AQUATIC ECOLOGICAL ASSESSMENT AS PART OF THE ENVIRONMENTAL ASSESSMENT AND AUTHORISATION PROCESS FOR THE PROPOSED MANAGEMENT AND CONTROL OF THE BRAAMFONTEINSPRUIT IN JOHANNESBURG WITHIN THE GAUTENG PROVINCE

Prepared for:

SRK Consulting (South Africa) (Pty) Ltd

NOVEMBER 2017

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EXECUTIVE SUMMARY

Based on the findings of this study, the ecological integrity of the Braamfonteinspruit is deemed largely to severely modified, and therefore the proposed rehabilitation and intervention measures are likely to result in the improved functioning and ecological integrity of the system. It is therefore the opinion of the ecologists that the proposed rehabilitation / intervention measures be authorised by the relevant authorities.

MANAGEMENT SUMMARY

Scientific Aquatic Services was appointed by SRK Consulting (South Africa) (Pty) Ltd to conduct an aquatic ecological assessment of the Braamfonteinspruit in Johannesburg, Gauteng as part of the rehabilitation initiative to be implemented by the Johannesburg Roads Agency (JRA) and as required in terms of the National Environmental Management Act (Act 107 of 1998) and the National Water Act (Act 36 of 1998). This document presents the results obtained during the ecological survey of aquatic ecosystems during the autumn high flow season (March 2016). It includes a desktop assessment of the aquatic ecosystems and a field assessment which includes an assessment of the *in situ* water quality at a number of points along the Braamfonteinspruit, a survey of habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate community integrity, diatom analysis and toxicological analysis at various problem areas along the length of the main stem of the Braamfonteinspruit. The sampling sites were selected to highlight the present ecological state at various points along the Braamfonteinspruit to highlight the various issues impacting the watercourse, as well as highlight the specific intervention measures required for suitable rehabilitation of the identified problem areas observed. The protocols of applying the indices were strictly adhered to and all work was carried out by a South African River Health Program (SA RHP) accredited assessor. A risk assessment based on the findings of both the desktop and field assessments is provided.

The following tables summarise the findings on the Braamfonteinspruit:

<table>
<tr><td colspan="2">Braamfonteinspruit</td></tr>
<tr><td colspan="2">Site BS1 (Located in the upper reaches of the Braamfonteinspruit, adjacent to Barry Hertzog Ave and approximately 800m North of Empire Road, Richmond)</td></tr>
<tr><td>Water Quality
pH 7.95
Conductivity (mS/m) 48.9
Temperature (º C) 24.6
DO (mg/L) 4.91
DO (% sat) 68.49</td><td rowspan="2">  </td></tr>
<tr><td>Current impacts and Essential Mitigation
➢ Severe water quality impacts as a result of industrial activities upstream of this point;
➢ The river is completely canalised at this point and natural substrates are thus absent;
➢ Severe impacts in terms of exotic alien vegetation encroachment, with special mention of Pennisetum clandestinum;
➢ Litter observed instream;
➢ Large pieces of rubble observed instream;
➢ Significant sedimentation affecting the instream substrates and flow at this point.</td></tr>
</table>

Site BS2 (Located at the Southern end of the Parkview Golf course in the vicinity of the intersection between Mowbray Road and Barry Hertzog, Melville).

Water Quality

pH	7.60
Conductivity (mS/m)	40.0
Temperature (º C)	24.2
DO (mg/L)	5.48
DO (% sat)	24.2

Habitat Assessment

Class	Inadequate
IHAS Score	64

Aquatic Macro-invertebrate community assessment
Dickens & Graham,2002: Class F
Dallas, 2007: Class E/F
MIRAI: Class E
SASS5 Score: 6
ASPT Score: 2

Diatom analysis
Ecological Category E (Bad Quality)
Specific Pollution Sensitivity Index: 1.7
Pollution Tolerant Valves: 93.3

Toxicity testing
Class 2
Daphnia pulex: 30% mortalities
Poecilia reticulata: 13% mortalities
Vibreo fischerii: 19% growth
Selenastrum capricornutum: 33% inhibition

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Failure of historical bank stabilisation infrastructure;
- Debris from concrete and failing infrastructure including pipes, bricks, metal sheets and poles, etc.
- Litter observed instream as well as in the riparian area including car tyres, fabric, various paper and plastic refuse.

Site BS3 (Located within the Parkview Golf course approx. 150 m north of Gleneagles Road, Greenside).

Water Quality

pH	7.71
Conductivity (mS/m)	41.0
Temperature (º C)	22.9
DO (mg/L)	6.28
DO (% sat)	84.92

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding. Erosion and incision is aggravated at this point as a result of inadequate energy breakers downstream of the concrete channel;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of the concrete channel which ends at this point;
- Large pieces of rubble, metal debris and collapsed infrastructure observed instream;
- Some historical bank stabilisation in some areas at this point.

Site BS4 (Located within the Parkview Golf course approx. 300 m north of Gleneagles Road, Greenside).

Water Quality

pH	7.68
Conductivity (mS/m)	41.0
Temperature (º C)	22.5
DO (mg/L)	6.19
DO (% sat)	83.08

Current impacts and Essential Mitigation

- Litter both instream as well as in the riparian zone;
- Construction debris, metal and concrete debris in the active channel;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Quite a few stormwater inlets were observed between sites BS 3 and BS 4, which may play a role in aggravating erosion and incision under high rainfall conditions as well as affect water quality in a downstream direction.

Site BS5 (Located just off of Rustenburg Road opposite the Victory Park Shopping Centre, between Victory Park and Parkhurst).

Water Quality

pH	7.62
Conductivity (mS/m)	34.0
Temperature (º C)	21.1
DO (mg/L)	6.47
DO (% sat)	84.58

Habitat Assessment

Class	Highly suited
IHAS Score	81

Aquatic Macro-invertebrate community assessment
Dickens & Graham,2002: Class F
Dallas, 2007: Class E/F
MIRAI: Class D
SASS5 Score: 50
ASPT Score: 4.5

Diatom analysis
Ecological Category E (Bad Quality)
Specific Pollution Sensitivity Index: 4.0
Pollution Tolerant Valves: 83.0

Toxicity testing
Class 2
Daphnia pulex: 20% mortalities
Poecilia reticulata: 38% mortalities
Vibreo fischerii: 29% growth
Selenastrum capricornutum: 27% inhibition

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.

Site BS6 (Located at the intersection between Conrad Drive and Jan Smuts, Blairgowrie).

Water Quality

pH	7.98
Conductivity (mS/m)	39.0
Temperature (º C)	21.3
DO (mg/L)	6.43
DO (% sat)	73.7

Habitat Assessment

Class	Highly suited
IHAS Score	79

Aquatic Macro-invertebrate community assessment
Dickens & Graham,2002: Class F
Dallas, 2007: Class E/F
MIRAI: Class D
SASS5 Score: 39
ASPT Score: 4.3

Diatom analysis
Ecological Category D (Poor Quality)
Specific Pollution Sensitivity Index: 7.9
Pollution Tolerant Valves: 29.8

Toxicity testing
Class 2
Daphnia pulex: 25% mortalities
Poecilia reticulata: 13% mortalities
Vibreo fischerii: 13% growth
Selenastrum capricornutum: 13% inhibition

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Little observed instream as well as in the riparian area.

Site BS7 (Located upstream of the confluence of the Braamfonteinspruit with an unnamed tributary near the intersection of Republic Road and William Nicol Road)

Water Quality

pH	7.27
Conductivity (mS/m)	39.0
Temperature (º C)	24.0
DO (mg/L)	5.22
DO (% sat)	59.9

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Some impacts in terms of inundation under high flow conditions were observed at this point;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area;
- Large pieces of rubble and collapsed infrastructure observed instream;
- Significant sedimentation affecting the instream substrates at this point.

Site BS8 (Located on the unnamed tributary that confluences with the Braamfonteinspruit near the intersection of Republic Road and William Nicol Road)

Water Quality

pH	7.43
Conductivity (mS/m)	28.0
Temperature (º C)	24.2
DO (mg/L)	3.1
DO (% sat)	35.7

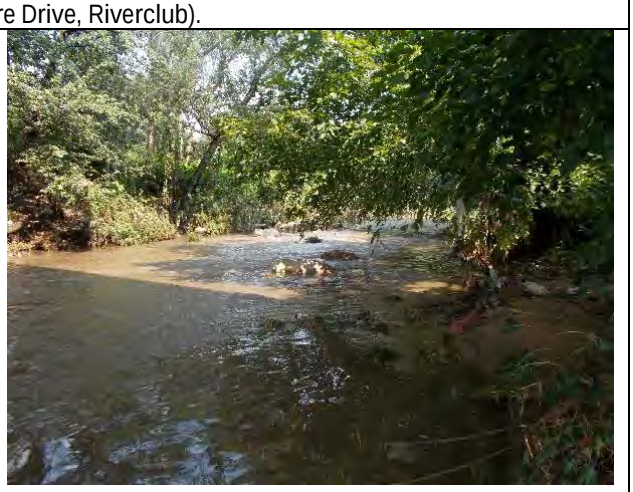
Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Some impacts in terms of inundation under high flow conditions were observed at this point;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area;
- Large pieces of rubble and collapsed infrastructure observed instream;
- Significant sedimentation affecting the instream substrates at this point.

Site BS9 (Located where the Braamfonteinspruit flows under Ballyclare Drive, Riverclub).

Water Quality

pH	7.28
Conductivity (mS/m)	37.0
Temperature (º C)	23.6
DO (mg/L)	3.48
DO (% sat)	39.9



Habitat Assessment

Class	Adequate
IHAS Score	73

Aquatic Macro-invertebrate community assessment

Dickens & Graham,2002: Class F
Dallas, 2007: Class E/F
MIRAI: Class D
SASS5 Score: 42
ASPT Score: 3.8

Diatom analysis

Ecological Category D (Poor Quality)
Specific Pollution Sensitivity Index: 6.0
Pollution Tolerant Valves: 55.0

Toxicity testing

Class 2
Daphnia pulex: 35% mortalities
Poecilia reticulata: 0% mortalities
Vibreo fischerii: 24% growth
Selenastrum capricornutum: 15% inhibition

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision and sedimentation;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.

Site BS10 (Located at the low lying bridge on Belgrave Road, between The River Road and Brooke Avenue, Riverclub).

Water Quality

pH	7.81
Conductivity (mS/m)	45.0
Temperature (º C)	23.7
DO (mg/L)	7.15
DO (% sat)	82.0

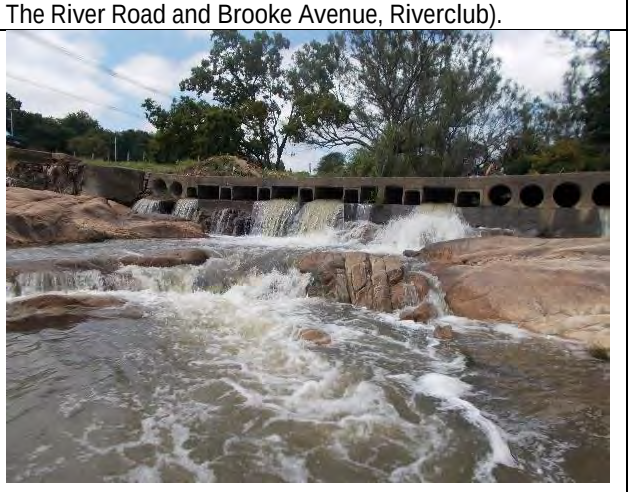
Habitat Assessment

Class	Adequate
IHAS Score	82

Aquatic Macro-invertebrate community assessment
Dickens & Graham,2002: Class F
Dallas, 2007: Class E/F
MIRAI: Class D
SASS5 Score: 41
ASPT Score: 5.1

Diatom analysis
Ecological Category D (Poor Quality)
Specific Pollution Sensitivity Index: 8.6
Pollution Tolerant Valves: 20.0

Toxicity testing
Class 2
Daphnia pulex: 35% mortalities
Poecilia reticulata: 13% mortalities
Vibreo fischerii: 23% growth
Selenastrum capricornutum: 21% inhibition



Current impacts and Essential Mitigation

- Some impacts observed in terms of erosion and incision at this point;
- Severe impacts related to inundation associated with poor bridge design and insufficient flow connectivity at this point;
- Build-up of debris upstream of the bridge resulting in flooding and inundation upstream of the bridge under high flow conditions;
- Flow modification as a result of weirs and impoundments along the length of the system;
- A failing gabion structure was observed at this point at the time of the assessment;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Litter observed instream as well as in the riparian area.

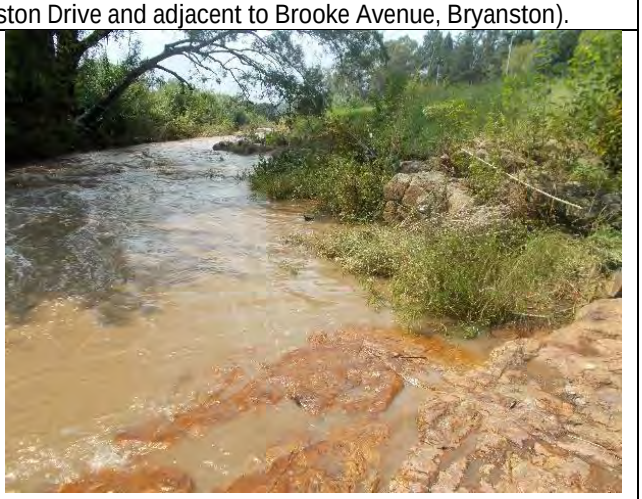
Site BS11 (Located where the Braamfonteinspruit flows under Bryanston Drive and adjacent to Brooke Avenue, Bryanston).

Water Quality

pH	7.60
Conductivity (mS/m)	52.0
Temperature (º C)	22.0
DO (mg/L)	7.16
DO (% sat)	82.1

Current impacts and Essential Mitigation

- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.



Site BS12 (Located where the Braamfonteinspruit flows under Cowley Street, Rivonia).

Water Quality

pH	7.60
Conductivity (mS/m)	52.0
Temperature (º C)	22.0
DO (mg/L)	7.13
DO (% sat)	81.8

Current impacts and Essential Mitigation

- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.
- Severe impacts as a result of large pieces of rubble and collapsed infrastructure observed instream;
- Rubble and disturbed soils affect bank stability in the vicinity of the bridge crossing;
- Significant sedimentation affecting the instream substrates at this point.

Site BS13 (Located at the confluence of the Braamfonteinspruit with the Sand Spruit near Umfolozi Road, Paulshof)

Water Quality

pH	7.51
Conductivity (mS/m)	51.0
Temperature (º C)	21.7
DO (mg/L)	7.24
DO (% sat)	83.0

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area;
- Large pieces of rubble and collapsed infrastructure observed instream;
- Rudimentary stabilisation of the banks observed at this point through the concreting of some areas;
- Significant sedimentation affecting the instream substrates at this point.

Site BS14 (Located further downstream of the confluence of the Braamfonteinspruit with the Sand Spruit near Umfolozi Road, Paulshof).

Water Quality

pH	7.60
Conductivity (mS/m)	52.0
Temperature (º C)	22.0
DO (mg/L)	7.14
DO (% sat)	81.9

Habitat Assessment

Class	Highly suited
IHAS Score	81

Aquatic Macro-invertebrate community assessment
Dickens & Graham,2002: Class F
Dallas, 2007: Class E/F
MIRAI: Class D
SASS5 Score: 41
ASPT Score: 5.1

Diatom analysis
Ecological Category D (Poor Quality)
Specific Pollution Sensitivity Index: 7.9
Pollution Tolerant Valves: 45.0

Toxicity testing
Class 2
Daphnia pulex: 5% mortalities
Poecilia reticulata: 0% mortalities
Vibreo fischerii: 15% growth
Selenastrum capricornutum: 13% inhibition

Current impacts and Essential Mitigation

- Some impacts observed in terms of erosion and incision at this point;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Litter observed instream as well as in the riparian area. In addition, deposition of failing infrastructure was observed instream;
- Housing in close proximity to the banks of the river has resulted in severe modification of the riparian zone at this point, however, mowed lawns provide good cover and thus aid in limiting erosion and incision at this point;
- Severe sedimentation of the instream substrates.

Conclusion

Severe impacts as a result of erosion, incision, sedimentation and embedding were evident along the length of the system. Closely associated with these impacts and a key driver of change in this regard is flow modification observed along the entire length of the system. Weirs, barriers and inadequately designed bridges, as well as modifications to the channel and the stream substrate in some areas, all contribute to the significant flow modifications observed along the length of the system. The effects of erosion and incision due to inadequately controlled stormwater runoff during storm events and high water volume events are evident throughout the system. Further compounding issues are severe impacts, in terms of exotic vegetation encroachment, which appear to worsen in a downstream direction. Large pieces of rubble, metal debris and collapsed infrastructure were observed instream at various points of interest. Failing infrastructure in terms of historically canalised sections, old bridges and roads and failed gabions were also observed. Historical bank stabilisation in some areas were observed.

Aquatic community integrity in the upper reaches of the Braamfonteinspruit, with special mention of sites BS1 and BS2, may be considered to be in a severely modified condition according to both the Dallas (2007) classification method as well as on application of the MIRAI to the BS2 site. Impaired water quality and critically altered stream substrates at this point are likely the key drivers of change in the upper reaches of the Braamfonteinspruit. It is deemed critical for the improved integrity of the upper reaches of the Braamfonteinspruit that the sources resulting in impaired water quality in the upper reaches be identified and mitigated as far as possible. The impact of impaired water quality in this system becomes evident further downstream as pollutants become more diluted on confluence with the Westdene Spruit and an improvement in aquatic community integrity is observed at site BS5. Point and diffuse sources of pollution in terms of hydrocarbons and pollutants associated with road crossings, industry, urban runoff, as well as impacts related to historical French drains and domestic waste water,

affect the Braamfonteinspruit to varying degrees along the length of the system, as is reflected in the SASS5 results observed throughout.

As with the aquatic community assessment, the diatom and analysis revealed highly eutrophic, electrolyte-rich and extremely polluted waters in the upper reaches of the Braamfonteinspruit, improving in a downstream direction as industrial pollutants and pollutants associated with urban areas, such as sewage effluent) become more diluted.

The toxicological assessment of the risk posed to the aquatic receiving environment revealed a slight toxicological hazard (Class 2) along the entire length of the Braamfonteinspruit, with slight improvements noted in a downstream direction.

It is the opinion of the ecologist that rehabilitation of the Braamfonteinspruit will require a multi-faceted approach addressing impacts to water quality in terms of urban runoff, industrial waste and impacts associated with sewerage and domestic waste water. In terms of habitat, stabilisation of failing banks and infrastructure through the use of gabions and possibly some hard engineering may be necessary in some areas. In areas of severe incision and erosion, banks should be re-profiled and revegetated where possible and an on-going alien vegetation removal and management plan is deemed necessary. In-stream substrate should be rehabilitated in terms of removal of existing litter and debris and where possible, litter traps should be installed, and a management plan to ensure ongoing maintenance should be implemented. Adequate stormwater management and erosion control measures need to be put in place and careful planning will be required in order to ensure that adequate energy dissipation takes place under high rainfall and high water volume conditions.

DOCUMENT GUIDE

NEMA Regulations (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Appendix 5
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix 5
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix 5
An indication of the scope of, and the purpose for which, the report was prepared	Section 1
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 1
A description of the methodology adopted in preparing the report or carrying out the specialised process	Appendix 1
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 3
An identification of any areas to be avoided, including buffers	Section 3
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 1
A description of any assumptions made and any uncertainties or gaps in knowledge;	N/A
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
Any mitigation measures for inclusion in the EMPr	Section 4 and Appendix 2
Any conditions for inclusion in the environmental authorisation	N/A
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	N/A
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	Section 5
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 4
A description of any consultation process that was undertaken during the course of carrying out the study	Consultation with interested and affected parties will be undertaken as part of the environmental impact assessment and environmental management programme process conducted by SRK
A summary and copies if any comments that were received during any consultation process	Comments and responses that are raised by interested and affected parties will be included in the BAR to be prepared by SRK
Any other information requested by the competent authority.	No information requested at this time

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1. PROJECT OBJECTIVES AND SCOPE

Scientific Aquatic Services was appointed by SRK Consulting (South Africa) (Pty) Ltd to conduct an aquatic ecological assessment of the Braamfonteinspruit in Johannesburg, Gauteng as part of the rehabilitation initiative to be implemented by the Johannesburg Roads Agency (JRA) and as required in terms of the National Environmental Management Act (Act 107 of 1998) and the National Water Act (Act 36 of 1998).

This document presents the results obtained during the ecological survey of aquatic ecosystems during the autumn high flow season (March 2016). It includes a desktop assessment of the aquatic ecosystems and a field assessment which includes an assessment of the in situ water quality at a number of points along the Braamfonteinspruit, a survey of habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate community integrity, diatom analysis and toxicological analysis at various problem areas along the length of the main stem of the Braamfonteinspruit. The sampling sites were selected to highlight the present ecological state at various points along the Braamfonteinspruit to highlight the various issues impacting the watercourse, as well as highlight the specific intervention measures required for suitable rehabilitation of the identified problem areas observed. The protocols of applying the indices were strictly adhered to and all work was carried out by a South African River Health Program (SA RHP) accredited assessor. An impact assessment based on the findings of both the desktop and field assessments is provided.

The study aims to define the Ecological Importance and Sensitivity (EIS) and Present Ecological State (PES) of the main stem of the Braamfonteinspruit and further aims to identify risks and both current and potential impacts on the watercourse as well as to define measures to manage and mitigate these impacts. Special attention will be paid to current impacts identified as a result of:

- Instability of the natural watercourse as a result of erosion due to increased flood peaks;
- Blockage of road crossings as a result of debris and excessive siltation;
- Under capacity of road crossings and drainage structures; and
- Environmental degradation due to the loss of soil cover and vegetation.

In addition, attention will be given to manage and mitigate potential impacts related to the anticipated intervention activities including:

- Upgrades of undersized bridge and culvert crossings;

- Implementation of erosion control measures along the river banks (such as rock cladding and gabion structures);
- Reshaping and reprofiling of the river banks; and
- Implementation of siltation control structures and artificial wetlands.

In order to assess the levels of aquatic ecological integrity of this section of the Braamfonteinspruit, careful site selection took place. The following criteria were used in identifying suitable sites:

- The site location in relation to identified problem areas and other areas of concern along the watercourse;
- Accessibility with a vehicle in order to allow for the transport of equipment; and
- As far as possible, sites were also selected where there were good habitat conditions with a good level of diversity, suitable for supporting a diverse aquatic community.

