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Description of the service

Executive overview

According to Eskom's Zero Liquid Effluent Discharge (ZLED) philosophy, no effluent is allowed to leave the sites. Impacted water is therefore utilised in an ever-cascading quality level until it reaches the ashing system where it is used for the slurring and transportation of the ash and/or for dust suppression on the ash dump.

The Contractor must supply a proposal for the testing of the various wastewaters with the shear enhanced vibrating membrane processing technology. The testing will take place in two phases, first being laboratory testing to determine the optimal membrane to use and secondly pilot testing with a skid installed at the various sites.

Five streams will be considered for evaluation:

1. Wastewater which contains high levels of ash and oil (Tutuka Power Station)
2. Ash water return (Kriel/Duvha Power Station)
3. Flue Gas desulphurisation (FGD) bleedstream (Kusile Power Station)
4. Reverse Osmosis plant reject (Tutuka Power Station)
5. CCW for a sensitivity analysis) (Kriel/Tutuka Power Station).

Employer's requirements for the service.

1.2.1 Technology to be tested

Research has developed new technologies, which have not been proven on Eskom waters. These systems are classified as dynamic filtration, which generates high shear rates more efficiently than cross-flow filtration. In dynamic filtration, shear rates are generated not by a pump, but by moving parts or vibrations. Also called shear-enhanced filtration, these movements create the membrane shear rate necessary to maintain the filtration by vibrating the membranes. This mode of operation allows high shear rates, of the order of $1-3 \times 10^5 \text{ s}^{-1}$ to be generated and increases both permeate flux and membrane selectivity. Vibrating modules (i.e., Shear-Enhanced Vibrating Membrane processing technology) consist of a stack of circular membranes oscillating around a vertical shaft at its resonant frequency.

The Contractor must supply a proposal for the testing of the various wastewater as described above, with the shear enhanced vibrating membrane processing technology. This technology must be versatile, and shall be able to be used with MF, NF and RO membranes. The industrial membrane area per module must be more than 120m². The Contractor must provide proof consisting of at least five case studies, with water similar to the described streams, where this technology has been tested and installed in industrial applications in the world and has shown very successful results.

In a typical system, membranes are arranged in a plate and frame configuration. Different types of membranes (Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis) can be used in a module to achieve the required product quality. The system requires a pilot test protocol to obtain a right membrane material in combination with vibration to provide a stable flux.

The system must achieve high-energy efficiency by applying shear into a thin zone near the filter surface. This precise application of shear results in efficient energy conversion and very low power consumption. In these systems, nearly 99% of the total energy utilized is converted to shear at the membrane surface. The disk stack of the unit is oscillated above a torsion spring that moves the stack back and forth. The oscillation produces a shear at the membrane surface of approximately 150,000 inverse seconds, which is much higher than conventional cross-flow systems. The shear waves produced by the membrane's vibration cause solids and foulants to be lifted off the membrane surface and remixed with the bulk material flowing through the membrane stack. The system proposed must be simple and compact. The system must not depend on feed flow to induce shearing forces, the feed slurry can become extremely viscous and still be successfully dewatered. The concentrate is essentially extruded between the vibrating disc elements and exits the machine once it reaches the desired concentration level. Thus, the system must be able to run in a single pass through the system, eliminating the need for costly working tanks, ancillary equipment and associated valving.

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Membrane selection is the single most important parameter that affects the quality of the separation. Other important parameters that affect system performance are pressure, temperature, vibration amplitude, and residence time. All of these elements are optimized during testing.

The testing will take place in two phases, first being laboratory testing to determine the optimal membrane to use and secondly pilot testing with a skid installed at the various sites.

The *Contractor* must sign a Non-Disclosure Agreement with Eskom. All results emanating from the trial/test form a part of Eskom's Intellectual Property (IP) and cannot be shared or published without Eskom's permission."

1.2.2 Aim of the testing

The aim of the pilot testing is to determine if the system being tested, will be able to treat the various identified streams efficiently and effectively.

The primary aims of the treatment plant are as follows:

- a) It must be cost effective;
- b) It must be able to recover an economically feasible maximum amount of treated water suitable for reuse;
- c) It must minimise treatment process complexity and footprint; and
- d) it must minimise waste handling issues.

1.2.3 Parameters to be tested

The following key parameters will be tested and the acceptance criteria for the pilot tests must be as follows:

1. The permeate produced must be of raw water quality or better (for the specific station as detailed below).
2. A maximum recovery which can be achieved must be compared to the life cycle costs of the system (membrane replacement, energy, chemicals) for the most economical solution.
3. The cleaning frequency will be evaluated and used to determine life cycle costs.
4. Determine the degree of deterioration of membrane performance over time will be evaluated and used to determine life cycle costs.

1.2.4 Laboratory scale tests

The *contractor* will be responsible to firstly do laboratory tests at the *contractors* premises. If possible, Eskom will witness the tests. The costs for the transport of the samples as well as the testing and development of the report to be included. This must be done to optimise the following:

- operating pressure,
- the type of membrane to use,
- the shear rate,
- operating temperature
- pH conditions
- flux

The equipment for the laboratory scale tests must be supplied by the *Contractor*. The testing equipment typically consists of a

- feed tank,
- permeate tank,
- concentrate tank
- manual ball valves for isolation
- feed pump
- The membrane assembly with a:
 - driving system that generates vibration,
 - membrane module,
 - torsion spring which transfers vibration to the membrane module, and
 - system for controlling vibration.

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This is a typical description, but the responsibility still lies with the *contractor* to decide on the equipment required for the laboratory testing.

The *Contractor* shall use a single membrane for each test. Various membranes are tested with each waste water source to determine which membrane will be optimal. Operating pressure must be varied during the test depending on the type of membrane used, and the shear rate must also be varied.

The apparatus must be able to vibrate the membrane with a frequency of up to 60Hz and a maximum vibratory amplitude of 25.4mm (1"). The vibratory amplitude at the rim of the membrane module must be varied to evaluate the effect of vibration. All the parameters which are changed (independent variables), as well as the dependent variables (those that will change) will be tested frequently (every 5-10 minutes).

During the test, operational and performance data shall be collected by the *contractor*. An example of the variables are as follows. But the responsibility will belong to the contractor to decide on the procedure for testing.

Variables

Independent variables

- Type of membrane used
- Feed concentration

Dependent variables

- Change in flux
- Concentration of the reject stream
- Concentration of the permeate
- Removal percentage

Controlling Variables

- The feedwater pressure

The procedure which will be required for testing must be supplied to the *Employer* for acceptance. The *Contractor* must provide a cost for the laboratory testing which shall include the transportation of the water samples to the *contractors* location. A report must be produced detailing the tests experimental procedure/methodology, results and conclusions.

1.2.5 Pilot scale tests

For the pilot scale tests, the candidate membrane of choice from the lab scale tests will be configured in an element stack of approximately 15-25 membranes. However, the equipment must be mounted on a trailer, with all the cleaning equipment incorporated as well. The cleaning equipment must include the heaters for the CIP tank. The system must also be automated with loggers installed to log all the physical parameters (flow, pressure and temperature). The *Contractor* must also include resources for maintenance and operation. Chemicals required for the duration of the trial must also be provided by the *Contractor*. The *Contractor* must also supply all the spares required for the maintenance of the system, as well as the spares to address any defects on the system. These spares must be readily available within 24hrs.

The Pilot test skid must be completely independent and must not require any utilities from the *Employer*, e.g. electrical supply, or compressed air supply. All equipment required to run the pilot test skid must be supplied by the *contractor* (compressor, generator, etc.). The equipment will be situated in a very isolated area, and hence the equipment must be lockable to keep it safe from harm or theft. A new membrane needs to be installed at the start of testing for each new stream as a minimum. If replacement membranes are required during the testing, the *contractor* must make allowance for this as well.

The *Contractor* will provide a cost for the disconnection, transport and reconnection of the pilot plant as it is moved from station to station.

The water required to run the skid will be available from a nearby source, preferably within 1km. The *Contractor* must supply the pump, piping, valves and any other equipment required to supply the skid with the water, as well as to discharge the clean water back into the Eskom plant.

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The testing methodology which will be required for testing must be supplied to the *Employer* for acceptance. The methodology should describe if it is required to do the test either during normal working hours or on a 24 hour, 7 days a week operation. This methodology must prove that the plant will simulate operational conditions and that the interruption in operation will not alter the results. There will be no payment during the time periods when the skid is not operational. In the event that there are issues with test as a result of the contractors equipment, then the contractor will be liable for the costs. If the fault is as a result of the *Employer*, then the *Employer* is liable for costs.

Membrane cleaning concepts that would be applicable to actual plant criteria must also be evaluated. The *contractor* must evaluate the efficacy of using standard commercially available cleaning chemicals versus proprietary chemicals.

In these tests, the following, as a minimum, will be tested and optimised:

- Determine the optimum operating pressure.
- Pre-treatment optimisation.
- Determine flux rates and achievable concentration with a range of operating conditions.
- Determine the maximum recovery.
- Determine the cleaning requirements and regime as well as optimisation of the cleaning protocols and chemicals.
- Determine required membrane area; and
- Determine the degree of deterioration of membrane performance over time.

The *Contractor* must also provide a cost for the autopsy of the membrane.

A report must be produced detailing the tests experimental procedure/methodology, results and conclusions. Monthly reports must be provided as the tests are ongoing. After the completion of the tests on each source water, a draft report must be submitted for that specific source water. The report must also contain information with regards to the sizing of the plant for each source water, the associated capital cost as well as operating and maintenance cost for the life cycle of the plant. At the end of all the tests, a final report must be submitted no later than a month after the conclusion of the final tests. This document must consolidate all the information for the lab scale tests, pilot scale tests as well as results of the autopsy.

1.2.6 Various Feedwaters which will be tested

a. Wastewater which contains high levels of ash and oil

The dirty water dams receive the wastewater from the station. This includes all drains from the water and steam circuit, drains from the CW pipework in the units, floor-washing effluent, etc. These drains are contaminated with ash when the stations are forced to implement emergency floor ashing to clear the boiler throat prior to shutting down the unit to repair the defect. The ash is washed into the station drains and ends up in these dirty water dams. In addition to this, the water is contaminated with oil from leaks which exist on the plant. This is also washed into the station drains. The design of the system is such that this water must be treated by an oil and grit system. However, this system is only designed for certain levels of oil and grit and is usually overloaded, and hence it is not effective. As part of the ZLED philosophy, the water from this system must be returned to the cooling water system for further treatment. This excess ash then impacts the cooling water treatment system and causes frequent failures on the clarifiers bridges and stirrers.

A solution is required for this dirty water dam water which will remove all the ash and oil from the water and produce water which is of a raw water quality or better. This analysis is the dissolved species. The intention is to test the capability of the technology with regards to the removal of ash and oil. At the time of testing, the *Employer* will add these components to the water supply if the levels.

The typical analysis of raw water quality is as per Table 1 and Figures 1-15 below:

Table 1: Raw Vaal water supplied to Tutuka Power Station

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Parameter	Unit	Minimum	Maximum	Average	95 th percentile
Conductivity	µS/cm	110.0	433.0	237.6	327.0
pH		4.3	9.9	7.5	8.9
m-alkalinity as CaCO ₃	mg/kg	15.0	129.5	71.8	108.0
p-alkalinity as CaCO ₃	mg/kg	0.0	19.1	0.4	0
Ca Hardness as CaCO ₃	mg/kg	6.0	104.0	38.8	62.9
Mg Hardness as CaCO ₃	mg/kg	3.8	91.6	38.4	66.4
Chloride	mg/kg	0.4	29.7	11.8	20.1
Potassium	mg/kg	1.7	4.5	3.2	4.0
Phosphate	mg/kg	0.0	2.0	1.0	2.0
Silicate	mg/kg	2.4	51.7	23.1	42
Sulphate	mg/kg	7.4	46.0	26.7	42.3
Sodium	mg/kg	6.0	32.2	15.5	26.7
Total organic carbon as C	mg/kg	4.2	10.4	7.6	9.6
Total hardness as CaCO ₃	mg/kg	28.9	170.0	69.4	124.5
Turbidity	NTU	0	88.3	29.3	58.0

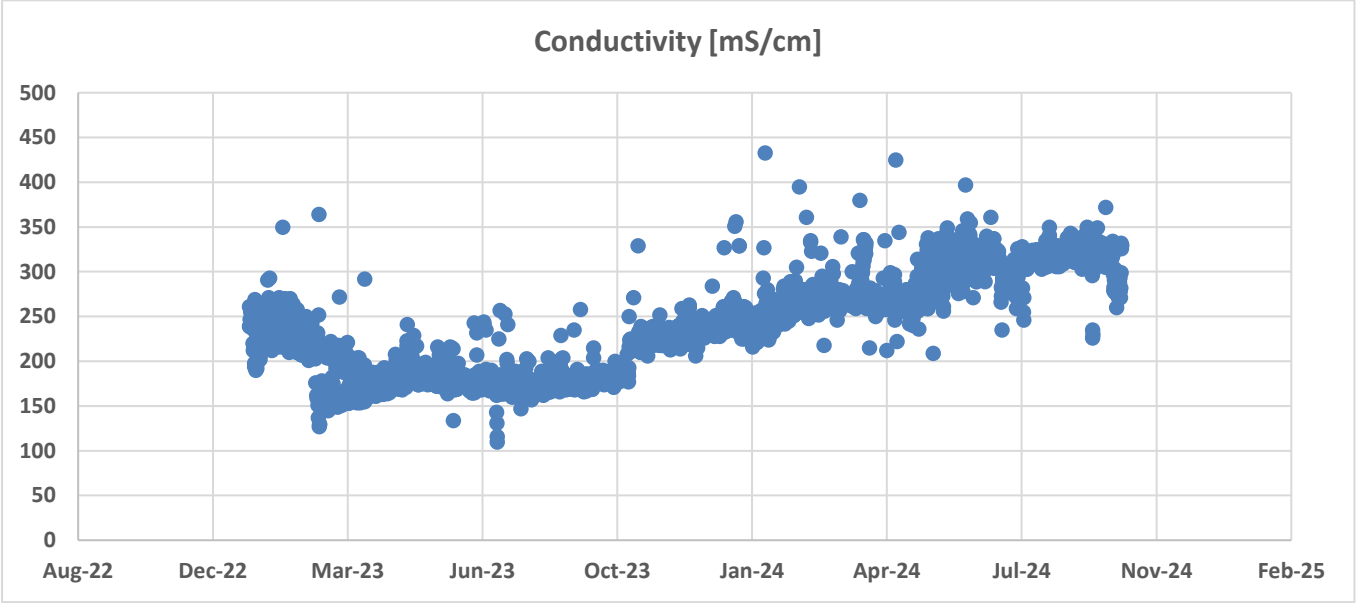


Figure 1: Raw water conductivity at Tutuka Power Station

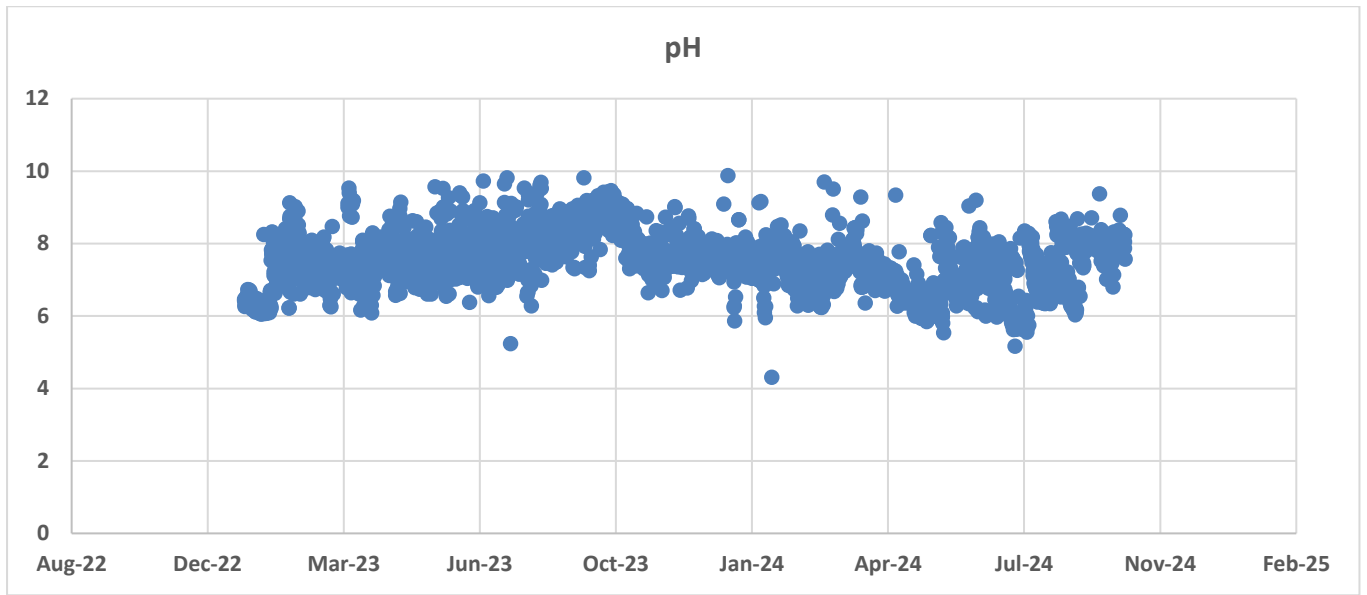


Figure 2: Raw water pH at Tutuka Power Station

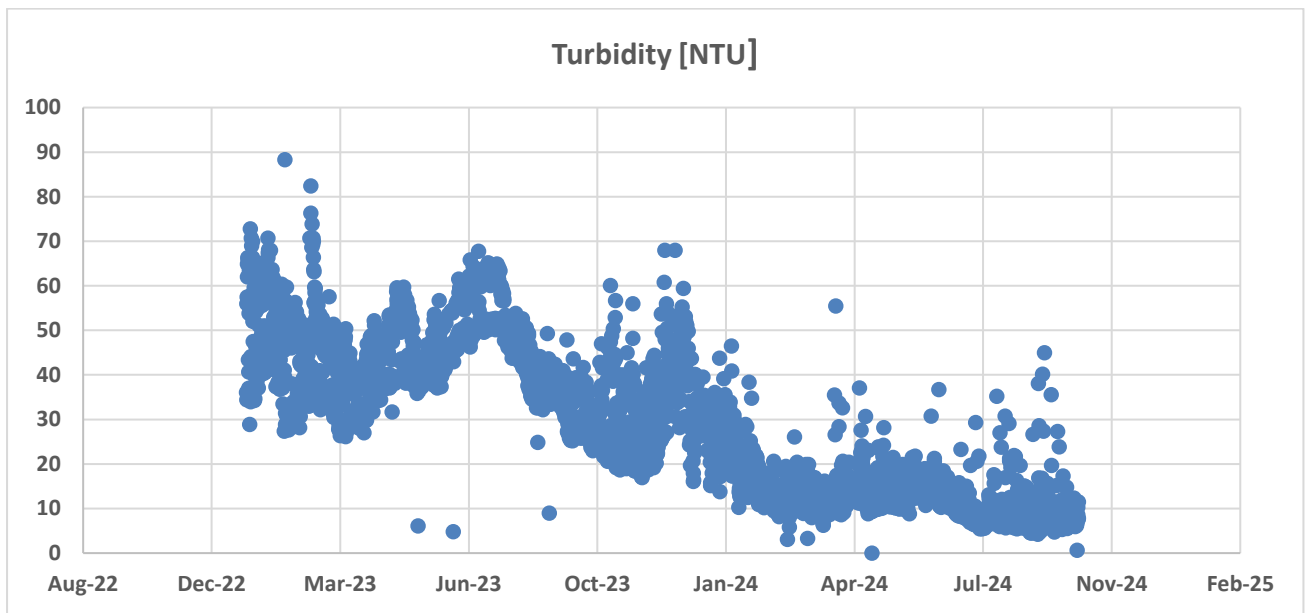


Figure 3: Raw water turbidity at Tutuka Power Station

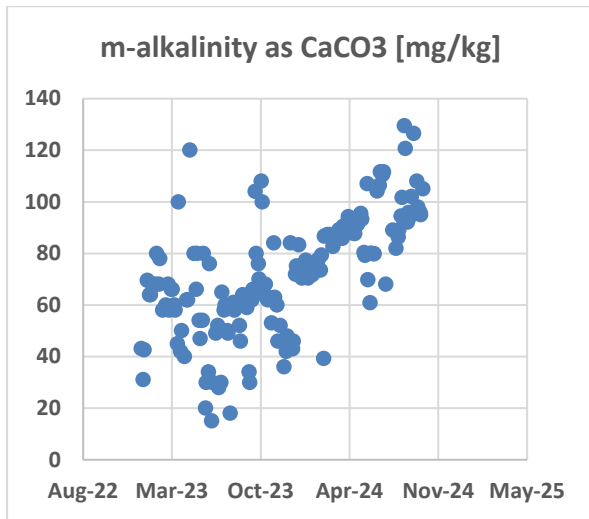


Figure 4: Raw water m-alkalinity

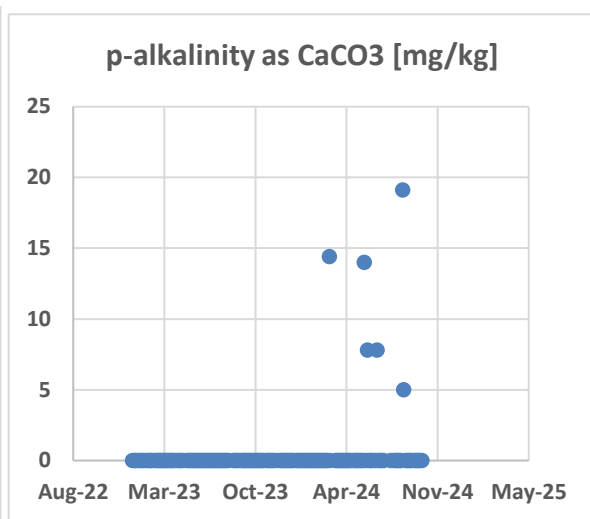


Figure 5: Raw water P-alkalinity

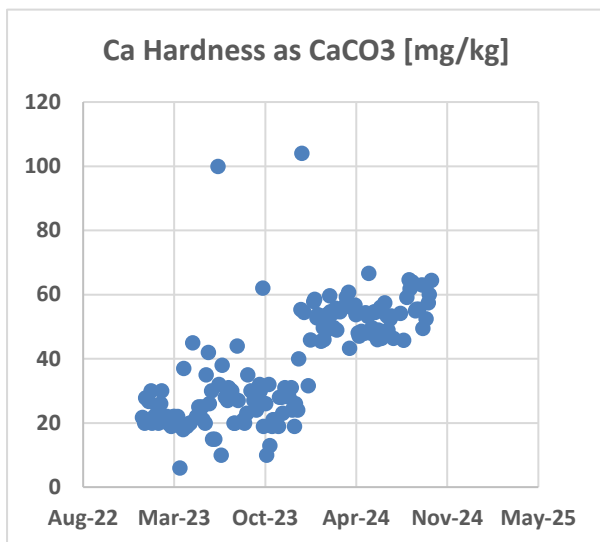


Figure 6: Raw water Ca hardness

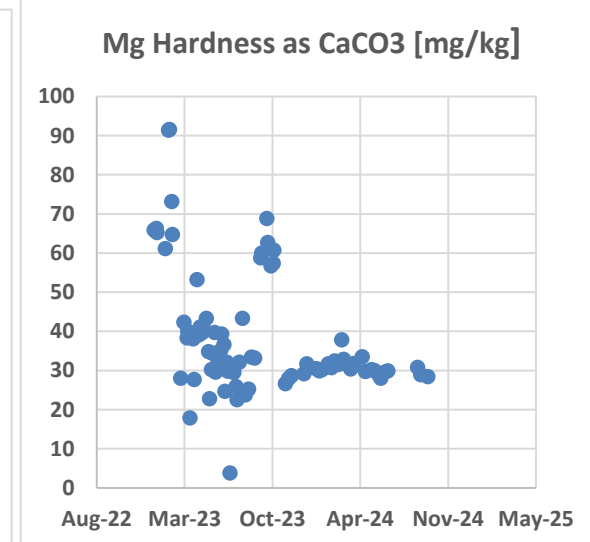
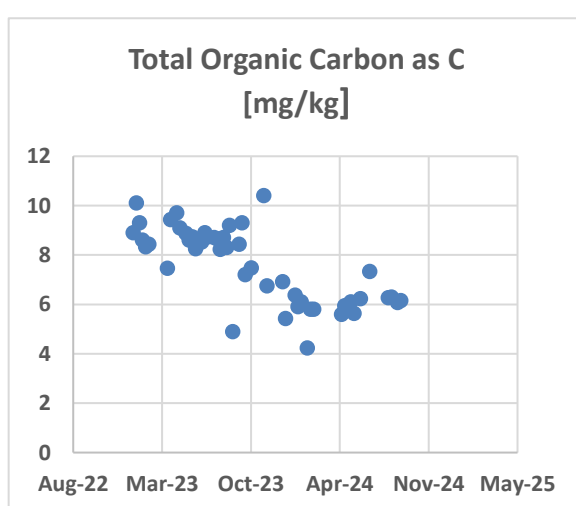
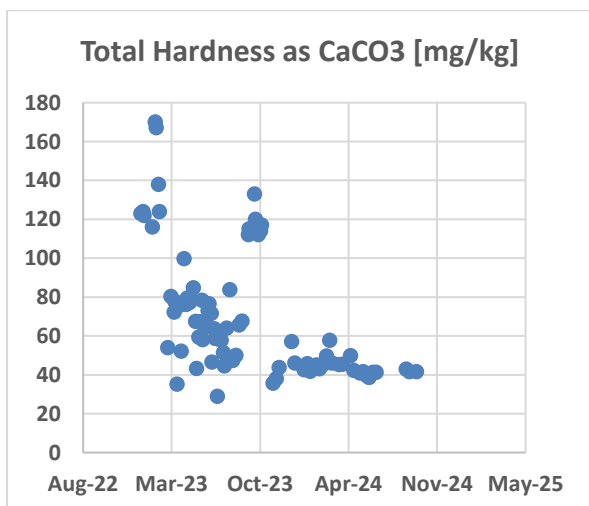


Figure 7: Raw water Mg hardness



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Figure 8: Raw water total hardness carbon

Figure 9: Raw water Total organic

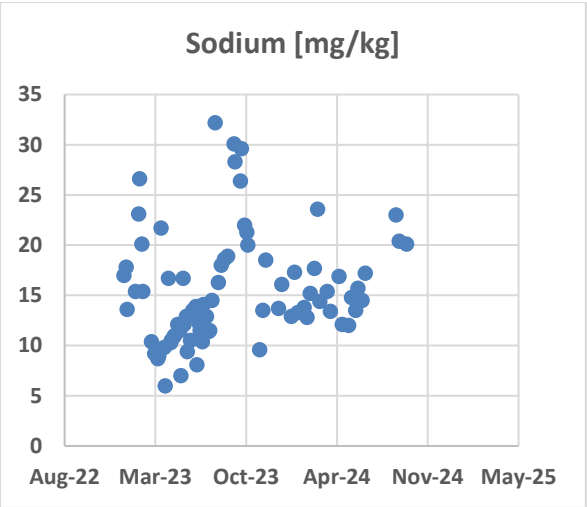


Figure 10: Raw water sodium

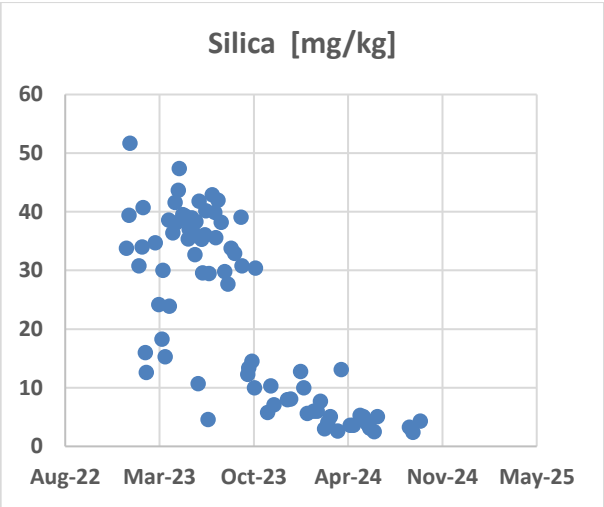


Figure 11: Raw water silica

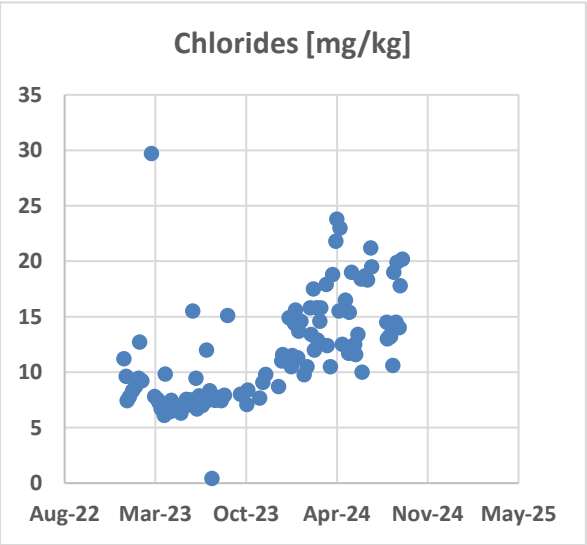


Figure 12: Raw water Chlorides

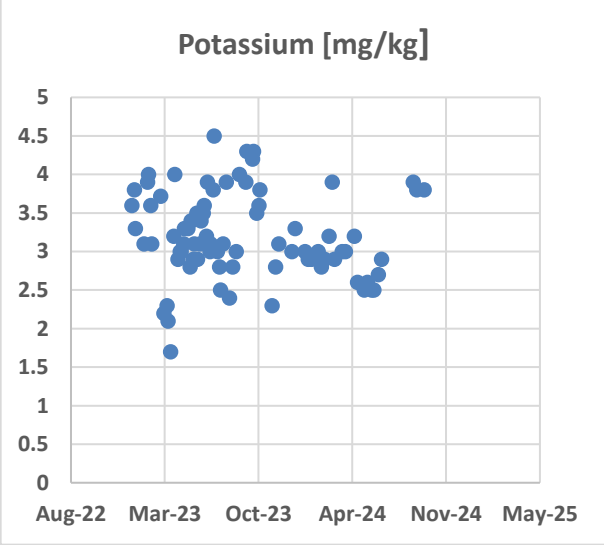


Figure 13: Raw water Potassium

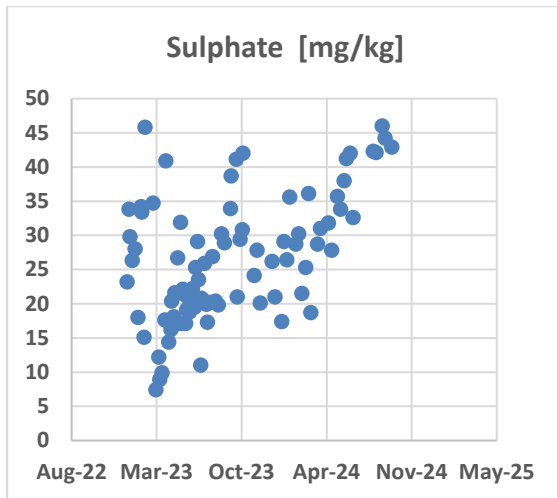


Figure 14: Raw water sulphate

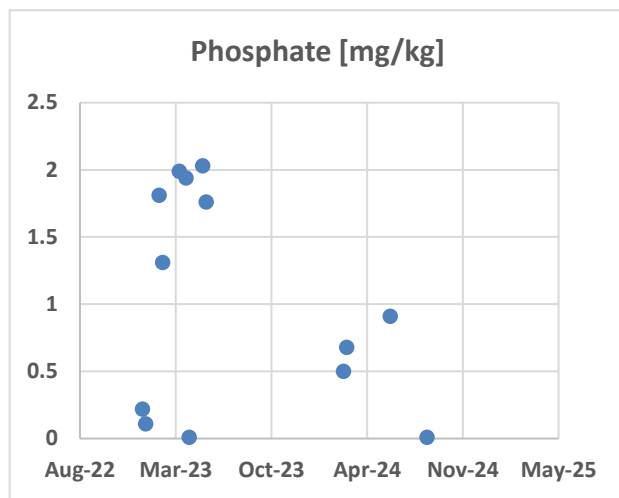


Figure 15: Raw water phosphate

The typical range of water quality in the dirty water dams is as indicated in the Table 2 and Figures 16 to 25 below:

