

- The groundwater levels at most of the groundwater sites have decreased since the previous monitoring phase even though the sampling phase took at the end of the wet season.

- Borehole B06 had a slight increase.

4.3.3 Chemical analyses results

- From the tables and charts in **Paragraph 3.3.3** of this document it can be concluded that the activities at the Power Station have some impact on the surface water qualities of the Witpunt Spruit Central Tributary. Several of the bacteriological concentrations measured at some of the sites are above the South Africa National Standard: Drinking Water.
  - A matter of concern is that 88% of the clean water surface sites has an above recommended standard water quality. Only one of the 8 clean water sites sampled is not within the recommended standard (Sites C26).
  - Canal C26 has an above recommended standard due to elevated Fe and Mn. This water seep from the SANDF property and must be brought under their attention. Keep monitoring this area.
  - Sewage effluent K01 (standard of operations of sewage plant and quality of water released into the reclamation dam) can be classified as above recommended standard due to an elevated NO_3-N and NH_4- N count. Operations at the sewage plant must be inspected regularly and kept up to the standard as set by the water use licence.
  - The very high bacteriological count of canal C20 stems from the concrete pipe that flows into the canal. The water from the pipe was analysed and has and extremely high

bacteriological count. The source of the pollution must be found and the pipe sealed off.

– No Hydro Carbons were detected in the Reclamation Dam P08 but some oil and grease was. Although the water from the Reclamation Dam P08 is contained within the dirty water dam and it holds little or no risk to the environment the operations at the oil skimmers must be still be monitored closely.

– Low quantities of Oil and grease were also detected at the following sites C16 and B08. The oil and grease detected in Borehole B06 must be monitored closely.

- From the tables and charts in **Paragraph 3.3.3** of this document it can be concluded that the Power Station activities have a very limited impact on the groundwater qualities of the Witpunt Spruit Central Tributary.

  – Although all of the groundwater sites sampled in the sub-catchment are within the recommended standard the pollution index shows that the Power Station probability could have an impact on the groundwater.

4.4 Problems identified at Effected Major Drainage Area 1 - Witpunt Spruit

4.4.1 Current state of the pollution sources and their associated water monitoring systems

- The runoff from this area seems to be limited and free from garbage or rubble and is in a satisfactory condition.

4.4.2 Chemical analyses results

- From the tables and charts in **Paragraph 3.3.4** of this document it can be concluded that the Power Station activities have a limited impact on the surface water qualities of the Witpunt Spruit Tributary.

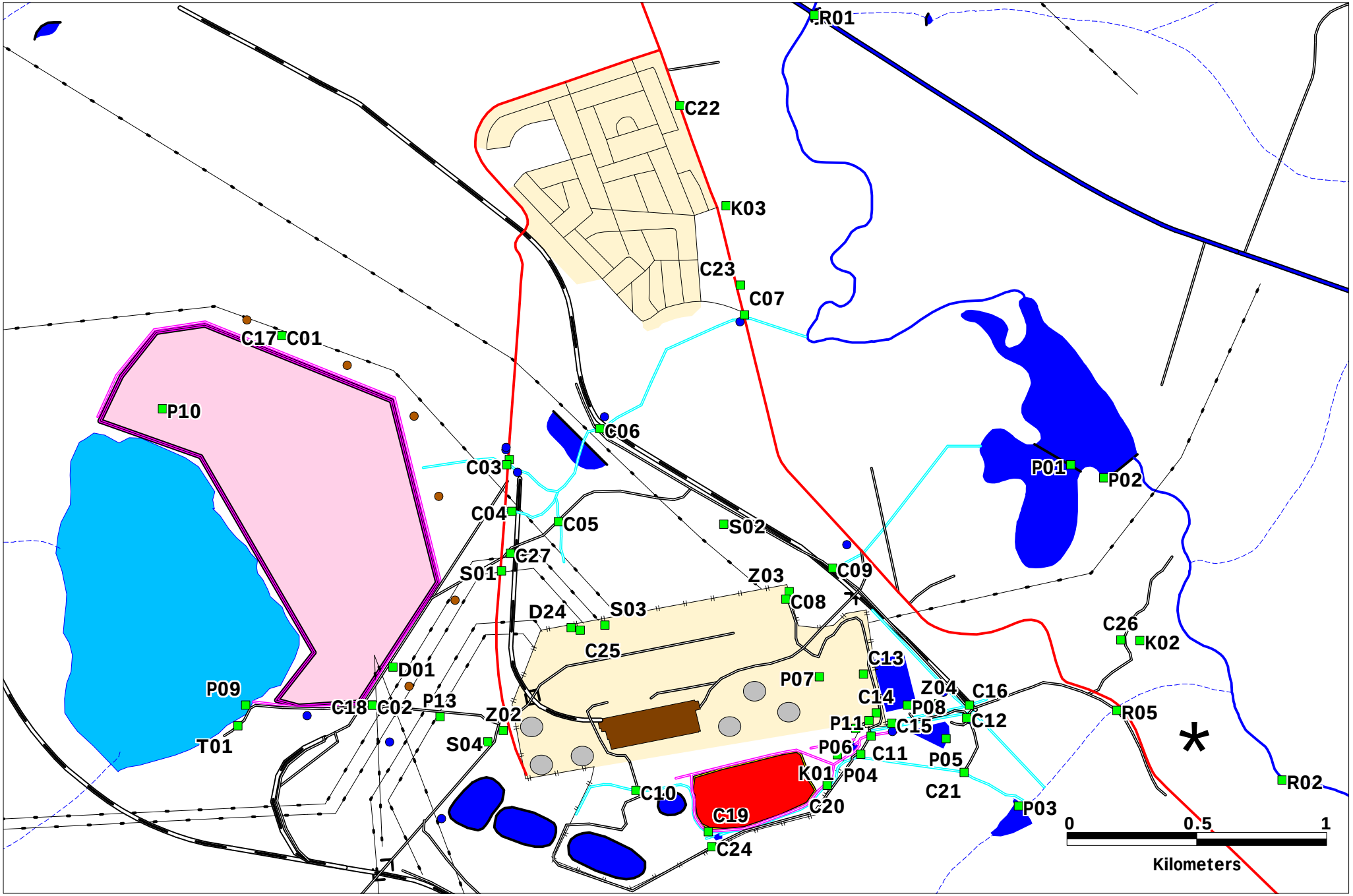
  – All samples taken in the Witpunt Spruit Drainage Area have a water quality which is below the recommended standard.

28 May 2014

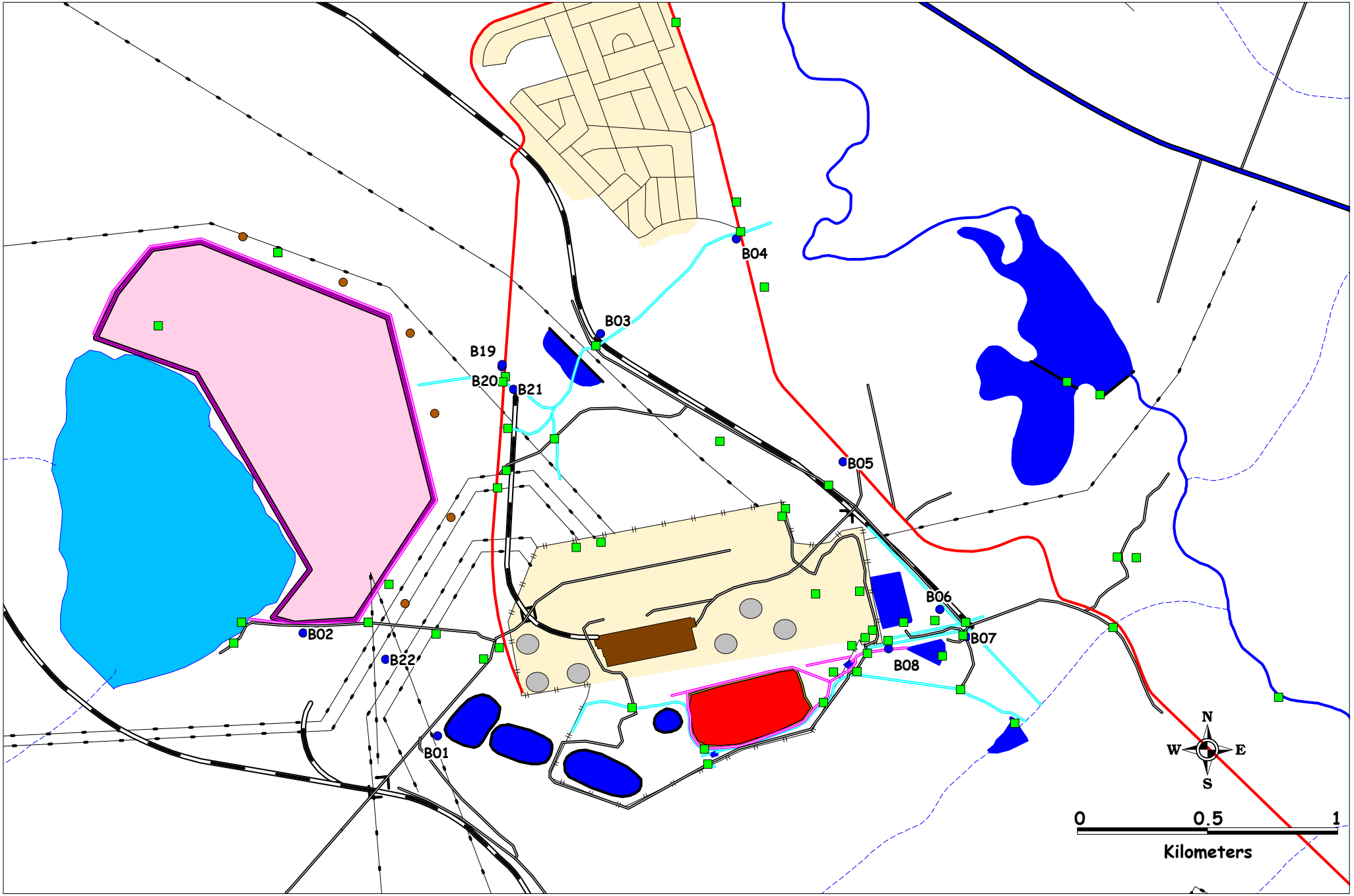
L.J. van Niekerk ***Date***

APPENDIX A
Locality Maps

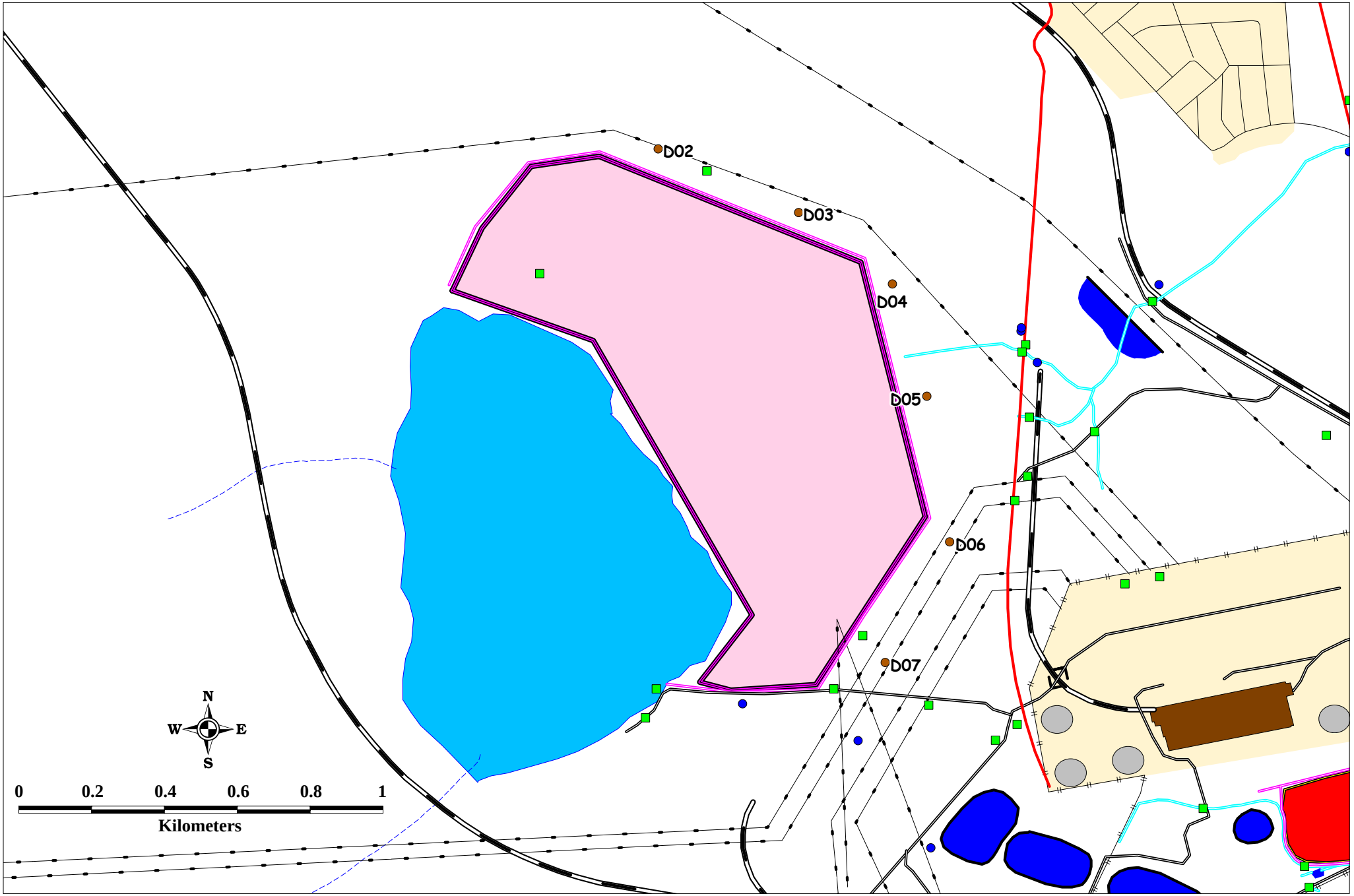
Camden Power Station - Surface Water Sites



Camden Power Station - Groundwater Sites



Camden Power Station - Auger Sites



APPENDIX B
Current State Description and Response Tables

Table 5. Witpunt Spruit Northern Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled	Type Analyses	Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	P09	Large pan west of Ash Dam used as ash water return dam - De Jager Pan.	26.62000	30.07420		2014/04/03	11:13	Danger - ously High	Yes	N,M	1	Water level dangerously high. The integrity of the ash dam may be at risk due to the fact that the high water level in the De Jager Pan is saturating the base of the ash dam. Field ph 10.6	Urgent attention must be given to the dangerously high water level of the De Jager Pan. The Water level must be controlled and monitored regularly.	M. Ueckermann / P Mkhize		
	C17	AWR canal next to ash dam. Inspect and monitoring water quality if required.	26.60570	30.07560		2014/04/03	12:51	Low	No	V	2, 3, 4, 5	The pump system that has been introduced to the canals reduced the water level significantly. A pan containing oil on ground at NW corner of ash dam	Keep monitoring water level. Inspect pumps regularly and clean any spills. Pan with oil must be removed.	S Shabangu/ Roshcon		
	C18		26.62000	30.07910		2014/04/03	11:20	Low	No	V						
	Domestic Waste Site	Historic Waste Site. Inspect and monitoring standing water quality if required.	26.62014	30.07672		2014/04/03	12:10	~	No	~		Lots of standing water.	This area must be levelled and monitored regularly.	T Mpongo		
	*C01	Seepage north of road. Road filling act as clean-dirty water separation. Inspect and monitoring water quality.	26.60570	30.07560		2014/04/03	12:58	Low / Stagnant	Yes	N	6	Water level still extremely high. Water quality is above recommended standard. SO4 -624mg/l, EC - 173mS/m.	Water from C01 must be prevented to dam in the area or flow into the surrounding area. Water levels in the AWR canals must be monitored regularly.	I Hogdskin		
	D02	Monitoring shallow groundwater contamination of ash dam.	-26.60509	30.07425		2014/04/03	12:50	0.76	Yes	N,M		Water quality is above recommended standard. Due to seepage from the ash dam complex. Mn - 2.4mg/l	Monitor regularly.	V Pandaram/ S Shabangu		

Table 5. Continues.

Ash Facility and Associated Drainage Systems.	D04	Monitoring shallow groundwater contamination of ash dam.	-26.60882	30.08072		2014/04/03	12:44	1.24	Yes	N,M		Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 865mg/l, EC - 228mS/m, Na - 214mg/l, Mn - 6.02mg/l	Water levels in the AWR canals must be monitored regularly.	V Pandaram/ S Shabangu		
	D05	Monitoring shallow groundwater contamination of ash dam.	-26.61192	30.08167		2014/04/03	12:28	1.54	Yes	N,M		Water quality is above recommended standard. Due to seepage from the ash dam complex. Na - 222mg/l,	Water levels in the AWR canals must be monitored regularly.	V Pandaram/ S Shabangu		
	B20	Monitoring groundwater contamination east of ash dam and north of power station.	26.61012	30.08427	14	2014/04/03	11:15	Artesian	Yes	N,M	7	Salt precipitation around borehole due to artesian nature of borehole. Water quality is above recommended standard. Seepage investigation in progress. pH - 10.3	Complete seepage investigation.	V Pandaram / T Mpongo		
	B21	Monitoring groundwater contamination east of ash dam and north of power station.	26.61099	30.08472	18	2014/04/03	11:24	4.95	Yes	N,M		Excavation work around borehole in progress.	Care must be taken not to compromise the integrity of the borehole.	T Mpongo / A Simelane		
	*C03	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61070	30.08430		2014/04/03	11:22	Low / Slow	Yes	N	8	The seepage from the AWR canals has reduce significantly. Canals C03 and C06 still has an above recommended water quality. C03: SO4 - 1159mg/l, EC - 302mS/m, Na - 390mg/l, Ca - 314mg/l C06: SO4 - 1058mg/l, EC - 270mS/m, Na - 305mg/l, Ca - 312mg/l C07: SO4 - 960mg/l, EC - 252mS/m, Na - 286mg/l	Water levels in the AWR canals must be monitored regularly.	M Ueckermann / S Shabangu		
	*C06	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.60930	30.08790		2014/04/03	11:06	Low / Mod	Yes	N	9			M Ueckermann / S Shabangu		
	*C07	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.60490	30.09350		2014/04/03	11:19	Low / Mod	Yes	N,M				M Ueckermann / S Shabangu		
	B03	Monitoring groundwater contamination east of ash dam and north of power station.	26.60911	30.08775	6	2014/04/03	11:05	Artesian	Yes	N,M	10	Satisfactory condition. Artesian nature of borehole likely due to recent heavy rains and seepage from the shallow aquifer into the borehole.	Keep monitoring borehole.	V Pandaram		
Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	D07	Monitoring shallow groundwater contamination of ash dam.	-26.61927	30.08052		2014/04/03	12:08	0.95	Yes	N,M		Wrong number on number plate. .	Water levels in the AWR canals must be monitored regularly. Replace number plate.	V Pandaram/ S Shabangu		
	B22	Monitoring groundwater contamination South east from Ash dam and Domestic Waste Site.	26.62143	30.07977	18	2014/04/03	11:51	1.05	Yes	N,M	11	Wrong number on number plate. Water quality is above recommended standard due to elevated Fe. Fe - 0.558mg/l	Rectify number and monitor Fe closely.	T Mpongo		
	*P13	Dugged pit west of PS between PS and DWS. Monitor water quality.	26.62036	30.08171		2014/04/03	11:48	Damp	No	N,M		Satisfactory condition.	~	Maintenance??		
	*S04	Clean water run-off canal next to road passing raw water dams. Monitoring water quality.	26.62059	30.08369		2014/04/03	11:47	High / Stagnant	Yes	N,M		Satisfactory condition. SO4 - 350mg/l	A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	V Pandaram/T Mpongo		
	*Z02	Leaking Pipes. Standing contaminated water spilled in the area. Inspect and monitoring water quality.	26.62098	30.08416		2014/04/03	11:39	Dry	No	V		Satisfactory condition.	~	A.Sebothoma / M Dubazana		
	D06	Monitoring shallow groundwater contamination of ash dam.	-26.61594	30.08230		2014/04/03	12:30	1.52	No	N,M		Wrong number on number plate. Water level to low to sample. Water quality historically above recommended standard due to seepage from the ash dam complex.	Water levels in the AWR canals must be monitored regularly. Replace number plate.	V Pandaram/ S Shabangu		

Table 5. Continues.

Witpunt Spruit Northern Tributary - Ash Facility and Associated Drainage Systems.	*C04	Clean water run-off canal collecting water from ashing area. Monitoring water quality.	26.61250	30.08450		2014/04/03	11:51	Low / Slow	Yes	N	12	Water quality is above recommended standard. Due to seepage from the ash dam complex. SO4 - 907mg/l, EC - 194mS/m	Water levels in the AWR canals must be monitored regularly.	M Ueckermann/ H. Jairaj		
	*S03	Run-off from area north of PS released into natural environment. Monitor water quality.	26.61690	30.08810		2014/04/03	09:14	Mod / Stagnant	Yes	N,M	13	S03 and C25 is historically the most severe contaminated surface site. S03 pH - 3.27 , SO4 -2632 mg/l, EC 346mS/m Ca - 494 mg/l Fe - 59mg/l C25 SO4 - 519 mg/l Fe - 0.389 mg/l Fe - Mn 5.08mg/l	The source of the pollution must be establish and removed. A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.	V Pandaram / T Mpongo		
	*C25	Run-off from area north of PS released into natural environment. Monitor water quality.	26.61710	30.08714		2014/04/03	09:13	Low / Stagnant	Yes	N	14			V Pandaram / T Mpongo		
	D24	Dugged Pit west of clean water canal C25.	26.61704	30.08679		2014/04/03	09:14	Full	Yes	N	15	A pit dugged by Power Station to determine source of seepage and pollution at S03. D24 has an above recommended standard water quality. pH - 3.96, SO4 - 1996mg/l, EC - 254mS/l, Ca - 497mg/l, Mn - 6.86mg/l, Mg - 120mg/l, Al - 26.70	The source of the pollution must be establish and removed. A seepage investigation will be done as part of the new contract to determine the extent and impact of the of seepage.			
	*C05	Clean water run-off canal downstream from C25. Monitoring water quality.	26.61290	30.08630		2014/04/03	13:06	Low	Yes	N		Water quality is above recommended standard. SO4 - 563mg/l	The area must be monitored closely.	V Pandaram / T Mpongo		

* Surface water sites supposed to contain clean water

Table 6. Witpunt Spruit Central Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled		Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Central Tributary - Area East of Power Station.	*C08	Run-off from area north-east of PS released into natural environment. Monitor water quality.	26.61590	30.09510		2014/04/03	09:12	Low / Slow	Yes	N	16	Satisfactory condition. SO4 - 73.5mg/l	~	V Pandaram / T Mpongo		
	*Z03	Leaking Pipes east of C08 at security fence. Inspect and monitoring water quality.	26.61561	30.09520		2014/04/03	13:18	Low / Stagnant	No	V		Standing water visible between the two fences.	The leaking pipe must be fixed.	A Sebothoma		
	*S02	Surface run-off and seepage from PS. Possibly a fountain. Monitor water quality.	26.61300	30.09270		2014/04/03	13:12	Dry	No	N,M		Satisfactory condition.	The area must be monitored regularly.	V Pandaram / T Mpongo		
	*C09	Clean water run-off canal. Monitoring water quality.	26.61470	30.09690		2014/04/03	10:59	Low / Slow	Yes	N		Satisfactory condition. SO4 - 429mg/l	~			
	B05	Monitoring groundwater quality north-east of PS.	26.61372	30.09761	8	2014/04/03	11:15	1.05	Yes	N		Satisfactory condition.	~			

* Surface water sites supposed to contain clean water

Table 7. Witpunt Spruit Southern Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	Sites	Description / Objective	Latitude (°S)	Longitude (°E)	Sample Depth	Date	Time	Water Level / Flow	Sampled		Photo nr.	Current State	Proposed Mitigation	Responsible Person	Completion Date	Remarks
Witpunt Spruit Central Tributary - Clean water bypass system.	*C20	Clean water run-off canal south-east of CSY downstream from C19 released into natural environment. Monitoring water quality.	26.62310	30.09670		2014/04/03	08:38	Low / Slow	Yes	N,B	17	Water flowing into canal from old pipe upstream near old power box. The pipe seem to come from outside the Power Station fence. The water has a dangerous water quality (Class 4) due to high bacteriological count. C20 SO4 - 453mg/l, E.Coli - 74cfu/100ml, Total Coliforms - 76/100ml	Pipe must be removed from canal. Operations at the sewage plant must be improved and no effluent must be discharged into C20.	I Hogdskin		
Witpunt Spruit Central Tributary - Dirty water interception system.	K01	Standard of operations of sewage plant and quality of water released into the reclamation dam.	26.62310	30.09670		2014/04/03	08:45	Low /Slow	Yes	N,B		Water has a dangerous water quality (Class 4) due to high bacteriological count and elevated NO3-N. pH - 3.60 NO3-N - 22.3mg/l, NH4 -4.79mg/l	The treatment of the effluent must be monitored regularly to ensure that is up to standard as set by the water use license.	I Hogdskin		
	P04	Coal settling pond & Splitter box. Inspect operations.	26.62190	30.09800		2014/04/03	08:39	Full	No	V	18, 19, 20	Some coal and dibrisin coal settling pond. Some debris in splitter box and canals surrounding the coal stock yard	Regular inspections in this area must be conducted and problems rectified..	S Shabangu		
	C11	Dirty water run-off canal downstream from CSY. Inspect all dirty water canals.	26.62120	30.09840		2014/04/03	09:52	Low / Mod	No	V	21, 22	Slow water flow. Area between the fences are blocked with silt and debris. Oil visible in water.	The area between the fences must be cleaned regularly and oil removed .	M Dubazana		
	P05	CSY dam receiving dirty water run-off. Inspect regularly & monitor water quality.	26.62130	30.10130		2014/04/03	09:50	Low	No	N	23	Construction in progress. Satisfactory condition.	Dam must be inspected regularly.	M Dubazana		
Witpunt Spruit Central Tributary - Area East of Power Station.	P11	Station drain dams collection sump. Inspect operations.	26.61880	30.09810		2014/04/03	08:52	Full	No	V	24	Lots of oil and silt in sump.	Operations at the sump must be inspected regularly and cleaned to prevent oil spills into the environment.	M Dubazana / T Mpongo		
	C13	Canal discharge contaminated water from northern station dams into reclamation dam. Monitoring water quality.	26.61880	30.09810		2014/04/03	08:55	Low / Mod	No	V		Lots of ash visible in canal.	Canal must be cleaned.	M Dubazana		
	P08	Reclamation dam. Inspect and monitoring water quality.	26.62000	30.09980		2014/04/03	10:54	Low	Yes	N,M ,H,B	25	Oil visible in dam. Water has a dangerous water quality (Class 4) due to high No2, N and NH4 and also bacteriological count. NO2 - 1.53mg/l, N- 13.5mg/l NH4 - 5.25mg/l E.Coli - 74/100ml, Total Coliforms - 76/100ml	Operations at the oil skimmers must be improved to prevent oil spills into the environment. Work to be completed.	M Ueckermann/ M Dubazana		
	*Z04	Leaking pipes south of B06. Inspect and monitoring water quality.	26.61993	30.10101		2014/04/03	09:13	Low / Slow	No	V		Satisfactory condition.	~	A.Sebothoma		

Table 7. Continues.

Witpunt Spruit Central Tributary.	*C15	Clean run-off from area east of PS released into natural environment. Monitor water quality.	26.62070	30.09920		2014/04/03	10:54	Damp	No	N		Satisfactory condition.	Monitor water quality closely. If high levels of contamination persist a seepage investigation must be done to determine the source of pollution.	T Mpongo		
	*C16	Clean run-off from area east of PS downstream of C15 released into natural environment. Monitor water quality.	26.62000	30.10220		2014/04/03	09:38	Low / Slow	Yes	N,H		Lots of coal visible in canal. SO4 - 494mg/l	Coal must be removed from canal.	S Shabangu		
	*C26	Dugged canal west of SANDF sewage plant. Inspect regularly & monitoring discharge water quality.	26.61748	30.10806		2014/04/03	10:11	Low / Slow	Yes	N	26	Satisfactory condition. SO4 - 116mg/l, Fe 0.915mg/l, Mn - 0.908	Water responsibility of SANDF, Keep monitoring water quality. Relevant authorities needs to be notified.	V.Pandaram		
	*K02	Sewage plant at SANDF. Inspect regularly & monitoring discharge water quality.	26.61750	30.10880		2014/04/03	10:12	Dry	No	V		Satisfactory condition.	~	D. Khumalo/ H. Jairaj		
Witpunt Spruit Central Tributary.	*R05	Western tributary downstream from P03, C12, C16 & C21. Possible pollution from PS entering Witpunt Spruit.	26.62020	30.10790		2014/04/03	10:31	Low / Fast	Yes	N,M	27	Satisfactory condition. SO4 -94.7mg/l	~	I Hodgskin/ T Mpongo		

* Surface water sites supposed to contain clean water

Table 8. Witpunt Spruit Tributary problems identified during Phase 57 with proposed mitigation.

Site Information						Current State Description								Response		
Area With Possible Env. Hazards	**Sites**	**Description / Objective**	**Latitude (°S)**	**Longitude (°E)**	**Sample Depth**	**Date**	**Time**	**Water Level / Flow**	**Sampled**		**Photo nr.**	**Current State**	**Proposed Mitigation**	**Responsible Person**	**Completion Date**	**Remarks**
Witpunt Spruit Water Course	*R01	Witpunt Spruit background water quality entering the system.	26.59330	30.09620		2014/04/03	13:25	High / Fast	Yes	N,M		Water has a dangerous water quality, mostlikely due to minning operations upstream. pH - 4.86 SO4 -241mg/l, Mn 0.878mg/l	The area must be monitored regularly.	I Hogdskin		
	*P01	Dam receiving run-off from PS and SANDF contributing to Witpunt Spruit. Monitoring water quality.	26.61200	30.10650		2014/04/03	10:20	Mod	Yes	N	28	Satisfactory condition. SO4 -316mg/l	~	I Hogdskin / Pierre		
	*P02	Dam receiving run-off from PS and SANDF contributing to Witpunt Spruit. Monitoring water quality.	26.61120	30.10740		2014/04/03	10:21	Mod	Yes	N	29	Satisfactory condition. SO4 -199mg/l	~	I Hogdskin / Pierre		
	*R02	Witpunt Spruit final water quality released from the system.	26.62290	30.11430		2014/04/03	10:29	High / Fast	Yes	N,M	30	Satisfactory condition. SO4 -228mg/l	~	I Hogdskin		
Vaal River Water Course	*R03	Vaal River background water quality entering the system.	26.64870	30.15170		2014/04/03	13:31	High / Fast	Yes	N,M		Satisfactory condition. SO4 -22.6mg/l	~	I Hogdskin		
	*R04	Vaal River final water quality released from the system.	26.67880	30.12390		2014/04/03	13:45	High / Fast	Yes	N,M		Satisfactory condition. SO4 -44.1mg/l	~	I Hogdskin		

* Surface water sites supposed to contain clean water

APPENDIX C
Current State Chemistry – Surface and groundwater quality

CAMDEN POWER STATION CHEMICAL ANALYSES PHASE 57

SUB DRAINAGE SYSTEM 1: WITPUNT SPRUIT NORTHERN TRIBUTARY - SURFACE WATER

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
P09	10.30	159.00	1165	171.00	0.497	187.00	40.60	80.30	635.00	1.480		1.430		0.003	0.001	1.750	1.290	0.001	0.002	0.001	0.001			54.600	16.76	17.75	2.860
*C01	8.03	173.00		215.00	41.300	142.00	28.80	96.20	624.00	0.242		0.309		0.003	0.001	2.490	0.003							218.000	20.10	21.04	2.280
*C03	7.99	302.00		314.00	29.600	390.00	66.70	245.00	1159.00	0.112		0.312		0.003	0.001	4.580	0.003							240.000	35.87	36.77	1.240
*S04	7.88	96.80	725	95.70	56.800	45.90	3.53	17.80	350.00	0.405		0.299		0.003	0.001	0.186	0.003	0.001	0.002	0.001	0.001			237.000	12.57	11.53	-4.300
*C04	7.57	194.00		247.00	67.100	152.00	12.10	90.50	907.00	0.157		0.315		0.003	0.001	1.020	0.003							141.000	24.29	24.77	0.980
*S03	3.27	346.00		494.00	272.000	56.60	8.85	16.10	2632.00	0.097		0.303		59.000	15.400	0.634	0.536							2.480	55.33	51.05	-4.020
*D24	3.96	254.00		497.00	120.000	38.70	9.85	9.08	1996.00	0.055		0.361		0.085	6.860	0.477	26.700							2.480	41.89	36.73	-6.560
*C25	6.65	95.50	767	113.00	48.600	16.60	11.70	11.20	519.00	0.468		0.312		0.389	5.080	0.177	0.003							32.500	11.82	10.76	-4.700
*C05	7.87	130.00		148.00	59.300	75.30	10.90	44.70	563.00	0.300		0.302		0.003	0.001	0.383	0.003							176.000	16.54	15.82	-2.230
*C06	7.66	270.00		312.00	56.700	305.00	43.00	181.00	1058.00	0.142		0.300		0.003	0.001	2.730	0.003							215.000	31.46	34.60	4.750
*C07	8.22	252.00	1911	271.00	52.800	286.00	39.30	165.00	960.00	0.147		0.313		0.003	0.163	2.450	0.003	0.001	0.002	0.001	0.001			193.000	28.53	31.32	4.650

* Surface water sites supposed to contain clean water.

SUB DRAINAGE SYSTEM 1: WITPUNT SPRUIT NORTHERN TRIBUTARY - GROUNDWATER

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
SHALLOW PURGED AQUIFER																											
D07	6.99	47.80	287	40.30	13.400	23.60	8.970	15.20	126.00	0.008		0.454		0.003	0.393	0.326	0.003	0.001	0.008	0.001	0.001			54.600	4.18	4.38	2.330
D02	6.23	26.60	159	18.70	5.040	19.70	3.850	16.80	68.40	0.104		0.316		0.003	2.400	0.120	0.003	0.001	0.002	0.001	0.001			24.200	2.41	2.35	-1.330
D04	8.27	228.00	1717	274.00	57.100	214.00	20.300	112.00	865.00	0.295		0.726		0.003	6.020	3.010	0.003	0.001	0.002	0.001	0.001			249.000	26.22	28.31	3.840
D05	7.57	150.00	1098	107.00	12.100	222.00	51.500	95.90	493.00	0.168		0.754		0.003	0.001	1.740	0.003	0.001	0.002	0.001	0.001			154.000	16.11	17.31	3.580
B19	8.50	39.10	180	15.00	3.390	50.20	3.490	102.00	0.04	0.099		0.370		0.003	0.001	0.034	0.003	0.001	0.002	0.001	0.001			7.240	3.05	3.30	3.870
B21	8.98	94.70	645	32.70	17.500	146.00	13.400	75.70	335.00	0.137		0.364		0.003	0.001	1.190	0.003	0.001	0.002	0.001	0.001			31.800	9.78	9.76	-0.070
B03	7.20	42.10	310	47.20	17.600	13.00	3.130	13.70	99.10	0.093		0.922		0.003	0.001	0.005	0.003	0.001	0.002	0.001	0.001			93.700	4.39	4.45	0.610
B04	7.49	35.00	197	16.50	6.100	49.80	2.830	28.40	0.04	0.261		0.353		0.003	0.380	0.068	0.003	0.001	0.002	0.001	0.001			141.000	3.66	3.57	-1.250
DEEP UTILIZABLE AQUIFER																											
B20	10.30	38.40	354	1.65	0.009	84.50	1.510	24.20	8.43	0.055		0.328		0.003	0.001	0.429	0.003	0.001	0.002	0.001	0.001			147.000	3.82	3.80	-0.360
B22	7.71	19.70	165	9.55	5.470	20.90	2.640	14.10	0.20	0.283		0.345		0.558	0.032	0.025	0.003	0.001	0.002	0.001	0.001			82.700	2.10	1.91	-4.550

CAMDEN POWER STATION CHEMICAL ANALYSES PHASE 57

SUB DRAINAGE SYSTEM 2: WITPUNT SPRUIT CENTRAL TRIBUTARY - SURFACE WATER

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
*C08	7.52	29.00		29.70	8.050	12.30	2.3100	7.64	73.50	0.235		2.660		0.003	0.001	0.135	0.003							36.900	2.69	2.74	0.960
*C09	7.63	96.50		96.90	30.500	69.80	5.3900	33.10	429.00	0.366		0.931		0.003	0.001	0.328	0.003							45.300	10.86	10.52	-1.590

* Surface water sites supposed to contain clean water.

SUB DRAINAGE SYSTEM 2: WITPUNT SPRUIT CENTRAL TRIBUTARY - GROUNDWATER

Site No.	pH	EC mS/m	TDS mg/l	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	NH_4-N mg/L	Fe mg/L	Mn mg/L	B mg/L	Al mg/L	Cu mg/L	Zn mg/L	Cr mg/L	Cd mg/L	PO4 mg/L	COD mg/L	Alk mg/L	Anion meq/l	Cation meq/l	Ionbal %
SHALLOW PURGED AQUIFER																											
B05	7.88	32.10		22.00	11.700	29.50	3.550	7.36	6.66	0.153		0.312		0.003	0.001	0.007	0.003							168.000	3.74	3.43	-4.220

CAMDEN POWER STATION CHEMICAL ANALYSES PHASE 57

SUB DRAINAGE SYSTEM 3: WITPUNT SPRUIT SOUTHERN TRIBUTARY - SURFACE WATER

Site No.	pH	EC	TDS	Ca	Mg	Na	K	Cl	SO4	F	NO_2-N	NO_3-N	NH_4-N	Fe	Mn	B	Al	Cu	Zn	Cr	Cd	PO4	COD	Alk	Anion	Cation	Ionbal
		mS/m	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/l	meq/l	%
*C10	7.90	37.30		32.90	20.700	13.90	1.740	8.85	71.10	0.137		0.345		0.003	0.001	0.080	0.003							120.000	4.16	3.99	-2.060
*C24	7.30	48.10	304	41.00	21.900	25.00	5.170	13.30	105.00	0.426		0.378		0.018	0.001	0.058	0.003	0.001	0.002	0.001	0.001			114.000	4.89	5.07	1.770
*C20	8.14	99.00		109.00	57.300	37.00	4.190	13.50	453.00	0.129	0.062	0.307	0.043	0.003	0.001	0.117	0.003					0.010	25.200	159.000	13.02	11.87	-4.630
K01	3.60	57.30		30.50	9.700	29.50	9.180	59.80	52.00	0.204	0.060	22.300	4.790	0.003	0.135	0.058	0.003					2.460	11.100	2.480	4.42	3.84	-7.040
P08	7.37	78.70		58.30	19.500	56.60	13.600	44.50	180.00	0.465	1.530	13.500	5.250	0.003	0.126	0.214	0.003	0.001	0.002	0.001	0.001	1.160	498.000	84.700	7.69	7.33	-2.400
*C16	7.56	118.00		109.00	35.200	88.40	23.000	64.40	494.00	0.910		3.980		0.003	0.001	0.503	0.003						141.000	79.300	14.02	12.77	-4.670
*C26	6.65	48.50		34.20	8.720	25.80	8.790	33.10	116.00	0.291		0.317		0.915	0.908	0.043	0.003							28.100	3.95	3.80	-1.870
*C21	7.84	98.60		107.00	55.000	37.00	4.080	13.40	416.00	0.133		0.332		0.003	0.001	0.115	0.003							157.000	12.21	11.58	-2.660
*C12	7.27	41.30		30.80	17.200	20.30	4.400	16.20	105.00	0.102		0.462		0.003	0.001	0.063	0.003							46.600	3.61	3.95	4.420
*R05	7.55	90.60	648	81.40	27.700	63.60	16.000	47.60	346.00	0.636		2.050		0.003	0.001	0.360	0.003	0.001	0.002	0.001	0.001			67.500	10.08	9.52	-2.860

* Surface water sites supposed to contain clean water.

SUB DRAINAGE SYSTEM 3: WITPUNT SPRUIT SOUTHERN TRIBUTARY - GROUNDWATER

Site No.	pH	EC	TDS	Ca	Mg	Na	K	Cl	SO4	F	NO2-N	NO3-N	NH4-N	Fe	Mn	B	Al	Cu	Zn	Cr	Cd	PO4	COD	Alk	Anion	Cation	Ionbal
		mS/m	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/l	meq/l	%
SHALLOW PURGED AQUIFER																											
B01	7.43	113.00		108.00	74.700	54.50	1.220	24.90	280.00	0.189		0.325		0.003	0.200	0.023	0.003							339.000	13.35	13.94	2.180
B08S	7.91	95.00		62.10	62.400	58.10	5.890	23.60	394.00	0.080		0.314		0.003	0.232	0.196	0.003						0.080	154.000	11.98	10.91	-4.640
B06	7.30	110.00		93.80	40.900	87.30	14.000	63.90	442.00	0.393		0.315		0.003	0.315	0.319	0.003						69.700	96.000	12.97	12.21	-3.030
B07	6.85	27.00		9.76	7.150	25.10	3.580	11.00	75.60	0.063		0.350		0.003	0.180	0.029	0.003							26.300	2.44	2.26	-3.760
DEEP UTILIZABLE AQUIFER																											
B08D	7.95	92.20		52.70	61.400	57.800	5.460	23.30	377.00	0.055		0.318		0.003	0.233	0.191	0.003							140.000	11.33	10.34	-4.580

CAMDEN POWER STATION CHEMICAL ANALYSES PHASE 57

MAJOR DRAINAGE SYSTEM 1: WITPUNT SPRUIT

Site No.	pH	EC	TDS	Ca	Mg	Na	K	Cl	SO4	F	NO_2-N	NO_3-N	NH_4-N	Fe	Mn	B	Al	Cu	Zn	Cr	Cd	PO4	COD	Alk	Anion	Cation	Ionbal
		mS/m	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/l	meq/l	%
*R01	4.86	52.90	362	38.60	25.300	18.00	5.790	15.70	241.00	0.308		0.458		0.003	0.878	0.400	0.699	0.001	0.006	0.001	0.001			2.480	5.56	4.95	-5.750
*P01	7.38	81.40		60.40	33.200	56.60	11.600	38.80	316.00	0.263		0.334		0.003	0.001	0.368	0.003							43.600	8.58	11.17	-0.470
*P02	6.36	52.40		41.10	23.900	19.50	6.920	16.80	199.00	0.275		0.329		0.003	0.114	0.063	0.003							8.580	4.83	5.04	2.200
*R02	5.51	50.90	343	39.90	23.200	17.20	6.210	13.60	228.00	0.225		0.364		0.003	0.379	0.046	0.255	0.001	0.002	0.001	0.001			2.480	5.22	4.81	-4.030
*R03	6.89	13.20	70	6.58	4.220	6.06	3.970	10.70	22.60	0.115		0.236		0.094	0.001	0.018	0.035	0.001	0.002	0.001	0.001			7.950	0.95	1.04	4.330
*R04	6.70	16.00	94	9.12	5.680	6.77	4.080	10.60	44.10	0.117		0.354		0.014	0.001	0.020	0.003	0.001	0.002	0.001	0.001			4.460	1.34	1.32	-0.630

* Surface water sites supposed to contain clean water.