Fifteen sites were assessed as indicated in a digital satellite image in Figures 1 and 2, which shows the full biomonitoring points in red and sites where only visual and water quality assessments were conducted are shown in green (Table 1).

Table 1: Co-ordinates of each sample site.

Site	Description	GPS co-ordinates	
		South	East
BS1	Located in the upper reaches of the Braamfonteinspruit, adjacent to Barry Hertzog Ave and approximately 800m North of Empire Road, Richmond.	26°10'33.66"S	28°01'01.14"E
BS2	Located at the Southern end of the Parkview Golf course in the vicinity of the intersection between Mowbray Road and Barry Hertzog, Melville.	26°10'13.78"S	28°00'52.71"E
BS3	Located within the Parkview Golf course approx. 150 m north of Gleneagles Road, Greenside.	26°08'59.75"S	28°01'18.38"E
BS4	Located within the Parkview Golf course approx. 300 m north of Gleneagles Road, Greenside.	26°08'54.67"S	28°01'17.25"E
BS5	Located just off of Rustenburg Road opposite the Victory Park Shopping Centre, between Victory Park and Parkhurst.	26°08'17.77"S	28°04'38.58"E
BS6	Located at the intersection between Conrad Drive and Jan Smuts, Blairgowrie.	26°06'54.46"S	28°01'11.25"E
BS7	Located upstream of the confluence of the Braamfonteinspruit with an unnamed tributary near the intersection of Republic Road and William Nicol Road.	26°05'35.76"S	28°01'34.76"E
BS8	Located on the unnamed tributary that confluences with the Braamfonteinspruit near the intersection of Republic Road and William Nicol Road.	26°05'36.12"S	28°01'38.38"E
BS9	Located where the Braamfonteinspruit flows under Ballyclare Drive, Riverclub.	26°04'24.77"S	28°02'17.25"E

Site	Description	GPS co-ordinates	
		South	East
BS10	Located at the low lying bridge on Belgrave Road, between The River Road and Brooke Avenue, Riverclub.	26°03'57.51"S	28°02'29.25"E
BS11	Located where the Braamfonteinspruit flows under Bryanston Drive and adjacent to Brooke Avenue, Bryanston.	26°03'36.86"S	28°02'53.79"E
BS12	Located where the Braamfonteinspruit flows under Cowley Street, Rivonia.	26°02'34.96"S	28°03'02.60"E
BS13	Located at the confluence of the Braamfonteinspruit with the Sand Spruit near Umfolozi Road, Paulshof.	26°01'37.41"S	28°03'26.34"E
BS14	Located further downstream of the confluence of the Braamfonteinspruit with the Sand Spruit near Umfolozi Road, Paulshof).	26°01'33.49"S	28°03'28.13"E

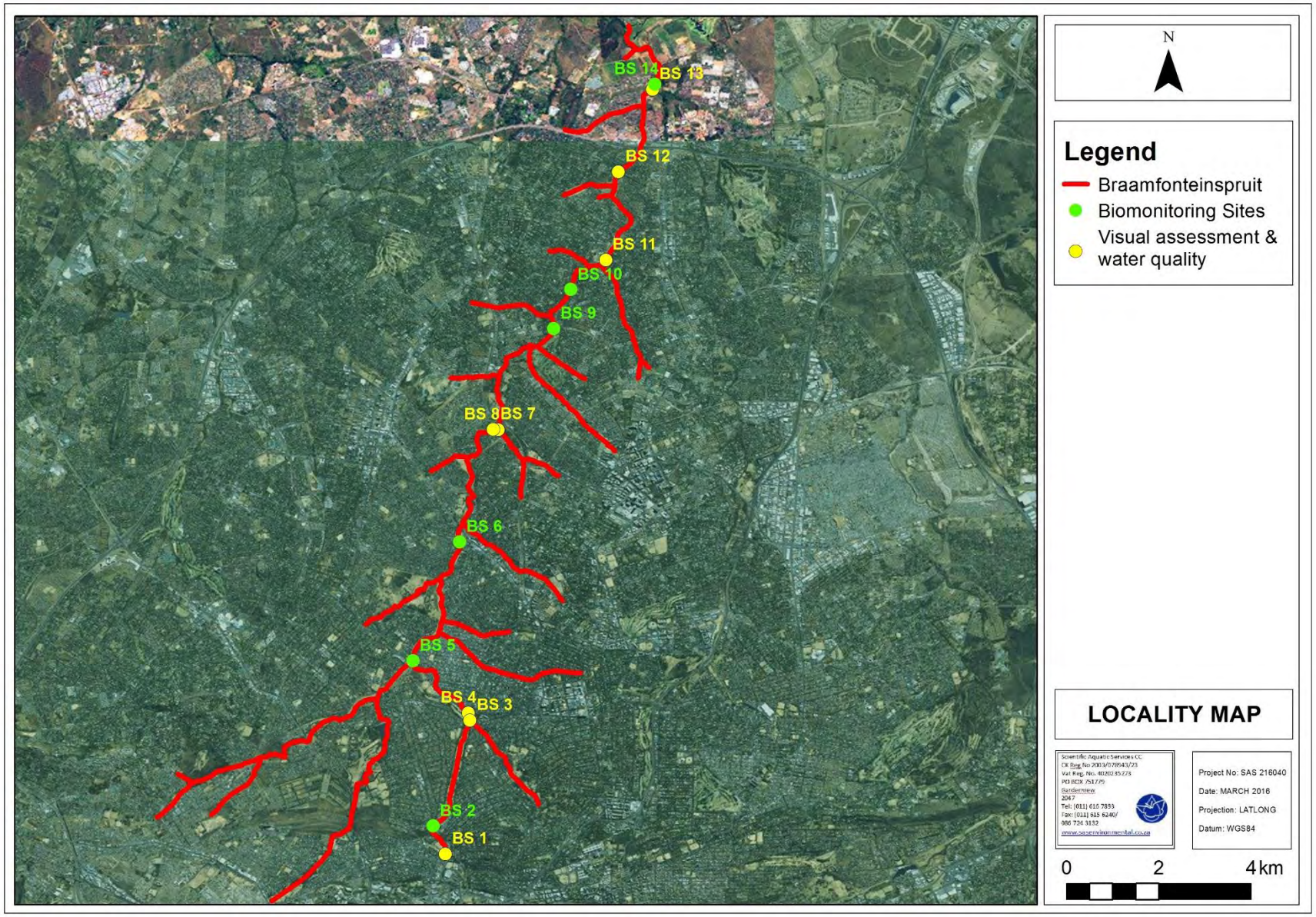

Figure 1: Assessment points presented on an aerial photograph

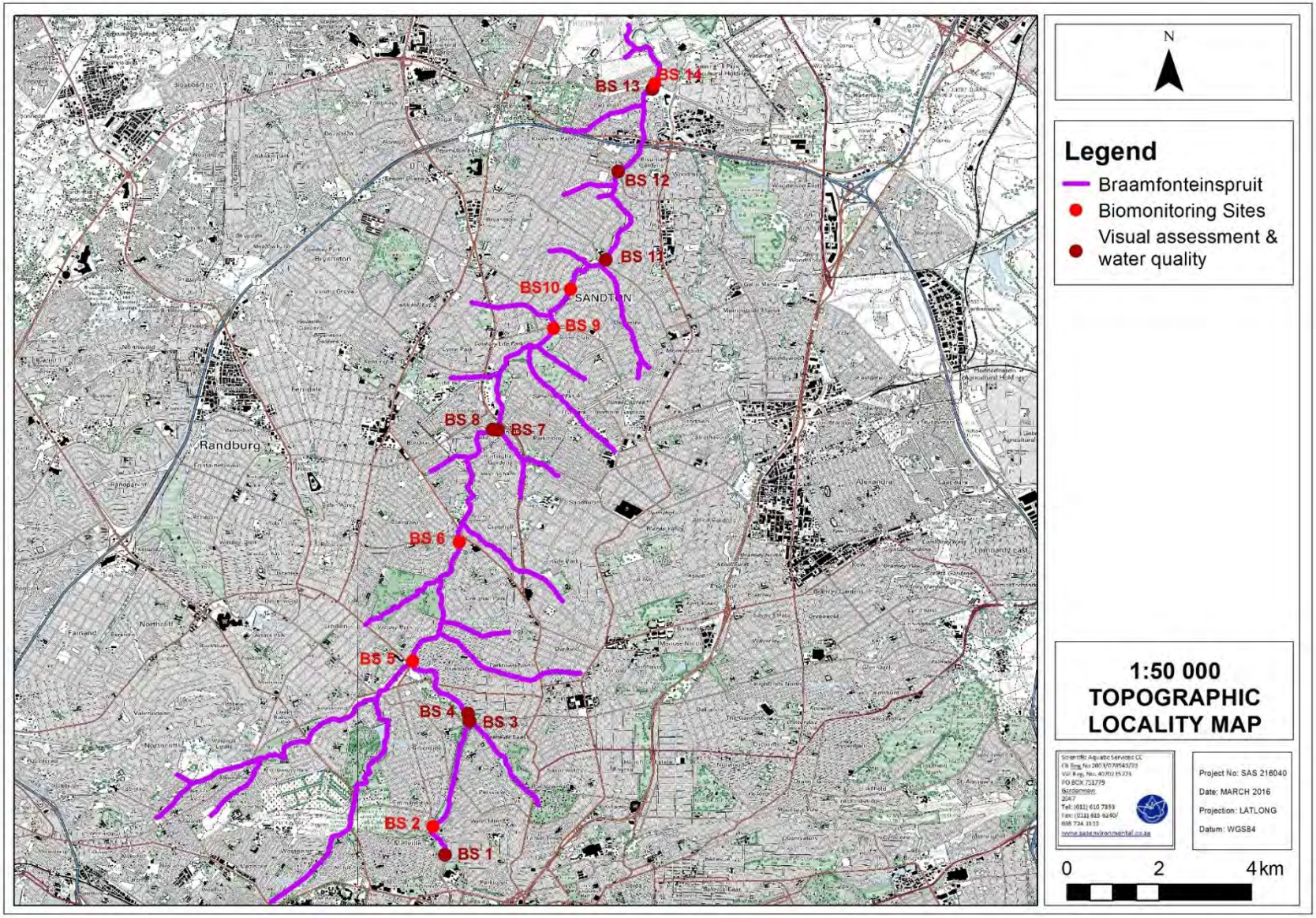

Figure 2: Assessment points presented on a topographic locality map.

2. METHOD OF INVESTIGATION

This study is comprised of both a desktop study as well as a field assessment, the results of which have been used to compile a detailed impact assessment of the proposed rehabilitation and intervention project associated with the Braamfonteinspruit watercourse. A background study, including a literature review, was conducted in order to determine the Ecoregion and Ecostatus of the main stem of the Braamfonteinspruit, situated in Johannesburg, Gauteng. Best practice methodologies (detailed methodologies to be provided on request) were used to assess the aquatic ecological integrity of the various assessment sites based on water quality, instream and riparian habitat condition and biological impacts and integrity. All work was undertaken by a South African River Health Program (SA RHP) accredited assessor. Factors investigated included, but are not all encompassing along the entire length of the Braamfonteinspruit, the following:

- Visual conditions of the site, including an assessment of impacts on the stream, at each point;
- On-site testing of biota specific water quality parameters including pH, electrical conductivity (EC), dissolved oxygen concentration (DO) and temperature. The results aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems as defined by the Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF 1996 vol. 7);
- Habitat suitability for aquatic macro-invertebrates was determined using the IHAS (Invertebrate Habitat Assessment System) method and was applied according to the protocol of McMillan (1998);
- The integrity of the aquatic macro-invertebrate community was assessed using the SASS5 (South African Scoring System version 5) as defined by Dickens & Graham (2002);
- Interpretation of the results, in relation to reference scores, was made according to the classification of SASS5 scores presented in the SASS5 methodology, published by Dickens & Graham (2002) as well as according to the SASS5 data interpretation guidelines (Dallas 2007). Aquatic macro-invertebrates expected within the system were derived from the DWS Resource Quality Information Services (RQIS) PES/EIS database;
- The integrity of the fish community was assessed using the FRAI (Fish Response Assessment Index) (Kleynhans 2008);

- Sampling of diatom communities was performed according to the methodology described by Taylor *et al.* (2007a) and Taylor *et al.* (2005) and taxa were identified mainly according to standard floras (Krammer and Lange- Bertalot, 2000); and
- Due to the urban proximity of the Braamfonteinspruit and thus the increased potential for impacts related to urban runoff, sewage and the ingress of pollutants such as hydrocarbons to the system, toxicological testing was carried out in order to qualify and quantify the toxicological risk the water in the Braamfonteinspruit poses to the aquatic communities likely to occur along the length of the Braamfonteinspruit. To assess possible acute effects on aquatic organisms, acute WET tests were performed. The battery of WET tests included *Daphnia pulex* (representing aquatic macro-invertebrates), *Poecilia reticulata* (representing fish), *Vibrio fischeri* (representing bacteria) and *Selenastrum capricornutum* (representing algae). Test organisms were exposed to water samples under controlled laboratory conditions. Tests were run along strictly defined protocols of the US EPA (2002) for the waterflea test, US EPA (1996) for the fish test, EN ISO 11348-3 (2007) for the bacteria test and the OECD Guideline 201 (2006) for the algae test. The results from these tests would indicate if there is any risk to the aquatic ecological integrity of the receiving environment on any one of the four trophic levels assessed as a result of current impacts expressed on the Braamfonteinspruit.

3. RESULTS AND INTERPRETATION

3.1 Ecoregion

The main stem of the Braamfonteinspruit is the longest stream in Johannesburg, Gauteng, originating from a natural spring in Berea, the watercourse runs through Pieter Roos Park, down Empire Road to the Frank Brown Park and towards the German School in Auckland Park. The watercourse then flows towards and through the Parkview Golf Course, where sections of the watercourse are canalised. The Braamfonteinspruit then exits the golf course and runs through Parkhurst, where it is joined by the Westdene Spruit tributary. The watercourse continues through Blairgowrie, River Club, Bryanston, Rivonia and Sunninghill. In Sunninghill, the Braamfonteinspruit joins the Sand Spruit, before confluencing with the Jukskei River in Leeuwkop Prison. According to Mucina and Rutherford (2006), the upper reaches of the Braamfonteinspruit occur in the Soweto Highveld Grassland, with a small portion then running through Gold Reef Mountain Bushveld and the remainder and majority portions of the Braamfonteinspruit then falling within the Egoli Granite Grassland, grassland

and savanna biomes. The entire length of the Braamfonteinspruit watercourse is situated within the Highveld Aquatic Ecoregion (refer to Figure 3) (Kleynhans et al., 2005). The desktop information for this ecoregion is used as the source of background information.

The Highveld Aquatic Ecoregion can be considered to contain relatively moderate aquatic macro-invertebrate community diversity and sensitivity (Dallas, 2007). Historically, a fairly diverse fish community was expected in these systems, however, current impacts in terms of flow modifications, weirs and impoundments along the length of this watercourse have resulted in a significant loss of fish diversity within the more heavily urbanised areas within the Gauteng region.

Table 2: Main attributes of the Highveld Aquatic Ecoregion.

MAIN ATTRIBUTES	HIGHVELD
Terrain Morphology: Broad division (dominant types in bold) (Primary)	Plains; Low Relief; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief (limited)
Vegetation types (dominant types in bold) (Primary)	Mixed Bushveld limited); Rocky Highveld Grassland; Dry Sandy Highveld Grassland; Dry Clay Highveld Grassland; Moist Cool Highveld Grassland; Moist Cold Highveld Grassland; North Eastern Mountain Grassland; Moist Sandy Highveld Grassland; Wet Cold Highveld Grassland (limited); Moist Clay Highveld Grassland; Clay Highveld Grassland: Patches Afromontana Forest (very limited)
Altitude (m a.m.s.l) (modifying)	1100-2100, 2100-2300 (very limited)
MAP (mm) (Secondary)	400 to 1000
Coefficient of Variation (% of annual precipitation)	<20 to 35
Rainfall concentration index	45 to 65
Rainfall seasonality	Early to late summer
Mean annual temp. (°C)	12 to 20
Mean daily max. temp. (°C): February	20 to 32
Mean daily max. temp. (°C): July	14 to 22
Mean daily min. temp. (°C): February	10 to 18
Mean daily min temp. (°C): July	-2 to 4
Median annual simulated runoff (mm) for quaternary catchment	5 to >250

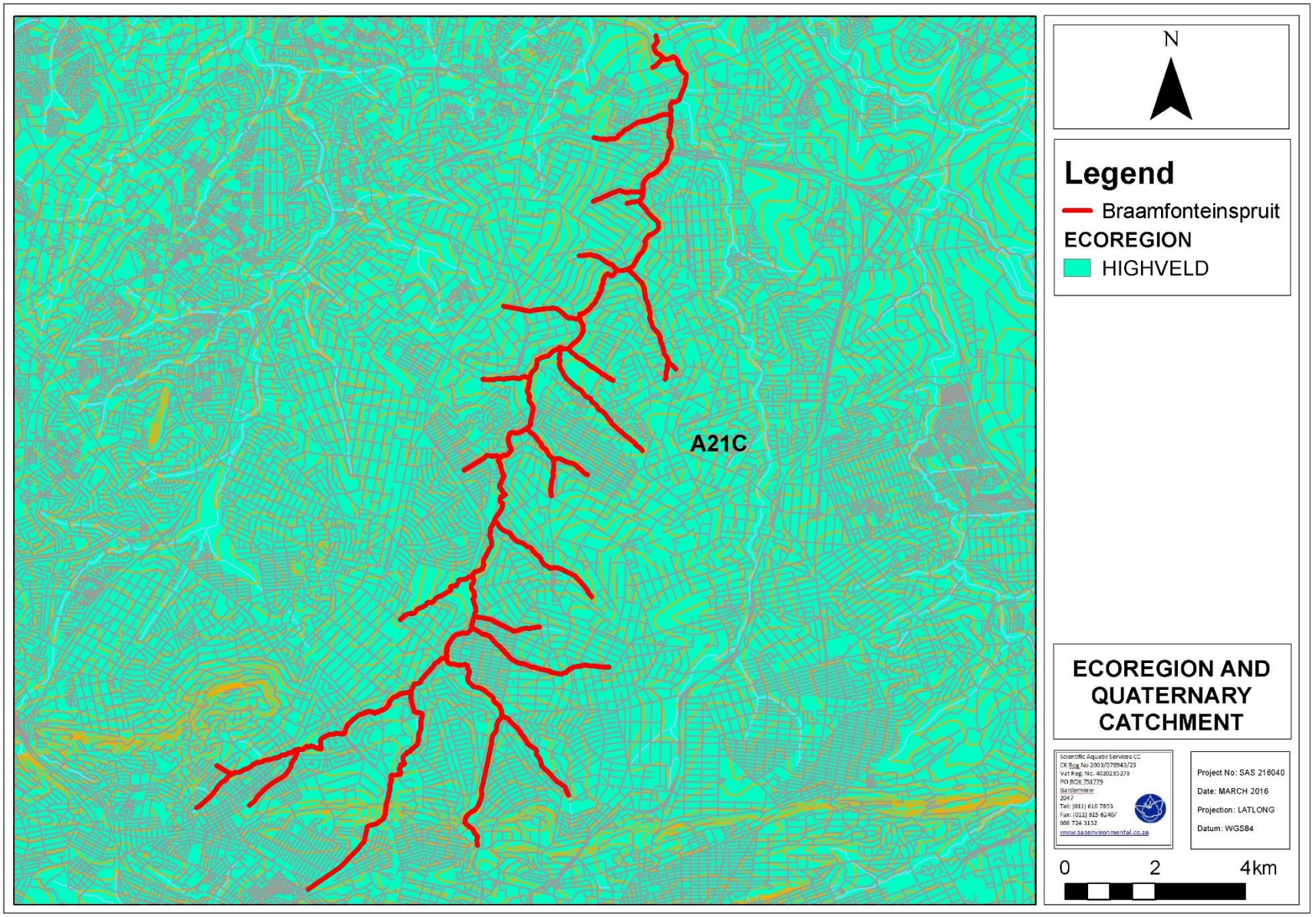

Figure 3: Assessment points presented on level 1 Aquatic Ecoregions and Quaternary Catchment map.

3.2 Ecostatus

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems prior to assessment, or as part of a desktop assessment. The study area falls within the A21C quaternary catchment (Figure 3).

This database was searched for the quaternary catchment of concern (A21C) in order to define the EIS, PEMC and DEMC. According to the ecological importance classification for the A21C quaternary catchment, the Jukskei River system, into which the Braamfonteinspruit flows, can be classified as a moderately sensitive system which, in its present state can be considered to be a Class C (Moderately Modified) stream (Class D based on desktop certainty). The findings are based on a study undertaken by Kleynhans (1999) as part of "A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers". The results of the assessment are summarised in the table below. It must however be noted that the results of this study are now largely outdated and with the results more applicable to the larger Jukskei River system, they must be interpreted and extrapolated with caution.

Table 3: Summary of the ecological status of quaternary catchment A21J, based on Kleynhans 1999.

Catchment	Resource	EIS	PEMC	DEMC
A21C	Jukskei	Moderate	Class BC	Class C: Moderately sensitive systems

The points below summarise the impacts on the aquatic resources in this quaternary catchment (Kleynhans 1999):

- The aquatic resources in this quaternary catchment provide a moderate diversity of habitat with both pools and riffles being present;
- The aquatic resources in this quaternary catchment have a low importance in terms of natural areas conservation;
- The aquatic resources in this quaternary catchment are regarded as having a high importance for rare and endangered aquatic species conservation, with special mention of *Opsaridium peringueyi;*

- The aquatic resources in this quaternary catchment are of a low importance in terms of the maintenance of unique habitats and endemic species, however, *Amphilius uranoscopus* is recorded as being reliant on this system;
- The aquatic resources in this quaternary catchment are considered to be of low importance in terms of provision of migration routes in the instream and riparian environments;
- The aquatic resources in this quaternary catchment have a moderate importance in terms of providing refugia for aquatic community members;
- The aquatic resources in this quaternary catchment can be considered to be moderately sensitive to changes in water quality and relatively sensitive to changes in flow; and
- The aquatic resources in this quaternary catchment are of moderate importance in terms of species richness.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- High impact on the bed structure of the Jukskei River has occurred at this point in time;
- Very high flow modification has occurred due to changes in the flood peaks along the length of this watercourse as a result of altered flow regimes and severely increased urban runoff reaching the system during rainfall events within the catchment;
- High impact in the catchment from the introduction of alien fish species, namely *Cyprinus carpio* and *Gambusia affinis*, has occurred;
- Very high impact from inundation is evident at the present time due to the construction of weirs within this quaternary catchment; and
- High riparian impacts from riparian activities are evident and the riparian vegetation of the area is often affected due to the encroachment of various exotics along the entire length of this watercourse.

