KARKLOOF RIVER WALK

AQUATIC AND RIPARIAN ASSESSMENT

FINAL REPORT

GroundTruth
Water, Wetlands and Environmental Engineering

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Executive summary

The 2017 Karkloof River Walk was an initiative of the Karkloof Conservancy, undertaken in partnership with WWF-SA and Endangered Wildlife Trust. GroundTruth Water, Wetland and Environmental Engineering Consultants provided technical support directing the measurements and assessments that would be undertaken during the walk, and analysis of the data collected.
The core walkers were Twané Clarke (Karkloof Conservancy), Sue Viljoen (WWF-SA), Nduduzo Khoza (Endangered Wildlife Trust) and Ayanda Lipheyana (GroundTruth). Simon Bruton and Jenna Taylor (GroundTruth) stepped in as substitutes for a day each. Representatives of SAPPI and other land owners joined in at various stages of the walk.

The river walk covered approximately 65Km of river and took 6 days to complete. The findings from the river walk indicated that in general, the river was in a fair to good condition. There were a few areas where impacts were more intense, but these were most often of a very limited extent.

The main impacts noted along the walk were invasive alien plants and diminished water quality. The three most dominant species of alien plant were Bramble, Black Wattle and Bugweed. These are categorised invasive species under categories 1b and 2 of the National Environmental Management: Biodiversity Act No. 10 of 2004 and require active control and management.

Water quality issues were related to *E. coli* and nutrient enrichment, the sources of which were both from natural causes and related to agricultural management practices adjacent to the river. There were only 2 sites of the 37 sites assessed that had major water quality issues and these were related to elevated *E. coli* counts.

The initial and final sites along the Karkloof River found the river to be in a good condition.

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Definition of terms

Terms/Abbreviation	Description
Biophysical	Biological and physical elements which comprise a habitat/ecosystem. For example the vegetation and channel/banks which comprise a watercourse.
Clarity	Clarity is a surrogate measurement for turbidity and suspended solids, as an indicator of levels of pollution or soil erosion.
Conductivity	The electrical conductivity of the water, which is measured as an indicator of the level of dissolved salts in the water. The level of dissolved salts (ions) in the water can be artificially increased by pollutants, i.e. from WWTW, urban & road runoff, and agricultural runoff.
Dissolved oxygen	The level of gaseous oxygen present in the water. Dissolved oxygen levels that are too high (i.e. super saturation) or too low can be harmful to aquatic life. Oxygen levels that remain below 1-2 mg/L for a few hours can result in the death of oxygen-breathing aquatic life, such as fish.
DWS	South African National Department of Water and Sanitation.
E. coli	*Escherichia coli* - Highly specific indicator of faecal pollution which originates from humans and warm-blooded animals – indicates the potential presence of water borne diseases.
RHA	Riparian Health Audit. A simplified citizen science tool developed for assessing riparian ecosystem integrity.
PES	Present Ecological State – current state/health of a system in comparison to a reference condition for that system.
pH	pH measures the level of acidity / alkalinity of the water.
Physico-chemical water quality determinants	Physical and chemical constituents of water quality such as pH, temperature, dissolved oxygen, conductivity and suspended solids (clarity), which are usually sampled on-site (*in-situ*).
miniSASS	A simplified biological sampling method using aquatic macroinvertebrates to indicate river health.

1. Introduction

The Karkloof River Walk was a jointly sponsored initiative between Karkloof Conservancy, WWF, Endangered Wildlife Trust and GroundTruth Water, Wetlands and Environmental Engineering (GroundTruth). GroundTruth were appointed to assist in the planning, implementation and reporting of a river walk for the Karkloof River from its source to the confluence with the uMgeni River.

The Karkloof catchment is located in the uMgungundlovu District Municipality, KwaZulu-Natal and in the uMgeni River Catchment (Figure 1.1). It is a major contributor to the uMgeni River and Albert Falls Dam (Figure 1.1), one of the main water resources for Durban, South Africa's third largest economic hub. The goal of the Karkloof River Walk was to determine what the current condition of the river was like at various points and to identify areas that would need attention in order to improve the condition of the river.

What is a River Walk?

A walk along a river from its source to its end point. At various points along the way assessments are done using simple tools to determine the condition/health of the river.

The Karkloof River walk covered 65km over six days, the section of river covered on each day is shown in Figure 1.2.

The aim of this assessment was to determine the current biological condition of the Karkloof River from its source to where the river confluence with the uMgeni.

A total of 37 sites were assessed during the walk. Results from the assessments are present for each site and summarised per day of the walk in, section three.

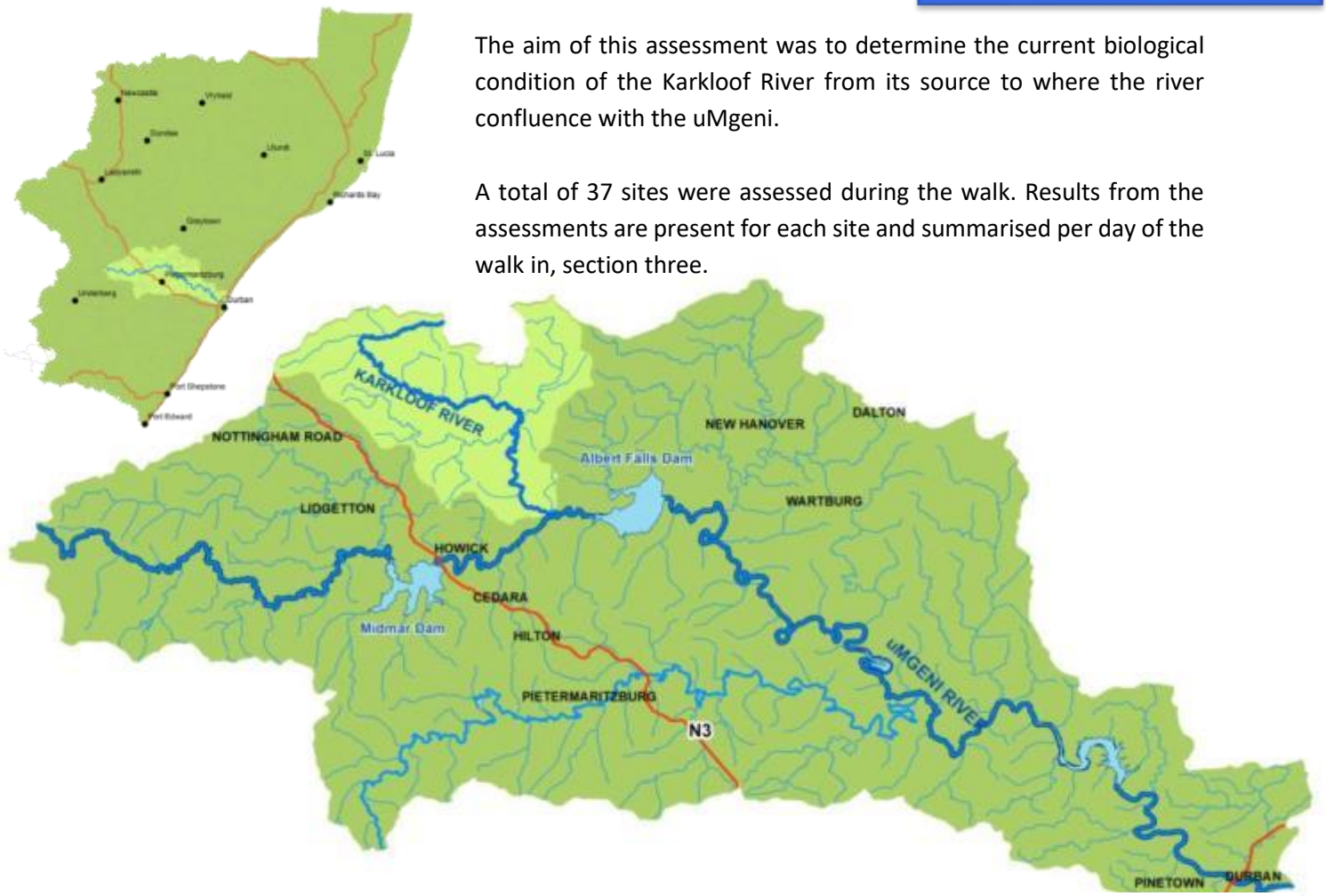


Figure 1.1: Overview of the uMgeni Catchment indicating the position of the Karkloof River (light green) in relation to the rest of the catchment

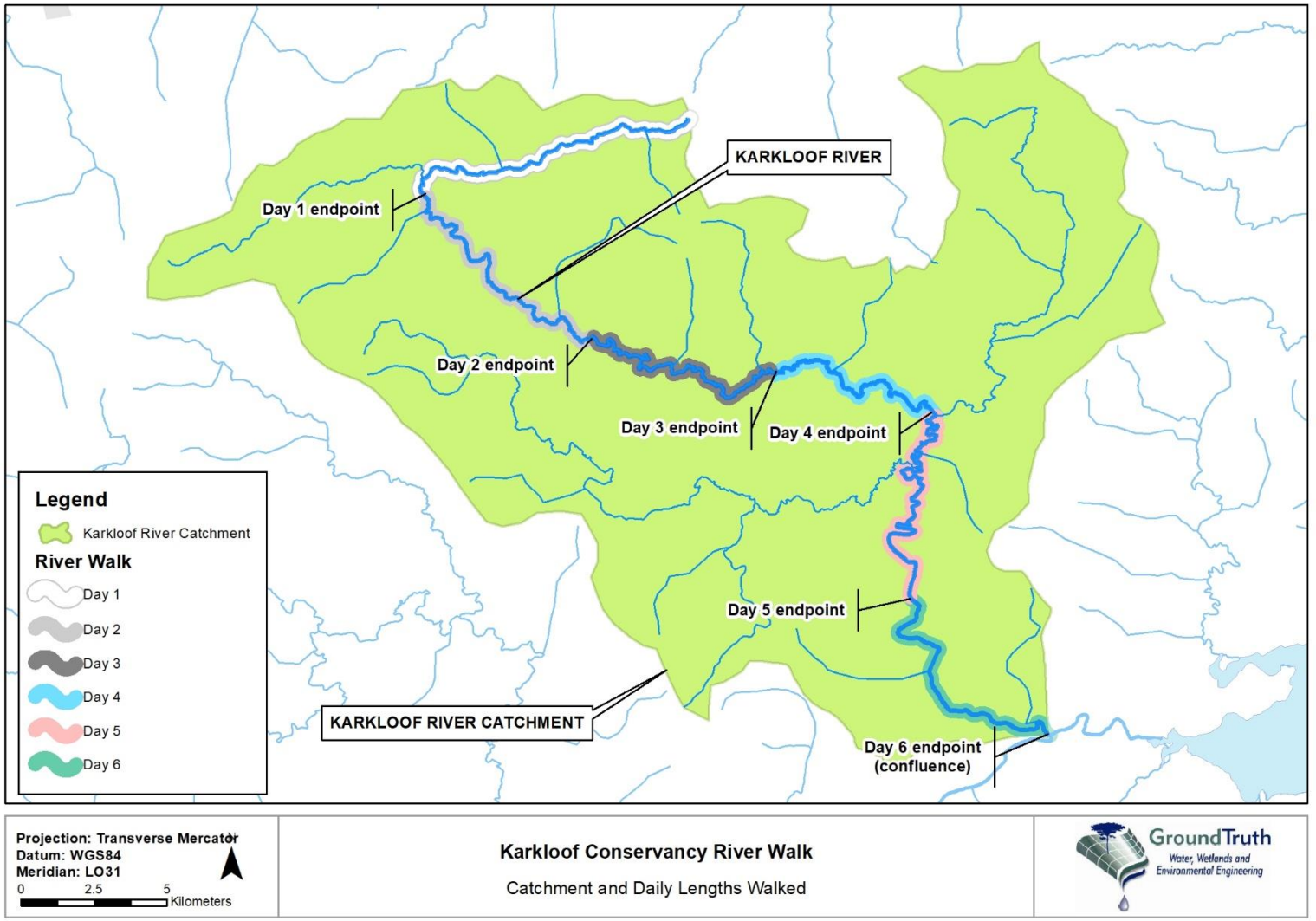


Figure 1.2: Karkloof River with sections indicating the areas covered each day of the river walk

2. Methods

The methodology that was applied drew on the latest citizen science tools available within South Africa for the assessment of ecological systems for aquatic and riparian biota. Aquatic and riparian sampling was conducted, and the appropriate selection of the various tools (Table 2.1) was informed by the available habitat on site, the flow conditions at the time of sampling and other biophysical limitations.

To inform the interpretation of the biological assessments (Table 2.1) the sampling was supplemented by the *in-situ* collection of a suite of water physico-chemical determinants including electrical conductivity, clarity (see appendix D), pH, dissolved oxygen, temperature and total dissolved salts.

Table 2.1: River health walk suite of assessments undertaken at various sampling sites

Assessment
Biological assessment (miniSASS)
Riparian health assessment (RHA)
Physico-chemical water quality

2.1 Assessment of Present Ecological State

The instream condition of the Karkloof River was determined using standard water chemistry tests as well as biological assessments. The instream biological assessments were conducted using the miniSASS tool. The miniSASS tool was designed for use in citizen science projects and is based on the South African Scoring System version 5 (SASS5, Dickens and Graham, 2002). SASS5 is the macroinvertebrate assessment used for the Department of Water and Sanitation (DWS) river health program and forms part of the river eco-classification suite of tools used at a national level to determine the condition of our rivers.

What is Citizen Science?

It is the collection and analysis of data relating to the natural world by members of the general public, often as part of a collaborative project with professional scientists.

Citizen Science tools are generally relatively accurate but simplified tools or methods based on more complex scientific processes, and require limited scientific background to apply.

The miniSASS method entails the collection of macroinvertebrates from a flowing water source preferably with rocks present. A net is placed in current downstream of the collection point, where stones, rocks, vegetation and sand etc. are disturbed with hands and feet to dislodge macro-invertebrates into the net. Alternatively, the stones, vegetation, sand and mud can be collected by hand and the macroinvertebrates gently picked off or out of these substrates with fingers or forceps.
This collection is done for 5 to 10 minutes while moving around the site to sample as many areas as possible.