APPENDIX D
Time Graphs, MMAC Plots & Chemical Diagrams

APPENDIX D: MMAC AND TIME GRAPHS

Quality of Domestic Water Supplies, SANS, Edition 1, 2011

Determinand	Risk	Unit	Standard limits [a] (Class I)
Physical and aesthetic determinands			
Free chlorine	Chronic health	mg/L	≤ 5
Monochloramine	Chronic health	mg/L	≤ 3
Colour	Aesthetic	mg/L Pt-Co	≤ 15
Conductivity at 25 ° C	Aesthetic	mS/m	≤ 170
Odour or taste	Aesthetic	-	Inoffensive
Total dissolved solids	Aesthetic	mg/L	≤ 1 200
Turbidity [b]	Operational	NTU	≤ 1
	Aesthetic	NTU	≤ 5
pH at 25 ° C [c]	Operational	pH units	≥ 5 to ≤ 9,7
Chemical determinands — macro-determinands			
Nitrate as N [d]	Acute health - 1	mg/L	≤ 11
Nitrite as N [d]	Acute health - 1	mg/L	≤ 0,9
Sulfate as SO_4^{2-}	Acute health - 1	mg/L	≤ 500
	Aesthetic	mg/L	≤ 250
Fluoride as F^-	Chronic health	mg/L	≤ 1,5
Ammonia as N	Aesthetic	mg/L	≤ 1,5
Chloride as Cl^-	Aesthetic	mg/L	≤ 300
Sodium as Na	Aesthetic	mg/L	≤ 200
Zinc as Zn	Aesthetic	mg/L	≤ 5
Chemical determinands — micro-determinands			
Antimony as Sb	Chronic health	µg/L	≤ 20
Arsenic as As	Chronic health	µg/L	≤ 10
Cadmium as Cd	Chronic health	µg/L	≤ 3
Total chromium as Cr	Chronic health	µg/L	≤ 50
Cobalt as Co	Chronic health	µg/L	≤ 500
Copper as Cu	Chronic health	µg/L	≤ 2 000
Cyanide (recoverable) as CN^-	Acute health - 1	µg/L	≤ 70
Iron as Fe	Chronic health	µg/L	≤ 2 000
	Aesthetic	µg/L	≤ 300
Lead as Pb	Chronic health	µg/L	≤ 10
Manganese as Mn	Chronic health	µg/L	≤ 500
	Aesthetic	µg/L	≤ 100
Mercury as Hg	Chronic health	µg/L	≤ 6
Nickel as Ni	Chronic health	µg/L	≤ 70
Selenium as Se	Chronic health	µg/L	≤ 10
Uranium as U	Chronic health	µg/L	≤ 15
Vanadium as V	Chronic health	µg/L	≤ 200
Aluminium as Al	Operational	µg/L	≤ 300

Quality of Domestic Water Supplies, SANS, Edition 6.1, 2006

Determinand	Unit	Class I (recommended operational limit)	Class II (max. allowable for limited duration)	Class II water consumption period,[a] max.
Physical and organoleptic requirements				
Colour (aesthetic)	mg/L pt	< 20	20-50	No limit[b]
Conductivity at 25 °C (aesthetic)	mS/m	< 150	150-370	7 years
Dissolved solids (aesthetic)	mg/L	< 1 000	1 000-2 400	7 years
Odour (aesthetic)	TON	<5	5-10	No limit[b]
pH value at 25 °C (aesthetic/operational)	pH units	5,0 - 9,5	4,0 - 10,0	No limit[c]
Taste (aesthetic)	FTN	< 5	5-10	No limit
Turbidity (aesthetic/operational/indirect health)	NTU	< 1	1-5	No limit[d]
Chemical requirements — macro-determinand				
Ammonia as N (operational)	mg/L	< 1,0	1,0-2,0	No limit[d]
Calcium as Ca (aesthetic/operational)	mg/L	< 150	150-300	7 years
Chloride as Cl^- (aesthetic)	mg/L	< 200	200-600	7 years
Fluoride as F^- (health)	mg/L	< 1,0	1,0-1,5	1 year
Magnesium as Mg (aesthetic/health)	mg/L	< 70	70- 100	7 years
(Nitrate and nitrite) as N (health)	mg/L	< 10	10-20	7 years
Potassium as K (operational/health)	mg/L	< 50	50- 100	7 years
Sodium as Na (aesthetic/health)	mg/L	< 200	200-400	7 years
Sulfate as $SO_4^{=}$ (health)	mg/L	< 400	400-600	7 years
Zinc as Zn (aesthetic/health)	mg/L	< 5,0	5,0- 10	1 year

Determinand	Unit	Class I (recommended operational limit)	Class II (max. allowable for limited duration)	Class II water consumption period," max.
Chemical requirements — mlcro-determlnand				
Aluminium as AI (health)	mg/L	< 300	300-500	1 year
Antimony as Sb (health)	mg/L	< 10	10-50	1 year
Arsenic as As (health)	mg/L	< 10	10-50	1 year
Cadmium as Cd (health)	mg/L	<5	5- 10	6 months
Total Chromium as Cr (health)	mg/L	< 100	100-500	3 months
Cobalt as Co (health)	mg/L	< 500	500-1 000	1 year
Copper as Cu (health)	mg/L	< 1 000	1 000-2 000	1 year
Cyanide (recoverable) as CW (health)	mg/L	<50	50-70	1 week
Iron as Fe (aesthetic/ operational)	mg/L	< 200	200-2 000	7 years[b]
Lead as Pb (health)	mg/L	< 20	20-50	3 months
Manganese as Mn (aesthetic)	mg/L	< 100	100-1000	7 years
Mercury as Hg (health)	mg/L	< 1	1-5	3 months
Nickel as Ni (health)	mg/L	< 150	150- 350	1 year
Selenium as Se (health)	mg/L	< 20	20-50	1 year
Vanadium as V (health)	mg/L	< 200	200- 500	1 year
Chemical requirements — organic determinand				
Dissolved organic carbon as C (aesthetic/health)	mg/L	< 10	10-20	3 months[e]
Total trihalomethanes (health)	mg/L	< 200	200-300	10 years[f]
Phenols (aesthetic/health)	mg/L	< 10	10-70	No limi[b]

[a] The limits for the consumption of class II water are based on the consumption of 2 L water per day by a person of mass 70 kg

[b] The limits given are based on aesthetic aspects.

[c] No primary health effect- low pH values can result in structural problems in the distribution system.

[d] These values can indicate process efficiency and risks associated with pathogens.

[e] When dissolved organic carbon is deemed of natural origin, the consumption period can be extended.

[f] This is a suggested value because trihalomethanes have not been proven to have any effect on human health.

Quality of Domestic Water Supplies, DWA&F, Second Edition 1998

PARAMETER	CLASS 0	CLASS 1	CLASS 2	CLASS 3	CLASS 4
~ Microbiological Quality ~					
Faecal Coliforms	0	0 - 1	1 - 10	10 - 100	> 100
Total Coliforms	0	0 - 10	10 - 100	100 - 1 000	> 1 000
~ Physical Quality ~					
Electrical Conductivity (mS/m)	< 70	70 - 150	150 - 370	370 - 520	> 520
pH	5 - 9.5	4.5 - 5 & 9.5 - 10	4 - 4.5 & 10 - 10.5	3 - 4 & 10.5 - 11	< 3 & >11
Total Dissolved Solids [TDS] mg/L	< 450	450 - 1 000	1 000 - 2 400	2 400 - 3 400	> 3 400
Turbidity	< 0.1	0.1 - 1	1 - 20	20 - 50	> 50
~ Chemical Quality ~					
Arsenic [As] (mg/L)	< 0.010	0.01 - 0.05	0.05 - 0.2	0.2 - 2.0	> 2
Cadmium [Cd] (mg/L)	< 0.003	0.003 - 0.005	0.005 - 0.020	0.020 - 0.050	> 0.050
Calcium [Ca] (mg/L)	0 - 80	80 - 150	150 - 300	> 300	~
Chloride [Cl] (mg/L)	< 100	100 - 200	200 - 600	600 - 1 200	> 1 200
Copper [Cu] (mg/L)	0 - 1	1 - 1.3	1.3 - 2.0	2.0 - 15	> 15
Fluoride [F] (mg/L)	< 0.7	0.7 - 1.0	1 - 1.5	1.5 - 3.5	> 3.5
Iron [Fe] (mg/L)	< 0.5	0.5 - 1	1 - 5	5 - 10	> 10
Total Hardness	0 - 200	200 - 300	300 - 600	> 600	~
Magnesium [Mg] (mg/L)	< 70	70 - 100	100 - 200	200 - 400	> 400
Manganese [Mn] (mg/L)	0 - 0.1	0.1 - 0.4	0.4 - 4	4 - 10	> 10
Nitrate [N] (mg/L)	< 6	6 - 10	10 - 20	20 - 40	> 40
Nitrite [N] (mg/L)	< 6	6 - 10	10 - 20	20 - 40	> 40
Potassium [K] (mg/L)	< 25	25 - 50	50 - 100	100 - 500	> 500
Sodium [Na] (mg/L)	< 100	100 - 200	200 - 400	400 - 1 000	> 1 000
Sulphate [SO_4] (mg/L)	< 200	200 - 400	400 - 600	600 - 1 000	> 1 000
Boron [B] (mg/L)	0 - 0.5	0.5 - 2	2 - 4	4 - 6	> 6
Zinc [Zn] (mg/L)	< 3	3 - 5	5 - 10	10 - 20	> 20

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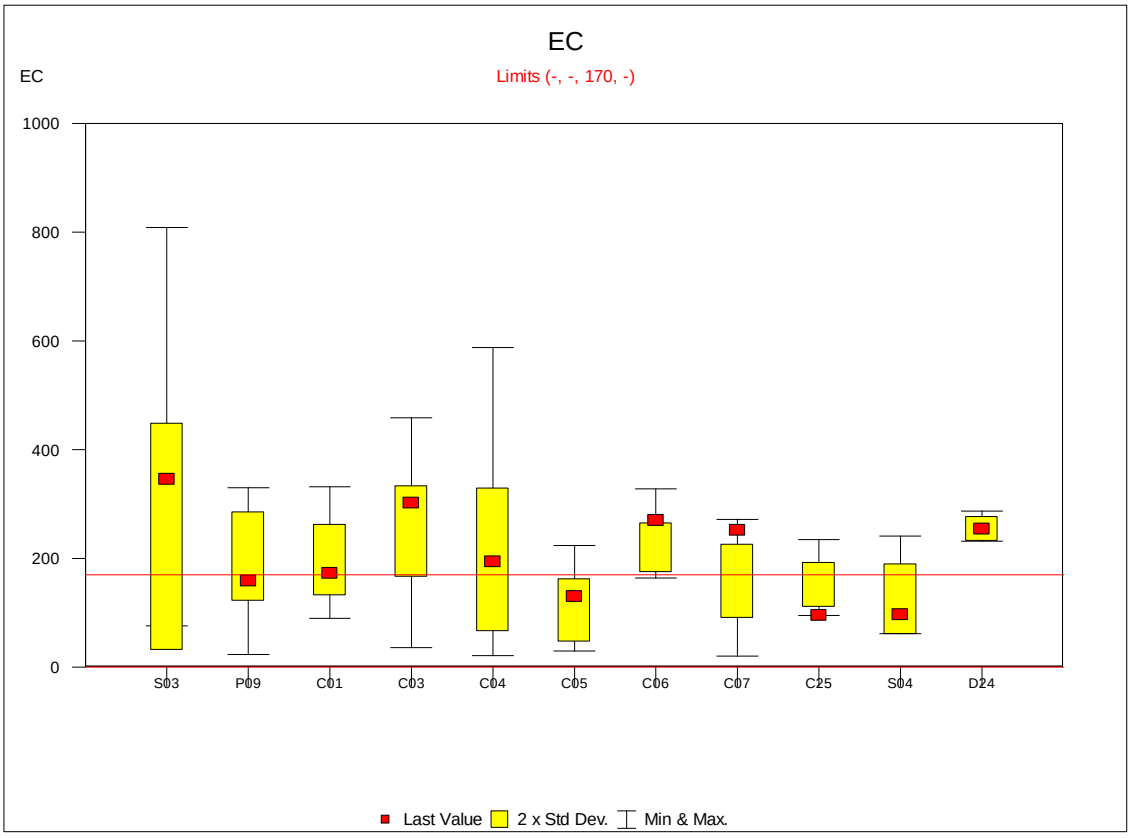
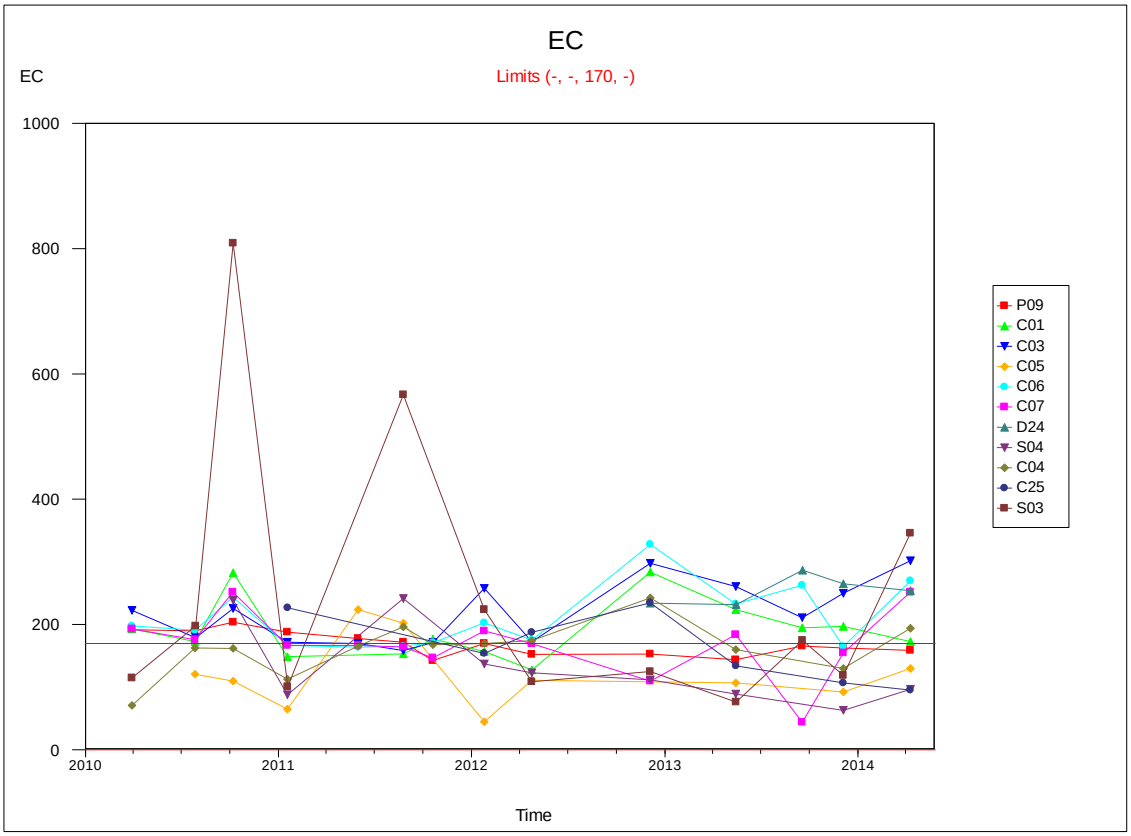
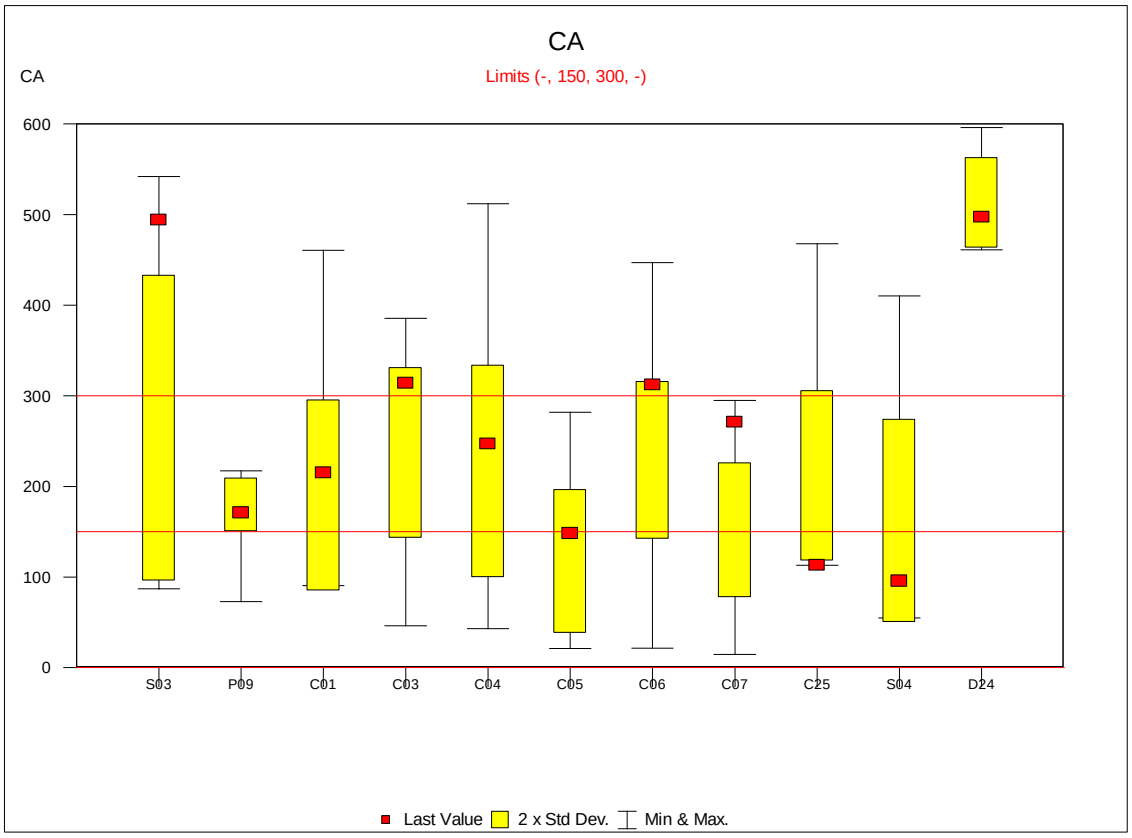
D1. SUB DRAINAGE SYSTEM 1: WITPUNT SPRUIT NORTHERN TRIBUTARY