3.3 Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS Database

According to the PES/EIS database, as developed by the DWS RQIS department, the following sub-quaternary catchment reaches (SQR) are applicable to the proposed Braamfonteinspruit rehabilitation project:

A21C-01254 Braamfonteinspruit

A21C-01262 Braamfonteinspruit

Key information on the background conditions in the vicinity of the proposed rehabilitation project, as contained in this database and pertaining to the Present Ecological State (PES), Ecological Importance and Ecological Sensitivity (EIS) for the Braamfonteinspruit is tabulated in the tables below.

From the assessment of the PES/EIS data, the following points are highlighted, which summarise the data:

The Ecological Importance (EI) data for SQR A21C-01254 and A21C-01262 (Braamfonteinspruit) has no recorded data for the occurrence of either fish or aquatic macro-invertebrate communities expected to occur in this section of the catchment. The tables below provide a summary of the data available for these two reaches.

Table 4: Summary of the ecological status of the sub-quaternary catchment (SQ) reach SQR A21C-01254 (Braamfonteinspruit) based on the DWS RQIS PES/EIS database.

Synopsis (SQ reach A21C-01254)					
PES[1] category median	Mean EI[2] class	Mean ES[3] class	Length	Stream order	Default EC[4]
E	Low	Moderate	1.81	2	C
PES details					
Instream habitat continuity MOD		Serious	Riparian/wetland zone MOD		Large
RIP/wetland zone continuity MOD		Serious	Potential flow MOD activities		Serious
Potential instream habitat MOD activities		Serious	Potential physico-chemical MOD activities		Serious
EI details					
Fish spp/SQ		3.00	Fish average confidence		1.0
Fish representivity per secondary class		Very low	Fish rarity per secondary class		Very low
Invertebrate taxa/SQ		24.00	Invertebrate average confidence		3.00
Invertebrate representivity per secondary class		Moderate	Invertebrate rarity per secondary class		Moderate
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating		Low	Habitat diversity class		Very low
Habitat size (length) class		Very low	Instream migration link class		Low
Riparian-wetland zone migration link		Low	Riparian-wetland zone habitat integrity class		Moderate
Instream habitat integrity class		Low	Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m		Low
Riparian-wetland natural vegetation rating based on expert rating					High
ES details					
Fish physical-chemical sensitivity description		Low	Fish no-flow sensitivity		Low
Invertebrates physical-chemical sensitivity description		Moderate	Invertebrates velocity sensitivity		Very high
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description					Low
Stream size sensitivity to modified flow/water level changes description					Low
Riparian-wetland vegetation intolerance to water level changes description					High

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.
NA = Not Available

Table 5: Summary of the ecological status of the sub-quaternary catchment (SQ) reach SQR A21C-01262 (Braamfonteinspruit) based on the DWS RQIS PES/EIS database.

Synopsis (SQ reach A21C-01262 Braamfonteinspruit)					
PES[1] category median	Mean EI[2] class	Mean ES[3] class	Length	Stream order	Default EC[4]
E	Low	Moderate	20.51	1	C
PES details					
Instream habitat continuity MOD		Serious	Riparian/wetland zone MOD		Serious
RIP/wetland zone continuity MOD		Serious	Potential flow MOD activities		Serious
Potential instream habitat MOD activities		Serious	Potential physico-chemical MOD activities		Critical
EI details					
Fish spp/SQ		3.00	Fish average confidence		1.0
Fish representivity per secondary class		Very low	Fish rarity per secondary class		Very low
Invertebrate taxa/SQ		25.00	Invertebrate average confidence		4.44
Invertebrate representivity per secondary class		Moderate	Invertebrate rarity per secondary class		High
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating		Low	Habitat diversity class		Very low
Habitat size (length) class		Low	Instream migration link class		Low
Riparian-wetland zone migration link		Low	Riparian-wetland zone habitat integrity class		Low
Instream habitat integrity class		Low	Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m		Very low
Riparian-wetland natural vegetation rating based on expert rating					High
ES details					
Fish physical-chemical sensitivity description		Low	Fish no-flow sensitivity		Low
Invertebrates physical-chemical sensitivity description		Moderate	Invertebrates velocity sensitivity		Very high
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description					Low
Stream size sensitivity to modified flow/water level changes description					High
Riparian-wetland vegetation intolerance to water level changes description					High

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.
NA = Not Available

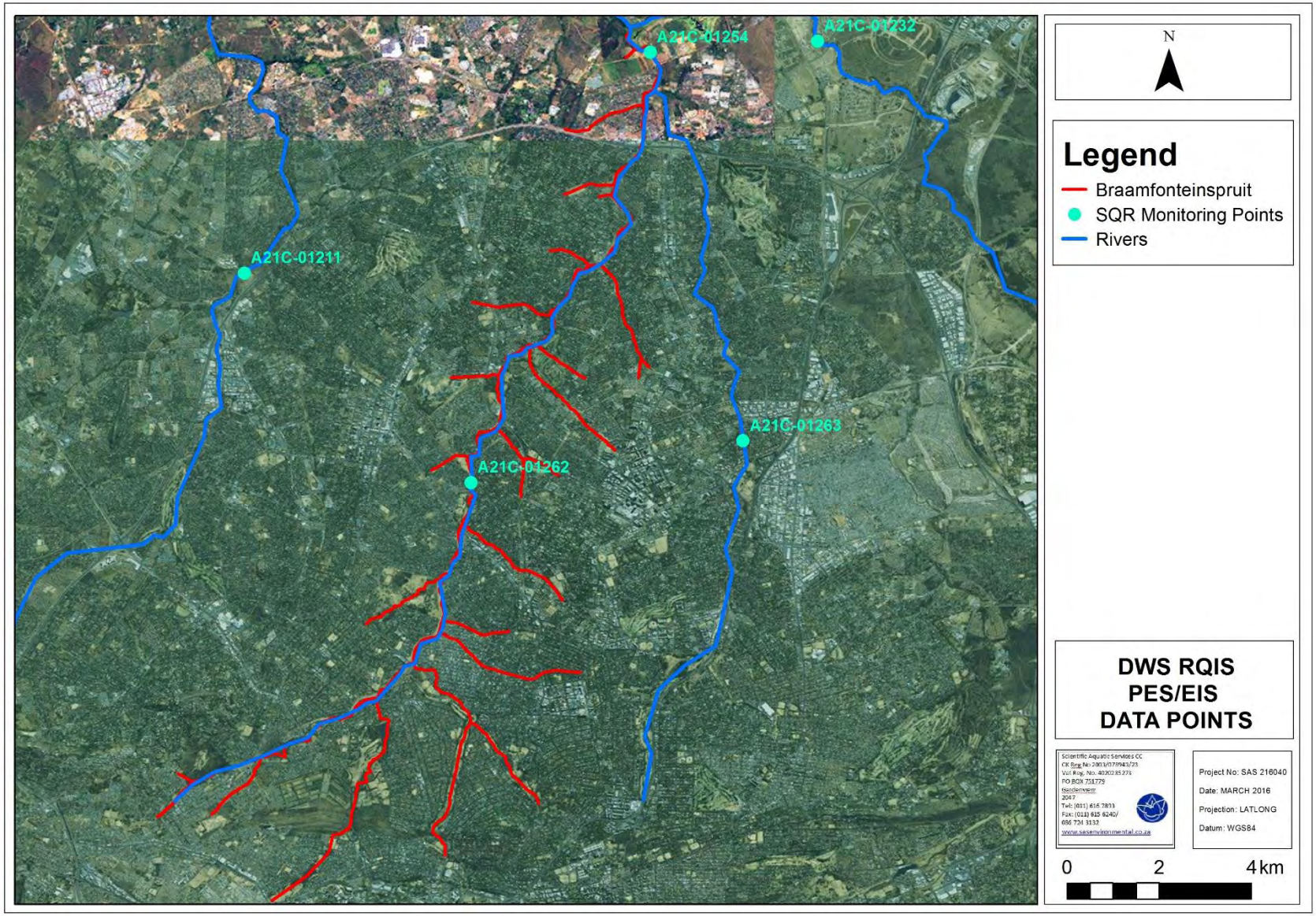

Figure 4: DWS RQIS PES/EIS sub-quaternary catchment reaches (SQRs) indicated in the vicinity of the study area.

3.4 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) (2011), database was consulted to define the aquatic ecology of the main stem of the Braamfonteinspruit rehabilitation project that may be of ecological importance. Aspects applicable to this project are discussed below.

- The subject property falls within the Crocodile (West) and Marico Water Management Area (WMA). Each Water Management Area is divided into several sub-Water Management Areas (subWMA), where catchment or watershed is defined as a topographically defined area which is drained by a stream or river network. The Sub-Water management unit indicated for the subject property is the Upper Crocodile sub-WMA;
- The study area is situated in the vicinity of five FEPA Rivers, the Braamfonteinspruit, the Modderfontein, the Sandspruit, the Jukskei and the Klein-Jukskei (Figure 5); and
- All five of the above-mentioned rivers may be classified as being Class D (largely modified) rivers.

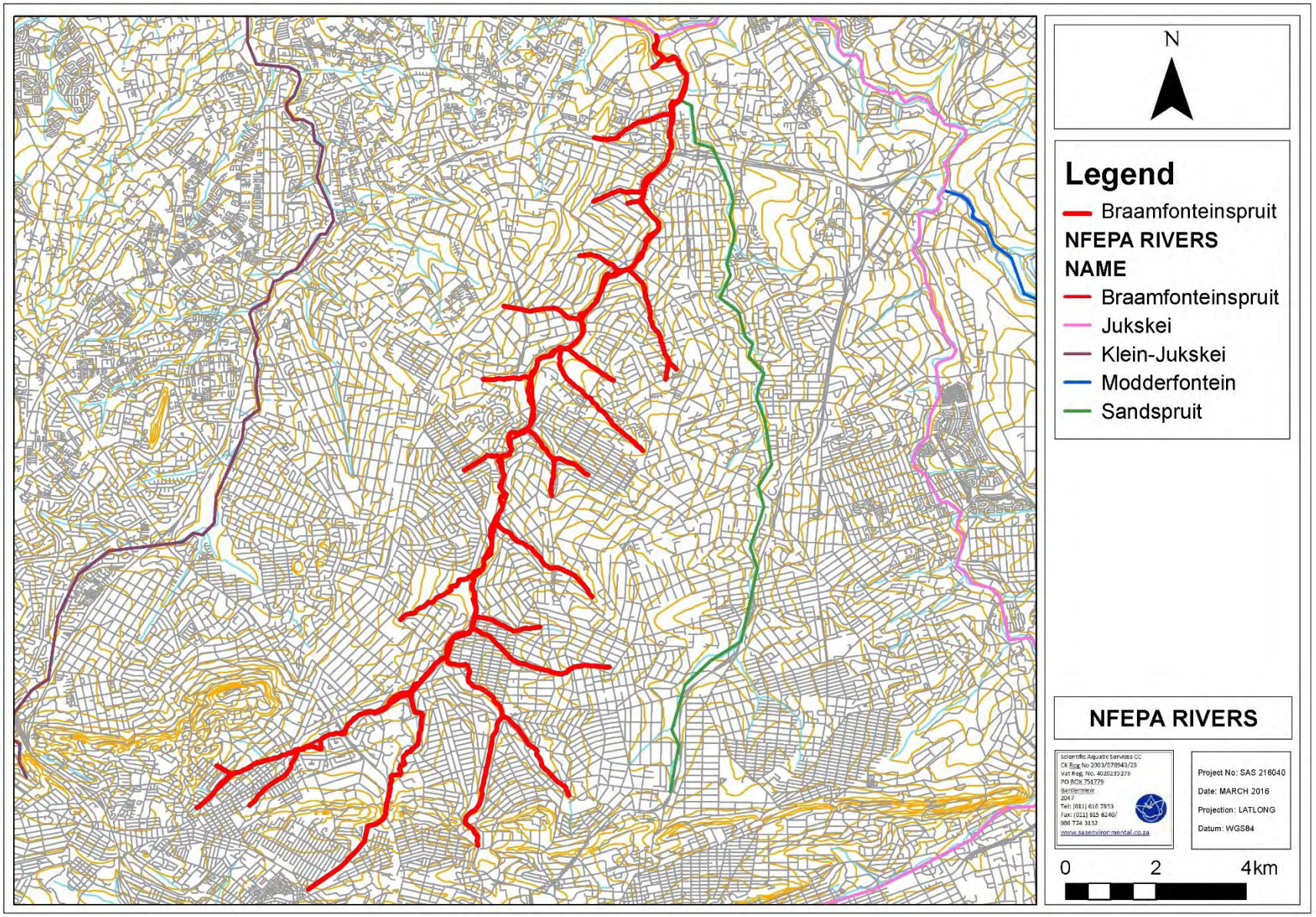

Figure 5: Rivers occurring in and around the study area according to the NFEPA database.

3.5 Field assessment

3.5.1 The Braamfonteinspruit

Results are presented as “dashboard” reports (Tables 6 to 19 as well as Figures 6 to 19). These dashboard reports aim to present concise summaries of the data on as few pages as possible in order to allow for integration of results by the reader to take place. Where required further discussion and interpretation is provided. The dashboard tables that follow present the results obtained at each assessment site on the Braamfonteinspruit on application of the various aquatic indices briefly described in Section 2.

Table 6: Results of the assessment at Site BS 1 (located in the upper reaches of the Braamfonteinspruit, adjacent to Barry Hertzog Ave and approximately 800m North of Empire Road, Richmond).

Site BS 1		*In situ* physico-chemical water quality	
 Figure 6: General upstream view of the BS 1 site at the time of the assessment (left) indicating the point where the Braamfonteinspruit emerges from underground. Flow within the canal at this point is severely affected as a result of sediment deposits, rubble instream and also establishing Kikuyu stands (right).		pH EC (mS/m) DO (mg/L) DO (% sat) Temp (℃)	7.95 48.9 4.91 68.49 24.6
Algal proliferation	No algal proliferation was evident at the current time.	Current impacts and Essential Mitigation ➢ Severe water quality impacts as a result of industrial activities upstream of this point; ➢ The river is completely canalised at this point and natural substrates are thus absent; ➢ Severe impacts in terms of exotic alien vegetation encroachment, with special mention of Kikuyu; ➢ Litter observed instream; ➢ Large pieces of rubble observed instream; ➢ Significant sedimentation affecting the instream substrates and flow at this point.	
Depth profiles	The stream was relatively shallow at this point (generally <½ m).		
Flow condition	The stream consisted of very slow runs and still pools.		
Dominant instream substrate	The river at this point emerges from underground and is completely canalized, some sediment deposits as well as rubble is present within the channel and some vegetation cover has become established on these deposits.		
Water clarity and odour	Water emerging from underground was grey-blue in colour, thereafter taking on a silty brown appearance. No obvious odour.		
Riparian zone characteristics	The banks of the Braamfonteinspruit are completely canalised at this point. Some stands of Kikuyu have become established on some of the instream sediment deposits at this point.		
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Pennisetum clandestinum, Celtis sinensis, Persicaria lapathifolia*		

Table 7: Results of the assessment at Site BS 2 (located at the Southern end of the Parkview Golf course in the vicinity of the intersection between Mowbray Road and Barry Hertzog, Melville).

Site BS 2

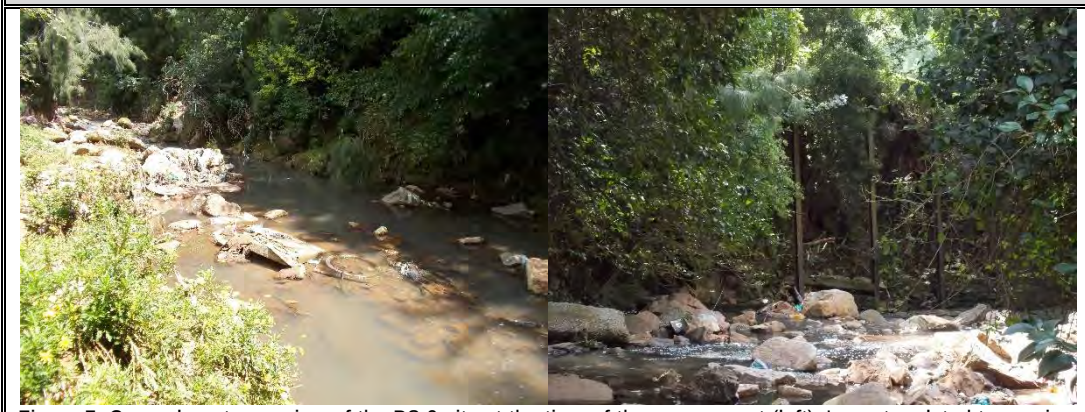

Figure 7: General upstream view of the BS 2 site at the time of the assessment (left). Impacts related to erosion, incision, failure of bank stabilizing structures, instream little and rubble and alien vegetation encroachment (right).

In situ physico-chemical water quality

pH	7.60
EC (mS/m)	40.0
DO (mg/L)	5.48
DO (% sat)	75.89
Temp (℃)	24.2

Invertebrate community assessment (SASS5 and IHAS)

	Scores	% of Reference Scores
SASS5	6	2.6%
Number of taxa	3	NA
ASPT	2	29.9%
IHAS	64 (Inadequate)	NA
MIRAI	23.08	NA

Algal proliferation	Significant algal proliferation at this point
Depth profiles	The stream was relatively shallow at this point (generally <½ m).
Flow condition	The stream consisted of very slow flowing glides, runs and pools.
Water clarity and odour	Water was very discoloured. A slight chemical odour was noted at this point.
Riparian zone characteristics	Very narrow and severely incised (bank height approx. 3 – 4 m). Incision, erosion and bank failure is evident. Collapse of historical bank stabilisation structures/canals. Significant alien vegetation encroachment.
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Morus alba, Celtis sinensis, Acacia mearnsii*, sparce understory.

Diatom analysis

Specific Pollution Sensitivity Index (SPI)	1.7
Pollution Tolerant Valves (% PTV)	93.3

Comments relating to diatom community composition

- Based on the OMNIDIA results, the ecological water quality at this point is a category E (Bad quality);
- Recorded at this point is prevalent taxon *Nitzschia palea, a* cosmopolitan taxon found in highly eutrophic, electrolyte-rich, extremely polluted waters and implies that this site is severely anthropogenically impacted.

Toxicological analysis

Daphnia pulex % mortality	30
Poecilia reticulata % mortality	13
Vibrio fischeri growth/inhibition	+19
Selenastrum capricornutum growth/inhibition	-33

Comments relating to toxicity

The toxicological results at this point indicate a toxicological impact in the upper reaches of the Braamfonteinspruit before any significant impacts as a result of the ingress of sewage, urban runoff and the ingress of pollutants such as hydrocarbons and motor oils. Specific impacts are thus suspected to be taking place as a result of industry in the upper most reaches of this stream. It is deemed critical that the sources of any industrial or chemical pollution into the Braamfonteinspruit upstream of this point be identified and suitably mitigated as impacts affecting the water to such an extent so high up in the catchment is deemed to critically affect the integrity of the Braamfonteinspruit along the entire length of the system in a downstream direction.

SITE ECOSTATUS CATEGORY	
Dickens & Graham (2002)	Category F
Dallas (2007)	Category E/F
MIRAI	Category E
Diatom analysis	Category E (Bad quality)
Toxicological analysis	Class 2 (Slight Acute Hazard)

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Failure of historical bank stabilisation infrastructure;
- Debris from concrete and failing infrastructure including pipes, bricks, metal sheets and poles, etc.
- Litter observed instream as well as in the riparian area including car tyres, fabric, various paper and plastic refuse.

NA = Not Applicable, SASS5 reference score = 230, ASPT reference score =6.7

Table 8: Results of the assessment at Site BS 3 (located within the Parkview Golf course approx. 150 m north of Gleneagles Road, Greenside).

Site BS 3

Figure 8: Local view of the BS 3 site at the time of the assessment (left) indicating bank failure, incision and erosion at this point. Banks are heavily incised and bankside vegetation is absent in some areas (right).

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was relatively deep at this point (generally ½ - 1 m), however some shallower riffle and rapid areas were observed.
Flow condition	The stream consisted of a mix of flow types with still to slow flowing pools and faster runs and rapids.
Dominant instream substrate	The concrete channel ends at this point and drops into natural substrate of bedrock and large boulders and cobble areas with sediment deposits in some areas.
Water clarity and odour	Very discoloured, however, no odours evident.
Riparian zone characteristics	Severe incision, bank failure and erosion was observed in some areas where bankside vegetation was absent. Bankside vegetation is dominated by grasses and creepers with little tree and shrub cover at this point.
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*

In situ physico-chemical water quality

pH	7.71
EC (mS/m)	41.0
DO (mg/L)	6.28
DO (% sat)	84.92
Temp (℃)	22.9

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding. Erosion and incision is aggravated at this point as a result of inadequate energy breakers downstream of the concrete channel;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of the concrete channel which ends at this point;
- Large pieces of rubble, metal debris and collapsed infrastructure observed instream;
- Some historical bank stabilasation in some areas at this point.

Table 9: Results of the assessment at Site BS 4 (located within the Parkview Golf course approx. 300 m north of Gleneagles Road, Greenside).

Site BS 4

Figure 9: Local view of the BS 4 site at the time of the assessment (left) indicating bank failure, incision and erosion at this point. Banks are heavily incised and bankside vegetation is absent in some areas (right).

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was relatively shallow at this point (generally ½m).
Flow condition	The stream consisted of a mix of flow types with still to slow flowing pools and faster runs and rapids.
Dominant instream substrate	Large boulders, cobble and sediment deposits
Water clarity and odour	Slightly discoloured, however, no odours evident.
Riparian zone characteristics	Gradual well vegetated slopes, with some exposed soils observed in some areas.
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*

In situ physico-chemical water quality

pH	7.68
EC (mS/m)	41.0
DO (mg/L)	6.19
DO (% sat)	83.08
Temp (℃)	22.5

Current impacts and Essential Mitigation

- Litter both instream as well as in the riparian zone;
- Construction debris, metal and concrete debris in the active channel;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Quite a few stormwater inlets were observed between sites BS 3 and BS 4, which may play a role in aggravating erosion and incision under high rainfall conditions as well as affect water quality in a downstream direction.