Once collection is complete, the sample is turned out of the net into a sampling tray and the groups of macroinvertebrates are identified using a dichotomous key (i.e. questions with yes

or no answers that lead to the next question and eventually to identifying the organism).

The quality scores for each of the groups found are then summed together and divided by the total number of groups to generate a health score. The health score is then interpreted according to Table 2.2. The miniSASS health score interpretation needs to take into account the habitat conditions at the sample sites, as sites with poor habitat availability generally have low scores regardless of the water quality.

Table 2.2: miniSASS ecological category interpretation table

Ecological Category (condition)		River Category	
		Sandy River	Rocky River
	**NATURAL CONDITION** (Unchanged/untouched – Blue)	**> 6.9**	**> 7.2**
	**GOOD CONDITION** (Few modifications – Green)	**5.9 to 6.8**	**6.2 to 7.2**
	**FAIR CONDITION** (Some modifications – Orange)	**5.4 to 5.8**	**5.7 to 6.1**
	**POOR CONDITION** (Lots of modifications – Red)	**4.8 to 5.3**	**5.3 to 5.6**
	**VERY POOR CONDITION** (Seriously to Critically modified – Purple)	**< 4.8**	**< 5.3**

The Riparian Health Audit (RHA) is also a citizen science tool developed for assessing riparian ecosystem integrity.

The method involves the rating of eight criteria from 0 to 5 with 0 representing no impact / change and 5 representing 90 – 100% impact / change. The criteria rated include; presence of exotic vegetation, rubbish dumping, bank erosion, inundation, flow modification, evidence of decreased water quality, vegetation removal and channel modification.

The ratings data are captured in a computer model which generates a percentage change score, which is interpreted according to Table 2.3

Table 2.3: Summary of scores and percentage of change and their respective Ecological Condition for the Riparian Health Audit

Score	Percentage Change	Ecological Condition
0-4.5	0-10	**Natural**
5-11.5	11-29	**Good**
12-19.5	30-49	**Fair**
20-27.5	50-69	**Poor**
28-35.5	70-89	**Very Poor**
36-40	90-100	**Critical**

The ecological and management perspectives for the above categories are summarised in Table 2.4

Table 2.4: River health classes and their attendant ecological and management perspectives (derived from WRC 2008)

River health classes	Ecological perspective	Management perspective
Natural	No or negligible modification of in-stream and riparian habitats and biota.	Protected rivers; relatively untouched by human hands; no discharges or impoundments allowed.
Good	Ecosystems essentially in good state; biodiversity largely intact.	Some human-related disturbance but mostly of low impact potential.
Fair	A few sensitive species may be lost; lower abundances of biological populations may occur.	Zones of competing uses; developmental pressures are dominant feature.
Poor	Habitat diversity and availability have declined; mostly only tolerant species present; species present are often diseased; population dynamics have been disrupted (e.g. biota can no longer breed or alien species have invaded the ecosystem).	Often characterised by high human densities or extensive resource exploitation. Management intervention is needed to improve river health – e.g. to restore flow patterns, river habitats or water quality.
Seriously Modified	Loss of habitat availability and high levels of pollution, result in few families being present due to the loss on most intolerant forms.	Often characterised by high human densities, pollution or extensive resource exploitation and modification. Management intervention is needed for improvement to occur.

In addition to the biological data, water chemistry samples were collected where applicable; this was to help interpret the biological data and general condition of the river. The chemical data was interpreted according to various DWS water quality guidelines (DWAF 1998). The criteria for the different guidelines are summarised in Table 2.5. The results are summarised in Appendix A.

Table 2.5: Summary of DWS target water quality ranges for various water uses

Determinands	Environmental Water quality target range	Domestic use target range	Irrigation target range	Livestock watering target range
pH	6 - 9	5 - 9.5	6.5 - 8.4	5 - 9.5
Electrical conductivity	15% of background average	150 mS/m	40 mS/m	300 mS/m
TDS	15% of background average	1000 mg/L	260 mg/L	2000
Dissolved oxygen	80-120%	NA	NA	NA
Nitrate	0.5 mg/L	10 mg/L	5 mg/L	100 mg/L
Orthophosphate	0.005 mg/L	NA	NA	NA
E. coli	NA	0 counts	1 counts	200 counts

Dissolved Oxygen
DO is measured in mg/L and as a % saturation and indicates how much oxygen is available for use by aquatic organisms. The environmental guidelines recommend 80 – 120 %; however, DO fluctuates naturally throughout the day and is influenced by temperature and altitude, A single reading can be useful, but must be interpreted according to the time of day, habitat, temperature and altitude.

3. Results

3.1 Current Ecological State

The results from the various assessments conducted to determine the current ecological state of the Karkloof River and ancillary site data are grouped per day and summarised per site in the tables below. Each table shows an up and downstream image of the site as well as an aerial view at a scale of 1:5000. The tables provide location details, as well as ancillary data relevant to the water management areas and summarise the assessment results for the relevant parameters collected at each site.

The river reaches covered are represented graphically per day in figures 3.1 to 3.7 and an overall summary map showing the entire Karkloof River is provided in the appendices. The background aerial imagery contained in the maps is from 2013 Spot5 satellite imagery

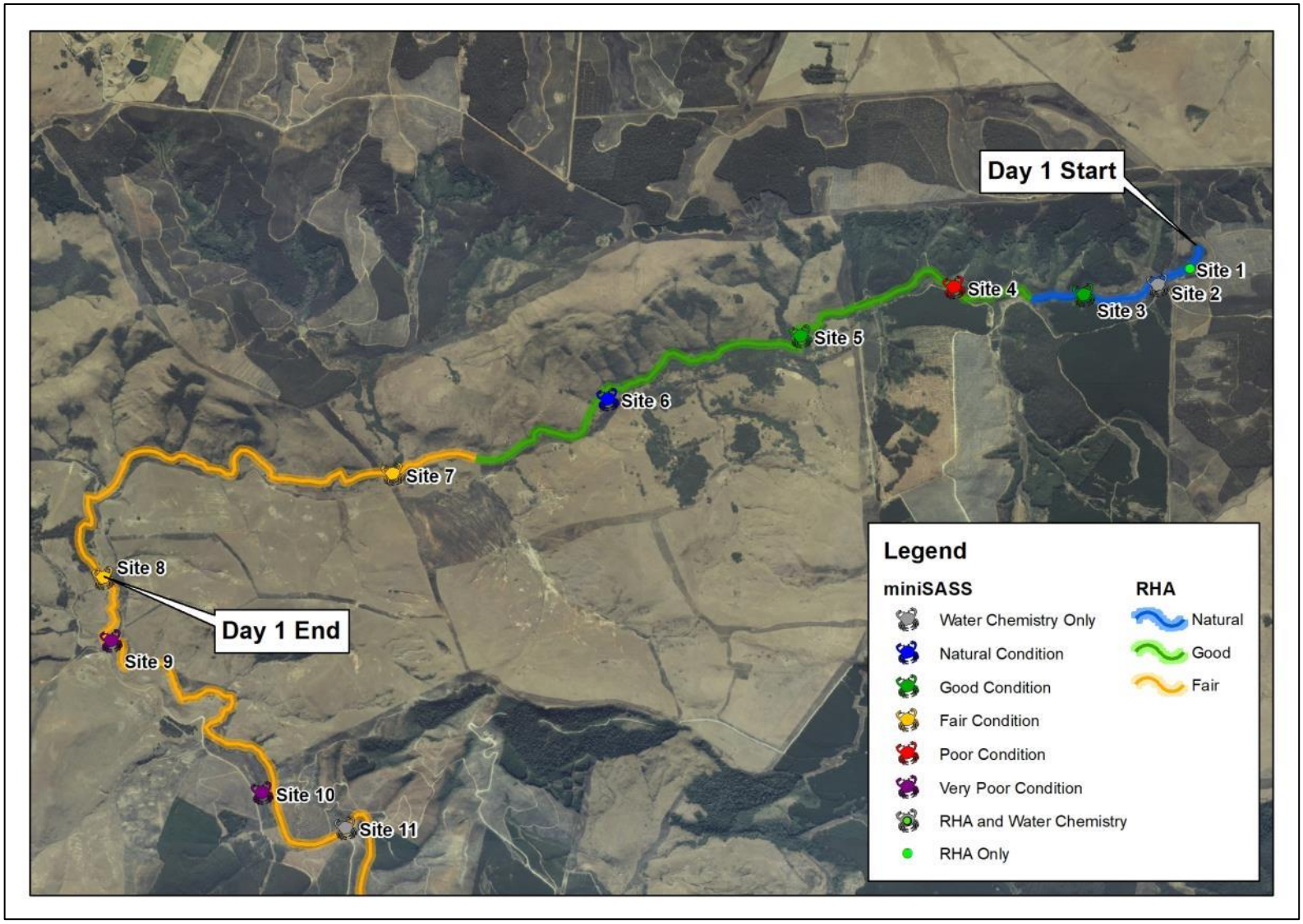


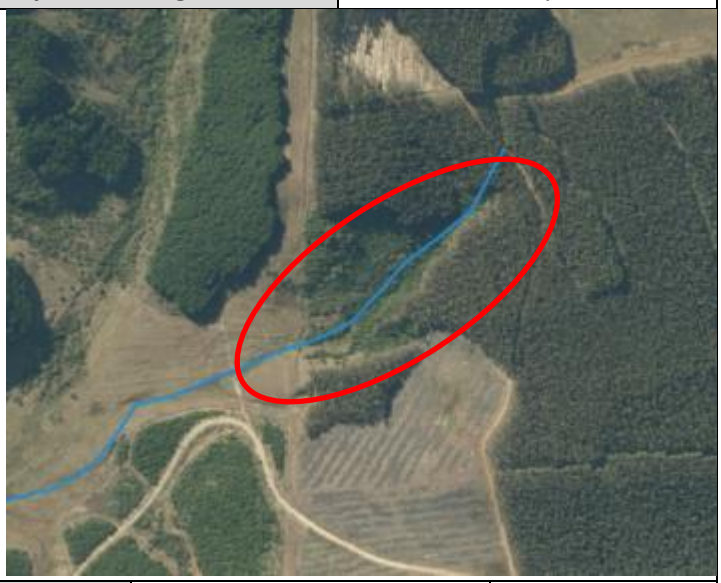
Figure 3.1: Karkloof River Walk day one sample sites.

3.2 Summary of Day 1 Sites

Upstream view from sample site

Downstream view from sample site

Day 1	Site 1	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.258056		
Longitude (E) DD	30.209201		



Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	2
% transformed	5
Condition	Natural

In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	ns	**pH**	ns
Dissolved oxygen (%)	ns	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	ns	**Nitrate/Nitrite (mg/L)**	ns
Total dissolved salts (mg/l)	ns	**Orthophosphate (mg/l)**	ns

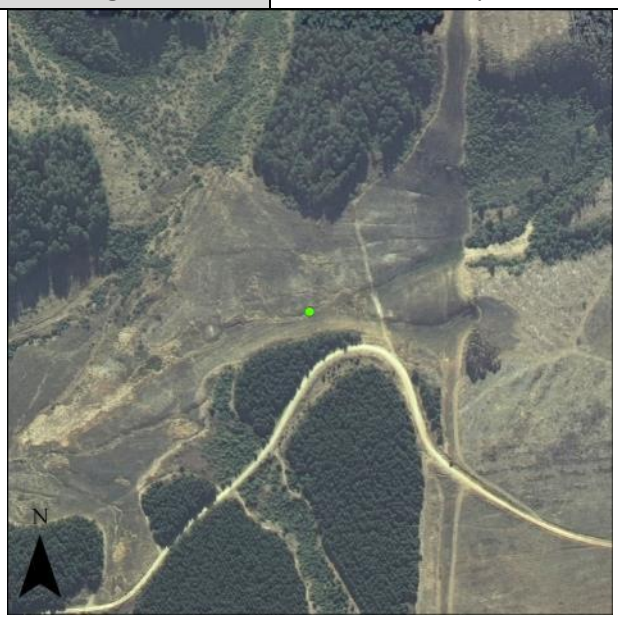
Description: This site is at the source of the Karkloof River and was dry at the time of the river walk so only a riparian health audit was done at the site. The upper reaches of the catchment are surrounded by, or are in plantations. The drainage line which constitutes the uppermost reach of the Karkloof river is located in a stand of Ouhout trees (*Leucosidea sericea*). The lack of water this high up in the catchment is not unusual due to the relatively small size of the catchment but limited the assessments that could be done at the site. The overall condition of the site is considered to be in a near to natural condition.

View of sample point

Downstream view from sample site

Day 1	Site 2	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.259171		
Longitude (E) DD	30.206844		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns



In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	15.17	**pH**	6.43
Dissolved oxygen (%)	37.5	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	4.8	**Nitrate/Nitrite (mg/L)**	ns
Total dissolved salts (mg/l)	24	**Orthophosphate (mg/l)**	ns

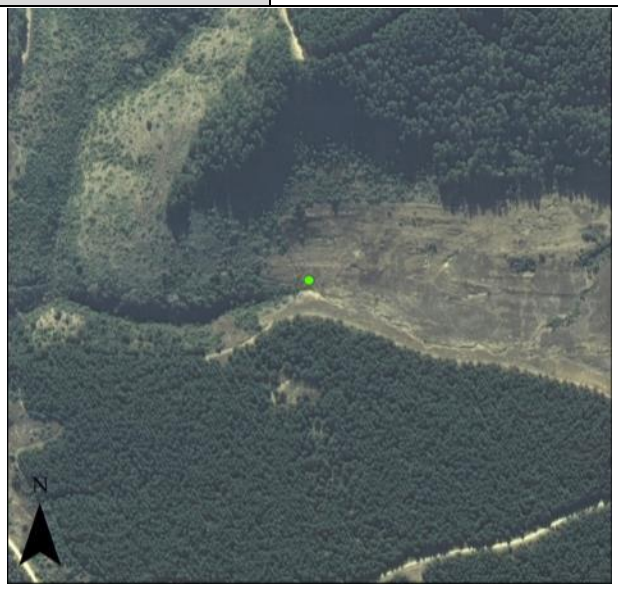
Description: This site was located in the open grassy valley below the Ouhout covered drainage line that is the source of the Karkloof River. This site was the first place where surface water was available for sampling, but still being high up in the catchment the volume was limited and only *in-situ* water quality could be sampled. This site was the first point along the walk where signs of bramble and bugweed were present. Dissolved oxygen was the only parameter outside of the recommended range, however, this is not of concern because this site was still high up in the catchment, and the river had no chance to tumble/cascade/encounter rapids/ waterfalls etc. and as such had little opportunity to absorb oxygen.