Table 2: Wastewater which contains high levels of ash and oil (Dirty Water Dam recovery -Tutuka Power Station)

Parameter	Unit	Range	Average	95 th percentile
pH	-	6.91 - 10.9	9.1	9.7
Conductivity	µS/cm	809 – 33564	10036.7	25654.8
Turbidity	NTU	1.2 – 343.0	20.5	47.1
Calcium Hardness as CaCO ₃	mg/kg	17.9 – 1431.0	113.7	251.5
Magnesium Hardness as CaCO ₃	mg/kg	42.1 – 1191	342.7	926
Total Hardness as CaCO ₃	mg/kg	65.8 – 1309.0	430.1	1065.4
m-alkalinity	mg/kg	22.8 – 946.8	361.7	680
p-alkalinity	mg/kg	0 - 222	58.0	176.8
Sodium	mg/kg	58.8 - 10180	2034.6	5537
Potassium	mg/kg	8 - 214	56.8	167.2
Chloride	mg/kg	56.7 - 7726	1778.6	6140.5
Silica as SiO ₂	mg/kg	0.8 - 339	17.0	29.7
Sulphate	mg/kg	214 - 27000	3970.2	10424.5
FOG	mg/kg	100-5000	4682	4754

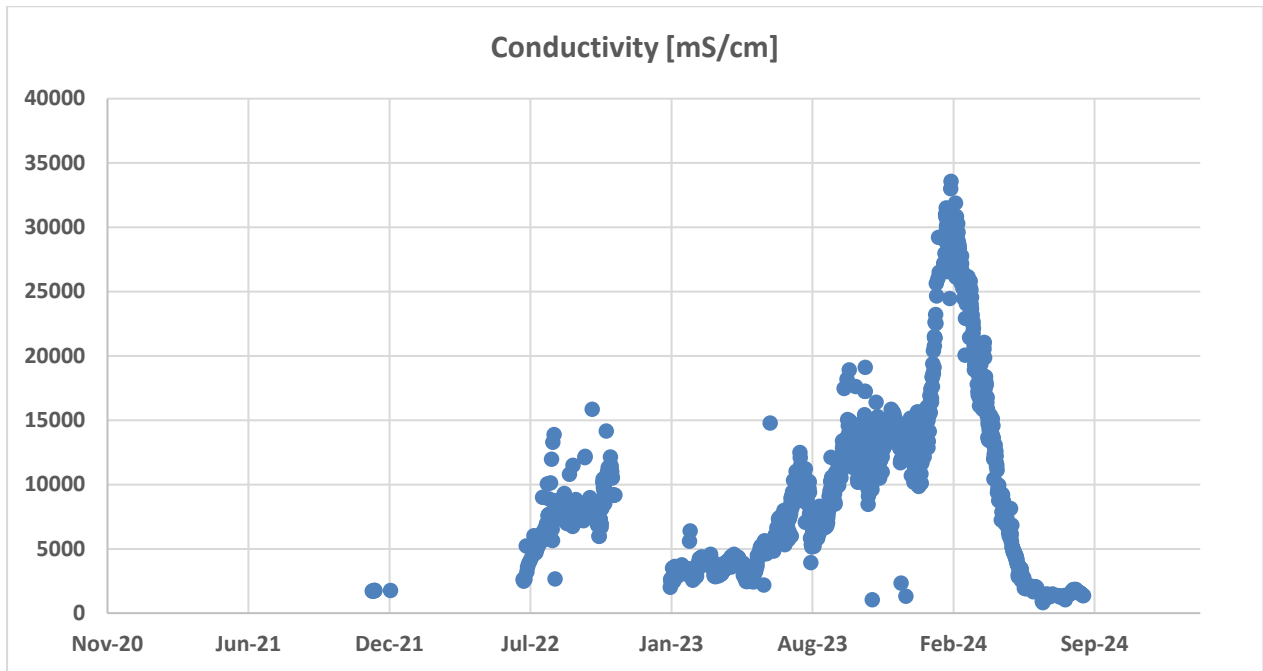


Figure 16: Dirty water dam recovery conductivity at Tutuka Power Station

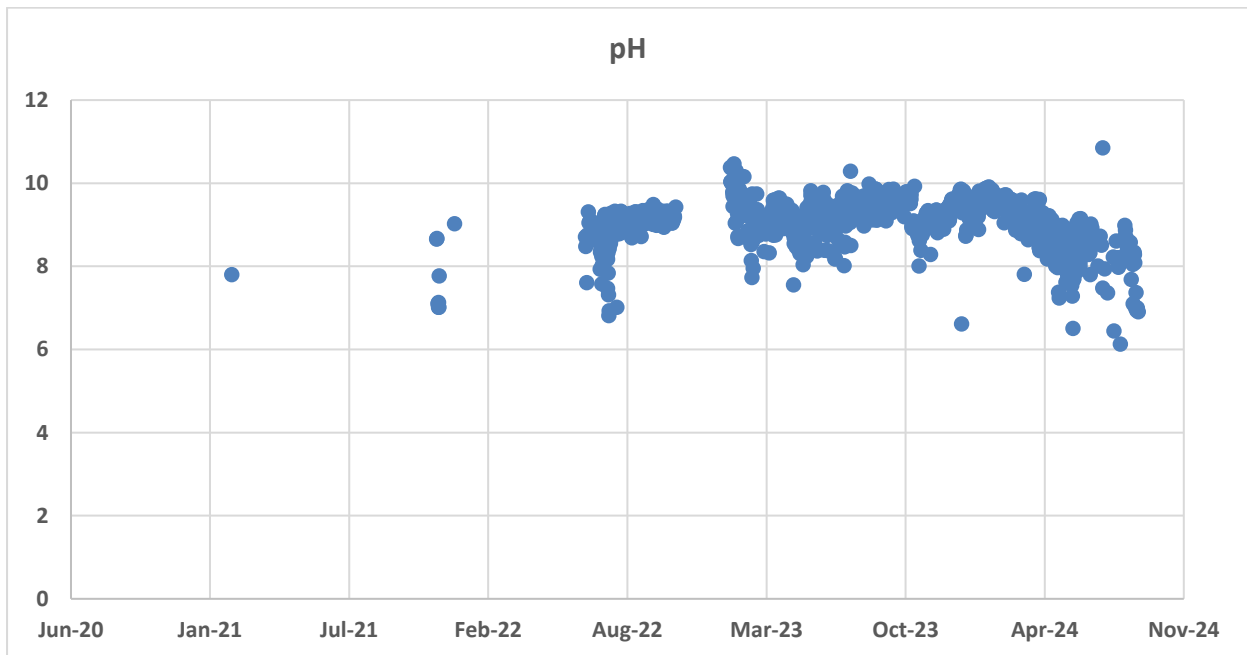


Figure 17: Dirty water dam recovery pH at Tutuka Power Station

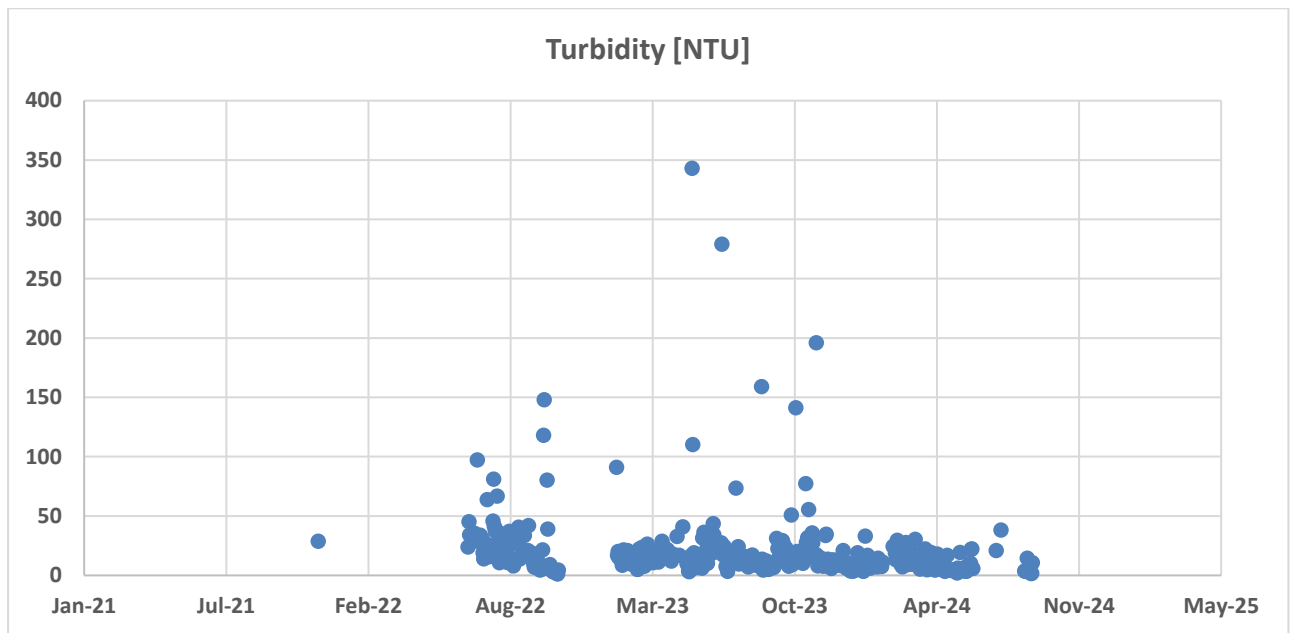


Figure 18: Dirty water dam recovery turbidity at Tutuka Power Station

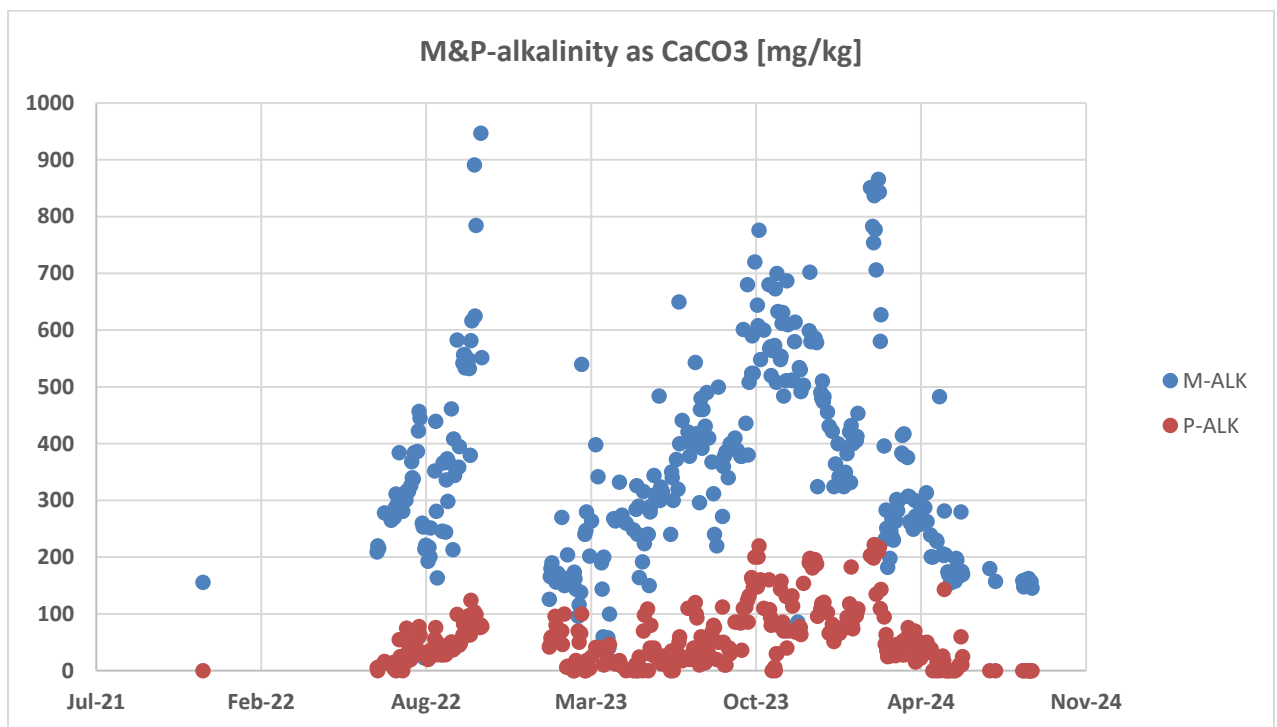


Figure 19: Dirty water dam recovery M&P alkalinity at Tutuka Power Station

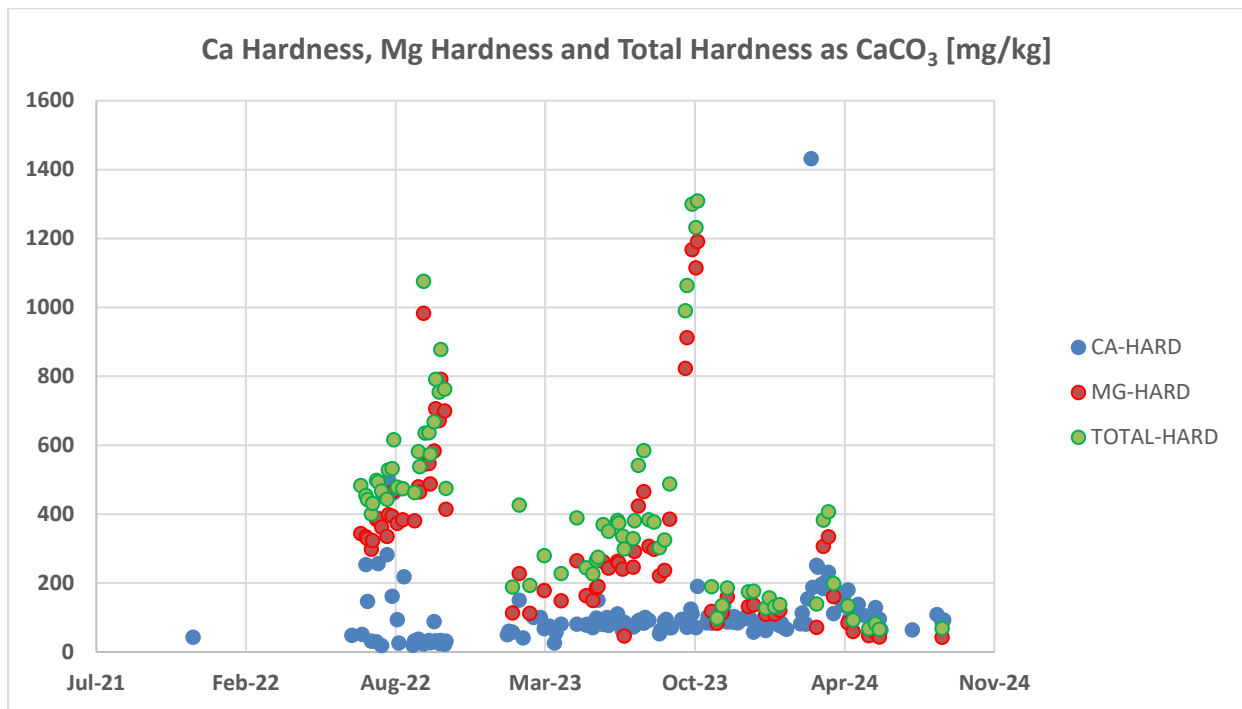


Figure 20: Dirty water dam recovery Calcium, magnesium and total hardness at Tutuka Power Station

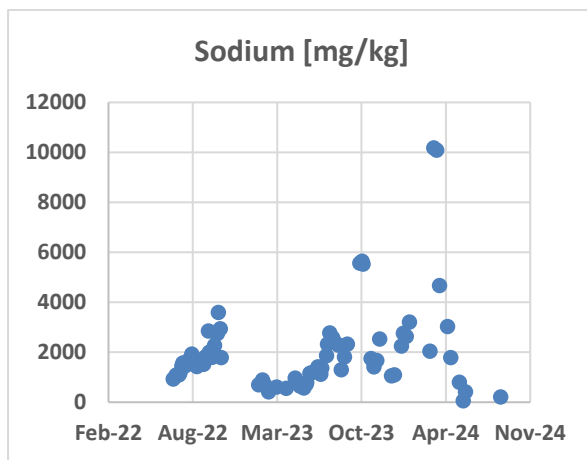


Figure 21: Dirty water recovery Sodium Potassium

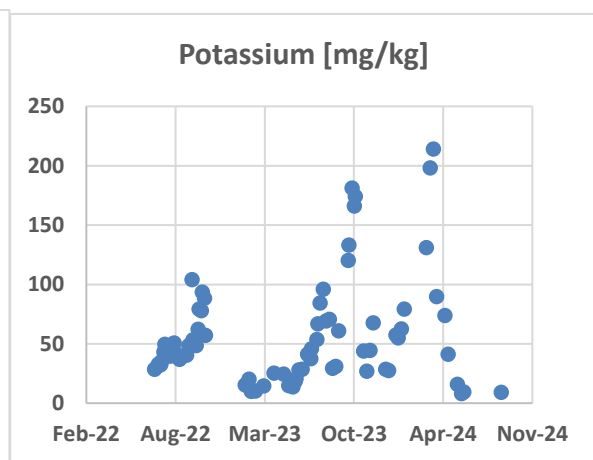


Figure 22: Dirty water recovery

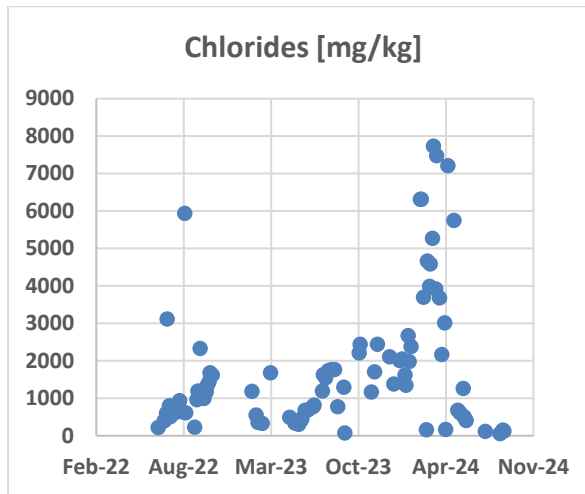


Figure 23: Dirty water recovery chlorides

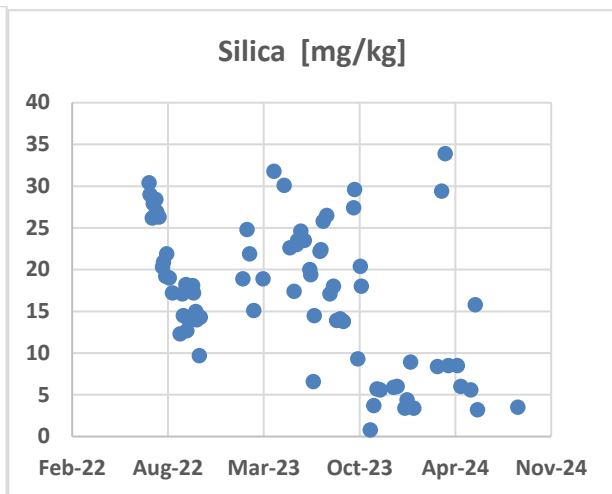


Figure 24: Dirty water recovery silica

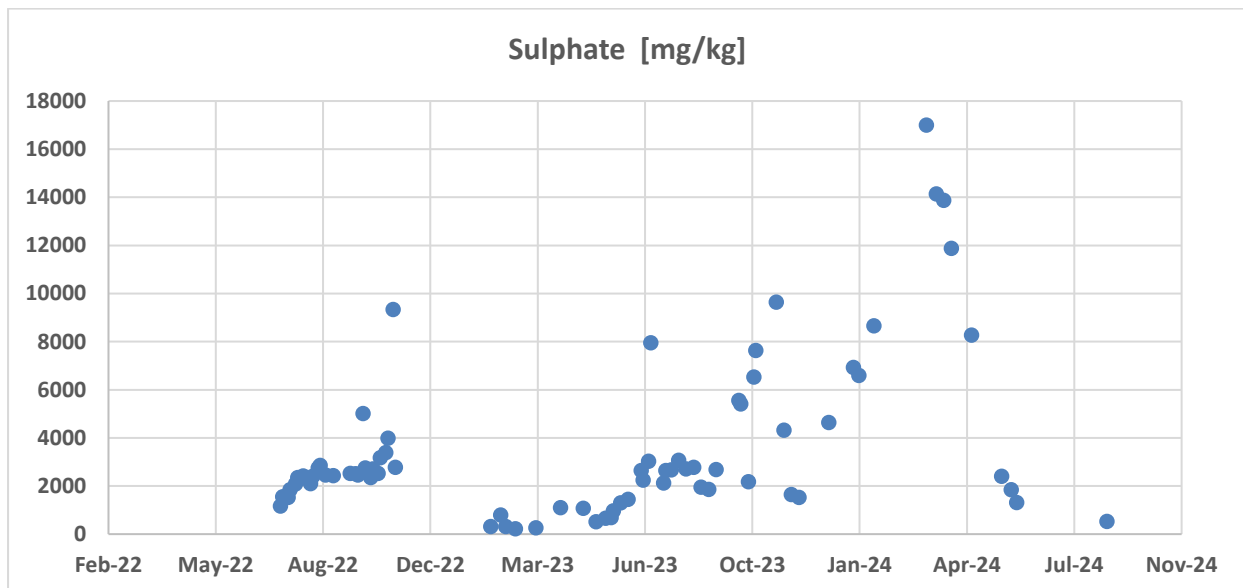


Figure 25: Dirty water recovery Sulphate

The water that is recovered must be of a quality similar to raw water quality in Table 1 or better. The flow requirement differs for each of the sites from 100 l/s to about 400l/s. The water to be treated (i.e. the DWD recovery stream) is predominantly a mixture of clay, sand and coal in water. The indicative dry base ash of a DWD sample is 63%. The typical particle size of the solids in the water is between 0.25 μm – 794.33 μm .

b. Ash water – high pH

Many of the stations have problems with very high levels of water in the ash system. Reverse osmosis plants have been built at some of the stations to treat this water. These reverse osmosis plants are problematic as a result frequent scaling. A solution is required for the treatment of this high salinity, high pH water. The intention is to test the capability of the technology with regards to the removal of ash. At the time of testing, the Employer will add these components to the water supply if the levels are too low.

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The typical water quality for treatment from the ash dams at Duvha is as indicated in the Figures 26-32 and Table 3 below:

Table 3: Ash water return (Duvha Power Station)

Parameter	Unit	Range	Average	95 th percentile
pH	-	7.99 – 12.48	11.14	12.06
Conductivity	µS/cm	152 - 4707	1897.01	3524.9
Turbidity	NTU	0.22-14.4	2.34	6.21
Calcium Hardness as CaCO ₃	mg/kg	300-1784	77.35	1394.7
Magnesium Hardness as CaCO ₃	mg/kg	86 – 327	163.98	224.9
Total Hardness as CaCO ₃	mg/kg	330 – 1970	921.87	1540.7
m-alkalinity	mg/kg	20.7 – 700.8	179.48	532.8
p-alkalinity	mg/kg	9.2 – 687.7	164.68	520.68
Sodium	mg/kg	8.38 – 277	134.54	174.3
Ammonium	mg/kg	0 – 1.1	0.1	0.335
Nitrate	mg/kg	0 – 18.7	4.16	12.1
Phosphate	mg/kg	0.1 – 27.6	0.91	6.6
Potassium	mg/kg	16.6 – 315	39.89	56.84
Chloride	mg/kg	4.37 – 252	91.18	126.8
Fluoride	mg/kg	0 – 12.5	0.86	4.67
Sulphate	mg/kg	37.4 – 1403	649.09	969.35
TOC as C	mg/kg	0.762 – 6	2.38	3.94