Table 10: Results of the assessment at Site BS 5 (located just off of Rustenburg Road opposite the Victory Park Shopping Centre, between Victory Park and Parkhurst).

Site BS 5

Figure 10: General upstream view of the BS 5 site at the time of the assessment (left) indicating severe incision and erosion at this point. Impacts related to litter, sedimentation and alien vegetation encroachment (right) are evident.

In situ physico-chemical water quality

pH	7.62
EC (mS/m)	34.0
DO (mg/L)	6.47
DO (% sat)	84.58
Temp (℃)	21.1

Invertebrate community assessment (SASS5 and IHAS)

	Scores	% of Reference Scores
SASS5	50	21.7%
Number of taxa	11	NA
ASPT	4.5	67.2%
IHAS	81 (Highly suited)	NA
MIRAI	44.1	NA

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream consisted of a variety of depth profiles at this point, with deep pools and shallower riffles, rapids and runs at the time of the assessment.
Flow condition	Mixed flow types at this point at the time of the assessment.
Water clarity and odour	Discoloured. No odours evident.
Riparian zone characteristics	Narrow and severely incised. Incision, erosion and bank failure is evident in some areas. Significant alien vegetation encroachment.
Dominant species observed in the riparian zone (Aliens marked with **an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*

Diatom analysis

Specific Pollution Sensitivity Index (SPI)	4.0
Pollution Tolerant Valves (% PTV)	83.0

Comments relating to diatom community composition

- Based on the OMNIDIA results, the ecological water quality at this point may be classified as a category E (Bad quality);
- Recorded at this point is the presence of prevalent taxon *Sellaphora seminulum, a* cosmopolitan taxon found in highly eutrophic, electrolyte-rich, extremely polluted waters and implies that this site is severely anthropogenically impacted.

Toxicological analysis

Daphnia pulex % mortality	20
Poecilia reticulata % mortality	38
Vibrio fischeri growth/inhibition	+29
Selenastrum capricornutum growth/inhibition	-27

Comments relating to toxicity

The toxicological results at this point indicate a slight deterioration in the toxicological threat posed to fish in this section of the Braamfonteinspruit, while a slight improvement in terms of macro-invertebrate mortalities is observed. Algal growth inhibition remains largely unchanged in relation to the BS 2 site, while an increase in bacterial growth stimulation is evident. The improvement in dissolved oxygen concentrations as well as the reduced EC concentration in relation to the BS 2 site is likely to play a role in the reduced mortality rate observed in the aquatic macro-invertebrate toxicity test, however, the declining mortality rate in the fish toxicity test serves as an indication that water quality is still largely affected by the ingress of specific chemical and biological pollutants upstream of this point. As with site BS 2, the toxicological threat at this point may be categorised as a Class 2 (Slight Toxicological Hazard).

SITE ECOSTATUS CATEGORY	
Dickens & Graham (2002)	Category E
Dallas (2007)	Category E/F
MIRAI	Category D
Diatom analysis	Category E (Bad quality)
Toxicological analysis	Class 2 (Slight Acute Hazard)

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.

NA = Not Applicable, SASS5 reference score = 230, ASPT reference score = 6.7

Table 11: Results of the assessment at Site BS 6 (located at the intersection between Conrad Drive and Jan Smuts, Blairgowrie).

Site BS1

Figure 11: General upstream view of the BS1 site at the time of the assessment (left). Impacts related to erosion, incision, bank failure and alien vegetation encroachment (right).

In situ physico-chemical water quality

pH	7.98
EC (mS/m)	39.0
DO (mg/L)	6.43
DO (% sat)	73.7
Temp (℃)	21.3

Invertebrate community assessment (SASS5 and IHAS)

	Scores	% of Reference Scores
SASS5	39	17.0%
Number of taxa	9	NA
ASPT	4.3	64.2%
IHAS	79 (Highly suited)	NA
MIRAI	47.1	NA

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was relatively shallow at this point (generally <½ m).
Flow condition	The stream consisted of slow flowing glides and pools with some riffles present in some places
Water clarity and odour	Discoloured. No odours evident.
Riparian zone characteristics	Narrow and severely incised. Incision, erosion and bank failure is evident in some areas. Significant alien vegetation encroachment.
Dominant species observed in the riparian zone (Aliens marked with **an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia, Acaia mearnsii*

Diatom analysis

Specific Pollution Sensitivity Index (SPI)	7.9
Pollution Tolerant Valves (% PTV)	29.8

Comments relating to diatom community composition

- Based on the OMNIDIA results, the ecological water quality at this point is of an Ecological Category D (Poor quality);
- This point is dominated by highly pollution tolerant taxa indicative of nutrient, electrolyte and organic enrichment such as *Cocconeis placentula*, *Nitzschia palea, Sellaphora seminulum* and *Eolimna subminuscula*;
- In addition, is the presence of dominant taxon *Navicula cryptotenelloides* which is found in meso- to eutrophic calcareous streams.

Toxicological analysis

Daphnia pulex % *mortality*	25
Poecilia reticulata % *mortality*	13
Vibrio fischeri growth/inhibition	+13
Selenastrum capricornutum growth/inhibition	-13

Comments relating to toxicity

Some improvement in the toxicological threat is once again observed at this point in relation to the upstream reaches, with a reduced toxicological response observed in the fish toxicity test as well as the *Vibreo fischeri* and the *Selenastrum capricornutum* growth/inhibition toxicity tests. The toxicological threat remains in a Class 2 (Slight Toxicological Threat).

SITE ECOSTATUS CATEGORY	
Dickens & Graham (2002)	Category F
Dallas (2007)	Category E/F
MIRAI	Category D
Diatom analysis	Category D (Poor quality)
Toxicological analysis	Class 2 (Slight Acute Hazard)

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision, sedimentation and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Little observed instream as well as in the riparian area.

NA = Not Applicable, SASS5 reference score = 230, ASPT reference score = 6.7

Table 12: Results of the assessment at Site BS 7 (located upstream of the confluence of the Braamfonteinspruit with an unnamed tributary near the intersection of Republic Road and William Nicol Road).

Site BS 7		*In situ* physico-chemical water quality	
 Figure 12: General upstream view of the BS7 site at the time of the assessment (left) indicating the effects of inundation at this point and structures built on the system for recreational activities. Some areas of unstable sediment deposition and exposed soils were observed (right).		pH EC (mS/m) DO (mg/L) DO (% sat) Temp (℃)	7.27 39.0 5.22 59.9 24.0
Algal proliferation	No algal proliferation was evident at the current time.	Current impacts and Essential Mitigation ➢ Severe impacts as a result of erosion, incision and embedding; ➢ Severe impacts in terms of exotic alien vegetation encroachment; ➢ Some impacts in terms of inundation under high flow conditions were observed at this point; ➢ Flow modification as a result of weirs and impoundments along the length of the system; ➢ Litter observed instream as well as in the riparian area; ➢ Large pieces of rubble and collapsed infrastructure observed instream; ➢ Significant sedimentation affecting the instream substrates at this point.	
Depth profiles	The stream was relatively shallow at this point (generally <½ m), however some deeper pool areas were observed.		
Flow condition	The stream consisted of slow flowing glides and pools with some faster flowing riffles present in some places		
Dominant instream substrate	Bedrock and boulders present, however, sandbanks and sediment deposits dominate the substrate at this point.		
Water clarity and odour	Discoloured. No odours evident.		
Riparian zone characteristics	Banks were well vegetated along most parts of the river at this point, however, vegetation is dominated by alien vegetation species. Slopes are relatively gradual at this point, however, some areas of exposed soils increase the risk of erosion at this point under high flow conditions.		
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Morus alba, Celtis sinensis, Persicaria lapathifolia, Helichrysum* sp, *Ipomoea purpurea, Canna indica, Selanum maritianum*		

Table 13: Results of the assessment at Site BS 8 (located on the unnamed tributary that confluences with the Braamfonteinspruit near the intersection of Republic Road and William Nicol Road).

Site BS 8

Figure 13: General view of the BS 8 site at the time of the assessment (left) indicating collapsed rubble instream, bankfailure and unstable infrastructure. Collapsed infrastructure, rubble, litter and debris observed at this point (right).

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was deep at this point (generally >1 m) upstream of the weir observed.
Flow condition	The stream consisted of slow flowing glides and pools.
Dominant instream substrate	The substrate at this point is severely affected by rubble and debris.
Water clarity and odour	Water is opaque with a slight chemical odour.
Riparian zone characteristics	Banks were well vegetated along most parts of the river at this point, however, vegetation is dominated by alien vegetation species. Slopes are relatively gradual at this point, however, some areas of exposed soils increase the risk of erosion at this point under high flow conditions.
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Morus alba, Celtis sinensis, Persicaria lapathifolia, Helichrysum* sp., *Ipomoea purpurea, Canna indica, Selanum maritianum, Acacia mearnsii*

In situ physico-chemical water quality

pH	7.43
EC (mS/m)	28.0
DO (mg/L)	3.1
DO (% sat)	35.7
Temp (℃)	24.2

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision and embedding;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Some impacts in terms of inundation under high flow conditions were observed at this point;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area;
- Large pieces of rubble and collapsed infrastructure observed instream;
- Significant sedimentation affecting the instream substrates at this point.

Table 14: Results of the assessment at Site BS 9 (located where the Braamfonteinspruit flows under Ballyclare Drive, Riverclub).

Site BS 9

Figure 14: General upstream view of the BS1 site at the time of the assessment (left). Impacts related to erosion, incision, bank failure and alien vegetation encroachment (right).

In situ physico-chemical water quality

pH	7.28
EC (mS/m)	37.0
DO (mg/L)	3.48
DO (% sat)	39.9
Temp (℃)	23.6

Invertebrate community assessment (SASS5 and IHAS)

	Scores	% of Reference Scores
SASS5	42	18.3%
Number of taxa	11	NA
ASPT	3.8	56.7%
IHAS	73 (Adequate)	NA
MIRAI	45.3	NA

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was relatively shallow at this point (generally <½ m).
Flow condition	The stream consisted of moderate flowing glides and pools with some riffles present in some places
Water clarity and odour	Water was silty and turbid. No odours evident.
Riparian zone characteristics	Narrow and severely incised on the right bank. Incision, erosion and bank failure is evident in some areas where riparian vegetation is lacking. Significant alien vegetation encroachment.
Dominant species observed in the riparian zone (Aliens marked with an "*").	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia, Acacia mearnsii*

Diatom analysis

Specific Pollution Sensitivity Index (SPI)	6.0
Pollution Tolerant Valves (% PTV)	55.0

Comments relating to diatom community composition

- Based on the OMNIDIA results, the ecological water quality at this site is of an Ecological Category D (Poor quality);
- The site is dominated by highly pollution tolerant taxa indicative of nutrient, electrolyte and organic enrichment such as *Cocconeis placentula*, *Nitzschia palea, Sellaphora seminulum* and *Eolimna subminuscula*.

Toxicological analysis

Daphnia pulex % mortality	35
Poecilia reticulata % mortality	0
Vibrio fischeri	+24
Selenastrum capricornutum	-15

Comments relating to toxicity

The toxicological risk posed to the aquatic communities present at this point may be classified as a Slight Acute Hazard (Class 2) according to the response observed in the *Daphnia pulex* toxicological test (representing aquatic macro-invertebrates).

SITE ECOSTATUS CATEGORY	
Dickens & Graham (2002)	Category F
Dallas (2007)	Category E/F
MIRAI	Category D
Diatom analysis	Category D (Poor quality)
Toxicological analysis	Class 2 (Slight Acute Hazard)

Current impacts and Essential Mitigation

- Severe impacts as a result of erosion, incision and sedimentation;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.

NA = Not Applicable, SASS5 reference score = 230, ASPT reference score = 6.7

Table 15: Results of the assessment at Site BS 10 (located at the low lying bridge on Belgrave Road, between The River Road and Brooke Avenue, Riverclub).

Site BS 10

Figure 15: Local view of the BS 10 site at the time of the assessment (left). Impacts related to build up of debris and inundation (right).

In situ physico-chemical water quality

pH	7.81
EC (mS/m)	45.0
DO (mg/L)	7.15
DO (% sat)	82.0
Temp (℃)	23.7

Invertebrate community assessment (SASS5 and IHAS)

	Scores	% of Reference Scores
SASS5	41	17.8%
Number of taxa	8	NA
ASPT	5.1	76.1%
IHAS	82 (Highly suited)	NA
MIRAI	44.8	NA

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was relatively shallow at this point (generally ½ - 1 m).
Flow condition	The stream consisted of fast flowing glides, rapids, runs and slow flowing pools.
Water clarity and odour	Water was discoloured. No odours evident.
Riparian zone characteristics	The riparian zone at this point is slightly wider than that observed in the reaches upstream of this point. While some erosion and incision is observed, banks are gradual and relatively well vegetated at this point. Significant alien vegetation encroachment is evident. Some litter impacts the riparian zone.
Dominant species observed in the riparian zone (Aliens marked with an "*").	*Penniseteum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*

Diatom analysis

Specific Pollution Sensitivity Index (SPI)	8.6
Pollution Tolerant Valves (% PTV)	20.0

Comments relating to diatom community composition

- Based on the OMNIDIA results, the ecological water quality at this point is of an Ecological Category D (Poor quality);
- The site is dominated by highly pollution tolerant taxa indicative of nutrient, electrolyte and organic enrichment such as *Cocconeis placentula*, *Nitzschia palea, Sellaphora seminulum* and *Eolimna subminuscula*;
- This site has the least amount of nutrient and organic impact of all the study sites as indicted by the lower % PTV value at this site;
- The other dominant taxon recorded is *Planothidium frequentissimum* which is common in flowing, circumneutral to alkaline waters with a moderate electrolyte content.

Toxicological analysis

Daphnia pulex % mortality	35
Poecilia reticulata % mortality	13
Vibrio fischeri	+23
Selenastrum capricornutum	-21

Comments relating to toxicity

The toxicological risk posed to the aquatic communities present at this point may be classified as a Slight Acute Hazard (Class 2) according to the response observed in the *Selenastrum capricornutum* toxicological test (representing algae and aquatic vegetation) as well as according to the mortality rate of 35% observed in the *Daphnia pulex* toxicity test.

SITE ECOSTATUS CATEGORY	
Dickens & Graham (2001)	Category F
Dallas (2007)	Category E/F
MIRAI	Category D
Diatom analysis	Category D (Poor quality)
Toxicological analysis	Class 2 (Slight Acute Hazard)

Current impacts and Essential Mitigation

- Some impacts observed in terms of erosion and incision at this point;
- Severe impacts related to inundation associated with poor bridge design and insufficient flow connectivity at this point;
- Build-up of debris upstream of the bridge resulting in flooding and inundation upstream of the bridge under high flow conditions;
- Flow modification as a result of weirs and impoundments along the length of the system;
- A failing gabion structure was observed at this point at the time of the assessment;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Litter observed instream as well as in the riparian area.

Table 16: Results of the assessment at Site BS 11 (located where the Braamfonteinspruit flows under Bryanston Drive and adjacent to Brooke Avenue, Bryanston).

Site BS 11

Figure 16: General upstream view of the BS 11 site at the time of the assessment (left) indicating the well vegetated banks and flow in the Braamfonteinspruit after 1 hour of rainfall. Slopes are gradual and the site is dominated by bedrock (right).

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was relatively shallow at this point (generally ½ m), however some deeper glides areas were observed.
Flow condition	The stream consisted of moderate to fast flowing glides and relatively slow to still backwater areas. Some fast flowing riffles and rapids present in some places under the increased flow conditions.
Dominant instream substrate	Bedrocks and large boulders dominated the site at the time of the assessment.
Water clarity and odour	Silty and turbid. No odours evident.
Riparian zone characteristics	Riparian zone at this point, as with site BS 10, is slightly wider than the upstream reaches of the Braamfonteinspruit. Banks were well vegetated along most parts of the river at this point, however, vegetation is dominated by alien vegetation species.
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*

In situ physico-chemical water quality

pH	7.60
EC (mS/m)	52.0
DO (mg/L)	7.16
DO (% sat)	82.1
Temp (℃)	22.0

Current impacts and Essential Mitigation

- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.

Table 17: Results of the assessment at Site BS 12 (located where the Braamfonteinspruit flows under Cowley Street, Rivonia).

Site BS 12

Figure 17: General upstream view of the BS 12 site at the time of the assessment (left) indicating impacts as a result of rubble and debris instream as well as disturbance of soils. Prolific alien vegetation encroachment (right).

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The stream was comprised of a variety of depth profiles, with deep pools and glides and shallower rapids and runs.
Flow condition	The stream consisted of moderate to fast flowing glides and relatively slow to still backwater areas. Some fast flowing riffles and rapids present in some places under the increased flow conditions.
Dominant instream substrate	Bedrock, large boulders, sediment deposits.
Water clarity and odour	Silty and turbid. No odours evident.
Riparian zone characteristics	Riparian zone at this point is severely affected by erosion and incision in the vicinity of the bridge crossing, however, the remainder of this section of the Braamfonteinspruit is well vegetated and dominated by trees and alien vegetation species.
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Arundo donax, Ipomoea puppurea, Persicaria lapathifolia, Salix babylonica*

In situ physico-chemical water quality

pH	7.60
EC (mS/m)	52.0
DO (mg/L)	7.13
DO (% sat)	81.8
Temp (℃)	22.0

Current impacts and Essential Mitigation

- Severe impacts in terms of exotic alien vegetation encroachment;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Litter observed instream as well as in the riparian area.
- Severe impacts as a result of large pieces of rubble and collapsed infrastructure observed instream;
- Rubble and disturbed soils affect bank stability in the vicinity of the bridge crossing;
- Significant sedimentation affecting the instream substrates at this point.

Table 18: Results of the assessment at Site BS 13 (located at the confluence of the Braamfonteinspruit with the Sand Spruit near Umfolozi Road, Paulshof).

Site BS2		*In situ* physico-chemical water quality	
 Figure 18: General upstream view of the BS2 site at the time of the assessment (left) indicating collapsed rubble instream. Some areas of the banks have been reinforced/stabilized with concrete at this point (right).		pH EC (mS/m) DO (mg/L) DO (% sat) Temp (℃)	7.51 51.0 7.24 83.0 21.7
Algal proliferation	No algal proliferation was evident at the current time.	Current impacts and Essential Mitigation ➢ Severe impacts as a result of erosion, incision, sedimentation and embedding; ➢ Severe impacts in terms of exotic alien vegetation encroachment; ➢ Flow modification as a result of weirs and impoundments along the length of the system; ➢ Little observed instream as well as in the riparian area; ➢ Large pieces of rubble and collapsed infrastructure observed instream; ➢ Rudimentary stabilisation of the banks observed at this point through the concreting of some areas; ➢ Significant sedimentation affecting the instream substrates at this point.	
Depth profiles	The stream was relatively shallow at this point (generally ½ m), however some deeper pool areas were observed.		
Flow condition	The stream consisted of slow flowing glides and pools with some riffles and rapids present in some places		
Dominant instream substrate	Bedrocks, sandbanks and sediment.		
Water clarity and odour	Clear. No odours evident.		
Riparian zone characteristics	Banks were well vegetated along most parts of the river at this point, however, vegetation is dominated by alien vegetation species. Severe incision, bank failure and erosion was observed in some areas.		
Dominant species observed in the riparian zone (Aliens marked **with an "*").**	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Acacia mearnsii, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*		

Table 19: Results of the assessment at Site BS 14 (located further downstream of the confluence of the Braamfonteinspruit with the Sand Spruit near Umfolozi Road, Paulshof).

Site BS 14

Figure 19: General upstream view of the BS 14 site at the time of the assessment (left). Impacts related to sediment deposits and alien vegetation encroachment (right).

In situ physico-chemical water quality

pH	7.60
EC (mS/m)	52.0
DO (mg/L)	7.14
DO (% sat)	81.9
Temp (℃)	22.0

Invertebrate community assessment (SASS5 and IHAS)

	Scores	% of Reference Scores
SASS5	41	17.8%
Number of taxa	8	NA
ASPT	5.1	76.1
IHAS	81 (Highly suited)	NA
MIRAI	47.5	NA

Algal proliferation	No algal proliferation was evident at the current time.
Depth profiles	The river was relatively shallow at this point (generally <½ m), however some deeper pool areas were observed.
Flow condition	The stream consisted of faster flowing glides and runs and slow flowing pools.
Water clarity and odour	Water was clear. No odours evident.
Riparian zone characteristics	Banks were well vegetated along most parts of the river at this point, however, vegetation is dominated by alien vegetation species. Severe incision, bank failure and erosion was observed in some areas.
Dominant species observed in the riparian zone (Aliens marked with an "*").	*Pennisetum clandestinum, Morus alba, Helichrysum* sp., *Canna indica, Celtis sinensis, Acacia mearnsii, Arundo donax, Ipomoea purpurea, Persicaria lapathifolia*

Diatom analysis

Specific Pollution Sensitivity Index (SPI)	7.9
Pollution Tolerant Valves (% PTV)	45.0

Toxicological analysis

Daphnia pulex % mortality	5
Poecilia reticulata % mortality	0
Vibrio fischeri	+15
Selenastrum capricornutum	-13

Comments relating to diatom community composition

- Based on the OMNIDIA results, the ecological water quality at this site is of an Ecological Category D;
- This site is dominated by highly pollution tolerant taxa indicative of nutrient, electrolyte and organic enrichment such as *Cocconeis placentula*, *Nitzschia palea, Sellaphora seminulum* and *Eolimna subminuscula*;
- In addition, recorded at this site are the dominant taxa *Achnanthidium exiguum* and *Mayamaea atomus var. permitis*, which favour alkaline waters with elevated electrolyte content and which are often found in industrial wastewater.

Comments relating to toxicity

- The toxicological risk posed to the aquatic communities present at this point may be classified as a Slight Acute Hazard (Class 2) according to the response observed in the *Selenastrum capricornutum* toxicological test (representing algae and aquatic vegetation).

SITE ECOSTATUS CATEGORY	
Dickens & Graham (2002)	Category F
Dallas (2007)	Category E/F
MIRAI	Category D
Diatom analysis	Category D (Poor quality)
Toxicological analysis	Class 2 (Slight Acute Hazard)

Current impacts and Essential Mitigation

- Some impacts observed in terms of erosion and incision at this point;
- Flow modification as a result of weirs and impoundments along the length of the system;
- Severe impacts in terms of exotic alien vegetation encroachment;
- Litter observed instream as well as in the riparian area. In addition, deposition of failing infrastructure was observed instream;
- Housing in close proximity to the banks of the river has resulted in severe modification of the riparian zone at this point, however, mowed lawns provide good cover and thus aid in limiting erosion and incision at this point;
- Severe sedimentation of the instream substrates.