Upstream view from sample site

Downstream view from sample site

Day 1	Site 3	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.25994		
Longitude (E) DD	30.20136		

Aquatic Assessments	
MiniSASS	
Total score	33
No. Groups	5
Average score	6.6
Condition	Good
RHA	
Score	4
% transformed	10
Condition	Natural



In situ and chemical water quality		**Clarity (cm)**	25
Temperature (°C)	14.3	**pH**	7.4
Dissolved oxygen (%)	61.1	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	8.6	**Nitrate/Nitrite (mg/L)**	ns
Total dissolved salts (mg/l)	43	**Orthophosphate (mg/l)**	ns

Description: This site was located upstream of a small waterfall and was surrounded by a stand of Ouhout and predominantly natural vegetation as indicated by the near to natural RHA score. However, bramble, wattle, pine and erosion were having a minor impact on this reach. The site provided the first encounter with bedrock and thanks to increased flows and volumes of water, this was the first site with sufficient habitat to conduct a miniSASS assessment. The miniSASS score showed a good condition, which is lower than expected and related to the limited habitat rather than water quality. Dissolved oxygen was lower than the recommended target water quality range, but this is not unexpected for a small stream this high up in the catchment where the limited stones habitat has not allowed time for the water to tumble and generate the dissolved oxygen. From the point below the waterfall, an increase in the percentage exotic vegetation was noted and weed control for this area is recommended.

View of riparian area at sample site

Downstream view from sample site

Day 1	Site 4	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.260238		
Longitude (E) DD	30.201259		

Aquatic Assessments	
MiniSASS	
Total score	27
No. Groups	5
Average score	5.4
Condition	Poor
RHA	
Score	5
% transformed	12.5
Condition	Good

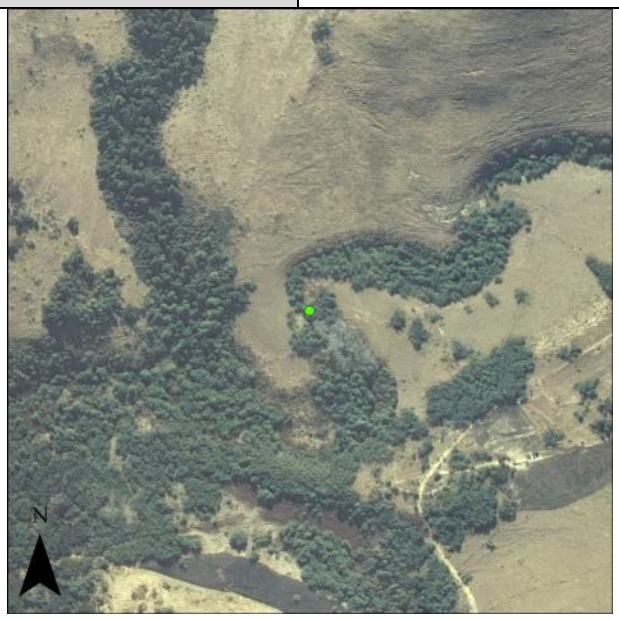
In situ and chemical water quality		**Clarity (cm)**	54
Temperature (°C)	14.46	**pH**	7.1
Dissolved oxygen %	58.7	***E. coli* (mpn/100ml)**	140
Electrical Conductivity (mS/m)	4.9	**Nitrate (mg/l)**	<0.18
Total dissolved salts (mg/l)	49	**Orthophosphate(mg/l)**	0.086

Description: Evaluation for the RHA started from below a small water fall and continued to directly below the dam. There were grape vines growing over the sample site for the miniSASS. This section was the first where an invasive willow species was noticed. There was a sheer cliff face on one side and gentle incline on other. This was the first reach where litter was evident. A noticeable flow and volume increase compared to the previous sites was observed and is related to input from an upstream tributary. The sample site was near a log jam causing some inundation and the water was somewhat discoloured but still relatively clear (54cm clarity). The miniSASS result indicated a poor score. This is related to limited habitat and potentially as a result of the water discolouration. Water chemistry was mostly in a good condition as well. The dissolved oxygen was a little low but not seriously so. The *E. coli* was not suitable for domestic use and caution should be used if the water is to be used for irrigation.

Upstream view from sample site

Downstream view from sample site

Day 1	Site 5	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.262978		
Longitude (E) DD	30.180571		



Aquatic Assessments	
MiniSASS	
Total score	40
No. Groups	6
Average score	6.6
Condition	Good
RHA	
Score	4.5
% transformed	11.25
Condition	Good

In situ and chemical water quality			
Temperature (°C)	15.04	**pH**	7.6
Dissolved oxygen %	60.2	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	6.0	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	38	**Orthophosphate(mg/l)**	ns
		Clarity (cm)	48

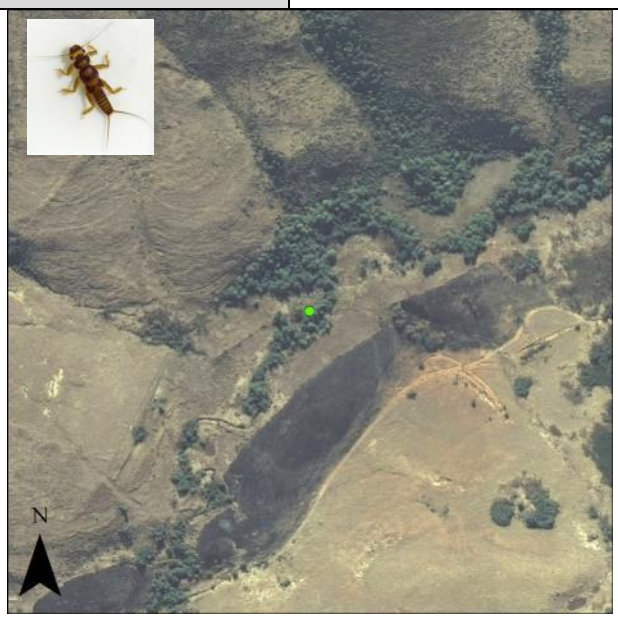
Description: Open grassland after Plantation. Both the miniSASS and RHA results show this reach to be in a good condition, the water chemistry was also within the acceptable range except for a low dissolved oxygen score but as before, the river at this point has had limited opportunities to absorb oxygen.

Upstream view from sample site

Downstream view from sample site

Day 1	Site 6	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.267601		
Longitude (E) DD	30.166406		

Aquatic Assessments	
MiniSASS	
Total score	48
No. Groups	5
Average score	9.6
Condition	Natural
RHA	
Score	8.5
% transformed	21.25
Condition	Good



In situ and chemical water quality		**Clarity (cm)**	36
Temperature (°C)	15.04	**pH**	7.1
Dissolved oxygen %	60.2	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	6.0	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	30	**Orthophosphate(mg/l)**	ns

Description: This was the first site where the sensitive stonefly (*Perlidae sp*.) was found. Upstream of the sample site was extensive invasion by exotic vegetation but in a limited area and an area where bad erosion was evident. From this point on the system slows down below the sample site and begins to meander. In general the water quality and riparian areas were in a near to natural and good condition respectively. The on-site water chemistry was within specification.

Upstream view from sample site

Downstream view from sample site

Day 1	Site 7	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.27310		
Longitude (E) DD	30.15056		

Aquatic Assessments	
MiniSASS	
Total score	48
No. Groups	8
Average score	6a
Condition	Fair
RHA	
Score	9.0
% transformed	22.50
Condition	Good

In situ and chemical water quality			
Temperature (°C)	ns	**Clarity (cm)**	ns
Dissolved oxygen %	ns	**pH**	ns
Electrical Conductivity (mS/m)	ns	***E. coli* (mpn/100ml)**	92
Total dissolved salts (mg/l)	ns	**Nitrate (mg/l)**	<0.18
		Orthophosphate(mg/l)	<0.03

Description: This site was the rockiest site of day one. The miniSASS score indicated that the water quality was fair; this was influenced by the habitat available which was limiting. The RHA indicated that the riparian areas were in a good condition, although there were some erosion evident and bare areas following the clearing of some exotic vegetation along the river and a nearby upstream tributary.

Upstream view from sample site		Downstream view from sample site	
Day 1	Site 8	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.280704		
Longitude (E) DD	30.129396		

Aquatic Assessments	
MiniSASS	
Total score	47
No. Groups	8
Average score	5.8
Condition	Fair
RHA	
Score	13.5
% transformed	33.75
Condition	Fair

In situ and chemical water quality		**Clarity (cm)**	51
Temperature (°C)	14.52	**pH**	8.25
Dissolved oxygen %	64.7	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	8.4	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	42	**Orthophosphate(mg/l)**	ns

Description: The final site of day 1. Water quality and riparian habitat were both in a fair condition. The riparian assessment for this reach found erosion and exotic vegetation to be problematic, there was also some litter present along the reach, and these accounted for the fair condition. The miniSASS scores would also have been impacted by the alien vegetation and erosion by altering habitat and food availability

Day 1 overview

The overall miniSASS scores for day 1 were generally of a good condition, with only site 4 being considered poor, and this due mainly to the limited habitat at the site and not related to water quality issues. The Riparian Health Assessment results indicated that the sites were in a good to near natural condition. Exotic vegetation was the main impact in the riparian areas during day one with certain sections having extensive invasion. Bramble *(Rubus cuneifolius)* was the predominant invasive species found, with both Pine (*Pinus patula)* and Wattle *(Acacia mearnsii)* also contributing to the impact ratings. Site 3 has a substantial amount of exposed banks and it is recommended that this area be revegetated as this exposure could lead to increased amounts of erosion, which could have further negative impacts on the stream. Water quality was mostly within the recommended water quality ranges, although dissolved oxygen was low at all of the sites, this is not of major concern as the nature and location of the river during day one was not conducive to oxygen absorption. Only two sites were analysed for nutrients and *E. coli* on day one and while *E. coli* counts were not very high, both sites were in excess of the recommended allowances for domestic use and irrigation. The likely source of the *E. coli* is from livestock and other mammals utilizing the river and riparian areas.

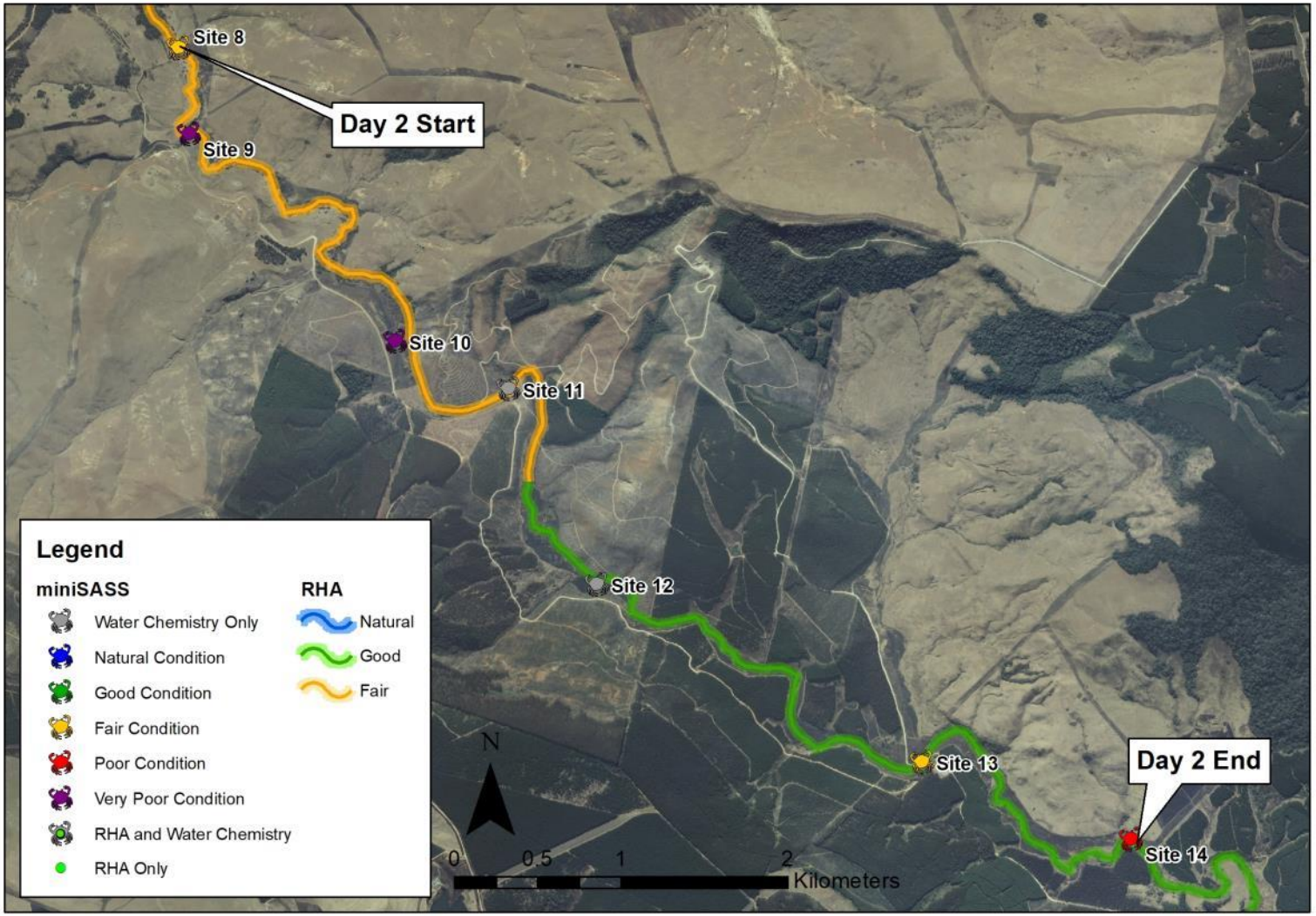


Figure 3.2: Karkloof River Walk day two sample sites.