D1.1. WITPUNT SPRUIT NORTHERN TRIBUTARY - SURFACE WATER



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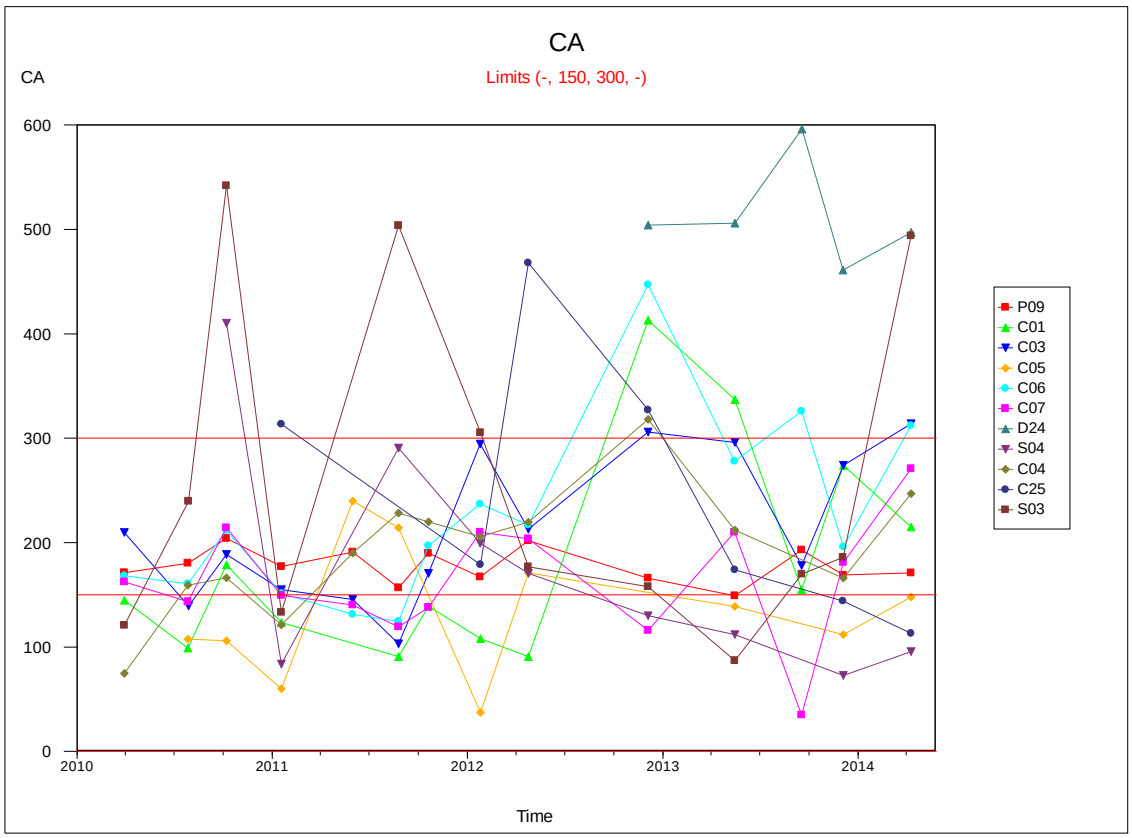
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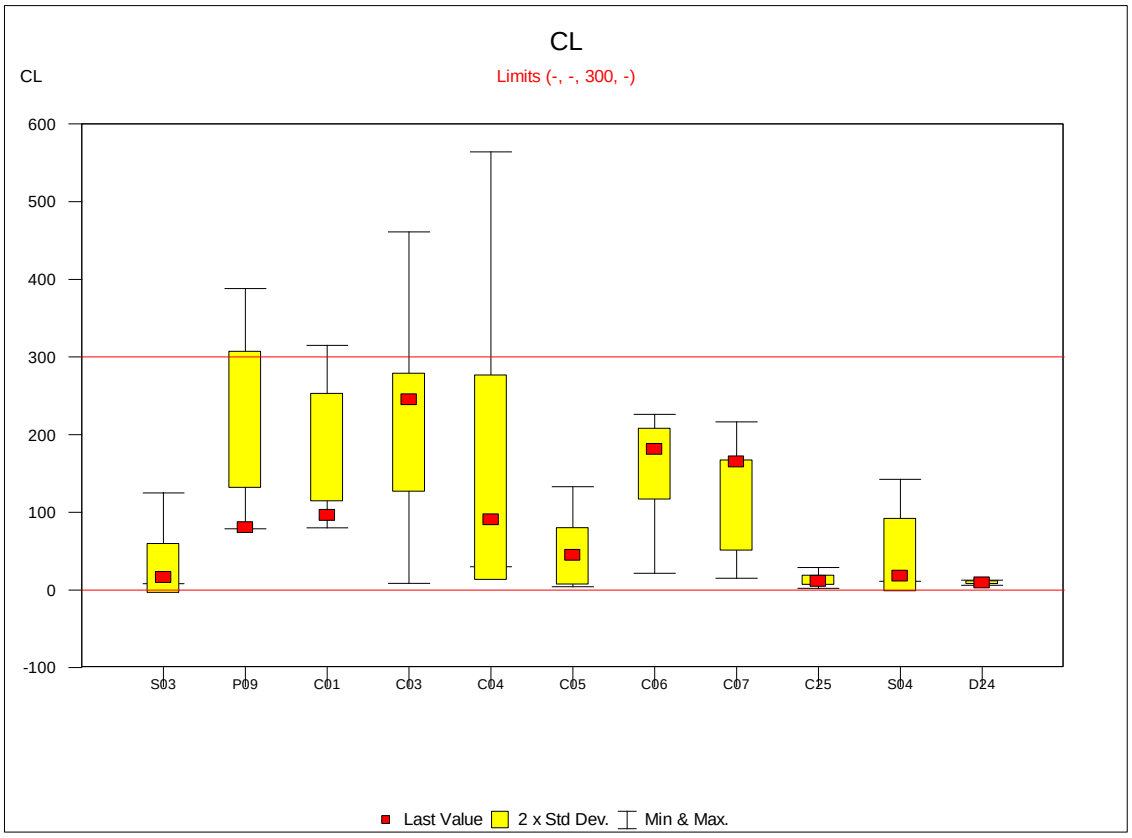
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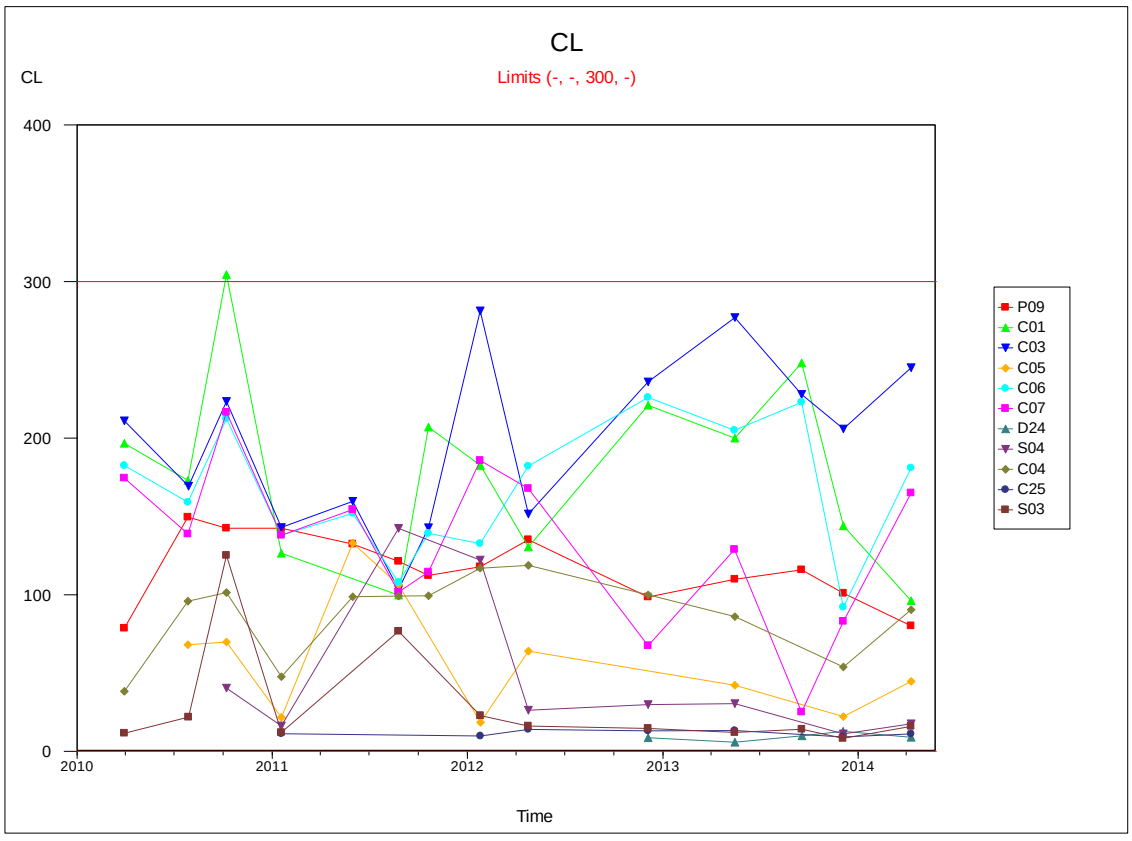
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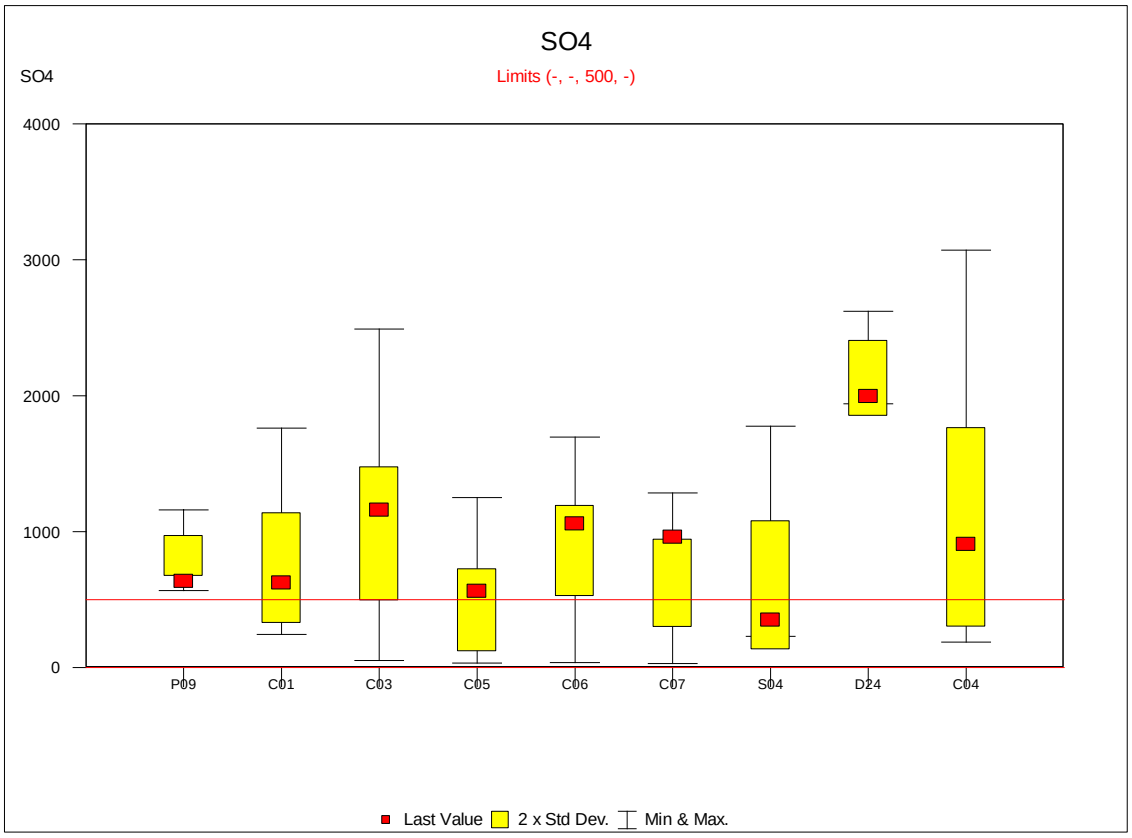
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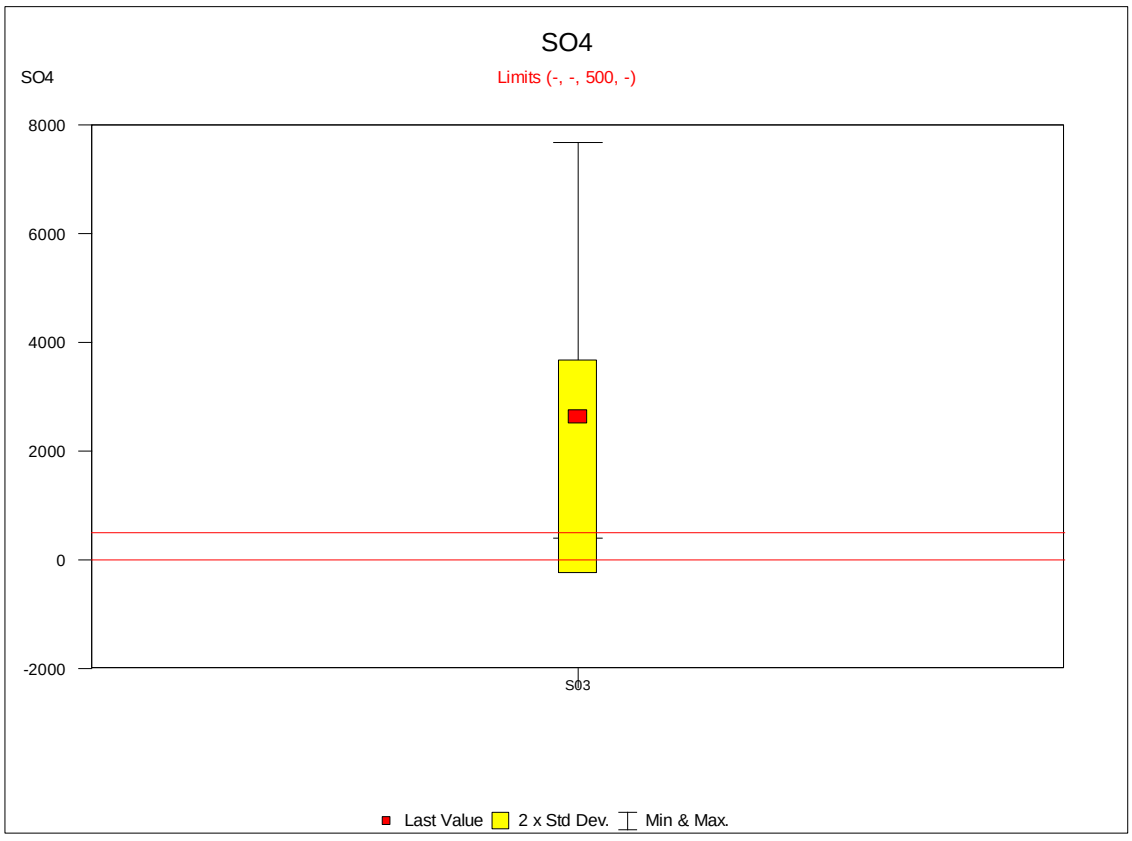
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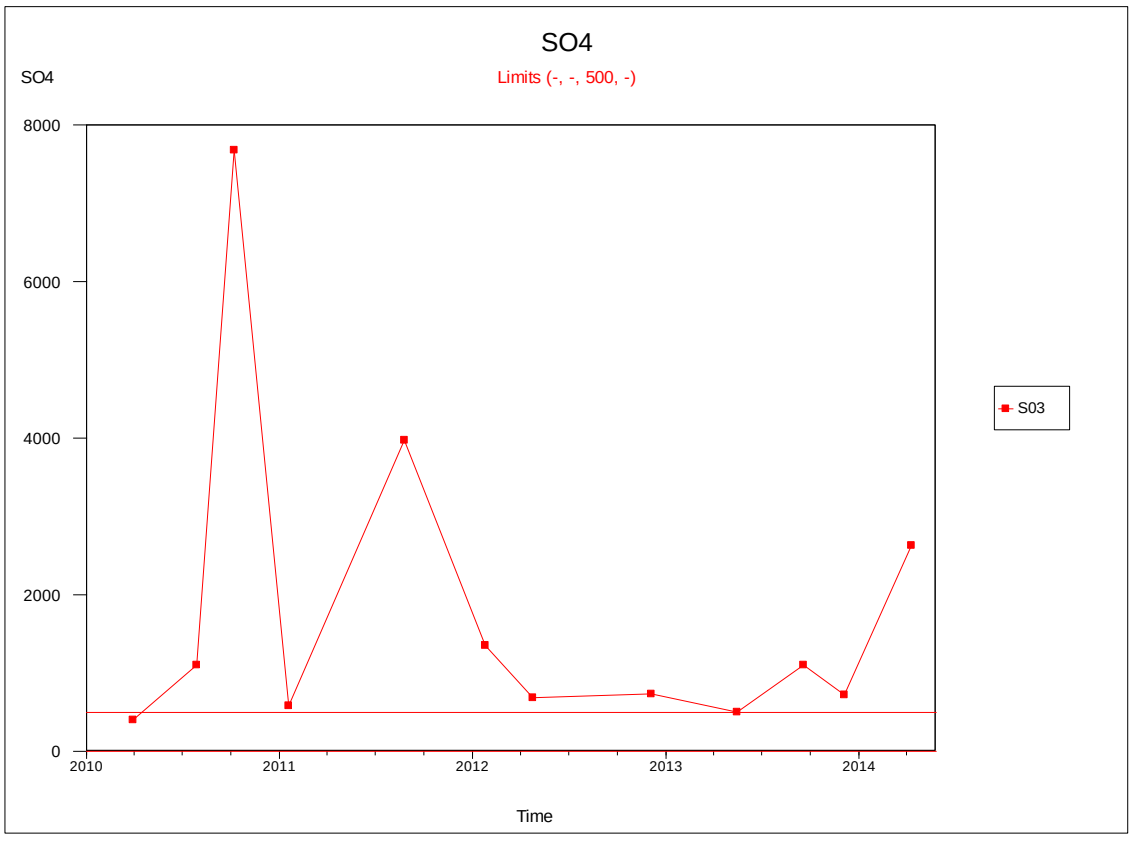
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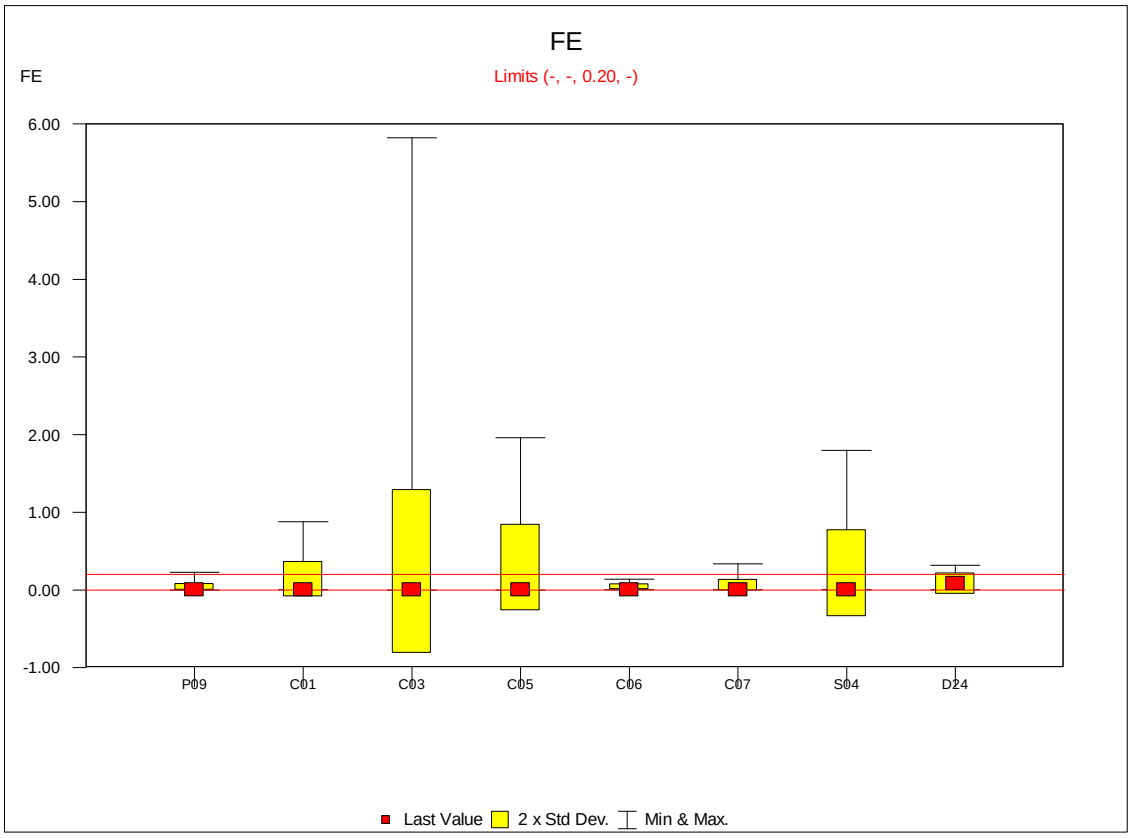
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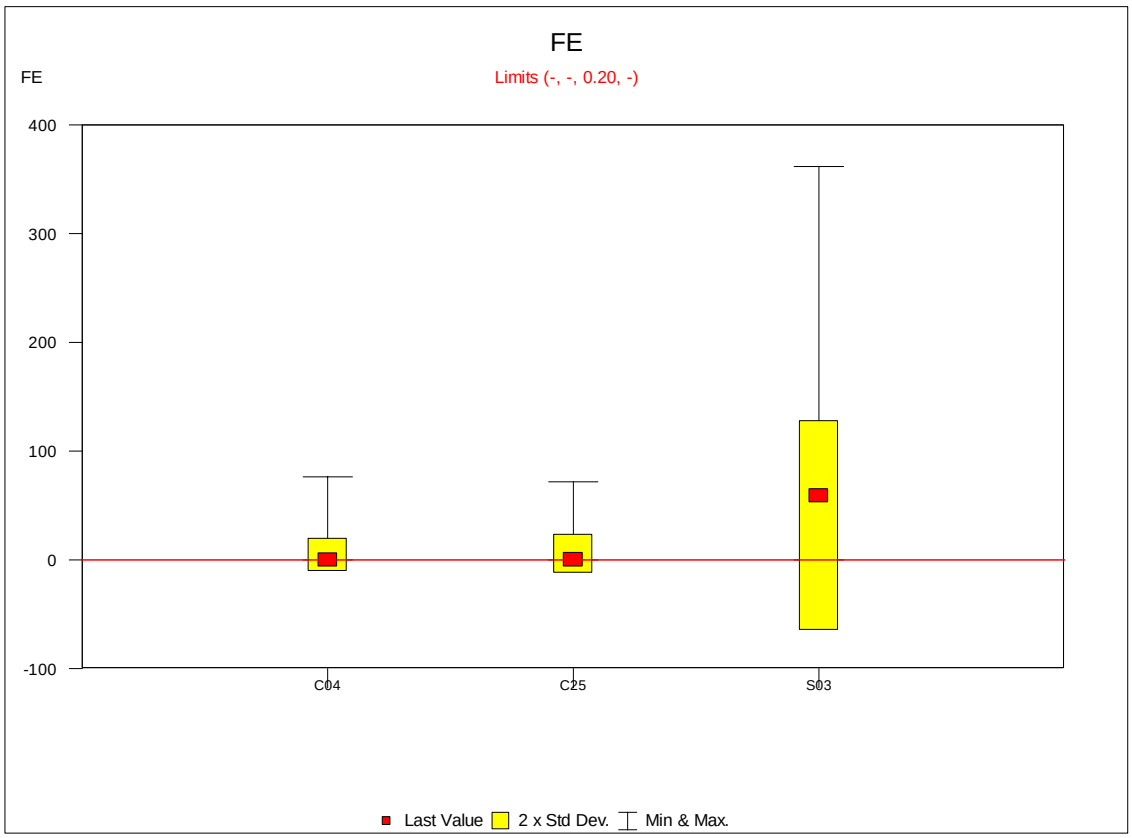
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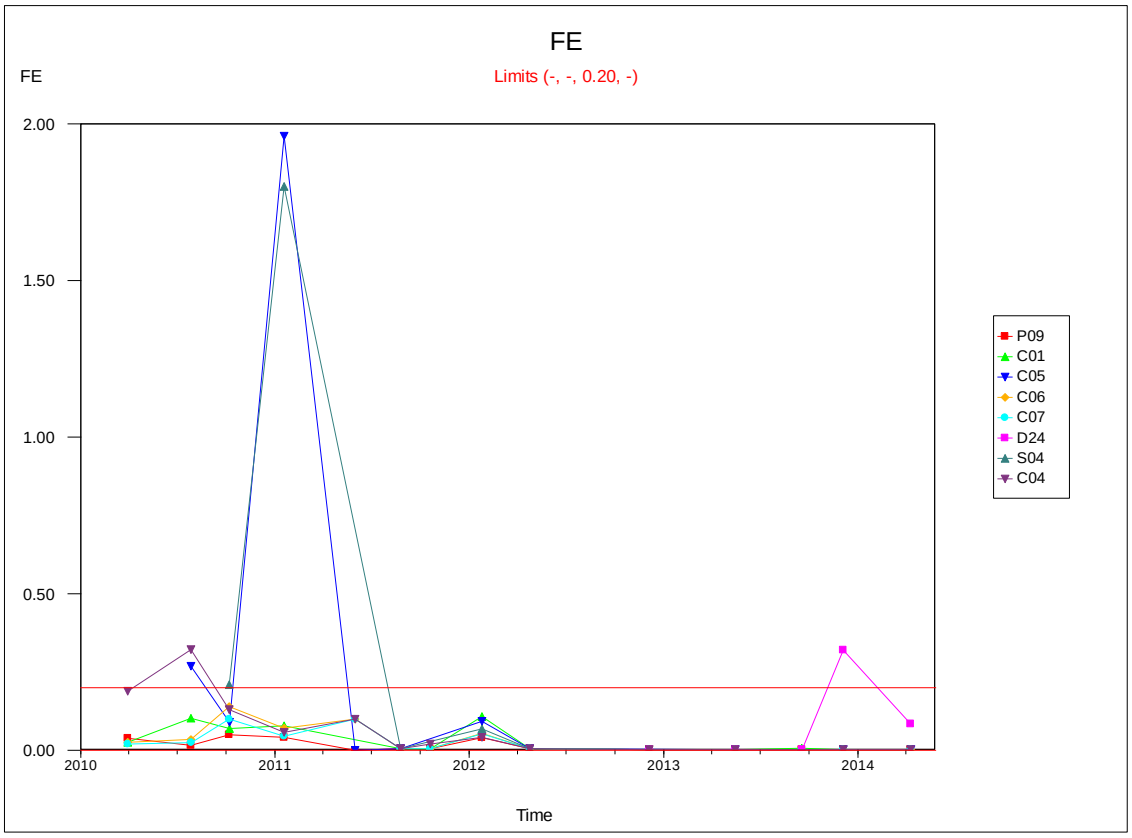
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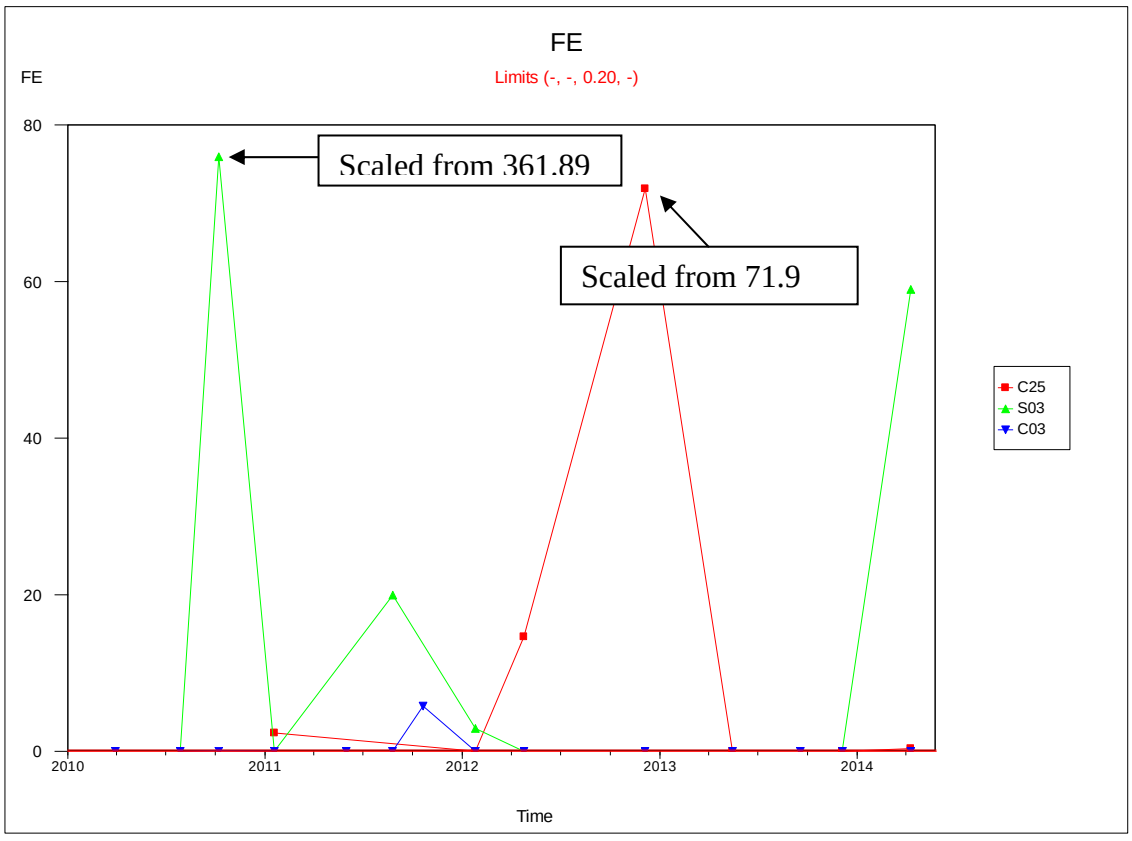
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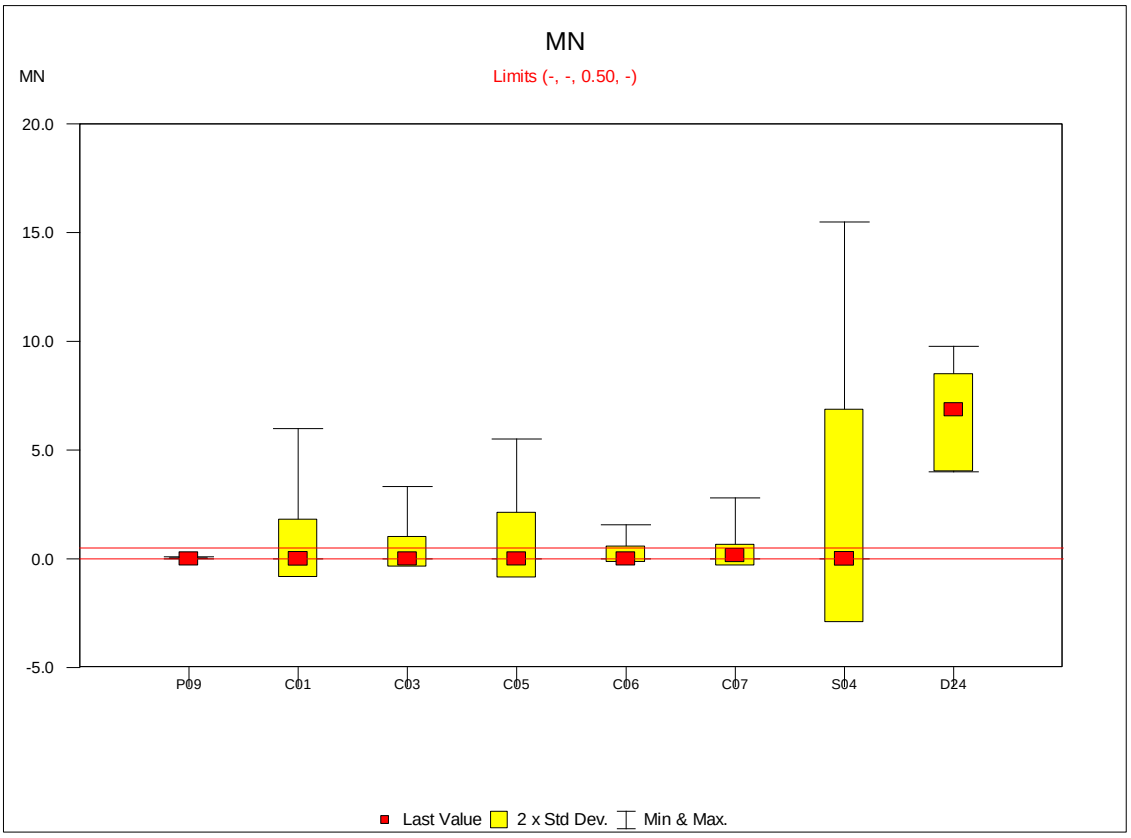
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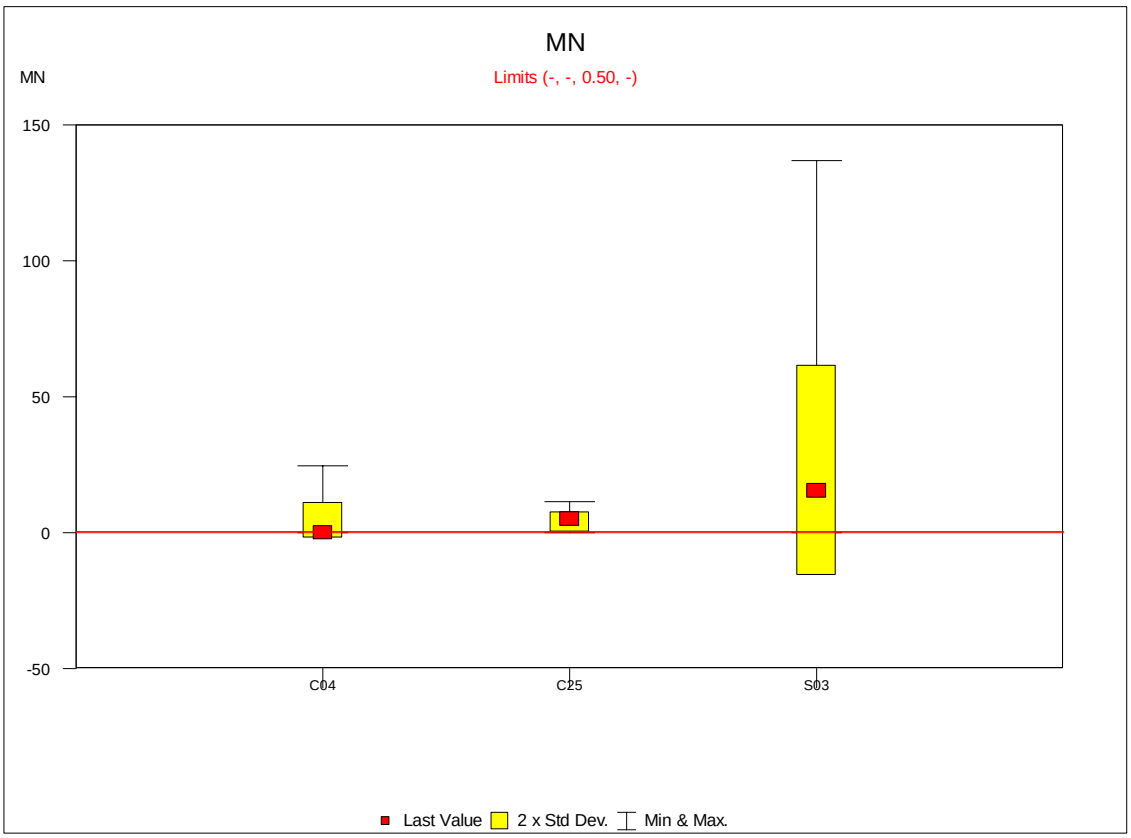
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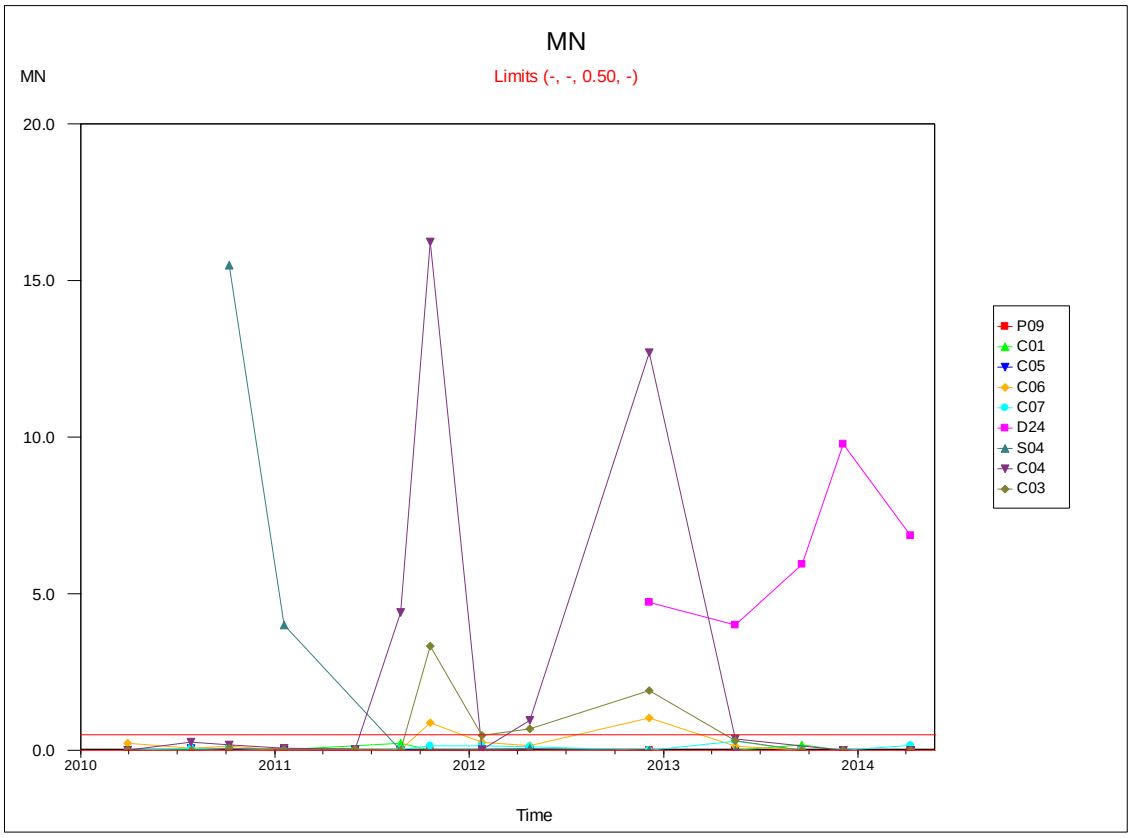
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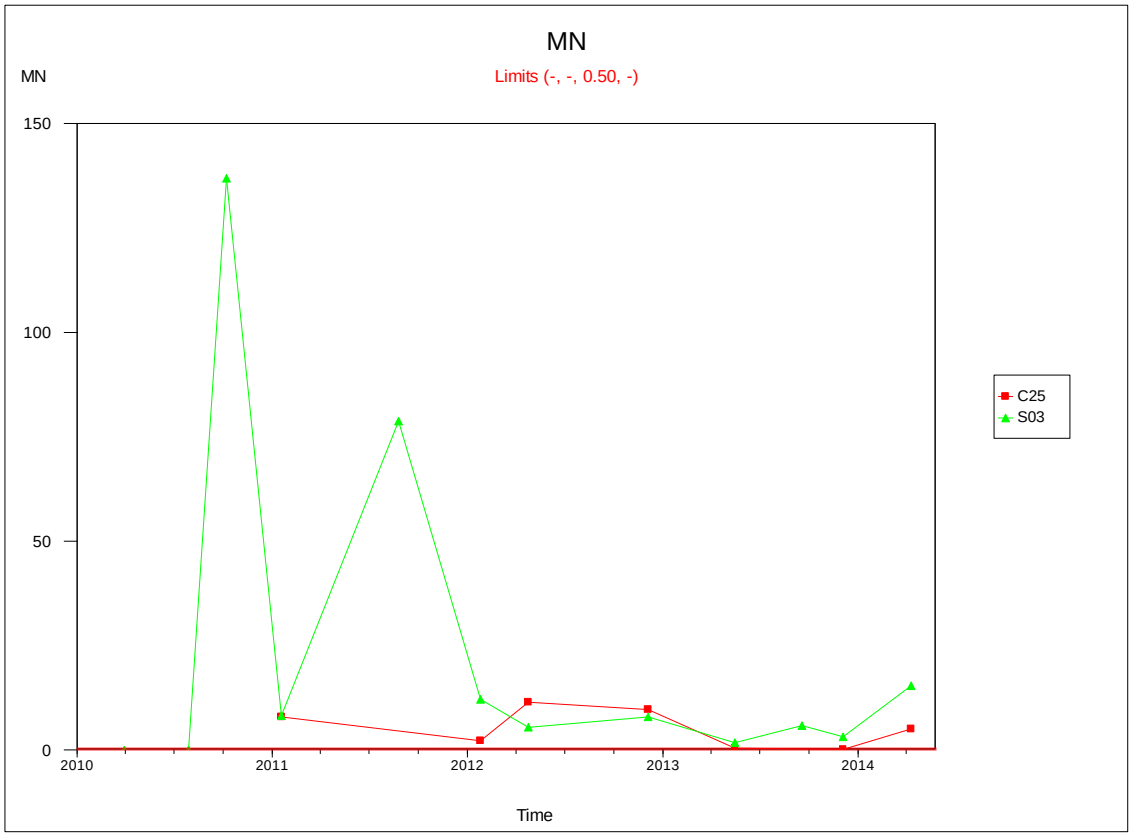
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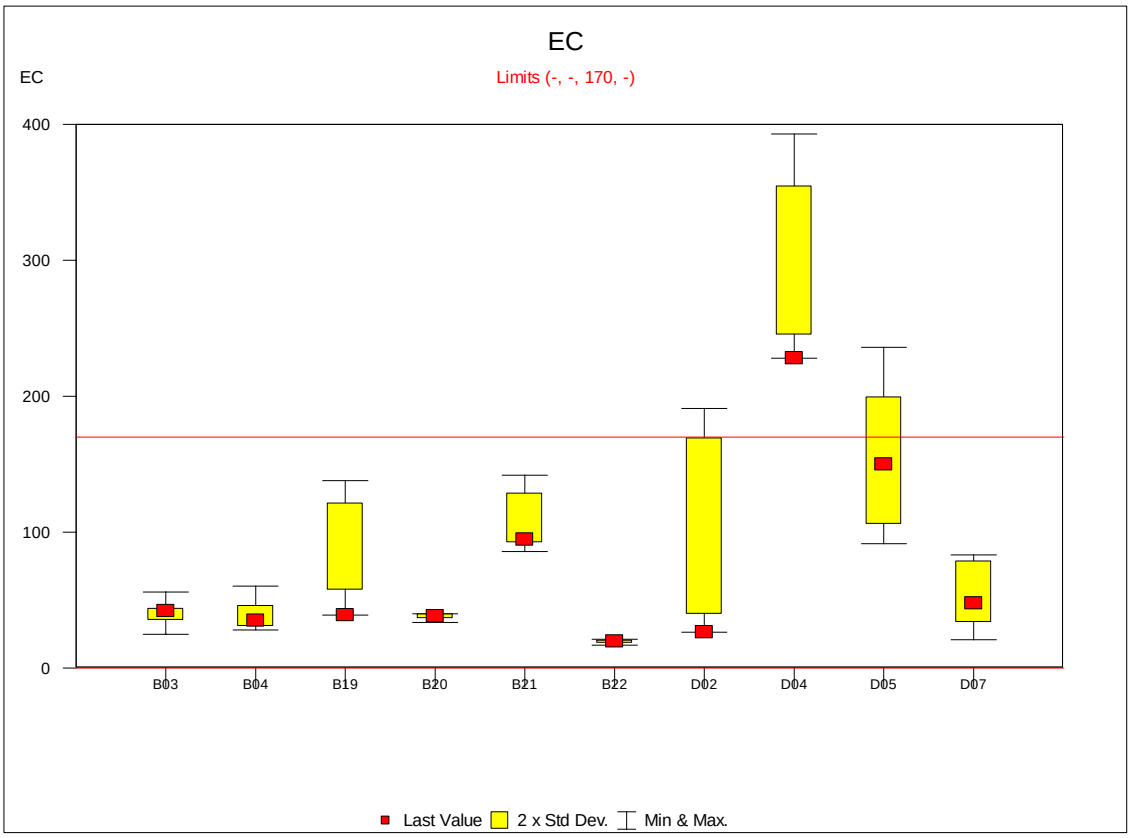
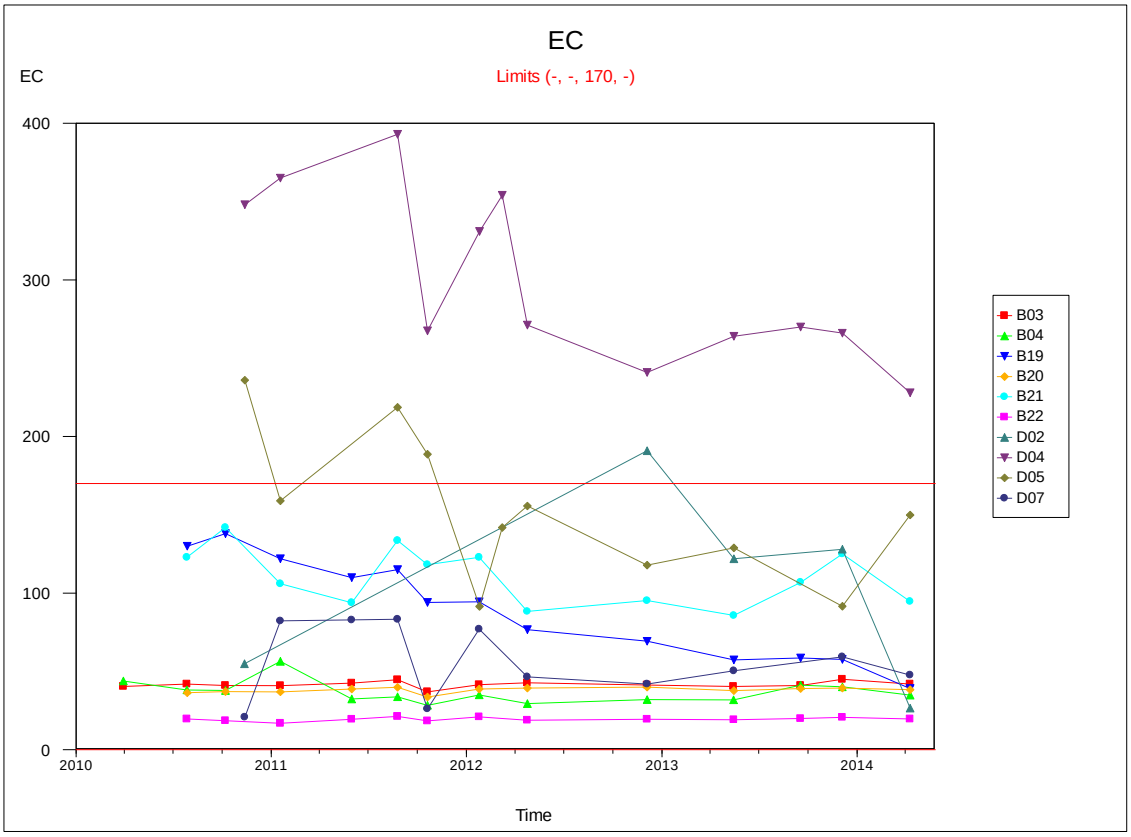
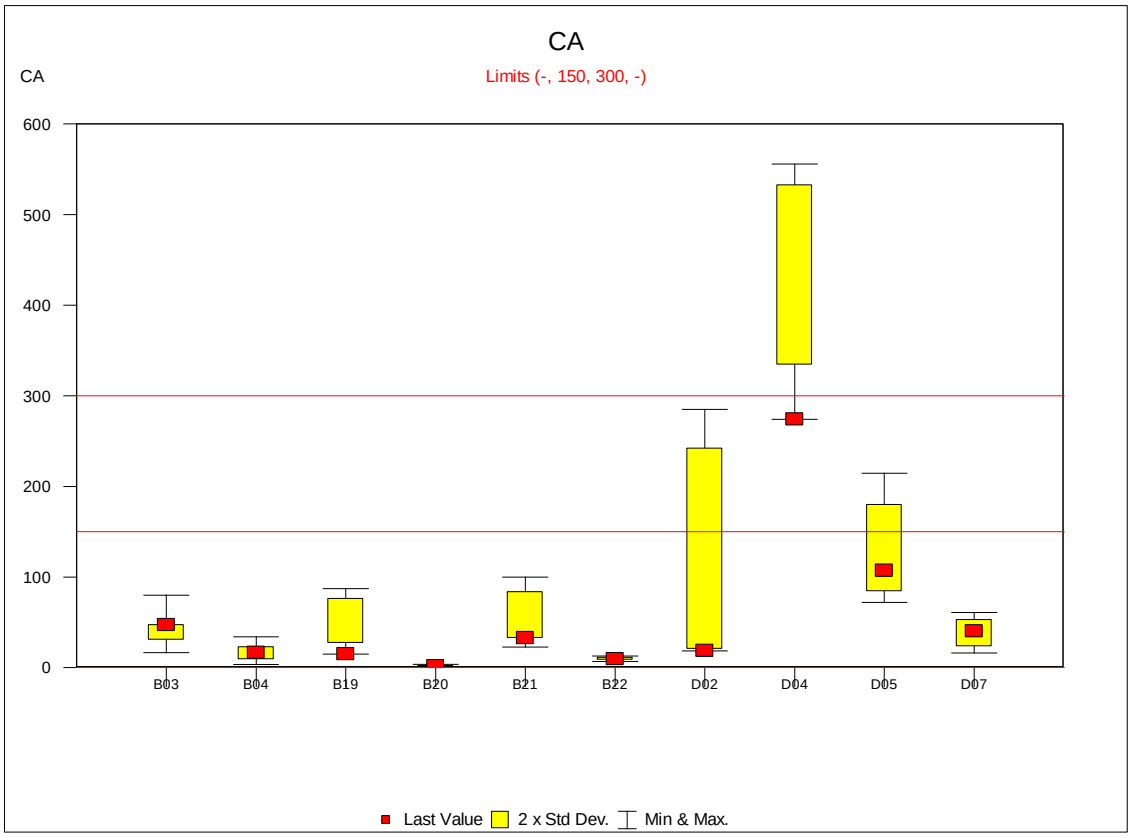
D1.2. WITPUNT SPRUIT NORTHERN TRIBUTARY - GROUNDWATER



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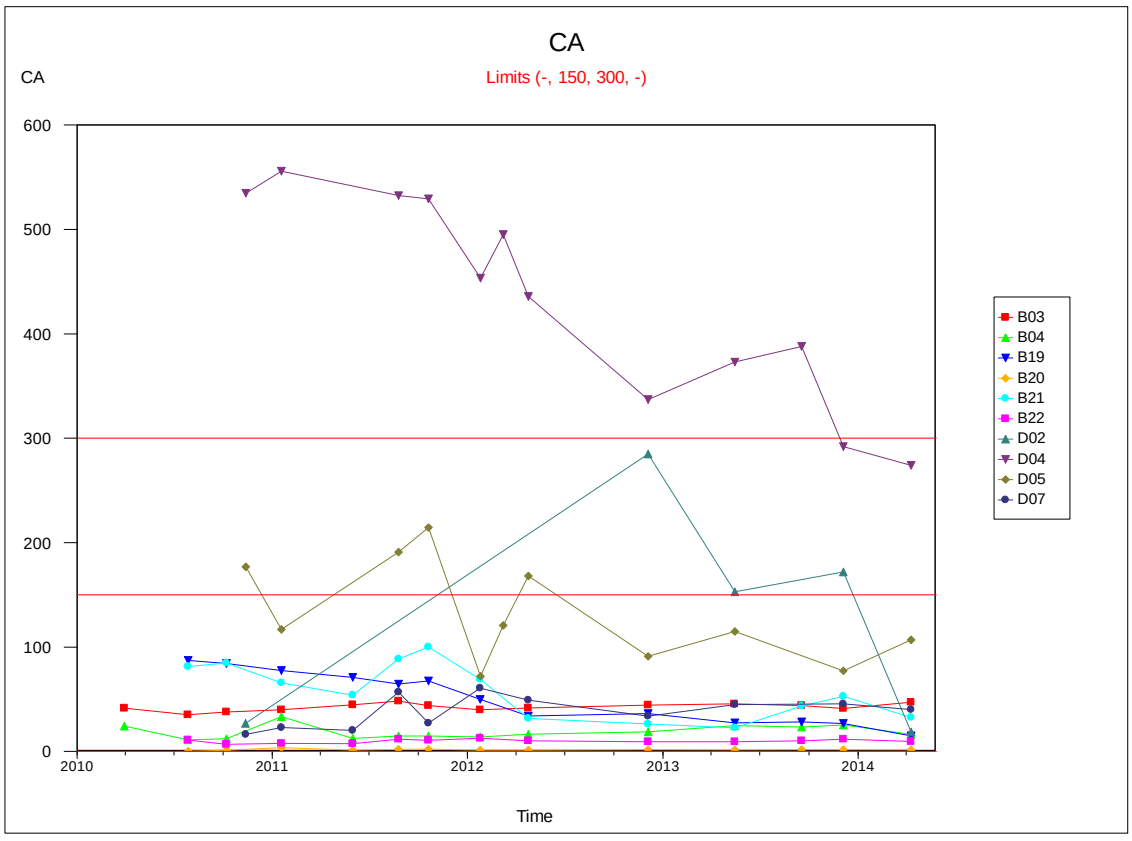
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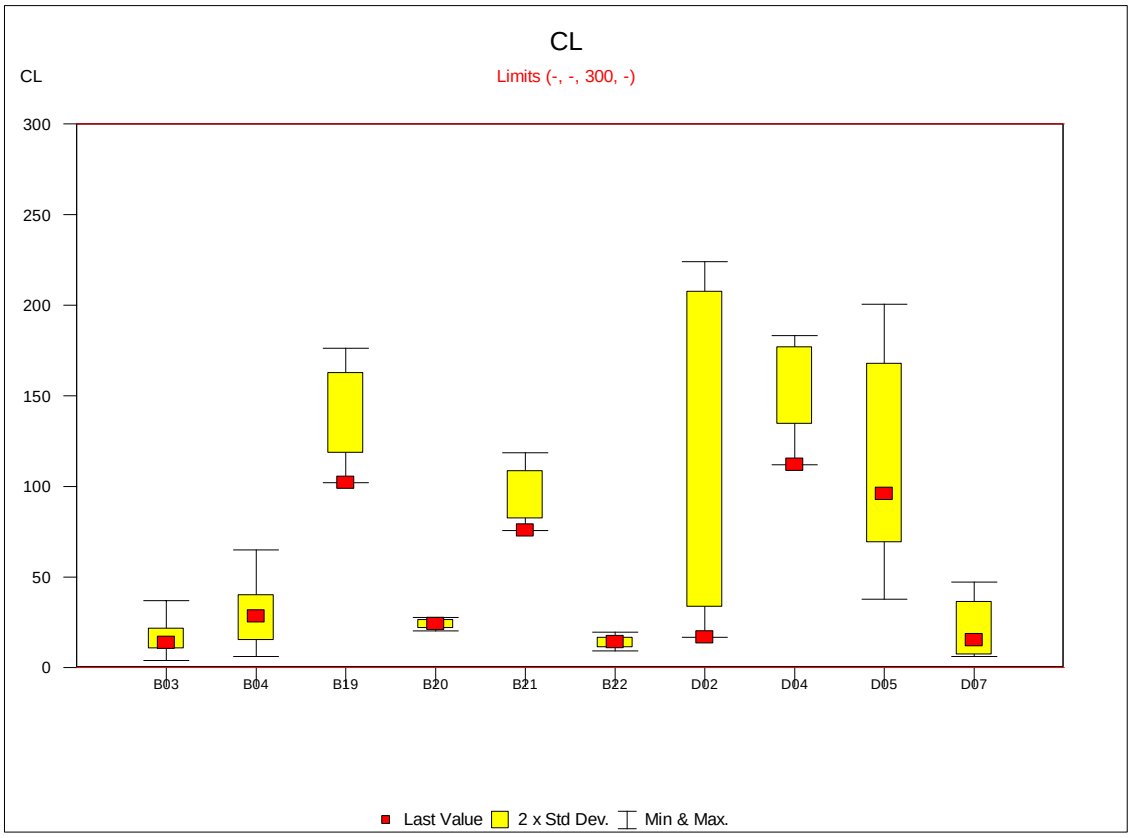
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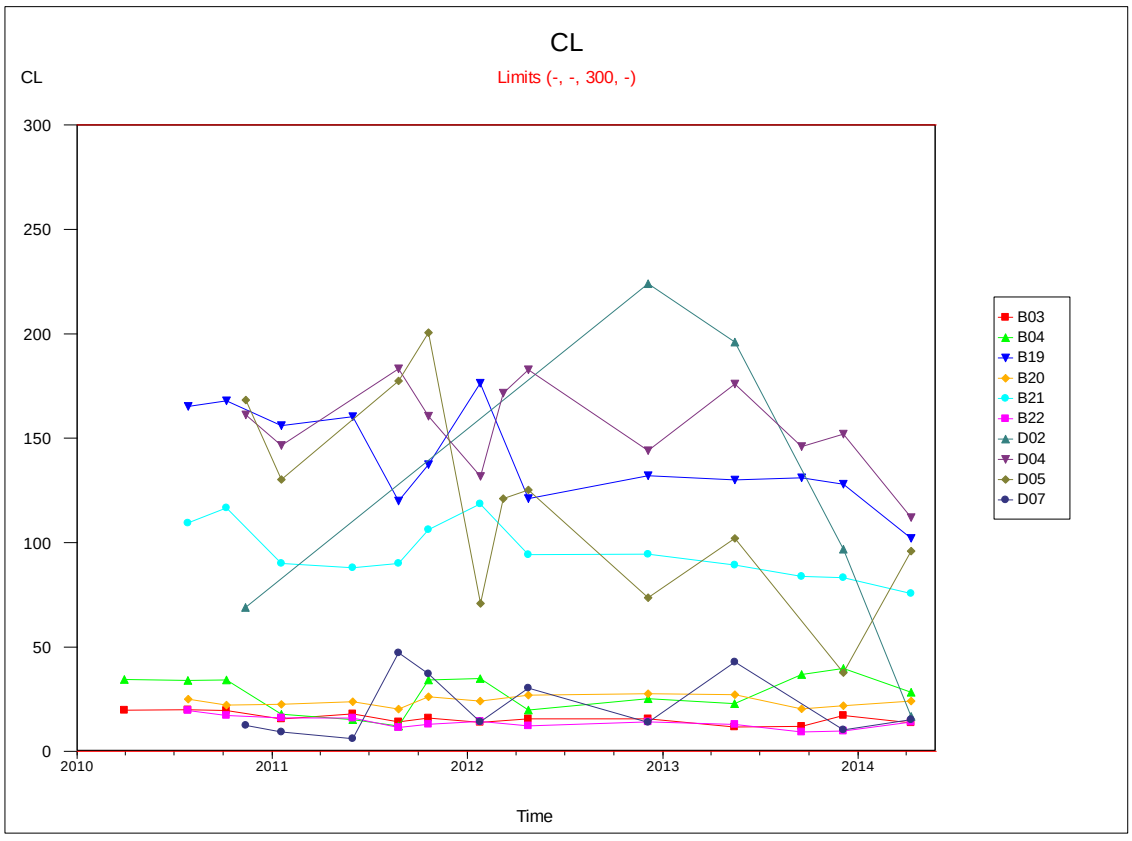
Min & Max.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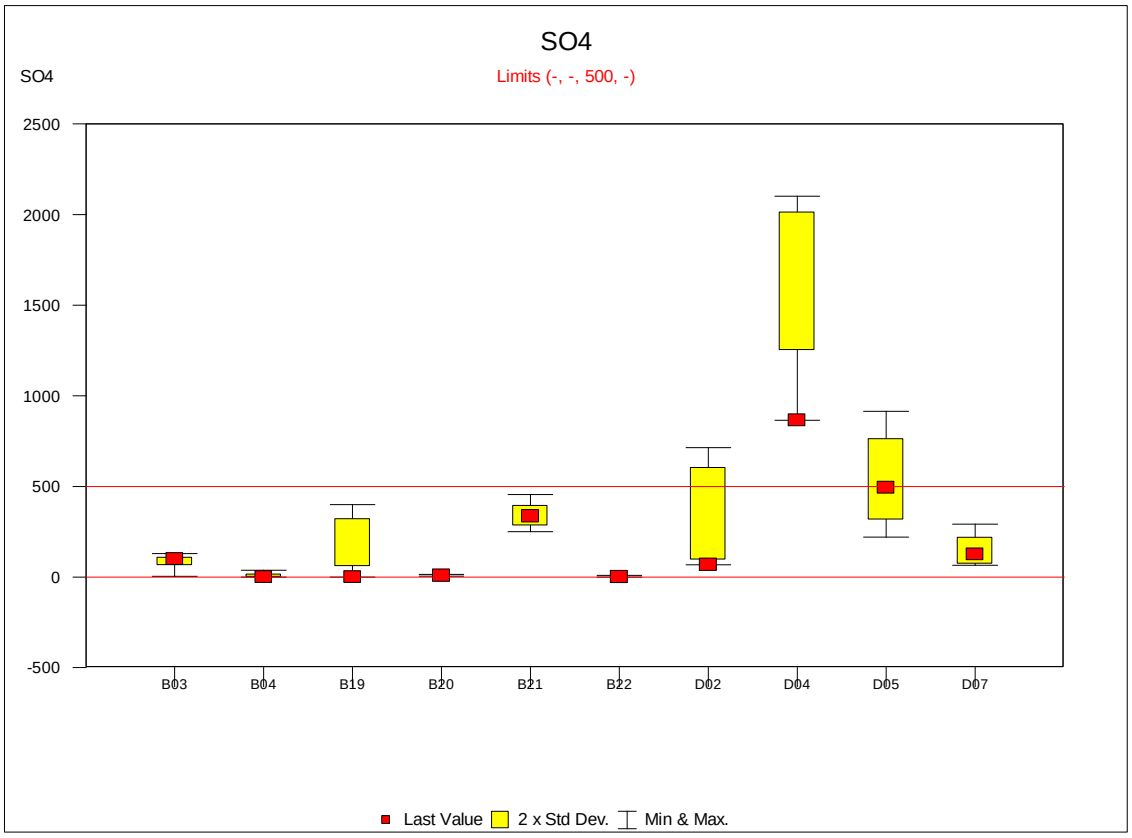
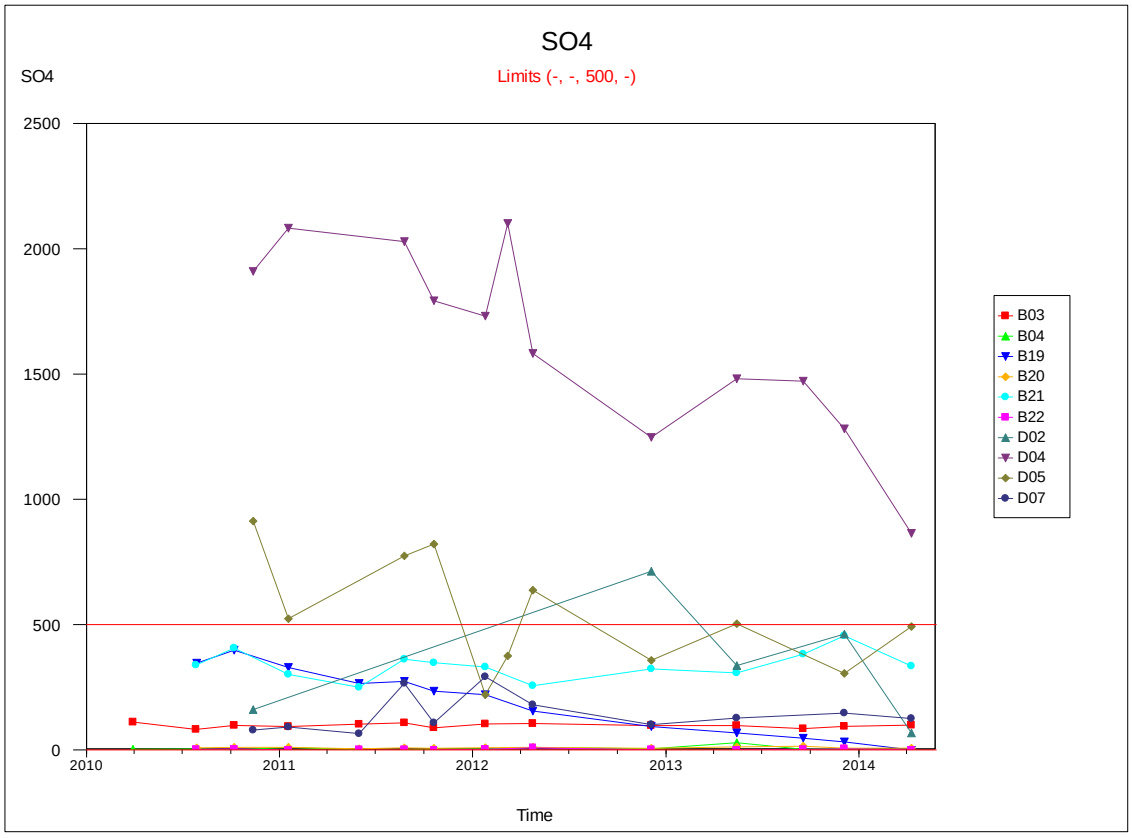
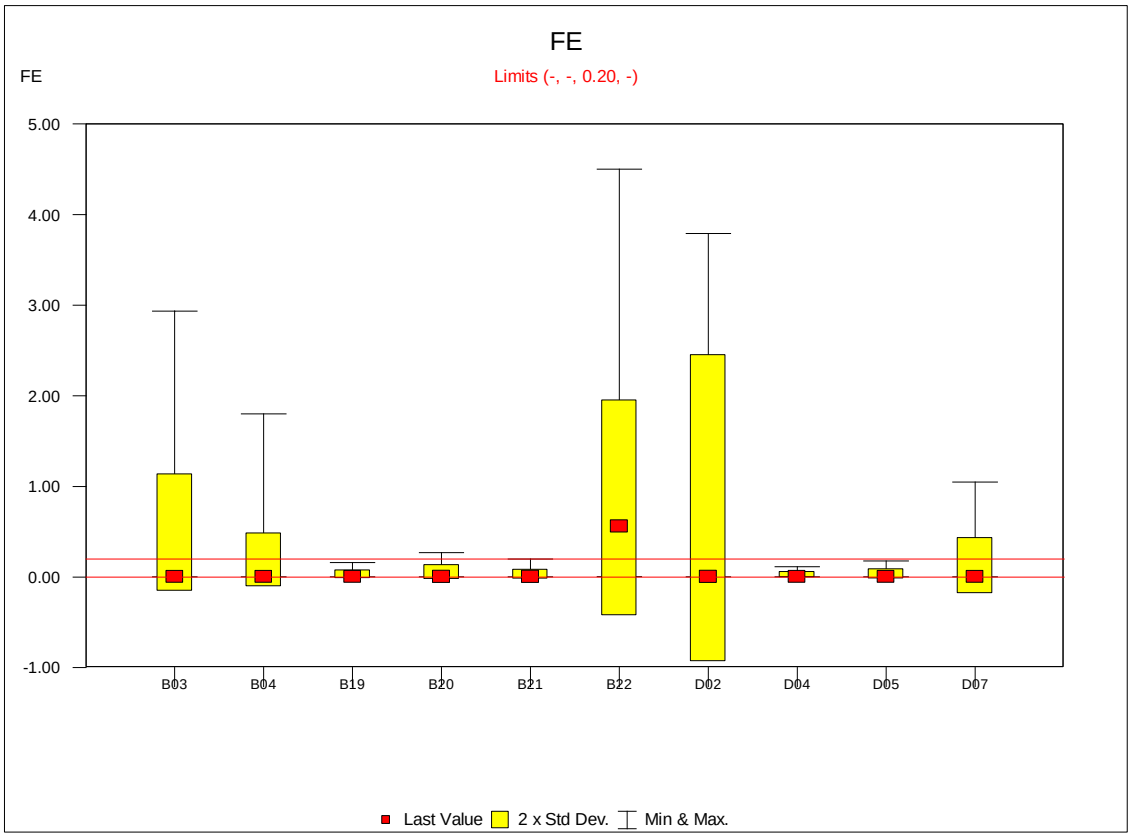
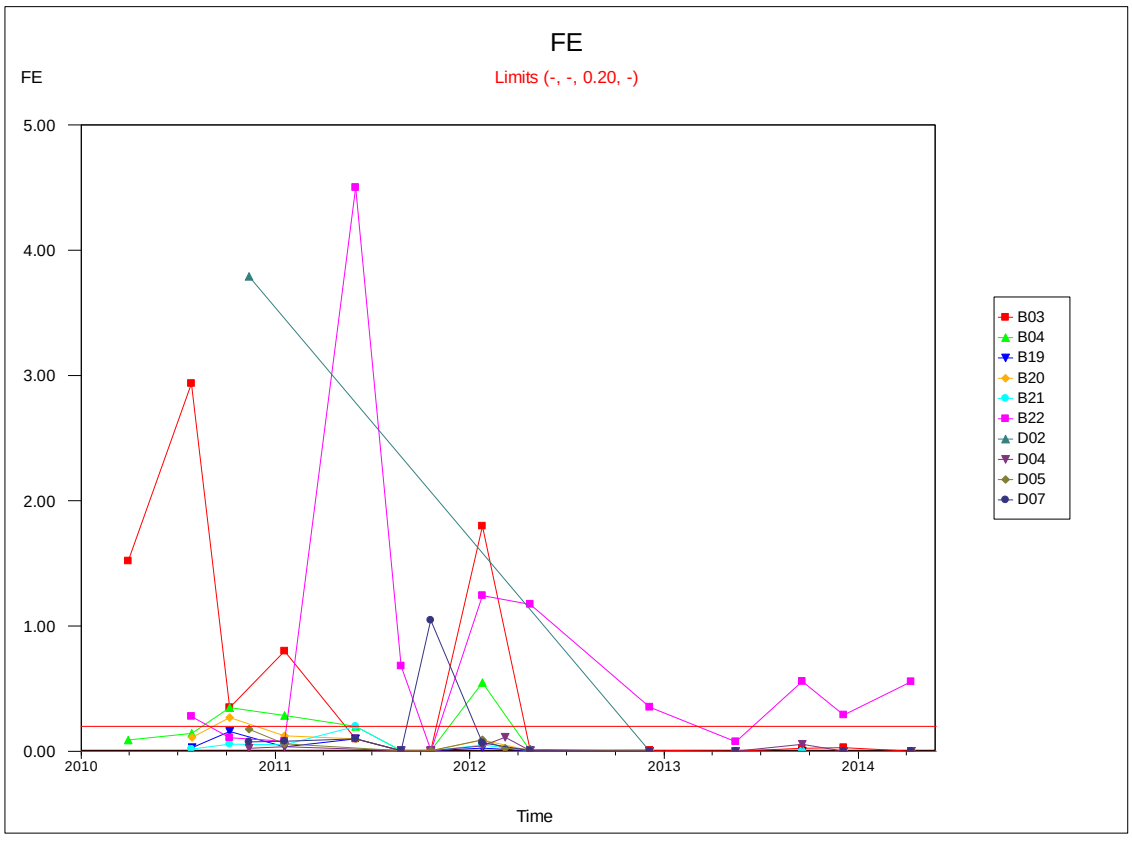
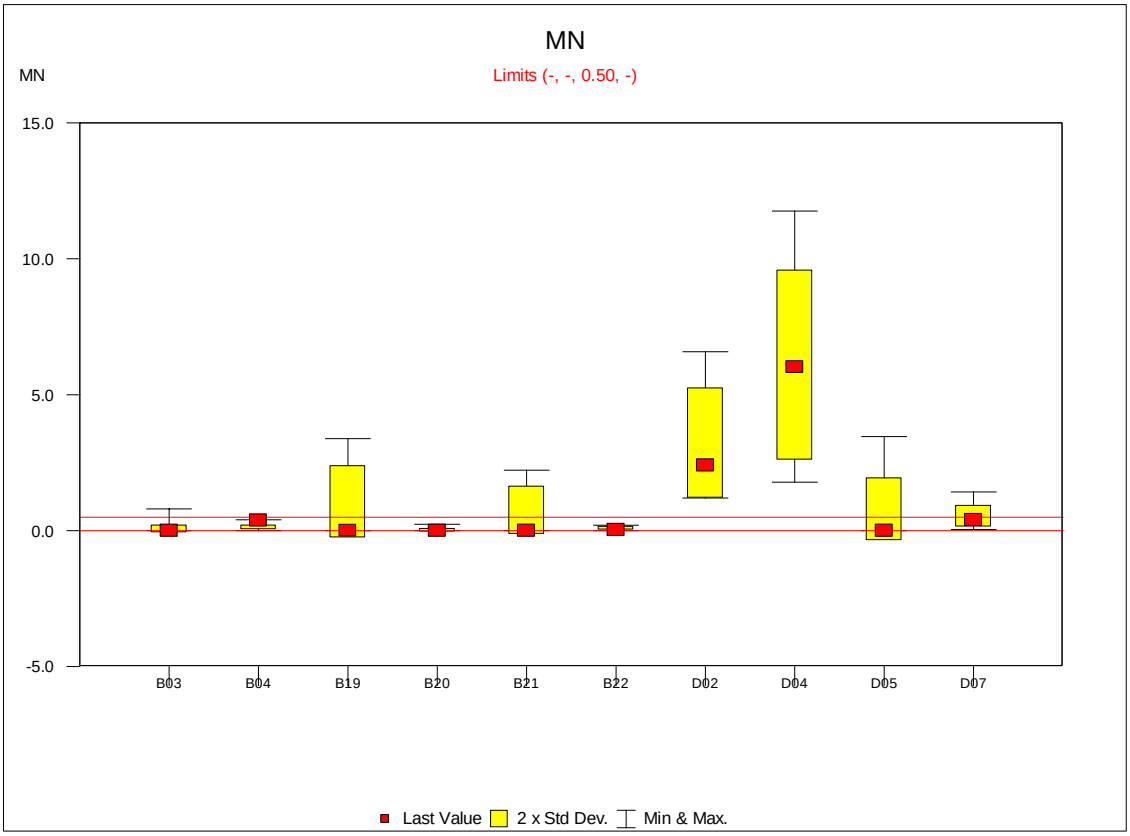
B22
D02
D04
D05
D07