4. RISK ASSESSMENT

This section presents the significance of potential impacts on the aquatic ecology of the Braamfonteinspruit. In addition, it also indicates the required mitigatory measures needed to minimise the perceived impacts of the proposed rehabilitation/intervention measures, and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures and assuming that they are fully implemented.

4.1 Identified Impacts of Concern

During the site visit, key impacts affecting the integrity of the Braamfonteinspruit were identified and include the following:

- Loss of riparian habitat and ecological structure
  - Alien and terrestrial vegetation encroachment;
  - Erosion and incision of river banks resulting in bank failure; and
  - Failing infrastructure, both current and historical.
- Changes to ecological and socio-cultural service provision
  - Inadequate stormwater runoff; and
  - Recreational activities (dog walkers, mountain-biking, runners, horse-riding, bird walks).
- Impacts affecting hydrological function and sediment balance
  - Sedimentation and embedding of the instream substrates;
  - Failing infrastructure, both current and historical;
  - Build-up of debris upstream of low lying and inadequately designed bridges; and
  - Weirs and dams built along the system and various bridge crossings.
- Loss of instream flow
  - Litter and debris both instream as well as in the riparian zone;
  - Concrete rubble and building debris as well as failed infrastructure instream;
  - Failing infrastructure, both current and historical;
  - Build-up of debris upstream of low lying and inadequately designed bridges; and
  - Loss of flow continuity.
- Impacts on water quality
  - Industrial wastewater;
  - Failing sewerage infrastructure and French drains; and
  - Ingress of hydrocarbons and other pollutants related to stormwater runoff.

- Loss of instream aquatic habitat
- Loss of aquatic biodiversity and sensitive taxa
    - Loss of stream connectivity, loss of continuous flow and various weirs and impoundments on the system have resulted in a loss of natural migration routes along the system thus resulting in a severe loss of fish species and other species reliant on strong stream connectivity;
    - Impaired water quality limits the sensitivity of the aquatic communities and species reliant on this water feature; and
    - Variations in high flows, base flows and low flows are highly variable in this system and thus affect the community structures of the aquatic species present.

The risk assessment was applied twice: initially, for the purpose of Phase 1, which entailed the installation of gabions in seven priority areas. Phase 2 includes a further fifty sites that are prone to erosion, and where severe flooding could occur, particularly during a 1 in 50 year flood event (SRK, 2017). Thus, erosion protection structures are required at these sites, and three conceptual designs were provided by SRK (2017) which will be implemented based on site-specific constraints and practicalities. These consist of either vegetated berms with riprap, concrete wall with 1:2.5 bank slope and riprap, and concrete wall without side slope and without riprap protection.

In addition, a further three sites were identified which require specific interventions, namely;

- Stilling basin downstream of the Barry Hertzog Avenue culvert;
- Proposed new bridge at 2nd Street, Parkhurst (to replace the existing bridge);
- Repairs to the damaged canal within the Parkview Golf Club.

For details and conceptual illustrations of the proposed intervention measures, please refer to the *Braamfontein Spruit Rehabilitation Methodology Statement for Phase* 2. Report Number 490243/2 prepared for the Johannesburg Roads Agency by SRK (June 2017).

The results of the risk assessment applied to both the installation of gabions in Phase 1, and the construction of additional remedial measures proposed in Phase 2, are summarised in Tables 20 and 21.

When applying the risk assessment method, allowance can be made for scores which are just outside the LOW risk class to be manually amended (to a maximum of 25), after considering additional mitigation measures, alternatives (methods) or specific activities, in order to reduce a risk rating class from Medium to Low.

The installation of seven gabions at key localities along the Braamfonteinspruit during Phase 1 and the proposed remedial actions for Phase 2 are considered to be urgent interventions, in order to address severe incision and erosion, which if not addressed as a matter of priority, may result in significant damages to private property, as well as further negative impacts on the riparian and instream ecology of the Braamfonteinspruit. This was taken into consideration when applying the risk assessments, and it is the opinion of the ecologists that, due to the significantly decreased ecological integrity of the riparian and instream ecology, along with the long-term positive impact that the installation of these gabions will have, the reduction of some impact ratings from 'Medium' to 'Low' is justified, with the proviso that the stipulated mitigation measures are strictly enforced throughout the installation of the gabions and further remedial infrastructure.

Table 20: A summary of the results obtained from the risk assessment conducted to ascertain the significance of impacts arising from the installation of gabions in seven specified locations (Phase 1).

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW	PES AND EIS OF WATERCOURSE
1	Construction	Site preparation prior to gabion installation, including placement of contractor laydown areas and storage facilities	Removal of vegetation and associated disturbances to soils	➢ Exposure of soils, leading to increased runoff and erosion, and thus increased sedimentation of the instream habitat. ➢ Increased sedimentation of riparian habitat, leading to smothering of flora and potentially further altering surface water quality.	M	➢ Contractor laydown areas, vehicle re-fuelling areas and material storage facilities to remain outside of the delineated riparian zone and the GDARD recommended buffer zone. ➢ Vegetation removal to be kept to a minimum, and preferably only alien floral species to be removed. ➢ Retain as much indigenous vegetation as possible. ➢ Limit vehicle/construction equipment activity within the active channel to what is absolutely essential. Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting. Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. The duration of impacts on the riparian areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible.	-9 L	Watercourse has historically undergone numerous and varying degrees of modification. Rehabilitation and interventions are aimed at improving the PES/EIS of watercourse.

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW	PES AND EIS OF WATERCOURSE
1	Construction	Excavation within the active channel for foundations	Temporary diversion of stream to allow for excavations to take place. Movement of construction equipment/vehicles within the active channel. Possible spills or leaks from construction vehicles. Disturbances of soils within the active channel. Removal of topsoils and creation of soil stockpiles.	➢ Altered flow regime, leading to possible loss of recharge to downstream areas, impacting on downstream biota. ➢ Possible incision/erosion in the vicinity of the diversion as a result of the (temporary) formation of a concentrated flow path. ➢ Possible sedimentation of downstream areas during the diversion. ➢ Possible moisture stress to riparian vegetation downstream of the diversion. ➢ Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. ➢ Possible contamination of riparian soils, instream sediment and surface water, leading to further reduced ability to support biodiversity. ➢ Altered runoff patterns, leading to increased erosion and sedimentation of riparian habitat. Altered flow regimes. Impacts to stream connectivity. Loss of refuge for aquatic species.	M	➢ Activity will result in bank stabilisation, and reduction in bank incision and sedimentation of the resource. ➢ Ensure sediment control devices are in place prior to any excavation activates within the active channel. ➢ Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. ➢ Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting. ➢ The duration of impacts on the riparian areas and instream flow should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible. ➢ Limit vehicle/machinery activity within the active channel to what is absolutely essential. ➢ Ensure water movement is maintained through the system at all times. ➢ Ensure that no mounds of topsoil are left on the site. ➢ Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. Regarding any potentially necessary temporary stream diversions, special care should be taken to keep the footprint of activities as small as possible. Special care must be taken to prevent sedimentation of the downstream resources. Any alterations to the stream bed substrates must be suitably rehabilitated with special mention of removal of sediment deposits and any rough debris associated with the proposed gabion construction activities. Ensure that stream beds are rehabilitated with smooth river cobbles where necessary. Flow continuity and connectivity must be maintained throughout the proposed gabion installation activities. No building materials associated with the proposed gabion installations must be left instream on completion of the construction activities. No litter or waste should be dumped instream for the duration of the construction activities including litter resulting from contractor presence on-site. Gabion installations must take place under low-flow conditions to ensure impacts related to erosion, incision and sedimentation as a result of exposed soils and excavations are minimised as far as possible.	-17 L	

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW	PES AND EIS OF WATERCOURSE
1	Construction	Installation of gabion strictures including tie-ins	Movement of construction machinery/vehicles within the active channel. Possible spills/ leaks from construction vehicles. Possible discard of construction material within the active channel and riparian zone. Ongoing disturbances to soils as gabions are installed.	➢ Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. ➢ Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity. ➢ Alterations to flow patterns, possible contamination of water. ➢ Increased sedimentation of areas downstream of the installation site. Increased sedimentation as a result of disturbances. ➢ Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances. ➢ Altered flow regimes. Altered stream depth profiles. Alteration of stream substrate. Impacts to stream connectivity.	M	➢ Activity will result in bank stabilisation, and reduction in bank incision and sedimentation of the resource. ➢ Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. ➢ Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting. ➢ The duration of impacts on the riparian areas and instream flow should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible. ➢ Limit vehicle/machinery activity within the active channel to what is absolutely essential. ➢ Ensure water movement is maintained through the system at all times. ➢ Ensure that no mounds of topsoil are left on the site. ➢ Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ➢ Vegetation removal to be kept to a minimum, and preferably only alien floral species to be removed. Retain as much indigenous vegetation as possible. ➢ All disturbed areas must be suitably rehabilitated. Special mention is made of unnatural roughly edged rocky substrate associated with construction and building activities. Rocky substrate must be rehabilitated with natural smooth river cobbles and banks must be suitably re-profiled and re-vegetated to prevent erosion and sedimentation further downstream. Any alterations to the stream bed substrates must be suitably rehabilitated with special mention of removal of sediment deposits and any rough debris associated with the proposed gabion construction activities. Ensure that stream beds are rehabilitated with smooth river cobbles where necessary. Flow continuity and connectivity must be maintained throughout the proposed gabion installation activities. No building materials associated with the proposed gabion installations must be left instream on completion of the construction activities. No litter or waste should be dumped instream for the duration of the construction activities including litter resulting from contractor presence on-site. Gabion installations must take place under low-flow conditions to ensure impacts related to erosion, incision and sedimentation as a result of exposed soils and excavations are minimised as far as possible.	-17 L	
1	Construction	Re-profiling and re-vegetation of slopes in areas affected by the construction activities related to the gabion installations	Movement of construction machinery/vehicles within the active channel. Possible spills/ leaks from construction vehicles.	➢ Increased sedimentation as a result of disturbances ➢ Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances. ➢ Loss of refuge for aquatic species.	M	➢ Duration of impacts must be minimised. ➢ Ensure that runoff occurs in a natural diffuse manner with no unnatural concentration of flow. ➢ Soil erosion as a result of runoff from areas where invasive vegetation has been cleared must be prevented/ mitigated through the application of biodegradable hessian material where required.	-17 L	

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW	PES AND EIS OF WATERCOURSE
			Site clearing. Ongoing disturbances to the riparian zone and disturbance and compaction of soils.	➢ Alteration of stream beds. Alteration of depth profiles. Alteration of flow regimes.		➢ When re-profiling takes place it should be done to ensure water movement through the system at all times. ➢ In areas of severe incision and erosion, banks should be re-profiled to a maximum angle of 18 degrees. ➢ In areas where severe gully formation has taken place, these affected areas should be appropriately backfilled to achieve the correct gradient. ➢ Final finishing and shaping must take place with topsoil free from invasive species. ➢ Re-seed with indigenous species. ➢ A mulch cover may be required to stabilise the soil during the winter months when grass does not grow or grows poorly. ➢ All alien invasive floral species should be removed on a continual basis from the rehabilitated areas. ➢ All removed alien plant species must be disposed of at a registered garden refuse site and may not be burned on site. ➢ Where chemicals are used the following guidelines and precautions apply: • Do not transport chemicals in bulk as this gives the potential for serious accidents occur; • Apply chemicals in cool, dry and non-windy weather to prevent drift from reaching water bodies; • Contaminated equipment should not be cleaned in field; • Many chemicals (e.g. pesticides/herbicides) are harmful to human and environmental health, and should therefore only be applied by properly trained and equipped workers that are registered according to the statuary requirements; • Herbicides and pesticides have the same toxic effect on aquatic plants and organisms as they do on the terrestrial plants and organisms to which they were applied. Therefore, when applying pesticides best practice guidelines should be strictly adhered to (as indicated in the label instructions) to minimise spray drift or wash-off into water resources and the killing of aquatic organisms. These include application under suitable weather conditions (i.e. sufficiently dry and calm), seeking professional advice on the type and quantity of pesticides that should be applied and considering the environmental conditions and hazards at the site; • Over application must not take place and spray plans should also be continuously updated to prevent over application and contamination of water resources; • Herbicide should not be used if weed cover is low. The best way to keep weeds at bay is to maintain healthy, dense vegetation that shades the ground surface, preventing weed seedlings from taking root. Mulching can also be used to prevent weeds. However, if weeds do take hold, they should be dug or pulled out;		

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW	PES AND EIS OF WATERCOURSE
						• Herbicides should be used to spot-treat weeds only and not applied universally. In steep areas ensure that energy dissipation takes place to ensure that under high flow conditions and times of high rainfall, water does not flow into the Braamfonteinspruit in such a manner such as to result in erosion and incision of the stream bed and stream banks. Ensure that runoff does not lead to excessive sedimentation in the area through careful planning of stormwater drains and similar structures. Stormwater runoff must be managed taking into consideration areas of increased erosion potential. If any erosion is observed the affected areas should immediately be rehabilitated through levelling the area, profiling of soils and revegetating the area. Gullies and other areas of active erosion, if noted, should be stabilised through infilling with topsoil, cover with biodegradable hessian material/ geotextile such as GeoJute, and revegetated to minimise sediment entering the Braamfonteinspruit.		
2	Operation	Monitoring of structural integrity of installed gabions	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion, incision and alien vegetation encroachment. Proactive monitoring to ensure that any litter or debris which may accumulate on and around the gabions is cleared to maintain the flow of water.	No direct impacts perceived.	L	➢ Limit vehicle/machinery activity within the active channel as well as in the riparian zone to what is absolutely essential. ➢ Disturbances to the riparian zone should be limited as far as possible. ➢ Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ➢ Activities should not obstruct flow. ➢ Where possible, existing access roads should be used for monitoring purposes so as to minimise the compaction of soils and loss of both riparian and instream habitat. ➢ Hot spots for buildup of debris must be identified and debris must be regularly removed to prevent flooding and damage of infrastructure. In this regard, special mention is made of periods following high rainfall and subsequent high instream water volumes. ➢ During monitoring, always use the shortest routes possible so as to minimise disturbance and loss of habitat both instream as well as in the riparian zone. ➢ The riparian zone must be monitored for alien vegetation encroachment and all alien vegetation/weeds must be removed according to a suitable alien vegetation control plan. ➢ Any erosion or gully formation must be identified on an ongoing basis and re-profiled and revegetated accordingly. ➢ Use of biodegradable hessian sheeting must be made to prevent sedimentation of downstream resources.	NA	
		Monitoring of re-profiled slopes in the vicinity of the gabion installations	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion, incision and alien vegetation encroachment.	Compaction of soils and loss of habitat as a result of ongoing disturbance from vehicles and machinery.	L		NA	

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW	PES AND EIS OF WATERCOURSE
		Monitoring of water quality and instream integrity both upstream and downstream of gabion installations	Proactive monitoring to ensure that the system is recovering sufficiently and not suffering harm post-construction activities.	No direct impacts perceived.	L		NA	
		Ongoing alien vegetation removal in the vicinity of the gabion installations	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion, incision and alien vegetation encroachment.	Compaction of soils and loss of habitat as a result of ongoing disturbance from vehicles and machinery. Impacts to water quality as a result of the application of herbicides. Disturbance of soils and resulting erosion and sedimentation.	L		NA	

Table 21: A summary of the results obtained from the risk assessment conducted to ascertain the significance of impacts arising from the installation of additional remedial measures (berms, concrete walls, stilling basin, bridge, repair of concrete canal) (Phase 2).

No.	Phases	Activity	Aspect	Impact	Risk Rating	Control Measures	Borderline LOW MODERATE Rating	PES AND EIS OF WATERCOURSE
1	Construction	Site preparation prior to installation of remedial infrastructure (riprap / berms / concrete walls / stilling basin / bridge), specifically the placement of contractor laydown areas and storage facilities.	Removal of vegetation and associated disturbances to soils	➢ Exposure of soils, leading to increased runoff and erosion, and thus increased sedimentation of the resource. ➢ Increased sedimentation of riparian habitat, leading to smothering of flora and potentially further altering surface water quality.	L	➢ Contractor laydown areas, vehicle re-fuelling areas and material storage facilities to remain outside of the delineated riparian zone and the GDARD recommended buffer zone. ➢ Vegetation removal to be kept to a minimum and preferably only alien floral species to be removed. Retain as much indigenous vegetation as possible. ➢ Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting.	NA	*Watercourse has historically undergone numerous and varying degrees of modification. *Rehabilitation and interventions are aimed at improving the PES/EIS of watercourse.
1	Construction	Site preparation within the riparian zone prior to installation of remedial infrastructure.	Removal of riparian vegetation, and disturbances to stream banks, including associated disturbances to soils.	➢ Exposure of soils, potentially resulting in further erosion, and thus increased sedimentation of the resource. ➢ Increased sedimentation of riparian habitat, leading to smothering of flora and potentially further altering surface water quality.	M	➢ Removal of riparian and instream vegetation to be kept to a minimum; preferably only alien floral species to be removed. Retain as much indigenous vegetation as possible. ➢ Disturbances to soils to be minimised as far as feasible. ➢ Sediment control devices to be in place prior to the commencement of site preparation activities. Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting.	-16.5 L	
1	Construction	Excavation within active channel for foundations.	Temporary diversion of stream to allow for excavations to take place.	➢ Altered flow regime, leading to possible loss of recharge to downstream areas, impacting on downstream biota. ➢ Possible incision/erosion in the vicinity of the diversion as a result of the (temporary) formation of a concentrated flow path. ➢ Possible sedimentation of downstream areas during the diversion.	M	➢ Ensure sediment control devices are in place prior to diverting the stream. ➢ Ensure that the creation of the diversion does not result in a significant water level difference upstream or downstream of the installation site. ➢ The duration of impacts on the riparian areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible. ➢ All construction activity within the active channel for construction of bridge pier (at 8th Ave) should take place in the low flow period of winter. ➢ The construction of piles within coffer dams must be done as quickly as possible to reduce the duration of construction activity within the active channel of the river. ➢ The extent of the coffer dam must be kept as small as possible.	-5.5 L	

						➢ Pier must be designed in such a way as to pose the least hydraulic resistance possible. Stream diversion must be kept as small as possible; extreme caution must be taken to prevent sedimentation of d/s resources and activities must take place in low flow period.		
1			Movement of construction machinery/vehicles within the active channel. Possible spills / leaks from construction vehicles. Disturbances to soils within the active channel. Removal of topsoil's and creation of soil stockpiles.	➢ Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. ➢ Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity. ➢ Altered runoff patterns, leading to increased erosion and sedimentation of riparian habitat.	L	➢ Limit vehicle/construction equipment activity within the active channel to what is absolutely essential. ➢ Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ➢ Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas.	NA	
		Installation/construction of remedial infrastructure	Movement of construction machinery/vehicles within the active channel. Possible spills / leaks from construction vehicles. Possible discard of construction material within the active channel and riparian zone. Ongoing disturbances to soils as infrastructure is installed	➢ Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. ➢ Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity. ➢ Alterations to flow patterns, possible contamination of water. ➢ Increased sedimentation of areas downstream of the installation site. ➢ Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances.	M	➢ Limit vehicle/construction equipment activity within the active channel to what is absolutely essential. ➢ Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ➢ Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. ➢ Duration of impacts must be minimised. ➢ Re-seed with indigenous species as soon as installation is completed. Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas.	-17.5 L	*Watercourse has historically undergone numerous and varying degrees of modification. *Rehabilitation and interventions are aimed at improving the PES/EIS of watercourse.
		Re-profiling of slopes in the vicinity of remedial infrastructure	Ongoing disturbances to soils Removal of vegetation.	➢ Increased sedimentation as a result of disturbances. ➢ Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances.	M	Duration of impacts must be minimised. Re-seed with indigenous species as soon as the gabion installation is completed.	-13.8 L	

2	Operation	Monitoring of structural integrity of remedial infrastructure	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion around the infrastructure. Proactive monitoring to ensure that any litter or debris which may accumulate on and around the infrastructure is cleared to maintain the flow of water.	No direct impacts perceived	L	There should be no need to encroach the active channel to obtain a visual assessment of the structural integrity of the remedial infrastructure.	NA	
		Maintenance of installed infrastructure in the event of failure (if necessary)	Diversion of stream to allow maintance/repairs to be undertaken	Temporarily altered flow regime, leading to possible loss of recharge to downstream areas, impacting on downstream biota. Possible incision/erosion in the vicinity of the diversion as a result of the (temporary) formation of a concentrated flow path.	M	➢ Ensure sediment control devices are in place prior to diverting the stream. ➢ Ensure that the creation of the diversion does not result in a significant water level difference upstream or downstream of the installation site. ➢ The duration of impacts on the riparian areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible.	-5.5 L	*Watercourse has historically undergone numerous and varying degrees of modification. *Rehabilitation and interventions are aimed at improving the PES/EIS of watercourse.
			Disturbances to soils as a result of movement of machinery/vehicles, and/or as a result of replacement of failed infrastructure. Potential spills/leaks from vehicles/machinery.	Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity.	L	➢ Limit vehicle/construction equipment activity within the active channel to what is essential. ➢ Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ➢ Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas.	NA	
			Disturbances to or removal of vegetation whilst accessing infrastructure to carry out maintenance activities	Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances.	L	➢ Ensure that the footprint area of cleared vegetation remains as small as possible. ➢ Limit clearing of indigenous vegetation. ➢ If deemed necessary, re-seed with indigenous vegetation once maintenance activities have been completed.	NA	

4.2 Impact Mitigation

General “good practice” mitigation measures applicable to the proposed interventions and rehabilitation measures of the Braamfonteinspruit are provided in Appendix 2, and these should be implemented in conjunction with those stipulated below.

Mitigation measures applicable to the emergency installation of gabions at seven key locations:

- Installation of the gabions should preferably commence at the most upstream location, to minimise the cumulative impacts on downstream areas arising from the activities at each site;
- No storage of materials, contractor laydown areas, or re-fueling of vehicles must be permitted within the delineation riparian zone or the recommended buffer zones;
- Clearing of some vegetation will be necessary at the installation sites. Wherever possible, indigenous vegetation must be protected, and clearing should focus on the removal of alien vegetation;
- The duration of impacts on the riparian area should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible, and if at all feasible, installation/construction activities should be scheduled for the drier months/low flow season to decrease the risk of erosion during heavy thunderstorms;
- The following mitigation measures are applicable to the creation of any temporary stream diversions:
    - Prior to creating any required stream diversions, erosion and sediment controls such as sandbags and protection of exposed soils with suitable geotextiles, must be implemented around the site, in order to minimise the risk of sedimentation of the downstream areas;
    - Creation of stream diversions must not result in a significant water level difference upstream or downstream of the installation site;
    - The inlet and outlet of temporary stream diversions must be stabilized using appropriate erosion control techniques, and the outlet of the diversion must be monitored for erosion; and
    - Following completion of the installation, the stream diversion must be removed and the affected area rehabilitated.