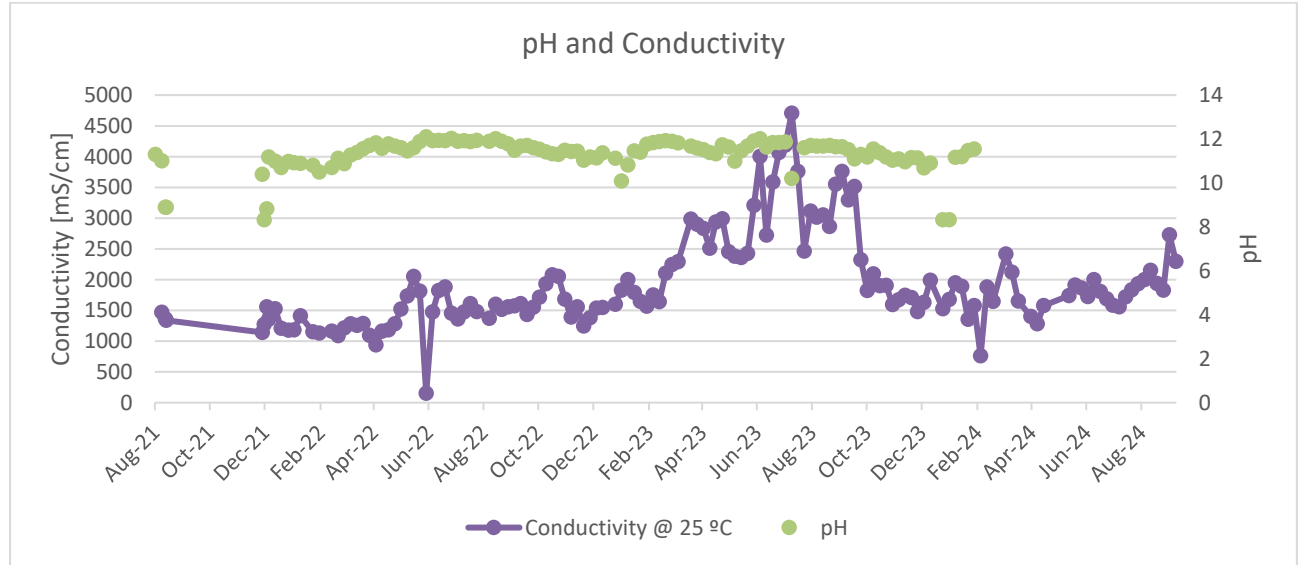


Figure 26: Duvha Ash Water pH and Conductivity

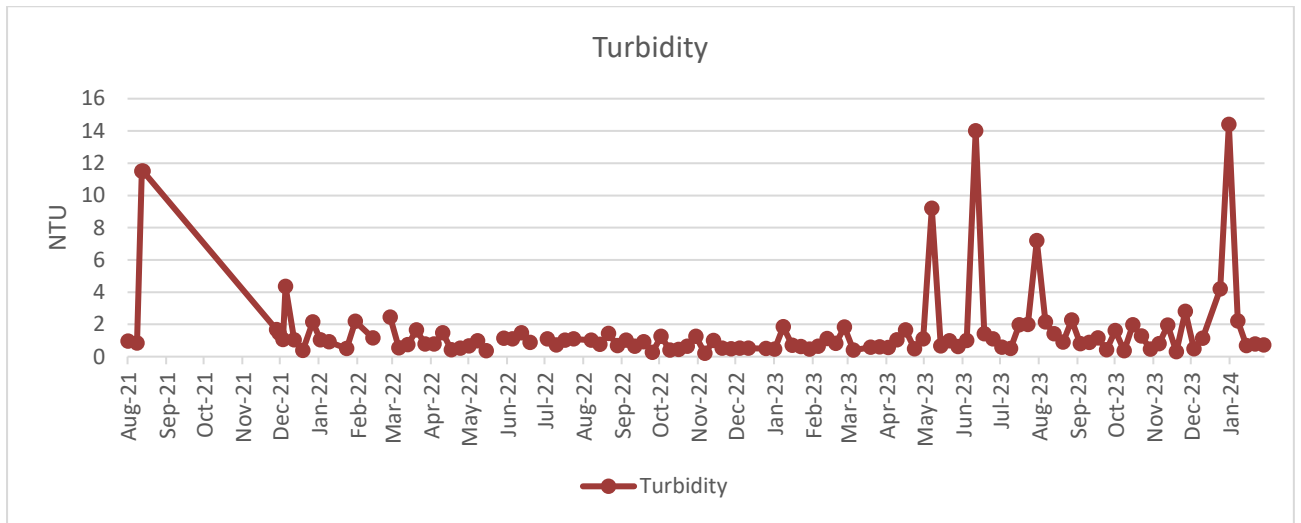


Figure 27: Duvha Ash Water Turbidity

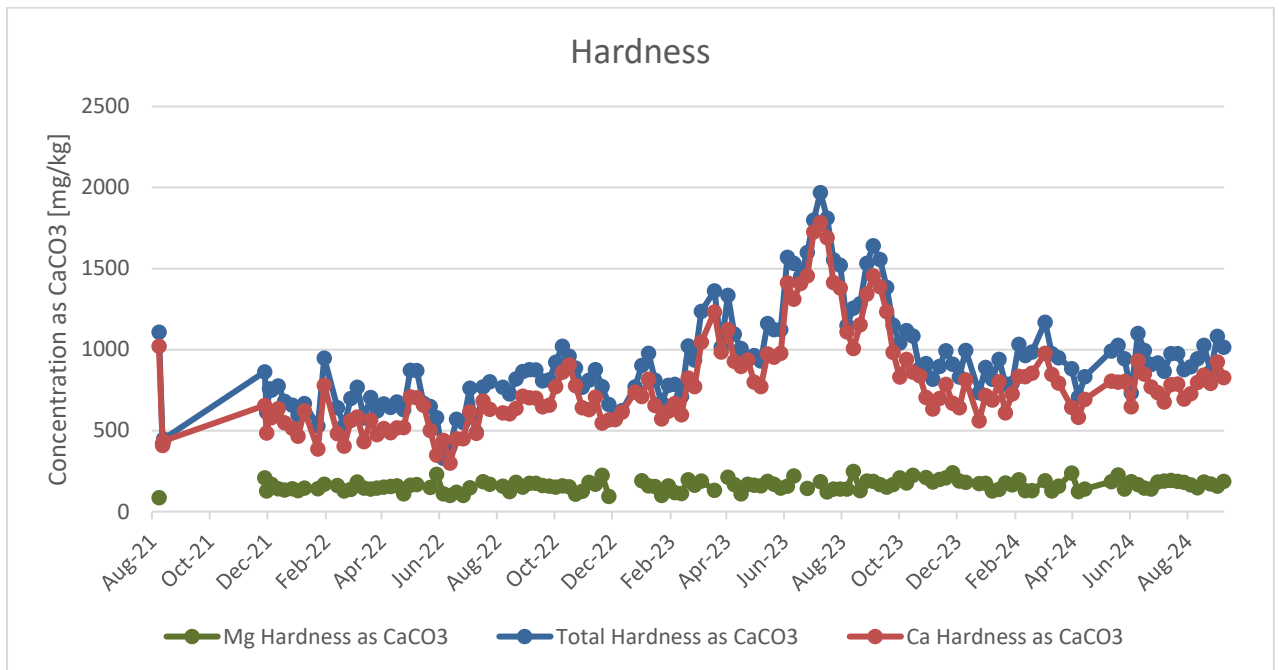


Figure 28: Duvha Ash Water Hardness

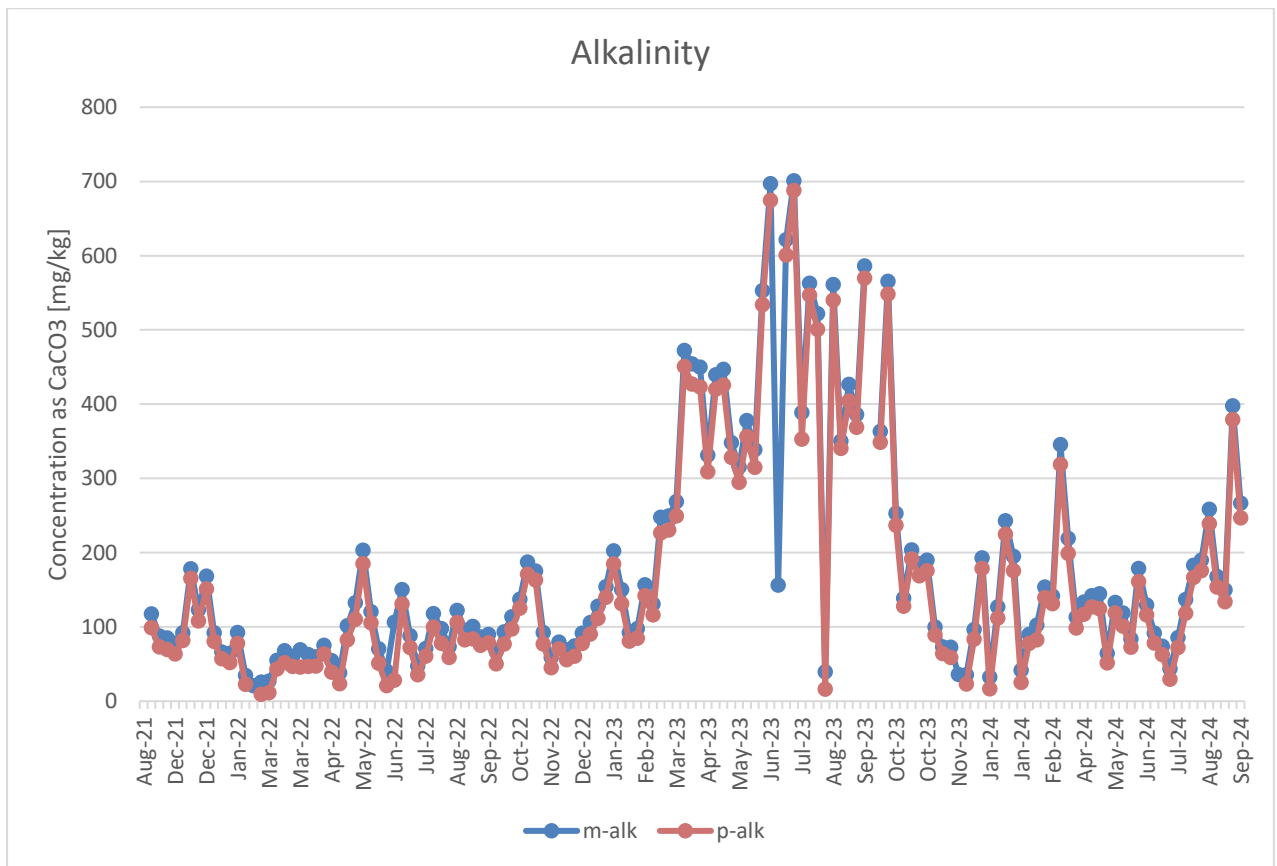


Figure 29: Duvha Ash Water Alkalinity

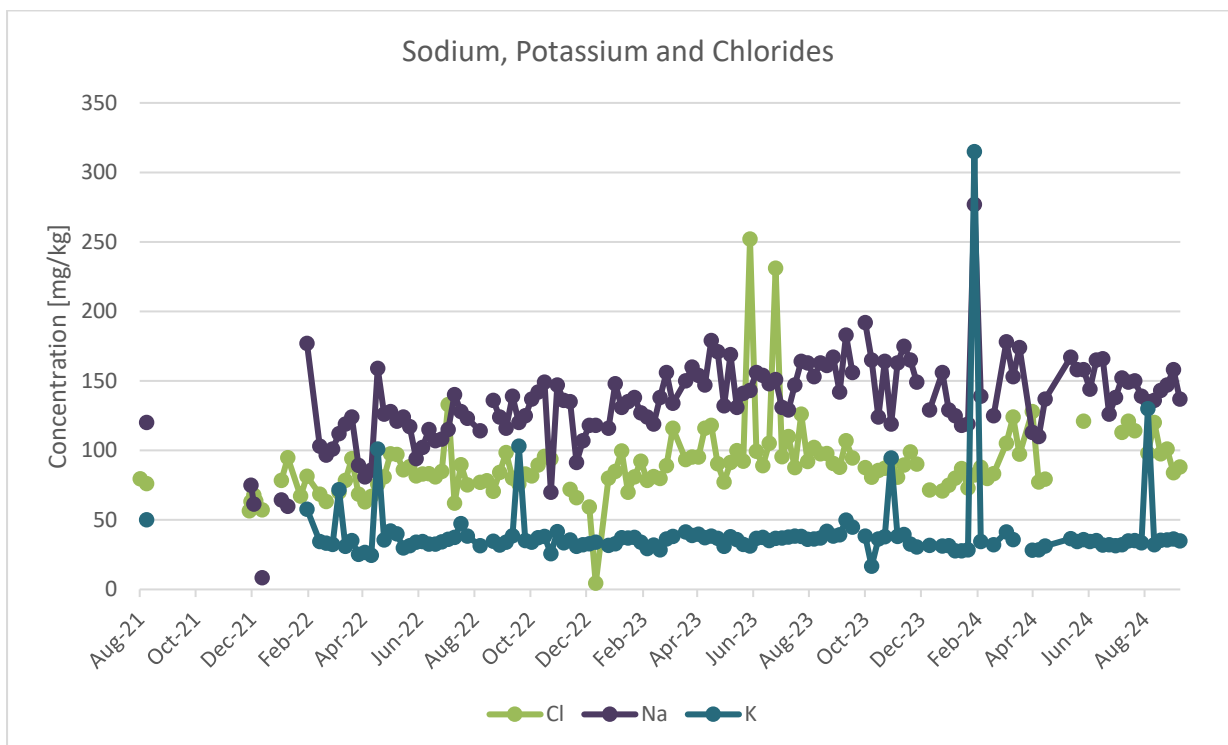


Figure 30: Duvha Ash Water Sodium, Chlorides and Potassium

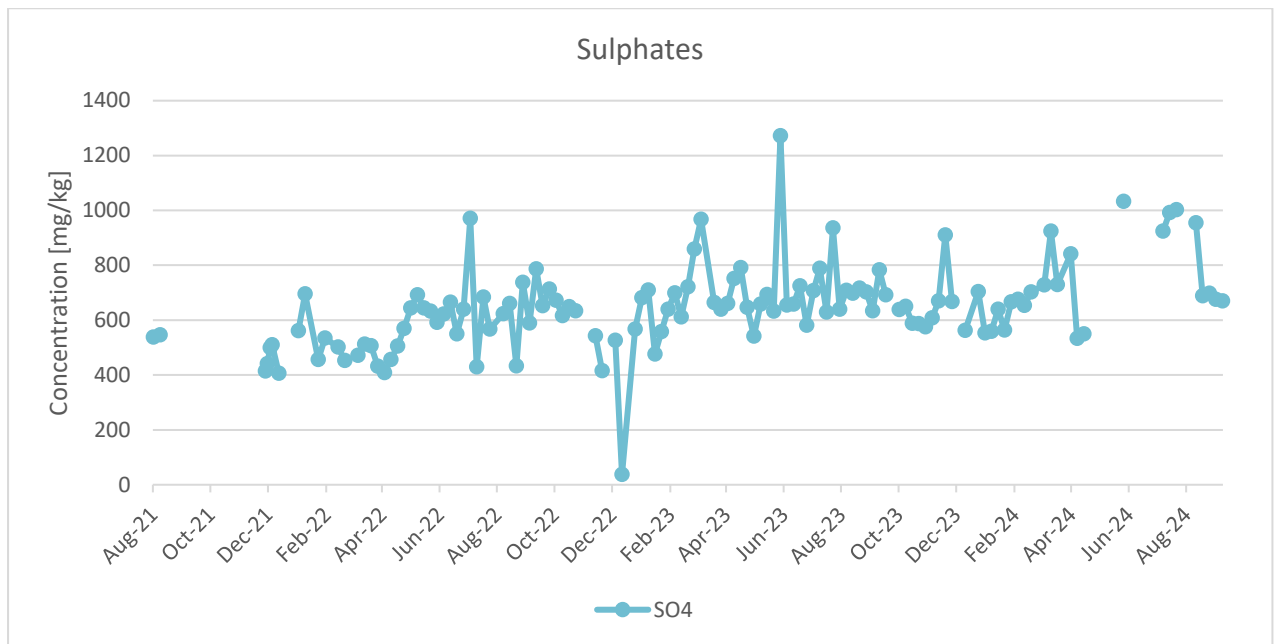


Figure 31: Duvha Ash Water Sulphates

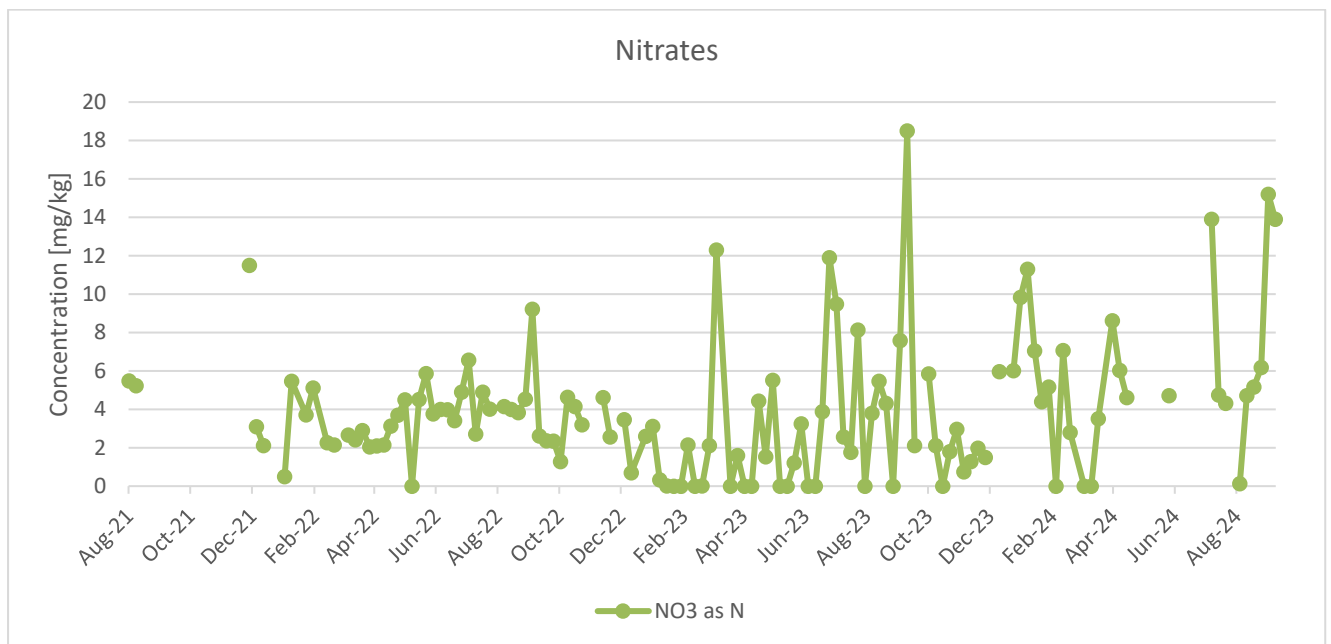


Figure 32: Duvha Ash Water Nitrates

The typical water quality for treatment from the ash dams at Kriel is as indicated in the Figures 33-39 and Table 4 below:

Table 4: Ash water return (Kriel Power Station)

Parameter	Unit	Range	Average	95 th percentile
pH	-	7.4 – 12.23	10.713	11.94
Conductivity	µS/cm	229 - 4640	2628.21	4435
Turbidity	NTU	0.61 – 3.35	1.75	3.19

Calcium Hardness as CaCO ₃	mg/kg	21.3-890	386.58	836
Magnesium Hardness as CaCO ₃	mg/kg	2.47 - 563	58.47	379.8
Total Hardness as CaCO ₃	mg/kg	42.7 – 1348	523.82	1269.7
m-alkalinity	mg/kg	15.5 – 662.6	189.48	545.58
p-alkalinity	mg/kg	0 – 623.1	133.92	335.5
Sodium	mg/kg	193 – 380	327.54	378.3
Nitrate	mg/kg	0.02 – 2.51	0.76	2.44
Potassium	mg/kg	42.7 – 97.5	82.13	96.81
Chloride	mg/kg	78 – 307	111.56	165.6
Fluoride	mg/kg	0.01 – 1.67	0.49	1.47
Sulphate	mg/kg	425 – 1671	923.19	1169.25

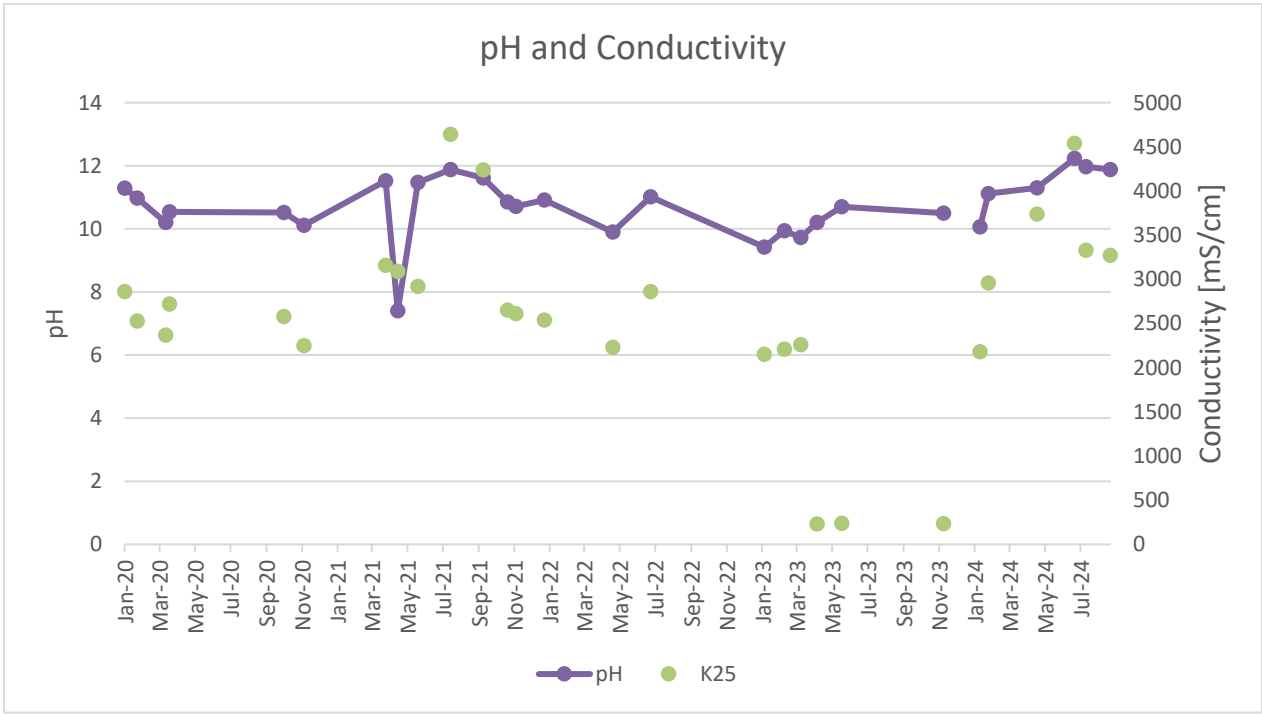


Figure 33: Kriel Ash Water pH and Conductivity

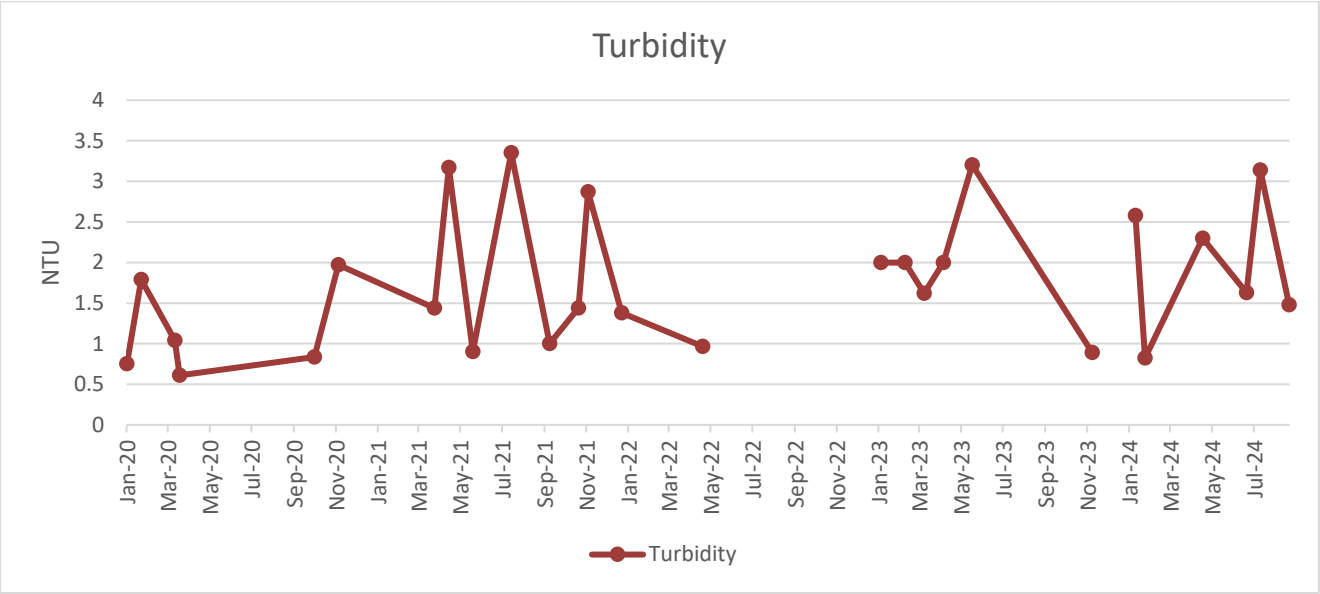


Figure 34: Kriel Ash Water Turbidity

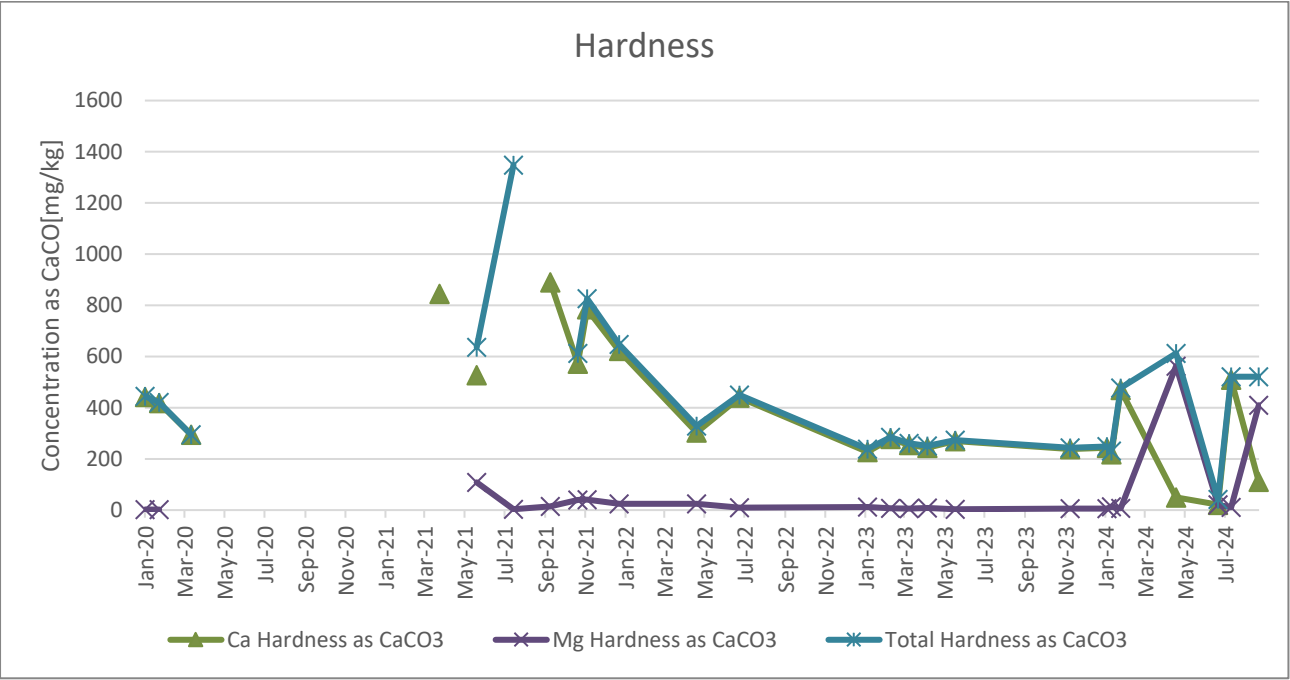


Figure 35: Kriel Ash water Hardness

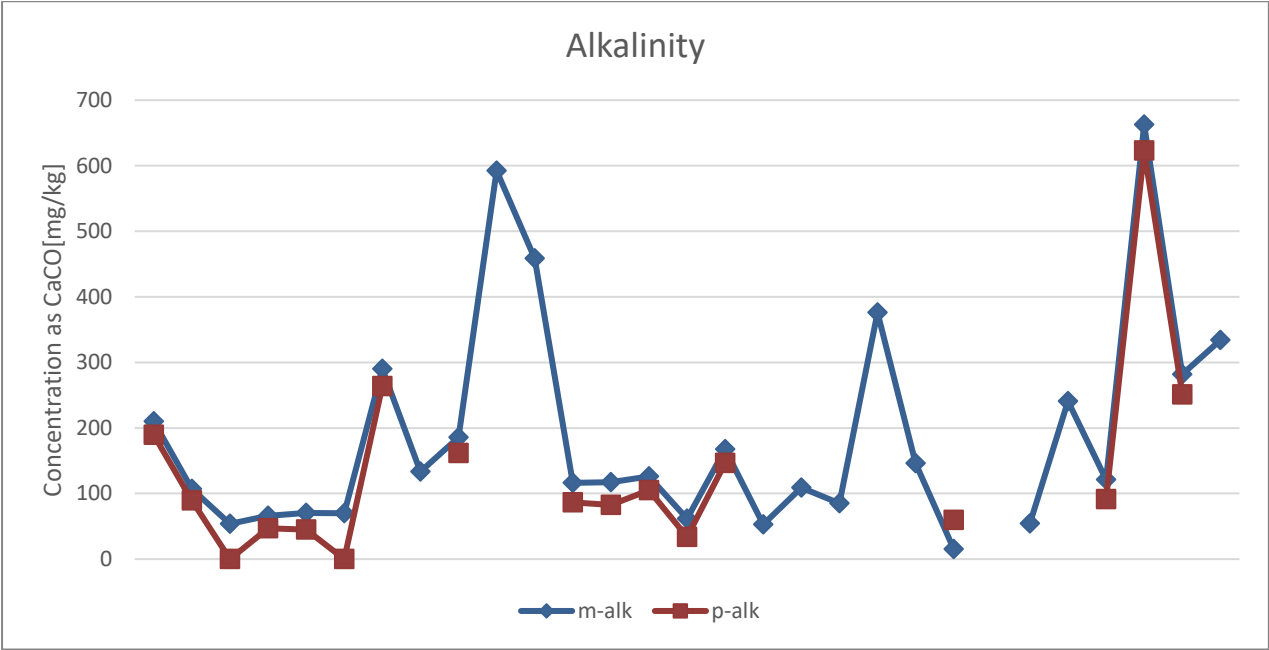


Figure 36: Kriel Ash water Alkalinity

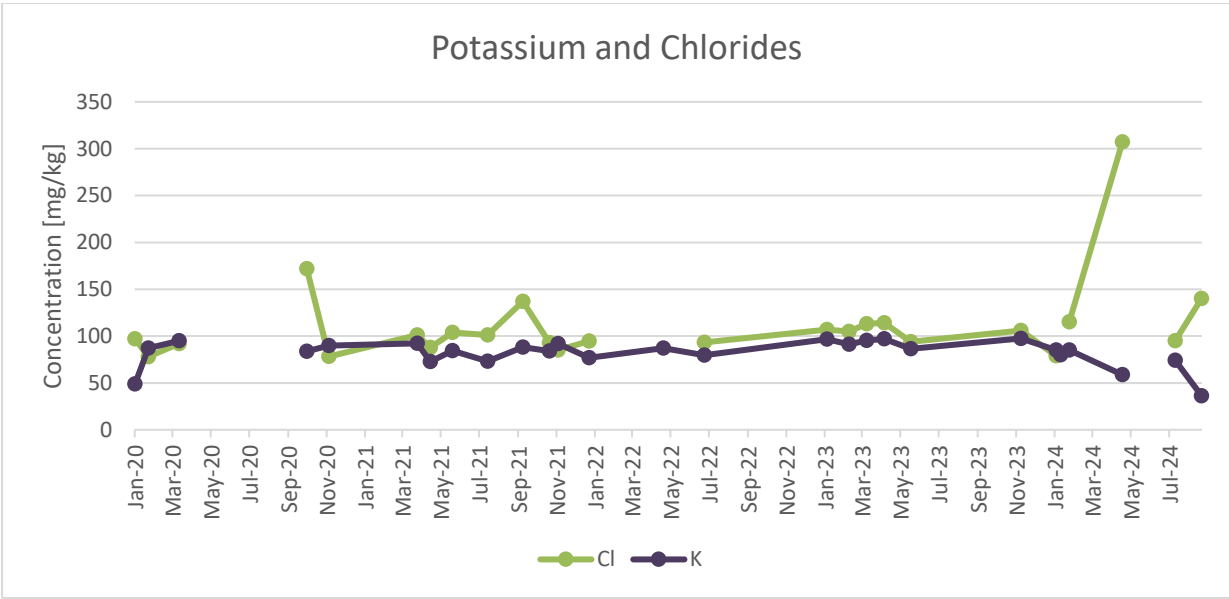


Figure 37: Kriel Ash water Potassium and Chloride concentration

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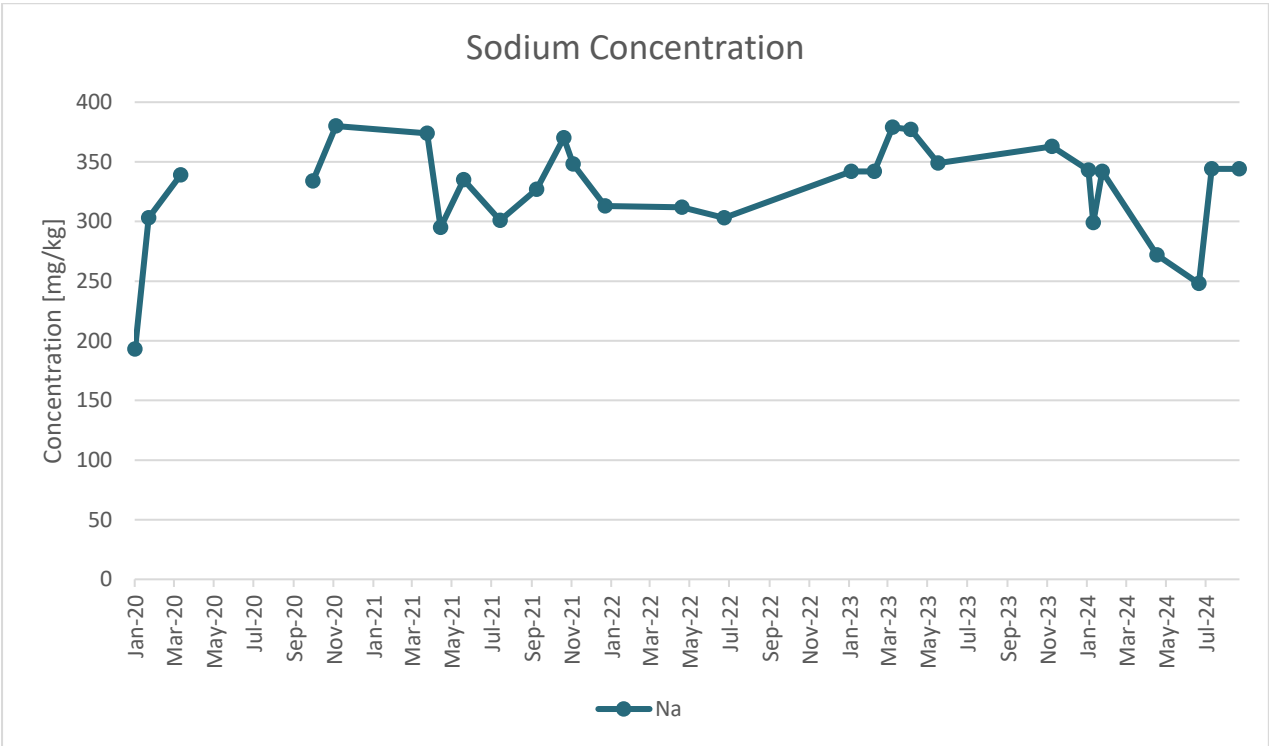


Figure 38: Kriel Ash water sodium concentration

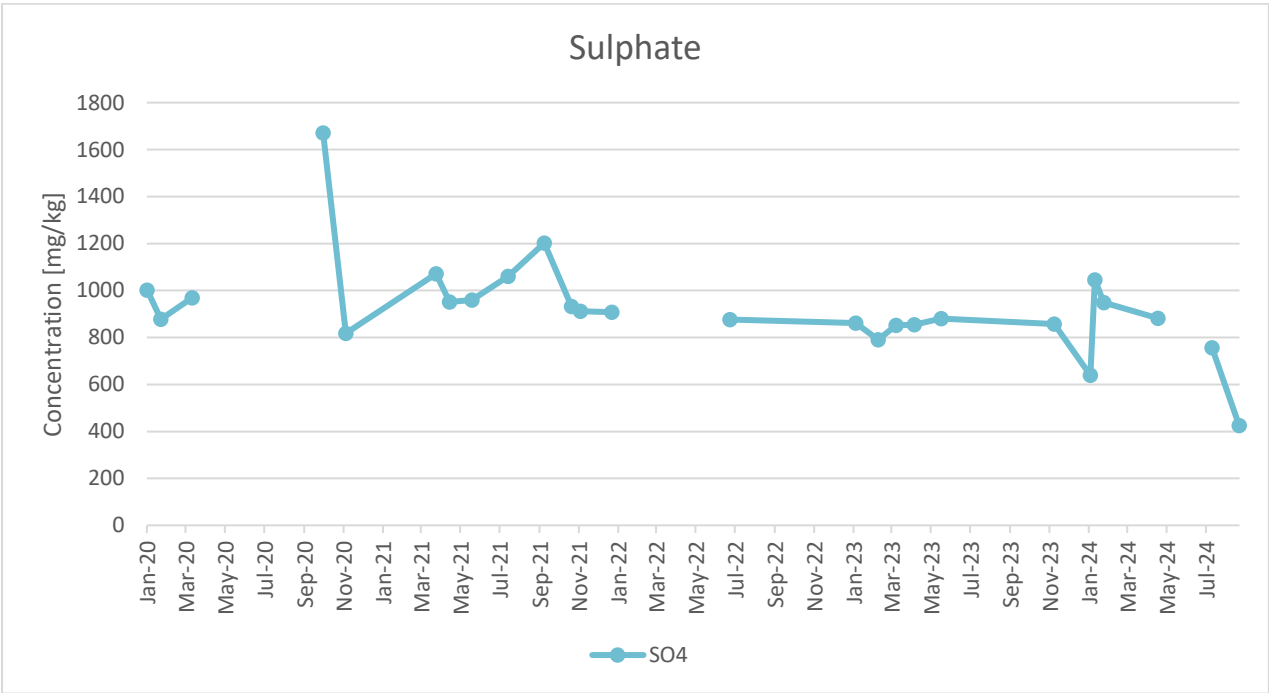


Figure 39: Kriel Ash water sulphate concentration

The flow requirement differs for each of the sites from 3 to 6Ml/day.