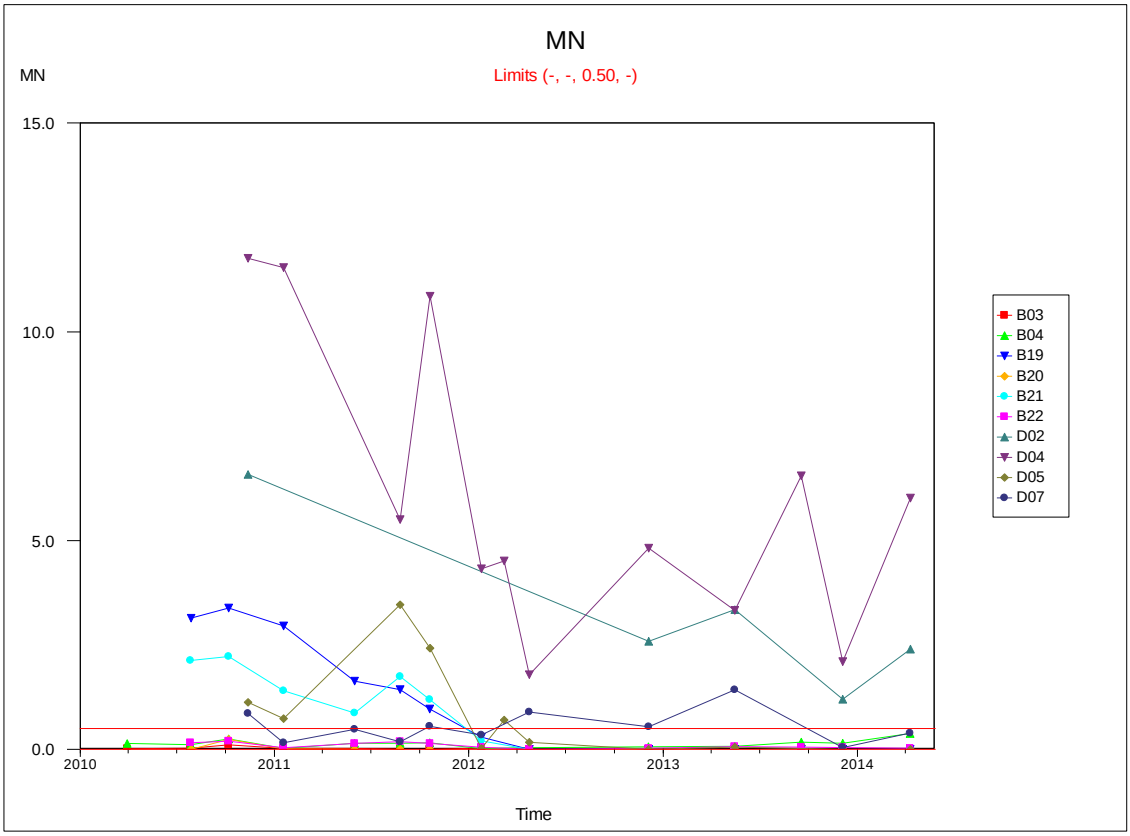

SO4
SO4
Limits (-, -, 500, -)
2500
2000
1500
1000
500
0
-500
B03
B04
B19
B20
B21
B22
D02
D04
D05
D07
Last Value
2 x Std Dev.
Min & Max.


SO4
SO4
Limits (-, -, 500, -)
2500
2000
1500
1000
500
0
2010
2011
2012
2013
2014
Time
B03
B04
B19
B20
B21
B22
D02
D04
D05
D07


FE
FE
Limits (-, -, 0.20, -)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
B03
B04
B19
B20
B21
B22
D02
D04
D05
D07
Last Value
2 x Std Dev.
Min & Max.

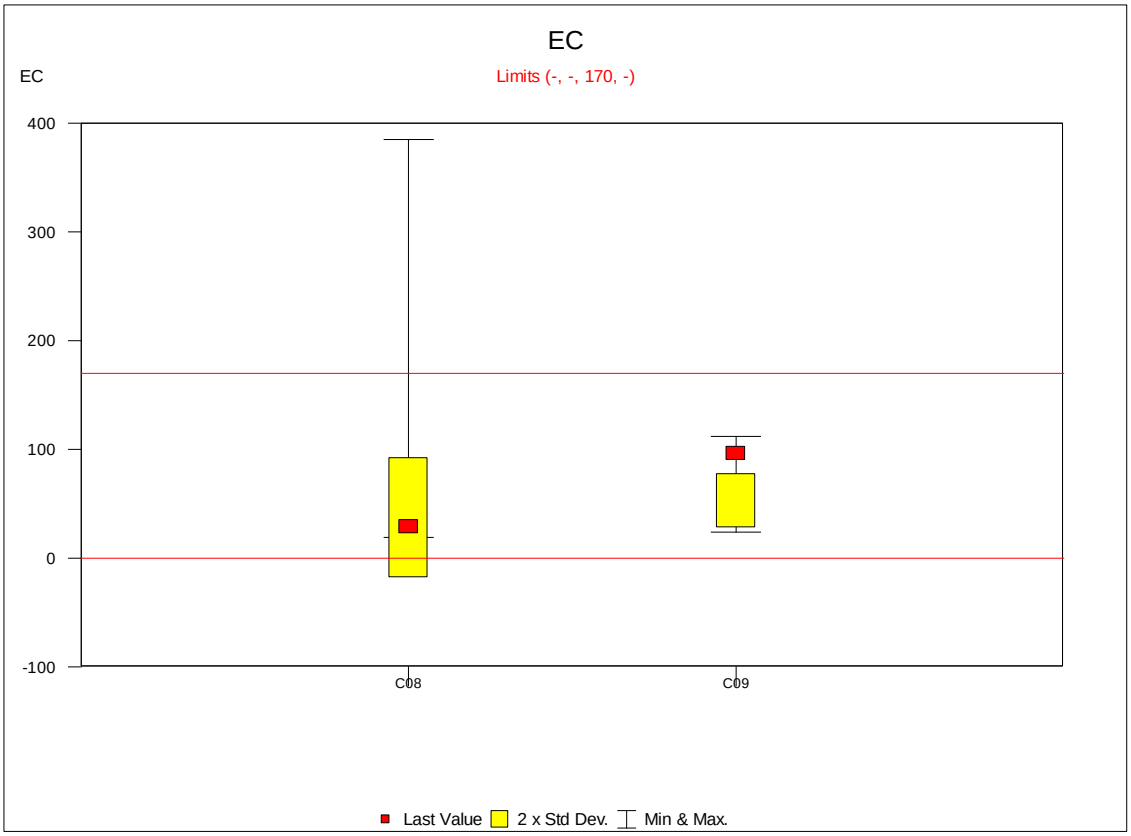

FE
FE
Limits (-, -, 0.20, -)
5.00
4.00
3.00
2.00
1.00
0.00
2010
2011
2012
2013
2014
Time
B03
B04
B19
B20
B21
B22
D02
D04
D05
D07

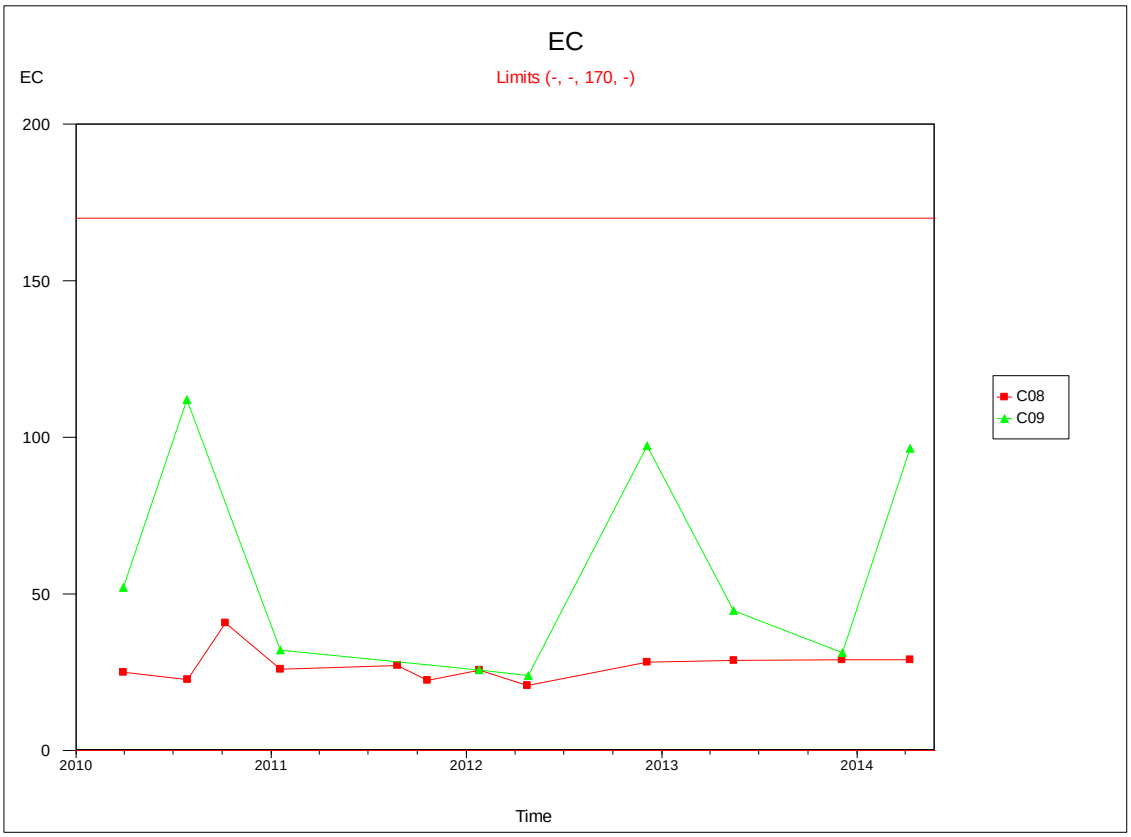

MN
MN
Limits (-, -, 0.50, -)
15.0
10.0
5.0
0.0
-5.0
B03
B04
B19
B20
B21
B22
D02
D04
D05
D07
Last Value
2 x Std Dev.
Min & Max.

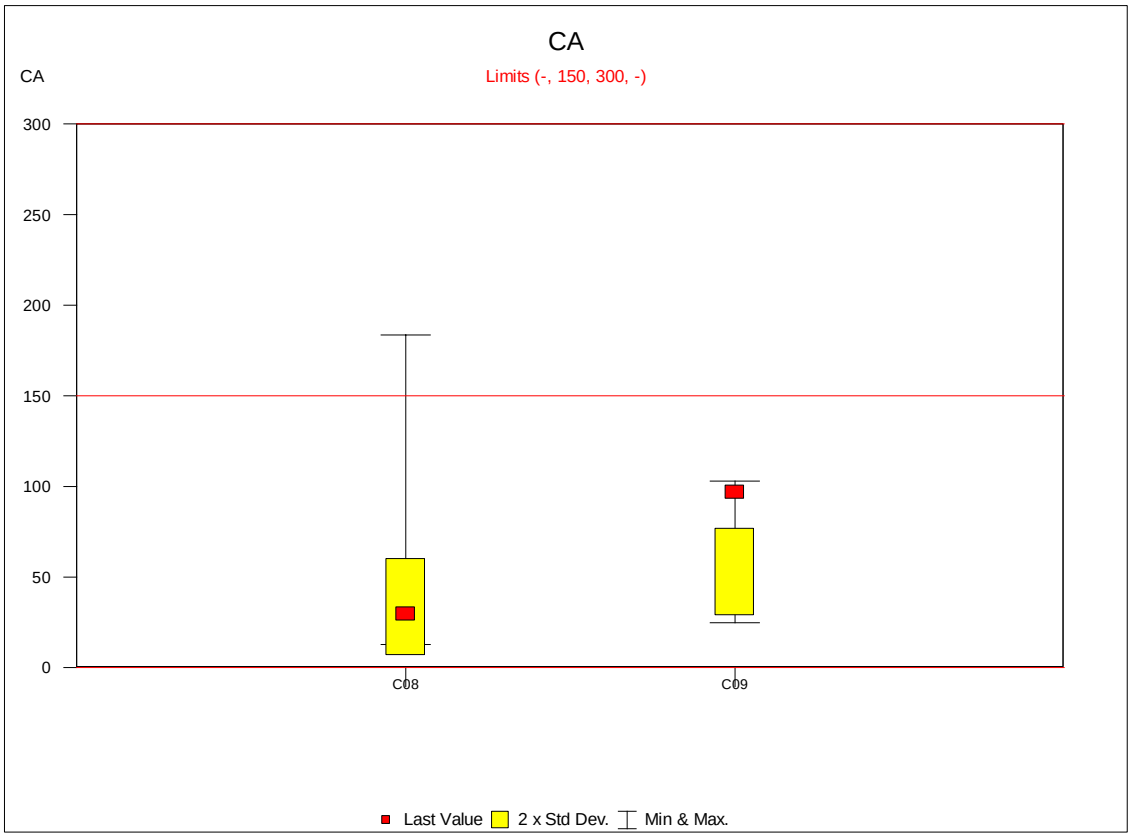

MN
MN
Limits (-, -, 0.50, -)
15.0
10.0
5.0
0.0
2010
2011
2012
2013
2014
Time
B03
B04
B19
B20
B21
B22
D02
D04
D05
D07

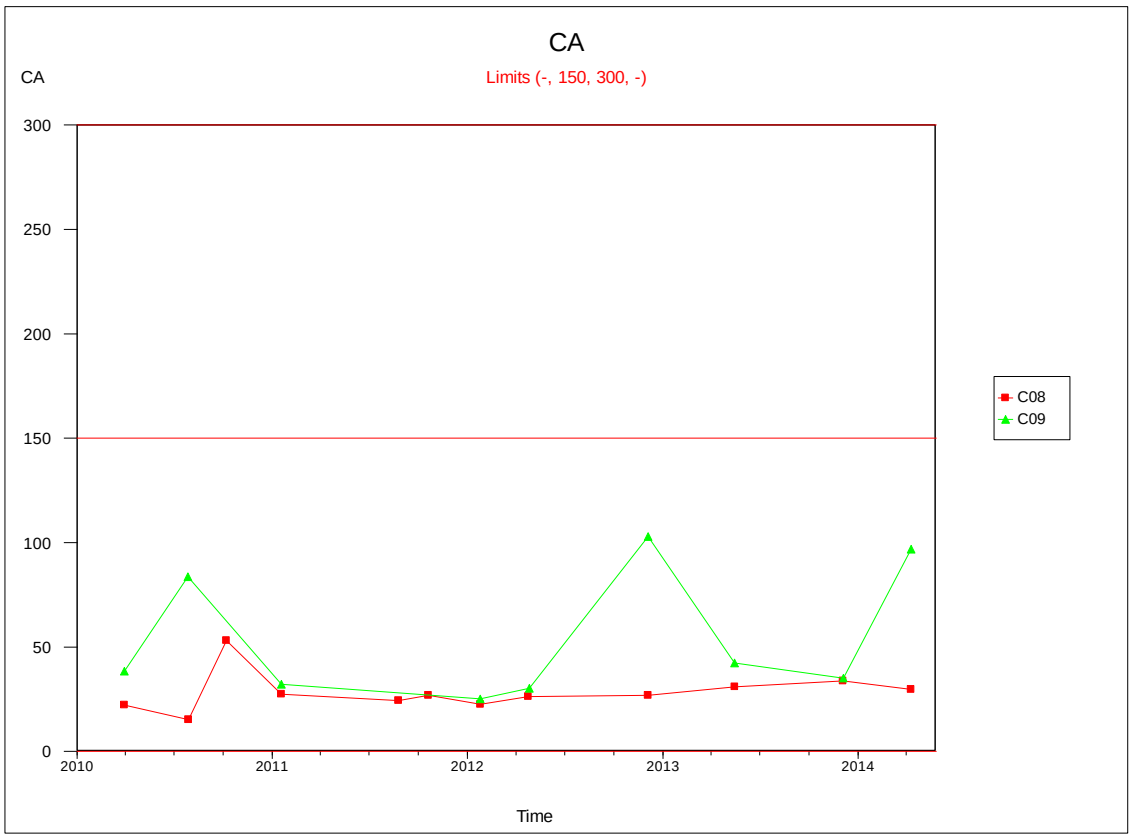
D2. SUB DRAINAGE SYSTEM 2: WITPUNT SPRUIT CENTRAL TRIBUTARY

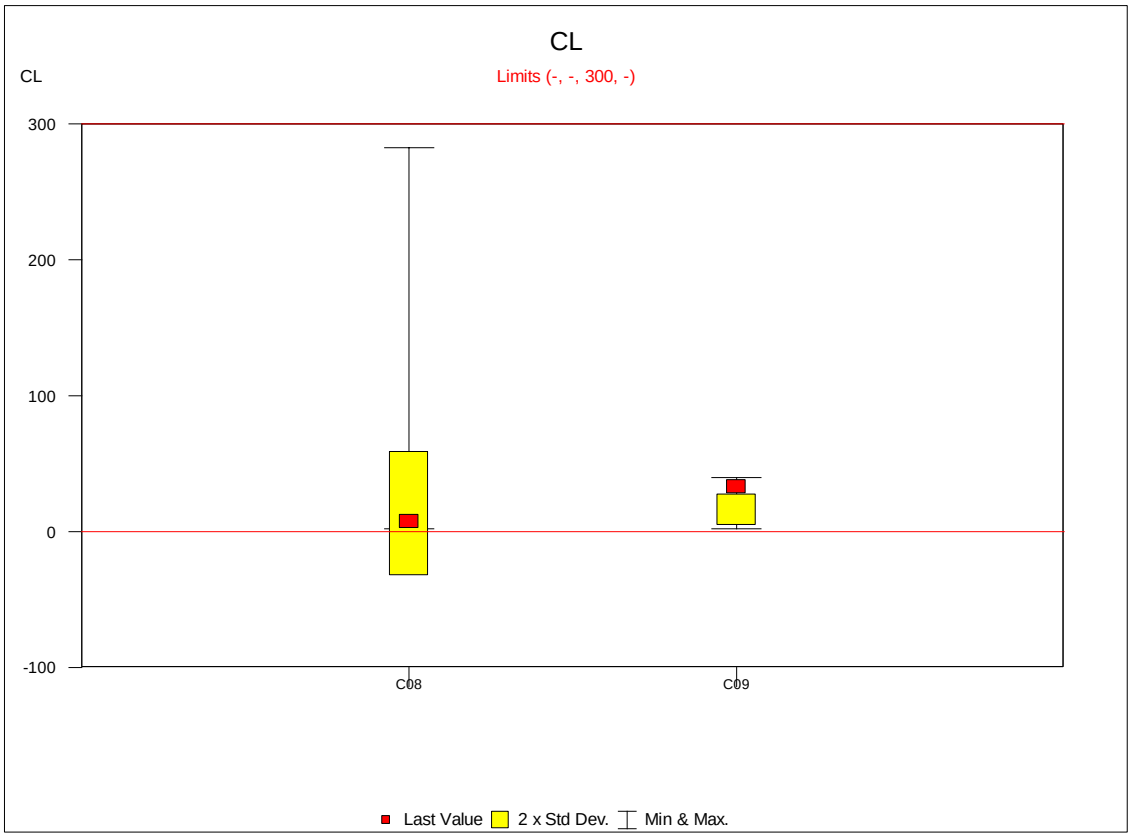
D2.1. WITPUNT SPRUIT CENTRAL TRIBUTARY - SURFACE WATER

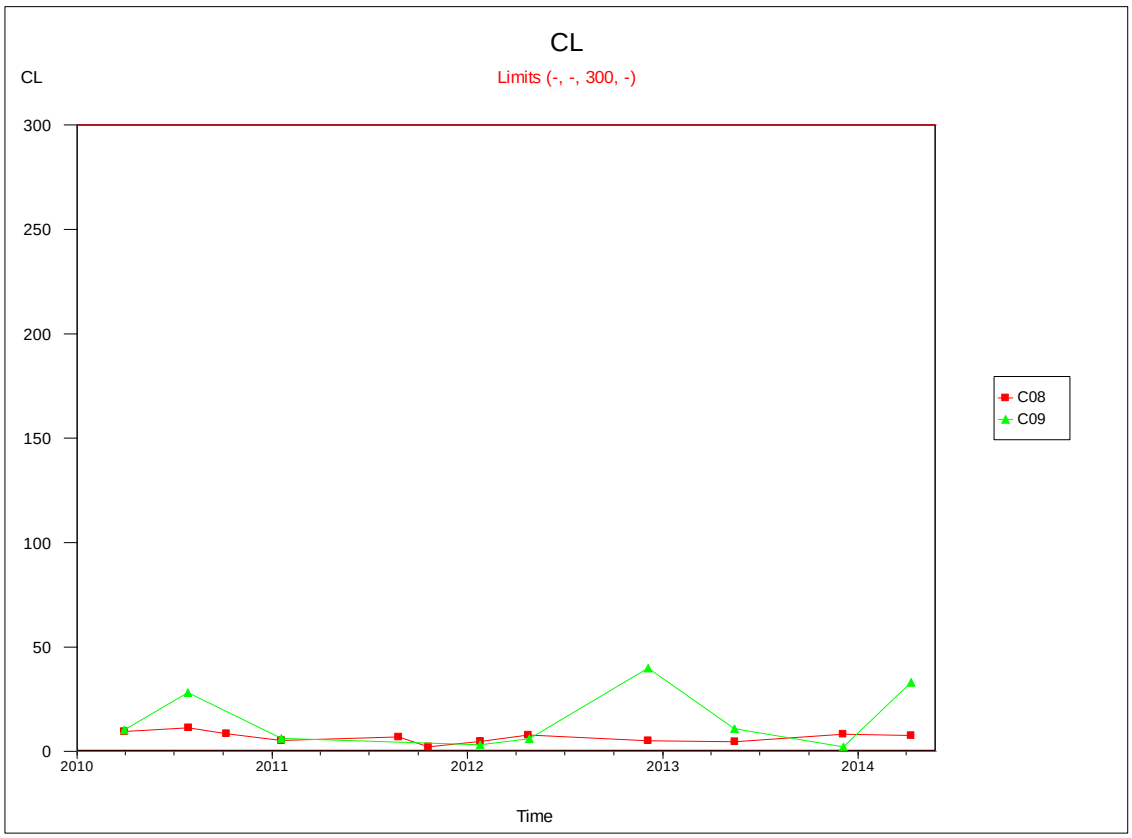


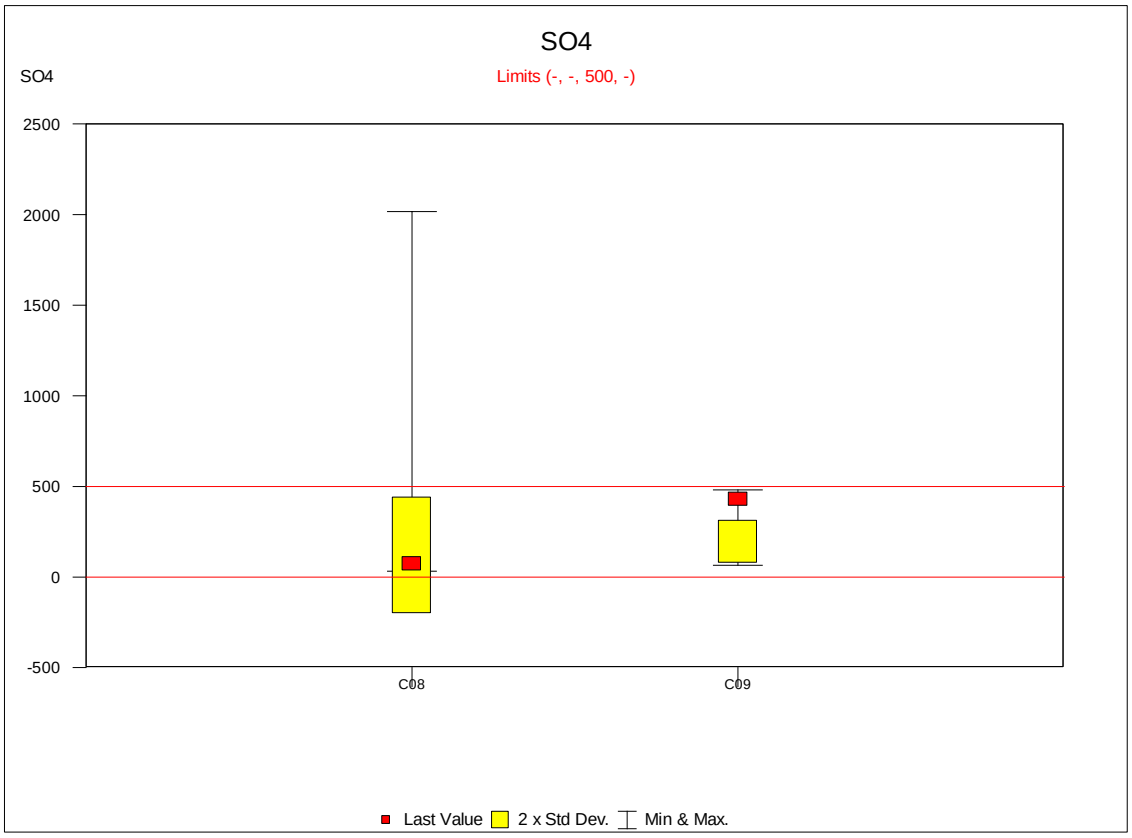


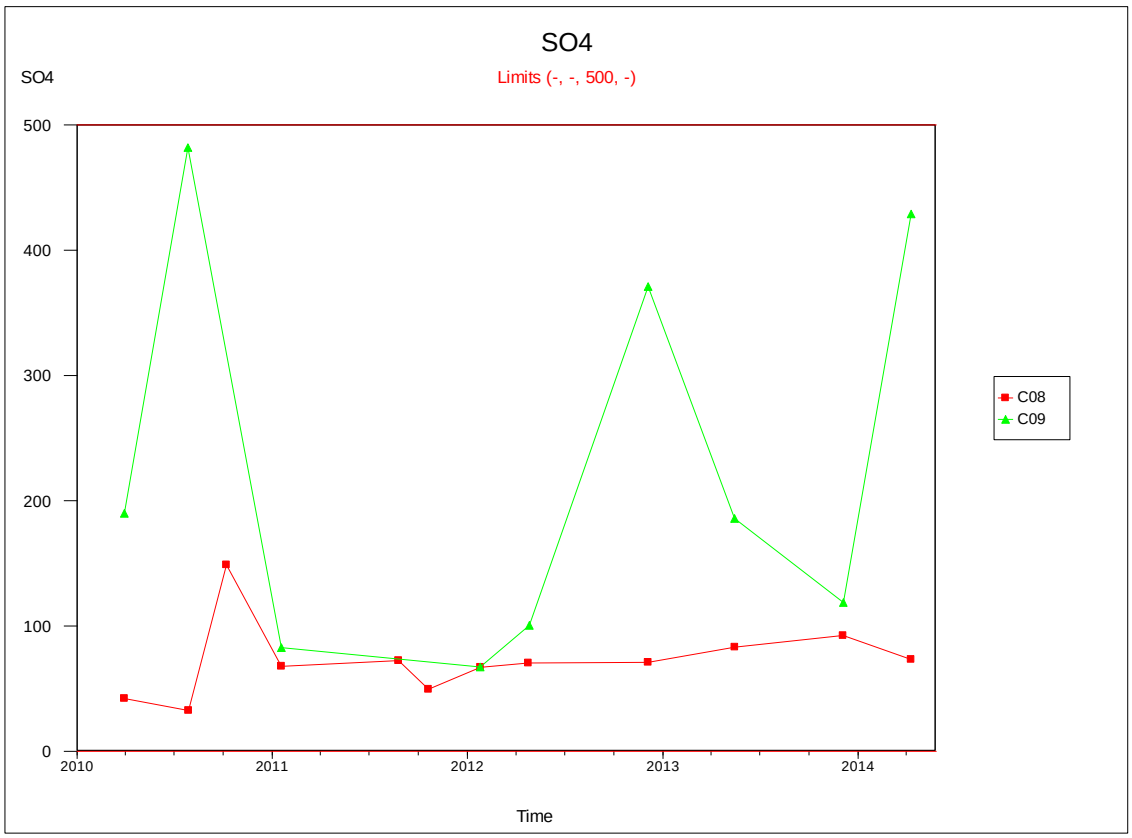

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
C08
C09
Last Value
2 x Std Dev.
Min & Max.

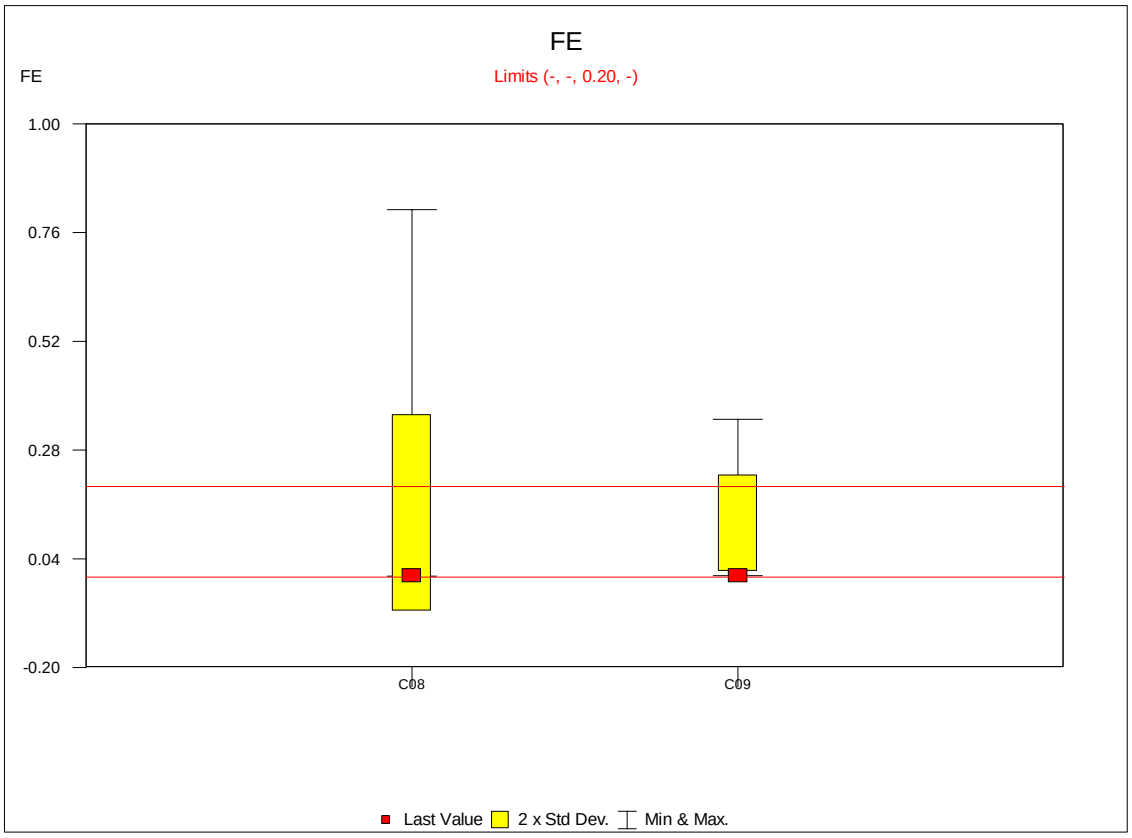

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
C08
C09

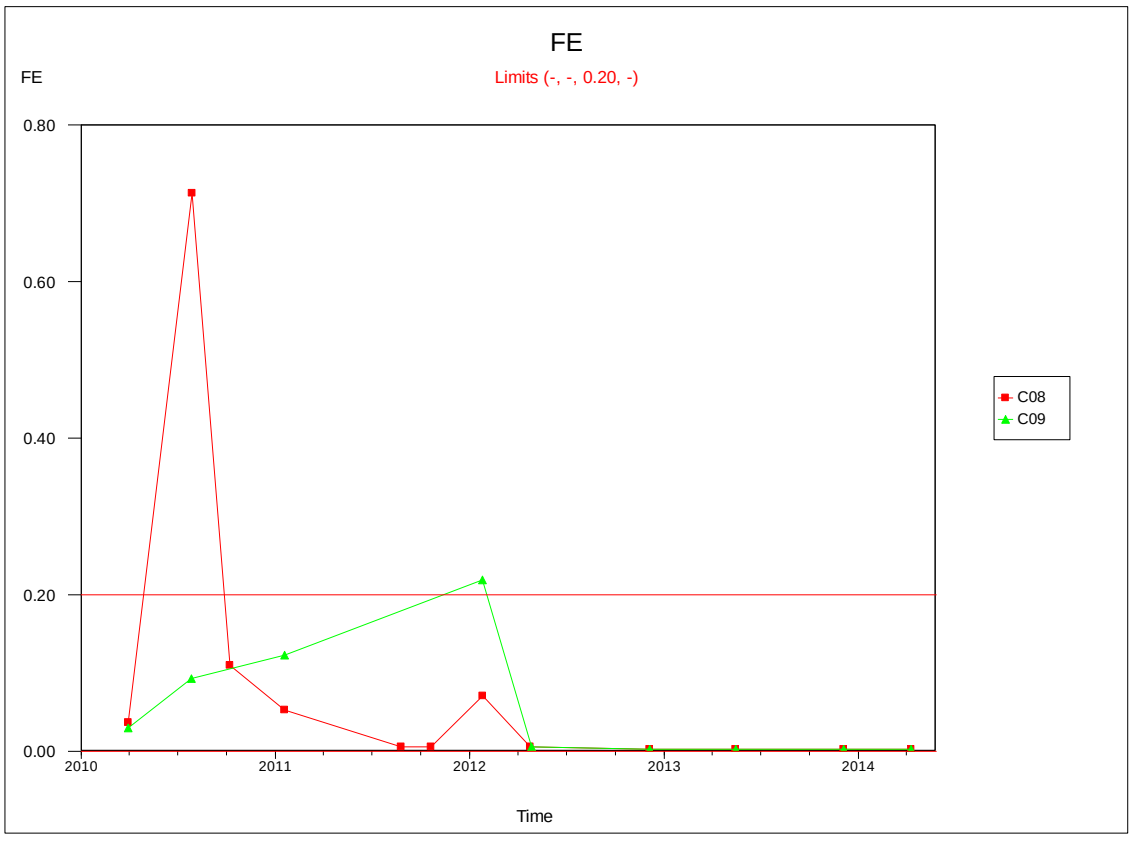

CL
CL
Limits (-, -, 300, -)
300
200
100
0
-100
C08
C09
Last Value
2 x Std Dev.
Min & Max.