- Erosion control measures around the installation sites are considered crucial. Such measures may include sandbags to stabilize banks, and protection of exposed soils with suitable geotextiles such as hessian sheeting; and
- Following the installation of the gabions, establishment of indigenous vegetation must be undertaken, as per the recommendations of the Landscape Architect.

Mitigation measures applicable to Phase 2 remedial intervention measures:

Due to the similarity in nature of the perceived impacts arising from the remedial measures proposed as part of the Phase 2 rehabilitation, the mitigation measures stipulated above for the Phase 1 emergency installation of gabions are deemed to be applicable to all of the following proposed remedial measures:

- Typical protection structures 1 to 3 i.e. vegetated berms with riprap, vertical wall with riprap and vertical wall without riprap;
- Concrete stilling basin downstream of the Barry Hertzog Road culverts;
- Upgrade of bridge at 2nd Street, Parkhurst;
- Repair / reinstatement of the concrete canal within the Parkview Golf Club.

However, in addition to the mitigation measures stipulated above, as well as general “best practice” mitigation measures applicable to activities of this nature (as provided in Appendix 2 of this report), additional mitigation measures specific to the proposed remedial measures are considered essential in order to decrease the significance of perceived impacts associated with each of the aforementioned remedial measures. These are as follows:

Typical Protection Structures 1 to 3: Berms / vertical walls with / without riprap:

- The ‘tie-ins’ of the flood berms must be designed and constructed in such a way that should a flood event occur, turbulent and/or super critical flows are not created as far as possible, i.e. the flood berms should not cause water to be re-directed by the tie-ins, thus causing erosion anywhere along the length of the berms and further downstream;
- The area around the flood berms must be monitored regularly (at minimum once per annum, but if feasible, once per month during the rainy season) to ensure that no erosion or incision of either the banks or bed of the watercourse occurs.

Concrete stilling basin:

- As with the berms and vertical walls, the ‘tie-ins’ of the stilling basin must be designed and constructed in such a way that should a flood event occur, turbulent and/or super critical flows are not created as far as possible; and

- The 'toe' of the stilling basin must be level with the stream bed, in order to prevent erosion at that point; and
- The stilling basin must not alter the direction of flow such that it will lead to downstream erosion, incision and sedimentation.

Upgrade of bridge

- Effective and strict erosion control throughout the construction phase is imperative. Erosion berms should be installed to prevent gully formation and further siltation of the watercourse, and all soil stockpiles should be placed outside of the 32m buffer zone, and protected with a suitable geotextile. Erosion controls must be regularly maintained, at minimum on a fortnightly basis, particularly if rain is forecast or immediately following a rainfall event;
- As it is absolutely unavoidable that the watercourse and associated riparian habitat will be affected, especially during bridge construction, disturbance to the riparian zone at the crossing point must be minimised and suitably rehabilitated. In this regard, very careful attention to the design criteria and bridge design will need to take place, with special mention of the following:
    - Disturbances within the river bed/active channel need to be minimised as far as possible. In this regard, the bridge should cross the river at a 90 degree angle to minimise the damage to riparian areas; and
- According to SRK (2017) the proposed bridge design will only require one pier within the 1:100 year floodline. Nevertheless, it is considered critical that the following key design criteria be considered:
    - If feasible, the required pier should be constructed on bedrock in the stream minimising the impacts on the hydrology under low flow conditions;
    - The pier structure must be designed in such a way as to ensure that turbulent flow is minimised through the use of streamlined support column shapes;
    - The foundations of the pier must ensure that no changes to stream flow direction occur and that minimisation of turbulent flow and scour is ensured.
- Bridge design must ensure that no upstream ponding and no downstream erosion and scouring occur.

Repair of concrete canal within Parkview Golf Club

- Re-profiling of the affected banks to a maximum of a 1:3 gradient prior to re-instatement of the canal is preferred, in order to minimise the risk of bank incision and erosion occurring behind the canal wall;

- The design and construction of the tie-ins to the existing canal structure must ensure that in the event of a flood event, turbulent and/or super critical flows in order to prevent damage to the canal;
- The 'toe' of the canal must be level with the streambed and must be protected from undercutting, in order to prevent further erosion of the streambed.

5. CONCLUSION

Severe impacts as a result of erosion, incision, sedimentation and embedding were evident along the length of the system. Closely associated with these impacts and a key driver of change in this regard is flow modification observed along the entire length of the system. Weirs, barriers and inadequately designed bridges, as well as modifications to the channel and the stream substrate in some areas, all contribute to the significant flow modifications observed along the length of the system. The effects of erosion and incision due to inadequately controlled stormwater runoff during high rainfall and high water volume events are evident throughout the system. Further compounding issues are severe impacts, in terms of exotic vegetation encroachment, which appear to worsen in a downstream direction. Large pieces of rubble, metal debris and collapsed infrastructure were observed instream at various points of interest. Failing infrastructure in terms of historically canalised sections, old bridges and roads and failed gabions were also observed. Historical bank stabilisation in some areas were observed.

Aquatic community integrity in the upper reaches of the Braamfonteinspruit, with special mention of sites BS1 and BS2, may be considered to be in a severely modified condition according to both the Dallas (2007) classification method as well as on application of the MIRAI to the BS2 site. Impaired water quality and critically altered stream substrates at this point are likely the key drivers of change in the upper reaches of the Braamfonteinspruit. It is deemed critical for the improved integrity of the upper reaches of the Braamfonteinspruit that the sources resulting in impaired water quality in the upper reaches be identified and mitigated as far as possible. The impact of impaired water quality in this system becomes evident further downstream as pollutants become more diluted on confluence with the Westdene Spruit and an improvement in aquatic community integrity is observed at site BS5. Point and diffuse sources of pollution in terms of hydrocarbons and pollutants associated with road crossings, industry, urban runoff, as well as impacts related to historical French drains and domestic waste water, affect the Braamfonteinspruit to varying degrees along the length of the system, as is reflected in the SASS5 results observed throughout.

As with the aquatic community assessment, the diatom and analysis revealed highly eutrophic, electrolyte-rich and extremely polluted waters in the upper reaches of the Braamfonteinspruit, improving in a downstream direction as industrial pollutants become more diluted.

The toxicological assessment of the risk posed to the aquatic receiving environment revealed a slight toxicological hazard (Class 2) along the entire length of the Braamfonteinspruit, with slight improvements noted in a downstream direction.

It is the opinion of the ecologist that rehabilitation of the Braamfonteinspruit will require a multi-faceted approach addressing impacts to water quality in terms of urban runoff, industrial waste and impacts associated with sewerage and domestic waste water. In terms of habitat, stabilisation of failing banks and infrastructure through the use of gabions and possibly some hard engineering may be necessary in some areas. In areas of severe incision and erosion, banks should be re-profiled and revegetated where possible and an on-going alien vegetation removal and management plan is deemed necessary. In-stream substrate should be rehabilitated in terms of removal of existing litter and debris and where possible, litter traps should be installed, and a management plan to ensure ongoing maintenance should be implemented. Adequate stormwater management and erosion control measures need to be put in place and careful planning will be required in order to ensure that adequate energy dissipation takes place under high rainfall and high water volume conditions.

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APPENDIX 1: Method of Investigation

The field assessment took place in March 2016. For the ecological indicators, the assessment of possible impacts was based on comparisons between affected and control conditions on a spatial basis as applicable. The current assessments will also provide baseline conditions for future temporal comparisons.

The sections below describe the methodology used to assess the aquatic ecological integrity of the various sites based on water quality, instream and riparian habitat condition and biological impacts and integrity.

Visual Assessment

Each site was investigated in order to identify visible impacts on the site, with specific reference to impacts from surrounding activities and any effects from the mine. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the system, were identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site specific visual assessments included the following:

- Stream morphology;
- Instream and riparian habitat diversity;
- Stream continuity;
- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area; and
- Other life forms reliant on aquatic ecosystems.

Physico Chemical Water Quality Data

On-site testing of biota specific water quality variables took place. Parameters measured include pH, electrical conductivity (EC), dissolved oxygen (DO) concentration and temperature. The results of on-site biota specific water quality analyses were used to aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems as compiled by the Department of Water and Sanitation (DWS), formerly the Department of Water Affairs and Forestry (DWAF, 1996 vol. 7).

Habitat Suitability

General Habitat Integrity

The general habitat integrity of each site was discussed based on the application of the Intermediate Habitat Integrity Assessment (IHIA) for use in rapid and intermediate habitat assessments (Kemper 1999). It is important to assess the habitat of each site in order to aid in the interpretation of the results of the community integrity assessments by taking habitat conditions and impacts into consideration. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitat at each site. The method classifies habitat integrity into one of six classes, ranging from unmodified/natural (Class A) to critically modified (Class F), as indicated in Table 1A below. Reference conditions for the area were considered as unmodified/natural (Class A).

Table 1A: Classification of Present State Classes in terms of Habitat Integrity [Based on DWAF 1999].

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications.	80-90
C	Moderately modified.	60-79
D	Largely modified.	40-59
E	Extensively modified.	20-39
F	Critically modified.	<20

Habitat for aquatic macro-invertebrates

The Invertebrate Habitat Assessment System (IHAS) was applied according to the protocol of McMillan (1998). This index was used to determine specific habitat suitability for aquatic macro-invertebrates, as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. Scores for the IHAS index were interpreted according to the guidelines of McMillan (1998) as follows:

- <65%: habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community;
- 65%-75%: habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community; and
- >75% habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community.

Aquatic Macro-Invertebrates: South African Scoring System version 5 (SASS5)

Aquatic Macro-invertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System version 5) (Dickens and Graham, 2002). The SASS5 method has been specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (1998). The assessment was undertaken according to the protocol, as defined by Dickens & Graham (2002). All work was undertaken by an accredited SASS5 practitioner.

The SASS5 method was designed to incorporate all available biotypes at a given site and to provide an indication of the integrity of the of the aquatic macro-invertebrate community through recording the presence of various macro-invertebrate families at each site, as well as consideration of abundance of various populations, community diversity and community sensitivity. Each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas 2007).

This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net, with a pore size of 1000 micron mounted on a 300 mm square frame, over the churned up area several times. In stony bottomed flowing water biotopes (rapids, riffles, runs, etc.) the net downstream of the assessor and the area immediately upstream of the net is disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net was also swept under the edge of marginal and aquatic vegetation to cover from 1-2 meters. Identification of the organisms was made to family level (Thirion *et al*., 1995; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

Interpretation of the results of biological monitoring depends, to a certain extent, on interpretation of site-specific conditions (Thirion *et.al*, 1995). In the context of this investigation it would be best not to use SASS5 scores in isolation, but rather in comparison with relevant habitat scores. The reason for this is that some sites have a less desirable habitat or fewer biotopes than others do. In other words, a low SASS5 score is not necessarily regarded as poor in conjunction with a low habitat score. Also, a high SASS5 score, in conjunction with a low habitat score, can be regarded as better than a high SASS5 score in conjunction with a high habitat score. A low SASS5 score, together with a high habitat score, would be indicative of poor conditions. The IHAS Index is valuable in helping to interpret SASS5 scores and the effects of habitat variation on aquatic macro-invertebrate community integrity.

Classification of the system took place by comparing the present community status to reference conditions which reflect the best conditions that can be expected in rivers and streams within a specific area and also reflect natural variation over time. SASS and ASPT reference conditions were obtained from Dallas (2007), as presented in Figure below. Reference conditions are stated as a SASS score of 230 and an ASPT score of 6.7. Sites were classified according to the classification system for the Highveld Ecoregion according to Dallas (2007), as well as the classification system of Dickens & Graham (2002).

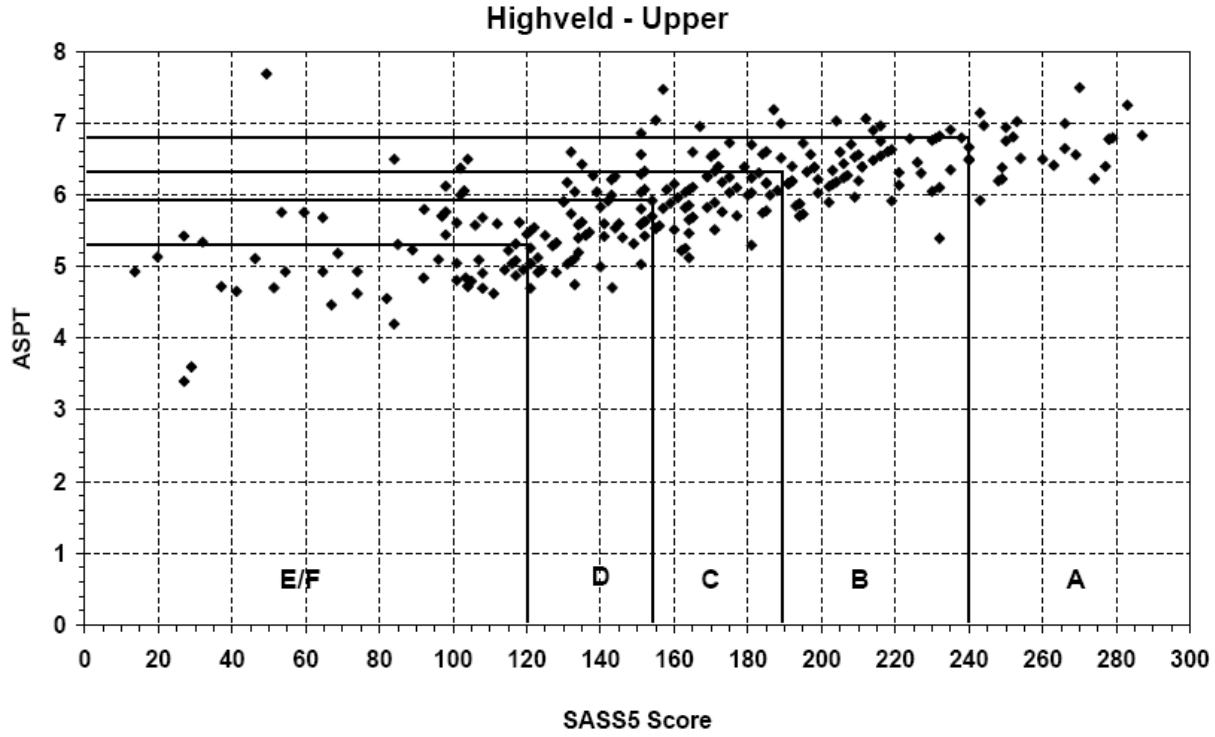

Figure 1A: SASS5 Classification using biological bands calculated form percentiles for the Highveld ecoregion, Dallas, 2007.

Table 1B: Definition of Present State Classes in terms of SASS scores as presented in Dickens & Graham (2002).

Class	Description	SASS Score%	ASPT%
A	Unimpaired. High diversity of taxa with numerous sensitive taxa.	90-100 80-89	Variable >90
B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.	80-89 70-79 70-89	<75 >90 76-90
C	Moderately impaired. Moderate diversity of taxa.	60-79 50-59 50-79	<60 >75 60-75
D	Largely impaired. Mostly tolerant taxa present.	50 – 59 40-49	<60 Variable
E	Severely impaired. Only tolerant taxa present.	20-39	Variable
F	Critically impaired. Very few tolerant taxa present.	0-19	Variable

Aquatic Macro-Invertebrates: Macro-invertebrate Response Assessment Index (MIRAI)

The four major components of a stream system that determine productivity, with particular reference to aquatic organisms, are flow regime, physical habitat structure, water quality and energy inputs. An interplay between these factors (particularly habitat and availability of food sources) result in the discontinuous, patchy distribution pattern of aquatic macro-invertebrate populations. As such aquatic invertebrates shall respond to habitat changes (i.e. changes in driver conditions).

To relate drivers to such changes in habitat and aquatic invertebrate condition, two key elements are required. Firstly, habitat preferences and requirements for each taxa present should be obtained. As such reference conditions can be established against which any response to drivers can be measured. Secondly habitat features should be evaluated in terms of suitability and the requirements mentioned in the first point. As a result, expected and actual patterns can be evaluated to achieve an Ecostatus Category (ECat) rating.

Based on the three key requirements, the MIRAI provides an approach to deriving and interpreting aquatic invertebrate response to driver changes. The index has been applied to all sites following methodology described by Thirion (2007). Aquatic macro-invertebrates expected at each point were derived both from available macro-invertebrate preference lists compiled for habitat, flow and water parameters (Thirion, 2007).

Diatom analysis

APPROACH
Diatoms are the unicellular algal group most widely used as indicators of river and wetland health as they provide a rapid response to specific physico-chemical conditions in the water and are often the first indication of change. The presence or absence of indicator taxa can be used to detect specific changes in environmental conditions such as eutrophication, organic enrichment, salinisation and changes in pH. They are therefore useful for providing an overall picture of trends within an aquatic system.

ANALYSIS
Diatom slides were prepared by acid oxidation using hydrochloric acid and potassium permanganate. Clean diatom frustules were mounted onto a glass slide ready for analysis. Taxa were identified mainly according to standard floras (Krammer & Lange- Bertalot, 2000). The aim of the data analysis was to identify and count diatom valves (400 counts) to produce semi-quantitative data from which ecological conclusions can be drawn.

FINDINGS

Sites were sampled within moderate flowing waters hence the use of the diatom software package OMNIDIA to infer water quality conditions at each site was applicable. Index values were calculated in OMNIDIA for epilithon data (attached to rocks) (Lecointe *et al.* 1993). In general, each diatom species used in the calculation of the index is assigned two values; the first value reflects the tolerance or affinity of the particular diatom species to a certain water quality (good or bad) while the second value indicates how strong (or weak) the relationship is. These values are then weighted by the abundance of the particular diatom species in the sample. The general water quality indices (integrating impacts from organic material, electrolytes, pH and nutrients), used in the assessment, are:

- The Specific Pollution sensitivity Index (SPI), one of the most extensively tested indices in Europe; and
- The percentage of (organic) pollution tolerant valves (%PTV).

The interpretation of the SPI scores applied in this study is displayed in Table 1C**.**

Table 1C: Class limit boundaries for the Specific Pollution sensitivity Index (SPI) (Koekemoer and Taylor, 2011).

SPI Score	Class	Ecological Category
>17.3	High quality	A
16.8-17.2		A/B
13.3-16.7	Good quality	B
12.9-13.2		B/C
9.2-12.8	Moderate quality	C
8.9-9.1		C/D
5.3-8.8	Poor quality	D
4.8-5.2		D/E
<4.8	Bad quality	E

Toxicological Analysis

Whole Effluent Toxicity (WET) procedures have been used successfully worldwide (SETAC, 1995) in countries such as the United States (USEPA, 1993; 1994), Canada (MISA, 1992) and in Europe (OECD, 1987). Governmental, industrial and international agencies have increasingly adopted single-species toxicity tests to predict potential effects on the environment. These tests are scientifically sound and in conjunction with chemical and ecological measurements can identify, monitor and serve as basis to implement control measures on the discharge of complex effluents. The Department of Water and Sanitation (DWS), previously the Department of Water Affairs and Forestry (DWAF), has for the past four decades controlled water pollution by managing levels of single substances in water. However, experience shows that substance-specific methods are not in themselves able to fully assess the ecological and toxicity hazard that may be posed by complex industrial wastewater discharges. Such methods are not effective in assessing the direct environmental toxicity hazard of discharges containing mixtures of substances (DWS formerly DWAF, 1996).

For some time now, water managers and scientists have called for a more comprehensive approach to assess in a holistic manner the potential toxicity hazard of complex industrial wastewater discharges as a means to protecting the ecological integrity of aquatic ecosystems. This call is particularly relevant in light of Chapter 3 of the National Water Act (Act 36 of 1998), which focuses on the protection of the water resource itself. Indeed, a number of industries in their quest to improve environmental management, to ensure compliance to regulations and to avoid or reduce unnecessary spending on treatment and disposal of wastewater, have begun to investigate more holistic methodologies for directly assessing the ecological hazard of complex industrial wastewater discharges. To address the mentioned holistic approach DWS produced a discussion document (DWS formerly DWAF, 2003) in which the current situation related to complex industrial wastewater discharges, pointing out the current

approach and methods, as well as the shortcomings and remaining challenges in protecting the ecological integrity of aquatic ecosystems are investigated. For the protection of aquatic life against the toxic effects of effluents and receiving waters a battery approach is recommended by Slabbert *et al.* (1998). According to DWS, WET tests are important additions to chemical-specific measurements because:

- Test organisms respond to compounds, which are not readily identifiable or measured by analytical techniques;
- Test organisms respond to unknown compounds;
- Effects due to chemical interaction, e.g. synergism, antagonism and addition are detected;
- Information on the type of hazardous chemical activity in an effluent, i.e. toxicity is provided; and
- Information on the impact on particular groups of target organisms is provided.

In order to qualify and quantify the potential impact of the past spills on the associated aquatic environment and to assess possible acute effects on aquatic organisms, acute WET tests were performed. The battery of WET tests included *Vibrio fischeri* (representing bacteria), *Selenastrum capricornutum* (representing aquatic vegetation) *Daphnia pulex* (representing aquatic macro-invertebrates) and *Poecilia reticulata* (representing fish).

Test organisms were exposed to water samples under controlled laboratory conditions. Tests were run along strictly defined protocols of the US EPA (2002) for the daphnia test, US EPA (1996) for the guppy test, EN ISO 11348-3 (2007) for the *Vibrio fischeri* bioluminescent test, OECD Guideline 201 (2006) for the *Selenastrum capricornutum* growth inhibition test. The results from these tests would indicate if there is any risk to the aquatic ecological integrity of the receiving environment on any one of four trophic levels should discharge or seepage occurs.

The tables below serve as a summary of the methods used for acute toxicity screening tests.

Table 1D: Summary of the test conditions and test acceptability criteria for the *Daphnia pulex* (US EPA 2002) and *Poecilia reticulata* (US EPA 1996) acute toxicity screening tests.