- c. FGD bleedstream

 Eskom	Scope of Work	Template Identifier	240-	Rev	1
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		Review Date	April 2027		

In a drive to reduce the particulate emissions at the newly built power stations, flue gas desulphurisation plants have been built at Kusile and the intention is for another to be built at Medupi. However, the bleedstream from this water has to be treated further. Thermal crystallisation is one of the techniques being utilised to treat this water. This plant has been installed at Kusile. However, it is a very cost intensive plant with extremely high capital and operating costs. An alternative solution must be investigated which could treat this water.

The typical range of water quality for treatment is not known as yet since the analysis of these streams are still in progress. However, the chemical analysis as per the design is in the table below. The flow requirement differs for this plant is a design of 50 m³/hr and a normal operating flowrate of 25m³/hr. The table below refers to the design parameters for the plant.

Table 5: Designed chemical parameters for the Bleedstream from the FGD plant (Kusile Power Station)

PARAMETER	CONCENTRATION [mg/L ion] BEFORE PRE-TREATMENT
Chloride	30,000
Sulfate	1,500 - 8,000
Sulfite	<20
Nitrate	100 – 1,500
Fluoride	30 – 200
Calcium	4,000 – 20,000
Magnesium	200 – 5,600
Sodium	75 – 1,200
Iron	30 – 400
Aluminum	50 – 800
Arsenic	0.05 – 3.0
Boron	20 – 40
Boron (as HBO ₃)	
Cadmium	0.04 – 0.5
Cobalt	0.05 – 0.4
Chromium Total	0.3 – 5.0
Copper	0.1 – 0.85
Mercury	0.05 – 0.8
Nickel	0.2 – 6.0
Lead	0.1 – 3.0
Selenium	0.2 – 1.0
Vanadium	0 – 2.4
Zinc	5 – 10
Ammonium	<10 – 100
Ammonia	
COD	100 – 150
pH	4 – 7
TSS	300 – 10,000
Bicarbonate	
Silica	
TOC	

However, the samples from the plant have been tested and certain parameters are less than the designed parameters. Refer to the table below for the last set of samples. Since the intention is to test the water to the design parameters of the plant, the contractor must make allowance for recycle of the concentrate stream in order to cycle up the ions.

Table 6: Chemical operational parameters for the Bleedstream from the FGD plant (Kusile Power Station)

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PARAMETER	UNITS	CONCENTRATION [mg/L ion] BEFORE PRE-TREATMENT
Total Alkalinity (pH>4.5)	mg CaCO ₃ /L	60.2
Bicarbonate Alkalinity	mg CaCO ₃ /L	60.2
Carbonate Alkalinity	mg CaCO ₃ /L	0.00
M Alkalinity (8.3>pH>4.5)	mg CaCO ₃ /L	60.2
P Alkalinity (pH>8.3)	mg CaCO ₃ /L	0.00
Conductivity (Laboratory)	mS/cm	2560
pH (Laboratory)		6.69
Total Hardness	mg CaCO ₃ /L	13215
Calcium Hardness	mg CaCO ₃ /L	2068
Magnesium Hardness	mg CaCO ₃ /L	11147
Total Dissolved Solids (TDS)	mg/L	17779
Suspended Solids (TSS)	mg/L	5528
Temperature	°C	21.0
Chemical Oxygen Demand (COD)	mg O ₂ /L	4000
Ammonia and Ammonium	mg N/L	
Calcium	mg Ca/L	828
Chloride	mg Cl/L	1004
Magnesium	mg Mg/L	2707
Nitrate and Nitrite (TON)	mg N/L	4.14
Potassium	mg K/L	136
Sodium	mg Na/L	1369
Silicon	mg Si/L	34.5
Sulphate	mg SO ₄ /L	9008
Aluminium	mg Al/L	1.33
Antimony	mg Sb/L	
Arsenic	mg As/L	0.06
Barium	mg Ba/L	0.10
Beryllium	mg Be/L	0.01
Boron	mg B/L	68.8
Bromide	mg Br/L	
Cadmium	mg Cd/L	0.002
Chromium	mg Cr/L	0.01
Cobalt	mg Co/L	0.10
Copper	mg Cu/L	0.01
Fluoride	mg F/L	71.7
Iron	mg Fe/L	0.09
Lead	mg Pb/L	0.23
Lithium	mg Li/L	6.86
Total Manganese	mg Mn/L	

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Manganese	mg Mn/L	2317
Mercury	mg Hg/L	0.003
Molybdenum	mg Mo/L	0.08
Nickel	mg Ni/L	0.84
Selenium	mg Se/L	1.21
Strontium	mg Sr/L	1.29
Tin	mg Sn/L	0.04
Vanadium	mg V/L	0.96
Zinc	mg Zn/L	0.41

d. Effluent from the Spiral Reverse Osmosis plant

The resin regeneration and reverse osmosis effluent is sent to the neutralisation sump. From this sump it is further sent for co-disposal with the ash. Legislation passed in 2013, states that brine with a high salt content (TDS>5%), cannot be co-disposed with the ash from 2021 onwards.

Hence, a solution is required to treat this water instead of the co-disposal with ash.

The typical range of water quality for treatment of the SRO brine is as per table and Figures 40-52 below when the plant was last in service.

Table 7: SRO brine (Tutuka Power Station)

Parameter	Unit	Tutuka SRO brine		
		Range	Average	95 th percentile
pH	-	2.5 - 9.1	6.9	8
Conductivity	µS/cm	5.6 – 35373	29393	34192.8
Turbidity	NTU	0.2 – 2.7	0.7	1.3
Calcium Hardness as CaCO ₃	mg/kg	20 - 1580	828	1560.7
Magnesium Hardness as CaCO ₃	mg/kg	61.4 - 5178	2515.8	5155.9
Total Hardness as CaCO ₃	mg/kg	109 - 6678	3343.8	6065.2
m-alkalinity	mg/kg	0 – 968.2	351.7	793.1
p-alkalinity	mg/kg	0 – 32.5	0.6	0
Sodium	mg/kg	172 - 13500	5103.9	8593.4
Potassium	mg/kg	11.6 - 709	287.5	450.3
Chloride	mg/kg	0 - 5463	3700.3	5201.2
Sulphate	mg/kg	559 - 106840	34744.2	98032.5
Silica as SiO ₂	mg/kg	1.9 - 85	46.9	83
COD	mg/kg	633 -2302	1073.1	1955.2