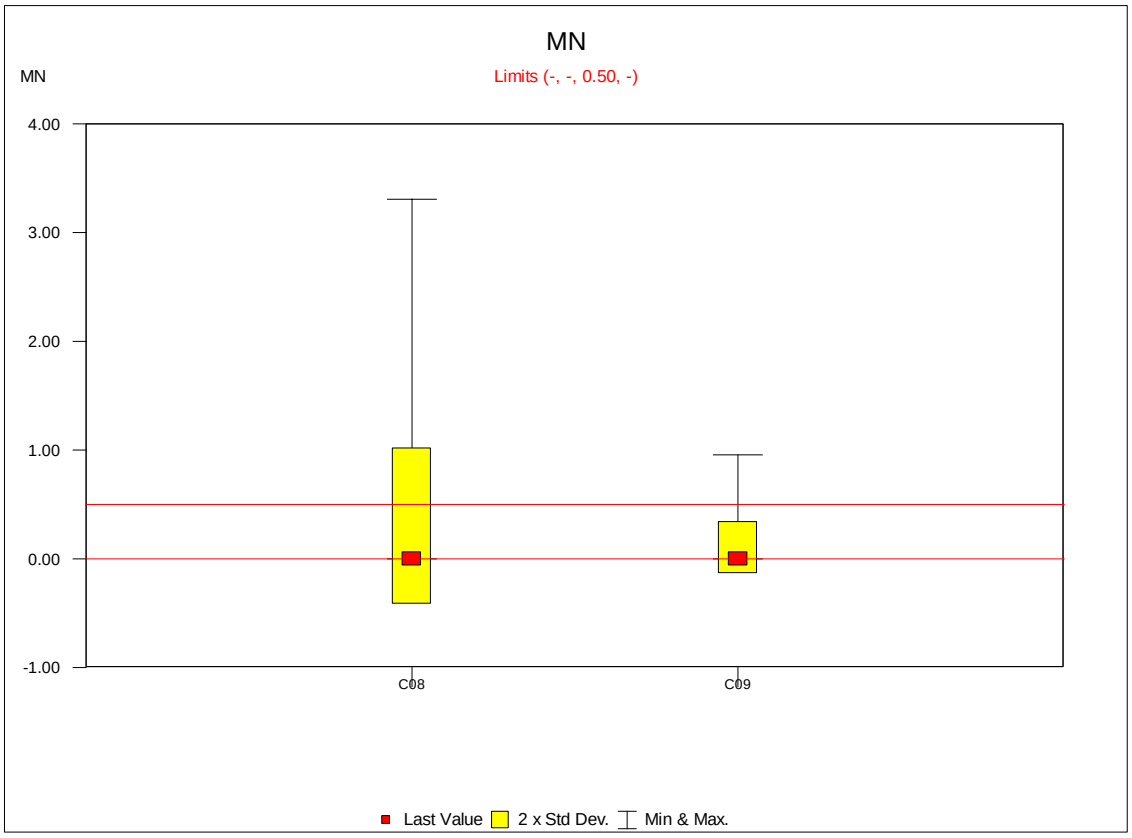

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
C08
C09

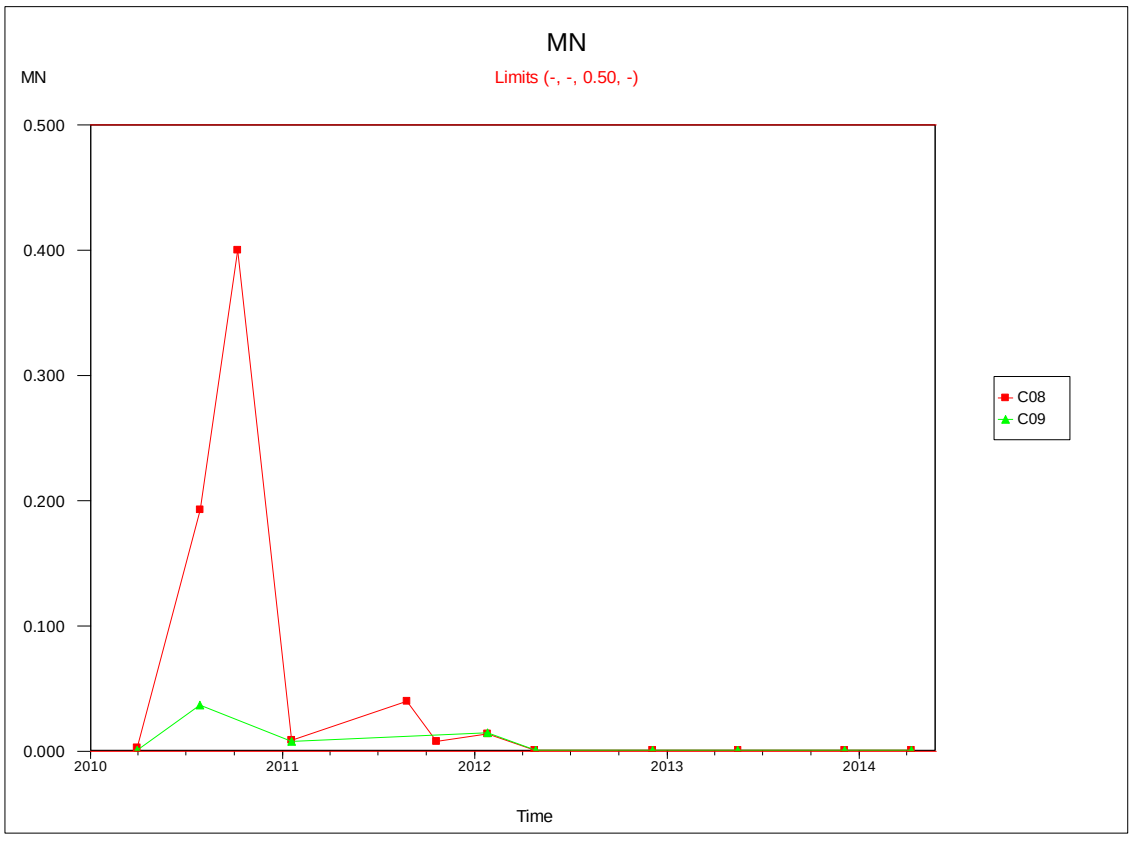

SO4
SO4
Limits (-, -, 500, -)
2500
2000
1500
1000
500
0
-500
C08
C09
Last Value
2 x Std Dev.
Min & Max.


SO4
SO4
Limits (-, -, 500, -)
500
400
300
200
100
0
2010
2011
2012
2013
2014
Time
C08
C09

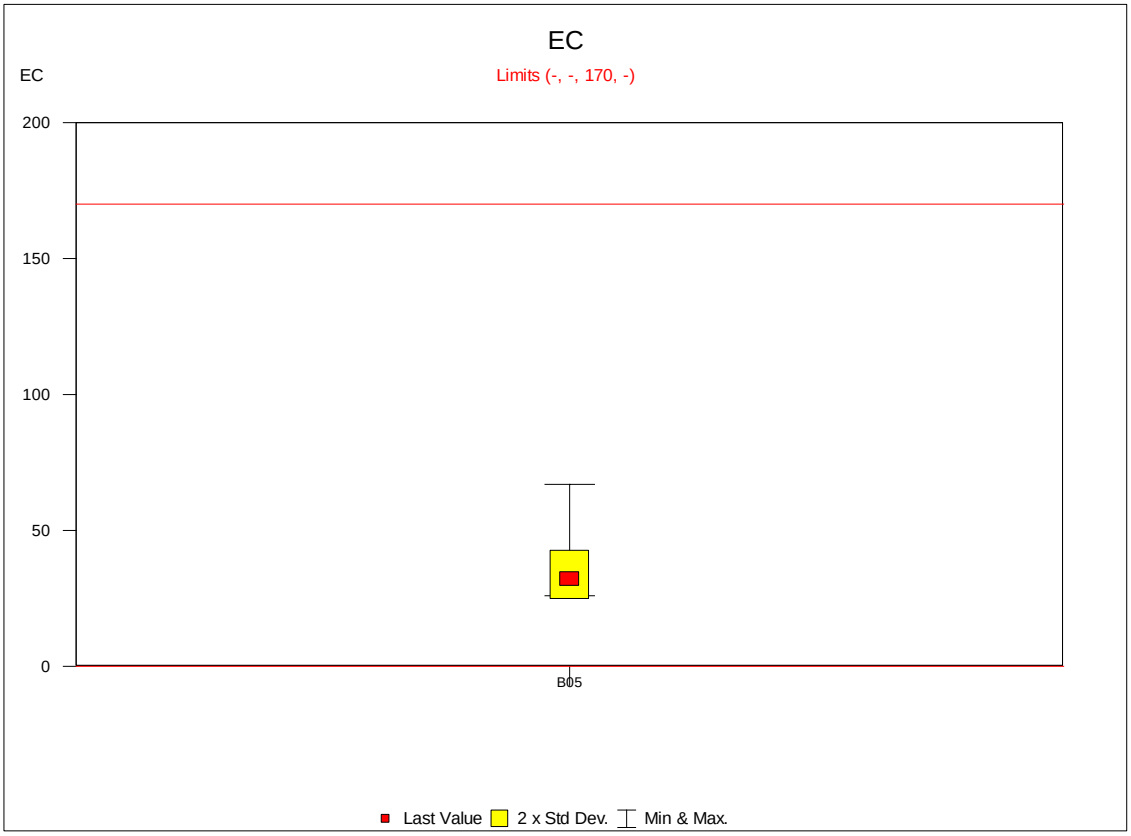

FE
FE
Limits (-, -, 0.20, -)
1.00
0.76
0.52
0.28
0.04
-0.20
C08
C09
Last Value
2 x Std Dev.
Min & Max.

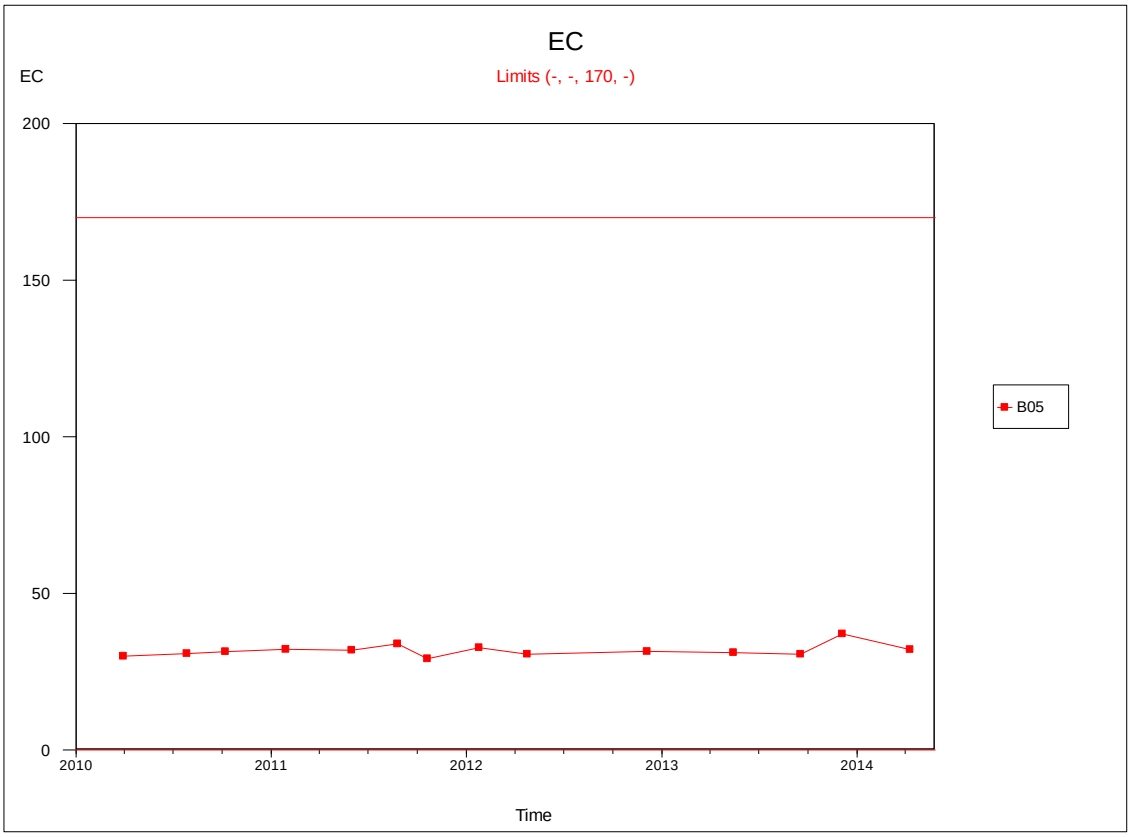

FE
FE
Limits (-, -, 0.20, -)
0.80
0.60
0.40
0.20
0.00
2010
2011
2012
2013
2014
Time
C08
C09

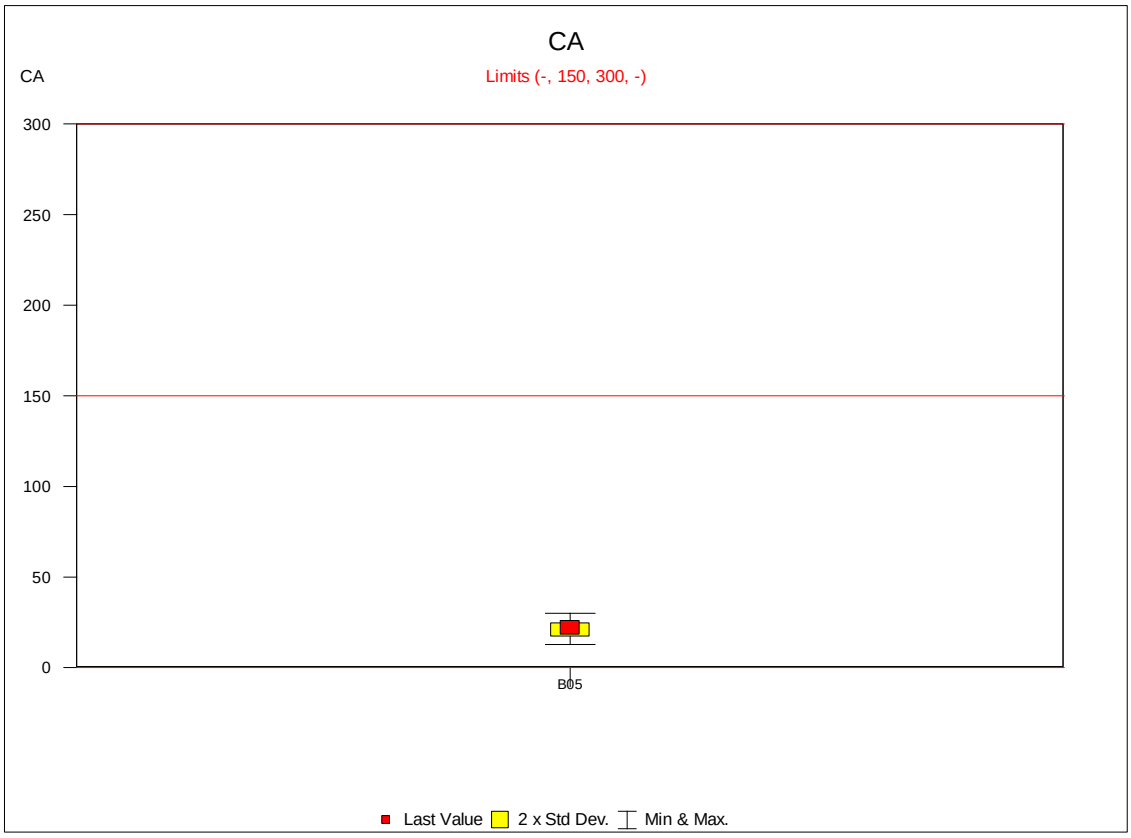

MN
MN
Limits (-, -, 0.50, -)
4.00
3.00
2.00
1.00
0.00
-1.00
C08
C09
Last Value
2 x Std Dev.
Min & Max.

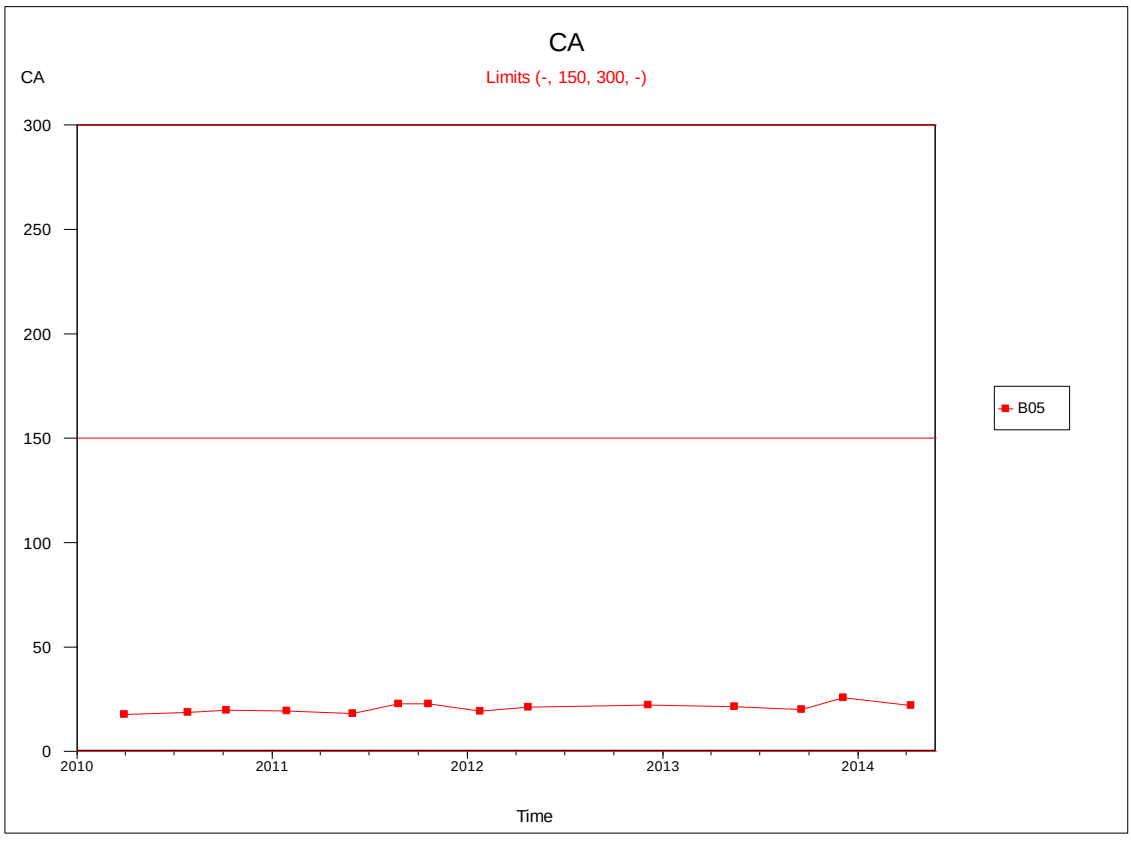

MN
MN
Limits (-, -, 0.50, -)
0.500
0.400
0.300
0.200
0.100
0.000
2010
2011
2012
2013
2014
Time
C08
C09

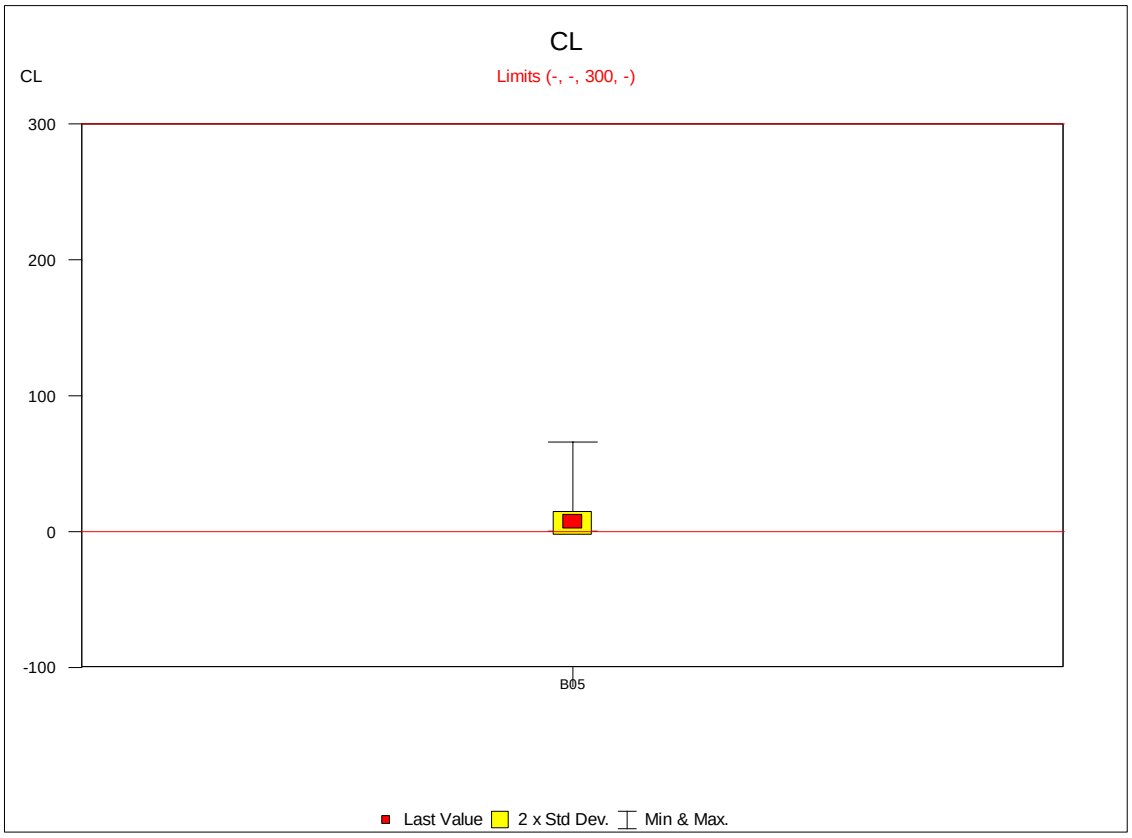
D2.2. WITPUNT SPRUIT CENTRAL TRIBUTARY - GROUNDWATER

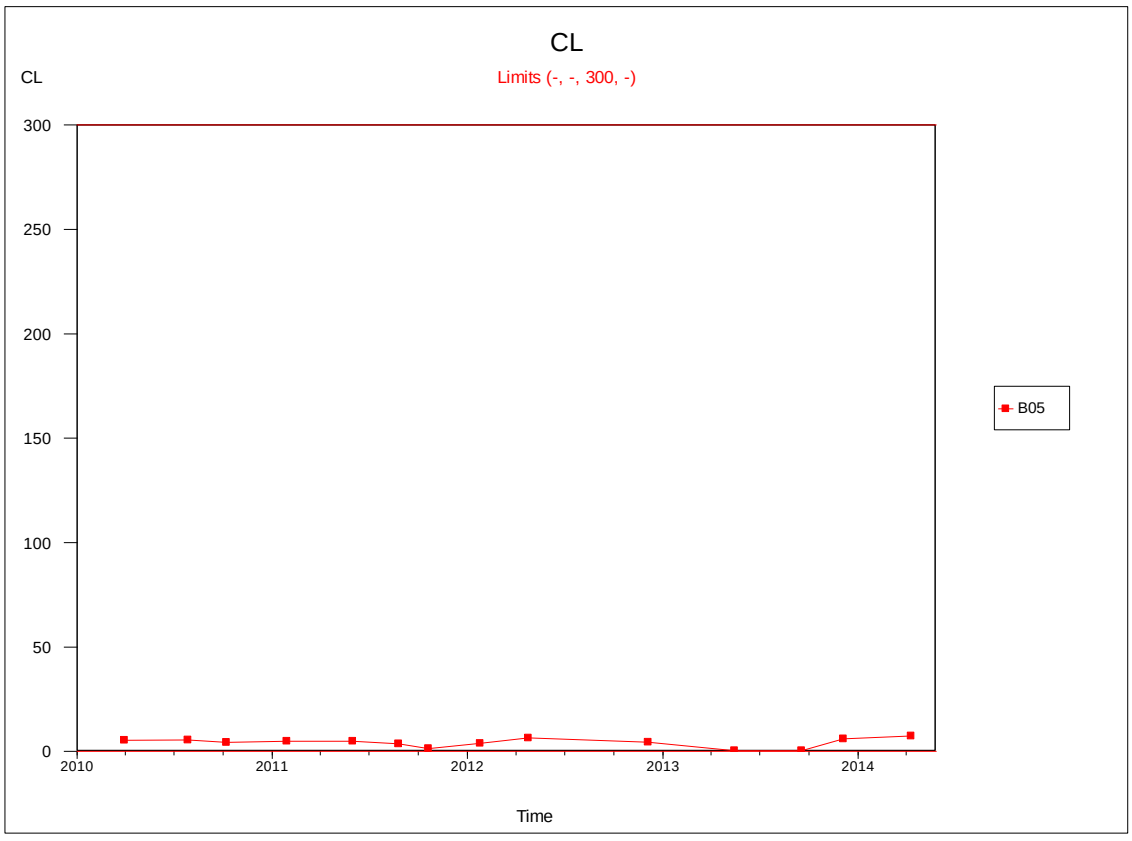


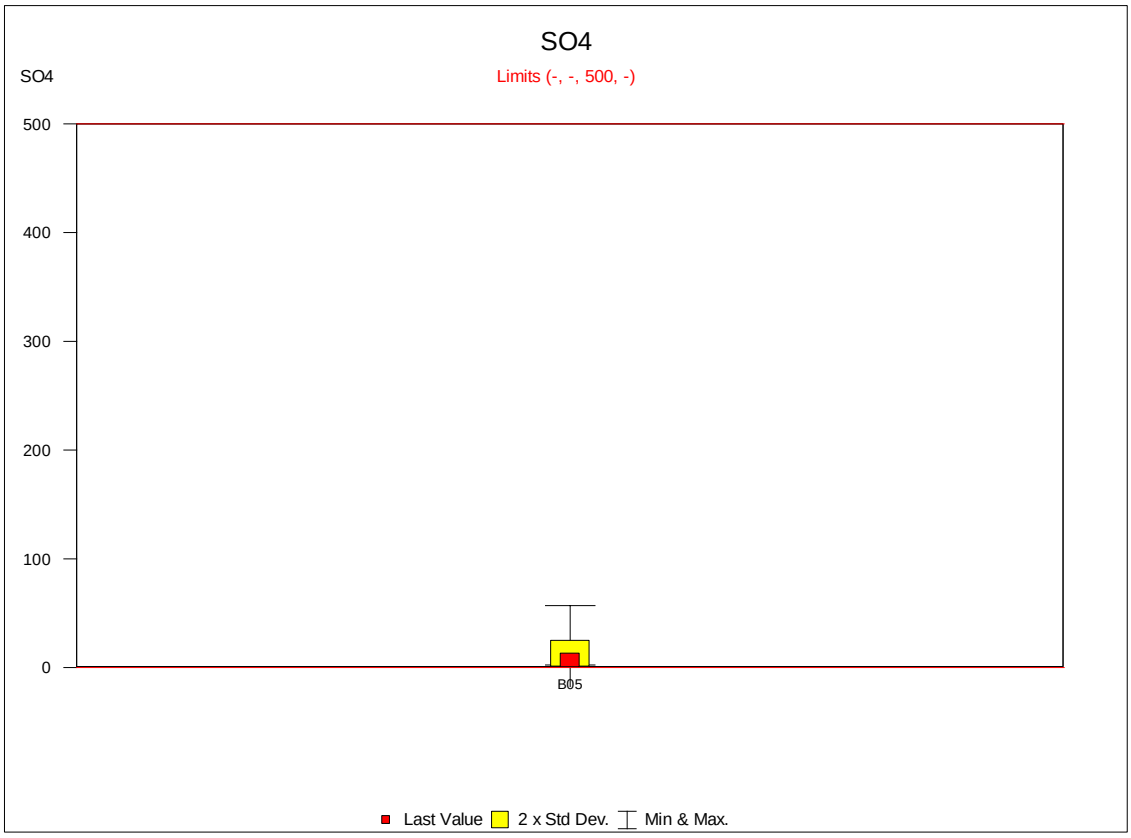


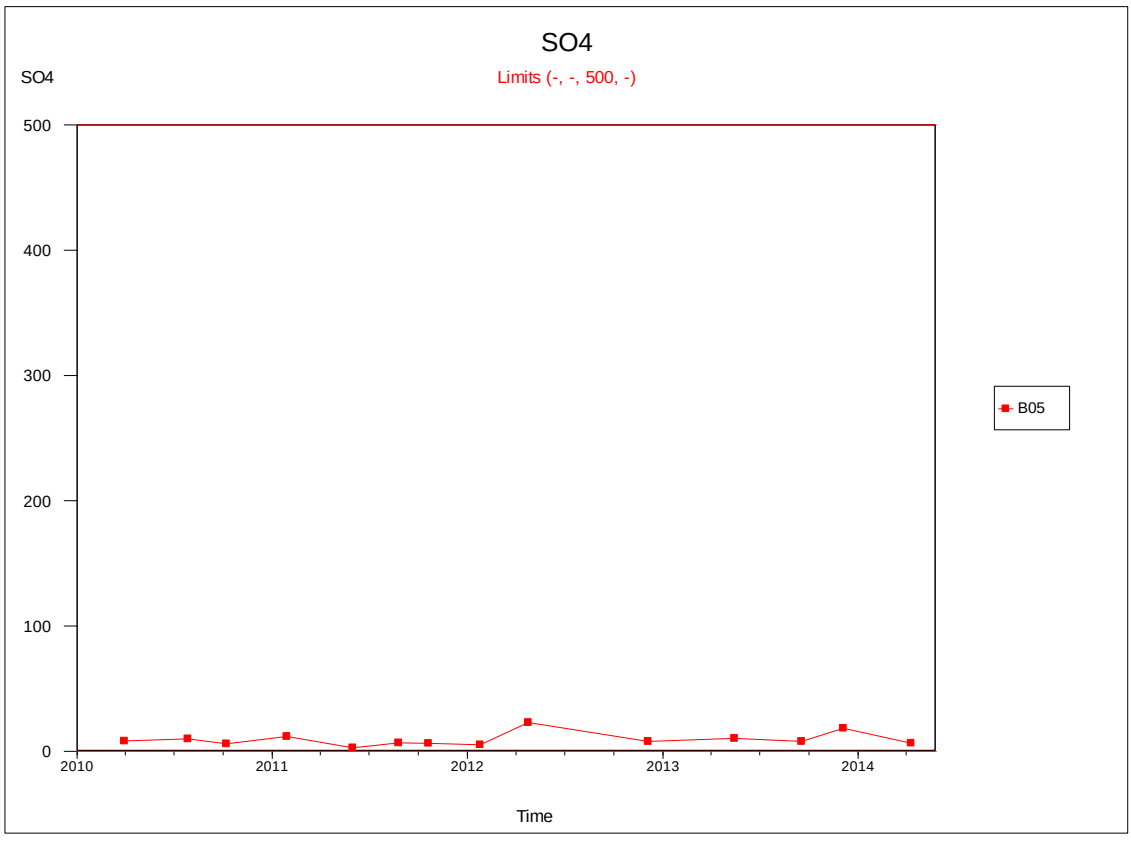

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
B05
Last Value
2 x Std Dev.
Min & Max.

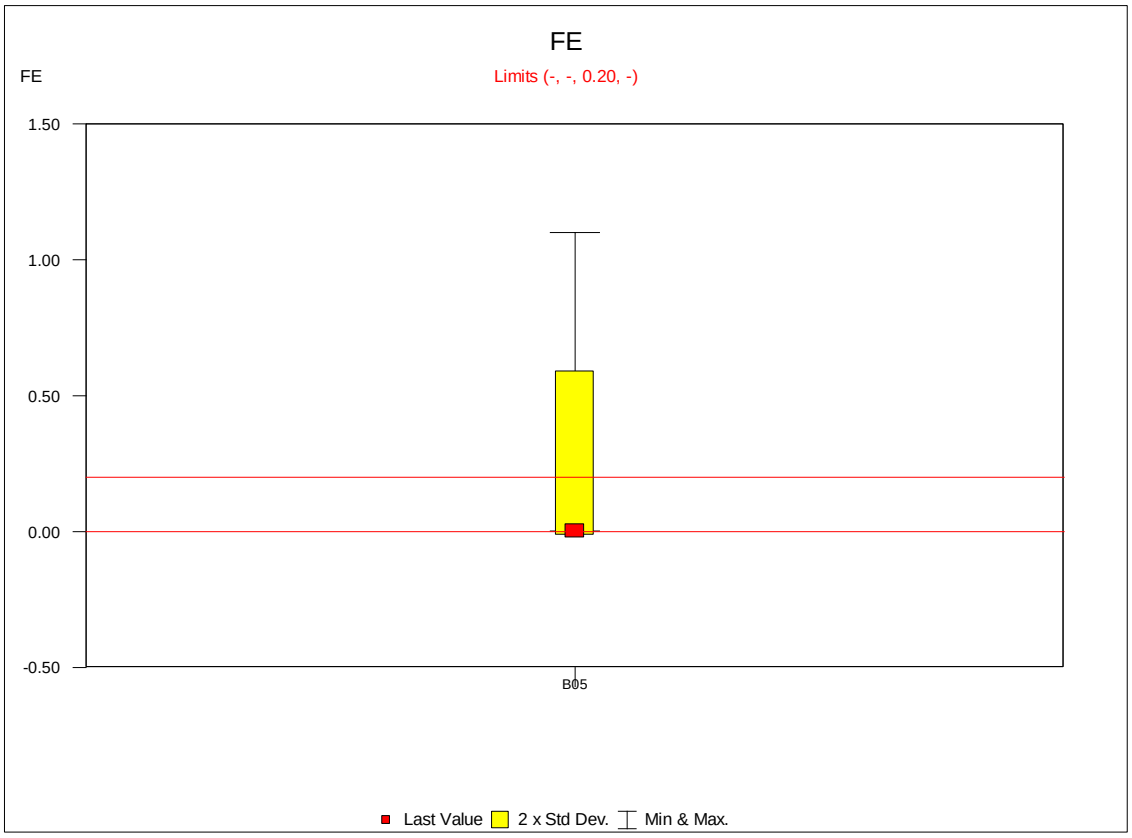

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
B05

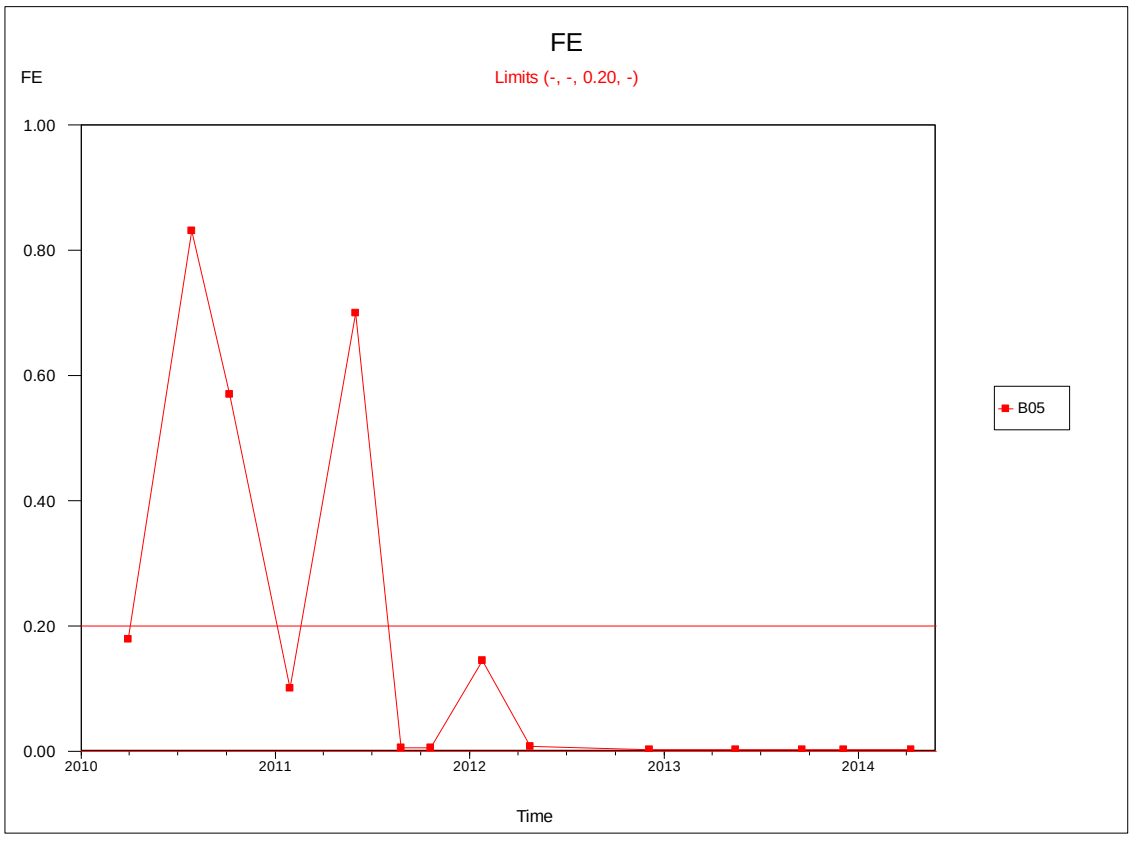

CL
CL
Limits (-, -, 300, -)
300
200
100
0
-100
B05
Last Value
2 x Std Dev.
Min & Max.