3.3 Summary of Day 2 sites

Upstream view from sample site

Downstream view from sample site

Day 2	Site 9	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.421787		
Longitude (E) DD	30.213564		

Aquatic Assessments	
MiniSASS	
Total score	35
No. Groups	7
Average score	5.0
Condition	Very poor
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	45
Temperature (°C)	15.13	**pH**	7.5
Dissolved oxygen %	63.9	***E. coli* (mpn/100ml)**	80
Electrical Conductivity (mS/m)	11.1	**Nitrate (mg/l)**	<0.18
Total dissolved salts (mg/l)	54	**Orthophosphate(mg/l)**	0.035

Description: This was the first site to score very poor. The results were impacted by the decline of instream habitat where bedrock habitat was dominant. It is also located downstream of 3 smaller tributaries that pass through low intensity housing, forestry and agriculture. Alien plants and erosion also contributed to this low score. The water quality parameters were within acceptable ranges, except *E. coli* which was too high for domestic use and irrigation.

Upstream view from sample site

Downstream view from sample site

Day 2	Site 10	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.296526		
Longitude (E) DD	30.141053		

Aquatic Assessments	
MiniSASS	
Total score	36
No. Groups	7
Average score	5.1
Condition	Very poor
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	49
Temperature (°C)	16.16	**pH**	7.32
Dissolved oxygen %	55.0	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	8.6	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	42	**Orthophosphate(mg/l)**	ns

Description: The site was in plantation and agricultural land use, change of land owner. There was decline of instream habitat; the most abundant habitat was mud and clay**.** The water quality at site was still very poor according to the miniSASS results and there was a minor decline in the water chemistry results as well**.** Erosion was evident at the site**.** The first site to notice knot or smartweed (*Persicaria lapathifolia*) which is often associated with organic enrichment such as sewage or fertilizer.

Upstream view from sample site

Downstream view from sample site

Day 2	Site 11	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.299099		
Longitude (E) DD	30.147188		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	34
Temperature (°C)	17.95	**pH**	7.72
Dissolved oxygen %	74.6	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	8.5	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	ns

Description: This site was located near the Sappi loading zone upstream of river crossing, bedrock was common and there were reaches where the river had steep banks. In general the riparian areas were maintained by SAPPI with only a few wattle escapees and some other invasive plants present along with some felling debris. Only in-situ water chemistry was taken and this was found to be within acceptable levels.

Upstream view from sample site

Downstream view from sample site

Day 2	Site 12	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.30960		
Longitude (E) DD	30.15190		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	49
Temperature (°C)	20.22	**pH**	7.7
Dissolved oxygen %	77	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	8.6	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	34	**Orthophosphate(mg/l)**	ns

Description: This was the rock site on day 2 and maintained in controlling invasive alien plants. The site had minor impact of *Solanum mauritianum*. Upstream of the site was natural grassland. Only in-situ water chemistry was collected at this site and was found to be within acceptable ranges

Upstream view from sample site

Downstream view from sample site

Day 2	Site 13	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.319233		
Longitude (E) DD	30.169473		

Aquatic Assessments	
MiniSASS	
Total score	47
No. Groups	8
Average score	5.9
Condition	Fair
RHA	
Score	7.0
% transformed	17.5
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	47
Temperature (°C)	19.05	**pH**	7.56
Dissolved oxygen %	76	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	8.6	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	43	**Orthophosphate(mg/l)**	ns

Description: On Sappi plantation near a road crossing, upstream of the road the water is slower flowing possible as a result of the bridge, downstream the speed of the river increases, the miniSASS results improved to a fair condition and the riparian assessments improved to a good condition. Habitat also improved at this site compared to those upstream earlier on day 2 with more variety was present. Upstream of the site had good instream habitat, mostly rocky habitat. Water chemistry was also within acceptable ranges.

Day 2 overview

Day two could be categorized into two distinct sections, the first half of the days walk passed through areas of predominantly grassland, with several minor tributaries having passed through low density rural housing entering the Karkloof system. The latter half of the days walk passed through commercial timber plantations. The grassland sections mainly had riparian areas in a fair condition with erosion and alien invasive plants being the major drivers of this condition. The riparian maintenance program and the clearing of alien invasive plants in the riparian areas resulted in the condition improving to a good condition. The miniSASS results mirrored the riparian results with the initial sites being in a very poor condition and improving further downstream to a fair condition. The water chemistry results throughout the day were in acceptable ranges and therefore the impacts relating to the miniSASS scores are more likely related to physical impacts such as erosion and not chemical water quality.

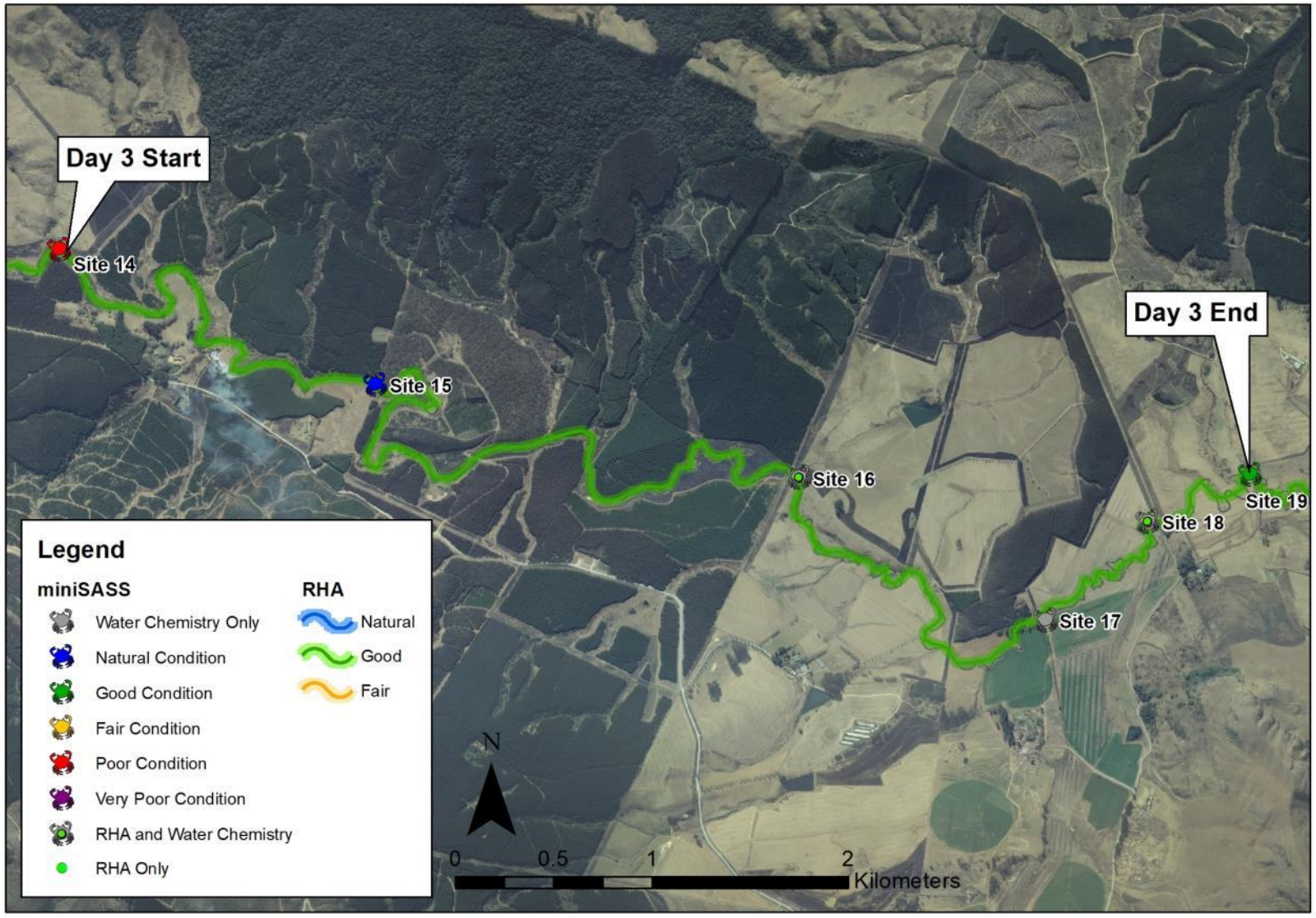


Figure 3.3: Karkloof River Walk day three sample sites.

3.4 Summary of Day 3 Sites

<table>
<tr><td colspan="2">  </td><td colspan="2">  </td></tr>
<tr><td colspan="2">Upstream view from sample site</td><td colspan="2">Downstream view from sample site</td></tr>
<tr><td>Day 3</td><td>Site 14</td><td>Water Management Area</td><td>uMvoti to uMzimkhulu</td></tr>
<tr><td>River</td><td>Karkloof</td><td>1:50000 map reference</td><td>2930AC</td></tr>
<tr><td>Quaternary Catchment</td><td>U20D</td><td>Aquatic Ecoregion</td><td>South eastern Uplands</td></tr>
<tr><td>Latitude (S) DD</td><td>-29.323414</td><td colspan="2" rowspan="10">  </td></tr>
<tr><td>Longitude (E) DD</td><td>30.180752</td></tr>
<tr><td colspan="2">Aquatic Assessments</td></tr>
<tr><td colspan="2">MiniSASS</td></tr>
<tr><td>Total score</td><td>44</td></tr>
<tr><td>No. Groups</td><td>8</td></tr>
<tr><td>Average score</td><td>5.5</td></tr>
<tr><td>Condition</td><td>Poor</td></tr>
<tr><td colspan="2">RHA</td></tr>
<tr><td>Score</td><td>ns</td></tr>
<tr><td>% transformed</td><td>ns</td></tr>
<tr><td>Condition</td><td>ns</td></tr>
<tr><td colspan="2">In situ and chemical water quality</td><td>Clarity (cm)</td><td>50</td></tr>
<tr><td>Temperature (°C)</td><td>16.45</td><td>pH</td><td>7.45</td></tr>
<tr><td>Dissolved oxygen %</td><td>72.3</td><td>E. coli (mpn/100ml)</td><td>52</td></tr>
<tr><td>Electrical Conductivity (mS/m)</td><td>7.1</td><td>Nitrate (mg/l)</td><td><0.18</td></tr>
<tr><td>Total dissolved salts (mg/l)</td><td>36</td><td>Orthophosphate(mg/l)</td><td><0.03</td></tr>
<tr><td colspan="4">Description: This site was dominated by boulders with other limited habitats. The miniSASS results indicated the site was in a poor condition, while the water chemistry results were in acceptable ranges. The miniSASS result may have been impacted by the limited habitat or from inputs from the tributary upstream of the site which was also affecting habitat, as there is erosion occurring in the upper reaches of the tributary.</td></tr>
</table>

Upstream view from sample site

Downstream view from sample site

Day 3	Site 15	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.329597		
Longitude (E) DD	30.195221		

Aquatic Assessments	
MiniSASS	
Total score	36
No. Groups	5
Average score	7.2
Condition	Natural
RHA	
Score	5.5
% transformed	13.5
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	46
Temperature (°C)	17.87	**pH**	7.45
Dissolved oxygen %	77.6	***E. coli* (mpn/100ml)**	28
Electrical Conductivity (mS/m)	7.1	**Nitrate (mg/l)**	<0.18
Total dissolved salts (mg/l)	36	**Orthophosphate(mg/l)**	<0.03

Description: The site was below a local soccer field and above a small path crossing the river. The river had passed through a fairly healthy section with improved instream habitat conditions and the riparian habitat results also indicated a good condition. The miniSASS results showed the system was in a near to natural condition. The water chemistry results were in acceptable ranges. Downstream of the site the riparian areas became badly invaded by exotic plants, the main culprit being bramble (*Rubus cuneifolius*).

Upstream view from sample site

Downstream view from sample site

Day 3	Site 16	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.33380		
Longitude (E) DD	30.21450		

Aquatic Assessments	
MiniSASS	
Total score	57
No. Groups	8
Average score	7,13
Condition	Good
RHA	
Score	9.5
% transformed	23.75
Condition	Good

In situ and chemical water quality			
Temperature (°C)	14.23	**Clarity (cm)**	47
Dissolved oxygen %	99.2	**pH**	4.59
Electrical Conductivity (mS/m)	8.9	***E. coli* (mpn/100ml)**	76
Total dissolved salts (mg/l)	34	**Nitrate (mg/l)**	<0.18
		Orthophosphate(mg/l)	<0.03

Description: The site is between plantation plots and farms. The miniSASS results showed the site to be of good health. This was the second site where the sensitive stonefly (*Perlidae sp.*) was found. The river had passed through sections with good instream habitat and the RHA results also indicated good habitat conditions. However, the riparian areas were badly impacted by invasive alien plants, mostly bramble (*Rubus cuneifolius),* in the research plantation plots. The water chemistry results were within acceptable ranges, with the exception of pH which was found more acidic than the recommended range. The pH was only marginally more acidic than the recommended range and the increased acidity is likely related to increased humic acid from decomposing vegetation.

Upstream view from sample site

Day 3	Site 17	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.34040		
Longitude (E) DD	30.22590		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	ns	**pH**	ns
Dissolved oxygen %	ns	***E. coli* (mpn/100ml)**	120
Electrical Conductivity (mS/m)	ns	**Nitrate (mg/l)**	<0.18
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	<0.03

Description: The site is located next to agricultural land and is near a pump house, above the site there were cattle tracks on the bank of the river and this reach is accessed directly by cattle for drinking purposes. At this point the river had gone through a stretch of knot weed *(Persicaria lapathifolia*) vegetation. Only a water sample was collected at the site.