	Daphnia pulex acute toxicity test	*Poecilia reticulata* acute toxicity test
Test endpoint	% mortality /LC_{50}	% mortality/LC_{50}
Exposure period	48h	96h
Deviation from reference method	None	None
Test chamber type	50 mℓ disposable polystyrene cups	250mℓ disposable polystyrene cup.
Test sample volume	25mℓ	200mℓ
Number of test organisms per chamber	5	10
Number of replicates per sample	4	2
Feeding frequency	None	None
Test temperature	21 ± 2°C	23 ± 2°C
Test organism species name and source	*Daphnia pulex* <24h old obtained from in-house cultures	*Poecilia reticulata* 7-21 days old obtained from internal stock
Test protocol	% mortality /LC_{50}	% mortality/LC_{50}
Statistical methods used:	Probit software / TSK	Probit software / TSK

Table 1E: Summary of the test conditions for the *Selenastrum capricornutum* growth potential test, EN ISO 11348-3 (2006) and the *Vibrio fischeri* bioluminescent test, EN ISO 11348-3 (2007).

	Selenastrum capricornutum growth inhibition test	*Vibrio fischeri bioluminescent test*
Test endpoint:	% growth inhibition relative to control and/or EC20 and EC50 values	% growth inhibition relative to control and/or EC20 and EC50 values
Exposure period:	72h	30 min
Deviation from reference method:	None	None
Test chamber type:	10 cm path length long cells	Polystyrene cuvettes for luminometer
Test sample volume:	25 ml	500 ul
Number of replicates per sample:	2	2
Test temperature:	21-25°C	15°C ± 2°C
Test organism species name and source:	*Selenastrum capricornutum,* Printz algae beads (CCAP 278/4 Cambridge, UK)	Lyophilized *Vibrio fischeri* luminescent bacteria (NRRL B-11177)
Measurement:	Jenway 6300 Spectrophotometer	Luminoskan TL, Hygiene Monitoring System
Test organism source:	CCAP 278/4 Cambridge, UK	Not stated
Batch number:	SC	VF
Statistical methods used:	Regression analyses	Bio Orbit software

Interpretation of data was undertaken by classifying the results for each site into one of five categories. These categories are indicated in the table below.

Table 1F: Definition of Hazard classes in terms of Daphnia and guppy screening level toxicity tests.

Class	Description	Measurement
A	No acute hazard	None of the tests shows a toxic effect (i.e. an effect value that is significantly higher than that in the controls.
B	Slight acute hazard.	A statistically significant EP is reached in at least one test, but the effect level is below 50%.
C	Acute hazard.	The 50% Effect Percentage (EP50) is reached or exceeded in at least one test, but the effect level is below 100%.
D	High acute hazard	The EP100 is exceeded in at least one test.
E	Very high acute hazard.	The EP100 is exceeded in all tests.

Risk Assessment Method

Risk Assessment Method

In order for the Environmental Assessment Practitioner (EAP) to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.
The first stage of risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below:

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that is possessed by an organisation;
- An **environmental aspect** is an 'element of an organizations activities, products and services which can interact with the environment'[1]. The interaction of an aspect with the environment may result in an impact;
- **Environmental risks/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise

[1] The definition has been aligned with that used in the ISO 14001 Standard.

and health effects due to poorer air quality. In the case where the impact is on human health or wellbeing, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is;

- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems;
- **Resources** include components of the biophysical environment;
- **Frequency of activity** refers to how often the proposed activity will take place;
- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor;
- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards;
- **Spatial extent** refers to the geographical scale of the impact; and
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the Table 1O. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance-rating matrix and are used to determine whether mitigation is necessary[2].

The assessment of significance is undertaken twice. Initial, significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

"RISK ASSESSMENT KEY" (Based on DWS 2016 publication: Section 21 c and i water use Risk Assessment Protocol)

Table 1G: Severity (How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, and habitat).

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.	

[2] Some risks/impacts that have low significance will however still require mitigation.

Table 1H: Spatial Scale (How big is the area that the aspect is impacting on).

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighbouring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

Table 1I: Duration (How long does the aspect impact on the resource quality).

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5
PES and EIS (sensitivity) must be considered.	

Table 1J: Frequency of the activity (How often do you do the specific activity).

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

Table 1K: The frequency of the incident or impact (How often does the activity impact on the resource quality).

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

Table 1L: Legal issues (How is the activity governed by legislation?).

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5
Located within the regulated areas	

Table 1M: Detection (How quickly or easily can the impacts/risks of the activity be observed on the resource quality, people and resource).

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

Table 1N: Rating Classes.

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

A low risk class must be obtained for all activities to be considered for a GA

Table 1O: Calculations.

Consequence = Severity + Spatial Scale + Duration
Likelihood = Frequency of Activity + Frequency of Incident + Legal Issues + Detection
Significance\Risk = Consequence X Likelihood

The following points were considered when undertaking the assessment:

- Risks and impacts were analysed in the context of the *project's area of influence* encompassing:
  - Primary project site and related facilities that the client and its contractors develops or controls;
  - Areas potentially impacted by cumulative impacts for any existing project or condition and other project-related developments; and
  - Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.
- Risks/Impacts were assessed for all stages of the project cycle including:
  - Pre-construction;
  - Construction; and
  - Operation.
- If applicable, transboundary or global effects were assessed;
- Individuals or groups who may be differentially or disproportionately affected by the project because of their *disadvantaged* or *vulnerable* status were assessed; and
- Particular attention was paid to describing any residual impacts that will occur after rehabilitation.

Mitigation measure development

The following points present the key concepts considered in the development of mitigation measures for the proposed development.

- *Mitigation* and *performance improvement measures* and actions that address the risks and impacts[3] are identified and described in as much detail as possible;
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation; and
- Desired outcomes are defined, and have been developed in such a way as to be *measurable events with performance indicators, targets and acceptable criteria* that can be tracked over *defined periods*, with estimates of the *resources* (including human resource and training requirements) *and responsibilities for implementation.*

Recommendations

Recommendations were developed to address and mitigate impacts associated with the proposed development. These recommendations also include general management measures which apply to the proposed development as a whole. Mitigation measures have been developed to address issues in all phases throughout the life of the operation from planning, through to construction and operation.

[3] *Mitigation measures should address both positive and negative impacts*

APPENDIX 2: Impact Analysis and Mitigation Measures

General management and good housekeeping practices
The following essential mitigation measures are considered to be standard best practice measures applicable to a project of this nature, and must be implemented during all phases of the proposed rehabilitation activities, in conjunction with those stipulated in the individual tables in the following sections which define the mitigatory measures specific to the minimisation of impacts on the Braamfonteinspruit.

Development footprint
- All rehabilitation footprint areas should remain as small as possible and should not encroach into neighbouring riparian areas unless absolutely essential. It must be ensured that the riparian habitat is off-limits to non-essential construction vehicles and non-essential personnel;
- The boundaries of footprint areas, including contractor laydown areas, are to be clearly defined and it should be ensured that all activities remain within defined footprint areas. All storage facilities and contractor laydown areas are to remain outside of the riparian zone and the stream channel;
- Planning of temporary roads and access routes should avoid the riparian zone and remain out of the active channel and be restricted to existing roads and bridges where possible;
- Appropriate sanitary facilities must be provided for the life of the construction phase and all waste removed to an appropriate waste facility. All sanitary facilities must remain outside of the riparian zone and recommended buffer zones;
- All hazardous chemicals as well as stockpiles should be stored on bunded surfaces, away from the riparian zone and active stream channel, and have facilities constructed to control runoff from these areas;
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage;
- No fires should be permitted in or near the rehabilitation areas; and
- Ensuring that an adequate number of waste and “spill” bins are provided will also prevent litter and ensure the proper disposal of waste and spills.

Vehicle access
- All vehicles must be regularly inspected for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into the topsoil;
- In the event of a vehicle breakdown, maintenance of vehicles must take place with care and the recollection of spillage should be practiced near the surface area to prevent ingress of hydrocarbons into topsoil and subsequent habitat loss; and
- All spills should they occur, should be immediately cleaned up and treated accordingly.

Vegetation
- Proliferation of alien and invasive species is expected within any disturbed areas. The vegetation component within the riparian zone is already transformed as a result of alien plant invasion; therefore these species should be eradicated and controlled to prevent their spread beyond the project footprint. Alien plant seed dispersal within the top layers of the soil within footprint areas, that will have an impact on future rehabilitation, has to be controlled The Floral Assessment (SAS, 2016) should be consulted for more detail in this regard;
- Removal of the alien and weed species encountered within the riparian zone must take place in order to comply with existing legislation (amendments to the regulations under the Conservation of Agricultural Resources Act, 1983 and Section 28 of the National Environmental Management Act, 1998). Removal of species should take place throughout the construction, operational, and maintenance phases;
- Species specific and area specific eradication recommendations:
  - Care should be taken with the choice of herbicide to ensure that no additional impact and loss of indigenous plant species occurs due to the herbicide used;
  - Footprint areas should be kept as small as possible when removing alien plant species; and
  - No vehicles should be allowed to drive through designated sensitive wetland areas during the eradication of alien and weed species.

Soils and sediment

- Sheet runoff from temporary access roads should be slowed down by the strategic placement of berms;
- As far as possible, all rehabilitation activities, particularly those which involve activities within the active channel, should occur in the low flow season, during the drier winter months;
- As much vegetation growth as possible (of indigenous floral species) should be encouraged to protect soils;
- No stockpiling of topsoils is to take place within the recommended buffer zone of 16m around the riparian zone (Refer to the Wetland Assessment (SAS, 2016)), and all stockpiles must be protected with biodegradable hessian or a suitable geotextile to prevent sedimentation of the river;
- All soils compacted as a result of rehabilitation activities as well as maintenance activities should be ripped and profiled; and
- A monitoring plan for the rehabilitation project and the immediate zone of influence should be implemented to prevent erosion and incision.

Rehabilitation

- All construction rubble must be collected and disposed of at a suitable landfill site;
- No rough debris should be left in the active channel and in areas where the stream bed requires rehabilitation, care must be taken for use of appropriately sized river cobbles and boulders; and
- All alien vegetation in the footprint area as well as immediate vicinity of the proposed rehabilitation area should be removed. Alien vegetation control should take place for a minimum period of two growing seasons after rehabilitation is completed.

Risk Analyses

Impact ratings on the riparian ecology

The tables below serve to summarise the anticipated impacts that might occur during the construction/rehabilitation and operational phases as well as the mitigation measures that must be implemented in order to maintain and enhance the aquatic ecological integrity of the Braamfonteinspruit. It should be noted that the risk assessment was undertaken based on the proposed emergency installation of gabions at seven specified sites.

Table 2A: Impact Ratings and Mitigation Measures (Phase 1).

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
1	Construction	Site preparation prior to gabion installation, including placement of contractor laydown areas and storage facilities	Removal of vegetation and associated disturbances to soils	Exposure of soils, leading to increased runoff and erosion, and thus increased sedimentation of the instream habitat. Increased sedimentation of riparian habitat, leading to smothering of flora and potentially further altering surface water quality.		8	64	M	70	Contractor laydown areas, vehicle re-fuelling areas and material storage facilities to remain outside of the delineated riparian zone and the GDARD recommended buffer zone. ● Vegetation removal to be kept to a minimum, and preferably only alien floral species to be removed. ● Retain as much indigenous vegetation as possible. ● Limit vehicle/machinery activity within the active channel to what is absolutely essential. Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting. Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. The duration of impacts on the riparian areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible.	-9	L

1	Construction	Excavation within the active channel for foundations	Temporary diversion of stream to allow for excavations to take place. Movement of construction machinery/vehicles within the active channel. Possible spills or leaks from construction vehicles. Disturbances of soils within the active channel. Removal of topsoils and creation of soil stockpiles.	Altered flow regime, leading to possible loss of recharge to downstream areas, impacting on downstream biota. Possible incision/erosion in the vicinity of the diversion as a result of the (temporary) formation of a concentrated flow path. Possible sedimentation of downstream areas during the diversion. Possible moisture stress to riparian vegetation downstream of the diversion. Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. Possible contamination of riparian soils, instream sediment and surface water, leading to further reduced ability to support biodiversity. Altered runoff patterns, leading to increased erosion and sedimentation of riparian habitat. Altered flow regimes. Impacts to stream connectivity. Loss of refuge for aquatic species.		8	72	M	70	Activity will result in bank stabilisation, and reduction in bank incision and sedimentation of the resource. ● Ensure sediment control devices are in place prior to any excavation activities within the active channel. ● Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. ● Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting. ● The duration of impacts on the riparian areas and instream flow should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible. ● Limit vehicle/machinery activity within the active channel to what is absolutely essential. ● Ensure water movement is maintained through the system at all times. ● Ensure that no mounds of topsoil are left on the site. ● Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ● Regarding any potentially necessary temporary stream diversions, special care should be taken to keep the footprint of activities as small as possible. Special care must be taken to prevent sedimentation of the downstream resources. Any alterations to the stream bed substrates must be suitably rehabilitated with special mention of removal of sediment deposits and any rough debris associated with the proposed gabion construction activities. Ensure that stream beds are rehabilitated with smooth river cobbles where necessary. Flow continuity and connectivity must be maintained throughout the proposed gabion installation activities. No building materials associated with the proposed gabion installations must be left instream on completion of the construction activities. No litter or waste should be dumped instream for the duration of the construction activities including litter resulting from contractor presence on-site. Gabion installations must take place under low-flow conditions to ensure impacts related to erosion, incision and sedimentation as a result of exposed soils and excavations are minimised as far as possible.	-17	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
1	Construction	Installation of gabion structures including tie-ins	Movement of construction machinery/vehicles within the active channel. Possible spills/ leaks from construction vehicles. Possible discard of construction material within the active channel and riparian zone. Ongoing disturbances to soils as gabions are installed.	Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity. Alterations to flow patterns, possible contamination of water. Increased sedimentation of areas downstream of the installation site. Increased sedimentation as a result of disturbances Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances. Altered flow regimes. Altered stream depth profiles. Alteration of stream substrate. Impacts to stream connectivity.		9	72	M	70	Activity will result in bank stabilisation, and reduction in bank incision and sedimentation of the resource. ● Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. ● Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting. ● The duration of impacts on the riparian areas and instream flow should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible. ● Limit vehicle/machinery activity within the active channel to what is absolutely essential. ● Ensure water movement is maintained through the system at all times. ● Ensure that no mounds of topsoil are left on the site. ● Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ● Vegetation removal to be kept to a minimum, and preferably only alien floral species to be removed. Retain as much indigenous vegetation as possible. ● All disturbed areas must be suitably rehabilitated. Special mention is made of unnatural roughly edged rocky substrate associated with construction and building activities. Rocky substrate must be rehabilitated with natural smooth river cobbles and banks must be suitably re-profiled and re-vegetated to prevent erosion and sedimentation further downstream. Any alterations to the stream bed substrates must be suitably rehabilitated with special mention of removal of sediment deposits and any rough debris associated with the proposed gabion construction activities. Ensure that stream beds are rehabilitated with smooth river cobbles where necessary. Flow continuity and connectivity must be maintained throughout the proposed gabion installation activities. No building materials associated with the proposed gabion installations must be left instream on completion of the construction activities. No litter or waste should be dumped instream for the duration of the construction activities including litter resulting from contractor presence on-site. Gabion installations must take place under low-flow conditions to ensure impacts related to erosion, incision and sedimentation as a result of exposed soils and excavations are minimised as far as possible.	-17	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
1	Construction	Re-profiling and re-vegetation of slopes in areas affected by the construction activities related to the gabion installations	Movement of construction machinery/vehicles within the active channel. Possible spills/ leaks from construction vehicles. Site clearing. Ongoing disturbances to the riparian zone and disturbance and compaction of soils.	Increased sedimentation as a result of disturbances Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances. Loss of refuge for aquatic species. Alteration of stream beds. Alteration of depth profiles. Alteration of flow regimes.		8	72	M	70	Duration of impacts must be minimised. ● Ensure that runoff occurs in a natural diffuse manner with no unnatural concentration of flow. ● Soil erosion as a result of runoff from areas where invasive vegetation has been cleared must be prevented/ mitigated through the application of biodegradable hessian material where required. ● ● When re-profiling takes place it should be done to ensure water movement through the system at all times. ● In areas of severe incision and erosion, banks should be re-profiled to an angle of 18 degrees. ● In areas where severe gully formation has taken place, these affected areas should be appropriately backfilled to achieve the correct gradient. ● Final finishing and shaping must take place with topsoil free from invasive species. ● Re-seed with indigenous species. ● A mulch cover may be required to stabilise the soil during the winter months when grass does not grow or grows poorly. ● All alien invasive floral species should be removed on a continual basis from the rehabilitated areas. ● All removed alien plant species must be disposed of at a registered garden refuse site and may not be burned on site. ● Where chemicals are used the following guidelines and precautions apply: o Do not transport chemicals in bulk as this gives the potential for serious accidents occur; o Apply chemicals in cool, dry and non-windy weather to prevent drift from reaching water bodies; o Contaminated equipment should not be cleaned in field; o Many chemicals (e.g. pesticides/herbicides) are harmful to human and environmental health, and should therefore only be applied by properly trained and equipped workers that are registered according to the statuary requirements; o Herbicides and pesticides have the same toxic effect on aquatic plants and organisms as they do on the terrestrial plants and organisms to which they were applied. Therefore, when applying pesticides best practice guidelines should be strictly adhered to (as indicated in the label instructions) to minimise spray drift or wash-off into water resources and the killing of aquatic organisms. These include application under suitable weather conditions (i.e. sufficiently dry and calm), seeking professional advice on the type and quantity of pesticides that should be applied and considering the environmental conditions and hazards at the site;	-17	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
										o Over application must not take place and spray plans should also be continuously updated to prevent over application and contamination of water resources; o Herbicide should not be used if weed cover is low. The best way to keep weeds at bay is to maintain healthy, dense vegetation that shades the ground surface, preventing weed seedlings from taking root. Mulching can also be used to prevent weeds. However, if weeds do take hold, they should be dug or pulled out; o Herbicides should be used to spot-treat weeds only and not applied universally. In steep areas ensure that energy dissipation takes place to ensure that under high flow conditions and times of high rainfall, water does not flow into the Braamfonteinspruit in such a manner such as to result in erosion and incision of the stream bed and stream banks. Ensure that runoff does not lead to excessive sedimentation in the area through careful planning of stormwater drains and similar structures. Stormwater runoff must be managed taking into consideration areas of increased erosion potential. If any erosion is observed the affected areas should immediately be rehabilitated through levelling the area, reprofiling of soils and revegetating the area. Gullies and other areas of active erosion, if noted, should be stabilised through infilling with topsoil, cover with biodegradable hessian material/ geotextile such as GeoJute, and revegetated to minimise sediment entering the Braamfonteinspruit.		

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
2	Operation	Monitoring of structural integrity of installed gabions	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion, incision and alien vegetation encroachment. Proactive monitoring to ensure that any litter or debris which may accumulate on and around the gabions is cleared to maintain the flow of water.	No direct impacts perceived.		8	24	L	70	Limit vehicle/machinery activity within the active channel as well as in the riparian zone to what is absolutely essential. ● Disturbances to the riparian zone should be limited as far as possible. ● Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. ● Activities should not obstruct flow. ● Where possible, existing access roads should be used for monitoring purposes so as to minimise the compaction of soils and loss of both riparian and instream habitat. ● Hot spots for buildup of debris must be identified and debris must be regularly removed to prevent flooding and damage of infrastructure. In this regard, special mention is made of periods following high rainfall and subsequent high instream water volumes. ● During monitoring, always use the shortest routes possible so as to minimise disturbance and loss of habitat both instream as well as in the riparian zone. ● The riparian zone must be monitored for alien vegetation encroachment and all alien vegetation/weeds must be removed according to a suitable alien vegetation control plan. ● Any erosion or gully formation must be identified on an ongoing basis and re-profiled and revegetated accordingly. ● Use of biodegradable hessian sheeting must be made to prevent sedimentation of downstream resources.	0	L
		Monitoring of re-profiled slopes in the vicinity of the gabion installations	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion, incision and alien vegetation encroachment.	Compaction of soils and loss of habitat as a result of ongoing disturbance from vehicles and machinery.		8	24	L	70		0	L
		Monitoring of water quality and instream integrity both upstream and downstream of gabion installations	Proactive monitoring to ensure that the system is recovering sufficiently and not suffering harm post-construction activities.	No direct impacts perceived.		8	24	L	70		0	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
		Ongoing alien vegetation removal in the vicinity of the gabion installations	Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion, incision and alien vegetation encroachment.	Compaction of soils and loss of habitat as a result of ongoing disturbance from vehicles and machinery. Impacts to water quality as a result of the application of herbicides. Disturbance of soils and resulting erosion and sedimentation.		8	40	L	70		0	L

Table 2B: Impact Ratings and Mitigation Measures (Phase 2).