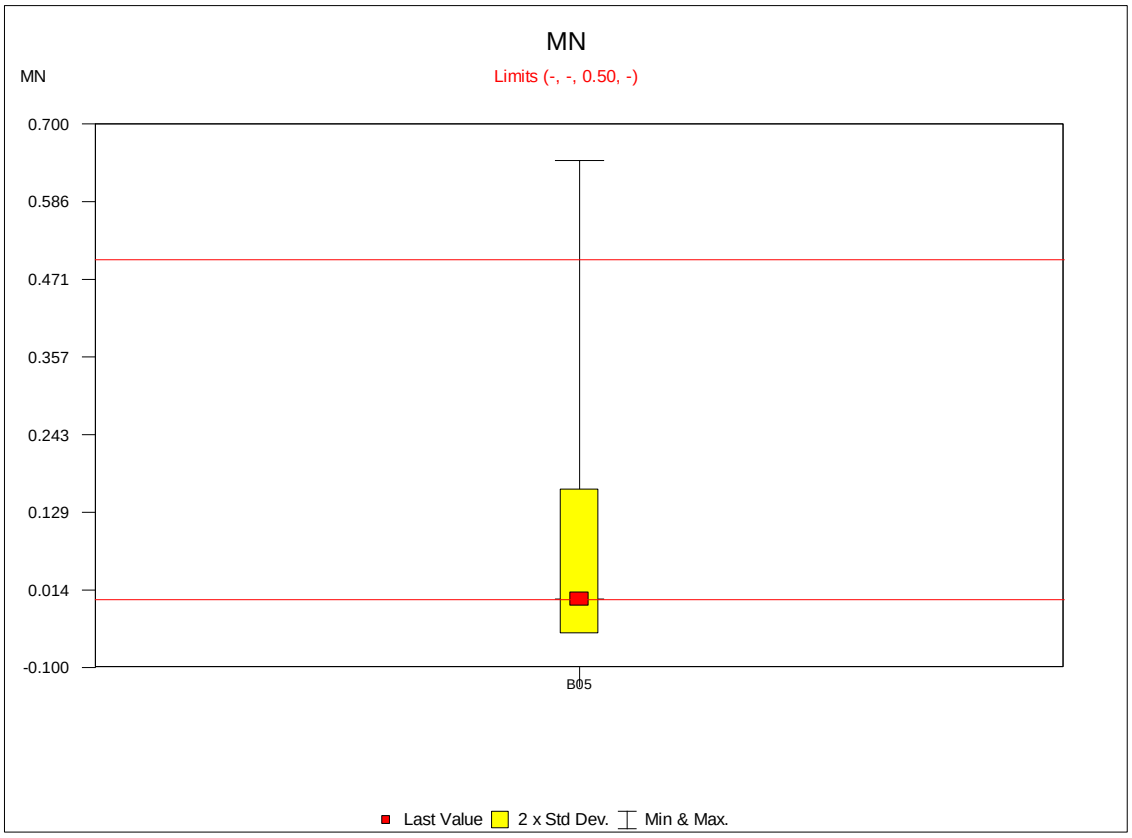

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
B05

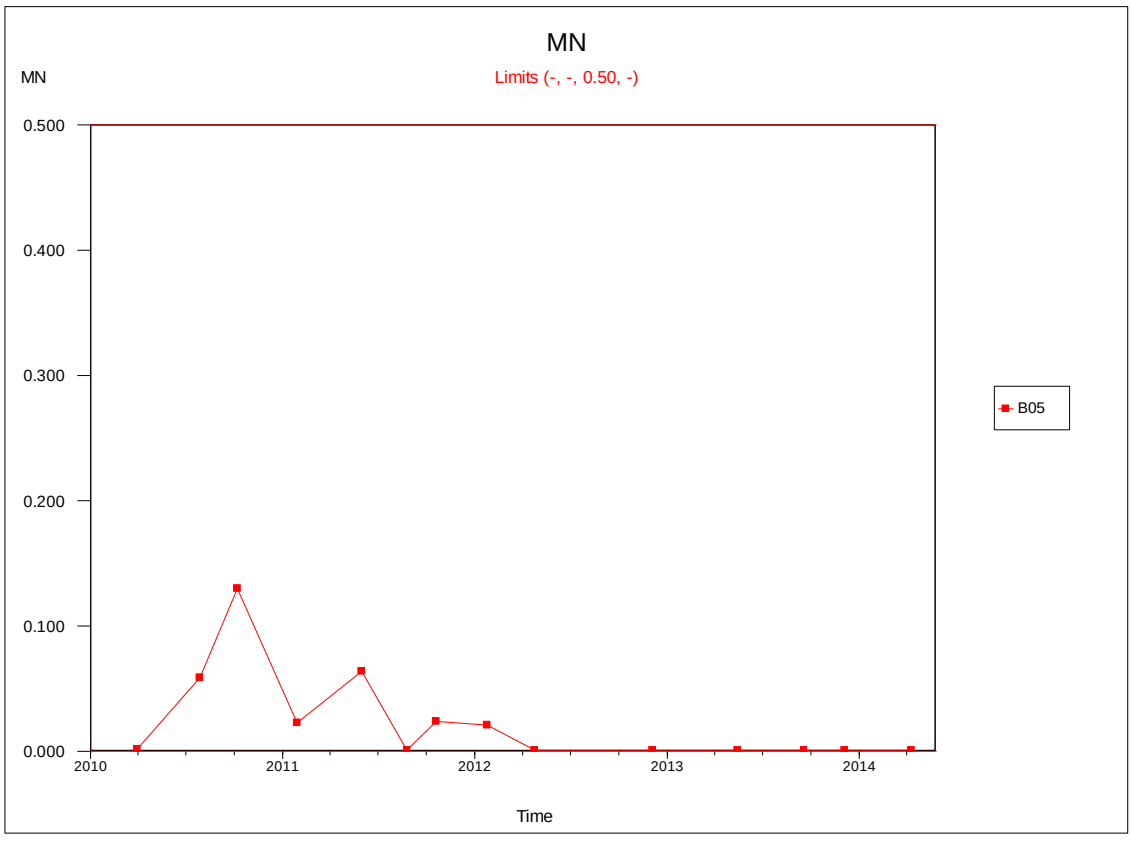

SO4
SO4
Limits (-, -, 500, -)
500
400
300
200
100
0
B05
Last Value
2 x Std Dev.
Min & Max.


SO4
SO4
Limits (-, -, 500, -)
500
400
300
200
100
0
2010
2011
2012
2013
2014
Time
B05


FE
FE
Limits (-, -, 0.20, -)
1.50
1.00
0.50
0.00
-0.50
B05
Last Value
2 x Std Dev.
Min & Max.

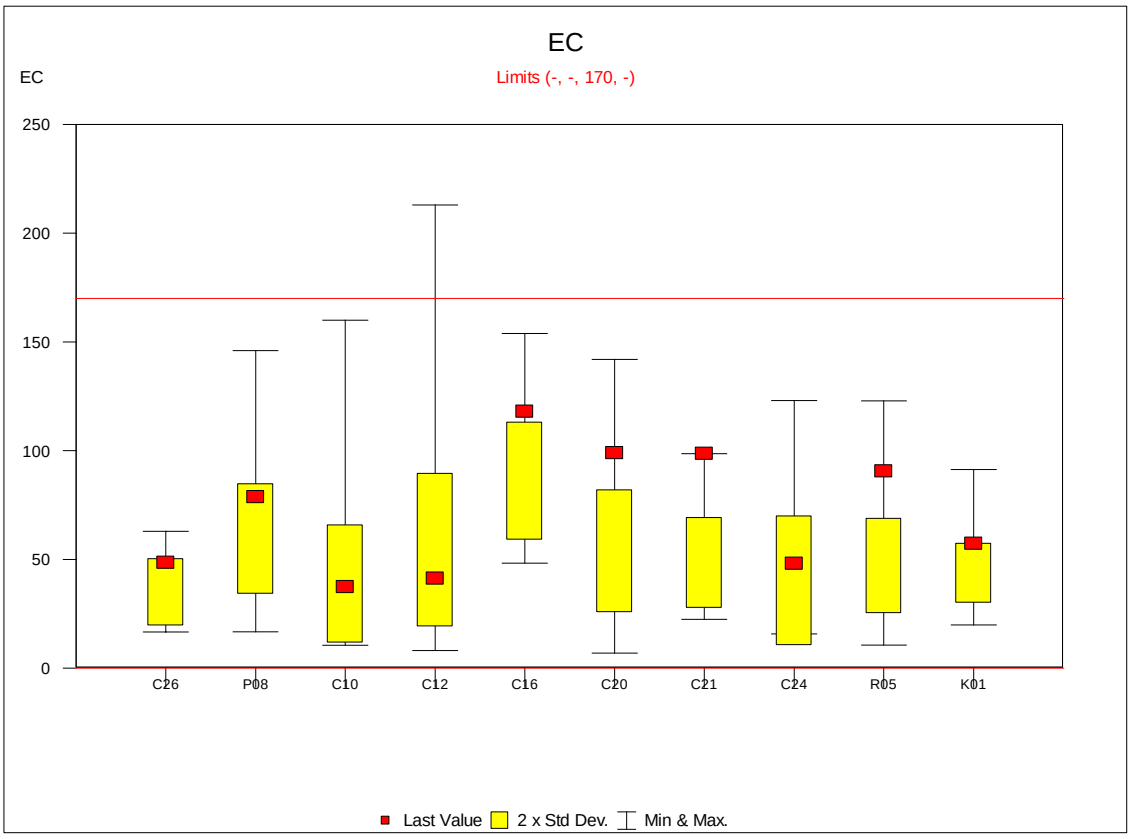

FE
FE
Limits (-, -, 0.20, -)
1.00
0.80
0.60
0.40
0.20
0.00
2010
2011
2012
2013
2014
Time
B05

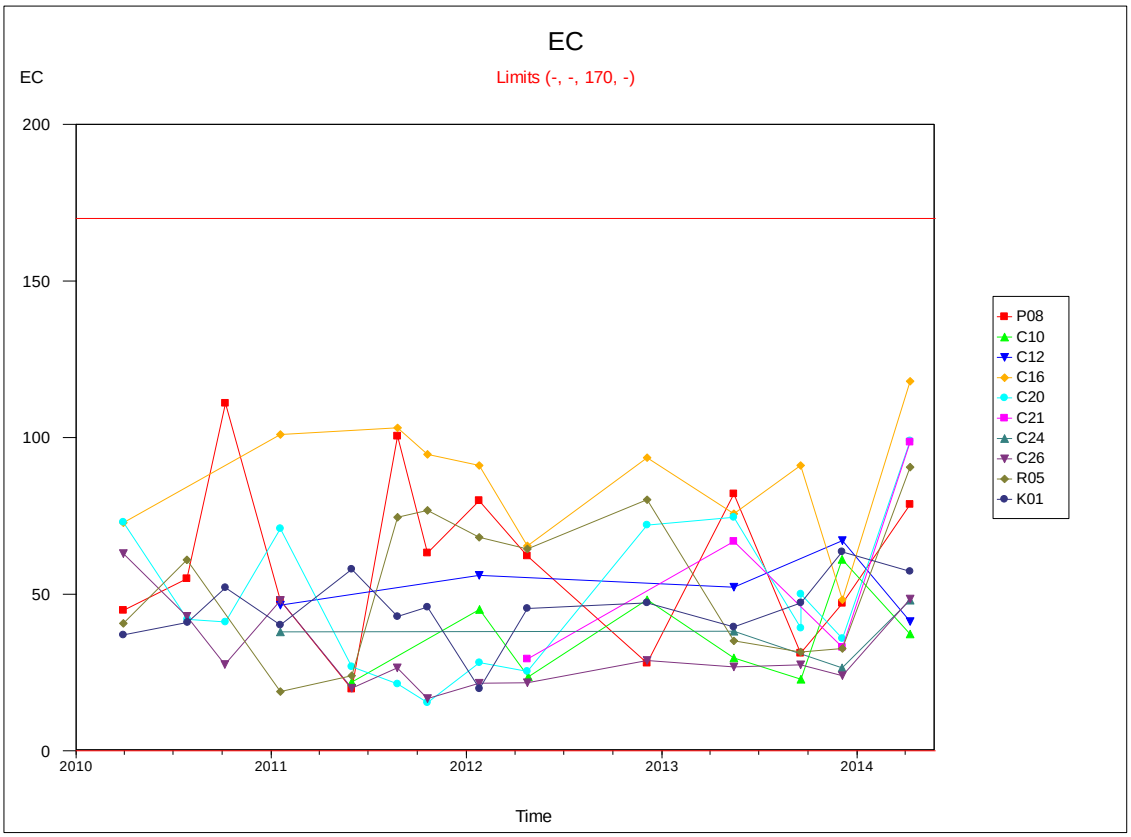

MN
MN
Limits (-, -, 0.50, -)
0.700
0.586
0.471
0.357
0.243
0.129
0.014
-0.100
B05
Last Value
2 x Std Dev.
Min & Max.

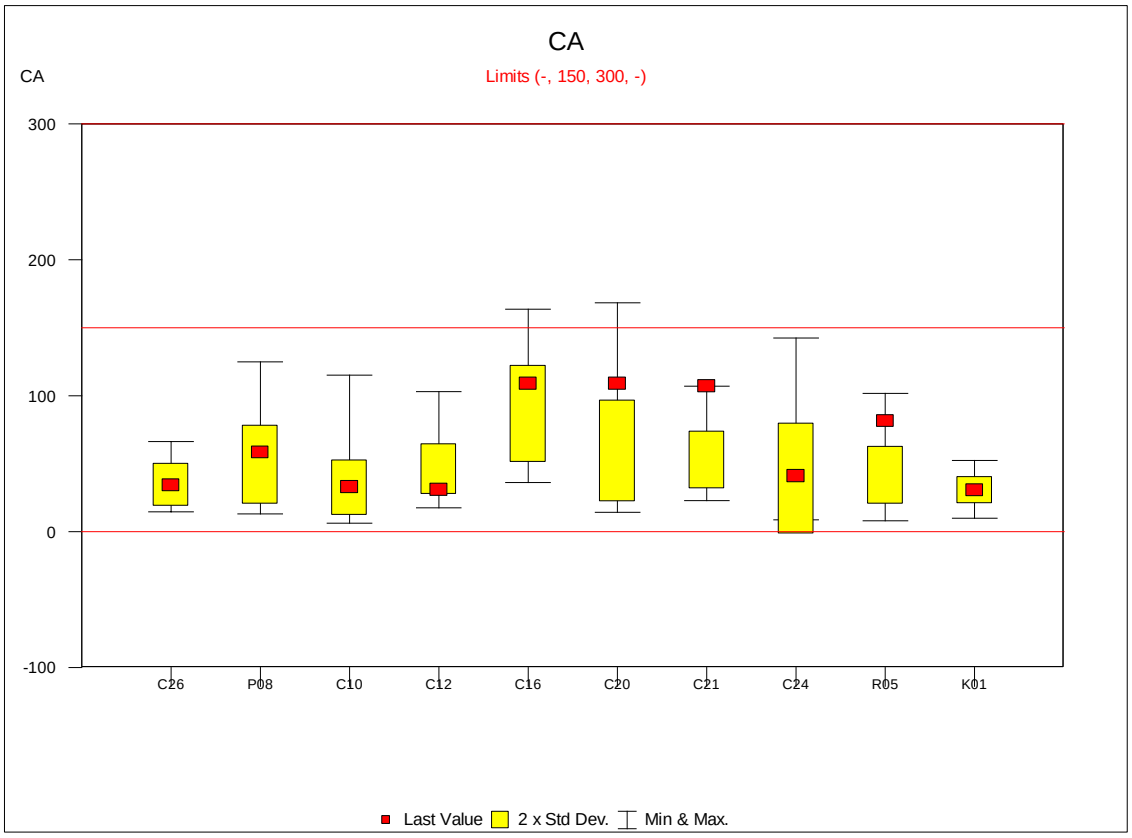

MN
MN
Limits (-, -, 0.50, -)
0.500
0.400
0.300
0.200
0.100
0.000
2010
2011
2012
2013
2014
Time
B05

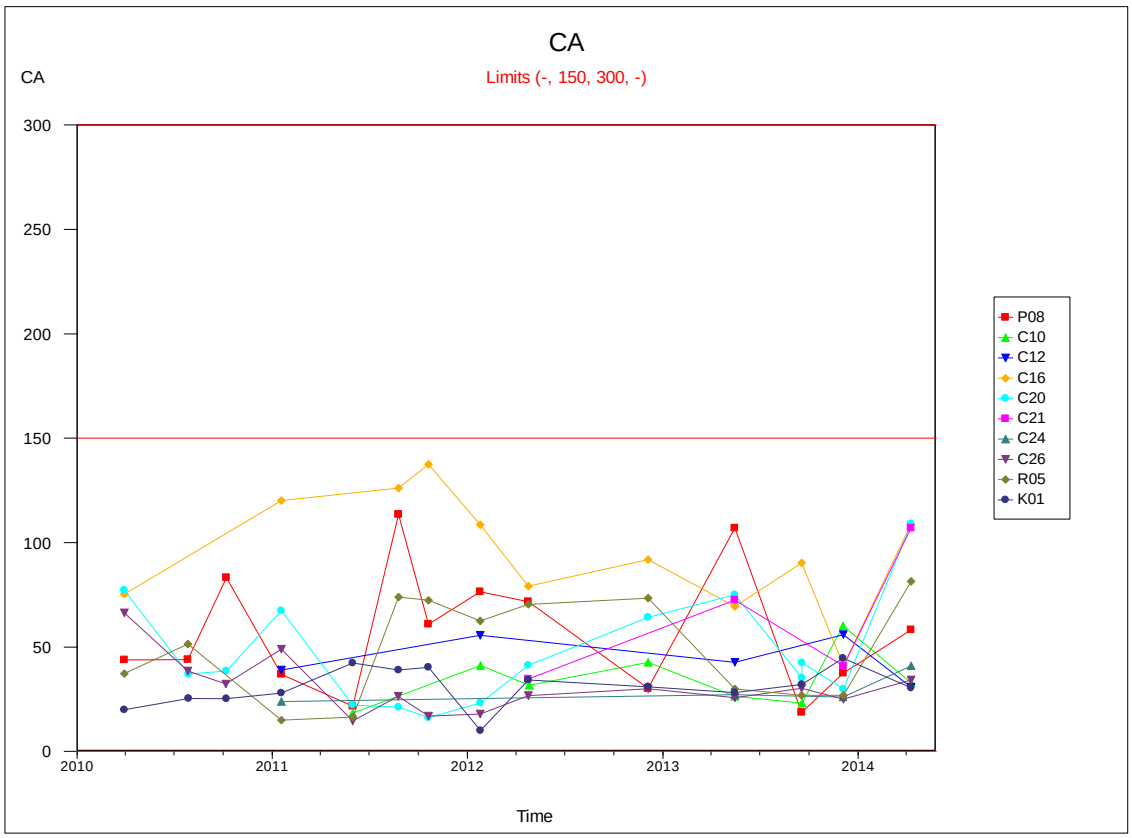
D3. SUB DRAINAGE SYSTEM 3: WITPUNT SPRUIT SOUTHERN TRIBUTARY

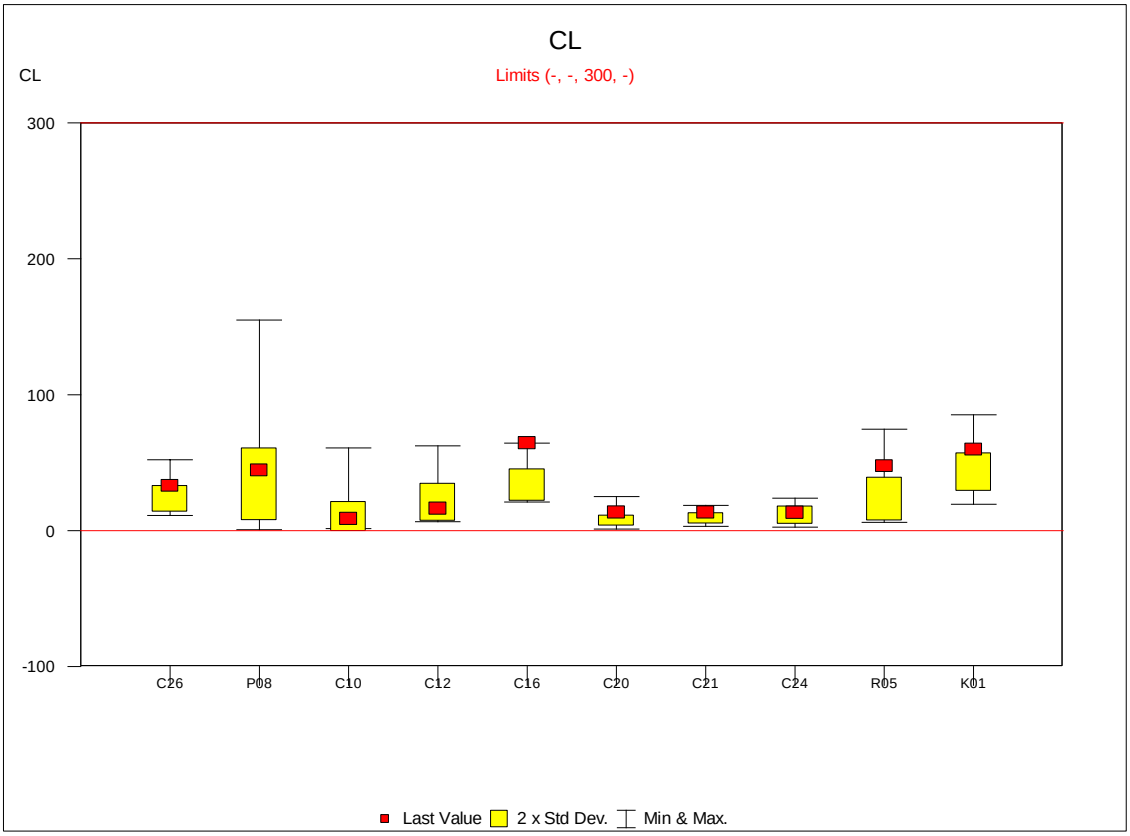
D3.1. WITPUNT SPRUIT SOUTHERN TRIBUTARY - SURFACE WATER

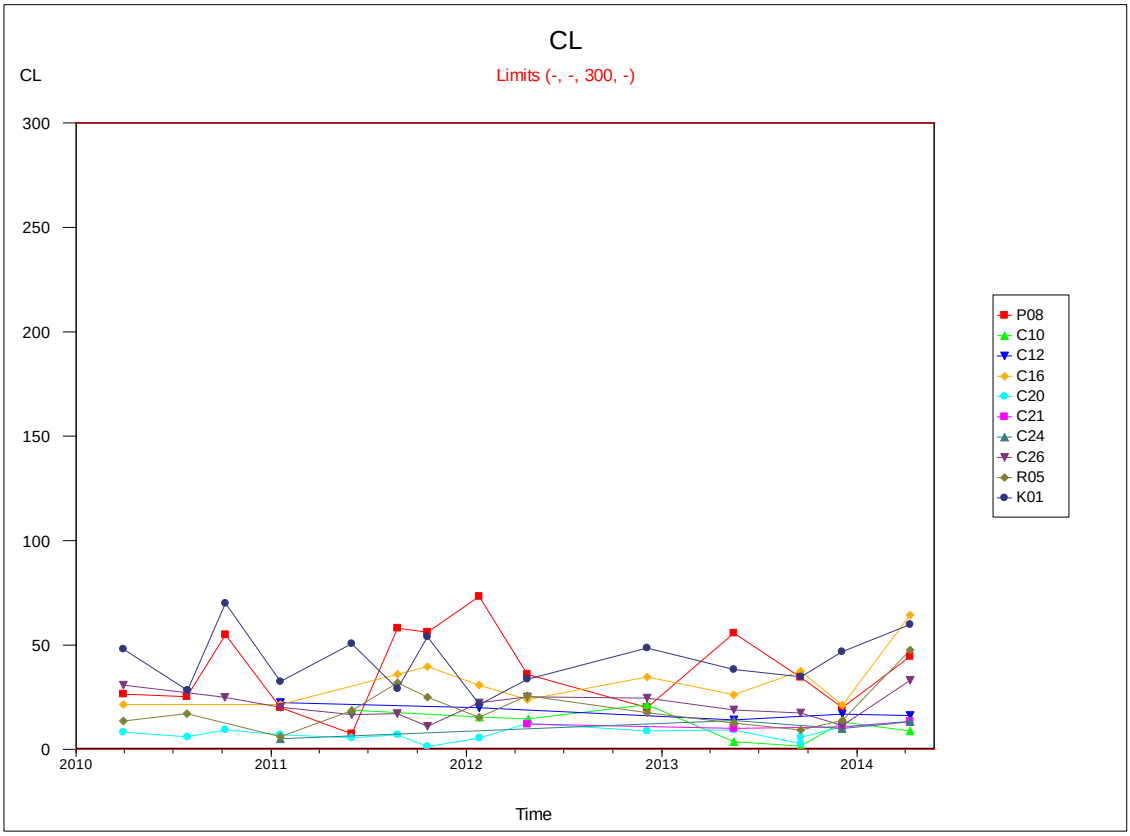


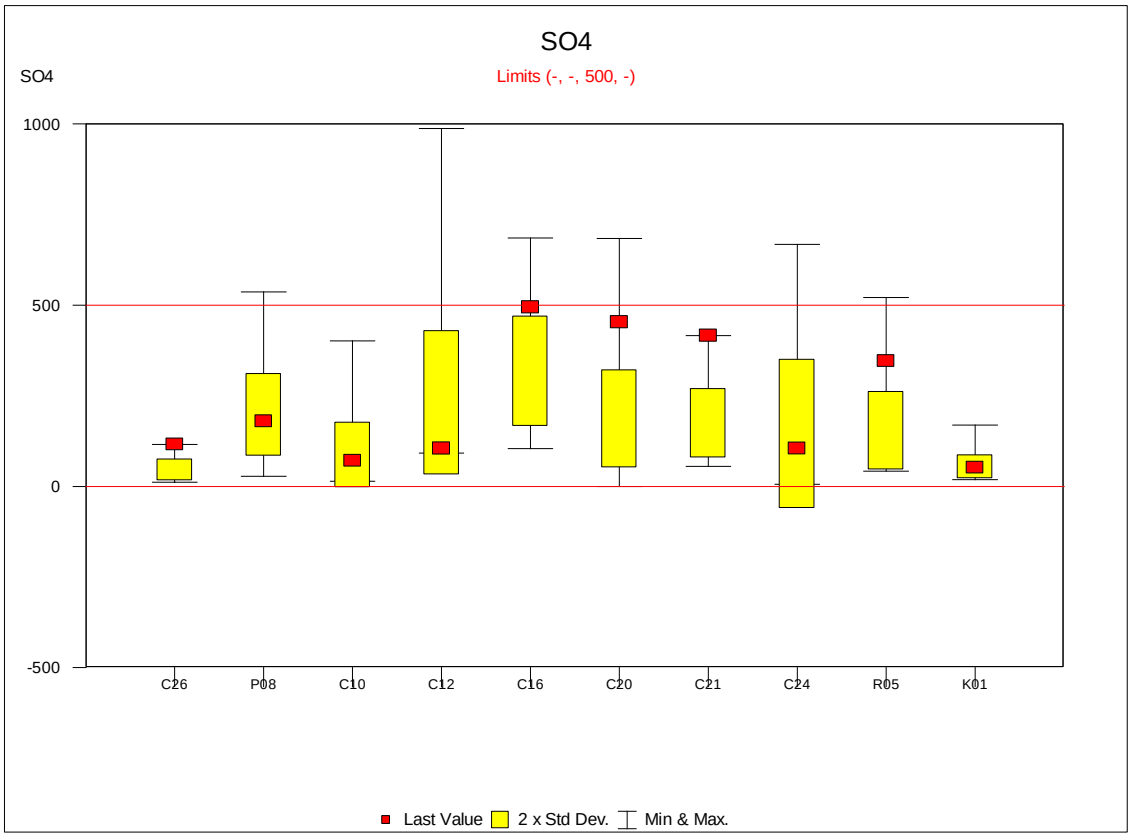


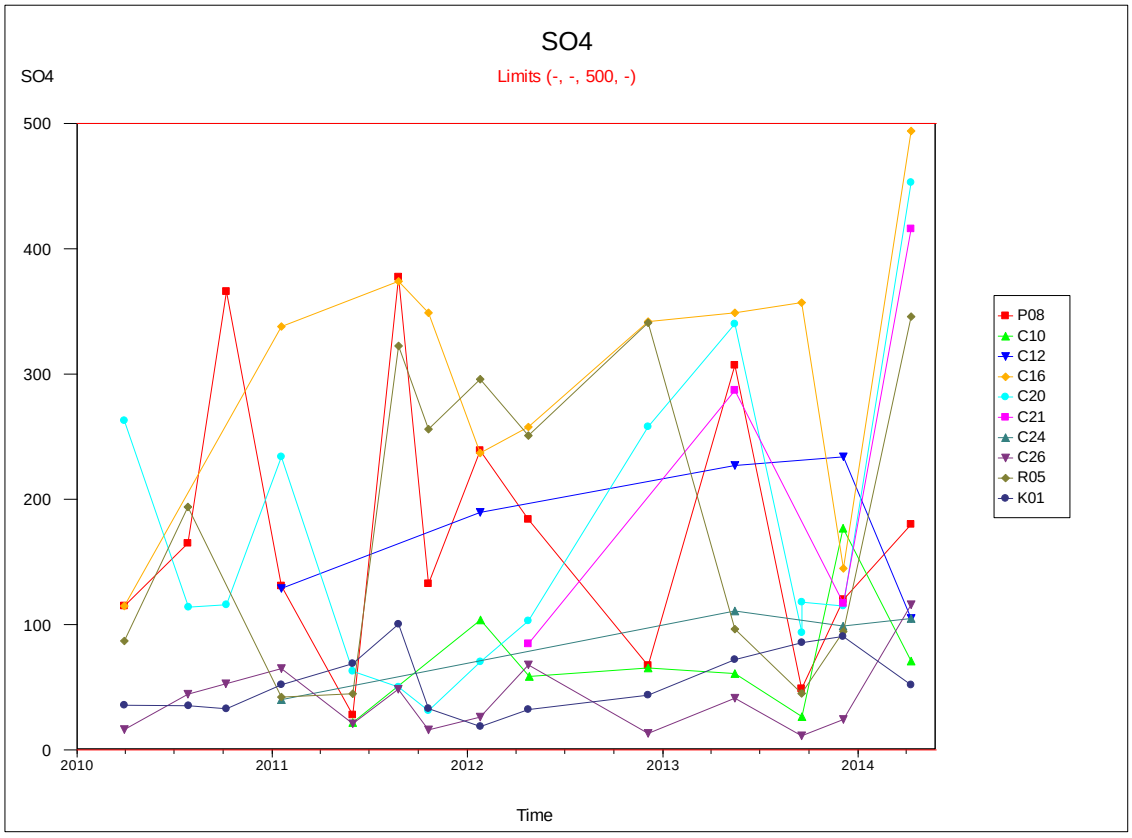

CA
CA
Limits (-, 150, 300, -)
300
200
100
0
-100
C26
P08
C10
C12
C16
C20
C21
C24
R05
K01
Last Value
2 x Std Dev.
Min & Max.

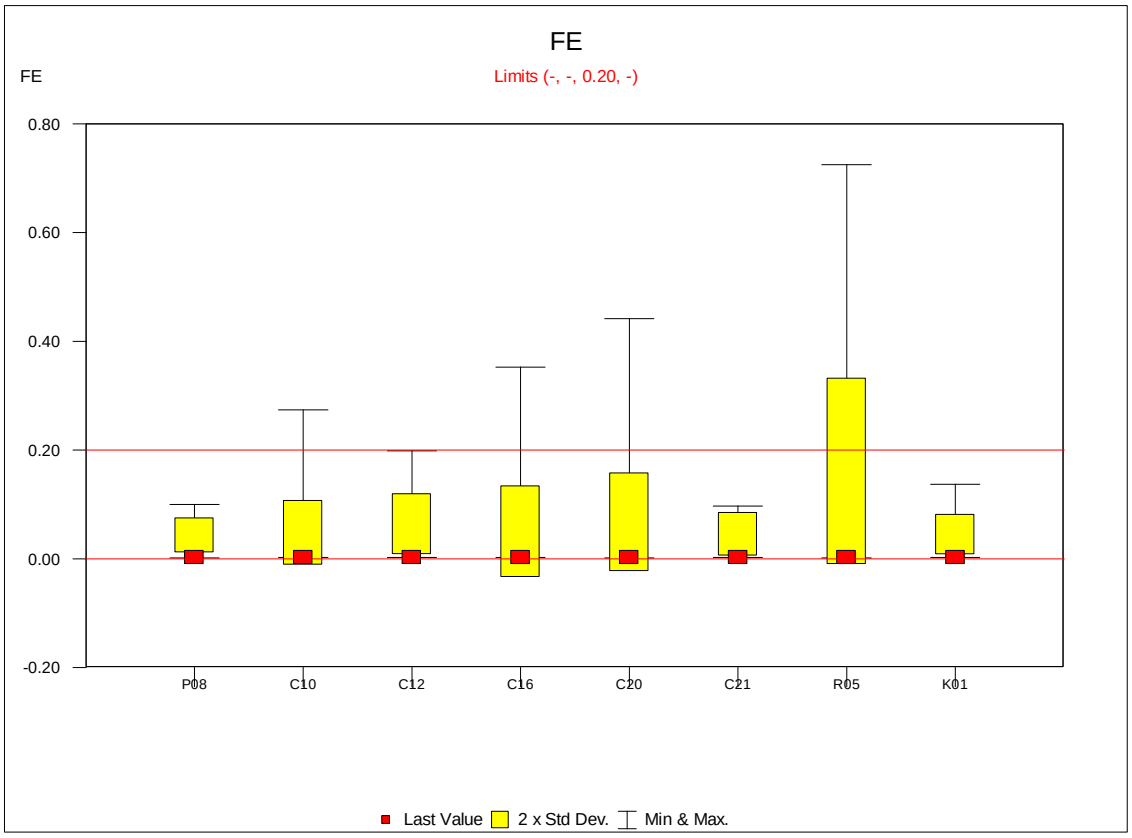

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
P08
C10
C12
C16
C20
C21
C24
C26
R05
K01

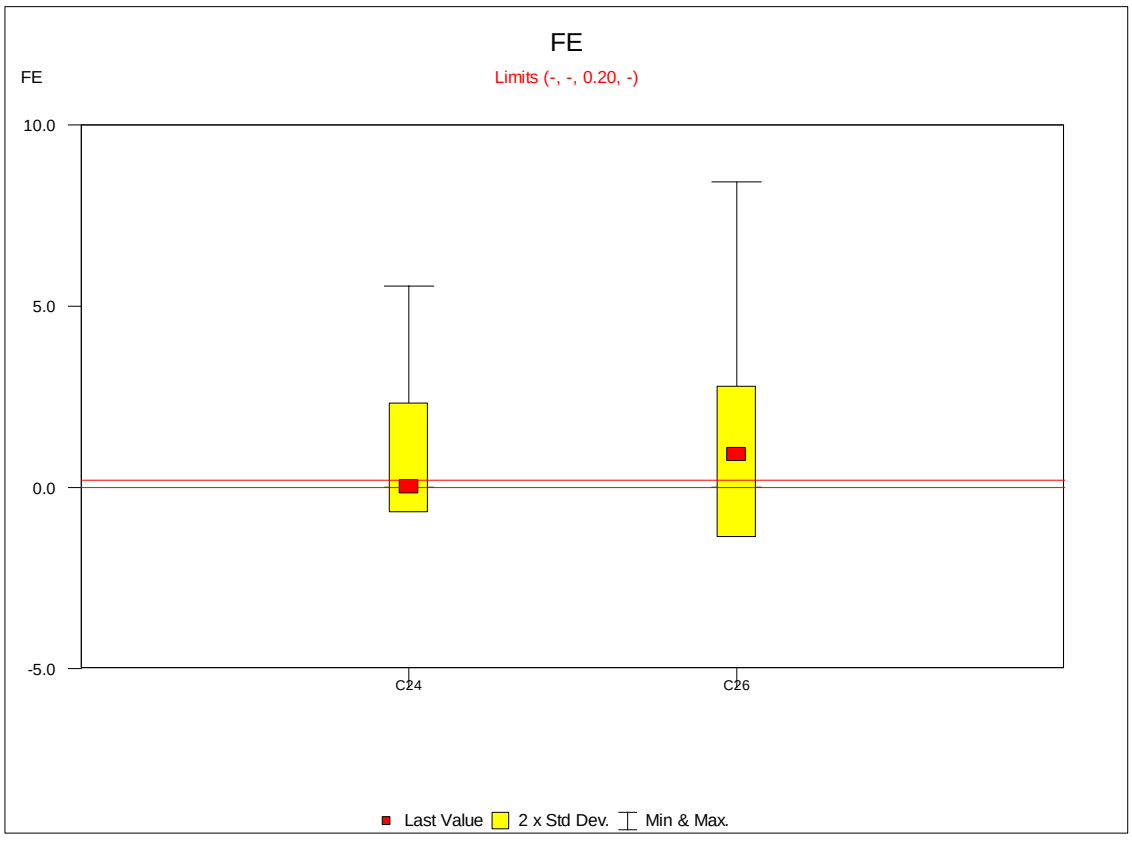

CL
CL
Limits (-, -, 300, -)
300
200
100
0
-100
C26
P08
C10
C12
C16
C20
C21
C24
R05
K01
Last Value
2 x Std Dev.
Min & Max.

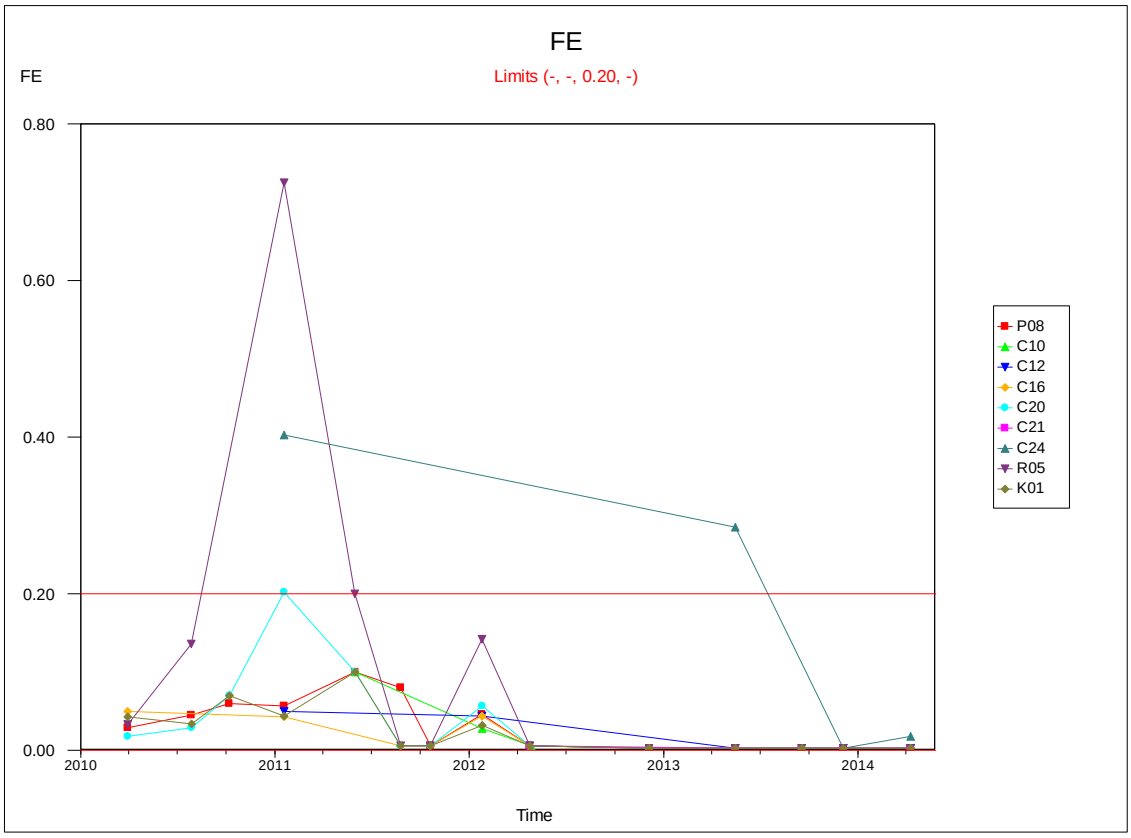

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
P08
C10
C12
C16
C20
C21
C24
C26
R05
K01

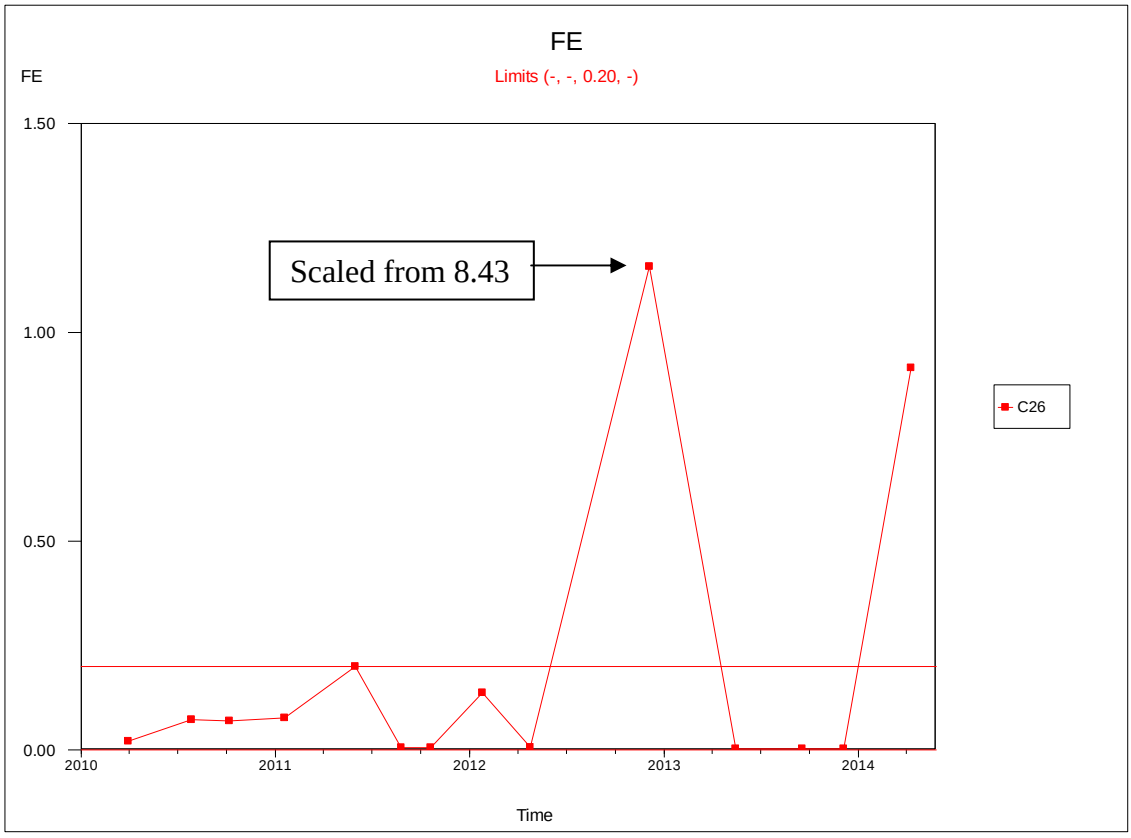

SO4
SO4
Limits (-, -, 500, -)
1000
500
0
-500
C26
P08
C10
C12
C16
C20
C21
C24
R05
K01
Last Value
2 x Std Dev.
Min & Max.