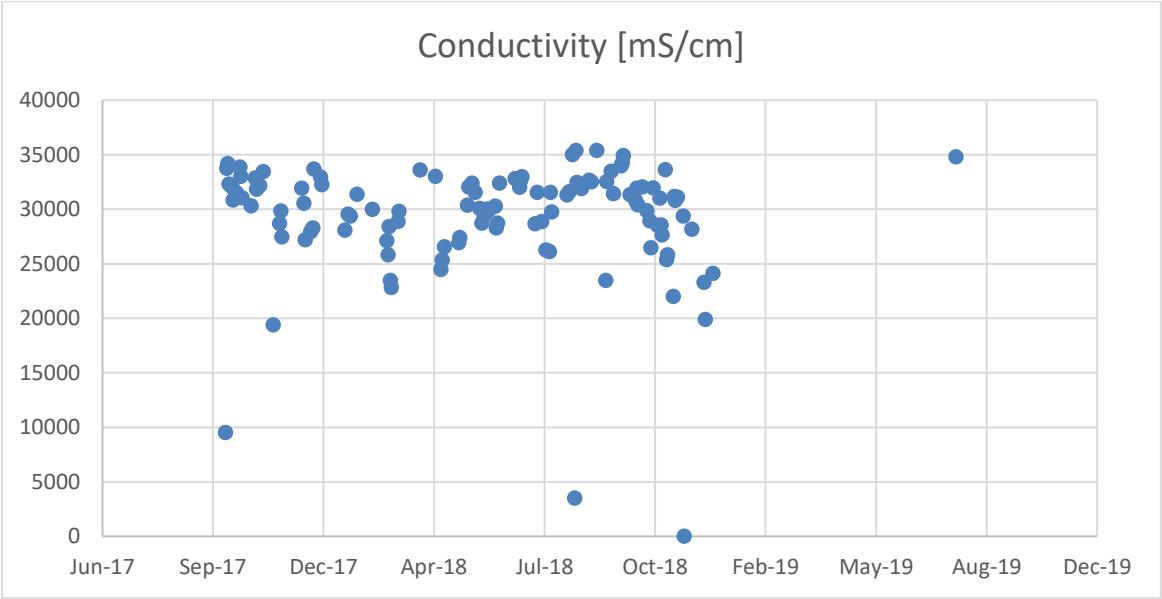


Figure 40: Tutuka SRO brine conductivity

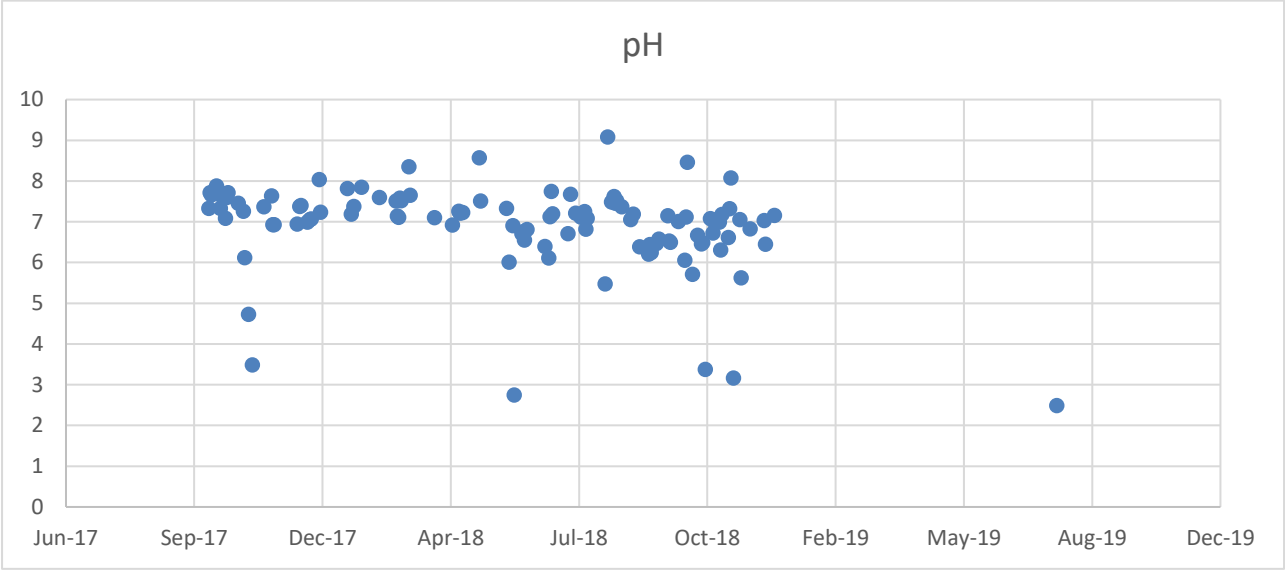


Figure 41: Tutuka SRO brine pH

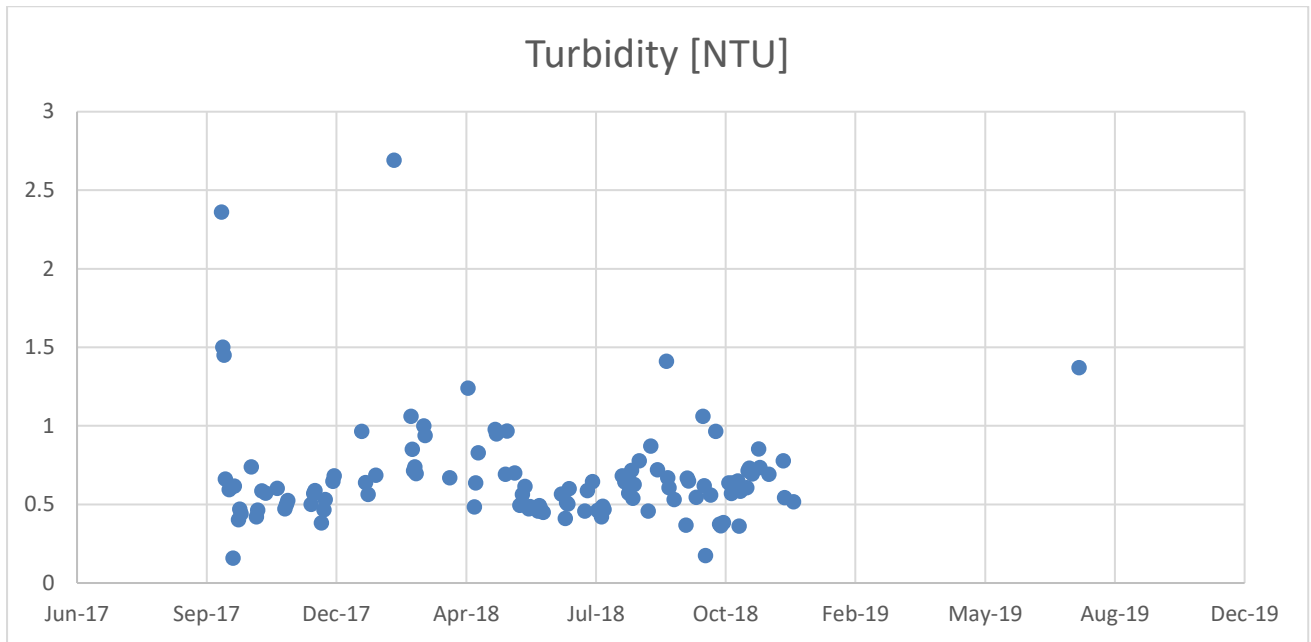


Figure 42: Tutuka SRO brine turbidity

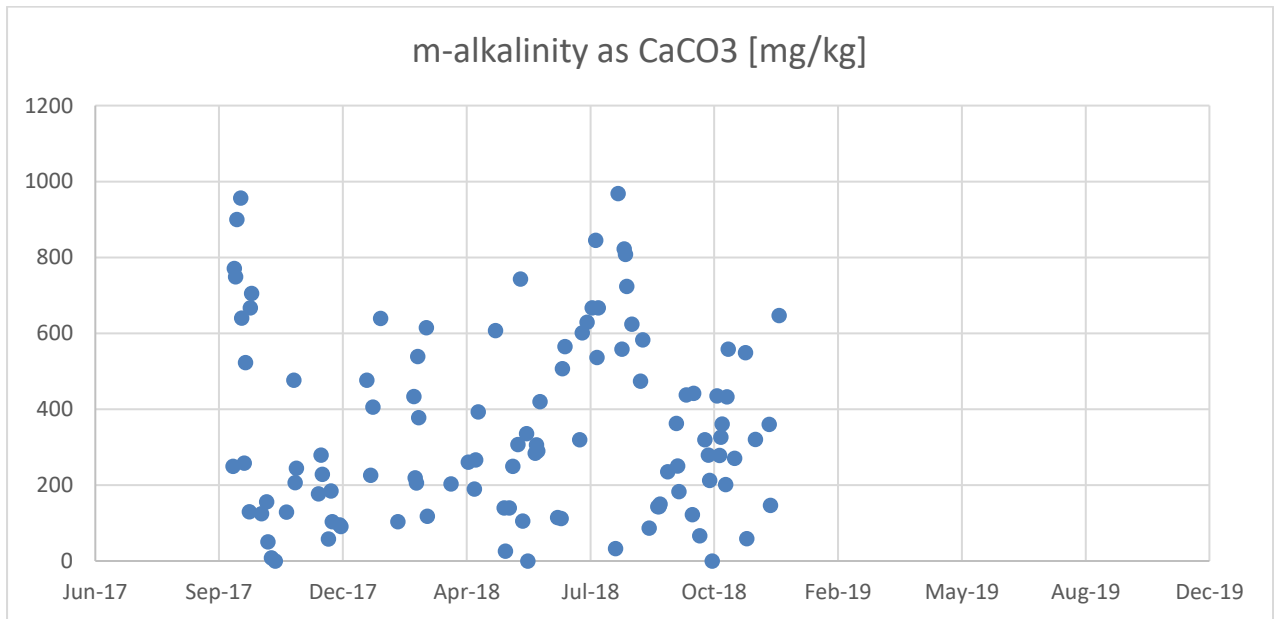


Figure 43: Tutuka SRO brine m-alkalinity

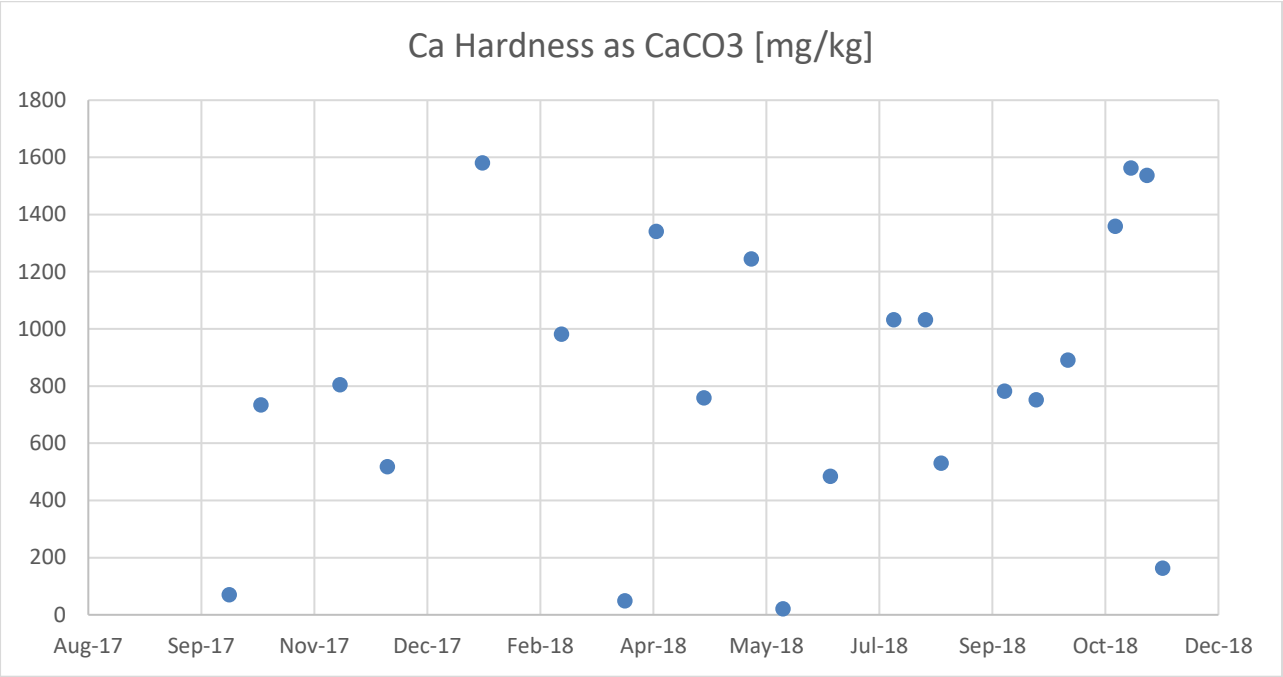


Figure 44: Tutuka SRO Calcium hardness

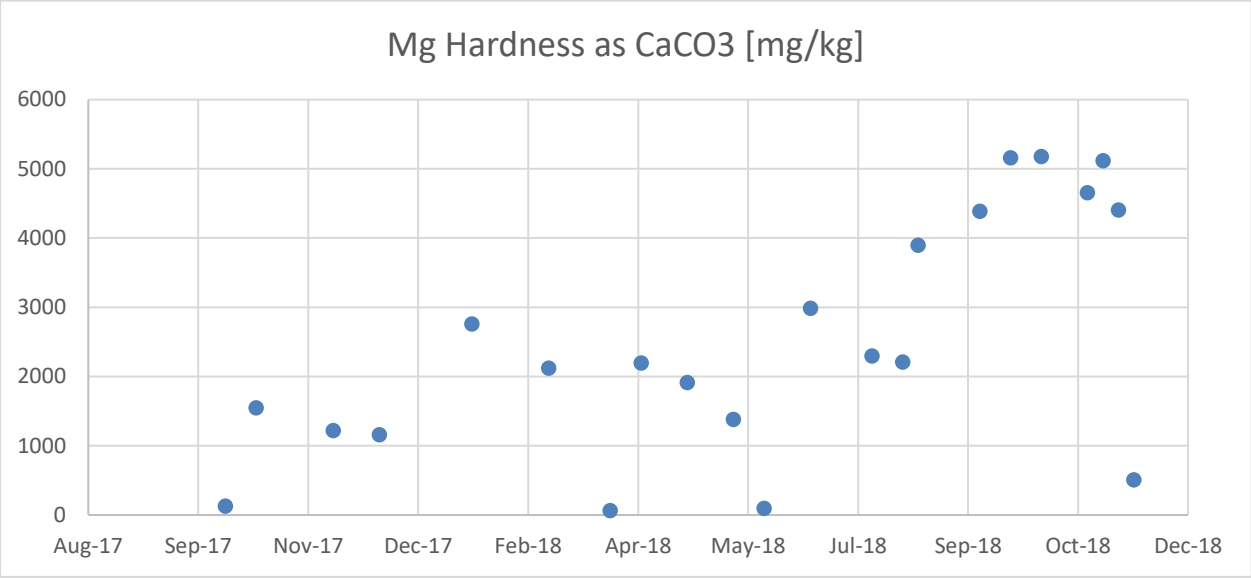


Figure 45: Tutuka SRO brine magnesium hardness

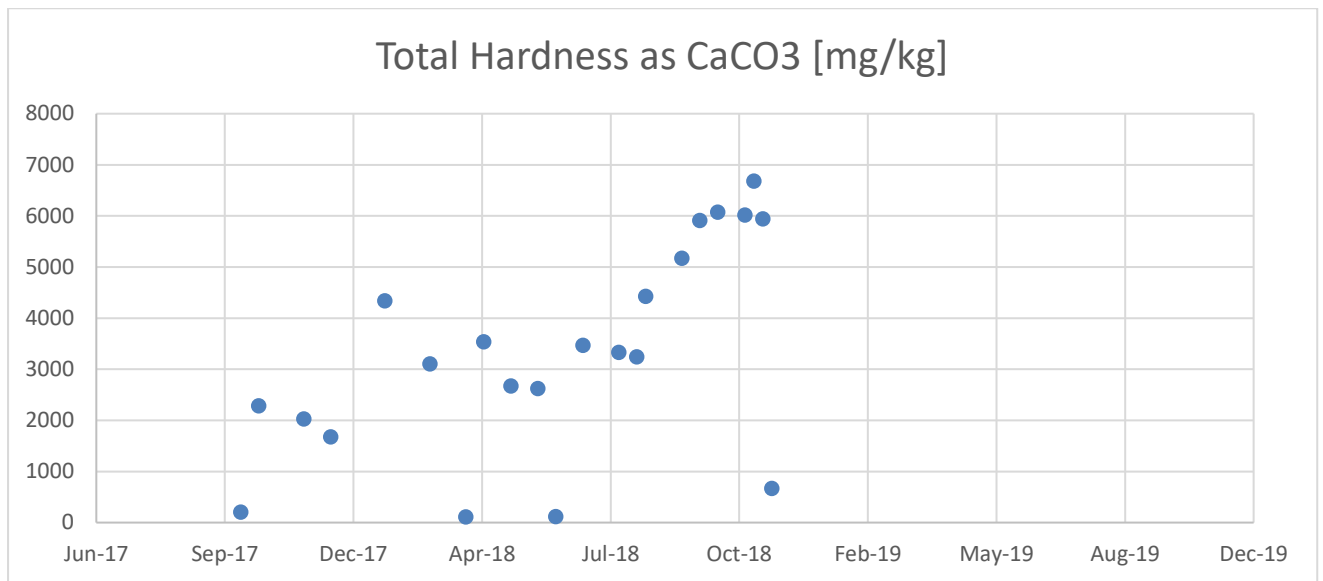


Figure 46: Tutuka SRO total hardness

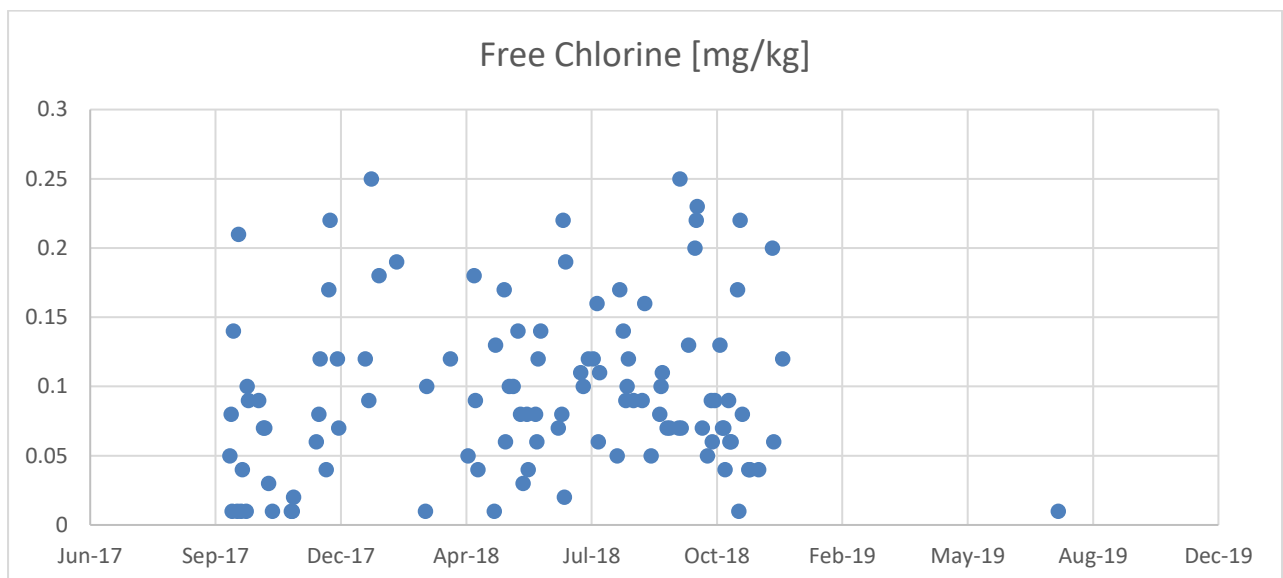


Figure 47: Tutuka SRO brine Free chlorine

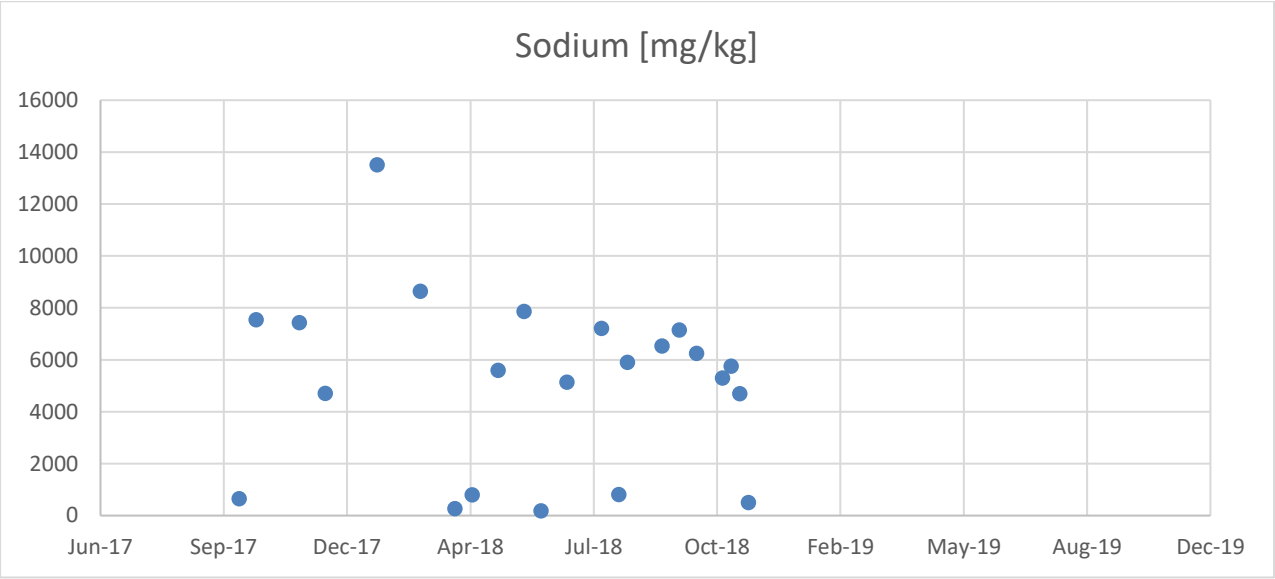


Figure 48: Tutuka SRO sodium concentration

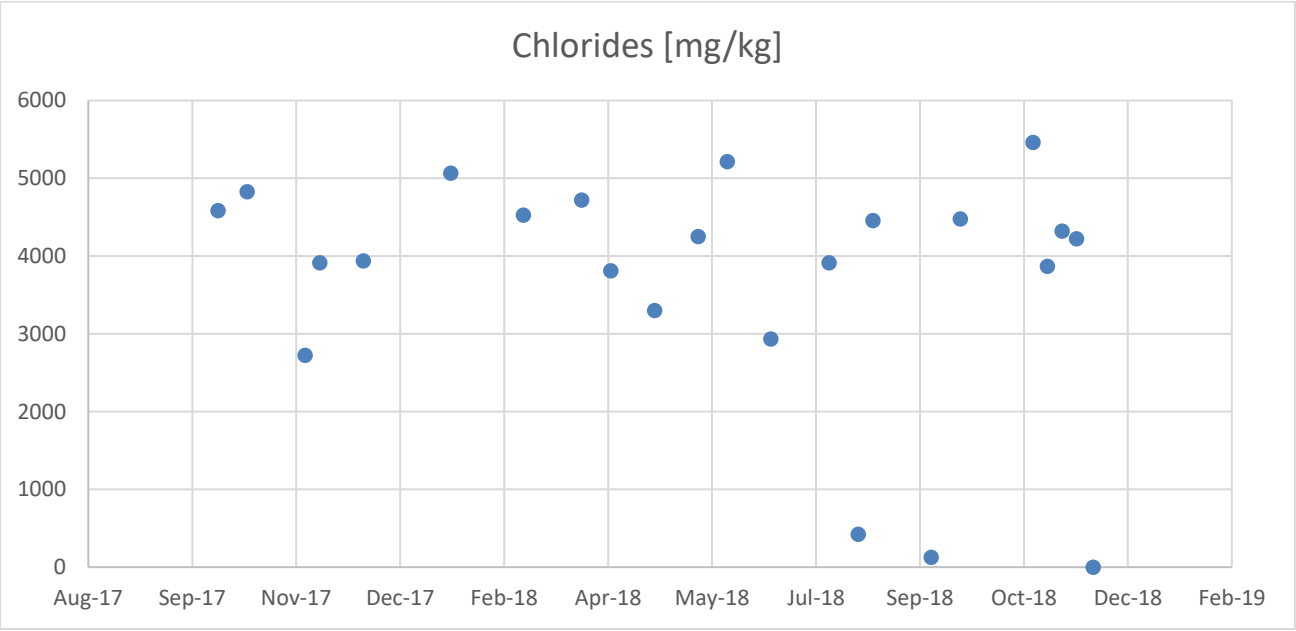


Figure 49: Tutuka SRO chlorides concentration

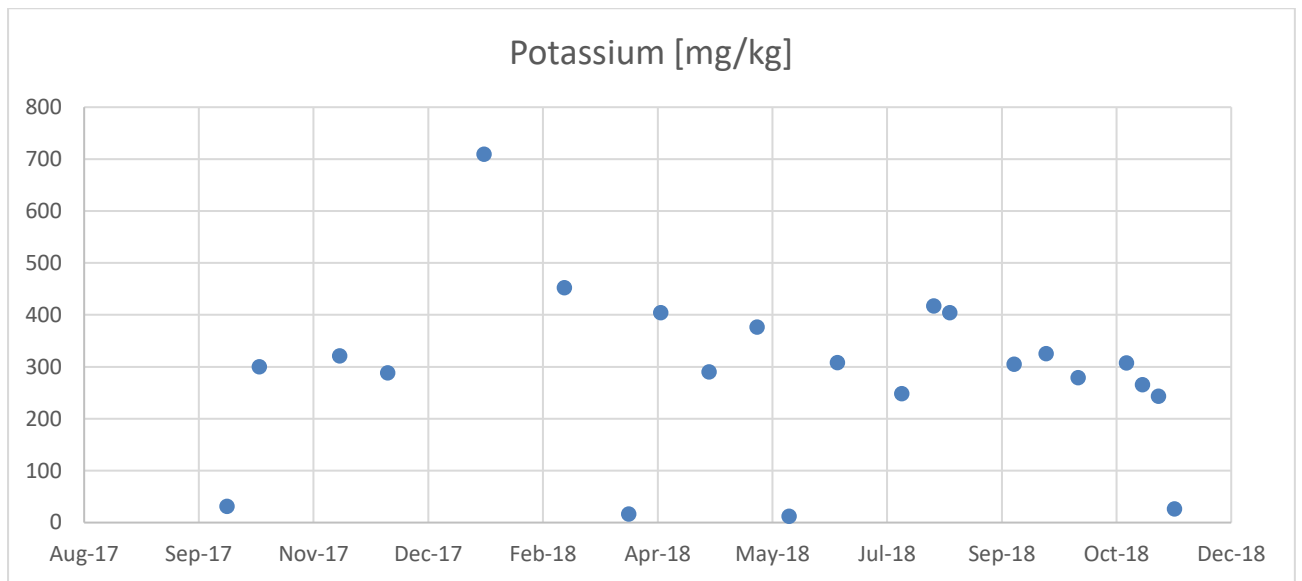


Figure 50: Tutuka SRO potassium concentration

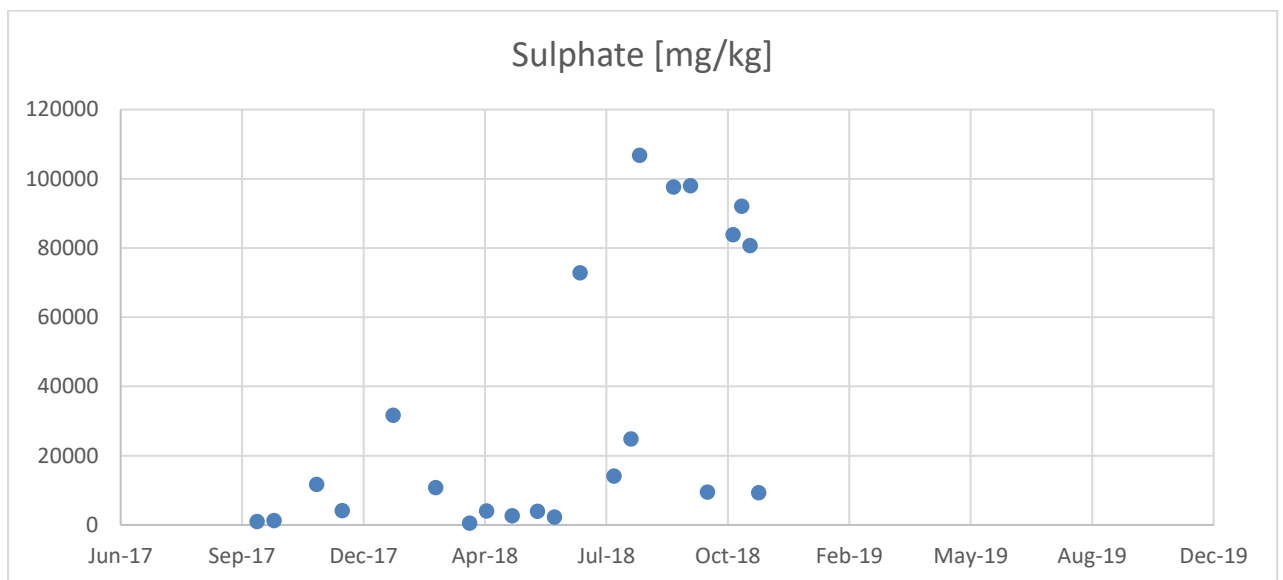


Figure 51: Tutuka SRO sulphate concentration

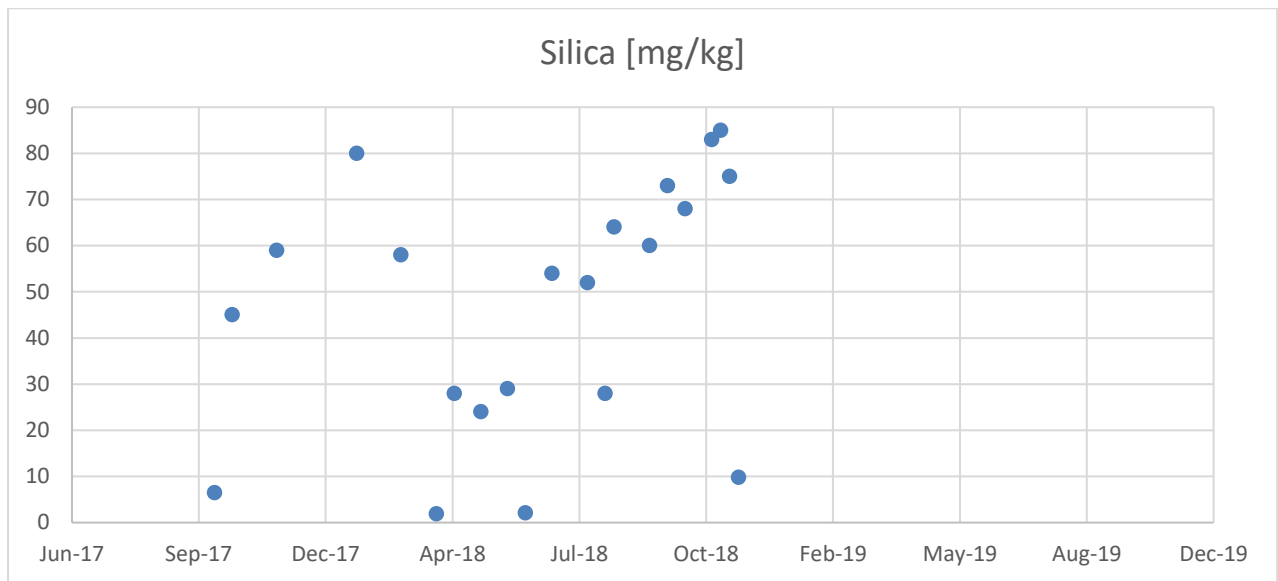


Figure 52: Tutuka SRO silica concentration

e. Concentrated Cooling Water (CCW) sidestream / blowdown

Water from the concentrated cooling water system is blown down when the water quality is out of specification with respect to the limits in the Eskom Cooling Water Chemistry standard. There are times when the water cannot be blown down because of high water levels in the ash system. The water then concentrates out of specification which exacerbates the scaling potential of the water and results in scaling of the cooling water system. Currently, lime softening treatment has been employed at many stations to treat the concentrated cooling water on a side stream. These plants have however been found to be problematic and are often out of service. Since this water is not as saline as the other waters being tested, this stream will be tested for sensitivity analysis purposes.

The typical range of water quality for treatment from the CCW at Kriel is as indicated in the figures below:

Table 8: Concentrated Cooling water (Kriel Power Station)

Parameter	Unit	Kriel CW South			Kriel CW north		
		Range	Average	95 th percentile	Range	Average	95 th percentile
pH	-	4.4 - 9.7	8.5	8.8	3.37 – 10.8	8.53	8.82
Conductivity	µS/cm	350 - 9390	2628	4150	154 – 6530	2637.95	4120
Turbidity	NTU	2.06 - 253	29.5	74.9	3.75 – 205	29.55	68.47
CCPP as CaCO ₃	mg/kg	-71.8 – 121.7	36.7	80.7	-71.8 – 151.7	38.69	83.31
Calcium Hardness as CaCO ₃	mg/kg	3.5 – 1925	301.4	533.0	2.75 – 1925	295.85	523
Magnesium Hardness as CaCO ₃	mg/kg	1.8 – 1665	362.8	781.0	1.81 – 1665	377.2	789

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		Kriel CW South			Kriel CW north		
Total Hardness as CaCO ₃	mg/kg	9.2 - 2402	662.3	1236.4	6.79 - 2402	671.82	1239
m-alkalinity	mg/kg	20.7 – 436.3	147.5	168.4	17.2 – 436.3	152.2	238.45
p-alkalinity	mg/kg	0 – 133.3	8.1	18.4	0 – 263.5	8.7	19.3
Sodium	mg/kg	17.5 - 898	339.1	603.9	17.5 – 1131	339.07	592
Potassium	mg/kg	6.01 - 544	82.1	142	6.01 –544	82.1	138.1
Chloride	mg/kg	4.1 – 527	200.8	359.4	2.88 – 662	205.81	358
Sulphate	mg/kg	23.7 - 2471	850.3	1518.8	34.6 – 2471	849.74	1509.4
Nitrates	mg/kg	0 – 28.2	3.7	8.3	0 – 54.2	3.59	8.42
Phosphates	mg/kg	0 - 930	90.4	110.1	0 - 1057	33.54	17.44
Silicate at SiO ₂	mg/kg	1 - 35	12.7	202.3	1 – 36	12.73	23
COD	mg/kg	9 - 373	137.1	245	9 – 257	140.6	245