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
1	Construction	Site preparation prior to installation of remedial infrastructure (riprap / berms / concrete walls / stilling basin / bridge), specifically the placement of contractor laydown areas and storage facilities.	Removal of vegetation and associated disturbances to soils	*Exposure of soils, leading to increased runoff and erosion, and thus increased sedimentation of the resource. *Increased sedimentation of riparian habitat, leading to smothering of flora and potentially further altering surface water quality.		8	46	L	70	*Contractor laydown areas, vehicle re-fuelling areas and material storage facilities to remain outside of the delineated riparian zone and the GDARD recommended buffer zone. *Vegetation removal to be kept to a minimum and preferably only alien floral species to be removed. Retain as much indigenous vegetation as possible. *Exposed soils to be protected by means of a suitable geotextile covering such as hessian sheeting.	NA	
1	Construction	Site preparation within the riparian zone prior to installation of remedial infrastructure.	Removal of riparian vegetation, and disturbances to stream banks, including associated disturbances to soils.	*Exposure of soils, potentially resulting in further erosion, and thus increased sedimentation of the resource. *Increased sedimentation of riparian habitat, leading to smothering of flora and potentially further altering surface water quality.		11	71.5	M	70	*Removal of riparian and instream vegetation to be kept to a minimum; preferably only alien floral species to be removed. Retain as much indigenous vegetation as possible. *Disturbances to soils to be minimised as far as feasible. *Sediment control devices to be in place prior to the commencement of site preparation activities.	-16.5	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
1	Construction	Excavation within active channel for foundations.	Temporary diversion of stream to allow for excavations to take place.	*Altered flow regime, leading to possible loss of recharge to downstream areas, impacting on downstream biota. *Possible incision/erosion in the vicinity of the diversion as a result of the (temporary) formation of a concentrated flow path. *Possible sedimentation of downstream areas during the diversion.		11	60.5	M	70	*Ensure sediment control devices are in place prior to diverting the stream. *Ensure that the creation of the diversion does not result in a significant water level difference upstream or downstream of the installation site. *The duration of impacts on the riparian areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible. *All construction activity within the active channel for construction of bridge pier (at 8th Ave) should take place in the low flow period of winter. *Stream diversion must be kept as small as possible; extreme caution must be taken to prevent sedimentation of downstream resources and activities must take place in low flow period. *The construction of piles within coffer dams must be done as quickly as possible to reduce the duration of construction activity within the active channel of the river. *The extent of the coffer dam must be kept as small as possible. *Pier must be designed in such a way as to pose the least hydraulic resistance possible.	-5.5	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
1	Construction		*Movement of construction machinery/vehicles within the active channel *Possible spills / leaks from construction vehicles. *Possible discard of construction material within the active channel and riparian zone. *Ongoing disturbances to soils as infrastructure is installed	*Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. *Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity. *Alterations to flow patterns, possible contamination of water. *Increased sedimentation of areas downstream of the installation site. *Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances.		10	55	L	70	*Limit vehicle/construction equipment activity within the active channel to what is absolutely essential. *Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. *Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas. *Duration of impacts must be minimised. *Re-seed with indigenous species as soon as installation is completed.	NA	
		Re-profiling of slopes in the vicinity of remedial infrastructure	*Ongoing disturbances to soils. *Removal of vegetation	*Increased sedimentation as a result of disturbances. *Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances.		11	68.75	M	70	*Duration of impacts must be minimised. *Re-seed with indigenous species as soon as the gabion installation is completed.	-13.75	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
2	Operation	Monitoring of structural integrity of remedial infrastructure	*Proactive monitoring to ensure structural integrity is maintained and to identify early signs of erosion around the infrastructure. *Proactive monitoring to ensure that any litter or debris which may accumulate on and around the infrastructure is cleared to maintain the flow of water.	No direct impacts perceived		9	36	L	70	There should be no need to encroach the active channel to obtain a visual assessment of the structural integrity of the remedial infrastructure.	NA	
		Maintenance of installed infrastructure in the event of failure (if necessary)	Diversion of stream to allow maintenance/repairs to be undertaken	*Temporarily altered flow regime, leading to possible loss of recharge to downstream areas, impacting on downstream biota. *Possible incision/erosion in the vicinity of the diversion as a result of the (temporary) formation of a concentrated flow path.		11	60.5	M	70	*Ensure sediment control devices are in place prior to diverting the stream. *Ensure that the creation of the diversion does not result in a significant water level difference upstream or downstream of the installation site. *The duration of impacts on the riparian areas should be minimised as far as possible by ensuring that the duration of time in which flow alteration and sedimentation will take place is minimised – therefore the construction period should be kept as short as possible.	-5.5	L

No.	Phases	Activity	Aspect	Impact		Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Required Score Adjustment	Adjusted Risk Rating
			*Disturbances to soils as a result of movement of machinery/vehicles, and/or as a result of replacement of failed infrastructure. *Potential spills/leaks from vehicles/machinery.	*Disturbances of soils leading to increased alien vegetation proliferation, and in turn to further altered riparian habitat. *Possible contamination of riparian soils and surface water, leading to further reduced ability to support biodiversity.		11	55	L	70	*Limit vehicle/construction equipment activity within the active channel to what is essential. *Re-fuelling of vehicles to take place outside of the riparian zone & associated buffer zones, on sealed surfaces. *Maintain sediment/erosion control devices to minimise risk of sedimentation of downstream areas.	NA	
			Disturbances to or removal of vegetation whilst accessing infrastructure to carry out maintenance activities	*Potential loss of indigenous vegetation and the further proliferation of alien floral species due to disturbances.		10	35	L	70	*Ensure that the footprint area of cleared vegetation remains as small as possible. *Limit clearing of indigenous vegetation. *If deemed necessary, re-seed with indigenous vegetation once maintenance activities have been completed.	NA	

APPENDIX 3: IHAS Score Sheets March 2016

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: BRAAMFONTEINSPRUIT
Site Name: BS1
Date: 14/03/2016

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC Score (max 20):				**15**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					**14**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					**13**	
HABITAT TOTAL (MAX 55):					**42**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	flood	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX						**37**
TOTAL IHAS SCORE (%):					**79**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: BRAAMFONTEINSPRUIT
Site Name: BS3
Date: 14/03/2016

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC Score (max 20):				**14**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					**13**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					**14**	
HABITAT TOTAL (MAX 55):					**41**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	flood	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX 40						
TOTAL IHAS SCORE (%):					**81**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: BRAAMFONTEINSPRUIT
Site Name: BS7
Date: 14/03/2016

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
				SIC Score (max 20):	**10**	
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
				Vegetation Score (max 15):	**13**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
				Other Habitat Score (max 20):	**14**	
				HABITAT TOTAL (MAX 55):	**37**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	flood	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
				STREAM CONDITIONS TOTAL (MAX	**36**	
				TOTAL IHAS SCORE (%):	**73**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:
Site Name: BS11 **Date**: 15/03/2016

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC Score (max 20):				**15**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					**13**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					**13**	
HABITAT TOTAL (MAX 55):					**41**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	flood	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX 40						
TOTAL IHAS SCORE (%):					**81**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:
Site Name: BS12 **Date**: 15/03/2016

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC Score (max 20):				**15**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					**13**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					**13**	
HABITAT TOTAL (MAX 55):					**41**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	flood	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX						**41**
TOTAL IHAS SCORE (%):					**82**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: BRAAMFONTEINSPRUIT
Site Name: BS15
Date: 15/03/2016

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC Score (max 20):				**12**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none	0	1-25	26-50	51-75	>75
Vegetation Score (max 15):					**8**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
Other Habitat Score (max 20):					**8**	
HABITAT TOTAL (MAX 55):					**28**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	flood	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (MAX 36						
TOTAL IHAS SCORE (%):					**64**	

APPENDIX 4: SASS5 Score Sheets March 2016

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 14/03/2016	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S:°	COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
E:°	TURBELLARIA	3					Corixidae*	3		•	•	A	Blepharoceridae	15				
SITE CODE: BS1	ANNELIDA:						Gerridae*	5					Ceratopogonidae	5				
RIVER: BRAAMFONTEINSPRUIT	Oligochaeta	1	•			1	Hydrometridae*	6					Chironomidae	2	•	B	•	B
SITE DESCRIPTION: REP.	Leeches	3	•			1	Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: COOL AND CLEAR	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP: 21.3 °C	Amphipoda	13					Notonectidae*	3	•			1	Empididae	6				
Ph: 7.98	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 39.0 mS/m	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5	B	B	A	C
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEGIC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEGOOC: DOM SP:	Baetidae 2 sp	6			A		Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	B	B		B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	•	B	•	B	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		32	32	22	39
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		7	6	5	9
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		5	5.3	4	4.3
	Chlorolestidae	8					Pisuliidae	10					IHAS:		79%			
	Coenagrionidae	4		•		1	Sericostomatidae SWC	13					OTHER BIOTA:					
	Lestidae	8					COLEOPTERA:						DAPH. B					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					COMMENTS:					
	Protoneuridae	8					Elmidae/Dryopidae*	8										
	Zygoptera juvs.	6					Gyrinidae*	5										
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 14/03/2016	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E:°	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: BS3	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: BRAAMFONTEINSPRUIT	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	•	•	•	**A**
SITE DESCRIPTION: REP.	Leeches	3		•		**1**	Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: COOL AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 22.0 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.60	Potamonautidae*	3	•			**1**	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 52.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	•	•	•	**A**
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6			**B**		Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	**B**	**B**		**B**	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	**B**	**B**	•	**B**	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		28	32	25	41
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		5	6	5	8
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		6	5.3	5	5.1
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		81%			
	Coenagrionidae	4		•		**1**	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					LITTER, FAILING INFRASTRUCTURE, RESIDENTIA					
	Zygoptera juvs.	6					Gyrinidae*	5					HOUSING ON BANK, MOWED LAWNS					
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6			**A**	**A**	Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 14/03/2016	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3		•		1	Athericidae	10				
E:°	**TURBELLARIA**	3					Corixidae*	3		B		B	Blepharoceridae	15				
SITE CODE: BS7	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: BRAAMFONTEINSPRUIT	Oligochaeta	1			•	1	Hydrometridae*	6					Chironomidae	2	•	•	•	A
SITE DESCRIPTION: REP.	Leeches	3					Naucoridae*	7					Culicidae*	1		•		1
WEATHER CONDITION: COOL AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 23.6 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.28	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 37.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5		B	•	B
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1		•		1
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4		•		1	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6			A		Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	B	B		B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	B		B	B	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		20	35	20	42
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		3	9	5	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		7	3.9	4	3.8
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	73%				
	Coenagrionidae	4		•		1	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**						1x CATFISH					
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8										
	Zygoptera juvs.	6					Gyrinidae*	5										
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 15/03/2016	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E:°	**TURBELLARIA**	3					Corixidae*	3		•		1	Blepharoceridae	15				
SITE CODE: BS11	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: BRAAMFONTEINSPRUIT	Oligochaeta	1	B	B	B	B	Hydrometridae*	6					Chironomidae	2	B	B	B	B
SITE DESCRIPTION:	Leeches	3	•			1	Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: WARM AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 21.1 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.62	Potamonautidae*	3	•			1	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 34.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	B	B	B	C
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6	B			B	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	B			B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	B	B	A	B	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		38	26	14	50
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		8	7	4	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		5	3.7	4	4.5
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:		81%			
	Coenagrionidae	4		•		1	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8										
	Zygoptera juvs.	6					Gyrinidae*	5		•		1						
	Aeshnidae	8					Halipidae*	5										
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 15/03/2016	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3	•			1	Athericidae	10				
E:°	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: BS12	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	B	•		B
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 23.7 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.81	Potamonautidae*	3	A			A	Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 45.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5	A	•	•	A
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6			B		Hydropsychidae 2 sp	6	A			A	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12	B	B		B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6	B	B	B	B	Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		37	29	17	41
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		7	5	3	8
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		5	5.8	6	5.1
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	82%				
	Coenagrionidae	4		B		B	Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					LOW BRIDGE					
	Zygoptera juvs.	6					Gyrinidae*	5					INUNDATION US					
	Aeshnidae	8					Halipidae*	5					FAILING GABION					
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 15/03/2016	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3					Athericidae	10				
E:°	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: BS15	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5				
RIVER: BRAAMFONTEINSPRUIT	Oligochaeta	1			•	1	Hydrometridae*	6					Chironomidae	2	A	A	A	A
SITE DESCRIPTION: REP.	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION: HOT AND CLEAR	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP: 24.2 °C	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph: 7.60	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: mg/l	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond: 40.0 mS/m	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3			•	1
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		2	2	6	6
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		1	1	3	3
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		2	2.0	2	2.0
	Chlorolestidae	8					Pisuliidae	10					**IHAS**:	64%				
	Coenagrionidae	4					Sericostomatidae SWC	13					**OTHER BIOTA**:					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5					**COMMENTS**:					
	Protoneuridae	8					Elmidae/Dryopidae*	8					FAILURE OF INFRASTRUCTURE, LITTER INSTREA					
	Zygoptera juvs.	6					Gyrinidae*	5					DEBRIS FROM CONCRETE AND FAILING INFRAS					
	Aeshnidae	8					Halipidae*	5					HEAVILY INCISED, SPARSE UNDERGROWTH					
	Corduliidae	8					Helodidae	12					* = airbreathers					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					SWC = South Western Cape T = Tropical					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation ST = Sub-tropical					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud S = Stone & rock					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

APPENDIX 5: Details, Expertise and Curriculum Vitae of Specialists

1. (a) (i) Details of the specialist who prepared the report

Stephen van Staden MSc (Environmental Management) (University of Johannesburg)

Amanda Mileson NDip Nature Conservation (UNISA)

1. (a)(ii) The expertise of that specialist to compile a specialist report including a curriculum vitae

Company of Specialist:	Scientific Aquatic Services		
Name / Contact person:	Stephen van Staden		
Postal address:	29 Arterial road West Oriel, Bedfordview		
Postal code:	1401	Cell:	083 415 2356
Telephone:	011 616 7893	Fax:	011 615 6240/ 086 724 3132
E-mail:	stephen@sasenvgroup.co.za		
Qualifications	MSc (Environmental Management) (University of Johannesburg) BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)		
Registration / Associations	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP) Accredited River Health practitioner by the South African River Health Program (RHP) Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum		

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Managing member, Ecologist, Aquatic Ecologist
Date of Birth	13 July 1979
Nationality	South African
Languages	English, Afrikaans
Joined SAS	2003 (year of establishment)
Other Business	Trustee of the Serenity Property Trust

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)

Accredited River Health practitioner by the South African River Health Program (RHP)

Member of the South African Soil Surveyors Association (SASSO)

Member of the Gauteng Wetland Forum

EDUCATION

Qualifications

MSc (Environmental Management) (University of Johannesburg)	2002
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2000
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	1999

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces

Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe

Eastern Africa – Tanzania

West Africa – Ghana, Liberia, Angola, Guinea Bissau

Central Africa – Democratic Republic of the Congo

SELECTED PROJECT EXAMPLES OUT OF OVER 2000 PROJECTS WORKED ON

Development compliance studies

- Project co-leader for the development of the EMP for the use of the Wanderers stadium for the Ubuntu village for the World Summit on Sustainable Development (WSSD).
- Environmental Control Officer for Eskom for the construction of an 86Km 400KV power line in the Rustenburg Region.
- Numerous Environmental Impact Assessment (EIA) and EIA exemption applications for township developments and as part of the Development Facilitation Act requirements.
- EIA for the extension of mining rights for a Platinum mine in the Rustenburg area by Lonmin Platinum.
- EIA Exemption application for a proposed biodiesel refinery in Chamdor.
- Compilation of an EIA as part of the Bankable Feasibility Study process for proposed mining of a gold deposit in the Lofa province, Liberia.
- EIA for the development of a Chrome Recovery Plant at the Two Rivers Platinum Mine in the Limpopo province, South Africa.

- Compilation of an EIA as part of the Bankable Feasibility Study process for the Mooihoek Chrome Mine in the Limpopo province, South Africa.
- Mine Closure Plan for the Vlakfontein Nickel Mine in the North West Province.

Specialist studies and project management

- Development of a zero discharge strategy and associated risk, gap and cost benefit analyses for the Lonmin Platinum group.
- Development of a computerised water balance monitoring and management tool for the management of Lonmin Platinum process and purchased water.
- The compilation of the annual water monitoring and management program for the Lonmin Platinum group of mines.
- Analyses of ground water for potable use on a small diamond mine in the North West Province.
- Project management and overview of various soil and land capability studies for residential, industrial and mining developments.
- The design of a stream diversion of a tributary of the Olifants River for a proposed opencast coal mine.
- Waste rock dump design for a gold mine in the North West province.
- Numerous wetland delineation and function studies in the North West, Gauteng and Mpumalanga Kwa-Zulu Natal provinces, South Africa.
- Hartebeespoort Dam Littoral and Shoreline PES and rehabilitation plan.
- Development of rehabilitation principles and guidelines for the Crocodile West Marico Catchment, DWAF North West.

Aquatic and water quality monitoring and compliance reporting

- Development of the Resource quality Objective framework for Water Use licensing in the Crocodile West Marico Water management Area.
- Development of the Resource Quality Objectives for the Local Authorities in the Upper Crocodile West Marico Water management Area.
- Development of the 2010 State of the Rivers Report for the City of Johannesburg.
- Development of an annual report detailing the results of the Lonmin Platinum groups water monitoring program.
- Development of an annual report detailing the results of the Everest Platinum Mine water monitoring program.
- Initiation and management of a physical, chemical and biological monitoring program, President Steyn Gold Mine Welkom.
- Aquatic biomonitoring programs for several Xstrata Alloys Mines and Smelters.
- Aquatic biomonitoring programs for several Anglo Platinum Mines.
- Aquatic biomonitoring programs for African Rainbow Minerals Mines.
- Aquatic biomonitoring programs for several Assmang Chrome Operations.
- Aquatic biomonitoring programs for Petra Diamonds.
- Aquatic biomonitoring programs for several coal mining operations.
- Aquatic biomonitoring programs for several Gold mining operations.
- Aquatic biomonitoring programs for several mining operations for various minerals including iron ore, and small platinum and chrome mining operations.
- Aquatic biomonitoring program for the Valpre bottled water plant (Coca Cola South Africa).
- Aquatic biomonitoring program for industrial clients in the paper production and energy generation industries.
- Aquatic biomonitoring programs for the City of Tshwane for all their Waste Water Treatment Works.
- Baseline aquatic ecological assessments for numerous mining developments.
- Baseline aquatic ecological assessments for numerous residential commercial and industrial developments.
- Baseline aquatic ecological assessments in southern, central and west Africa.
- Lalini Dam assessment with focus on aquatic fish community analysis.
- Musami Dam assessment with focus on the FRAI and MIRAI aquatic community assessment indices.

Wetland delineation and wetland function assessment

- Wetland biodiversity studies for three copper mines on the copper belt in the Democratic Republic of the Congo.
- Wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa.
- Terrestrial and wetland biodiversity studies for developments in the mining industry.
- Terrestrial and wetland biodiversity studies for developments in the residential commercial and industrial sectors.
- Development of wetland riparian resource protection measures for the Hartbeespoort Dam as part of the Harties Metsi A Me integrated biological remediation program.

- Priority wetland mammal species studies for numerous residential, commercial, industrial and mining developments throughout South Africa.

Terrestrial ecological studies and biodiversity studies

- Development of a biodiversity offset plan for Xstrata Alloys Rustenburg Operations.
- Biodiversity Action plans for numerous mining operations of Anglo Platinum throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plans for numerous mining operations of Assmang Chrome throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plans for numerous mining operations of Xstrata Alloys and Mining throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plan for the Nkomati Nickel and Chrome Mine Joint Venture.
- Terrestrial and wetland biodiversity studies for three copper mines on the copperbelt in the Democratic Republic of the Congo.
- Terrestrial and wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa.
- Numerous terrestrial ecological assessments for proposed platinum and coal mining projects.
- Numerous terrestrial ecological assessments for proposed residential and commercial property developments throughout most of South Africa.
- Specialist Giant bullfrog (*Pyxicephalus adspersus*) studies for several proposed residential and commercial development projects in Gauteng, South Africa.
- Specialist Marsh sylph (*Metisella meninx*) studies for several proposed residential and commercial development projects in Gauteng, South Africa.
- Project management of several Red Data Listed (RDL) bird studies with special mention of African grass owl (*Tyto capensis*).
- Project management of several studies for RDL Scorpions, spiders and beetles for proposed residential and commercial development projects in Gauteng, South Africa.
- Specialist assessments of terrestrial ecosystems for the potential occurrence of RDL spiders and owls.
- Project management and site specific assessment on numerous terrestrial ecological surveys including numerous studies in the Johannesburg-Pretoria area, Witbank area, and the Vredefort dome complex.
- Biodiversity assessments of estuarine areas in the Kwa-Zulu Natal and Eastern Cape provinces.
- Impact assessment of a spill event on a commercial maize farm including soil impact assessments.

Fisheries management studies

- Tamryn Manor (Pty.) Ltd. still water fishery initiation, enhancement and management.
- Verlorenkloof Estate fishery management strategising, fishery enhancement, financial planning and stocking strategy.
- Mooifontein fishery management strategising, fishery enhancement and stocking programs.
- Wickams retreat management strategising.
- Gregg Brackenridge management strategising and stream recalibration design and stocking strategy.
- Eljira Farm baseline fishery study compared against DWAF 1996 aquaculture and aquatic ecosystem guidelines.

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF KIEREN JAYNE BREMNER

PERSONAL DETAILS

Position in Company	Aquatic and Wetland Ecologist
Date of Birth	20 September 1983
Nationality	South African
Languages	English (Fluent), Afrikaans (Fluent), Spanish (Basic), French (Basic)
Joined SAS	2015

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Accredited River Health practitioner by the South African River Health Program (RHP)

EDUCATION

Qualifications

MSc (Aquatic Ecology) (University of Johannesburg)	2011
BSc (Hons) Natural Sciences (Aquatic Ecology) (University of Johannesburg)	2005
BSc (Zoology and Biochemistry) (Rand Afrikaans University)	2004

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces

Southern Africa – Botswana

West Africa – Ghana

Central Africa – Democratic Republic of the Congo

SELECTED PROJECT EXAMPLES

Specialist studies and project management

- Numerous wetland delineation and function studies in the Gauteng, Free State and Mpumalanga provinces, South Africa.
- Development of an aquatic intervention plan and regional impact analysis for the Nokeng Flourspar Mine, Gauteng.
- Development and project management of aquatic biomonitoring studies at the Cronimet Mine, Limpopo Province, and the NECSA complex, Pelindaba.
- Implementation of a water quality monitoring programme on the Bushmans and Kariega Estuaries, Eastern Cape.

Aquatic and water quality monitoring and compliance reporting

- Development of the 2010 State of the Rivers Report for the City of Johannesburg.
- Development of an annual report detailing the results of the Everest Platinum Mine water monitoring program.
- Aquatic biomonitoring programs for several Xstrata Alloys Mines and Smelters.
- Aquatic biomonitoring programs for several Anglo Platinum Mines.
- Aquatic biomonitoring programs for several Assmang Chrome Operations.
- Aquatic biomonitoring programs for Petra Diamonds.
- Aquatic biomonitoring programs for several coal mining operations.
- Aquatic biomonitoring programs for several mining operations for various minerals including iron ore, and small platinum and chrome mining operations.

- Aquatic biomonitoring program for industrial clients in the paper production and energy generation industries.
- Aquatic biomonitoring programs for the City of Tshwane for all their Waste Water Treatment Works.
- Aquatic biomonitoring programs for the North West Wastewater Treatment Works.
- Baseline aquatic ecological assessments for numerous mining developments.
- Baseline aquatic ecological assessments for numerous residential commercial and industrial developments.
- Baseline aquatic ecological assessments in Ghana and the Democratic Republic of Congo.
- Water quality monitoring on the Bushmans and Kariega estuaries, Eastern Cape.

Wetland delineation and wetland function assessment

- Wetland biodiversity studies for developments in the mining industry.
- Wetland biodiversity studies for developments in the residential commercial and industrial sectors.

Public Participation Processes

- Team member in the Public Participation Process for the Cronimet Mine.
- Team member in the Public Participation Process for Wesizwe Platinum Mine.

Training and education

- Training of junior staff in the aquatic biomonitoring field.
- Educational workshops in mini-SASS in both Mpumalanga and the Eastern Cape.
- Educational workshops on water quality monitoring and environmental awareness in the Eastern Cape Province.

1. (b) a declaration that the specialist is independent in a form as may be specified by the competent authority

I, Stephen van Staden, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Signature of the Specialist