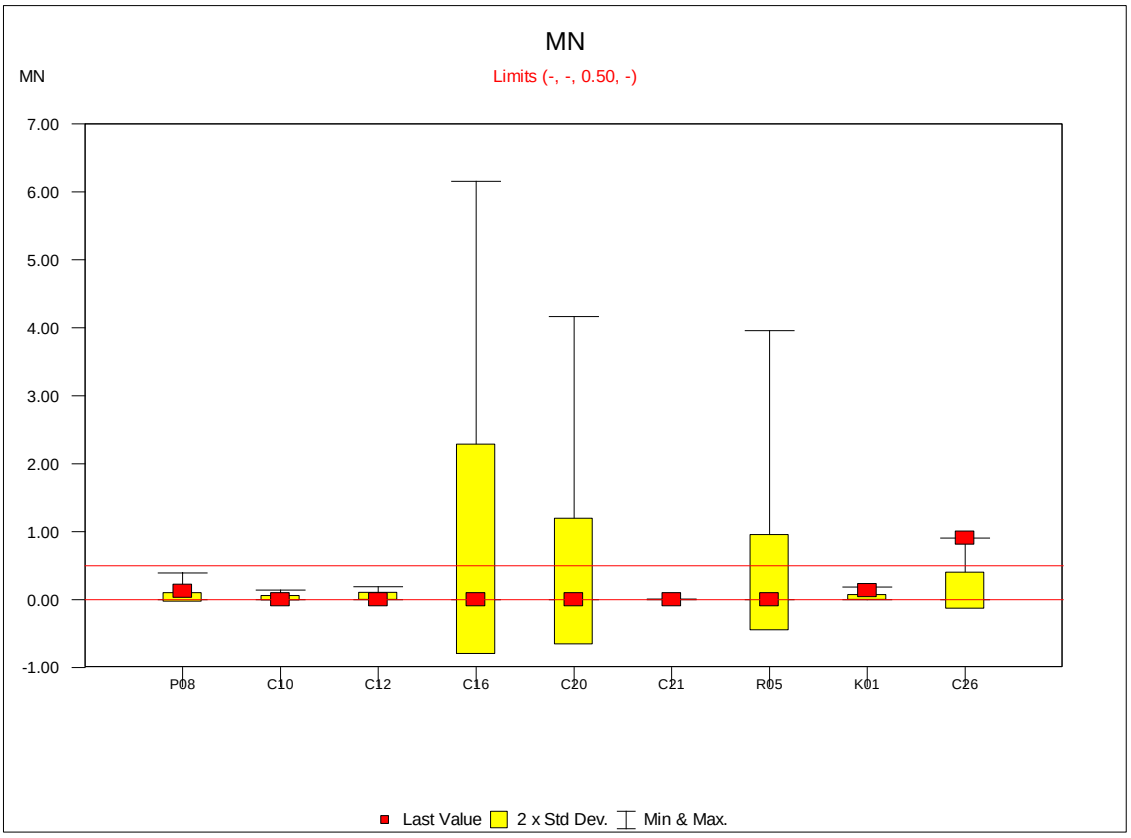

SO4
SO4
Limits (-, -, 500, -)
500
400
300
200
100
0
2010
2011
2012
2013
2014
Time
P08
C10
C12
C16
C20
C21
C24
C26
R05
K01

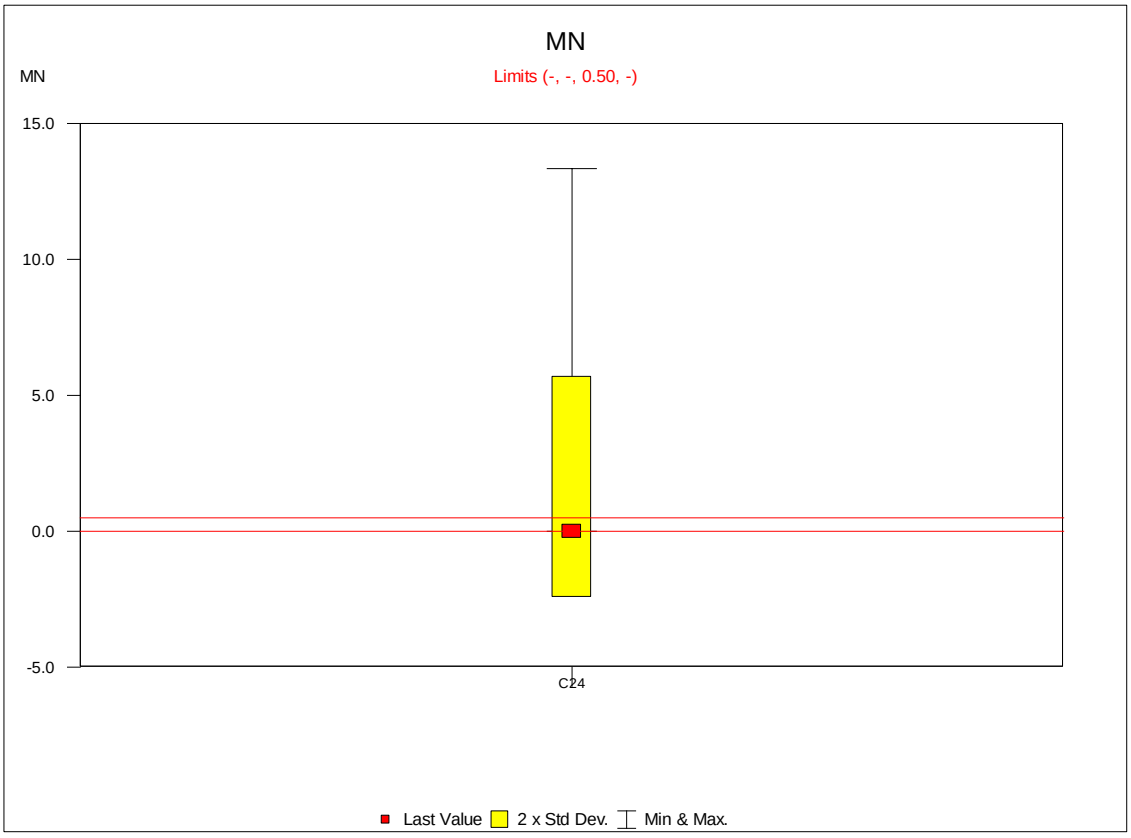

FE
FE
Limits (-, -, 0.20, -)
0.80
0.60
0.40
0.20
0.00
-0.20
P08
C10
C12
C16
C20
C21
R05
K01
Last Value
2 x Std Dev.
Min & Max.

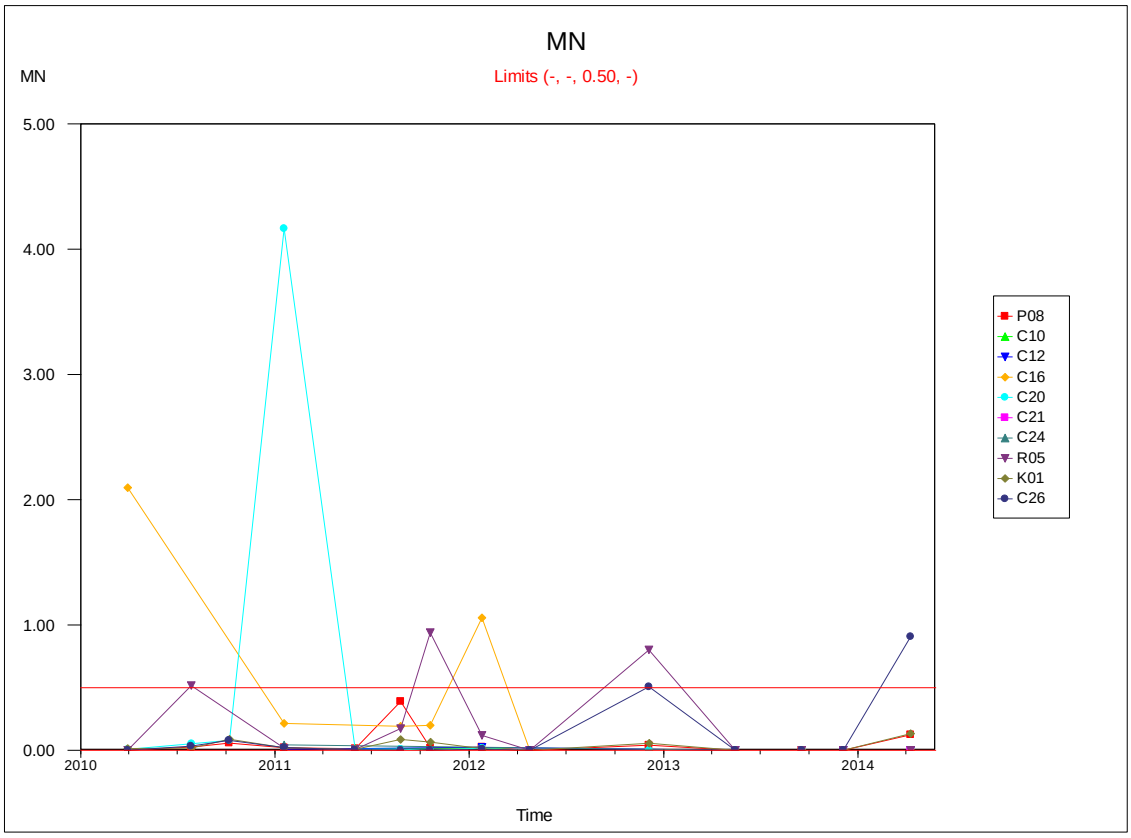

FE
FE
Limits (-, -, 0.20, -)
10.0
5.0
0.0
-5.0
C24
C26
Last Value
2 x Std Dev.
Min & Max.


FE
FE
Limits (-, -, 0.20, -)
0.80
0.60
0.40
0.20
0.00
2010
2011
2012
2013
2014
Time
P08
C10
C12
C16
C20
C21
C24
R05
K01

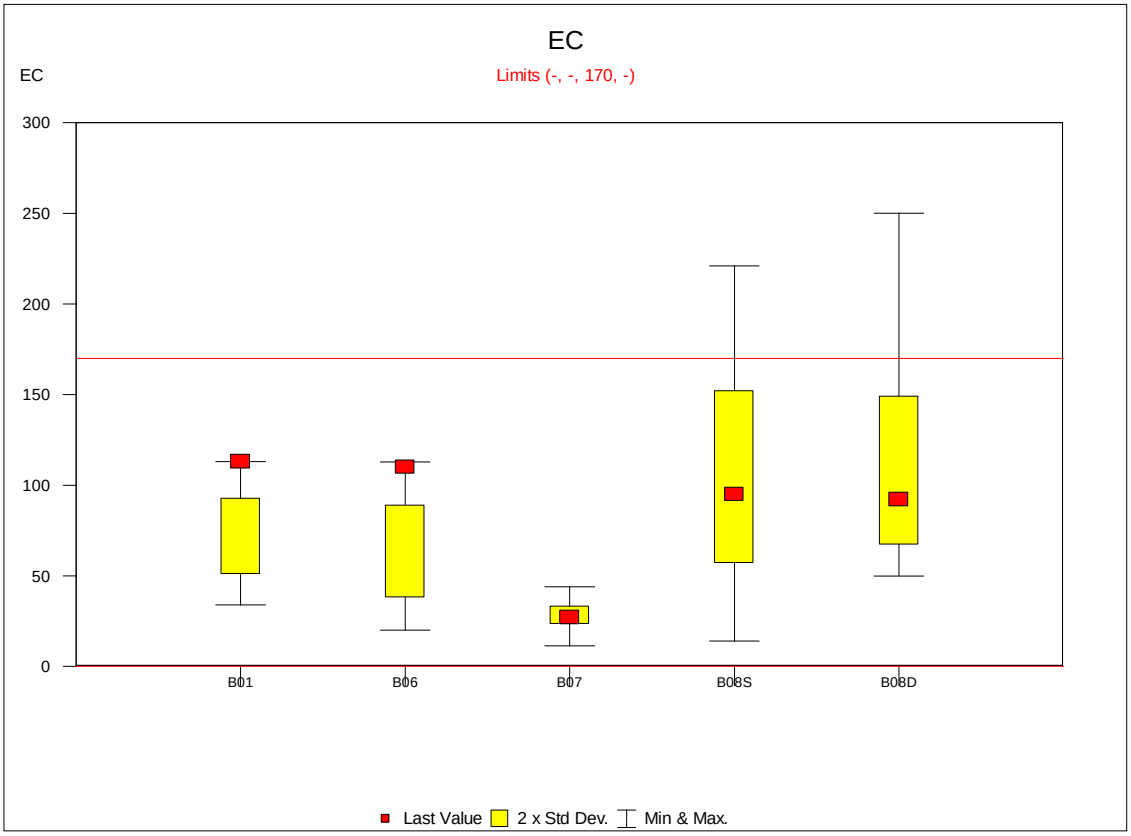

FE
FE
Limits (-, -, 0.20, -)
1.50
1.00
0.50
0.00
Scaled from 8.43
2010
2011
2012
2013
2014
Time
C26

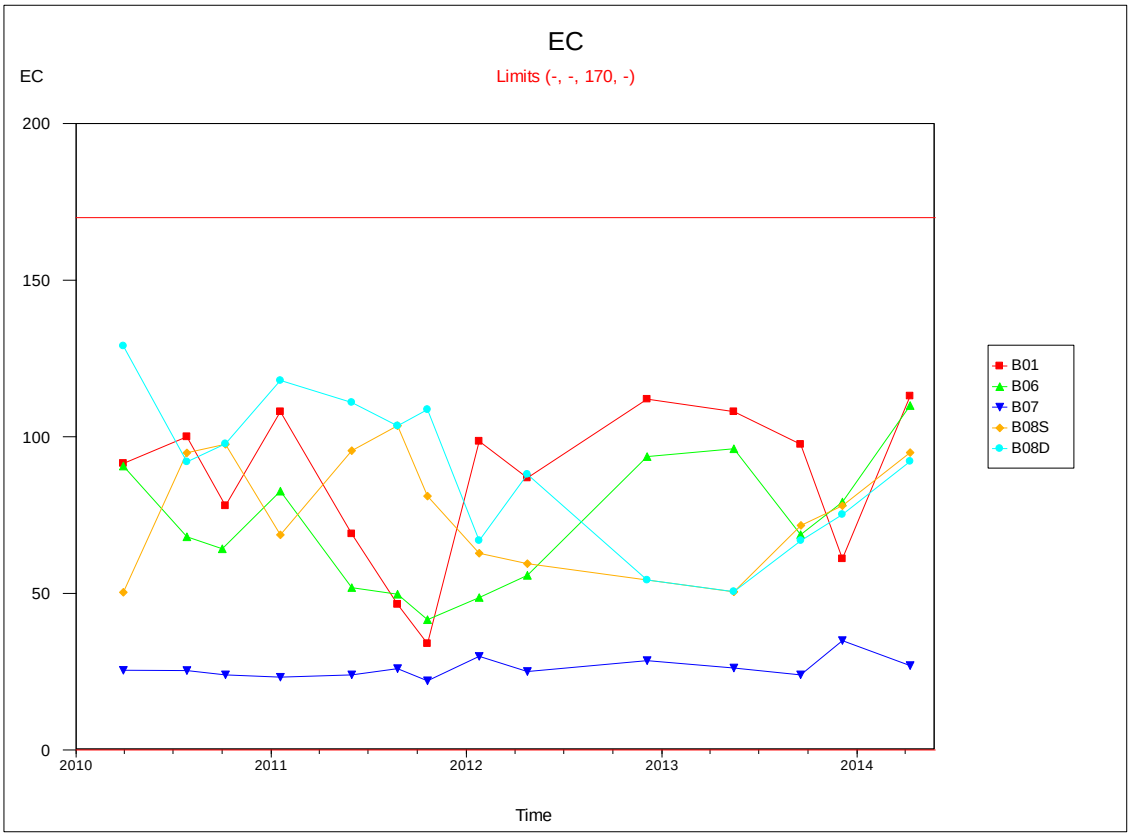

MN
MN
Limits (-, -, 0.50, -)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
P08
C10
C12
C16
C20
C21
R05
K01
C26
Last Value
2 x Std Dev.
Min & Max.

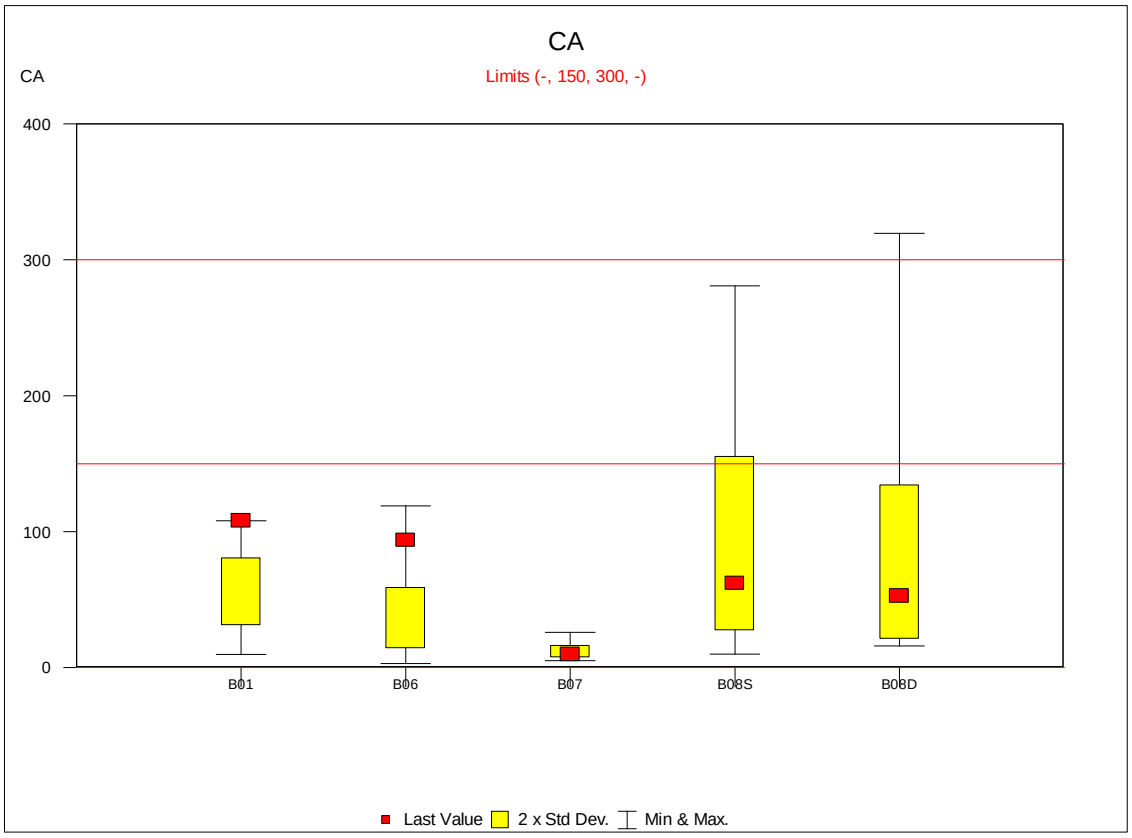

MN
MN
Limits (-, -, 0.50, -)
15.0
10.0
5.0
0.0
-5.0
C24
Last Value
2 x Std Dev.
Min & Max.

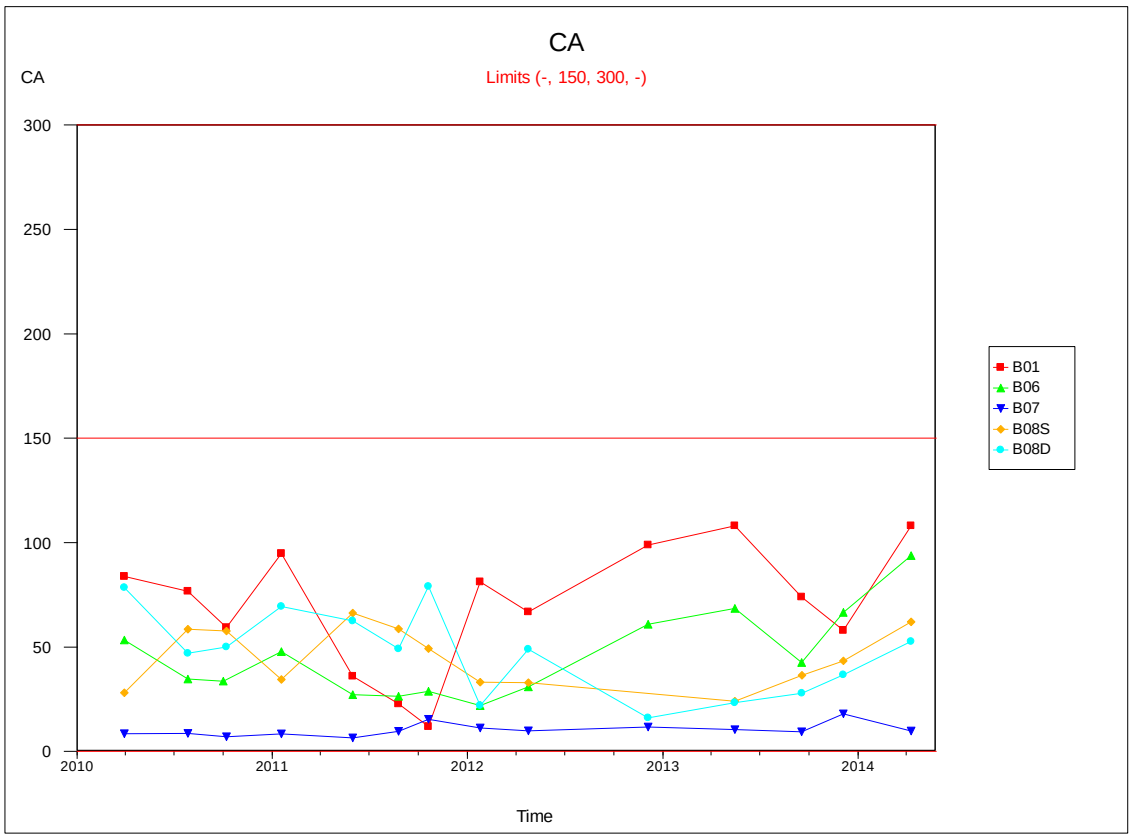

MN
MN
Limits (-, -, 0.50, -)
5.00
4.00
3.00
2.00
1.00
0.00
2010
2011
2012
2013
2014
Time
P08
C10
C12
C16
C20
C21
C24
R05
K01
C26

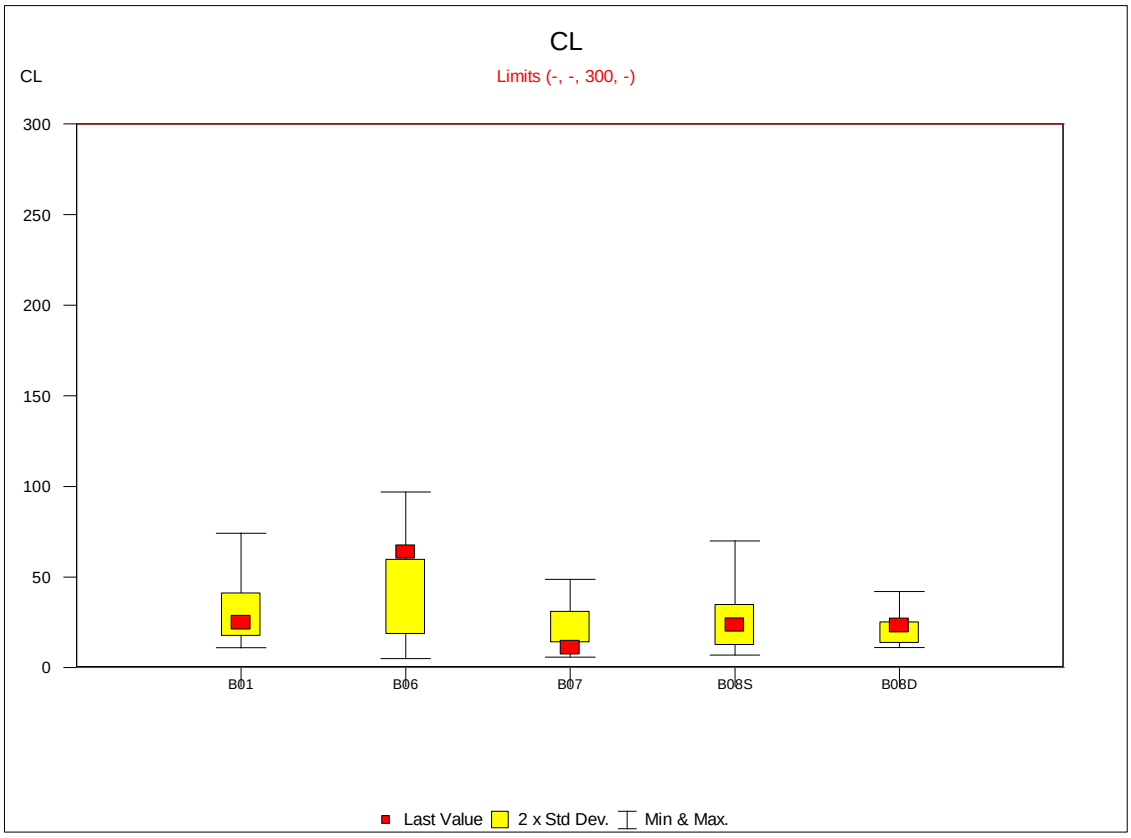
D3.2. WITPUNT SPRUIT SOUTHERN TRIBUTARY - GROUNDWATER

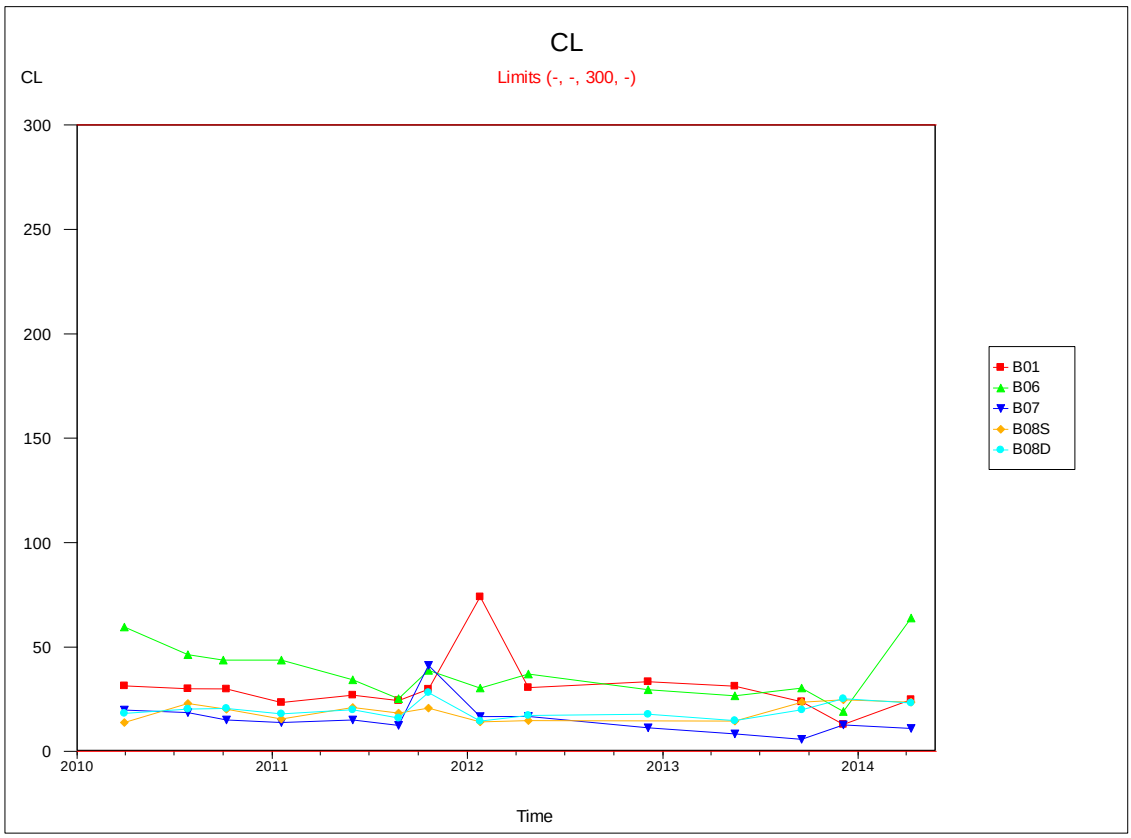


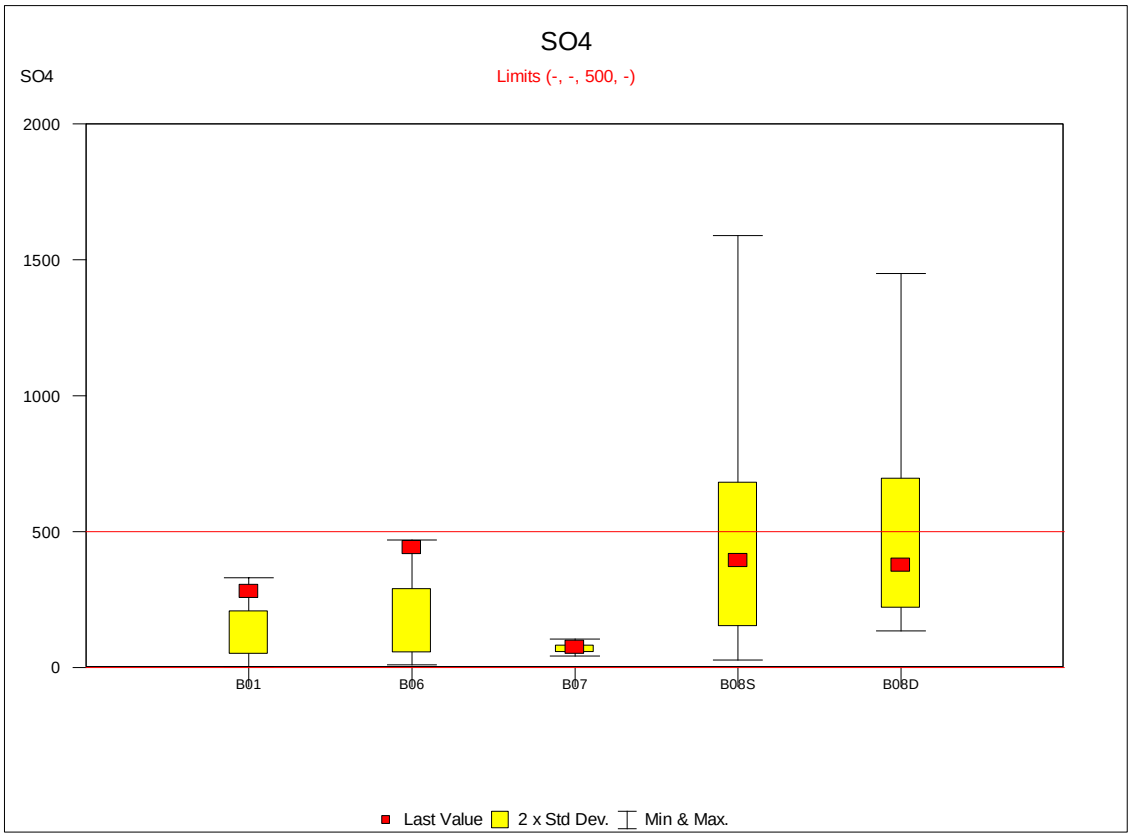


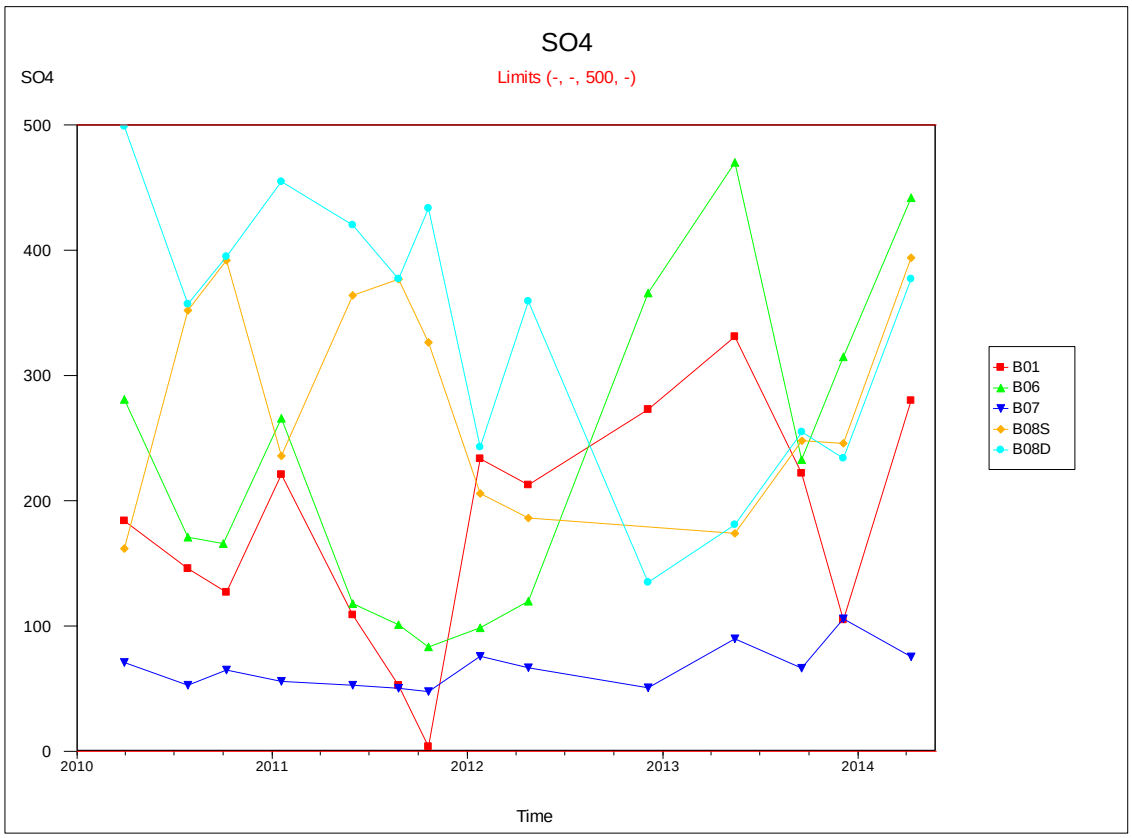

CA
CA
Limits (-, 150, 300, -)
400
300
200
100
0
B01
B06
B07
B08S
B08D
Last Value
2 x Std Dev.
Min & Max.

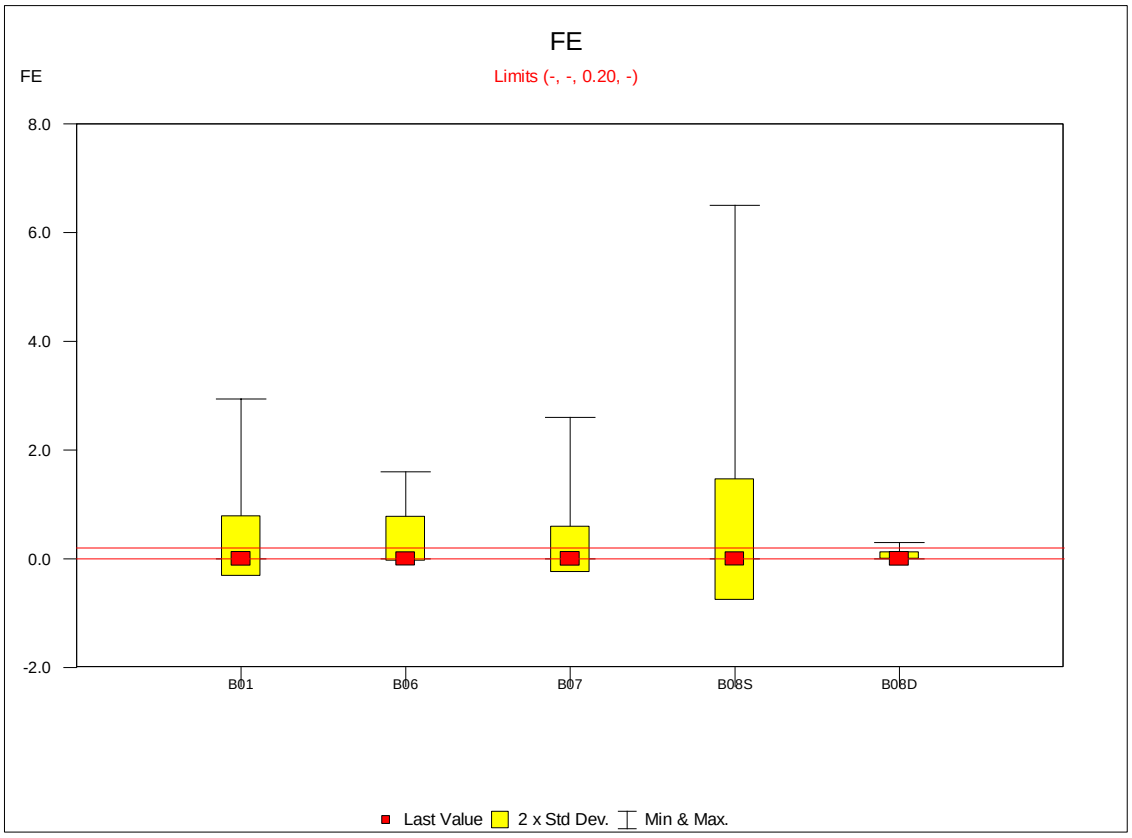

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
B01
B06
B07
B08S
B08D

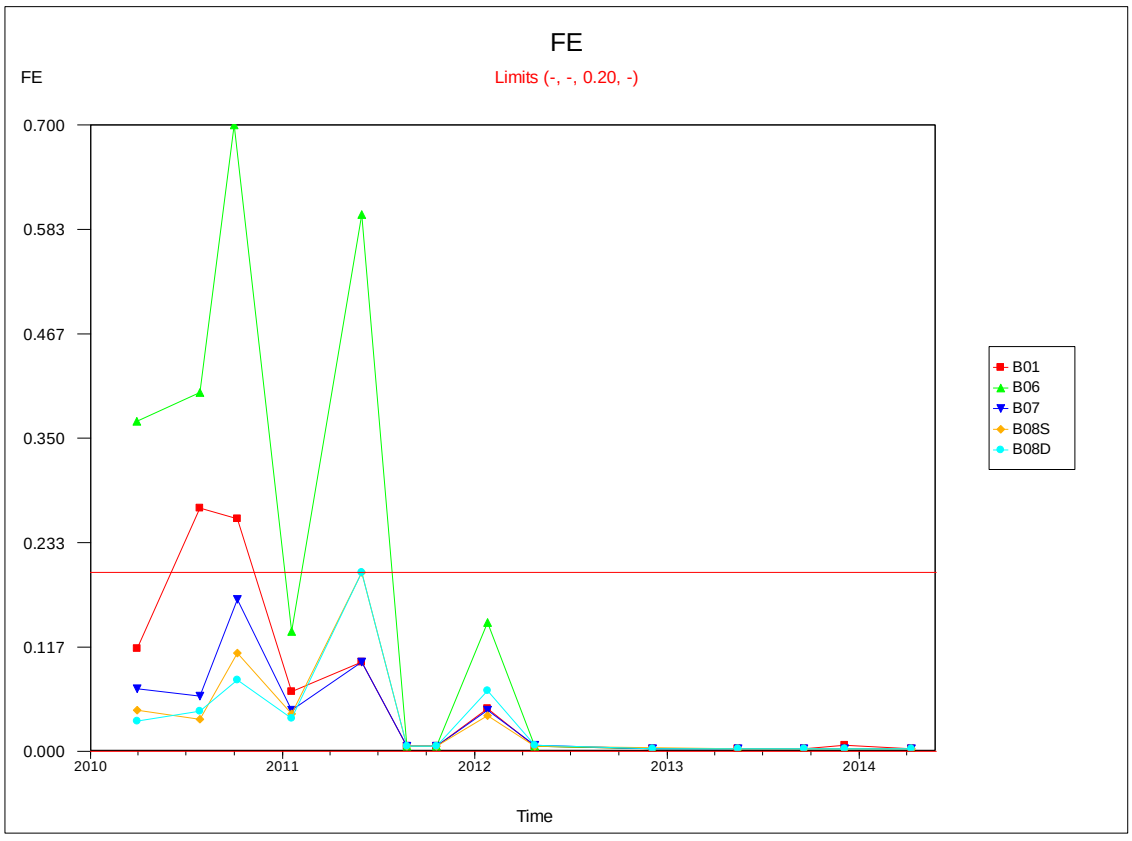

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
B01
B06
B07
B08S
B08D
Last Value
2 x Std Dev.
Min & Max.