Day 3 overview

The overall miniSASS scores for day 3 were generally of a good condition. Site 14 was the only site considered to be poor. This was due to limited habitat and from potential impacts associated with an upstream tributary affecting habitat at the site. The Riparian Health Assessment results indicated that the sites were in a good condition; however, the riparian areas particularly between sites 15 and16 were largely impacted by dense stands of bramble (*Rubus cuneifolius*) and black wattle (*Acacia mearnsii*), needing urgent attention. Other than a decline in pH at site 15 the overall physio chemistry results for day 3 were within target ranges.

One area stood out due to severe erosion pictured above. This reach was the first section where Formosa lily was seen and it was found along most of the reach.

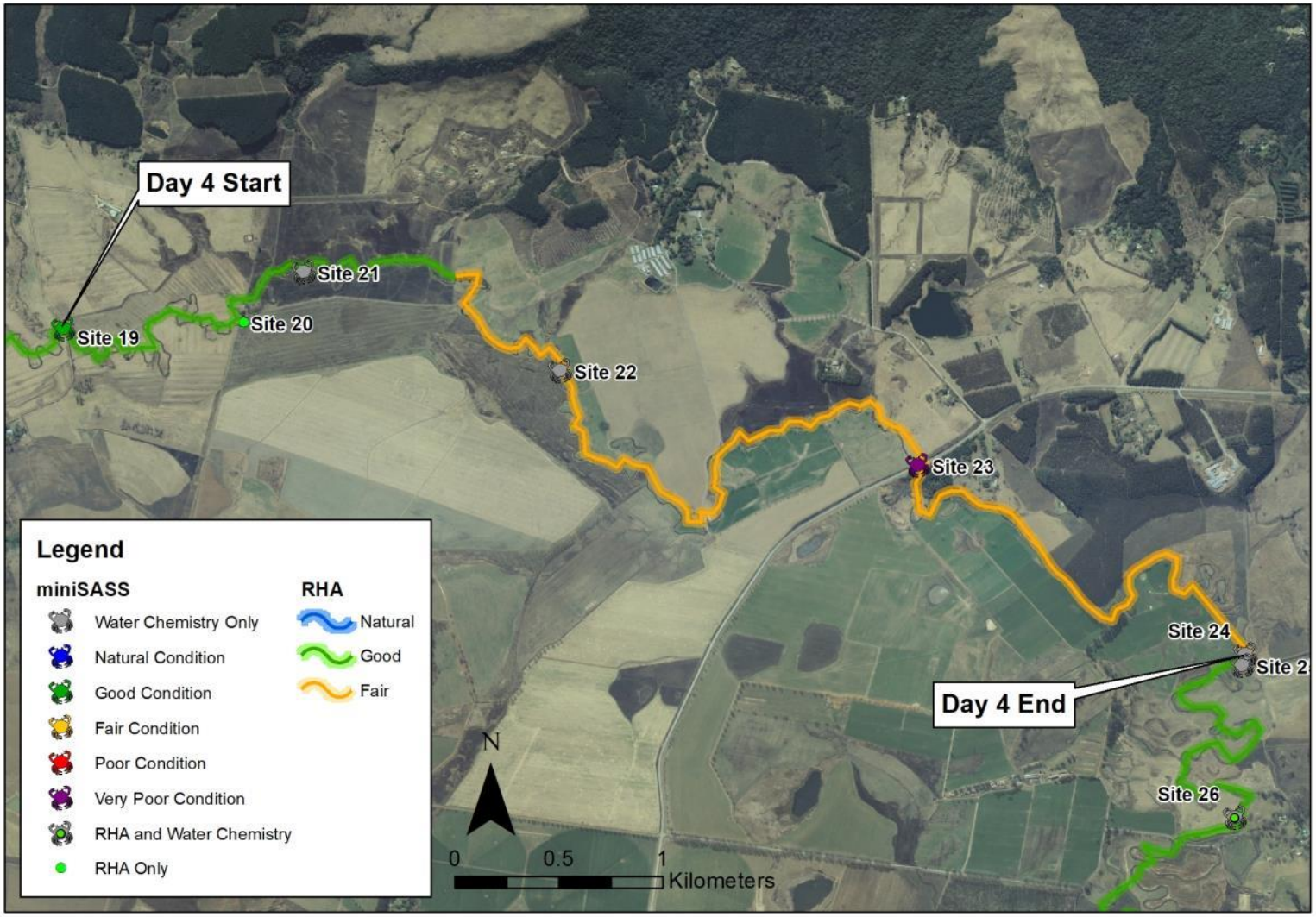


Figure 3.4: Karkloof River Walk day four sample sites

3.5 Summary of Day 4 Sites

Upstream view from sample site

Downstream view from sample site

Day 4	Site 18	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.33580		
Longitude (E) DD	30.23060		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	5
% transformed	12.5
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	ns	**pH**	ns
Dissolved oxygen %	ns	***E. coli* (mpn/100ml)**	88
Electrical Conductivity (mS/m)	ns	**Nitrate (mg/l)**	0.2
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	<0.03

Description: This site was located on the river after traversing approximately 4km of farmlands. The flow velocity had decreased and the river was deeper, as a result the site was not suitable for SASS5. The RHA found the site to be in a generally good condition with only some physical disturbance from cattle, minor water abstraction and a few exotic plants impacting this reach.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 19	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.333708		
Longitude (E) DD	30.235243		

Aquatic Assessments	
MiniSASS	
Total score	63
No. Groups	9
Average score	7
Condition	Good
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality			
Temperature (°C)	17.20	**pH**	6.88
Dissolved oxygen %	66.9	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	6.6	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)		**Orthophosphate(mg/l)**	ns
		Clarity (cm)	48

Description: The site was a few kilometres downstream from site 18 and provided habitat for miniSASS sampling. The riparian condition was similar to that recoded at site 18. The water velocity had increased and the miniSASS results showed the site to be in a good condition. This was the third site where the sensitive stonefly (*Perlidae sp*.) was found. The water chemistry results were in acceptable ranges. Downstream of this point the land use began to change.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 20	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.33130		
Longitude (E) DD	30.24560		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	4.5
% transformed	11.25
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	ns	**pH**	ns
Dissolved oxygen %	ns	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	ns	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	ns

Description: The site was located near a pump house and feedlot. The Riparian Habitat Assessment result indicated the site was in a good condition. The riparian zones were however impacted by invasive alien plants, most notably Bugweed *(Solanum mauritianum*). The form of agriculture changed to predominantly livestock farming along this reach.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 21	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AC
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.331256		
Longitude (E) DD	30.245622		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	50
Temperature (°C)	17.67	**pH**	6.92
Dissolved oxygen %	74.3	***E. coli* (mpn/100ml)**	64
Electrical Conductivity (mS/m)	6.4	**Nitrate (mg/l)**	0.22
Total dissolved salts (mg/l)		**Orthophosphate(mg/l)**	<0.03

Description: The flows had once again slowed down and the water was deeper at this site. The reach was surrounded by good quality grassland vegetation and there was livestock in the vicinity but in limited numbers. Water chemistry was the only assessment done at the site and the results were within the target ranges, albeit that *E. coli* was too high for domestic use.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 22	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.33550		
Longitude (E) DD	30.25670		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	41
Temperature (°C)	18.14	**pH**	7.04
Dissolved oxygen %	80.4	***E. coli* (mpn/100ml)**	340
Electrical Conductivity (mS/m)	6.2	**Nitrate (mg/l)**	0.42
Total dissolved salts (mg/l)	31	**Orthophosphate(mg/l)**	<0.03

Description: The site was located below and a piggery cattle feedlot. The water chemistry results were in an acceptable range except for *E. coli* which had increased notably. This increase is likely related to impacts from the livestock operations upstream.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 23	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.33960		
Longitude (E) DD	30.27210		

Aquatic Assessments	
MiniSASS	
Total score	22
No. Groups	5
Average score	4.4
Condition	Very poor
RHA	
Score	14.5
% transformed	36.25
Condition	Fair

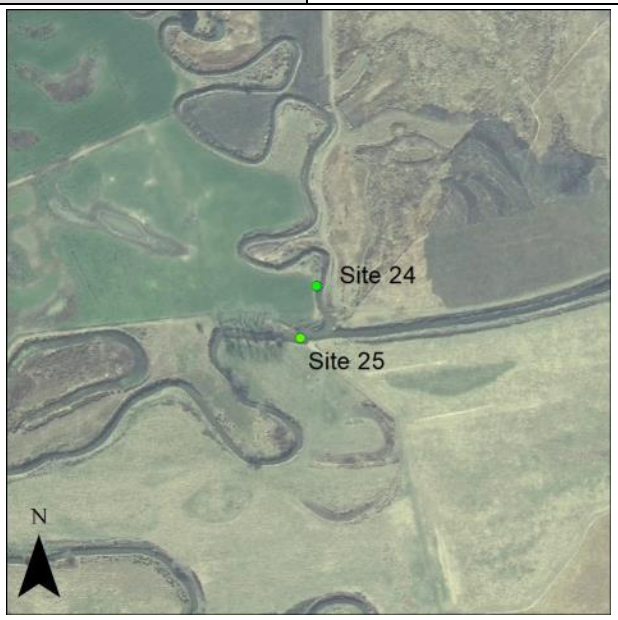
In situ and chemical water quality		**Clarity (cm)**	47
Temperature (°C)	18.88	**pH**	6.59
Dissolved oxygen %	75.5	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	6.4	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)		**Orthophosphate(mg/l)**	ns

Description: The site is below the bridge on the Karkloof road. The miniSASS results indicated the health at the site was very poor. There was a decline in the instream habitat and macroinvertebrate community, this is likely related to impacts from the dumping tar/asphalt associated with road repairs being pushed/dumped into the river and from irrigation of slurry onto lands closer than 100m from the river. The riparian habitat was in fair condition, with the river passing through an extensive patch of *Phragmites* reeds.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 24	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.34780		
Longitude (E) DD	30.28630		



Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality			
Temperature (°C)	19.01	**pH**	6.81
Dissolved oxygen %	76.5	***E. coli* (mpn/100ml)**	122
Electrical Conductivity (mS/m)	6.6	**Nitrate (mg/l)**	0.42
Total dissolved salts (mg/l)		**Orthophosphate(mg/l)**	<0.03
Clarity (cm)	42		

Description: This site is located on the Karkloof River approximately 20 metres upstream of the Yarrow River confluence. Only water chemistry was collected and other than slightly elevate *E. coli* levels the water quality was within acceptable ranges.

Upstream view from sample site		**Downstream view from sample site**	
Day 4	Site 25	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.348258		
Longitude (E) DD	30.285908		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	ns	**pH**	ns
Dissolved oxygen %	ns	***E. coli* (mpn/100ml)**	218
Electrical Conductivity (mS/m)	ns	**Nitrate (mg/l)**	0.52
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	<0.03

Description: This site is on the Karkloof shortly after the confluence with the Yarrow River, which significantly increased the volume of water. Only a water chemistry sample was collected at the site, the nitrate and *E. coli* were slightly elevated indicating the possible influence of livestock entering from the Yarrow.

Upstream view from sample site

Downstream view from sample site

Day 4	Site 26	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.350382		
Longitude (E) DD	30.283161		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	9.5
% transformed	23.75
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	32
Temperature (°C)	19.78	**pH**	6.91
Dissolved oxygen %	94.5	***E. coli* (mpn/100ml)**	190
Electrical Conductivity (mS/m)	5.9	**Nitrate (mg/l)**	0.46
Total dissolved salts (mg/l)	29	**Orthophosphate(mg/l)**	<0.03

Description: This site is upstream of a plantation and downstream of a pump house. The river was wide and deep at this point making it unsuitable for miniSASS. The RHA indicated that this reach was generally in a good condition, with some degraded vegetation and cattle trampling being the main riparian impacts.

Day 4 overview

The overall miniSASS scores for day 4 were generally of a fair to poor condition, with only two sites falling out of this category; these being site 19 which was considered to be in a good condition and site 23 which was in a very poor condition resulting from limited instream habitat and rubbish dumping. The Riparian Health Assessment results indicated that the sites were in a good condition. Exotic vegetation was the main impact in the riparian areas on the first section of day 4 including sections which had extensive invasions of knot weed (*Persicaria lapathifolia*). In the last reaches of day 4 between site 22 and 23 extensive beds of common reed (*Phragmites australis*) were present. However, tar/asphalt had been dumped in the river near the bridge and the irrigation of slurry was happening less than 100m from the river edge. In addition, a temporary feed lot had been set up on the river bank in the one section. This does pose some concern relating to the water quality, as there were pumphouses located along this section. These are used for pumping water for agricultural purposes e.g. piggery, dairy, beef and maize.

The river characteristics changed on day 4 compared to the previous days, as the river itself was flowing noticeably slower due to the floodplain, which increased the meandering nature of the river resulting in many oxbows along this section. This flood plain area had crane friendly habitat.