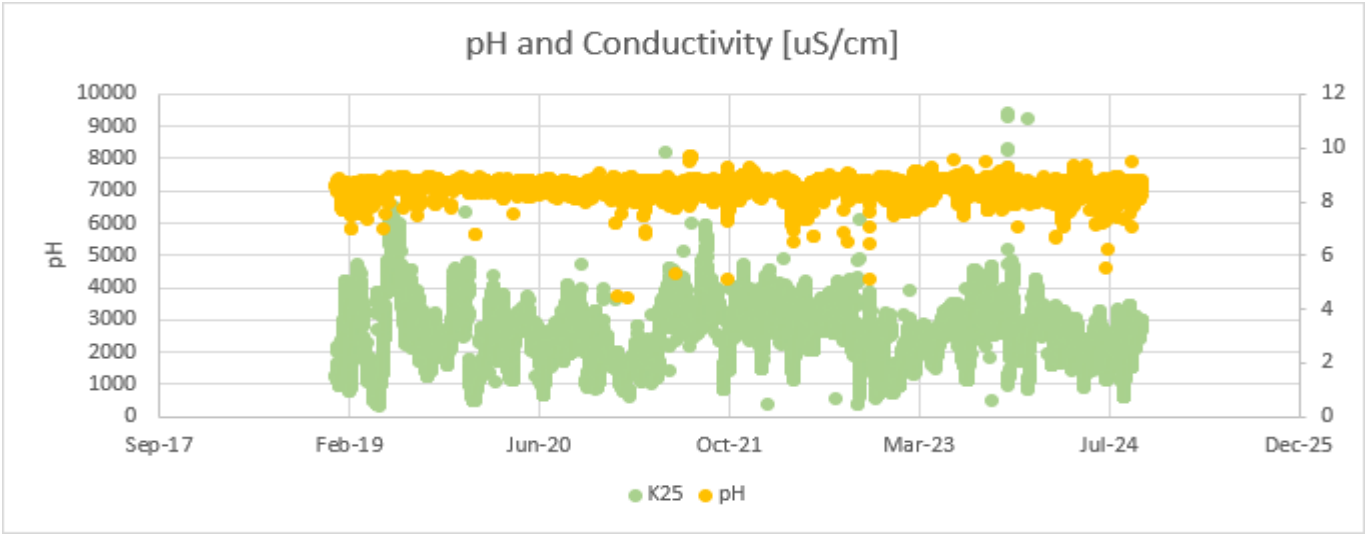


Figure 53: Kriel Cooling water South pH and conductivity

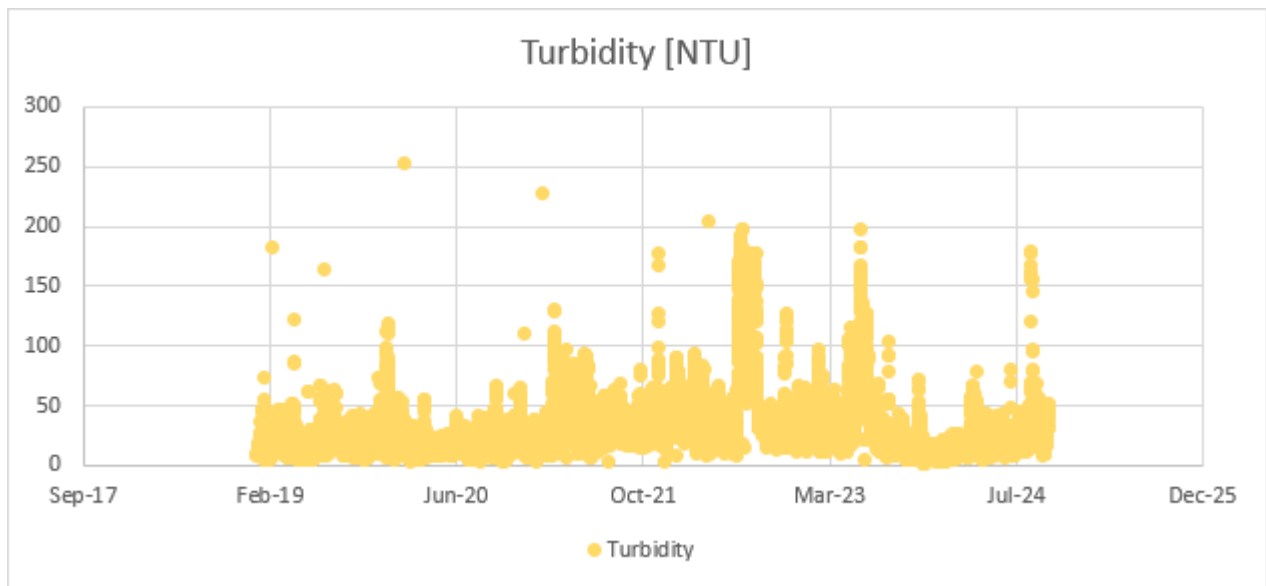


Figure 54: Kriel Cooling water South Turbidity

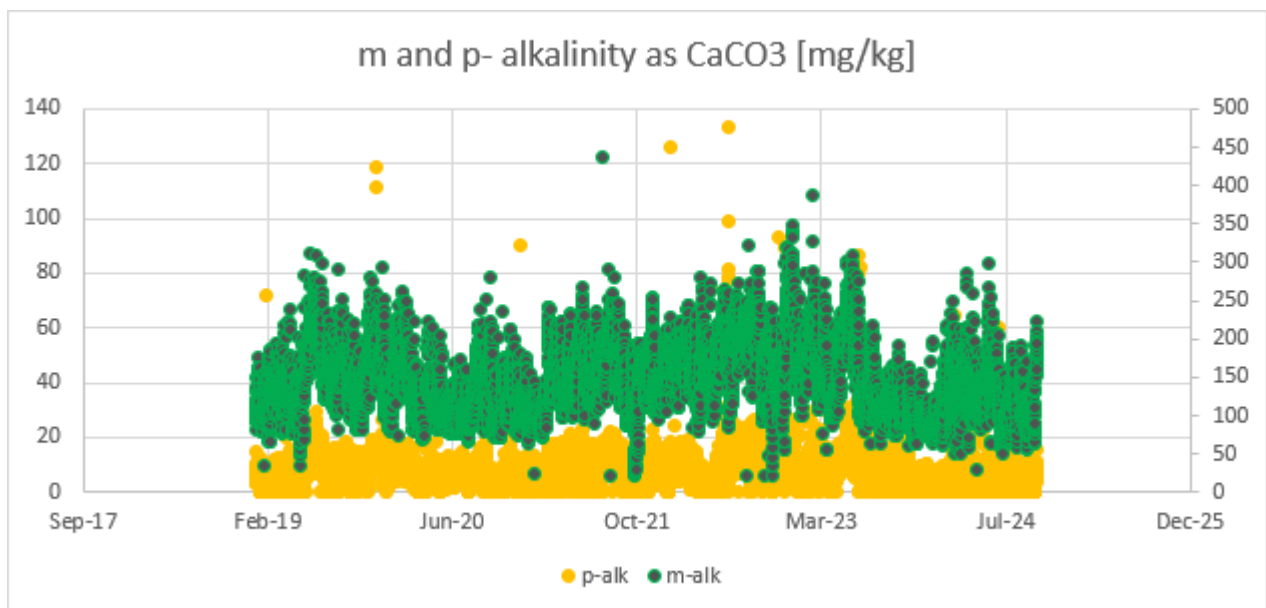


Figure 55: Kriel Cooling water South p-alkalinity and m-alkalinity

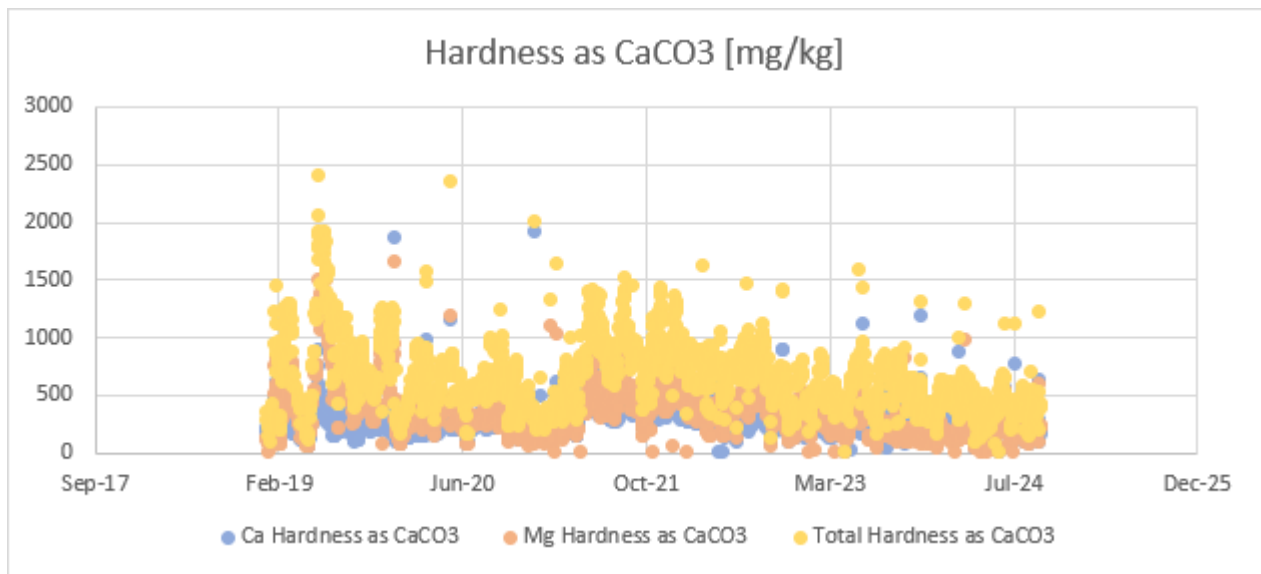


Figure 56: Kriel Cooling water South Hardness

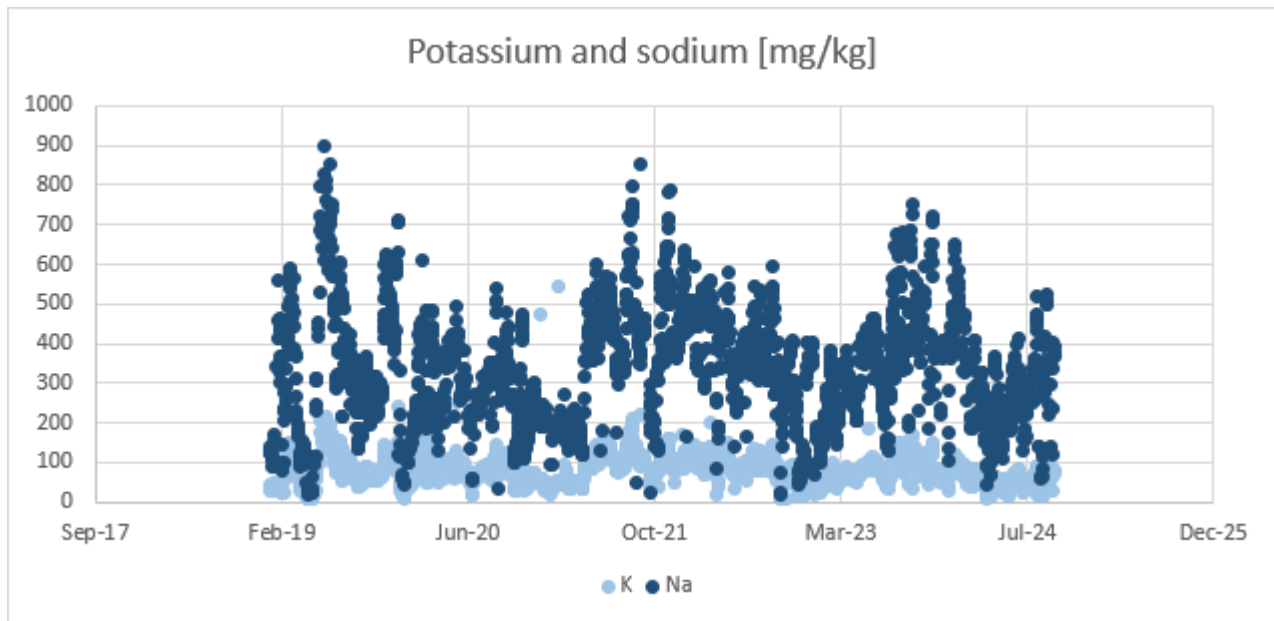


Figure 57: Kriel Cooling water South Potassium and sodium

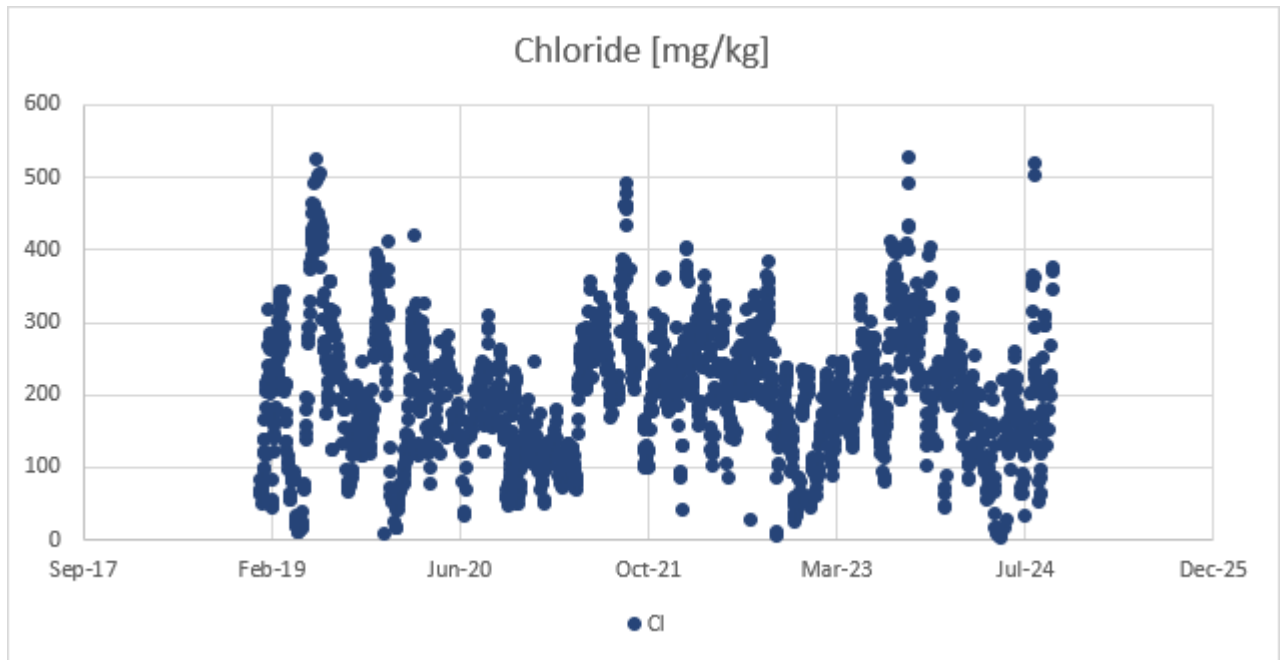


Figure 58: Kriel Cooling water South Chloride

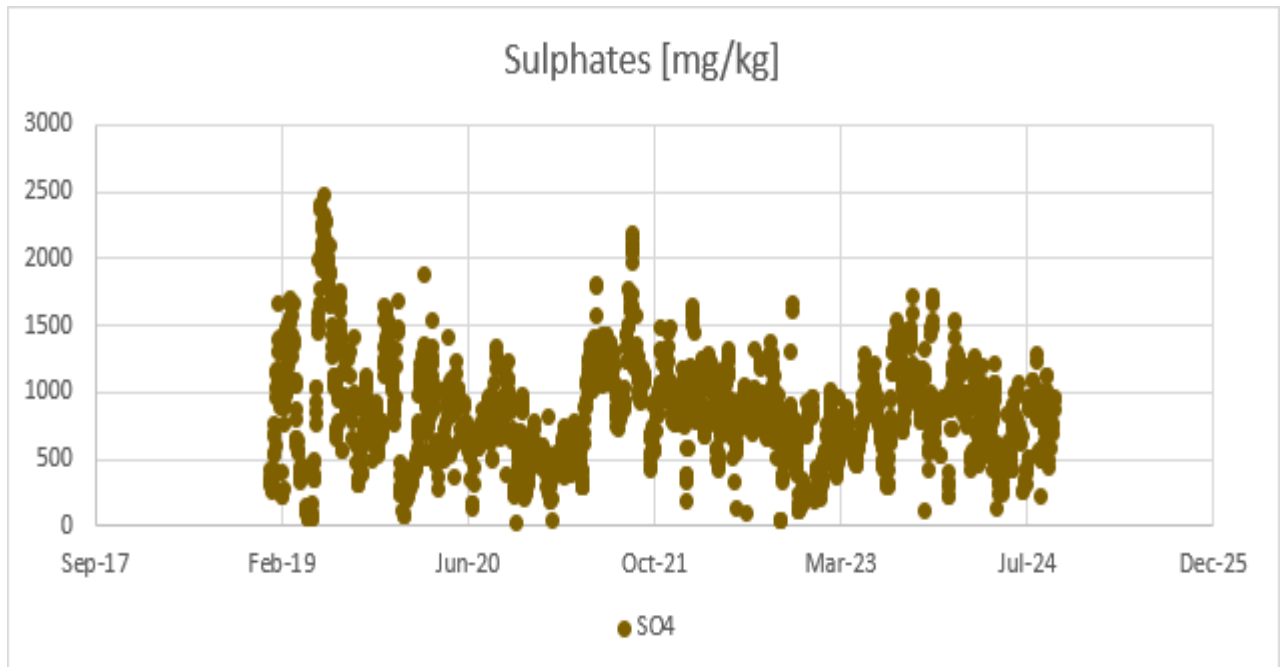


Figure 59: Kriel Cooling water South pH and sulphate

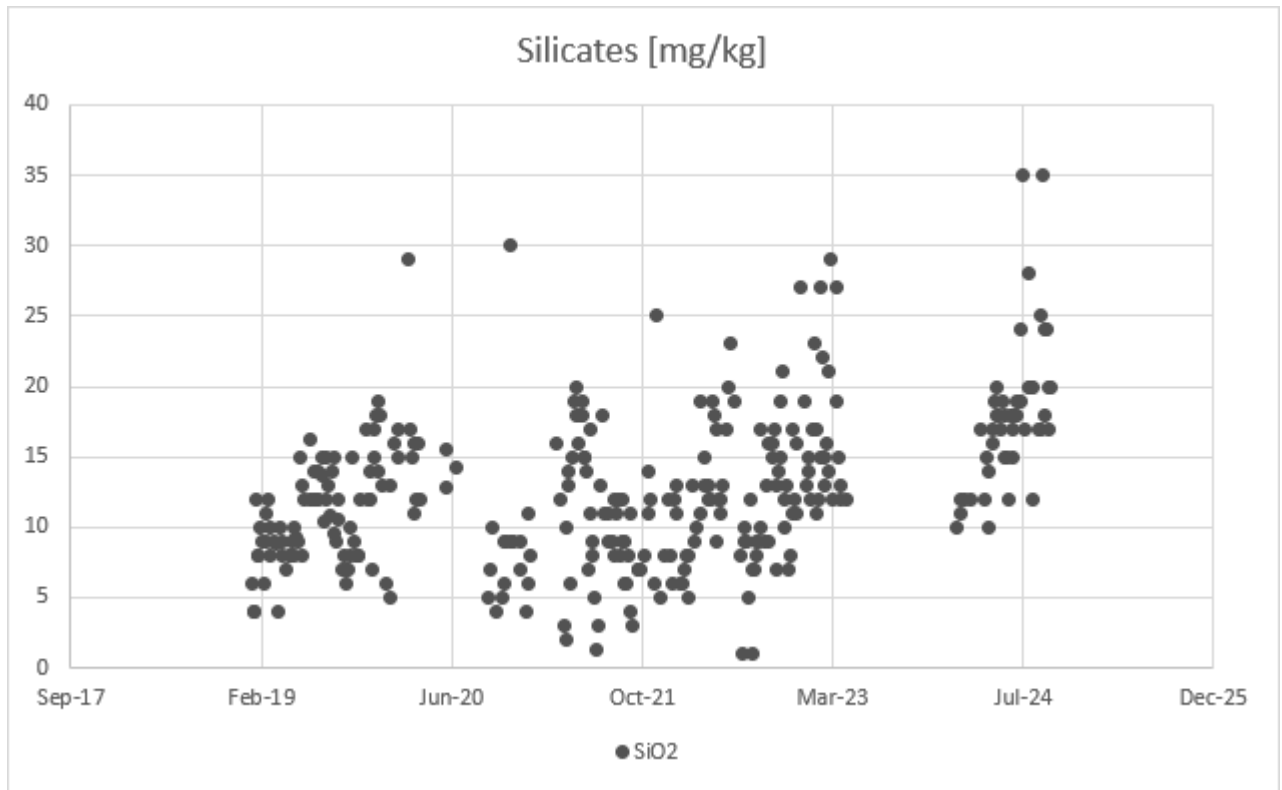


Figure 60: Kriel Cooling water South silicate

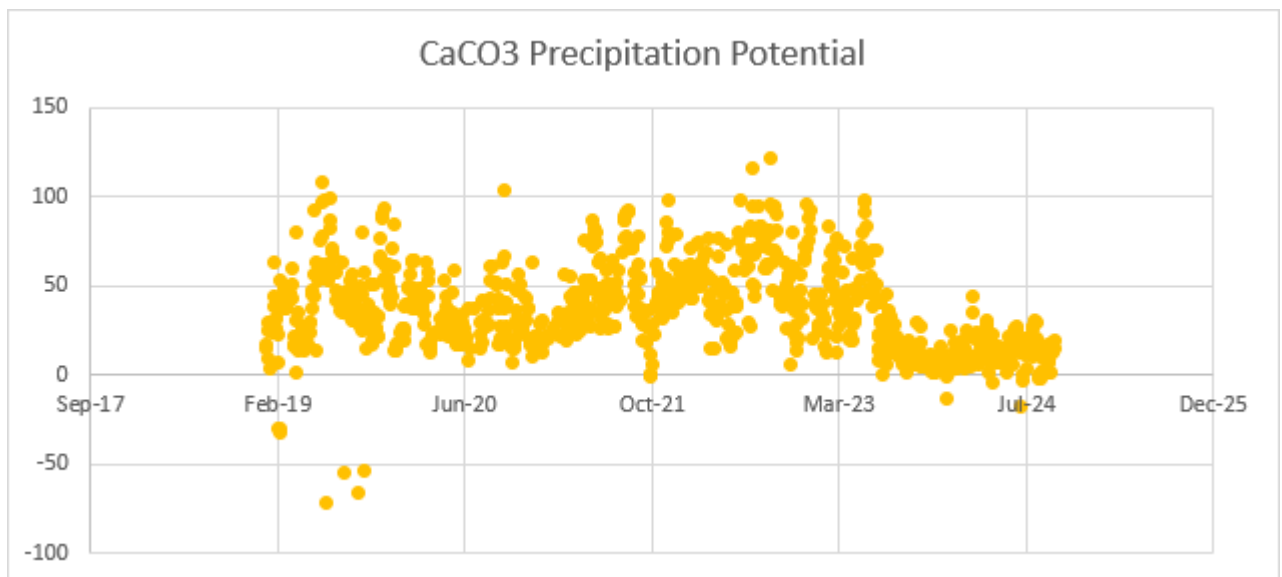


Figure 61: Kriel Cooling water South Calcium Carbonate Precipitation Potential

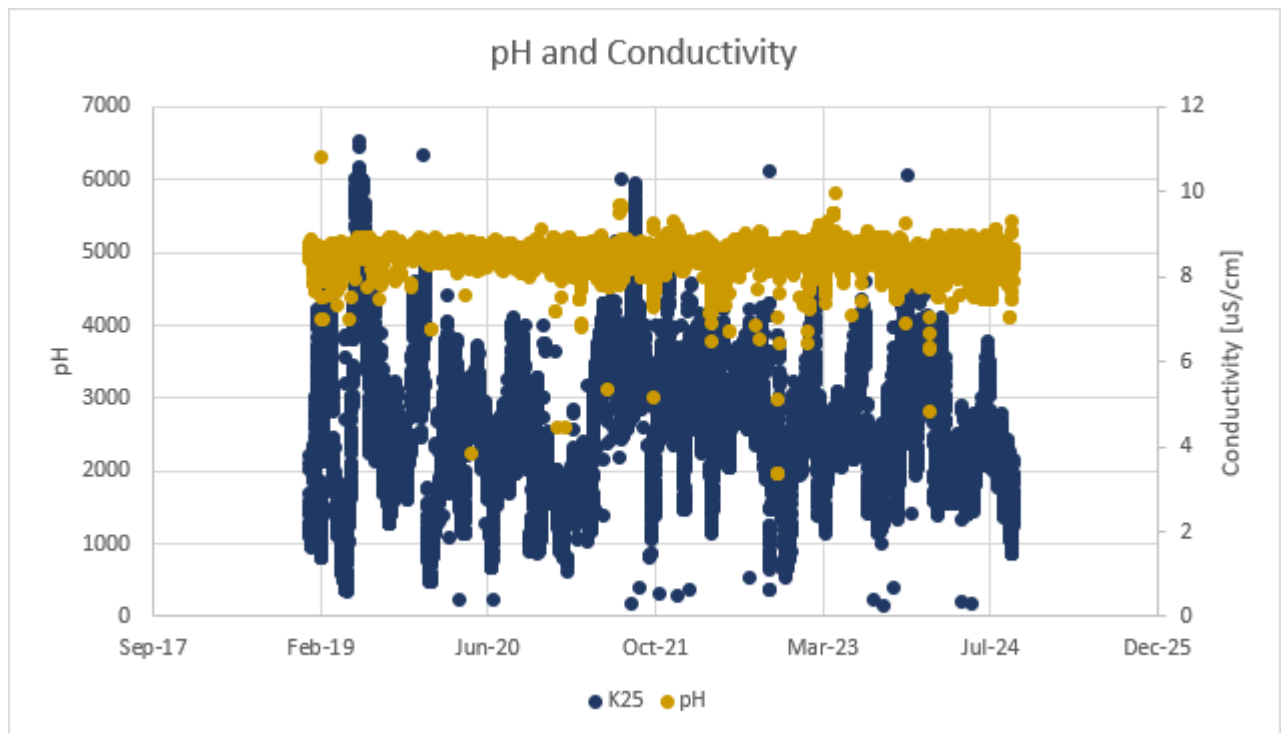


Figure 62: Kriel Cooling water North pH and conductivity

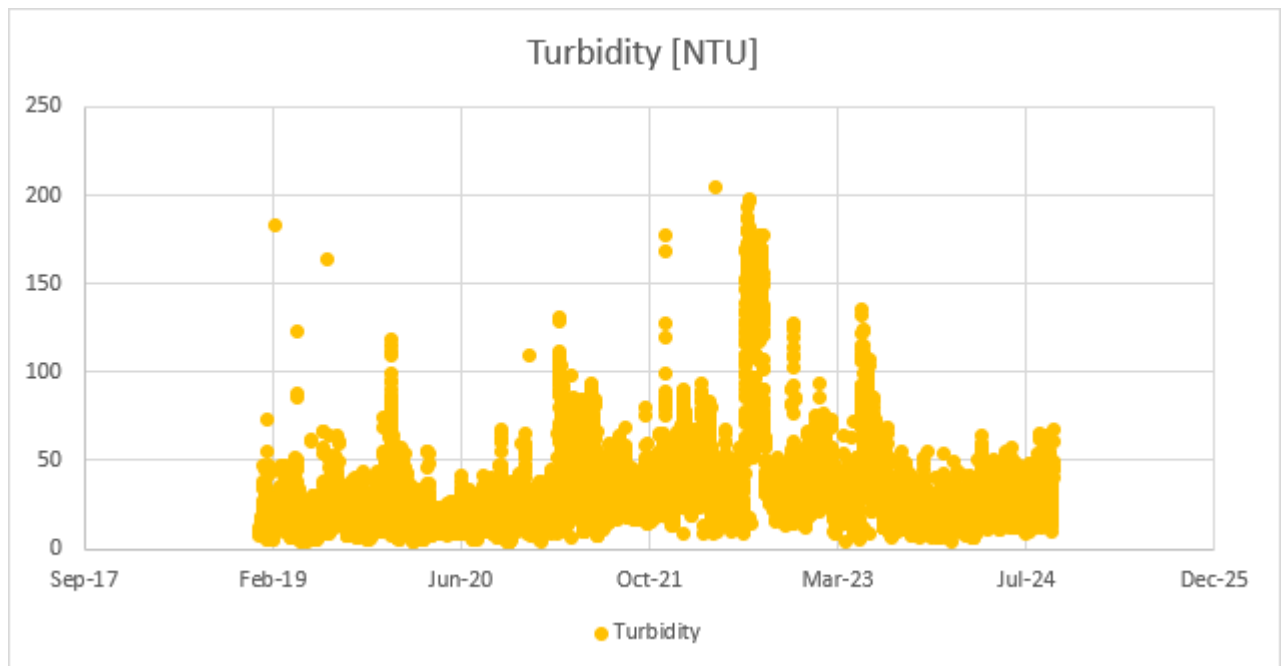


Figure 63: Kriel Cooling water North turbidity

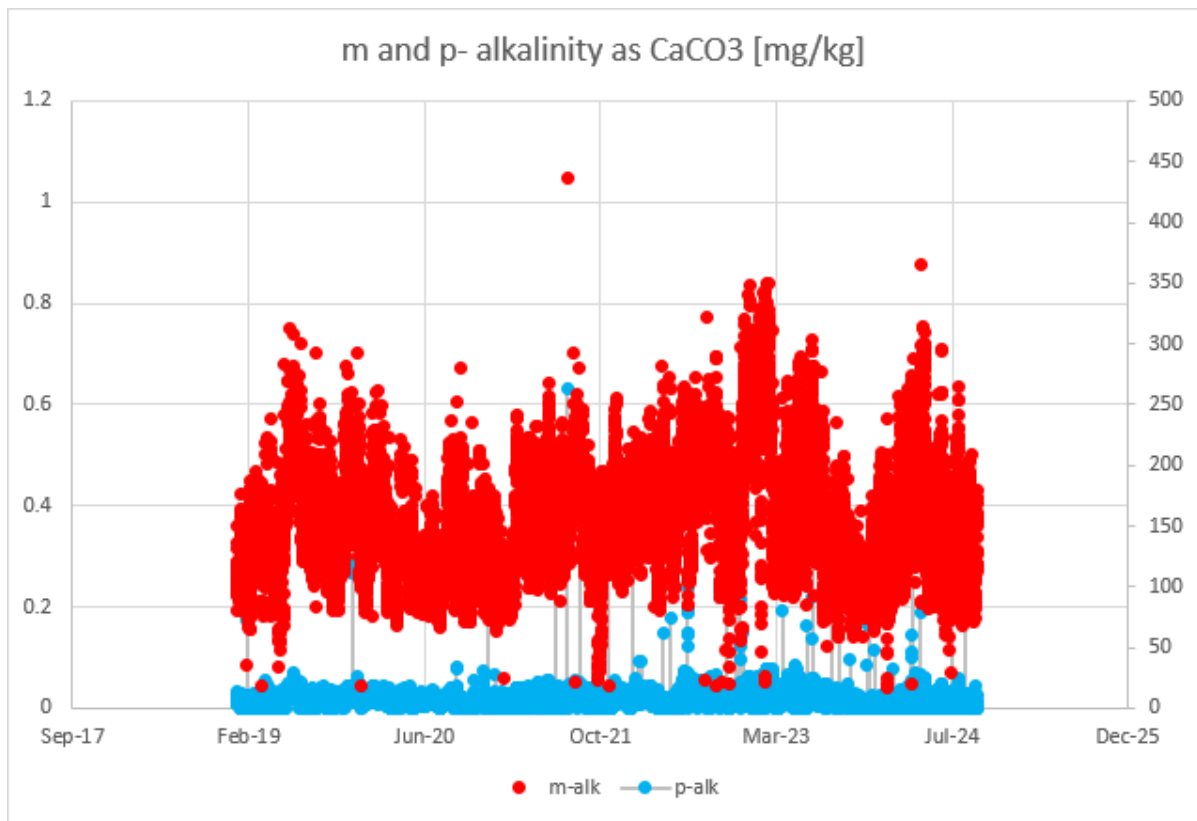


Figure 64: Kriel Cooling water North m-alkalinity and p-alkalinity

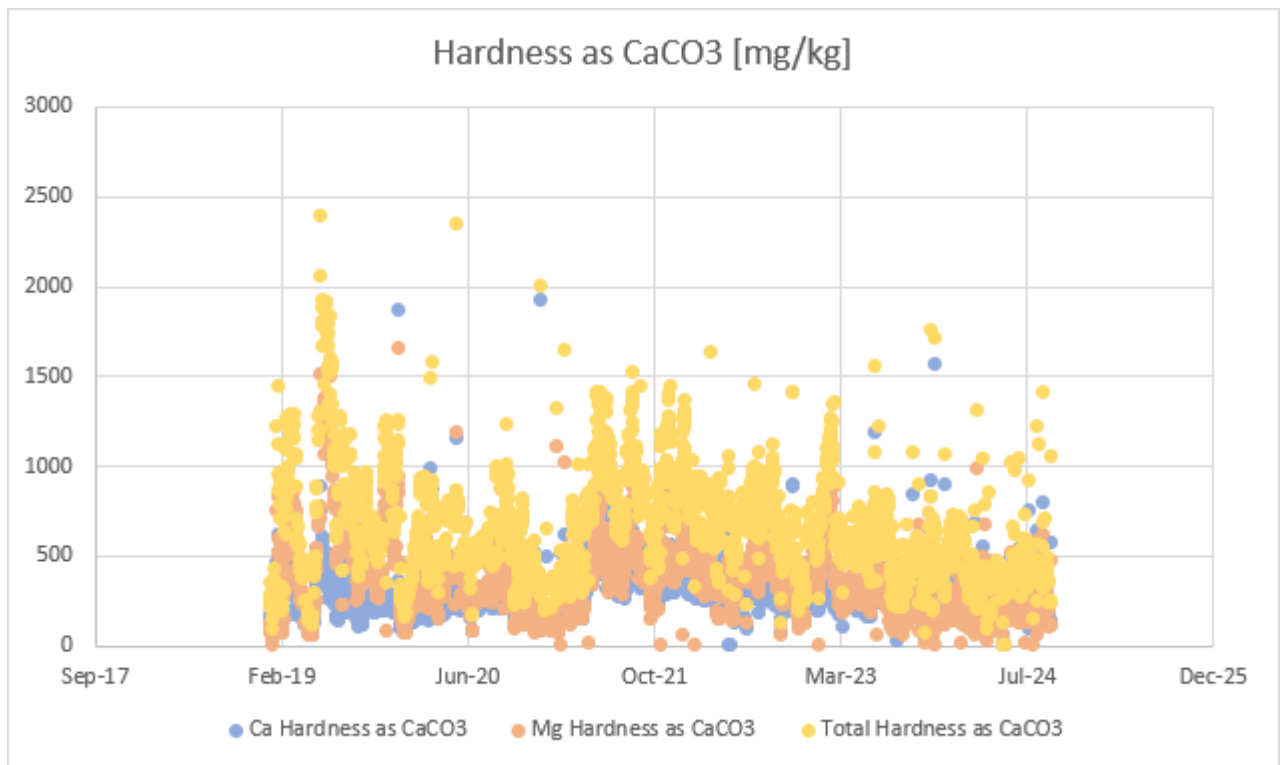


Figure 65: Kriel Cooling water North hardness

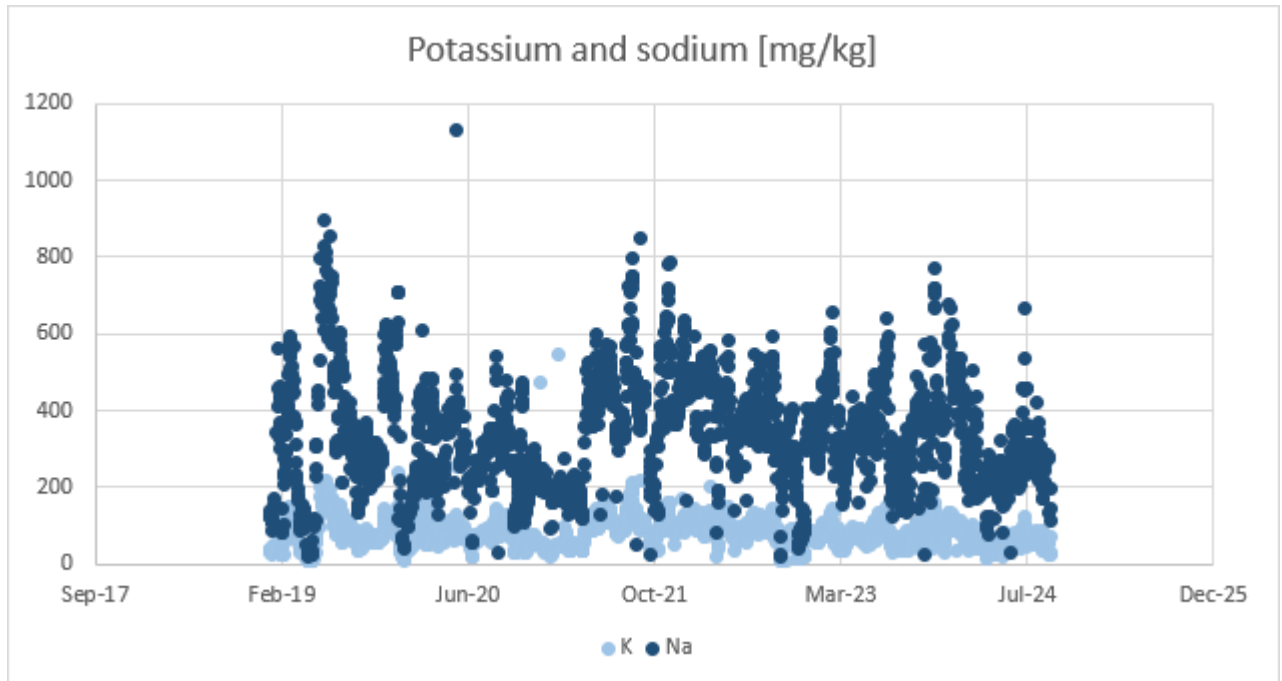


Figure 66: Kriel Cooling water North Potassium and Sodium

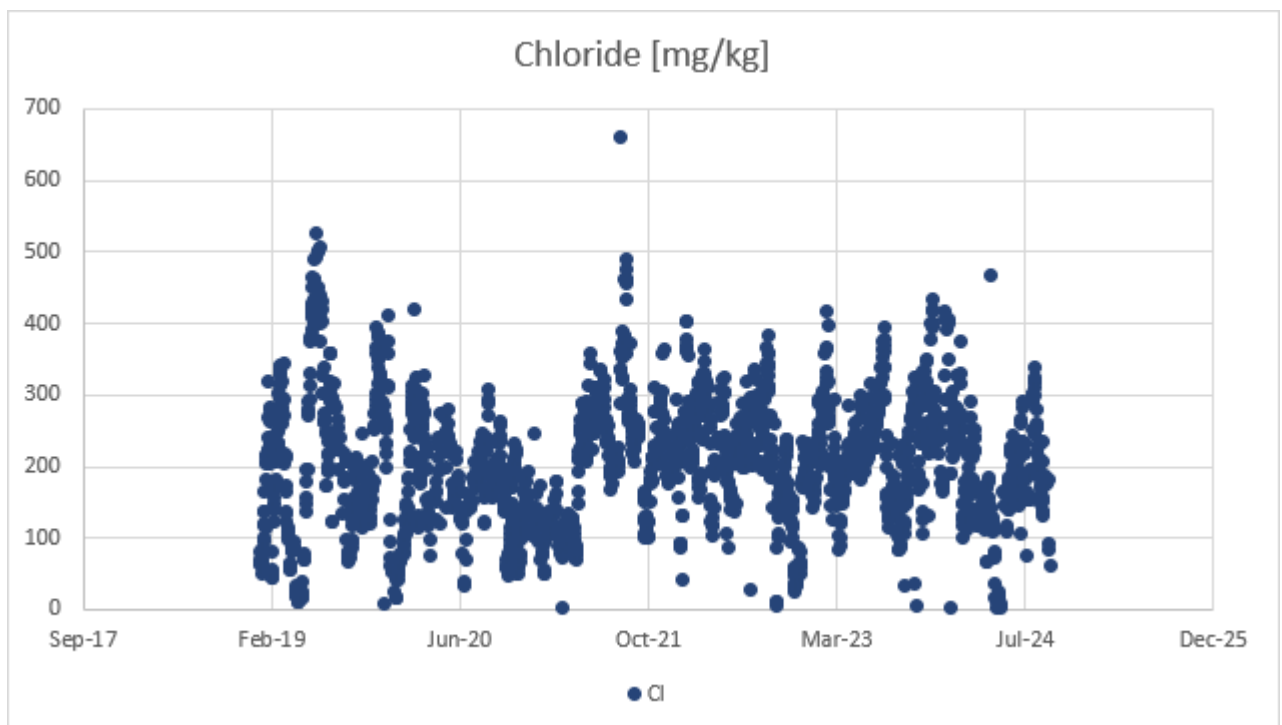


Figure 67: Kriel Cooling water North Chlorides

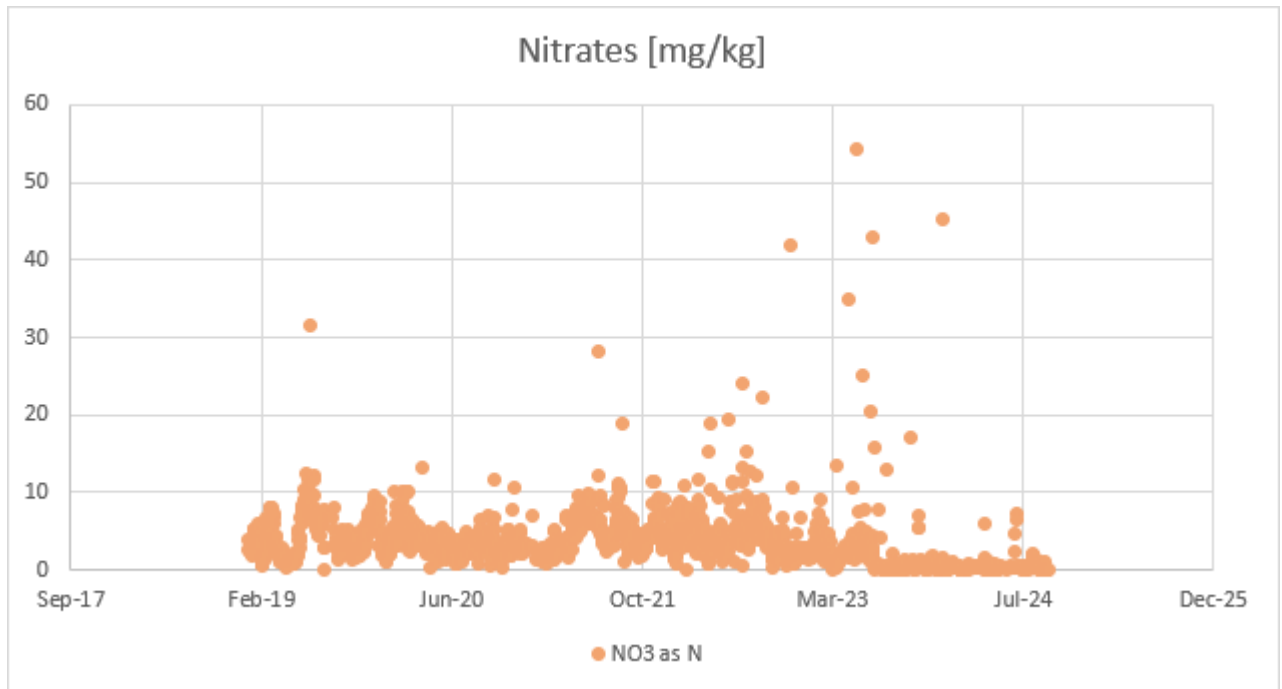


Figure 68: Kriel Cooling water North Nitrates

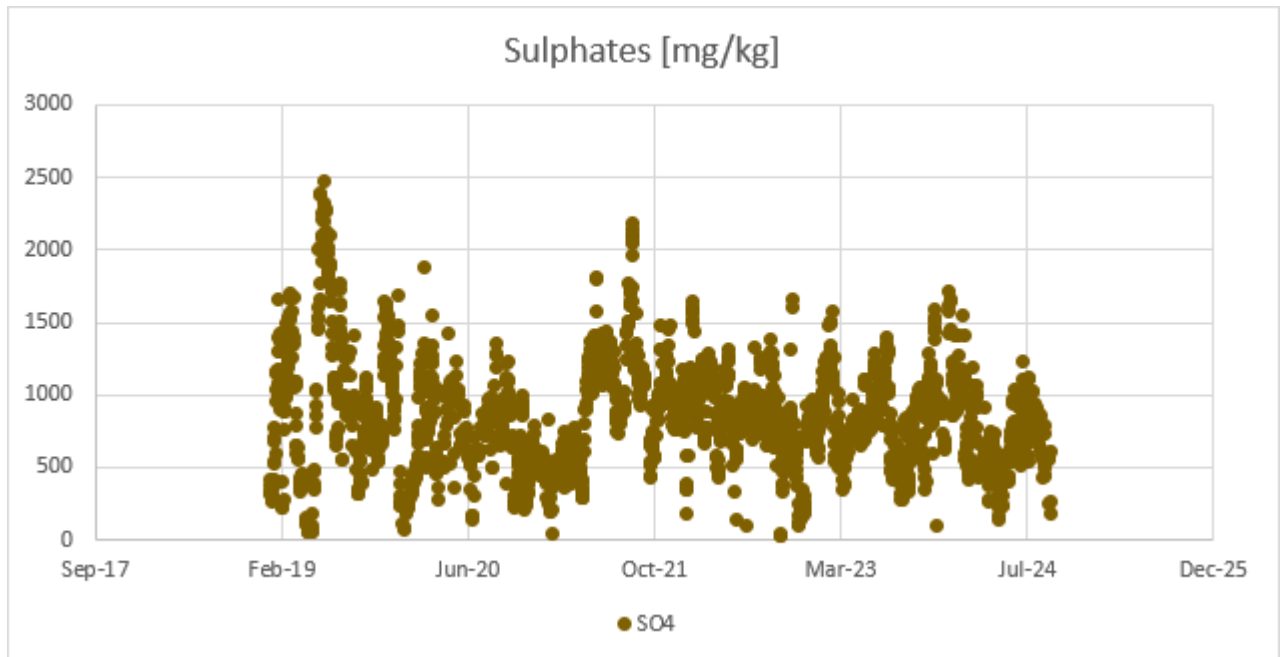


Figure 69: Kriel Cooling water North Sulphates

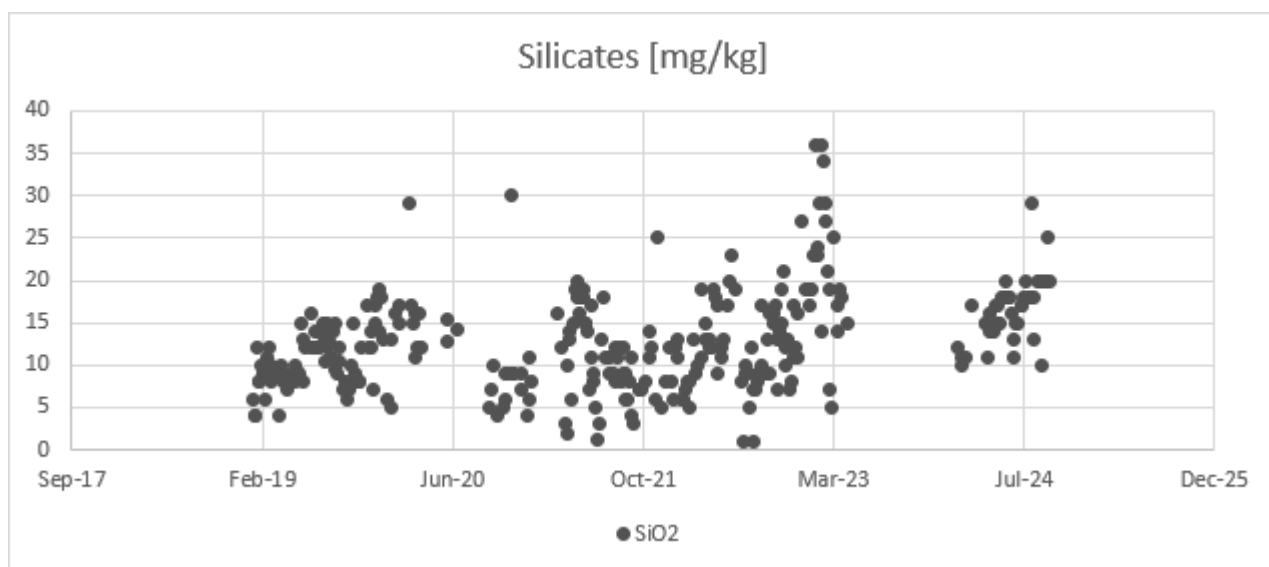


Figure 70: Kriel Cooling water North Silicates

The typical range of water quality for treatment from the CCW at Tutuka is as indicated in the tables and figures below:

Table 9: Concentrated Cooling water (Tutuka Power Station)

Parameter	Unit	Tutuka CW East			Tutuka CW west		
		Range	Average	95 th percentile	Range	Average	95 th percentile
pH	-	6.2 – 12.31	8.84	9.54	6.05 – 12	8.91	9.59
Conductivity	µS/cm	292 - 52700	52700	9332	178 – 48209	8512	25734
Turbidity	NTU	1.69 - 359	71.08	191.85	0.872 – 279	33.1	82.5
CCPP as CaCO ₃	mg/kg	0 – 3332	139.9	558	-1.4 – 174.6	52.02	119.2
Calcium Hardness as CaCO ₃	mg/kg	0 – 3332	139.93	558	2.49 – 1740	101.89	340.3
Magnesium Hardness as CaCO ₃	mg/kg	0 – 3449	413.53	1634.75	0 – 2060	301.69	981.2
Total Hardness as CaCO ₃	mg/kg	37.7 - 4960	1063.27	3386	10.4 - 3119	656.28	2319.3
m-alkalinity	mg/kg	0 – 4720	276.89	720	0 – 1528	301.2	604.03
p-alkalinity	mg/kg	0 – 3519	37.64	171.85	0 – 939	36.67	145.12
Sodium	mg/kg	0.01 - 11040	1967.8	6522	0.01 – 5972	1456.25	4719.7
Potassium	mg/kg	0.3 - 1183	109.77	313.6	0.01 – 834	74.2	252.75
Chloride	mg/kg	14.6 – 5080	736.87	3213.5	0 – 8900	753.15	2336.7
Sulphate	mg/kg	0.06 - 34290	3612.68	17164	0 – 16845	2728.02	10136

		Tutuka CW East			Tutuka CW west		
Nitrates	mg/kg	0.01 – 101	17.35	64.15	0 – 78.9	10.69	46.1
Phosphates	mg/kg	0.01 - 1810	33.59	139.83	0.01 - 1015	11.13	11.26
Silicate at SiO ₂	mg/kg	0.01 - 130	36.65	90	1.3 – 126	20.83	49.98
TOC	mg/kg	0.44 - 135	30.66	76.46	0 – 73	18.78	43.09