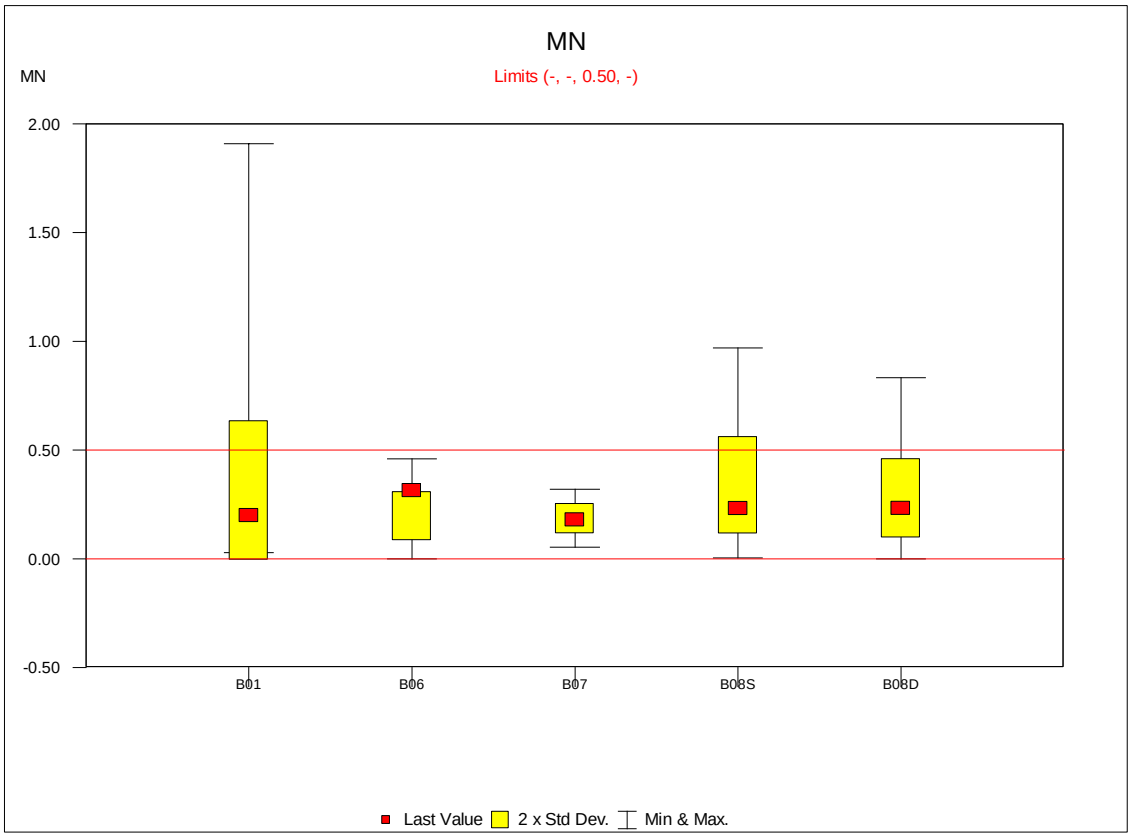

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
B01
B06
B07
B08S
B08D

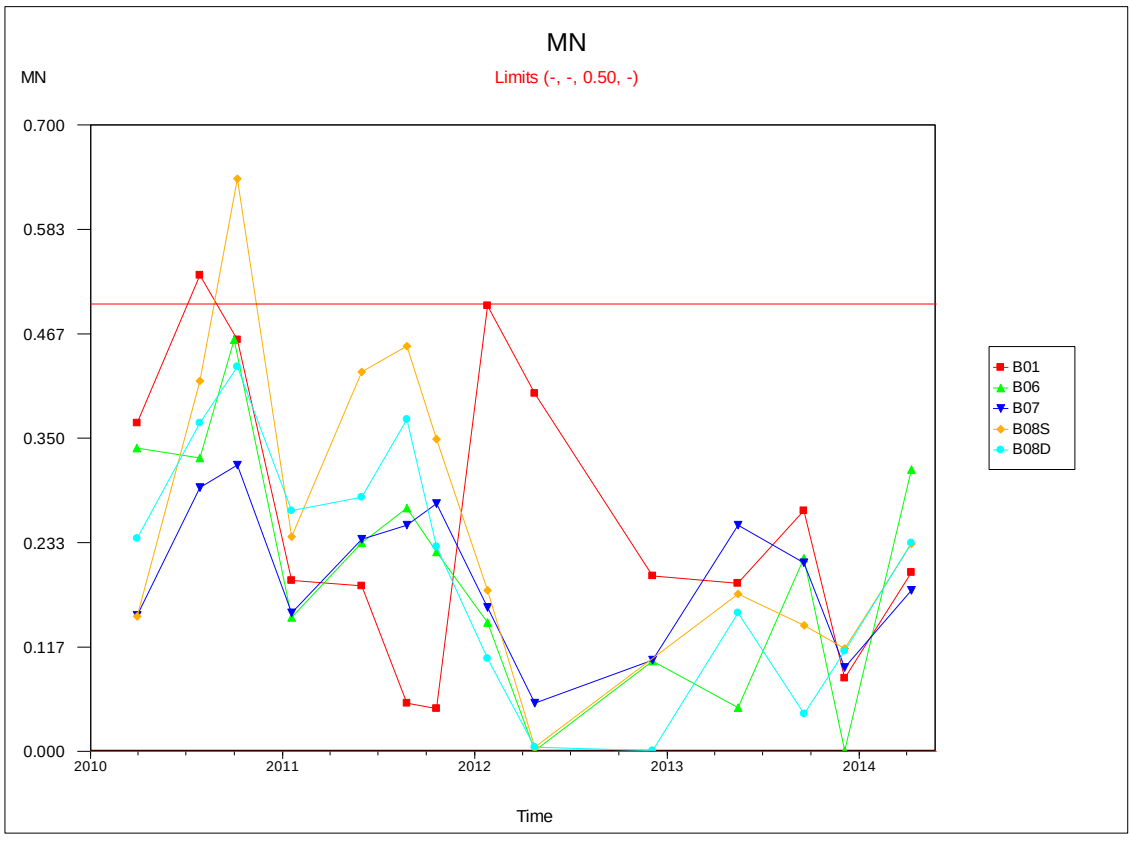

SO4
SO4
Limits (-, -, 500, -)
2000
1500
1000
500
0
B01
B06
B07
B08S
B08D
Last Value
2 x Std Dev.
Min & Max.


SO4
SO4
Limits (-, -, 500, -)
500
400
300
200
100
0
2010
2011
2012
2013
2014
Time
B01
B06
B07
B08S
B08D

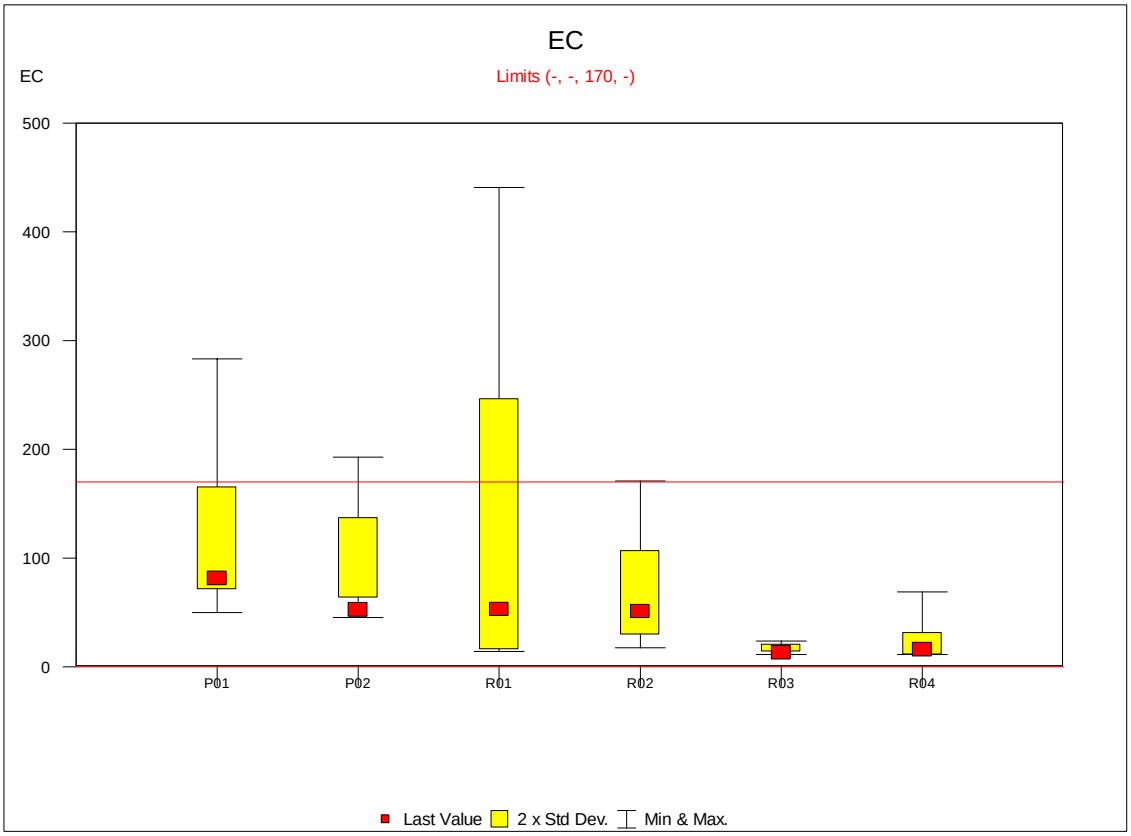

FE
FE
Limits (-, -, 0.20, -)
8.0
6.0
4.0
2.0
0.0
-2.0
B01
B06
B07
B08S
B08D
Last Value
2 x Std Dev.
Min & Max.

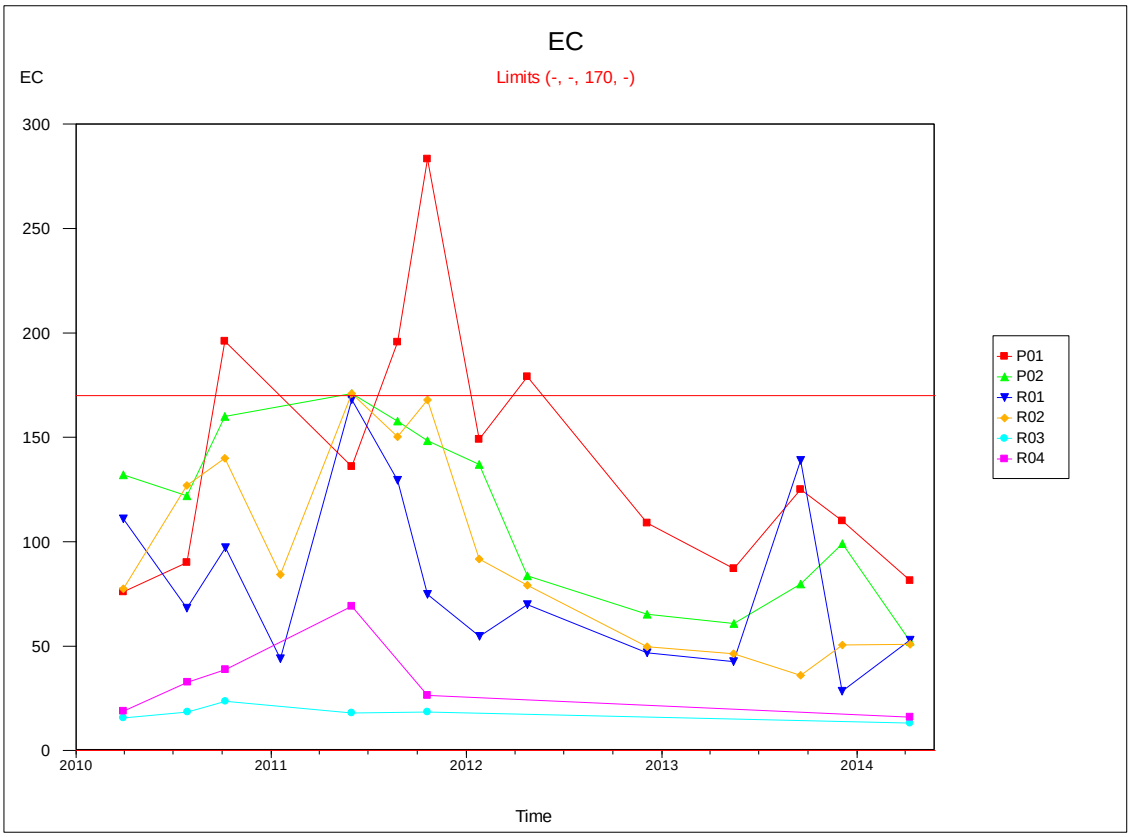

FE
FE
Limits (-, -, 0.20, -)
0.700
0.583
0.467
0.350
0.233
0.117
0.000
2010
2011
2012
2013
2014
Time
B01
B06
B07
B08S
B08D

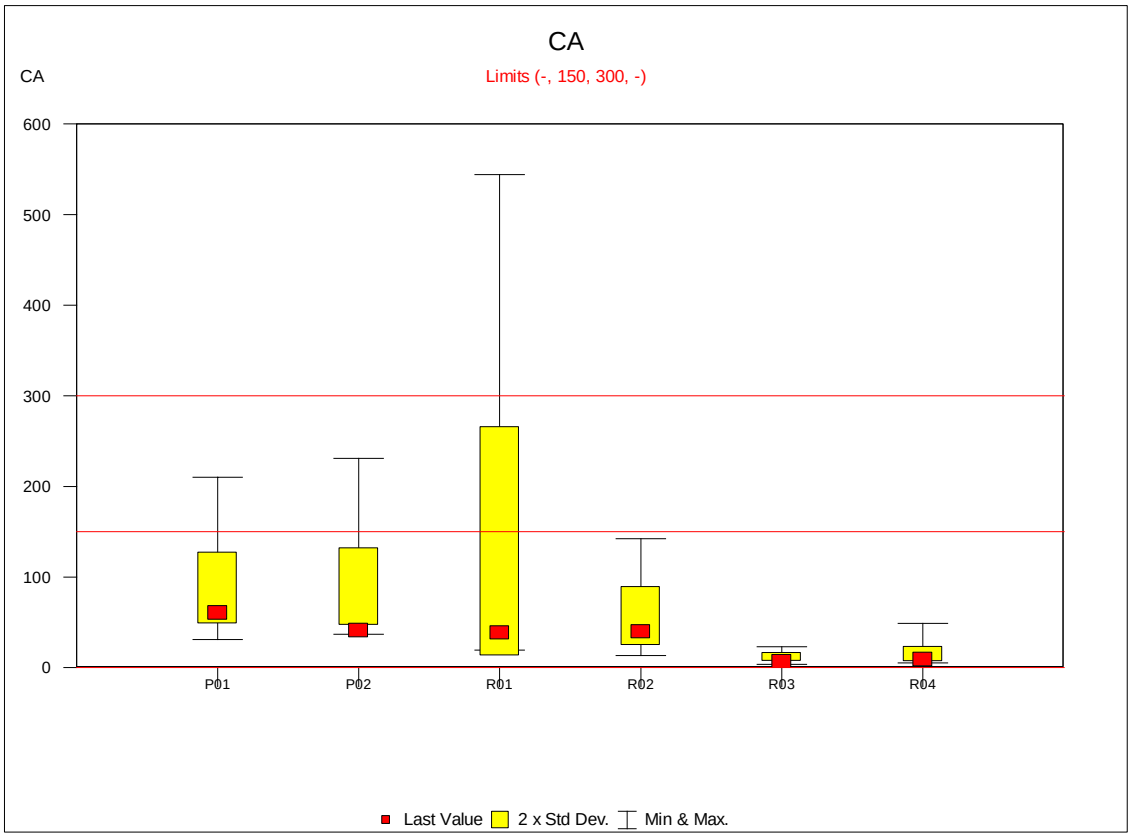

MN
MN
Limits (-, -, 0.50, -)
2.00
1.50
1.00
0.50
0.00
-0.50
B01
B06
B07
B08S
B08D
Last Value
2 x Std Dev.
Min & Max.

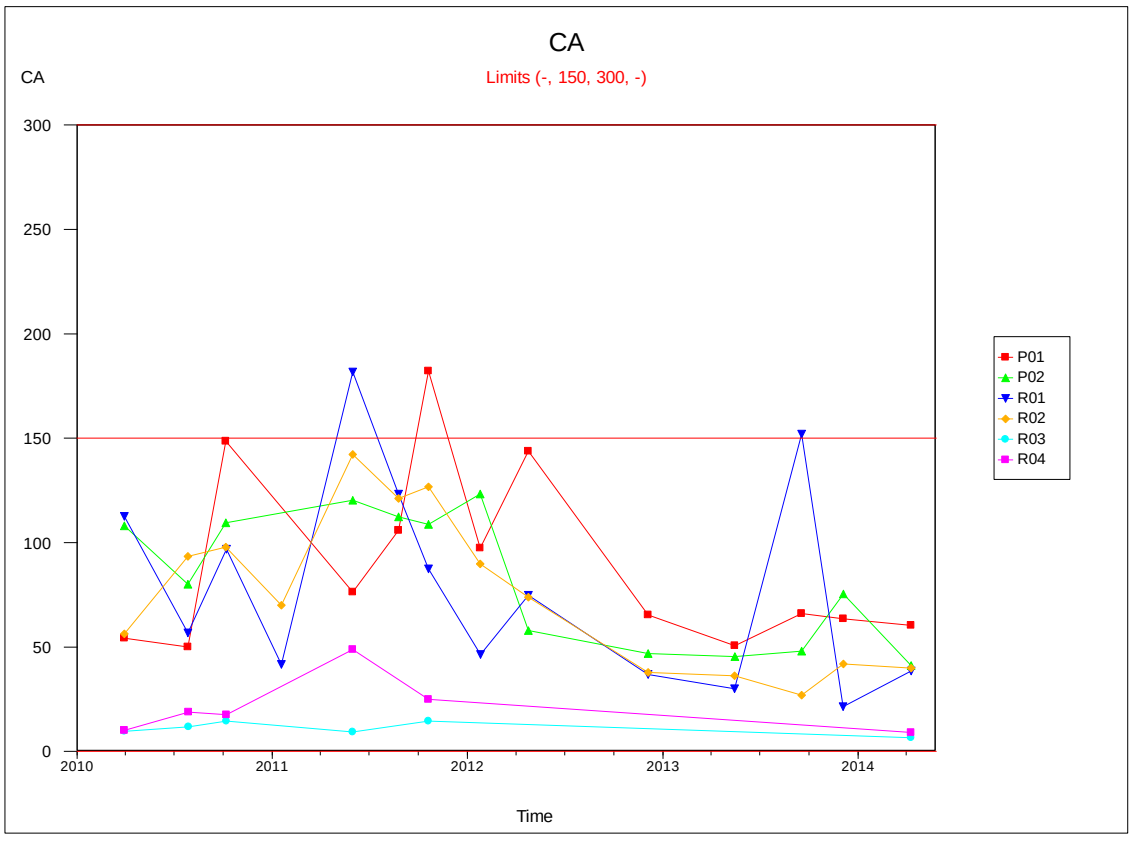

MN
MN
Limits (-, -, 0.50, -)
0.700
0.583
0.467
0.350
0.233
0.117
0.000
2010
2011
2012
2013
2014
Time
B01
B06
B07
B08S
B08D

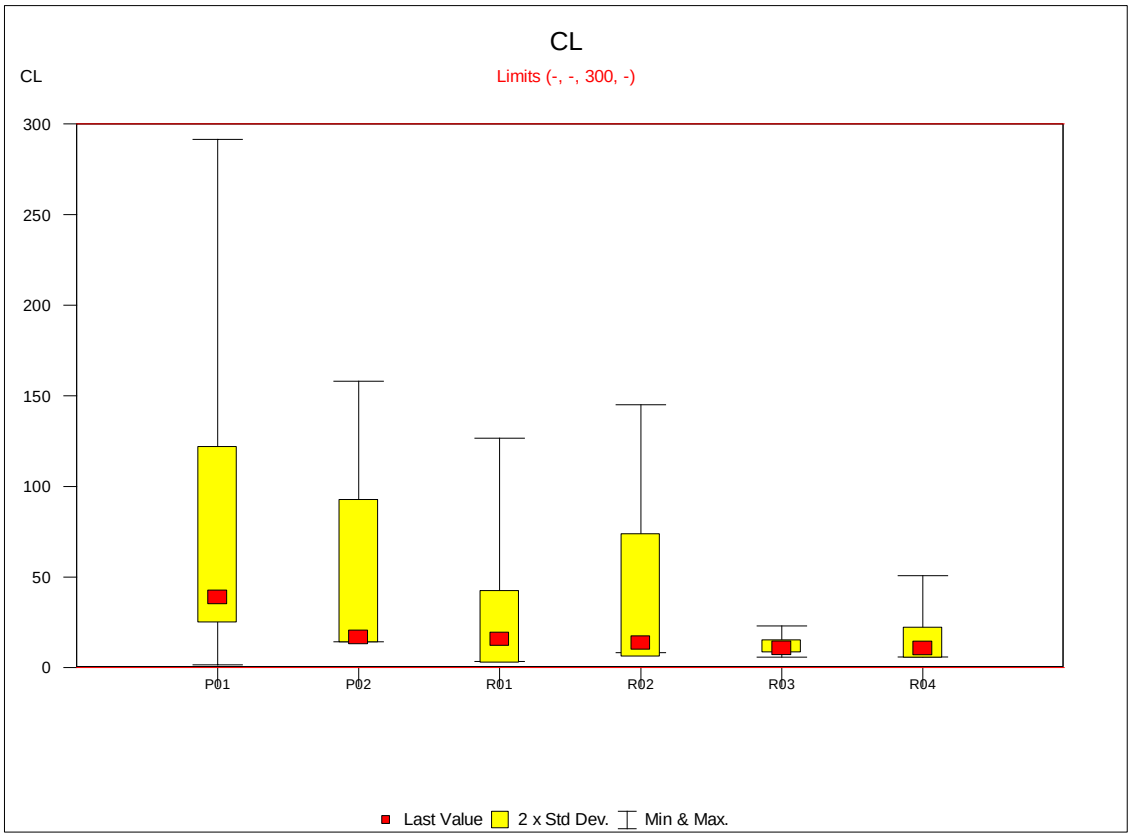
D4. MAJOR DRAINAGE SYSTEM 1: WITPUNT SPRUIT

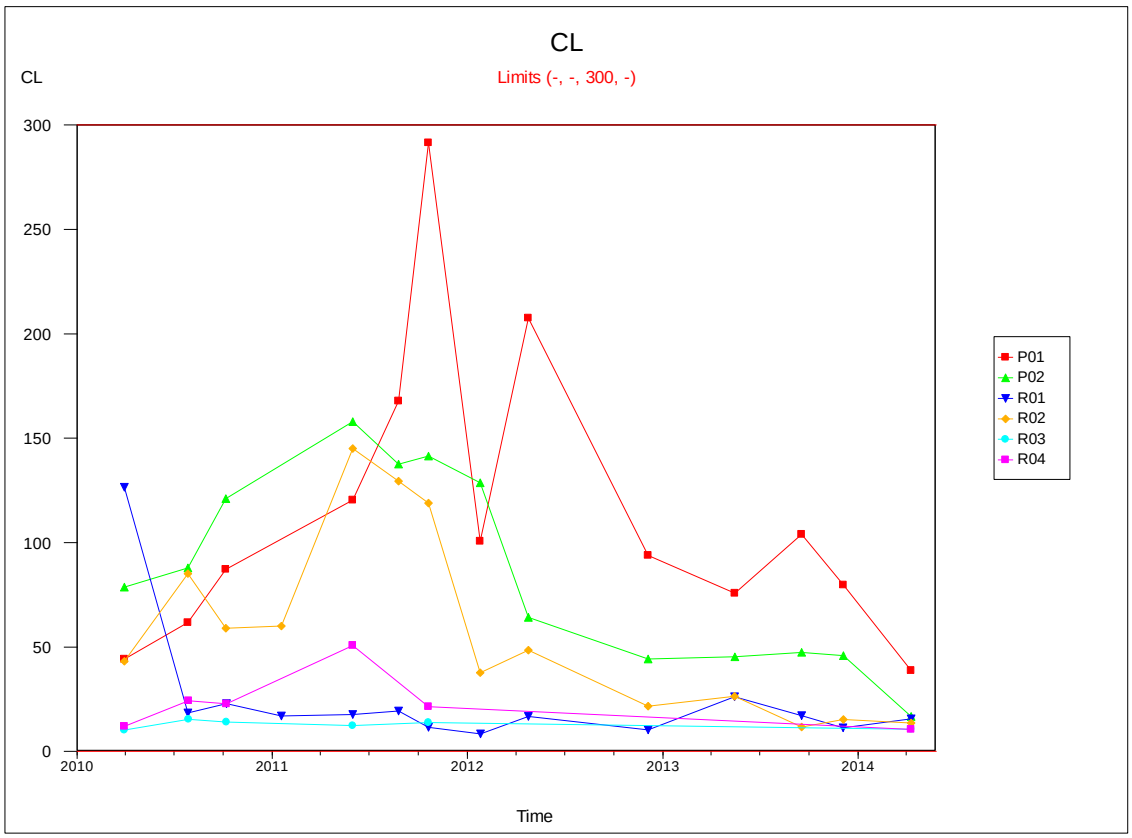


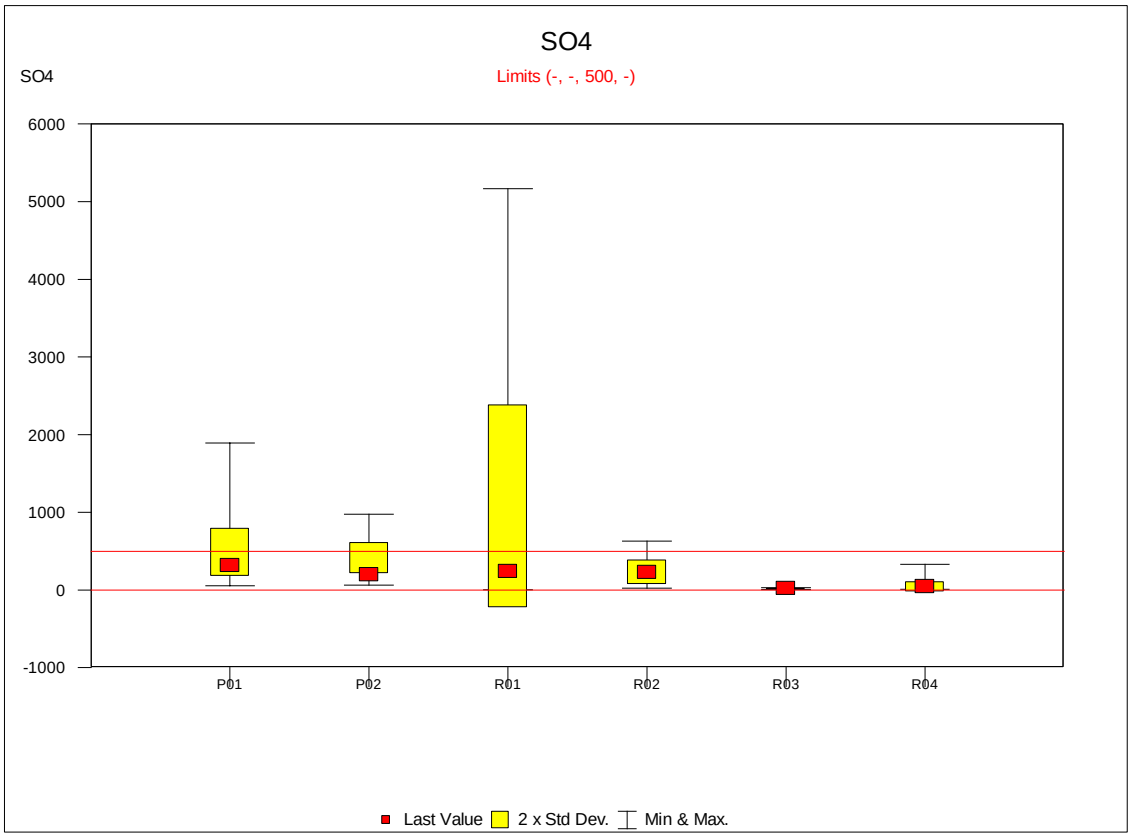


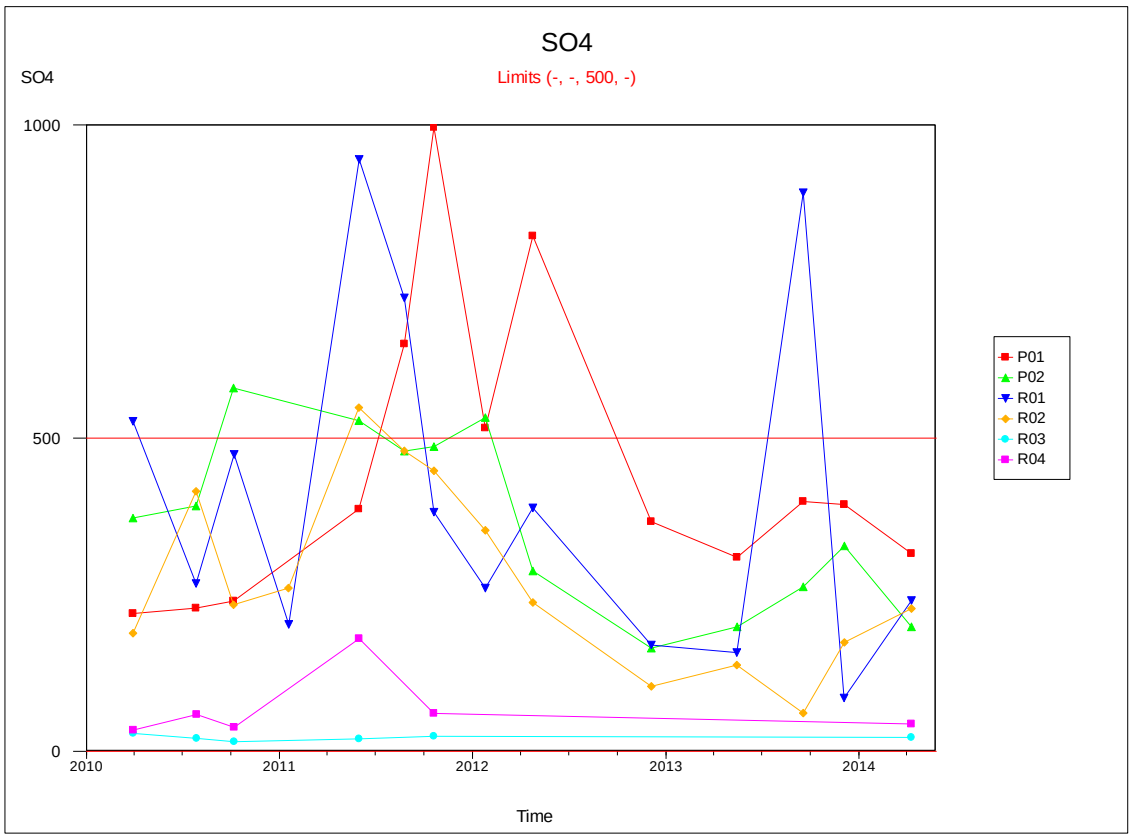

CA
CA
Limits (-, 150, 300, -)
600
500
400
300
200
100
0
P01
P02
R01
R02
R03
R04
Last Value
2 x Std Dev.
Min & Max.

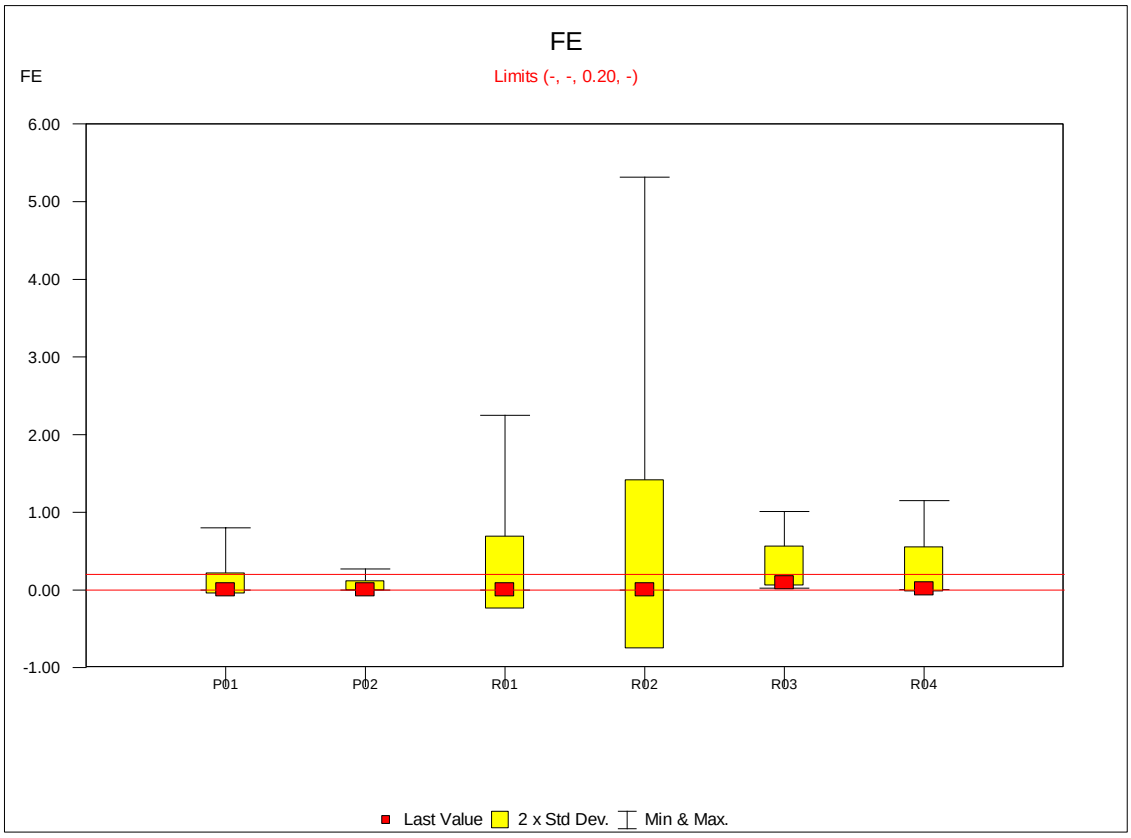

CA
CA
Limits (-, 150, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
P01
P02
R01
R02
R03
R04

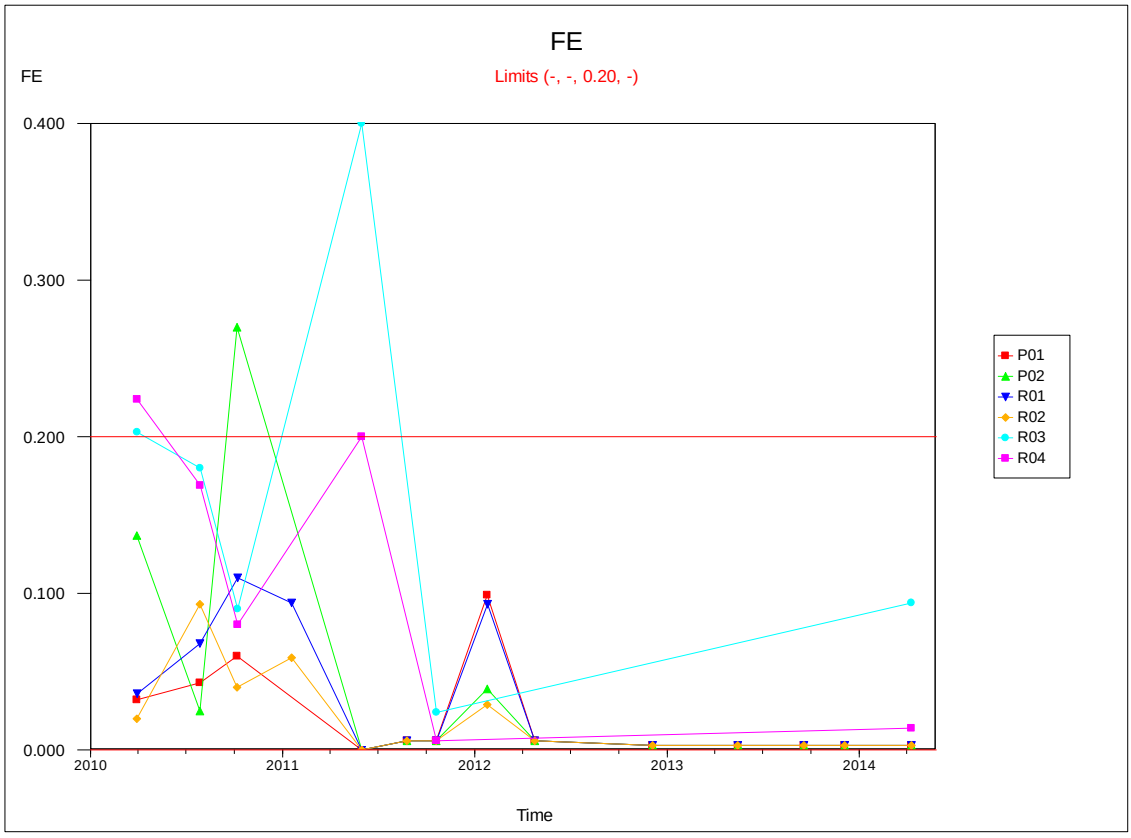

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
P01
P02
R01
R02
R03
R04
Last Value
2 x Std Dev.
Min & Max.

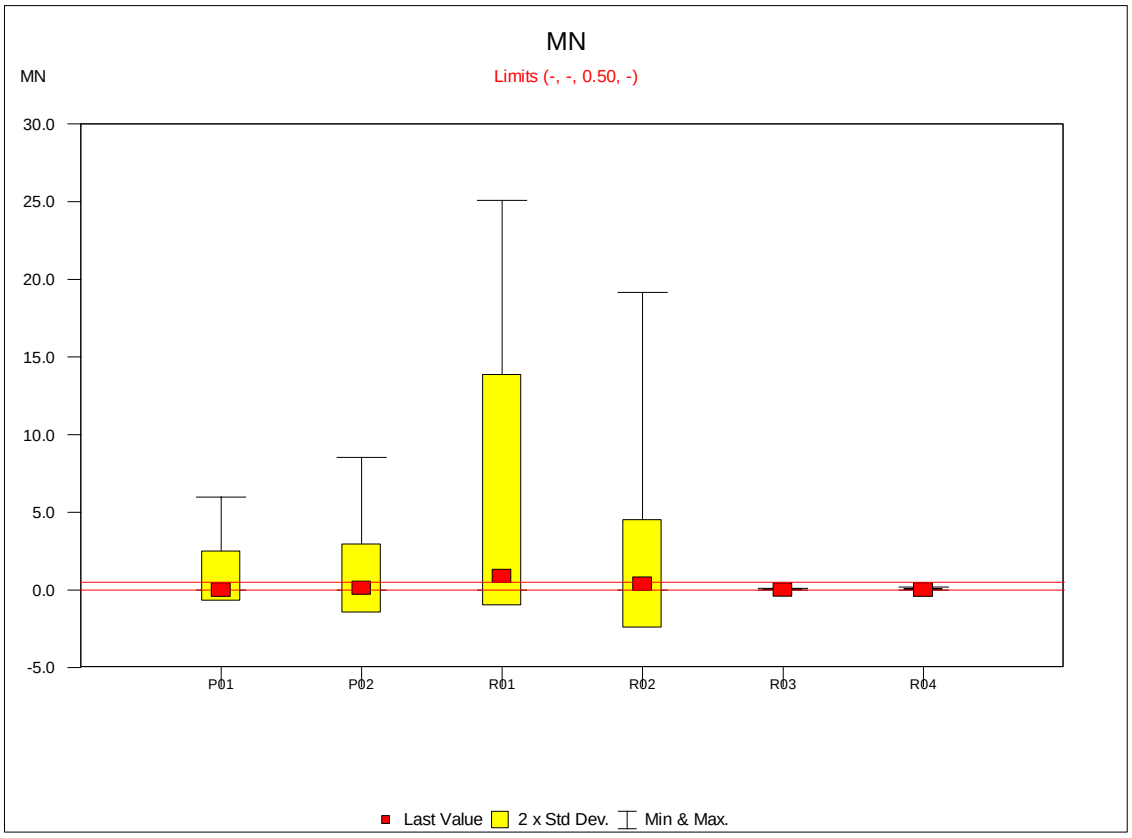

CL
CL
Limits (-, -, 300, -)
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
Time
P01
P02
R01
R02
R03
R04

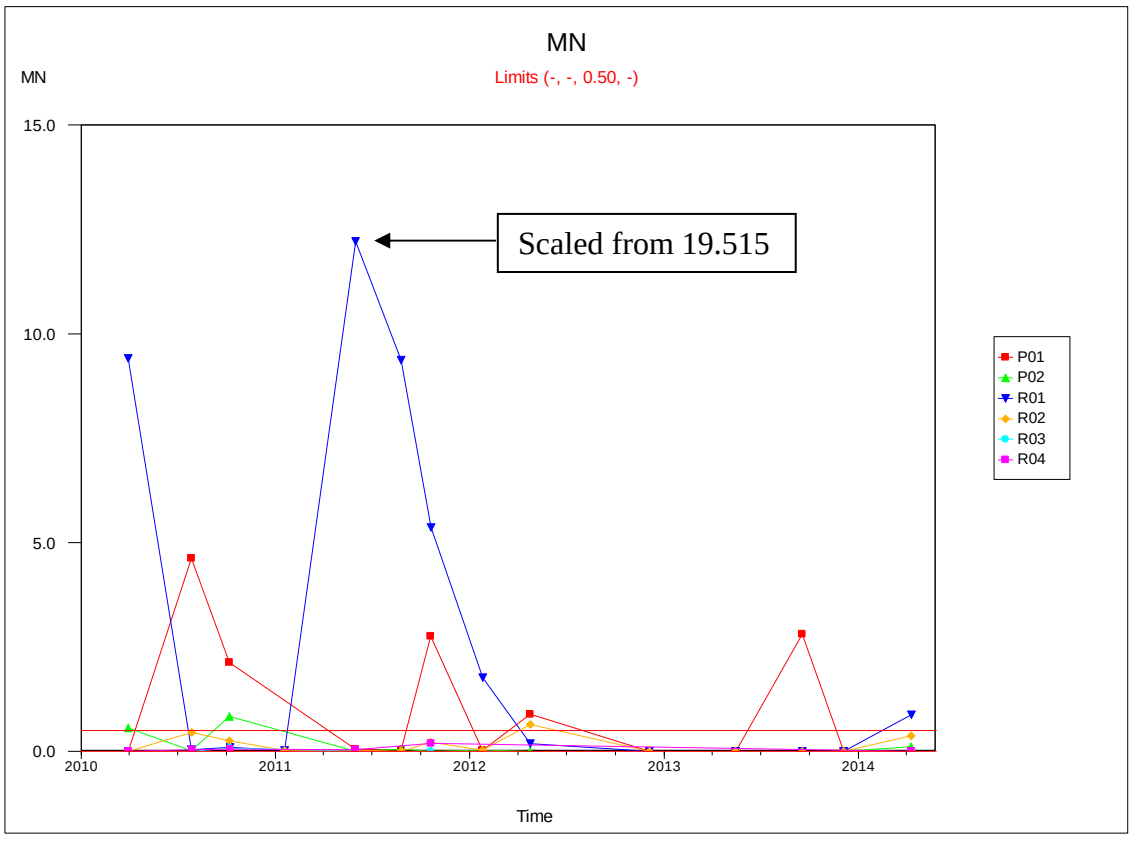

SO4
SO4
Limits (-, -, 500, -)
6000
5000
4000
3000
2000
1000
0
-1000
P01
P02
R01
R02
R03
R04
Last Value
2 x Std Dev.
Min & Max.


SO4
SO4
Limits (-, -, 500, -)
1000
500
0
2010
2011
2012
2013
2014
Time
P01
P02
R01
R02
R03
R04


FE
FE
Limits (-, -, 0.20, -)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
P01
P02
R01
R02
R03
R04
Last Value
2 x Std Dev.
Min & Max.


FE
FE
Limits (-, -, 0.20, -)
0.400
0.300
0.200
0.100
0.000
2010
2011
2012
2013
2014
Time
P01
P02
R01
R02
R03
R04


MN
MN
Limits (-, -, 0.50, -)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
P01
P02
R01
R02
R03
R04
Last Value
2 x Std Dev.
Min & Max.


MN
MN
Limits (-, -, 0.50, -)
15.0
10.0
5.0
0.0
Scaled from 19.515
2010
2011
2012
2013
2014
Time
P01
P02
R01
R02
R03
R04