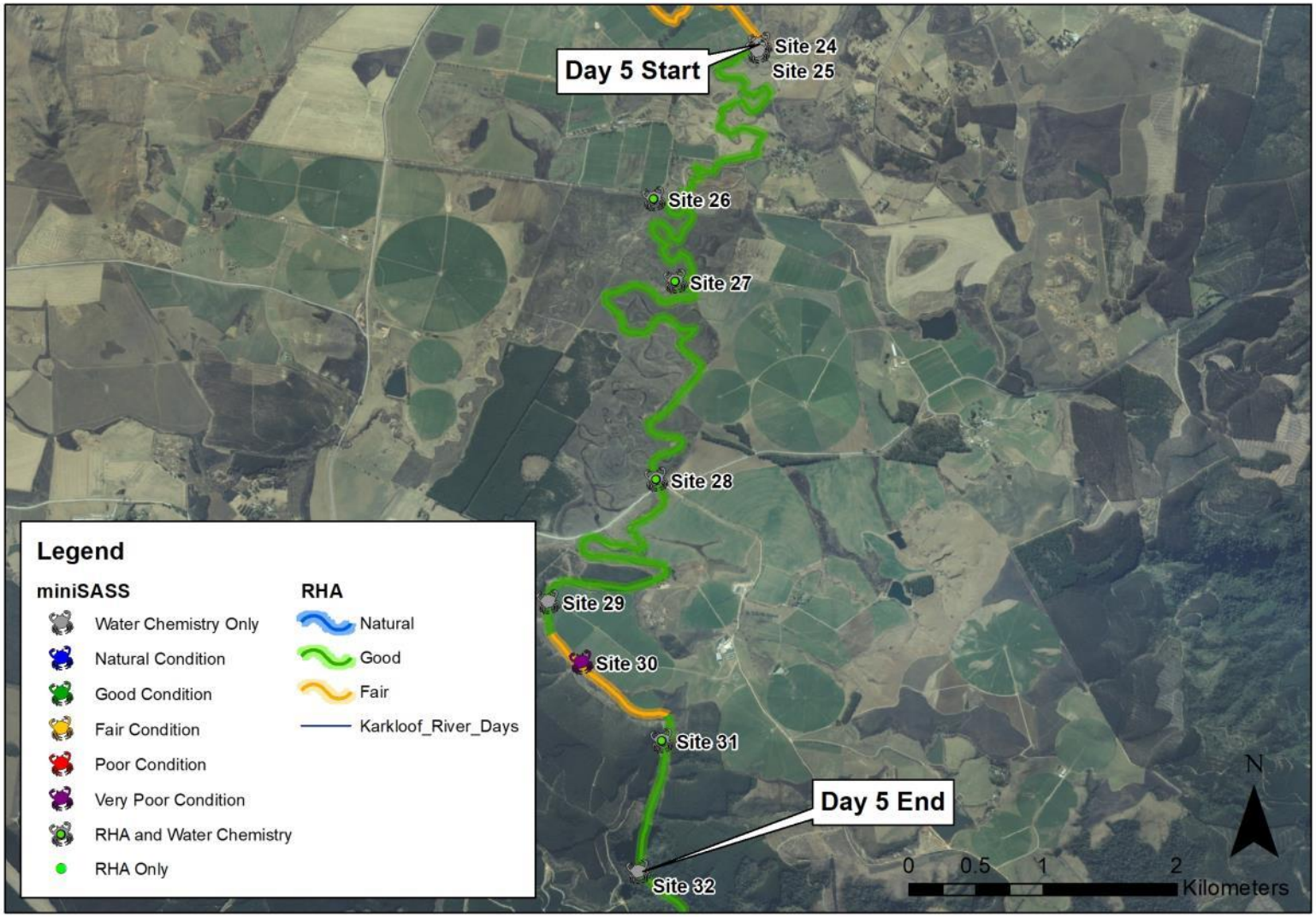


Figure 3.5: Karkloof River Walk day five sample sites.

3.6 Summary of Day 5 Sites

Upstream view from sample site

Downstream view from sample site

Day 5	Site 27
River	Karkloof
Quaternary Catchment	U20D
Latitude (S) DD	-29.363751
Longitude (E) DD	30.280588

Water Management Area	uMvoti to uMzimkhulu
1:50000 map reference	2930AD
Aquatic Ecoregion	South eastern Uplands

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	10.5
% transformed	26.25
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	37
Temperature (°C)	17.49	**pH**	7.0
Dissolved oxygen %	70.8	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	6.2	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	31	**Orthophosphate(mg/l)**	ns

Description: The site was located on land historically planted to timber in a wetland section, now in the process of being rehabilitated, where the water was deep and the banks slightly incised. The site was upstream of the Kusane confluence. The RHA results indicated the reach was in a good condition, but the site was largely impacted by bramble (*Rubus cuneifolius*) and Knot weed (*Persicaria lapathifolia*). Water chemistry results fell within acceptable ranges.

Upstream view from sample site

Downstream view from sample site

Day 5	Site 28	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20D	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.37710		
Longitude (E) DD	30.27930		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	6.5
% transformed	16.25
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	40
Temperature (°C)	18.01	**pH**	6.83
Dissolved oxygen %	76.7	***E. coli* (mpn/100ml)**	10000
Electrical Conductivity (mS/m)	6.4	**Nitrate (mg/l)**	0.42
Total dissolved salts (mg/l)	34	**Orthophosphate(mg/l)**	<0.03

Description: The site is approximately 10 meters upstream of Karkloof bridge on the Crammond road. The river had passed through approximately 5km of degraded wetland between site27 and site 28. This was the first site with very high *E. coli* counts. There is a tributary that joins the Karkloof between sites 27 and 28, which may have contributed to the higher *E. coli* counts. The RHA results indicate the site to be in a good condition; however the site had large areas of Common Reed (*Phragmites australis*) which can indicate degradation. In certain sections extensive bramble (*R. cuneifolius*) coverage was a concern.

Upstream view from sample site

Downstream view from sample site

Day 5	Site 29	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.38499		
Longitude (E) DD	30.27229		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality			
Temperature (°C)	ns	**Clarity (cm)**	ns
Dissolved oxygen %	ns	***E. coli* (mpn/100ml)**	2300
Electrical Conductivity (mS/m)	ns	**Nitrate (mg/l)**	0.5
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	0.044

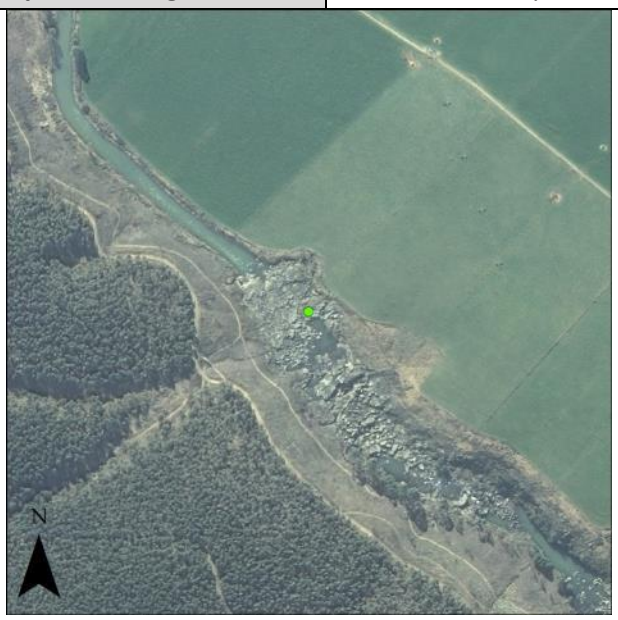
Description: The river was approximately 12 metres wide and more than half a metre deep at this site. The flatter topography and wider river resulted in slower flows. Maize was being grown in the reach upstream. Only water chemistry samples were collected at this site and these showed an increase in nitrate and orthophosphate. These nutrients are normally related to fertilizers.

Upstream view from sample site

Downstream view from sample site

Day 5	Site 30	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.38940		
Longitude (E) DD	30.27420		

Aquatic Assessments	
MiniSASS	
Total score	22
No. Groups	5
Average score	4.4
Condition	Very poor
RHA	
Score	13.5
% transformed	33.75
Condition	Fair



In situ and chemical water quality		**Clarity (cm)**	48
Temperature (°C)	18.58	**pH**	6.64
Dissolved oxygen %	79.1	***E. coli* (mpn/100ml)**	300
Electrical Conductivity (mS/m)	6.3	**Nitrate (mg/l)**	0.5
Total dissolved salts (mg/l)	32	**Orthophosphate(mg/l)**	<0.03

Description: Located at the first bed rocks site before Karkloof Falls – Water quality looked poor, there was a dead bush buck (death due to natural causes) in the water, The riparian are was impacted by exotics such as Bamboo (*Bambusa sp.*), gum (*Eucalyptus sp.*), bramble (*Rubus cuneifolius*) and elderflower (*Sambucus sp.*) and the adjacent agriculture extended into the riparian zone in several places these impacts were the cause of the fair condition in the riparian zone. The site was shallower than the previous site but wider (up to 20m). Habitat was available for miniSASS (the only site where miniSASS was possible for day five) but habitat was limited. The limited habitat and poorer water quality are the likely causes of the very poor condition scored by the miniSASS assessment. Nitrate was at the maximum target value and *E. coli* exceeded the recommended range for domestic and irrigation usage.

Upstream view from sample site

Downstream view from sample site

Day 5	Site 31	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South Eastern Uplands
Latitude (S) DD	-29.39460		
Longitude (E) DD	30.27970		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	10.5
% transformed	26.25
Condition	Good

In situ and chemical water quality		**Clarity (cm)**	48
Temperature (°C)	19.9	**pH**	7.35
Dissolved oxygen %	93.7	***E. coli* (mpn/100ml)**	220
Electrical Conductivity (mS/m)	6.3	**Nitrate (mg/l)**	0.51
Total dissolved salts (mg/l)	32	**Orthophosphate(mg/l)**	<0.03

Description: The last site before the first Karkloof waterfall. The site has a deep, slow flowing pool. Rubbish was the largest riparian impact as the site is used as a recreational park. The water quality, as with the previous sites, had elevated *E. coli* and nitrates when compared to the sites sampled on earlier days of the walk. The RHA assessment indicated that the site was in a good condition despite the rubbish and maintained lawns in the riparian area. The water chemistry result was within acceptable ranges except for *E. coli*. and borderline nitrates.

Day 5 overview

The river reaches covered during day five traversed the Karkloof floodplain and were in general slower flowing, deeper pools that were not suitable for miniSASS, the one site where miniSASS was possible showed the condition to be very poor; however, this may have been exaggerated due to the limited habitat that was available. The surrounding areas of the reach covered on day 5 included a mixture of agriculture, forestry and tourism. There was a weir and several pumphouse along the route, as well as, areas where there were inadequate buffers and a restored wetland. The Kusane River joined the Karkloof just downstream of site 27. Water quality was an issue for the sites on day five with *E. coli* regularly being high and the highest recorded nutrient concentration's being found over this stretch. The overall RHA results indicated that the sites were in a good condition. However, invasive and exotic vegetation was present in most of the riparian zones and is problematic and needs to be kept in check.

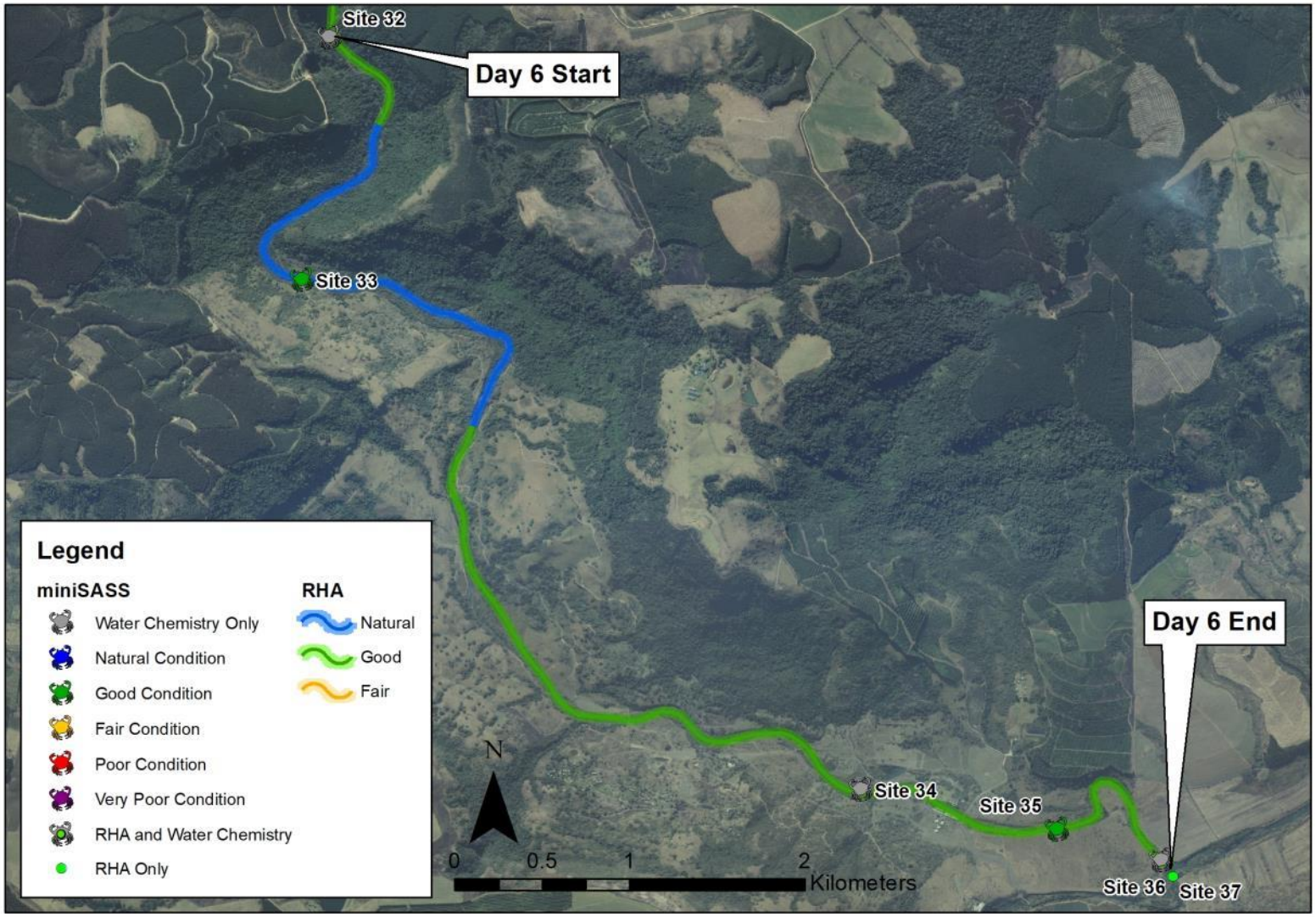


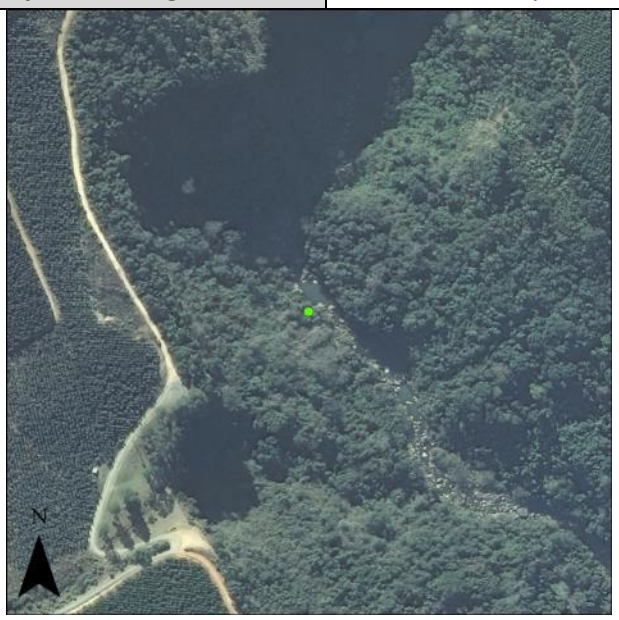
Figure 3.6: Karkloof River Walk day six sample sites

3.7 Summary of Day 6 Sites

Upstream view from sample site

Downstream view from sample site

Day 6	Site 32	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South Eastern Uplands
Latitude (S) DD	-29.40350		
Longitude (E) DD	30.27810		



Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	63
Temperature (°C)	18.81	**pH**	7.42
Dissolved oxygen %	81.1	***E. coli* (mpn/100ml)**	310
Electrical Conductivity (mS/m)	7.0	**Nitrate (mg/l)**	0.66
Total dissolved salts (mg/l)	35	**Orthophosphate(mg/l)**	0.034

Description: Site 32 was located below falls along the boardwalk and was the closest accessible site downstream of the falls. This section of the river predominantly flows around large boulders. The site is in a valley where the river banks are steep and well covered with dense indigenous vegetation. The nutrients, nitrate and orthophosphate where marginally higher than seen at site 31. *E. coli* was still higher than the recommended target range for domestic use and irrigation.