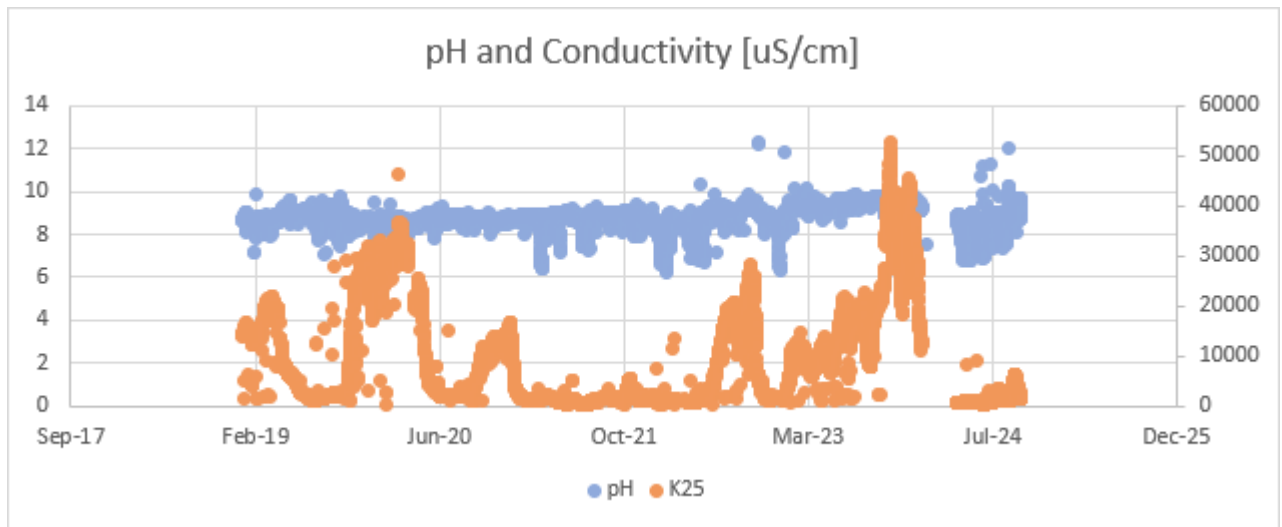


Figure 71: Tutuka Cooling water East pH and Conductivity

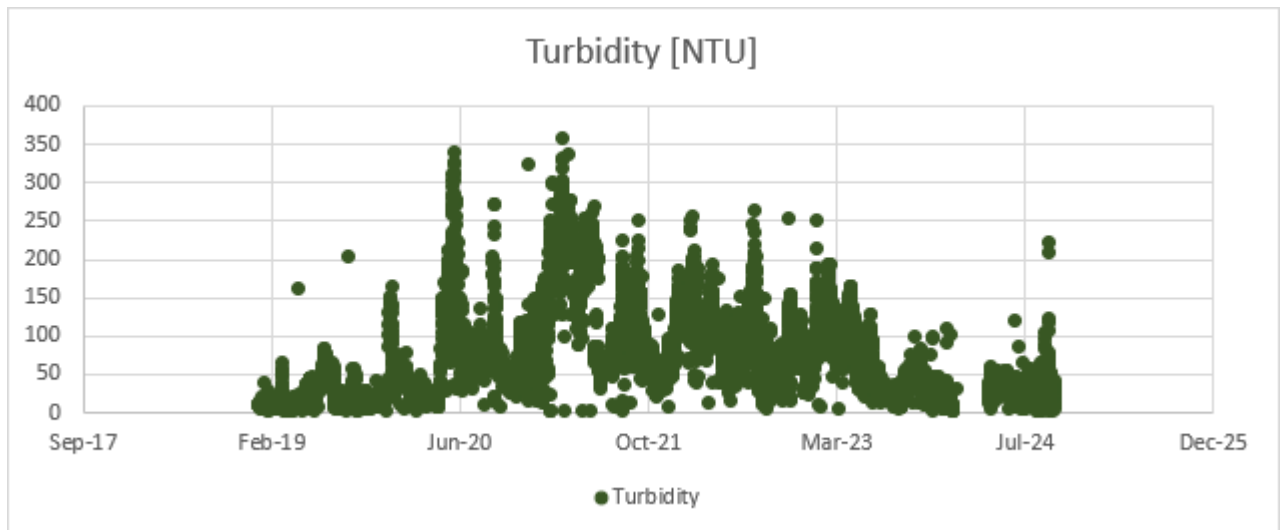


Figure 72: Tutuka Cooling water East Turbidity

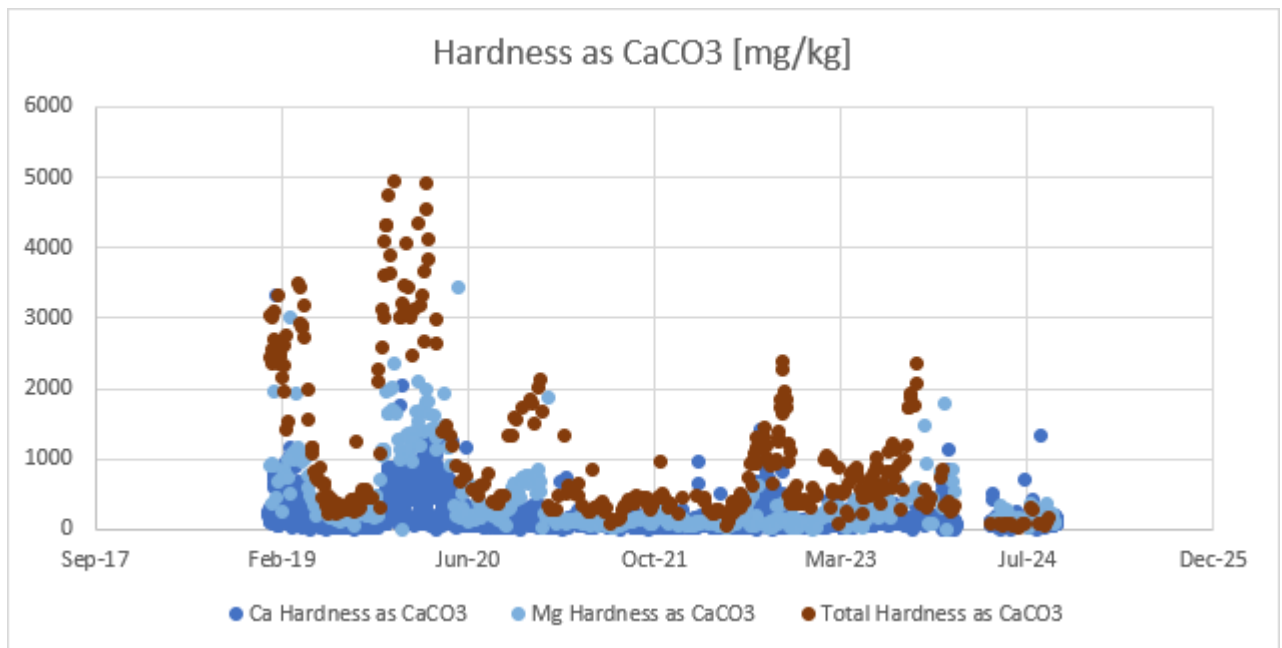


Figure 73: Tutuka Cooling water East Hardness

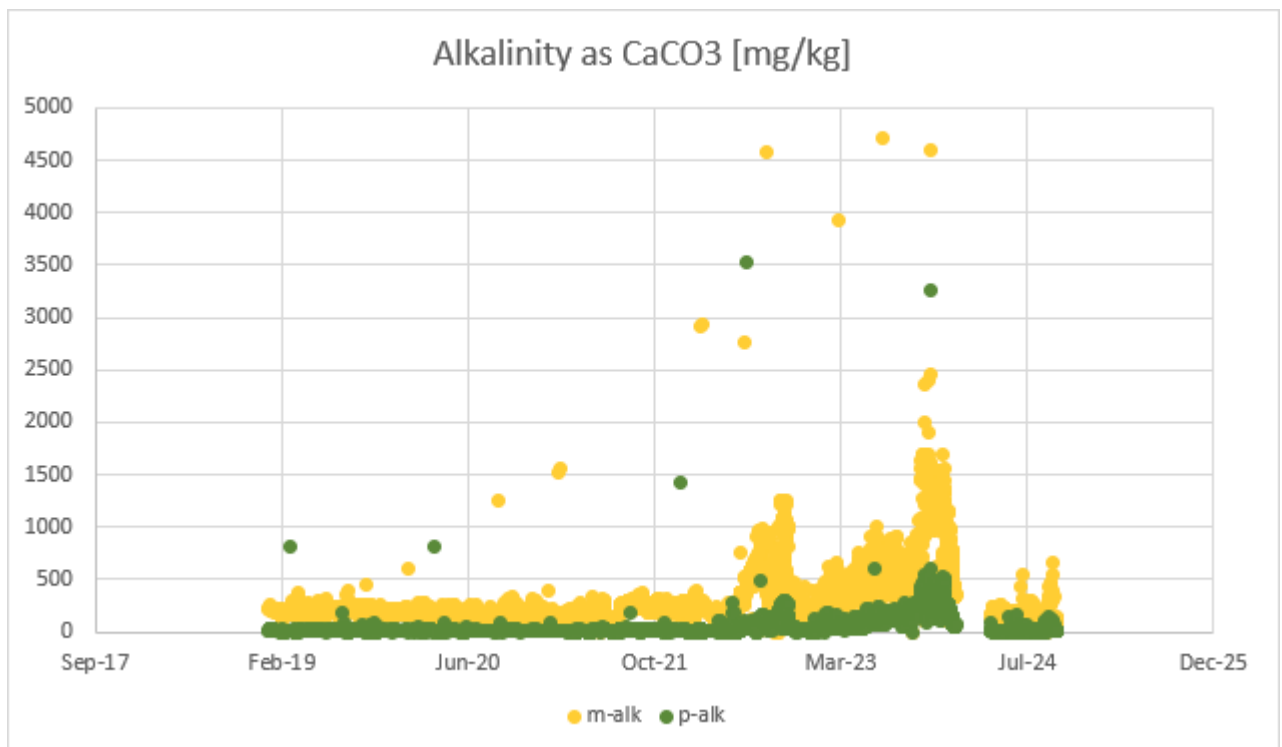


Figure 74: Tutuka Cooling water East Alkalinity

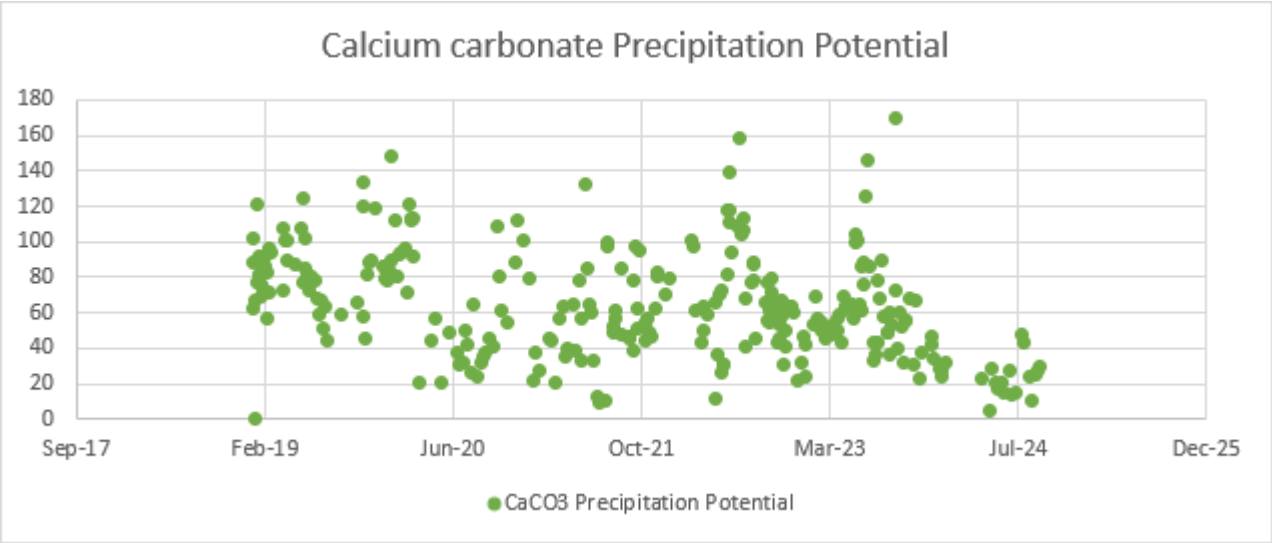


Figure 75: Tutuka Cooling water East Calcium carbonate precipitation potential

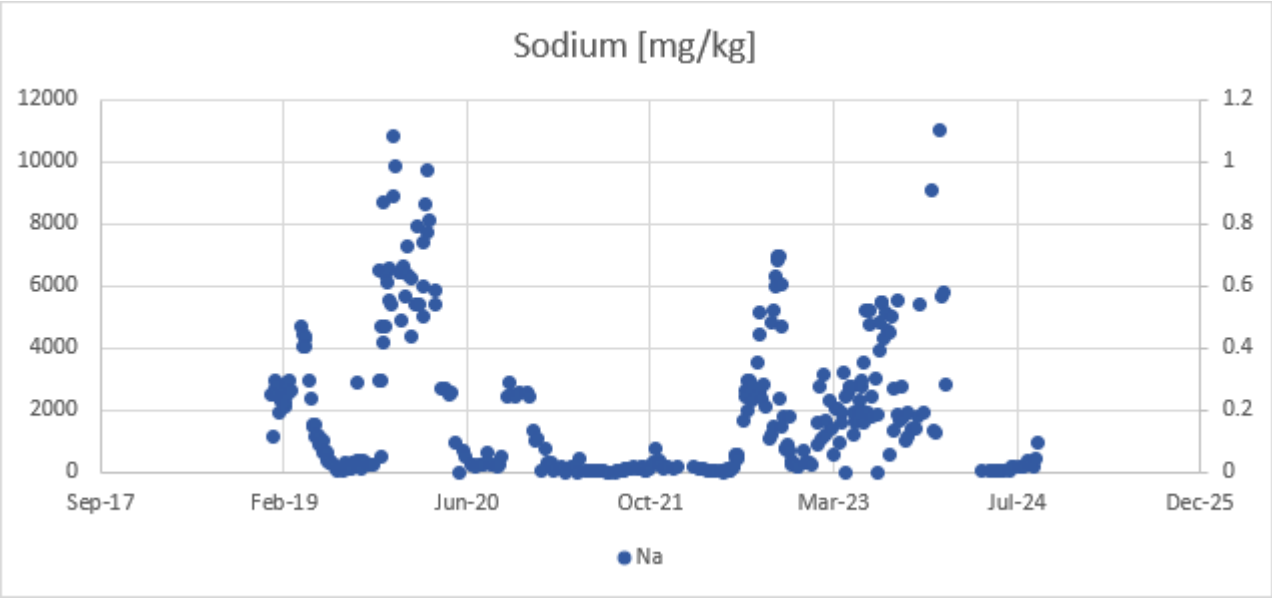


Figure 76: Tutuka Cooling water East Sodium

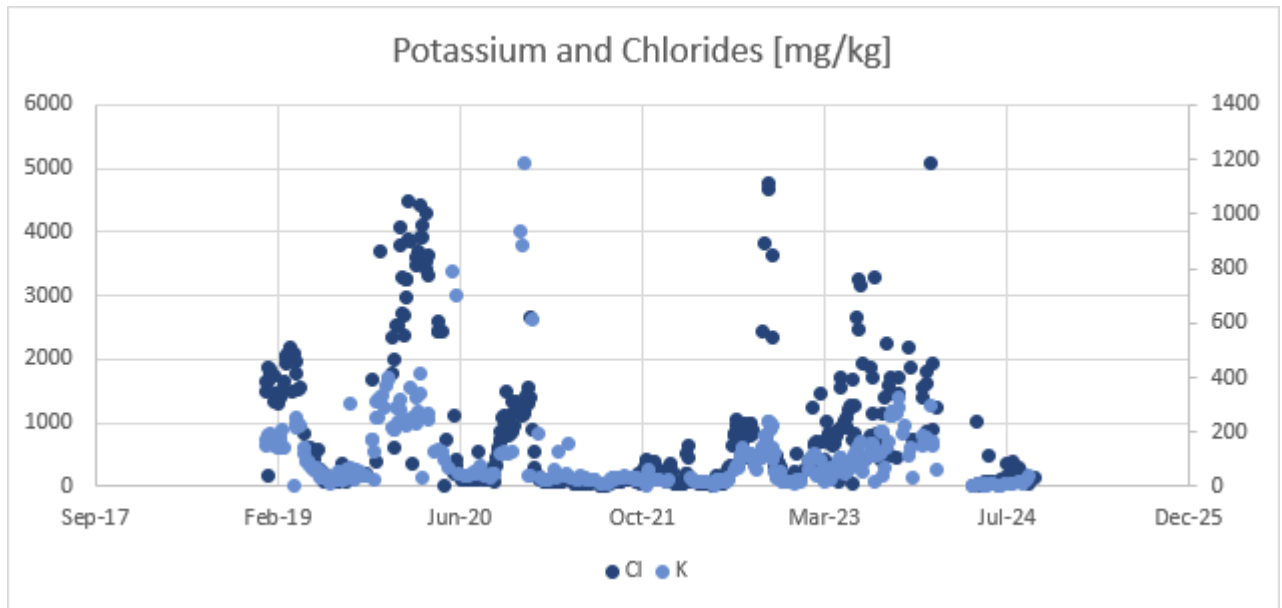


Figure 77: Tutuka Cooling water East Chlorides and Potassium

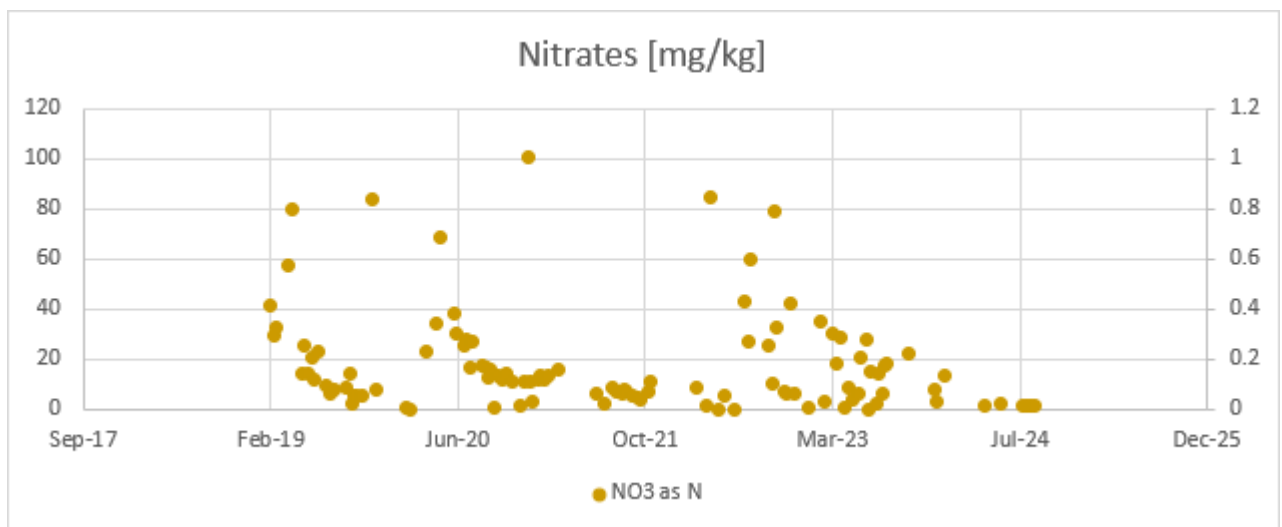


Figure 78: Tutuka Cooling water East Nitrates

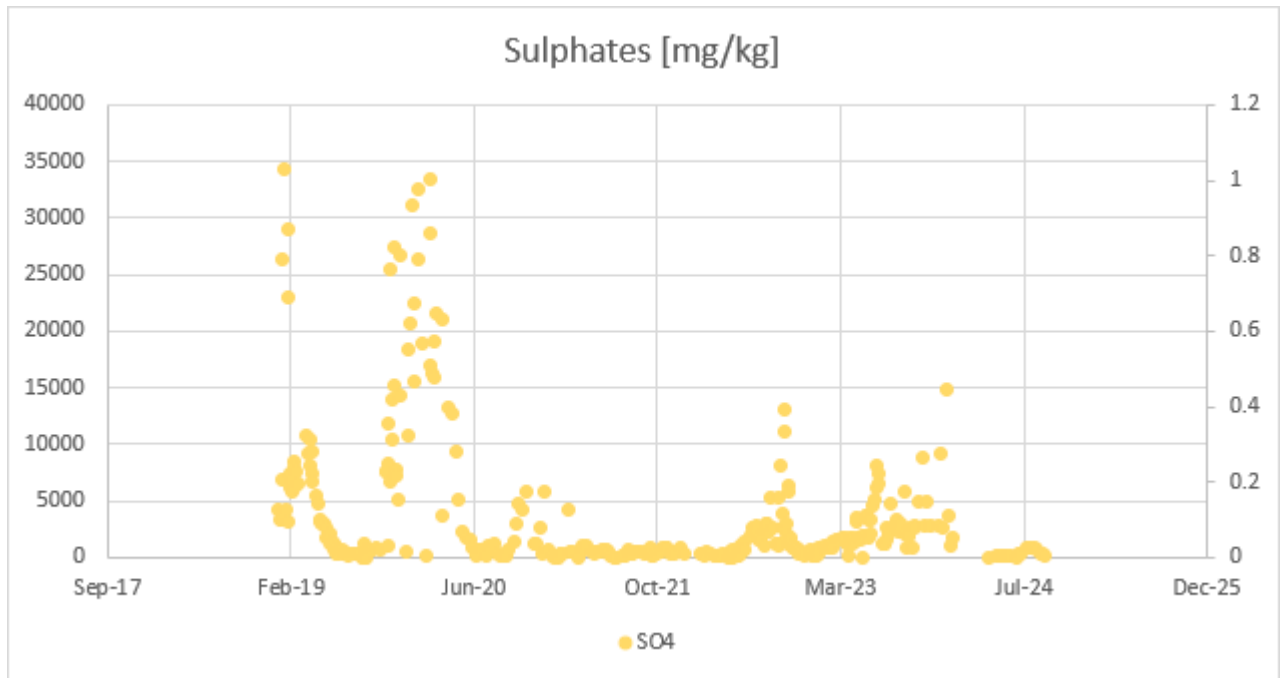


Figure 79: Tutuka Cooling water East Sulphates

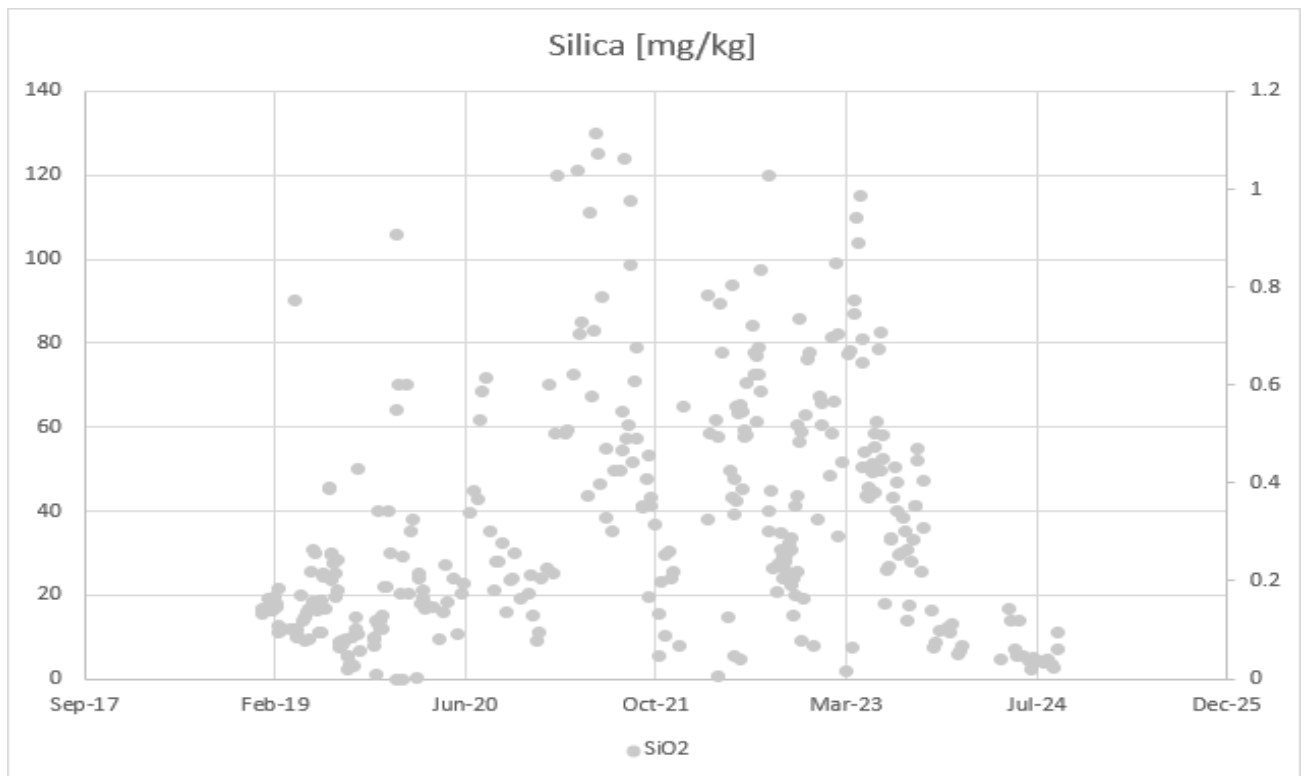


Figure 80: Tutuka Cooling water East Silicates

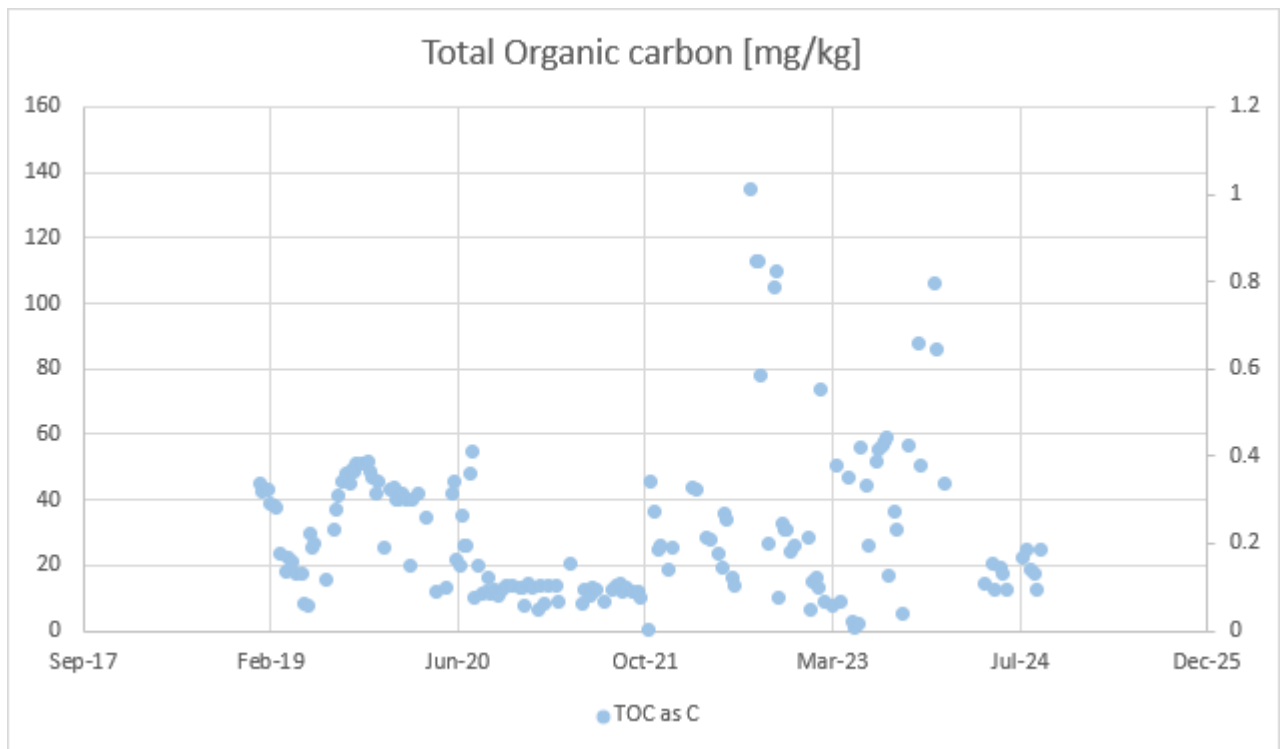


Figure 81: Tutuka Cooling water East Total organic carbon

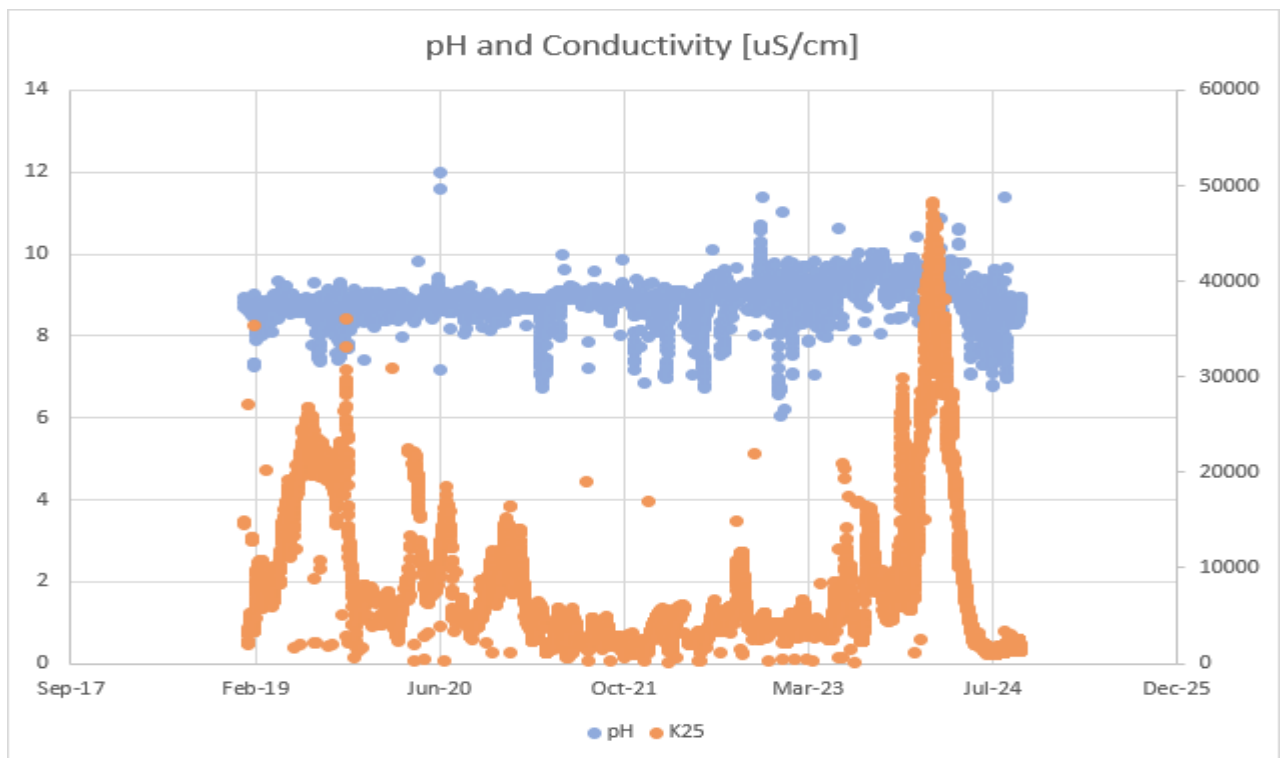


Figure 82: Tutuka Cooling water West pH and conductivity

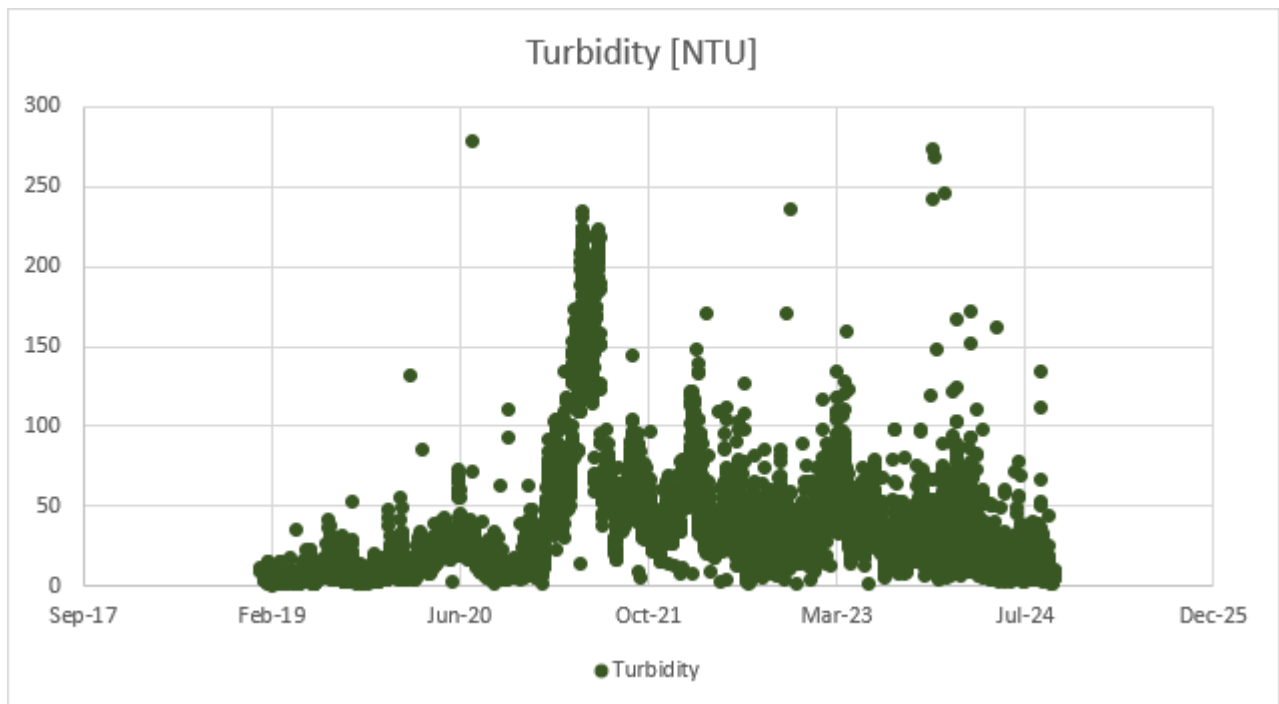


Figure 83: Tutuka Cooling water West turbidity

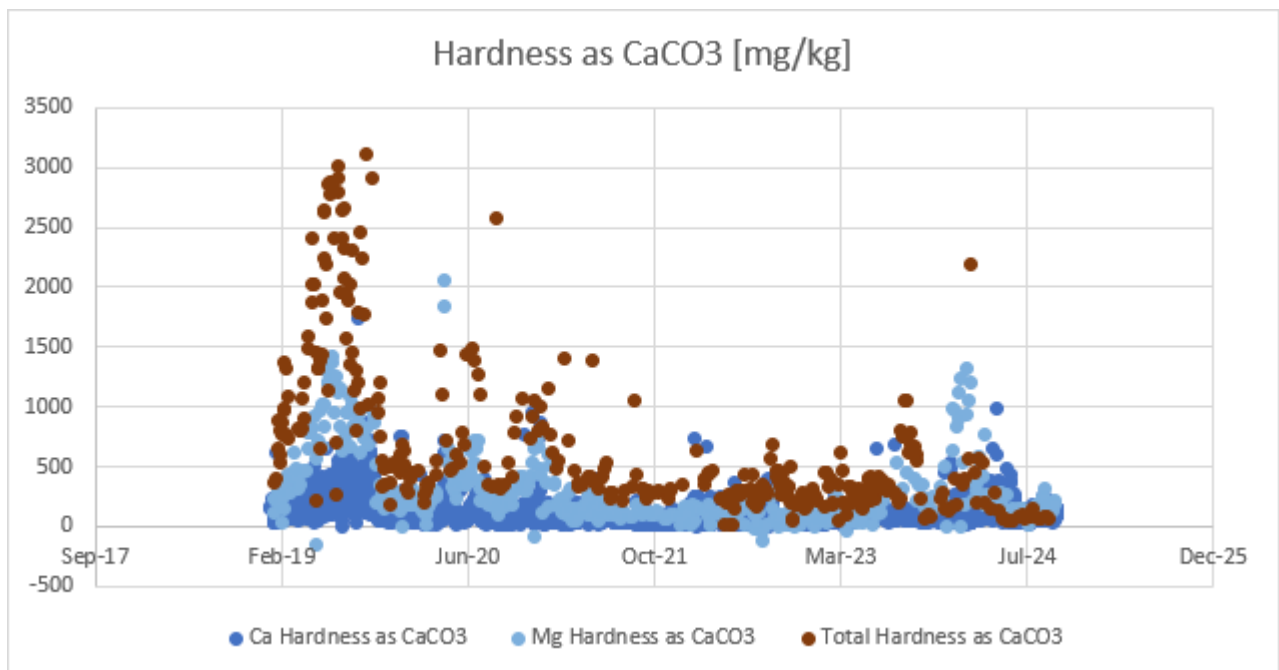


Figure 84: Tutuka Cooling water West Hardness

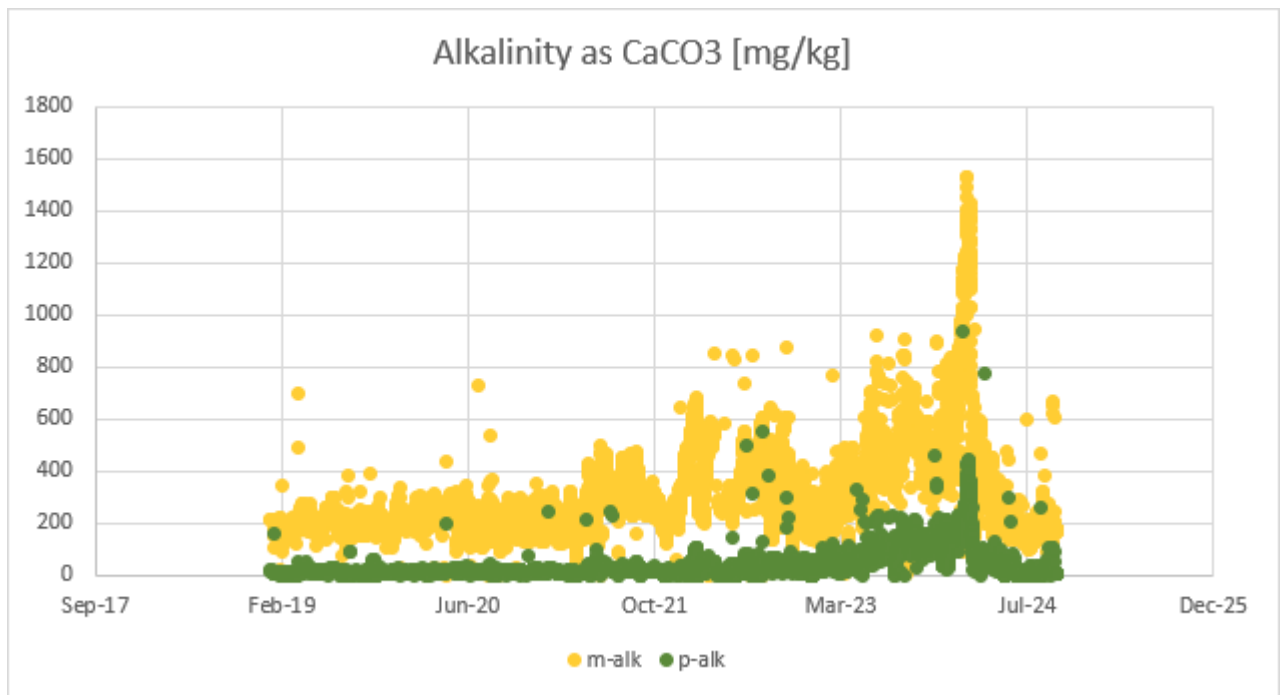


Figure 85: Tutuka Cooling water West alkalinity

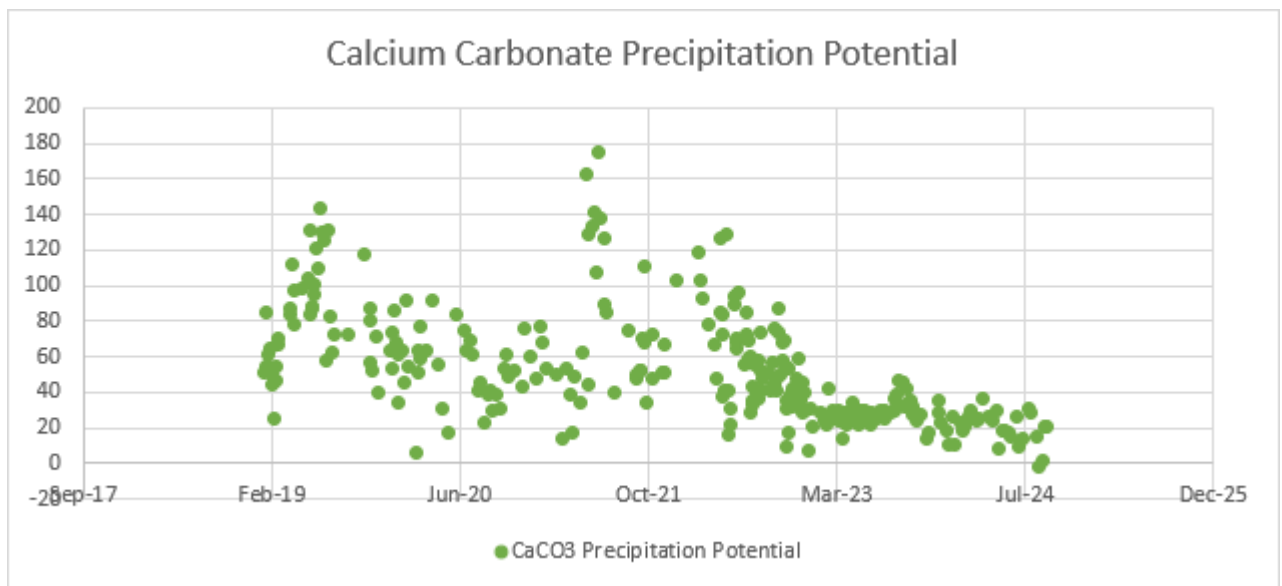


Figure 86: Tutuka Cooling water West Calcium carbonate precipitation potential

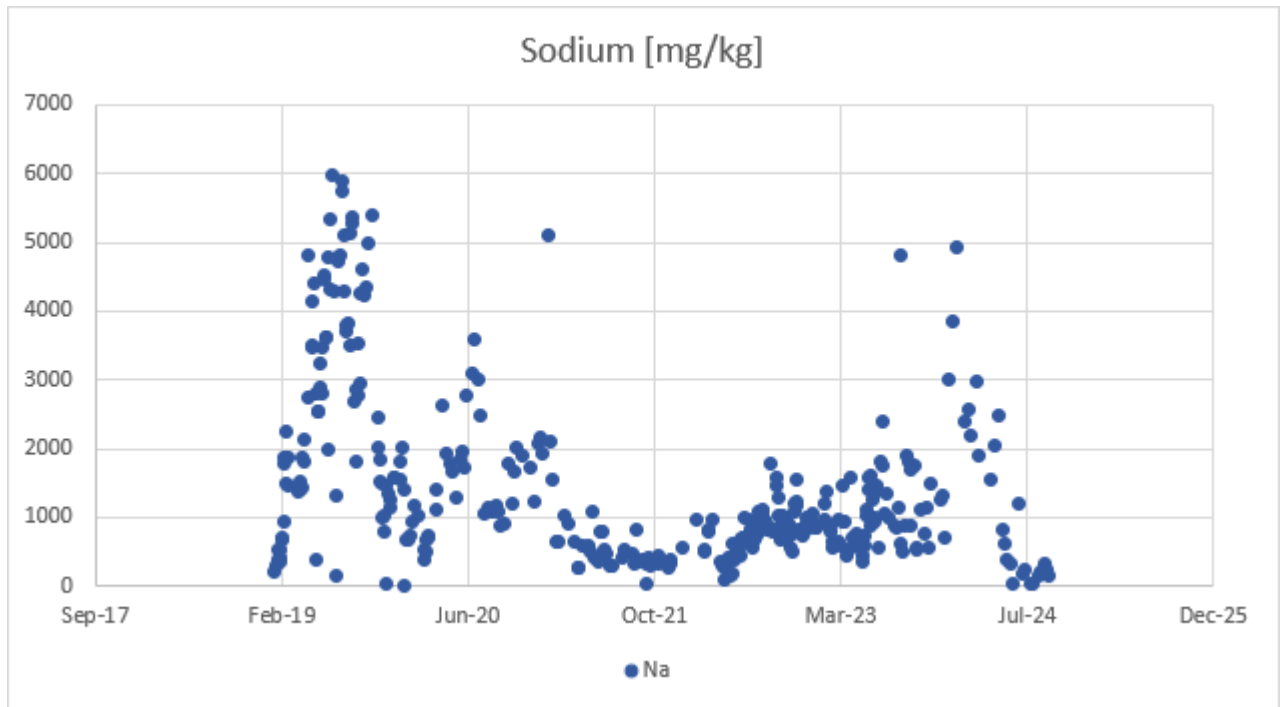


Figure 87: Tutuka Cooling water West sodium

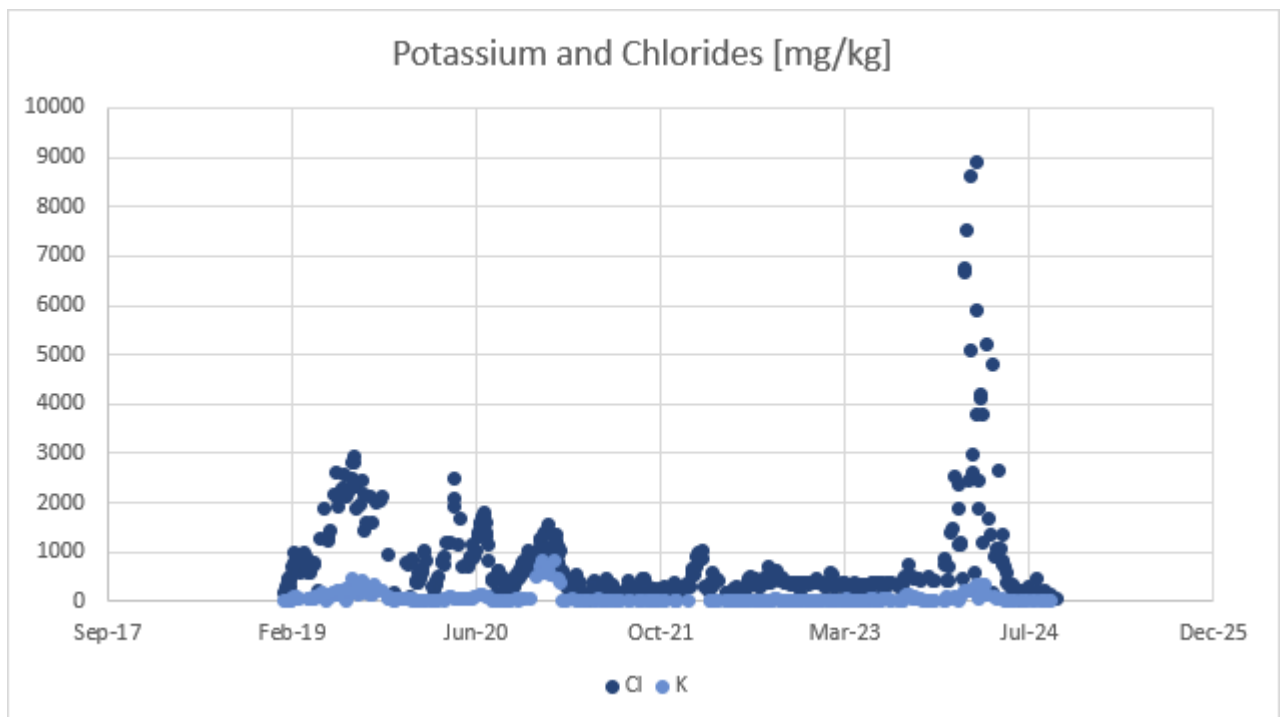


Figure 88: Tutuka Cooling water West Potassium and chlorides

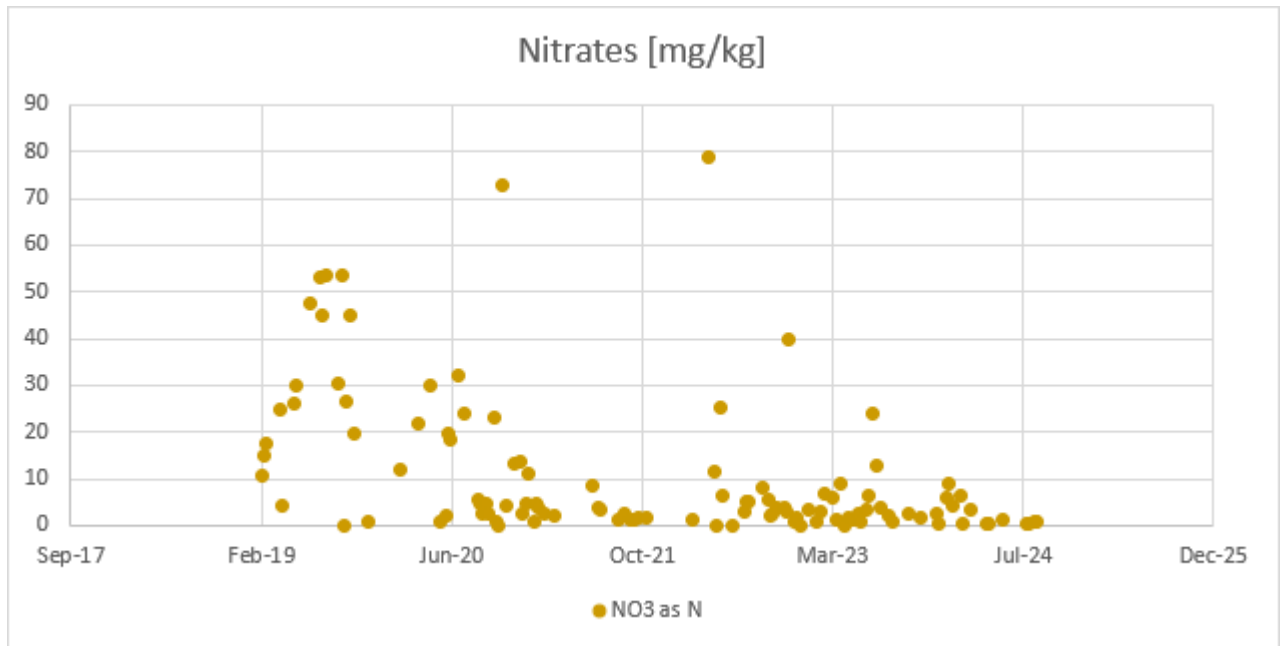


Figure 89: Tutuka Cooling water West Nitrates

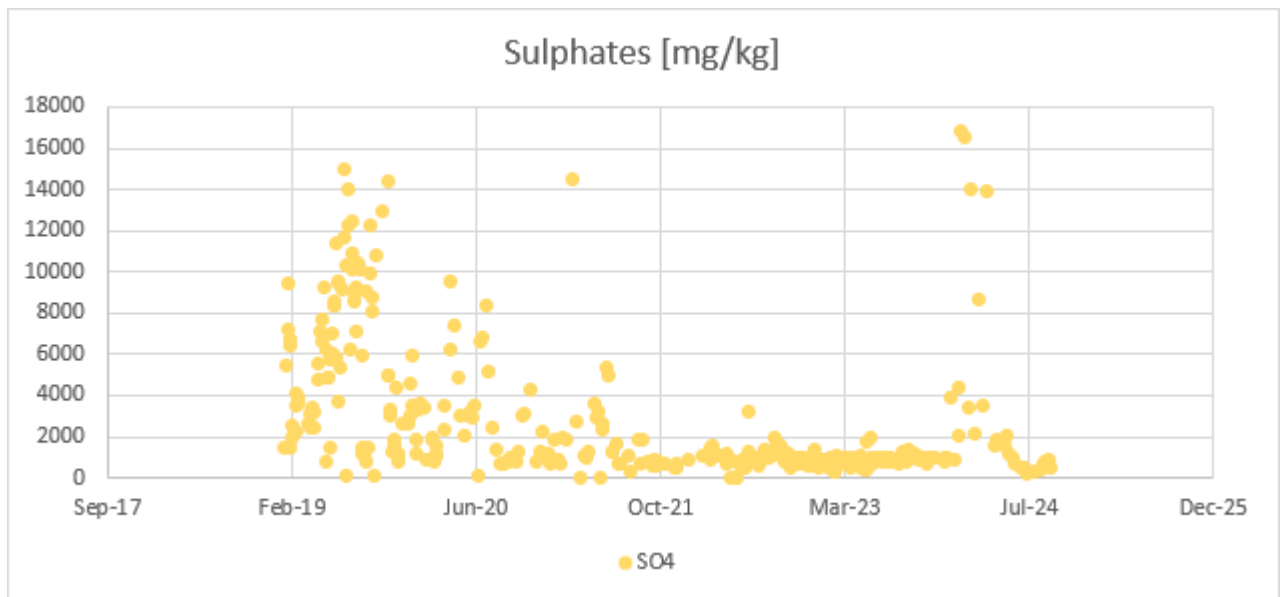


Figure 90: Tutuka Cooling water West sulfates

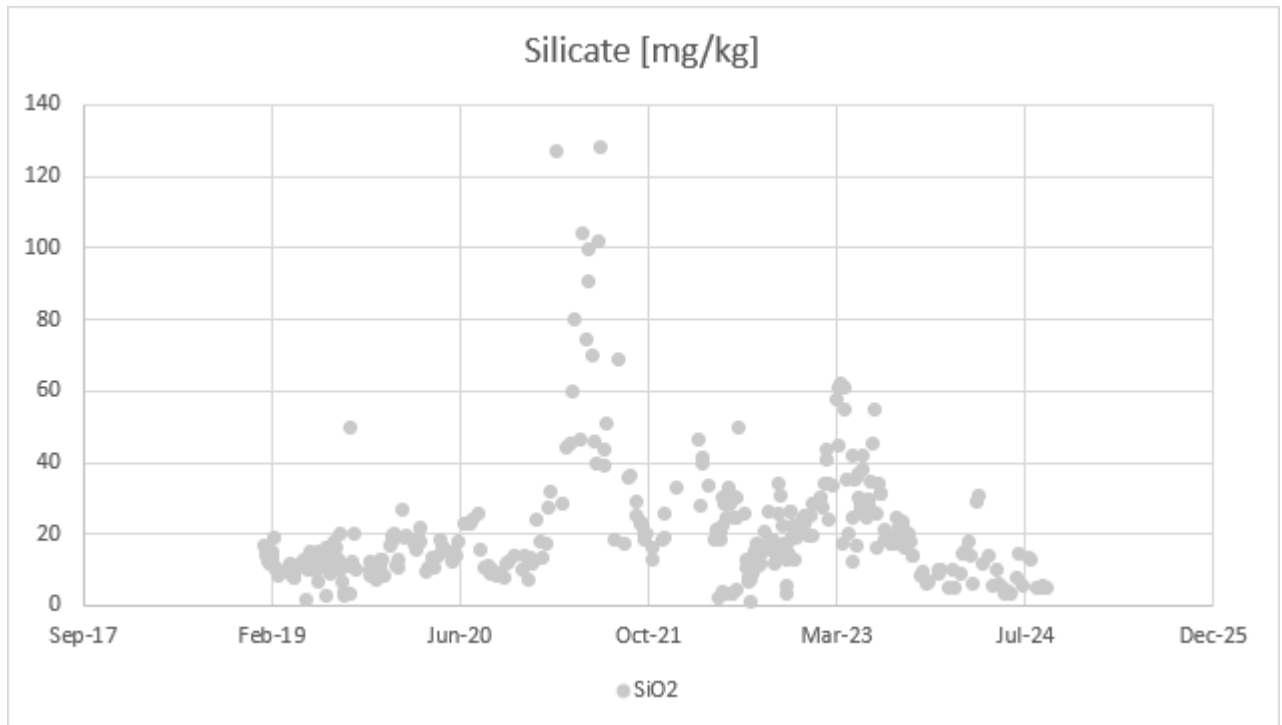


Figure 91: Tutuka Cooling water West silicates

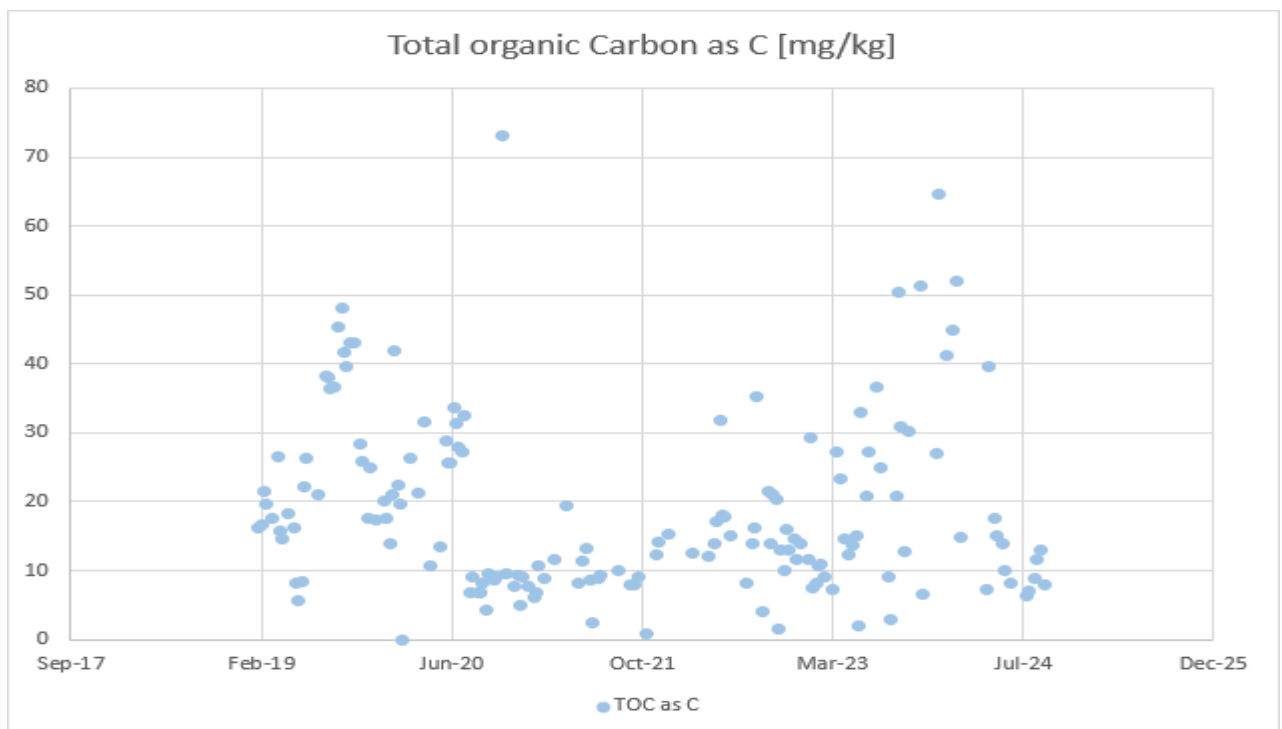


Figure 92: Tutuka Cooling water West total organic carbon

PLANT BATTERY LIMITS

The plant battery limits will be different for the different source waters to the plant.

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a. Wastewater which contains and high levels of ash and oil (Tutuka Power Station)

The source water to the plant will be taken from the sump, which normally feeds the submersible pumps. The permeate will be collected in a tank and will be re-used for the cleans. The rest of the permeate will be fed back to the sump which feeds the clean water return pumps. The concentrate produced will be collected and discharged as per the procedure on the station when dredging the dams, or into the brine concentrate sump. The Employer will use the analysis of the brine (concentrate) stream to decide where it must be discharged.

b. Ash water return (Duvha/Kriel Power Station)

The source water will be taken directly from the AWR dam. The permeate will be collected in a tank and will be re-used for the cleans. The rest of the permeate will be fed back to the dam for the period of the test. The Employer will use the analysis of the brine (concentrate) stream to decide where it must be discharged.

c. Flue Gas desulphurisation (FGD) bleedstream (Kusile Power Station)

The source water will be taken directly from the wastewater storage tank itself or on the discharge. The permeate will be collected in a tank and will be re-used for the cleans. The rest of the permeate will be fed to the process drain recovery sump if the quality is better than raw water quality, otherwise station drains. The Employer will use the analysis of the brine (concentrate) stream to decide where it must be discharged.

d. Effluent from the neutralisation sump (ENS) (Tutuka Power Station)

The source water to the plant will be taken from the effluent neutralisation sump. The permeate will be collected in a tank and will be re-used for the cleans. The rest of the permeate will be fed back to the cooling water return launders. The Employer will use the analysis of the brine (concentrate) stream to decide where it must be discharged.

e. Concentrated cooling water (Tutuka/Kriel Power Station)

The source water to the plant will be taken from the Cooling water inlet to the clarifiers. The permeate will be collected in a tank and will be re-used for the cleans. The rest of the permeate will be fed back to the cooling water return launders. The Employer will use the analysis of the brine (concentrate) stream to decide where it must be discharged.

MODES OF OPERATION

The testing rig must be fully automated with an integrated logger to log the physical parameters. However, the rest of the operating and sampling will be done by the *contractor*.

LABORATORY TESTING

The *Contractor* must also allow for analysis of the water at a SANS 17025 accredited laboratory. The requirement is daily full analysis of at least the feed, concentrate and permeate throughout the entire period of testing. The daily sample should be a composite sample from the operations during the day. Refer to the table below for the minimum required parameters.

Daily Analysis required			
pH	TOC	Beryllium	Strontium
Conductivity	FOG	Boron	Zinc
"P" alkalinity	Chloride	Cadmium	Calcium
"M" alkalinity	Fluoride	Cobalt	Magnesium
Turbidity	Nitrates	Chromium	Sodium
Total hardness	Nitrates	Copper	Potassium

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Calcium hardness	Sulphates	Iron	Nickel
Magnesium hardness	Silica	Phosphate	Lead
TDS	Aluminium	Manganese	Barium
TSS	COD	Ammonium	

The wastewater which contains oil (tutuka water from the wastewater dam) will require Fats, oils and grease (FOG) analysis to be done.

It should be noted that the stream from the FGD bleedstream is concentrated and will need special treatment during sampling and analysis. The contractor must sample and analyse as per the requirements in EPRI technical report 1013347: FGD Chemistry and Analytical Methods Handbook Volume 1 and 2 - Chemical and Physical Test Methods (Revision 2).

DURATION OF THE TEST

An estimated schedule for the duration of the tests is as per the Table below.

No.	Activity	Duration	Person Responsible
1.	Contract award		Eskom
2.	Lab scale tests	2-4 weeks	Contractor
3.	Pilot testing Oil and grit water	4 months	Contractor
4.	Pilot testing ENS water	3 months	Contractor
5.	Pilot testing FGD bleedstream water	3 months	Contractor
6.	Pilot testing AWR water	3 months	Contractor
7.	Pilot testing of CW	3 months	Contractor
8.	Review of results and compilation of the report	1 month	Contractor
9.	Review the report and accept	1 month	Eskom