Upstream view from sample site

Downstream view from sample site

Day 6	Site 33	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930ACD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.41600		
Longitude (E) DD	30.27670		

Aquatic Assessments	
MiniSASS	
Total score	44
No. Groups	7
Average score	6.3
Condition	Good
RHA	
Score	2.5
% transformed	6.25
Condition	Natural

In situ and chemical water quality		**Clarity (cm)**	63
Temperature (°C)	19.43	**pH**	7.36
Dissolved oxygen %	77.0	***E. coli* (mpn/100ml)**	168
Electrical Conductivity (mS/m)	7.0	**Nitrate (mg/l)**	0.65
Total dissolved salts (mg/l)	35	**Orthophosphate(mg/l)**	<0.03

Description: At the spa road crossing, the site is immediately upstream of the bridge. It was an extremely rocky river bed. The site is on the outer edge of a large indigenous forest. Both the miniSASS and RHA results showed an improvement for the day five site results, indicating an improvement in the system. Water quality was good, with only nitrates and *E. coli* falling outside of recommended target water quality ranges.

Upstream view from sample site

Downstream view from sample site

Day 6	Site 34	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.44220		
Longitude (E) DD	30.30540		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality		**Clarity (cm)**	56
Temperature (°C)	20.34	**pH**	7.14
Dissolved oxygen %	89.4	***E. coli* (mpn/100ml)**	36
Electrical Conductivity (mS/m)	7.0	**Nitrate (mg/l)**	0.46
Total dissolved salts (mg/l)	35	**Orthophosphate(mg/l)**	<0.03

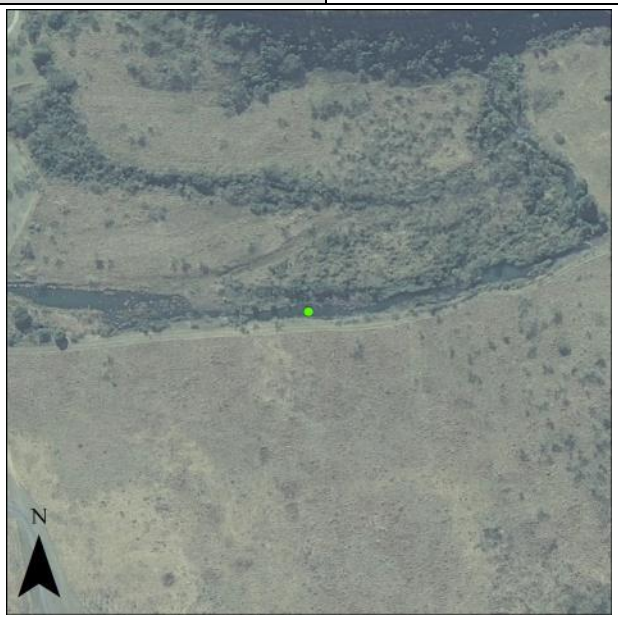
Description: At a weir, the river bed is partially made up of artificial substrate both upstream and downstream of the weir. The water was pooled and slow-flowing upstream of the weir. Thick reed beds (*Phragmites*) were present downstream of the weir. The water quality parameters had improved from this point with only *E. coli* being marginally higher than the recommended domestic and irrigation target ranges.

Upstream view from sample site

Downstream view from sample site

Day 6	Site 35	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.44430		
Longitude (E) DD	30.31560		

Aquatic Assessments	
MiniSASS	
Total score	38
No. Groups	6
Average score	6.3
Condition	Good
RHA	
Score	ns
% transformed	ns
Condition	ns



In situ and chemical water quality		**Clarity (cm)**	59
Temperature (°C)	20.61	**pH**	7.30
Dissolved oxygen %	89.7	***E. coli* (mpn/100ml)**	74
Electrical Conductivity (mS/m)	7.0	**Nitrate (mg/l)**	0.44
Total dissolved salts (mg/l)	35	**Orthophosphate(mg/l)**	0.149

Description: Hippo entry site, the site is at a wide section of the river. Mostly a sandy river bed. Open grassland on the one side of the river and thicker indigenous bush on the opposite side. The miniSASS results show the site to be in a good condition. Water quality was in the acceptable range except for *E. coli.* Orthophosphate was the highest recorded of all the sites. The slightly higher orthophosphate and *E. coli* are likely the result of the site being utilized by hippo.

Upstream view from sample site

Downstream view from sample site

Day 6	Site 36	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.445894		
Longitude (E) DD	30.320927		

Aquatic Assessments	
MiniSASS	
Total score	ns
No. Groups	ns
Average score	ns
Condition	ns
RHA	
Score	ns
% transformed	ns
Condition	ns

In situ and chemical water quality			
Temperature (ºC)	20.62	**Clarity (cm)**	59
Dissolved oxygen %	89.7	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	7.0	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)		**Orthophosphate(mg/l)**	ns

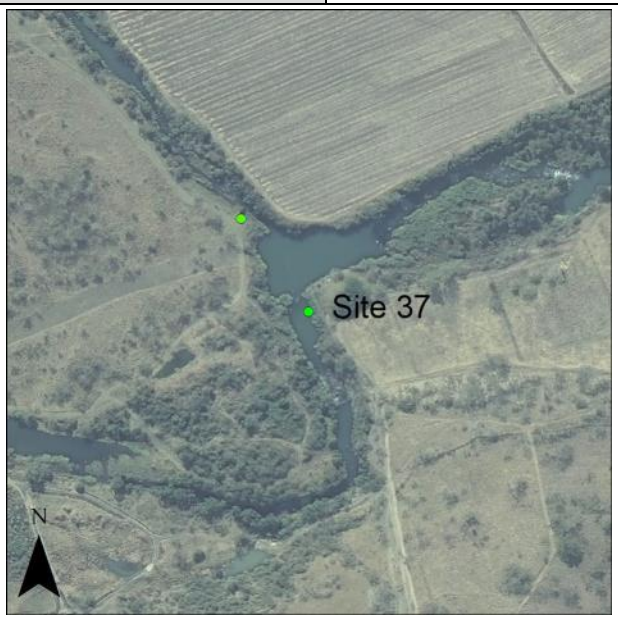
Description: This site is similar to site 35, the difference being that it was deeper and rockier. This was the last site assessed before the confluence of the Karkloof River with the uMgeni River. Access was not suitable for miniSASS and dangerous game were in the vicinity so the assessment was limited to in-situ water quality for this site. These results were all within the acceptable ranges. The condition of this site was similar, if not better, than site 35 and the overall condition is considered to be good.

Upstream view from sample site

Downstream view from sample site

Day 6	Site 37	**Water Management Area**	uMvoti to uMzimkhulu
River	Karkloof	**1:50000 map reference**	2930AD
Quaternary Catchment	U20E	**Aquatic Ecoregion**	South eastern Uplands
Latitude (S) DD	-29.44590		
Longitude (E) DD	30.32090		

Aquatic Assessments	
MiniSASS	
Total score	na
No. Groups	na
Average score	na
Condition	na
RHA	
Score	11
% transformed	27.5
Condition	Good



In situ and chemical water quality		**Clarity (cm)**	ns
Temperature (°C)	ns	**pH**	ns
Dissolved oxygen %	ns	***E. coli* (mpn/100ml)**	ns
Electrical Conductivity (mS/m)	ns	**Nitrate (mg/l)**	ns
Total dissolved salts (mg/l)	ns	**Orthophosphate(mg/l)**	ns

Description: This RHA covered the river from the bridge near site 33 all the way down to the confluence with the uMgeni River past site 36 an ending at site 37. The RHA showed the reach to be in a good condition. There were diversion channels from the river to feed ponds, lantana was present in the riparian areas and the presents of man-made structures such as road crossings and a weir were found within the reach and these impacts prevented the site from scoring a near to natural result.

Day 6 overview

Day 6 started at the falls and the river was much larger, deeper and faster flowing than on the previous days and was the first section of the river considered to be channelled. The initial sites on day six still showed some impacts from a weir and from the impoverished water quality seen at the day 5 sites, this included slightly elevated *E. coli* and nutrients but at lower concentrations than found on day 5. A spotted neck otter (Hydrictis maculicollis, an indicator of good water quality) was seen in the river. The surrounding areas on day 6 were predominantly under wildlife management and as a result of this limited impact, the miniSASS and RHA results showed that this section of the river had improved to a good to natural condition and the river had noticeably healed itself.

4. Conclusions and recommendations

In general the riparian areas along the Karkloof River were in a good condition. The riparian areas in the very upper reaches of the river were in a near to natural condition. Only three reaches were considered to be fair, these were at the start of the reach on day two, the central reach on day 4 and a section at the end of day 5. Even though the riparian areas were in a good condition, almost all of the areas were affected, to varying degrees, by exotic vegetation. Bramble was the most conspicuous, with wattle and bug weed also being common.

After exotic vegetation the next largest impacts were reduced water quality and flow modification. Water quality issues were identified by algal growth, discolouration of the water, foam, litter and water chemistry, such as nitrates and *E. coli*. Flow modification impacts were related to extraction for irrigation, weirs, dams, road crossings, log jams and excessive growth of instream vegetation.

The water quality assessments showed that water quality varied along the length of the river. The miniSASS assessments were not possible at all sites due to habitat limitations and some of the sites where miniSASS was conducted had poor habitat, which would have had an impact on the final scores. There were issues around *E. coli* and nutrients in several reaches along the river which would also have had an impact on the scores. Unsurprisingly the worst miniSASS scores were recorded at or near the sites where the riparian areas were also the most impacted. Some of the more noticeable impacts along the river such as the dumping of tar/asphalt into the river near the bridge at the crossing on the Karkloof road, and the temporary cattle feedlot contributed to combined riparian/water quality issues. It is recommended that livestock access be restricted to certain areas where maintenance can be conducted and that riparian buffer zones, be rehabilitated or reinstated. This is one of the biggest contributions landowners can make to improving the overall condition of the Karkloof System. As the ecological services that the natural riparian vegetation plays in buffering water quality e.g. sedimentation and nutrient trapping, should not be underestimated.

The main water chemistry impact was *E. coli,* while this was not very high at most sites it exceeded the limit for domestic use (0 counts) and irrigation (1 count) at all sites sampled. The *E. coli* also exceeded the recommended limit for livestock watering (200 counts) at site 22, and sites 28 to 32. Sites 28 and 29 had 10000 and 2300 counts respectively and were the two highest recorded *E. coli* readings during the river walk. Naturally riverine systems can have *E. coli* counts into the hundreds due to wildlife interactions with rivers. Readings of 10000 counts point to more concentrated sources such as sewage effluent. Nutrients consisting of nitrates and orthophosphates were generally within the recommended ranges. Only site 32 had marginally elevated concentrations for both of these nutrients.

Generally, the river had minor impacts that were distributed over wide reaches whilst intense impacts were very localised. Overall the river walk found the Karkloof River to be in a fair to good condition.

The invasive species in the riparian area needs to be managed according to the NEMBA regulations of 2014 (Government notice No. R. 589) as per the NEMBA Act of 2004. According to this legislation the

bramble and bugweed fall in to category 1b and the wattle into category 2. The implications of these categories are listed below:

NEMBA – Section 75 Control and eradication of listed invasive species

(1) Control and eradication of a listed invasive species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs.
(2) Any action taken to control and eradicate a listed invasive species must be executed with caution and in a manner that may cause the least possible harm to biodiversity and damage to the environment.
(3) The methods employed to control and eradicate a listed invasive species must also be directed at the offspring, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.
(4) The Minister must ensure the coordination and implementation of programmes for the prevention, control or eradication of invasive species.
(5) The Minister may establish an entity consisting of public servants to coordinate and implement programmes for the prevention, control or eradication of invasive species.

Category 1b

(2) Category 1b listed species must be controlled in compliance with section 75(1), (2) and (3) of the ACT.

(3) If an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme.

(4) A person contemplated in sub-regulation(2) must allow an authorised official from the Department to enter onto the land to monitor, assist with or implement the control of the listed invasive species, or compliance with the Invasive Species Management Programme contemplated in section 75(4) of the Act.

Category 2

(1) Category 2 Listed Invasive Species are those species listed by notice in terms of section 70(1)(a) of the Act as species which require a permit to carry out a restricted activity within an area specified in the Notice or an area specified in the permit, as the case may be.

(2) Unless otherwise indicated in the Notice, no person may carry out a restricted activity in respect of a Category 2 Listed Invasive Species without a permit.

(3) A landowner on whose land a Category 2 Listed Invasive Species occurs or person in possession of a permit, must ensure that the specimens of the species do not spread outside of the land or the area specified in the Notice or permit.

(4) If an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme.

(5) Unless otherwise specified in the Notice, any species listed as a Category 2 Listed Invasive Species that occurs outside the specified area contemplated in sub-regulation (1), must, for purposes of these regulations, be considered to be a Category 1 b Listed Invasive Species and must be managed according to Regulation 3.

(6) Notwithstanding the specific exemptions relating to existing plantations in respect of Listed Invasive Plant Species published in Government Gazette No. 37886, Notice 599 of 1 August 2014 (as amended), any person or organ of state must ensure that the specimens of such Listed Invasive Plant Species do not spread outside of the land over which they have control

5. References

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6. Appendices

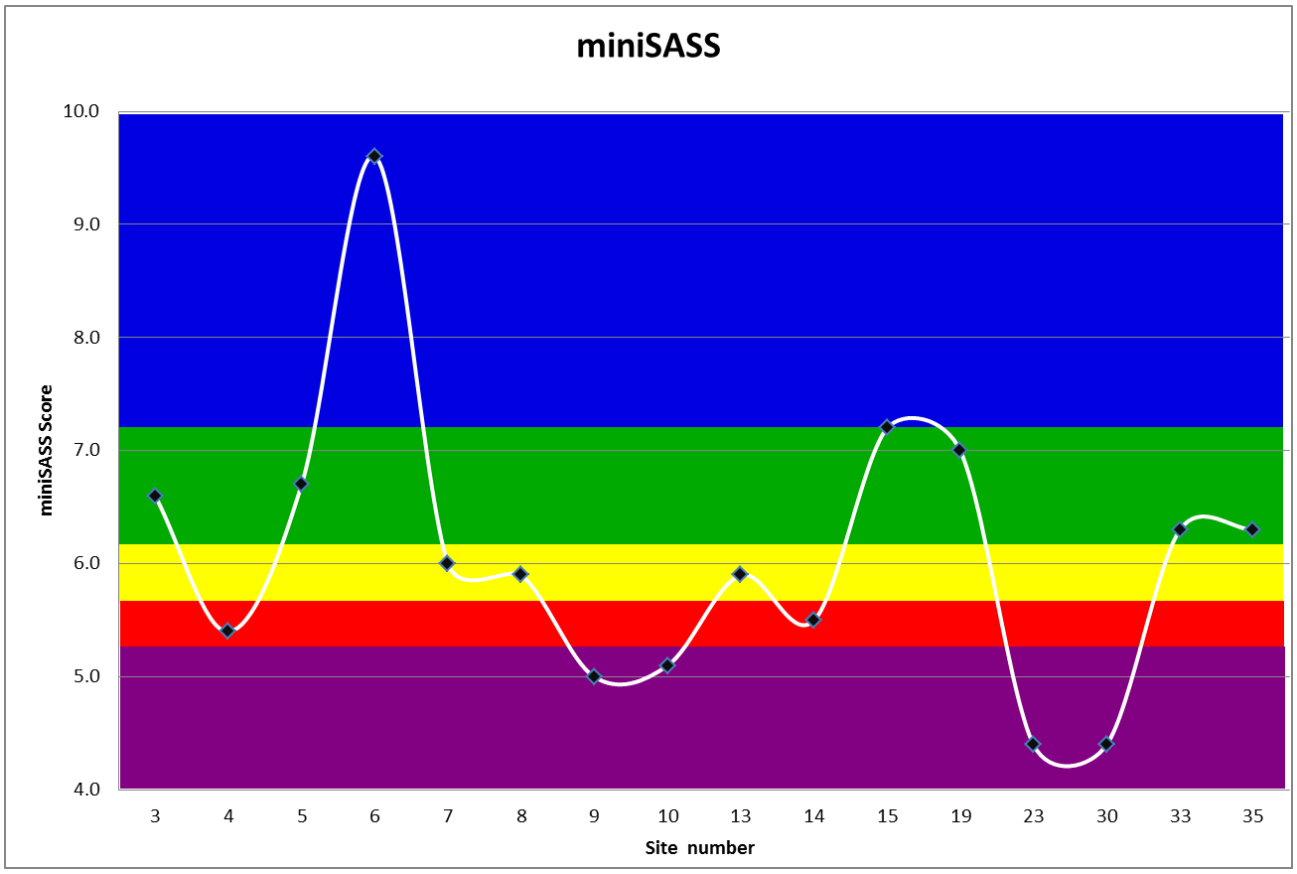
6.1 Appendix A

Index of assessment result summaries

Site No.	miniSASS	RHA	Water chemistry			
			Environmental	Domestic	Livestock	Irrigation
1	ns	Natural	ns	ns	ns	ns
2	ns	ns	DO	ns	ns	ns
3	Good	Natural	DO	ns	ns	ns
4	Poor	Good	DO / P	*E. coli*	Ok	*E. coli*
5	Good	Good	DO	ns	ns	ns
6	Natural	Good	DO	ns	ns	ns
7	Fair	Good	ns	*E. coli*	Ok	*E. coli*
8	Fair	Fair	DO	ns	ns	ns
9	V poor	ns	DO	*E. coli*	Ok	*E. coli*
10	V poor	ns	DO	ns	ns	ns
11	ns	ns	DO	ns	ns	ns
12	ns	ns	Ok	ns	ns	ns
13	Fair	Good	Ok	ns	ns	ns
14	Poor	ns	DO	*E. coli*	Ok	*E. coli*
15	Natural	Good	Ok	*E. coli*	Ok	*E. coli*
16	*	Good	*	*E. coli*	Ok	*E. coli*
17	ns	ns	ns	*E. coli*	Ok	*E. coli*
18	ns	Good	ns	*E. coli*	Ok	*E. coli*
19	Good	ns	DO	ns	ns	ns
20	ns	Good	ns	ns	ns	ns
21	ns	ns	Ok	*E. coli*	Ok	*E. coli*
22	ns	ns	Ok	*E. coli*	*E. coli*	*E. coli*
23	V Poor	Fair	Ok	ns	ns	ns
24	ns	ns	Ok	*E. coli*	Ok	*E. coli*
25	ns	ns	ns	*E. coli*	*E. coli*	*E. coli*
26	ns	Good	Ok	*E. coli*	Ok	*E. coli*
27	ns	Good	DO	ns	ns	ns
28	ns	Good	Ok	*E. coli*	*E. coli*	*E. coli*
29	ns	ns	ns	*E. coli*	*E. coli*	*E. coli*
30	V Poor	Fair	Ok	*E. coli*	*E. coli*	*E. coli*
31	ns	Good	Ok	*E. coli*	*E. coli*	*E. coli*
32	ns	ns	N / P	*E. coli*	*E. coli*	*E. coli*
33	Good	Natural	N	*E. coli*	Ok	*E. coli*
34	ns	ns	Ok	*E. coli*	Ok	*E. coli*
35	Good	ns	P	*E. coli*	Ok	*E. coli*
36	ns	ns	Ok	ns	ns	ns
37	ns	Good	ns	ns	ns	ns

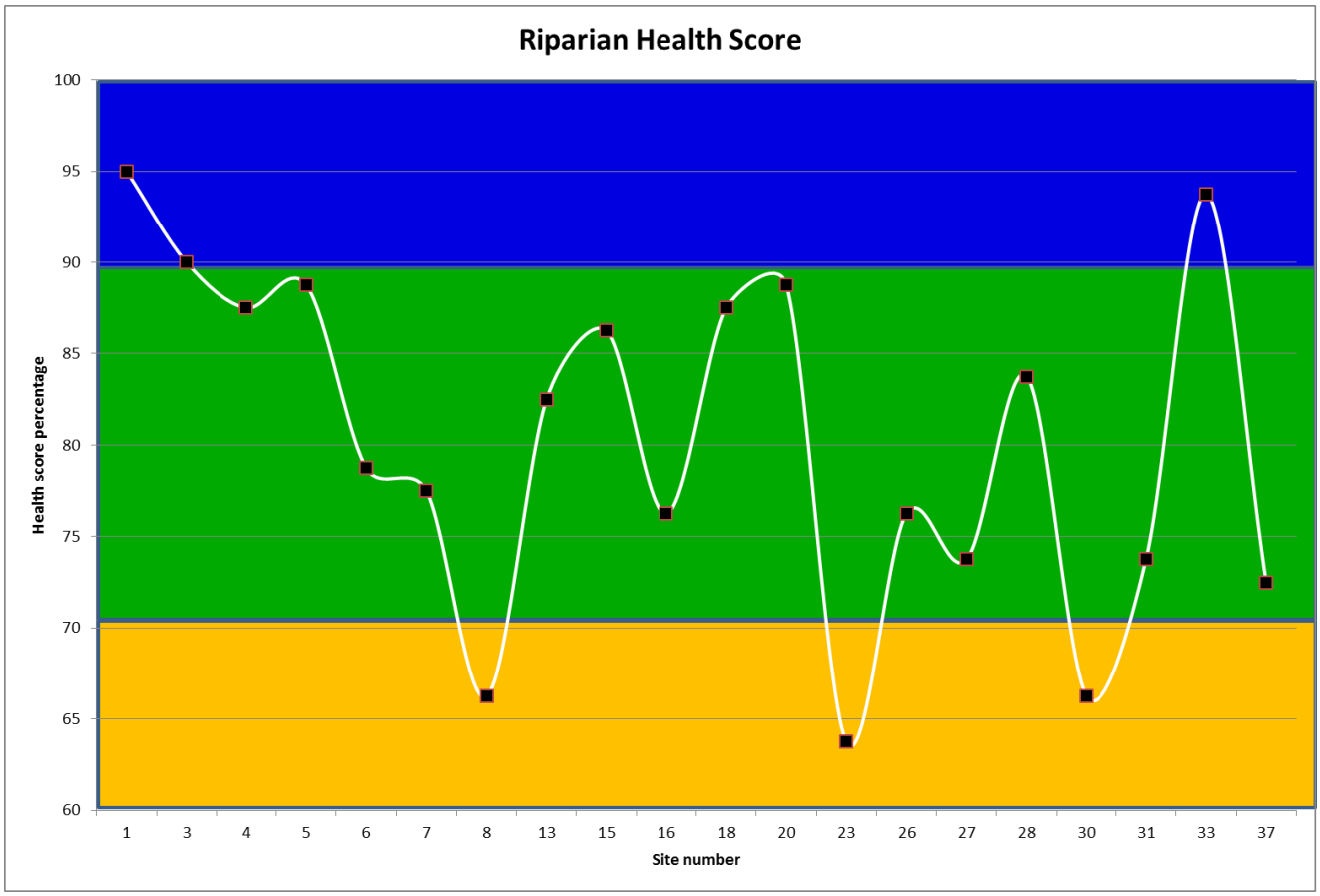
6.2 Appendix B

MiniSASS Assessment health categories from Source to confluence



6.3 Appendix C

RHA health categories from source to confluence



6.4 Appendix D

The Clarity Tube – To measure water clarity in streams

How to use the clarity tube (Figure 1)

- Water is extracted from the desired point (this can be from anywhere as the water can be collected in a bucket, the clarity tube does not need to be placed in the water).
- The water is then poured into the 1m x 50mm clear tube until it is full (i.e. no bubbles) and sealed with the black cap (F).
- The tube is held horizontally (if there are any bubbles in the tube you should tilt the tube slightly so that they gather at the capped end F) and at 90 degrees to the sun, the black disk (C) is then moved up and down in the tube using the magnets (D&E).

- Looking through the clear base (A), mark the point where the disk appears and mark the point where the disk disappears using the scale (B) on the side of the tube. This should be done at least twice.
- Take the average distance to the closest centimetre between these two points and use as the clarity measurement.
- Units of measure (clarity) are in cm.
- Results may be summarized on a simple spreadsheet recording the site, date and clarity measurement.

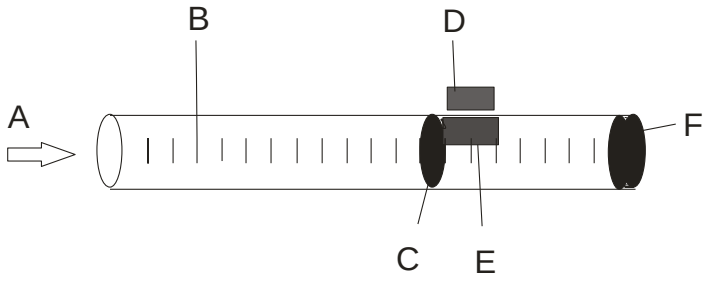


Figure 1: Sketch of Clarity Tube showing key components

Key to Figure 1

A) Clear base for viewing disk; B) Metered scale on the side of the tube; C) Black disk; D & E) Magnets for moving disk; F) Black cap for sealing tube.

Monitoring Protocol

There are two main types of monitoring, routine and event driven.

- Routine monitoring should be carried out once a month on a designated day (e.g. the first Monday of the month).
- Event driven monitoring should be in response to significant events, such as by heavy rainfall, spills, blasting, dam construction, river diversion or other disturbances to the river.
- For all monitoring comments should be made on the light conditions as this is a factor in the accuracy of the measurements.
- Additionally, for event driven measurements comments should be made on what the event was and the duration for which it continued.

Care and Maintenance

- If the Clarity tube is to be stored for more than a few days without being in use, place upside down with the cap off and allow the tube to dry before storage.
- Do not store in a warm dark place if there is moisture in the tube, this will cause algae to grow and will interfere with the readings.
- If algal growth is a problem in the tube, mix 5mL of bleach into 1L of water and wash out the tube. A long reach bottle brush may also assist.
- Always store and transport the clarity tube in the supplied case or other protective covering to prevent scratching the tube.
- Do not place the viewing disk (A) on the ground as this will cause scratches which may interfere with the readings.

The Clarity Tube is an inexpensive, robust, efficient and easily transported tool, which covers a range of practical uses in the South African & African context and is internationally recommended for use by farmers, school groups, citizen monitoring groups and local government agencies. Clarity tubes are now made locally in SA and are available from GroundTruth cc. Contact them on 033 343 2229 or admin@groundtruth.co.za for further details.

6.5 Appendix E

Karkloof Catchment Summary map